Danielle Wold
Project Manager

June 12, 2020

Ms. Jordan Haserot
Water Resource Control Engineer
Central Coast Regional Water Quality Control Board
Land Disposal Unit
895 Aerovista Place, Suite 101
San Luis Obispo, CA 93401-7906

Guadalupe Restoration Project
Transmittal Letter Revised Soil Management Area ROWD

Dear Ms. Haserot:

Attached, per our response to comment letters dated April 10, 2020 and May 8, 2020, please find attached a revised Report of Waste Discharge (ROWD) for the proposed Soil Management Area (SMA) to be located at the Guadalupe Restoration Project. This revised ROWD contains the following principal updates:

- Attached concurrence letter from Cal Recycle as Appendix A.2,
- Updated the discussion in Section 2.2 on the water supply well,
- Added a discussion in Section 2.2 on the remediation wells,
- Amended Figure 6 to show the existing water production well onsite, and Figure 7 (showing the entire Guadalupe Restoration Project and the former oil production wells) to include the remediation wells
- Expanded the discussion in Section 2.2 on oil production wells. The section includes recently obtained information that shows abandoned production well K-13 is within the current SMA footprint. Chevron intends to modify the footprint to exclude K-13, and will present those modifications in the design report,
- Revised Sections 4.1, 4.6.3, and 5.3 to show that the distance between the lowest point of the SMA liner and the highest recorded groundwater is 9.8 feet. This information is supported by an isopach (thickness) analysis between those surfaces which is provided as a new appendix,
- Expanded the discussion in Section 5.9 to provide further detail on stormwater management, and provided a set of conceptual diagrams in a new appendix, Appendix M,
- Corrected the phasing diagrams in Appendix C,
- Updated the HELP analysis to reflect recent hydraulic conductivity testing of the dune sand prevalent at the Guadalupe Restoration Project,
- Revised Detail 3 on Sheet 7 (General Development Drawings-Appendix B) to show a weld between the ends of the upper and lower geomembrane in the anchor trench, and

Chevron Environmental Management Company
Downstream Business Unit
2184 Thornberry Road
Guadalupe, CA 93434
PO Box 7261
Arroyo Grande, CA 93421
Tel 805 858 3028 Mobile 832 581 5426
DanielleWold@chevron.com

- Added additional information to the Drainage Analysis (Appendix N) showing that the existing AWTS has sufficient capacity to treat the combined remediation, leachate, and typical stormwater flows during a wet season, and that 500,000 gallons of temporary storage is needed for the 1,000-year 24-hour storm and for flow equalization.

If you have questions, or need further information, please do not hesitate to call.

Sincerely,

Danielle Wold

Danielle Wold
Chevron Environmental Management Company

REPORT OF WASTE DISCHARGE

Soil Management Area

Guadalupe Restoration Project

Submitted to:

Union Oil Company of California
Chevron Environmental Management Company
Former Unocal Guadalupe Oilfield
2184 West Thornberry Road
San Luis Obispo County, California 93434

Submitted by:

Golder Associates Inc.
1000 Enterprise Way, Suite 190 Roseville, California, USA 95678

+1 916 786-2424

1783552

June 12, 2020

Distribution List

Daniel Pelikan - Central Coast Regional Water Quality Control Board

Danielle Wold – Chevron Environmental Company

Owen Ranta – Chevron Environmental Company

Golder Associates Inc.

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Abbreviations

ADC	Alternative Daily Cover
APCD	Air Pollution Control District
AWTS	Advanced Water Treatment System
bgs	Below ground surface
BMP	Best Management Practice(s)
BTEX	Benzene, Toluene, Ethylbenzene, and total Xylenes
CAO	Cleanup or Abatement Order
CCR	California Code of Regulations
CDP	Coastal Development Permit
CFR	Code of Federal Regulations
CGS	Coast Ranges geomorphic
CIMIS	California Irrigation Management System
CPT	Cone Penetration Test
CQA	Construction Quality Assurance
DP	Development Permit
DSA	Dune Sand Aquifer
DSHA	Deterministic Seismic hazard Analysis
DT Area	Diluent Tanks Area
EPA	Environmental Protection Agency
ET	Evapotranspirative
FEMA	Federal Emergency Management Agency
FWS	U.S. Fish and Wildlife Service
GCL	Geosynthetic Clay Liner
HDPE	High-Density Polyethylene
HELP	Hydrologic Evaluation of Landfill Performance

HSA	Hollow Stem Auger
LCRS	Leachate Collection and Removal System
LEA	Local Enforcement Agency
LNAPL	Light Non-Aqueous Petroleum Liquid
LTU	Land Treatment Unit
MAP	Monoammonium Phosphate
MCE	Maximum Credible Earthquake
Mg/Kg	Milligrams/Kilogram
Mg/L	Milligrams/Liter
M-K Test	Mann Kendall Trend Test
MSL	Mean Sea Level
No.	Number
NOAA	National Oceanic and Atmospheric Administration
NPDES	National Pollutant Discharge Elimination System
PGA	Peak Ground Acceleration
PLC	Programmable Logic Controller
PROS	Pavement, Roadway, Oil Spray
PTO	Permit to Operate
REC	Recreational (zoning)
RL	Rural Lands
RWQCB	Central Coast Regional Water Quality Control Board
SWFP	Solid Waste Facility Permit
SLO	San Luis Obispo
SMA	Soil Management Area
SSRP	Site-Specific Restoration Plan
SWPPP	Storm Water Pollution Prevention Plan

TB-9	Tank Battery 9
TPH	Total Petroleum Hydrocarbon
TPHg	Total Petroleum Hydrocarbon – gasoline range
U.S.	United States
USGS	U.S. Geological Survey
USFWS	U.S. Fish and Wildlife Service
VOC	Volatile Organic Compound
WDR	Waste Discharge Requirements

1.0 INTRODUCTION

On behalf of Chevron Environmental Management Company (Chevron), Golder Associates, Inc. (Golder) has prepared this Report of Waste Discharge (ROWD) for the Soil Management Area (SMA), a proposed Class II Landfill, which will be constructed at the Guadalupe Oil Field (Field) shown in Figure 1. In 1998, the Central Coast Regional Water Quality Control Board (RWQCB) issued Cleanup and Abatement Order (CAO) 98-38 (RWQCB, 1998) to Union Oil Company of California (now Chevron)[1], for the remediation of petroleum hydrocarbon (TPH) contamination and sumps at the 2,700-acre Field. The SMA is intended to support that remedial effort by providing a permanent repository for petroleum impacted soil excavated from various locations at the Field as required by the CAO.

The SMA will be located in the former TB-9 Area of the Field (Figure 2). The selected location is near the remaining remediation areas, has good access via the existing road network and is close to other supporting infrastructure such as the Advanced Water Treatment System (AWTS). In addition, the SMA will be constructed over groundwater with existing impacts, reducing the potential risk to other groundwater resources.

Use of the SMA to support remediation is expected to have other environmental benefits as well. Previous remedial actions at the Field used the Santa Maria Regional Landfill (SMRL) to manage excavated impacted soil. Since the SMA is onsite and near the remaining remediation areas it is expected to eliminate the emissions, traffic congestion, and safety concerns associated with the off-site trucking required to use the SMRL. In addition, the existing disposal capacity at the SMRL is preserved for other public use.

This ROWD has been prepared in accordance with California Code of Regulations (CCR) Title 27 Division 2, Solid Waste. An Application/Report of Waste Discharge General Information Form for Waste Discharge Requirements (Form 200) is provided in Appendix A. Since, however, the landfill will be used solely for the disposal of petroleum impacted soil, it is considered exempt and excluded site under 27 CCR §215659(b). As such, joint permitting with CalRecycle is not required and, therefore, a Form E-1-77 requesting a Solid Waste Facilities Permit (SWFP) has not been submitted. A letter of concurrence from CalRecycle was received on April 16, 2020 and is also included in Appendix A.

In addition to approval by the RWQCB, construction of the proposed SMA requires an amendment to the San Luis Obispo County-approved Coastal Development Permit/Development Plan (CDP/DP) D890558D (SLOC, 1998) and California Coastal Commission -approved Coastal Development Permit E-99-009 which provided land use authorization for the remediation activities required by CAO 98-38. Amendment of CDP/DP D890558D requires environmental review in accordance with the California Environmental Quality Act (CEQA), which is being performed by San Luis Obispo County.

Appendix B includes design drawings for the construction, filling and closure of the proposed SMA development and closure. Appendix C provides the proposed phasing for the SMA development.

[1] Union Oil Company of California (Unocal) was acquired by Chevron in 2005. Chevron will be used for all references to the property owner, which includes the historical activities by Unocal.

2.0 UNIT CLASSIFICATION AND SITING

Based on previous discussions with the RWQCB, the proposed SMA will be designed, permitted, and operated as a Class II designated waste management unit. Although amendment will be used to promote degradation of the petroleum impacting the soil, the unit should not be considered a treatment unit or land farm.

2.1 Site Information

The Field is located on the coastline approximately 9 miles from the City of Santa Maria (Figure 1). The closest town is Guadalupe, which is about one mile from the southeastern property boundary. The Field is comprised of six separate parcels, totaling approximately 2,700-acres located within the Guadalupe/Nipomo Dunes Complex (Figure 3) north of the Santa Maria River. Most of the Field (2,630 acres) is in the southwest corner of San Luis Obispo County (SLO County) and a small portion (75 acres) is in Santa Barbara County.

Starting in the late 1940's the Field was used for the production, storage, and transmission of crude oil. The pre-field development topography of the Field is illustrated in Figure 4. However, the current topography is generally similar to the pre-development condition since most of the petroleum extraction and management uses did not require significant grading.

The Field has been in active remediation and restoration since oil production and processing operations ceased in 1994 and is currently managed by Chevron. Construction of the SMA over the TB-9 Area is part of that remediation effort.

The TB-9 Area is located on parcel numbers 092-041-001 and 092-041-005 in San Luis Obispo County (Figure 3) within Section 1 of Township 10N, Range 36W. The SMA is accessed from an existing paved access road from the Field entrance on Thornberry Road.

2.2 Surrounding Land and Water Use

As noted above, the Field is located almost entirely in San Luis Obispo County and within that county the Field is predominately zoned recreation (REC) with about 1/3 of the field zoned as Rural Lands. The former TB-9 Area straddles these land uses. The Rural Lands designation was originally intended to allow for continued oil field operations in those areas. The REC allows limited passive recreational activities such as walking trails. The 75 acres of the field located in Santa Barbara County are zoned as open space (Figure 5).

Approximately 70 percent of the land within one mile of the proposed SMA location is within the boundary of the Field. As such, there are only about 540 acres of agricultural land within a mile of the SMA location that are not owned and managed by Chevron and those lands are on the opposite side of the Santa Maria River (Figure 5). Lands within the Field to the north and due east are zoned REC. The portion of the land south and west of the SMA location within San Luis Obispo County is designated Rural Lands. The county line is approximately 0.5 mile southeast of the proposed SMA location. The Santa Barbara County land within one mile of the SMA zoned as AG-II-100 (Figure 5).

The only significant water body within one mile of the proposed SMA location is the Santa Maria River (Figure 5). For reference the Pacific Ocean is approximately 1.4 miles from the proposed SMA location.

The beneficial uses of groundwater in the vicinity of the Field are agricultural and industrial supply. According to publicly available information from San Luis Obispo County and the California Department of Water Resources (DWR), there are no water supply wells are within one mile of the Field (Figure 6). Two water wells are located within one mile from the proposed SMA location. One is within the field (WCR2017-007760), and the other

(WCR1944-000333) is on agricultural land in Santa Barbara County, across the Santa Maria River. Available information on these water wells is summarized in Table 5. Both wells are upgradient of the proposed SMA location. A well completion report for the off-site well is not on file with the California Department of Water Resources.

The principal water supply well for the Field is provided by a 10-inch diameter production well just over a mile from the SMA (Figure 6). That well does not appear on the WDR report. Chevron is working to rectify the WDR records. The production well has a total depth of 365-feet with screened sections between 175 and 195 feet below ground surface, and between 247 feet below ground surface and the bottom of the well. Both screened sections are completed within the Primary Aquifer. Although there is limited communication between the Principal Aquifer and the overlying Confining Unit, there does not appear to be any direct connection between the Principal Aquifer and the Dune Sand Aquifer that directly underlies the SMA. Consequently, pumping from the onsite water supply well is not expected to affect groundwater elevations at or around the SMA.

There are five product recovery (remediation) wells within 1,000 feet of the SMA and a total of 20 across the Field (Figure 7). The remediation wells are typically constructed of 4-inch diameter PVC and installed with screened sections positioned to remove diluent from the surface of the Dune Sand Aquifer. They are equipped with low-flow top loading pneumatic pumps that typically operate in the range of 200 to 300 gallons per day, but no more than 1,700 gallons per day. The wells are designed and operated to remove as little groundwater as possible and as such, they are not anticipated to affect groundwater elevations at or around the SMA.

As an operating oil field up to 1994, there is extraction, pumping and handling infrastructure throughout the Field and some of it is near the proposed SMA location. The existing oil and gas supply wells and related infrastructure for the Field are shown on Figure 7. Figure 8 shows the abandoned wells around SMA. The lateral limits of the SMA were configured to avoid these wells, based on the data available at the time. A preconstruction survey confirmed the locations of all of the wells, except K-13. A subsequent geophysical survey (confirmed by excavation) found the well at the location shown in Figure 8, which is within the SMA perimeter. Chevron does not propose to construct the landfill over abandoned well K-13, although the design drawings included in Appendix B of this ROWD have not been revised to reflect this new information. A design report with updated construction documents will be submitted to the RWQCB for approval prior to construction of the SMA. Those construction documents will include altering a portion of the northeastern boundary to avoid abandoned well K-13.

2.3 Volumetric Capacity and Site Life Estimate

Estimates of the SMA air space, fill capacity, service life, and earthwork requirements are presented in Table 2 and the supporting capacity calculations are presented in Appendix D.

The total airspace of the proposed SMA is estimated to be approximately 1,430,200 cubic yards. This estimate was derived by measuring the volume between the contours of the Base Grading Plan (Appendix B, Drawing 4) and the Final Grading Plan (Appendix B, Drawing 5) using AutoCAD Civil 3D.

The soil requirements were based on the soil necessary for constructing the liner system, general earthfill, and final cover. After considering the volume of soil required for the liner system and final cover, the net airspace (fill space) of the proposed SMA is approximately 1,203,900 cubic yards.

Chevron anticipates that remediation may consume up to 400,000 cubic yards of the SMA's net airspace annually and that SMA will reach capacity in approximately three years. It is anticipated that closure activities for the SMA will be completed in 2025.

2.4 Future Land Use

Restoration activities at the SMA will be completed consistent with the agency-approved Site-Specific Restoration Plan (Appendix E). Note that a condition of CDP/DP D890558D future uses of the Field to opens space and limited passive recreational activities. Commercial, industrial and residential uses are explicitly prohibited.

It is anticipated the finished surface of the SMA will consist of dune scrub vegetation and sand, which will be like the existing native stabilized dune habitat of the Field. The existing asphalt-paved road along the northeast side of the SMA will remain to provide access to SMA environmental facilities and the vehicle turn-around at well pad M-15 (Figure 7).

2.5 Ancillary Facilities

Existing all-weather access roads will provide routes for vehicles to the SMA. An access road will be constructed with grades no steeper than 9 percent to the top of the SMA. The Field has a number of temporary and permanent facilities in place to serve current operational needs. Existing site facilities include access roads to the facility, environmental monitoring, and the advanced water treatment plant. The SMA access road locations are shown on the site location map in Appendix B, Drawing 2.

3.0 WASTE CHARACTERISTICS

3.1 Types and Quantities of Material

For planning purposes, Chevron has conservatively estimated that 1,185,000 cubic yards of non-hazardous TPH-affected material from oilfield remediation and decommissioning activities at the Field will be placed in the proposed SMA (actual volumes are likely to be less). Soil samples representative of each type of feature such as roads, pads, sumps, diluent stains, and oil spray to be excavated and transported to the SMA for final disposition have been completed. The results of this investigation are summarized in Tables 3 and 4. Based on the estimated averages of total TPH (C_4-C_{40}) concentrations and volumes, the average concentration of total TPH (C_4-C_{40}) in soil is expected to be 8,182 mg/Kg (Table 3).

The soil samples were also analyzed for Volatile Organic Compounds (VOCs) per EPA Test Method 8015 for TPH as gasoline [C_4-C_{12}] and EPA Test Method 8260 full list of VOC analytes in the TPH-affected material. Detected concentrations of TPH-g (C_4-C_{12}) and VOCs analytes are summarized below as well as in Table 4.

- TPH-g (C_4-C_{12}): Detected concentration of TPH-g in soil samples collected from the sources described ranged from 0.22 mg/Kg to 2,500 mg/Kg, with an average concentration of 404 mg/Kg. TPH-g accounted for approximately 4.9% of the total TPH detected in the soil samples.
- Benzene: Detected concentrations of Benzene ranged from 0.0078 mg/Kg to 0.39 mg/Kg, with an average concentration of 0.9 mg/Kg.
- Ethylbenzene: Detected concentrations of Ethylbenzene ranged from 0.0054 mg/Kg to 14 mg/Kg, with an average concentration of 1.22 mg/Kg.
- Xylenes: Detected concentrations of Xylenes ranged from 0.011 mg/Kg to 25 mg/Kg, respectively, with an average concentration of 1.23 mg/Kg.
- Toluene: Detected concentrations of Toluene from 0.030 mg/Kg to 43 mg/Kg, with an average concentration of 0.96 mg/Kg.

In addition, analytical results indicated Naphthalene and alkylated VOCs (n-Butylbenzene, sec- Butylbenzene, Isopropylbenzene, n-Propylbenzene, p-Isopropyltoluene, 1,2,4-Trimethylbenzene, and 1,3,5-Trimethylbenzene) were detected in a select number of samples.

3.2 Soil Amendment and Placement

As noted at the beginning of this section, the fundamental purpose of the SMA is the long-term interment of the impacted soils of the Field requiring remediation. Given the success of a bench-scale and field-scale land treatment studies, Chevron proposes to amend soils placed in the SMA with an approved remediation nutrient, such as monoammonium phosphate (MAP), to enhance biodegradation of petroleum hydrocarbons. The studies definitively demonstrated that land treatment of diluent-affected soils from SMA excavations resulted in significant biodegradation of diluent range hydrocarbons. A further bench-scale study (Padre 2018) was conducted to establish the operational requirements needed to maximize hydrocarbon degradation in sump affected soil using biological land treatment.

Soil will be placed within the SMA in 12-inch lifts and spread by a large dozer. MAP, a one hundred percent soluble crystalline solid, will be pre-mixed into dust control water. It will then be applied in a liquid form over each lift using water trucks or sprinkler system. Each lift will then be compacted to achieve the desired relative density.

3.3 Waste Decomposition

By itself, the soil to be placed in the SMA is inert and non-putrescible. However, TPH that is comingled with the soil particles will biologically degrade, even though the TPH-affected soils are weathered and exhibit low VOC concentrations, as shown in Table 3.

The addition of MAP (See Section 3.2) will tend to promote aerobic degradation of the TPH over anaerobic pathways. As determined in the Land Treatment Bench Study (Padre 2018), addition of MAP resulted in a decrease in gasoline (C_4 – C_{12}) and diesel fuel (C_{13} – C_{22}) concentrations were measured over the course of the study. Conversely, there was little to no hydrocarbon degradation within the motor oil (C_{23} – C_{40}) carbon chain range. Given the relatively low proportion of hydrocarbon in the C_4 – C_{22} rand the addition of MAP is expected to further reduce the mass of light-end hydrocarbons in the soil. As remediation is completed and the SMA is closed this will impede the anaerobic biodegradation pathways, which favor lighter end hydrocarbons while being dependent on numerous factors including appropriate electron receptors such as nitrate, iron, and sulfur compounds, as well as complex syntrophic microbial communities and acceptable environmental conditions (e.g., temperature). Consequently, it is expected that the interred soil will produce relatively low quantities of methane and carbon dioxide.

3.4 Hazardous Waste

Only non-hazardous TPH-affected soil from on-site sources will be placed in the SMA. By definition TPH-affected soil is considered non-hazardous per 22 CCR §66261.10, *Criteria for Identifying Characteristics of Hazardous Waste*.

4.0 SMA CHARACTERISTICS

4.1 Groundwater and Surface Water Impairment Potential

As required by 27 CCR §21750(a), the discharger is to analyze how the SMA could be affected by groundwater and surface water, and how the groundwater and surface water could be adversely affected by a release from the SMA.

This information is to be provided in order to determine the suitability of the SMA with respect to the groundwater protection and avoidance of geologic hazards and to demonstrate compliance with 27 CCR §20240 et seq.

As described in Section 4.6 three distinct water bearing hydrostratigraphic units are found beneath the SMA; the Dune Sand Aquifer (DSA), the Confining Unit (CU), and the Principal Aquifer (PA). The DSA is the near surface aquifer that has been impacted by historic oil field operations. The CU is an interlayered bed greater than 100 feet thick of primarily fine-grained soils that effectively prevents contaminant transport between the overlying DSA and the underlying PA, which is the zone from which groundwater is regionally extracted for various uses.

As described in Section 5.3 the SMA has been designed to prevent groundwater from affecting the SMA by providing more than the regulatory minimum separation of 5 feet between the highest groundwater level and waste. Appendix F contains an isopach figure that shows the thickness between a surface representing the highest recorded groundwater levels in each local monitoring well and the top of clay. The lowest point of the SMA (the sump area) will be approximately 9.8 feet above the highest historic groundwater elevation in the monitoring record. Across the SMA footprint, the separation between the base of the liner and groundwater is 30 feet or more.

As described in Section 4.3, the SMA is not within the 100-year floodplain of the Santa Maria River. Run-on controls will divert storm water around the SMA, and they will be designed to accommodate the 1,000-year return period storm, so it is unlikely that flood waters could affect the SMA.

It is also unlikely that a release from the SMA could adversely affect surface water. Storm water controls at the SMA will direct run-off (or a release) to the AWTS. Those controls will also be designed to accommodate peak flows for the 1,000-year return period storm. In addition, there are no surface water bodies immediately adjacent to the SMA. Surface drainage will be designed to control erosion and sediment.

In the unlikely event of a release from the SMA it is possible that groundwater might be impacted, but those impacts would be limited to the already impacted groundwater in the DSA (Figure 9). A release from the SMA would manifest as either liquid (leachate) or gas migration. For leachate to impact groundwater, the liquid must be gravity-driven through the unsaturated zone and into the saturated zone. Leachate impacts to groundwater would appear as dissolved phase petroleum hydrocarbons and volatile organic compounds (VOCs) like the existing impacts.

Methane and carbon dioxide will be produced during the biodegradation of the petroleum compounds managed in the SMA. Migration of these gases can be driven by a pressure gradient that results from their generation, which can also transport other volatile compounds. However, due to various other factors (see Section 3.3) the generation of methane and carbon dioxide is expected to be low. In addition, migration to the surface provides a lower energy (i.e., preferential) pathway than migrating through the liner, leachate, and leak detection components of the SMA. In the unlikely event of a gas release from the SMA impacts to groundwater in the DSA would include the dissolution of carbon dioxide and VOCs. Increases in carbon dioxide concentrations can lower pH and affect the general chemistry of impacted groundwater. Any potential impacts would be limited, however, to the DSA since it is not possible for migrating gases to directly affect the CU or the PA.

Existing impacts to groundwater beneath the SMA are VOCs attributed to crude oil sump material and diluent (Figure 9). For the purposes of identifying a potential release from the SMA, as required by 27 CCR §21750, a similar release of VOCs is assumed. Such a release would have little to no impact to beneficial uses of groundwater for the following reasons:

- The groundwater underlying the SMA is already impacted by TPH and is the subject of an on-going remediation program at the Field that is cleaning up potential groundwater impact sources (Figure 9).

- The existing impacts to groundwater have been generated by free-phase hydrocarbon on groundwater and, to a lesser extent, hydrocarbon impacted soils. Those hydrocarbon-impacted soils are being consolidated from their current location to the SMA. Consequently, groundwater quality within the Field should improve overall irrespective of a hypothetical release from the SMA.
- A release from the SMA is unlikely to occur in such volume that it could affect groundwater resources beyond the existing impact limits given that the current impacts are largely driven by the free-phase product source (Figure 9).

The potential for the SMA to affect beneficial uses of groundwater is judged insignificant because of existing groundwater impacts, and SMA design and operational elements to prevent leachate or gas migration to groundwater. The design elements are:

- Groundwater separation - separation between the SMA and groundwater is a minimum of 9.8 feet, and more generally about 30 feet, which exceeds the 27 CCR design standard of 5 feet.
- The SMA is in a climatologically dry area. The average annual rainfall is only 13 inches. Additionally, because the rainstorms that do occur tend to be short duration/high intensity storms, much of the rainfall will run off the SMA and will not infiltrate the SMA surface. Thus, reducing the potential formation of leachate.
- The SMA will be constructed with a double composite liner exceeding regulatory requirements. The composite liners on the landfill base will be comprised of a high-density polyethylene (HDPE) geomembrane and a low-hydraulic conductivity layer that meets the performance criteria of the state and federal regulations.
- The HDPE material will be selected to ensure a high degree of compatibility with petroleum.
- A leachate collection and removal system (LCRS) will be constructed over the primary liner on the landfill base. The leachate collection removal system is designed to collect twice the estimated daily peak quantity of leachate in the SMA and allow it to be removed.
- A leak detection system between the primary and secondary composite liners will provide an early determination of any leaks in the primary composite liner. The leak detection system is designed to allow any leakage to be removed.
- The drainage system is designed to divert off-site run-on around the SMA so that run-on does not enter the SMA area.

The operational elements are:

- No liquid wastes will be placed in the SMA
- The waste is compacted to decrease its permeability and increase its ability to shed water
- The cell will be filled as rapidly as possible to allow sheet flow off the filled surface
- Active measure such as temporary visqueen lined stormwater ponds and pumps will be used to prevent stormwater from ponding and infiltrating into the waste mass before the fill prism has reached the surrounding grade
- Waste will be graded to promote run-off away from active waste disposal areas to prevent stormwater from entering the waste

- Cover (compacted soil or alternative daily cover) will be placed on the waste which minimizes water entering the waste
- Leachate sumps will be emptied as needed to maintain the fluid depth at 12 inches or less

Final cover will be placed on the SMA as soon as practical, which will minimize moisture entering the SMA.

4.2 Topography

In the SMA area, the elevation ranges from approximately 65 feet to 105 feet mean sea level (MSL). The grade slopes generally from the northwest to the southeast. The existing topography is shown in Appendix B, Drawing 3.

4.3 Floodplain

The SMA is in the south-central portion of the Field approximately 1.25 miles east of the Pacific Ocean and 0.4 miles north of the Santa Maria River. The SMA site is located in Zone X, an area outside the 100-year flood plain with minimal flood hazard. Flood information was taken from the Federal Emergency Management Agency (FEMA) map number 06079C1880F, effective August 28, 2008. The floodplains of the nearby surface water bodies are provided on Figure 10.

4.4 Climatology

Precipitation data for the period of 1948 to 2018 was taken from the National Oceanic and Atmospheric Administration (NOAA) for Santa Maria Public Airport Station 047946 (NOAA, 2018) located approximately 11 miles from the SMA Area. The maximum and minimum annual precipitation was recorded to be 28.24 inches in 1998 and 2.99 inches in 2013, respectively. The average annual precipitation is 12.76 inches for this station, however, the isohyetal map prepared by San Luis Obispo County Flood Control and Water Conservation District shows the mean annual precipitation is closer to 14 inches at the SMA as shown on Figure 11. For the station record period, the months with the least precipitation are July and August (0.03 inches) and the month with the most precipitation is February (2.73 inches).

The 1,000 year, 24-year storm event for the SMA is approximately 5.27 inches of rain. Data for the 1,000-year, 24-hour storm event was obtained from the NOAA Atlas 14, Volume 6, Version 2 Point Precipitation Frequency Estimates website for the Guadalupe – Union Oil station.

The average annual maximum and minimum temperatures for the Santa Maria Public Airport are 68.8° F and 45.9° F, respectively. September has the highest average maximum temperature of 74.4° F and December has the lowest average minimum temperature of 38.7° F.

The evaporation loss for the SMA is estimated to be approximately 48.73 inches per year. The evapotranspiration (ETo) data was sourced from the California Irrigation Management System (CIMIS) website for the Nipomo Station (Station 202), located approximately 5 miles northeast of the SMA. The estimated average monthly ETo is 4.06 inches, with a minimum ETo of 1.93 inches typically occurring in December and a maximum of 5.89 inches typically occurring in July.

Winds in the SMA are generally in the northwest direction and average 8.9 miles per hour. Peak wind speeds are estimated to be as high as 25 miles per hour as shown on Figure 12.

4.5 Regional and Local Geology

4.5.1 Regional Geology

The SMA is located in San Luis Obispo County, California, near its boundary with Santa Barbara County, and within about 1.4 miles of the Pacific coastline. The SMA is located in the Coast Ranges geomorphic province (CGS, 2002) dominated by northwest-trending, moderately elevated mountains and valleys that extend parallel to the central California coastline. The Coast Ranges province extends from Humboldt County in the northwest to the Transverse Ranges, north of Los Angeles, in the southeast, a distance of about 600 mi (965 km). The Coast Ranges province is bounded on the east by the Great Valley province.

The SMA is situated within coastal sand dune deposits that mantle the western extent of the Santa Maria River Valley. The valley is bounded:

- On the northeast by low coastal mountains that include Temettate Ridge (1,800 ft / 550 m), Newsome Ridge (1,600 ft / 485 m) and Loma Pelona (1,785 ft / 545 m)
- On the southwest by the Casmalia Hills, with a maximum elevation of 1,660 ft (505 m) at Mount Lospe.

The Casmalia Hills are the northern and westernmost onshore extent of the Transverse Ranges and the southwestern edge of Santa Maria River valley forms the boundary between the Coastal Ranges and Transverse Ranges geomorphic provinces.

Southwest of the SMA, the Casmalia Hills rise above the coastline exposing basement rocks composed of the Point Sal Ophiolite, a metamorphosed assemblage of Jurassic-aged mafic igneous and deep marine sedimentary rocks. The basement rocks are overlain by Cretaceous-aged Espada Formation marine sedimentary deposits, including shale, sandstone and conglomerate. This entire assemblage has been unconformably buried by the Oligocene-aged non-marine Lospe Formation (claystone and sandstone), early- to mid-Miocene aged Point Sal formation (shale, sandstone and dolomite) and mid- to late Miocene aged marine sediments of the Monterey Shale formation. A younger sequence of marine, shallow-marine and non-marine sedimentary units are in fault contact with older rocks along the northern flank of the Casmalia Hills (Dibblee, 1989).

North and northeast of the SMA, the hills rising from Santa Maria Valley expose a moderately folded sequence of rocks that range from Miocene (Obispo Formation volcanic rocks) through Quaternary (Paso Robles Formation). Several prominent sets of northwest-trending hills are present between the Santa Maria Valley to the southwest and the Huasna Valley to the northeast, including Temettate Ridge and Newsome Ridge. The West Huasna fault dissects these hills with a steep down-to-the-west geometry (Dibblee, 2006).

4.5.2 Local Geology

The SMA is in the Coast Range Geomorphic Province of California, which consists of a faulted network of northwest-trending mountains and intervening valleys located between the Central Valley and the Pacific Ocean. A geological map and cross section of the SMA site are included as Figures 13 and 14, respectively.

A geotechnical investigation was performed by Padre Associates, Inc in October 2018 (Appendix G). The geotechnical site assessment included 3 hollow stem auger (HSA) drill holes to depths ranging from 40 to 61.5 feet below ground surface (ft bgs) and 14 cone penetration tests (CPTs) pushed to depths from 31.8 to 59.9 ft bgs. A copy of the summary report is included as an appendix to Static and Seismic Slope Stability Analysis in Appendix H.

Quaternary aeolian dune deposits of varying thickness (Guadalupe Dune Sand Complex) are the predominant surficial sediments at the SMA. These deposits are reported by Padre to consist of unconsolidated, well sorted, fine to medium grained sands, with less than two percent fines. In the vicinity of the SMA Padre found the dune deposits to be between 36 and 61.5 feet thick.

Underlying the surficial dune sand deposits in the area of the SMA is Quaternary alluvium which is made up of an upper member consisting of interbedded silt, clay, and sand (comprising the Confining Unit), and a lower member of coarser grained material that forms the Principal Aquifer.

Based on the cross section from Dibblee (1994), the generalized depositional sequence underlying the Santa Maria River Valley and the SMA are:

- **Coastal Dune Deposits (Qs)**: Wind-blown sands, deposited mainly along the coastline (Holocene)
- **Valley Floodplain Alluvium (Qa)**: A thin veneer of surficial alluvium deposited on the valley floor (Holocene)
- **Orcutt Formation (Qo)**: Non-marine weakly-consolidated wind-blown sand and gravel deposit (Pleistocene)
- **Paso Robles Formation (QTp)**: Non-marine weakly-consolidated alluvial gravels, sands and clay (Pleistocene)
- **Careaga Sand (Tca)**: Marine, weakly-indurated fossiliferous sand (Pliocene-Pleistocene)
- **Foxen Claystone (Tf)**: Marine claystone (Pliocene)
- **Sisquoc Formation (Tsq)**: Marine diatomaceous claystone (Miocene-Pliocene)
- **Monterey Shale (Tm)**: Marine (biogenic) thin-bedded siliceous shale (late-Miocene)

The weakly consolidated Quaternary units (including the Careaga Sand deposits) have a maximum thickness of about 8,000 feet (ft) in the Santa Maria Valley. Neogene and older sedimentary rocks make up an additional 18,000 ft before reaching the Jurassic Franciscan Formation rocks that form the local bedrock (Woodring and Bramlette, 1950).

4.5.3 Faults and Seismicity

While no known faults cross the SMA, there are active and potentially active faults in the vicinity, that have the potential to generate strong ground motion. The closest known fault to the SMA is the San Luis Bay Segment of the Shoreline fault zone, which is approximately 1 mi (1.6 km) from the SMA. A site-specific seismic hazard analysis is included as Appendix I.

More than 600 earthquakes greater than **M**3.0 have epicenters within about 62 mi (100 km) of the SMA since the early-19th century. There are 21 significant faults mapped within 62 mi (100 km) of the SMA, and of those, two fault sections (San Andreas fault, Cholame-Carrizo and Parkfield sections) have experienced surface fault rupture within historic time (since mid-19th century) and seven faults exhibit surface rupture within the last 15,000 years (Figure 15).

Casmalia Fault Zone

The Casmalia fault zone was the source of a May 1980 earthquake (**M**5.1), associated aftershocks and several other earthquakes recorded between October 1987 and January 1997 (Hanson et al., 2004). Focal mechanisms

constructed from p-wave data indicate that the fault motion was almost pure reverse associated with a relatively steep-dipping Casmalia fault plane (55° to 80° SW).

The Casmalia fault forms the boundary between structural blocks associated with the offshore Hosgri fault zone, including the Santa Maria Valley and Casmalia structural blocks (Willingham et al., 1995). The Casmalia structural block is bounded by the Casmalia fault zone on the northeast and the Lions Head fault on the southeast. The Casmalia Hills represent a horst (raised block) developed between the two faults.

Oceanic – West Huasna Fault Zone

Rupture on the Oceanic fault produced the 2003 **M**6.6 San Simeon earthquake, although surface rupture is not known to have accompanied the 2003 earthquake. The fault links and transfers slip from the Hosgri fault system in the west to the West Huasna fault in the east (Graymer et al., 2014) (Figure 15). Its orientation relative to the Hosgri and West Huasna Faults results in a significant component of reverse (up to the northeast) slip. The Oceanic and West Huasna faults are combined within the current Uniform California Earthquake Rupture Forecast, Version 3 (UCERF3) fault model (Field et al., 2013).

Golder performed a deterministic seismic hazard analysis (DSHA) that indicates the Casmalia fault develops the highest maximum credible earthquake (MCE) peak ground acceleration (PGA) at the SMA. The strongest median PGA value for an assumed stiff soil site (i.e., $V_{S,30}$ = 760 m/s) arises from an **M**6.9earthquake located about 2.8 mi (4.5 km) from the SMA. The estimated PGA is 0.48 g. This PGA value has a return period estimated from the 2014 USGS national seismic hazard maps at about 4,000 years.

4.6 Hydrogeology

Regionally, the Field is part of the Arroyo Grande-Santa Maria Ground Water Basin that extends through the southwestern portion of San Luis Obispo County and the northwestern portion of Santa Barbara County. The western boundary of the groundwater basin is the Pacific Ocean; although the basin extends beyond the shoreline and under the ocean. Groundwater in the main Santa Maria Basin is primarily recharged by stream infiltration and subsurface inflow. Water released from Twitchell Dam also recharges the basin.

The SMA is underlain by three distinct hydrostratigraphic units that are pertinent to this ROWD. These are (from top to bottom) the DSA, the Confining Unit (CU), and the Principal Aquifer (PA). The descriptions below are taken from, *Version 2.1 Confining Unit Integrity Report, Former Guadalupe Oil Field, San Luis Obispo, California* (LFR 2003a).

Depth to groundwater varies across the Field due primarily to the varied dune topography. However, the depth to groundwater generally decreases from east to west. Infiltration within the Field is rapid and recharge to the dune sand aquifer is primarily from percolation and precipitation. Groundwater flow is primarily to the west where groundwater discharges to the Pacific Ocean. Groundwater flow in the southern portions of the Field is towards the Santa Maria River. The average groundwater gradient across the Field is 0.004 feet per foot.

4.6.1 Dune Sand Aquifer

The DSA is a shallow unconfined aquifer comprised of recently deposited dune sands with a relatively high hydraulic conductivity. It is not considered a regional hydrostratigraphic unit, being limited to the Field and the surrounding dune areas. It is reported to have saturated thicknesses at the Pacific Ocean on the order of 25 to 30 feet. In the southeastern portion of the Field the saturated thickness of the DSA may be as little as 5 feet. It is generally recharged from above by local precipitation. Groundwater flow is typically from east to west with a southerly

component in the vicinity of the Santa Maria River. The mean DSA groundwater gradient around the SMA has been estimated to be 0.0043 (Figure 9). The horizontal hydraulic conductivity ranges between 40 to 150 feet per day with a geometric mean of 77 feet per day. Beneath the SMA, the saturated thickness of the DSA is approximately 5 feet, with groundwater fluctuating historically between 24.7 and 31.7 feet below the ground surface (measured at TB9-6).

Light non-aqueous phase liquid (LNAPL) is present in several wells at thicknesses ranging from approximately 0.03 to 2.55 ft. Historical results of groundwater monitoring activities conducted at eight wells in the vicinity of the SMA during the period from 1998 through 2017 indicate dissolved phase TPH as diluent is present in six wells at concentrations ranging from 0.081 mg/L to 18 mg/L (Figure 9). The TB-9 diluent recovery system is located approximately 875 ft hydrogeologically downgradient from the SMA.

Three groundwater samples were collected as part of a supplemental site assessment in 2016 and chemically analyzed for the presence of TPH as diluent (C_{12}-C_{32}) and benzene, toluene, ethylbenzene, and total xylenes (BTEX) (Padre, 2016e). Laboratory analytical results indicate the groundwater samples contain concentrations of TPH as diluent ranging from 0.6 milligrams per liter (mg/L) to 2,000 mg/L, benzene concentrations ranging from 0.0016 mg/L to 0.0018 mg/L, and ethylbenzene concentrations ranging from 0.0073 mg/L to 0.011 mg/L. One groundwater sample indicated a toluene concentration of 0.00050 mg/L and a total xylenes concentration of 0.039 mg/L.

4.6.2 Confining Unit

The hydrostratigraphic unit underlying the DSA is the CU, which is comprised of interbedded alluvial sediments consisting primarily of fine-grained silts and clays, with some sand and few gravels. These beds vary in thickness across the Field. Beneath the SMA the beds appear to be on the order of 135 feet thick. The soils within the constituent layers of the CU are locally continuous and can be predominately fine-grained while other layers trend to greater proportion of coarse-grained soils. Collectively this unit is characterized by low vertical hydraulic conductivity (on the order of 10^{-2} to 10^{-5} feet per day), whereas the horizontal hydraulic conductivity will vary depending on the soil texture. Although the CU is hydraulically connected to the DSA water quality data suggests that contaminant movement between the two is limited and localized. In areas investigated by LFR chemical signatures characteristic of DSA groundwater have only partially penetrated the CU, which effectively prevents communication between the DSA and the underlying PA (discussed below).

4.6.3 Principal Aquifer

Below the CU are coarse-grained alluvial materials with characteristically high hydraulic conductivities capable of producing significant volumes of groundwater from water supply wells. This aquifer, the PA, serves as the primary water supply for agricultural operations directly east and south of the Field and for municipalities east of the Field. Although a limited number of on-site wells are completed within the PA, sampling of these wells has produced no definitive or confirmed detections of petroleum hydrocarbons characteristic of diluent. Regionally, the PA is part of the Main Water Body of the Santa Maria Valley, which also includes groundwater in the underlying Lower Alluvium (LA; Worts, 1951), Paso Robles Formation (PRF), and Careaga Sand.

Since the depth to groundwater is greater than 9.8 feet below the proposed base liner system and the site is underlain by sand, capillary rise is estimated to be negligible.

5.0 DESIGN AND CONSTRUCTION STANDARDS

5.1 General Design Parameters

The SMA design features and construction standards are based on state and federal regulatory requirements, including 27 CCR, implementing Subtitle D requirements, and the Resource Conservation and Recovery Act 1976, Section 40, Code of Federal Regulations (CFR), Parts 257 and 258 (Subtitle D). General development plans are included in Appendix B, project specifications are included in Appendix J, and liner and final cover construction quality assurance (CQA) plans are included in Appendix K.

5.2 Remedial Excavation and Project Phasing

There are an estimated 262,500 cubic yards of petroleum impacted soil beneath the proposed SMA that must be removed prior to its construction. The vertical and lateral limits of the required excavation are shown in the general development drawings (Appendix B). The excavation is roughly divided into an eastern and a western half. The larger of the two is the eastern portion. An existing stockpile of impacted soil sits over the western portion. This existing division will be used as the basis of a phasing plan for the project.

To maintain project impacts within the permitted disturbance footprint of the TB-9 Area, it will be necessary to phase subgrade excavation, construction, and filling as shown conceptually in Appendix C. The eastern portion will be built first, which will allow construction of the sumps for the leachate collection and leak detection systems. Impacted soils from the eastern portion will be placed in an expansion of the existing stockpile that remains within the approved TB-9 Area disturbance limits.

Following construction of the eastern portion, the stockpile will be moved to the newly constructed liner. Subsequently, the impacted soils within the western portion of the SMA will be excavated, and then the design subgrade will be established. The remaining portion of the SMA liner system will be constructed, and the complete SMA will then be available to receive impacted soils.

5.3 Grading Plan

Prior to construction, the TPH-affected sump material will be excavated from the SMA. Clean soil located within the SMA footprint will be used to establish the subgrade before liner construction. The base elevations vary from approximately 80 feet in the western portion of the base to approximately 45 feet at the leachate collection sump. Excavation slopes will be inclined no steeper than 2H:1V (horizontal:vertical). Base grades of the SMA will be graded to drain towards a leachate collection sump along the eastern end with centerline minimum slope of 2 percent with cross slopes of 1.8 percent or more. The base grading plan (Appendix B, Drawing 4) has been developed considering the highest anticipated groundwater elevation and anticipated settlement of the natural earth materials underlying the base of the future modules.

As noted in Section 4.6, groundwater elevations in the SMA range from approximately 27 to 33 feet msl. With the sand below the SMA, minimal, if any, capillary rise of groundwater would be anticipated. Across the majority of the SMA footprint there is about 30 feet of separation between groundwater and the bottom of the liner system. In the area of the sump, the lowest SMA base elevation is approximately 46 feet msl, which provides a minimum of 9.8 feet of separation between groundwater and the bottom of the liner. The liner system, as described in Section 5.4, is a double composite liner that will provide added separation between groundwater and TPH-affected soil.

Settlement is discussed in Section 7.4 below.

The final grades of the SMA will be graded with side slopes at 3H:1V or flatter with a minimum 3 percent slope of the top deck. Proposed final grades are shown on Appendix B, Drawing 5. Slope stability of the proposed final grades and final cover veneer stability are discussed in Section 7.3.

5.4 Liner System

The proposed liner for the SMA is a double composite liner system (primary liner and secondary liner) with a leak detection system. The primary liner will consist of a geosynthetic clay liner (GCL) overlain by a HDPE geomembrane. The secondary liner will consist of a compacted clay layer overlain by a HDPE geomembrane. The two liners will be separated by a geocomposite that will act as a leak detection layer.

The liner design consists of, from bottom to top (Appendix B, Drawings 7 through 9):

- Prepared subgrade
- Minimum 1-foot thick low-permeability layer with a maximum hydraulic conductivity of 1 x 10^{-7} cm/sec
- HDPE Geomembrane
- Geocomposite Leak Detection Layer
- GCL
- HDPE Geomembrane
- Geotextile
- Minimum 1-foot thick granular leachate collection layer
- Geotextile
- Minimum 1-foot thick soil operations layer to protect the liner and to provide working surface for TPH-affected material management

Subgrade preparation will include the grading of clean sand from the SMA footprint or the placement of sand from the E4A Area, Q4 Borrow Area, or other approved clean soil source at the Field.

5.5 Petroleum Compatibility with Liner Components

HDPE which is intended for use in the SMA liner in part because it is a durable material with an extremely low permeation rate. So low, in fact, as to be effectively considered impermeable in most situations. HDPE is, however, a petroleum product and can slowly absorb other hydrocarbons (if present in high concentrations). This process tends to favor low molecular weight aromatic hydrocarbons such as found in fuels. It is a very slow process that is also dependent on temperature. Although this process results in a softening of the HDPE it has not been found to compromise its integrity. Further, the process is not permanent, and is reversible if the source material is removed (Knight Piesold 2016).

A review of compatibility charts provided by geomembrane manufacturers for their HDPE liners generally show satisfactory to limited suitability for petroleum products (e.g., gasoline) based on temperature. It should be noted, though, that these guidelines assume that pure product is in direct contact with the liner, not the fraction of a percent concentrations that will be found in SMA leachate. Further, HDPE liners have been used successfully in municipal landfill liners that are exposed to dissolved aromatic compounds such as benzene, toluene, and xylene for many

decades, and are the preferred construction material in this situation. In an extreme example, HDPE has been used as a liner material to remediate fuel spills in Antarctica. Sacrificial samples of the geomembrane material have been periodically exhumed and tested and have shown no degradation of their structural or permittivity qualities (McWatters 2016).

Soil excavated for remediation is expected to have an average TPH concentrations of 8,182 mg/kg but may range as high as 165,000 mg/kg. The liner design includes a 12-inch thick operations layer constructed from soil unimpacted by petroleum. In addition, Chevron intends to manage operations in a manner that sequesters high-TPH impacted soils towards the center of the fill. Consequently, the upper composite liner elements (60-mil HDPE geomembrane over GCL) will never directly contact oil as a potentially free-phase product, but only as a dissolved constituent in leachate at a low concentration given the low solubility of petroleum in water. This will be a situation like that seen in municipal solid waste landfills.

Based on these considerations it is expected that the upper composite liner elements will not show adverse effects from the petroleum impacted soil to be managed in the SMA. Additional protection is provided by the leak detection system which includes a complete secondary composite liner (60-mil HDPE over 12-inches of low permeability clay) beneath the primary (upper) composite liner. It will exhibit the same performance as the primary liner. As such, the proposed liner system is considered suitable for containment of the petroleum impacted soils.

5.6 Leachate Collection and Removal System

The leachate collection and removal system (LCRS) will collect leachate that may develop in the SMA. The LCRS is designed to handle twice the peak leachate generation in accordance with 27 CCR §20340 and to limit leachate buildup on the liner to a maximum depth of 30 centimeters (approximately 12 inches) or the thickness of the LCRS collection layer, whichever is less. The system will also be designed to withstand deformations of the foundation materials anticipated during the design earthquake so that any permanent displacement of the foundation slopes does not impair the integrity of the liner or LCRS.

The LCRS will include a geotextile wrapped gravel drainage layer, leachate piping, collection sump, and riser piping. Specifications for the design of the gravel drainage layer and leachate piping are based on the Hydrologic Evaluation of Landfill Performance (HELP) model developed by the USACE for the U.S. EPA. The leachate collection layer will direct leachate within a 1-foot layer of gravel above the HDPE geomembrane to an 8-inch perforated HDPE leachate collection pipe installed within the leachate collection gravel layer. The pipe will convey leachate to the collection sump. The leachate collection sump will be located at the downgradient end of the SMA. The 8-inch leachate collection pipe will connect to a 12-inch riser pipe within the collection sump. The riser pipe will follow the side slope of the SMA and daylight at the ground surface. Leachate collected in the leachate collection sump will be pumped to the surface with a standard submersible electrical leachate pump. Details of the leachate collection system are shown on Drawings 7, 8, and 9 in Appendix B. The maximum peak leachate generation is estimated to be 5,650 gal/acre/day. The HELP model results are included in Appendix L.

An electrical control panel will be installed at the surface and utilize either site power or a solar panel to operate the leachate collection pump. The pump may be operated manually on an identified frequency or a level sensor will be installed in the leachate collection sump. The level sensor would then be tied into the Programmable Logic Controller (PLC) which will engage the leachate collection pump as needed. The leachate recovery system will be designed based on the leachability of the treated material placed in the SMA and the capacity of the leachate collection sump. Leachate will be pumped to the AWTS or processed through a pre-treatment system prior to the AWTS as designed to minimize sediment transport through the site water handling system. Treated water from the AWTS will be

discharged to the E4A or E5A areas at the Field or reused at construction locations for dust suppression in accordance with the WDR for the Field.

5.7 Leak Detection System

A geocomposite layer between the primary and secondary composite liners will act as a leak detection layer. The leak detection layer will slope towards a perforated HDPE pipe that will be located parallel to the leachate collection pipe. A 6-inch-diameter perforated pipe will be placed between the primary liner and secondary liner in a gravel envelope. Any leachate that leaks through the primary liner will be contained by the secondary liner and captured by the leak detection layer and flow to the leak detection pipe. The leachate will then be conveyed to the leak detection collection sump, located at the downgradient end of the SMA, adjacent to the LCRS collection sump. A 12-inch riser pipe will extend from the leak detection collection sump up the side slope of the SMA to the surface. The riser pipe will allow monitoring of the leak detection collection sump and removal of any leachate from the sump using a standard leachate pump. Details of the leak detection system are shown on Drawings 7, 8, and 9 in Appendix B.

5.8 Daily & Intermediate Cover

It is proposed to use the placed material as daily and intermediate cover. The impacted soil is considered non-hazardous and operations will preferentially use less impacted soils for this purpose. In addition, run-off from the SMA will be directed to the onsite storm water treatment system (see Section 5.7).

5.9 Precipitation and Drainage Controls

The SMA has been designed to limit ponding, infiltration, inundation, erosion, slope failure, washout, and overtopping during operation and after final closure.

It is anticipated that there will be four distinct conditions relative to managing stormwater at the SMA as follows:

Stage 1 – Filling of Phase 1 and construction of Phase 2

Stage 2 – Filling of the SMA while below surrounding grade

Stage 3 – Filling of the SMA while above existing grade

Stage 4 – Post-closure

Conceptual plans illustrating Stages 1 through 3 are shown Appendix M. In summary, each stage will be managed as described below:

- Stage 1 stormwater management, Run-on towards the SMA will be diverted into the surrounding natural drainages. Run-off that has been in contact with the impacted soils will be routed to a collection point within the lined portion of the landfill. The collection point will be underlain with a temporary flexible membrane liner and provided with a pump to immediately remove run-off. A set of temporary HDPE pipes will route water to one or more temporary water storage locations. Bladder tanks or temporary rigid wall tanks will hold the water until it can be processed through the AWTS. The water will be transferred from the temporary tanks to the AWTS via a pump and temporary HDPE pipelines.
- Stage 2 stormwater management, in Stage 2 the entire SMA liner system will have been completed, but the fill will be below the surrounding grade. Stormwater management will be essentially the same as described for Stage 1, but the collection point will be moved, as needed, to accommodate fill operations. It is also understood

that given the high hydraulic conductivity of the dune sands, a significant portion of any precipitation will infiltrate and be collected by the LCRS and managed as leachate, which will also be treated at the AWTS.

- Stage 3 stormwater management, as portions of the fill prism rise above the surrounding grade, those permanent slopes will be provided with at least 1 foot of clean soil consistent with the material that will be used for the final cover. Run-off from these areas will be directed to an adjacent natural drainage. Exposed working areas within the SMA will be managed as described for Stages 1 and 2, directing run-off to an internal collection point, routing the water to temporary storage, and processing through the AWTS.

Preliminary details of the interim drainage structures including diversion berms, down-drains and a perimeter v-ditch to convey surface drainage away from the SMA are shown in Appendix B, Drawing 4. Additional information regarding the management of leachate and precipitation related contact water is provided in Section 5.10, below. All hydrology and hydraulic calculations for sizing of permanent ditches, pipes and inlets are calculated in accordance with the Rational method and designed to accommodate the peak runoff from a 1,000-year, 24-hour storm. Drainage calculations are presented in Appendix N.

Following closure of the SMA precipitation run-off will no longer be considered contact water. The finished surface of the SMA will consist of dune scrub vegetation and a silty-sand material, which will be similar to the native stabilized sand dune habitat of the Field. The finish grade slopes of the SMA will range from 3H:1V to 5H:1V. The configuration of the slopes and the construction of concrete-lined v-ditches will drain all four sides of the SMA and direct surface water to natural depressions and low-lying areas in the general vicinity of the SMA. Drainage from the surface of the SMA will be directed to, or discharge to, the natural drainage swale that leads towards the Santa Maria River. Final drainage is described further in Section 7.2.

5.10 Management of Leachate and Runoff at the AWTS

The current AWTS is expected to be able to handle the current remediation related flows, anticipated leachate flows, and run-off from the 1,000-year 24-hour storm with the addition of approximately 500,000 gallons of temporary storage. It has adequate processing capacity for this condition but will operate much more frequently (effectively continuously during the winter/spring) and may need some supplemental infrastructure to ensure adequate system redundancy.

The system operators report that the AWTS has an effective maximum flow rate of 160 gallons per minute (gpm). It currently operates in a batch mode based on the fluid level in the storage tanks (approximately 100,000 gallons capacity), which receives fluids from remediation wells and, during the wet season (November-April), storm water run-off from various remediation areas. Monitoring data indicate that during the dry months the typical flow from the recovery wells is between 3-6 gpm. During the wet season that increases to 5-10 gpm. The largest monthly flow seen is approximately 19 gpm (see Appendix N).

Completion and operation of the SMA will introduce two new fluid inputs to the AWTS. One will be leachate collected from the LCRS, and the other will be precipitation run-off from the open working face. Once the SMA begins to operate, and has been subject to a wet season, the LCRS will begin collecting leachate, which must be removed and treated. For the purpose of this analysis, it is assumed that once leachate production begins it will be continuous and will it be at the maximum peak flow estimated by the HELP model (Appendix L), which was calculated to be 78 gpm.

Historically, January and February experience the greatest average monthly precipitation depths, 2.49 and 2.28 inches, respectively (Appendix N). If it is assumed that the entire 20-acre footprint of the SMA is open, and that

runoff from the sand is 80 percent of the precipitation depth, the equivalent nominal average monthly flow rate would be approximately 24 gpm. The existing 100,000 gallons of permanent storage at the AWTS and the proposed 500,000 gallons of temporary storage (see below) will attenuate peak flow rates and allow consideration of average flow rates. Collectively, then, the combined flow from the remediation wells and remediation area storm water, the leachate collected from the LCRS, and the peak storm water run-off from the entire SMA during a typical wet season is approximately 122 gpm, which is well within the effective maximum flow rate of the AWTS.

To address run-off from the 1,000-year 24-hour storm temporary storage capacity will be provided in the form of bladder tanks or lake tanks. The greatest runoff volume from the SMA will be generated following construction of Phase 2 as the waste fill is being brought to the surrounding grade. It is assumed that those portions of the Phase 1 fill that are permanent slopes will be provided with at least 12-inches of clean cover. Run-off from the remaining areas is assumed to have been impacted and that volume is estimated to be approximately 410,000 gallons (Appendix N). Consequently, 500,000 gallons of temporary storage capacity will be provided during the operational period.

The storage tanks are expected to be sufficient for any reasonably large storm, or series of storms that might be encountered during the operational period. They provide capacity to store runoff from 5.4 inches of precipitation. In addition, the incremental capacity of the ATWS (38 gpm) is able to treat runoff resulting from a 0.5-inch precipitation event without storage. This analysis is considered conservative in that it assumes peak flows from the remediation system, remediation area run-off, and LCRS occur simultaneously with the most exposed operating condition of the landfill, and the 1,000-year 24-hour storm. Consequently, it is believed that the AWTS with the temporary storage will be adequate for not only the extreme conditions, but for the conditions likely to be encountered during its expected 5-year operational period.

5.11 Construction Quality Assurance

An example construction quality assurance (CQA) plan was prepared for liner and final cover construction. The plan was prepared in accordance with 27 CCR §20324 by a California-registered civil engineer. The CQA plan is included as Appendix K. A specific CQA plan will be prepared in conjunction with the final design of each liner or final cover segment.

Construction will be supervised by a registered civil engineer or certified engineering geologist who will document that construction is performed consistent with the applicable regulations, permits, and the appropriate CQA plan.

6.0 ENVIRONMENTAL MONITORING

6.1 Groundwater Monitoring

Groundwater monitoring at the Field is conducted per *Version 5.0 Monitoring Plan for Water Monitoring and Remediation Activities at the Guadalupe Restoration Project* (URS 2009). The site-wide program utilizes the wells shown in the inset portion of Figure 9. It is anticipated that monitoring in accordance with that plan will continue following completion, operation and closure of the SMA. This will include the wells surrounding the SMA.

The DSA groundwater beneath the SMA is already impacted by either free-phase diluent or dissolved-phase hydrocarbons (Figure 9). The presence of the diluent makes it impractical to detect changes in dissolved-phase hydrocarbon concentrations that would be indicative of a release from the SMA. Consequently, this ROWD does not propose any changes to that plan by the addition of new wells or in changes to its implementation.

In lieu of groundwater monitoring wells the design of the SMA incorporates an additional composite liner beneath the primary composite liner elements and a leak detection system between them (see Section 5.5). The leak detection system will be monitored as described in Section 6.3, below.

6.2 Leachate Monitoring

Leachate sump levels will be monitored and recorded quarterly. If leachate is detected in the sump, it will be removed from the sump using a submersible pump. Leachate will be pumped to the AWTS for treatment. Pre-treatment of the leachate may be needed if monitoring shows constituents present that cannot be processed by the AWTS.

The LCRS will be monitored by periodic observation and sampling of collected leachate. The design configuration of the LCRS provides for the conveyance of leachate to a sump and a pipe riser system to permit leachate detection, sampling, and removal, if necessary. Annual LCRS testing will consist of visually monitoring the physical condition of the aboveground components and any leachate in the sump via the sump riser pipe. The results will be submitted to the RWQCB.

Additionally, the LCRS will be tested annually consistent with 27 CCR §20340(d).

6.3 Leak Detection Monitoring

A geocomposite layer between the primary and secondary composite liners will act as a leak detection layer. The leak detection layer will slope toward a perforated HDPE pipe that will be located parallel to the leachate collection pipe. Any leachate that leaks through the primary liner will be contained by the secondary liner, captured by the leak detection layer, and flow to the leak detection pipe. The leachate will then be conveyed to the leak detection collection sump, located at the downgradient end of the SMA, adjacent to the LCRS collection sump. A 12-inch riser pipe will extend from the leak detection collection sump up the side of the SMA to the surface. The riser pipe will allow monitoring of the leak detection collection sump and removal of any leachate from the sump using a standard leachate pump.

The leak detection sump will be monitored quarterly by “dipping” the sump to determine if there is liquid present. If a sufficient quantity of liquid is present, a sample will be collected using a submersible pump or other means. The sample will be analyzed for the same parameters as leachate. The analytical results will be compared to the most recent leachate analytical results to determine if the sampled liquid is leachate. Should leachate be detected, the RWQCB will be notified in accordance with CCR Title 27.

6.4 Gas Monitoring

Biodegradation of the hydrocarbons in the TPH-affected soil will result in the production of carbon dioxide (CO_2) and methane (CH_4), but the rate of generation, and the mass produced, are expected to be minimal. The process of methanogenic degradation of hydrocarbons occurs where electron acceptors (e.g., NO_3^-, SO_4^{2-}, Fe^{3+}) are depleted such as in oil reservoirs, coal deposits, and groundwater aquifers. These conditions are also common in landfill environments. The process is slow, temperature sensitive, syntrophic, and favors low molecular weight hydrocarbons. Given the preponderance of weathered heavier end hydrocarbons and the low concentration of water-soluble hydrocarbons and weathered heavier end hydrocarbon, the production of CO_2 and CH_4 is expected to be low.

After placement of TPH-affected soils, air quality monitoring will be performed to determine if carbon dioxide and methane are being produced above air quality standards. Should these gases be detected above the allowable limit

a gas collection and control and monitoring system will be installed in the final cover system as required by 27 CCR §21160.

6.5 Inspection Procedures

Periodically or after significant natural or man-made events, the SMA will be inspected for signs or indications of distress, erosion, leakage, failure, and general integrity. Areas or structures will be repaired/remediated on an as-needed basis. Regulatory notifications and approvals are per applicable standards.

During the active life of the SMA, surface drainage facilities, final cover areas, intermediate fill surfaces, and on-site access roads will be observed routinely, and at least weekly during high-intensity rainfall periods. In the event of damage, necessary repairs will be performed promptly. Ditches, temporary berms, straw mulch, or other erosion-control measures will be used to prevent further erosion damage of soil cover areas until weather conditions permit completion of the necessary repairs.

Regular maintenance will ensure preservation of the soil cover in completed areas by maintaining proper surface drainage and vegetative cover. Routine maintenance will be primarily focused on three areas: sealing cracks caused by settlement or desiccation; repairing erosion damage that has occurred as a result of heavy rainfall; and reporting to the appropriate regulatory agencies any unusual site occurrences such as slope failures, vandalism, progressive increase in leachate generation, or permit violations. Reporting requirements are discussed in greater detail in Emergency Response Plan (Appendix O).

Inspection and maintenance programs will be conducted on a regular basis and designed to minimize potential problems at the site, in addition to the routine maintenance activities described above. These will include:

- Monitoring well maintenance program;
- Routine preventative maintenance program for all equipment used on site;

7.0 PRELIMINARY CLOSURE PLAN

The final cover for the SMA is proposed to be an evapotranspirative (ET) cover.

CQA monitoring will be implemented during closure to verify that the construction complies with approved construction drawings, specifications, and the CQA plan. The CQA activities will be completed under the supervision of a Registered Civil Engineer or Certified Engineering Geologist in the State of California as required by 27 CCR §20950(b).

Existing environmental monitoring systems will remain in operation during the closure and postclosure maintenance periods until it is determined that they will no longer be required.

7.1 Final Cover

As the remediation and decommissioning work within the Field is completed, or the SMA design capacity is reached, the SMA will be capped and covered with an ET final cover designed using a water balance model to meet the performance objectives of 27 CCR §20950(a)(2)(A), graded to tie-in to the surrounding dune features, and revegetated to meet onsite restoration goals consistent with the surrounding dune scrub habitat.

In contrast to the proposed ET cover, a conventional final cover system relies on the hydraulic impedance provided by low-hydraulic conductivity barrier layers (e.g., low-permeability soil and/or geomembrane) to minimize infiltration and percolation, and the consequent leachate generation in landfills. Instead, the ET cover acts like a “sponge”

that stores water when the precipitation exceeds evapotranspiration; and releases that water during drier periods through evaporation from the soil surface and by transpiration from vegetation. In concept, it consists of a thick layer of finer-textured soil that provides the storage capacity needed to minimize percolation of surface water through the final cover. In comparison to the prescriptive final cover system in 27 CCR §21090, an ET cover provides the following benefits:

- Lower percolation rates;
- It is easier to build and ensure high-quality construction;
- It is less susceptible to damage from potential differential settlement, desiccation cracking, or physical degradation; and
- It provides greater compatibility with site restoration plans.

The proposed ET cover will be designed to provide the retention capacity necessary to store water during site-specific wet periods and adequate vegetation to maximize transpiration. Based on other ET covers built in the area the SMA ET cover is expected to consist of a 2-foot thick foundation layer and 4-foot thick ET soil layer. The foundation layer may be soil, TPH-affected soil, or other material with appropriate engineering properties to be used for a foundation layer. As the materials placed and treated within the SMA will be primarily TPH-affected soil, this material will be suitable for the foundation layer.

By themselves the dune sands at and around the proposed SMA location are not suitable for the ET soil layer. They lack the proper water retention properties generally found in finer-grained soils (e.g., silty sands) that are necessary to hold and release water in a reasonable layer thickness. As such, it is proposed to blend locally available clean dune sand from a local source (e.g., the E4A area, Q4 area) with an imported fine-grained soil.

Chevron is in the process of evaluating several sources of fine-grained soils that are in the vicinity of the Field. These soils are combined with the onsite dune sands into test blends with fine-grained soil proportions ranging from approximately 10 percent to 70 percent. Screening level laboratory analyses of the test blends are performed to determine grain size, soil classification, and hydraulic conductivity. The objective of this screening is to identify a test blend that provides a hydraulic conductivity around 1 x 10^{-5} cm/sec with the minimum amount of imported soil from the closest borrow source. Initial screening may include preliminary water balance modeling using a simplified unsaturated flow model such as HELP. The most suitable test blend will undergo more stringent laboratory testing including estimating van Genuchten parameters allowing construction of a soil-moisture characteristics curve (SWCC). The SWCC curve is necessary for the modelling of unsaturated flow within the ET soil layer.

Once the necessary data has been collected the proposed test blend and liner design will be evaluated using an unsaturated flow model employing a finite difference method (e.g., UNSAT-H). Such models incorporate rigorous algorithms to account for runoff, evaporation, and transpiration. Consequently, they require data on soil surface albedo (reflective characteristic), daily precipitation, daily minimum and maximum air temperatures, daily solar radiation, average daily dew point temperature, cloud cover, and average daily wind speed, in addition to soil hydraulic characteristics. The model results will be compared to recommended equivalent percolation criteria based on the EPA-sponsored Alternative Cover Assessment Program and will be used to determine the required thick of the ET soil layer.

As noted, this evaluation is still in progress. The results of the analysis will be provided to the RWQCB for review and approval. The Closure Plan for the SMA will be amended to reflect the approved analysis.

7.2 Drainage Controls

The closed SMA will be protected against the adverse effects of wind and rain by a combination of measures. After placement of the final cover, it is anticipated the finished surface of the SMA will consist of dune scrub vegetation and sand, which will be similar to the existing native stabilized dune habitat of the Field. The dune scrub vegetation in conjunction with the ET cover will protect the closed SMA from wind and rain erosion, to prevent ponding of rainwater, and generally to minimize postclosure maintenance of the cover system.

The drainage ditches will be sized to convey the peak runoff from a 1,000-year, 24-hour storm. Drainage ditches on the access road will carry runoff to down drains and convey to the natural drainage areas via the perimeter channel.

Calculations based on the Universal Soil Loss Equation (Appendix P) show that final cover erosion (soil loss) will be minimal. The annual soil erosion rate is computed as approximately 0.07 tons per acre per year for the top deck and approximately 1.55 tons per year for the side slope, which is less than the EPA guideline of 2 tons per acre per year. This erosion rate is based on relatively conservative parameters for the final cover section as follows:

- Evaluation of a simplified average section of exposed surface
- Discounting beneficial effect of the interceptor benches in the sideslopes to minimize sheet flow, and
- Erosion layer modeled as predominantly silty clay (60 percent), which is less resistant than the proposed ET cover to erosion by impinging precipitation and surface flows

7.3 Slope Stability

A slope stability analysis of the proposed final grades is included in Appendix H. Both global stability and ET cover veneer stability were evaluated. These analyses address the design seismic ground motions recommended by Golder included in Appendix I. For seismic analyses, the MCE event required for Class II landfills was used.

The results of the static slope stability analyses, assuming a large-strain friction angle of 12 degrees for the liner system, are presented in Appendix H. The analyses show static factors of safety of 1.51 and 1.90 for cross sections A-A' and B-B', respectively. Traditional geotechnical practice recommends a minimum static factor of safety of 1.5 for long-term slope stability of permanent slopes. Therefore, the static factors of safety determined for sections A-A' and B-B' are acceptable.

27 CCR §21750(f)(5)(D) requires that a dynamic factor of safety of 1.5 or greater must be achieved for the critical slope, unless a more rigorous method of analysis is used that provides a quantified estimate of the magnitude of slope movement. If a more rigorous method is used, it should be demonstrated that the predicted slope movement could be accommodated without jeopardizing the integrity of the unit. As discussed in Appendix H, a rigorous seismic slope stability analysis was performed for the SMA to determine the potential for displacement along the critical slopes. Also, a permanent slope displacement of 6 inches was considered as the maximum acceptable limit, based on the *RCRA Subtitle D (Part 258) Seismic Design Guidance for Municipal Solid Waste Landfill Facilities* (U.S. EPA, 1995). The rigorous seismic slope stability analysis included performing the following tasks:

- Deterministic Seismic Hazard Assessment (DSHA) to determine the magnitude of the MCE for the site and associated peak ground acceleration (PGA) and acceleration spectrum.
- Pseudo-static slope stability analyses to estimate the yield acceleration for each critical cross section analyzed, where yield acceleration is the horizontal acceleration that results in a pseudo-static factor of safety of 1.

- Site response analyses using the SHAKE91 (Idriss ad Sun, 1992) computer program to estimate the time history of average horizontal equivalent acceleration (HEA) for the critical failure surface associated with the yield acceleration of each cross section.
- Newmark displacement analyses, which involved the double-integration of the average HEA values that are in excess of the yield acceleration, to estimate the likely magnitudes of permanent displacement during the MCE.

The above is described in detail in Appendix H.

The magnitudes of the seismically induced permanent displacement for the critical failure surface along cross section A-A′ were estimated by numerically double integrating the average HEA values that are in excess of the yield acceleration, consistent with Newmark (1965). The numerical double integration was performed using the computer program DISPLMT developed by Houston et al. (1987). The estimated maximum permanent displacement for section A-A' is less than 0.1 inch. Therefore, the estimated seismically induced permanent displacement is significantly less than the maximum acceptable limit of 6 inches.

The proposed SMA final slopes are 3H:1V or flatter. Based on 27 CCR §21090(a), a slope stability analysis of the final cover is not required for final slopes that are 3H:1V or flatter. A slope stability analysis of the final cover will be performed after the blend of site sand and imported fine-grained soil is determined.

7.4 Settlement

The final cover grades include 3H:1V to 5H:1V side slopes with a top deck graded at three percent. The side slope inclination in conjunction with the top deck grading is designed to prevent ponding as supported by the calculations described below.

Settlement analyses were performed to evaluate the impact of postclosure settlement on the final cover grades. Settlement typically exhibits a large, rapid, initial settlement rate referred to as primary settlement, which is followed by a long-term, progressively decreasing, settlement rate that is referred to as secondary settlement. Primary settlement generally occurs within weeks to months of the initial placement and secondary settlement occurs for many years as waste materials compress. However, since the TPH-affect soils are predominately sands, both primary and secondary settlement will occur relative quickly.

The calculated postclosure settlements assume that primary settlement is complete prior to closure, but secondary settlement is expected to continue throughout the entire 30-year postclosure period although to a decreasing extent over time. As indicated in Appendix Q, the postclosure grades following settlement will be approximately two percent or greater, which is sufficient to promote positive drainage from the cover and comply with 27 CCR §21090(b)(1)(B).

7.5 Site Restoration

Surface restoration activities at the SMA will be completed in accordance with the agency approved Site-Specific Restoration Plan (SSRP). The steps to be used to implement surface restoration of the SMA site detailed in the. Site Specific Restoration Plan included as Appendix E.

7.6 Closure Cost Estimate

Cost estimates for closure of the SMA area are based upon the detailed engineering design prepared by Golder. The following key assumptions were made in compiling the closure cost estimate:

- An ET cover consisting of a 2-foot thick soil foundation layer and a 4-foot thick soil layer.

- The ET cover will be comprised of on-site sand blended with imported fine-grained soil.
- All environmental monitoring facilities will be installed prior to closure construction.
- All costs are based on third-party, prevailing wages.
- Equipment rates are based on the most recent Caltrans equipment rental rates.

As shown in Table 6, the total estimated closure cost, in 2020 dollars, is estimated at $4,833,895, which includes a 20 percent contingency. Appendix R includes the detailed worksheet used to calculate the closure costs.

8.0 PRELIMINARY POSTCLOSURE MAINTENANCE PLAN

This section describes the responsibilities, resources, and inspection frequencies for carrying out postclosure maintenance for the SMA area following its closure. Specific inspection and maintenance activities are detailed in subsequent sections. The contents of this Postclosure Maintenance Plan have been developed to comply with the requirements set forth in 27 CCR §21769(c)(2) and §21830.

8.1 Responsibilities

Chevron or a future land manager will be responsible for all inspection, maintenance and monitoring activities related to the mining units such as:

- Final Cover
- Drainage Systems
- Final Grading
- Environmental Control Systems
- Emergency Response

Personnel responsible for the postclosure maintenance of the SMA and their emergency phone numbers are as follows:

Name	Position	Address	Phone Number
Danielle Wold	Chevron Project Manager	PO Box 7261 Arroyo Grande, CA 93421	805-858-3028
Owen Ranta	Chevron Area Manager	PO Box 7261 Arroyo Grande, CA 93421	805-546-6921

8.2 Inspection and Monitoring Activities

Postclosure maintenance and monitoring of the SMA area will be performed in accordance with 27 CCR §21180. Postclosure activities will consist of groundwater and surface water monitoring, and the inspection of the final cover system, and environmental monitoring systems, and inspection of the site security system. Postclosure monitoring and maintenance will occur until the SMA is determined to no longer pose a risk to human health or the environment

and the termination of postclosure monitoring and maintenance is approved by the regulatory agency having jurisdiction for the SMA.

8.2.1 Final Cover System Maintenance

The final cover will be inspected annually to ensure that the final cover continues to function as designed. Visual inspections will be performed for the following:

- **Final Cover Integrity**. Qualified personnel will inspect the final cover for signs of settlement and subsidence, erosion, cracking, excessive animal burrowing, or other items that adversely affect the integrity and effectiveness of the final cover. Items requiring corrective action will be repaired as soon as feasible. Repair of areas with excessive settlement will be completed using the procedures described in Appendix J.
- **Cover Vegetation**. Qualified personnel will inspect the cover vegetation for areas that lack sufficient vegetative growth. The inspection will focus on signs of stress, stunted growth, wilting, color changes, and bare spots. Areas requiring corrective action will be remediated as soon as feasible. It is anticipated that the maintenance will involve application of additional seed and plantings to areas with inadequate vegetative cover.

8.2.2 Drainage System

The surface drainage controls will be inspected semi-annually for any evidence of damage, excessive erosion, settlement, and obstruction by debris. The effectiveness of the surface water drainage ditches will be maintained by keeping the ditches and culverts clear of debris, excess soils and vegetation. Repairs to the structures will be made if the inspections reveal excessive damage to the ditches and culverts. In addition, regrading will be performed as necessary to maintain positive drainage.

8.2.3 Environmental Controls

As part of the water quality monitoring program, leachate sump riser, leachate detection sump riser, and gas monitoring wells will be inspected for damage. Locks, caps, sampling ports and or tubes that appear damaged will be identified and replaced.

Preventative maintenance will be carried out on all accessible components of the LCRS at regular intervals to ensure proper operations. This consists of performing the manufacturer's recommended maintenance schedule for the pumps and visually verifying that the conveyance piping is not leaking. The entire piping system and individual well pump controls will be inspected annually. This inspection includes assessing the condition of system components for possible leakage, failure, or damage, and adjusting individual well pump controls for optimum performance. Any potential or existing failure points will be noted, and repairs are implemented promptly. Additionally, annually testing of the LCRS will be performed consist with 27 CCR §20340(9d).

8.2.4 Security

Security for the SMA will be provided by Chevron until final cover installation and completion of site restoration work. All locks, gates, signs, and fences will be inspected on a quarterly basis. Any damage to the security system due to vandalism, trespassing, or natural wear and tear will be immediately repaired and/or replaced. Signs will be repainted or replaced on an as-needed basis in order to maintain visibility. Future land manager will take over the site security responsibility following the completion of site restoration work.

8.3 Postclosure Monitoring of Environmental Controls

Postclosure monitoring of environmental controls will include the following activities in accordance with the site's Waste Discharge Requirements:

- Monitoring of the groundwater monitoring network
- Monitoring of the leachate collection and removal system
- Monitoring of the gas collection and/or monitoring system, if installed.

8.4 Final Cover System Repair

The ET cover is designed to minimize the need for maintenance and repair. It is anticipated that cover repair will largely involve the repair of erosion rills and revegetation of bare areas of the cover system.

If erosion rills are identified, they will be graded smooth and/or filled with soil, lightly compacted, and reseeded and/or replanted. This type of repair would be completed with a small backhoe or small, low ground-pressure dozer, or by hand depending on the extent of the area requiring repair. Efforts will be made to identify and mitigate the cause of the erosion rills.

Repairs to the cover system will be made promptly. It is anticipated that significant repairs will be made in the dry season during or following the inspection that noted the need for the repairs. If permanent repairs are delayed until the dry season, interim measures will be implemented to stabilize the area requiring repair.

8.5 Preliminary Postclosure Maintenance Cost Estimate

Preliminary postclosure cost estimates for closure of the SMA area are based upon information presented in this report. This following key assumptions were made in the postclosure cost estimate:

- Completion of groundwater and surface water monitoring according to the current WDR's.
- Annual average revegetation of 1 acre of final cover area.
- Postclosure maintenance to be performed by a third-party contractor.
- Costs based on prevailing wage rates and CalTrans equipment rates where appropriate.

Cost estimates for preliminary postclosure maintenance for the SMA area are summarized in Table 7. Appendix S includes a detailed worksheet for the postclosure costs.

8.6 Financial Assurance Mechanism

Financial assurance instruments shall be provided as required in 27 CCR Subchapter 2. Financial assurance shall cover Closure, Postclosure Maintenance. Operating Liability, and Requirements for Corrective Action; 27 CCR Subchapter 2 Articles 1-4, respectively. Chevron proposes to use a financial means test as allowed in 27 CCR §22246 as a financial assurance mechanism. A copy of the current financial assurance mechanism is provided in Appendix T.

Signature Page

Golder Associates Inc.

Lindsey Angell, PE
Senior Civil Engineer

Robert Van Hyning, PE
Practice Leader

CMN/LMA/cb

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Tables

Table 1 - SWRCB Index
Soil Management Area
Guadalupe Restoration Project

SWRCB Requirement	SWRCB Citation	JTD Section No. Fulfilling SWRCB Citation
Chapter 1. General **Article 1. Purpose, Scope and Applicability of this subdivision**		
20080. General Requirements. (engineered alternatives to prescriptive standards)	20080 (b-c)	pg. 15 - 16
Chapter 3. Criteria for All Waste Management Units, Facilities, and Disposal Sites ** **Subchapter 2. Siting and Design ****		
Article 2. SWRCB - Waste Classification and Management ** **20200. SWRCB - Applicability and Classification Criteria**		
Concept (and describes possible exemption)	20200(a)	pg. 2 - 3
Demonstration proposing to allow discharge of a particular waste to a particular landfill of lower classification	20200(a)(1)	N/A
Dedicated units/cells for certain wastes	20200(b)-(b)(2)(C)	pg. 3 - 4
Waste characterization	20200(c)	pg. 2 - 3
Management of liquids	20200(d)-(d)(3)	pg. 11 - 12
20220. Nonhazardous Solid Waste		pg. 2 - 3
Demonstration by discharger	20220(b)-(b)(2)	
Dewatered sludge (describes conditions for discharge)	20220(c)-(c)(3)	N/A
Ash (allows discharge of non-hazardous ash to Class III landfills w/o determining of ash is designated waste)	20220(d)	N/A
Article 3. Waste Management Unit, Facility, or Disposal Site Classification and Siting **		
20240. Classification and Siting Criteria	20240	pg. 1 - 4
20250. Class II: Waste Management Units for Designated Waste	20250	pg. 1 - 4
20260. Class III: Landfills for Nonhazardous Solid Waste	20260	pg. 1 - 4
Article 4. SWRCB - Waste Management Unit Construction Standards **		
20310.General Construction Criteria	20310	pg. 10 - 12
20320. General Criteria for Containment Structures	20320	pg. 10
20323 & 20324. CQA Plan & Requirements	20323 & 20324	pg. 12
20330. Liners	20330	pg. 10 - 11
20340. Leachate Collection and Removal Systems (LCRS)	20340	pg. 11
20360. Subsurface Barriers	20360	pg. 11 - 12
20365. Precipitation and Drainage Controls	20365	pg. 12
20370. Seismic Design	20370	pg. 16 - 17
20375. Special Requirements for Surface Impoundments	20375	N/A

SWRCB Requirement	SWRCB Citation	JTD Section No. Fulfilling SWRCB Citation
Subchapter 3. Water Monitoring **		
Article 1. SWRCB - Water Quality Monitoring and Response Programs for Solid Waste Management Units** **20380. SWRCB - Applicability**		
Corrective action financial assurance	20380(b)	Appendix T
Duration of Applicability	20380(d)-(d)(2)	Appendix D
Limitations on engineered alternatives	20380(e)-(e)(3)	N/A
20385. Required Programs	20385	pg. 12 - 14
20390. Water Quality Protection Standard (Water Standard)	20390	pg. 13
20395. Constituents of Concern (COCs)		Appendix S
COCs	20395(a)	Appendix S
MSW COCs	20395(b)	Appendix S
20400. Concentration Limits		
Proposing COCs	20400(a)-(a)(3)	Appendix L
Adoption of concentration limits	20400(b)-(b)(3)	Appendix L
Establishing a CLGB (for corrective action only)	20400(c-h)	Appendix L
Decreasing a CLGB (in DMP following a CAP)	20400(i)	Appendix L
20405. Monitoring Points and the Point of Compliance	20405(a-b)	Appendix K
20410. Compliance Period	20410(a-c)	Appendix L
20415. General Water Quality Monitoring and System Requirements		
Section Applies to all monitoring programs	20415(a)	
G.W. Mon. System (general)	20415(b)-(b)(4)(D)	pg. 13
Surface Water Mon. (general)	20415(c)-(c)(2)(D)	Appendix L
Unsaturated Zone. Mon. (general)	20415(d)-(d)(4)	pg. 14
Mon. systems designed by RG or RCE	20415(e)(1)	pg. 12 - 14, Appendix L
Logging of borings	20415(e)(2)-(e)(2)(C)	Appendix L
Shared monitoring system demonstration for contiguous Units	20415(e)(3)	N/A
Monitoring sample QA/QC	20415(e)(4)-(e)(4)(D)	Appendix L
Sampling & analytical methods (perf. std. for)	20415(e)(5)	Appendix L
Monitoring data procurement, analysis, and submittal	20415(e)(6)-(c)(15)	Appendix L
20420. Detection Monitoring Program	20420	Appendix L
20425. SWRCB - Evaluation Monitoring Program	20425	Appendix L
20430. Corrective Action Program	20430	Appendix L

SWRCB Requirement	SWRCB Citation	JTD Section No. Fulfilling SWRCB Citation
Subchapter 4. Criteria for Landfills and Disposal Sites Article 2. CIWMB - Daily and Intermediate Cover		
20705. Standards for Daily and Intermediate (Interim) Cover	20705	pg. 12
Subchapter 5. Closure and Post-Closure Maintenance **		
Article 1. General Standards For All Waste Management Units **		
20950. General Closure and Post-Closure Maintenance Standards Applicable to Waste Management Units (Units) for Solid Waste	20950	pg. 14 - 20
Article 2. Closure and Post-Closure Maintenance Standards for Disposal Sites and Landfills 21090. Closure and Post-Closure Maintenance Requirements for Solid Waste Landfills		
Final cover requirements (general)	21090(a)-(a)(2)	pg. 15 - 16
Erosion control layer	21090(a)(3)-(a)(3)(A)3	pg. 16
Maintenance (& plan for)	21090(a)(4)-(a)(4)(D)	pg. 18 - 20
Discharges of liquids to covers (leachate & condensate)	21090(a)(5)(A)	pg. 11
Discharges of liquids to covers (other liquids)	21090(a)(5)(B)	pg. 11 - 12
Stability analysis	21090(a)(6)	pg. 16 - 17
Grading requirements (performance standards)	21090(b)-(b)(3)	pg. 15 - 16
General post-closure duties	21090(c)-(c)(5)	pg. 18 -19
Landfill closure deadline & extension	21090(d)	Appendix D
Final cover survey(s)	21090(e)-(e)(4)	Appendix S
Optional clean closure	21090(f)-(f)(2)	N/A
21132. Landfill Emergency Response Plan Review	21132	Appendix M
21400. Closure Requirements for Surface Impoundments	21400	N/A
21410. SWRCB - Closure Requirements for Waste Piles	21410	N/A

SWRCB Requirement	SWRCB Citation	JTD Section No. Fulfilling SWRCB Citation
Chapter 4. Documentation and Reporting For Regulatory Tiers, Permits, WDRs, and Plans Subchapter 3. Development of waster Discharge Requirements (WDRs) and Solid Waste Facility Permits		
Article 2. CIWMB - Applicant Requirements		
21585. SWRCB - Joint Technical Document (JTD). [format for submittal of Section 21710, 21750, 21760 information]	21585	N/A
Article 4. SWRCB - Development of Waste Discharge Requirements (WDRs) **		
21710. SWRCB - Report Of Waste Discharge (ROWD) and Other Reporting Requirements. [see also Section 21585]	21710	pg. 1 - 20
21720. SWRCB - Waste Discharge Requirements (WDRs)	21720(d-f)	Appendix A
21730. SWRCB - Public Participation. [proposed listing of potentially interested parties]	21730(a)	N/A
21740. SWRCB - Waste Characteristics	21740	pg. 2 - 4
21750. SWRCB - Waste Management Unit (Unit) Characteristics and Attributes to be Described in the ROWD		
Analysis of potential for impairment	21750(a)	pg. 4 - 5
Support for proposed Unit classification	21750(b)	pg. 1 - 2
Listing and incorporation of supporting documents	21750(c)	N/A
Topographic map	21750(d)(1)	Figure 4, Appendix B
Floodplain analysis	21750(d)(2)-(d)(2)(C)2	pg. 5, Figure 8
Climate	21750(e)-(e)(6)	pg. 6, Figure 9
Geology	21750(f)-(f)(7)	pg. 6 - 8, Figure 11
Hydrogeology	21750(g)-(g)(7)(D)	pg. 9, Appendix E
Land/Water Use	21750(h)-(h)(5)	pg. 2, Figure 5
Preliminary closure plan	21750(i)	pg. 14 - 18, Appendix R
21760. SWRCB - Design Report and Operations Plan		
Preliminary and as-built plans	21760(a)(1)	Section 5.0/ Appendix B
Monitoring Systems Plans and Rationale	21760(a)(3)-(a)(4)	Section 6.0/Appendix L
Operation Plan	21760(b)-(b)(3)	pg. 3/Section 8.0
Subchapter 4. Development of Closure/Post-Closure Maintenance Plans 21769. SWRCB - Closure and Post-Closure Maintenance Plan Requirements		
Prelim. CI/P-CI Plan purpose	21769(b)(1)	pg. 14 - 20
Prelim. CI/P-CI Plan Contents and cost analysis	21769(b)(2)-(b)(2)(B)5	pg. 14- 20, Appendix R & S
Final CI/P-CI Plan	21769(c)-(c)(2)(H)3	N/A

SWRCB Requirement	SWRCB Citation	JTD Section No. Fulfilling SWRCB Citation
Chater 5. Enforcement **Article 4. Enforcement by Regional Water Quality Control Board (RWQCB)****		
22190. SWRCB - Mandatory Closure (Cease and Desist Orders).	22190(b)	Appendix D
Chapter 6. Financial Assurances at Solid Waster Facilities and at Waste Management Units for Solid Waste **Subchapter 2. Financial Assurance Requirements**		
Article 1. Financial Assurance for Closure		
22207. SWRCB - Closure Funding Requirements.	22207(a)	pg. 18 & 20, Appendix T
Article 2. Financial Assurance for Postclosure Maintenance		
22212. SWRCB - Post-Closure Funding Requirements.	22212(a)	Appendix T
Article 4. Financial Assurance Requirements for Corrective Action		
22222. SWRCB - Corrective Action Funding Requirements.	22222	Appendix T

Table 2 - Site Capacity, Service Life, and Earthwork
Soil Management Area
Guadalupe Restoration Project

Item	LF-2
Total Airspace (cy)[1]	1,430,200
TPH Affected Soil Excavation (cy)[2]	262,500
Clean Overburden Soil Excavation (cy)[2]	56,500
Base Grading Plan Excavation (cy)[3]	164,300
Total Clean Soil Excavation (cy)[4]	220,800
Base Grading Plan Earthfill (cy)[3]	51,000
Base Liner Low-Permeability Clay Layer - 1ft thick (cy)	26,350
Base Liner Operations Layer - 1 ft thick (cy)	26,350
Base Liner LCRS Gravel - 1ft thick (cy)	14,500
Base Liner Volume (cy)[5]	67,200
Final Cover Select Waste Foundation - 2ft thick (cy)	53,000
Final Cover Soils - 4ft thick (cy)	106,100
Access Road Additional Fill (cy)	1,400
Total Clean Soil Consumed (cy)[6]	184,850
Soil Surplus (cy)	35,950
Net Airspace (cy)[7]	1,203,900
Assumed Airspace Consumed per Year (cy)[8]	400,000
Fill Duration (year)	3.0
Closure Date	2025

Notes:

1. Total airspace calculated by measuring the volume between the Base Grading Plan (Appendix B, Drawing 4) and the Final Grading Plan (Appendix B, Drawing 5) using AutoCAD Civil 3D.

2. Calculated by measuring the volume between the existing topography dated January 26, 2018 and excavation grading plane (Appendix B, Drawing 3).

3. Calculated by measuring the volume between the existing topography dated January 26, 2018 and excavation grading plane (Appendix B, Drawing 4).

4. Excavated clean soil volume includes soil excavated for the excavation plan and base grading plan.

5. Base liner volume includes low-permeability clay layer, drainage gravel layer and operations layer.

6.Total clean soil volume consumed includes base grading plan earthfill, operations layer, 4ft thick final cover soil, and the access road fill.

7. Net airspace volume is calculated from the top of the operations layer to the bottom of the select waste foundation layer.

8. Assumed airspace consumption volume provided by Chevron.

Table 3 - Average TPH Concentration by Source Area
Soil Management Area
Guadalupe Restoration Project

Source Area	Description	Estimated Volume (cubic yards)	Average TPH Concentration (mg/kg)
TB8 Area	Complete Excavation Per Cannon DRAFT Grading Construction Plan	181,580	13,993
TB9 Area	Complete Excavation Per Cannon DRAFT Grading Construction Plan & Golder's 90% Conceptual Design Drawings	206,000	16,786
TB9 Stockpile	Current Stockpile Volume from PROS III Excavations and M1 Excavation	85,000	918
B4A	Complete Sump Excavation per Excavation Grading Plan	3,500	11,545
B5 Sump	In-place Sump Material	4,050	158
CP Area	Consistent with PROS Program, Three Acres of Surface Restoration 5 ft maximum Depth	25,000	10,000
DT Area	Consistent with PROS Program, Three Acres of Surface Restoration 5 ft maximum Depth	25,000	10,000
PROS V	Excavation/Restoration of Sumps and Diluents Stains	10,000	1,954
PROS IV	Excavation/Restoration of Sumps and Diluents Stains Based on Completed PROS Excavation	90,000	3,720
PROS VI	Excavation/Restoration of Sumps and Diluents Stains Based on Completed PROS Excavation	90,000	15,534
PROS VII	Excavation/Restoration of Sumps and Diluents Stains Based on Completed PROS Excavation	90,000	6,712
8X	Diluent Stain Excavation	5,000	11,096
ROADS	Excavate all Roads Except Main Road, TB9 Road, South and North Access	67,500	9,610
PADS	Excludes main office, Water Plant, M3, I3A, J2A, DT, CP, TB8, Growing Facility	102,975	3,210
Pads likely to stay in place	Assuming dpeth of 3 ft based on observation in field, conservative to account for potential impacts uncovered Main Office, Water Plant, M3, I3A, J2A, DT pad, CP pad, Growing Facility	39,967	3,210
Property Line to WP	Assuming 15ft width, 1.5ft depth, and similar road mix and asphalt construction	3,350	9,610
Q4 Loop	Assuming 15ft width, 1.5ft depth	5,980	9,610
Main Road Loop	Assuming 18ft width, 1.5ft depth	22,300	9,610
St4 to Main Road (DT Access)	Assuming 15ft width, 1.5ft depth	1,475	9,610
TB9 RW Road	Assuming 12ft width, 1.5ft depth	1,300	9,610
South Access	Assuming 13ft width, 1.5ft depth	5,825	9,610
North Access	Assuming 13ft width, 1.5ft depth	9,555	9,610
M3 to K8	Assuming 13ft width, 1.5ft depth	2,370	9,610
	Total	**1,077,727**	**8,182**
	10%	**107772.7**	**Average TPH**
	Final Total	**1,185,500**	**Value (mg/kg)**

Note:
1. Information provided by Chevron.

Table 4 - TPH-g and VOC Concentrations Breakdown Summary
Soil Management Area
Guadalupe Restoration Project

Source	Average TPH Concentration ($C_4 - C_{40}$) mg/kg	Total TPH Range (C_4-C_{40}) mg/kg	TPH as Gasoline (C_4 to C_{12})			Volatile Organic Compounds (VOCs)							
						Benzene		Ethylbenzene		Toluene		Xylenes	
			Range mg/kg	Average Concentration mg/kg	% TPH-G of Total TPH	Range mg/kg	Average mg/kg	Range mg/kg	Average mg/kg	Range mg/kg	Average (mg/kg)	Range mg/kg	Average mg/kg
TB8 Area	13,993	0.52 - 165,000	0.22 - 1,900	424	up to 9 1.2%	0.011 - 0.39	0.13	0.0082 - 14	1.73	0.063 - 0.064	0.06	0.012 - 2.6	0.81
TB9 Area	16,786	12 - 70000	0.24 - 2500	310	up to 3.6%	0.0078 - 0.18	0.05	0.0054 - 3.3	0.46	0.030 - 0.33	0.18	0.011 - 3.5	0.56
TB9 Stockpile	918	460 - 4610	0.45	--	0.01%	--	--	--	--	--	--	--	--
B4A	11,545	--	--	--	--	--	--	--	--	--	--	--	--
B5 Sump	158	--	--	--	--	--	--	--	--	--	--	--	--
CP Area	10,000	--	--	--	--	--	--	--	--	--	--	--	--
DT Area	10,000	--	--	--	--	--	--	--	--	--	--	--	--
PROS V	1,954	35 - 89700	2.5 - 2200	893	up to 2.5%	<0.025 - <5.0	--	0.37 - 11	5.7	4.3	--	0.064 - 25	9.3
PROS IV	3,720												
PROS VI	15,534												
PROS VII	6,712												
8X	11,096	--	3.7 - 730	441	up to 60%	--	--	--	--	--	--	--	--
ROADS	9,610	35 - 89700	2.5 - 2200	893		<0.025 - <5.0	--	0.37 - 11	5.7	4.3		0.064 - 25	9.3
PADS	3,210												
Pads likely to stay in place	3,210	--	--	--	--	--	--	--	--	--	--	--	--
Property Line to WP	9,610	--	<0.20	--	0.00%	<0.0050	--	<0.0050	--	<0.0050	--	<0.0050	--
Q4 Loop	9,610												
Main Road Loop	9,610												
St4 to Main Road (DT Access)	9,610												
TB9 RW Road	9,610												
South Access	9,610												
North Access	9,610												
M3 to K8	9,610												
Average Results (mg/kg)	**8,182**	**0.52 - 165000**	**0.22 - 2500**	**404**	**up to 4.9%**	**0.0078 - 0.39**	**0.09**	**0.0054 - 14**	**1.22**	**0.030 - 4.3**	**0.96**	**0.001 - 25**	**1.23**

Note:
1. Information provided by Chevron.

GOLDER

Table 5 - Water Well Summary
Soil Management Area
Guadalupe Restoration Project

Well	WCR2017-007769	WCR1944-000333
Location	34.98, -120.61	34.97, -120.61
Owner	Chevron 2184 West Thornberry Rd Guadalupe, CA 93434	-
Driller	Gregg Drilling and Testing, Inc 950 Howe Rd, Martinez, CA 94553	-
Year Built	2017	1944
Depth (ft)	47.5	147
Casing Diamter (in)	4	6
Perforation Depth (ft)	19	3

Table 6
Closure Cost Summary
Soil Management Area
Chevron Guadalupe

Item	Unit	Unit Cost	Quantity	Total Cost
1. Soil Layers				
a. Foundation Layer[1]	cy	$ 5.90	59,804	$ 352,844
b. Evapotranspiration Layer	cy	$ 5.40	105,700	$ 570,780
c. Excavation[2]	cy	$ 0.80	426,800	$ 341,440
d. LCRS Gravel Layer	cy	$ 8.70	14,981	$ 130,335
2. Geosynthics				
a. Geomembrane	sf	$ 0.21	1,511,133	$ 317,338
b. GCL	sf	$ 0.75	755,567	$ 566,675
c. Geotextile	sf	$ 0.37	781,500	$ 289,155
d. Geocomposite	sf	$ 0.71	1,120,333	$ 795,436
3. Design/Construction Quality Assurance				
a. Design, Plans, Specifications	ls	$ 99,341	1	$ 99,341
b. Post-Closure Maintenance Plan	ls	$ 31,600	1	$ 31,600
c. CQA	acre	$ 7,900	17	$ 134,300
4. Revegetation	acre	$ 1,275	17	$ 21,675
5. Landfill Gas Monitoring[3]	lump sum	--	--	$ -
6. Gas Control System[3]	lump sum	--	--	$ -
7. Groundwater Monitoring System[4]	lump sum	$ 43,412	1	$ 43,412
8. Drainage Structures				
a. CMP Downdrains	lf	$ 30.00	9,500	$ 285,000
b. V-ditches	lf	$ 11.30	3,100	$ 35,030
9. Security Measures[5]	lump sum	$ 6,075	1	$ 6,075
10. Closure Survey, Settlement Monuments	lump sum	$ 7,810	1	$ 7,810
			Subtotal:	$ 4,028,245
			Contingency (20%):	$ 805,649
			Total:	$ 4,833,895

Notes:

1. Includes subgrade fill, low permeability clay, and operations layer.
2. Includes clean material excavation and sump material excavation.
3. Landfill Gas Monitoring and Control System not required.
4. Assumes four additional groundwater wells will be installed to complete the groundwater monitoring system.
5. Perimeter fence is already in place. Costs for security include upgrading the site entrance gate at closure

Table 7
Postclosure Maintenance Cost Summary
Soil Mangement Area
Chevron Guadalupe

Item	Unit	Unit Cost	Annual Quantity	Total
1. Vegetation Maintenance[1]	acre	$ 7,840	0.2	$ 1,568
2. Leachate Monitoring & Maintenance				
a. Sampling and Inspection[2]	annually	$ 4,640	1	$ 4,640
b. O&M	annually	$ 1,549	1	$ 1,549
3. Landfill Gas Monitoring/Maintenance[3]				
a. Monitoring and Inspection	annually			
a. Operations and Maintenance	annually			
4. Leak Detection Monitoring/Maintenance	annually	$ 18,098	1	$ 18,098
5. Vadose Zone Monitoring/Maintenance	annually			
6. Groundwater Monitoring/Maintenance	annually	$ 15,921	1	$ 15,921
7. Surface Water Monitoring	annually	$ 4,591	1	$ 4,591
8. Drainage/Cover Maintenance				
a. Drainage Maintenance	every ten yrs	$ 13,515	0.1	$ 1,352
b. Settlement Regrading Maintenance	every five yrs	$ 8,884	0.2	$ 1,777
9. Security Maintenance	annually	$ 1,475	1	$ 1,475
10. Inspections	semi-annually	$ 1,729	2	$ 3,457
11. Miscellaneous				
a. Aerial Survey, Settlement Report	every five yrs	$ 11,000	0.2	$ 2,200
b. DM-1 Groundwater Maintenance	annually	$ 11,000	1	$ 11,000
12. Permitting Fees[4]	annually	$ 11,650	1	$ 11,650
			Total Annual Cost:	$ 79,276
			Cost x 30 yrs:	$ 2,378,294

Notes:

1. Assumes 1% of total area (17 acres) per year will need hydroseeding.

2. Sampling and testing costs based on testing protocol outlined in the WDR's.

3. Landfill gas monitoring not required.

4. Fees include Waste Discharge Requirements (WDR's) annual fees, Stormwater Discharge Permit, and Air Board Permit to Operate.

GOLDER

Figures

LEGEND

- APPROXIMATE FIELD BOUNDARY
- SMA LOCATION

0 1.5 3 6 Miles

CLIENT
CHEVRON ENVIRONMENTAL MANAGEMENT COMPANY
2184 WEST THORNBERRY ROAD
GUADALUPE, CA 93434

PROJECT
GUADALUPE RESTORATION PROJECT
SOIL MANAGEMENT AREA
TANK BATTERY 9 AREA

TITLE
VICINITY MAP

CONSULTANT
GOLDER

YYYY-MM-DD	2019-05-23
DESIGNED	LMA
PREPARED	CB
REVIEWED	LMA
APPROVED	RGH

PROJECT NO.	REV.	FIGURE
1783552	0	1

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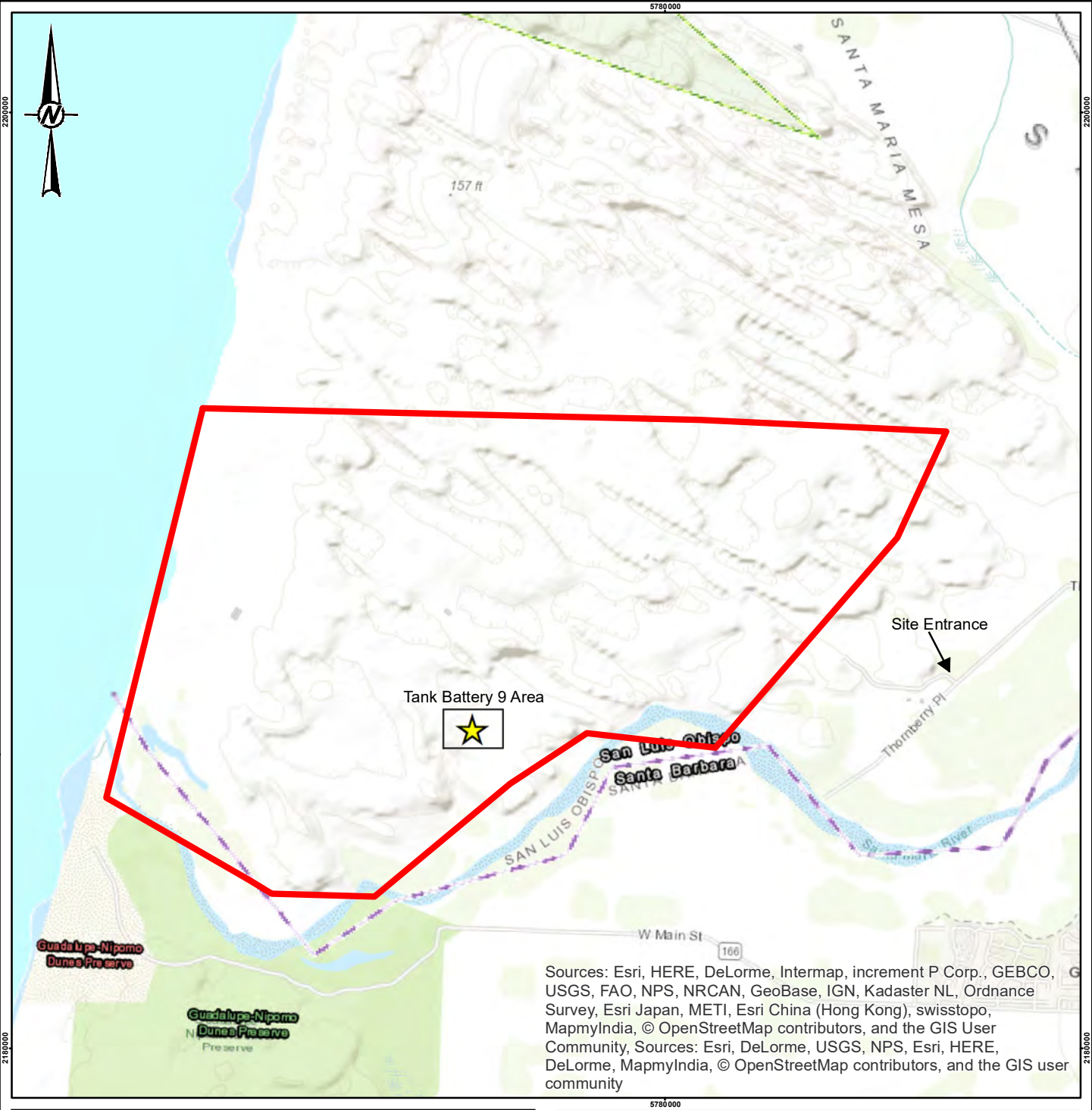

LEGEND

- APPROXIMATE FIELD BOUNDARY
- SMA LOCATION

0 0.25 0.5 1 Miles

CLIENT
CHEVRON ENVIRONMENTAL MANAGEMENT COMPANY
2184 WEST THORNBERRY ROAD
GUADALUPE, CA 93434

PROJECT
GUADALUPE RESTORATION PROJECT
SOIL MANAGEMENT AREA
TANK BATTERY 9 AREA

TITLE
SITE LOCATION MAP

CONSULTANT
GOLDER

YYYY-MM-DD	2019-05-23
DESIGNED	LMA
PREPARED	CB
REVIEWED	RV
APPROVED	RGH

PROJECT NO.	REV.	FIGURE
1783552	0	2

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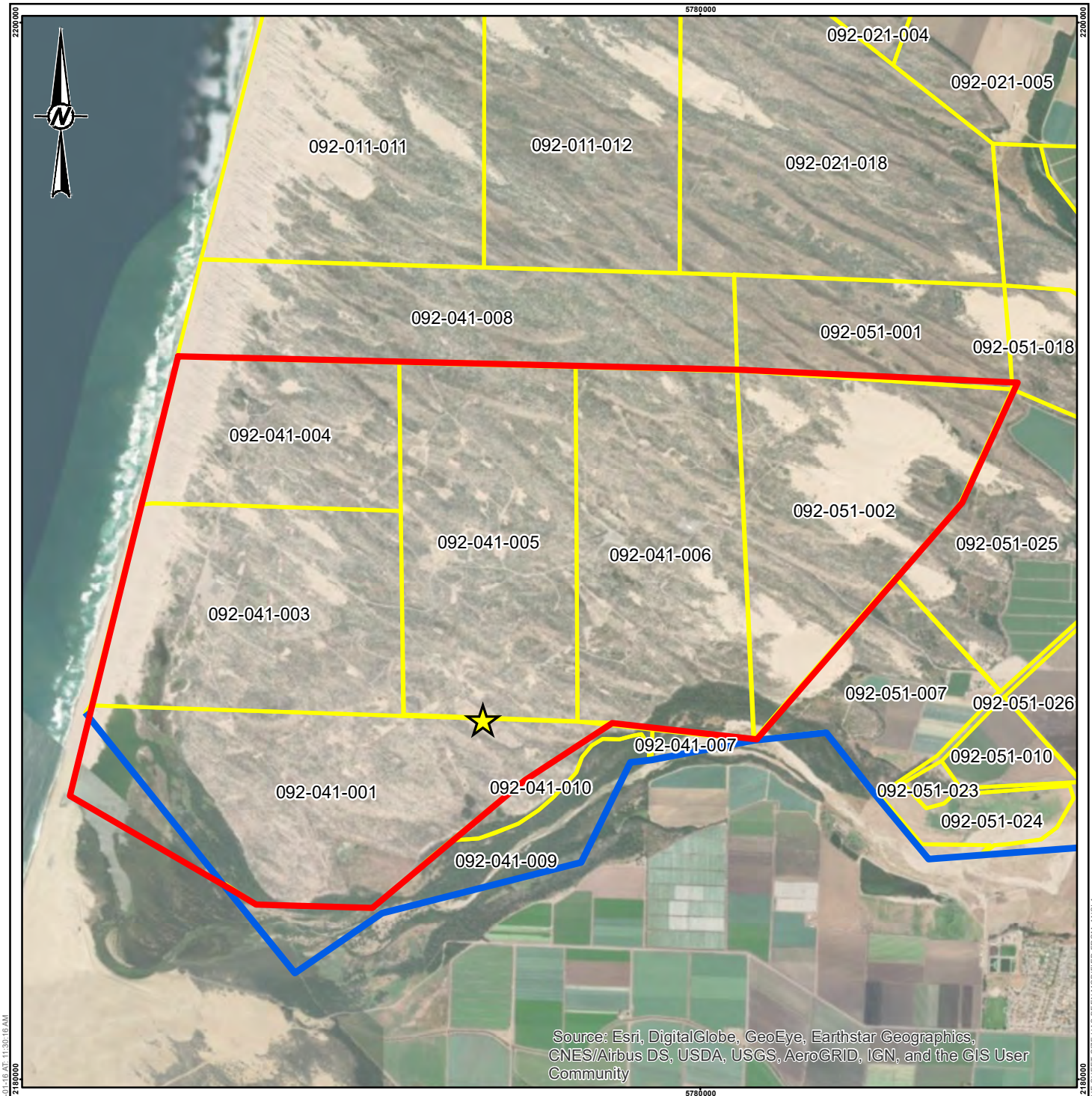

LEGEND

- SMA LOCATION
- APPROXIMATE FIELD BOUNDARY
- PARCEL BOUNDARY
- SAN LUIS OBISPO COUNTY BOUNDARY

0 0.25 0.5 1 Miles

REFERENCE(S)

1. PARCEL DATA FROM SAN LUIS OBISPO COUNTY GIS SERVER GIS.SLOCOUNTY.CA.GOV.

CLIENT
CHEVRON ENVIRONMENTAL MANAGEMENT COMPANY
2184 WEST THORNBERRY ROAD
GUADALUPE, CA 93434

PROJECT
GUADALUPE RESTORATION PROJECT
SOIL MANAGEMENT AREA
TANK BATTERY 9 AREA

TITLE
PARCEL MAP

CONSULTANT
GOLDER

YYYY-MM-DD	2019-05-23
DESIGNED	LMA
PREPARED	CB
REVIEWED	RV
APPROVED	RGH

PROJECT NO.	REV.	FIGURE
1783552	0	3

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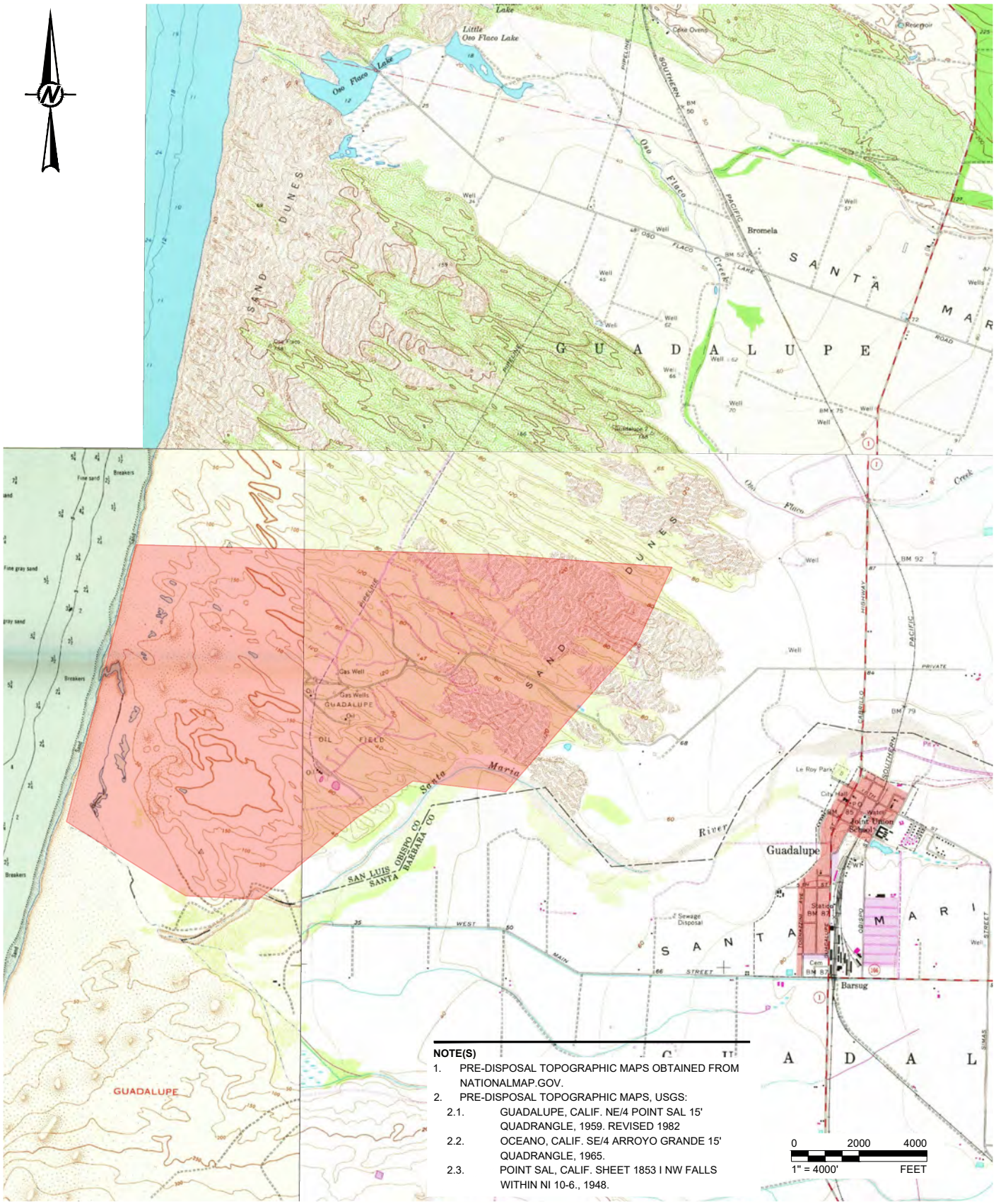

NOTE(S)

1. PRE-DISPOSAL TOPOGRAPHIC MAPS OBTAINED FROM NATIONALMAP.GOV.
2. PRE-DISPOSAL TOPOGRAPHIC MAPS, USGS:
   - 2.1. GUADALUPE, CALIF. NE/4 POINT SAL 15' QUADRANGLE, 1959. REVISED 1982
   - 2.2. OCEANO, CALIF. SE/4 ARROYO GRANDE 15' QUADRANGLE, 1965.
   - 2.3. POINT SAL, CALIF. SHEET 1853 I NW FALLS WITHIN NI 10-6., 1948.

CLIENT
CHEVRON ENVIRONMENTAL MANAGEMENT COMPANY
2184 WEST THORNBERRY ROAD
GUADALUPE, CA 93434

CONSULTANT
GOLDER

YYYY-MM-DD	2019-08-06
DESIGNED	CMN
PREPARED	CMN
REVIEWED	LMA
APPROVED	RGH

PROJECT
GUADALUPE RESTORATION PROJECT
SOIL MANAGEMENT AREA
TANK BATTERY 9 AREA

TITLE
PRE-FIELD DEVELOPMENT TOPOGRAPHY

PROJECT NO.	REV.	FIGURE
1783552	0	4

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Path: \\sacramento\acad\Sites\Chevron - Guadalupe\CIVIL 3D\Chevron Guadalupe ROW\D\ | File Name: Figure 5 - Pre-Disposal Topography Map.dwg

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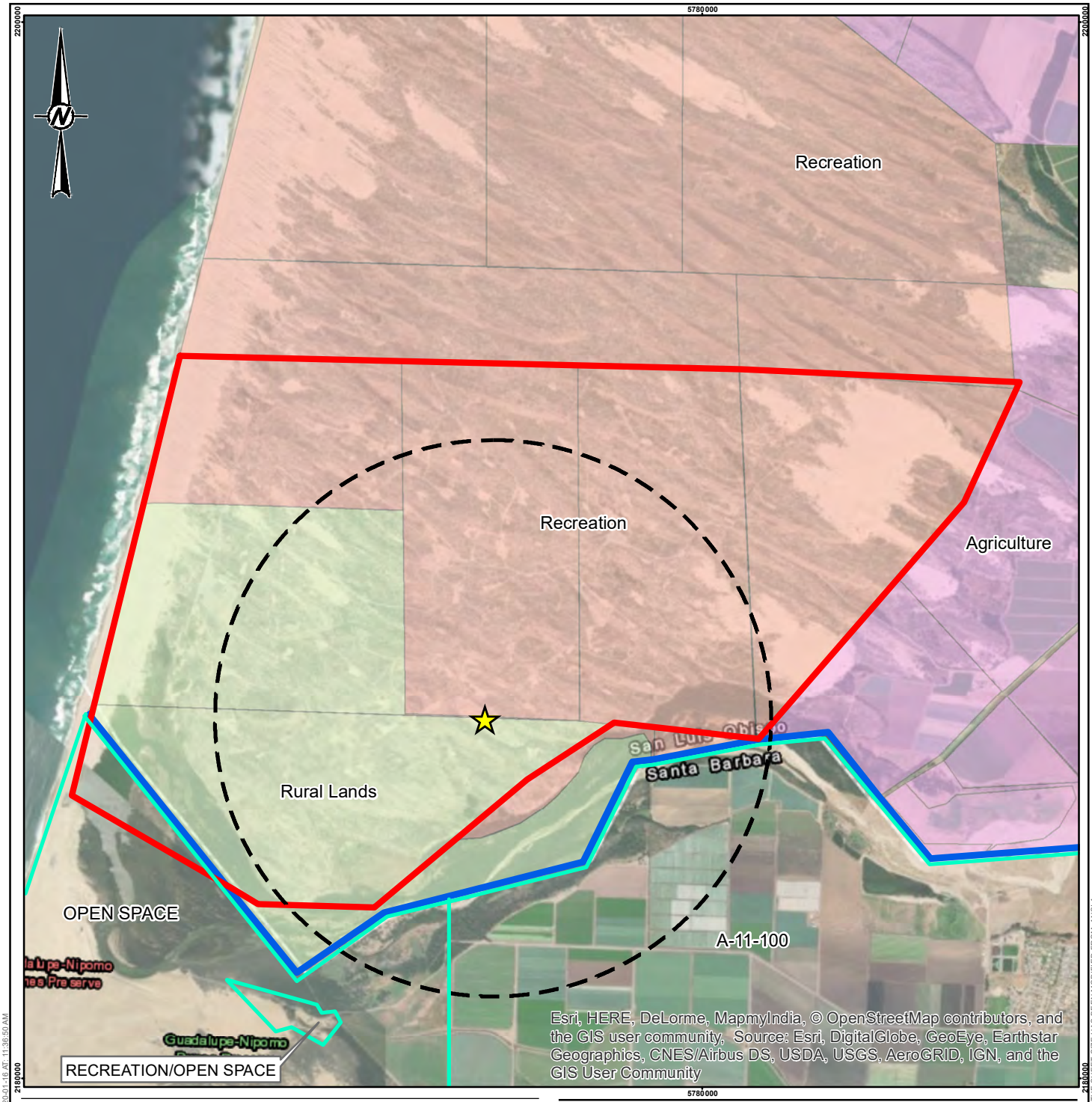


LEGEND

- SMA LOCATION
- ONE MILE AREA
- APPROXIMATE FIELD BOUNDARY
- SAN LUIS OBISPO COUNTY BOUNDARY
- SANTA BARBARA COUNTY LAND USE BOUNDARY

Land Use

- Agriculture
- Recreation
- Rural Lands

0 0.25 0.5 1 Miles

REFERENCE(S)

1. LAND USE DATA FROM SAN LUIS OBISPO COUNTY GIS SERVER GIS.SLOCOUNTY.CA.GOV. & FROM SANTA BARBARA COUNTY INTERACTIVE LAND USE AND ZONING MAP.
2. A-11-100 IS A SANTA BARBARA COUNTY LAND USE DESIGNATION THAT DESIGNATES A MINIMUM 100-ACRE LOT SIZE.

CLIENT
CHEVRON ENVIRONMENTAL MANAGEMENT COMPANY
2184 WEST THORNBERRY ROAD
GUADALUPE, CA 93434

PROJECT
GUADALUPE RESTORATION PROJECT
SOIL MANAGEMENT AREA
TANK BATTERY 9 AREA

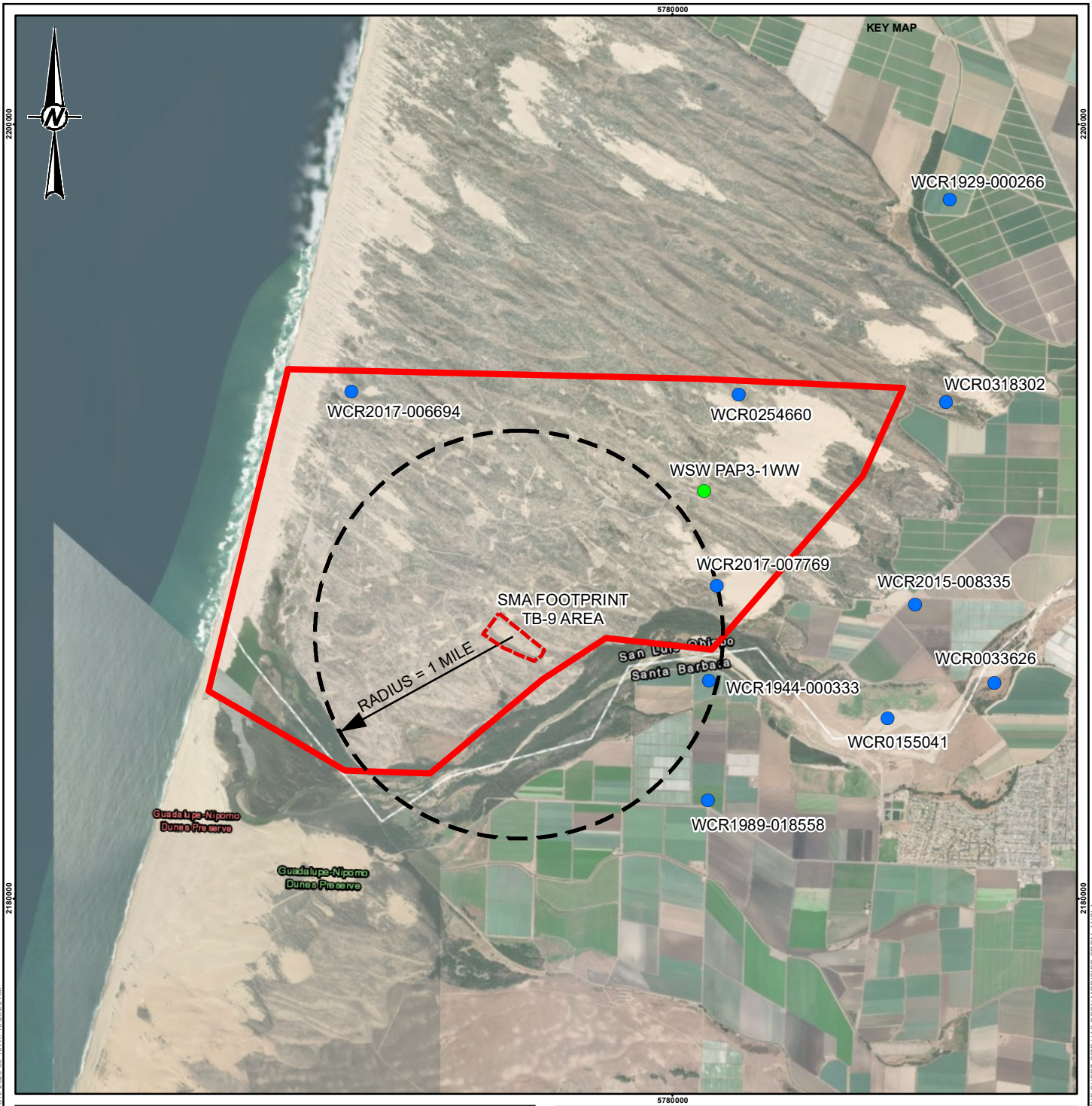
TITLE
LAND USE MAP

CONSULTANT
GOLDER

YYYY-MM-DD	2019-05-28
DESIGNED	LMA
PREPARED	CB
REVIEWED	RV
APPROVED	RGH

PROJECT NO.	REV.	FIGURE
1783552	0	5

PATH: M:\Sites\Chevron - Guadalupe\GIS\Chevron Guadalupe ROW\DLand Use Map.mxd PRINTED ON: 2020-01-16 AT: 11:36:00 AM
IF THIS MEASUREMENT DOES NOT MATCH WHAT IS SHOWN, THE SHEET SIZE HAS BEEN MODIFIED FROM: ANSI A
1 in
0



LEGEND

- APPROXIMATE FIELD BOUNDARY
- SMA FOOTPRINT TB-9 AREA
- ONE MILE AREA
- WATER SUPPLY WELL
- APPROXIMATE WATER WELL LOCATIONS

Miles
0 0.25 0.5 1

NOTE(S)

1. WELL LOCATIONS ARE APPROXIMATE AND BASED ON WELL COMPLETION REPORTS FROM THE THE DEPARTMENT OF WATER RESOURCES. LOCATIONS NOT FIELD VERIFIED.

REFERENCE(S)

1. WELL LOCATIONS FROM CALIFORNIA DEPARTMENT OF WATER RESOURCES' ONLINE SYSTEM FOR WELL COMPLETION RECORDS. HTTPS://GIS.WATER.CA.GOV/ARCGIS/REST/SERVICES/ENVIRONMENT/I07_WELLCOMPLETIONREPORTS/FEATURESERVER.
2. WELL INFORMATION ON TABLE 5 IN THE REPORT OF WASTE DISCHARGE.

CLIENT
CHEVRON ENVIRONMENTAL MANAGEMENT COMPANY
2184 WEST THORNBERRY ROAD
GUADALUPE, CA 93434

PROJECT
GUADALUPE RESTORATION PROJECT
SOIL MANAGEMENT AREA
TANK BATTERY 9 AREA

TITLE
SURROUNDING GROUNDWATER WELL LOCATION MAP

CONSULTANT
GOLDER

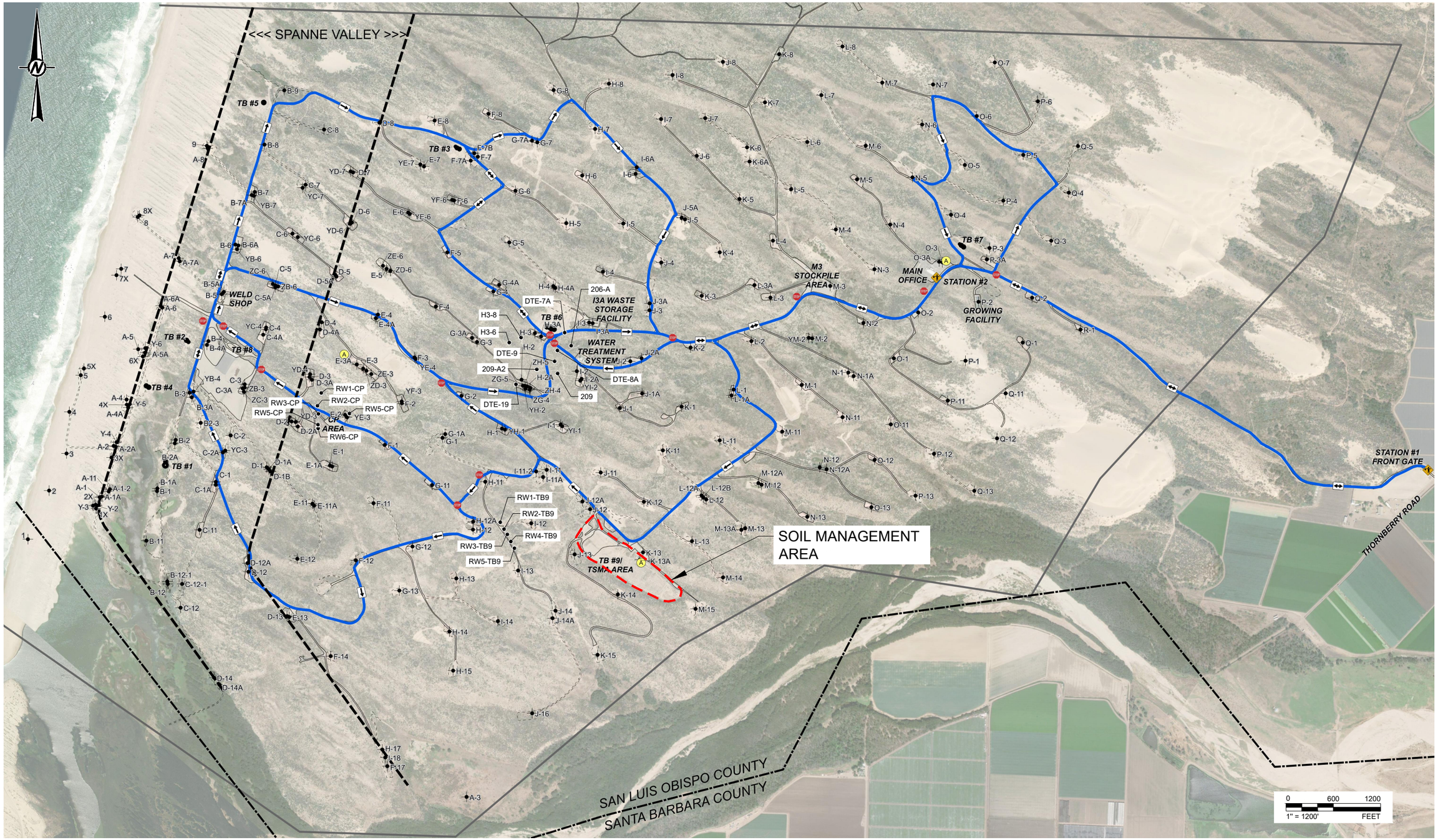
YYYY-MM-DD	2020-06-09
DESIGNED	LMA
PREPARED	HSG
REVIEWED	RV
APPROVED	RGH

PROJECT NO.	REV.	FIGURE
1783552	0	6

IF THIS MEASUREMENT DOES NOT MATCH WHAT IS SHOWN, THE SHEET SIZE HAS BEEN MODIFIED FROM: ANSI A

PATH: M:\Sites\Chevron - Guadalupe\GIS\Chevron Guadalupe ROWD\Water Well Survey Map.mxd PRINTED ON: 2020-06-10 AT: 10:23:22 AM

Path: \\sacramento\acad\Sites\Chevron - Guadalupe\CIVIL 3D\Chevron Guadalupe ROW.dwg | File Name: Oil and Gas Well Survey Map.dwg | Last Edited By: hsgill Date: 2020-06-05 Time:1:06:17 PM | Printed By: HSG# Date: 2020-06-10 Time:2:53:21 PM



EXPLANATION

- EMERGENCY ASSEMBLY AREA
- STOP SIGN
- TRAFFIC CONTROL
- FORMER PRODUCTION WELL
- APPROXIMATE LOCATION OF ACTIVE FREE-PRODUCT RECOVERY WELL (NOTE 1)
- SPANNE VALLEY BOUNDARY
- MAIN TRAFFIC ROUTE
- COUNTY LINE
- PROPERTY BOUNDARY
- SOIL MANAGEMENT AREA
- EXISTING ROADWAY OR WELL PAD FEATURE
- FORMER ROADWAY OR WELL PAD FEATURE
- FORMER TANK BATTERY LOCATION
- TB = TANK BATTERY
- CP = COMPRESSOR PLANT

NOTE(S)

1. ACTIVE FREE-PRODUCT RECOVERY WELL LOCATIONS BASED ON FIGURE 4-1, ACTIVE FREE-PRODUCT RECOVERY PROGRAM: COMPRESSOR PLANT, DILUENT TANKS, AND TANK BATTER 9 AREAS PREPARED BY TRIHYDRO CORPORATION DATED APRIL 20TH, 2020.

CLIENT
CHEVRON ENVIRONMENTAL MANAGEMENT COMPANY
2184 WEST THORNBERRY ROAD
GUADALUPE, CA 93434

CONSULTANT
GOLDER

YYYY-MM-DD	2019-06-06
DESIGNED	CMN
PREPARED	CMN
REVIEWED	LMA
APPROVED	KGH

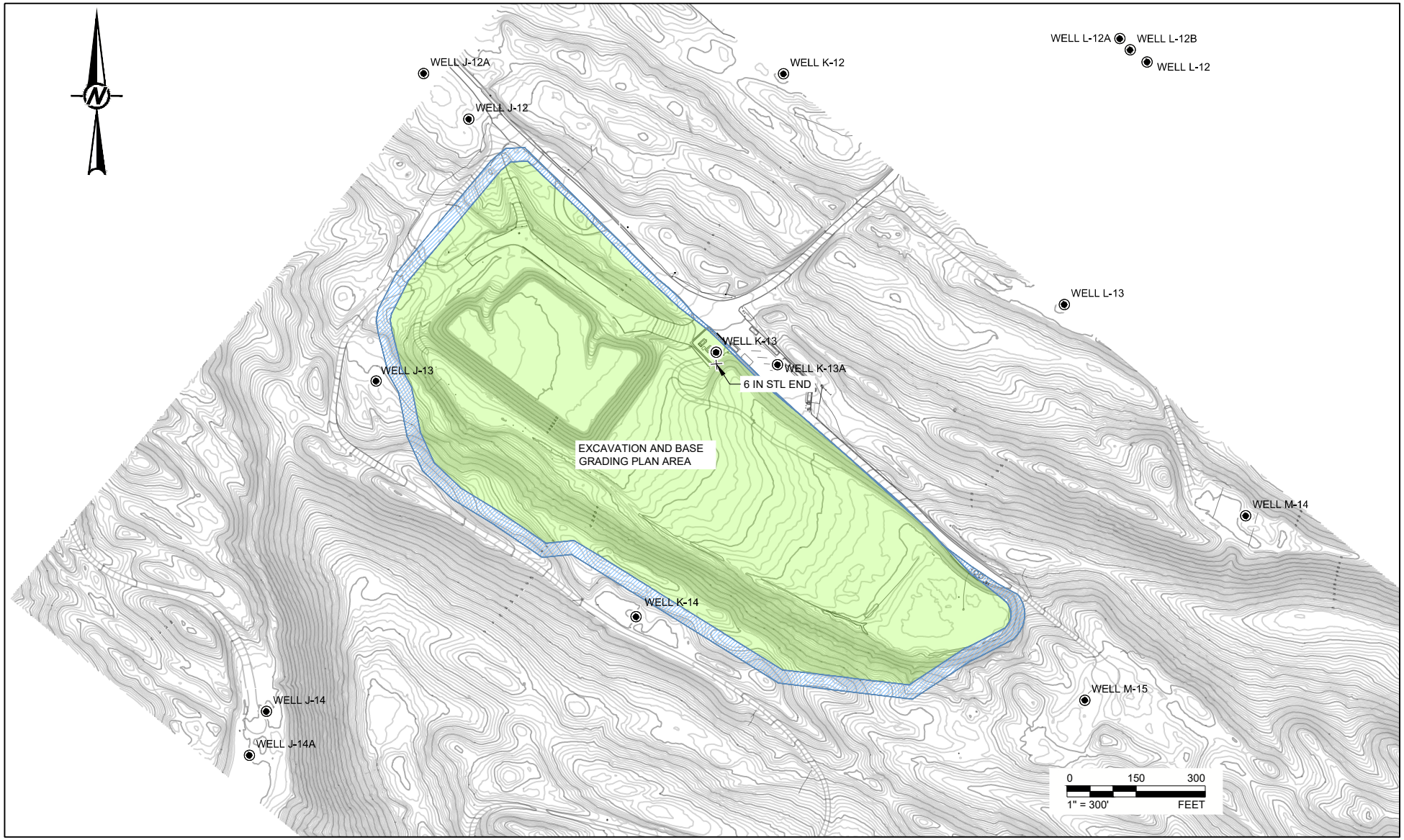
PROJECT
GUADALUPE RESTORATION PROJECT
SOIL MANAGEMENT AREA
TANK BATTERY 9 AREA

TITLE
OIL, GAS AND REMEDIATION WELL SURVEY MAP

PROJECT NO.	REV.	FIGURE
1783552	0	7

IF THIS MEASUREMENT DOES NOT MATCH WHAT IS SHOWN, THE SHEET SIZE HAS BEEN MODIFIED FROM: ANSI B
0 1 in

Last Edited By: micgonzalez Date: 2020-06-10 Time:9:57:33 AM | Printed By: MicGonzalez Date: 2020-06-10 Time:9:59:32 AM
Path: \\sacramento\acad\Sites\Chevron - Guadalupe\CIVIL 3D\Chevron Guadalupe ROWD\ | File Name: FIGURE 8 - ABANDONED OIL WELLS.dwg



NOTE(S)

1. THIS MAP WAS PREPARED USING PHOTOGRAMMETRIC METHODS BY CENTRAL COAST AERIA; MAPPING, INC. DATE OF TOPOGRAPHY: JANUARY 2020.

CLIENT
CHEVRON ENVIRONMENTAL MANAGEMENT COMPANY
2184 WEST THORNBERRY ROAD
GUADALUPE, CA 93434

CONSULTANT
GOLDER

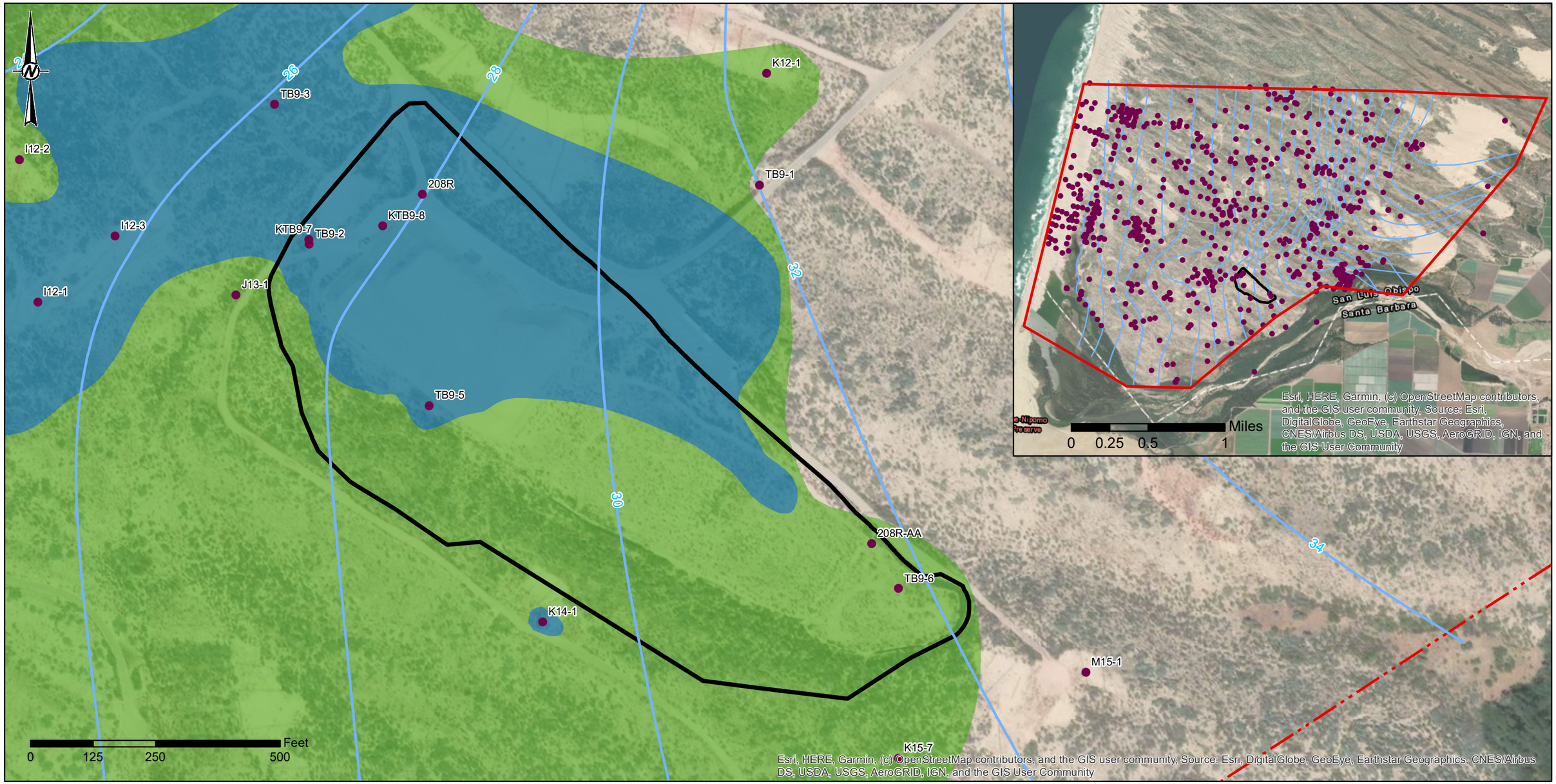
YYYY-MM-DD	2020-06-04
DESIGNED	MAG
PREPARED	MAG
REVIEWED	LMA
APPROVED	RVH

PROJECT
GUADALUPE RESTORATION PROJECT
SOIL MANAGEMENT AREA
TANK BATTERY 9 AREA

TITLE
ABANDONED OIL WELLS NEAR THE SMA

PROJECT NO.	REV.	FIGURE
178352	0	8

IF THIS MEASUREMENT DOES NOT MATCH WHAT IS SHOWN, THE SHEET SIZE HAS BEEN MODIFIED FROM: ANSI A
1 in
0



LEGEND

- GROUNDWATER MONITORING WELLS
- DUNE SAND AQUIFER
- SMA BOUNDARY
- APPROXIMATE FIELD BOUNDARY
- LATERAL EXTENT OF FREE-PHASE HYDROCARBON ON DUNE SAND AQUIFER GROUNDWATER
- LATERAL EXTENT OF DISSOLVED PHASE HYDROCARBON IN DUNE SAND AQUIFER GROUNDWATER (1Q2017)

CLIENT
CHEVRON ENVIRONMENTAL MANAGEMENT COMPANY
2184 WEST THORNBERRY ROAD
GUADALUPE, CA 93434

CONSULTANT
GOLDER

YYYY-MM-DD	2020-02-13
DESIGNED	CMM
PREPARED	CMM
REVIEWED	LMA
APPROVED	RVH

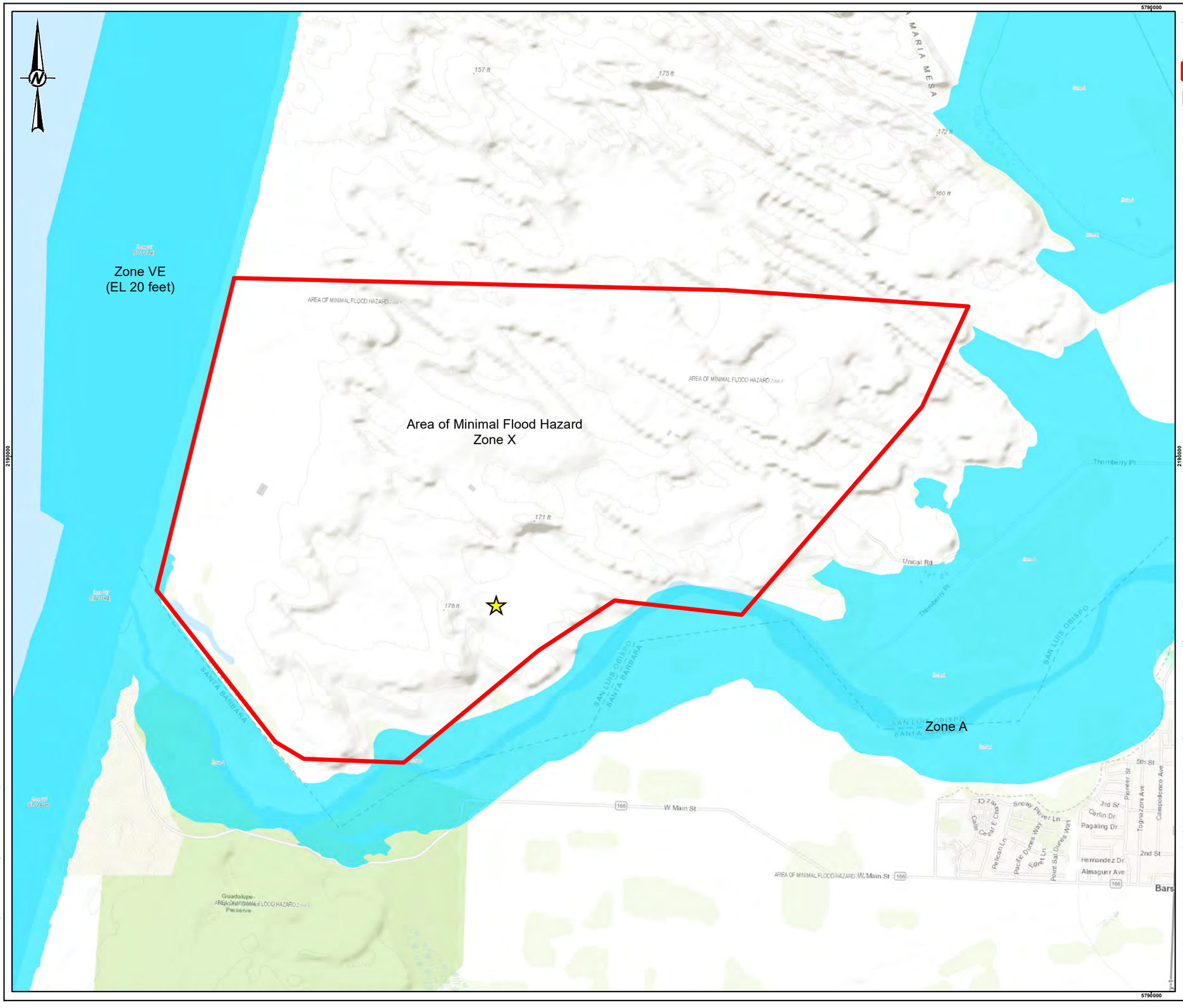
PROJECT
GUADALUPE RESTORATION PROJECT
SOIL MANAGEMENT AREA
TANK BATTERY 9 AREA

TITLE
GROUNDWATER MONITORING WELLS, DUNE SAND AQUIFER POTENTIOMETRIC SURFACE, & LATERAL EXTENTS OF HYDROCARBON IMPACTS TO GROUNDWATER

PROJECT NO.	REV.	FIGURE
1783552	0	9

PATH: M:\Sites\Chevron - Guadalupe\GIS\Chevron Guadalupe ROW\DGW Well and GW Contour Map.mxd PRINTED ON: 2020-06-10 AT: 10:43:44 AM

IF THIS MEASUREMENT DOES NOT MATCH WHAT IS SHOWN, THE SHEET SIZE HAS BEEN MODIFIED FROM: ANSI B



LEGEND

- SMA LOCATION
- APPROXIMATE FIELD BOUNDARY
- 1% ANNUAL CHANCE FLOOD HAZARD (FEMA NFHL)

0 0.25 0.5 1 Miles

NOTE(S)

1. FLOOD DATA OBTAINED FROM US FEMA WEBSITE (HTTPS://MSC.FEMA.GOV). DATE OF PUBLICATION: NOV. 1, 2016.

CLIENT
CHEVRON ENVIRONMENTAL MANAGEMENT COMPANY
2184 WEST THORNBERRY ROAD
GUADALUPE, CA 93434

PROJECT
GUADALUPE RESTORATION PROJECT
SOIL MANAGEMENT AREA
TANK BATTERY 9 AREA

TITLE
REGIONAL FEMA 100-YEAR FLOOD MAP

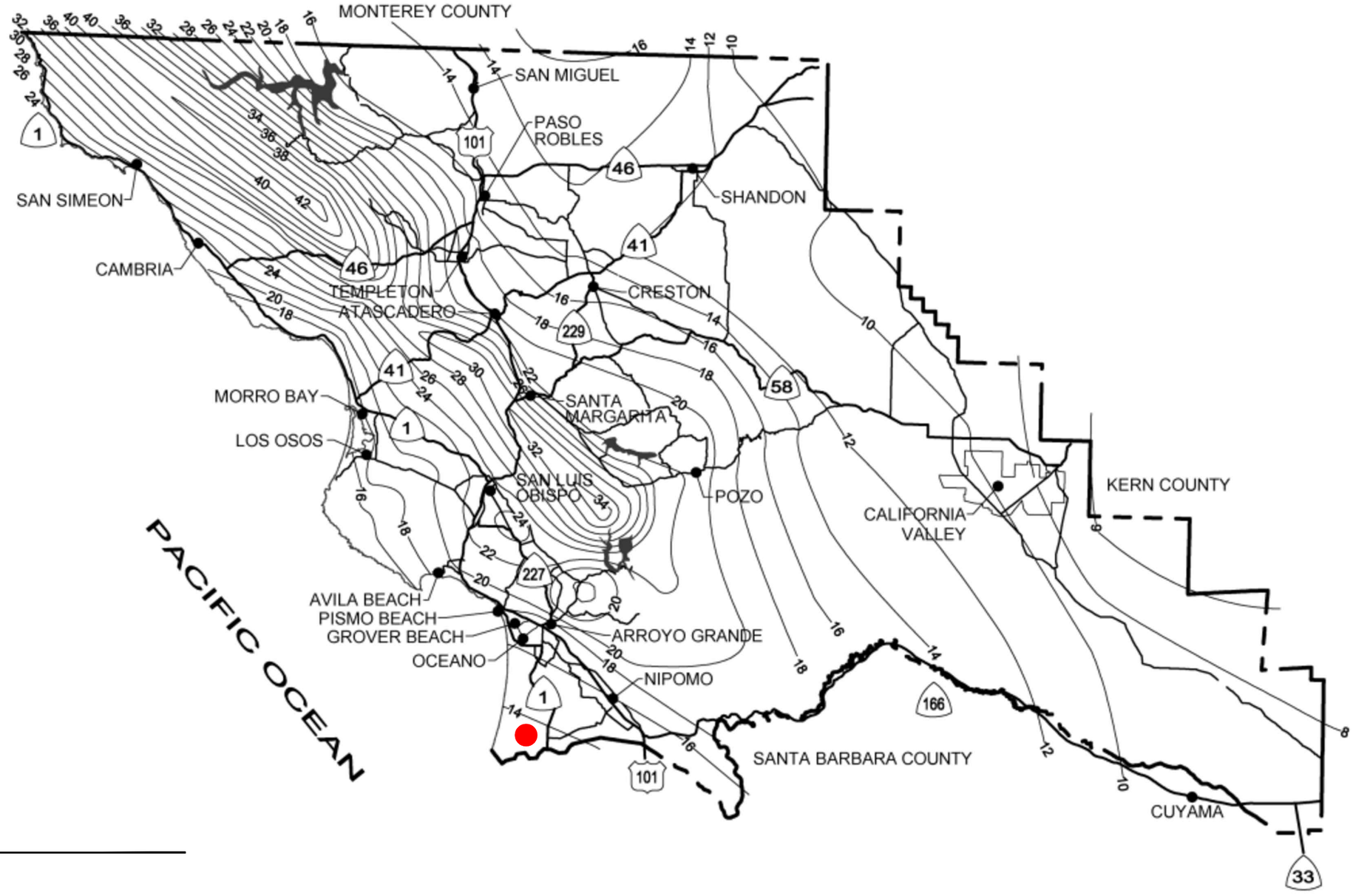
CONSULTANT
GOLDER

YYYY-MM-DD	2019-05-28
DESIGNED	LMA
PREPARED	CB
REVIEWED	LMA
APPROVED	RGH

PROJECT NO. 1783552 | REV. 0 | FIGURE 10

PATH: M:\Sites\Chevron - Guadalupe\GIS\Chevron Guadalupe ROWD 100-Year Flood Map.mxd PRINTED ON: 2019-10-04 AT: 9:09:49 AM

IF THIS MEASUREMENT DOES NOT MATCH WHAT IS SHOWN, THE SHEET SIZE HAS BEEN MODIFIED FROM: ANSI B



LEGEND

PROJECT LOCATION

NOTE(S)

1. ISOHYETAL MAP NOT TO SCALE.
2. SAN LUIS OBISPO COUNTY AVERAGE ANNUAL PRECIPITATION MAP (JULY 1 THROUGH JUNE 30, FOR 42 YEAR PERIODS FROM 1955-56 THROUGH 1997-98) OBTAINED FROM SAN LUIS OBISPO COUNTY DEPARTMENT OF PUBLIC WORKS, ISSUED AUGUST 2006.

CLIENT
CHEVRON ENVIRONMENTAL MANAGEMENT COMPANY
2184 WEST THORNBERRY ROAD
GUADALUPE, CA 93434

CONSULTANT
GOLDER

YYYY-MM-DD	2019-08-16
DESIGNED	CMN
PREPARED	CMN
REVIEWED	LMA
APPROVED	RGH

PROJECT
GUADALUPE RESTORATION PROJECT
SOIL MANAGEMENT AREA
TANK BATTERY 9 AREA

TITLE
ISOHYETAL RAINFALL MAP

PROJECT NO.	REV.	FIGURE
1783552	0	11

Path: \\sacramento\acad\Sites\Chevron - Guadalupe\CIVIL 3D\Chevron Guadalupe ROW\D\ | File Name: Isohyetal Map.dwg | Last Edited By: hsgill Date: 2020-06-10 Time:10:39:21 AM | Printed By: HSG# Date: 2020-06-10 Time:10:39:43 AM
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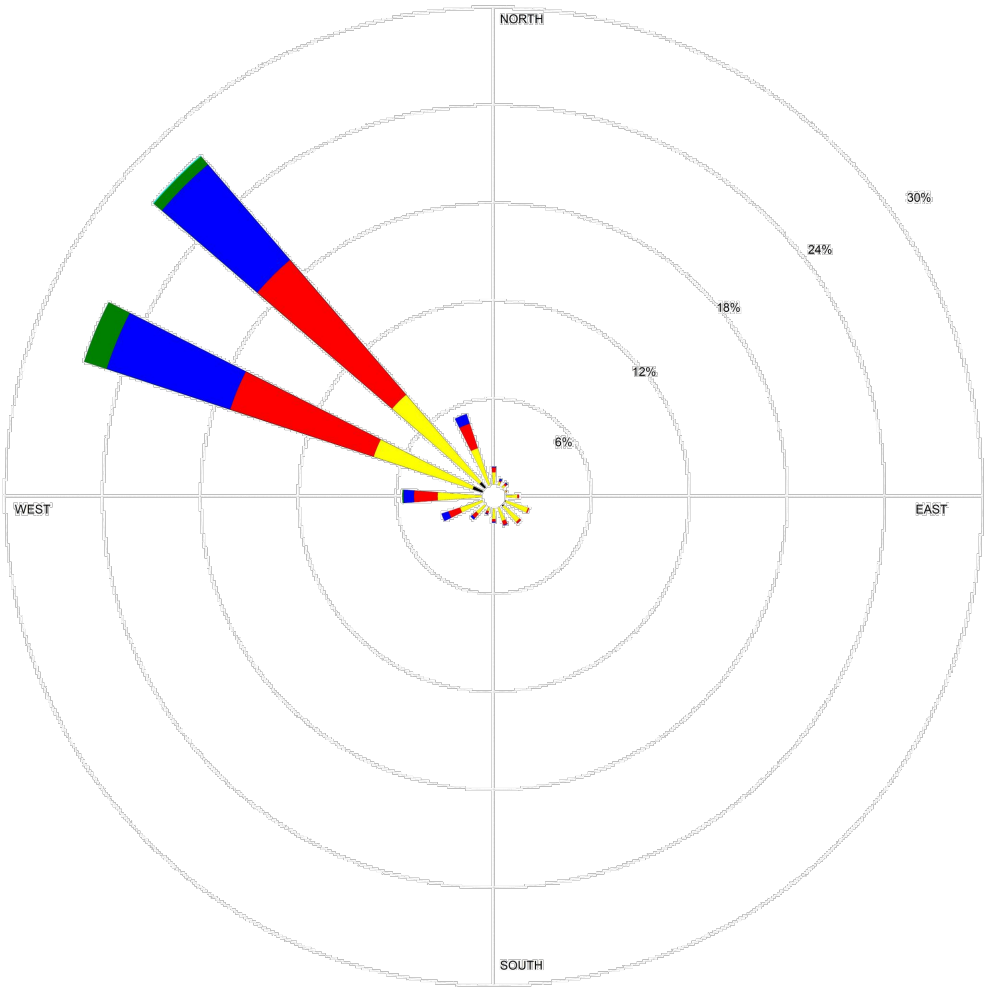
1 in
0

WIND ROSE PLOT

Station #23273 - ,



Wind Speed (m/s)

- ≥ 11.06
- 8.49 - 11.06
- 5.40 - 8.49
- 3.34 - 5.40
- 1.80 - 3.34
- 0.51 - 1.80

MODELER	DATE	COMPANY NAME
Sara West	**9/6/2002**	**USDA-ARS**
DISPLAY	UNIT	COMMENTS
Wind Speed	**m/s**	
AVG. WIND SPEED	CALM WINDS	
3.98 m/s	**13.88%**	
ORIENTATION	PLOT YEAR-DATE-TIME	
Direction (blowing from)	**1961 Sep 1 - Sep 30 Midnight - 11 PM**	

WRPLOT View 3.5 by Lakes Environmental Software - www.lakes-environmental.com

NOTE(S)

1. WIND ROSE DATA OBTAINED FROM THE UNITED STATES DEPARTMENT OF AGRICULTURE NATURAL RESOURCES CONSERVATION SERVICE. (WWW.WCC.NRCS.USDA.GOV). WIND ROSE PLOT OF SANTA MARIA, CALIFORNIA OBTAINED ON JUNE 6, 2019.

CLIENT
CHEVRON ENVIRONMENTAL MANAGEMENT COMPANY
2184 WEST THORNBERRY ROAD
GUADALUPE, CA 93434

CONSULTANT
GOLDER

YYYY-MM-DD	2019-06-06
DESIGNED	CMN
PREPARED	CMN
REVIEWED	LMA
APPROVED	RGH

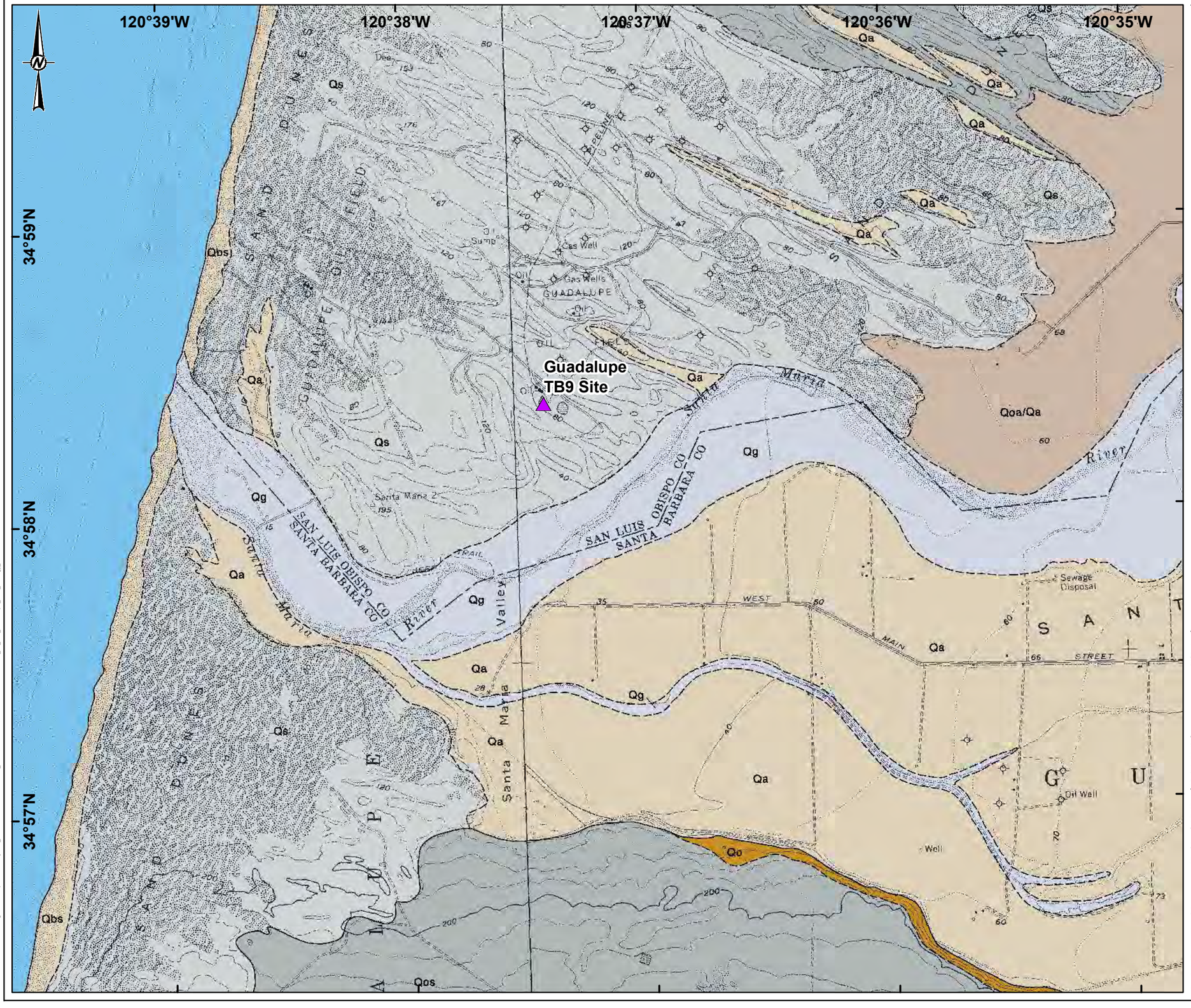
PROJECT
GUADLAUPE RESTORATION PROJECT
SOIL MANAGEMENT AREA
TANK BATTERY 9 AREA

TITLE
WIND ROSE

PROJECT NO.	REV.	FIGURE
1783552	0	12

Last Edited By: caseymay Date: 2020-02-14 Time:12:12:44 PM | Printed By: HSGill Date: 2020-06-10 Time:10:37:47 AM
Path: \\sacramento\acad\Sites\Chevron - Guadalupe\CIVIL 3D\Chevron Guadalupe ROWD\ | File Name: Wind Rose.dwg

IF THIS MEASUREMENT DOES NOT MATCH WHAT IS SHOWN, THE SHEET SIZE HAS BEEN MODIFIED FROM: ANSI A
0 1 in



LEGEND

- Guadalupe TB9 Site

Surficial Geology

- Qa - Valley and floodplain alluvium
- Qbs - Beach sand deposits
- Qg - Stream channel deposits of sand and silt
- Qoa/Qa - Older dissected surficial sediments
- Qs - Dune sand deposits
- Qos - Older Dune sand deposits
- Qo - Orcutt sand

0 0.2 0.4 0.8
MILES
0 0.325 0.65 1.3
KILOMETERS

REFERENCE(S)
1. DIBBLEE (2009) - GEOLOGY
2. COORDINATE SYSTEM: NAD 1983 UTM ZONE 10N
3. SERVICE LAYER CREDITS:

CLIENT
CHEVRON ENVIRONMENTAL MANAGEMENT COMPANY
2184 WEST THORNBERRY ROAD
GUADALUPE, CA 93434

PROJECT
GUADALUPE RESTORATION PROJECT
SOIL MANAGEMENT AREA
TANK BATTERY 9 AREA

TITLE
SURFICIAL GEOLOGY MAP

CONSULTANT
GOLDER

YYYY-MM-DD	2018-07-12
PREPARED	HJ
REVIEWED	DL
APPROVED	AH

PROJECT NO.	PHASE	REV.	FIGURE
1783552	-	A	13

IF THIS MEASUREMENT DOES NOT MATCH WHAT IS SHOWN, THE SHEET SIZE HAS BEEN MODIFIED FROM: ANSI B

PATH: G:\Chevron\Environmental\Mgmt\Guadalupe\Tank Battery\999_PROJECTS\1783552\SHA\02_PRODUCTION\MXD\FIGURES\RevA\1783552_01_F02_Guadalupe_SHA_Geology_RevA.mxd

A
Northwest

A'
Southeast

ELEVATION, FEET, MSL

120
110
100
90
80
70
60
50
40
30
20
10
0

SBTB9-82
SBTB9-73
BASIN
SBTB9-57
BASIN
SBTB9-58
SBTB9-59
SBTB9-60
SBTB9-61
SBTB9-62
SBTB9-63
SBTB9-64
SBTB9-65
SBTB9-26

AF
AF

DUNE SAND

CONFINING UNIT
(SILTS AND CLAYS)

200
400
600
800
1,000
1,200
1,400
1,600

DISTANCE ALONG LINE, FEET

LEGEND

- SILT (ML)
- CLAYEY SILT (CL-ML)
- LEAN CLAY (CL)
- POORLY GRADED SAND (SP)
- SANDY SILT (ML)
- ASPHALT AND CONCRETE
- SUMP MATERIAL
- ARTIFICIAL FILL (AF)
- GROUND SURFACE (CANNON 2016)
- 1998 TB9 BASIN TOPOGRAPHY
- CURRENT GROUNDWATER ELEVATION (1Q17)
- INFERRED CONTACT
- HIGH-DENSITY POLYETHYLENE (HDPE) LINER

NOTE(S)

1. GEOLOGICAL CROSS SECTION PREPARED BY PADRE ASSOCIATES, INC. JANUARY 2018.
2. THIS CROSS SECTION WAS CREATE FOR INFORMATIONAL AND DISPLAY PURPOSES ONLY.
3. CURRENT GROUNDWATER ELEVATION OF 29 TO 31 FT MSL.
4. VERTICAL EXTENT OF CRUDE OIL/SUMP MATERIAL IS BASED ON LIGHOLOGIC LOG WHERE TPH RESULTS ARE NOT AVAILABLE.

ABBREVIATIONS:
TB9 = TANK BATTERY 9
TPH = TOTAL PETROLEUM HYDROCARBONS
MSL = MEAN SEA LEVEL

CLIENT
CHEVRON ENVIRONMENTAL MANAGEMENT COMPANY
2184 WEST THORNBERRY ROAD
GUADALUPE, CA 93434

CONSULTANT
GOLDER

YYYY-MM-DD	2019-08-16
DESIGNED	CMN
PREPARED	CMN
REVIEWED	LMA
APPROVED	RGH

PROJECT
GUADALUPE RESTORATION PROJECT
TREATED SOIL MANAGEMENT AREA
TANK BATTERY 9 AREA

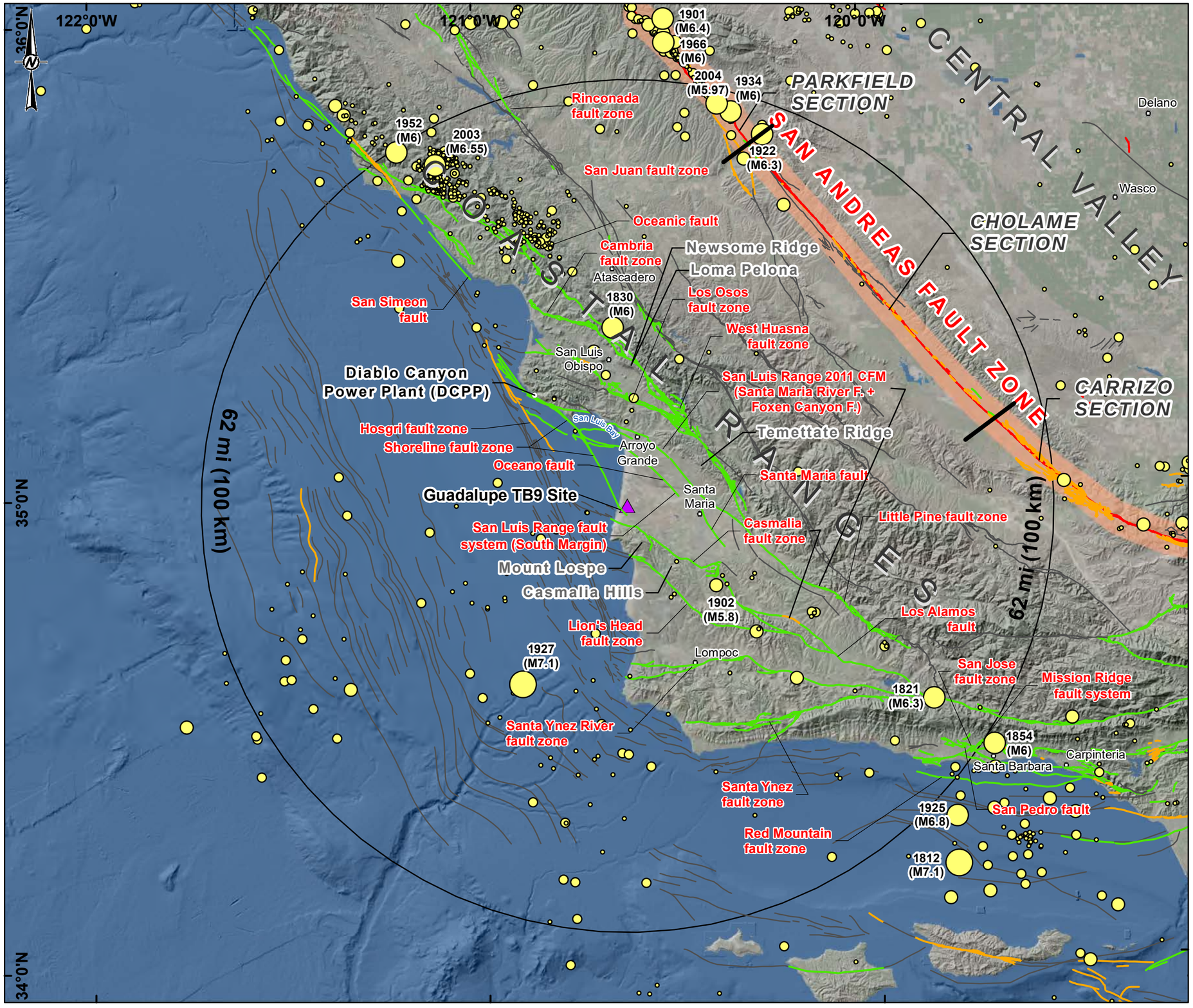
TITLE
GEOLOGICAL CROSS SECTION

PROJECT NO. 1783552
REV. 0
FIGURE 14

IF THIS MEASUREMENT DOES NOT MATCH WHAT IS SHOWN, THE SHEET SIZE HAS BEEN MODIFIED FROM: ANSI B

0 1 in

Path: \\sacramento\acad\Sites\Chevron - Guadalupe\CIVIL 3D\Chevron Guadalupe ROWD\ | File Name: Figure 12 Cross Section.dwg | Last Edited By: caseymay Date: 2020-02-14 Time: 12:16:14 PM | Printed By: HSG# Date: 2020-06-10 Time:10:33:56 AM



LEGEND

Guadalupe TB9 Site

Historical Earthquake Epicenters

Magnitude

- 3.0 - 3.9
- 4.0 - 4.9
- 5.0 - 5.9
- 6.0 - 6.9
- 7.0 - 7.9

(Year and magnitude of significant events labeled)

Faults

Age of Most Recent Activity

- Historic (<150 years)
- Holocene (<15,000 years)
- Late Quaternary (<130,000 years)
- Undifferentiated Quaternary
- 1857 San Andreas Fault Rupture

0 5 10 20
MILES

0 12.5 25 50
KILOMETERS

REFERENCE(S)

1. EARTHQUAKE EPICENTERS (FIELD ET AL. 2013)
2. FAULT LOCATIONS: USGS (2018), NISHENKO ET AL. (2018), PG&E (2015)
3. COORDINATE SYSTEM: NAD 1983 UTM ZONE 10N
4. SERVICE LAYER CREDITS: AIRBUS,USGS,NGA,NASA,CGIAR,GEBCO,NCEAS,NLS,OS,NMA,GEODATASTYRELSEN,GSA,GSI AND THE GIS USER COMMUNITY
   SOURCE: ESRI, DIGITALGLOBE, GEOEYE, EARTHSTAR GEOGRAPHICS, CNES/AIRBUS DS, USDA, USGS, AEROGRID, IGN, AND THE GIS USER COMMUNITY

CLIENT
CHEVRON ENVIRONMENTAL MANAGEMENT COMPANY
2184 WEST THRONBERRY ROAD
GUADALUPE, CA 93434

PROJECT
GUADALUPE RESTORATION PROJECT
SOIL MANAGEMENT AREA
TANK BATTERY 9 AREA

TITLE
REGIONAL FAULT MAP

CONSULTANT
GOLDER

YYYY-MM-DD	2018-09-07
PREPARED	HJ
REVIEWED	DL
APPROVED	AH

PROJECT NO.	PHASE	REV.	FIGURE
1783552	-	A	15

IF THIS MEASUREMENT DOES NOT MATCH WHAT IS SHOWN, THE SHEET SIZE HAS BEEN MODIFIED FROM: ANSI B

PATH: G:\Chevron\Environmental\Mgmt\Guadalupe Tank Battery 9\99_PROJECTS\1783552\SHA\02_PRODUCTION\MXD\FIGURES\RevA\1783552_01_F01_Guadalupe_SHA_TectonicSetting_RevA.mxd

APPENDIX A

Form 200 Application/Report of Waste Discharge General Information Form/CalRecycle Concurrence

INTRODUCTION

This application package constitutes a Report of Waste Discharge (ROWD) pursuant to California Water Code Section 13260. Section 13260 states that persons discharging or proposing to discharge waste that could affect the quality of the waters of the State, other than into a community sewer system, shall file a ROWD containing information which may be required by the appropriate Regional Water Quality Control Board (RWQCB).

This package is to be used to start the application process for all waste discharge requirements (WDRs) and National Pollutant Discharge Elimination System (NPDES) permits* issued by a RWQCB except:

1. Those landfill facilities that must use a joint Solid Waste Facility Permit Application Form, California Integrated Waste Management Board Form E-1-77; and

2. General WDRs or general NPDES permits that use a Notice of Intent to comply or specify the use of an alternative application form designed for that permit.

This application package contains:

1. Application/General Information Form for WDRs and NPDES Permits [Form 200 (10/97)].

2. Application/General Information Instructions.

Instructions

Instructions are provided to assist you with completion of the application. If you are unable to find the answers to your questions or need assistance with the completion of the application package, please contact your RWQCB representative. The RWQCBs strongly recommend that you make initial telephone or personal contact with RWQCB regulatory staff to discuss a proposed new discharge before submitting your application. The RWQCB representative will be able to answer procedural and annual fee related questions that you may have. (See map and telephone numbers inside of application cover.)

All dischargers regulated under WDRs and NPDES permits must pay an annual fee, except dairies, which pay a filing fee only. The RWQCB will notify you of your annual fee based on an evaluation of your proposed discharge. Please do NOT submit a check for your first annual fee or filing fee until requested to do so by a RWQCB representative. Dischargers applying for reissuance (renewal) of an existing NPDES permit or update of an existing WDR will be billed through the annual fee billing system and are therefore requested NOT to submit a check with their application. Checks should be made payable to the State Water Resources Control Board.

Additional Information Requirements

A RWQCB representative will notify you within 30 days of receipt of the application form and any supplemental documents whether your application is complete. If your application is incomplete, the RWQCB representative will send you a detailed list of discharge specific information necessary to complete the application process. The completion date of your application is normally the date when all required information, including the correct fee, is received by the RWQCB.

***NPDES PERMITS:** If you are applying for a permit to discharge to surface water, you will need an NPDES permit which is issued under both State and Federal law and may be required to complete one or more of the following Federal NPDES permit application forms: Short Form A, Standard Form A, Forms 1, 2B, 2C, 2D, 2E, and 2F. These forms may be obtained at a RWQCB office or can be ordered from the National Center for Environmental Publications and Information at (513) 891-6561

APPENDIX A.1

Form 200 Application/Report of Waste Discharge General Information Form

State of California
Regional Water Quality Control Board

APPLICATION/REPORT OF WASTE DISCHARGE
GENERAL INFORMATION FORM FOR
WASTE DISCHARGE REQUIREMENTS OR NPDES PERMIT

INSTRUCTIONS

Instructions for completing the application/report of waste discharge general information form for: waste discharge requirements/ NPDES permit.

If you have any questions on the completion of any part of the application, please contact your RWQCB representative. A map of RWQCB locations, addresses, and telephone numbers is located on the reverse side of the application cover.

I. FACILITY INFORMATION

You must provide the factual information listed below for ALL owners, operators, and locations and, where appropriate, for ALL general partners and lease holders.

A. ***FACILITY:*** Legal name, physical address including the county, person to contact, phone number, and email at the facility. (NO P.O. Box numbers. If no address exists, use street and nearest cross street).

B. ***FACILITY OWNER:*** Legal owner, address, person to contact, phone number, and email. Also include the owner's Federal Tax Identification Number.

Owner Type: Check the appropriate owner type. The legal owner will be named in the WDRs/NPDES permit.

C. ***FACILITY OPERATOR (The agency or business, not the person):*** If applicable, the name, address, person to contact, telephone number, and email for the facility operator. Check the appropriate Operator Type. If identical to B. above, enter "same as owner".

D. ***OWNER OF THE LAND:*** Legal owner of the land(s) where the facility is located, address, person to contact, and phone number. Check the appropriate Owner Type. If identical to B. above, enter "same as owner".

E. ***ADDRESS WHERE LEGAL NOTICE MAY BE SERVED:*** Address where legal notice may be served, person to contact, and phone number. If identical to B. above, enter "same as owner".

Address where annual fee invoices should be sent, person to contact, and phone number. If identical to B. above, enter "same as owner".

F. ***BILLING ADDRESS:*** Address where annual fee invoices should be sent, person to contact, and phone number. If identical to B. above, enter "same as owner".

II. TYPE OF DISCHARGE

Mark the appropriate box to describe whether the waste will be discharged to: Land or Surface Water.

Check the appropriate box(es) which best describe the activities at your facility.

Hazardous Waste: If you check the Hazardous Waste box, STOP and contact a representative of the RWQCB for further instructions.

Landfills: A separate form, APPLICATION FOR SOLID WASTE FACILITY PERMIT/WASTE DISCHARGE REQUIREMENTS, California Integrated Waste Management Board Form E-1-77, may be required. Contact a RWQCB representative to help determine the appropriate form for your discharge.

III. LOCATION OF THE FACILITY

- Enter the Assessor's Parcel Number(s) (APN), which is located on the property tax bill. The number can also be obtained from the County Assessor's Office. Indicate the APN for both the facility and the discharge point.

- Enter the Latitude of the entrance to the proposed/existing facility and of the discharge point. Latitude and longitude information can be obtained from a U.S. Geological Survey quadrangle topographic map. Other maps may also contain this information.

- Enter the Longitude of the entrance to the proposed/existing facility and of the discharge point.

IV. REASON FOR FILING

NEW DISCHARGE OR FACILITY: A discharge or facility that is proposed but does not now exist, or that does not yet have WDRs or an NPDES permit.

CHANGE IN DESIGN OR OPERATION: A material change in design or operation from existing discharge requirements. Final determination of whether the reported change is material will be made by the RWQCB.

CHANGE IN QUANTITY/TYPE OF DISCHARGE: A material change in characteristics of the waste from existing discharge requirements. Final determination of whether the reported change would have a significant effect will be made by the RWQCB.

CHANGE IN OWNERSHIP/ OPERATOR: Change of legal owner of the facility. Complete Parts I, III, and IV only and contact the RWQCB to determine if additional information is required.

WASTE DISCHARGE REQUIREMENTS UPDATE OR NPDES PERMIT REISSUANCE: WDRs must be updated periodically to reflect changing technology standards and conditions. A new application is required to reissue an NPDES permit which has expired.

OTHER: If there is a reason other than the ones listed, please describe the reason on the space provided. (If more space is needed, attach a separate sheet.)

V. CALIFORNIA ENVIRONMENTAL QUALITY ACT (CEQA)

It should be emphasized that communication with the appropriate RWQCB staff is vital before starting the CEQA documentation and is recommended before completing this application. There are Basin Plan issues which may complicate the CEQA effort, and RWQCB staff may be able to help in providing the needed information to complete the CEQA documentation.

Name the Lead Agency responsible for completion of CEQA requirements for the project, i.e., completion and certification of CEQA documentation.

Check YES or NO. Has a public agency determined that the proposed project is exempt from CEQA? If the answer is YES, state the basis for the exemption and the name of the agency supplying the exemption on the space provided. (Remember that, if extra space is needed, use an extra sheet of paper, but be sure to indicate the attached sheet under Section VII. Other.)

Check YES or NO. Has the “Notice of Determination” been filed under CEQA? If YES, give the date the notice was filed and enclose a copy of the Notice of Determination and the Initial Study, Environmental Impact Report, or Negative Declaration. If NO, check the box of the expected type of CEQA document for this project, and include the expected date of completion using the timelines given under CEQA. The date of completion should be taken as the date that the Notice of Determination will be submitted. (If not known, write “Unknown”)

VI. OTHER REQUIRED INFORMATION

To be approved, your application MUST include a COMPLETE characterization of the discharge. If the characterization is found to be incomplete, RWQCB staff will contact you and request that additional specific information be submitted.

This application MUST be accompanied by a site map. A USGS 7.5’ Quadrangle map or a street map, if more appropriate, is sufficient for most applications.

VII. OTHER

If any of the answers on your application form need further explanation, attach a separate sheet. Please list any attachments with the titles and dates on the space provided.

VIII. CERTIFICATION

Certification by the owner of the facility or the operator of the facility, if the operator is different from the owner, is required. The appropriate person must sign the application form.

Acceptable signatures are:

1. for a corporation, a principal executive officer of at least the level of senior vice-president;

2. for a partnership or individual (sole proprietorship), a general partner or the proprietor;

3. for a governmental or public agency, either a principal executive officer or ranking elected/appointed official.

Discharge Specific Information

In most cases, a request to supply additional discharge specific information will be sent to you by a representative of the RWQCB. If the RWQCB determines that additional discharge specific information is not needed to process your application, you will be so notified.

State of California
Regional Water Quality Control Board

APPLICATION/REPORT OF WASTE DISCHARGE
GENERAL INFORMATION FORM FOR
WASTE DISCHARGE REQUIREMENTS OR NPDES PERMIT

I. FACILITY INFORMATION

A. FACILITY:

Name Soil Management Area

Address 2184 W Thornberry Road

City/County/State/Zip Code Guadalupe/Santa Barbara/CA/93434

Contact Person Danielle Wold

Telephone Number 805-858-3028 Email DanielleWold@chevron.com

B. FACILITY OWNER:

Name Union Oil Company of California

Address 2184 W Thornberry Road

City/State/Zip Code Guadalupe/San Luis Obispo/CA/93434

Contact Person Danielle Wold

Telephone Number 805-858-3028 Email DanielleWold@chevron.com

Federal Tax ID 95-1315450

Owner Type (*Mark one*):

☐ Individual ☑ Corporation ☐ Governmental Agency ☐ Partnership

☐ Other: _____

C. FACILITY OPERATOR (The agency or business, not the person):

Name Chevron Environmental Management Company

Address 2184 W Thornberry Road

City/State/Zip Code Guadalupe/San Luis Obispo/CA/93434

Contact Person Danielle Wold

Telephone Number 805-858-3028 Email DanielleWold@chevron.com

Operator Type (*Mark one*):

☐ Individual ☑ Corporation ☐ Governmental Agency ☐ Partnership

☐ Other: _____

D. OWNER OF THE LAND

Name Union Oil Company of California

Address 2184 W Thornberry Road

City/State/Zip Code Guadalupe/San Luis Obispo/CA/93434

Contact Person Danielle Wold

Telephone Number 805-858-3028 Email DanielleWold@chevron.com

Owner Type (*Mark one*):

☐ Individual ☑ Corporation ☐ Governmental Agency ☐ Partnership

☐ Other: _____

E. ADDRESS WHERE LEGAL NOTICE MAY BE SERVED

Address 6001 Bollinger Canyon Road

City/State/Zip Code San Ramon/CA/94583

Contact Person Owen Ranta

Telephone Number 805-546-6912 Email OwenRanta@chevron.com

F. BILLING ADDRESS

Address PO Box 1332

City/State/Zip Code San Luis Obispo/CA/93407

Contact Person Danielle Wold

Telephone Number 805-858-3028 Email DanielleWold@chevron.com

II. TYPE OF DISCHARGE

Check Type of Discharge(s) Described in this Application:

☑ **Waste Discharge to Land** ☐ **Waste Discharge to Surface Water**

Check all that apply:

☐ Animal or Aquacultural Wastewater
☐ Animal Waste Solids
☐ Biosolids/Residual
☐ Cooling Water
☐ Domestic/ Municipal Wastewater Treatment and Disposal
☐ Dredge Material Disposal
☐ Hazardous Waste (*see instructions*)
☐ Industrial Process Wastewater
☐ Land Treatment Unit
☑ Landfill (*see instructions*)
☐ Mining
☐ Storm Water
☐ Surface Impoundment
☐ Waste Pile
☐ Wastewater Reclamation
☐ Other, *please describe* _____

III. LOCATION OF THE FACILITY

Describe the physical location of the facility:

1. Assessor's Parcel Number(s)
   Facility: 092-041-005
   Discharge Point: 092-041-001
2. Latitude
   Facility: 34.973611
   Discharge Point: _____
3. Longitude
   Facility: 120.6225
   Discharge Point: _____

IV. REASON FOR FILING

Check all that apply:

- ☑ New Discharge or Facility
- ☐ Change in Design or Operation
- ☐ Change in Quantity/Type of Discharge
- ☐ Changes in Ownership/Operator (see instructions)
- ☐ Waste Discharge Requirements Update or NPDES Permit Reissuance
- ☐ Other: _____

V. CALIFORNIA ENVIRONMENTAL QUALITY ACT (CEQA)

Name of Lead Agency San Luis Obispo County

Has a public agency determined that the proposed project is exempt from CEQA?

☐ Yes ☑ No

If yes, state the basis for the exemption and the name of the agency supplying the exemption on the line below:

_____

_____

Has a "Notice of Determination" been filed under CEQA?

☐ Yes ☑ No

If Yes, enclose a copy of the CEQA document, Environmental Impact Report (EIR), or Negative Declaration. If No, identify the expected type of CEQA document and expected date of completion.

Expected CEQA Documents: ☐ EIR ☑ Negative Declaration

Expected CEQA Completion Date: June 1, 2020

VI. OTHER REQUIRED INFORMATION

Please provide a COMPLETE characterization of your discharge. A complete characterization includes, but is not limited to, design and actual flows, a list of constituents and the discharge concentration of each constituent, a list of other appropriate waste discharge characteristics, a description and schematic drawing of all treatment processes, a description of any Best Management Practices (BMPs) used, and a description of disposal methods.

Also include a site map showing the location of the facility and, if you are submitting this application for an NPDES permit, identify the surface water to which you propose to discharge. Please try to limit your maps to a scale of 1:24,000 (7.5' USGS Quadrangle) or a street map, if more appropriate.

VII. OTHER

Attach additional sheets to explain any responses which need clarification. List attachments with titles and dates below:

Report of Waste Discharge, Feb 2020

You will be notified by a representative of the RWQCB within 30 days of receipt of your application. The notice will state if your application is complete or if there is additional information you must submit to complete your Application/Report of Waste Discharge, pursuant to Division 7, Section 13260 of the California Water Code.

VIII. CERTIFICATION

"I certify under penalty of law that this document, including all attachments and supplemental information, were prepared under my direction and supervision in accordance with a system designed to assure that qualified personnel properly gathered and evaluated the information submitted. Based on my inquiry of the person or persons who manage the system, or those persons directly responsible for gathering the information, the information submitted is, to the best of my knowledge and belief, true, accurate, and complete. I am aware that there are significant penalties for submitting false information, including the possibility of fine and imprisonment."

Print Name Owen Ranta Title Environmental Compliance Officer

Signature Owen Ranta, as Environmental Compliance Officer for Chevron Environmental Management Company Date February 17, 2020

FOR OFFICE USE ONLY

Date Form 200 Received:	Letter to Discharger:	Fee Amount Received:	Check #:

California Environmental Protection Agency
Bill of Rights for Environmental Permit Applicants

California Environmental Protection Agency (Cal/EPA) recognizes that many complex issues must be addressed when pursuing reforms of environmental permits and that significant challenges remain. We have initiated reforms and intend to continue the effort to make environmental permitting more efficient, less costly, and to ensure that those seeking permits receive timely responses from the boards and departments of the Cal/EPA. To further this goal, Cal/EPA endorses the following precepts that form the basis of a permit applicant's "Bill of Rights."

1. Permit applicants have the right to assistance in understanding regulatory and permit requirements. All Cal/EPA programs maintain an Ombudsman to work directly with applicants. Permit Assistance Centers located throughout California have permit specialists from all the State, regional, and local agencies to identify permit requirements and assist in permit processing.
2. Permit applicants have the right to know the projected fees for review of applications, how any costs will be determined and billed, and procedures for resolving any disputes over fee billings.
3. Permit applicants have the right of access to complete and clearly written guidance documents that explain the regulatory requirements. Agencies must publish a list of all information required in a permit application and of criteria used to determine whether the submitted information is adequate.
4. Permit applicants have the right of timely completeness determinations for their applications. In general, agencies notify the applicant within 30 days of any deficiencies or determine that the application is complete. California Environmental Quality Act (CEQA) and public hearing requests may require additional information.
5. Permit applicants have the right to know exactly how their applications are deficient and what further information is needed to make their applications complete. Pursuant to California Government code Section 65944, after an application is accepted as complete, an agency may not request any new or additional information that was not specified in the original application.
6. Permit applicants have the right of a timely decision on their permit application. The agencies are required to establish time limits for permit reviews.
7. Permit applicants have the right to appeal permit review time limits by statute or administratively that have been violated without good cause. For state environmental agencies, appeals are made directly to the Cal/EPA Secretary or to a specific board. For local environmental agencies, appeals are generally made to the local governing board or, under certain circumstances, to Cal/EPA. Through this appeal, applicants may obtain a set date for a decision on their permit and, in some cases, a refund of all application fees (ask boards and departments for details).
8. Permit applicants have the right to work with a single lead agency where multiple environmental approvals are needed. For multiple permits, all agency actions can be consolidated under a lead agency. For site remediation, all applicable laws can be administered through a single agency.
9. Permit applicants have the right to know who will be reviewing their application and the time required to complete the full review process.

APPENDIX A.2

CalRecycle Concurrence

April 16, 2020

Robert Van Hyning, PE
Golder Associates Inc.
7 Corporate Park, Suite 260
Irvine CA, 92606

SUBJECT: Nonhazardous Petroleum Contaminated Soil Exclusion for the Proposed Class II Landfill at the Guadalupe Oil Field, San Luis Obispo County

Mr. Van Hyning:

Department of Resources Recycling and Recovery (CalRecycle) staff, as the solid waste Enforcement Agency (EA) for San Luis Obispo County, have reviewed the Submittal of Information Documenting Proposed Class II Landfill at the Guadalupe Oil Field as a Contaminated Soil Excluded Operation (Request) for the subject facility, dated April 6, 2020. The Request was received by CalRecycle on April 7, 2020.

CalRecycle staff has determined the proposed Operation meets the requirements of Title 14, California Code of Regulations (14 CCR), Section 17362.1 and is excluded from the regulatory requirements of 14 CCR 17360 et seq. Staff made this determination based on the following:

- the proposed waste meets the definition of contaminated soil per 14 CCR 17361(b);
- the disposal of the contaminated soil will be from a single Petroleum Exploration and Production Company, its parent, or subsidiary to property owned or leased by the same Petroleum Exploration and Production Company, its parent, or subsidiary (Unocal Corporation); and
- pursuant to Water Code 13263 (a), the waste will be regulated by the Central Coast Regional Water Quality Control Board (RWQCB; confirmed in an email by RWQCB staff dated April 13, 2020). The RWQCB received a Report of Waste Discharge and the Operation will be regulated under site specific Waste Discharge Requirements.

Note that nothing precludes CalRecycle from inspecting an excluded operation or facility to verify that the operation or facility is being conducted in a manner that qualifies as an excluded operation or facility or from taking any appropriate enforcement action. Should operations change, CalRecycle reserves the right to review the changes to determine if the Operation continues to meet the exclusion or is subject to CalRecycle regulatory requirements.

If you have any questions or comments regarding this letter, please contact Cody Oquendo at 916.341.6719 or Cody.Oquendo@calrecycle.ca.gov.

Sincerely,

Jeff Hackett, Manager
Permits & Assistance South Section
Permitting & Assistance Branch

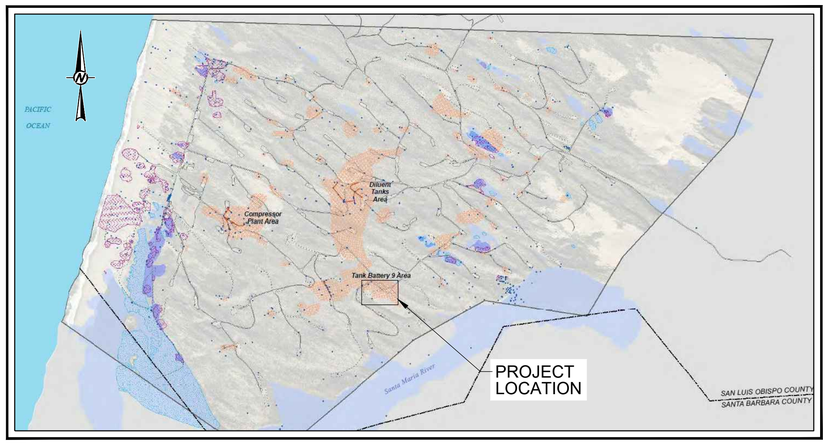
cc via email: Jordan.Haserot@Waterboards.ca.gov – RWQCB
Candice.Houghton@CalRecycle.ca.gov – CalRecycle
Cody.Oquendo@CalRecycle.ca.gov - CalRecycle
Benjamin.Escotto@CalRecycle.ca.gov - CalRecycle

APPENDIX B

General Development Drawings

GUADALUPE RESTORATION PROJECT
SOIL MANAGEMENT AREA
TANK BATTERY 9 AREA
CHEVRON ENVIRONMENTAL MANAGEMENT COMPANY

GUADALUPE, CALIFORNIA
REVISION 0



LOCATION MAP

FIGURE NO.	TITLE
1	TITLE SHEET
2	SITE LOCATION MAP
3	PROPOSED IMPACTED SOIL EXCAVATION GRADING PLAN
4	PROPOSED BASE GRADING PLAN
5	PROPOSED FINAL COVER GRADING PLAN
6	SECTIONS
7	DETAILS (1 of 3)
8	DETAILS (2 of 3)
9	DETAILS (3 of 3)

REV.	YYYY-MM-DD	DESCRIPTION	DESIGNED	PREPARED	REVIEWED	APPROVED
0	2020-06-01	ISSUED FOR PERMITTING	MAG	MAG	LMA	RVH

SEAL

NOT FOR CONSTRUCTION
90% DRAFT

CLIENT
CHEVRON ENVIRONMENTAL MANAGEMENT COMPANY
2184 WEST THORNBERRY ROAD
GUADALUPE, CA 93434

CONSULTANT
GOLDER
SACRAMENTO OFFICE
1000 ENTERPRISE WAY, SUITE 190
ROSEVILLE, CA 95678
USA
(916) 786-2424
www.golder.com

PROJECT
GUADALUPE RESTORATION PROJECT
SOIL MANAGEMENT AREA
TANK BATTERY 9 AREA

TITLE
TITLE SHEET

PROJECT NO. 1783552 | REV. 0 | 1 of 9 | DRAWING 1

IF THIS MEASUREMENT DOES NOT MATCH WHAT IS SHOWN, THE SHEET SIZE HAS BEEN MODIFIED FROM: ANSI D

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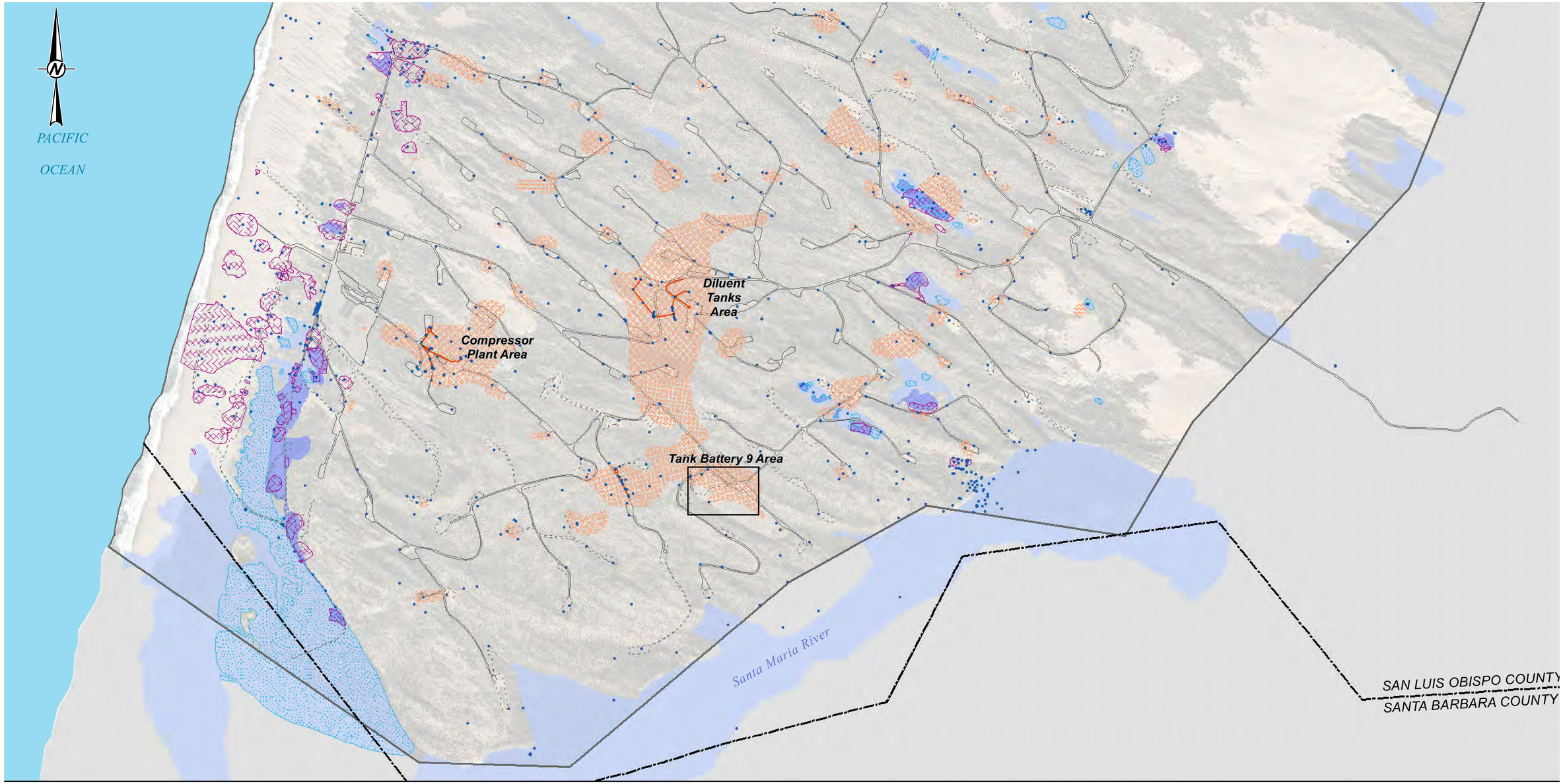

LEGEND:

- Groundwater Monitoring Well
- County Line
- Property Boundary
- Active LNAPL Recovery System Infrastructure
- Existing Roadway or Well Pad Feature
- Former Roadway or Well Pad Feature
- Excavated LNAPL Source Area or Sump
- LNAPL Source Zone
- Federal Wetland (June 2004)
- Restored Wetland (Not Formally Designated)
- State Wetland (June 2003)

NOTE(S)

1. SOURCE: PADRE ASSOCIATES, INC CHEVRON ENVIRONMENTAL MANAGEMENT COMPANY GUADALUPE RESTORATION PROJECT DECEMBER 2016

REV.	YYYY-MM-DD	DESCRIPTION	DESIGNED	PREPARED	REVIEWED	APPROVED
0	2020-06-01	ISSUED FOR PERMITTING	MAG	MAG	LMA	RVH

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PROJECT
GUADALUPE RESTORATION PROJECT
SOIL MANAGEMENT AREA
TANK BATTERY 9 AREA

TITLE
SITE LOCATION MAP

PROJECT NO. 1783552 | REV. 0 | 2 of 9 | DRAWING 2

IF THIS MEASUREMENT DOES NOT MATCH WHAT IS SHOWN, THE SHEET SIZE HAS BEEN MODIFIED FROM: ANSI D

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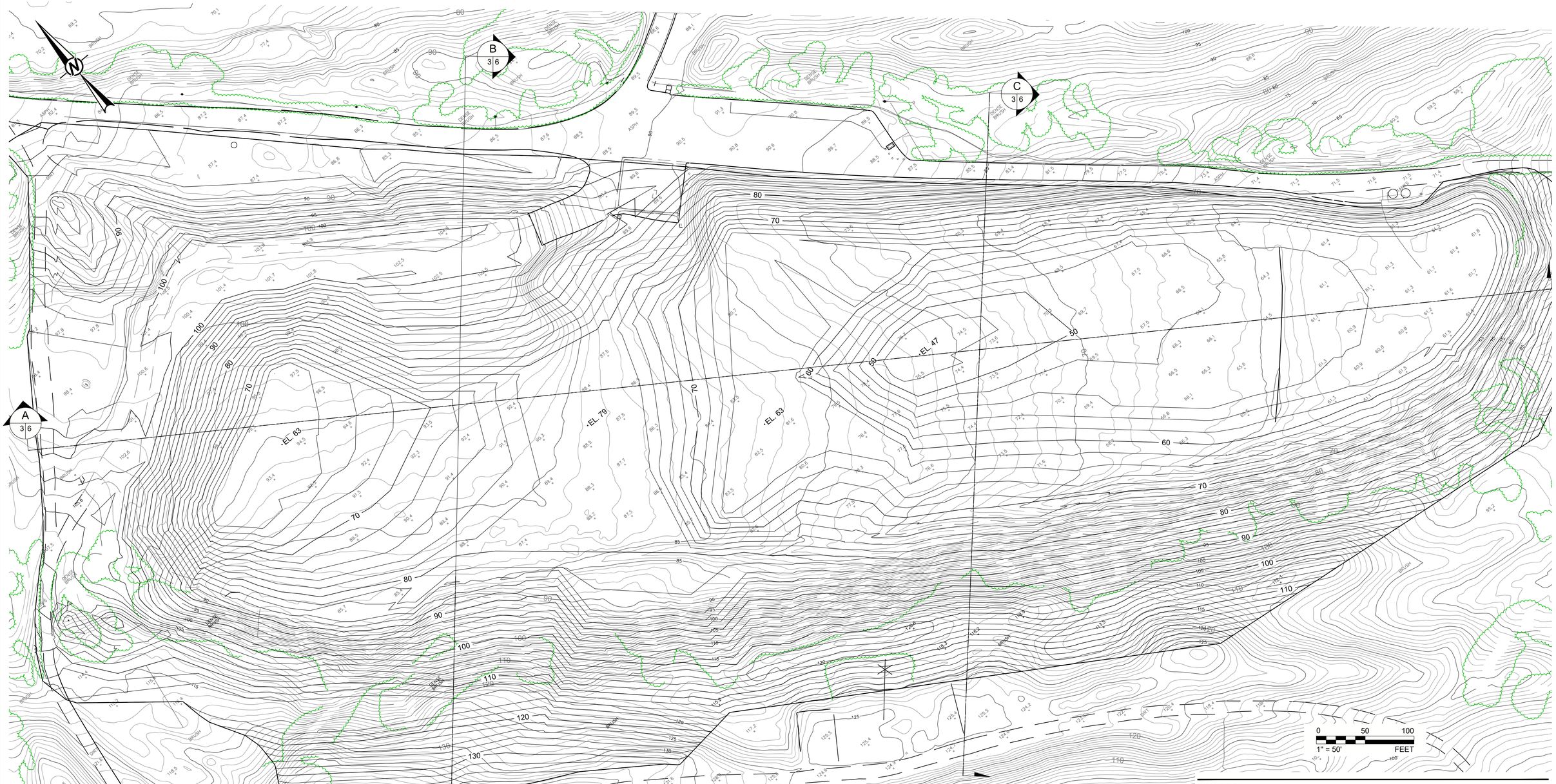

QUANTITIES
TOTAL COMPACTED SOIL EXCAVATION: 262,500 CY
TPH-AFFECTED SOIL: 206,000 CY
CLEAN OVERBURDEN SOIL: 56,500 CY

REV.	YYYY-MM-DD	DESCRIPTION	DESIGNED	PREPARED	REVIEWED	APPROVED
0	2020-06-01	ISSUED FOR PERMITTING	MAG	MAG	LMA	RVH

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GUADALUPE, CA 93434

CONSULTANT
GOLDER
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ROSEVILLE, CA 95678
USA
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PROJECT
GUADALUPE RESTORATION PROJECT
SOIL MANAGEMENT AREA
TANK BATTERY 9 AREA

TITLE
PROPOSED IMPACTED SOIL EXCAVATION GRADING PLAN

PROJECT NO. 1783552 | REV. 0 | 3 of 9 | DRAWING 3

IF THIS MEASUREMENT DOES NOT MATCH WHAT IS SHOWN, THE SHEET SIZE HAS BEEN MODIFIED FROM: ANSI D
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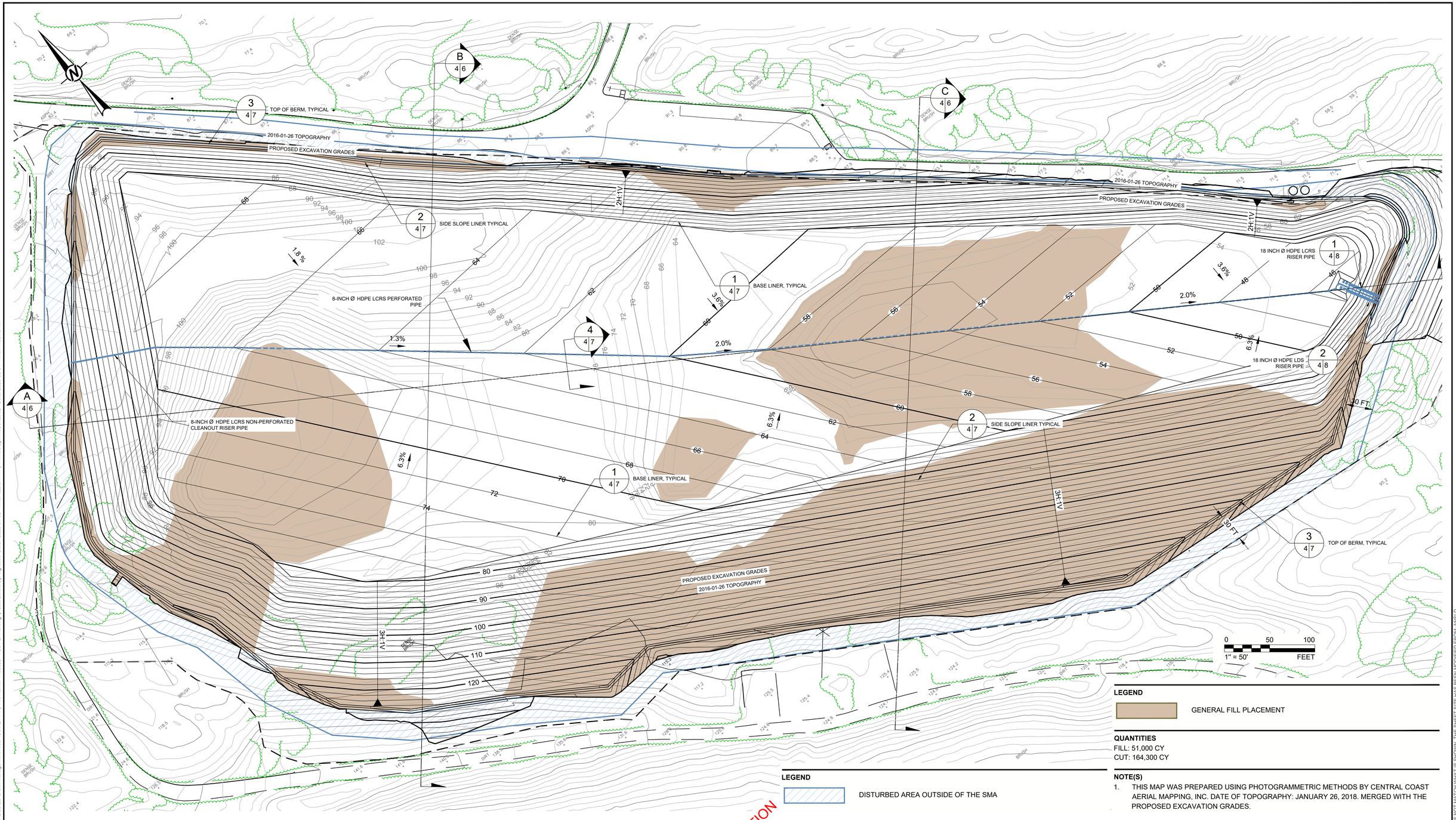

LEGEND

GENERAL FILL PLACEMENT

QUANTITIES

FILL: 51,000 CY
CUT: 164,300 CY

LEGEND

DISTURBED AREA OUTSIDE OF THE SMA

NOTE(S)

1. THIS MAP WAS PREPARED USING PHOTOGRAMMETRIC METHODS BY CENTRAL COAST AERIAL MAPPING, INC. DATE OF TOPOGRAPHY: JANUARY 26, 2018. MERGED WITH THE PROPOSED EXCAVATION GRADES.

REV.	YYYY-MM-DD	DESCRIPTION	DESIGNED	PREPARED	REVIEWED	APPROVED
0	2020-06-01	ISSUED FOR PERMITTING	MAG	MAG	LMA	RVH

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PROJECT
GUADALUPE RESTORATION PROJECT
SOIL MANAGEMENT AREA
TANK BATTERY 9 AREA

TITLE
PROPOSED BASE GRADING PLAN

PROJECT NO. 1783552 | REV. 0 | 4 of 9 | DRAWING 4

IF THIS MEASUREMENT DOES NOT MATCH WHAT IS SHOWN, THE SHEET SIZE HAS BEEN MODIFIED FROM: ANSI D

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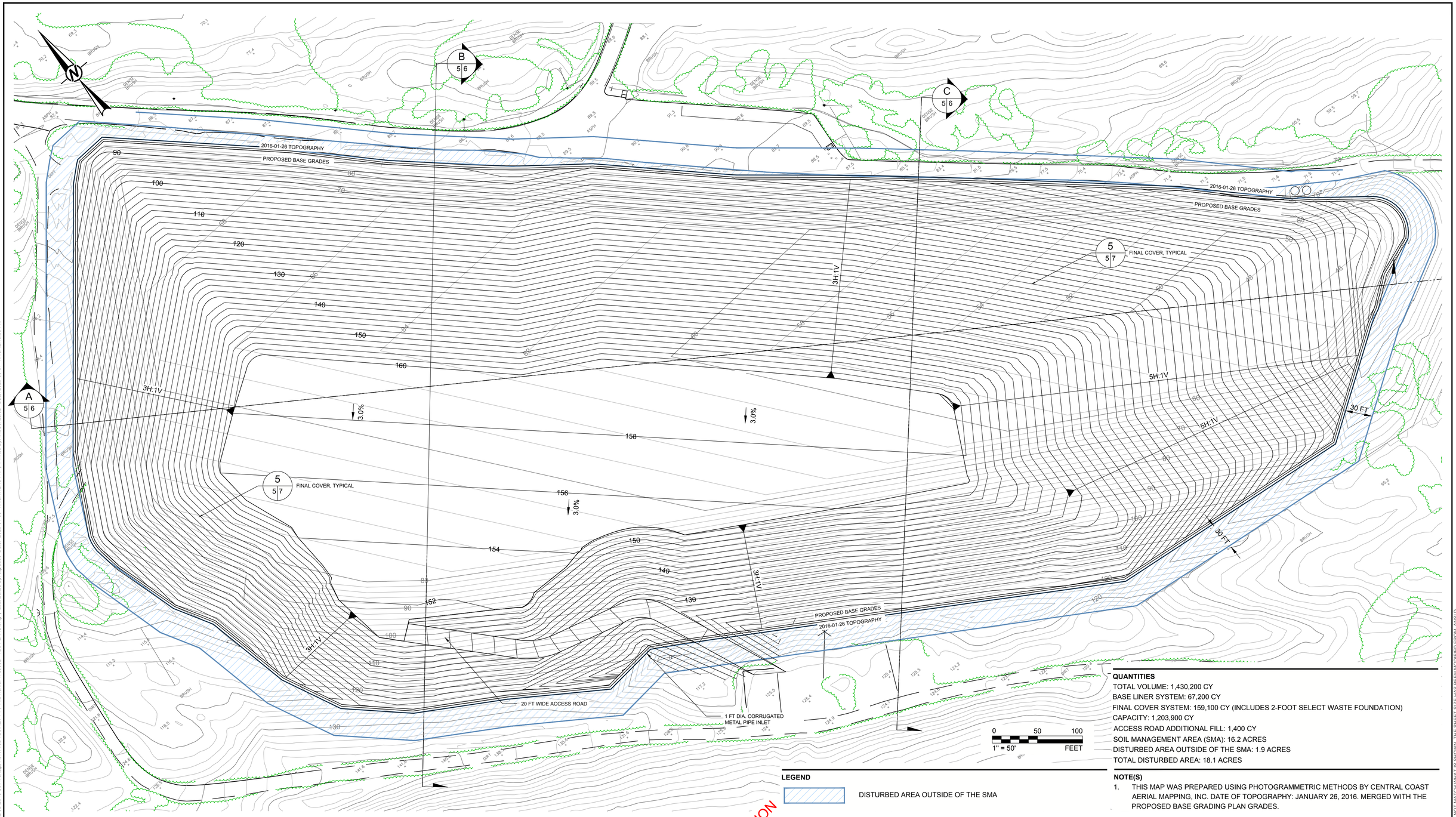

QUANTITIES

TOTAL VOLUME: 1,430,200 CY
BASE LINER SYSTEM: 67,200 CY
FINAL COVER SYSTEM: 159,100 CY (INCLUDES 2-FOOT SELECT WASTE FOUNDATION)
CAPACITY: 1,203,900 CY
ACCESS ROAD ADDITIONAL FILL: 1,400 CY
SOIL MANAGEMENT AREA (SMA): 16.2 ACRES
DISTURBED AREA OUTSIDE OF THE SMA: 1.9 ACRES
TOTAL DISTURBED AREA: 18.1 ACRES

LEGEND

DISTURBED AREA OUTSIDE OF THE SMA

NOTE(S)

1. THIS MAP WAS PREPARED USING PHOTOGRAMMETRIC METHODS BY CENTRAL COAST AERIAL MAPPING, INC. DATE OF TOPOGRAPHY: JANUARY 26, 2016. MERGED WITH THE PROPOSED BASE GRADING PLAN GRADES.

REV.	YYYY-MM-DD	DESCRIPTION	DESIGNED	PREPARED	REVIEWED	APPROVED
0	2020-06-01	ISSUED FOR PERMITTING	MAG	MAG	LMA	RVH

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GUADALUPE, CA 93434

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USA
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PROJECT
GUADALUPE RESTORATION PROJECT
SOIL MANAGEMENT AREA
TANK BATTERY 9 AREA

TITLE
PROPOSED FINAL COVER GRADING PLAN

PROJECT NO. 1783552 | REV. 0 | 5 of 9 | DRAWING 5

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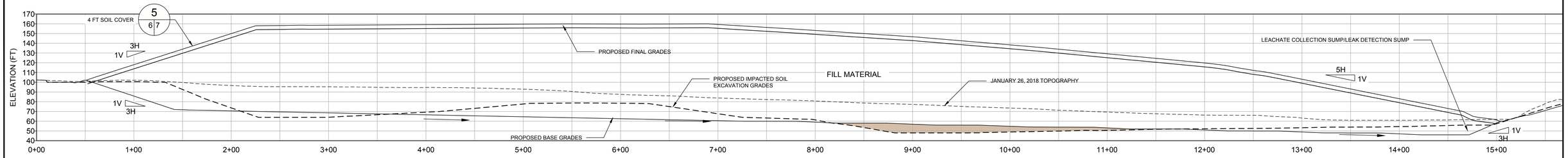
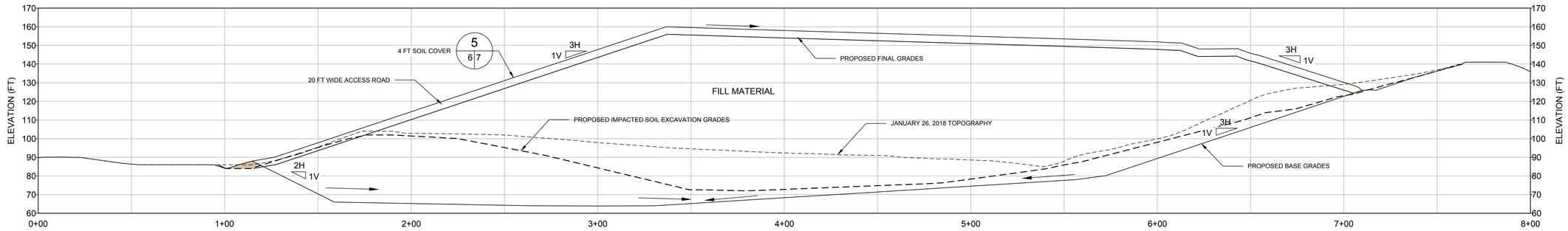


SCALE 1" = 50' (A 3,4,6,5)

CROSS-SECTION A-A'

0 50 100
1" = 50' FEET



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CROSS-SECTION B-B'

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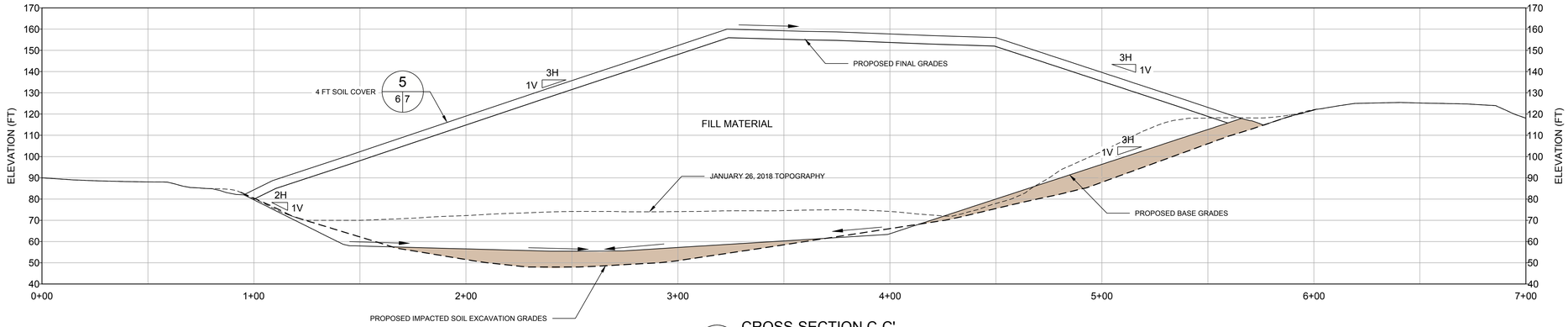
1" = 50' FEET



SCALE 1" = 30' (C 3,4,6,5)

CROSS-SECTION C-C'

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1" = 50' FEET

LEGEND

GENERAL FILL PLACEMENT

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0	2020-06-01	ISSUED FOR PERMITTING	MAG	MAG	LMA	RVH

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PROJECT
GUADALUPE RESTORATION PROJECT
SOIL MANAGEMENT AREA
TANK BATTERY 9 AREA

TITLE
SECTIONS

PROJECT NO. 1783552 | REV. 0 | 6 of 9 | DRAWING 6

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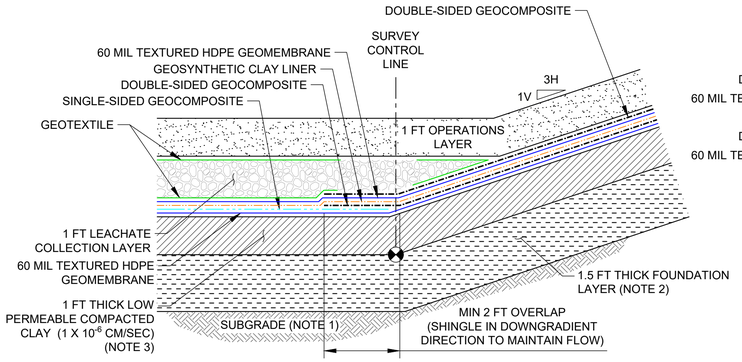

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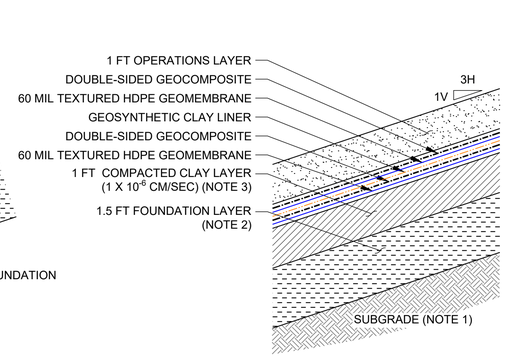

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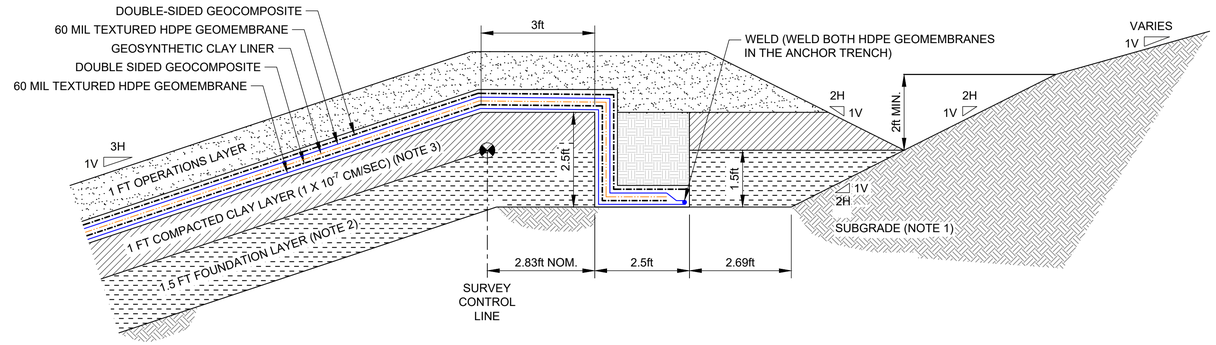

SCALE A 3 4|7 TOP BERM DETAIL

SCALE A 4 4|7 TYPICAL LEACHATE COLLECTION PIPE AND LEAK DETECTION PIPE

SCALE A 5 4,6|7 TYPICAL FINAL COVER

NOTE(S)

1. ADD MOISTURE AND COMPACT SAND SURFACE TO PROVIDE FIRM WORKING SURFACE. MAINTAIN MOISTURE CONTENT IN SAND DURING CONSTRUCTION TO PROVIDE A FIRM WORKING SURFACE AND TO PREVENT RAVELING OF THE SAND.
2. THE FOUNDATION LAYER WILL REPLACE THE UPPER 18-INCHES OF THE EXISTING SAND SUBGRADE. THE FOUNDATION LAYER WILL BE PLACED IN LIFTS NO THICKER THAN 8-INCHES. EACH LIFT WILL BE COMPACTED, BUT ONLY THE UPPER 6-INCHES OF THE FOUNDATION LAYER WILL NEED TO MEET A 90-PERCENT RELATIVE COMPACTION REQUIREMENT PER ASTM D1557.
3. LOW-PERMEABILITY SOIL TO BE A MINIMUM 12-INCH THICKNESS OF SOIL PROCESSED AND PLACED AS DESCRIBED IN THE CONSTRUCTION SPECIFICATIONS.

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0 2 4
1" = 2' SCALE A FEET

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PROJECT
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SOIL MANAGEMENT AREA
TANK BATTERY 9 AREA

TITLE
DETAILS (1 OF 3)

PROJECT NO. 1783552 | REV. 0 | 7 of 9 | DRAWING 7

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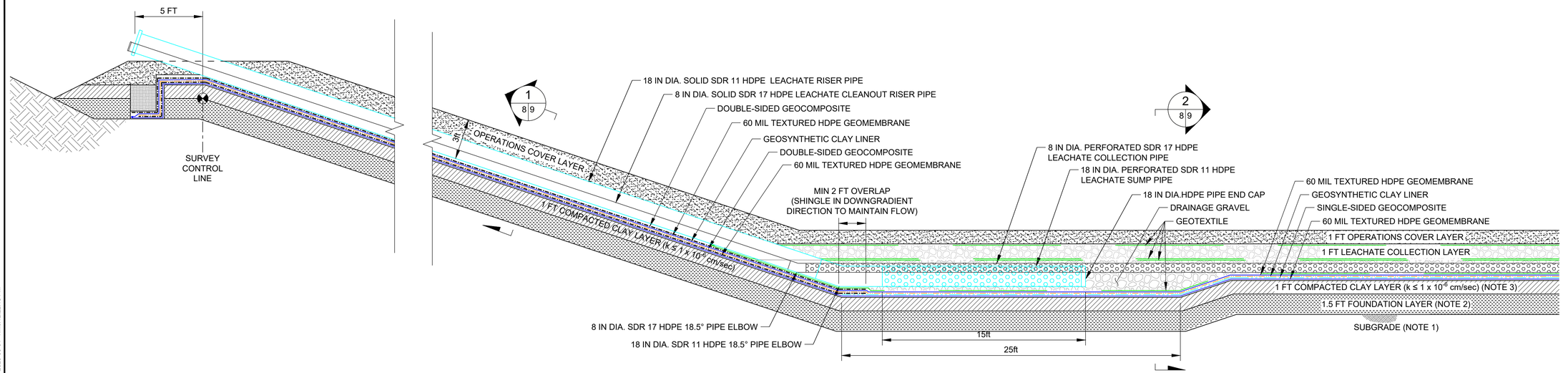

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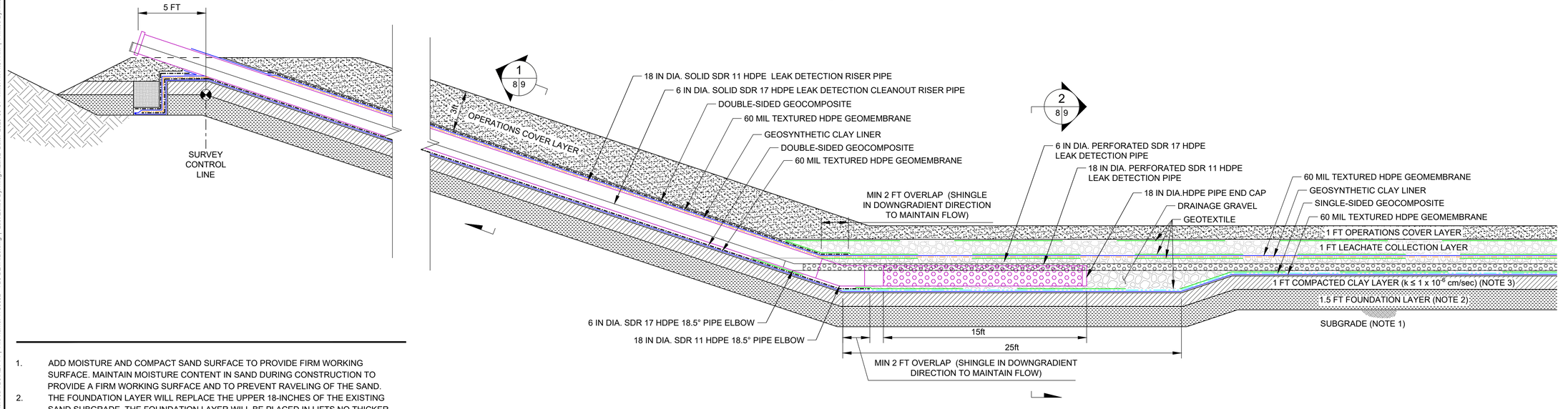

SCALE A 2 (4 8) 18-IN Ø HDPE LEAK DETECTION RISER PIPE

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1" = 4' SCALE A FEET

1. ADD MOISTURE AND COMPACT SAND SURFACE TO PROVIDE FIRM WORKING SURFACE. MAINTAIN MOISTURE CONTENT IN SAND DURING CONSTRUCTION TO PROVIDE A FIRM WORKING SURFACE AND TO PREVENT RAVELING OF THE SAND.
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PROJECT
GUADALUPE RESTORATION PROJECT
SOIL MANAGEMENT AREA
TANK BATTERY 9 AREA

TITLE
DETAILS (2 OF 3)

PROJECT NO. 1783552 | REV. 0 | 8 of 9 | DRAWING 8

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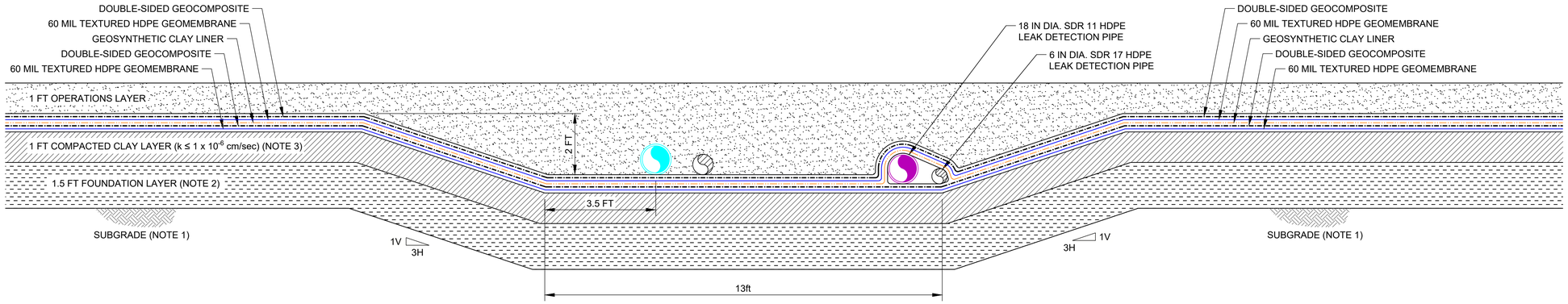

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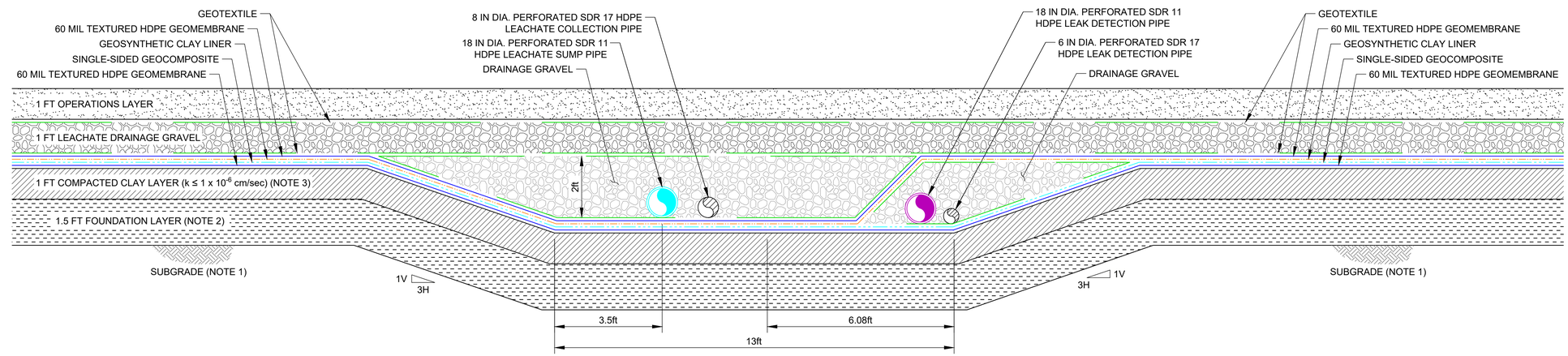

SCALE A 2 (8|9) SUMP CROSS SECTION

NOTE(S)

1. ADD MOISTURE AND COMPACT SAND SURFACE TO PROVIDE FIRM WORKING SURFACE. MAINTAIN MOISTURE CONTENT IN SAND DURING CONSTRUCTION TO PROVIDE A FIRM WORKING SURFACE AND TO PREVENT RAVELING OF THE SAND.
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PROJECT
GUADALUPE RESTORATION PROJECT
SOIL MANAGEMENT AREA
TANK BATTERY 9 AREA

TITLE
DETAILS (3 OF 3)

PROJECT NO. 1783552 | REV. 0 | 9 of 9 | DRAWING 9

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1" = 2' SCALE A FEET

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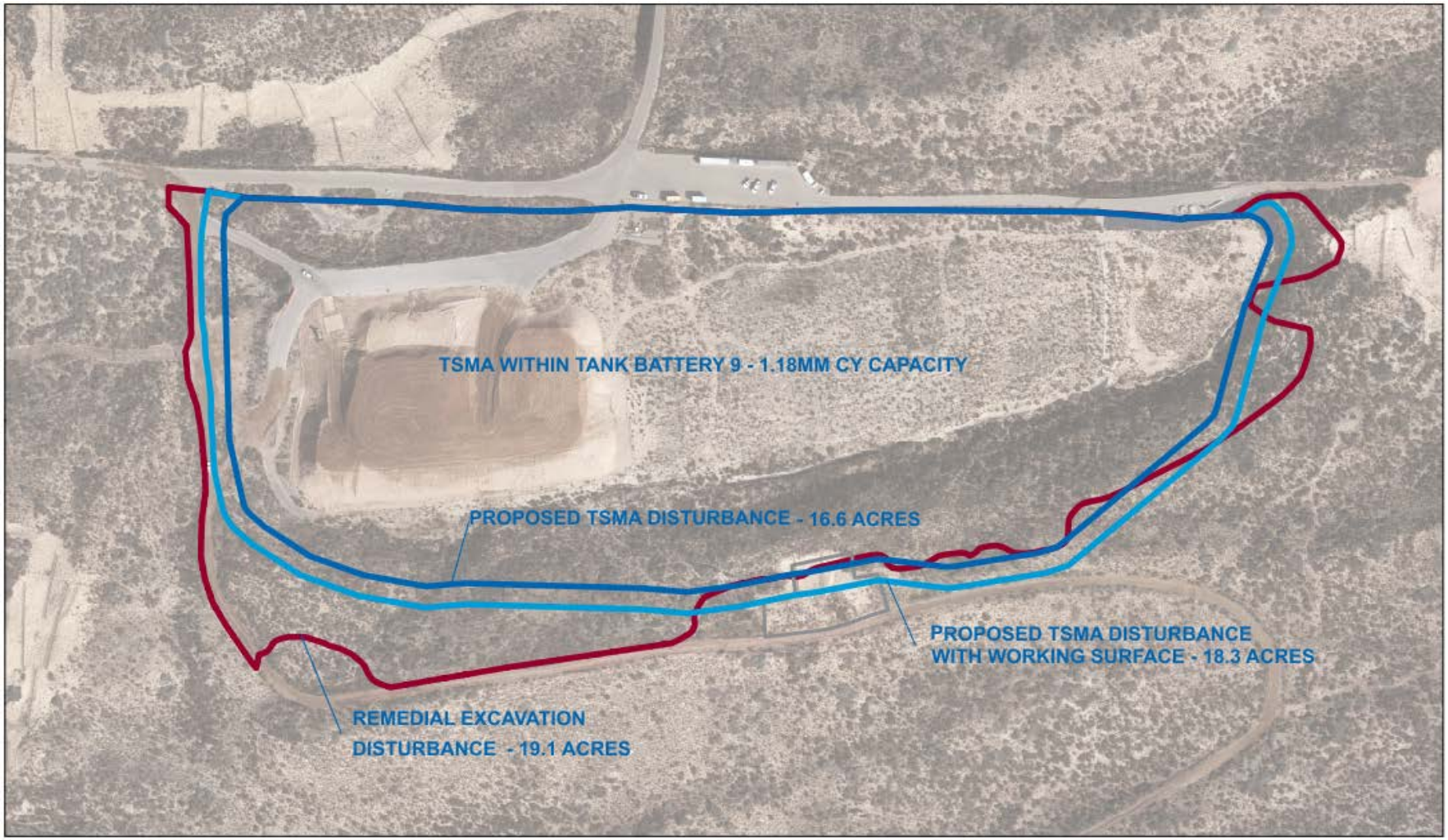
APPENDIX C

Phasing Plan

Soil Management Area (TSMA)



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SMA Construction Process

GUADALUPE RESTORATION PROJECT
Guadalupe, California

- **CURRENT CONDITIONS OF TB9 AREA**
- **PHASE 1 EXCAVATION**
- **PHASE 1 LINER PREP**
- **PHASE 1 LINER INSTALLATION**
- **PLACEMENT OF STOCKPILE INTO PHASE 1 LINER AND PHASE 2 EXCAVATION**
- **PHASE 2 LINER PREP**
- **PHASE 2 LINER INSTALLATION**
- **SOIL CAP / FINAL GRADE**

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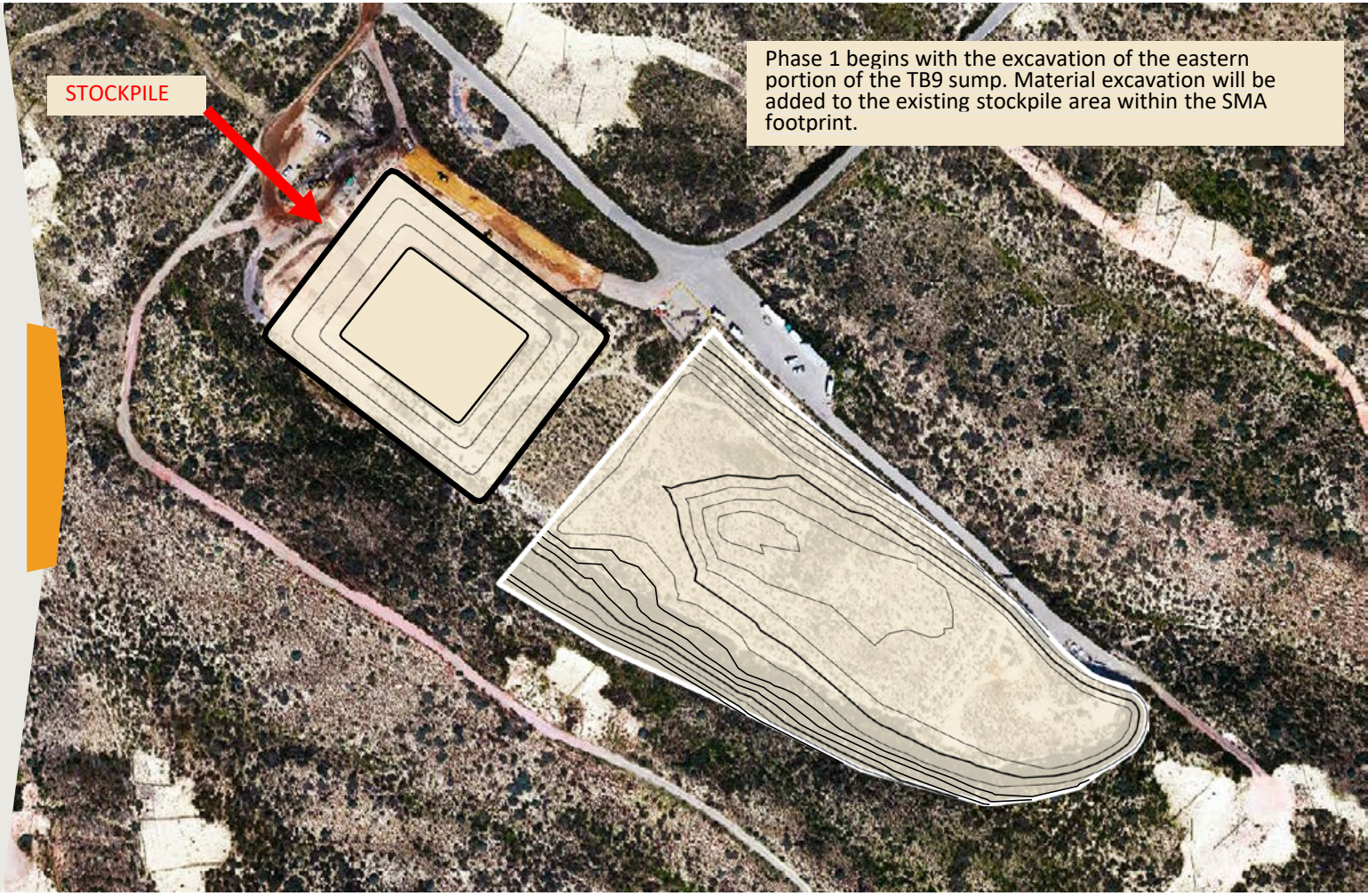
GUADALUPE RESTORATION PROJECT
Guadalupe, California

- CURRENT CONDITIONS OF TB9 AREA
- PHASE 1 EXCAVATION
- PHASE 1 LINER PREP
- PHASE 1 LINER INSTALLATION
- PLACEMENT OF STOCKPILE INTO PHASE 1 LINER AND PHASE 2 EXCAVATION
- PHASE 2 LINER PREP
- PHASE 2 LINER INSTALLATION
- SOIL CAP / FINAL GRADE



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GUADALUPE RESTORATION PROJECT
Guadalupe, California

- CURRENT CONDITIONS OF TB9 AREA
- PHASE 1 EXCAVATION
- PHASE 1 LINER PREP
- PHASE 1 LINER INSTALLATION
- PLACEMENT OF STOCKPILE INTO PHASE 1 LINER AND PHASE 2 EXCAVATION
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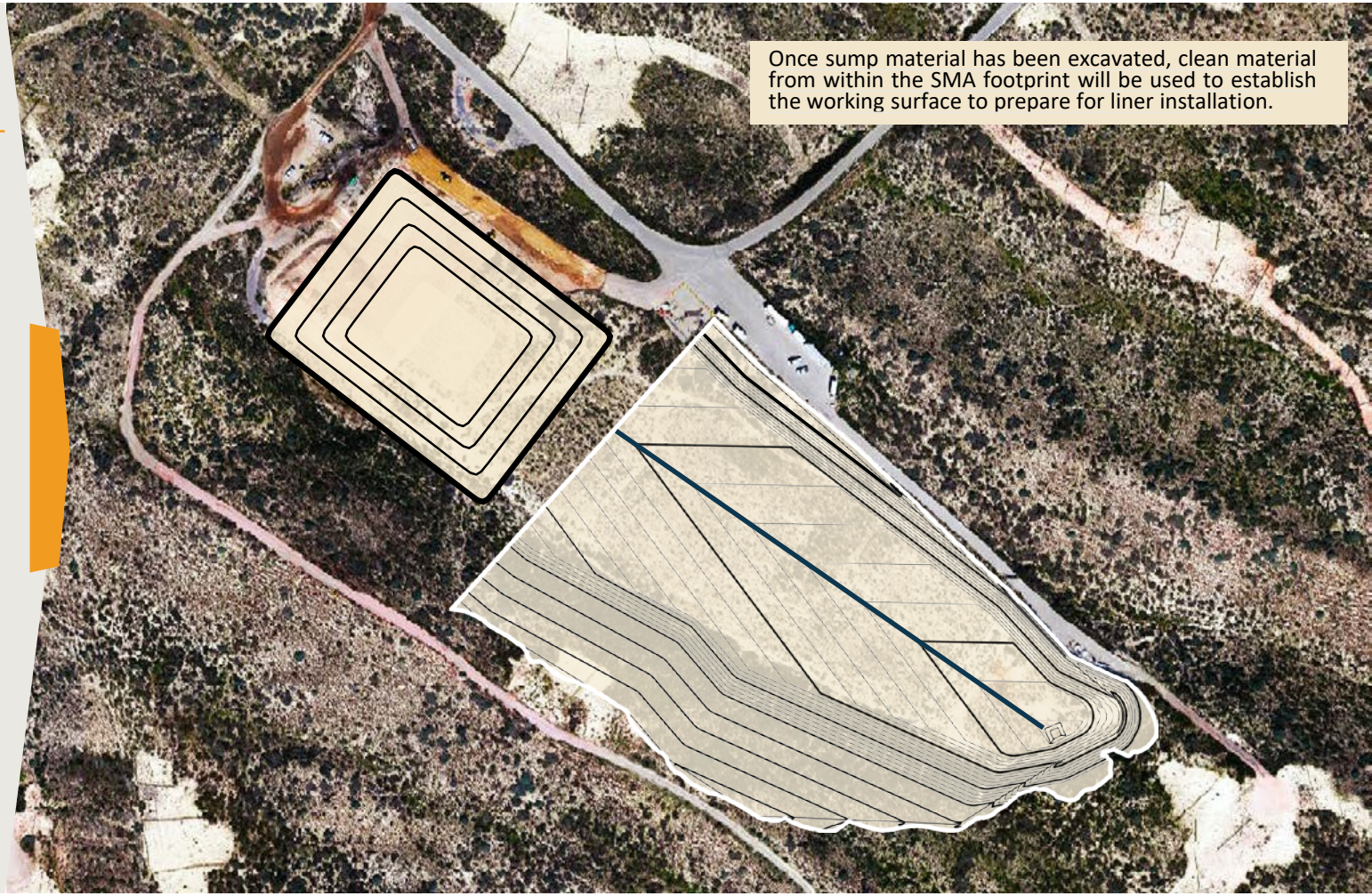

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GUADALUPE RESTORATION PROJECT
Guadalupe, California

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- PHASE 1 EXCAVATION
- PHASE 1 LINER PREP
- PHASE 1 LINER INSTALLATION
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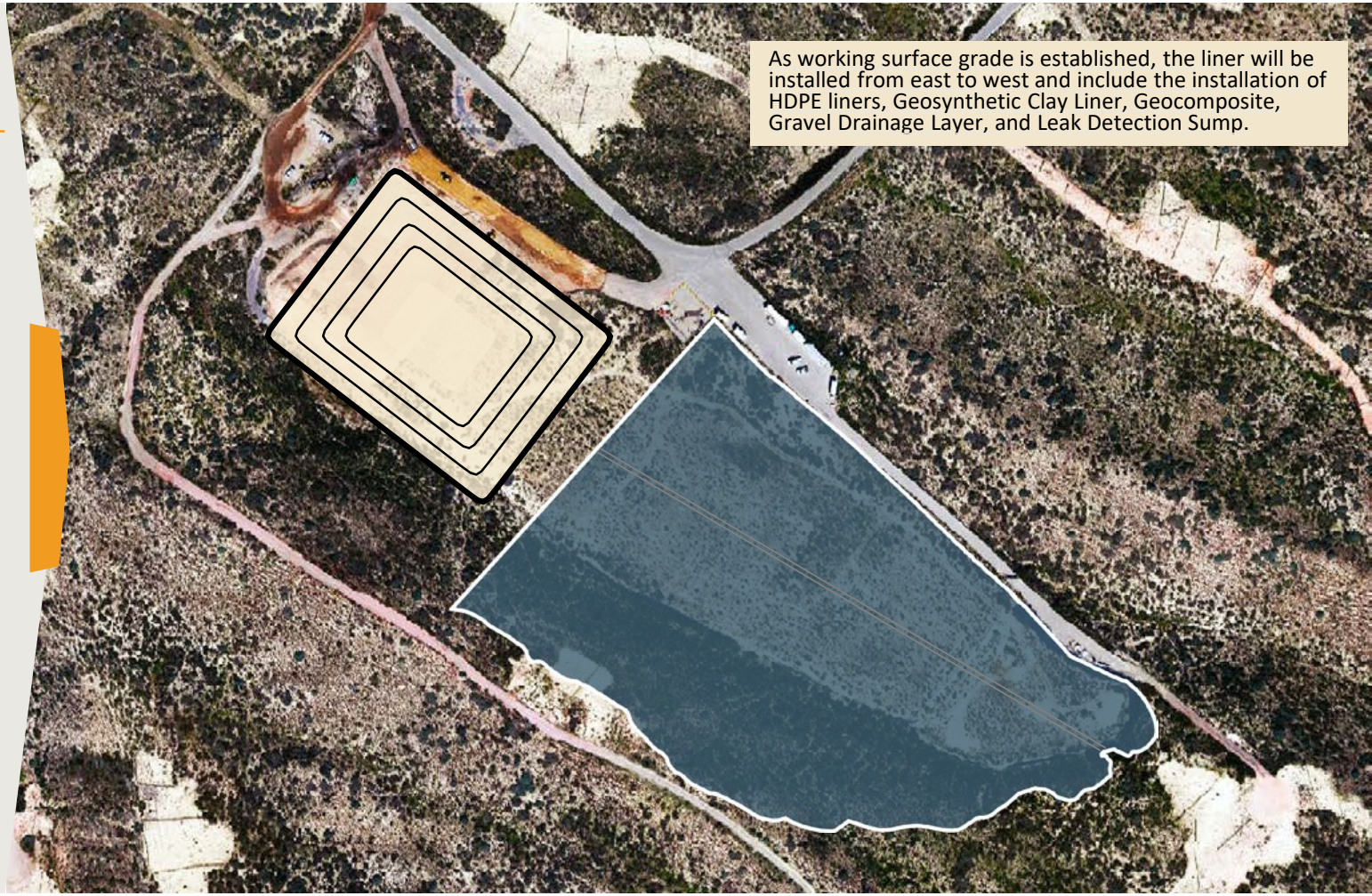

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GUADALUPE RESTORATION PROJECT
Guadalupe, California

- CURRENT CONDITIONS OF TB9 AREA
- PHASE 1 EXCAVATION
- PHASE 1 LINER PREP
- PHASE 1 LINER INSTALLATION
- PLACEMENT OF STOCKPILE INTO PHASE 1 LINER AND PHASE 2 EXCAVATION
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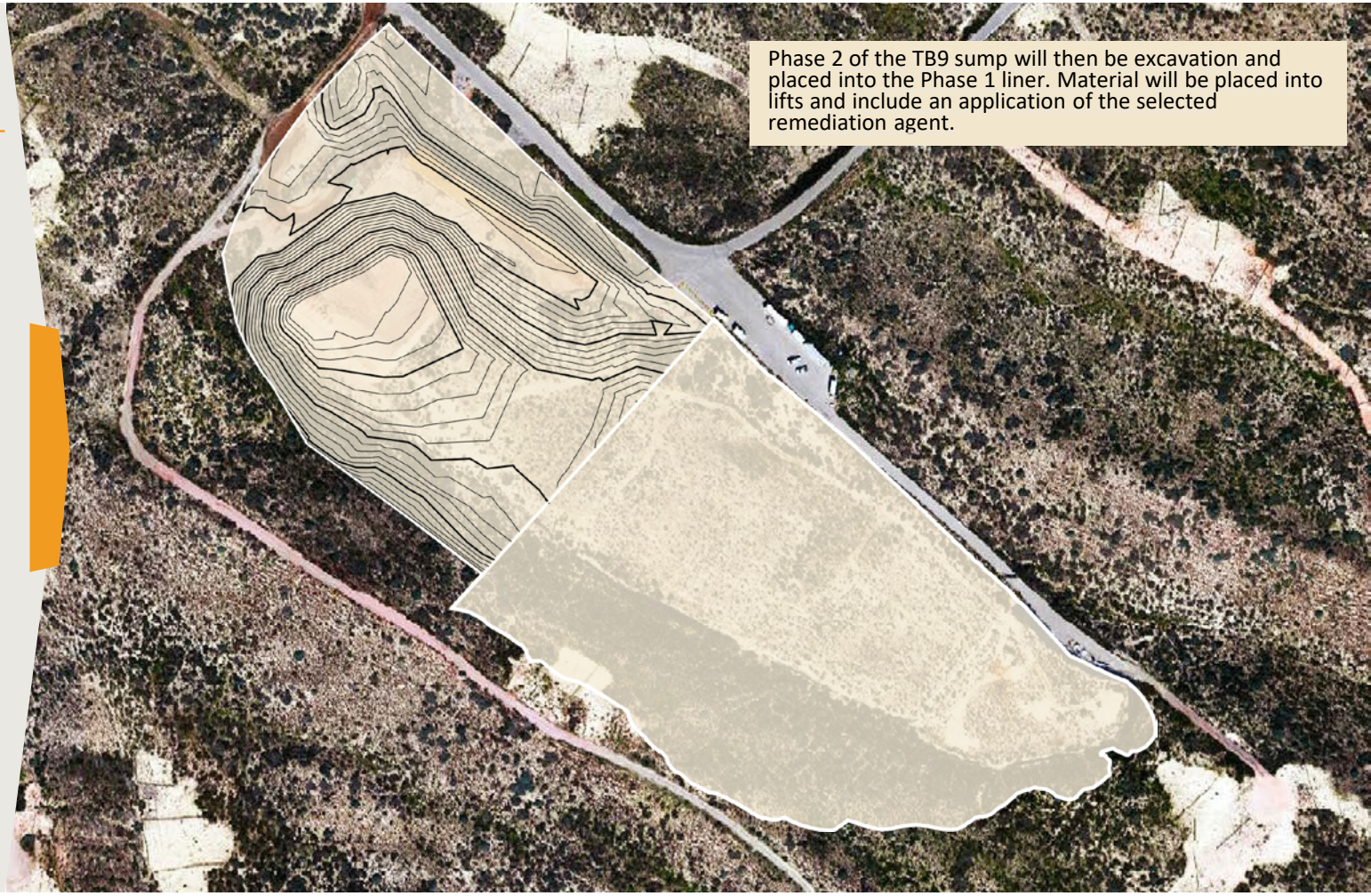

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GUADALUPE RESTORATION PROJECT
Guadalupe, California

- CURRENT CONDITIONS OF TB9 AREA
- PHASE 1 EXCAVATION
- PHASE 1 LINER PREP
- PHASE 1 LINER INSTALLATION
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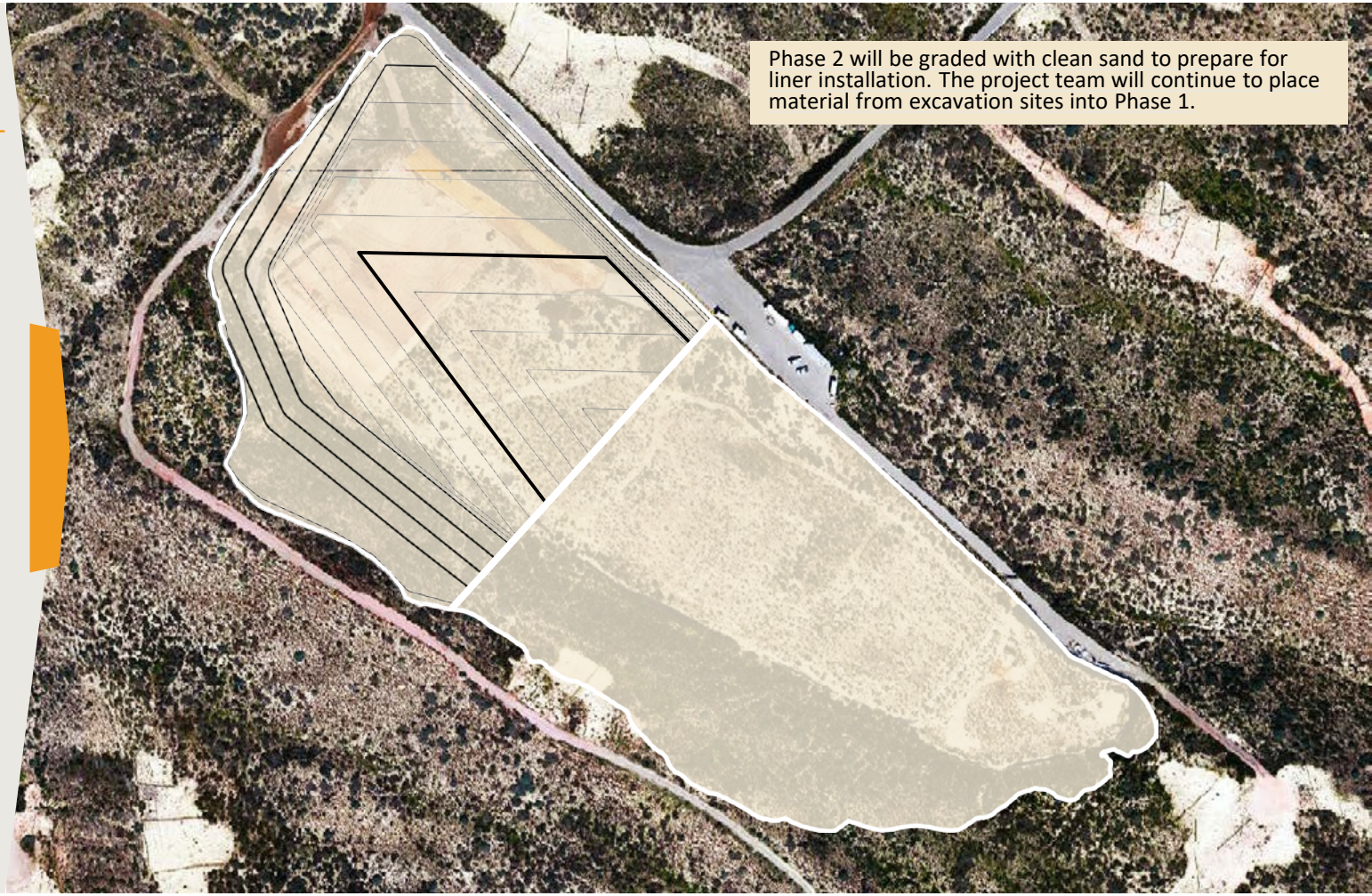

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Guadalupe, California

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- PHASE 1 LINER PREP
- PHASE 1 LINER INSTALLATION
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GUADALUPE RESTORATION PROJECT
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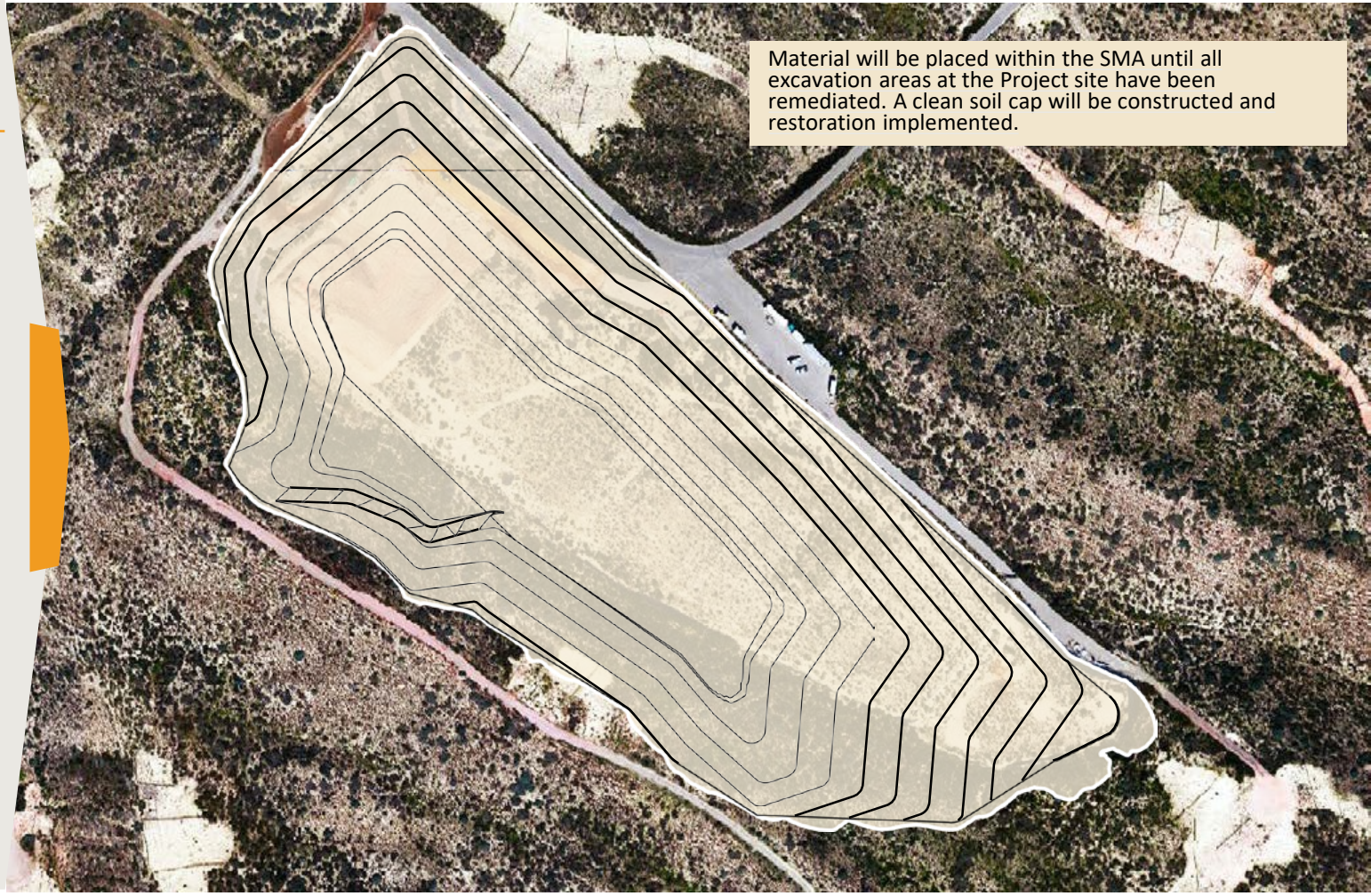

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APPENDIX D

Site Capacity and Service Life Calculations

APPENDIX D

SITE CAPACITY AND SERVICE LIFE CALCULATIONS

CHEVRON GUADALUPE

Period[2]	Airspace (cy)	
	Consumed	Remaining
2020 - 2021		1,203,900
2021 - 2022	241,000	962,900
2022 - 2023	241,000	721,900
2023 - 2024	241,000	480,900
2024 - 2025	241,000	239,900
2025 - 2026	239,900	0

Notes:

1. Total site capacity is 1,203,900 cubic yards.
2. Consumed and Remaining airspace is based upon a predicted fill rate of 241,000 cubic yards per year.

APPENDIX E

Site Specific Restoration Plan

SITE SPECIFIC RESTORATION PLAN

TREATED SOIL MANAGEMENT AREA
TB-9 AREA RESTORATION
GUADALUPE RESTORATION PROJECT

GUADALUPE OIL FIELD
2184 WEST THORNBERRY ROAD, GUADALUPE
SAN LUIS OBISPO COUNTY, CALIFORNIA

Project No. 1801-2191

Prepared for:

Chevron Environmental Management Company
2184 West Thornberry Road
Guadalupe, California 93455

Prepared by:

Padre Associates, Inc.
Post Office Box 730
Guadalupe, California 93434

AUGUST 2018

padre associates, inc.
ENGINEERS, GEOLOGISTS & ENVIRONMENTAL SCIENTISTS

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1 Site Location Map
2 Post-Construction Grading Plan

ATTACHMENTS

1 Pre-Disturbance Photographs

TANK BATTERY 9 – TREATED SOIL MANAGEMENT AREA (TSMA) SITE SPECIFIC RESTORATION PLAN

1.0 EXECUTIVE SUMMARY

The following is the Site-Specific Restoration Plan (SSRP) for the Tank Battery 9 Area (TB-9 Area) Treated Soil Management Area. Restoration success criteria follow those approved in the Pads, Roads, and Oil Spray (PROS) Program, Appendix A, Restoration and Monitoring Procedure Plan (Padre, 2016).

This TB-9 Area SSRP is intended to provide the appropriate level of detail necessary to guide the restoration and subsequent monitoring of the TB-9 Area upon completion of remediation activities. It first provides the Project history and then presents background information regarding the site, such as the ecological setting and existing biological resources, followed by an overview of remediation activities and an overview of restoration procedures for the control of non-native species, revegetation, and erosion control. Monitoring and maintenance activities for the revegetation areas include success criteria, monitoring methods, and suggested adaptive management measures. Specific and detailed information regarding the restoration of TB-9 Area is provided on the TB-9 Area Site Specific Restoration Plan Template (Section 2.0 of this document).

The remediation of the TB-9 Area will impact approximately 16.4 acres of coastal dune scrub habitat and includes all areas within the limits of the restoration boundary in the vicinity of the TB-9 Area, as well as related areas specifically prepared for staging, stockpiling, and other TSMA Project activities.

1.1 PROJECT HISTORY

The Chevron Environmental Management Company (Chevron) Guadalupe Restoration Project (GRP) is located within the Guadalupe-Nipomo Dunes in southern San Luis Obispo County (Project Site, or Field). The Project Site comprises approximately 2,830 acres and is bordered on the west by the Pacific Ocean, on the south by the Santa Maria River, to the north by the Guadalupe Nipomo Dunes National Wildlife Refuge, and to the east by agricultural lands on the western margin of the Santa Maria Valley.

The principal land use at the Field, from 1946 to March 1994, was the production of oil and natural gas. On April 3, 1998, the Central Coast Region of the California Regional Water Quality Control Board (RWQCB) issued Cleanup or Abatement Order (CAO) No. 98-38. Additionally, On December 10, 1998, the County of San Luis Obispo (SLO County) issued Coastal Development Permit/Development Plan (CDP/DP) D890558D for the remediation and restoration project (SLO County, 1998). CDP/DP Condition G.6 states: “all man-made features established on the Guadalupe oilfield for oil field purposes shall be removed and the areas recontoured, restored and revegetated, unless Chevron demonstrates to the reviewing agencies’ satisfaction that justification exists to allow any features to remain in place.”

1.2 OVERVIEW OF THE TB-9 AREA

The TB-9 Area is in the south-central portion of the Project Site, approximately 1.25 miles east of the Pacific Ocean and 0.4 miles north of the Santa Maria River (Plate 1 – Site Location Map). At the TB-9 Area, the elevation ranges from approximately 65 feet to 105 feet mean sea level (MSL). The TB-9 Area was decommissioned and dismantled in the early 2000s, which included removal of the concrete-lined basins. The area was later used for temporary soil stockpiling and was constructed with land treatment unit cells as part of the bioremediation pilot study. The TB-9 Area is currently used for stockpiling soil excavated from sumps and diluent stains. The eastern portion is constructed with a High-Density Polyethylene (HDPE) lined basin that supports the Project Site's water handling system.

The TB-9 Area has not been actively restored but has passively restored without management activities such as seeding or planting. The site has received weed control to prevent the spread of non-native plants into the adjacent undisturbed area.

The vegetation at the TB-9 Area can be described as coastal dune scrub but is different in species composition from the adjacent undisturbed coastal dune scrub habitat. This may be a result of the age of the community or because of the difference in substrate and the presence of the underlying HDPE lined containment.

The eastern portion of the TB-9 Area has a hard and more impermeable soil surface than in the western portion. The eastern portion also has lower vegetative cover than the western area and is dominated by coyote bush (*Baccharis pilularis*) with some clustered field sedge (*Carex praegracilis*) and spreading rush (*Juncus lescurii*) present in the understory. These species, though more commonly occurring near wetland areas, are also found less commonly in the coastal dune scrub. The western portion of the site has more sandy soils and species more common of the coastal dune scrub. The dominant shrub species was mock heather (*Ericameria ericoides*), with coastal buckwheat (*Eriogonum parvifolium*) and California aster (*Corethrogyne filaginifolia*) common.

There were 29 plant species observed within the coastal dune scrub at TB-9, with a total absolute cover of approximately 40 percent. Of these 29 species, 16 were native perennial species with a combined estimated absolute cover of 30 percent. Four native annual species were observed with approximately five percent absolute cover. Nine non-native plant species were observed, three of which were also invasive. Non-native species contributed approximately five percent absolute cover

Three sensitive plant species occur within the TB-9 Area. One of these three species is crisp dune mint (*Monardella undulata* spp. *crispa*) which has a California Rare Plant Rank (CRPR) 1B.2. The remaining two species: Nuttall's milkvetch (*Astragalus nuttallii*) and Blochman's groundsel (*Senecio blochmaniae*) have a CRPR 4.2. Plants with a CRPR of 1B are rare throughout their range with most of them endemic to California (CNPS 2018). Most of the plants that are ranked 1B have declined significantly over the last century. Plants with a CRPR 4 are of limited distribution or infrequent throughout a broader area in California. The ".2" is the threat ranking and indicates that these species are "moderately threatened in California (20-80% occurrences threatened/moderate degree and immediacy of threat)."

During the site surveys, no sensitive wildlife species were observed within the proposed limits of disturbance. Silvery legless lizard (*Anniella pulchra*), Western spadefoot (*Spea hammondii*), and Blainville's horned lizard (*Phrynosoma blainvillii*) are state species of special concern with potential to occur at the site. However, during previous surveys and assessment work Blainville's horned lizards and slivery legless lizards were observed within the TSMA Project area. There is no breeding habitat for the California red-legged frog (*Rana draytonii*, CRLF, federal threatened, state species of special concern) at the TB-9 Area but CRLF had previously been observed in the TB-9 Stockpile's concrete drainages that were removed in 2010.

A list of wildlife species identified at or adjacent to the site is provided in Table 1-1 - List of Wildlife Species Observed at or Adjacent to the TB-9 Area. Table 1-1 includes species identified through both direct (i.e. sight or sound) and indirect (i.e. some form of sign, such as tracks, scat, burrows, etc.) methods of observation.

Table 1-1. List of Wildlife Species Observed at or Adjacent to the TB-9 Area

Reptiles	
western fence lizard	*Sceloporus occidentalis*
Birds	
turkey vulture	*Cathartes aura*
bushtit	*Psaltriparus minimus*
white-crowned sparrow	*Zonotrichia leucophrys*
house finch	*Haemorhous mexicanus*
lesser goldfinch	*Carduelis psaltria*
American goldfinch	*Carduelis tristis*
Mammals	
coyote	*Canis latrans*
mule deer	*Odocoileus hemionus*
Heermann's kangaroo rat	*Dipodomys heermannii*
brush rabbit	*Sylvilagus bachmani*
black-tailed jackrabbit	*Lepus californicus*

Wildlife functions within the TB-9 Area include:

- Amphibian Cover/Refuge & Foraging Habitat
- Lizard Cover/Refuge & Foraging Habitat
- Terrestrial Snake Cover/Refuge & Foraging Habitat
- Raptor/Owl Hunting Habitat
- Ground Nesting Bird Habitat

- Songbird Foraging, Cover/Refuge, & Nesting Habitat
- Insectivorous Mammal Foraging, Cover/Refuge, & Breeding Habitat
- Carnivore Denning, Hunting, & Cover Habitat
- Herbivore Foraging & Cover Habitat
- Rodent Cover, Foraging, & Breeding Habitat

A list of the wildlife functions currently provided by the Site is presented in Wildlife Habitat Element Matrix provided in this SSRP.

1.3 OVERVIEW OF REMEDIATION ACTIVITIES

The following sections describe the remediation activities that will be undertaken at the TB-9 Area. Additional information and details pertaining to these activities are contained in the Project description of the TB-9 Area – Treated Soil Management Area Work Plan.

1.3.1 Pre-Construction Activities

Construction sites will be initially treated for weeds with a 20-foot buffer zone beyond the limits of disturbance around the site, at least one growing season in advance of any construction activities, if feasible. Treatment will include both hand-removal and selective herbicide application.

Within 30 days before construction, all TSMA Project locations (i.e., excavation areas, stockpiles, personnel and vehicle access routes, and staging areas) will be delineated with construction fencing consisting of T-posts and rope, and/or other delineators. A sensitive species survey will then be conducted. Any sensitive plant species that occurs within or adjacent to the disturbance area shall be identified. These include dune mint, Nuttall's milkvetch, and Blochman's groundsel. The percentage of ground coverage or other appropriate measures of presence shall be determined and recorded. Sensitive plant species or populations in proximity to the construction site will be flagged and/or fenced in consultation with the Onsite Environmental Coordinator (OEC). If any sensitive plant species may be impacted by TSMA Project activities, such impacts shall be mitigated by salvaging, or propagating the impacted species and planting them either in the impacted area or in other suitable habitat upon completion of the TSMA Project. Additionally, in consultation with the OEC, adjustments to the planned boundary may be made in the field to provide adequate protection to adjacent areas and/or sensitive resources.

Also prior to and during removal of vegetated overburden, wildlife monitor will survey the area for the presence of any wildlife. Any wildlife species found within or immediately adjacent to the excavation site that could be impacted by construction activities will be captured and relocated. Protocols used to protect wildlife, including capture and relocation are presented in the *Ecological Monitoring Program* (EMP; Unocal 2006). All capture and relocation activities will be documented on the Daily Field Reports and published in the Quarterly Ecological Progress Report (QEPR).

All baseline surveys will be updated as necessary during the sensitive species surveys (30 days prior to site disturbance) to reflect any ecological changes, with results documented in the QEPR.

1.3.2 Construction Activities

The scope of work includes removal of 180,000 CY of TPH-affected soil and construction of a lined engineered containment unit with imported clay material. A leachate collection system for managing infiltrated surface water will be installed as part of the onsite water handling system. The finished soil pile would be covered with at least four feet of clean fill, graded to match the surrounding dune features. The site will be re-contoured as specified in the approved post-construction plans (Plate 2 – Post Construction Plans).

1.4 OVERVIEW OF SITE RESTORATION ACTIVITIES

Upon completion of construction activities, the site will be restored in accordance with this SSRP. The SSRP contains the details of the methodologies that will be employed to restore the sites and monitor their restoration progress.

After remediation activities are complete, the area will be graded according to the restoration grading plans. To prevent slope failure, slopes will be less than 25 degrees whenever possible. The rough grading will be targeted to an elevation of one foot below the final grade to allow the application of retained vegetated overburden, if available, after approval of the pre-restoration contouring.

Stockpiled vegetated overburden (if available) will be returned to the area to be restored as needed to implement planned site-specific contouring. The vegetated overburden will be deposited from haul trucks and spread with a skidsteer. The goal is to cover the entire deposit area to a typical depth of six to twelve inches (dependent on material available) with an uneven finish grade. The use of an excavator or backhoe bucket may be used for spreading of material.

The plant material and densities specified in this SSRP are intended to provide a starting point to restore plant diversity in the disturbed areas. This approach identifies the plant species that are best suited to the specific conditions at specific sites and focuses on facilitating the best chance for successful restoration. Planting will occur after the disturbed upland areas have been filled, compacted, and graded to the planned elevations.

Revegetation target specifications are presented in the TB-9 Area SSRP Summary. The target species are based upon the species composition of each restoration site as documented in the pre-disturbance surveys, as well as on their likely rate of establishment and their erosion control functions. The species, collection and planting times, and the quantities to be planted may be adjusted, as necessary, depending on project-specific or environmental constraints.

Restoration activities include initial seeding and planting in early winter (November or December) following the first heavy rains. If this is not feasible, later in the winter (January or February) is acceptable. Both seeds originating from the Field and possibly container stock will be used. Native seeds will be collected by a seed collector/supplier with experience in site-specific, native seed collections; then dried, cleaned, and properly stored. The seed will hand-broadcast preferably in November or December after the first rains when the soils surface is damp. The seeds will then either be gently raked or harrowed in to the top half-inch of soil to ensure good seed-to-soil contact and a good seedbank.

Brush that has been harvested from the site prior to disturbance will then be placed at the site. The placement of this brush serves two purposes: 1) provides a beneficial micro-habitat for

seedling development and 2) prevents wind erosion of the soil. Additionally, if necessary, sand fence may be installed to prevent soil destabilization. Weeds will be removed through manual techniques or selective herbicide application on a regular basis to ensure successful establishment of the native plants.

1.5 OVERVIEW OF SUCCESS CRITERIA

Restoration programs require the development of criteria to evaluate the progress and success of restoration activities, and to guide the implementation of remedial measures or contingency actions when the criteria are not being met. A general description of success criteria for coastal dune scrub is provided in the Restoration and Monitoring Procedure Plan of the *PROS Program* (Padre, 2016).

1.5.1 Erosion Control and Soil Stabilization

- Topsoil at the restoration sites should be stable and not subject to water and wind erosion.
- No gullying or blowouts should persist.
- All erosion control and soil stabilization treatments should be effective until revegetation results in adequate protective cover.

1.5.2 Non-Native Plant Species Control

Within the Restoration Area, the mean absolute cover of non-native species, excluding specified invasive species will be less than five percent. This will be determined by the upper bound of the 80 percent confidence interval of the mean cover of non-native species. To meet the criteria, the upper bound of the 80 percent confidence interval of the mean must be less than five percent. The absolute cover of specified non-native invasive species within the TB-9 Area shall be zero. For purposes of this criterion, the non-native invasive species are: European beachgrass (*Ammophila arena*), iceplant (*Carpobrotus* spp.), slender-leaved iceplant (*Conicosia pugioniformis*), pampas grass (*Cortaderia* spp.), Sahara mustard (*Brassica tournefortii*), veldt grass, and sweet fennel (*Foeniculum vulgare*), or newly introduced invasive species rated by the California Invasive Plant Council (Cal-IPC) as high. Plants with a "High" listing are "…have severe ecological impacts on physical processes, plant and animal communities, and vegetation structure. Their reproductive biology and other attributes are conducive to moderate to high rates of dispersal and establishment. Most are widely distributed ecologically (Cal-IPC, 2018)."

1.5.3 Revegetation

- The native perennial species richness (number of native perennial species) at each restoration site shall be equal to or greater than the native perennial species richness of the Coastal Dune Scrub (CDS) Reference Sites or newly established reference transects. This determination will be made by comparing the number of species in areas of equal size at the restoration and reference sites.
- The mean cover of the native perennial species at the TB-9 Restoration Area should not be significantly less than the CDS Reference Site mean from the same year of data. To determine if the mean of the SSRP Area is significantly less than the mean of the CDS Reference Sites, a one-tailed two-sample t-test will be used.

1.5.4 Sensitive Plant Species

1.5.4.1 Intermediate Success Criteria

Intermediate success criteria have been established to function as thresholds for remedial activities. These intermediate guidelines are based on qualitative measures and not specific quantitative values.

The intermediate success criteria include:

- No weed interference with establishment of the sensitive plant species.
- Growth, vigor, and establishment of seedlings or transplanted plants.
- Survival of the initial generation of seedlings or transplanted plants.
- Additional qualitative measures determined by experience.

1.5.4.2 Final Success Criteria

Each sensitive plant species impacted due to remediation activities will be restored to densities or absolute cover equal to, or greater than pre-impact levels.

1.5.5 Wildlife

To meet the site-specific success criteria for wildlife a site must possess all of the functions and values associated with the vegetation association as measured by the presence of the essential wildlife habitat elements as shown on the attached Wildlife Functions and Habitat Elements Matrix.

If a specific function or value has been recorded as being present at a restored site but not all of the associated habitat elements are present, it will be concluded that the function or value has been replaced at the site and restoring the missing elements will not be required.

To be successful in meeting the site-specific wildlife success criteria, a site must possess either; (a) documented presence for 2 years of 100 percent of the wildlife habitat elements identified as being essential and 50 percent of those elements identified as being beneficial, or (b) documented presence for 2 years of the actual function or value.

1.6 MONITORING SCHEDULE

Monitoring will consist of qualitative and quantitative evaluations of vegetation development over a period of 10 years. The success criteria will not be considered met until all maintenance activities other than weed control have ceased at the restored sites for a minimum period of two years. If the criteria are not met after two years of no maintenance, remedial actions will be taken and monitoring will be extended as necessary to meet the success standards.

If the restoration monitoring indicates interim progress is substantially different from the interim success criteria, then the restoration approach may need to be reassessed. Depending on the situation, an adaptive management strategy may be necessary to take remedial actions and/or adjust the approach or methodology. Remedial measures to be evaluated and implemented as part of the adaptive management process could include but are not limited to: changes in plant selection, propagation and/or planting techniques, replanting or reseeding, or irrigation during establishment period.

Once Chevron determines that the TB-9 Area SSRP success criteria have been met, an Agency approved Independent Performance Monitor shall direct the final performance monitoring activities. Final performance monitoring shall be conducted for two consecutive years without maintenance or remediation activities other than weed control. When the County of San Luis Obispo Department of Planning and Building (Planning Department) and the Executive Director of the California Coastal Commission have determined that the success criteria have been met, no further performance monitoring shall be required.

If performance standards are not met in 10 years, or if prior to that time Chevron concludes that restoration and revegetation will not meet performance standards, within 180 days of the end of the 10-year period Chevron shall apply to the Planning Department for an amendment to the Coastal Development Permit which will include alternative mitigation.

2.0 TB-9 AREA SITE SPECIFIC RESTORATION PLAN TEMPLATE

Table 2-1 provides an overview of the TSMA Project and proposed SSRP.

Table 2-1. Site Specific Restoration Plan Reference Table

TSMA Project Description	
Location	Zone 2, TB-9 Section
Current Activity	Removal of TPH-affected soil and construction of a lined engineered containment unit with imported clay material. A leachate collection system for managing infiltrated surface water will be installed as part of the onsite water handling system. The finished soil pile would be covered with at least four feet of clean fill, graded to match the surrounding dune features.
Past Activity	Tank Battery / Land Treatment Unit / Stockpile
Time of Disturbance	2020
Area of Disturbance	Total Area: 16.4 acres
Topography	
Site Description	The TB-9 Area was decommissioned and dismantled in the early 2000s, which included removal of the concrete-lined basins. The area was later used for temporary soil stockpiling and was constructed with land treatment unit cells as part of the bioremediation pilot study. The TB-9 Area is currently used for stockpiling soil excavated from sumps and diluent stains. The eastern portion is constructed with a HDPE lined basin that supports the site water handling system.
Site Elevations	The elevation ranges from approximately 65 feet to 105 feet mean sea level (MSL).
Unique Natural Features	None. The TB-9 Area is a developed area. Upon completion, the TSMA Project site will be graded to match the surrounding dune features.
Pre-Disturbance Baseline Vegetation Survey	
Date(s) and Monitor	August 2016 (JL/MH); January 2018 (JL/LB)
Plant Community	Coastal Dune Scrub
Habitat Condition	Low cover of native perennial species and non-native species in comparison to undisturbed coastal dune scrub habitat.
Vegetative Cover - Absolute	Total cover: 40%; native perennial: 30%; native annual 5%; non-native: 5%
Dominant Native Species	Coyote brush, mock heather, coastal buckwheat and California aster
Special Status Plants	Dune mint < 1 percent Blochman's groundsel < 1 percent Nuttall's milkvetch < 1 percent

Non-Native Plant Species	Ripgut brome, red brome, iceplant, tocalote, slender-leaved iceplant, veldt grass, red-stemmed filaree, rattail fescue, golden-top grass veldt grass, slender-leaved iceplant.
Construction Monitoring	Botanical monitoring not required at this time.
Pre-Disturbance Wildlife Survey	
Date(s) and Monitor	July 2018 (VBT)
Potential Habitat - Special Status Species	Silvery legless lizard, western spadefoot, and Blainville's horned lizard
Special Status Species - Observed	None
Other Species - Observed	Coyote, mule deer, brush rabbit, black-tailed jack rabbit, Heermann's kangaroo rat, western fence lizard, turkey vulture, bushtit, white-crowned sparrow, house finch, lesser goldfinch, American goldfinch
Wildlife Functions (refer to Attachment 4 - Wildlife Survey Report for the TB-9 Area Site-Specific Restoration Plan, Table 2)	Amphibian Cover/Refuge & Foraging Habitat
	Lizard Cover/Refuge & Foraging Habitat
	Terrestrial Snake Cover/Refuge & Foraging Habitat
	Legless Lizard Habitat
	Raptor/Owl Hunting Habitat
	Ground Nesting Bird Habitat
	Songbird Foraging, Cover/Refuge, & Nesting Habitat
	Insectivorous Mammal Foraging, Cover/Refuge, & Breeding Habitat
	Carnivore Denning, Hunting, & Cover Habitat
	Herbivore Foraging & Cover Habitat
	Rodent Cover, Foraging, & Breeding Habitat
Pre-Disturbance Cultural / Archaeological Survey	
Date(s) and Monitor	March 6, 2018 (CL)
Cultural Resources Observed	None
Construction Monitoring	Cultural monitor for all soil removal activities. Cultural clearance for all treatment activities.
Pre-Disturbance Weed Control	
Date(s)	TBD
Treatment No. and Control Method	The disturbance areas will be treated with selective herbicide application prior to the initiation of construction activities.

Disturbance Expected Impacts			
Direct Impacts	Temporary removal of previously disturbed coastal dune scrub."		
Indirect Impacts	Low amount of sand migration following sand placement until area stabilizes, potential increase in weed species following sand placement.		
Proposed Soil/Vegetation Salvage			
Top Soil Quantities	None		
Salvaged Seed Species and Quantities	None; seed will be collected from native plants at the Field		
Species of Propagules Collected	None		
Salvaged Plant Species	None		
Proposed Erosion Control and Soil Stabilization			
Type of Erosion Control/Soil Stabilization	Surface of the restoration site will be disked perpendicular to the slope; installation of sand fences for wind erosion, straw wattles or silt fencing if needed.		
Revegetation			
Timing of Restoration Initiation	Winter 2021/2022		
Seed Mix / Planting Palette	**coastal dune scrub**	**Plant Material**	**Seed: lb/acre**
	Achillea millefolium	Seed	0.5
	Ambrosia chamissonis	Seed	7.0
	Astragalus nuttallii	Seed	0.5
	Camissoniopsis cheiranthifolia	Seed	0.5
	Ericameria ericoides	Seed	5.0
	Erigeron blochmaniae	Seed	0.5
	Eriogonum parvifolium	Seed	2.0
	Senecio blochmaniae	Seed	1.0
Plant Cuttings	None necessary		
Container Plants	Container plants of coastal dune scrub species may be planted after the initiation of restoration activities if monitoring indicates that species cover and diversity is lacking.		
Sensitive Plant Species	Nuttall's milkvetch and Blochman's groundsel will be included in the seed mix.		
Exotics Control			
Method of Control	Herbicide spray and/or mechanical removal of invasive exotics		
Control Schedule	Twice a year in Spring/Fall		

Table 2-2. Success Criteria and Evaluation Criteria TB-9 Area

Category	Success Criteria	Monitoring Frequency	Monitoring Finding	Action
Revegetation of coastal dune scrub (in accordance with the approved PROS Program)	Erosion control: Top soil shall be stable and not subject to water and wind erosion. No gullying, washouts or blowouts shall persist.	Erosion monitoring in accordance with the SWPPP.	Criteria met	Continue monitoring
			Criteria not met	Implement appropriate maintenance/remedial actions.
	Native Perennial Cover: The mean cover of the native perennial species at the FESSRP Area should not be significantly less than the CDS Reference Site mean from the same year of data. Native Perennial Richness The native perennial species richness (number of native perennial species) at each restoration site shall be equal to or greater than the native perennial species richness of the CDS Reference Sites or newly established reference transects.	Qualitative Monitoring in spring until the restoration area has reached success criteria.	Criteria Met	Restoration will be considered complete and final performance monitoring will be conducted.
		Quantitative Monitoring, when restoration area has reached success criteria; two years of quantitative monitoring will be conducted to confirm restoration completion.	Criteria not met	Implement appropriate maintenance/remedial actions.
	Non-Native Plant Cover: The mean absolute cover of non-native species, excluding specified invasive species will be less than five percent. The absolute cover of specified non-native invasive species within the FESSRP Area shall be zero.	Qualitative Monitoring in spring until the restoration area has reached success criteria. Quantitative Monitoring, when restoration area has reached success criteria; two years of quantitative monitoring will be conducted to confirm restoration completion.	Criteria Met	Restoration will be considered complete and final performance monitoring will be conducted.
			Criteria not met	Implement appropriate maintenance/remedial actions
Sensitive Plant Species Mitigation	Each sensitive plant species impacted due to remediation activities will be restored to densities or absolute cover equal to, or greater than pre-impact levels.	Qualitative Monitoring in spring until the restoration area has reached success criteria. Quantitative Monitoring, when restoration area has reached success criteria; two years of quantitative monitoring will be conducted to confirm restoration completion.	Criteria Met	Sensitive Species mitigation will be considered.
			Criteria Not Met	Assess cause; implement appropriate maintenance/remedial actions.
Wildlife Habitat Restoration	Site must possess either (a) documented presence for two years of 100% of the wildlife habitat elements identified as being essential and 50% of those elements identified as being beneficial or (b) documented presence for two years of the actual function or value. (Refer to the following Wildlife Element Matrix)	Annual wildlife habitat element survey	Criteria met	Continue monitoring until all criteria met
			Criteria not met	Continue monitoring until all functions have found to be present for at least two years

3.0 GUIDE TO THE WILDLIFE FUNCTIONS AND HABITAT ELEMENTS MATRIX

Table 3-1 provides the *Wildlife Functions and Habitat Elements Matrix,* which is used to identify those Wildlife Functions and related Wildlife Habitat Elements that are expected to be restored at a specific site based upon the Plant Association(s). Prior to site restoration, the Baseline Wildlife Functions and Habitat Elements Matrix is used to characterize the site. This Matrix is then used when conducting post restoration wildlife surveys. This guide will assist in the interpretation of the information presented in the Matrix.

Each individual Plant Association has certain Wildlife Functions that are associated with it. Each of these Wildlife Functions requires a suite of *essential* and *beneficial* Wildlife Habitat Elements to be present. A Plant Association that has been restored will have Wildlife Functions that may be provided by that type of habitat (i.e., Coastal Dune Scrub provides the Habitat Element suitable for rodent cover/refuge). For each of the Wildlife Functions to occur, multiple Wildlife Habitat Elements need to be present (i.e., for the Wildlife function raptor/owl hunting, certain vegetation, geologic, and animal diet elements must be present).

The Site name and Plant Associations to be restored are identified in the upper left-hand corner of the Matrix. Columns at the top of the Matrix represent all potential Wildlife Functions that could be provided by Plant Associations located at the Field. Rows along the left side of the Matrix represent all the potential Wildlife Habitat Elements that could be present. The Habitat Elements are grouped into seven categories:

- Vegetation Layers
- Vegetation Characteristics
- Geologic Elements
- Aquatic Elements
- Animal Diet Elements
- Plant Diet Elements
- Miscellaneous Elements

Columns highlighted in blue on the Matrix are Wildlife Functions that are expected to be restored at the Site. Wildlife Habitat Elements that are bolded in the left-hand column of the Matrix are those that are expected to be restored at the Site.

Boxes in the Matrix highlighted in green indicate a *beneficial* element and/or habitat for a given Wildlife Function. Boxes highlighted in pink indicate an *essential* element and/or habitat for a given Wildlife Function. These *essential* elements must be present for the corresponding Wildlife Function to occur at the site. In addition, certain Wildlife Habitat Element group headings are highlighted in pink**.** This indicates that two or more of the Wildlife Habitat Elements listed under that group heading are *essential* to the Wildlife Function in that column.

Table 3-1. Wildlife Functions and Habitat Elements Matrix

TB-9 Area 07/24/18 **Existing Plant Associations:** **coastal dune scrub**		Wildlife Functions																	
		AMPHIBIAN/REPTILES					AVIAN					MAMMALS							
		amphibian cover	amphibian foraging	lizards	terrestrial snakes	legless lizards	raptor/owl hunting	ground nesting birds	songbird nesting	songbird foraging	songbird cover	insectivorous mammals	bat foraging	carnivore denning	carnivore cover	carnivore hunting	herbivore foraging	herbivore cover	rodents
Habitat Elements	**Vegetation Layers**																		
	tree																		
	shrub	X	X	X	X	X	X	X	X	X	X	X		X	X	X	X	X	X
	tall herbaceous																		
	short herbaceous	X	X	X	X		X			X		X		X		X	X	X	X
	tall emergent aquatic																		
	short emergent aquatic																		
	floating mat																		
	submerged aquatic																		
	Vegetation Characteristics																		
	mature forest																		
	loose bark																		
	tree hollows/cavities																		
	snag/stump																		
	duff/litter	X	X	X	X	X	X			X		X							X
	woody debris																		
	logs																		
	brush pile/wood rat nest																		
	dead vegetation mat																		
	Geologic Elements																		
	bank/berm			X	X									X	X	X			X
	small mammal burrows	X		X	X		X					X		X		X			X

TB-9 Area 07/24/18 **Existing Plant Associations:** **coastal dune scrub**		Wildlife Functions																	
		AMPHIBIAN/REPTILES					AVIAN					MAMMALS							
		amphibian cover	amphibian foraging	lizards	terrestrial snakes	legless lizards	raptor/owl hunting	ground nesting birds	songbird nesting	songbird foraging	songbird cover	insectivorous mammals	bat foraging	carnivore denning	carnivore cover	carnivore hunting	herbivore foraging	herbivore cover	rodents
	friable soil																		
	loose soil	X		X		X						X							
	damp soil																		
	Aquatic Elements																		
	open water																		
	muddy bottom																		
	permanent surface water																		
	long term seasonal surface water																		
	short term seasonal surface water																		
	deep surface water																		
Habitat Elements	**Animal Diet Elements**																		
	invertebrates, terrestrial		X	X	X	X	X	X		X		X	X			X			X
	invertebrates, flying		X	X			X			X			X			X			X
	invertebrates, aquatic																		
	eggs																		
	fish																		
	amphibians																		
	reptiles		X		X		X					X				X			
	small birds (song)				X		X									X			
	large birds (raptors)						X									X			
	small mammals (rodents, lags)		X		X		X									X			
	large mammals (deer)															X			
	Plant Diet Elements																		
	fungi																		

TB-9 Area 07/24/18 **Existing Plant Associations:** **coastal dune scrub**	Wildlife Functions																	
	AMPHIBIAN/REPTILES					AVIAN					MAMMALS							
	amphibian cover	amphibian foraging	lizards	terrestrial snakes	legless lizards	raptor/owl hunting	ground nesting birds	songbird nesting	songbird foraging	songbird cover	insectivorous mammals	bat foraging	carnivore denning	carnivore cover	carnivore hunting	herbivore foraging	herbivore cover	rodents
algae																		
graminoids																X		X
forbs																X		X
shrub/tree leaves																X		X
twigs																X		X
seeds							X		X		X					X		X
berries																		
fruits																		
flowers/nectar									X							X		X
aquatic plants																		
Misc. Elements																		
aquatic basking sites																		
terrestrial basking sites			X	X														
perchsites						X			X									
roost sites																		

X Habitat Element present at or near the time of the baseline survey
Habitat Elements that are beneficial to a wildlife function
Habitat Elements that are essential to a wildlife function
Wildlife Function present at or near the time of the baseline survey

4.0 REFERENCES

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PLATES

ATTACHMENT 1

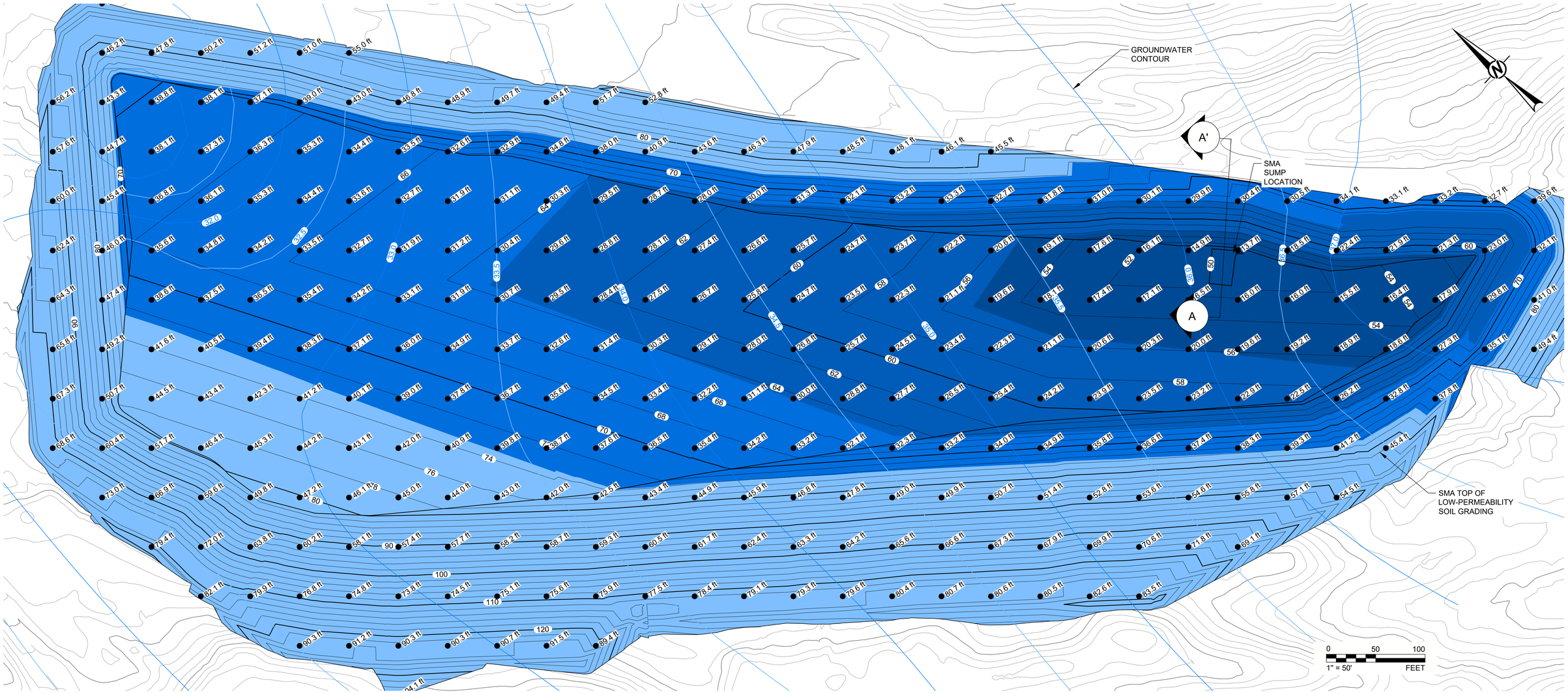
PRE-DISTURBANCE PHOTO

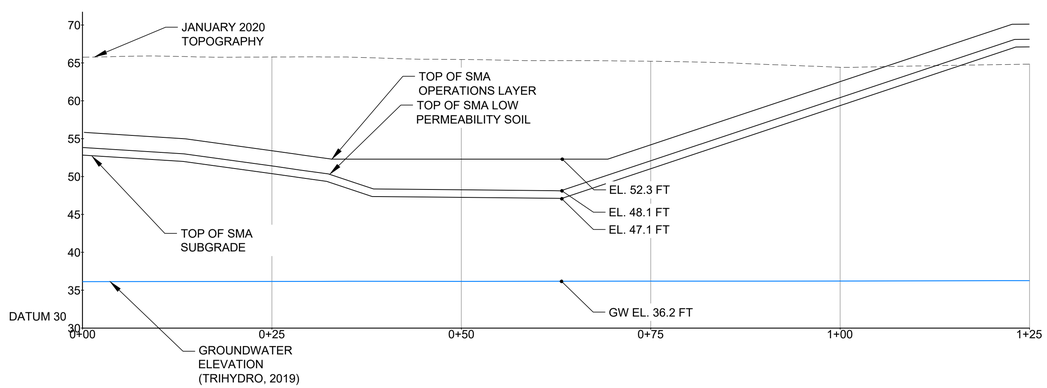
TB-9 Photo-station 1: View of TB-9 facing northeast

TB-9 Photo-station 2: View of TB-9 facing southeast

APPENDIX F

Groundwater Separation Isopachs





DEPTH TO GROUND WATER TABLE			
NUMBER	MIN. DEPTH TO GW (FT)	MAX. DEPTH TO GW (FT)	COLOR
1	0.0	10.0	
2	10.0	20.0	
3	20.0	30.0	
4	30.0	40.0	
5	40.0	110.0	

NOTE(S)

1. THIS MAP WAS PREPARED USING PHOTOGRAMMETRIC METHODS BY CENTRAL COAST AERIAL MAPPING, INC. DATE OF TOPOGRAPHY: JANUARY 2020.
2. GROUNDWATER CONTOURS FROM HISTORICAL DATA FROM 1993 TO 2019 BASED ON TRIHYDRO'S WATER MONITORING AND SITE REMEDIATION ACTIVITIES SEMI-ANNUAL REPORT,2019.
3. PROPOSED GRADES ARE BASED ON TOP OF THE LOW-PERMEABILITY SOIL.
4. POINT ELEVATIONS DISPLAYED ARE THE DEPTH TO GROUNDWATER FROM THE TOP OF LOW-PERMEABILITY SOIL LAYER.

CLIENT
CHEVRON ENVIRONMENTAL MANAGEMENT COMPANY
2184 WEST THORNBERRY ROAD
GUADALUPE, CA 93434

CONSULTANT
GOLDER

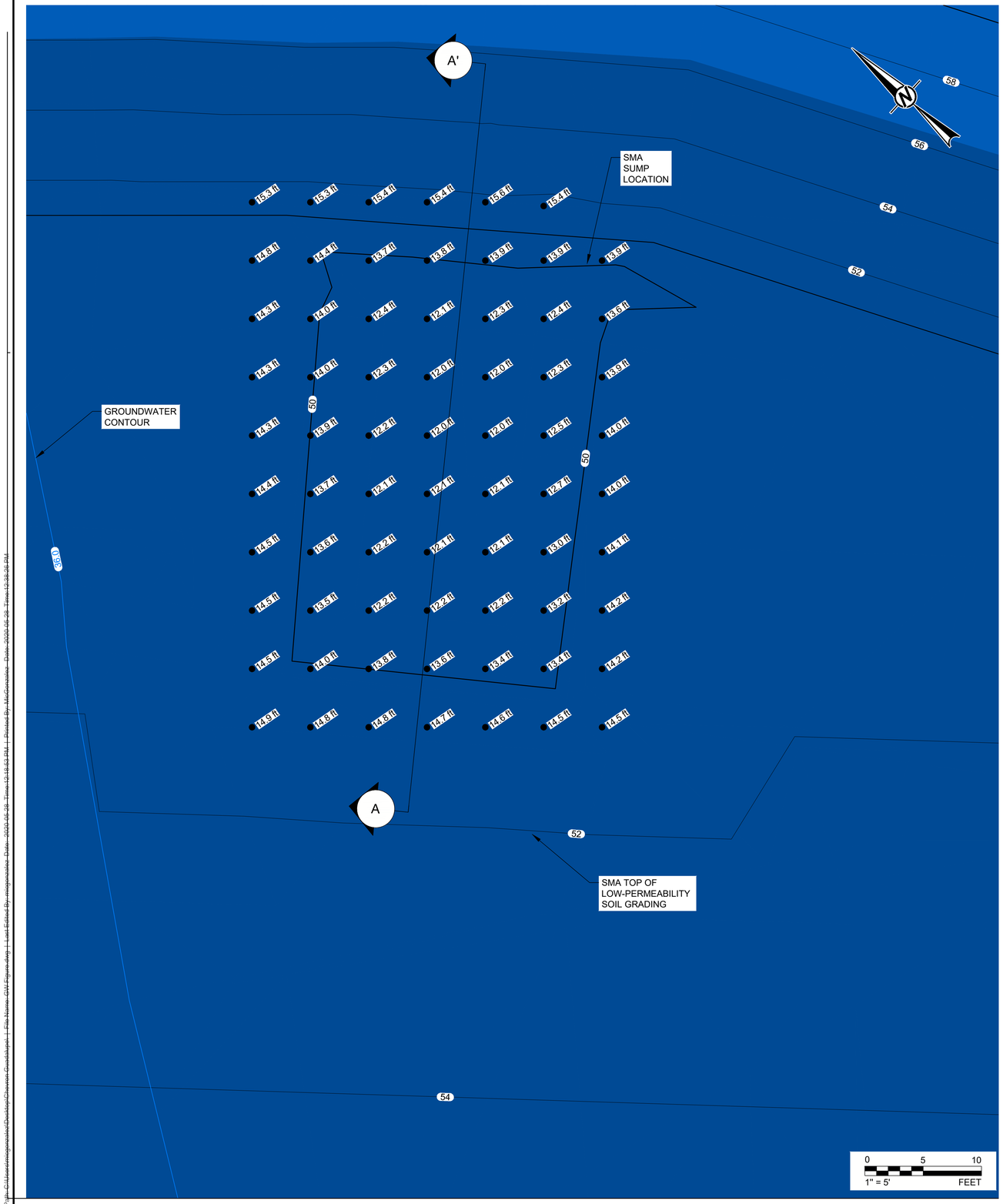
YYYY-MM-DD	2020-05-28
DESIGNED	MAG
PREPARED	MAG
REVIEWED	LMA
APPROVED	RVH

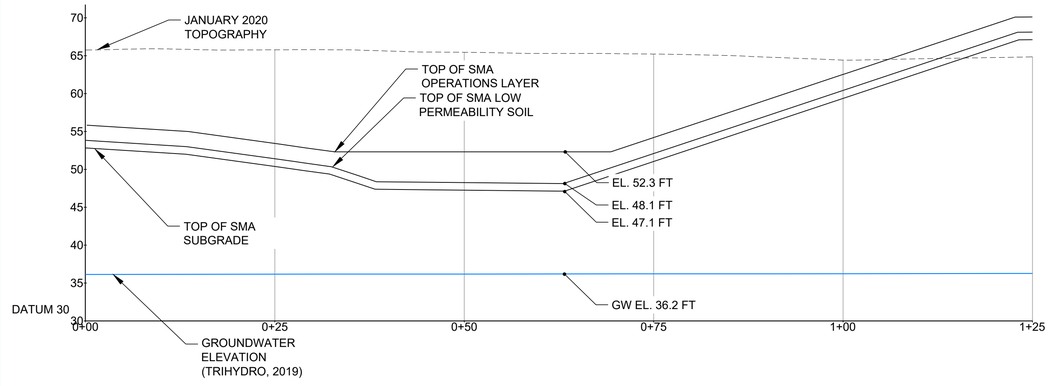
PROJECT
GUADALUPE RESTORATION PROJECT
SOIL MANAGEMENT AREA
TANK BATTERY 9 AREA

TITLE
FUTURE SMA TOP OF LOW-PERMEABILITY SOIL GRADING AND GROUNDWATER SEPARATION

PROJECT NO.	REV.	FIGURE
1783552	0	1

Path: C:\Users\migonzalez\Desktop\Chevron Guadalupe\ | File Name: GW Figure.dwg | Last Edited By: migonzalez Date: 2020-05-28 Time:12:13:14 PM | Printed By: MeGonzalez Date: 2020-05-28 Time:12:16:24 PM
0 1 in IF THIS MEASUREMENT DOES NOT MATCH WHAT IS SHOWN, THE SHEET SIZE HAS BEEN MODIFIED FROM: ANSI D





A SECTION A-A'

DEPTH TO GROUND WATER TABLE			
NUMBER	MIN. DEPTH TO GW (FT)	MAX. DEPTH TO GW (FT)	COLOR
1	0.0	10.0	
2	10.0	20.0	
3	20.0	30.0	
4	30.0	40.0	
5	40.0	110.0	

NOTE(S)

1. THIS MAP WAS PREPARED USING PHOTOGRAMMETRIC METHODS BY CENTRAL COAST AERIAL MAPPING, INC. DATE OF TOPOGRAPHY: JANUARY 2020.
2. GROUNDWATER CONTOURS FROM HISTORICAL DATA FROM 1993 TO 2019 BASED ON TRIHYDRO'S WATER MONITORING AND SITE REMEDIATION ACTIVITIES SEMI-ANNUAL REPORT,2019.
3. PROPOSED GRADES ARE BASED ON TOP OF THE LOW-PERMEABILITY SOIL.
4. POINT ELEVATIONS DISPLAYED ARE THE DEPTH TO GROUNDWATER FROM THE TOP OF LOW-PERMEABILITY SOIL LAYER.

CLIENT
CHEVRON ENVIRONMENTAL MANAGEMENT COMPANY
2184 WEST THORNBERRY ROAD
GUADALUPE, CA 93434

CONSULTANT
GOLDER

YYYY-MM-DD	2020-05-28
DESIGNED	MAG
PREPARED	MAG
REVIEWED	LMA
APPROVED	RVH

PROJECT
GUADALUPE RESTORATION PROJECT
SOIL MANAGEMENT AREA
TANK BATTERY 9 AREA

TITLE
FUTURE SMA TOP OF LOW-PERMEABILITY SOIL GRADING AND GROUNDWATER SEPARATION - SUMP AREA

PROJECT NO.	REV.	FIGURE
1783552	0	2

IF THIS MEASUREMENT DOES NOT MATCH WHAT IS SHOWN, THE SHEET SIZE HAS BEEN MODIFIED FROM: ANSI D

APPENDIX G

Geologic and Hydrological Information

padre associates, inc.
ENGINEERS, GEOLOGISTS & ENVIRONMENTAL SCIENTISTS

GEOTECHNICAL ASSESSMENT SERVICES DATA REPORT

TANK BATTERY 9 (TB9)
GUADALUPE RESTORATION PROJECT
2184 WEST THORNBERRY ROAD
GUADALUPE, SAN LUIS OBISPO COUNTY, CALIFORNIA

Prepared for:
CHEVRON ENVIRONMENTAL MANAGEMENT COMPANY

October 2018

1861 Knoll Drive ▪ Ventura, California 93003 ▪ 805-644-2220 ▪ www.padreinc.com

padre
associates, inc.
ENGINEERS, GEOLOGISTS & ENVIRONMENTAL SCIENTISTS

October 15, 2018
Project No. 1801-2191

Chevron Environmental Management Company
2184 West Thornberry Road
Guadalupe, California 93434

Attention: Ms. Danielle Wold
Project Manager

Subject: Geotechnical Assessment Data Report, Tank Battery 9 Area, Guadalupe Restoration Project, 2184 West Thornberry Road, Guadalupe, San Luis Obispo County, California

Dear Ms. Wold:

Padre Associates, Inc. (Padre), is pleased to present the attached geotechnical assessment data report to the Chevron Environmental Management Company (CEMC) describing the results of the geotechnical assessment for the design of the Tank Battery 9 (TB9) Area at the Guadalupe Restoration Project (Project Site). Services provided for this report were in general compliance with the site assessment plan for the Treated Soil Management Area (TSMA) presented in the CEMC letter to the Central Coast Regional Water Quality Control Board (CCRWQCB) dated July 25, 2018.

This data report provides a summary and findings from three hollow-stem auger (HSA) drill holes and fourteen cone penetrometer tests (CPTs) advanced within the area of the TSMA, as well as, the results of laboratory tests performed on soil samples collected from the site. We appreciate the opportunity to provide these services to CEMC on this project.

If you have any questions regarding this study, please contact us.

Sincerely,

PADRE ASSOCIATES, INC.

Eva E. von Thury, G.I.T.
Project Geologist

Jeffrey T. Damron, G.E.
Principal

REGISTERED PROFESSIONAL ENGINEER
JEFFREY T. DAMRON
No. 2546
GEOTECHNICAL
STATE OF CALIFORNIA

padre associates, inc.
ENGINEERS, GEOLOGISTS & ENVIRONMENTAL SCIENTISTS

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INTRODUCTION

Padre Associates, Inc. (Padre) is pleased to submit this summary geotechnical data report presenting the field methods and data collected during our field campaign for the proposed Tank Battery 9 (TB9) treated soil management area (TSMA) project at the Guadalupe Restoration Project (GRP), 2184 West Thornberry Road, Guadalupe, San Luis Obispo County, California (Project Site, Plate 1 - General Vicinity Map). The area of the Project Site where the TB9 Geotechnical Assessment was performed is shown on Plate 2 -Tank Battery 9 Area Site Location Map. The following sections present our project understanding, purpose, work performed, and a summary of the data collected.

PROJECT UNDERSTANDING AND STUDY PURPOSE

The Guadalupe Restoration Project (Project Site) is located in southwestern San Luis Obispo County, west of The City of Guadalupe. The Project Site was formerly part of the active Guadalupe Oil Field. Most of the aboveground infrastructure from the historical oil field operations have been abandoned and removed from the Project Site.

At the TB9 Area, a geotechnical site assessment was performed in support of preliminary TSMA design efforts at the Project Site. The geotechnical site assessment included 3 hollow-stem auger (has) drill holes to depths ranging from 40 (SBTB9-94) to 61.5 (SBTB9-92) feet below ground surface (ft bgs) and 14 cone penetration tests (CPTs) pushed to depths from 31.82 (TSMACPT-3) to 59.88 (TSMACPT-4) ft bgs.

WORK PERFORMED

The scope of work for this investigation was developed through written correspondence from Ms. Danielle Wold of CEMC and e-mail correspondence with Nagesh Koragappa of Golder Associates, Inc. (Golder). Field work was conducted in general accordance with the CEMC letter from Ms. Wold to Mr. Greg Bishop at CCRWQCB dated July 25, 2018. Work performed for this geotechnical data report included:

- Review of previous geoenvironmental studies conducted for the TB9 area and available geologic reports and maps relevant to the site;
- Marking of proposed exploration locations with GRP staff and notification of Underground Service Alert in an effort to locate underground utilities at the proposed exploration locations;
- Exploration of the site at 3 drill hole locations within the proposed improvements using a HSA limited access drill rig and 14 CPT locations. In addition, five, 5-gallon bucket bulk samples from one stockpile and the onsite borrow source material were collected for proctor testing. Approximate drill hole and CPT locations are shown on Plate 3 -

TB9 Geotechnical Exploration Location Map. The drill hole and CPT logs are presented in Appendix A - Subsurface Exploration;

- Laboratory testing of soil samples obtained from selected depth intervals within each exploration and of the soil samples collected from the potential borrow sources; a description of laboratory tests performed; and the results of those tests are presented in Appendix B - Laboratory Testing; and
- Preparation of this geotechnical data summary report.

HOLLOW-STEM AUGER DRILLING AND SAMPLING

Three hollow-stem auger drill holes were advanced using a Marl 5T track-mounted limited access drill rig supplied by Gregg Drilling, LLC (Gregg) of Signal Hill, California. The drill holes were excavated to depths ranging from 40 to 61.5 ft bgs, while a Padre field geologist logged the drill holes using the Unified Soil Classification System (USCS). The drill holes were sampled at approximately 5-foot intervals using a 2-inch outside diameter standard penetration test (SPT) split spoon sampler.

The split spoon samplers were driven into the materials below the bottom of the auger, at the bottom of the drill hole using a 140-pound automatic trip hammer with a 30-inch drop. Blow counts were recorded for each driven sample and an N-value recorded; where the N-value refers to the number of blows from the hammer that were needed to drive the sampler 1 foot after the sampler had been seated at least 6 inches into the material at the bottom of the hole. The sample intervals, N-values, and a description of the subsurface conditions encountered are presented on the logs of the drill holes (Appendix A).

Upon completion of drilling, the drill holes were abandoned by backfilling with a bentonite cement slurry until 1 foot from the ground surface. The last foot of each drill hole was backfilled with native materials.

CONE PENETROMETER TESTING (CPT)

Fourteen CPTs were pushed using a 20 Ton track-mounted CPT rig suited to traverse the Guadalupe Sand Dunes. The CPT rig used direct-push drilling methods to electronically, continuously log the downhole site lithology. Pore dissipation data was collected downhole at each of the 14 locations with the intention of assisting with creating a hydrogeologic profile. No physical samples were collected. Once the CPT was competed and the rods pulled from the hole, the hole was abandoned by backfilling with a bentonite cement slurry until one foot from the ground surface. The last foot of each CPT sounding hole was backfilled with native materials.

BORROW SOURCE MATERIAL BULK SAMPLES

Five, 5-gallon bucket bulk samples were collected from borrow source material stockpiles at the Project Site. Four bulk samples were collected from the Q4 dune sand stockpile, with one sample taken from each quadrant of the large stock pile (Plate 2). These samples were collected with the aid of a backhoe that cleared the top few feet of the pile and then collected the samples

for proctor testing from inside the pile. One bulk sample from the E4A red rock stockpile was also collected for proctor testing via hand shoveling and obtaining a sample from inside the pile (Plate 2). The red rock will be broken up and mixed as fines material with the sand for backfilling and compaction purposes.

LABORATORY TESTING

Laboratory testing was performed at the soil laboratories of Yeh & Associates, Inc., Grover Beach, California and Cal Poly Corporation GEO-E Laboratory, San Luis Obispo, California. Laboratory tests for moisture content, Atterberg Limits, sieve analyses, and hydrometer were performed on the SPT samples collected from the drill holes; modified proctor and flex wall permeability tests were performed on the bulk borrow source material samples. The tests were performed in general accordance with the applicable standards of ASTM. The results of the tests performed on samples collected from all three drill holes are presented in Appendix B - Laboratory Test Results.

FINDINGS

SITE LOCATION

The Project Site is located in the southwestern corner of San Luis Obispo County, approximately 3 miles west of The City of Guadalupe. Formerly, the Project Site was part of the active Guadalupe Oil Field. The Project Site is approximately 2,700 acres that are bordered to the south by the Santa Maria River and an estuary or lagoon system; to the west by the Pacific Ocean; to the north by the Guadalupe-Nipomo Dunes National Wildlife Refuge; and to the east by agricultural farmland. Oil production activities began in the late 1940s and continued through the early 1990s. In the 1950s, mid-range petroleum (referred to as diluent) was first used at the Guadalupe Oil Field to assist in the production of heavy crude oil.

SITE CONDITIONS

Topography

The Guadalupe Oil Field Site is located within the Guadalupe-Nipomo Dunes Complex at approximate elevations ranging from sea level to 180 feet above mean sea level (AMSL). The topography of the Project Site is mainly sand dunes, which form as narrow ridges separated by narrow valleys. At the TB9 Geotechnical Assessment Area, approximate elevations range from 60 to 105 ft AMSL.

Existing Land Uses

The Project Site is an active remediation/restoration project.

GEOLOGIC CONDITIONS

Regional Settings

The Project Site is located within the Coast Range Geomorphic Province of California. The province is characterized by a faulted network of northwest-trending mountains and intervening valleys located between the Great Valley of California and the Pacific Ocean.

Local Geology

The surficial sediments at the Project Site generally consist predominantly of Quaternary aeolian dune deposits of unconsolidated, well sorted, fine to medium grained sands, with less than two percent fines. The thickness of the dune sand varies in accordance with the topography. Surficial dune sand deposits are underlain by Quaternary alluvium, which may be informally divided into two members. The upper member consists of interbedded silt, clay, and sand, while the lower member is generally coarser grained. The Quaternary alluvium is underlain by the Paso Robles Formation of Pliocene and Pleistocene age (Worts, 1951; Eley and Knott, 1999). Near the Santa Maria River (SMR), riverbed deposits are encountered and likely lie directly on the upper member of the Quaternary alluvium.

Significant Faults

The State of California designates faults as active, potentially active, and inactive depending on the recency of the movement that can be substantiated for a fault. A fault is considered active if it can be substantiated that the fault has ruptured during the Holocene (the last 11,000 years). A fault is considered potentially active if it can be substantiated that it has ruptured during the Quaternary (the last 2-million years), but not the Holocene. A fault is considered inactive if it can be substantiated as not having ruptured within the Quaternary.

The California Division of Mines and Geology (CDMG) evaluate the activity rating of a fault in fault evaluation reports (FER). FERs compile available geologic and seismologic data and evaluate if a fault should be zoned as active, potentially active, or inactive. If a FER evaluates a fault as active, then it is typically incorporated into a Special Studies Zone in accordance with the Alquist-Priolo Earthquake Hazards Act (AP). An AP Special Studies Zone requires site-specific evaluation of a fault location and requires a structural setback if the fault is found traversing a project site. Our review of the regulatory required zone of study maps on the State of California, Department of Conservation web site indicates that there are currently no AP Special Studies Zones that cross the Project Site.

Local Faults

No active faults are known to project through the Project Site. However, there are active and potentially active faults in the vicinity of the Project Site that have the potential to generate strong ground motion. Local faults in the vicinity of the CEMC project site consist of the active Hosgri fault to the west and the potentially active Casmalia and San Luis fault systems, located south and north of the project site, respectively.

Hosgri Fault Zone. The Hosgri fault is a regional, active fault system made up of a complex zone of interlaced and parallel fault segments. This fault complex, includes the San Simeon Fault and has an estimated overall length of about 87 miles. The Hosgri fault zone is located entirely offshore, approximately 8 miles from the CEMC Project Site.

According to the Southern California Earthquake Data Center (2018) and Jennings (1994), the Hosgri fault zone is primarily a reverse and thrust fault with some right-lateral slip, dipping northeast. The probable maximum moment magnitude (Mw) for earthquakes on this fault will range from 6.5 to 7.5. The last major rupture of the Hosgri fault zone occurred on November 4, 1927, with a local magnitude (M_L) of 7.3.

Ground Water Conditions

Groundwater was encountered within two of the three drill holes advanced for this study at depths of approximately 53.9 (SBTB9-93) and 29.0 (SBTB9-94) ft bgs; groundwater was not encountered in SBTB9-92. Recent 2018 quarterly TB9 groundwater monitoring results generally agree with the depths to groundwater encountered during the geotechnical site investigation. Groundwater levels vary throughout the year, and from year to year. Groundwater conditions discussed herein represent only those conditions encountered at the time and location of our exploration and those previously documented by Padre in the GRP Semi-Annual Groundwater Report (January through June 2018).

Pore Pressure Dissipation tests were conducted on the 14 CPT soundings; however, the results from several of the soundings were viewed to be inconclusive when compared to recent groundwater measurements at adjacent drill holes and gauging wells. Therefore, groundwater elevations should be referenced from drill holes SBTB9-92, SBTB9-93, and SBTB9-94 and 2018, first (1Q18) and third (3Q18) quarters groundwater monitoring well gauging data.

EARTH MATERIALS

For this study, we advanced and collected soil samples from 3 hollow-stem-auger drill holes (SBTB9-92, SBTB9-93, and SBTB9-94) to depths ranging from 40 (SBTB9-94) to 61.5 (SBTB9-92) ft bgs. Two (SBTB9-93 and SBTB9-94) of the drill holes were advanced southeast of the existing TB9 stockpile and the third drill hole (SBTB9-92) was advanced northwest of the stockpile.

Fourteen CPTs were pushed in the TB9 site area to depths ranging from 31.82 (TSMACPT-3) to 59.88 (TSMACPT-4 and TSMACPT-8) ft bgs. Eleven CPTs were pushed southeast of the TB9 stockpile. The remaining three CPTs were pushed northeast (TSCMACPT-8), southwest (TSCMASCPT-9), and northwest (TSCMACPT-10) of the existing TB9 stockpile. Approximate drill hole and CPT locations are indicated on Plate 3. Earth materials encountered in the drill holes are described below.

Additionally, five, 5-gallon buckets of borrow source material were collected from the E4A stockpile and Q4 borrow source located at the project site for the generation of borrow source material proctor curves: one 5-gallon bucket of red rock and four 5-gallon buckets of dune sand, respectively.

Artificial Fill (af). Artificial fill was encountered in the upper 5 (SBTB9-94) to 20.5 (SBTB9-92) ft in all three of the drill holes advanced for this study. The artificial fill was primarily composed of loose to hard yellow (10YR 7/6) to dark yellowish brown (10YR 3/4) poorly graded sand (SBTB9-93) with silt (SBTB9-94) and angular gravel (SBTB9-92). The sand was slightly moist with a strong hydrocarbon odor in SBTB9-92 and SBTB9-94; a hydrocarbon odor was absent from the fill sand from SBTB9-93.

Sump material was encountered as soft lenses and pockets of material intermixed in the sand fill of SBTB9-92; however, in SBTB9-93 the sump material was encountered as a stiff 15-foot layer of fill. Sump material was observed to be black (2.5Y 2.5/1), slightly moist to moist, and contain a strong hydrocarbon odor. No sump material was encountered in SBTB9-94.

Guadalupe Sand Dune Complex (Qs and Qos). Dune sand deposits were encountered in all three drill holes, overlain by the artificial fill. The dune sand deposits extended to depths ranging from 35.75 (SBTB9-94) to greater than 61.5 (SBTB9-92) ft bgs before contact with the Confining Unit. The dune sand in the TB9 project area is generally comprised of medium dense to very dense, slightly moist to wet, yellowish brown (10YR 5/6) to brown (10YR 5/4) poorly graded sand (SP). Moderate to strong hydrocarbon odor was detected in the dune sand samples collected from SBTB9-93 and SBTB9-94; no hydrocarbon odors were detected in dune sand samples from SBTB9-92. Few to trace oxidation stains were observed in the dune sand samples of SBTB9-92 and SBTB9-94.

Confining Unit (CU). The confining unit was encountered in two of the three drill holes (SBTB9-93 and SBTB9-94) at 54 and 35.75 ft bgs, respectively. At TB9, the confining unit was generally comprised of stiff to very stiff, dark yellowish brown (10YR 4/6), moist to wet, lean clay with sand to lean clay (CL). A mild hydrocarbon odor was detected in SBTB9-93, but not in samples from SBTB9-94. Trace oxidation staining was observed only in SBTB9-94.

CLOSURE AND LIMITATIONS

This summary data report has been prepared for the exclusive use of CEMC, Golder, and their agents for specific application to the proposed TB9 TSMA project at the Project Site, as shown on Plates 1 through 3. Padre prepared the findings presented herein in accordance with generally accepted geotechnical engineering and geologic practices at the time and location that this report was prepared. No other warranty, express or implied, is made.

Soil and rock materials are typically not homogenous in type, strength, and other geotechnical properties and can vary between points of observation and exploration. In addition, groundwater and soil moisture conditions can vary seasonally and for other reasons. Padre does not and cannot have a complete knowledge of the subsurface conditions underlying a site. The

conclusions and recommendations presented in this report are based upon the findings at the points of exploration, interpolation and extrapolation of information between and beyond the points of observation, and are subject to confirmation of the conditions revealed by construction.

Findings of this report are valid as of the date of issuance; however, changes in condition of a property can and will occur with the passage of time. Furthermore, changes in applicable or appropriate standards occur whether they result from legislation or advancement in technology. Accordingly, findings of this report may be invalidated wholly or partially by changes outside of our control. This report is subject to our review and remains valid for a period of one year, unless we issue a written opinion of its continued applicability thereafter.

-- o --

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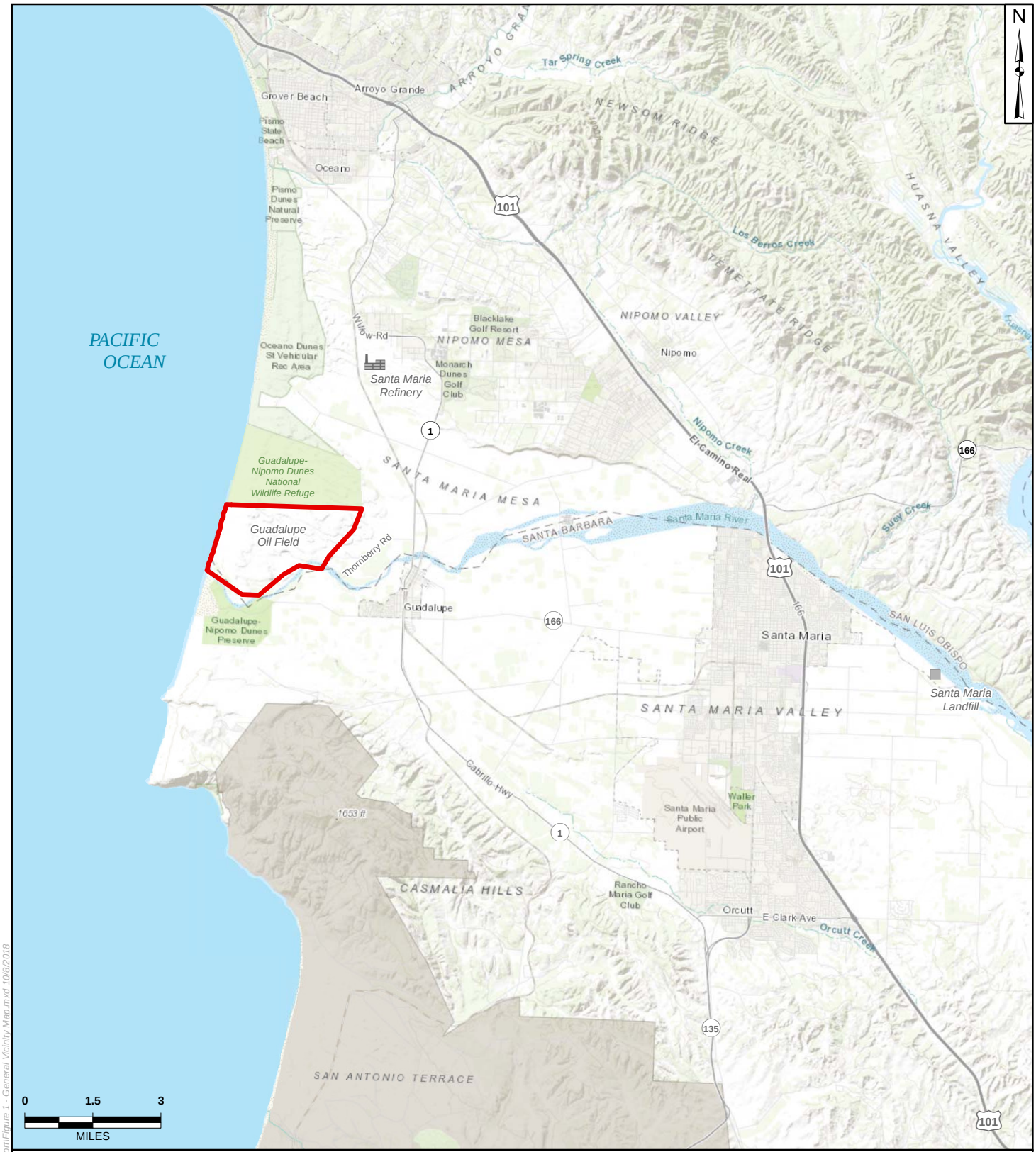
PLATES



LEGEND:

Guadalupe Restoration Project

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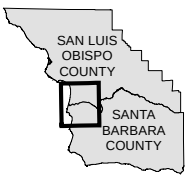

Source: Esri Online Basemap
Coordinate System: NAD 1983 StatePlane California V FIPS 0405 Feet
Notes: This map was created for informational and display purposes only

padre associates, inc.
ENGINEERS, GEOLOGISTS & ENVIRONMENTAL SCIENTISTS

PROJECT NAME: CHEVRON ENVIRONMENTAL MANAGEMENT COMPANY GUADALUPE RESTORATION PROJECT

PROJECT NUMBER: 1801-2191

DATE: October 2018

GENERAL VICINITY MAP

PLATE 1

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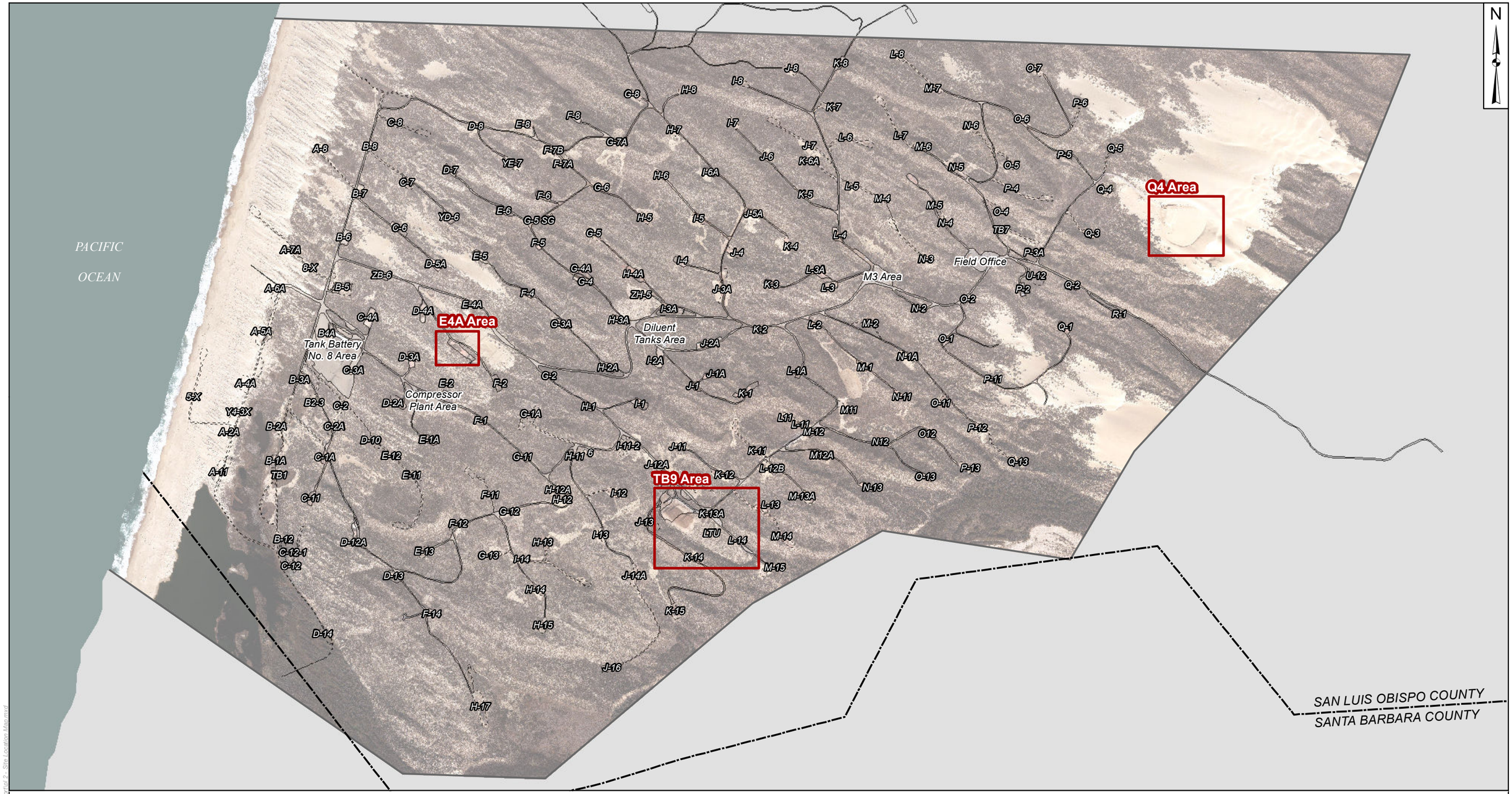

LEGEND:

Property Boundary | County Line | Existing Roadway or Well Pad Feature | Former Roadway or Well Pad Feature

0 650 1,300
FEET

Source: Cannon 2018 Image
Coordinate System: NAD 1927 StatePlane California V FIPS 0405
Abbreviation: TB = Tank Battery
Notes: This map was created for informational and display purposes only

padre associates, inc.
ENGINEERS, GEOLOGISTS & ENVIRONMENTAL SCIENTISTS

PROJECT NAME: CHEVRON ENVIRONMENTAL MANAGEMENT COMPANY GUADALUPE RESTORATION PROJECT
PROJECT NUMBER: 1801-2191
DATE: October 2018

TANK BATTERY 9 AREA SITE LOCATION MAP

FIGURE 2

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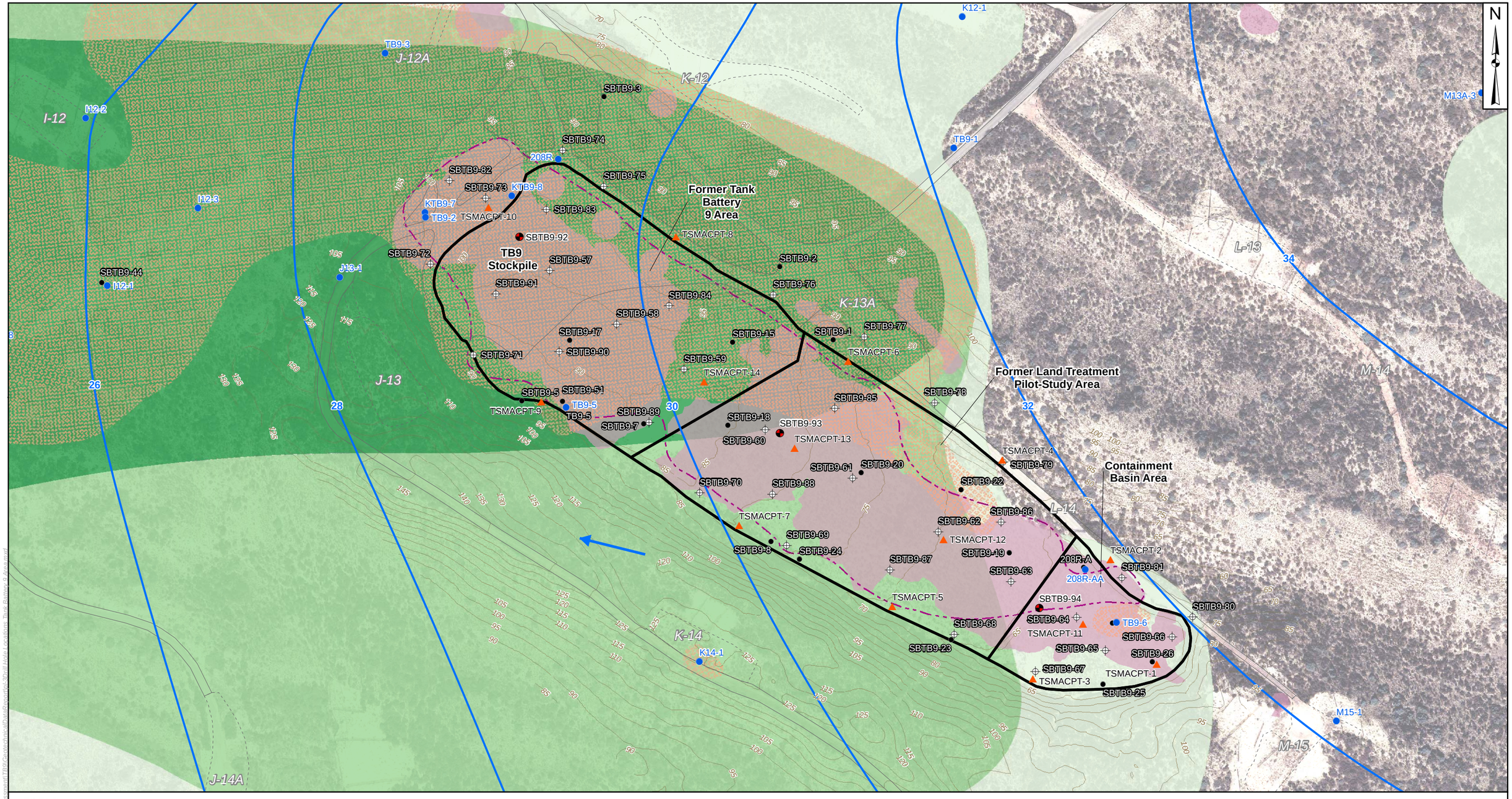


LEGEND:

- 4Q16 Drill Hole Location
- Historical Drill Hole Location
- Groundwater Monitoring Well
- 2018 Cone Penetrometer Test (CPT)
- 2018 Drill Hole Location
- 5-ft Topographic Elevation Contour
- Existing Roadway or Well Pad Feature
- Former Roadway or Well Pad Feature
- LNAPL Source
- Approximate Extent of Sump based on Aerial Photo Review
- Approximate Extent of Sump material based on Assessment Results
- 1Q18 TPH Concentrations in Groundwater Above Laboratory Reporting Limit of 0.05 to 1
- 1Q18 TPH Concentrations in Groundwater Ranging from 1 to 10 mg/L
- 1Q18 TPH Concentrations in Groundwater Greater than 10 mg/L
- 1Q18 Groundwater Elevation Contour (feet msl)
- Ground Water Flow Direction

0 80 160
FEET

Source: Cannon 4/2018 Image, Cannon 2016 Contours
Coordinate System: NAD 1927 StatePlane California V FIPS 0405
Abbreviations: ft = foot
LNAPL = Light Non-Aqueous Phase Liquid
mg/L = Milligrams per Liter
TB = Tank Battery
TPH = Total Petroleum Hydrocarbons
Notes: This map was created for informational and display purposes only.

padre associates, inc.
ENGINEERS, GEOLOGISTS & ENVIRONMENTAL SCIENTISTS

PROJECT NAME: CHEVRON ENVIRONMENTAL MANAGEMENT COMPANY GUADALUPE RESTORATION PROJECT
PROJECT NUMBER: 1801-2191
DATE: October 2018

TB9 GEOTECHNICAL EXPLORATION LOCATION MAP

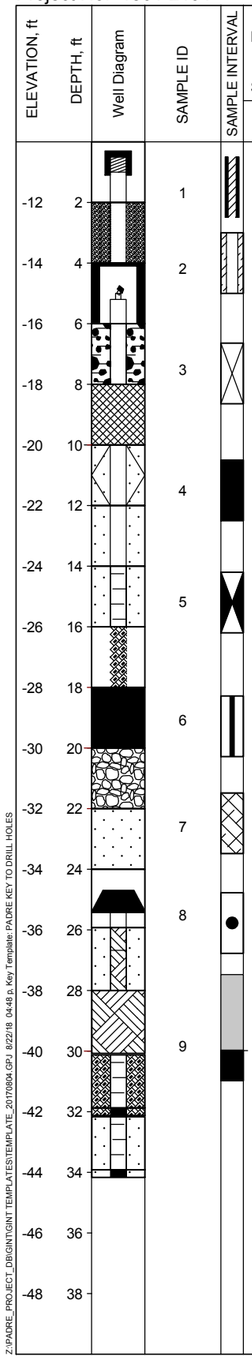
PLATE 3

z:\Kristin\GIS Maps\Maps Project\Guadalupe\Assessment\TB9\Geotechnical\Data Reporting\3 Drill Hole Locations, Tank Battery 9 Area.mxd

APPENDIX A
SUBSURFACE EXPLORATION

October 2018
Project No. 1801-2191

padre associates, inc.
ENGINEERS, GEOLOGISTS & ENVIRONMENTAL SCIENTISTS



LOCATION: The drill hole location referencing local landmarks or coordinates

SURFACE EL: Surface elevation based on MSL

MATERIAL DESCRIPTION

- Riser
- Solid Pipe Packed in Bentonite Chips
- Locking Well Cap in Traffic Box
- Solid Pipe in Concrete
- Native Backfill
- Centralizer with Solid Pipe in Sand
- Solid Pipe Packed in Sand
- Slotted Pipe Packed in Sand
- Abandoned Well
- Bentonite in Bottom of Hole
- Slough at Bottom of Hole
- Native Sand Backfill
- Well Cover for Vapor Probe Holes
- Grout Packed Slotted Pipe in Sand
- Grout / Neat Cement
- Slotted Pipe in Grout with Bottom Cap
- Slotted Pipe in Sand with Bottom Cap

WATER LEVEL SYMBOLS:

- Initial or perched water level
- Final groundwater level

CONTACT SYMBOLS:

- Inferred Contact
- Known Contact

GENERAL NOTES:

SAMPLE ID FOR:

1 Hand-Auger
2 Soil Core
3 Standard Penetration Test (SPT)
4 Environmental Jar Sample
5 Modified California
6 Shelby Tube
7 Bulk or Grab Bag
8 No Recovery
9 Direct Push Sample Interval:

Recovered Length of Driven Sampler

Soil Sample Retained for Laboratory Analysis

ABBREVIATIONS:

1) * = Sample collected but not sent for analysis
2) bgs = below ground surface
3) d/r = driven/recovered
4) El. = Elevation
5) ft = Feet
6) GP = Geoprobe
7) HA = Hand-Auger
8) HSA/DP = Hollow Stem Auger/Direct Push
9) J = J-Flagged (Estimated Value)
10) ksf = kips per square foot
11) m. = Mini Torvane
12) mg/Kg = milligrams per Kilogram
13) MSL = mean sea level
14) NA = not analyzed
15) NM = not measured
16) NR = no recovery
17) p. = pocket penetrometer
18) PID = Photoionization Detector
19) ppm = parts per million
20) ppmv = parts per million by volume
21) q. = Unconsolidated Undrained Triaxial
22) SB = Soil Boring
23) t. = Torvane
24) TD = Total Depth
25) tsf = tons per square foot
26) U. = Unconfined Compression
27) USCS = Unified Soil Classification System

NOTES:

1) All items in legend may not appear on logs.
2) Length of sample symbol approximates recovery length.
3) Classification of Soils per ASTM D2487 or D2488.
4) Geologic Formation noted in bold font at the top of interpretted interval.
5) Rock Quality Designation (RQD) is the sum of recovery core pieces grater than 4 inches divided by the length of the core interval.

SOIL AND ROCK TYPES:

- Asphalt or Concrete Pavement (AC)
- Artificial Fill (af)
- Base Material
- Top Soil
- Fat CLAY (CH)
- Gravelly Fat CLAY (CH)
- Silty Fat CLAY (CH)
- Sandy Fat CLAY (CH)
- Sandy Fat CLAY with gravel (CH)
- Fat CLAY with Sand (CH)
- Lean CLAY (CL)
- Lean CLAY with gravel (CL)
- Gravelly Lean CLAY with sand (CL)
- Silty CLAY (CL)
- Silty CLAY with sand (CL)
- Sandy Lean CLAY (CL)
- Lean CLAY with Sand and Gravel (CL)
- Lean CLAY with sand (CL)
- Clayey GRAVEL (GC)
- Silty, Clayey GRAVEL (with Sand, GC)
- Silty GRAVEL (GM)
- Silty GRAVEL with Sand (GM)
- Poorly Graded GRAVEL (GP)
- Poorly Graded GRAVEL with Clay (and Sand, GP)
- Poorly Graded GRAVEL with Silt (and Sand, GP)
- Sandy GRAVEL with Silt (GP)
- Poorly Graded GRAVEL with Sand (GP)
- Well Graded GRAVEL (GW)
- Well Graded GRAVEL with Clay (GW)
- Well Graded GRAVEL with Silt (and Sand, GW)
- Well Graded GRAVEL with Sand (GW)
- Elastic SILT (MH)
- Elastic SILT with Fat Clay (MH)
- Elastic SILT with Sand (MH)
- SILT (ML)
- Organic, Sandy SILT (ML)
- Sandy, Clayey SILT (ML)
- Clayey SILT (ML) to Clayey SAND (SC)
- SILT with gravel (ML)
- Sandy SILT (ML)
- Sandy SILT with gravel (ML)
- Sandy SILT with clay (ML)
- SILT with sand (ML)
- High Plasticity ORGANIC (OH)
- Low Plasticity ORGANIC (OL)
- Plastic ORGANIC (OH/OL)
- PEAT or ORGANIC MATTER (PT)
- Clayey SAND (SC)
- Clayey SAND and Basalt (SC)
- Clayey SAND with Gravel (SC)
- Silty, Clayey SAND (SC)
- Silty, Clayey SAND with Gravel (SC)
- Silty SAND (SM)
- Silty SAND with Gravel (SM)
- Silty SAND (SM) and Sandy SILT (ML)
- Poorly Graded SAND (SP)
- Poorly Graded SAND with CLAY (SP)
- Poorly Graded SAND with Gravel (SP)
- Gravelly SAND (SP)
- Poorly Graded SAND with (Silty) Clay (and Gravel, SP)
- Poorly Graded SAND with Silt (and Gravel, SP)
- Gravelly SAND with silt (SP)
- Well Graded SAND (SW)
- Well Graded SAND with gravel (SW)
- Well Graded SAND with (Silty) Clay (and Gravel, SW)
- Well Graded SAND with Silt (and Gravel, SW)
- BASALT
- BASE Material
- BEDROCK
- BOULDERS and COBBLES
- BRECCIA
- CHALK
- Chert
- CLAYSTONE
- CLAYSTONE and SILTSTONE
- CLAYSTONE and SANDSTONE
- COAL
- CONCRETE
- CONGLOMERATE
- CORAL or SHELLS
- DOLOMITE
- GYPSUM, ROCKSALT
- IGNEOUS ROCK
- LIMESTONE
- MELANGE
- METAMORPHIC ROCK
- MUDSTONE
- Rock Fragments
- Sand SLURRY (Cement Stabilized Sand)
- SANDSTONE
- SANDSTONE and SILTSTONE
- Interbedded SANDSTONE and SHALE
- SERPENTINITE
- SHALE
- SILTSTONE
- Tuff
- VEGETATION, SOD, or GROUNDCOVER

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KEY TO TERMS & SYMBOLS USED ON LOGS

Guadalupe Restoration Project
Guadalupe, California

PLATE A-1

October 2018
Project No. 1801-2191

padre associates, inc.
ENGINEERS, GEOLOGISTS & ENVIRONMENTAL SCIENTISTS

LOCATION: Tank Battery 9 Area
SURFACE ELEVATION: 99.37 ft +/- (relative datum MSL)
NORTHING: 546632.52
EASTING: 1214083.08
COORDINATE SYSTEM: NAD27 SP Ca Zn 5, ft

ELEVATION, ft / DEPTH, ft	USCS MATERIAL SYMBOL	SAMPLE ID	SAMPLE INTERVAL	SAMPLER BLOW COUNT/	MATERIAL DESCRIPTION	UNIT WET WEIGHT, pcf	UNIT DRY WEIGHT, pcf	WATER CONTENT, %	% PASSING #200 SIEVE	LIQUID LIMIT, %	PLASTICITY INDEX, %	UNDRAINED SHEAR STRENGTH, S_u, ksf	GAS MONITOR: MultiRAE Lite (ppm)
98 / 2		SBTB9-92a-0to5-081618			**ARTIFICIAL FILL (af)** Poorly graded SAND with gravel (SP), stiff, yellow (10YR 7/6), moist, medium grained								
96 / 4													
94 / 6		SBTB9-92a-5-081618		34	Hard, strong hydrocarbon odor								0.0
92 / 8													
90 / 10		SBTB9-92a-10,5-081618		29	Sump material (af), medium dense, black (10YR 2/1), mild hydrocarbon odor								0.0
88 / 12		SBTB9-92a-10-081618			Poorly graded GRAVEL (GP), yellow (10YR 7/6), medium grained, no hydrocarbon odor Dark brown (10YR 3/3)								
86 / 14													

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DRILLING DATE: August 16, 2018
DEPTH TO GROUNDWATER: Not Encountered
COMPLETION DEPTH: 61.5 ft
BACKFILLED WITH: Bentonite Grout

DRILLING/SAMPLING METHOD: 8-in. dia. Hollow Stem Auger
HAMMER TYPE: Automatic Trip
DRILLING COMPANY: Gregg Drilling
LOGGED BY: E. von Thury
CHECKED BY: R. Zukor, P.G.

LOG OF WELL SBTB9-92

Guadalupe Restoration Project
Guadalupe, California

PLATE A-1a

The log and data presented are a simplification of actual conditions encountered at the time of drilling at the drilled location. Subsurface conditions may differ at other locations and with the passage of time. Please refer to Key to Boring Log for symbol explanation.

October 2018
Project No. 1801-2191

padre associates, inc.
ENGINEERS, GEOLOGISTS & ENVIRONMENTAL SCIENTISTS

LOCATION: Tank Battery 9 Area
SURFACE ELEVATION: 99.37 ft +/- (relative datum MSL)
NORTHING: 546632.52
EASTING: 1214083.08
COORDINATE SYSTEM: NAD27 SP Ca Zn 5, ft

ELEVATION, ft / DEPTH, ft	USCS MATERIAL SYMBOL	SAMPLE ID	SAMPLE INTERVAL	SAMPLER BLOW COUNT/	MATERIAL DESCRIPTION	UNIT WET WEIGHT, pcf	UNIT DRY WEIGHT, pcf	WATER CONTENT, %	% PASSING #200 SIEVE	LIQUID LIMIT, %	PLASTICITY INDEX, %	UNDRAINED SHEAR STRENGTH, S_u, ksf	GAS MONITOR: MultiRAE Lite (ppm)
84		SBTB9-92a-15.5-081618		30	Medium dense, mild hydrocarbon odor								0.0
16		SBTB9-92a-15-081618			**Guadalupe Sand Dune Complex** Poorly graded SAND (SP), medium dense, light yellowish brown (10YR 6/4), slightly moist, medium grained, no hydrocarbon odor								
82													
18													
80													
20		SBTB9-92a-20-081618		26	Yellowish brown (10YR 5/4), no hydrocarbon odor			4	2				0.0
78													
22													
76													
24													
74		SBTB9-92a-25-081618		26	Yellowish brown (10YR 5/6), fine grained, no hydrocarbon odor								0.0
26					Medium grained Fine grained								
72													
28													
70													

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DRILLING DATE: August 16, 2018
DEPTH TO GROUNDWATER: Not Encountered
COMPLETION DEPTH: 61.5 ft
BACKFILLED WITH: Bentonite Grout

DRILLING/SAMPLING METHOD: 8-in. dia. Hollow Stem Auger
HAMMER TYPE: Automatic Trip
DRILLING COMPANY: Gregg Drilling
LOGGED BY: E. von Thury
CHECKED BY: R. Zukor, P.G.

LOG OF WELL SBTB9-92

Guadalupe Restoration Project
Guadalupe, California

PLATE A-1b

The log and data presented are a simplification of actual conditions encountered at the time of drilling at the drilled location. Subsurface conditions may differ at other locations and with the passage of time. Please refer to Key to Boring Log for symbol explanation.

October 2018
Project No. 1801-2191

padre associates, inc.
ENGINEERS, GEOLOGISTS & ENVIRONMENTAL SCIENTISTS

LOCATION: Tank Battery 9 Area
SURFACE ELEVATION: 99.37 ft +/- (relative datum MSL)
NORTHING: 546632.52
EASTING: 1214083.08
COORDINATE SYSTEM: NAD27 SP Ca Zn 5, ft

ELEVATION, ft / DEPTH, ft	USCS MATERIAL SYMBOL	SAMPLE ID	SAMPLE INTERVAL	SAMPLER BLOW COUNT/	MATERIAL DESCRIPTION	UNIT WET WEIGHT, pcf	UNIT DRY WEIGHT, pcf	WATER CONTENT, %	% PASSING #200 SIEVE	LIQUID LIMIT, %	PLASTICITY INDEX, %	UNDRAINED SHEAR STRENGTH, S_u, ksf	GAS MONITOR: MultiRAE Lite (ppm)
68 / 32		SBTB9-92a-30-081618		30	No hydrocarbon odor								0.0
66 / 34													
64 / 36		SBTB9-92a-35-081618		26	No hydrocarbon odor 0.25 inched thick of oxidation staining								0.0
62 / 38													
60 / 40		SBTB9-92a-40-081618		19				3	1				0.0
58 / 42													
56 / 44													

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DRILLING DATE: August 16, 2018
DEPTH TO GROUNDWATER: Not Encountered
COMPLETION DEPTH: 61.5 ft
BACKFILLED WITH: Bentonite Grout

DRILLING/SAMPLING METHOD: 8-in. dia. Hollow Stem Auger
HAMMER TYPE: Automatic Trip
DRILLING COMPANY: Gregg Drilling
LOGGED BY: E. von Thury
CHECKED BY: R. Zukor, P.G.

LOG OF WELL SBTB9-92

Guadalupe Restoration Project
Guadalupe, California

PLATE A-1c

The log and data presented are a simplification of actual conditions encountered at the time of drilling at the drilled location. Subsurface conditions may differ at other locations and with the passage of time. Please refer to Key to Boring Log for symbol explanation.

October 2018
Project No. 1801-2191

padre associates, inc.
ENGINEERS, GEOLOGISTS & ENVIRONMENTAL SCIENTISTS

LOCATION: Tank Battery 9 Area
SURFACE ELEVATION: 99.37 ft +/- (relative datum MSL)
NORTHING: 546632.52
EASTING: 1214083.08
COORDINATE SYSTEM: NAD27 SP Ca Zn 5, ft

ELEVATION, ft DEPTH, ft	USCS MATERIAL SYMBOL	SAMPLE ID	SAMPLE INTERVAL	SAMPLER BLOW COUNT/	MATERIAL DESCRIPTION	UNIT WET WEIGHT, pcf	UNIT DRY WEIGHT, pcf	WATER CONTENT, %	% PASSING #200 SIEVE	LIQUID LIMIT, %	PLASTICITY INDEX, %	UNDRAINED SHEAR STRENGTH, S_u, ksf	GAS MONITOR: MultiRAE Lite (ppm)
54 / 46		SBTB9-92a-45-081618		42	Dense, no hydrocarbon odor								0.0
52 / 48													
50 / 50		SBTB9-92a-50-081618		50	Medium dense, no hydrocarbon odor								0.0
48 / 52													
46 / 54													
44 / 56		SBTB9-92a-55-081618		50/6"	Hard, no hydrocarbon odor								0.0
42 / 58													
40													

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DRILLING DATE: August 16, 2018
DEPTH TO GROUNDWATER: Not Encountered
COMPLETION DEPTH: 61.5 ft
BACKFILLED WITH: Bentonite Grout

DRILLING/SAMPLING METHOD: 8-in. dia. Hollow Stem Auger
HAMMER TYPE: Automatic Trip
DRILLING COMPANY: Gregg Drilling
LOGGED BY: E. von Thury
CHECKED BY: R. Zukor, P.G.

LOG OF WELL SBTB9-92

Guadalupe Restoration Project
Guadalupe, California

PLATE A-1d

The log and data presented are a simplification of actual conditions encountered at the time of drilling at the drilled location. Subsurface conditions may differ at other locations and with the passage of time. Please refer to Key to Boring Log for symbol explanation.

October 2018
Project No. 1801-2191

padre associates, inc.
ENGINEERS, GEOLOGISTS & ENVIRONMENTAL SCIENTISTS

LOCATION: Tank Battery 9 Area
SURFACE ELEVATION: 99.37 ft +/- (relative datum MSL)
NORTHING: 546632.52
EASTING: 1214083.08
COORDINATE SYSTEM: NAD27 SP Ca Zn 5, ft

ELEVATION, ft / DEPTH, ft	USCS MATERIAL SYMBOL	SAMPLE ID	SAMPLE INTERVAL	SAMPLER BLOW COUNT/	MATERIAL DESCRIPTION	UNIT WET WEIGHT, pcf	UNIT DRY WEIGHT, pcf	WATER CONTENT, %	% PASSING #200 SIEVE	LIQUID LIMIT, %	PLASTICITY INDEX, %	UNDRAINED SHEAR STRENGTH, S_u, ksf	GAS MONITOR: MultiRAE Lite (ppm)
38 / 62		SBTB9-92a-60-081618		49	Very dense, brownish yellow (10YR 6/6), no hydrocarbon odor			4	2				0.0
36 / 64													
34 / 66													
32 / 68													
30 / 70													
28 / 72													
26 / 74													

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DRILLING DATE: August 16, 2018
DEPTH TO GROUNDWATER: Not Encountered
COMPLETION DEPTH: 61.5 ft
BACKFILLED WITH: Bentonite Grout

DRILLING/SAMPLING METHOD: 8-in. dia. Hollow Stem Auger
HAMMER TYPE: Automatic Trip
DRILLING COMPANY: Gregg Drilling
LOGGED BY: E. von Thury
CHECKED BY: R. Zukor, P.G.

LOG OF WELL SBTB9-92

Guadalupe Restoration Project
Guadalupe, California

PLATE A-1e

The log and data presented are a simplification of actual conditions encountered at the time of drilling at the drilled location. Subsurface conditions may differ at other locations and with the passage of time. Please refer to Key to Boring Log for symbol explanation.

October 2018
Project No. 1801-2191

padre associates, inc.
ENGINEERS, GEOLOGISTS & ENVIRONMENTAL SCIENTISTS

LOCATION: Tank Battery 9 Area
SURFACE ELEVATION: 81.94 ft +/- (relative datum MSL)
NORTHING: 546270.11
EASTING: 1214555.75
COORDINATE SYSTEM: NAD27 SP Ca Zn 5, ft

ELEVATION, ft / DEPTH, ft	USCS MATERIAL SYMBOL	SAMPLE ID	SAMPLE INTERVAL	SAMPLER BLOW COUNT/	MATERIAL DESCRIPTION	UNIT WET WEIGHT, pcf	UNIT DRY WEIGHT, pcf	WATER CONTENT, %	% PASSING #200 SIEVE	LIQUID LIMIT, %	PLASTICITY INDEX, %	UNDRAINED SHEAR STRENGTH, S_u, ksf	GAS MONITOR: MultiRAE Lite (ppm)
80 / 2		SBTB9-93-0to5-081418			**ARTIFICIAL FILL (af)** Poorly graded SAND (SP), loose, dark yellowish brown (10YR 4/6), slightly moist, medium grained, no hydrocarbon odor, few rootlets								
78 / 4		SBTB9-93-5-081418		35	Medium dense, no hydrocarbon odor								3.9
76 / 6		SBTB9-93-5.5-081418			Sump material (af), very dense, black (2.5Y 2.5/1), slightly moist, medium grained, strong hydrocarbon odor								
74 / 8													
72 / 10		SBTB9-93-10-081418		9	Stiff, strong hydrocarbon odor								394
70 / 12													
68 / 14		SBTB9-93-12.5-081418											

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DRILLING DATE: August 15, 2018
DEPTH TO GROUNDWATER: 53.9 ft
COMPLETION DEPTH: 56.5 ft
BACKFILLED WITH: Bentonite Grout

DRILLING/SAMPLING METHOD: 8-in. dia. Hollow Stem Auger
HAMMER TYPE: Automatic Trip
DRILLING COMPANY: Gregg Drilling
LOGGED BY: E. von Thury
CHECKED BY: R. Zukor, P.G.

LOG OF WELL SBTB9-93

Guadalupe Restoration Project
Guadalupe, California

PLATE A-2a

The log and data presented are a simplification of actual conditions encountered at the time of drilling at the drilled location. Subsurface conditions may differ at other locations and with the passage of time. Please refer to Key to Boring Log for symbol explanation.

October 2018
Project No. 1801-2191

padre associates, inc.
ENGINEERS, GEOLOGISTS & ENVIRONMENTAL SCIENTISTS

LOCATION: Tank Battery 9 Area
SURFACE ELEVATION: 81.94 ft +/- (relative datum MSL)
NORTHING: 546270.11
EASTING: 1214555.75
COORDINATE SYSTEM: NAD27 SP Ca Zn 5, ft

ELEVATION, ft / DEPTH, ft	USCS MATERIAL SYMBOL	SAMPLE ID	SAMPLE INTERVAL	SAMPLER BLOW COUNT/	MATERIAL DESCRIPTION	UNIT WET WEIGHT, pcf	UNIT DRY WEIGHT, pcf	WATER CONTENT, %	% PASSING #200 SIEVE	LIQUID LIMIT, %	PLASTICITY INDEX, %	UNDRAINED SHEAR STRENGTH, S_u, ksf	GAS MONITOR: MultiRAE Lite (ppm)
66 / 16		SBTB9-93-16-081418		6	Strong hydrocarbon odor								359
		SBTB9-93-15-081418											
64 / 18													
62 / 20		SBTB9-93-20.5-081418		32	Dense, moist, strong hydrocarbon odor								291
		SBTB9-93-20-081418			**Guadalupe sand dune complex** Poorly graded SAND (SP), dense, dark grayish brown (10YR 4/2), slightly moist, medium grained, slight hydrocarbon odor								
60 / 22		SBTB9-93-21.5-081418											
		SBTB9-93-22.5-081418			Strong hydrocarbon odor End 8/14/18 and resume 8/15/18								
58 / 24													
		SBTB9-93-25-081418		38	Brown (10YR 5/3), slightly moist, strong hydrocarbon odor			3	1				6.0
56 / 26													
54 / 28													

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DRILLING DATE: August 15, 2018
DEPTH TO GROUNDWATER: 53.9 ft
COMPLETION DEPTH: 56.5 ft
BACKFILLED WITH: Bentonite Grout

DRILLING/SAMPLING METHOD: 8-in. dia. Hollow Stem Auger
HAMMER TYPE: Automatic Trip
DRILLING COMPANY: Gregg Drilling
LOGGED BY: E. von Thury
CHECKED BY: R. Zukor, P.G.

LOG OF WELL SBTB9-93

Guadalupe Restoration Project
Guadalupe, California

PLATE A-2b

The log and data presented are a simplification of actual conditions encountered at the time of drilling at the drilled location. Subsurface conditions may differ at other locations and with the passage of time. Please refer to Key to Boring Log for symbol explanation.

October 2018
Project No. 1801-2191

padre associates, inc.
ENGINEERS, GEOLOGISTS & ENVIRONMENTAL SCIENTISTS

LOCATION: Tank Battery 9 Area
SURFACE ELEVATION: 81.94 ft +/- (relative datum MSL)
NORTHING: 546270.11
EASTING: 1214555.75
COORDINATE SYSTEM: NAD27 SP Ca Zn 5, ft

ELEVATION, ft / DEPTH, ft	USCS MATERIAL SYMBOL	SAMPLE ID	SAMPLE INTERVAL	SAMPLER BLOW COUNT/	MATERIAL DESCRIPTION	UNIT WET WEIGHT, pcf	UNIT DRY WEIGHT, pcf	WATER CONTENT, %	% PASSING #200 SIEVE	LIQUID LIMIT, %	PLASTICITY INDEX, %	UNDRAINED SHEAR STRENGTH, S_u, ksf	GAS MONITOR: MultiRAE Lite (ppm)
		SBTB9-93-30-081418		52	Very dense, moderate hydrocarbon odor, slightly indurated								0.0
-50 32													
-48 34													
		SBTB9-93-35-081418		45	Dense, grayish brown (10YR 5/2), moist, medium grained, moderate hydrocarbon odor			2	1				4.0
-46 36					Pale brown (10YR 6/3), slightly moist, fine grained								
-44 38													
-42 40		SBTB9-93-40.5-081418		45	Dark yellowish brown (10YR 3/4), moist, strong hydrocarbon odor								1.0
		SBTB9-93-40-081418			Brown (10YR 4/3)								
-40 42					Slight hydrocarbon odor								
-38 44													

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DRILLING DATE: August 15, 2018
DEPTH TO GROUNDWATER: 53.9 ft
COMPLETION DEPTH: 56.5 ft
BACKFILLED WITH: Bentonite Grout

DRILLING/SAMPLING METHOD: 8-in. dia. Hollow Stem Auger
HAMMER TYPE: Automatic Trip
DRILLING COMPANY: Gregg Drilling
LOGGED BY: E. von Thury
CHECKED BY: R. Zukor, P.G.

LOG OF WELL SBTB9-93

Guadalupe Restoration Project
Guadalupe, California

PLATE A-2c

The log and data presented are a simplification of actual conditions encountered at the time of drilling at the drilled location. Subsurface conditions may differ at other locations and with the passage of time. Please refer to Key to Boring Log for symbol explanation.

October 2018
Project No. 1801-2191

padre associates, inc.
ENGINEERS, GEOLOGISTS & ENVIRONMENTAL SCIENTISTS

LOCATION: Tank Battery 9 Area
SURFACE ELEVATION: 81.94 ft +/- (relative datum MSL)
NORTHING: 546270.11
EASTING: 1214555.75
COORDINATE SYSTEM: NAD27 SP Ca Zn 5, ft

ELEVATION, ft / DEPTH, ft	USCS MATERIAL SYMBOL	SAMPLE ID	SAMPLE INTERVAL	SAMPLER BLOW COUNT/	MATERIAL DESCRIPTION	UNIT WET WEIGHT, pcf	UNIT DRY WEIGHT, pcf	WATER CONTENT, %	% PASSING #200 SIEVE	LIQUID LIMIT, %	PLASTICITY INDEX, %	UNDRAINED SHEAR STRENGTH, S_u, ksf	GAS MONITOR: MultiRAE Lite (ppm)
		SBTB9-93-45-081418		62	Very dense, gray (10YR 5/1), medium grained, mild hydrocarbon odor								0.0
-36 46													
-34 48													
-32 50		SBTB9-93-50-081418		65	Yellowish brown (10YR 5/4), moist, slight hydrocarbon odor Wet								0.0
-30 52													
-28 54					**CONFINING UNIT**								
		SBTB9-93-55-081418		24	Lean CLAY with sand (CL), very stiff, dark yellowish brown (10YR 4/6), wet, mild hydrocarbon odor			26	80	26	17		0.0
-26 56													
-24 58													

U:\GINT\2-GRP\TB9\TB9-2018\GRP_TB9_1801-2191.GPJ 10/3/18 04:20 p, Template: PADRE_GEOW/ PIDNOWELL_APPA

DRILLING DATE: August 15, 2018
DEPTH TO GROUNDWATER: 53.9 ft
COMPLETION DEPTH: 56.5 ft
BACKFILLED WITH: Bentonite Grout

DRILLING/SAMPLING METHOD: 8-in. dia. Hollow Stem Auger
HAMMER TYPE: Automatic Trip
DRILLING COMPANY: Gregg Drilling
LOGGED BY: E. von Thury
CHECKED BY: R. Zukor, P.G.

LOG OF WELL SBTB9-93

Guadalupe Restoration Project
Guadalupe, California

PLATE A-2d

The log and data presented are a simplification of actual conditions encountered at the time of drilling at the drilled location. Subsurface conditions may differ at other locations and with the passage of time. Please refer to Key to Boring Log for symbol explanation.

October 2018
Project No. 1801-2191

padre associates, inc.
ENGINEERS, GEOLOGISTS & ENVIRONMENTAL SCIENTISTS

LOCATION: Tank Battery 9 Area
SURFACE ELEVATION: 60.91 ft +/- (relative datum MSL)
NORTHING: 545957.51
EASTING: 1215062.03
COORDINATE SYSTEM: NAD27 SP Ca Zn 5, ft

ELEVATION, ft / DEPTH, ft	USCS MATERIAL SYMBOL	SAMPLE ID	SAMPLE INTERVAL	SAMPLER BLOW COUNT/	MATERIAL DESCRIPTION	UNIT WET WEIGHT, pcf	UNIT DRY WEIGHT, pcf	WATER CONTENT, %	% PASSING #200 SIEVE	LIQUID LIMIT, %	PLASTICITY INDEX, %	UNDRAINED SHEAR STRENGTH, S_u, ksf	GAS MONITOR: MultiRAE Lite (ppm)
60 / 0		SBTB9-94-0to5-081418			**GUADALUPE SAND DUNE COMPLEX** Poorly graded SAND (SP), loose, dark yellowish brown (10YR 3/4), slightly moist, medium grained, moderate HC odor								
58 / 2													
56 / 4		SBTB9-94-5-081418		27	Poorly graded SAND with silt (SP-SM), medium dense, dark yellowish brown (10YR 4/6), dry			2	7				0.7
54 / 6					Poorly graded SAND (SP), HTP liner encountered, no hydrocarbon odor Light brownish yellow (10YR 6/4), moderate hydrocarbon odor, few oxidation stains								
52 / 8													
50 / 10		SBTB9-94-10-081418		25	Brown (10YR 5/4), moderate hydrocarbon odor								0.0
48 / 12		SBTB9-94-12.5-081418			Yellowish brown (10YR 5/6), trace oxidation stains								
46 / 14													

U:\GINT\2-GRP\TB9\TB9-2018\GRP_TB9_1801-2191.GPJ 10/3/18 04:20 p. Template: PADRE_GEOW/ PIDNOWELL_APPA

DRILLING DATE: August 14, 2018
DEPTH TO GROUNDWATER: 29.0 ft
COMPLETION DEPTH: 40.0 ft
BACKFILLED WITH: Bentonite Grout

DRILLING/SAMPLING METHOD: 8-in. dia. Hollow Stem Auger
HAMMER TYPE: Automatic Trip
DRILLING COMPANY: Gregg Drilling
LOGGED BY: E. von Thury
CHECKED BY: R. Zukor, P.G.

LOG OF WELL SBTB9-94

Guadalupe Restoration Project
Guadalupe, California

PLATE A-3a

The log and data presented are a simplification of actual conditions encountered at the time of drilling at the drilled location. Subsurface conditions may differ at other locations and with the passage of time. Please refer to Key to Boring Log for symbol explanation.

October 2018
Project No. 1801-2191

padre associates, inc.
ENGINEERS, GEOLOGISTS & ENVIRONMENTAL SCIENTISTS

LOCATION: Tank Battery 9 Area
SURFACE ELEVATION: 60.91 ft +/- (relative datum MSL)
NORTHING: 545957.51
EASTING: 1215062.03
COORDINATE SYSTEM: NAD27 SP Ca Zn 5, ft

ELEVATION, ft / DEPTH, ft	USCS MATERIAL SYMBOL	SAMPLE ID	SAMPLE INTERVAL	SAMPLER BLOW COUNT/	MATERIAL DESCRIPTION	UNIT WET WEIGHT, pcf	UNIT DRY WEIGHT, pcf	WATER CONTENT, %	% PASSING #200 SIEVE	LIQUID LIMIT, %	PLASTICITY INDEX, %	UNDRAINED SHEAR STRENGTH, S_u, ksf	GAS MONITOR: MultiRAE Lite (ppm)
16 / 44		SBTB9-94-15-081418		30	Slightly moist, medium grained, no hydrocarbon odor								0.8
18 / 42		SBTB9-94-17.5-081418											
20 / 40		SBTB9-94-20-081418		34	Dense, light yellowish brown (10YR 6/4), no hydrocarbon odor, trace oxidation staining				3				0.1
22 / 38		SBTB9-94-22.5-081418											
24 / 36		SBTB9-94-25-081418		54	Very dense, light yellowish brown (10YR 5/6), moist, no hydrocarbon odor, trace oxidation staining				3				0.3
26 / 34													
28 / 32													

U:\GINT\2-GRP\TB9\TB9-2018\GRP_TB9_1801-2191.GPJ 10/3/18 04:20 p. Template: PADRE_GEOW/ PIDNOWELL_APPA

DRILLING DATE: August 14, 2018
DEPTH TO GROUNDWATER: 29.0 ft
COMPLETION DEPTH: 40.0 ft
BACKFILLED WITH: Bentonite Grout

DRILLING/SAMPLING METHOD: 8-in. dia. Hollow Stem Auger
HAMMER TYPE: Automatic Trip
DRILLING COMPANY: Gregg Drilling
LOGGED BY: E. von Thury
CHECKED BY: R. Zukor, P.G.

LOG OF WELL SBTB9-94

Guadalupe Restoration Project
Guadalupe, California

PLATE A-3b

The log and data presented are a simplification of actual conditions encountered at the time of drilling at the drilled location. Subsurface conditions may differ at other locations and with the passage of time. Please refer to Key to Boring Log for symbol explanation.

October 2018
Project No. 1801-2191

padre associates, inc.
ENGINEERS, GEOLOGISTS & ENVIRONMENTAL SCIENTISTS

LOCATION: Tank Battery 9 Area
SURFACE ELEVATION: 60.91 ft +/- (relative datum MSL)
NORTHING: 545957.51
EASTING: 1215062.03
COORDINATE SYSTEM: NAD27 SP Ca Zn 5, ft

ELEVATION, ft DEPTH, ft	USCS MATERIAL SYMBOL	SAMPLE ID	SAMPLE INTERVAL	SAMPLER BLOW COUNT/	MATERIAL DESCRIPTION	UNIT WET WEIGHT, pcf	UNIT DRY WEIGHT, pcf	WATER CONTENT, %	% PASSING #200 SIEVE	LIQUID LIMIT, %	PLASTICITY INDEX, %	UNDRAINED SHEAR STRENGTH, S_u, ksf	GAS MONITOR: MultiRAE Lite (ppm)
		SBTB9-94-30-081418		32	Dense, dark yellowish brown (10YR 4/6), wet, no hydrocarbon odor								0.1
-30													
32													
-28													
34													
-26		SBTB9-94-35-081418		13	Loose, no hydrocarbon odor, heaving sands			19	3				0.8
		SBTB9-94-35.75-081418			**CONFINING UNIT** Lean CLAY with sand (CL), stiff, dark yellowish brown (10YR 4/4), moist, no hydrocarbon odor			20	81	27	19		0.0
36		SBTB9-94-36.5-081418			Trace ocidation staining			31		46	14		0.3
-24					Lean CLAY (CL), stiff, dark yellowish brown (10YR 4/4), moist, no hydrocarbon odor								
38													
-22													
40													
-20													
42													
-18													
44													
-16													

U:\GINT\2-GRP\TB9\TB9-2018\GRP_TB9_1801-2191.GPJ 10/3/18 04:20 p. Template: PADRE_GEOW/ PIDNOWELL_APPA

DRILLING DATE: August 14, 2018
DEPTH TO GROUNDWATER: 29.0 ft
COMPLETION DEPTH: 40.0 ft
BACKFILLED WITH: Bentonite Grout

DRILLING/SAMPLING METHOD: 8-in. dia. Hollow Stem Auger
HAMMER TYPE: Automatic Trip
DRILLING COMPANY: Gregg Drilling
LOGGED BY: E. von Thury
CHECKED BY: R. Zukor, P.G.

LOG OF WELL SBTB9-94

Guadalupe Restoration Project
Guadalupe, California

PLATE A-3c

The log and data presented are a simplification of actual conditions encountered at the time of drilling at the drilled location. Subsurface conditions may differ at other locations and with the passage of time. Please refer to Key to Boring Log for symbol explanation.

GREGG DRILLING, INC.
www.greggdrilling.com

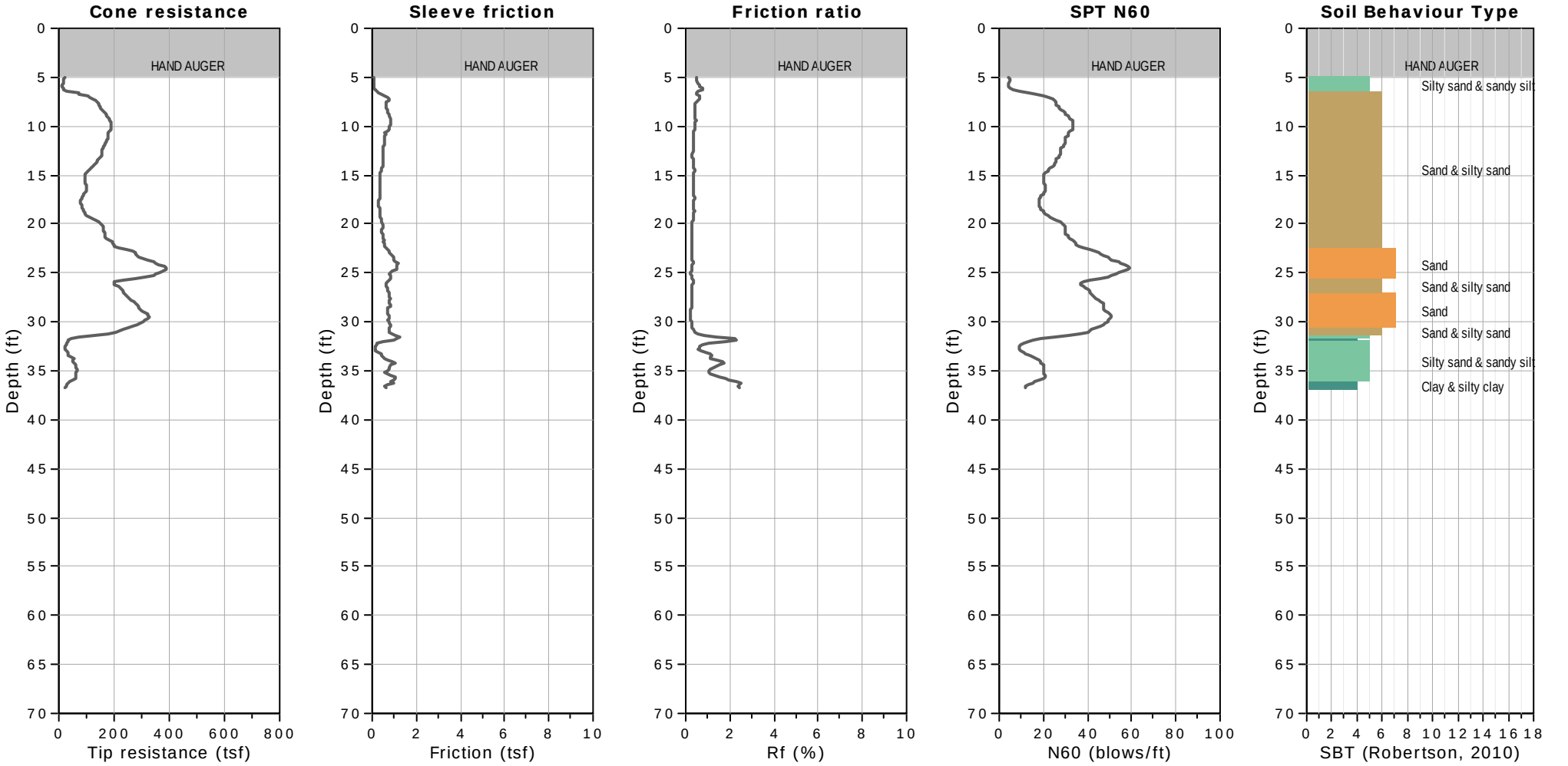
CPT: TSMACPT-1

CLIENT: PADRE ASSOCIATES, INC.

Field Rep: EVA

SITE: GUADALUPE RESTORATION PROJECT - SAN LUIS OBISPO, CA

Total depth: 36.75 ft, Date: 8/15/2018



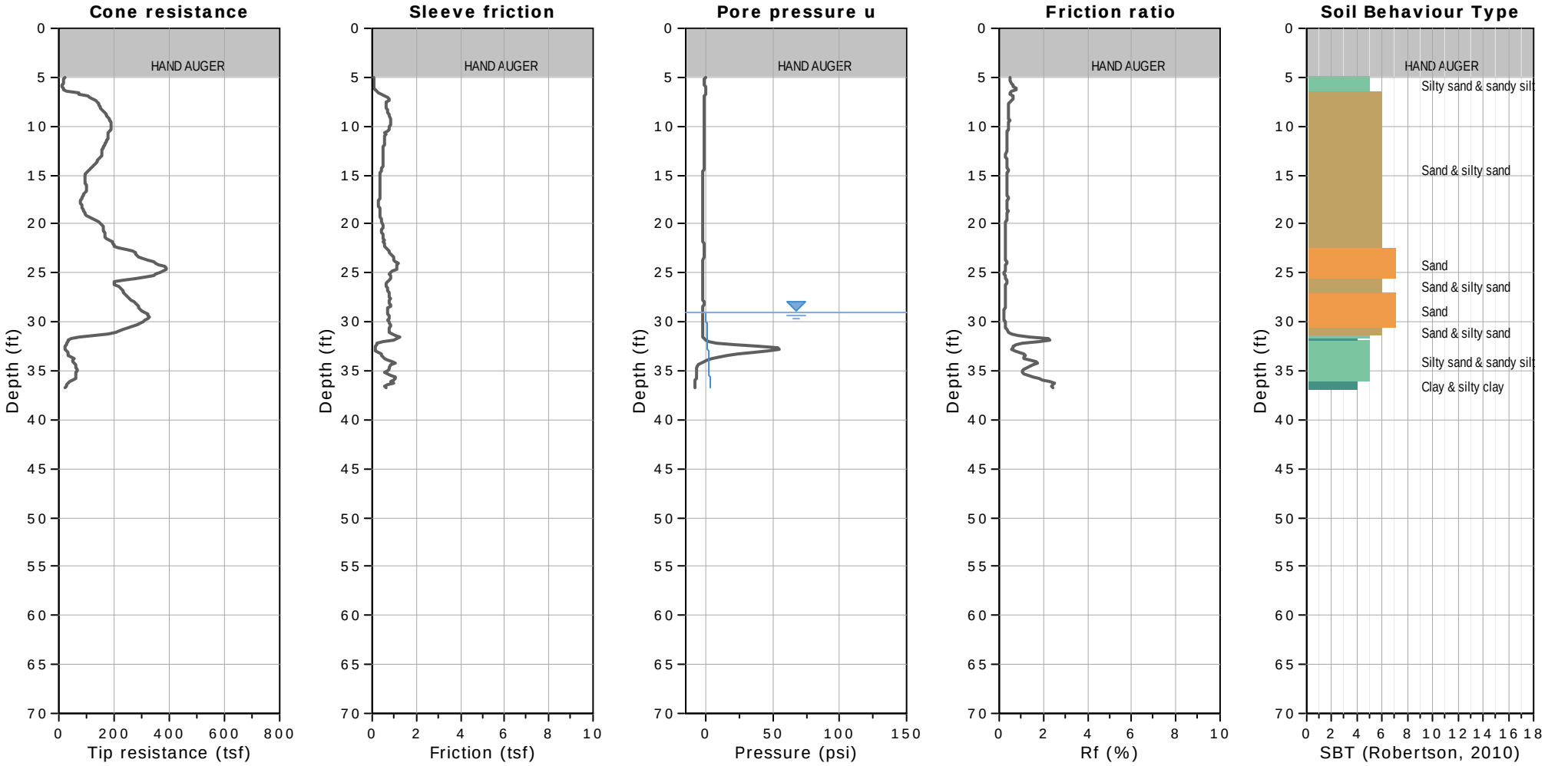
CPT: TSMACPT-1

CLIENT: PADRE ASSOCIATES, INC.

SITE: GUADALUPE RESTORATION PROJECT - SAN LUIS OBISPO, CA

Field Rep: EVA

Total depth: 36.75 ft, Date: 8/15/2018



SBTn legend

1. Sensitive fine grained
2. Organic material
3. Clay to silty clay
4. Clayey silt to silty clay
5. Silty sand to sandy silt
6. Clean sand to silty sand
7. Gravely sand to sand
8. Very stiff sand to clayey sand
9. Very stiff fine grained

WATER TABLE FOR ESTIMATING PURPOSES ONLY

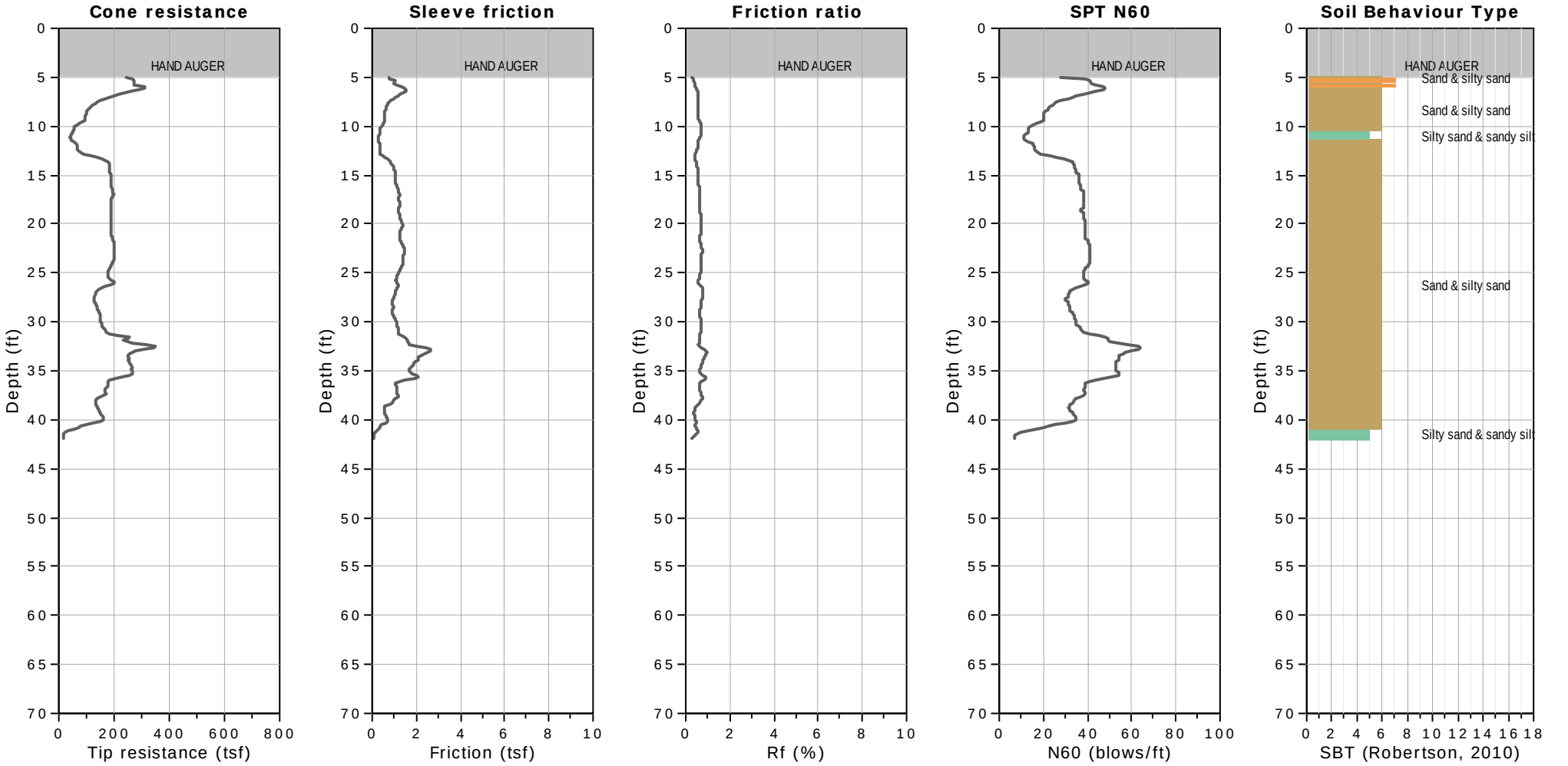
CPT: TSMACPT-2

CLIENT: PADRE ASSOCIATES, INC.

SITE: GUADALUPE RESTORATION PROJECT - SAN LUIS OBISPO, CA

Field Rep: EVA

Total depth: 41.83 ft, Date: 8/14/2018



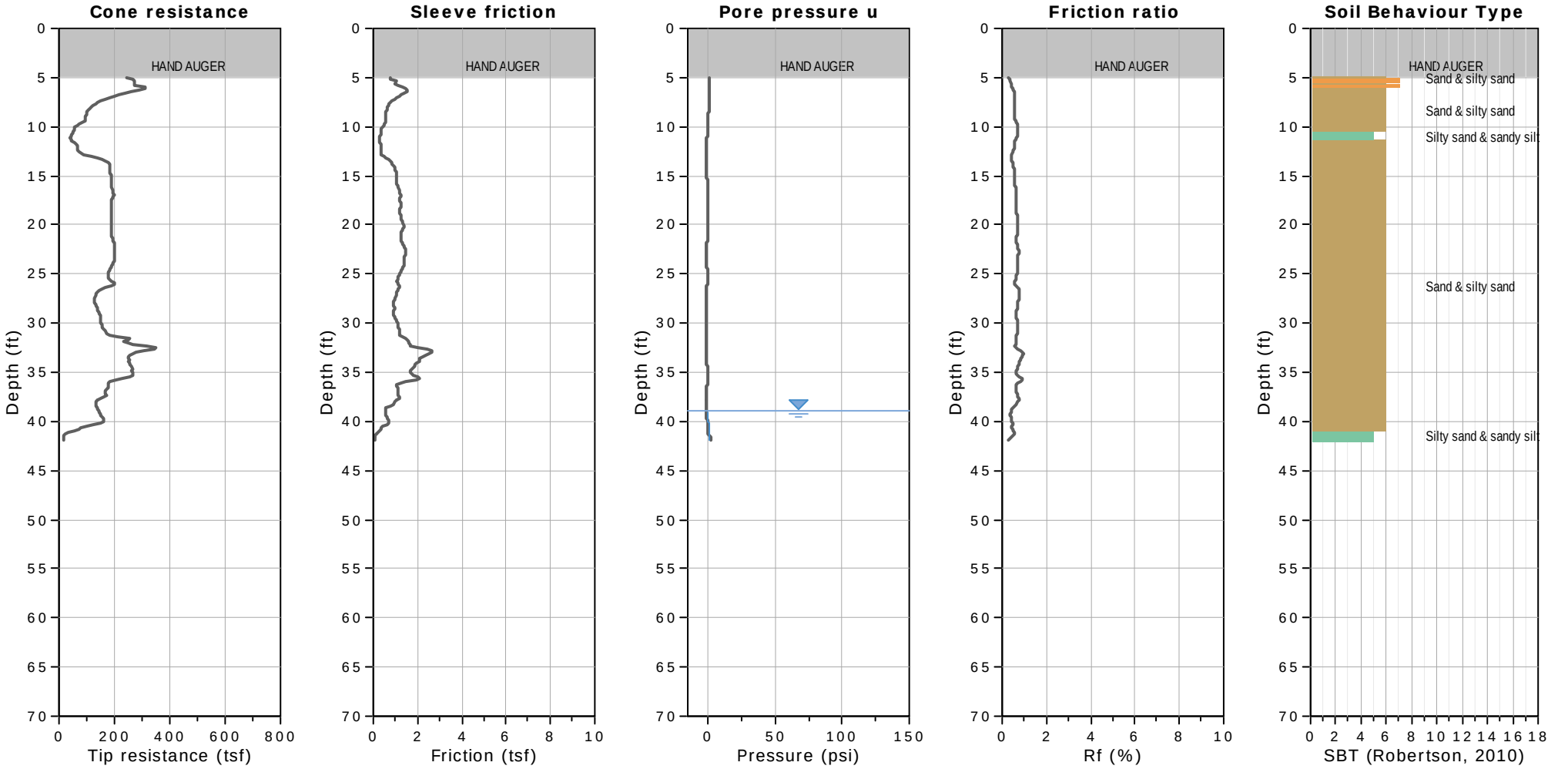
CPT: TSMACPT-2

CLIENT: PADRE ASSOCIATES, INC.

SITE: GUADALUPE RESTORATION PROJECT - SAN LUIS OBISPO, CA

Field Rep: EVA

Total depth: 41.83 ft, Date: 8/14/2018



SBTn legend

1. Sensitive fine grained
2. Organic material
3. Clay to silty clay
4. Clayey silt to silty clay
5. Silty sand to sandy silt
6. Clean sand to silty sand
7. Gravely sand to sand
8. Very stiff sand to clayey sand
9. Very stiff fine grained

WATER TABLE FOR ESTIMATING PURPOSES ONLY

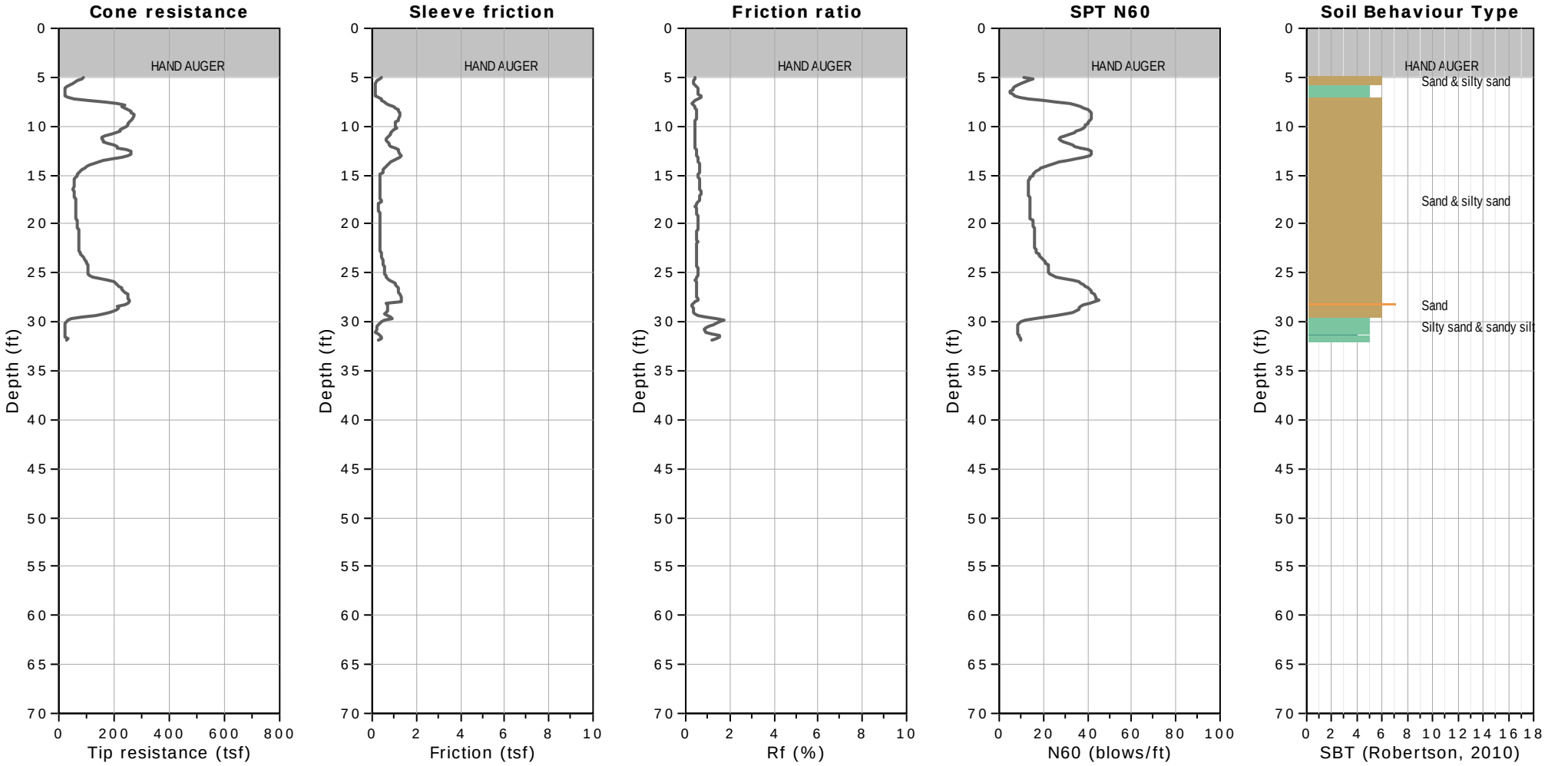
CPT: TSMACPT-3

CLIENT: PADRE ASSOCIATES, INC.

Field Rep: EVA

SITE: GUADALUPE RESTORATION PROJECT - SAN LUIS OBISPO, CA

Total depth: 31.82 ft, Date: 8/20/2018



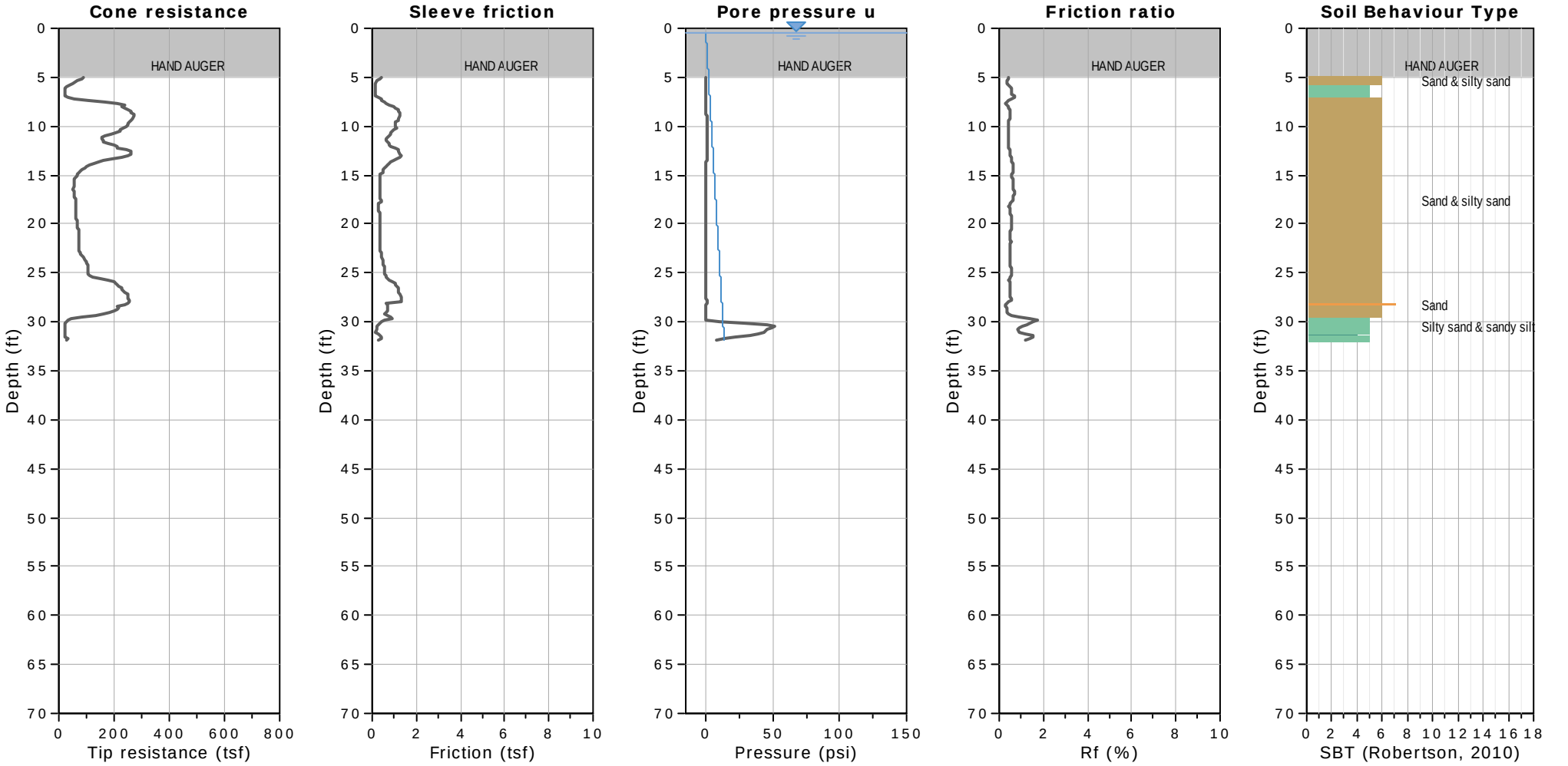
CPT: TSMACPT-3

CLIENT: PADRE ASSOCIATES, INC.

Field Rep: EVA

SITE: GUADALUPE RESTORATION PROJECT - SAN LUIS OBISPO, CA

Total depth: 31.82 ft, Date: 8/20/2018



WATER TABLE FOR ESTIMATING PURPOSES ONLY

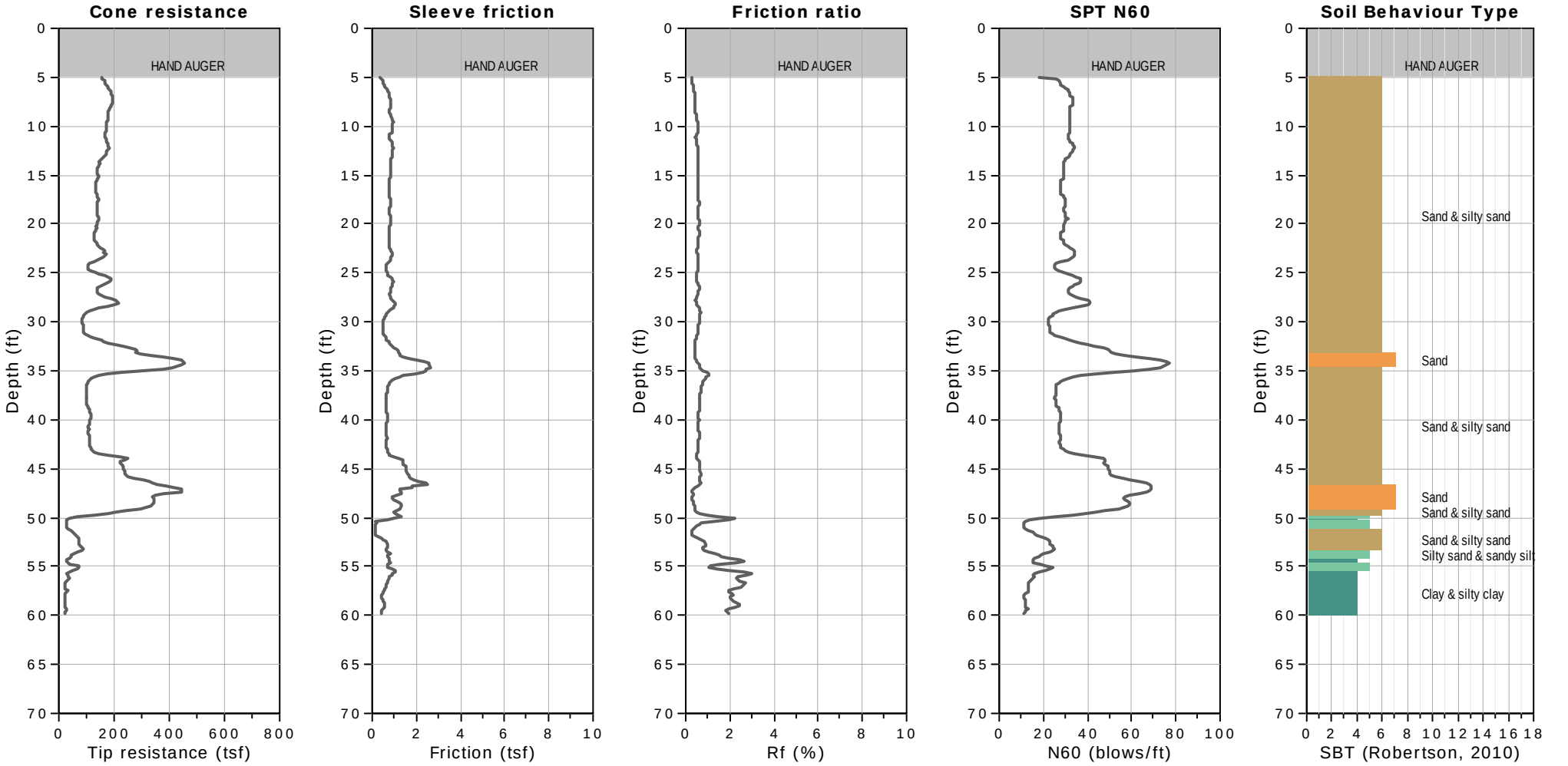
CPT: TSMACPT-4

CLIENT: PADRE ASSOCIATES, INC.

SITE: GUADALUPE RESTORATION PROJECT - SAN LUIS OBISPO, CA

Field Rep: EVA

Total depth: 59.88 ft, Date: 8/14/2018

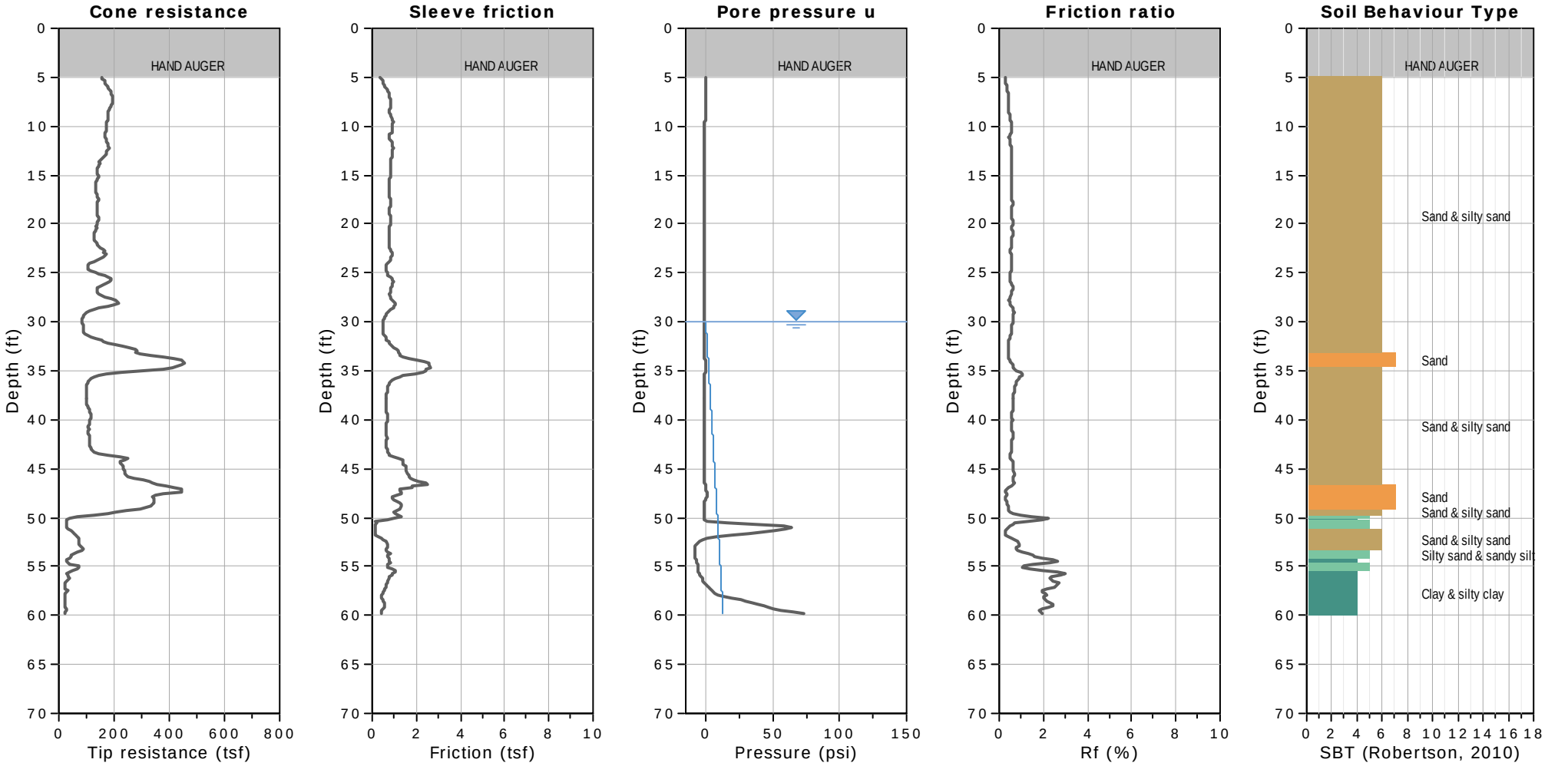


CLIENT: PADRE ASSOCIATES, INC.

SITE: GUADALUPE RESTORATION PROJECT - SAN LUIS OBISPO, CA

Field Rep: EVA

Total depth: 59.88 ft, Date: 8/14/2018



WATER TABLE FOR ESTIMATING PURPOSES ONLY

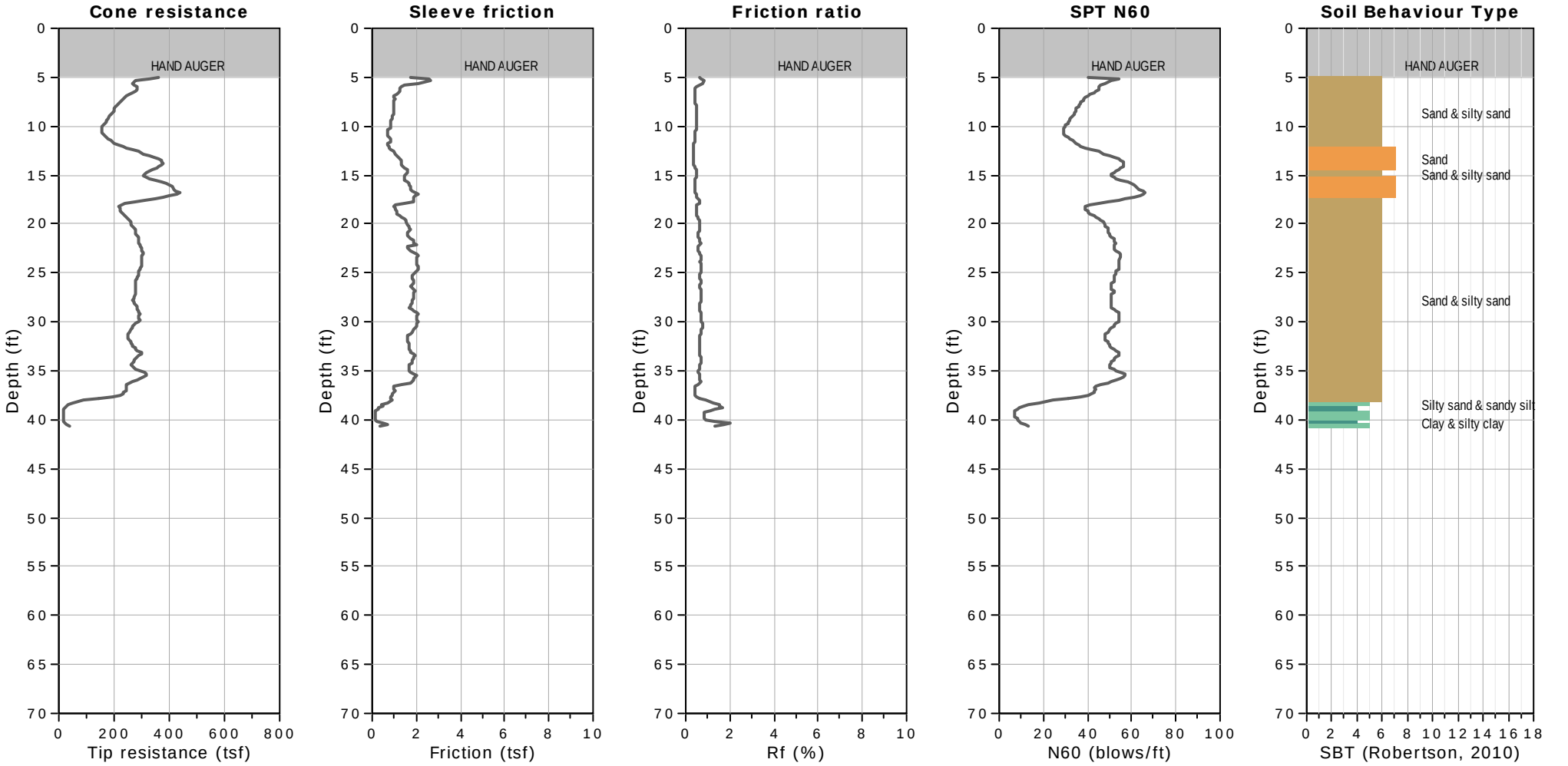
CPT: TSMACPT-5

CLIENT: PADRE ASSOCIATES, INC.

SITE: GUADALUPE RESTORATION PROJECT - SAN LUIS OBISPO, CA

Field Rep: EVA

Total depth: 40.68 ft, Date: 8/20/2018



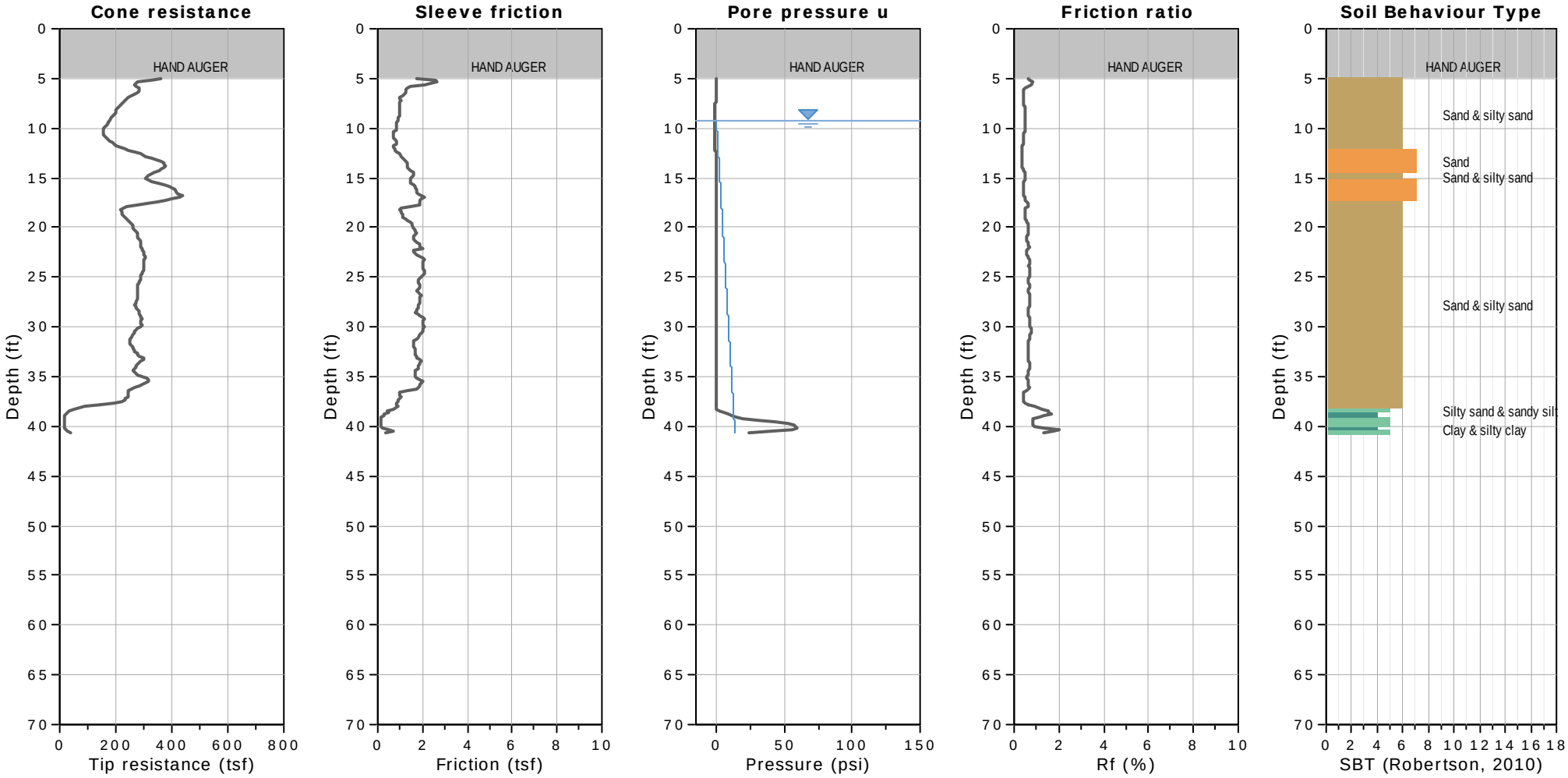
CPT: TSMACPT-5

CLIENT: PADRE ASSOCIATES, INC.

SITE: GUADALUPE RESTORATION PROJECT - SAN LUIS OBISPO, CA

Field Rep: EVA

Total depth: 40.68 ft, Date: 8/20/2018



SBTn legend

1. Sensitive fine grained
2. Organic material
3. Clay to silty clay
4. Clayey silt to silty clay
5. Silty sand to sandy silt
6. Clean sand to silty sand
7. Gravely sand to sand
8. Very stiff sand to clayey sand
9. Very stiff fine grained

WATER TABLE FOR ESTIMATING PURPOSES ONLY

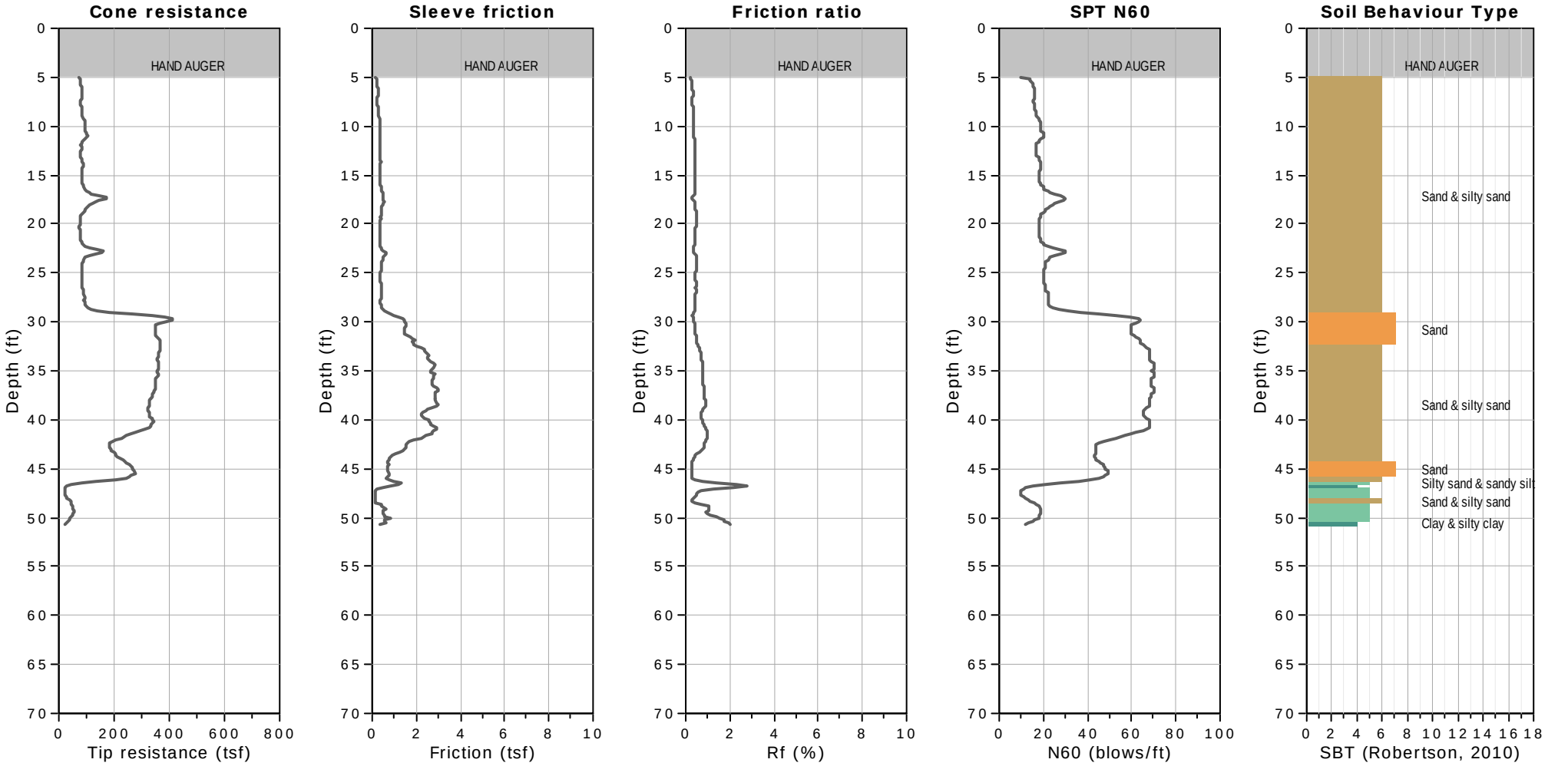
CPT: TSMACPT-6

CLIENT: PADRE ASSOCIATES, INC.

SITE: GUADALUPE RESTORATION PROJECT - SAN LUIS OBISPO, CA

Field Rep: EVA

Total depth: 50.69 ft, Date: 8/16/2018



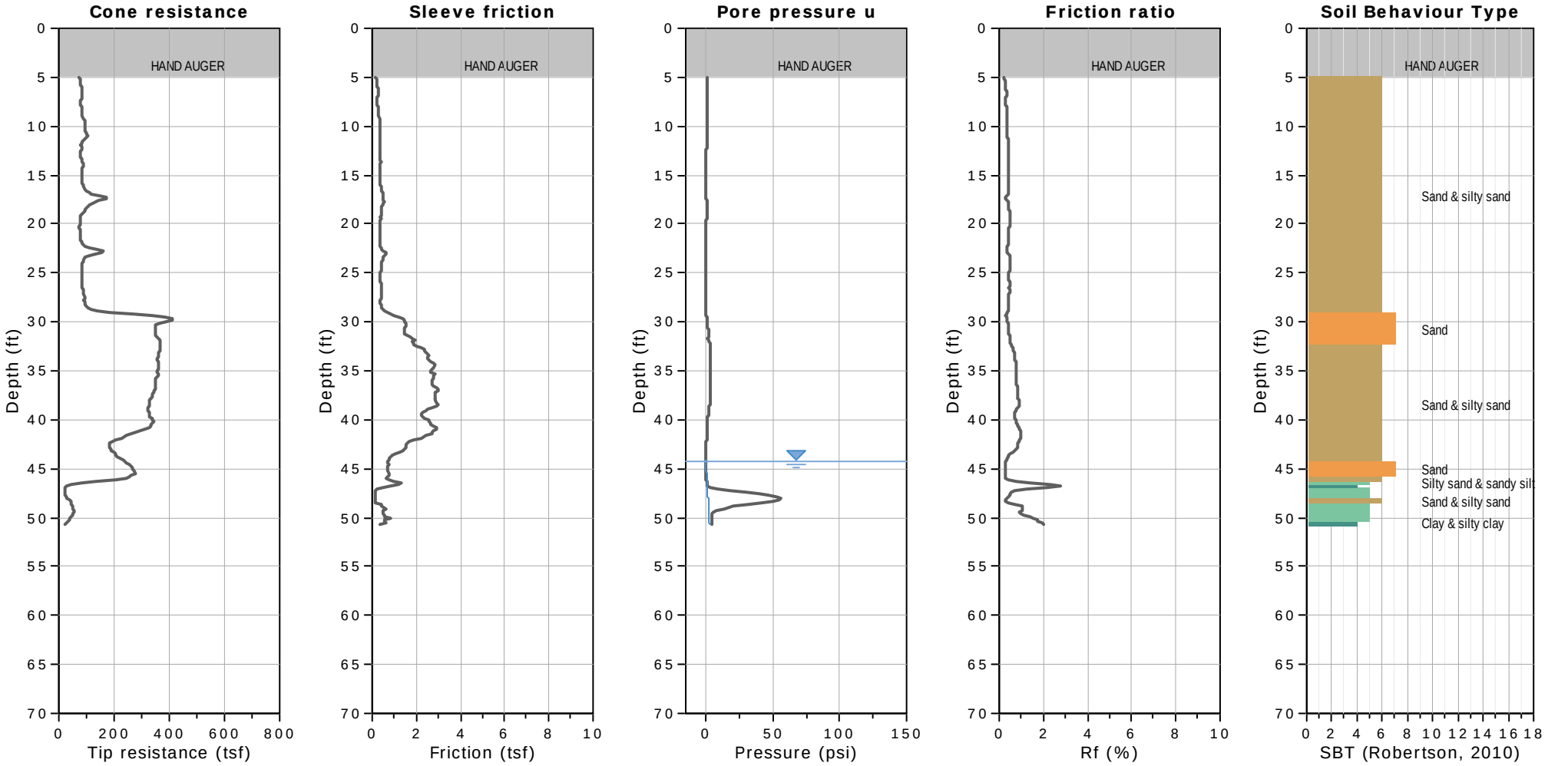
CPT: TSMACPT-6

CLIENT: PADRE ASSOCIATES, INC.

SITE: GUADALUPE RESTORATION PROJECT - SAN LUIS OBISPO, CA

Field Rep: EVA

Total depth: 50.69 ft, Date: 8/16/2018



WATER TABLE FOR ESTIMATING PURPOSES ONLY

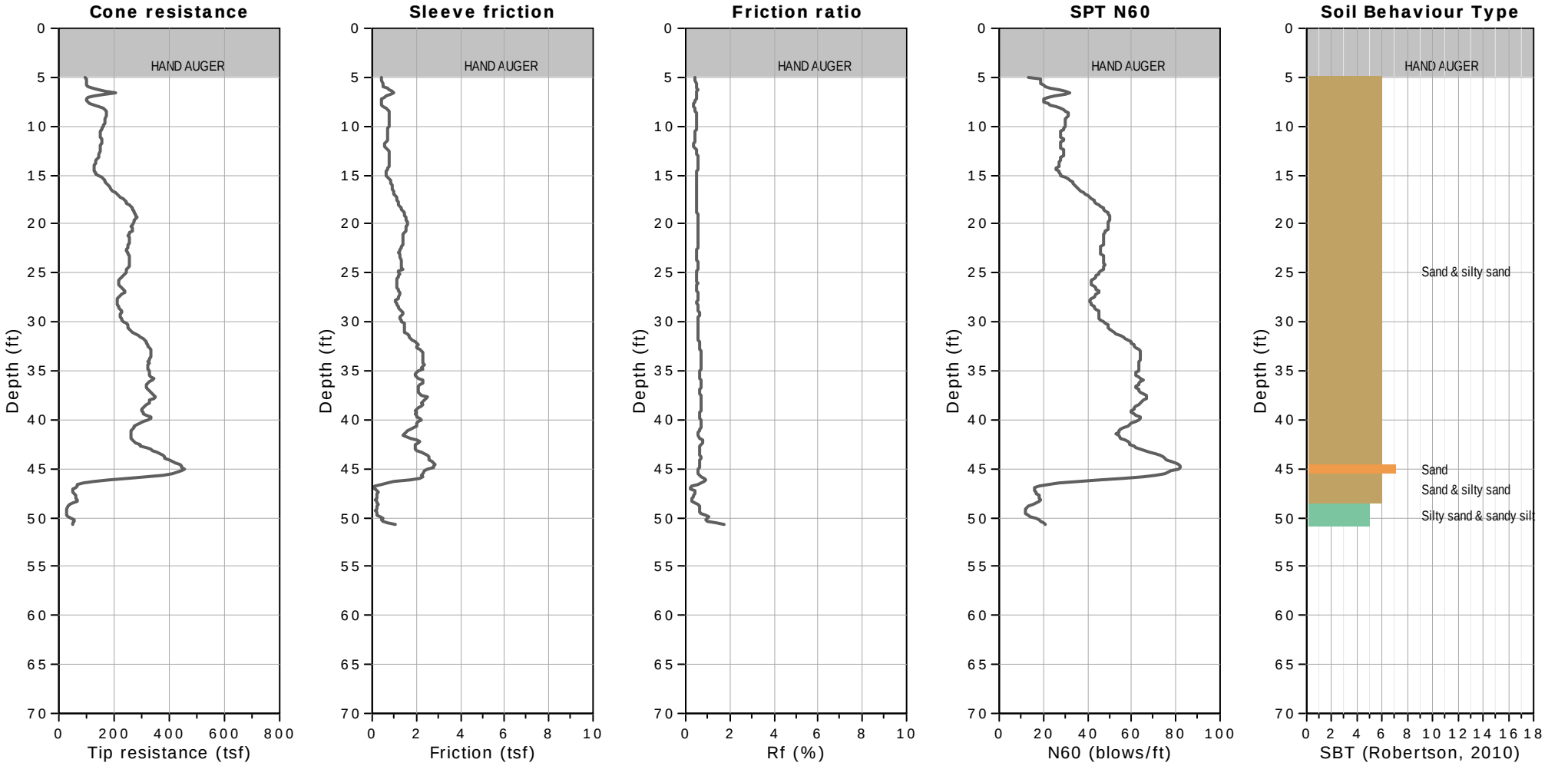
CPT: TSMACPT-7

CLIENT: PADRE ASSOCIATES, INC.

SITE: GUADALUPE RESTORATION PROJECT - SAN LUIS OBISPO, CA

Field Rep: EVA

Total depth: 50.69 ft, Date: 8/20/2018



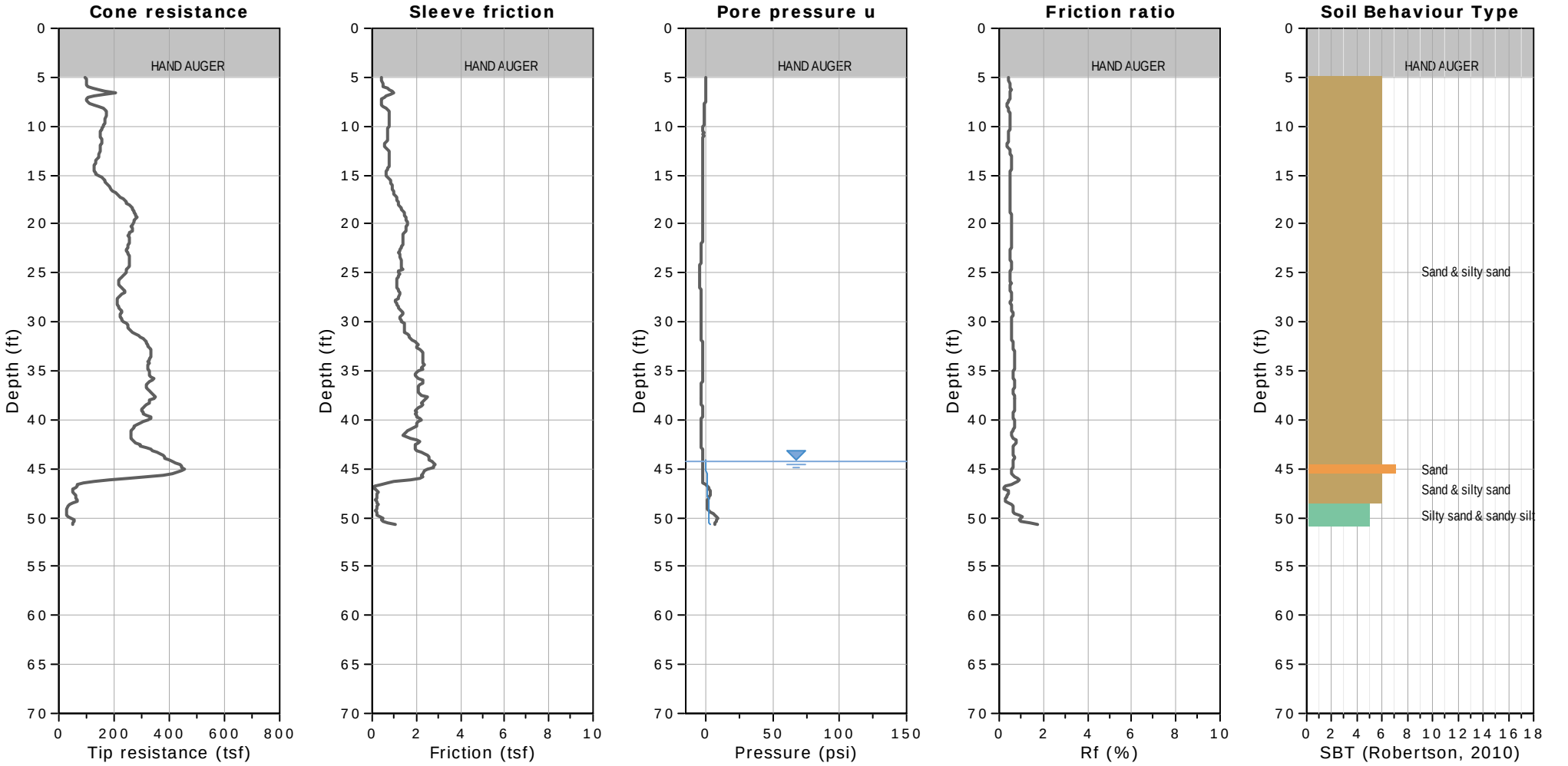
CPT: TSMACPT-7

CLIENT: PADRE ASSOCIATES, INC.

SITE: GUADALUPE RESTORATION PROJECT - SAN LUIS OBISPO, CA

Field Rep: EVA

Total depth: 50.69 ft, Date: 8/20/2018



WATER TABLE FOR ESTIMATING PURPOSES ONLY

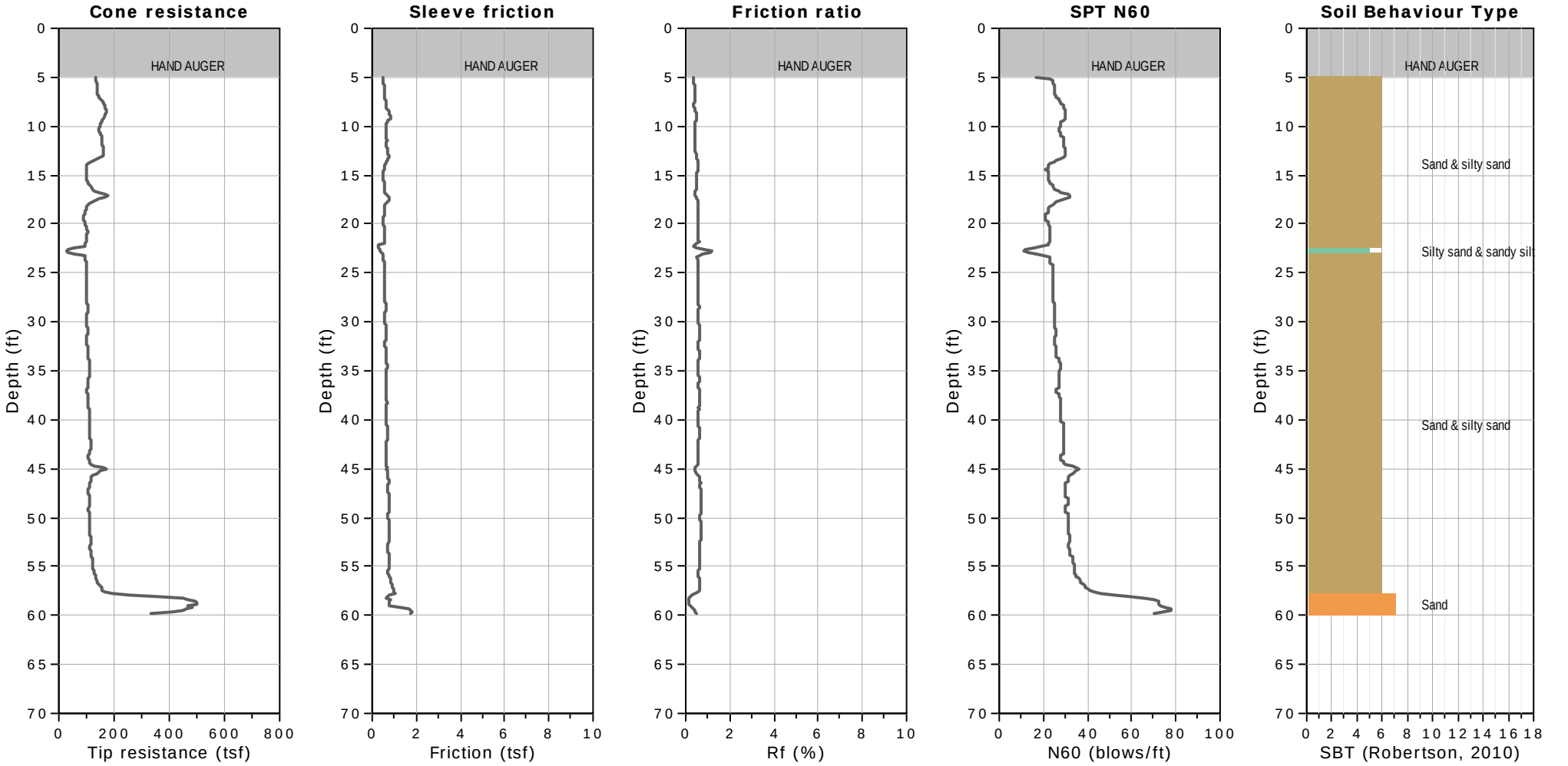
CPT: TSMACPT-8

CLIENT: PADRE ASSOCIATES, INC.

SITE: GUADALUPE RESTORATION PROJECT - SAN LUIS OBISPO, CA

Field Rep: EVA

Total depth: 59.88 ft, Date: 8/14/2018



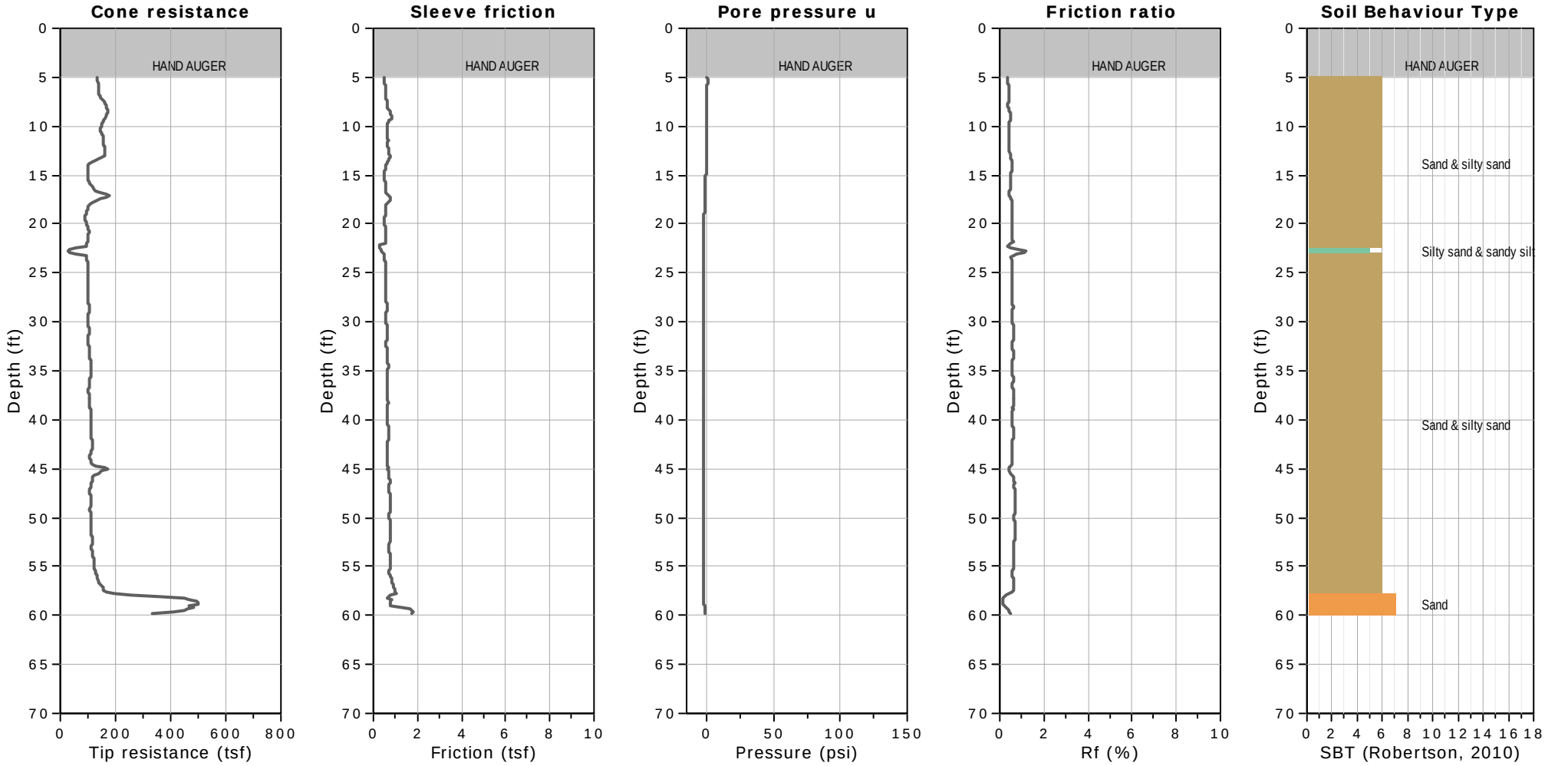
CPT: TSMACPT-8

CLIENT: PADRE ASSOCIATES, INC.

SITE: GUADALUPE RESTORATION PROJECT - SAN LUIS OBISPO, CA

Field Rep: EVA

Total depth: 59.88 ft, Date: 8/14/2018



WATER TABLE FOR ESTIMATING PURPOSES ONLY

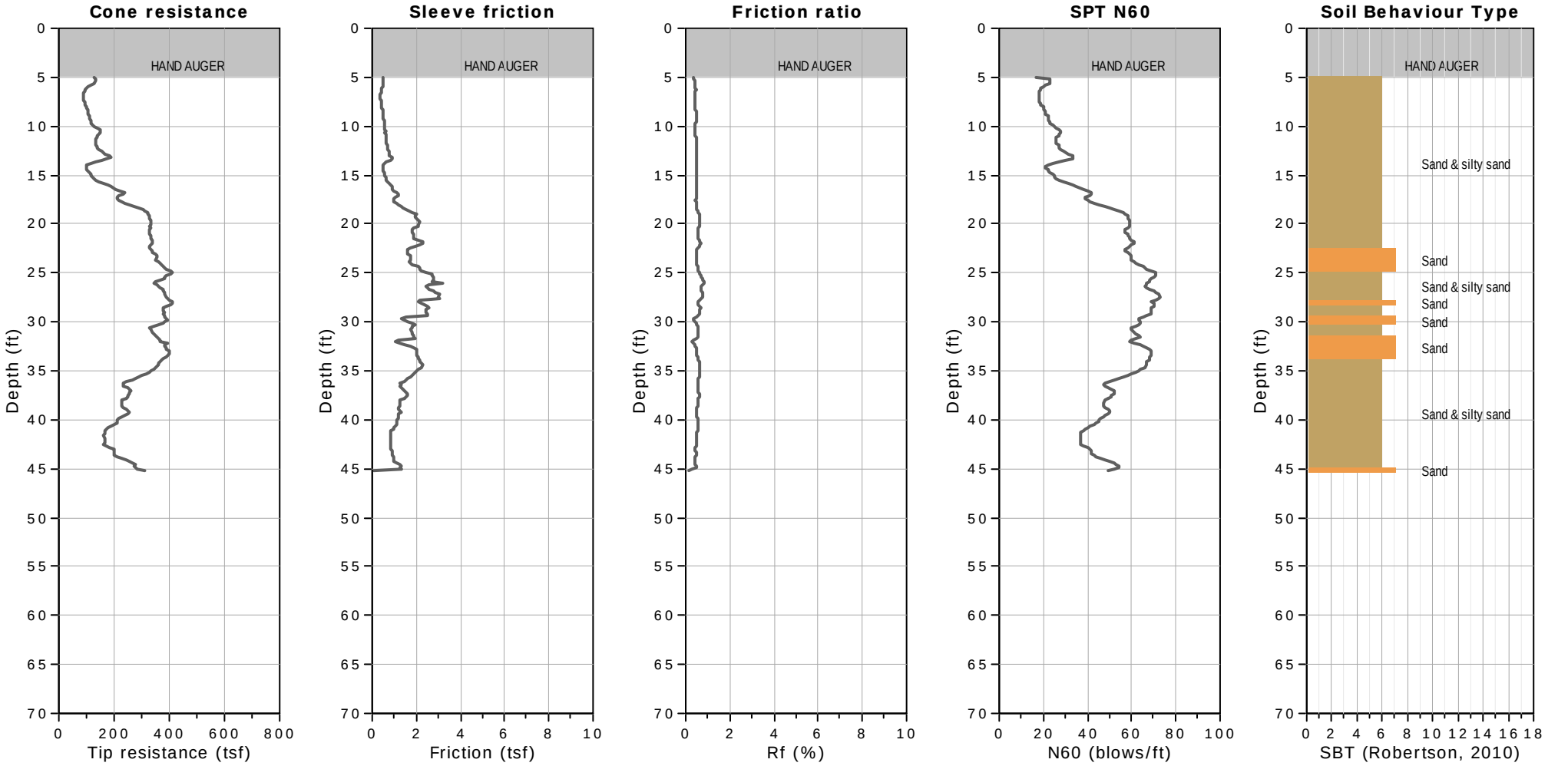
CPT: TSMACPT-9

CLIENT: PADRE ASSOCIATES, INC.

SITE: GUADALUPE RESTORATION PROJECT - SAN LUIS OBISPO, CA

Field Rep: EVA

Total depth: 45.28 ft, Date: 8/21/2018



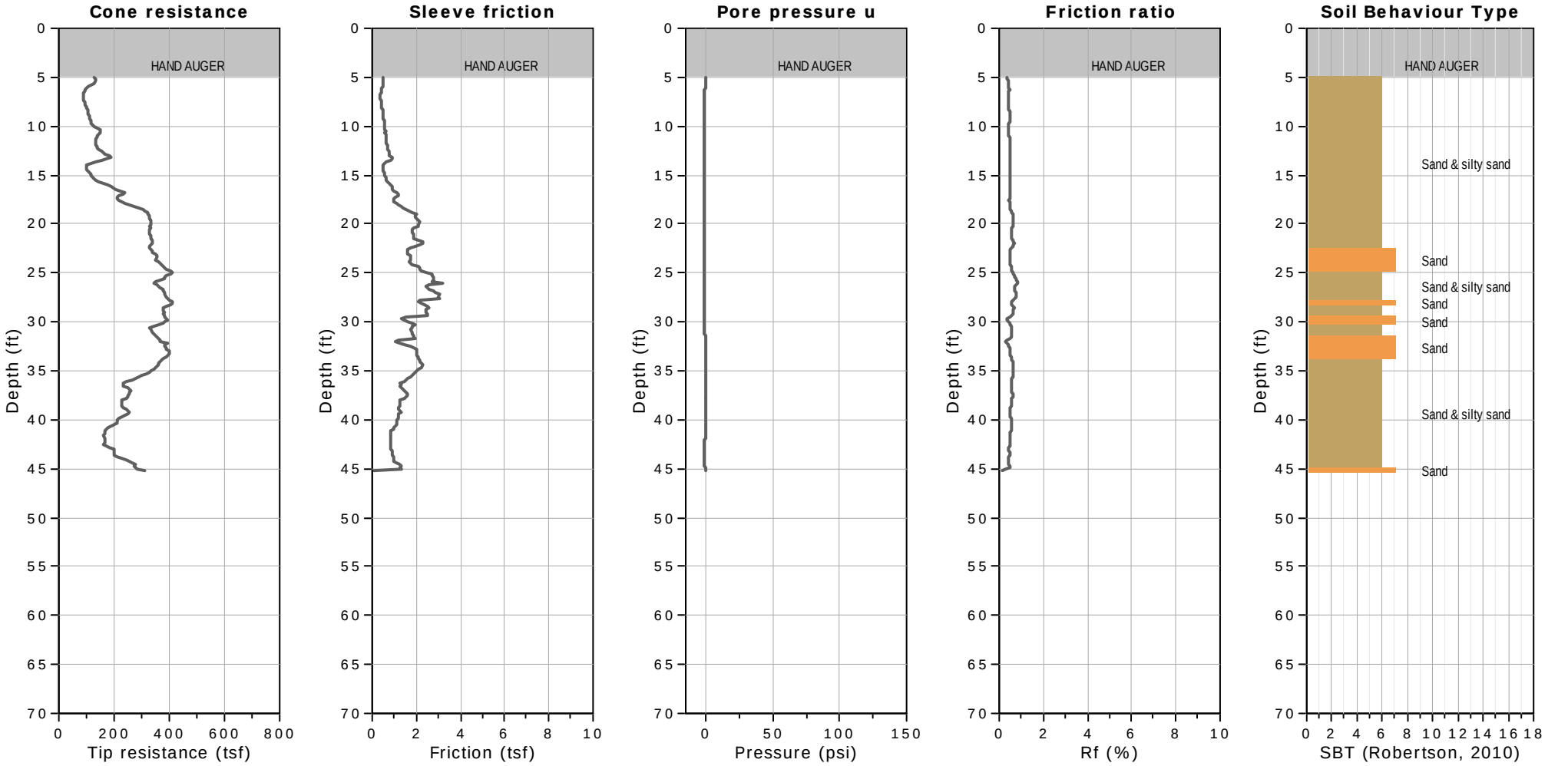
CPT: TSMACPT-9

CLIENT: PADRE ASSOCIATES, INC.

SITE: GUADALUPE RESTORATION PROJECT - SAN LUIS OBISPO, CA

Field Rep: EVA

Total depth: 45.28 ft, Date: 8/21/2018



WATER TABLE FOR ESTIMATING PURPOSES ONLY

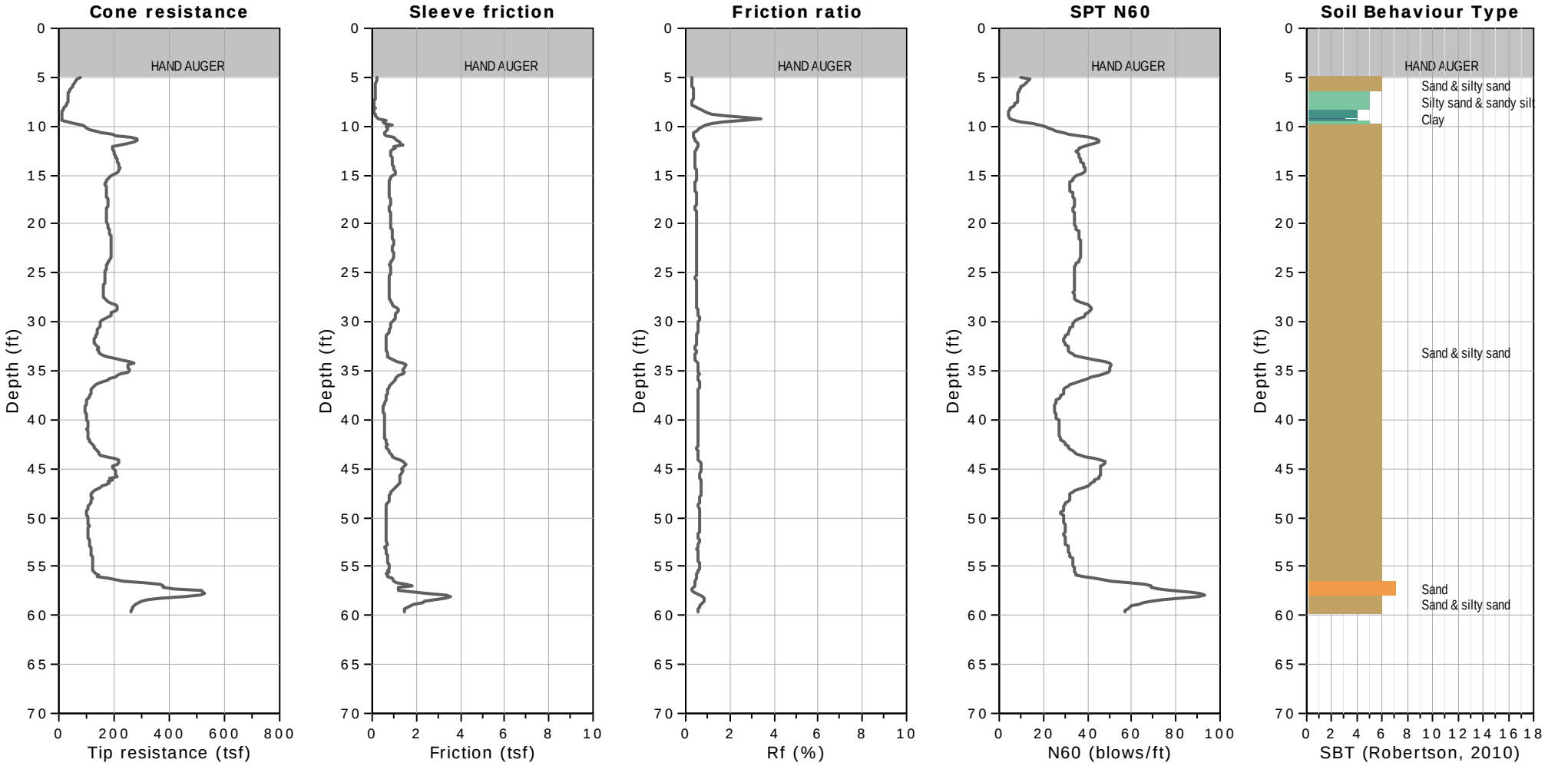
CPT: TSMACPT-10

CLIENT: PADRE ASSOCIATES, INC.

SITE: GUADALUPE RESTORATION PROJECT - SAN LUIS OBISPO, CA

Field Rep: EVA

Total depth: 59.71 ft, Date: 8/21/2018



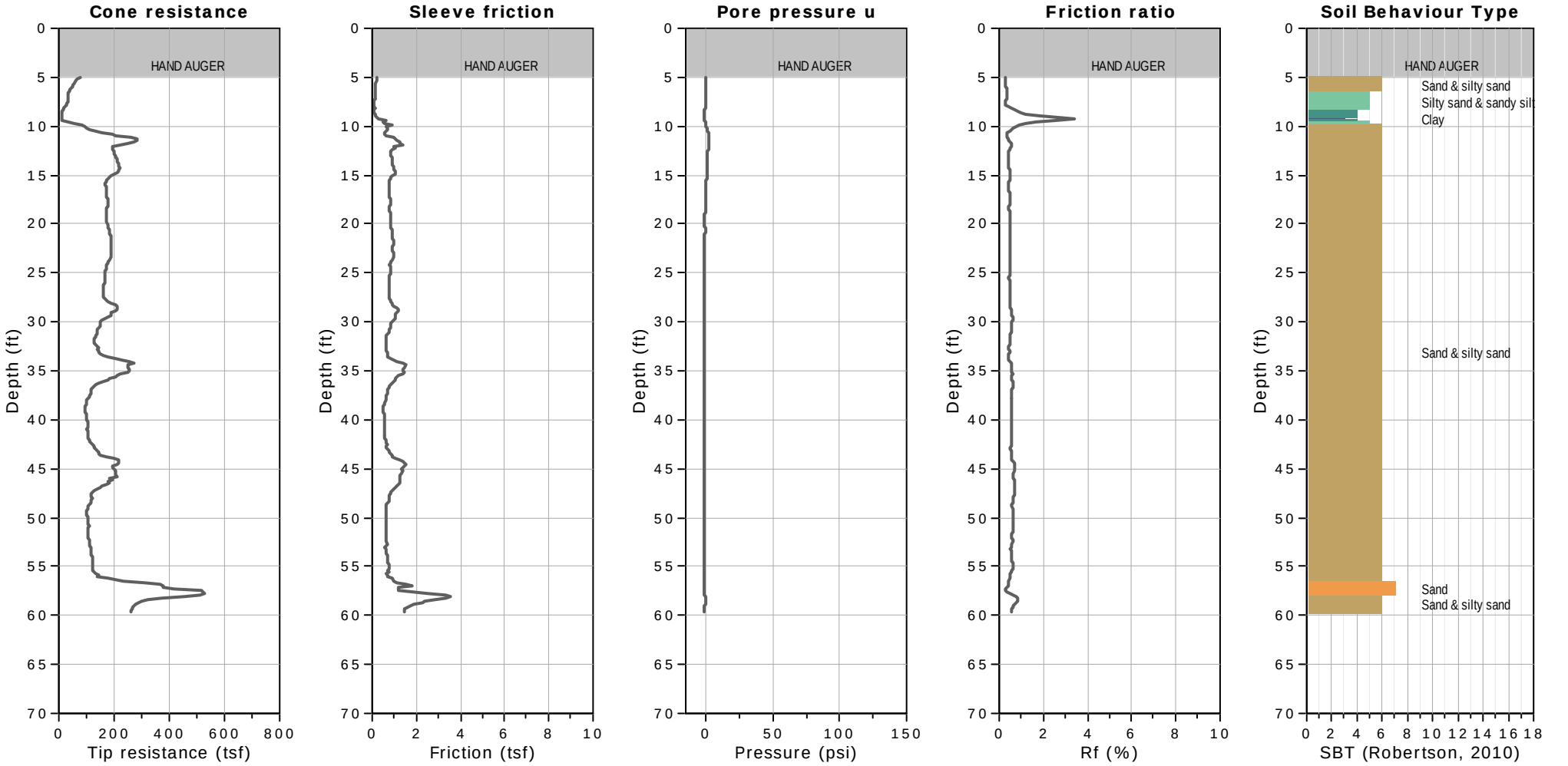
CPT: TSMACPT-10

CLIENT: PADRE ASSOCIATES, INC.

SITE: GUADALUPE RESTORATION PROJECT - SAN LUIS OBISPO, CA

Field Rep: EVA

Total depth: 59.71 ft, Date: 8/21/2018



WATER TABLE FOR ESTIMATING PURPOSES ONLY

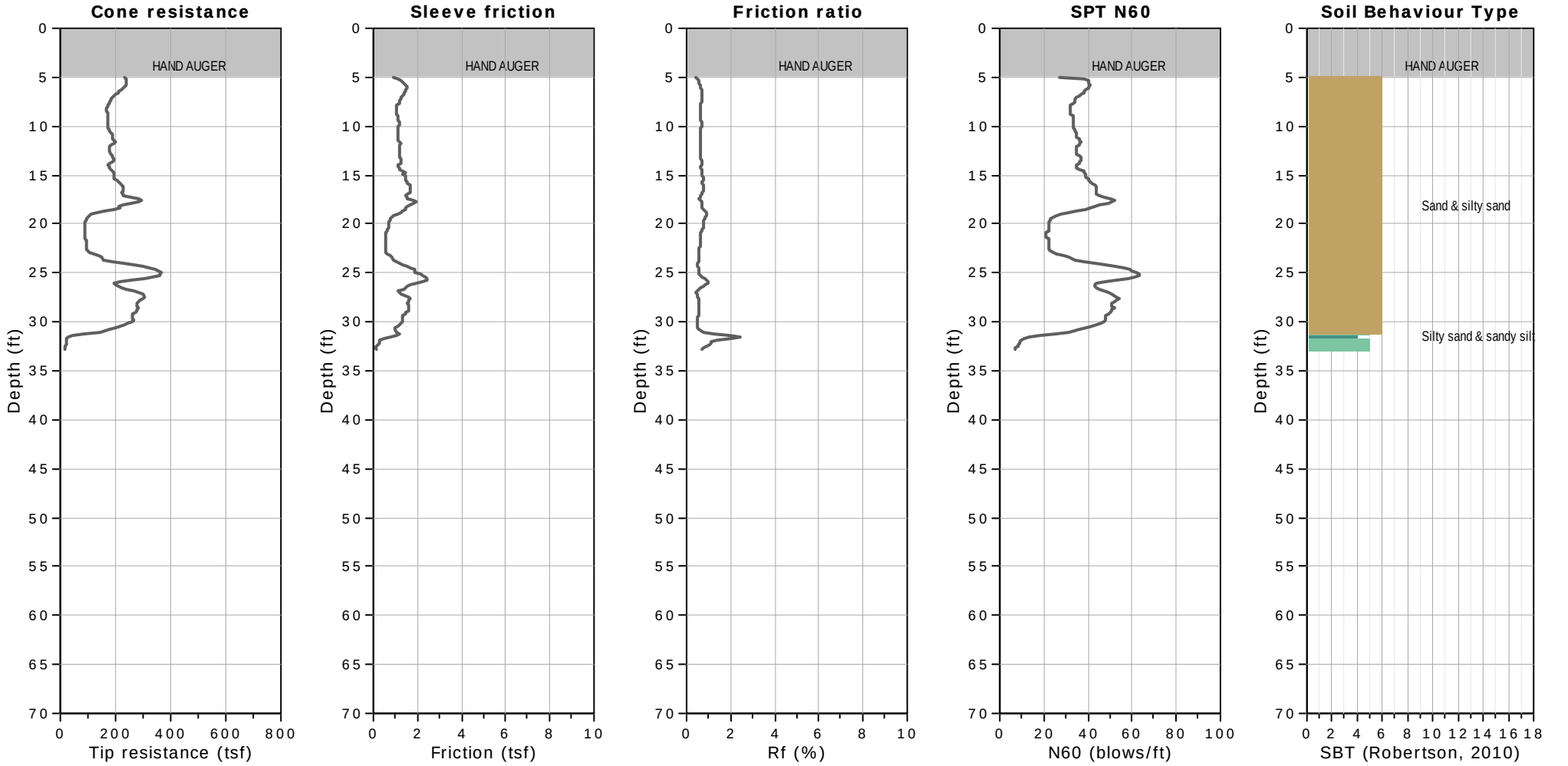
CPT: TSMACPT-11

CLIENT: PADRE ASSOCIATES, INC.

SITE: GUADALUPE RESTORATION PROJECT - SAN LUIS OBISPO, CA

Field Rep: EVA

Total depth: 32.81 ft, Date: 8/15/2018



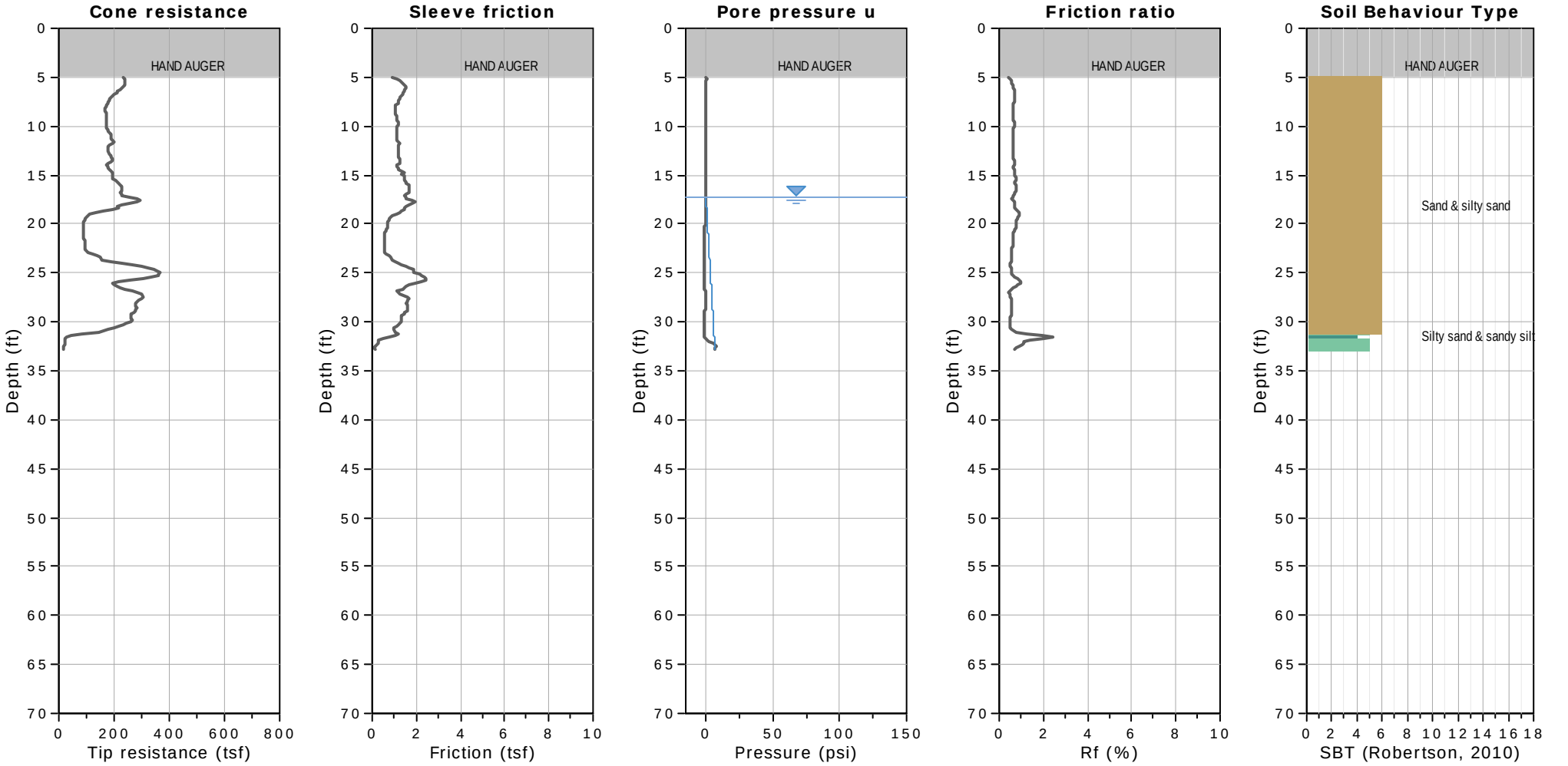
CPT: TSMACPT-11

CLIENT: PADRE ASSOCIATES, INC.

SITE: GUADALUPE RESTORATION PROJECT - SAN LUIS OBISPO, CA

Field Rep: EVA

Total depth: 32.81 ft, Date: 8/15/2018



WATER TABLE FOR ESTIMATING PURPOSES ONLY

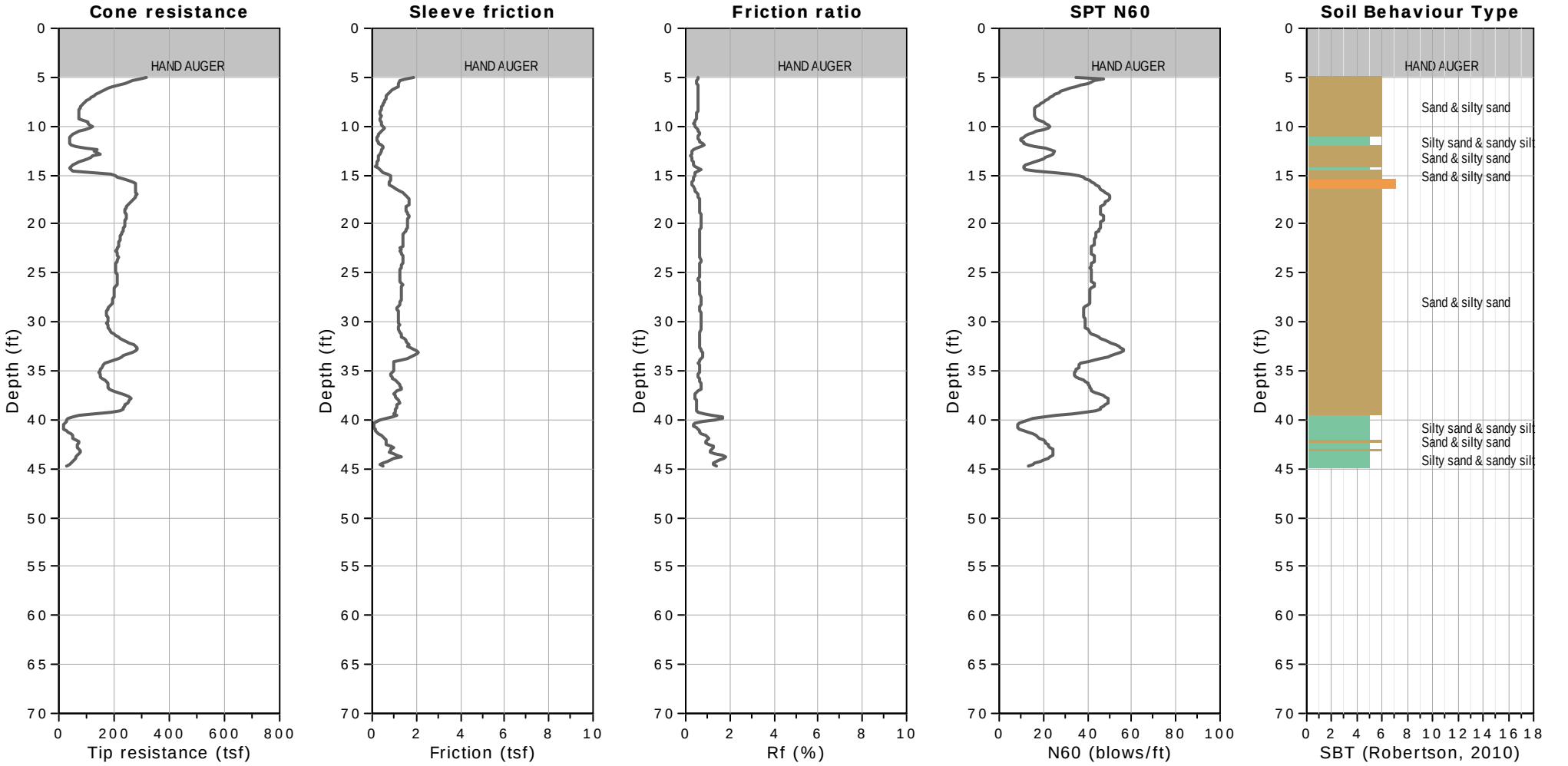
CPT: TSMACPT-12

CLIENT: PADRE ASSOCIATES, INC.

SITE: GUADALUPE RESTORATION PROJECT - SAN LUIS OBISPO, CA

Field Rep: EVA

Total depth: 44.78 ft, Date: 8/15/2018



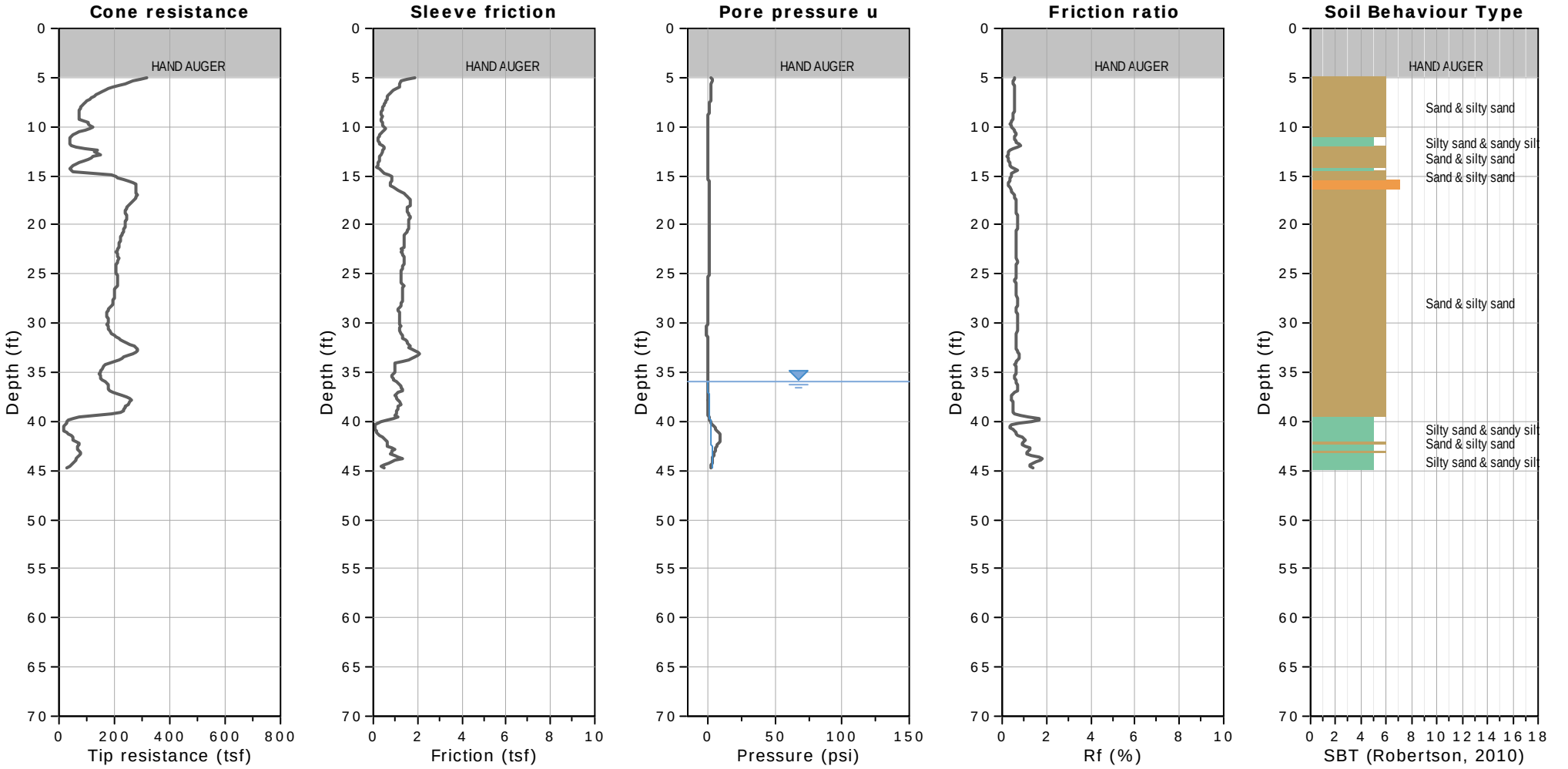
CPT: TSMACPT-12

CLIENT: PADRE ASSOCIATES, INC.

SITE: GUADALUPE RESTORATION PROJECT - SAN LUIS OBISPO, CA

Field Rep: EVA

Total depth: 44.78 ft, Date: 8/15/2018



SBTn legend

1. Sensitive fine grained
2. Organic material
3. Clay to silty clay
4. Clayey silt to silty clay
5. Silty sand to sandy silt
6. Clean sand to silty sand
7. Gravely sand to sand
8. Very stiff sand to clayey sand
9. Very stiff fine grained

WATER TABLE FOR ESTIMATING PURPOSES ONLY

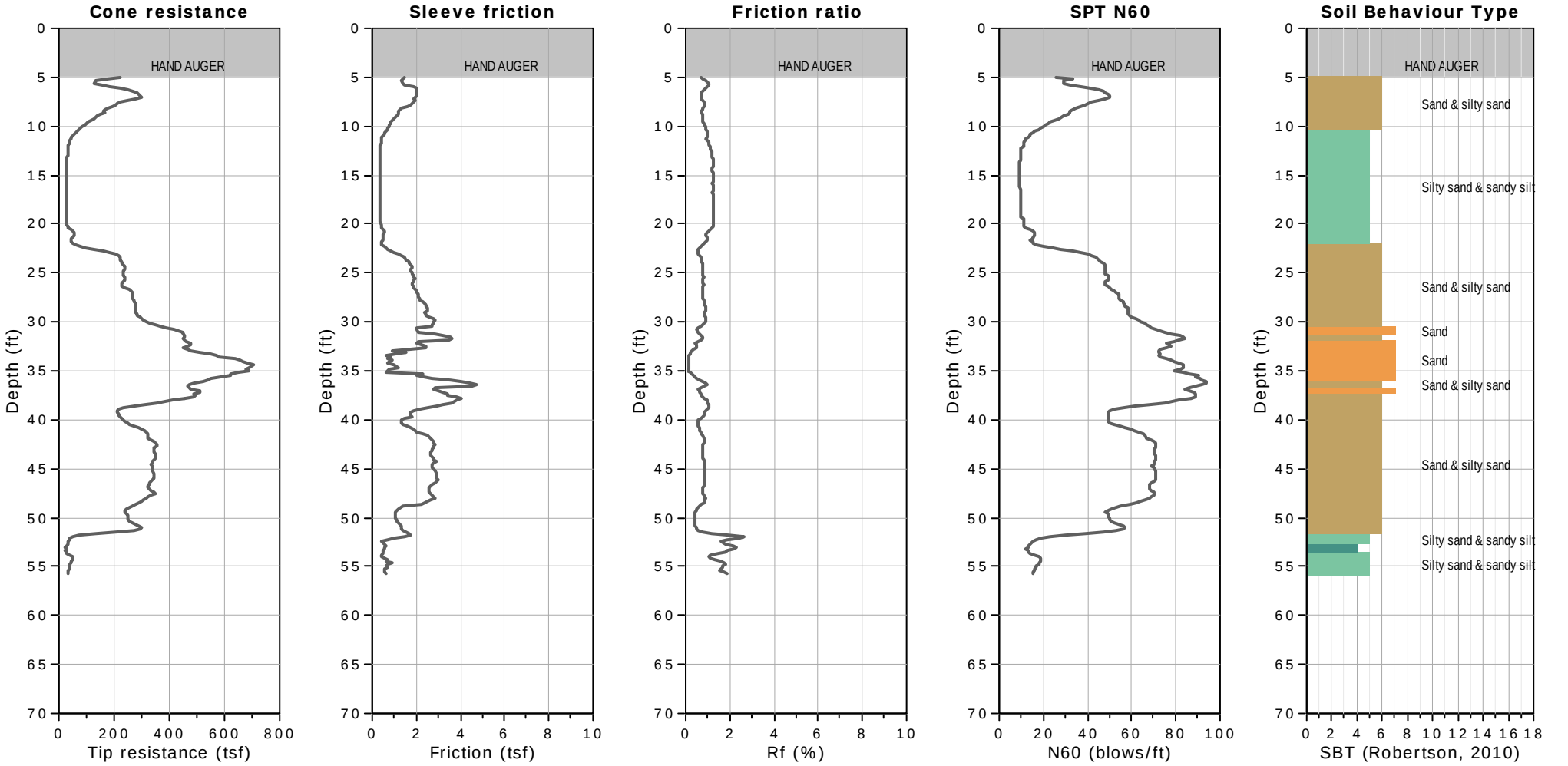
CPT: TSMACPT-13

CLIENT: PADRE ASSOCIATES, INC.

SITE: GUADALUPE RESTORATION PROJECT - SAN LUIS OBISPO, CA

Field Rep: EVA

Total depth: 55.77 ft, Date: 8/16/2018



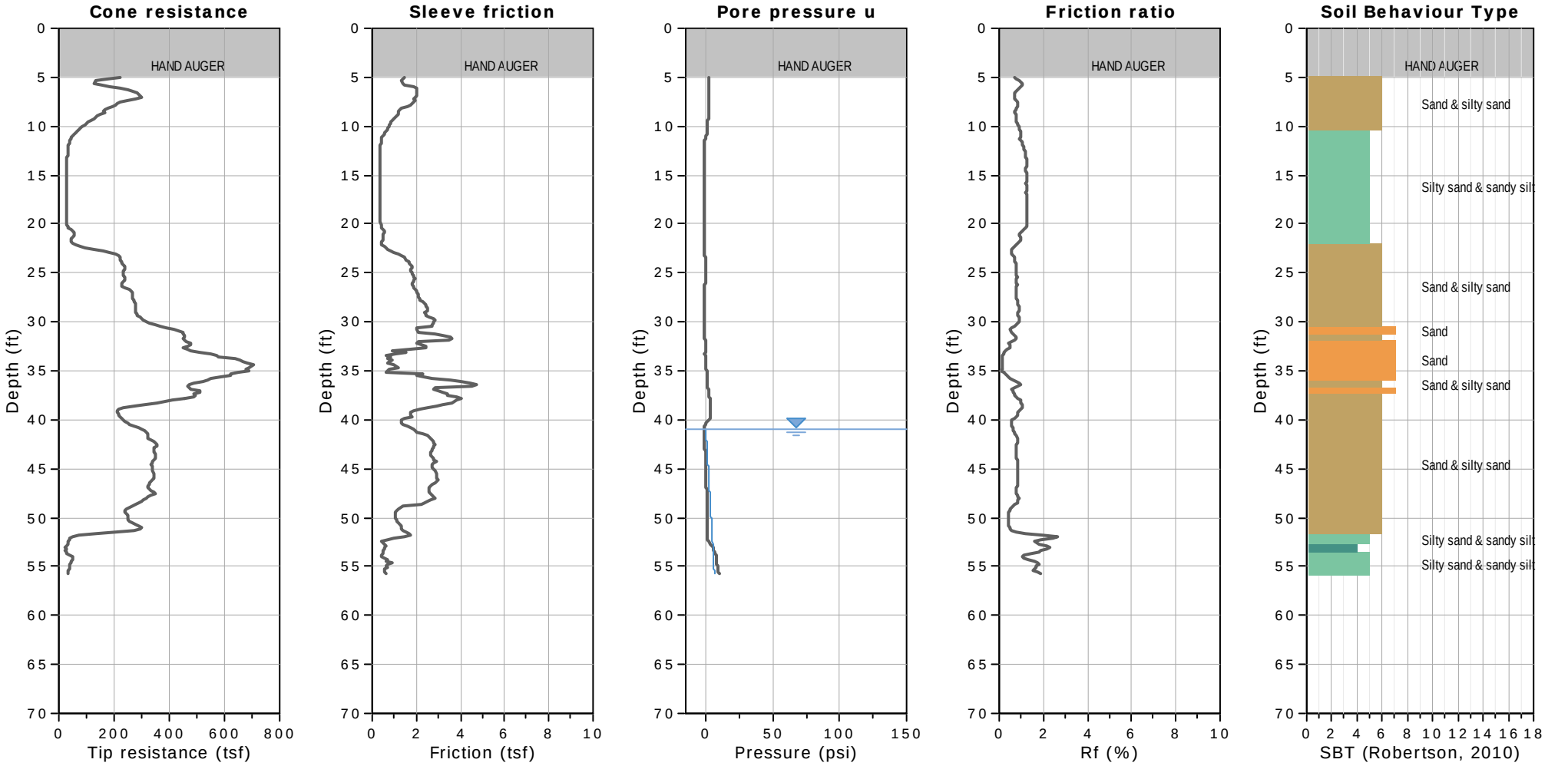
CPT: TSMACPT-13

CLIENT: PADRE ASSOCIATES, INC.

SITE: GUADALUPE RESTORATION PROJECT - SAN LUIS OBISPO, CA

Field Rep: EVA

Total depth: 55.77 ft, Date: 8/16/2018



WATER TABLE FOR ESTIMATING PURPOSES ONLY

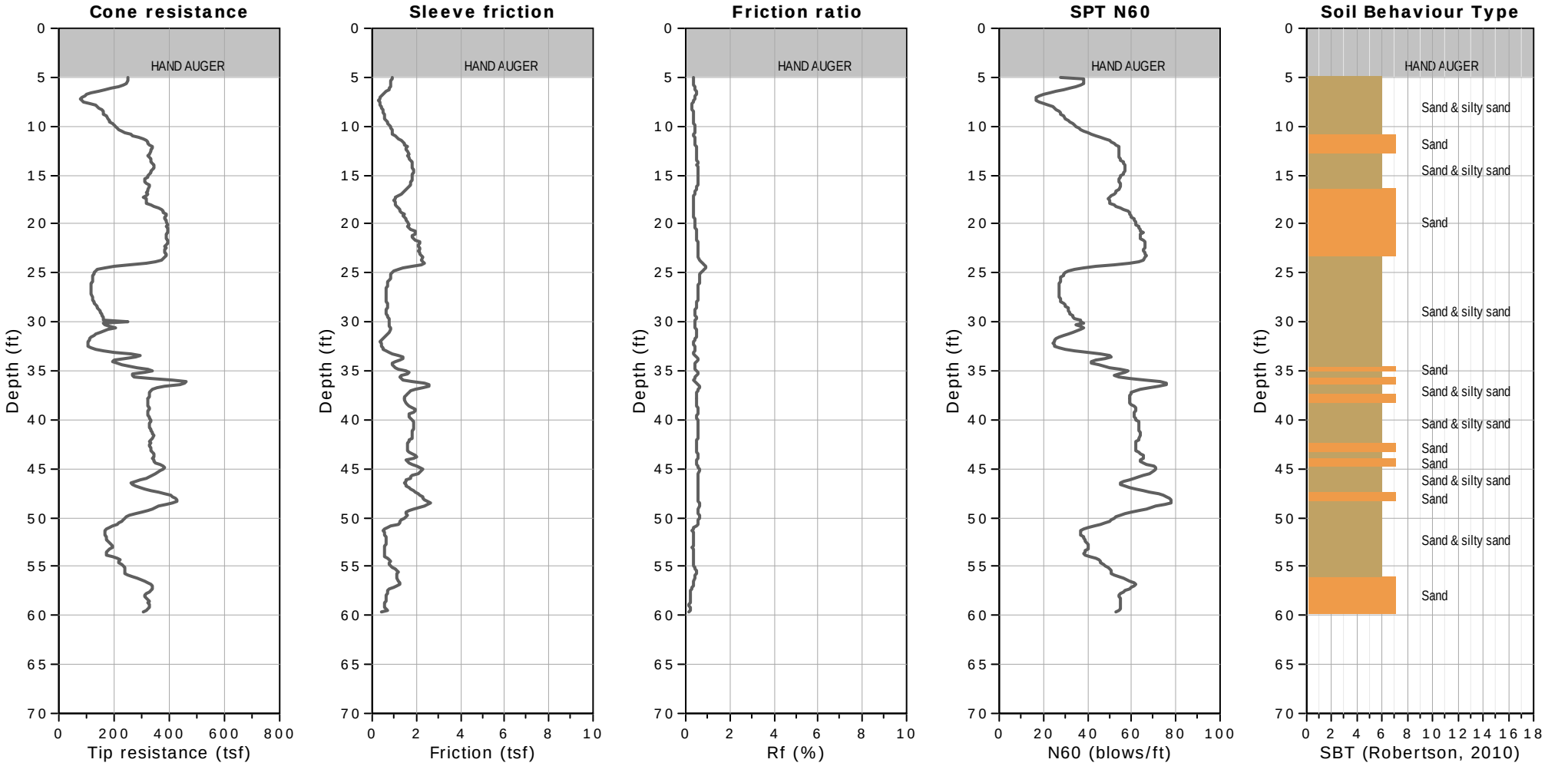
CPT: TSMACPT-14

CLIENT: PADRE ASSOCIATES, INC.

SITE: GUADALUPE RESTORATION PROJECT - SAN LUIS OBISPO, CA

Field Rep: EVA

Total depth: 59.71 ft, Date: 8/16/2018



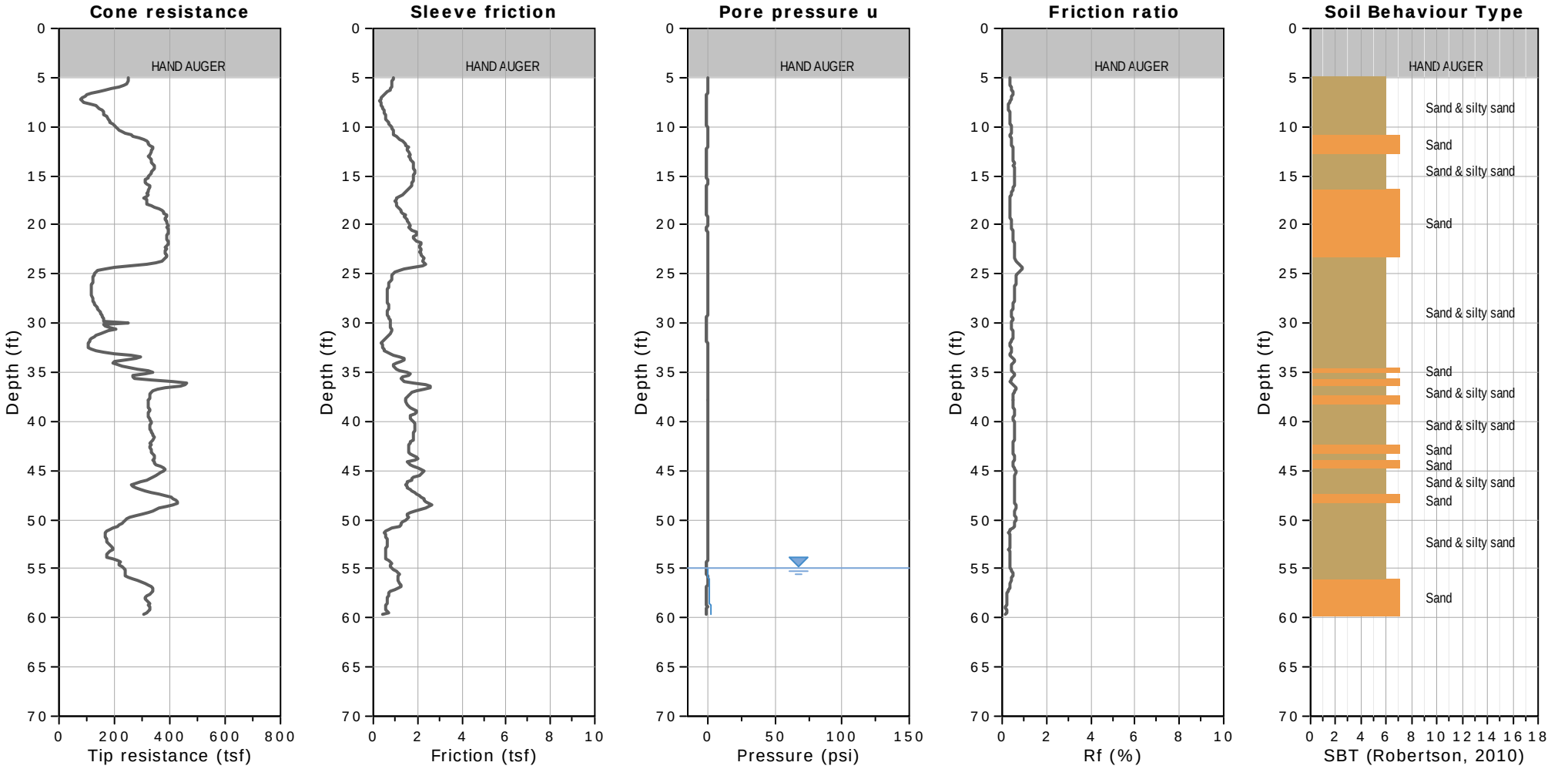
CPT: TSMACPT-14

CLIENT: PADRE ASSOCIATES, INC.

SITE: GUADALUPE RESTORATION PROJECT - SAN LUIS OBISPO, CA

Field Rep: EVA

Total depth: 59.71 ft, Date: 8/16/2018



SBTn legend

1. Sensitive fine grained
2. Organic material
3. Clay to silty clay
4. Clayey silt to silty clay
5. Silty sand to sandy silt
6. Clean sand to silty sand
7. Gravely sand to sand
8. Very stiff sand to clayey sand
9. Very stiff fine grained

WATER TABLE FOR ESTIMATING PURPOSES ONLY

APPENDIX B
LABORATORY TESTING

Yeh and Associates, Inc.
Consulting Engineers & Scientists

Summary of Laboratory Test Results

Project Name	Padre Misc. Lab Services - Guadalupe Restor.	Project No.	215-199.08	Date	9/17/2018	Project Manager	J. King	Checked By	J. King

Sample Location			Moisture Content (%)	Dry Unit Weight (pcf)	Gradation			Atterberg		Corrosion				Compaction		R-Value	USCS Classification
Sample I.D.	Depth (ft)	Sample Type			Gravel > #4 (%)	Sand (%)	Fines < #200 (%)	LL	PI	pH	R (ohm-cm)	SO_4^{2-} (mg/kg)	Cl^- (mg/kg)	Max. Unit Weight (pcf)	Optimum Water Content (%)		
SBTB9-92a-20-081618	20	SPT	4	--	0	98	2	--	--	--	--	--	--	--	--	--	Poorly graded SAND (SP)
SBTB9-92a-40-081618	40	SPT	3	--	0	99	1	--	--	--	--	--	--	--	--	--	Poorly graded SAND (SP)
SBTB9-92a-60-081618	60	SPT	4	--	0	98	2	--	--	--	--	--	--	--	--	--	Poorly graded SAND (SP)
SBTB9-93-25-081618	25	SPT	3	--	0	99	1	--	--	--	--	--	--	--	--	--	Poorly graded SAND (SP)
SBTB9-93-35-081618	35	SPT	2	--	0	99	1	--	--	--	--	--	--	--	--	--	Poorly graded SAND (SP)
SBTB9-93-55-081618	55	SPT	26	--	0	20	80	26	9	--	--	--	--	--	--	--	Lean CLAY with Sand (CL)
SBTB9-94-5-081418	5	SPT	2	--	2	91	7	--	--	--	--	--	--	--	--	--	Poorly graded SAND with silt (SP-SM)
SBTB9-94-20-081418	20	SPT	3	--	0	97	3	--	--	--	--	--	--	--	--	--	Poorly graded SAND (SP)
SBTB9-94-35-081418	35	SPT	19	--	0	97	3	--	--	--	--	--	--	--	--	--	Poorly graded SAND (SP)
SBTB9-94-35.75-081418	35.75	SPT	20	--	0	19	81	27	8	--	--	--	--	--	--	--	Lean CLAY with Sand (CL)
SBTB9-94-36.5-081418	36.5	SPT	31	--	0	8	92	46	32	--	--	--	--	--	--	--	Lean CLAY (CL)
GRPE4ATP-1-082918	--	Bulk	20	--	34	53	13	24	1	--	--	--	--	97	24	--	Clayey SAND with Gravel (SC)
GRPQ4TP-1-082918	--	Bulk	2	--	0	99	1	--	--	--	--	--	--	104	18	--	Poorly graded SAND (SP)
GRPQ4TP-2-082918	--	Bulk	2	--	0	99	1	--	--	--	--	--	--	105	14	--	Poorly graded SAND (SP)
GRPQ4TP-3-082918	--	Bulk	3	--	0	100	0	--	--	--	--	--	--	105	18	--	Poorly graded SAND (SP)
GRPQ4TP-4-082918	--	Bulk	3	--	0	99	1	--	--	--	--	--	--	105	17	--	Poorly graded SAND (SP)

Yeh and Associates, Inc.
Consulting Engineers & Scientists

Mechnical Sieve Analysis
Test Methods: ASTM D6913, D2487, D4718

Project Name	Padre Misc. Lab Services - Guadalupe Restoration	**Project No.**	215-199.08
Project Manager	J. King	**Tested By**	A. Limpert/N. Simon
Checked By	J. King	**Testing Date**	9/1/2018

SUMMARY OF RESULTS

Boring No.	Sample No.	Depth (ft)	Water Content (%)	Gravel (%)	Sand (%)	Fines (%)	D_{10} (mm)	D_{30} (mm)	D_{50} (mm)	D_{60} (mm)	C_u	C_c	USCS Classification & Soil Description	AASHTO Classification
GRPQ4TP-1-082918	--	--	2.1%	0%	99%	1%	0.18	0.25	0.31	0.34	1.90	1.00	Poorly graded SAND (SP) brown, moist	--
GRPQ4TP-2-082918	--	--	1.6%	0%	99%	1%	0.19	0.27	0.33	0.35	1.80	1.10	Poorly graded SAND (SP), brown, moist	--
GRPQ4TP-3-082918	--	--	2.5%	0%	100%	0%	0.19	0.27	0.32	0.35	1.90	1.10	Poorly graded SAND (SP), brown, moist	--
GRPQ4TP-4-082918	--	--	2.6%	0%	99%	1%	0.18	0.26	0.31	0.34	1.90	1.10	Poorly graded SAND (SP), brown, moist	--
SBTB9	92a	20	3.5%	0%	98%	2%	0.17	0.23	0.31	0.36	2.20	0.90	Poorly-Graded SAND (SP), yellowish-brown, moist	--

SUMMARY OF RESULTS														
Boring No.	**Sample No.**	**Depth (ft)**	**Water Content (%)**	**Gravel (%)**	**Sand (%)**	**Fines (%)**	**$D_{10\ (mm)}$**	**$D_{30\ (mm)}$**	**$D_{50\ (mm)}$**	**$D_{60\ (mm)}$**	**C_u**	**C_c**	**USCS Classification & Soil Description**	**AASHTO Classification**
SBTB9	92a	40	3.4%	0%	99%	1%	0.17	0.23	0.30	0.34	2.00	0.90	Poorly-Graded SAND (SP), yellowish-brown, moist	--
SBTB9	92a	60	3.9%	0%	98%	2%	0.20	0.29	0.35	0.38	1.90	1.10	Poorly-Graded SAND (SP), yellowish-brown, moist	--
SBTB9	93	25	3.1%	0%	99%	1%	0.20	0.30	0.38	0.42	2.10	1.10	Poorly-Graded SAND (SP), yellowish-brown, moist	--
SBTB9	93	35	2.2%	0%	99%	1%	0.20	0.31	0.41	0.49	2.50	1.00	Poorly-Graded SAND (SP), yellowish-brown, moist	--
SBTB9	94	5	2.1%	2%	91%	7%	0.13	0.26	0.34	0.39	3.00	1.40	Poorly-Graded SAND with Silt (SP-SM), yellowish-brown, moist	--
SBTB9	94	20	3.2%	0%	97%	3%	0.17	0.26	0.34	0.38	2.20	1.10	Poorly-Graded SAND (SP), yellowish-brown, moist	--
SBTB9	94	35	18.6%	0%	97%	3%	0.19	0.28	0.34	0.37	2.00	1.10	Poolry-Graded SAND (SP), yellowish-brown, moist	--

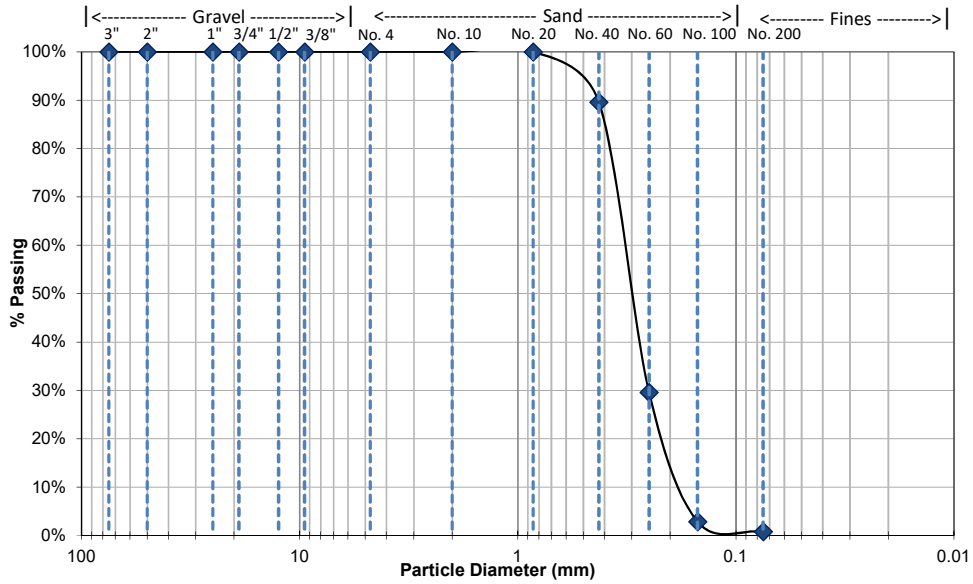
SUMMARY OF RESULTS														
Boring No.	**Sample No.**	**Depth (ft)**	**Water Content (%)**	**Gravel (%)**	**Sand (%)**	**Fines (%)**	**$D_{10\ (mm)}$**	**$D_{30\ (mm)}$**	**$D_{50\ (mm)}$**	**$D_{60\ (mm)}$**	**C_u**	**C_c**	**USCS Classification & Soil Description**	**AASHTO Classification**
SBTB9	94	36.5	30.8%	0%	8%	92%	--	--	--	--	--	--	Lean CLAY (CL), yellowish brown, moist	--

GRADATION CHARTS

Boring No.: GRPQ4TP-1-082918

Sample No.: --

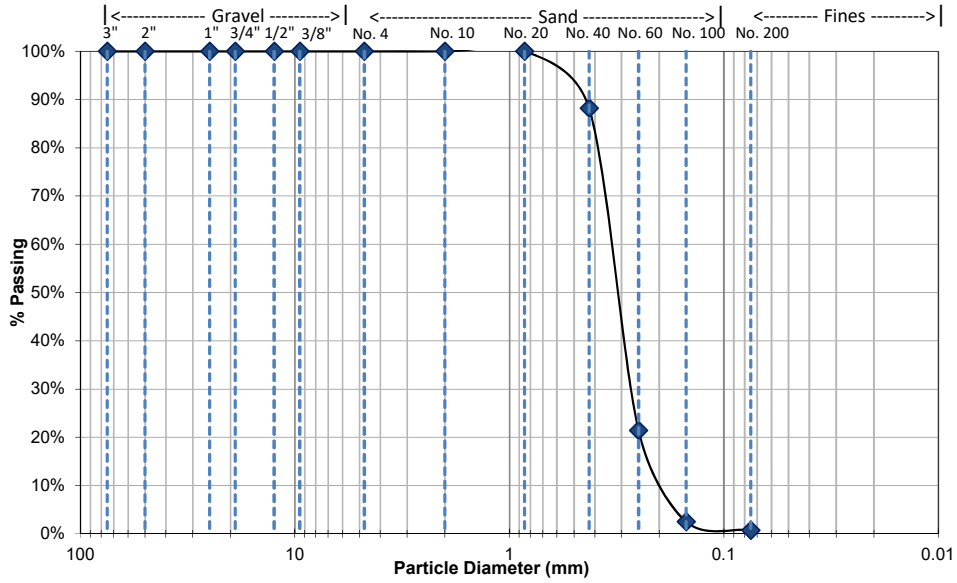
USCS Classification: Poorly graded SAND (SP)



Boring No.: GRPQ4TP-2-082918

Sample No.: --

USCS Classification: Poorly graded SAND (SP),

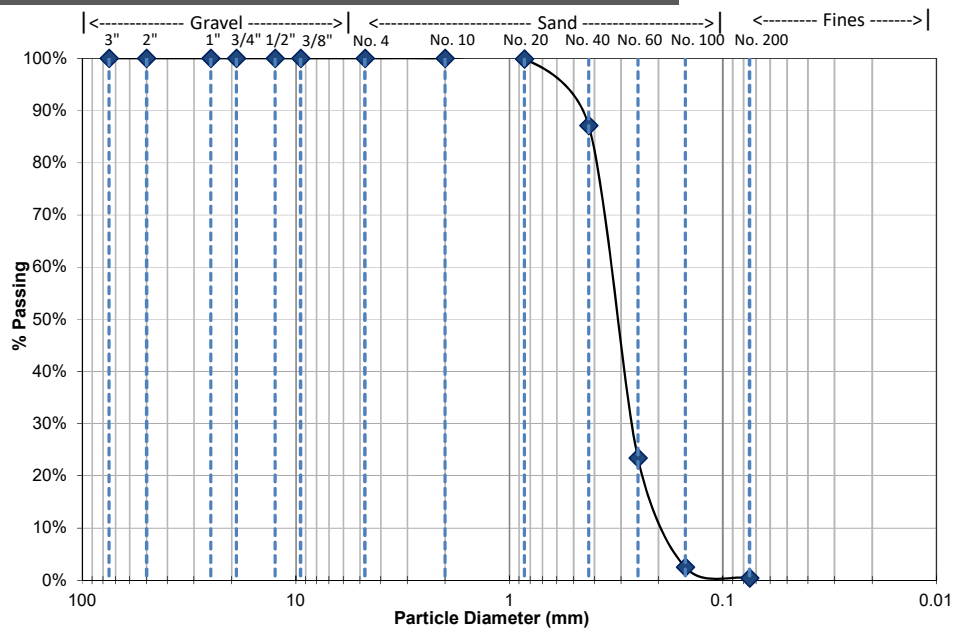


GRADATION CHARTS

Boring No.: GRPQ4TP-3-082918

Sample No.: --

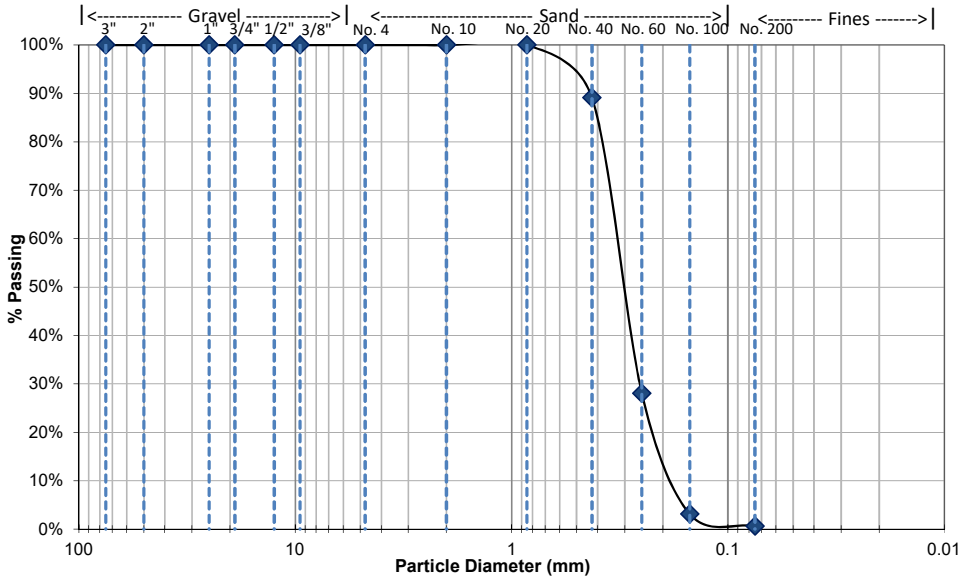
USCS Classification: Poorly graded SAND (SP),



Boring No.: GRPQ4TP-4-082918

Sample No.: --

USCS Classification: Poorly graded SAND (SP),

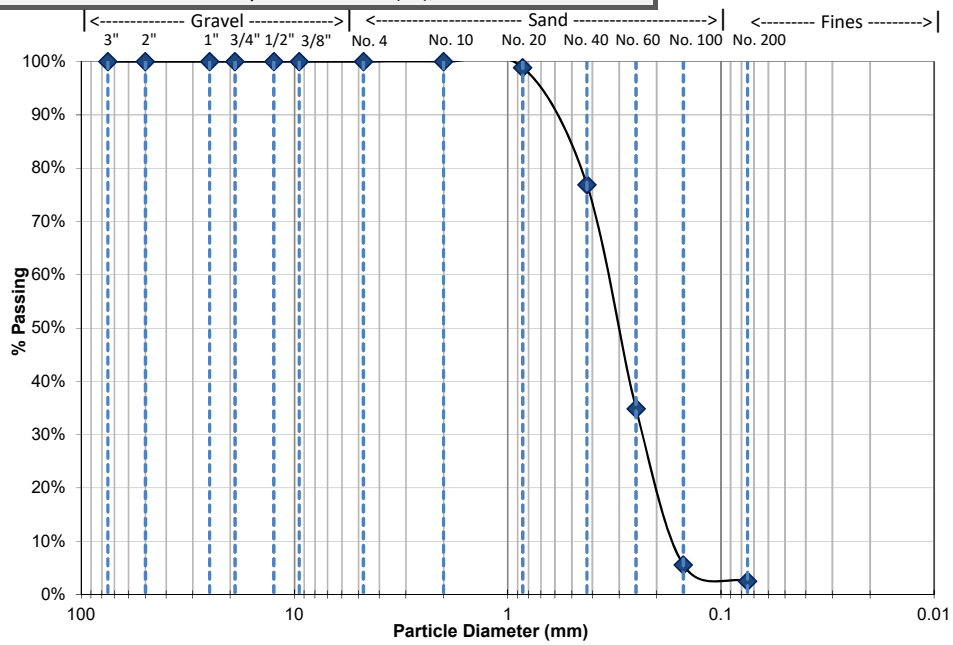


GRADATION CHARTS

Boring No.: SBTB9

Sample No.: 92a

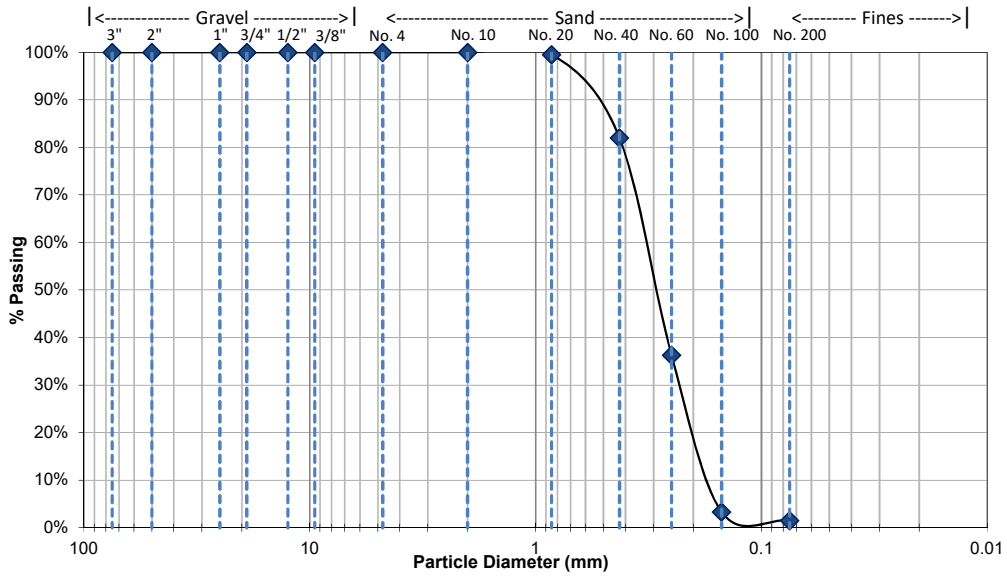
USCS Classification: Poorly-Graded SAND (SP),



Boring No.: SBTB9

Sample No.: 92a

USCS Classification: Poorly-Graded SAND (SP),

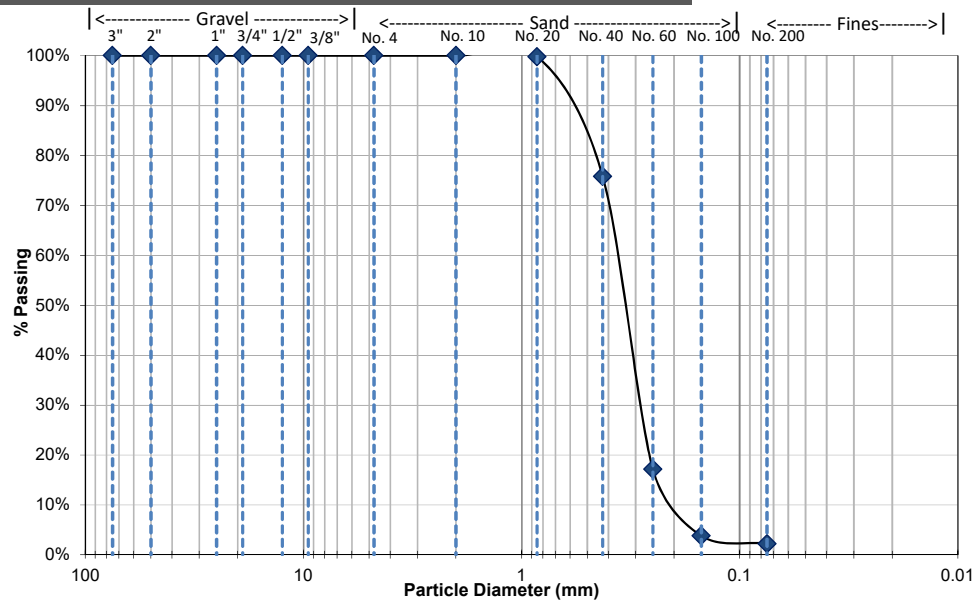


GRADATION CHARTS

Boring No.: SBTB9

Sample No.: 92a

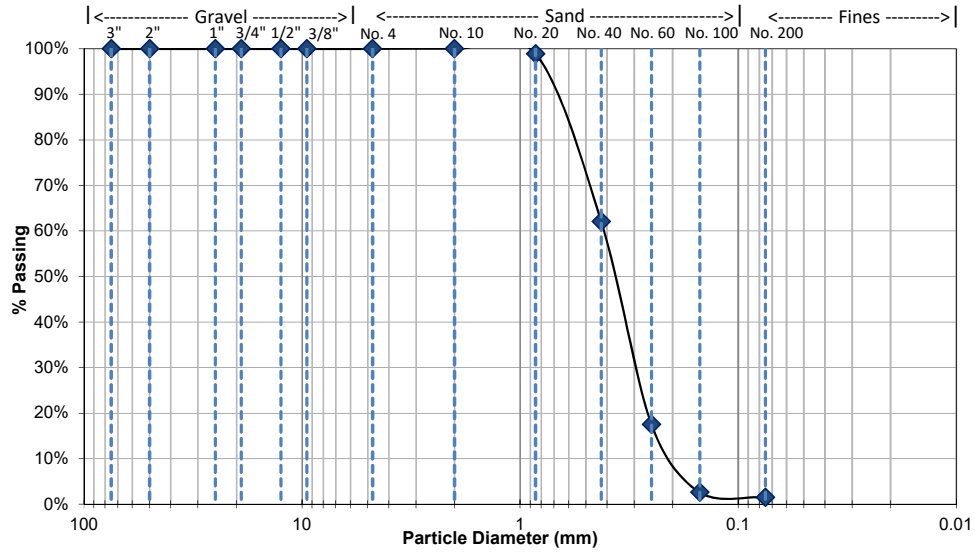
USCS Classification: Poorly-Graded SAND (SP),



Boring No.: SBTB9

Sample No.: 93

USCS Classification: Poorly-Graded SAND (SP),

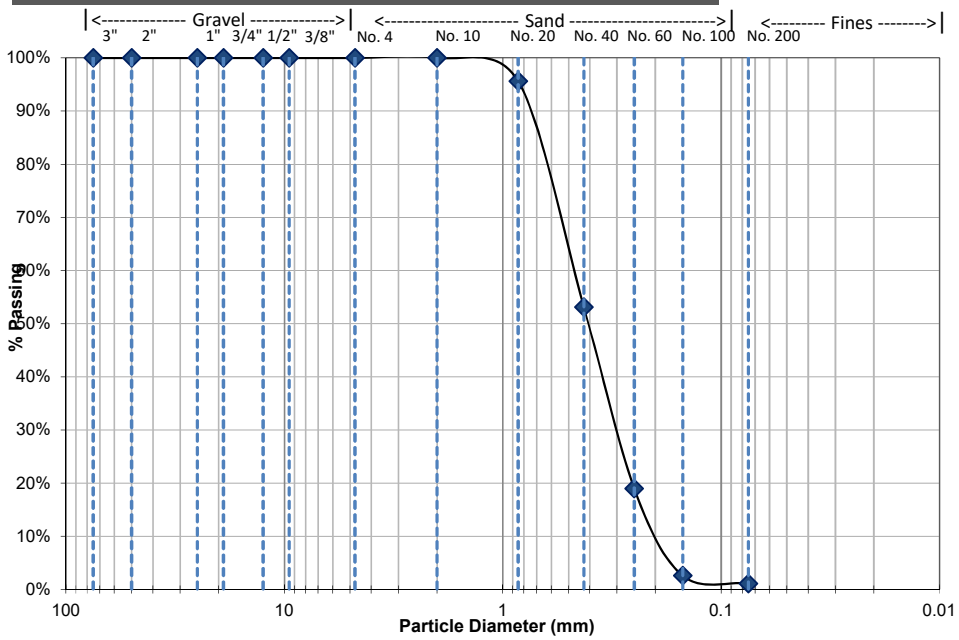


GRADATION CHARTS

Boring No.: SBTB9

Sample No.: 93

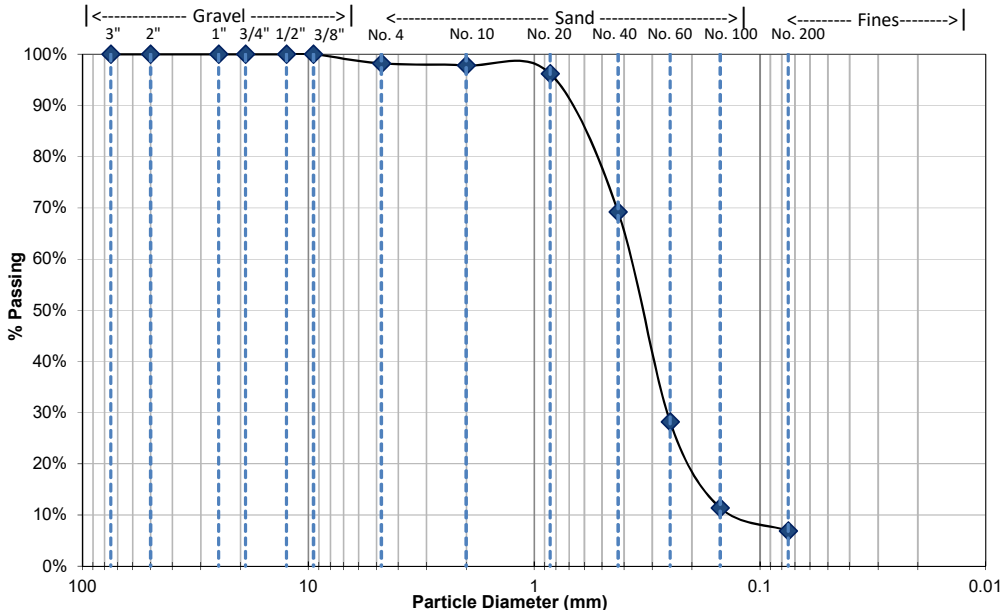
USCS Classification: Poorly-Graded SAND (SP),



Boring No.: SBTB9

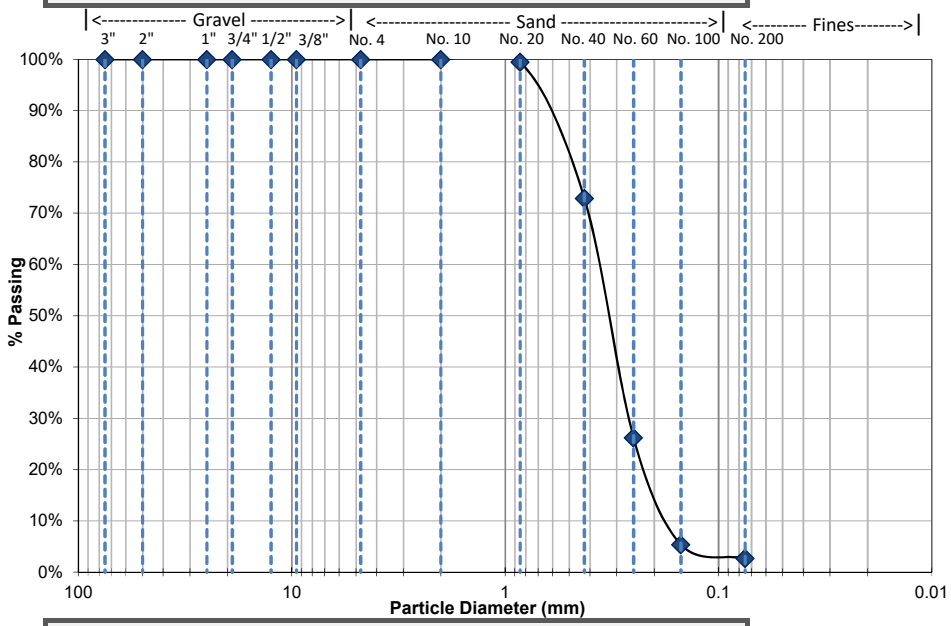
Sample No.: 94

USCS Classification: Poorly-Graded SAND with Silt (SP-SM),

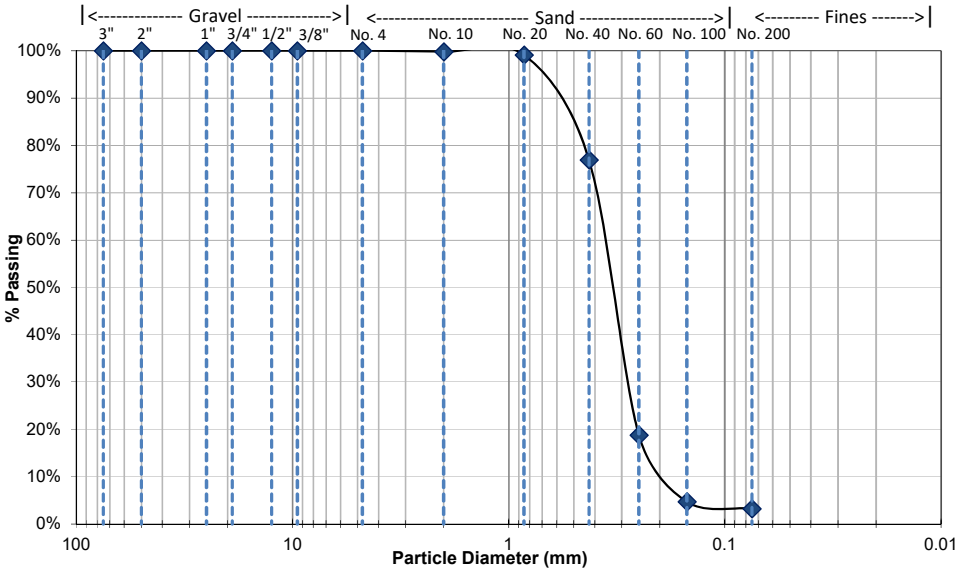


GRADATION CHARTS

Boring No.:	SBTB9
Sample No.:	94
USCS Classification:	Poorly-Graded SAND (SP),



Boring No.:	SBTB9
Sample No.:	94
USCS Classification:	Poolry-Graded SAND (SP),

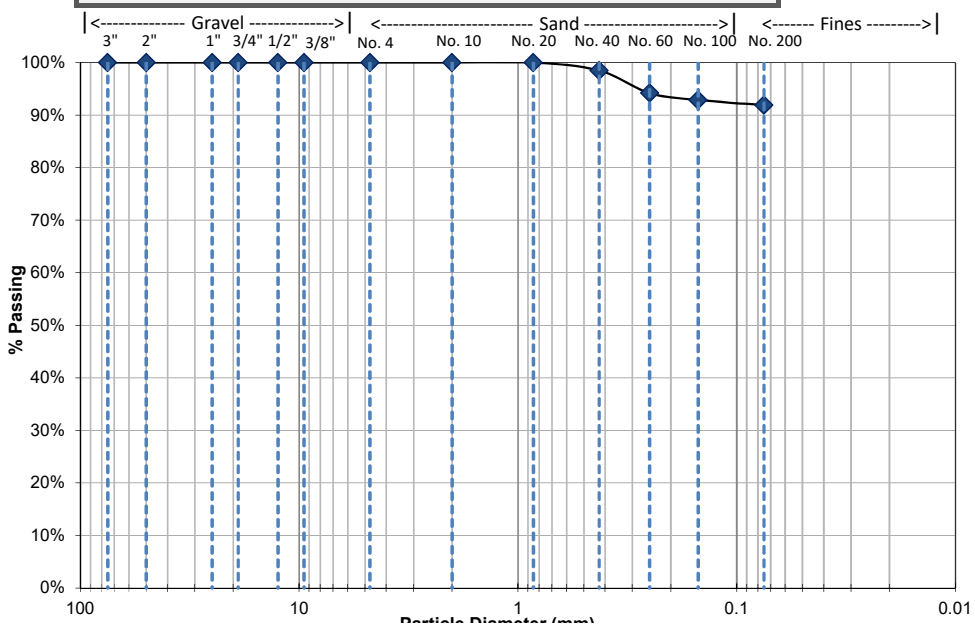


GRADATION CHARTS

Boring No.: SBTB9

Sample No.: 94

USCS Classification: Lean CLAY (CL),



Yeh and Associates, Inc.
Consulting Engineers & Scientists

Mechnical Sieve Analysis with Hydrometer
Test Methods: ASTM D6913, D2487, D4718, D422

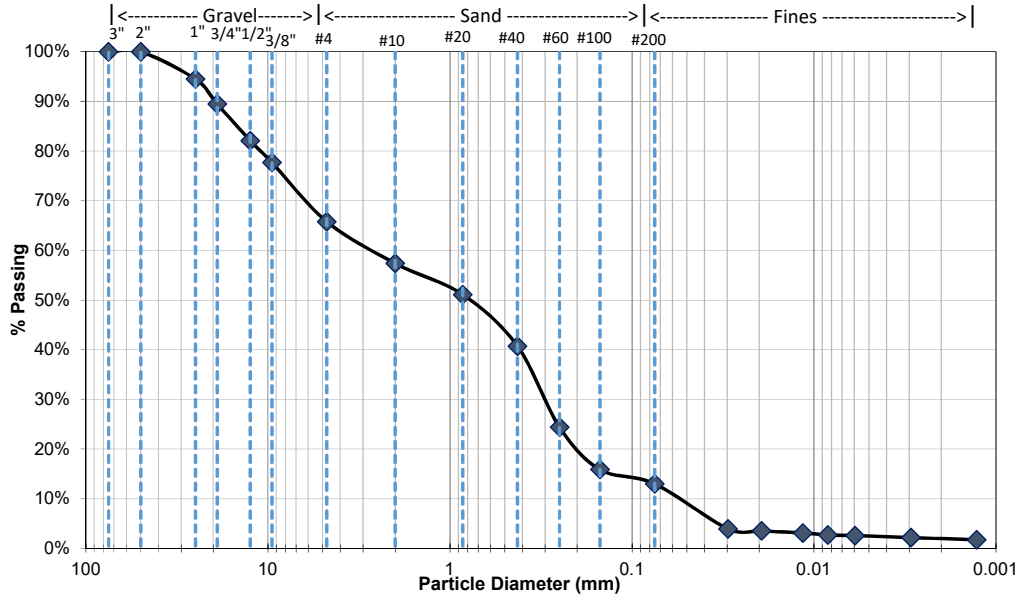
Project Name	217-199.08			**Project No.**	Guadalupe Restoration
Project Manager	J. King	**Tested By**		A. Limpert	
Checked By	N. Simon	**Testing Date**		9/7/2018	

SUMMARY OF RESULTS

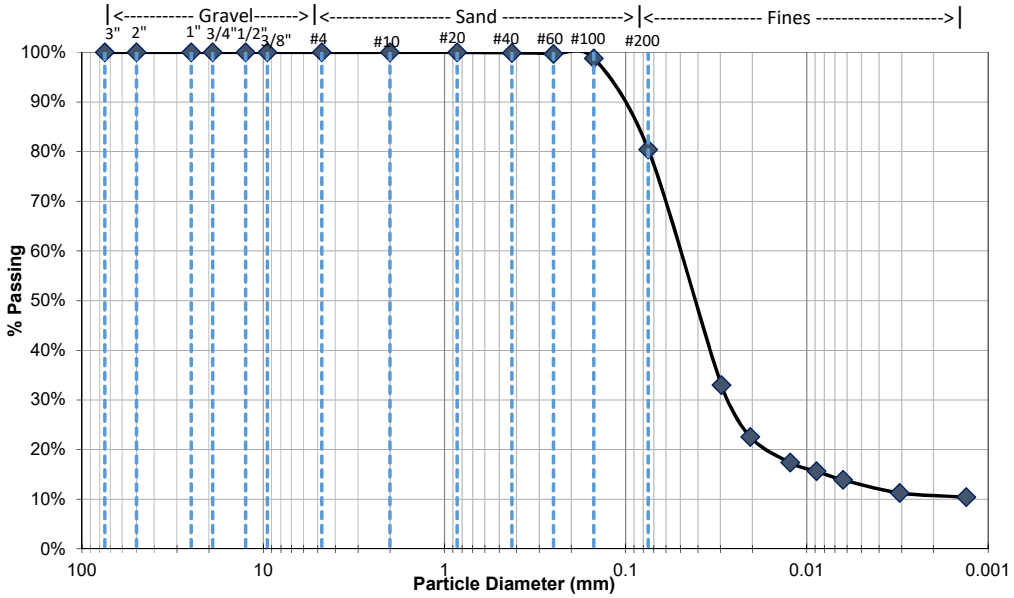
Boring No.	Sample No.	Depth (ft)	Water Content (%)	Gravel (%)	Sand (%)	Fines (%)	D_{10} (mm)	D_{30} (mm)	D_{50} (mm)	D_{60} (mm)	C_u	C_c	USCS Classification & Soil Description	AASHTO Classification
GRPE4ATP-1-082918	--	--	19.7%	34%	53%	13%	0.060	0.310	0.805	2.85	47.5	0.60	Clayey SAND with Gravel (SC) red, moist, subangular gravel	--
93	--	55	26.4%	0%	20%	80%	0.001	0.027	0.046	0.06	--	--	Lean CLAY with SAND (CL) yellowish brown, moist	--
94	--	35.75	20.3%	0%	19%	81%	0.001	0.008	0.020	0.03	--	--	Lean CLAY with SAND (CL) yellowish brown, moist	--

GRADATION CHARTS

Boring No.: GRPE4ATP-1-082918
Sample No.: --
USCS Classification: Clayey SAND with Gravel (SC)

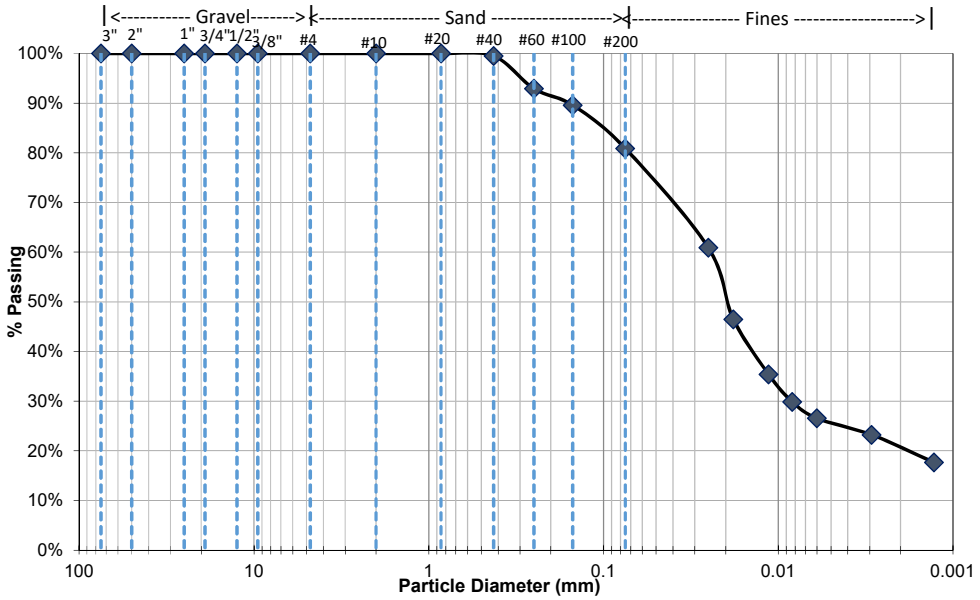


Boring No.: 93
Sample No.: --
USCS Classification: Lean CLAY with SAND (CL)



GRADATION CHARTS

Boring No.:	94
Sample No.:	--
USCS Classification:	Lean CLAY with SAND (CL)



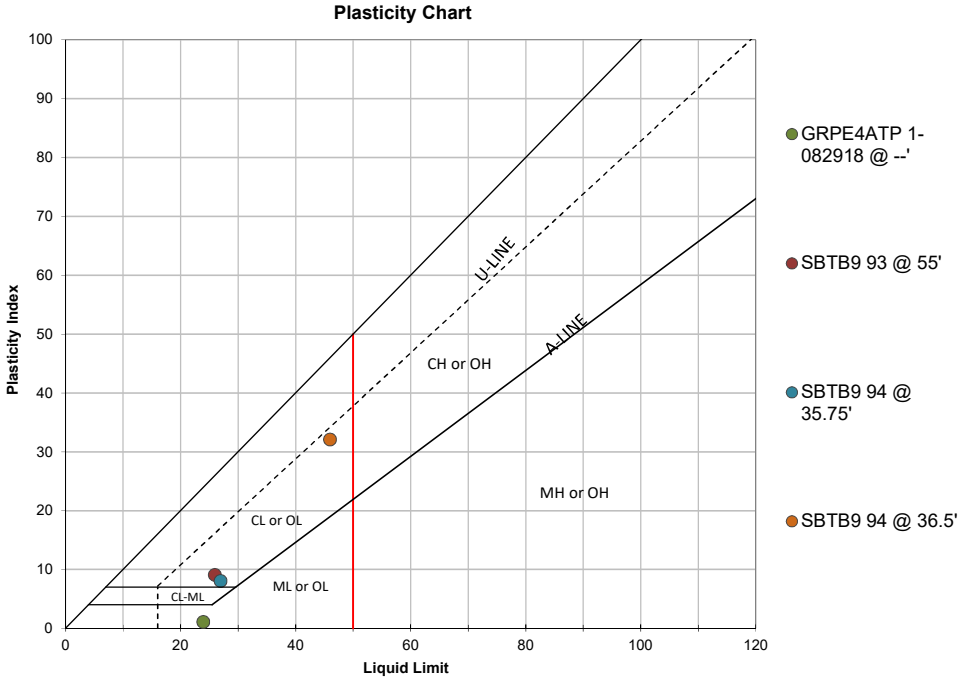
Yeh and Associates, Inc.
Consulting Engineers & Scientists

Atterberg Limits
Test Method: ASTM D4318

Project Name	Padre Misc. Lab Services - Guadalupe Restoration				
Project No.	215-199.08		**Project Manager**	J. King	
Tested By	N. Simon	**Checked By**	J. King	**Testing Date**	9/1/2018

SUMMARY OF RESULTS

Boring No.	Sample No.	Depth (ft)	Moisture Content (%)	Liquid Limit	Plastic Limit	Plasticity Index	USCS Classification & Soil Description	AASHTO Classification
GRPE4ATP	1-082918	--	18.8%	24	23	1	Clayey SAND with GRAVEL (SC), red, moist, subangular gravel	--
SBTB9	93	55.0	26.4%	26	17	9	Lean CLAY with SAND (CL), yellowish brown, moist	--
SBTB9	94	35.75	20.3%	27	19	8	Lean CLAY with SAND (CL), yellowish brown, moist	--
SBTB9	94	36.5	30.8%	46	14	32	Lean CLAY (CL), yellowish brown, moist	--



Yeh and Associates, Inc.
Consulting Engineers & Scientists

Proctor Compaction

Test Method: ASTM D698, D1557

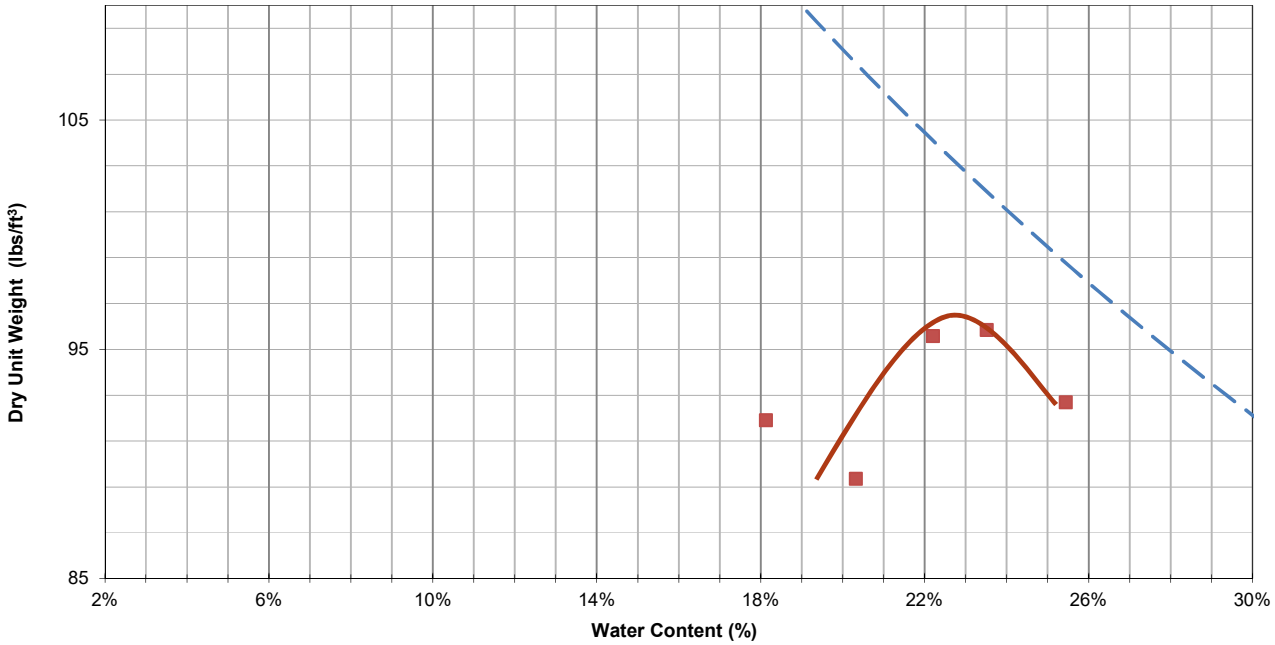
Project Name	Padre Misc. Lab Services - Guadalupe Restoration				
Project No.	215-199.08		**Project Manager**	J. King	
Tested By	A. Limpert	**Checked By**	J. King	**Testing Date**	9/1/2018

SPECIMEN ID AND CLASSIFICATION					
Boring No.	GRPE4ATP-1-082918	**Sample No.**	--	**Depth (ft)**	--
USCS Classification & Soil Description	Clayey SAND with Gravel (SC), red, moist, subangular gravel			**AASHTO Classification**	--

EQUIPMENT AND PROCEDURE					
Test Method (D698 or D1557)	1557B	**Ram. Mass (lbs)**	10	**# of Lifts**	5
Mold Volume (cm^3)	941	**Mold Mass(g)**	2010.8	**Blows/ Lift**	25

DENSITY AND MOISTURE MEASUREMENTS					
Mass of Soil + Mold (g)	3648	3632	3796	3764	3772
Dish ID	202A	106B	103A	108A	107A
Mass of Dish (g)	135.3	134.7	134.7	134.6	134.7
Mass of Moist Soil + Dish (g)	480.6	735.0	544.9	706.0	628.4
Mass of Dry Soil + Dish (g)	427.6	633.6	466.8	590.1	538.7

RESULTS					
Water Content	18.1%	20.3%	23.5%	25.4%	22.2%
Dry Density (Mg/m^3)	1.473	1.432	1.536	1.485	1.532
Dry Unit Weight (lbs/ft^3)	91.9	89.3	95.8	92.7	95.6
Lab Max. Dry Density (Mg/m^3)	1.536		**Optimum Water Content (%)**		23.6%
Lab Max. Dry Unit Wt. (lbs/ft^3)	96.5				



Yeh and Associates, Inc.
Consulting Engineers & Scientists

Proctor Compaction

Test Method: ASTM D698, D1557

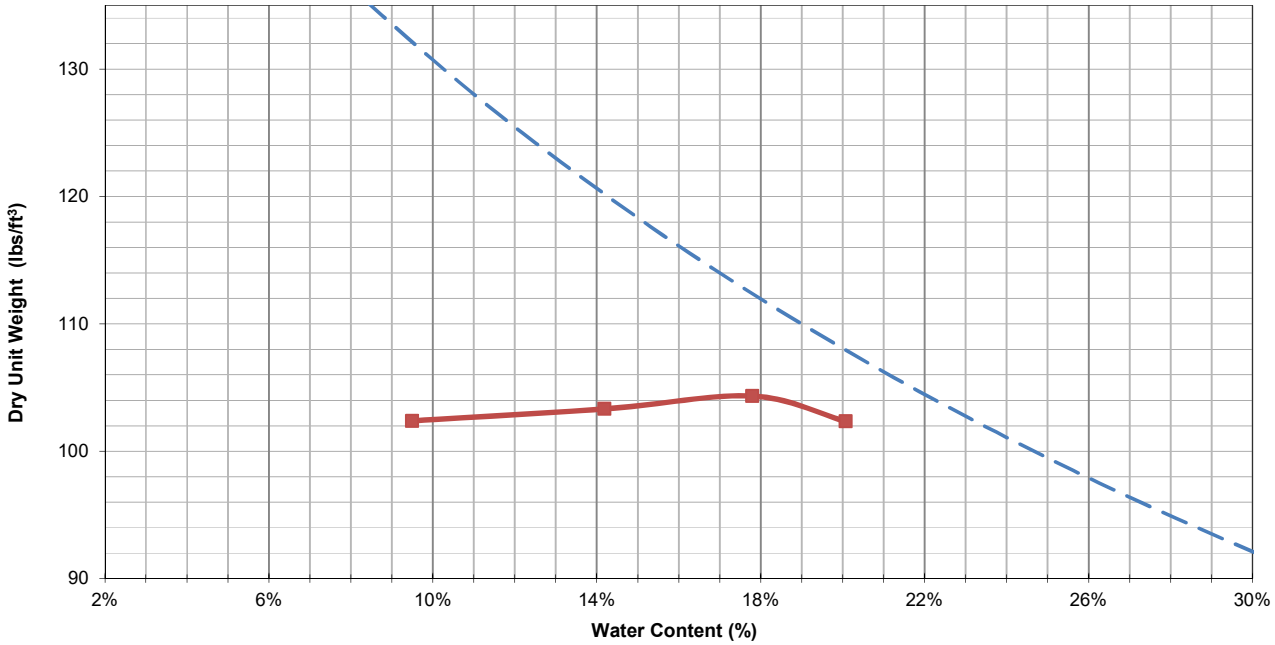
Project Name	Padre Misc. Lab Services - Guadalupe Restoration				
Project No.	215-199.08		**Project Manager**	J. King	
Tested By	A. Limpert	**Checked By**	J. King	**Testing Date**	9/1/2018

SPECIMEN ID AND CLASSIFICATION					
Boring No.	GRPQ4TP-1-082918	**Sample No.**	--	**Depth (ft)**	--
USCS Classification & Soil Description	Poorly graded SAND (SP), brown, moist			**AASHTO Classification**	--

EQUIPMENT AND PROCEDURE					
Test Method (D698 or D1557)	1557A	**Ram. Mass (lbs)**	10	**# of Lifts**	5
Mold Volume (cm^3)	914	**Mold Mass(g)**	2014	**Blows/ Lift**	25

DENSITY AND MOISTURE MEASUREMENTS					
Mass of Soil + Mold (g)	3602	3656	3742	3814	3814
Dish ID	101B	4A	107A	101B	102A
Mass of Dish (g)	135.0	134.8	135.7	134.9	134.7
Mass of Moist Soil + Dish (g)	560.9	750.5	708.8	765.8	812.9
Mass of Dry Soil + Dish (g)	536.7	697.1	637.6	670.5	699.5

RESULTS					
Water Content	6.0%	9.5%	14.2%	17.8%	20.1%
Dry Density (Mg/m^3)	1.639	1.641	1.656	1.672	1.640
Dry Unit Weight (lbs/ft^3)	102.3	102.4	103.3	104.3	102.3
Lab Max. Dry Density (Mg/m^3)	1.672		**Optimum Water Content (%)**		17.8%
Lab Max. Dry Unit Wt. (lbs/ft^3)	104.3				



Yeh and Associates, Inc.
Consulting Engineers & Scientists

Proctor Compaction

Test Method: ASTM D698, D1557

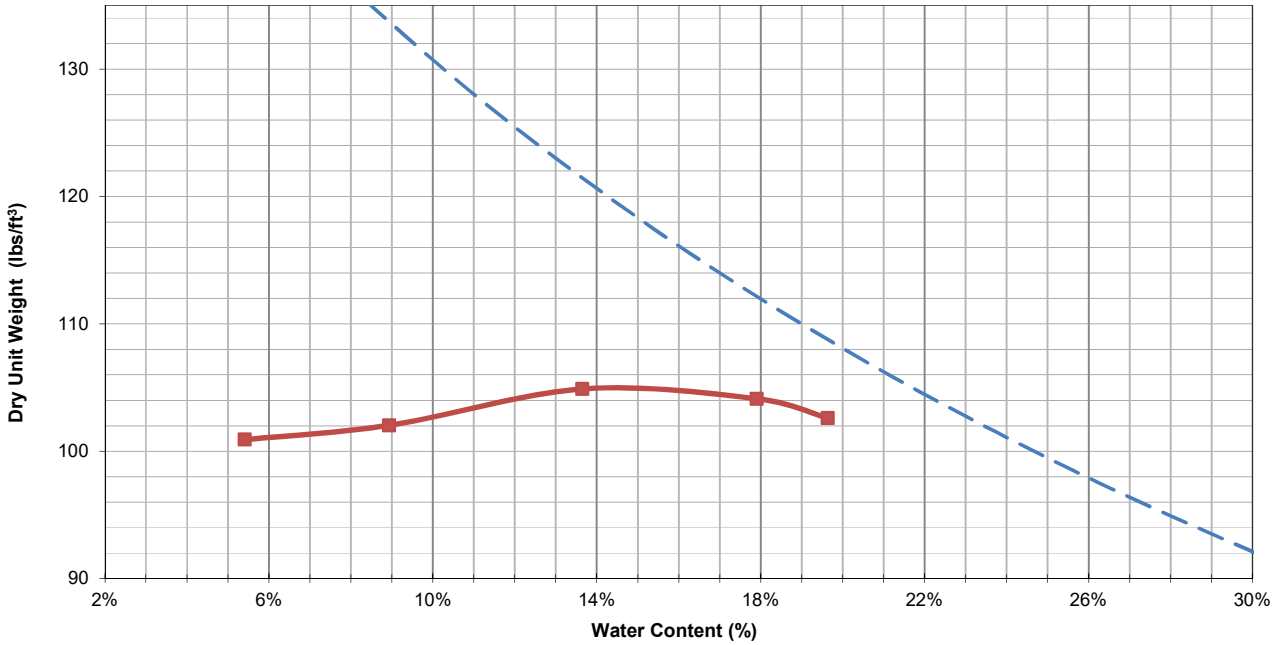
Project Name	Padre Misc. Lab Services - Guadalupe Restoration				
Project No.	215-199.08		**Project Manager**	J. King	
Tested By	A. Limpert	**Checked By**	J. King	**Testing Date**	9/1/2018

SPECIMEN ID AND CLASSIFICATION					
Boring No.	GRPQ4TP-2-082918	**Sample No.**	--	**Depth (ft)**	--
USCS Classification & Soil Description	Poorly graded SAND (SP), brown, moist			**AASHTO Classification**	--

EQUIPMENT AND PROCEDURE					
Test Method (D698 or D1557)	1557A	**Ram. Mass (lbs)**	10	**# of Lifts**	5
Mold Volume (cm^3)	914	**Mold Mass(g)**	2014	**Blows/ Lift**	25

DENSITY AND MOISTURE MEASUREMENTS					
Mass of Soil + Mold (g)	3572	3642	3760	3812	3812
Dish ID	104A	101R	202A	106B	102R
Mass of Dish (g)	136.2	136.0	135.3	134.6	134.8
Mass of Moist Soil + Dish (g)	669.7	611.5	718.2	676.0	650.2
Mass of Dry Soil + Dish (g)	642.3	572.5	648.2	593.8	565.6

RESULTS					
Water Content	5.4%	8.9%	13.6%	17.9%	19.6%
Dry Density (Mg/m^3)	1.617	1.635	1.681	1.669	1.644
Dry Unit Weight (lbs/ft^3)	100.9	102.0	104.9	104.1	102.6
Lab Max. Dry Density (Mg/m^3)	1.681		**Optimum Water Content (%)**		14.0%
Lab Max. Dry Unit Wt. (lbs/ft^3)	104.9				



Yeh and Associates, Inc.
Consulting Engineers & Scientists

Proctor Compaction

Test Method: ASTM D698, D1557

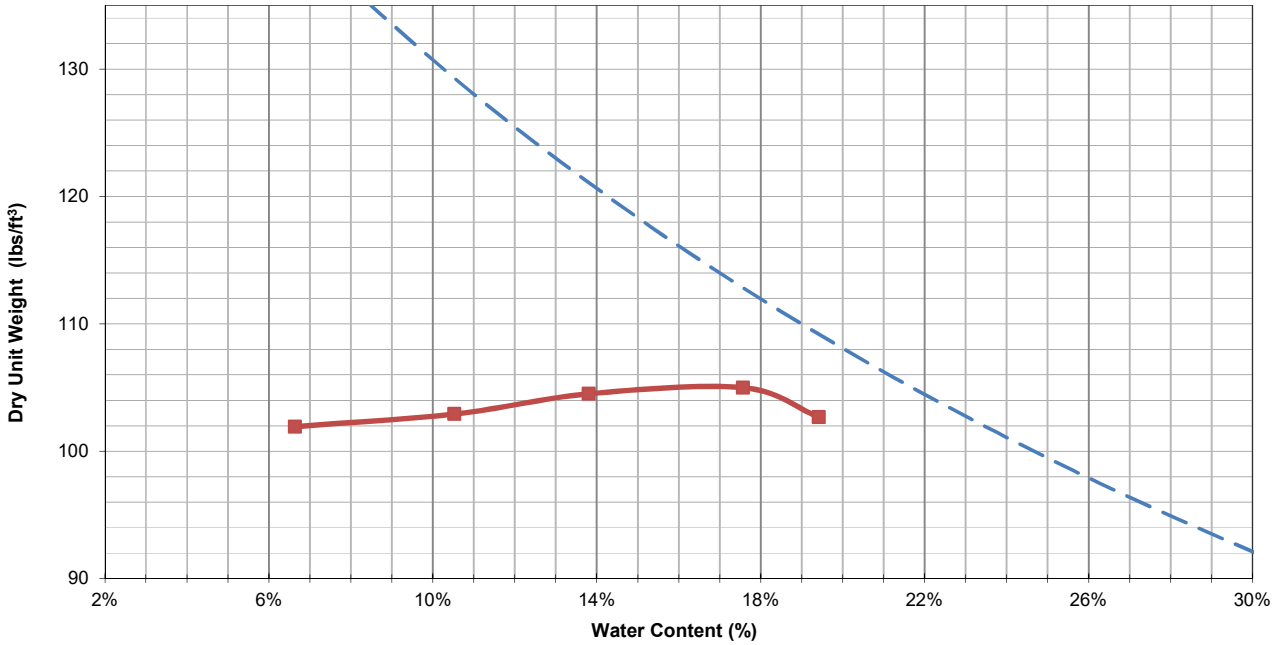
Project Name	Padre Misc. Lab Services - Guadalupe Restoration				
Project No.	215-199.08		**Project Manager**	J. King	
Tested By	A. Limpert	**Checked By**	J. King	**Testing Date**	9/1/2018

SPECIMEN ID AND CLASSIFICATION					
Boring No.	GRPQ4TP-3-082918	**Sample No.**	--	**Depth (ft)**	--
USCS Classification & Soil Description	Poorly Graded SAND (SP), brown, moist			**AASHTO Classification**	--

EQUIPMENT AND PROCEDURE					
Test Method (D698 or D1557)	1557A	**Ram. Mass (lbs)**	10	**# of Lifts**	5
Mold Volume (cm^3)	914	**Mold Mass(g)**	2014	**Blows/ Lift**	25

DENSITY AND MOISTURE MEASUREMENTS					
Mass of Soil + Mold (g)	3606	3680	3756	3822	3810
Dish ID	109B	105B	101B	101R	107C
Mass of Dish (g)	134.7	134.8	134.9	135.4	135.1
Mass of Moist Soil + Dish (g)	719.9	689.3	673.2	658.7	740.9
Mass of Dry Soil + Dish (g)	683.5	636.5	607.9	580.5	642.4

RESULTS					
Water Content	6.6%	10.5%	13.8%	17.6%	19.4%
Dry Density (Mg/m^3)	1.633	1.649	1.675	1.683	1.645
Dry Unit Weight (lbs/ft^3)	101.9	102.9	104.5	105.0	102.7
Lab Max. Dry Density (Mg/m^3)	1.683		**Optimum Water Content (%)**		17.5%
Lab Max. Dry Unit Wt. (lbs/ft^3)	105.0				



Yeh and Associates, Inc.
Consulting Engineers & Scientists

Proctor Compaction

Test Method: ASTM D698, D1557

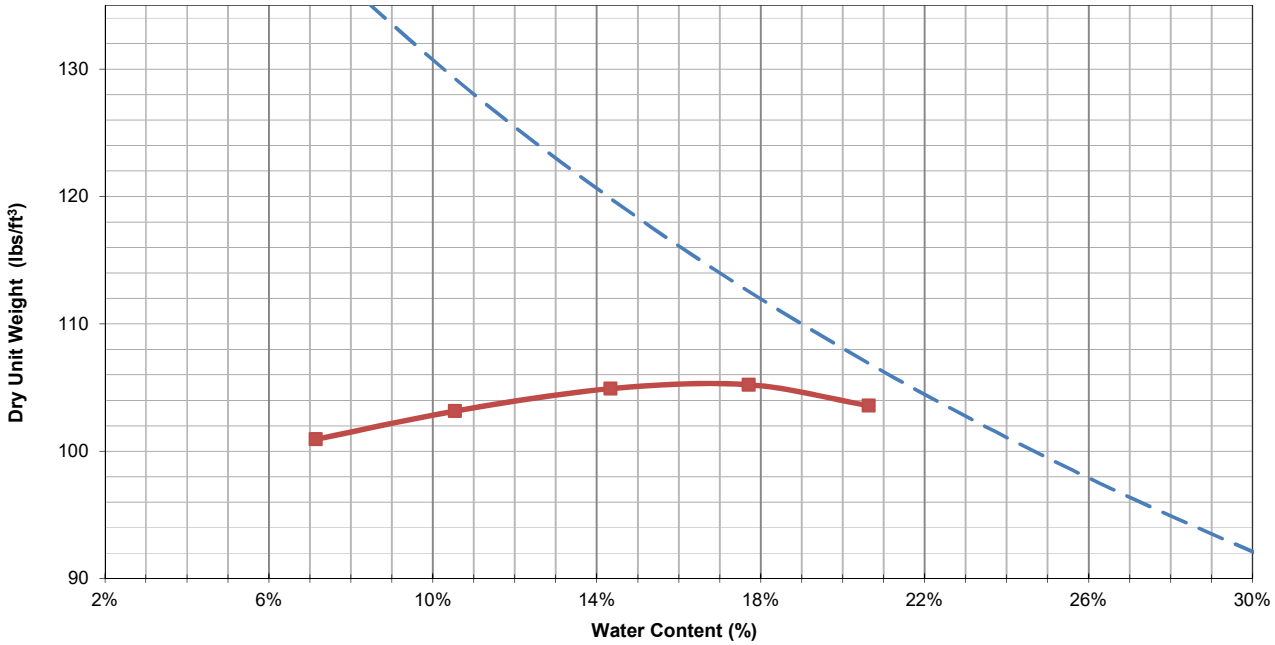
Project Name	Padre Misc. Lab Services - Guadalupe Restoration				
Project No.	215-199.08		**Project Manager**	J. King	
Tested By	A. Limpert	**Checked By**	J. King	**Testing Date**	9/1/2018

SPECIMEN ID AND CLASSIFICATION					
Boring No.	GRPQ4TP-4-082918	**Sample No.**	--	**Depth (ft)**	--
USCS Classification & Soil Description	Poorly Graded SAND (SP), brown, moist			**AASHTO Classification**	

EQUIPMENT AND PROCEDURE					
Test Method (D698 or D1557)	1557B	**Ram. Mass (lbs)**	10	**# of Lifts**	5
Mold Volume (cm^3)	914	**Mold Mass(g)**	2014	**Blows/ Lift**	25

DENSITY AND MOISTURE MEASUREMENTS					
Mass of Soil + Mold (g)	3598	3684	3771	3828	3844
Dish ID	103A	107C	101A	101B	107A
Mass of Dish (g)	134.9	137.2	134.8	135.0	134.8
Mass of Moist Soil + Dish (g)	638.6	788.5	732.1	771.8	725.8
Mass of Dry Soil + Dish (g)	605.0	726.4	657.2	676.0	624.7

RESULTS					
Water Content	7.1%	10.5%	14.3%	17.7%	20.6%
Dry Density (Mg/m^3)	1.617	1.653	1.681	1.686	1.660
Dry Unit Weight (lbs/ft^3)	100.9	103.1	104.9	105.2	103.6
Lab Max. Dry Density (Mg/m^3)	1.686		**Optimum Water Content (%)**		16.5%
Lab Max. Dry Unit Wt. (lbs/ft^3)	105.2				



SAMPLE ID

Boring Number	--
Sample Number	GRPE4ATP-1-082918
Sample Depth, ft	--
Classification	Silty SAND (SM): red

SAMPLE PROPERTIES

	Intial	Final
Mass, g	401.36	421.55
Water Content, %	27.6%	34.0%
Dry Density, pcf	86.8	86.8
Saturation, %	81%	100%
Void Ratio	0.90	0.90
Diameter, in	2.42	2.42
Height, in	3.00	3.00
Area, in^2	4.60	4.60
Volume, in^3	13.80	13.80

CLASSIFICATION

Sieve Size	% Passing
3/8-in. (9.5mm)	---
#4 (4.75mm)	---
#16 (1.18mm)	---
#30 (0.6mm)	---
#100 (0.150mm)	---
#200 (0.075mm)	---

Other Parameters	
Liquid Limit	---
Plastic Limit	---
Plasticity Index	---
Estimated Gs	2.65

TEST SUMMARY

Sample Type	RC = 90%
Permeant	Deaired Tap-Water
Pipette Area, cm^2	0.263
k_{avg} 20ºC, cm/s	1.6E-03
Tested By	ND

REMARKS

Test Method: ASTM D5084 (Method C)

Project: Guadalupe Restoration - TB9 Assessment
Project No. 1801-2191

PERMEATION DATA

Trial	Date	Time, sec	$Temp_{Avg}$, ºC	σ', ksf	μ, ksf	i_o	i_f	k_t, cm/s
1	9/17/18	85	21.1	0.3	13.0	5.0	0.7	1.6E-03
2	9/17/18	81	21.1	0.3	13.0	5.0	0.7	1.7E-03
3	9/17/18	82	21.1	0.3	13.0	5.0	0.7	1.7E-03
4	9/17/18	80	21.1	0.3	13.0	5.0	0.7	1.7E-03
5	9/17/18	80	21.1	0.3	13.0	5.0	0.7	1.7E-03
6	9/17/18	81	21.1	0.3	13.0	5.0	0.7	1.7E-03

SAMPLE IMAGES

SAMPLE ID

Boring Number	--
Sample Number	GRPQ4TP-1-082918
Sample Depth, ft	--
Classification	Poorly-graded SAND (SP): light brown, fine

SAMPLE PROPERTIES

	Intial	Final
Mass, g	405.31	439.88
Water Content, %	19.2%	29.4%
Dry Density, pcf	93.9	93.9
Saturation, %	65%	100%
Void Ratio	0.80	0.80
Diameter, in	2.42	2.42
Height, in	3.00	3.00
Area, in^2	4.60	4.60
Volume, in^3	13.80	13.80

CLASSIFICATION

Sieve Size	% Passing
3/8-in. (9.5mm)	---
#4 (4.75mm)	---
#16 (1.18mm)	---
#30 (0.6mm)	---
#100 (0.150mm)	---
#200 (0.075mm)	---

Other Parameters	
Liquid Limit	---
Plastic Limit	---
Plasticity Index	---
Estimated Gs	2.7

TEST SUMMARY

Sample Type	RC = 90%
Permeant	Deaired Tap-Water
Pipette Area, cm^2	0.263
k_{avg} 20ºC, cm/s	8.7E-03
Tested By	ND

REMARKS

Test Method: ASTM D5084 (Method C)

Project: Guadalupe Restoration - TB9 Assessment

Project No. 1801-2191

PERMEATION DATA

Trial	Date	Time, sec	$Temp_{Avg}$, ºC	σ', ksf	μ, ksf	i_o	i_f	k_t, cm/s
1	9/12/18	10	21.0	0.3	13.0	4.5	1.2	8.9E-03
2	9/12/18	10	21.0	0.3	13.0	4.5	1.2	8.9E-03
3	9/12/18	10	21.0	0.3	13.0	4.5	1.2	8.9E-03
4	9/12/18	10	21.0	0.3	13.0	4.5	1.2	8.8E-03
5	9/12/18	10	21.0	0.3	13.0	4.5	1.2	8.8E-03
6	9/12/18	10	21.0	0.3	13.0	4.5	1.2	8.8E-03

SAMPLE IMAGES

SAMPLE ID

Boring Number	--
Sample Number	GRPQ4TP-2-082918
Sample Depth, ft	--
Classification	Poorly-graded SAND (SP): light brown, fine

SAMPLE PROPERTIES

	Intial	Final
Mass, g	409.95	440.02
Water Content, %	19.0%	27.8%
Dry Density, pcf	95.1	95.1
Saturation, %	68%	100%
Void Ratio	0.74	0.74
Diameter, in	2.42	2.42
Height, in	3.00	3.00
Area, in^2	4.60	4.60
Volume, in^3	13.80	13.80

CLASSIFICATION

Sieve Size	% Passing
3/8-in. (9.5mm)	---
#4 (4.75mm)	---
#16 (1.18mm)	---
#30 (0.6mm)	---
#100 (0.150mm)	---
#200 (0.075mm)	---

Other Parameters	
Liquid Limit	---
Plastic Limit	---
Plasticity Index	---
Estimated Gs	2.65

TEST SUMMARY

Sample Type	RC = 90%
Permeant	Deaired Tap-Water
Pipette Area, cm^2	0.263
k_{avg} 20ºC, cm/s	8.8E-03
Tested By	ND

REMARKS

Test Method: ASTM D5084 (Method C)

Project: Guadalupe Restoration - TB9 Assessment
Project No. 1801-2191

PERMEATION DATA

Trial	Date	Time, sec	$Temp_{Avg}$, ºC	σ', ksf	μ, ksf	i_o	i_f	k_t, cm/s
1	9/12/18	14	21.0	0.3	13.0	5.0	0.7	9.2E-03
2	9/12/18	15	21.0	0.3	13.0	5.0	0.7	8.9E-03
3	9/12/18	15	21.0	0.3	13.0	5.0	0.7	8.9E-03
4	9/12/18	14	21.0	0.3	13.0	5.0	0.7	9.3E-03
5	9/12/18	15	21.0	0.3	13.0	5.0	0.7	8.7E-03
6	9/12/18	14	21.0	0.3	13.0	5.0	0.7	9.3E-03

SAMPLE IMAGES

SAMPLE ID

Boring Number	--
Sample Number	GRPQ4TP-3-082918
Sample Depth, ft	--
Classification	Poorly-graded SAND (SP): light brown, fine

SAMPLE PROPERTIES

	Intial	Final
Mass, g	386.65	438.89
Water Content, %	13.0%	28.2%
Dry Density, pcf	94.5	94.5
Saturation, %	46%	100%
Void Ratio	0.75	0.75
Diameter, in	2.42	2.42
Height, in	3.00	3.00
Area, in^2	4.60	4.60
Volume, in^3	13.80	13.80

CLASSIFICATION

Sieve Size	% Passing
3/8-in. (9.5mm)	---
#4 (4.75mm)	---
#16 (1.18mm)	---
#30 (0.6mm)	---
#100 (0.150mm)	---
#200 (0.075mm)	---

Other Parameters	
Liquid Limit	---
Plastic Limit	---
Plasticity Index	---
Estimated Gs	2.65

TEST SUMMARY

Sample Type	RC = 90%
Permeant	Deaired Tap-Water
Pipette Area, cm^2	0.263
k_{avg} 20ºC, cm/s	8.1E-03
Tested By	ND

REMARKS

Test Method: ASTM D5084 (Method C)

Project: Guadalupe Restoration - TB9 Assessment
Project No. 1801-2191

PERMEATION DATA

Trial	Date	Time, sec	$Temp_{Avg}$, ºC	σ', ksf	μ, ksf	i_o	i_f	k_t, cm/s
1	9/13/18	16	21.0	0.3	13.0	5.0	0.7	8.3E-03
2	9/13/18	16	21.0	0.3	13.0	5.0	0.7	8.3E-03
3	9/13/18	16	21.0	0.3	13.0	5.0	0.7	8.3E-03
4	9/13/18	16	21.0	0.3	13.0	5.0	0.7	8.3E-03
5	9/13/18	16	21.0	0.3	13.0	5.0	0.7	8.3E-03
6	9/13/18	16	21.0	0.3	13.0	5.0	0.7	8.3E-03

SAMPLE IMAGES

SAMPLE ID

Boring Number	--
Sample Number	GRPQ4TP-4-082918
Sample Depth, ft	--
Classification	Poorly-graded SAND (SP): light brown, fine

SAMPLE PROPERTIES

	Intial	Final
Mass, g	397.37	439.36
Water Content, %	15.9%	28.1%
Dry Density, pcf	94.7	94.7
Saturation, %	56%	100%
Void Ratio	0.75	0.75
Diameter, in	2.42	2.42
Height, in	3.00	3.00
Area, in^2	4.60	4.60
Volume, in^3	13.80	13.80

CLASSIFICATION

Sieve Size	% Passing
3/8-in. (9.5mm)	---
#4 (4.75mm)	---
#16 (1.18mm)	---
#30 (0.6mm)	---
#100 (0.150mm)	---
#200 (0.075mm)	---

Other Parameters	
Liquid Limit	---
Plastic Limit	---
Plasticity Index	---
Estimated Gs	2.65

TEST SUMMARY

Sample Type	RC = 90%
Permeant	Deaired Tap-Water
Pipette Area, cm^2	0.263
k_{avg} 20ºC, cm/s	8.5E-03
Tested By	ND

REMARKS

Test Method: ASTM D5084 (Method C)

Project: Guadalupe Restoration - TB9 Assessment
Project No. 1801-2191

PERMEATION DATA

Trial	Date	Time, sec	$Temp_{Avg}$, ºC	σ', ksf	μ, ksf	i_o	i_f	k_t, cm/s
1	9/14/18	16	21.1	0.3	13.0	5.0	0.7	8.3E-03
2	9/14/18	15	21.1	0.3	13.0	5.0	0.7	8.9E-03
3	9/14/18	15	21.1	0.3	13.0	5.0	0.7	8.9E-03
4	9/14/18	15	21.1	0.3	13.0	5.0	0.7	8.9E-03
5	9/14/18	15	21.1	0.3	13.0	5.0	0.7	8.9E-03
6	9/14/18	15	21.1	0.3	13.0	5.0	0.7	8.9E-03

SAMPLE IMAGES

Owen Ranta
Team Lead

Refining Business Unit
Environmental Management Company
2184 West Thornberry Road
Guadalupe, CA 93434
Tel 805 343 0836
Fax 805 343 6558
owenranta@chevron.com

December 9, 2016

Richard Chandler
California Regional Water Quality Control Board
895 Aerovista Place, Suite 101
San Luis Obispo, CA 93401-7906

Guadalupe Restoration Project
Supplemental Site Assessment Report for the Tank Battery 9 Area

PDF via email

Dear Mr. Chandler:

Enclosed is the *Supplemental Site Assessment Report for the Tank Battery 9 Area*. This report was prepared by Padre Associates, Inc. (Padre) to summarize the supplemental site assessment activities completed at the Tank Battery 9 (TB9) Area located at the Guadalupe Restoration Project (GRP), 2184 West Thornberry Road, Guadalupe, California. The supplemental site assessment activities were completed in accordance with Padre's *Technical Work Plan* (TWP), dated September 2016.

A copy of this report will be uploaded to the State Water Resources Control Board Geotracker database. If you have any questions or require additional information, please contact me at (805) 343-0836.

Sincerely,

Owen Ranta, Attorney-in-Fact

Owen Ranta - Team Lead
Chevron Environmental Management Company
Guadalupe Restoration Project

cc: w/enclosure(s)
Ted Mullen, MRS
Guadalupe Compliance Library

padre associates, inc.
ENGINEERS, GEOLOGISTS & ENVIRONMENTAL SCIENTISTS

SUPPLEMENTAL SITE ASSESSMENT REPORT

TANK BATTERY 9 AREA
GUADALUPE RESTORATION PROJECT
2184 WEST THORNBERRY ROAD
GUADALUPE, SAN LUIS OBISPO COUNTY, CALIFORNIA

Prepared by:
PADRE ASSOCIATES, INC.

Submitted by:
CHEVRON ENVIRONMENTAL MANAGEMENT COMPANY

December 2016

Post Office Box 730 ▪ Guadalupe, California 93434 ▪ 805-858-3034 ▪ www.padreinc.com

padre associates, inc.
ENGINEERS, GEOLOGISTS & ENVIRONMENTAL SCIENTISTS

December 9, 2016
Project No. 1601-2193

Chevron Environmental Management Company
2184 West Thornberry Road
Guadalupe, California 93434

Attention: Mr. Owen Ranta
Team Lead

Subject: Supplemental Site Assessment Report, Tank Battery 9 Area, 2184 West Thornberry Road, Guadalupe, San Luis Obispo County, California

Dear Mr. Ranta:

Padre Associates, Inc. (Padre), on behalf of Chevron Environmental Management Company (CEMC), has prepared this report summarizing supplemental site assessment activities completed at the Tank Battery 9 (TB9) Area at the Guadalupe Restoration Project, 2184 West Thornberry Road, Guadalupe, San Luis Obispo County, California (Project Site). The supplemental site assessment activities at the TB9 Area were completed in accordance with Padre's Technical Work Plan (TWP), dated September 2016.

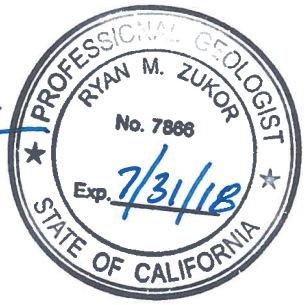
Padre appreciates the opportunity to assist CEMC with the Guadalupe Restoration Project. If you have any questions or require additional information, please contact the undersigned.

Sincerely,

PADRE ASSOCIATES, INC.

Michael A. McAlpin, G.I.T.
Staff Geologist

Ryan M. Zukor, P.G.
Principal



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APPENDIX B: LABORATORY ANALYTICAL REPORTS (PROVIDED ON CD)

1.0 INTRODUCTION

Padre Associates, Inc. (Padre), on behalf of Chevron Environmental Management Company (CEMC), has prepared this report to document the results of supplemental site assessment activities completed at the Former Tank Battery 9 (TB9), Former Land Treatment Pilot-Study, and Containment Basin Areas herein referred to as the TB9 Area at the Guadalupe Restoration Project (GRP), located at 2184 West Thornberry Road, Guadalupe, San Luis Obispo County, California (Project Site). The location of the Project Site is presented as Plate 1 - Site Location Map. The supplemental site assessment and historical drill hole locations are presented on Plate 2 - Drill Hole Locations - TB9 Area.

The supplemental site assessment activities were completed during the period from October 13, 2016 through November 9, 2016 in accordance with the *Technical Work Plan* (TWP), dated September 2016 (Padre, 2016). The Regional Water Quality Control Board, Central Coast Region (RWQCB) approved the TWP in a letter dated September 22, 2016 (RWQCB, 2016).

2.0 TB9 AREA BACKGROUND

The TB9 Area is located in the south-central portion of the Project Site approximately 1.25 miles east of the Pacific Ocean and 0.4 miles north of the Santa Maria River. At the TB9 Area, the elevation ranges from approximately 65 feet to 105 feet mean sea level (MSL). Two lithologic units that represent Quaternary aeolian dune sand and alluvial deposits were identified during site assessment activities.

Historical soil assessment activities have identified sump material beneath the Former TB9, Former Land Treatment Pilot-Study, and Containment Basin Areas. In the *Sump Data Interpretation Report,* dated 2003, and prepared by Levine-Fricke, sump material is defined as a tank, pit, or natural depression used to collect drilling wastes which may include cuttings, cement, drilling mud, sand, petroleum, or wastes from other oilfield operations. Sumps associated with the former tank batteries at the Project Site historically received oil production-related fluids, primarily crude oil with some associated diluent, produced water, and sediment (LFR, 2003).

The Containment Basin Area is currently utilized to manage recovered fluids prior to being transferred to the onsite Advanced Water Treatment System (AWTS) at the Project Site. The containment basin is constructed with a high-density polyethylene (HDPE) liner and partially filled with soil.

Groundwater monitoring has been conducted in the TB9 Area since the second quarter of 1993 (2Q93). There are 12 groundwater monitoring wells in the vicinity of the TB9 Area that are monitored. Currently one groundwater monitoring well (TB9-1) is sampled and gauged annually as part of the Site-Wide Dune Sand Aquifer (DSA) Monitoring Program. The depth to

water in three groundwater monitoring wells (I12-2, I12-3, and J13-1) is measured quarterly as part of the Site-Wide DSA Monitoring Program. Eight wells (208R, I12-1, TB9-2, TB9-3, TB9-5, TB9-6, KTB9-7, and KTB9-8) are monitored as part of the Passive Free-Product Recovery Program. The TB9 Active Recovery System is located hydrogeologically downgradient and towards the west of the TB9 Area.

Based on available data from the groundwater monitoring wells located in the vicinity of the TB9 Area, the groundwater flow direction in this area is generally towards the west-northwest. The most recent groundwater monitoring data collected from wells located in the TB9 Area during the 2Q16 monitoring period indicated depths to groundwater ranging from approximately 29 feet to 76 feet below grade depending on topography, with a corresponding groundwater elevation ranging from approximately 28 feet to 32 feet above MSL.

3.0 ASSESSMENT METHODOLOGY

Summarized below are the descriptions of the procedures and methods used to complete the supplemental site assessment activities at the TB9 Area.

3.1 PRE-FIELD ACTIVITIES

Padre utilized the existing site-specific health and safety plan (HASP) for the Project Site. Underground Service Alert (USA) was also notified 48 hours prior to the commencement of field activities to identify any underground utility hazards in the work area.

3.2 DRILLING AND SAMPLING ACTIVITIES

During the period from October 13, 2016 through November 9, 2016, Padre observed and collected data at 35 drill hole locations (SBTB9-57 through SBTB9-91) at the TB9 Area to total depths ranging from approximately 24 to 80 feet bgs. The drill hole locations are presented on Plate 2 – Drill Hole Locations – Tank Battery 9 Area.

The drill hole locations were selected to further delineate the lateral and vertical extents of TPH-affected soil and to provide additional groundwater data at the TB9 Area. Twenty-six drill hole locations were advanced approximately 5 feet into groundwater or to approximately 5 feet below the vertical extent of TPH-affected sump material. Nine drill holes were advanced to approximately 20 feet passed suspected sump material. Soil samples were collected at discrete depths to define the vertical extent of TPH-affected soil, from the capillary fringe, and from the total depth of each drill hole location. Groundwater samples were also collected from temporary wells set at drill hole locations SBTB9-58, STBTB9-59, and SBTB9-65. Attempts were made to collect groundwater samples from drill hole locations SBTB9-61 and SBTB9-70; however, groundwater samples could not be collected due to slow groundwater recharge and low groundwater yield.

Padre contracted the services of Gregg Drilling Company (Gregg) of Signal Hill, California, a State of California C57 drilling contractor, to complete the advancement of 35 drill

holes; Gregg utilized a limited access drilling rig equipped with hollow-stem auger and direct-push drilling capabilities.

The direct-push and hollow-stem auger drill holes were continuously cored using the Macro-Core® soil sampling system. Continuous soil samples were collected in 4-foot long, 2-inch diameter clear acetate liners advanced using a stainless-steel sampler. The acetate liners were opened to allow the project geologist to record the lithology in accordance with the Unified Soil Classification System (USCS) and to determine the desired sampling depth. A field calibrated photoionization detector (PID) was utilized to measure volatile organic compounds (VOCs) in the field. The PID readings and discrete soil sample identifications were recorded on the drill hole logs provided in Appendix A - Drill Hole Logs.

At a minimum, discrete-depth soil samples were collected from each drill hole location at depths that contained TPH-affected soil, the vadose zone, capillary fringe, and total depth of each drill hole.

The discrete-depth soil samples that were submitted for chemical analyses were transferred into pre-cleaned laboratory grade 4-ounce or 8-ounce glass sample jars. The soil samples were logged, labeled, placed in a plastic bag, and preserved in a cooler pending delivery to the analytical laboratory under chain of custody (COC) documentation.

Hydropunch groundwater sampling methodology was not used to collect groundwater samples at the TB9 Area because the re-useable stainless steel Hydropunch sampler did not yield sufficient groundwater for sampling due to a thin phreatic zone within the DSA. Groundwater samples were collected by installing a temporary polyvinyl chloride (PVC) well casing in the drill hole. The temporary monitoring wells were constructed of two-inch diameter schedule 40 PVC with five feet of 0.020-inch slotted screen filtered by a well sock. Groundwater samples were collected using disposable Teflon bailers. The groundwater was transferred into pre-cleaned laboratory grade 1-liter amber glass bottles and three volatile organic analysis (VOA) vials, which were logged, labeled, and placed in a cooler with ice pending delivery to the analytical laboratory under COC documentation.

Upon completion, each drill hole was backfilled with bentonite chips to within approximately 1 foot of the surface and hydrated in-place. The remainder of each drill hole was restored with clean native material and when necessary patched with asphalt to match the surrounding ground surface. The drill hole locations are presented on Plate 2, and drill hole logs are provided in Appendix A – Drill Hole Logs.

3.3 LABORATORY ANALYTICAL PROGRAM

A total of 178 discrete-depth soil samples and three groundwater samples were submitted for chemical analyses to BC Laboratories (BC Labs) located in Bakersfield, California. BC Labs is certified by the California State Environmental Laboratory Accreditation Program (ELAP) to perform the requested analyses.

The 178 discrete-depth soil samples were chemically analyzed for the presence of the following:

- TPH carbon chain breakdown (C_4-C_{12}), (C_{13}-C_{22}), and (C_{23}-C_{40}) by U.S. EPA Method 8015M; and
- Benzene, toluene, ethylbenzene, and total xylenes (BTEX) by U.S. EPA Method 8260.

Three groundwater samples were chemically analyzed for the presence of:

- TPH as diluent (C_{12}-C_{32}) by U.S. EPA Method 8015M; and
- BTEX by U.S. EPA Method 8260B.

Ten discrete-depth soil samples were also chemically analyzed for the presence of the following California Code of Regulations (CCR) Title 22 hazardous waste characteristics:

- Volatile organic compounds (VOCs) by U.S. EPA Method 8260B;
- CAM 17/Title 22 metals by U.S. EPA Method 6000/7000 series;
- Polychlorinated biphenyls (PCBs) by U.S. EPA Method 8082;
- Semi-volatile organic compounds (SVOCs) by U.S. EPA Method 8270C;
- Polyaromatic Hydrocarbons (PAHs) by U.S. EPA Method 8270C Selected Ion Monitoring (SIM).
- Organochlorine pesticides by U.S. EPA Method 8081B;
- pH by U.S. EPA Method 9040;
- Reactive Cyanide by SW846 7.3.3.2;
- Reactive Sulfide by SW846 7.3.4.2;
- Burning Rate by U.S. EPA Method 1030;
- Fathead minnow hazardous waste screen bioassay; and
- Soluble Threshold Limit Concentrations (STLC) for TPH carbon chain breakdown (C_4-C_{12}), (C_{13}-C_{22}), and (C_{23}-C_{40}) by U.S. EPA Method 8015M.

3.4 QUALITY ASSURANCE/QUALITY CONTROL (QA/QC) PROCEDURES

Quality Assurance/Quality Control (QA/QC) procedures were utilized in both sample collection and chemical analyses. The purpose of the QA/QC procedures was to ensure the reliability and compatibility of all data generated during the sampling program.

Field QA/QC Procedures. Field QA/QC procedures were performed during the sampling program and consist of the following measures:

- COC forms were used to document soil and groundwater sample submittal to the laboratory. A COC record accompanied each set of soil and groundwater samples submitted for chemical analyses; and
- Information regarding soil sample collection such as sample type, sample identification number, and sample date/time were collected and recorded on drill hole logs.

Laboratory QA/QC Procedures. Laboratory QA/QC procedures include the following:

- Chemical analyses were performed within the required holding time for all samples;
- A State-certified hazardous waste testing laboratory conducted the requested analyses; and
- The laboratory provided the following information for each sample:
  - Method blank data;
  - Surrogate recovery, instrument tuning, and calibration data; and
  - Signed laboratory reports including the sample designation, date of sample collection, date of sample analyses, laboratory analytical method employed, sample volume, and the minimum reporting limit.

3.5 DECONTAMINATION PROCEDURES

Re-usable field sampling equipment was cleaned before use, between sample locations, and after completion of sampling activities using a non-phosphate detergent wash, one rinse with tap water, and a final rinse with distilled water. The re-usable hollow-stem augers and direct-push rods were pressure-washed between drill hole locations.

3.6 INVESTIGATION - DERIVED WASTES

Investigation-derived wastes (IDW) consisted of decontaminant wash water and drill hole soil cuttings. Wash water was contained in covered buckets and ultimately placed in the site water treatment system. Soil cuttings were transported to the onsite M3 Stockpile Area. A soil tracking/inventory form is completed at the Project Site each week to track the volume of soil disposed of as part of the supplemental site assessment activities at the TB9 Area.

3.7 SURVEY

Cannon Associates, Inc. (Cannon), a California-licensed Land Surveyor from San Luis Obispo, California, surveyed the completed drill hole locations. The survey data is presented on Table 1 - Summary of Survey Results, TB9 Area.

4.0 RESULTS AND DISCUSSION

4.1 FIELD OBSERVATIONS DURING DRILLING ACTIVITIES

Earth materials encountered during the supplemental site assessment activities consisted primarily of poorly graded, fine to medium-grained sand, silt, and lean clay that contained a combination of crude oil sump material and diluent depending on depth.

In drill holes SBTB9-57 through SBTB9-59, SBTB9-71, SBTB9-73, SBTB9-82 through SBTB9-84, SBTB9-90, and SBTB9-91 advanced in the former TB9 Area, crude oil sump material was encountered to depths ranging from approximately 1.5 feet bgs to 30 feet bgs. Crude oil sump material was not encountered in drill holes SBTB9-72, SBTB9-74 through SBTB9-76, and SBTB9-89. Diluent-affected soil was encountered at the capillary fringe with corresponding depths ranging from approximately 51 feet bgs to 79 feet bgs depending on the ground surface elevation.

Crude oil sump material was encountered in drill holes SBTB9-60 through SBTB9-63, SBTB9-69, and SBTB9-85 through SBTB9-88 which were advanced in the Former Land Treatment Pilot-Study Area to depths ranging from approximately 2 feet bgs to 29.25 feet bgs. Crude oil sump material was not encountered in drill holes SBTB9-68, SBTB9-70, and SBTB9-77 through SBTB9-79. Diluent-affected soil was encountered at the capillary fringe with corresponding depths ranging from 52 feet bgs to 60.5 feet bgs depending on the ground surface elevation.

TPH-affected soil was encountered in the Containment Basin Area at depths ranging from 3.5 feet bgs to 8 feet bgs. Crude oil sump material was encountered outside of the Containment Basin Area in drill hole SBTB9-81 at depths ranging from 5.5 to 9.5 feet bgs. Crude oil sump material was not encountered in drill holes SBTB9-64 through SBTB9-67, or SBTB9-80. TPH-affected soil was not observed at the capillary fringe in the drill holes advanced in the Containment Basin Area.

Total depths of the 35 direct-push/hollow-stem auger drill holes advanced at the TB9 Area ranged from approximately 24 feet bgs to 80 feet bgs, at elevations ranging from approximately 20.53 to 76.76 feet above MSL. Groundwater was encountered at 26 of the 35 drill hole locations at approximate depths ranging from approximately 26.75 feet bgs to 71.5 feet bgs, at elevations ranging from approximately 28.57 to 37.56 feet above MSL. Depth to groundwater varied due to the topography within the TB9 Area.

4.2 LABORATORY ANALYTICAL RESULTS

The laboratory analytical results for the discrete-depth soil and groundwater samples are presented as Table 2 - Summary of TB9 Area Assessment, BTEX and TPH Analytical Results; Table 3 - Summary of TB9 Area Assessment, Waste Profile Analytical Results; and Table 4 - Summary of TB9 Area Assessment, TTLC and STLC Analytical Results. The laboratory analytical reports are attached as Appendix B – Laboratory Analytical Reports.

4.2.1 Results of Soil Assessment Activities

TPH. The results for 51 of the 178 soil samples collected from the 35 drill hole locations indicate total TPH (C_4-C_{40}) concentrations identified as crude oil sump material in excess of the laboratory analytical method reporting limit ranging from 12 mg/Kg (SBTB9-81-9.5) to 51,700 mg/Kg (SBTB9-88-12) at approximate depths ranging from 0.5 feet bgs to 29.5 feet bgs.

The results for 42 of the 178 soil samples collected from the 35 drill hole locations indicate TPH concentrations identified as diluent in soil at the capillary fringe in excess of the laboratory analytical method reporting limit ranging from 14 mg/Kg (SBTB9-58-66) to 83,520 mg/Kg (SBTB9-72-72) at approximate depths ranging from the 50.5 feet bgs to 74.5 feet bgs.

The results for seven of the 22 soil samples collected from the four drill holes located within the Containment Basin Area indicate TPH concentrations identified as diluent in soil at shallow depths. The results indicate TPH concentrations in excess of the laboratory analytical method reporting limit ranging from 29 mg/Kg (SBTB9-64-6) to 9,000 mg/Kg (SBTB9-64-3.5) at approximate depths ranging from 3.5 feet bgs to 8 feet bgs.

Ten discrete-depth crude oil sump material soil samples were also chemically analyzed for STLC for TPH carbon chain ranges (C_4-C_{12}), (C_{13}-C_{22}), and (C_{23}-C_{40}). The STLC results for TPH carbon chain ranges (C_4-C_{12}), (C_{13}-C_{22}), and (C_{23}-C_{40}) indicated concentrations ranging from 0.25 milligrams per liter (mg/L) to 13 mg/L, 2.2 mg/L to 10 mg/L, and <1.0 mg/L to <2.5 mg/L, respectively.

BTEX. The results indicate five of the 178 soil samples contain benzene concentrations ranging from 0.0078 mg/Kg to 0.18 mg/Kg. The results indicate 27 of the 178 soil samples contain ethylbenzene concentrations ranging from 0.0054 mg/Kg to 3.3 mg/Kg. The results indicate two of the 178 soil samples contain toluene concentrations ranging from 0.030 mg/Kg to 0.33 mg/Kg. The results indicate 20 of the 178 soil samples contain total xylenes concentrations ranging from 0.011 mg/Kg to 3.5 mg/Kg.

VOCs. The results indicate eight of the ten soil samples analyzed for VOC constituents contain concentrations ranging from 0.015 mg/Kg (1,3,5-trimethylbenzene) to 3.5 mg/Kg (total xylenes).

SVOCs. The results indicate soil sample SBTB9-73-1.5 contains 2-methylnapthalene at a concentration of 21 mg/Kg.

PAHs. The results indicate all ten of the soil samples analyzed for PAH constituents contain concentrations ranging from 0.29 mg/Kg (fluoranthene) to 10 mg/Kg (phenanthrene).

PCBs. The results indicate that all ten of the soil samples analyzed for PCB constituents do not contain concentrations in excess of the laboratory analytical method reporting limits.

CAM 17 Metals. Metals concentrations reported for all ten of the soil samples were compared to their respective TTLC values for hazardous waste as listed in Title 22 of the CCR, Section 66261.24(a)(2)(A). The reported metals concentrations do not exceed the respective TTLC or STLC values for any of the soil samples chemically analyzed.

Organochlorine Pesticides. The results indicate that all ten of the soil samples analyzed for organochlorine pesticide do not contain concentrations in excess of the laboratory analytical method reporting limits.

Inorganic and Bioassay Results. The laboratory analytical results indicate that pH, burning rate, reactive cyanide, and reactive sulfide values for all ten soil samples analyzed do not exceed federal and state hazardous waste criteria as defined in 40CFR261 and 22CCR66261, respectively. Additionally, all ten soil samples passed the bioassay screening.

4.2.2 Results of Groundwater Assessment Activities

TPH and BTEX. Three groundwater samples (HPSBTB9-58, HPSBTB9-59, and HPSBTB9-65) were collected and chemically analyzed for the presence of TPH as diluent (C_{12}-C_{32}) and BTEX. Laboratory analytical results indicate the groundwater samples contain concentrations of TPH as diluent ranging from 0.6 mg/L to 2,000 mg/L, benzene concentrations ranging from 0.0016 mg/L to 0.0018 mg/L, and ethylbenzene concentrations ranging from 0.0073 mg/L to 0.011 mg/L. One groundwater sample indicated a toluene concentration of 0.00050 mg/L and a total xylenes concentration of 0.039 mg/L.

5.0 SUMMARY

Supplemental site assessment activities were completed at the TB9 Area during the period from October 13, 2016 through November 9, 2016 in accordance with Padre's TWP dated September 2016.

The laboratory analytical results indicate 51 of the 178 soil samples contain TPH concentrations identified as crude oil sump material ranging from 12 mg/Kg to 51,700 mg/Kg. The laboratory analytical results indicate 42 of the 178 soil samples contain TPH concentrations identified as diluent at the capillary fringe ranging from 14 mg/Kg to 83,520 mg/Kg. The laboratory analytical results indicate 7 of the 22 soil samples from the Containment Basin Area contain TPH concentrations identified as diluent at shallow depths ranging from 29 mg/Kg to 9,000 mg/Kg.

The results for groundwater samples indicate TPH as diluent concentrations ranging from 0.6 mg/L to 2,000 mg/L, benzene concentrations ranging from 0.0016 mg/L to 0.0018 mg/L, and ethylbenzene concentrations ranging from 0.0073 mg/L to 0.011 mg/L. The results indicate one of the three groundwater samples contained a toluene concentration of 0.00050 mg/L and a total xylenes concentration of 0.039 mg/L.

6.0 REFERENCES

Levine-Fricke (LFR) (2003). *Sump Data Interpretation Report, Version 2.1, Former Guadalupe Oil Field, Guadalupe, San Luis Obispo County, California.* Dated July 31.

Padre Associates, Inc. (Padre) (2016). *Technical Work Plan, TB9 Area, Guadalupe Restoration Project, 2184 West Thornberry Road, Guadalupe, San Luis Obispo County, California.* Dated September.

Regional Water Quality Control Board, Central Coast (RWQCB) (2016). *Site Cleanup Program: Technical Work Plan for Supplemental Site Assessment Activities at the Tank Battery 9 Area, Guadalupe Restoration Project, California.* Dated October 4.

PLATES

PACIFIC OCEAN

Diluent Tanks Area

Compressor Plant Area

Tank Battery 9 Area

Santa Maria River

SAN LUIS OBISPO COUNTY

SANTA BARBARA COUNTY

N

LEGEND:

- Groundwater Monitoring Well
- County Line
- Property Boundary
- Active LNAPL Recovery System Infrastructure
- Existing Roadway or Well Pad Feature
- Former Roadway or Well Pad Feature
- Excavated LNAPL Source Area or Sump
- LNAPL Source Zone
- Federal Wetland (June 2004)
- Restored Wetland (Not Formally Designated)
- State Wetland (June 2003)

0 650 1,300

FEET

Source: Cannon 2015 Image
Coordinate System: NAD 1927 StatePlane California V FIPS 0405
Abbreviations: LNAPL = liquid non-aquous phase liquid
Notes: This map was created for informational and display purposes only

padre associates, inc.
ENGINEERS, GEOLOGISTS & ENVIRONMENTAL SCIENTISTS

PROJECT NAME: CHEVRON ENVIRONMENTAL MANAGEMENT COMPANY GUADALUPE RESTORATION PROJECT

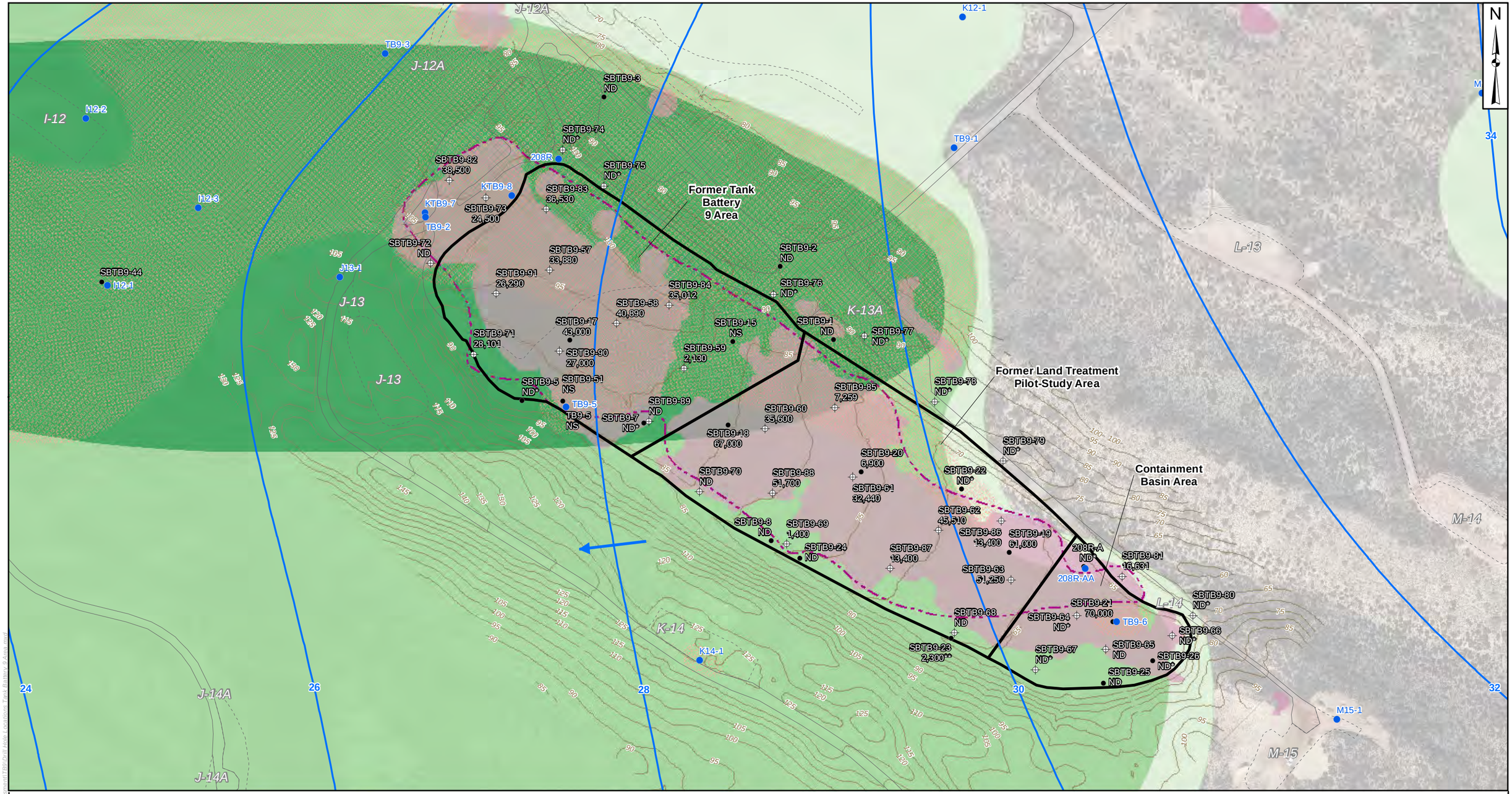
PROJECT NUMBER: 1601-2193

DATE: December 2016

SITE LOCATION MAP

PLATE 1

Z:\Kirkin\GIS Maps\Map Project\Guadalupe\Assessment\TBRSite Location.mxd



LEGEND:

- Drill Hole Identification / Maximum TPH Concentration in Sump Material (mg/Kg) — SBTB9-57 / 33,880
- Drill Hole Identification / Maximum TPH Concentration in Sump Material (mg/Kg) — SBTB9-8 / ND
- 4Q16 Drill Hole Location
- Historical Drill Hole Location
- Groundwater Monitoring Well
- 5-ft Topographic Elevation Contour (2016)
- Existing Roadway or Well Pad Feature
- Former Roadway or Well Pad Feature
- LNAPL Source Area
- Approximate Extent of Sump based on Aerial Photo Review
- Approximate Extent of Sump material based on Assessment Results
- TPH Concentrations in Groundwater Above Laboratory Reporting Limit of 0.05 to 1 mg/L
- TPH Concentrations in Groundwater Ranging from 1 to 10 mg/L
- TPH Concentrations in Groundwater Greater than 10 mg/L
- 2Q16 Groundwater Elevation Contour (feet msl)
- Ground Water Flow Direction

0 80 160
FEET

Source: Cannon 2016 Image, Cannon 2016 Contours
Coordinate System: NAD 1927 StatePlane California V FIPS 0405
Abbreviations: LNAPL = Light Non-Aqueous Phase Liquid
mg/L = Milligrams per Liter
mg/Kg = Milligrams per Kilogram
ND = Not detected above laboratory reporting limit

ND = Sump material not observed during drilling, not sampled*
NS = Sump material observed during drilling, not sampled
TB = Tank Battery
TPH = Total Petroleum Hydrocarbons
*Notes: ** = TPH result in soil stockpile material*
This map was created for informational and display purposes only.

padre associates, inc.
ENGINEERS, GEOLOGISTS & ENVIRONMENTAL SCIENTISTS

PROJECT NAME: CHEVRON ENVIRONMENTAL MANAGEMENT COMPANY GUADALUPE RESTORATION PROJECT
PROJECT NUMBER: 1601-2193
DATE: December 2016

DRILL HOLE LOCATIONS TANK BATTERY 9 AREA

PLATE 2

Z:\Kriston\GIS Maps\Maps Project\Groundwater\Assessment\TB9\Drill Hole Locations Tank Battery 9 Area.mxd

TABLES

Table 1. Summary of Survey Results
TB9 Area
Guadalupe Restoration Project

Sample Location	Northing	Easting	Sample Surface Elevation *feet msl*
Soil Boring Samples			
SBTB9-57	546546.764	1214162.264	95.56
SBTB9-58	546455.449	1214276.586	93.65
SBTB9-59	546378.503	1214391.548	89.07
SBTB9-60	546275.271	1214530.334	82.70
SBTB9-61	546193.394	1214679.507	76.72
SBTB9-62	546101.740	1214825.837	69.97
SBTB9-63	546016.844	1214950.079	65.95
SBTB9-64	545956.592	1215062.035	60.96
SBTB9-65	545899.046	1215111.365	61.03
SBTB9-66	545922.776	1215225.151	61.59
SBTB9-67	545864.021	1214991.638	61.27
SBTB9-68	545927.155	1214852.936	65.98
SBTB9-69	546078.383	1214567.093	75.31
SBTB9-70	546168.042	1214418.227	83.71
SBTB9-71	546403.110	1214032.259	85.57
SBTB9-72	546557.620	1213958.532	101.54
SBTB9-73	546670.301	1214053.336	100.53
SBTB9-74	546751.697	1214184.428	100.97
SBTB9-75	546690.311	1214254.503	103.56
SBTB9-76	546505.253	1214544.021	90.33
SBTB9-77	546433.882	1214699.630	90.32
SBTB9-78	546321.670	1214819.497	87.01
SBTB9-79	546220.190	1214936.791	80.01
SBTB9-80	545956.696	1215260.440	72.95
SBTB9-81	546023.594	1215139.334	71.11
SBTB9-82	546699.849	1213990.840	98.53
SBTB9-83	546650.507	1214156.724	98.87
SBTB9-84	546486.512	1214365.885	98.76
SBTB9-85	546311.850	1214649.166	76.81
SBTB9-86	546118.007	1214932.830	67.16

Table 1. Summary of Survey Results
TB9 Area
Guadalupe Restoration Project

Sample Location	Northing	Easting	Sample Surface Elevation *feet msl*
SBTB9-87	546036.922	1214743.216	71.14
SBTB9-88	546165.892	1214542.829	79.77
SBTB9-89	546288.072	1214331.897	88.27
SBTB9-90	546408.385	1214178.577	90.65
SBTB9-91	546506.759	1214070.533	93.30

Notes:

msl = Mean Sea Level
SB = Soil Boring
TB9 = Tank Battery 9

QA/QC Review: BWP
Date: 11/23/16

Table 2. Summary of TB9 Area Assessment
BTEX and TPH Analytical Results
Guadalupe Restoration Project

Sample Location	Sample Identification	Laboratory Reference Number	Laboratory	Sample Date	Sample Depth *feet bgs*	Sample Elevation *feet msl*	Benzene	Ethylbenzene	Toluene	Xylenes	TPH C_{12} - C_{32}	TPH C_4 - C_{12}	TPH C_{13} - C_{22}	TPH C_{23} - C_{40}	Total TPH
Soil Boring Results							**All Results Reported in mg/Kg**								
SBTB9-57	SBTB9-57-4-101316	1628979-01	BC	10/13/16	4	91.56	<0.0050	<0.0050	<0.0050	<0.010	--	<0.20	500	1,400	1,900
	SBTB9-57-4.5-101316	1628979-02	BC	10/13/16	4.5	91.06	<0.0050	<0.0050	<0.0050	<0.010	--	<0.20	<110	1,100	1,100
	SBTB9-57-14.5-101316	1628979-03	BC	10/13/16	14.5	81.06	0.0078	0.026	<0.0050	0.092	--	880	13,000	20,000	33,880
	SBTB9-57-28-101316	1628979-04	BC	10/13/16	28	67.56	<0.0050	0.033	<0.0050	0.023	--	350	6,300	8,700	15,350
	SBTB9-57-32-101316	1628979-05	BC	10/13/16	32	63.56	<0.0050	<0.0050	<0.0050	<0.010	--	<0.20	<10	<20	0[1]
	SBTB9-57-63-101316	1628979-06	BC	10/13/16	63	32.56	<0.0050	<0.0050	<0.0050	<0.010	--	80	1,600	<200	1,680
	SBTB9-57-66-101316	1628979-07	BC	10/13/16	66	29.56	<0.0050	0.013	<0.0050	0.016	--	400	**38,000**	<8,000	38,400
	SBTB9-57-71.5-101316	1628979-08	BC	10/13/16	71.5	24.06	<0.0050	<0.0050	<0.0050	<0.010	--	<0.20	<10	<20	0[1]
SBTB9-58	SBTB9-58-4-101716	1629091-01	BC	10/17/16	4	89.65	**0.18**	1.7	0.33	2.6	--	890	**23,000**	17,000	40,890
	SBTB9-58-19.5-101716	1629091-02	BC	10/17/16	19.5	74.15	0.023	0.090	<0.010	<0.020	--	730	14,000	22,000	36,730
	SBTB9-58-20-101716	1629091-03	BC	10/17/16	20	73.65	<0.0050	<0.0050	<0.0050	<0.010	--	<0.20	<10	<20	0[1]
	SBTB9-58-58.5-101716	1629091-04	BC	10/17/16	58.5	35.15	<0.0050	0.020	<0.0050	<0.010	--	40	4,000	1,900	5,940
	SBTB9-58-63-101716	1629091-05	BC	10/17/16	63	30.65	<0.0050	0.030	<0.0050	0.014	--	88	6,900	3,800	10,788
	SBTB9-58-64-101716	1629091-06	BC	10/17/16	64	29.65	<0.0050	0.19	<0.0050	0.087	--	140	**15,000**	8,500	23,640
	SBTB9-58-66-101716	1629091-07	BC	10/17/16	66	27.65	<0.0050	<0.0050	<0.0050	<0.010	--	0.72	13	<20	14
	SBTB9-58-71.5-101716	1629091-08	BC	10/17/16	71.5	22.15	<0.0050	<0.0050	<0.0050	<0.010	--	<0.20	<10	<20	0[1]
SBTB9-59	SBTB9-59-4-101816	1629427-01	BC	10/18/16	4	85.07	<0.0050	<0.0050	<0.0050	<0.010	--	<0.20	730	1,400	2,130
	SBTB9-59-6.5-101816	1629427-02	BC	10/18/16	6.5	82.57	<0.0050	<0.0050	<0.0050	<0.010	--	<0.20	22	54	76
	SBTB9-59-55-101816	1629427-03	BC	10/18/16	55	34.07	<0.0050	<0.0050	<0.0050	<0.010	--	<0.20	1,000	1,500	2,500
	SBTB9-59-60.5-101816	1629427-04	BC	10/18/16	60.5	28.57	<0.0050	0.29	<0.0050	0.011	--	89	**20,000**	15,000	35,089
	SBTB9-59-61-101816	1629427-05	BC	10/18/16	61	28.07	<0.0050	<0.0050	<0.0050	<0.010	--	0.70	34	<20	35
	SBTB9-59-63.5-101816	1629427-06	BC	10/18/16	63.5	25.57	<0.0050	<0.0050	<0.0050	<0.010	--	<0.20	<10	<20	0[1]
SBTB9-60	SBTB9-60-5-101916	1629427-08	BC	10/19/16	5	77.70	0.039	<0.025	<0.025	0.20	--	**1,600**	**15,000**	19,000	35,600
	SBTB9-60-18.5-101916	1629427-09	BC	10/19/16	18.5	64.20	<0.025	<0.025	<0.025	<0.050	--	1.2	39	57	97
	SBTB9-60-24-101916	1629427-10	BC	10/19/16	24	58.70	<0.0050	<0.0050	<0.0050	<0.010	--	<0.20	<10	<20	0[1]
	SBTB9-60-40-101916	1629427-11	BC	10/19/16	40	42.70	<0.0050	<0.0050	<0.0050	<0.010	--	<0.20	<160	<320	0[1]
	SBTB9-60-50.5-101916	1629427-12	BC	10/19/16	50.5	32.20	<0.0050	<0.0050	<0.0050	<0.010	--	<0.20	<10	<20	0[1]
	SBTB9-60-52-101916	1629427-13	BC	10/19/16	52	30.70	<0.0050	<0.0050	<0.0050	<0.010	--	<0.20	<10	<20	0[1]
	SBTB9-60-55.5-101916	1629427-14	BC	10/19/16	55.5	27.20	<0.0050	<0.0050	<0.0050	<0.010	--	<0.20	<10	<20	0[1]

Table 2. Summary of TB9 Area Assessment
BTEX and TPH Analytical Results
Guadalupe Restoration Project

Sample Location	Sample Identification	Laboratory Reference Number	Laboratory	Sample Date	Sample Depth *feet bgs*	Sample Elevation *feet msl*	Benzene	Ethylbenzene	Toluene	Xylenes	TPH C_{12} - C_{32}	TPH C_4 - C_{12}	TPH C_{13} - C_{22}	TPH C_{23} - C_{40}	Total TPH
Soil Boring Results (Continued)							**All Results Reported in mg/Kg**								
SBTB9-61	SBTB9-61-7.5-101916	1629427-15	BC	10/19/16	7.5	69.22	<0.010	<0.010	<0.010	<0.020	--	58	5,700	5,800	11,558
	SBTB9-61-25-102016	1629654-03	BC	10/20/16	25	51.72	<0.025	0.032	<0.025	0.071	--	440	14,000	18,000	32,440
	SBTB9-61-29.5-102016	1629654-04	BC	10/20/16	29.5	47.22	<0.0050	0.0054	<0.0050	<0.010	--	53	460	<320	513
	SBTB9-61-32-102016	1629654-05	BC	10/20/16	32	44.72	<0.025	<0.025	<0.025	<0.050	--	<1.0	<10	<20	0[1]
	SBTB9-61-44.5-102016	1629654-06	BC	10/20/16	44.5	32.22	<0.0050	<0.0050	<0.0050	<0.010	--	<0.20	<10	<20	0[1]
	SBTB9-61-45-102016	1629654-07	BC	10/20/16	45	31.72	<0.0050	<0.0050	<0.0050	<0.010	--	<0.20	<10	<20	0[1]
	SBTB9-61-46.5-102016	1629654-08	BC	10/20/16	46.5	30.22	<0.0050	<0.0050	<0.0050	<0.010	--	<0.20	<10	<20	0[1]
SBTB9-62	SBTB9-62-5-102016	1629654-01	BC	10/20/16	5	64.97	<0.0050	<0.0050	<0.0050	<0.010	--	0.78	510	650	1,161
	SBTB9-62-6-102016	1629654-02	BC	10/20/16	6	63.97	0.012	0.026	<0.010	0.049	--	510	**23,000**	22,000	45,510
	SBTB9-62-16-102016	1629654-09	BC	10/20/16	16	53.97	<0.0050	<0.0050	<0.0050	<0.010	--	<0.20	21	<20	21
	SBTB9-62-38-102016	1629654-10	BC	10/20/16	38	31.97	<0.0050	<0.0050	<0.0050	<0.010	--	<0.20	<10	<20	0[1]
	SBTB9-62-38.5-102016	1629654-11	BC	10/20/16	38.5	31.47	<0.0050	<0.0050	<0.0050	<0.010	--	<0.20	<10	<20	0[1]
	SBTB9-62-39-102016	1629654-12	BC	10/20/16	39	30.97	<0.0050	<0.0050	<0.0050	<0.010	--	<0.20	<10	<20	0[1]
SBTB9-63	SBTB9-63-7-102016	1629654-13	BC	10/20/16	7	58.95	<0.010	0.054	<0.010	0.042	--	250	**25,000**	26,000	51,250
	SBTB9-63-8-102416	1629753-01	BC	10/24/16	8	57.95	<0.050	0.090	<0.050	0.12	--	15	**17,000**	18,000	35,015
	SBTB9-63-12.5-102416	1629753-02	BC	10/24/16	12.5	53.45	<0.0050	<0.0050	<0.0050	<0.010	--	<0.20	14	<20	14
	SBTB9-63-33-102416	1629753-03	BC	10/24/16	33	32.95	<0.0050	<0.0050	<0.0050	<0.010	--	<0.20	<10	<20	0[1]
	SBTB9-63-33.5-102416	1629753-04	BC	10/24/16	33.5	32.45	<0.0050	<0.0050	<0.0050	<0.010	--	<0.20	<10	<20	0[1]
	SBTB9-63-36-102416	1629753-05	BC	10/24/16	36	29.95	<0.0050	<0.0050	<0.0050	<0.010	--	<0.20	40	42	82
SBTB9-64	SBTB9-64-3.5-102416	1629753-06	BC	10/24/16	3.5	57.46	<0.025	0.17	0.030	0.85	--	**1,400**	7,600	<1,000	9,000
	SBTB9-64-6-102416	1629753-09	BC	10/24/16	6	54.96	<0.0050	<0.0050	<0.0050	<0.010	--	<0.20	29	<20	29
	SBTB9-64-26.5-102416	1629753-10	BC	10/24/16	26.5	34.46	<0.0050	<0.0050	<0.0050	<0.010	--	<0.20	<10	<20	0[1]
	SBTB9-64-30-102416	1629753-11	BC	10/24/16	30	30.96	<0.0050	<0.0050	<0.0050	<0.010	--	<0.20	<10	<20	0[1]
	SBTB9-64-32.5-102416	1629753-12	BC	10/24/16	32.5	28.46	<0.0050	<0.0050	<0.0050	<0.010	--	<0.20	<10	<20	0[1]
SBTB9-65	SBTB9-65-5-102416	1629753-07	BC	10/24/16	5	56.03	<0.0050	<0.0050	<0.0050	<0.010	--	<0.20	<50	220	220
	SBTB9-65-5.5-102416	1629753-08	BC	10/24/16	5.5	55.53	<0.0050	<0.0050	<0.0050	<0.010	--	<0.20	96	240	336
	SBTB9-65-10-102416	1629753-15	BC	10/24/16	10	51.03	<0.0050	<0.0050	<0.0050	<0.010	--	<0.20	<10	<20	0[1]
	SBTB9-65-18-102416	1629753-16	BC	10/24/16	18	43.03	<0.0050	<0.0050	<0.0050	<0.010	--	<0.20	<10	<20	0[1]
	SBTB9-65-27.5-102416	1629753-17	BC	10/24/16	27.5	33.53	<0.0050	<0.0050	<0.0050	<0.010	--	<0.20	<10	<20	0[1]
	SBTB9-65-28-102416	1629753-18	BC	10/24/16	28	33.03	<0.0050	<0.0050	<0.0050	<0.010	--	<0.20	<10	<20	0[1]
	SBTB9-65-32.5-102516	1629996-01	BC	10/25/16	32.5	28.53	<0.0050	<0.0050	<0.0050	<0.010	--	<0.20	<10	<20	0[1]
SBTB9-66	SBTB9-66-6-102416	1629753-13	BC	10/24/16	6	55.59	<0.0050	<0.0050	<0.0050	<0.010	--	<0.20	440	870	1,310

Table 2. Summary of TB9 Area Assessment
BTEX and TPH Analytical Results
Guadalupe Restoration Project

Sample Location	Sample Identification	Laboratory Reference Number	Laboratory	Sample Date	Sample Depth *feet bgs*	Sample Elevation *feet msl*	Benzene	Ethylbenzene	Toluene	Xylenes	TPH C_{12} - C_{32}	TPH C_4 - C_{12}	TPH C_{13} - C_{22}	TPH C_{23} - C_{40}	Total TPH
Soil Boring Results (Continued)							**All Results Reported in mg/Kg**								
SBTB9-66	SBTB9-66-7-102516	1629996-03	BC	10/25/16	7	54.59	<0.0050	<0.0050	<0.0050	<0.010	--	<0.20	<10	<20	0[1]
	SBTB9-66-27-102516	1629996-04	BC	10/25/16	27	34.59	<0.0050	<0.0050	<0.0050	<0.010	--	<0.20	<10	<20	0[1]
	SBTB9-66-27.5-102516	1629996-05	BC	10/25/16	27.5	34.09	<0.0050	<0.0050	<0.0050	<0.010	--	<0.20	<10	<20	0[1]
	SBTB9-66-32-102516	1630247-01	BC	10/25/16	32	29.59	<0.0050	<0.0050	<0.0050	<0.010	--	<0.20	<10	<20	0[1]
SBTB9-67	SBTB9-67-4.5-102416	1629753-14	BC	10/24/16	4.5	56.77	<0.0050	<0.0050	<0.0050	<0.010	--	<0.20	390	1,100	1,490
	SBTB9-67-8-102516	1629996-06	BC	10/25/16	8	53.27	<0.0050	<0.0050	<0.0050	<0.010	--	<0.20	<10	150	150
	SBTB9-67-28-102516	1629996-07	BC	10/25/16	28	33.27	<0.0050	<0.0050	<0.0050	<0.010	--	<0.20	<10	<20	0[1]
	SBTB9-67-28.5-102516	1629996-08	BC	10/25/16	28.5	32.77	<0.0050	<0.0050	<0.0050	<0.010	--	<0.20	<10	<20	0[1]
	SBTB9-67-30-102516	1629996-09	BC	10/25/16	30	31.27	<0.0050	<0.0050	<0.0050	<0.010	--	<0.20	<10	<20	0[1]
SBTB9-68	SBTB9-68-8-102516	1629996-10	BC	10/25/16	8	57.98	<0.0050	<0.0050	<0.0050	<0.010	--	<0.20	<10	<20	0[1]
	SBTB9-68-33.5-102616	1629996-11	BC	10/26/16	33.5	32.48	<0.0050	<0.0050	<0.0050	<0.010	--	<0.20	<10	<20	0[1]
	SBTB9-68-34-102616	1629996-12	BC	10/26/16	34	31.98	<0.0050	<0.0050	<0.0050	<0.010	--	<0.20	<10	<20	0[1]
	SBTB9-68-39-102616	1629996-13	BC	10/26/16	39	26.98	<0.0050	<0.0050	<0.0050	<0.010	--	<0.20	<10	<20	0[1]
SBTB9-69	SBTB9-69-2.5-102616	1629996-14	BC	10/26/16	2.5	72.81	<0.0050	<0.0050	<0.0050	<0.010	--	<0.20	33	67	100
	SBTB9-69-3-102616	1629996-15	BC	10/26/16	3	72.31	<0.0050	<0.0050	<0.0050	<0.010	--	<0.20	<99	860	860
	SBTB9-69-6-102616	1629996-16	BC	10/26/16	6	69.31	<0.0050	<0.0050	<0.0050	<0.010	--	<0.20	<170	720	720
	SBTB9-69-7-102616	1629996-17	BC	10/26/16	7	68.31	<0.0050	<0.0050	<0.0050	<0.010	--	<0.20	<200	1,400	1,400
	SBTB9-69-42.5-102616	1629996-18	BC	10/26/16	42.5	32.81	<0.0050	<0.0050	<0.0050	<0.010	--	<0.20	<10	<20	0[1]
	SBTB9-69-44-102616	1629996-19	BC	10/26/16	44	31.31	<0.0050	<0.0050	<0.0050	<0.010	--	<0.20	<10	<20	0[1]
	SBTB9-69-46.5-102616	1629996-20	BC	10/26/16	46.5	28.81	<0.0050	<0.0050	<0.0050	<0.010	--	<0.20	<10	<20	0[1]
SBTB9-70	SBTB9-70-52.5-102716	1630247-02	BC	10/27/16	52.5	31.21	<0.0050	<0.0050	<0.0050	<0.010	--	<0.20	<10	<20	0[1]
	SBTB9-70-53-102716	1630247-03	BC	10/27/16	53	30.71	<0.0050	<0.0050	<0.0050	<0.010	--	<0.20	<10	<20	0[1]
	SBTB9-70-55.5-102716	1630247-04	BC	10/27/16	55.5	28.21	<0.0050	<0.0050	<0.0050	<0.010	--	<0.20	<10	<20	0[1]
SBTB9-71	SBTB9-71-0.5-102616	1629996-21	BC	10/26/16	0.5	85.07	<0.0050	<0.0050	<0.0050	<0.010	--	6.0	8,900	12,000	20,906
	SBTB9-71-2.5-102616	1629996-22	BC	10/26/16	2.5	83.07	<0.0050	<0.0050	<0.0050	<0.010	--	0.50	<1,100	28,000	28,001
	SBTB9-71-53-102716	1630247-05	BC	10/27/16	53	32.57	<0.0050	<0.0050	<0.0050	<0.010	--	2.3	**16,000**	14,000	30,002
	SBTB9-71-56-102716	1630247-06	BC	10/27/16	56	29.57	<0.0050	<0.0050	<0.0050	<0.010	--	120	7,700	4,800	12,620
	SBTB9-71-56.5-102716	1630247-07	BC	10/27/16	56.5	29.07	<0.025	<0.025	<0.025	<0.050	--	240	**29,000**	15,000	44,240
	SBTB9-71-58.5-102716	1630247-08	BC	10/27/16	58.5	27.07	<0.0050	<0.0050	<0.0050	<0.010	--	<0.20	<10	<20	0[1]
SBTB9-72	SBTB9-72-69-103116	1630334-01	BC	10/31/16	69	32.54	<0.0050	<0.0050	<0.0050	<0.010	--	0.37	6,500	5,800	12,300
	SBTB9-72-70.5-103116	1630334-02	BC	10/31/16	70.5	31.04	<0.0050	<0.0050	<0.0050	<0.010	--	310	8,300	5,500	14,110
	SBTB9-72-72-103116	1630334-03	BC	10/31/16	72	29.54	<0.010	0.036	<0.010	0.039	--	320	**56,000**	27,000	83,320

Table 2. Summary of TB9 Area Assessment
BTEX and TPH Analytical Results
Guadalupe Restoration Project

Sample Location	Sample Identification	Laboratory Reference Number	Laboratory	Sample Date	Sample Depth *feet bgs*	Sample Elevation *feet msl*	Benzene	Ethylbenzene	Toluene	Xylenes	TPH C_{12} - C_{32}	TPH C_4 - C_{12}	TPH C_{13} - C_{22}	TPH C_{23} - C_{40}	Total TPH
Soil Boring Results (Continued)							**All Results Reported in mg/Kg**								
SBTB9-72	SBTB9-72-74.5-103116	1630334-04	BC	10/31/16	74.5	27.04	<0.0050	<0.0050	<0.0050	<0.010	--	<0.20	17	<20	17
SBTB9-73	SBTB9-73-1.5-103116	1630334-05	BC	10/31/16	1.5	99.03	<0.025	0.97	<0.025	0.081	--	**2,500**	12,000	10,000	24,500
	SBTB9-73-13-103116	1630334-06	BC	10/31/16	13	87.53	<0.0050	<0.0050	<0.0050	<0.010	--	<0.20	<10	<20	0[1]
	SBTB9-73-68-110116	1630755-01	BC	11/01/16	68	32.53	<0.0050	0.0081	<0.0050	<0.010	--	56	5,300	2,700	8,056
	SBTB9-73-71-110116	1630755-02	BC	11/01/16	71	29.53	<0.0050	<0.0050	<0.0050	<0.010	--	120	7,600	4,800	12,520
	SBTB9-73-71.5-110116	1630755-03	BC	11/01/16	71.5	29.03	<0.025	<0.025	<0.025	<0.050	--	160	13,000	6,900	20,060
	SBTB9-73-72-110116	1630755-04	BC	11/01/16	72	28.53	<0.025	0.058	<0.025	<0.050	--	130	**24,000**	14,000	38,130
	SBTB9-73-80-110116	1630755-05	BC	11/01/16	80	20.53	<0.0050	<0.0050	<0.0050	<0.010	--	<0.20	<10	<20	0[1]
SBTB9-74	SBTB9-74-64.5-110116	1630755-06	BC	11/01/16	64.5	36.47	<0.0050	<0.0050	<0.0050	<0.010	--	<0.20	1,500	2,100	3,600
	SBTB9-74-66-110116	1630755-07	BC	11/01/16	66	34.97	<0.0050	<0.0050	<0.0050	<0.010	--	<0.20	600	880	1,480
	SBTB9-74-68-110116	1630755-08	BC	11/01/16	68	32.97	<0.0050	<0.0050	<0.0050	<0.010	--	1.1	2,800	2,200	5,001
	SBTB9-74-70-110116	1630755-09	BC	11/01/16	70	30.97	<0.0050	0.0059	<0.0050	<0.010	--	80	9,500	5,000	14,580
	SBTB9-74-70.5-110116	1630755-10	BC	11/01/16	70.5	30.47	<0.025	0.23	<0.025	0.16	--	110	**21,000**	14,000	35,110
	SBTB9-74-73-110116	1630755-11	BC	11/01/16	73	27.97	<0.0050	<0.0050	<0.0050	<0.010	--	<0.20	40	<20	40
	SBTB9-74-74.5-110116	1630755-12	BC	11/01/16	74.5	26.47	<0.0050	<0.0050	<0.0050	<0.010	--	<0.20	18	<20	18
SBTB9-75	SBTB9-75-65-110216	1630755-13	BC	11/02/16	65	38.56	<0.0050	<0.0050	<0.0050	<0.010	--	<0.20	1,900	2,200	4,100
	SBTB9-75-66-110216	1630755-14	BC	11/02/16	66	37.56	<0.0050	<0.0050	<0.0050	<0.010	--	25	3,700	2,200	5,925
	SBTB9-75-70.5-110216	1630755-15	BC	11/02/16	70.5	33.06	<0.025	0.12	<0.025	<0.050	--	33	1,200	800	2,033
	SBTB9-75-73.5-110216	1630755-16	BC	11/02/16	73.5	30.06	<0.0050	<0.0050	<0.0050	<0.010	--	0.51	41	<20	42
	SBTB9-75-75.5-110216	1630755-17	BC	11/02/16	75.5	28.06	<0.0050	<0.0050	<0.0050	<0.010	--	<0.20	<10	<20	0[1]
SBTB9-76	SBTB9-76-3.5-110216	1630755-18	BC	11/02/16	3.5	86.83	<0.0050	<0.0050	<0.0050	<0.010	--	<0.20	310	230	540
	SBTB9-76-5.5-110216	1630755-19	BC	11/02/16	5.5	84.83	<0.0050	<0.0050	<0.0050	<0.010	--	<0.20	15	<20	15
	SBTB9-76-50.5-110216	1630755-20	BC	11/02/16	50.5	39.83	<0.0050	<0.0050	<0.0050	<0.010	--	<0.20	1,000	870	1,870
	SBTB9-76-58.5-110216	1630755-21	BC	11/02/16	58.5	31.83	<0.025	0.027	<0.025	<0.050	--	68	1,600	820	2,488
	SBTB9-76-60-110216	1630755-22	BC	11/02/16	60	30.33	<0.025	0.76	<0.025	0.088	--	140	**24,000**	13,000	37,140
	SBTB9-76-62.5-110216	1630755-23	BC	11/02/16	62.5	27.83	<0.0050	<0.0050	<0.0050	<0.010	--	11	230	150	391
SBTB9-77	SBTB9-77-52-110316	1631066-01	BC	11/03/16	52	38.32	<0.12	<0.12	<0.12	<0.25	--	10	9,400	6,100	15,510
	SBTB9-77-58-110316	1631066-02	BC	11/03/16	58	32.32	<0.12	<0.12	<0.12	<0.25	--	56	3,000	1,600	4,656
	SBTB9-77-58.5-110316	1631066-03	BC	11/03/16	58.5	31.82	<0.25	<0.25	<0.25	<0.50	--	380	13,000	4,400	17,780
	SBTB9-77-60.5-110316	1631066-04	BC	11/03/16	60.5	29.82	<0.0050	<0.0050	<0.0050	<0.010	--	0.24	27	<20	27
	SBTB9-77-62.5-110316	1631066-05	BC	11/03/16	62.5	27.82	<0.0050	<0.0050	<0.0050	<0.010	--	<0.20	<10	<20	0[1]
SBTB9-78	SBTB9-78-54-110316	1631066-06	BC	11/03/16	54	33.01	<0.0050	<0.0050	<0.0050	<0.010	--	<0.20	<10	<20	0[1]

Table 2. Summary of TB9 Area Assessment
BTEX and TPH Analytical Results
Guadalupe Restoration Project

Sample Location	Sample Identification	Laboratory Reference Number	Laboratory	Sample Date	Sample Depth *feet bgs*	Sample Elevation *feet msl*	Benzene	Ethylbenzene	Toluene	Xylenes	TPH C_{12} - C_{32}	TPH C_4 - C_{12}	TPH C_{13} - C_{22}	TPH C_{23} - C_{40}	Total TPH
Soil Boring Results (Continued)							**All Results Reported in mg/Kg**								
SBTB9-78	SBTB9-78-54.5-110316	1631066-07	BC	11/03/16	54.5	32.51	<0.0050	<0.0050	<0.0050	<0.010	--	<0.20	<10	<20	0[1]
	SBTB9-78-59-110316	1631066-08	BC	11/03/16	59	28.01	<0.0050	<0.0050	<0.0050	<0.010	--	<0.20	<10	<20	0[1]
SBTB9-79	SBTB9-79-46.5-110416	1631066-10	BC	11/04/16	46.5	33.51	<0.0050	<0.0050	<0.0050	<0.010	--	<0.20	<10	<20	0[1]
	SBTB9-79-47-110416	1631066-11	BC	11/04/16	47	33.01	<0.0050	<0.0050	<0.0050	<0.010	--	<0.20	<10	<20	0[1]
	SBTB9-79-51.5-110416	1631066-12	BC	11/04/16	51.5	28.51	<0.0050	<0.0050	<0.0050	<0.010	--	<0.20	<10	<20	0[1]
SBTB9-80	SBTB9-80-40-110416	1631066-20	BC	11/04/16	40	32.95	<0.0050	<0.0050	<0.0050	<0.010	--	<0.20	<10	<20	0[1]
	SBTB9-80-40.5-110416	1631066-21	BC	11/04/16	40.5	32.45	<0.0050	<0.0050	<0.0050	<0.010	--	<0.20	<10	<20	0[1]
	SBTB9-80-42.5-110416	1631066-22	BC	11/04/16	42.5	30.45	<0.0050	<0.0050	<0.0050	<0.010	--	<0.20	<10	<20	0[1]
SBTB9-81	SBTB9-81-5.5-110316	1631066-09	BC	11/03/16	5.5	65.61	<0.0050	<0.0050	<0.0050	<0.010	--	<0.20	4,900	9,400	14,300
	SBTB9-81-8.5-110416	1631066-13	BC	11/04/16	8.5	62.61	<0.25	<0.25	<0.25	<0.50	--	31	7,500	9,100	16,631
	SBTB9-81-9.5-110416	1631066-23	BC	11/04/16	9.5	61.61	<0.0050	<0.0050	<0.0050	<0.010	--	<0.20	12	<20	12
	SBTB9-81-37.5-110416	1631066-14	BC	11/04/16	37.5	33.61	<0.0050	<0.0050	<0.0050	<0.010	--	<0.20	<10	<20	0[1]
	SBTB9-81-38-110416	1631066-15	BC	11/04/16	38	33.11	<0.0050	<0.0050	<0.0050	<0.010	--	<0.20	<10	<20	0[1]
	SBTB9-81-43.5-110416	1631066-16	BC	11/04/16	43.5	27.61	<0.0050	<0.0050	<0.0050	<0.010	--	<0.20	<10	<20	0[1]
SBTB9-82	SBTB9-82-0.5-110416	1631066-17	BC	11/04/16	0.5	98.03	<0.25	<0.25	<0.25	<0.50	--	74	11,000	13,000	24,074
	SBTB9-82-1.5-110416	1631066-18	BC	11/04/16	1.5	97.03	<0.25	3.3	<0.25	<0.50	--	**1,500**	**15,000**	22,000	38,500
	SBTB9-82-2-110416	1631066-19	BC	11/04/16	2	96.53	<0.0050	<0.0050	<0.0050	<0.010	--	<0.20	21	48	69
	SBTB9-82-67.5-110516	1631197-01	BC	11/05/16	67.5	31.03	<0.0050	<0.0050	<0.0050	<0.010	--	2.0	9,700	6,700	16,402
	SBTB9-82-68.5-110516	1631197-02	BC	11/05/16	68.5	30.03	<0.12	<0.12	<0.12	<0.25	--	73	10,000	7,300	17,373
	SBTB9-82-75.5-110516	1631197-03	BC	11/05/16	75.5	23.03	<0.0050	<0.0050	<0.0050	<0.010	--	<0.20	<10	<20	0[1]
SBTB9-83	SBTB9-83-3-110716	1631197-04	BC	11/07/16	3	95.87	<0.25	0.58	<0.25	<0.50	--	530	**20,000**	16,000	36,530
	SBTB9-83-8-110716	1631197-05	BC	11/07/16	8	90.87	<0.0050	<0.0050	<0.0050	<0.010	--	<0.20	<10	<20	0[1]
	SBTB9-83-26.5-110716	1631197-06	BC	11/07/16	26.5	72.37	<0.0050	<0.0050	<0.0050	<0.010	--	<0.20	<10	<20	0[1]
SBTB9-84	SBTB9-84-2.5-110716	1631197-07	BC	11/07/16	2.5	96.26	<0.12	<0.12	<0.12	<0.25	--	12	14,000	21,000	35,012
	SBTB9-84-4-110716	1631197-08	BC	11/07/16	4	94.76	<0.0050	<0.0050	<0.0050	<0.010	--	<0.20	31	61	92
	SBTB9-84-22-110716	1631197-09	BC	11/07/16	22	76.76	<0.0050	<0.0050	<0.0050	<0.010	--	<0.20	<10	<20	0[1]
SBTB9-85	SBTB9-85-1.5-110716	1631197-11	BC	11/07/16	1.5	75.31	<0.12	<0.12	<0.12	<0.25	--	59	2,700	4,500	7,259
	SBTB9-85-2-110716	1631197-12	BC	11/07/16	2	74.81	<0.0050	<0.0050	<0.0050	<0.010	--	<0.20	160	660	820
	SBTB9-85-22.5-110716	1631197-10	BC	11/07/16	22.5	54.31	<0.0050	<0.0050	<0.0050	<0.010	--	<0.20	<10	<20	0[1]
SBTB9-86	SBTB9-86-12.5-110816	1631534-01	BC	11/08/16	12.5	54.66	<0.0050	<0.0050	<0.0050	<0.010	--	<0.20	4,200	9,200	13,400
	SBTB9-86-13-110816	1631534-02	BC	11/08/16	13	54.16	<0.0050	<0.0050	<0.0050	<0.010	--	<0.20	<10	<20	0[1]
	SBTB9-86-30.5-110816	1631534-03	BC	11/08/16	30.5	36.66	<0.0050	<0.0050	<0.0050	<0.010	--	<0.20	<10	<20	0[1]

Table 2. Summary of TB9 Area Assessment
BTEX and TPH Analytical Results
Guadalupe Restoration Project

Sample Location	Sample Identification	Laboratory Reference Number	Laboratory	Sample Date	Sample Depth *feet bgs*	Sample Elevation *feet msl*	Benzene	Ethylbenzene	Toluene	Xylenes	TPH C_{12} - C_{32}	TPH C_4 - C_{12}	TPH C_{13} - C_{22}	TPH C_{23} - C_{40}	Total TPH
Soil Boring Results (Continued)							**All Results Reported in mg/Kg**								
SBTB9-87	SBTB9-87-5-110816	1631534-04	BC	11/08/16	5	66.14	<0.25	<0.25	<0.25	3.5	--	**1,100**	5,800	6,500	13,400
	SBTB9-87-9-110816	1631534-05	BC	11/08/16	9	62.14	<0.0050	<0.0050	<0.0050	<0.010	--	<0.20	<10	<20	0[1]
	SBTB9-87-30-110816	1631534-06	BC	11/08/16	30	41.14	<0.0050	<0.0050	<0.0050	<0.010	--	<0.20	<10	<20	0[1]
SBTB9-88	SBTB9-88-2.5-110816	1631534-07	BC	11/08/16	2.5	77.27	<0.0050	<0.0050	<0.0050	<0.010	--	<0.20	2,000	5,300	7,300
	SBTB9-88-12-110816	1631534-08	BC	11/08/16	12	67.77	<0.25	2.6	<0.25	1.9	--	700	**27,000**	24,000	51,700
	SBTB9-88-14-110816	1631534-09	BC	11/08/16	14	65.77	<0.0050	<0.0050	<0.0050	<0.010	--	<0.20	<10	<20	0[1]
	SBTB9-88-34-110816	1631534-10	BC	11/08/16	34	45.77	<0.0050	<0.0050	<0.0050	<0.010	--	<0.20	<10	<20	0[1]
SBTB9-89	SBTB9-89-23-110916	1631534-11	BC	11/09/16	23	65.27	<0.0050	<0.0050	<0.0050	<0.010	--	<0.20	<10	<20	0[1]
SBTB9-90	SBTB9-90-6-110916	1631534-12	BC	11/09/16	6	84.65	<0.0050	<0.0050	<0.0050	<0.010	--	<0.20	14,000	13,000	27,000
	SBTB9-90-13-110916	1631534-13	BC	11/09/16	13	77.65	<0.0050	<0.0050	<0.0050	<0.010	--	<0.20	14	<20	14
	SBTB9-90-18-110916	1631534-14	BC	11/09/16	18	72.65	<0.25	1.4	<0.25	1.3	--	**1,200**	5,700	7,100	14,000
	SBTB9-90-21.5-110916	1631534-15	BC	11/09/16	21.5	69.15	<0.0050	<0.0050	<0.0050	<0.010	--	1.0	<10	<20	1.0
	SBTB9-90-28-110916	1631534-16	BC	11/09/16	28	62.65	<0.0050	<0.0050	<0.0050	<0.010	--	<0.20	<10	<20	0[1]
	SBTB9-90-43.5-110916	1631534-17	BC	11/09/16	43.5	47.15	<0.0050	<0.0050	<0.0050	<0.010	--	<0.20	<10	<20	0[1]
SBTB9-91	SBTB9-91-3-110916	1631534-18	BC	11/09/16	3	87.65	<0.0050	<0.0050	<0.0050	<0.010	--	<0.20	<200	500	500
	SBTB9-91-4.5-110916	1631534-19	BC	11/09/16	4.5	88.80	<0.0050	<0.0050	<0.0050	<0.010	--	<0.20	<180	720	720
	SBTB9-91-6-110916	1631534-20	BC	11/09/16	6	87.30	<0.25	<0.25	<0.25	<0.50	--	730	6,200	9,400	16,330
	SBTB9-91-7-110916	1631534-21	BC	11/09/16	7	86.30	<0.0050	<0.0050	<0.0050	<0.010	--	<0.20	<160	680	680
	SBTB9-91-18-110916	1631534-22	BC	11/09/16	18	75.30	<0.25	<0.25	<0.25	<0.50	--	290	12,000	14,000	26,290
	SBTB9-91-29.5-110916	1631534-23	BC	11/09/16	29.5	63.80	<0.0050	<0.0050	<0.0050	<0.010	--	<0.20	43	<20	43
	SBTB9-91-50.5-110916	1631534-24	BC	11/09/16	50.5	42.80	<0.0050	<0.0050	<0.0050	<0.010	--	<0.20	<10	<20	0[1]

Table 2. Summary of TB9 Area Assessment
BTEX and TPH Analytical Results
Guadalupe Restoration Project

Sample Location	Sample Identification	Laboratory Reference Number	Laboratory	Sample Date	Sample Depth *feet bgs*	Sample Elevation *feet msl*	Benzene	Ethylbenzene	Toluene	Xylenes	TPH C_{12} - C_{32}	TPH C_4 - C_{12}	TPH C_{13} - C_{22}	TPH C_{23} - C_{40}	Total TPH
Hydropunch Sample Results							**All Results Reported in mg/L**								
HPSBTB9-58	HPSBTB9-58-101716	1629091-09	BC	10/17/16	--	--	0.0016	0.011	0.00050	0.039	69	--	--	--	--
HPSBTB9-59	HPSBTB9-59-101816	1629427-07	BC	10/18/16	--	--	0.0018	0.0073	<0.00050	<0.0010	2,000	--	--	--	--
HPSBTB9-65	HPSBTB9-65-102516	1629996-02	BC	10/25/16	--	--	<0.50	<0.50	<0.50	<1.0	0.6	--	--	--	--
SMRL NHIS TTLC Acceptance Criteria - TPH							**All Results Reported in mg/Kg**								
							0.1	**70**	**15**	**175**	**--**	**1,000**	**15,000**	**200,000**	**--**

Abbreviations:

CC = Carbon Chain
EPA = Environmental Protection Agency
FFP = Fuel Finger Print
GS = Grab Sample
GS/MS = Gas Chromatography/Mass Spectrometry
HP = Hydropunch
msl = Mean Sea Level
mg/Kg = Milligrams per Kilogram
mg/L = Milligrams per Liter
NHIS = Non-Hazardous Hydrocarbon Impacted Soil
SB = Soil Boring
SMRL = Santa Maria Regional Landfill
TB9 = Tank Battery 9
TPH = Total Petroleum Hydrocarbons
TTLC = Total Threshold Limit Concentration

Notes:

[1] TPH was not detected at or above the Practical Quantitation Limits (PQL) for gasoline, diesel or motor oil carbon chain ranges as indicated in the table.

TPH analyses were performed by BC Laboratories (BC) following EPA-8015B analytical procedure calibrated against a gasoline standard on soil samples collected from soil boring locations SBTB9-157 through SBTB9-163.

TPH analyses were performed by BC Laboratories (BC) following the LUFT-GC/MS analytical procedure calibrated against a gasoline standard on all grab samples and soil samples collected from soil boring locations SBTB9-164 through SBTB9-167.

TPH analyses performed by BC Laboratories (BC) following EPA-8025CC analytical procedure calibrated against a diesel and motor oil standard on soil samples collected from soil boring locations SBTB9-157 through SBTB9-163.

TPH analyses performed by BC Laboratories (BC) following the LUFT-FFP analytical procedure calibrated against a diesel and motor oil standard on all grab samples and soil samples collected from soil boring locations SBTB9-164 through SBTB9-167.

< = Not detected at or above laboratory reporting limit indicated
15,000 = Result exceeds SMRL NHIS TTLC Acceptance Criteria

QA/QC Review: BWP
Date: 11/23/16

Table 3. Summary of TB9 Area Assessment
Waste Profile Analytical Results
Guadalupe Restoration Project

Method	Parameter	Units	Matrix	Soil									SMRL NHIS Acceptance Criteria	
			Sample ID	SBTB9-57-28-101316	SBTB9-60-5-101916	SBTB9-61-25-102016	SBTB9-63-8-102416	SBTB9-73-1.5-103116	SBTB9-81-8.5-110416	SBTB9-83-3-110716	SBTB9-87-5-110816	SBTB9-88-2.5-110816	SBTB9-90-6-110916	
			Sample Date	10/13/16	10/19/16	10/20/16	10/24/16	10/31/16	11/04/16	11/07/16	11/08/16	11/08/16	11/09/16	
			Lab Number	1628979-04	1629427-08	1629654-03	1629753-01	1630334-05	1631066-13	1631197-04	1631534-04	1631534-07	1631534-12	
				Milligrams per Kilogram									TTLC (mg/Kg)	STLC (mg/L)
Total Petroleum Hydrocarbons (TPH)														
LUFT-GC/MS	TPH - Gasoline (C_4-C_{12})			350	**1,600**	440	15	**2,500**	31	530	**1,100**	<0.20	<0.20	**1,000**[1]	**1.5**[1]
LUFT-FFP	TPH - Diesel (C_{13} - C_{22})			6,300	**15,000**	14,000	**17,000**	12,000	7,500	**20,000**	5,800	2,000	14,000	**15,000**[1]	**7.5**[1]
	TPH - Motor Oil (C_{23} - C_{40})			8,700	19,000	18,000	18,000	10,000	9,100	16,000	6,500	5,300	13,000	**200,000**[1]	**10**[1]
Calculated	TPH - Total			15,350	35,600	32,440	35,015	24,500	16,631	36,530	13,400	7,300	27,000	--	--
Volatile Organic Compounds (VOCs)														
EPA 8260B	Benzene			<0.0050	0.039	<0.025	<0.050	<0.025	<0.25	<0.25	<0.25	<0.0050	<0.0050	**0.1**	--
	Bromobenzene			<0.0050	<0.025	<0.025	<0.050	<0.025	<0.25	<0.25	<0.25	<0.0050	<0.0050	--	--
	Bromochloromethane			<0.0050	<0.025	<0.025	<0.050	<0.025	<0.25	<0.25	<0.25	<0.0050	<0.0050	--	--
	Bromodichloromethane			<0.0050	<0.025	<0.025	<0.050	<0.025	<0.25	<0.25	<0.25	<0.0050	<0.0050	--	--
	Bromoform			<0.0050	<0.025	<0.025	<0.050	<0.025	<0.25	<0.25	<0.25	<0.0050	<0.0050	--	--
	Bromomethane			<0.0050	<0.025	<0.025	<0.050	<0.025	<0.25	<0.25	<0.25	<0.0050	<0.0050	--	--
	n-Butylbenzene			<0.0050	<0.025	<0.025	<0.050	0.15	<0.25	0.84	0.57	<0.0050	<0.0050	--	--
	sec-Butylbenzene			0.019	<0.025	<0.025	<0.050	0.23	<0.25	0.66	<0.25	<0.0050	<0.0050	--	--
	tert-Butylbenzene			<0.0050	<0.025	<0.025	<0.050	<0.025	<0.25	<0.25	<0.25	<0.0050	<0.0050	--	--
	Carbon tetrachloride			<0.0050	<0.025	<0.025	<0.050	<0.025	<0.25	<0.25	<0.25	<0.0050	<0.0050	--	--
	Chlorobenzene			<0.0050	<0.025	<0.025	<0.050	<0.025	<0.25	<0.25	<0.25	<0.0050	<0.0050	--	--
	Chloroethane			<0.0050	<0.025	<0.025	<0.050	<0.025	<0.25	<0.25	<0.25	<0.0050	<0.0050	--	--
	Chloroform			<0.0050	<0.025	<0.025	<0.050	<0.025	<0.25	<0.25	<0.25	<0.0050	<0.0050	--	--
	Chloromethane			<0.0050	<0.025	<0.025	<0.050	<0.025	<0.25	<0.25	<0.25	<0.0050	<0.0050	--	--
	2-Chlorotoluene			<0.0050	<0.025	<0.025	<0.050	<0.025	<0.25	<0.25	<0.25	<0.0050	<0.0050	--	--
	4-Chlorotoluene			<0.0050	<0.025	<0.025	<0.050	<0.025	<0.25	<0.25	<0.25	<0.0050	<0.0050	--	--
	Dibromochloromethane			<0.0050	<0.025	<0.025	<0.050	<0.025	<0.25	<0.25	<0.25	<0.0050	<0.0050	--	--
	1,2-Dibromo-3-chloropropane			<0.0050	<0.025	<0.025	<0.050	<0.025	<0.25	<0.25	<0.25	<0.0050	<0.0050	--	--
	1,2-Dibromomethane			<0.0050	<0.025	<0.025	<0.050	<0.025	<0.25	<0.25	<0.25	<0.0050	<0.0050	--	--
	Dibromomethane			<0.0050	<0.025	<0.025	<0.050	<0.025	<0.25	<0.25	<0.25	<0.0050	<0.0050	--	--
	1,2-Dichlorobenzene			<0.0050	<0.025	<0.025	<0.050	<0.025	<0.25	<0.25	<0.25	<0.0050	<0.0050	--	--
	1,3-Dichlorobenzene			<0.0050	<0.025	<0.025	<0.050	<0.025	<0.25	<0.25	<0.25	<0.0050	<0.0050	--	--
	1,4-Dichlorobenzene			<0.0050	<0.025	<0.025	<0.050	<0.025	<0.25	<0.25	<0.25	<0.0050	<0.0050	--	--
	Dichlorodifluoromethane			<0.0050	<0.025	<0.025	<0.050	<0.025	<0.25	<0.25	<0.25	<0.0050	<0.0050	--	--
	1,1-Dichloroethane			<0.0050	<0.025	<0.025	<0.050	<0.025	<0.25	<0.25	<0.25	<0.0050	<0.0050	--	--
	1,2-Dichloroethane			<0.0050	<0.025	<0.025	<0.050	<0.025	<0.25	<0.25	<0.25	<0.0050	<0.0050	--	--
	1,1-Dichloroethene			<0.0050	<0.025	<0.025	<0.050	<0.025	<0.25	<0.25	<0.25	<0.0050	<0.0050	--	--
	cis-1,2-Dichloroethene			<0.0050	<0.025	<0.025	<0.050	<0.025	<0.25	<0.25	<0.25	<0.0050	<0.0050	--	--
	trans-1,2-Dichloroethene			<0.0050	<0.025	<0.025	<0.050	<0.025	<0.25	<0.25	<0.25	<0.0050	<0.0050	--	--
	Total 1,2-Dichloroethene			<0.010	<0.050	<0.050	<0.10	<0.050	<0.50	<0.50	<0.50	<0.010	<0.010	--	--
	1,2-Dichloropropane			<0.0050	<0.025	<0.025	<0.050	<0.025	<0.25	<0.25	<0.25	<0.0050	<0.0050	--	--
	1,3-Dichloropropane			<0.0050	<0.025	<0.025	<0.050	<0.025	<0.25	<0.25	<0.25	<0.0050	<0.0050	--	--
	2,2-Dichloropropane			<0.0050	<0.025	<0.025	<0.050	<0.025	<0.25	<0.25	<0.25	<0.0050	<0.0050	--	--
	1,1-Dichloropropene			<0.0050	<0.025	<0.025	<0.050	<0.025	<0.25	<0.25	<0.25	<0.0050	<0.0050	--	--
	cis-1,3-Dichloropropene			<0.0050	<0.025	<0.025	<0.050	<0.025	<0.25	<0.25	<0.25	<0.0050	<0.0050	--	--
	trans-1,3-Dichloropropene			<0.0050	<0.025	<0.025	<0.050	<0.025	<0.25	<0.25	<0.25	<0.0050	<0.0050	--	--
	Total 1,3-Dichloropropene			<0.010	<0.050	<0.050	<0.10	<0.050	<0.50	<0.50	<0.50	<0.010	<0.010	--	--
	Ethylbenzene			0.033	<0.025	0.032	0.090	0.97	<0.25	0.58	<0.25	<0.0050	<0.0050	**70**	--
	Hexachlorobutadiene			<0.0050	<0.025	<0.025	<0.050	<0.025	<0.25	<0.25	<0.25	<0.0050	<0.0050	--	--
	Isopropylbenzene			0.022	<0.025	<0.025	<0.050	0.23	<0.25	0.36	<0.25	<0.0050	<0.0050	--	--

Table 3. Summary of TB9 Area Assessment
Waste Profile Analytical Results
Guadalupe Restoration Project

Method	Parameter	Matrix / Sample ID / Sample Date / Lab Number / Units	SBTB9-57-28-101316 10/13/16 1628979-04	SBTB9-60-5-101916 10/19/16 1629427-08	SBTB9-61-25-102016 10/20/16 1629654-03	SBTB9-63-8-102416 10/24/16 1629753-01	SBTB9-73-1.5-103116 10/31/16 1630334-05	SBTB9-81-8.5-110416 11/04/16 1631066-13	SBTB9-83-3-110716 11/07/16 1631197-04	SBTB9-87-5-110816 11/08/16 1631534-04	SBTB9-88-2.5-110816 11/08/16 1631534-07	SBTB9-90-6-110916 11/09/16 1631534-12	SMRL NHIS Acceptance Criteria TTLC (mg/Kg)	SMRL NHIS Acceptance Criteria STLC (mg/L)
		Matrix	Soil											
		Units	Milligrams per Kilogram											
Volatile Organic Compounds (VOCs) (continued)														
EPA 8260B	p-Isopropyltoluene		<0.0050	<0.025	<0.025	<0.050	0.19	<0.25	0.59	0.63	<0.0050	<0.0050	--	--
	Methylene chloride		<0.010	<0.050	<0.050	<0.10	<0.050	<0.50	<0.50	<0.50	<0.010	<0.010	--	--
	Methyl t-butyl ether		<0.0050	<0.025	<0.025	<0.050	<0.025	<0.25	<0.25	<0.25	<0.0050	<0.0050	--	--
	Naphthalene		0.025	0.039	0.061	0.058	0.31	<0.25	1.5	1.2	<0.0050	<0.0050	--	--
	n-Propylbenzene		0.039	<0.025	<0.025	<0.050	0.38	<0.25	0.84	<0.25	<0.0050	<0.0050	--	--
	Styrene		<0.0050	<0.025	<0.025	<0.050	<0.025	<0.25	<0.25	<0.25	<0.0050	<0.0050	--	--
	1,1,1,2-Tetrachloroethane		<0.0050	<0.025	<0.025	<0.050	<0.025	<0.25	<0.25	<0.25	<0.0050	<0.0050	--	--
	1,1,2,2-Tetrachloroethane		<0.0050	<0.025	<0.025	<0.050	<0.025	<0.25	<0.25	<0.25	<0.0050	<0.0050	--	--
	Tetrachloroethene (PCE)		<0.0050	<0.025	<0.025	<0.050	<0.025	<0.25	<0.25	<0.25	<0.0050	<0.0050	--	--
	Toluene		<0.0050	<0.025	<0.025	<0.050	<0.025	<0.25	<0.25	<0.25	<0.0050	<0.0050	**15**	--
	1,2,3-Trichlorobenzene		<0.0050	<0.025	<0.025	<0.050	<0.025	<0.25	<0.25	<0.25	<0.0050	<0.0050	--	--
	1,2,4-Trichlorobenzene		<0.0050	<0.025	<0.025	<0.050	<0.025	<0.25	<0.25	<0.25	<0.0050	<0.0050	--	--
	1,1,1-Trichloroethane		<0.0050	<0.025	<0.025	<0.050	<0.025	<0.25	<0.25	<0.25	<0.0050	<0.0050	--	--
	1,1,2-Trichloroethane		<0.0050	<0.025	<0.025	<0.050	<0.025	<0.25	<0.25	<0.25	<0.0050	<0.0050	--	--
	Trichloroethene (TCE)		<0.0050	<0.025	<0.025	<0.050	<0.025	<0.25	<0.25	<0.25	<0.0050	<0.0050	**2,040**	**204**
	Trichlorofluoromethane		<0.0050	<0.025	<0.025	<0.050	<0.025	<0.25	<0.25	<0.25	<0.0050	<0.0050	--	--
	1,2,3-Trichloropropane		<0.0050	<0.025	<0.025	<0.050	<0.025	<0.25	<0.25	<0.25	<0.0050	<0.0050	--	--
	1,1,2-Trichloro-1,2,2-trifluoroethane		<0.0050	<0.025	<0.025	<0.050	<0.025	<0.25	<0.25	<0.25	<0.0050	<0.0050	--	--
	1,2,4-Trimethylbenzene		0.022	0.086	0.072	0.062	0.43	<0.25	2.0	2.3	<0.0050	<0.0050	--	--
	1,3,5-Trimethylbenzene		0.015	0.072	<0.025	<0.050	0.29	<0.25	0.81	1.3	<0.0050	<0.0050	--	--
	Vinyl chloride		<0.0050	<0.025	<0.025	<0.050	<0.025	<0.25	<0.25	<0.25	<0.0050	<0.0050	--	--
	Total Xylenes		0.023	0.20	0.071	0.12	0.081	<0.50	<0.50	3.5	<0.010	<0.010	**175**	--
Semi-Volatile Organic Compounds (SVOCs)														
EPA 8270C	Acenaphthene		<38	<40	<19	<60	<17	<30	<25	<27	<20	<21	--	--
	Acenaphthylene		<38	<40	<19	<60	<17	<30	<25	<27	<20	<21	--	--
	Aldrin		<38	<40	<19	<60	<17	<30	<25	<27	<20	<21	**1.4**	**0.14**
	Aniline		<75	<79	<38	<120	<33	<60	<50	<55	<39	<42	--	--
	Anthracene		<38	<40	<19	<60	<17	<30	<25	<27	<20	<21	--	--
	Benzidine		<1,100	<1,200	<570	<1,800	<500	<900	<750	<820	<590	<640	--	--
	Benzo[a]anthracene		<38	<40	<19	<60	<17	<30	<25	<27	<20	<21	--	--
	Benzo[b]fluoranthene		<38	<40	<19	<60	<17	<30	<25	<27	<20	<21	--	--
	Benzo[k]fluoranthene		<38	<40	<19	<60	<17	<30	<25	<27	<20	<21	--	--
	Benzo[a]pyrene		<38	<40	<19	<60	<17	<30	<25	<27	<20	<21	--	--
	Benzo[g,h,i]perylene		<38	<40	<19	<60	<17	<30	<25	<27	<20	<21	--	--
	Benzoic acid		<190	<200	<95	<300	<83	<150	<120	<140	<98	<110	--	--
	Benzyl alcohol		<38	<40	<19	<60	<17	<30	<25	<27	<20	<21	--	--
	Benzyl butyl phthalate		<38	<40	<19	<60	<17	<30	<25	<27	<20	<21	--	--
	alpha-BHC		<38	<40	<19	<60	<17	<30	<25	<27	<20	<21	--	--
	beta-BHC		<38	<40	<19	<60	<17	<30	<25	<27	<20	<21	--	--
	delta-BHC		<38	<40	<19	<60	<17	<30	<25	<27	<20	<21	--	--
	gamma-BHC (Lindane)		<38	<40	<19	<60	<17	<30	<25	<27	<20	<21	**4.0**	**0.4**
	bis(2-Chloroethoxy)methane		<38	<40	<19	<60	<17	<30	<25	<27	<20	<21	--	--
	bis(2-Chloroethyl) ether		<38	<40	<19	<60	<17	<30	<25	<27	<20	<21	--	--
	bis(2-Chloroisopropyl)ether		<38	<40	<19	<60	<17	<30	<25	<27	<20	<21	--	--
	bis(2-Ethylhexyl)phthalate		<75	<79	<38	<120	<33	<60	<50	<55	<39	<42	--	--

Table 3. Summary of TB9 Area Assessment
Waste Profile Analytical Results
Guadalupe Restoration Project

Method	Parameter	Matrix / Units	Soil									SMRL NHIS Acceptance Criteria	
		Sample ID	SBTB9-57-28-101316	SBTB9-60-5-101916	SBTB9-61-25-102016	SBTB9-63-8-102416	SBTB9-73-1.5-103116	SBTB9-81-8.5-110416	SBTB9-83-3-110716	SBTB9-87-5-110816	SBTB9-88-2.5-110816	SBTB9-90-6-110916	
		Sample Date	10/13/16	10/19/16	10/20/16	10/24/16	10/31/16	11/04/16	11/07/16	11/08/16	11/08/16	11/09/16	
		Lab Number	1628979-04	1629427-08	1629654-03	1629753-01	1630334-05	1631066-13	1631197-04	1631534-04	1631534-07	1631534-12	
		Units	Milligrams per Kilogram									TTLC (mg/Kg)	STLC (mg/L)
Semi-Volatile Organic Compounds (SVOCs) (continued)													
EPA 8270C	4-Bromophenyl phenyl ether		<38	<40	<19	<60	<17	<30	<25	<27	<20	<21	--	--
	4-Chloroaniline		<38	<40	<19	<60	<17	<30	<25	<27	<20	<21	--	--
	2-Chloronaphthalene		<38	<40	<19	<60	<17	<30	<25	<27	<20	<21	--	--
	4-Chlorophenyl phenyl ether		<38	<40	<19	<60	<17	<30	<25	<27	<20	<21	--	--
	Chrysene		<38	<40	<19	<60	<17	<30	<25	<27	<20	<21	--	--
	4,4'-DDD		<38	<40	<19	<60	<17	<30	<25	<27	<20	<21	**1.0**	**0.1**
	4,4'-DDE		<38	<40	<19	<60	<17	<30	<25	<27	<20	<21	**1.0**	**0.1**
	4,4'-DDT		<38	<40	<19	<60	<17	<30	<25	<27	<20	<21	**1.0**	**0.1**
	Dibenzo[a,h]anthracene		<38	<40	<19	<60	<17	<30	<25	<27	<20	<21	--	--
	Dibenzofuran		<38	<40	<19	<60	<17	<30	<25	<27	<20	<21	--	--
	1,2-Dichlorobenzene		<38	<40	<19	<60	<17	<30	<25	<27	<20	<21	--	--
	1,3-Dichlorobenzene		<38	<40	<19	<60	<17	<30	<25	<27	<20	<21	--	--
	1,4-Dichlorobenzene		<38	<40	<19	<60	<17	<30	<25	<27	<20	<21	--	--
	3,3-Dichlorobenzidine		<75	<79	<38	<120	<33	<60	<50	<55	<39	<42	--	--
	Dieldrin		<38	<40	<19	<60	<17	<30	<25	<27	<20	<21	**8.0**	**0.8**
	Diethyl phthalate		<38	<40	<19	<60	<17	<30	<25	<27	<20	<21	--	--
	Dimethyl phthalate		<38	<40	<19	<60	<17	<30	<25	<27	<20	<21	--	--
	Di-n-butyl phthalate		<38	<40	<19	<60	<17	<30	<25	<27	<20	<21	--	--
	2,4-Dinitrotoluene		<38	<40	<19	<60	<17	<30	<25	<27	<20	<21	--	--
	2,6-Dinitrotoluene		<38	<40	<19	<60	<17	<30	<25	<27	<20	<21	--	--
	Di-n-octyl phthalate		<38	<40	<19	<60	<17	<30	<25	<27	<20	<21	--	--
	1,2-Diphenylhydrazine		<38	<40	<19	<60	<17	<30	<25	<27	<20	<21	--	--
	Endosulfan I		<75	<79	<38	<120	<33	<60	<50	<55	<39	<42	--	--
	Endosulfan II		<75	<79	<38	<120	<33	<60	<50	<55	<39	<42	--	--
	Endosulfan sulfate		<38	<40	<19	<60	<17	<30	<25	<27	<20	<21	--	--
	Endrin		<75	<79	<38	<120	<33	<60	<50	<55	<39	<42	**0.2**	**0.02**
	Endrin aldehyde		<190	<200	<95	<300	<83	<150	<120	<140	<98	<110	--	--
	Fluoranthene		<38	<40	<19	<60	<17	<30	<25	<27	<20	<21	--	--
	Fluorene		<38	<40	<19	<60	<17	<30	<25	<27	<20	<21	--	--
	Heptachlor		<38	<40	<19	<60	<17	<30	<25	<27	<20	<21	**4.7**	**0.47**
	Hetachlor epoxide		<38	<40	<19	<60	<17	<30	<25	<27	<20	<21	**4.7**	**0.47**
	Hexachlorobenzene		<38	<40	<19	<60	<17	<30	<25	<27	<20	<21	--	--
	Hexachlorobutadiene		<38	<40	<19	<60	<17	<30	<25	<27	<20	<21	--	--
	Hexachlorocyclopentadiene		<38	<40	<19	<60	<17	<30	<25	<27	<20	<21	--	--
	Hexachloroethane		<38	<40	<19	<60	<17	<30	<25	<27	<20	<21	--	--
	Indeno[1,2,3-cd]pyrene		<38	<40	<19	<60	<17	<30	<25	<27	<20	<21	--	--
	Isophorone		<38	<40	<19	<60	<17	<30	<25	<27	<20	<21	--	--
	2-Methylnaphthalene		<38	<40	<19	<60	21	<30	<25	<27	<20	<21	--	--
	Naphthalene		<38	<40	<19	<60	<17	<30	<25	<27	<20	<21	--	--
	2-Naphthylamine		<1,100	<1,200	<570	<1,800	<500	<900	<750	<820	<590	<640	--	--
	2-Nitroaniline		<38	<40	<19	<60	<17	<30	<25	<27	<20	<21	--	--
	3-Nitroaniline		<75	<79	<38	<120	<33	<60	<50	<55	<39	<42	--	--
	4-Nitroaniline		<75	<79	<38	<120	<33	<60	<50	<55	<39	<42	--	--
	Nitrobenzene		<38	<40	<19	<60	<17	<30	<25	<27	<20	<21	--	--
	N-Nitrosodimethylamine		<38	<40	<19	<60	<17	<30	<25	<27	<20	<21	--	--

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Guadalupe Restoration Project

Method	Parameter	Units	Matrix	Soil									SMRL NHIS Acceptance Criteria	
			Sample ID	SBTB9-57-28-101316	SBTB9-60-5-101916	SBTB9-61-25-102016	SBTB9-63-8-102416	SBTB9-73-1.5-103116	SBTB9-81-8.5-110416	SBTB9-83-3-110716	SBTB9-87-5-110816	SBTB9-88-2.5-110816	SBTB9-90-6-110916	
			Sample Date	10/13/16	10/19/16	10/20/16	10/24/16	10/31/16	11/04/16	11/07/16	11/08/16	11/08/16	11/09/16	
			Lab Number	1628979-04	1629427-08	1629654-03	1629753-01	1630334-05	1631066-13	1631197-04	1631534-04	1631534-07	1631534-12	
				Milligrams per Kilogram									TTLC (mg/Kg)	STLC (mg/L)
Semi-Volatile Organic Compounds (SVOCs) (continued)														
EPA 8270C	N-Nitrosodi-n-propylamine			<38	<40	<19	<60	<17	<30	<25	<27	<20	<21	--	--
	N-Nitrosodiphenylamine			<38	<40	<19	<60	<17	<30	<25	<27	<20	<21	--	--
	Phenanthrene			<38	<40	<19	<60	<17	<30	<25	<27	<20	<21	--	--
	Pyrene			<38	<40	<19	<60	<17	<30	<25	<27	<20	<21	--	--
	1,2,4-Trichlorobenzene			<38	<40	<19	<60	<17	<30	<25	<27	<20	<21	--	--
	4-Chloro-3-methylphenol			<75	<79	<38	<120	<33	<60	<50	<55	<39	<42	--	--
	2-Chlorophenol			<38	<40	<19	<60	<17	<30	<25	<27	<20	<21	--	--
	2,4-Dichlorophenol			<38	<40	<19	<60	<17	<30	<25	<27	<20	<21	--	--
	2,4-Dimethylphenol			<38	<40	<19	<60	<17	<30	<25	<27	<20	<21	--	--
	4,6-Dinitro-2-methylphenol			<190	<200	<95	<300	<83	<150	<120	<140	<98	<110	--	--
	2,4-Dinitrophenol			<190	<200	<95	<300	<83	<150	<120	<140	<98	<110	--	--
	2-Methylphenol			<38	<40	<19	<60	<17	<30	<25	<27	<20	<21	--	--
	3- & 4-Methylphenol			<75	<79	<38	<120	<33	<60	<50	<55	<39	<42	--	--
	2-Nitrophenol			<38	<40	<19	<60	<17	<30	<25	<27	<20	<21	--	--
	4-Nitrophenol			<75	<79	<38	<120	<33	<60	<50	<55	<39	<42	--	--
	Pentachlorophenol			<75	<79	<38	<120	<33	<60	<50	<55	<39	<42	**17**	**1.7**
	Phenol			<38	<40	<19	<60	<17	<30	<25	<27	<20	<21	--	--
	2,4,5-Trichlorophenol			<75	<79	<38	<120	<33	<60	<50	<55	<39	<42	--	--
	2,4,6-Trichlorophenol			<75	<79	<38	<120	<33	<60	<50	<55	<39	<42	--	--
Polyaromatic Hydrocarbons (PAHs)														
EPA 8270C-SIM	Acenaphthene			0.71	0.67	2.4	<0.90	1.4	<0.38	3.4	0.79	<0.26	1.7	--	--
	Acenaphthylene			<0.29	<0.60	<1.9	<0.90	1.2	<0.38	<2.0	<0.25	<0.26	0.38	--	--
	Anthracene			<0.29	<0.60	<1.9	1.7	0.61	<0.38	<2.0	<0.25	<0.26	<0.35	--	--
	Benzo[a]anthracene			<0.29	<0.60	<1.9	<0.90	<0.53	<0.38	<2.0	<0.25	<0.26	<0.35	--	--
	Benzo[b]fluoranthene			<0.29	0.80	<1.9	<0.90	<0.53	<0.38	<2.0	<0.25	<0.26	<0.35	--	--
	Benzo[k]fluoranthene			<0.29	<0.60	<1.9	<0.90	<0.53	<0.38	<2.0	<0.25	<0.26	<0.35	--	--
	Benzo[a]pyrene			<0.29	<0.60	<1.9	<0.90	<0.53	<0.38	<2.0	<0.25	<0.26	<0.35	--	--
	Benzo[g,h,i]perylene			<0.29	<0.60	<1.9	<0.90	<0.53	<0.38	<2.0	<0.25	<0.26	<0.35	--	--
	Chrysene			<0.29	<0.60	<1.9	<0.90	<0.53	<0.38	<2.0	<0.25	<0.26	<0.35	--	--
	Dibenzo[a,h]anthracene			<0.29	<0.60	<1.9	<0.90	<0.53	0.50	<2.0	<0.25	<0.26	<0.35	--	--
	Fluoranthene			0.29	<0.60	<1.9	<0.90	<0.53	<0.38	<2.0	<0.25	<0.26	<0.35	--	--
	Fluorene			0.78	1.1	2.2	1.5	2.1	<0.38	2.7	1.2	<0.26	2.3	--	--
	Indeno[1,2,3-cd]pyrene			<0.29	<0.60	<1.9	<0.90	<0.53	0.42	<2.0	<0.25	<0.26	<0.35	--	--
	Naphthalene			0.87	2.0	3.0	1.7	7.3	0.50	3.0	0.71	0.32	2.5	--	--
	Phenanthrene			1.6	2.1	7.9	10	4.9	<0.38	8.0	2.1	<0.26	3.7	--	--
	Pyrene			0.55	<0.60	2.4	<0.90	1.4	0.46	2.0	0.48	0.38	1.0	--	--
Polychlorinated Biphenyls (PCBs)														
EPA 8082	PCB-1016			<0.17	<0.23	<0.23	<0.30	<0.21	<0.050	<0.050	<0.20	<0.18	<0.27	**5[1]**	**0.1[1]**
	PCB-1221			<0.17	<0.23	<0.23	<0.30	<0.21	<0.050	<0.050	<0.20	<0.18	<0.27	**5[1]**	**0.1[1]**
	PCB-1232			<0.17	<0.23	<0.23	<0.30	<0.21	<0.050	<0.050	<0.20	<0.18	<0.27	**5[1]**	**0.1[1]**
	PCB-1242			<0.17	<0.23	<0.23	<0.30	<0.21	<0.050	<0.050	<0.20	<0.18	<0.27	**5[1]**	**0.1[1]**
	PCB-1248			<0.17	<0.23	<0.23	<0.30	<0.21	<0.050	<0.050	<0.20	<0.18	<0.27	**5[1]**	**0.1[1]**
	PCB-1254			<0.17	<0.23	<0.23	<0.30	<0.21	<0.050	<0.050	<0.20	<0.18	<0.27	**5[1]**	**0.1[1]**
	PCB-1260			<0.17	<0.23	<0.23	<0.30	<0.21	<0.050	<0.050	<0.20	<0.18	<0.27	**5[1]**	**0.1[1]**

Table 3. Summary of TB9 Area Assessment
Waste Profile Analytical Results
Guadalupe Restoration Project

Method	Parameter	Matrix / Sample ID / Sample Date / Lab Number / Units	SBTB9-57-28-101316 10/13/16 1628979-04	SBTB9-60-5-101916 10/19/16 1629427-08	SBTB9-61-25-102016 10/20/16 1629654-03	SBTB9-63-8-102416 10/24/16 1629753-01	SBTB9-73-1.5-103116 10/31/16 1630334-05	SBTB9-81-8.5-110416 11/04/16 1631066-13	SBTB9-83-3-110716 11/07/16 1631197-04	SBTB9-87-5-110816 11/08/16 1631534-04	SBTB9-88-2.5-110816 11/08/16 1631534-07	SBTB9-90-6-110916 11/09/16 1631534-12	SMRL NHIS Acceptance Criteria TTLC (mg/Kg)	SMRL NHIS Acceptance Criteria STLC (mg/L)
		Soil / Milligrams per Kilogram												
CAM 17 Metals														
EPA 6010B	Antimony		<10	<5.0	<5.0	<5.0	<10	<5.0	<5.0	<5.0	<5.0	<5.0	**500**	**15**
	Arsenic		<2.0	**1.5**	**1.4**	**1.2**	<2.0	**2.0**	**1.1**	**2.3**	**1.9**	**1.7**	**500**	**5.0**
	Barium		**28**	**38**	**13**	**9.6**	**40**	**9.7**	**17**	**79**	**59**	**27**	**10,000**	**100**
	Beryllium		<1.0	<0.50	<0.50	<0.50	<1.0	<0.50	<0.50	<0.50	<0.50	<0.50	**75**	**0.75**
	Cadmium		<1.0	<0.50	<0.50	<0.50	<1.0	<0.50	<0.50	<0.50	<0.50	<0.50	**100**	**1.0**
	Chromium		**5.3**	**5.2**	**2.9**	**2.9**	**9.7**	**3.6**	**4.2**	**6.8**	**6.9**	**4.1**	**2,500**	**5.0**
	Cobalt		<5.0	<2.5	<2.5	<2.5	<5.0	<2.5	<2.5	<2.5	<2.5	<2.5	**8,000**	**80**
	Copper		**2.0**	**1.3**	**1.7**	**1.5**	**2.2**	**2.0**	**2.2**	**3.7**	**2.8**	**2.5**	**2,500**	**25**
	Lead		<5.0	<2.5	<2.5	<2.5	<5.0	<2.5	<2.5	**3.4**	<2.5	**4.7**	**1,000**	**5.0**
	Molybdenum		<5.0	<2.5	<2.5	<2.5	<5.0	<2.5	<2.5	<2.5	<2.5	<2.5	**3,500**	**350**
	Nickel		**13**	**13**	**11**	**9.1**	**20**	**9.7**	**12**	**16**	**11**	**12**	**2,000**	**20**
	Selenium		<2.0	<1.0	<1.0	<1.0	**2.5**	**1.1**	<1.0	<1.0	<1.0	<1.0	**100**	**1.0**
	Silver		<1.0	<0.50	<0.50	<0.50	<1.0	<0.50	<0.50	<0.50	<0.50	<0.50	**500**	**5.0**
	Thallium		<10	<5.0	<5.0	<5.0	<10	<5.0	<5.0	<5.0	<5.0	<5.0	**700**	**7.0**
	Vanadium		**22**	**25**	**25**	**19**	**36**	**21**	**22**	**34**	**20**	**23**	**2,400**	**24**
	Zinc		**16**	**7.0**	**8.7**	**7.7**	**12**	**6.8**	**13**	**16**	**13**	**17**	**5,000**	**250**
EPA 7471A	Mercury		<0.16	<0.16	<0.16	<0.16	<0.16	<0.16	<0.16	<0.16	<0.16	<0.16	**20**	**0.2**
Organochlorine Pesticides														
EPA 8081B	Aldrin		<0.88	<0.12	<0.15	<0.15	<0.12	<0.14	<0.15	<0.017	<0.042	<0.044	**1.4**	**0.14**
	alpha-BHC		<0.88	<0.12	<0.15	<0.15	<0.12	<0.14	<0.15	<0.017	<0.042	<0.044	--	--
	beta-BHC		<0.88	<0.12	<0.15	<0.15	<0.12	<0.14	<0.15	<0.017	<0.042	<0.044	--	--
	delta-BHC		<0.88	<0.12	<0.15	<0.15	<0.12	<0.14	<0.15	<0.017	<0.042	<0.044	--	--
	gamma-BHC (Lindane)		<0.88	<0.12	<0.15	<0.15	<0.12	<0.14	<0.15	<0.017	<0.042	<0.044	**4.0**	**0.4**
	Chlordane (Technical)		<8.8	<12	<15	<15	<12	<14	<15	<1.7	<4.2	<4.4	**2.5**	**0.25**
	4,4'-DDD		<0.88	<0.12	<0.15	<0.15	<0.12	<0.14	<0.15	<0.017	<0.042	<0.044	**1.0**	**0.1**
	4,4'-DDE		<0.88	<0.12	<0.15	<0.15	<0.12	<0.14	<0.15	<0.017	<0.042	<0.044	**1.0**	**0.1**
	4,4'-DDT		<0.88	<0.12	<0.15	<0.15	<0.12	<0.14	<0.15	<0.017	<0.042	<0.044	**1.0**	**0.1**
	Dieldrin		<0.88	<0.12	<0.15	<0.15	<0.12	<0.14	<0.15	<0.017	<0.042	<0.044	**8.0**	**0.8**
	Endosulfan I		<0.88	<0.12	<0.15	<0.15	<0.12	<0.14	<0.15	<0.017	<0.042	<0.044	--	--
	Endosulfan II		<0.88	<0.12	<0.15	<0.15	<0.12	<0.14	<0.15	<0.017	<0.042	<0.044	--	--
	Endosulfan sulfate		<0.88	<0.12	<0.15	<0.15	<0.12	<0.14	<0.15	<0.017	<0.042	<0.044	--	--
	Endrin		<0.88	<0.12	<0.15	<0.15	<0.12	<0.14	<0.15	<0.017	<0.042	<0.044	**0.2**	**0.02**
	Endrin aldehyde		<0.88	<0.12	<0.15	<0.15	<0.12	<0.14	<0.15	<0.017	<0.042	<0.044	--	--
	Heptachlor		<0.88	<0.12	<0.15	<0.15	<0.12	<0.14	<0.15	<0.017	<0.042	<0.044	**4.7**	**0.47**
	Hetachlor epoxide		<0.88	<0.12	<0.15	<0.15	<0.12	<0.14	<0.15	<0.017	<0.042	<0.044	**4.7**	**0.47**
	Methoxychlor		<0.88	<0.12	<0.15	<0.15	<0.12	<0.14	<0.15	<0.017	<0.042	<0.044	**100**	**10**
	Toxaphene		<8.8	<12	<15	<15	<12	<14	<15	<1.7	<4.2	<4.4	**5.0**	**0.5**
Inorganic Results														
EPA-9040	pH		**8.44**	**8.43**	**7.17**	**7.36**	**8.41**	**4.68**	**7.66**	**7.41**	**7.02**	**8.21**	**pH ≤ 2 or > 12.5**	
	pH Measurement Temperature		**19.7 °C**	**24.9 °C**	**22.0 °C**	**20.8 °C**	**21.7 °C**	**23.3 °C**	**21.9 °C**	**21.3 °C**	**22.2 °C**	**21.5 °C**	--	
SW-846 7.3.3.2	Reactive Cyanide		<0.025	<0.025	<0.025	<0.025	<0.025	<0.025	<0.025	<0.025	<0.025	<0.025	**<250 mg/kg**	
SW-846 7.3.4.2	Reactive Sulfide		<20	<20	<20	<20	<20	<20	<20	<20	<20	<20	**<500 mg/Kg**	
EPA 1030	Burning Rate		**Not Ignitable**	**Not Ignitable**	**Not Ignitable**	**Not Ignitable**	**Not Ignitable**	**Not Ignitable**	**Not Ignitable**	**Not Ignitable**	**Not Ignitable**	**Not Ignitable**	**Not-Ignitable**	

Table 3. Summary of TB9 Area Assessment
Waste Profile Analytical Results
Guadalupe Restoration Project

Method	Parameter	Matrix / Units	Soil										SMRL NHIS Acceptance Criteria	
		Sample ID	SBTB9-57-28-101316	SBTB9-60-5-101916	SBTB9-61-25-102016	SBTB9-63-8-102416	SBTB9-73-1.5-103116	SBTB9-81-8.5-110416	SBTB9-83-3-110716	SBTB9-87-5-110816	SBTB9-88-2.5-110816	SBTB9-90-6-110916		
		Sample Date	10/13/16	10/19/16	10/20/16	10/24/16	10/31/16	11/04/16	11/07/16	11/08/16	11/08/16	11/09/16		
		Lab Number	1628979-04	1629427-08	1629654-03	1629753-01	1630334-05	1631066-13	1631197-04	1631534-04	1631534-07	1631534-12		
		Units	Milligrams per Kilogram										TTLC (mg/Kg)	STLC (mg/L)
Toxicity Results														
Polisini & Miller (CDFG 1988)	96 Hour Fathead Minnow Bioassay Screen		**Pass (LC50>750 mg/L)**	**Pass (LC50>750 mg/L)**	**Pass (LC50>750 mg/L)**	**Pass (LC50>750 mg/L)**	**Pass (LC50>750 mg/L)**	**Pass (LC50>750 mg/L)**	**Pass (LC50>750 mg/L)**	**Pass (LC50>750 mg/L)**	**Pass (LC50>750 mg/L)**	**Pass (LC50>750 mg/L)**	**Pass**	

Notes:

CDFG = California Department of Fish and Game
EPA = Environmental Protection Agency
LUFT = Leaking Underground Fuel Tank
mg/Kg = Milligrams per Kilogram
mg/L = Milligrams per Liter
NHIS = Non-Hazardous Hydrocarbon Impacted Soil
PCB = Polychlorinated Biphenyl
SB = Soil Boring
SMRL = Santa Maria Regional Landfill
STLC = Soluble Threshold Limit Concentration
SVOCs = Semi-Volatile Organic Compounds
TB9 = Tank Battery 9
TPH = Total Petroleum Hydrocarbons
TTLC = Total Threshold Limit Concentration
VOCs = Volatile Organic Compounds
< = Not detected above laboratory reporting limit indicated
15,000 = Result exceeds SMRL NHIS TTLC Acceptance Criteria

[1] Santa Maria Regional Landfill NHIS Criteria

All analyses were performed by BC Laboratories, Bakersfield, CA.

QA/QC Review: BWP
Date: 11/23/16

Table 4. Summary of TB9 Area Assessment
TTLC and STLC Analytical Results

Method	Parameter	Matrix	Soil										SMRL Acceptance Criteria
		Sample ID	SBTB9-57-28-101316	SBTB9-60-5-101916	SBTB9-61-25-102016	SBTB9-63-8-102416	SBTB9-73-1.5-103116	SBTB9-81-8.5-110416	SBTB9-83-3-110716	SBTB9-87-5-110816	SBTB9-88-2.5-110816	SBTB9-90-6-110916	
		Sample Date	10/13/16	10/19/16	10/20/16	10/24/16	10/31/16	11/04/16	11/07/16	11/08/16	11/08/16	11/09/16	
		Lab Number	1628979-04	1629427-08	1629654-03	1629753-01	1630334-05	1631066-13	1631197-04	1631534-04	1631534-07	1631534-12	NHIS Limits
Total Petroleum Hydrocarbons (TPH) - TTLC Results													**TTLC (mg/Kg)**
LUFT-GC/MS	TPH - Gasoline (C_4-C_{12})		350	**1,600**	440	15	**2,500**	31	530	**1,100**	<0.20	<0.20	**1,000**[1]
LUFT-FFP	TPH - Diesel (C_{13} - C_{22})		6,300	**15,000**	14,000	**17,000**	12,000	7,500	**20,000**	5,800	2,000	14,000	**15,000**[1]
	TPH - Motor Oil (C_{23} - C_{40})		8,700	19,000	18,000	18,000	10,000	9,100	16,000	6,500	5,300	13,000	**200,000**[1]
Calculated	TPH - Total		15,350	35,600	32,440	35,015	24,500	16,631	36,530	13,400	7,300	27,000	--
Total Petroleum Hydrocarbons (TPH) - STLC Results													**STLC (mg/L)**
LUFT-GC/MS	TPH - Gasoline (C_4-C_{12})		**2.1**	**5.5**	**2.2**	**2.3**	**13**	0.31	**2.6**	**3.4**	0.25	**3.2**	**1.5**[1]
LUFT-FFP	TPH - Diesel (C_{13} - C_{22})		5.0	2.2	**7.7**	5.2	3.5	**10**	5.9	**9.6**	6.1	**8.6**	**7.5**[1]
	TPH - Motor Oil (C_{23} - C_{40})		<1.0	<1.0	<1.0	<1.0	<1.0	<2.5	<2.5	<2.5	<2.5	<2.5	**10**[1]
	TPH - Total		7.1	7.7	9.9	7.5	16.5	10.3	8.5	13.0	6.4	11.8	--

Abbreviations and Notes:

LUFT = Leaking Underground Fuel Tank
mg/Kg = Milligrams per Kilogram
mg/L = Milligrams per Liter
NHIS = Non-Hazardous Hydrocarbon Impacted Soil
SB = Soil Boring
SMRL = Santa Maria Regional Landfill
STLC = Soluble Threshold Limit Concentration
TB9 = Tank Battery 9
TPH = Total Petroleum Hydrocarbons
TTLC = Total Threshold Limit Concentration
< = Not detected above laboratory reporting limit indicated
15,000 = Result exceeds SMRL NHIS TTLC or STLC Acceptance Criteria

[1] Santa Maria Regional Landfill NHIS Criteria

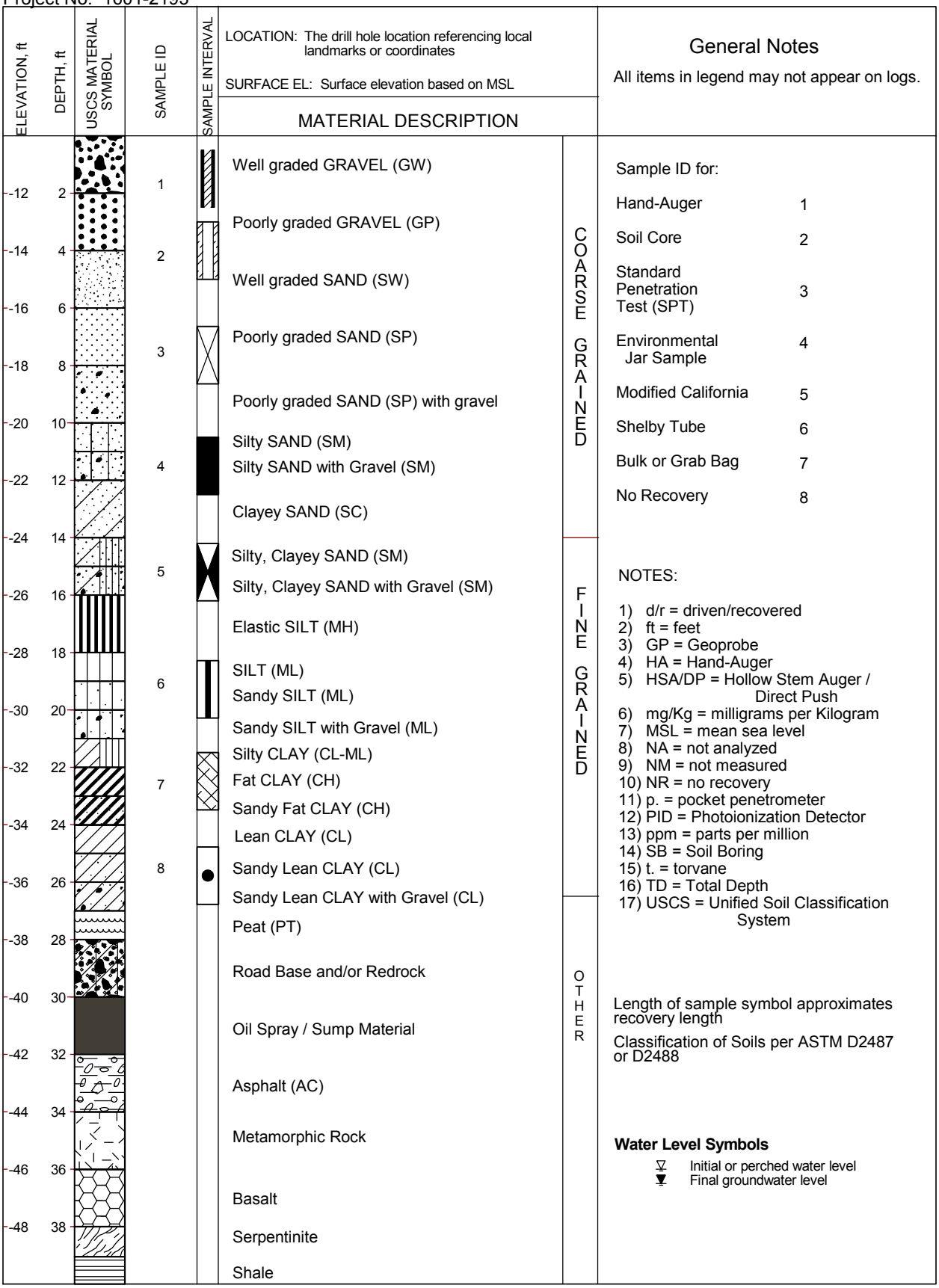
All analyses were performed by BC Laboratories, Bakersfield, CA.

QA/QC Review: BWP
Date: 11/23/16

APPENDIX A
DRILL HOLE LOGS

December 2016
Project No. 1601-2193

padre associates, inc.
ENGINEERS, GEOLOGISTS & ENVIRONMENTAL SCIENTISTS



General Notes

All items in legend may not appear on logs.

Sample ID for:

Hand-Auger	1
Soil Core	2
Standard Penetration Test (SPT)	3
Environmental Jar Sample	4
Modified California	5
Shelby Tube	6
Bulk or Grab Bag	7
No Recovery	8

NOTES:

1) d/r = driven/recovered
2) ft = feet
3) GP = Geoprobe
4) HA = Hand-Auger
5) HSA/DP = Hollow Stem Auger / Direct Push
6) mg/Kg = milligrams per Kilogram
7) MSL = mean sea level
8) NA = not analyzed
9) NM = not measured
10) NR = no recovery
11) p. = pocket penetrometer
12) PID = Photoionization Detector
13) ppm = parts per million
14) SB = Soil Boring
15) t. = torvane
16) TD = Total Depth
17) USCS = Unified Soil Classification System

Length of sample symbol approximates recovery length

Classification of Soils per ASTM D2487 or D2488

Water Level Symbols

▽ Initial or perched water level
▼ Final groundwater level

KEY TO TERMS & SYMBOLS USED ON LOGS

Guadalupe Restoration Project
Guadalupe, California

PLATE A-1

December 2016
Project No. 1601-2193

padre associates, inc.
ENGINEERS, GEOLOGISTS & ENVIRONMENTAL SCIENTISTS

LOCATION: Tank Battery 9 (TB9) Area
SURFACE ELEVATION: 95.56 ft +/- (relative datum MSL)
NORTHING: 546546.764
EASTING: 1214162.264
COORDINATE SYSTEM: NAD27 Ca SP Zn 5, feet

ELEVATION, ft MSL / DEPTH, ft	USCS MATERIAL SYMBOL	SAMPLE ID	SAMPLE INTERVAL	RECOVERY (d/r), feet	MATERIAL DESCRIPTION	Gas Monitor: MultiRAE Lite (ppm)	TOTAL TPH (mg/Kg)
94 / 2				4.0/3.5	Poorly graded SAND (SP), yellowish brown (10YR 5/4), very loose, dry, fine grained, trace silt Roots Reddish brown (5YR 4/4), slightly moist, very fine grained 1 to 2-inch diameter concrete aggregate Dark brown (10YR 3/3) 1/2-inch diameter asphalt fragment		
92 / 4		SBTB9-57-4-101316		4.0/3.5			1,900
		SBTB9-57-4.5-101316			1 1/2-inch thick layer Sump material, very dense, slightly moist, moderate odor, sheen	0	1,100
90 / 6					1 1/2-inch thick layer Sump material, dark brown (10YR 3/3), hard, dry		
88 / 8				4.0/3.5	3-inch thick layer asphalt material, dark brown (10YR 3/3), hard, dry, slight odor 3-inch thick layer concrete		
86 / 10					Asphalt, 2-inch diameter fragments, hard, dry Asphalt, 1/2-inch diameter fragments, hard, dry		
84 / 12				4.0/3.5	Sandy SILT (SM), very dark brown (10YR 2/2), 3-inch thick layer Dark brown (10YR 3/3), 1-inch diameter redrock fragment, 1-inch diameter asphalt/oil spray fragment		
82 / 14					1-inch diameter concrete fragment Black (10YR 2/1), trace silt		
		SBTB9-57-14.5-101316			Sump material, very dark greenish black (10GY 3/1), very dense, moist, strong odor, sheen	1,000+	33,880
80 / 16				4.0/3.5			
78 / 18							
76							

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DRILLING DATE: October 13, 2016
DEPTH TO GROUNDWATER: 66.0 ft
COMPLETION DEPTH: 72.0 ft
BACKFILLED WITH: Hydrated Bentonite Chips

DRILLING/SAMPLING METHOD: HSA/Direct Push
DRILLING COMPANY: Gregg Drilling
LOGGED BY: S. McAlpin
CHECKED BY: A. Sellinger, P.G., C.Hg.

LOG OF SOIL BORING SBTB9-57

Guadalupe Restoration Project
Guadalupe, California

The log and data presented are a simplification of actual conditions encountered at the time of drilling at the drilled location. Subsurface conditions may differ at other locations and with the passage of time. Please refer to Key to Boring Log for symbol explanation.

December 2016
Project No. 1601-2193

padre associates, inc.
ENGINEERS, GEOLOGISTS & ENVIRONMENTAL SCIENTISTS

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NORTHING: 546546.764
EASTING: 1214162.264
COORDINATE SYSTEM: NAD27 Ca SP Zn 5, feet

ELEVATION, ft MSL / DEPTH, ft	USCS MATERIAL SYMBOL	SAMPLE ID	SAMPLE INTERVAL	RECOVERY (d/r), feet	MATERIAL DESCRIPTION	Gas Monitor: MultiRAE Lite (ppm)	TOTAL TPH (mg/kg)
74 / 22				4.0/3.0			
72 / 24				4.0/3.0	Medium dense, moderate odor	>999	
70 / 26							
68 / 28		SBTB9-57-28-101316		4.0/3.0	Redrock fragments, moist, strong hydrocarbon odor	643	15,350
66 / 30					Poorly graded SAND (SP), very dark gray (10YR 3/1), loose, slightly moist, fine grained, moderate odor	91	
64 / 32		SBTB9-57-32-101316		4.0/3.0	Dark gray (10YR 4/1), slight odor	2	0*
62 / 34							
60 / 36				4.0/4.0	Dark yellowish brown (10YR 3/4), 1-inch thick layer		
58 / 38							
56							

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DRILLING DATE: October 13, 2016
DEPTH TO GROUNDWATER: 66.0 ft
COMPLETION DEPTH: 72.0 ft
BACKFILLED WITH: Hydrated Bentonite Chips

DRILLING/SAMPLING METHOD: HSA/Direct Push
DRILLING COMPANY: Gregg Drilling
LOGGED BY: S. McAlpin
CHECKED BY: A. Sellinger, P.G., C.Hg.

LOG OF SOIL BORING SBTB9-57

Guadalupe Restoration Project
Guadalupe, California

The log and data presented are a simplification of actual conditions encountered at the time of drilling at the drilled location. Subsurface conditions may differ at other locations and with the passage of time. Please refer to Key to Boring Log for symbol explanation.

December 2016
Project No. 1601-2193

padre associates, inc.
ENGINEERS, GEOLOGISTS & ENVIRONMENTAL SCIENTISTS

LOCATION: Tank Battery 9 (TB9) Area
SURFACE ELEVATION: 95.56 ft +/- (relative datum MSL)
NORTHING: 546546.764
EASTING: 1214162.264
COORDINATE SYSTEM: NAD27 Ca SP Zn 5, feet

ELEVATION, ft MSL / DEPTH, ft	USCS MATERIAL SYMBOL	SAMPLE ID	SAMPLE INTERVAL	RECOVERY (d/r), feet	MATERIAL DESCRIPTION	Gas Monitor: MultiRAE Lite (ppm)	TOTAL TPH (mg/Kg)
54 / 42				4.0/3.5			
52 / 44				4.0/3.5	Slight odor		
50 / 46							
48 / 48				4.0/3.0	Gray (5Y 5/1)		
46 / 50							
44 / 52				4.0/3.0			
42 / 54							
40 / 56				4.0/3.0	Dark gray (5Y 4/1), trace silt Gray (5Y 5/1), no silt		
38 / 58							
36							

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DRILLING DATE: October 13, 2016
DEPTH TO GROUNDWATER: 66.0 ft
COMPLETION DEPTH: 72.0 ft
BACKFILLED WITH: Hydrated Bentonite Chips

DRILLING/SAMPLING METHOD: HSA/Direct Push
DRILLING COMPANY: Gregg Drilling
LOGGED BY: S. McAlpin
CHECKED BY: A. Sellinger, P.G., C.Hg.

LOG OF SOIL BORING SBTB9-57

Guadalupe Restoration Project
Guadalupe, California

The log and data presented are a simplification of actual conditions encountered at the time of drilling at the drilled location. Subsurface conditions may differ at other locations and with the passage of time. Please refer to Key to Boring Log for symbol explanation.

December 2016
Project No. 1601-2193

padre associates, inc.
ENGINEERS, GEOLOGISTS & ENVIRONMENTAL SCIENTISTS

LOCATION: Tank Battery 9 (TB9) Area
SURFACE ELEVATION: 95.56 ft +/- (relative datum MSL)
NORTHING: 546546.764
EASTING: 1214162.264
COORDINATE SYSTEM: NAD27 Ca SP Zn 5, feet

ELEVATION, ft MSL / DEPTH, ft	USCS MATERIAL SYMBOL	SAMPLE ID	SAMPLE INTERVAL	RECOVERY (d/r), feet	MATERIAL DESCRIPTION	Gas Monitor: MultiRAE Lite (ppm)	TOTAL TPH (mg/Kg)
34 / 62				4.0/3.5			
		SBTB9-57-63-101316			Black (5Y 2.5/1), strong odor	11	1,680
32 / 64				4.0/3.5	Very dark gray (2.5Y 3/1), very moist		
30 / 66		SBTB9-57-66-101316			Wet, very fine grained	27	38,400
28 / 68				4.0/4.0			
26 / 70					Silty CLAY (CL-ML), dark grayish brown (2.5Y 4/2), dense		
					CLAY, brown (10YR 4/3), dense, moist		
24 / 72		SBTB9-57-71.5-101316				0	0*
22 / 74					*TPH was not detected at or above the Practical Quantitation Limits for gasoline, diesel or motor oil carbon chain ranges		
20 / 76							
18 / 78							
16							

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DRILLING DATE: October 13, 2016
DEPTH TO GROUNDWATER: 66.0 ft
COMPLETION DEPTH: 72.0 ft
BACKFILLED WITH: Hydrated Bentonite Chips

DRILLING/SAMPLING METHOD: HSA/Direct Push
DRILLING COMPANY: Gregg Drilling
LOGGED BY: S. McAlpin
CHECKED BY: A. Sellinger, P.G., C.Hg.

LOG OF SOIL BORING SBTB9-57

Guadalupe Restoration Project
Guadalupe, California

The log and data presented are a simplification of actual conditions encountered at the time of drilling at the drilled location. Subsurface conditions may differ at other locations and with the passage of time. Please refer to Key to Boring Log for symbol explanation.

December 2016
Project No. 1601-2193

padre associates, inc.
ENGINEERS, GEOLOGISTS & ENVIRONMENTAL SCIENTISTS

LOCATION: Tank Battery 9 (TB9) Area
SURFACE ELEVATION: 93.65 ft +/- (relative datum MSL)
NORTHING: 546455.449
EASTING: 1214276.586
COORDINATE SYSTEM: NAD27 Ca SP Zn 5, feet

ELEVATION, ft MSL / DEPTH, ft	USCS MATERIAL SYMBOL	SAMPLE ID	SAMPLE INTERVAL	RECOVERY (d/r), feet	MATERIAL DESCRIPTION	Gas Monitor: MultiRAE Lite (ppm)	TOTAL TPH (mg/Kg)
92 / 2	SP			8.0/8.0	Poorly graded SAND (SP), light yellowish brown (10YR 6/4), dry, fine grained, hand-augered from surface to 8 feet bgs		
90 / 4	SP	SBTB9-58-4-101716			Very dark gray (10YR 3/1), no odor Black (10YR 2/1) Sump material, poorly graded SAND (SP), black (N 2.5/0), moist, fine grained, strong odor, asphaltic	999+	40,890
88 / 6	SP						
86 / 8	SP				Continuous Direct Push sampling beginning at 8 feet bgs		
				4.0/2.0			
84 / 10	SP				Poorly graded SAND (SP), very dark gray (5Y 3/1), moist, strong odor		
82 / 12	SP			4.0/2.5	Sump material, poorly graded SAND (SP), black (N 2.5/0), moist, fine grained, strong odor, asphaltic		
80 / 14	SP						
78 / 16	SP			4.0/4.0			
76 / 18	SP						
74	SP	SBTB9-58-19.5-101716				853	36,730

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DRILLING DATE: October 17, 2016
DEPTH TO GROUNDWATER: 64.0 ft
COMPLETION DEPTH: 72.0 ft
BACKFILLED WITH: Hydrated Bentonite Chips

DRILLING/SAMPLING METHOD: HSA/Direct Push
DRILLING COMPANY: Gregg Drilling
LOGGED BY: M. McAlpin
CHECKED BY: A. Sellinger, P.G., C.Hg.

LOG OF SOIL BORING SBTB9-58

Guadalupe Restoration Project
Guadalupe, California

The log and data presented are a simplification of actual conditions encountered at the time of drilling at the drilled location. Subsurface conditions may differ at other locations and with the passage of time. Please refer to Key to Boring Log for symbol explanation.

December 2016
Project No. 1601-2193

padre associates, inc.
ENGINEERS, GEOLOGISTS & ENVIRONMENTAL SCIENTISTS

LOCATION: Tank Battery 9 (TB9) Area
SURFACE ELEVATION: 93.65 ft +/- (relative datum MSL)
NORTHING: 546455.449
EASTING: 1214276.586
COORDINATE SYSTEM: NAD27 Ca SP Zn 5, feet

ELEVATION, ft MSL / DEPTH, ft	USCS MATERIAL SYMBOL	SAMPLE ID	SAMPLE INTERVAL	RECOVERY (d/r), feet	MATERIAL DESCRIPTION	Gas Monitor: MultiRAE Lite (ppm)	TOTAL TPH (mg/Kg)
72 / 22		SBTB9-58-20-101716		4.0/3.0	Poorly graded SAND (SP), gray (5Y 5/1), moist, fine grained, moderate odor	2	0*
70 / 24				4.0/3.0	Grayish brown (2.5Y 5/2)		
68 / 26							
66 / 28				4.0/3.0	Slight odor		
64 / 30							
62 / 32				4.0/3.0	Light brownish gray (2.5Y 6/2), fine to medium grained		
60 / 34					Fine grained		
58 / 36				4.0/3.0	Brown (10YR 5/3)		
56 / 38					Trace mafic minerals		
54							

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DRILLING DATE: October 17, 2016
DEPTH TO GROUNDWATER: 64.0 ft
COMPLETION DEPTH: 72.0 ft
BACKFILLED WITH: Hydrated Bentonite Chips

DRILLING/SAMPLING METHOD: HSA/Direct Push
DRILLING COMPANY: Gregg Drilling
LOGGED BY: M. McAlpin
CHECKED BY: A. Sellinger, P.G., C.Hg.

LOG OF SOIL BORING SBTB9-58

Guadalupe Restoration Project
Guadalupe, California

The log and data presented are a simplification of actual conditions encountered at the time of drilling at the drilled location. Subsurface conditions may differ at other locations and with the passage of time. Please refer to Key to Boring Log for symbol explanation.

December 2016
Project No. 1601-2193

padre associates, inc.
ENGINEERS, GEOLOGISTS & ENVIRONMENTAL SCIENTISTS

LOCATION: Tank Battery 9 (TB9) Area
SURFACE ELEVATION: 93.65 ft +/- (relative datum MSL)
NORTHING: 546455.449
EASTING: 1214276.586
COORDINATE SYSTEM: NAD27 Ca SP Zn 5, feet

ELEVATION, ft MSL / DEPTH, ft	USCS MATERIAL SYMBOL	SAMPLE ID	SAMPLE INTERVAL	RECOVERY (d/r), feet	MATERIAL DESCRIPTION	Gas Monitor: MultiRAE Lite (ppm)	TOTAL TPH (mg/Kg)
52 / 42				4.0/3.0	Pale brown (10YR 6/3)		
					1-inch thick layer medium grained		
50 / 44					Yellowish brown (10YR 5/4)		
				4.0/3.0			
48 / 46							
46 / 48				4.0/2.5			
44 / 50							
42 / 52				4.0/3.5	Light yellowish brown (10YR 6/4)		
40 / 54							
38 / 56				4.0/3.0			
36 / 58							
34		SBTB9-58-58.5-101716			Gray (2.5Y 5/1), moderate odor	81	5,940

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DRILLING DATE: October 17, 2016
DEPTH TO GROUNDWATER: 64.0 ft
COMPLETION DEPTH: 72.0 ft
BACKFILLED WITH: Hydrated Bentonite Chips

DRILLING/SAMPLING METHOD: HSA/Direct Push
DRILLING COMPANY: Gregg Drilling
LOGGED BY: M. McAlpin
CHECKED BY: A. Sellinger, P.G., C.Hg.

LOG OF SOIL BORING SBTB9-58

Guadalupe Restoration Project
Guadalupe, California

The log and data presented are a simplification of actual conditions encountered at the time of drilling at the drilled location. Subsurface conditions may differ at other locations and with the passage of time. Please refer to Key to Boring Log for symbol explanation.

December 2016
Project No. 1601-2193

padre associates, inc.
ENGINEERS, GEOLOGISTS & ENVIRONMENTAL SCIENTISTS

LOCATION: Tank Battery 9 (TB9) Area
SURFACE ELEVATION: 93.65 ft +/- (relative datum MSL)
NORTHING: 546455.449
EASTING: 1214276.586
COORDINATE SYSTEM: NAD27 Ca SP Zn 5, feet

ELEVATION, ft MSL / DEPTH, ft	USCS MATERIAL SYMBOL	SAMPLE ID	SAMPLE INTERVAL	RECOVERY (d/r), feet	MATERIAL DESCRIPTION	Gas Monitor: MultiRAE Lite (ppm)	TOTAL TPH (mg/Kg)
32 / 62				4.0/3.5			
		SBTB9-58-63-101716				35	10,788
30 / 64		SBTB9-58-64-101716		4.0/4.0	Dark gray (N 4/0), wet, slight to moderate odor	14	23,640
28 / 66		SBTB9-58-66-101716			Sandy SILT (ML), dark gray (5Y 4/1), wet, very fine sand, no odor	1	14
					Dark gray (2.5Y 4/1)		
26 / 68				4.0/4.0	Silty SAND (SM)		
					Clayey Silt (ML), dark grayish brown (10YR 4/2)		
24 / 70					CLAY (CL)		
					SILT (ML)		
					Silty CLAY (CL), trace carbon staining		
22 / 72		SBTB9-58-71.5-101716				0	0*
20 / 74					*TPH was not detected at or above the Practical Quantitation Limits for gasoline, diesel or motor oil carbon chain ranges		
18 / 76							
16 / 78							
14							

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DRILLING DATE: October 17, 2016
DEPTH TO GROUNDWATER: 64.0 ft
COMPLETION DEPTH: 72.0 ft
BACKFILLED WITH: Hydrated Bentonite Chips

DRILLING/SAMPLING METHOD: HSA/Direct Push
DRILLING COMPANY: Gregg Drilling
LOGGED BY: M. McAlpin
CHECKED BY: A. Sellinger, P.G., C.Hg.

LOG OF SOIL BORING SBTB9-58

Guadalupe Restoration Project
Guadalupe, California

The log and data presented are a simplification of actual conditions encountered at the time of drilling at the drilled location. Subsurface conditions may differ at other locations and with the passage of time. Please refer to Key to Boring Log for symbol explanation.

December 2016
Project No. 1601-2193

padre associates, inc.
ENGINEERS, GEOLOGISTS & ENVIRONMENTAL SCIENTISTS

LOCATION: Tank Battery 9 (TB9) Area
SURFACE ELEVATION: 89.07 ft +/- (relative datum MSL)
NORTHING: 546378.503
EASTING: 1214391.548
COORDINATE SYSTEM: NAD27 Ca SP Zn 5, feet

ELEVATION, ft MSL / DEPTH, ft	USCS MATERIAL SYMBOL	SAMPLE ID	SAMPLE INTERVAL	RECOVERY (d/r), feet	MATERIAL DESCRIPTION	Gas Monitor: MultiRAE Lite (ppm)	TOTAL TPH (mg/Kg)
88 / 2				8.0/8.0	Poorly graded SAND (SP), light yellowish brown (10YR 6/4), dry, fine grained, hand-augered from surface to 8 feet bgs		
					Brown (10YR 4/3)		
86 / 4		SBTB9-59-4-101816			Very dark grayish brown (10YR 3/2)	1	2,130
84					Sump material, poorly graded SAND (SP), black (N 2.5/0), moist, fine grained, strong odor, asphaltic		
6					Poorly graded SAND (SP), very dark brown (10YR 2/2), hard, moist, fine grained, moderate odor		
82		SBTB9-59-6.5-101816				0	76
8					Continuous Direct Push sampling beginning at 8 feet bgs		
80				4.0/3.0			
10							
78							
12				4.0/3.5			
76							
14					Frequent laminated trace mafic minerals		
74					Fine to medium grained		
16				4.0/3.0			
72							
18							
70							

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DRILLING DATE: October 18, 2016
DEPTH TO GROUNDWATER: 60.5 ft
COMPLETION DEPTH: 64.0 ft
BACKFILLED WITH: Hydrated Bentonite Chips

DRILLING/SAMPLING METHOD: HSA/Direct Push
DRILLING COMPANY: Gregg Drilling
LOGGED BY: M. McAlpin
CHECKED BY: A. Sellinger, P.G., C.Hg.

LOG OF SOIL BORING SBTB9-59

Guadalupe Restoration Project
Guadalupe, California

The log and data presented are a simplification of actual conditions encountered at the time of drilling at the drilled location. Subsurface conditions may differ at other locations and with the passage of time. Please refer to Key to Boring Log for symbol explanation.

December 2016
Project No. 1601-2193

padre associates, inc.
ENGINEERS, GEOLOGISTS & ENVIRONMENTAL SCIENTISTS

LOCATION: Tank Battery 9 (TB9) Area
SURFACE ELEVATION: 89.07 ft +/- (relative datum MSL)
NORTHING: 546378.503
EASTING: 1214391.548
COORDINATE SYSTEM: NAD27 Ca SP Zn 5, feet

ELEVATION, ft MSL / DEPTH, ft	USCS MATERIAL SYMBOL	SAMPLE ID	SAMPLE INTERVAL	RECOVERY (d/r), feet	MATERIAL DESCRIPTION	Gas Monitor: MultiRAE Lite (ppm)	TOTAL TPH (mg/Kg)
68 / 22				4.0/4.0	Frequent lenses of laminated of dark brown (7.5YR 3/2)		
66 / 24				4.0/3.0	Trace dark brown (7.5YR 3/2) mottling		
64 / 26					Frequent laminated dark brown (7.5YR 3/4) Light yellowish brown (10YR 6/4)		
62 / 28				4.0/3.0	Frequent stratified medium grained sand		
60 / 30					Frequent laminated trace mafic minerals		
58 / 32				4.0/0.0	No recovery from 32 to 40 feet bgs		
56 / 34							
54 / 36				4.0/0.0			
52 / 38							
50							

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DRILLING DATE: October 18, 2016
DEPTH TO GROUNDWATER: 60.5 ft
COMPLETION DEPTH: 64.0 ft
BACKFILLED WITH: Hydrated Bentonite Chips

DRILLING/SAMPLING METHOD: HSA/Direct Push
DRILLING COMPANY: Gregg Drilling
LOGGED BY: M. McAlpin
CHECKED BY: A. Sellinger, P.G., C.Hg.

LOG OF SOIL BORING SBTB9-59

Guadalupe Restoration Project
Guadalupe, California

The log and data presented are a simplification of actual conditions encountered at the time of drilling at the drilled location. Subsurface conditions may differ at other locations and with the passage of time. Please refer to Key to Boring Log for symbol explanation.

December 2016
Project No. 1601-2193

padre associates, inc.
ENGINEERS, GEOLOGISTS & ENVIRONMENTAL SCIENTISTS

LOCATION: Tank Battery 9 (TB9) Area
SURFACE ELEVATION: 89.07 ft +/- (relative datum MSL)
NORTHING: 546378.503
EASTING: 1214391.548
COORDINATE SYSTEM: NAD27 Ca SP Zn 5, feet

ELEVATION, ft MSL / DEPTH, ft	USCS MATERIAL SYMBOL	SAMPLE ID	SAMPLE INTERVAL	RECOVERY (d/r), feet	MATERIAL DESCRIPTION	Gas Monitor: MultiRAE Lite (ppm)	TOTAL TPH (mg/Kg)
48 / 42				4.0/3.0	Frequent stratified medium grained sand Trace dark brown (7.5YR 3/4) mottling		
46 / 44				4.0/3.0	Fine grained		
44 / 46				4.0/3.0	Dark grayish brown (10YR 4/2), trace silt, trace micaceous minerals		
42 / 48				4.0/3.0			
40 / 50				4.0/3.5	Light yellowish brown (10YR 6/4), trace yellowish brown (10YR 5/8) oxidation staining		
38 / 52					Dark grayish brown (10YR 4/2), slight odor		
36 / 54		SBTB9-59-55-101816			Gray (5Y 5/1), sheen visible on grains, moderate odor	0	2,500
34 / 56				4.0/2.7	Strong odor		
32 / 58					Gray (N 5/0)		
30							

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DRILLING DATE: October 18, 2016
DEPTH TO GROUNDWATER: 60.5 ft
COMPLETION DEPTH: 64.0 ft
BACKFILLED WITH: Hydrated Bentonite Chips

DRILLING/SAMPLING METHOD: HSA/Direct Push
DRILLING COMPANY: Gregg Drilling
LOGGED BY: M. McAlpin
CHECKED BY: A. Sellinger, P.G., C.Hg.

LOG OF SOIL BORING SBTB9-59

Guadalupe Restoration Project
Guadalupe, California

The log and data presented are a simplification of actual conditions encountered at the time of drilling at the drilled location. Subsurface conditions may differ at other locations and with the passage of time. Please refer to Key to Boring Log for symbol explanation.

December 2016
Project No. 1601-2193

padre associates, inc.
ENGINEERS, GEOLOGISTS & ENVIRONMENTAL SCIENTISTS

LOCATION: Tank Battery 9 (TB9) Area
SURFACE ELEVATION: 89.07 ft +/- (relative datum MSL)
NORTHING: 546378.503
EASTING: 1214391.548
COORDINATE SYSTEM: NAD27 Ca SP Zn 5, feet

ELEVATION, ft MSL / DEPTH, ft	USCS MATERIAL SYMBOL	SAMPLE ID	SAMPLE INTERVAL	RECOVERY (d/r), feet	MATERIAL DESCRIPTION	Gas Monitor: MultiRAE Lite (ppm)	TOTAL TPH (mg/Kg)
28 / 62		SBTB9-59-60-101816		4.0/4.0	Very dark gray (N 3/0), wet, slight odor	15	35,089
26 / 64		SBTB9-59-61-101816			Silty SAND (SM), dark greenish gray (10Y 4/1), wet, fine sand with silt, slight odor	1	35
24 / 66		SBTB9-59-63.5-101816			Sandy SILT (ML), dark gray (2.5Y 4/1), wet, silt with very fine sand, no odor, non-plastic	0	0*
22 / 68					*TPH was not detected at or above the Practical Quantitation Limits for gasoline, diesel or motor oil carbon chain ranges		
20 / 70							
18 / 72							
16 / 74							
14 / 76							
12 / 78							
10							

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DRILLING DATE: October 18, 2016
DEPTH TO GROUNDWATER: 60.5 ft
COMPLETION DEPTH: 64.0 ft
BACKFILLED WITH: Hydrated Bentonite Chips

DRILLING/SAMPLING METHOD: HSA/Direct Push
DRILLING COMPANY: Gregg Drilling
LOGGED BY: M. McAlpin
CHECKED BY: A. Sellinger, P.G., C.Hg.

LOG OF SOIL BORING SBTB9-59

Guadalupe Restoration Project
Guadalupe, California

The log and data presented are a simplification of actual conditions encountered at the time of drilling at the drilled location. Subsurface conditions may differ at other locations and with the passage of time. Please refer to Key to Boring Log for symbol explanation.

December 2016
Project No. 1601-2193

padre associates, inc.
ENGINEERS, GEOLOGISTS & ENVIRONMENTAL SCIENTISTS

LOCATION: Tank Battery 9 (TB9) Area
SURFACE ELEVATION: 82.70 ft +/- (relative datum MSL)
NORTHING: 546275.271
EASTING: 1214530.334
COORDINATE SYSTEM: NAD27 Ca SP Zn 5, feet

ELEVATION, ft MSL / DEPTH, ft	USCS MATERIAL SYMBOL	SAMPLE ID	SAMPLE INTERVAL	RECOVERY (d/r), feet	MATERIAL DESCRIPTION	Gas Monitor: MultiRAE Lite (ppm)	TOTAL TPH (mg/Kg)
82 / 0				8.0/8.0	Poorly graded SAND (SP), light yellowish brown (10YR 6/4), slightly moist, fine grained, hand-augered from surface to 8 feet bgs		
2					Brown (10YR 4/3), moist		
80 / 4					Dark brown (10YR 3/3), slight odor		
78		SBTB9-60-5-101916			Sump material, black (N 2.5/0), moist, fine grained sand, strong odor, asphaltic	999+	35,600
6 / 76							
8 / 74				4.0/2.5	Continuous Direct Push sampling beginning at 8 feet bgs		
10 / 72							
12 / 70				4.0/2.5			
14 / 68							
16 / 66				4.0/3.0			
18 / 64		SBTB9-60-18.5-101916			Grayish brown (2.5Y 5/2), moist, strong odor	37	97

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DRILLING DATE: October 19, 2016
DEPTH TO GROUNDWATER: 51.5 ft
COMPLETION DEPTH: 56.0 ft
BACKFILLED WITH: Hydrated Bentonite Chips

DRILLING/SAMPLING METHOD: HSA/Direct Push
DRILLING COMPANY: Gregg Drilling
LOGGED BY: M. McAlpin
CHECKED BY: A. Sellinger, P.G., C.Hg.

LOG OF SOIL BORING SBTB9-60

Guadalupe Restoration Project
Guadalupe, California

The log and data presented are a simplification of actual conditions encountered at the time of drilling at the drilled location. Subsurface conditions may differ at other locations and with the passage of time. Please refer to Key to Boring Log for symbol explanation.

December 2016
Project No. 1601-2193

padre associates, inc.
ENGINEERS, GEOLOGISTS & ENVIRONMENTAL SCIENTISTS

LOCATION: Tank Battery 9 (TB9) Area
SURFACE ELEVATION: 82.70 ft +/- (relative datum MSL)
NORTHING: 546275.271
EASTING: 1214530.334
COORDINATE SYSTEM: NAD27 Ca SP Zn 5, feet

ELEVATION, ft MSL / DEPTH, ft	USCS MATERIAL SYMBOL	SAMPLE ID	SAMPLE INTERVAL	RECOVERY (d/r), feet	MATERIAL DESCRIPTION	Gas Monitor: MultiRAE Lite (ppm)	TOTAL TPH (mg/Kg)
62 / 22				4.0/2.5	Moderate odor		
60 / 24		SBTB9-60-24-101916		4.0/3.0	Light olive gray (5Y 6/2), slight odor	3	0*
58 / 26					Fine to medium grained		
56 / 28				4.0/3.0	Light brownish gray (2.5Y 6/2), fine grained		
54 / 30					Medium grained Fine grained		
52 / 32				4.0/3.0	Pale brown (10YR 6/3), no odor		
50 / 34							
48 / 36				4.0/3.0			
46 / 38					Frequent laminated trace mafic minerals Frequent striated medium grained and fine grained sand		
44							

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DRILLING DATE: October 19, 2016
DEPTH TO GROUNDWATER: 51.5 ft
COMPLETION DEPTH: 56.0 ft
BACKFILLED WITH: Hydrated Bentonite Chips

DRILLING/SAMPLING METHOD: HSA/Direct Push
DRILLING COMPANY: Gregg Drilling
LOGGED BY: M. McAlpin
CHECKED BY: A. Sellinger, P.G., C.Hg.

LOG OF SOIL BORING SBTB9-60

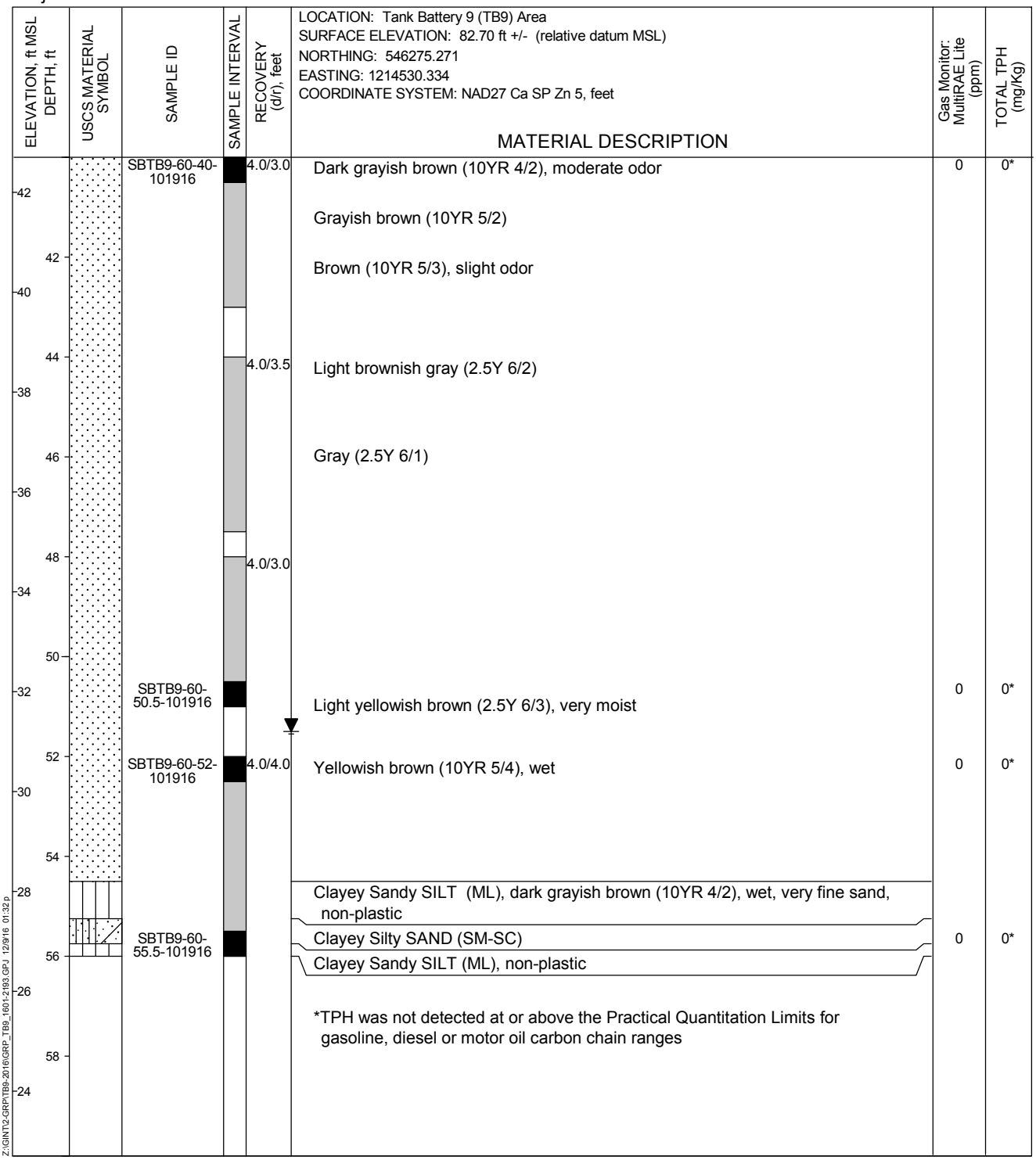
Guadalupe Restoration Project
Guadalupe, California

The log and data presented are a simplification of actual conditions encountered at the time of drilling at the drilled location. Subsurface conditions may differ at other locations and with the passage of time. Please refer to Key to Boring Log for symbol explanation.

December 2016
Project No. 1601-2193

padre associates, inc.
ENGINEERS, GEOLOGISTS & ENVIRONMENTAL SCIENTISTS

LOCATION: Tank Battery 9 (TB9) Area
SURFACE ELEVATION: 82.70 ft +/- (relative datum MSL)
NORTHING: 546275.271
EASTING: 1214530.334
COORDINATE SYSTEM: NAD27 Ca SP Zn 5, feet



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DRILLING DATE: October 19, 2016
DEPTH TO GROUNDWATER: 51.5 ft
COMPLETION DEPTH: 56.0 ft
BACKFILLED WITH: Hydrated Bentonite Chips

DRILLING/SAMPLING METHOD: HSA/Direct Push
DRILLING COMPANY: Gregg Drilling
LOGGED BY: M. McAlpin
CHECKED BY: A. Sellinger, P.G., C.Hg.

LOG OF SOIL BORING SBTB9-60

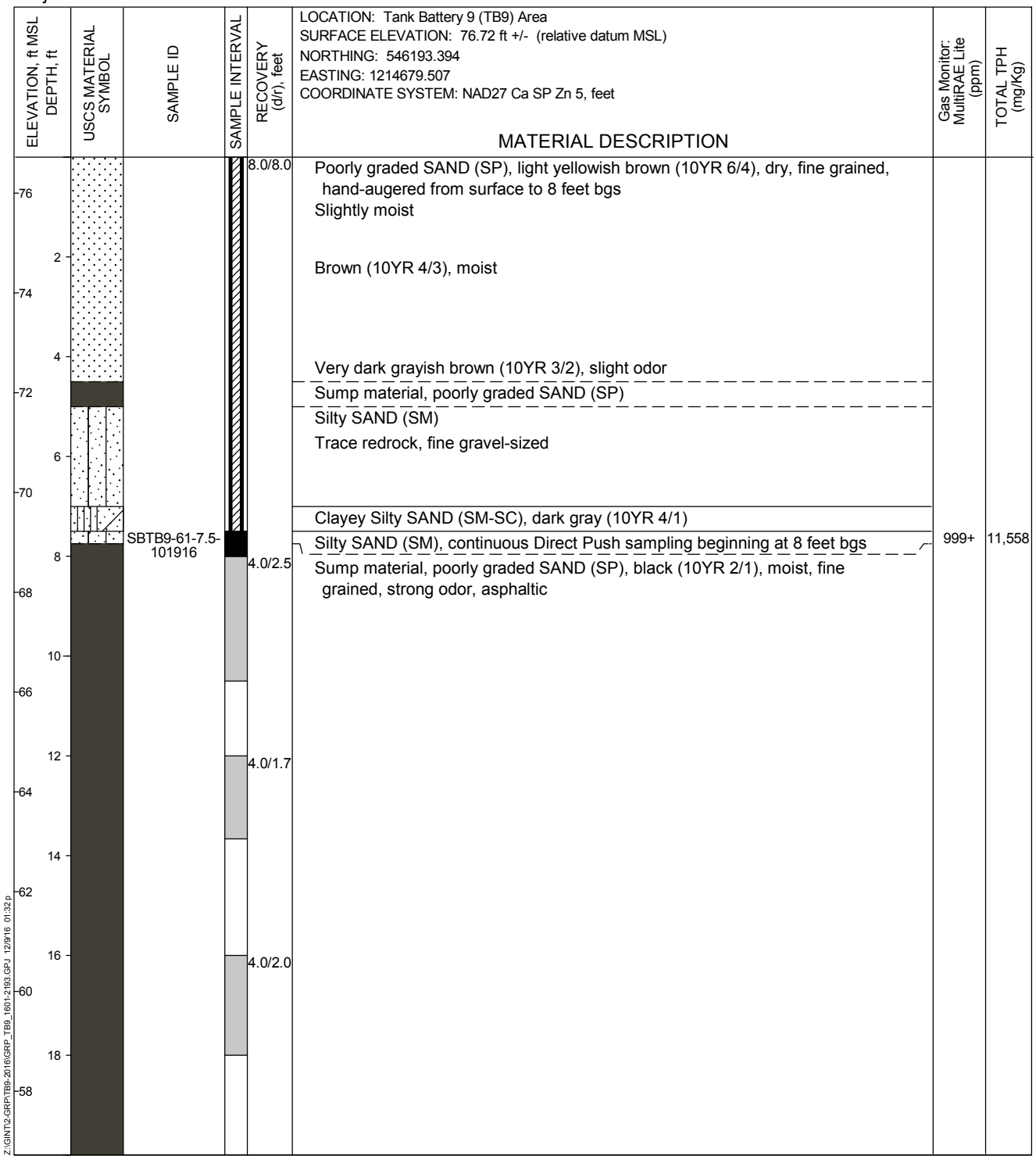
Guadalupe Restoration Project
Guadalupe, California

The log and data presented are a simplification of actual conditions encountered at the time of drilling at the drilled location. Subsurface conditions may differ at other locations and with the passage of time. Please refer to Key to Boring Log for symbol explanation.

December 2016
Project No. 1601-2193

padre associates, inc.
ENGINEERS, GEOLOGISTS & ENVIRONMENTAL SCIENTISTS

LOCATION: Tank Battery 9 (TB9) Area
SURFACE ELEVATION: 76.72 ft +/- (relative datum MSL)
NORTHING: 546193.394
EASTING: 1214679.507
COORDINATE SYSTEM: NAD27 Ca SP Zn 5, feet



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DRILLING DATE: October 20, 2016
DEPTH TO GROUNDWATER: 45.0 ft
COMPLETION DEPTH: 48.0 ft
BACKFILLED WITH: Hydrated Bentonite Chips

DRILLING/SAMPLING METHOD: HSA/Direct Push
DRILLING COMPANY: Gregg Drilling
LOGGED BY: M. McAlpin
CHECKED BY: A. Sellinger, P.G., C.Hg.

LOG OF SOIL BORING SBTB9-61

Guadalupe Restoration Project
Guadalupe, California

The log and data presented are a simplification of actual conditions encountered at the time of drilling at the drilled location. Subsurface conditions may differ at other locations and with the passage of time. Please refer to Key to Boring Log for symbol explanation.

December 2016
Project No. 1601-2193

padre associates, inc.
ENGINEERS, GEOLOGISTS & ENVIRONMENTAL SCIENTISTS

LOCATION: Tank Battery 9 (TB9) Area
SURFACE ELEVATION: 76.72 ft +/- (relative datum MSL)
NORTHING: 546193.394
EASTING: 1214679.507
COORDINATE SYSTEM: NAD27 Ca SP Zn 5, feet

ELEVATION, ft MSL / DEPTH, ft	USCS MATERIAL SYMBOL	SAMPLE ID	SAMPLE INTERVAL	RECOVERY (d/r), feet	MATERIAL DESCRIPTION	Gas Monitor: MultiRAE Lite (ppm)	TOTAL TPH (mg/kg)
56 / 22				4.0/2.3			
54 / 24				4.0/2.3			
52 / 26		SBTB9-61-25-102016				999+	32,440
50 / 28				4.0/3.0			
48 / 30		SBTB9-61-29.5-102016			Poorly graded SAND (SP), grayish brown (10YR 5/2), moist, fine grained, strong odor Brown (10YR 5/3), moderate odor	1	513
46 / 32		SBTB9-61-32-102016		4.0/3.5	Slight odor	1	0*
44 / 34							
42 / 36				4.0/3.5			
40 / 38							
38					Gray (10YR 5/1)		

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DRILLING DATE: October 20, 2016
DEPTH TO GROUNDWATER: 45.0 ft
COMPLETION DEPTH: 48.0 ft
BACKFILLED WITH: Hydrated Bentonite Chips

DRILLING/SAMPLING METHOD: HSA/Direct Push
DRILLING COMPANY: Gregg Drilling
LOGGED BY: M. McAlpin
CHECKED BY: A. Sellinger, P.G., C.Hg.

LOG OF SOIL BORING SBTB9-61

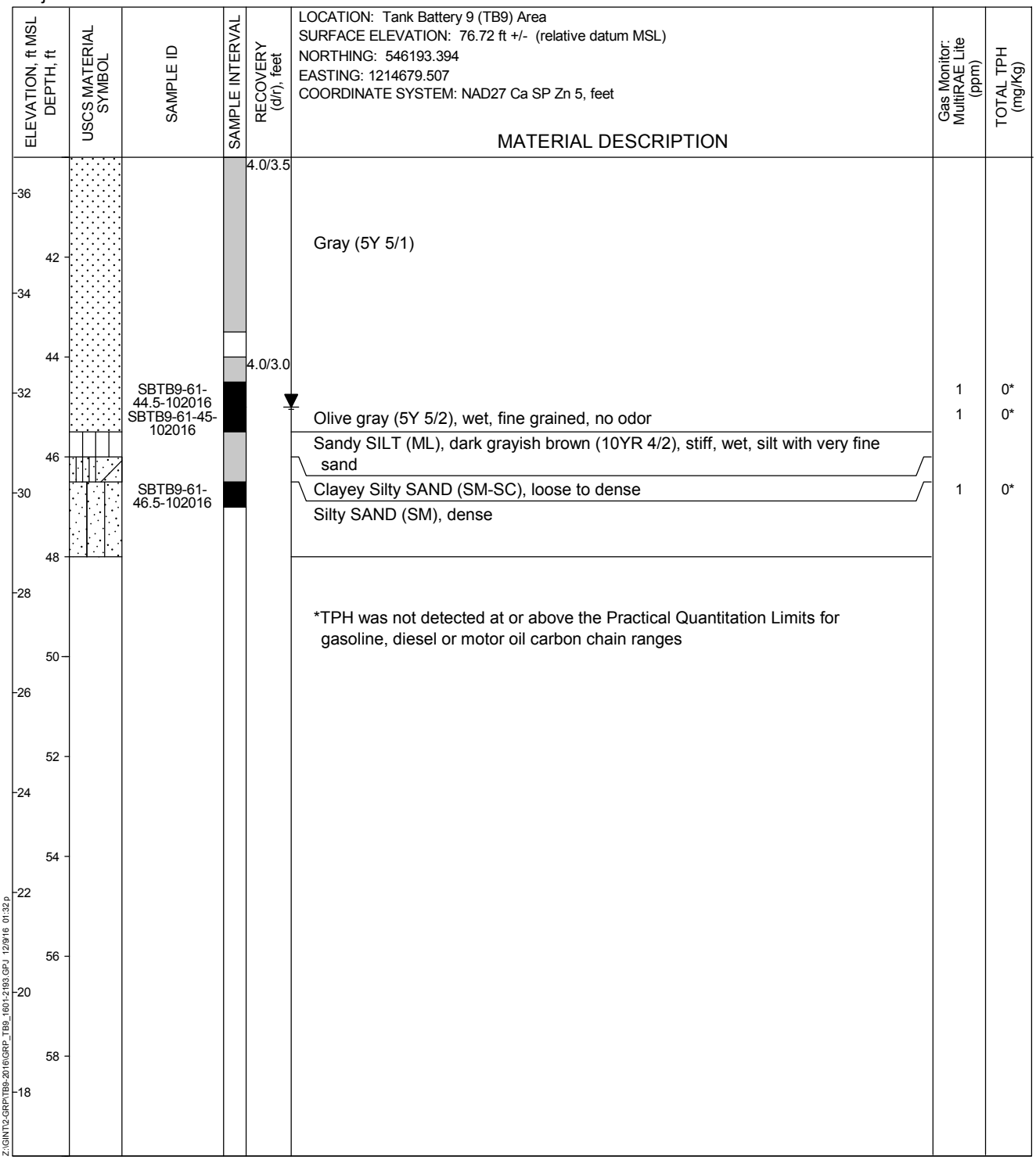
Guadalupe Restoration Project
Guadalupe, California

The log and data presented are a simplification of actual conditions encountered at the time of drilling at the drilled location. Subsurface conditions may differ at other locations and with the passage of time. Please refer to Key to Boring Log for symbol explanation.

December 2016
Project No. 1601-2193

padre associates, inc.
ENGINEERS, GEOLOGISTS & ENVIRONMENTAL SCIENTISTS

LOCATION: Tank Battery 9 (TB9) Area
SURFACE ELEVATION: 76.72 ft +/- (relative datum MSL)
NORTHING: 546193.394
EASTING: 1214679.507
COORDINATE SYSTEM: NAD27 Ca SP Zn 5, feet



*TPH was not detected at or above the Practical Quantitation Limits for gasoline, diesel or motor oil carbon chain ranges

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DRILLING DATE: October 20, 2016
DEPTH TO GROUNDWATER: 45.0 ft
COMPLETION DEPTH: 48.0 ft
BACKFILLED WITH: Hydrated Bentonite Chips

DRILLING/SAMPLING METHOD: HSA/Direct Push
DRILLING COMPANY: Gregg Drilling
LOGGED BY: M. McAlpin
CHECKED BY: A. Sellinger, P.G., C.Hg.

LOG OF SOIL BORING SBTB9-61

Guadalupe Restoration Project
Guadalupe, California

The log and data presented are a simplification of actual conditions encountered at the time of drilling at the drilled location. Subsurface conditions may differ at other locations and with the passage of time. Please refer to Key to Boring Log for symbol explanation.

December 2016
Project No. 1601-2193

padre associates, inc.
ENGINEERS, GEOLOGISTS & ENVIRONMENTAL SCIENTISTS

LOCATION: Tank Battery 9 (TB9) Area
SURFACE ELEVATION: 69.97 ft +/- (relative datum MSL)
NORTHING: 546101.740
EASTING: 1214825.837
COORDINATE SYSTEM: NAD27 Ca SP Zn 5, feet

ELEVATION, ft MSL	DEPTH, ft	USCS MATERIAL SYMBOL	SAMPLE ID	SAMPLE INTERVAL	RECOVERY (d/r), feet	MATERIAL DESCRIPTION	Gas Monitor: MultiRAE Lite (ppm)	TOTAL TPH (mg/Kg)
					8.0/8.0	Poorly graded SAND (SP), light yellowish brown (10YR 6/4), slightly moist, fine grained, hand-augered from surface to 8 feet bgs		
68	2							
66	4							
			SBTB9-62-5-102016			Clayey Sandy SILT (ML), brown (10YR 4/3), moist, silt with very fine sand and clay, slight odor		1,161
64	6		SBTB9-62-6-102016			Sump material, poorly graded SAND (SP), black (N 2.5/0), moist, fine grained, strong odor, asphaltic	999+	45,510
						Continuous Direct Push sampling beginning at 8 feet bgs		
62	8				4.0/2.3			
60	10							
58	12				4.0/2.0			
56	14							

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DRILLING DATE: October 20, 2016
DEPTH TO GROUNDWATER: 38.5 ft
COMPLETION DEPTH: 40.0 ft
BACKFILLED WITH: Hydrated Bentonite Chips

DRILLING/SAMPLING METHOD: HSA/Direct Push
DRILLING COMPANY: Gregg Drilling
LOGGED BY: M. McAlpin
CHECKED BY: A. Sellinger, P.G., C.Hg.

LOG OF SOIL BORING SBTB9-62

Guadalupe Restoration Project
Guadalupe, California

The log and data presented are a simplification of actual conditions encountered at the time of drilling at the drilled location. Subsurface conditions may differ at other locations and with the passage of time. Please refer to Key to Boring Log for symbol explanation.

December 2016
Project No. 1601-2193

padre associates, inc.
ENGINEERS, GEOLOGISTS & ENVIRONMENTAL SCIENTISTS

LOCATION: Tank Battery 9 (TB9) Area
SURFACE ELEVATION: 69.97 ft +/- (relative datum MSL)
NORTHING: 546101.740
EASTING: 1214825.837
COORDINATE SYSTEM: NAD27 Ca SP Zn 5, feet

ELEVATION, ft MSL / DEPTH, ft	USCS MATERIAL SYMBOL	SAMPLE ID	SAMPLE INTERVAL	RECOVERY (d/r), feet	MATERIAL DESCRIPTION	Gas Monitor: MultiRAE Lite (ppm)	TOTAL TPH (mg/Kg)
-54 16		SBTB9-62-16-102016		4.0/2.8	Poorly graded SAND (SP), grayish brown (2.5Y 5/2), moist, fine grained, slight odor	7	21
-52 18							
-50 20				4.0/3.0	Gray (2.5Y 5/1)		
-48 22							
-46 24				4.0/3.0			
-44 26							
-42 28				4.0/3.0			

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DRILLING DATE: October 20, 2016
DEPTH TO GROUNDWATER: 38.5 ft
COMPLETION DEPTH: 40.0 ft
BACKFILLED WITH: Hydrated Bentonite Chips

DRILLING/SAMPLING METHOD: HSA/Direct Push
DRILLING COMPANY: Gregg Drilling
LOGGED BY: M. McAlpin
CHECKED BY: A. Sellinger, P.G., C.Hg.

LOG OF SOIL BORING SBTB9-62

Guadalupe Restoration Project
Guadalupe, California

The log and data presented are a simplification of actual conditions encountered at the time of drilling at the drilled location. Subsurface conditions may differ at other locations and with the passage of time. Please refer to Key to Boring Log for symbol explanation.

December 2016
Project No. 1601-2193

padre associates, inc.
ENGINEERS, GEOLOGISTS & ENVIRONMENTAL SCIENTISTS

LOCATION: Tank Battery 9 (TB9) Area
SURFACE ELEVATION: 69.97 ft +/- (relative datum MSL)
NORTHING: 546101.740
EASTING: 1214825.837
COORDINATE SYSTEM: NAD27 Ca SP Zn 5, feet

ELEVATION, ft MSL / DEPTH, ft	USCS MATERIAL SYMBOL	SAMPLE ID	SAMPLE INTERVAL	RECOVERY (d/r), feet	MATERIAL DESCRIPTION	Gas Monitor: MultiRAE Lite (ppm)	TOTAL TPH (mg/kg)
38 32				4.0/3.0	Medium grained Fine to medium grained		
36 34							
34 36				4.0/3.5	Fine grained		
32 38		SBTB9-62-38-102016			Brown (10YR 5/3), wet	1	0*
		SBTB9-62-38.5-102016				0	0*
		SBTB9-62-39-102016			Clayey Sandy SILT (ML), brown (10YR 4/3), mottled dark gray (10YR 4/1), trace micaceous minerals, medium to stiff, wet, non-plastic, trace carbon staining	0	0*
30 40					*TPH was not detected at or above the Practical Quantitation Limits for gasoline, diesel or motor oil carbon chain ranges		
28 42							
26 44							

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DRILLING DATE: October 20, 2016
DEPTH TO GROUNDWATER: 38.5 ft
COMPLETION DEPTH: 40.0 ft
BACKFILLED WITH: Hydrated Bentonite Chips

DRILLING/SAMPLING METHOD: HSA/Direct Push
DRILLING COMPANY: Gregg Drilling
LOGGED BY: M. McAlpin
CHECKED BY: A. Sellinger, P.G., C.Hg.

LOG OF SOIL BORING SBTB9-62

Guadalupe Restoration Project
Guadalupe, California

The log and data presented are a simplification of actual conditions encountered at the time of drilling at the drilled location. Subsurface conditions may differ at other locations and with the passage of time. Please refer to Key to Boring Log for symbol explanation.

December 2016
Project No. 1601-2193

padre associates, inc.
ENGINEERS, GEOLOGISTS & ENVIRONMENTAL SCIENTISTS

LOCATION: Tank Battery 9 (TB9) Area
SURFACE ELEVATION: 65.95 ft +/- (relative datum MSL)
NORTHING: 546016.844
EASTING: 1214950.079
COORDINATE SYSTEM: NAD27 Ca SP Zn 5, feet

ELEVATION, ft MSL / DEPTH, ft	USCS MATERIAL SYMBOL	SAMPLE ID	SAMPLE INTERVAL	RECOVERY (d/r), feet	MATERIAL DESCRIPTION	Gas Monitor: MultiRAE Lite (ppm)	TOTAL TPH (mg/Kg)
64 / 2				8.0/8.0	Poorly graded SAND (SP), yellowish brown (10YR 5/4), very loose, dry, very fine to fine grained, hand-augered from surface to 8 feet bgs Redrock base fragments approximately 1/2 to 1-inch diameter Dark yellowish brown (10YR 4/4) Black cloth piece, 4-inches wide, possibly liner material Dark brown (10YR 3/3), loose, slightly moist, no odor 1 to 1 1/2-inch dry asphalt and oil spray fragments Very dark brown (10YR 2/2), silty sand, no odor Solid layer approximately 1-inch thick layer asphalt		
62 / 4							
60 / 6					Sump material, poorly graded SAND (SP), black (N 2.5/0), dense, moist, sheen, strong odor, asphaltic	+999	51,250
58 / 8		SBTB9-63-7-102016			Continuous Direct Push sampling beginning at 8 feet bgs		
		SBTB9-63-8-102416		4.0/2.0		999+	35,015
56 / 10							
54 / 12				4.0/2.0			
		SBTB9-63-12.5-102416			Poorly graded SAND (SP), light brownish gray (2.5Y 6/2), moist, fine grained, slight odor	1	14
52 / 14							
50 / 16				4.0/2.5	Brown (10YR 5/3)		
48 / 18							

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DRILLING DATE: October 24, 2016
DEPTH TO GROUNDWATER: 33.5 ft
COMPLETION DEPTH: 40.0 ft
BACKFILLED WITH: Hydrated Bentonite Chips

DRILLING/SAMPLING METHOD: HSA/Direct Push
DRILLING COMPANY: Gregg Drilling
LOGGED BY: S. McAlpin, M. McAlpin
CHECKED BY: A. Sellinger, P.G., C.Hg.

LOG OF SOIL BORING SBTB9-63

Guadalupe Restoration Project
Guadalupe, California

The log and data presented are a simplification of actual conditions encountered at the time of drilling at the drilled location. Subsurface conditions may differ at other locations and with the passage of time. Please refer to Key to Boring Log for symbol explanation.

December 2016
Project No. 1601-2193

padre associates, inc.
ENGINEERS, GEOLOGISTS & ENVIRONMENTAL SCIENTISTS

LOCATION: Tank Battery 9 (TB9) Area
SURFACE ELEVATION: 65.95 ft +/- (relative datum MSL)
NORTHING: 546016.844
EASTING: 1214950.079
COORDINATE SYSTEM: NAD27 Ca SP Zn 5, feet

ELEVATION, ft MSL / DEPTH, ft	USCS MATERIAL SYMBOL	SAMPLE ID	SAMPLE INTERVAL	RECOVERY (d/r), feet	MATERIAL DESCRIPTION	Gas Monitor: MultiRAE Lite (ppm)	TOTAL TPH (mg/Kg)
				4.0/2.8	Frequent laminated gray (10YR 5/1), trace mafic minerals		
-44 22							
-42 24				4.0/2.0			
-40 26							
-38 28				4.0/3.0	Grayish brown (10YR 5/2)		
-36 30							
-34 32				4.0/2.5			
		SBTB9-63-33-102416				0	0*
-32 34		SBTB9-63-33.5-102416			Yellowish brown (10YR 5/4), wet	0	0*
-30 36		SBTB9-63-36-102416		4.0/2.5			82
-28 38							
					*TPH was not detected at or above the Practical Quantitation Limits for gasoline, diesel or motor oil carbon chain ranges		

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DRILLING DATE: October 24, 2016
DEPTH TO GROUNDWATER: 33.5 ft
COMPLETION DEPTH: 40.0 ft
BACKFILLED WITH: Hydrated Bentonite Chips

DRILLING/SAMPLING METHOD: HSA/Direct Push
DRILLING COMPANY: Gregg Drilling
LOGGED BY: S. McAlpin, M. McAlpin
CHECKED BY: A. Sellinger, P.G., C.Hg.

LOG OF SOIL BORING SBTB9-63

Guadalupe Restoration Project
Guadalupe, California

The log and data presented are a simplification of actual conditions encountered at the time of drilling at the drilled location. Subsurface conditions may differ at other locations and with the passage of time. Please refer to Key to Boring Log for symbol explanation.

December 2016
Project No. 1601-2193

padre associates, inc.
ENGINEERS, GEOLOGISTS & ENVIRONMENTAL SCIENTISTS

LOCATION: Tank Battery 9 (TB9) Area
SURFACE ELEVATION: 60.96 ft +/- (relative datum MSL)
NORTHING: 545956.592
EASTING: 1215062.035
COORDINATE SYSTEM: NAD27 Ca SP Zn 5, feet

ELEVATION, ft MSL / DEPTH, ft	USCS MATERIAL SYMBOL	SAMPLE ID	SAMPLE INTERVAL	RECOVERY (d/r), feet	MATERIAL DESCRIPTION	Gas Monitor: MultiRAE Lite (ppm)	TOTAL TPH (mg/Kg)
60 / 2				6.0/6.0	Poorly graded SAND (SP), very pale brown (10YR 7/4), fine grained, no odor, hand-augered from surface to 6 feet bgs		
					Dark yellowish brown (10YR 4/4)		
58 / 4		SBTB9-64-3.5-102416					9,000
					Very dark brown (10YR 2/2), wet, moderate odor, HDPE liner		
					Dark yellowish brown (10YR 3/6)		
56 / 6					Gray (7.5YR 5/1), fine grained with trace fine gravel, moderate to strong odor		
					Black (10YR 2/1), moist, fine grained		
					Continuous Direct Push sampling beginning at 6 feet bgs		
		SBTB9-64-6-102416		4.0/3.0	Yellowish brown (10YR 5/4), wet, fine grained, slight odor	0	29
54 / 8							
52 / 10				4.0/2.0	Moist, no odor		
50 / 12							
48 / 14				4.0/2.8	Fine to medium grained		
46 / 16					Fine grained		
44 / 18				4.0/3.0			
42					Frequent laminations of dark yellowish brown (10YR 4/4) and trace mafic minerals		

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DRILLING DATE: October 24, 2016
DEPTH TO GROUNDWATER: 26.8 ft
COMPLETION DEPTH: 34.0 ft
BACKFILLED WITH: Hydrated Bentonite Chips

DRILLING/SAMPLING METHOD: HSA/Direct Push
DRILLING COMPANY: Gregg Drilling
LOGGED BY: C. Swithenbank, M. McAlpin
CHECKED BY: A. Sellinger, P.G., C.Hg.

LOG OF SOIL BORING SBTB9-64

Guadalupe Restoration Project
Guadalupe, California

The log and data presented are a simplification of actual conditions encountered at the time of drilling at the drilled location. Subsurface conditions may differ at other locations and with the passage of time. Please refer to Key to Boring Log for symbol explanation.

December 2016
Project No. 1601-2193

padre associates, inc.
ENGINEERS, GEOLOGISTS & ENVIRONMENTAL SCIENTISTS

LOCATION: Tank Battery 9 (TB9) Area
SURFACE ELEVATION: 60.96 ft +/- (relative datum MSL)
NORTHING: 545956.592
EASTING: 1215062.035
COORDINATE SYSTEM: NAD27 Ca SP Zn 5, feet

ELEVATION, ft MSL / DEPTH, ft	USCS MATERIAL SYMBOL	SAMPLE ID	SAMPLE INTERVAL	RECOVERY (d/r), feet	MATERIAL DESCRIPTION	Gas Monitor: MultiRAE Lite (ppm)	TOTAL TPH (mg/Kg)
40 / 22				4.0/3.0	Fine to medium grained		
38 / 24					Fine grained Laminated strong brown (7.5YR 5/8)		
36 / 26				4.0/0.6			
34		SBTB9-64-26.5-102416			Wet, poor recovery	0	0*
28 / 32							
30		SBTB9-64-30.5-102416		4.0/3.0		0	0*
30 / 32					Silty CLAY (CL), dark grayish brown (10YR 4/2), soft to very soft, no to low plasticity, trace carbon staining Trace brown (7.5YR 4/4) mottling		
28		SBTB9-64-32.5-102416				0	0*
34 / 26					*TPH was not detected at or above the Practical Quantitation Limits for gasoline, diesel or motor oil carbon chain ranges SBTB9-64 was advanced within the HDPE-lined containment basin		
36 / 24							
38 / 22							

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DRILLING DATE: October 24, 2016
DEPTH TO GROUNDWATER: 26.8 ft
COMPLETION DEPTH: 34.0 ft
BACKFILLED WITH: Hydrated Bentonite Chips

DRILLING/SAMPLING METHOD: HSA/Direct Push
DRILLING COMPANY: Gregg Drilling
LOGGED BY: C. Swithenbank, M. McAlpin
CHECKED BY: A. Sellinger, P.G., C.Hg.

LOG OF SOIL BORING SBTB9-64

Guadalupe Restoration Project
Guadalupe, California

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December 2016
Project No. 1601-2193

padre associates, inc.
ENGINEERS, GEOLOGISTS & ENVIRONMENTAL SCIENTISTS

LOCATION: Tank Battery 9 (TB9) Area
SURFACE ELEVATION: 61.03 ft +/- (relative datum MSL)
NORTHING: 545899.046
EASTING: 1215111.365
COORDINATE SYSTEM: NAD27 Ca SP Zn 5, feet

ELEVATION, ft MSL / DEPTH, ft	USCS MATERIAL SYMBOL	SAMPLE ID	SAMPLE INTERVAL	RECOVERY (d/r), feet	MATERIAL DESCRIPTION	Gas Monitor: MultiRAE Lite (ppm)	TOTAL TPH (mg/Kg)
60 / 2				6.0/6.0	Poorly graded SAND (SP), very pale brown (10YR 7/4), fine grained, no odor, hand-augered from surface to 6 feet bgs		
					Dark yellowish brown (10YR 4/4)		
58 / 4					Yellowish brown (10YR 5/4), moist		
		SBTB9-65-5-102416					220
56		SBTB9-65-5.5-102416			Wet, slight odor HDPE liner Moderate odor		336
6				4.0/3.0	Continuous Direct Push sampling beginning at 6 feet bgs		
54 / 8					Very dark gray (10YR 3/1), wet, moderate odor		
					Yellowish brown (10YR 5/4), slight odor		
52 / 10		SBTB9-65-10-102416		4.0/2.0		0	0*
50 / 12							
48 / 14				4.0/3.0	Trace mafic minerals		
46 / 16							
44 / 18		SBTB9-65-18-102416		4.0/2.8	Light yellowish brown (10YR 6/4), moist, no odor	0	0*
42							

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DRILLING DATE: October 25, 2016
DEPTH TO GROUNDWATER: 27.8 ft
COMPLETION DEPTH: 34.0 ft
BACKFILLED WITH: Hydrated Bentonite Chips

DRILLING/SAMPLING METHOD: HSA/Direct Push
DRILLING COMPANY: Gregg Drilling
LOGGED BY: C. Swithenbank, M. McAlpin
CHECKED BY: A. Sellinger, P.G., C.Hg.

LOG OF SOIL BORING SBTB9-65

Guadalupe Restoration Project
Guadalupe, California

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December 2016
Project No. 1601-2193

padre associates, inc.
ENGINEERS, GEOLOGISTS & ENVIRONMENTAL SCIENTISTS

LOCATION: Tank Battery 9 (TB9) Area
SURFACE ELEVATION: 61.03 ft +/- (relative datum MSL)
NORTHING: 545899.046
EASTING: 1215111.365
COORDINATE SYSTEM: NAD27 Ca SP Zn 5, feet

ELEVATION, ft MSL / DEPTH, ft	USCS MATERIAL SYMBOL	SAMPLE ID	SAMPLE INTERVAL	RECOVERY (d/r), feet	MATERIAL DESCRIPTION	Gas Monitor: MultiRAE Lite (ppm)	TOTAL TPH (mg/Kg)
40 / 22				4.0/2.5	Brownish yellow (10YR 6/6)		
38 / 24							
36 / 26				4.0/2.3	Yellowish brown (10YR 5/6), frequent laminated gray (10YR 5/1)		
34 / 28		SBTB9-65-27.5-102416			Black (N 2.5/0), laminated gray (5Y 5/1)	0	0*
		SBTB9-65-28-102416				0	0*
32 / 30				4.0/3.0	Dark greenish gray (10Y 4/1), wet, trace mafic minerals		
30 / 32					Black (N 2.5/0) Clayey Sandy SILT (ML), brown (10YR 4/3), soft to stiff, wet, non-plastic micaceous, trace gray (10YR 5/1) mottling		
28 / 34		SBTB9-65-32.5-102516				0	0*
26 / 36					*TPH was not detected at or above the Practical Quantitation Limits for gasoline, diesel or motor oil carbon chain ranges		
24 / 38					SBTB9-65 was advanced within the HDPE-lined containment basin		
22							

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DRILLING DATE: October 25, 2016
DEPTH TO GROUNDWATER: 27.8 ft
COMPLETION DEPTH: 34.0 ft
BACKFILLED WITH: Hydrated Bentonite Chips

DRILLING/SAMPLING METHOD: HSA/Direct Push
DRILLING COMPANY: Gregg Drilling
LOGGED BY: C. Swithenbank, M. McAlpin
CHECKED BY: A. Sellinger, P.G., C.Hg.

LOG OF SOIL BORING SBTB9-65

Guadalupe Restoration Project
Guadalupe, California

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December 2016
Project No. 1601-2193

padre associates, inc.
ENGINEERS, GEOLOGISTS & ENVIRONMENTAL SCIENTISTS

LOCATION: Tank Battery 9 (TB9) Area
SURFACE ELEVATION: 61.59 ft +/- (relative datum MSL)
NORTHING: 545922.776
EASTING: 1215225.151
COORDINATE SYSTEM: NAD27 Ca SP Zn 5, feet

ELEVATION, ft MSL / DEPTH, ft	USCS MATERIAL SYMBOL	SAMPLE ID	SAMPLE INTERVAL	RECOVERY (d/r), feet	MATERIAL DESCRIPTION	Gas Monitor: MultiRAE Lite (ppm)	TOTAL TPH (mg/Kg)
60 / 2				6.0/6.0	Poorly graded SAND (SP), light yellowish brown (10YR 6/4), fine grained, no odor, hand-augered from surface to 6 feet bgs		
					Yellowish brown (10YR 5/6)		
58 / 4					Dark yellowish brown (10YR 4/6)		
					Dark yellowish brown (10YR 3/4), wet		
					Black (7.5YR 2.5/1), HDPE liner		
56 / 6					Very dark brown (7.5YR 2.5/2), moderate odor		
		SBTB9-66-6-102416		4.0/2.5	Continuous Direct Push sampling beginning at 6 feet bgs		1,310
		SBTB9-66-7-102516			Brown (10YR 5/3), wet, trace mafic minerals, slight odor	0	0*
54 / 8							
52 / 10				4.0/2.3	Very moist		
50 / 12							
48 / 14				4.0/2.8	No odor		
46 / 16							
44 / 18				4.0/3.0	Moist		
42							

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DRILLING DATE: October 25, 2016
DEPTH TO GROUNDWATER: 27.8 ft
COMPLETION DEPTH: 34.0 ft
BACKFILLED WITH: Hydrated Bentonite Chips

DRILLING/SAMPLING METHOD: HSA/Direct Push
DRILLING COMPANY: Gregg Drilling
LOGGED BY: C. Swithenbank, M. McAlpin
CHECKED BY: A. Sellinger, P.G., C.Hg.

LOG OF SOIL BORING SBTB9-66

Guadalupe Restoration Project
Guadalupe, California

The log and data presented are a simplification of actual conditions encountered at the time of drilling at the drilled location. Subsurface conditions may differ at other locations and with the passage of time. Please refer to Key to Boring Log for symbol explanation.

December 2016
Project No. 1601-2193

padre associates, inc.
ENGINEERS, GEOLOGISTS & ENVIRONMENTAL SCIENTISTS

LOCATION: Tank Battery 9 (TB9) Area
SURFACE ELEVATION: 61.59 ft +/- (relative datum MSL)
NORTHING: 545922.776
EASTING: 1215225.151
COORDINATE SYSTEM: NAD27 Ca SP Zn 5, feet

ELEVATION, ft MSL / DEPTH, ft	USCS MATERIAL SYMBOL	SAMPLE ID	SAMPLE INTERVAL	RECOVERY (d/r), feet	MATERIAL DESCRIPTION	Gas Monitor: MultiRAE Lite (ppm)	TOTAL TPH (mg/kg)
40 / 22				4.0/2.3	Fine to medium grained Fine grained Fine to medium grained, frequent laminated strong brown (7.5YR 4/6)		
38 / 24					Fine grained		
36 / 26				4.0/2.3	Strong brown (7.5YR 4/6) mottling Grayish brown (10YR 5/2)		
		SBTB9-66-27-102516			Pale brown (10YR 6/3)	0	0*
34 / 28		SBTB9-66-27.5-102516			Brown (10YR 5/3), wet	0	0*
32 / 30				4.0/2.5			
30 / 32		SBTB9-66-32-102516			Clayey Sandy SILT (ML), dark grayish brown (10YR 4/2), stiff, wet, very fine sand, non-plastic, micaceous, trace dark gray (10YR 4/1) mottling, trace carbon staining	0	0*
28 / 34							
26 / 36					*TPH was not detected at or above the Practical Quantitation Limits for gasoline, diesel or motor oil carbon chain ranges SBTB9-66 was advanced within the HDPE-lined containment basin		
24 / 38							
22							

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DRILLING DATE: October 25, 2016
DEPTH TO GROUNDWATER: 27.8 ft
COMPLETION DEPTH: 34.0 ft
BACKFILLED WITH: Hydrated Bentonite Chips

DRILLING/SAMPLING METHOD: HSA/Direct Push
DRILLING COMPANY: Gregg Drilling
LOGGED BY: C. Swithenbank, M. McAlpin
CHECKED BY: A. Sellinger, P.G., C.Hg.

LOG OF SOIL BORING SBTB9-66

Guadalupe Restoration Project
Guadalupe, California

The log and data presented are a simplification of actual conditions encountered at the time of drilling at the drilled location. Subsurface conditions may differ at other locations and with the passage of time. Please refer to Key to Boring Log for symbol explanation.

December 2016
Project No. 1601-2193

padre associates, inc.
ENGINEERS, GEOLOGISTS & ENVIRONMENTAL SCIENTISTS

LOCATION: Tank Battery 9 (TB9) Area
SURFACE ELEVATION: 61.27 ft +/- (relative datum MSL)
NORTHING: 545864.021
EASTING: 1214991.638
COORDINATE SYSTEM: NAD27 Ca SP Zn 5, feet

ELEVATION, ft MSL / DEPTH, ft	USCS MATERIAL SYMBOL	SAMPLE ID	SAMPLE INTERVAL	RECOVERY (d/r), feet	MATERIAL DESCRIPTION	Gas Monitor: MultiRAE Lite (ppm)	TOTAL TPH (mg/Kg)
60 / 2				8.0/8.0	Poorly graded SAND (SP), light yellowish brown (10YR 6/4), fine grained, no odor, hand-augered from surface to 8 feet bgs		
58 / 4					Yellowish brown (10YR 5/6)		
		SBTB9-67-4.5-102416			HDPE liner Dark yellowish brown (10YR 3/4), wet Dark yellowish brown (10YR 3/6), moist, moderate odor		1,490
56 / 6							
54 / 8					Yellowish brown (10YR 5/8) Continuous Direct Push sampling beginning at 8 feet bgs		
		SBTB9-67-8-102516		4.0/2.8	Brown (10YR 5/3), slight odor	0	150
52 / 10							
50 / 12				4.0/3.0	No odor		
48 / 14					Laminated trace mafic minerals		
46 / 16				4.0/2.3	Yellowish brown (10YR 5/4), frequent laminated trace mafic minerals		
44 / 18							
42							

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DRILLING DATE: October 25, 2016
DEPTH TO GROUNDWATER: 28.5 ft
COMPLETION DEPTH: 32.0 ft
BACKFILLED WITH: Hydrated Bentonite Chips

DRILLING/SAMPLING METHOD: HSA/Direct Push
DRILLING COMPANY: Gregg Drilling
LOGGED BY: C. Swithenbank, M. McAlpin
CHECKED BY: A. Sellinger, P.G., C.Hg.

LOG OF SOIL BORING SBTB9-67

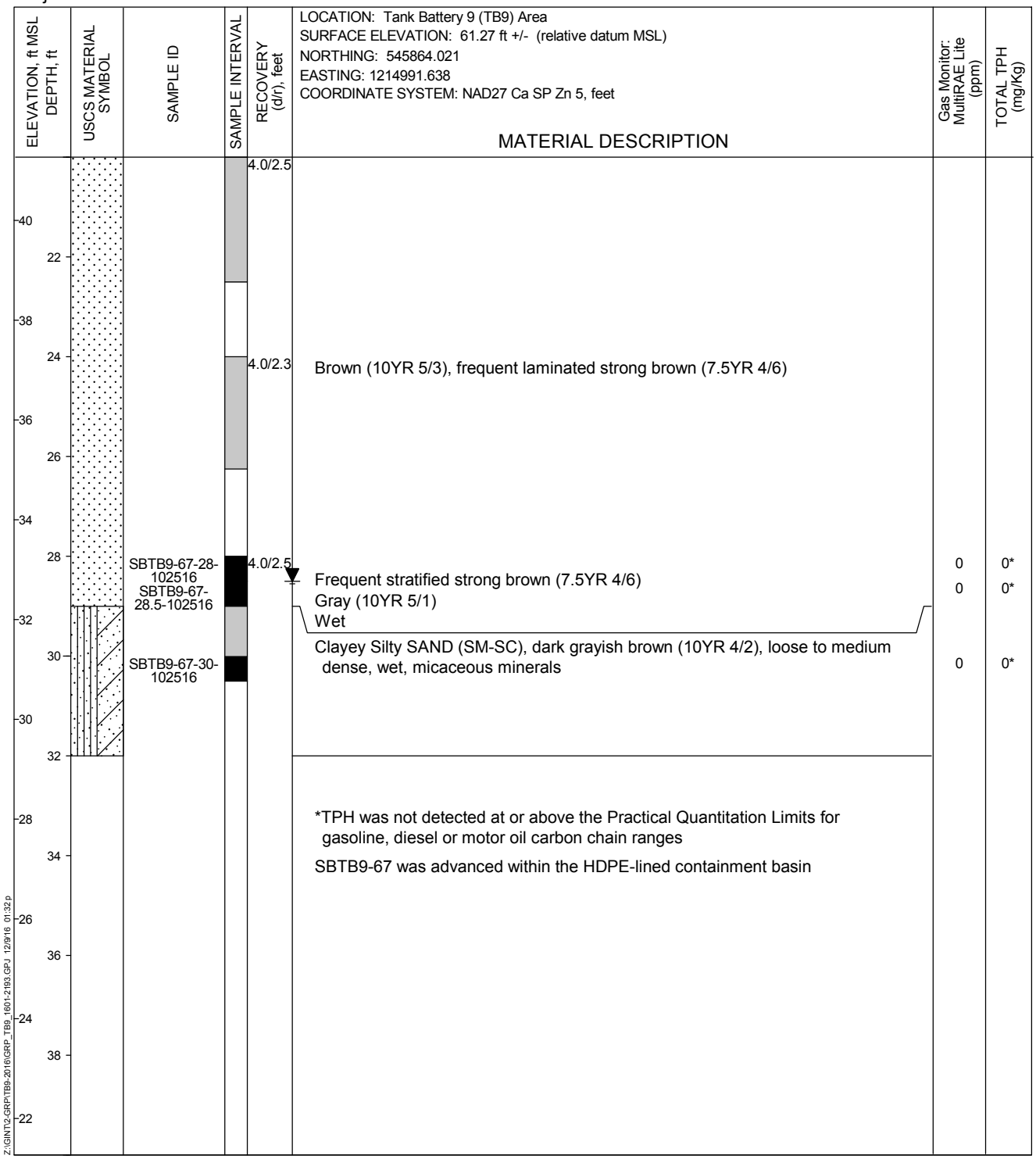
Guadalupe Restoration Project
Guadalupe, California

The log and data presented are a simplification of actual conditions encountered at the time of drilling at the drilled location. Subsurface conditions may differ at other locations and with the passage of time. Please refer to Key to Boring Log for symbol explanation.

December 2016
Project No. 1601-2193

padre associates, inc.
ENGINEERS, GEOLOGISTS & ENVIRONMENTAL SCIENTISTS

LOCATION: Tank Battery 9 (TB9) Area
SURFACE ELEVATION: 61.27 ft +/- (relative datum MSL)
NORTHING: 545864.021
EASTING: 1214991.638
COORDINATE SYSTEM: NAD27 Ca SP Zn 5, feet



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DRILLING DATE: October 25, 2016
DEPTH TO GROUNDWATER: 28.5 ft
COMPLETION DEPTH: 32.0 ft
BACKFILLED WITH: Hydrated Bentonite Chips

DRILLING/SAMPLING METHOD: HSA/Direct Push
DRILLING COMPANY: Gregg Drilling
LOGGED BY: C. Swithenbank, M. McAlpin
CHECKED BY: A. Sellinger, P.G., C.Hg.

LOG OF SOIL BORING SBTB9-67

Guadalupe Restoration Project
Guadalupe, California

The log and data presented are a simplification of actual conditions encountered at the time of drilling at the drilled location. Subsurface conditions may differ at other locations and with the passage of time. Please refer to Key to Boring Log for symbol explanation.

December 2016
Project No. 1601-2193

padre associates, inc.
ENGINEERS, GEOLOGISTS & ENVIRONMENTAL SCIENTISTS

LOCATION: Tank Battery 9 (TB9) Area
SURFACE ELEVATION: 65.98 ft +/- (relative datum MSL)
NORTHING: 545927.155
EASTING: 1214852.936
COORDINATE SYSTEM: NAD27 Ca SP Zn 5, feet

ELEVATION, ft MSL / DEPTH, ft	USCS MATERIAL SYMBOL	SAMPLE ID	SAMPLE INTERVAL	RECOVERY (d/r), feet	MATERIAL DESCRIPTION	Gas Monitor: MultiRAE Lite (ppm)	TOTAL TPH (mg/Kg)
				8.0/8.0	Poorly graded SAND (SP), light yellowish brown (10YR 6/4), fine grained, no odor, hand-augered from surface to 8 feet bgs		
64 2					Dark yellowish brown (10YR 4/4)		
					Dark yellowish brown (10YR 3/4)		
					Very dark brown (10YR 2/2), slight odor		
62 4					Trace redrock		
60 6					Redrock, some roots		
					Light yellowish brown (10YR 6/4), trace redrock, fine gravel sized, no odor		
58 8		SBTB9-68-8-102516		4.0/2.0	Continuous Direct Push sampling beginning at 8 feet bgs Yellowish brown (10YR 5/4), moist, fine grained	0	0*
56 10							
54 12				4.0/2.5			
52 14							
50 16				4.0/2.8			
48 18					Brown (10YR 5/3)		

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DRILLING DATE: October 26, 2016
DEPTH TO GROUNDWATER: 34.0 ft
COMPLETION DEPTH: 40.0 ft
BACKFILLED WITH: Hydrated Bentonite Chips

DRILLING/SAMPLING METHOD: HSA/Direct Push
DRILLING COMPANY: Gregg Drilling
LOGGED BY: C. Swithenbank, M. McAlpin
CHECKED BY: A. Sellinger, P.G., C.Hg.

LOG OF SOIL BORING SBTB9-68

Guadalupe Restoration Project
Guadalupe, California

The log and data presented are a simplification of actual conditions encountered at the time of drilling at the drilled location. Subsurface conditions may differ at other locations and with the passage of time. Please refer to Key to Boring Log for symbol explanation.

December 2016
Project No. 1601-2193

padre associates, inc.
ENGINEERS, GEOLOGISTS & ENVIRONMENTAL SCIENTISTS

LOCATION: Tank Battery 9 (TB9) Area
SURFACE ELEVATION: 65.98 ft +/- (relative datum MSL)
NORTHING: 545927.155
EASTING: 1214852.936
COORDINATE SYSTEM: NAD27 Ca SP Zn 5, feet

ELEVATION, ft MSL	DEPTH, ft	USCS MATERIAL SYMBOL	SAMPLE ID	SAMPLE INTERVAL	RECOVERY (d/r), feet	MATERIAL DESCRIPTION	Gas Monitor: MultiRAE Lite (ppm)	TOTAL TPH (mg/Kg)
					4.0/2.5	Frequent striated trace mafic minerals, trace pockets of strong brown (7.5YR 4/6)		
-44	22							
-42	24				4.0/2.3	Yellowish brown (10YR 5/6)		
-40	26							
-38	28				4.0/2.8			
-36	30					Laminated dark yellowish brown (10YR 4/4)		
-34	32				4.0/2.8			
						Strong brown (7.5YR 5/6)		
-32	34		SBTB9-68-33.5-102616			Light yellowish brown (10YR 6/4)	0	0*
			SBTB9-68-34-102616			Yellowish brown (10YR 5/4), wet, frequent laminated strong brown (7.5YR 5/6)	0	0*
						Gray (10YR 5/1)		
-30	36				4.0/3.2	Sandy Clayey SILT (ML), brown (10YR 4/3), soft, wet		
						Silty CLAY (CL), soft to stiff, trace carbon staining		
-28	38					Clayey Silt (ML), soft		
						Brown (10YR 5/3)		
			SBTB9-68-39-102616			*TPH was not detected at or above the Practical Quantitation Limits for gasoline, diesel or motor oil carbon chain ranges	0	0*

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DRILLING DATE: October 26, 2016
DEPTH TO GROUNDWATER: 34.0 ft
COMPLETION DEPTH: 40.0 ft
BACKFILLED WITH: Hydrated Bentonite Chips

DRILLING/SAMPLING METHOD: HSA/Direct Push
DRILLING COMPANY: Gregg Drilling
LOGGED BY: C. Swithenbank, M. McAlpin
CHECKED BY: A. Sellinger, P.G., C.Hg.

LOG OF SOIL BORING SBTB9-68

Guadalupe Restoration Project
Guadalupe, California

The log and data presented are a simplification of actual conditions encountered at the time of drilling at the drilled location. Subsurface conditions may differ at other locations and with the passage of time. Please refer to Key to Boring Log for symbol explanation.

December 2016
Project No. 1601-2193

padre associates, inc.
ENGINEERS, GEOLOGISTS & ENVIRONMENTAL SCIENTISTS

LOCATION: Tank Battery 9 (TB9) Area
SURFACE ELEVATION: 75.31 ft +/- (relative datum MSL)
NORTHING: 546078.383
EASTING: 1214567.093
COORDINATE SYSTEM: NAD27 Ca SP Zn 5, feet

ELEVATION, ft MSL / DEPTH, ft	USCS MATERIAL SYMBOL	SAMPLE ID	SAMPLE INTERVAL	RECOVERY (d/r), feet	MATERIAL DESCRIPTION	Gas Monitor: MultiRAE Lite (ppm)	TOTAL TPH (mg/Kg)
74 / 2				8.0/8.0	Poorly graded SAND (SP), light yellowish brown (10YR 6/4), fine grained, no odor, hand-augered from surface to 8 feet bgs		
					Dark yellowish brown (10YR 4/4)		
		SBTB9-69-2.5-102616			Black (10YR 2/1), trace sump material, moderate odor		
72 / 4		SBTB9-69-3-102616			Dark yellowish brown (10YR 4/4), no odor		100
							860
70 / 6		SBTB9-69-6-102616			Trace sump material		720
		SBTB9-69-7-102616					1,400
68 / 8					Dark yellowish brown (10YR 4/6), medium dense, moist Continuous Direct Push sampling beginning at 8 feet bgs		
				4.0/2.5	Light yellowish brown (10YR 6/4), frequent laminated trace mafic minerals		
66 / 10							
64 / 12				4.0/2.8			
62 / 14					Trace laminated mafic minerals		
60 / 16				4.0/2.8	Yellowish brown (10YR 5/4)		
58 / 18					Fine to medium grained		
					Fine grained		
56							

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DRILLING DATE: October 26, 2016
DEPTH TO GROUNDWATER: 43.5 ft
COMPLETION DEPTH: 48.0 ft
BACKFILLED WITH: Hydrated Bentonite Chips

DRILLING/SAMPLING METHOD: HSA/Direct Push
DRILLING COMPANY: Gregg Drilling
LOGGED BY: C. Swithenbank, M. McAlpin
CHECKED BY: A. Sellinger, P.G., C.Hg.

LOG OF SOIL BORING SBTB9-69

Guadalupe Restoration Project
Guadalupe, California

The log and data presented are a simplification of actual conditions encountered at the time of drilling at the drilled location. Subsurface conditions may differ at other locations and with the passage of time. Please refer to Key to Boring Log for symbol explanation.

December 2016
Project No. 1601-2193

padre associates, inc.
ENGINEERS, GEOLOGISTS & ENVIRONMENTAL SCIENTISTS

LOCATION: Tank Battery 9 (TB9) Area
SURFACE ELEVATION: 75.31 ft +/- (relative datum MSL)
NORTHING: 546078.383
EASTING: 1214567.093
COORDINATE SYSTEM: NAD27 Ca SP Zn 5, feet

ELEVATION, ft MSL / DEPTH, ft	USCS MATERIAL SYMBOL	SAMPLE ID	SAMPLE INTERVAL	RECOVERY (d/r), feet	MATERIAL DESCRIPTION	Gas Monitor: MultiRAE Lite (ppm)	TOTAL TPH (mg/Kg)
-54 / 22				4.0/2.5	Brown (10YR 4/3) Yellowish brown (10YR 5/4)		
-52 / 24				4.0/3.0			
-50 / 26							
-48 / 28				4.0/3.0			
-46 / 30							
-44 / 32				4.0/3.0	Trace mafic minerals		
-42 / 34					Dark yellowish brown (10YR 4/4)		
-40 / 36				4.0/3.0			
-38 / 38					Frequent laminated mafic minerals		
-36							

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DRILLING DATE: October 26, 2016
DEPTH TO GROUNDWATER: 43.5 ft
COMPLETION DEPTH: 48.0 ft
BACKFILLED WITH: Hydrated Bentonite Chips

DRILLING/SAMPLING METHOD: HSA/Direct Push
DRILLING COMPANY: Gregg Drilling
LOGGED BY: C. Swithenbank, M. McAlpin
CHECKED BY: A. Sellinger, P.G., C.Hg.

LOG OF SOIL BORING SBTB9-69

Guadalupe Restoration Project
Guadalupe, California

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December 2016
Project No. 1601-2193

padre associates, inc.
ENGINEERS, GEOLOGISTS & ENVIRONMENTAL SCIENTISTS

LOCATION: Tank Battery 9 (TB9) Area
SURFACE ELEVATION: 75.31 ft +/- (relative datum MSL)
NORTHING: 546078.383
EASTING: 1214567.093
COORDINATE SYSTEM: NAD27 Ca SP Zn 5, feet

ELEVATION, ft MSL / DEPTH, ft	USCS MATERIAL SYMBOL	SAMPLE ID	SAMPLE INTERVAL	RECOVERY (d/r), feet	MATERIAL DESCRIPTION	Gas Monitor: MultiRAE Lite (ppm)	TOTAL TPH (mg/Kg)
34 / 42				4.0/3.0	Dark yellowish brown (10YR 4/4), frequent laminated trace mafic minerals and yellowish brown (10YR 5/8)		
					Brown (10YR 5/3), trace mafic minerals		
		SBTB9-69-42.5-102616			Dark yellowish brown (10YR 4/4) Yellowish brown (10YR 5/6), frequent laminated strong brown (7.5YR 4/6)	0	0*
32 / 44		SBTB9-69-44-102616		4.0/3.0	Sandy SILT (ML), brown (10YR 4/3), wet, very fine grained sand	0	0*
30 / 46					Clayey Sandy SILT (ML), soft, non-plastic, micaceous, trace gray (10YR 5/1) and strong brown (7.5YR 4/6) mottling		
		SBTB9-69-46.5-102616				0	0*
28 / 48							
26 / 50					*TPH was not detected at or above the Practical Quantitation Limits for gasoline, diesel or motor oil carbon chain ranges		
24 / 52							
22 / 54							
20 / 56							
18 / 58							
16							

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DRILLING DATE: October 26, 2016
DEPTH TO GROUNDWATER: 43.5 ft
COMPLETION DEPTH: 48.0 ft
BACKFILLED WITH: Hydrated Bentonite Chips

DRILLING/SAMPLING METHOD: HSA/Direct Push
DRILLING COMPANY: Gregg Drilling
LOGGED BY: C. Swithenbank, M. McAlpin
CHECKED BY: A. Sellinger, P.G., C.Hg.

LOG OF SOIL BORING SBTB9-69

Guadalupe Restoration Project
Guadalupe, California

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December 2016
Project No. 1601-2193

padre associates, inc.
ENGINEERS, GEOLOGISTS & ENVIRONMENTAL SCIENTISTS

LOCATION: Tank Battery 9 (TB9) Area
SURFACE ELEVATION: 83.71 ft +/- (relative datum MSL)
NORTHING: 546168.042
EASTING: 1214418.227
COORDINATE SYSTEM: NAD27 Ca SP Zn 5, feet

ELEVATION, ft MSL / DEPTH, ft	USCS MATERIAL SYMBOL	SAMPLE ID	SAMPLE INTERVAL	RECOVERY (d/r), feet	MATERIAL DESCRIPTION	Gas Monitor: MultiRAE Lite (ppm)	TOTAL TPH (mg/Kg)
82 / 2				8.0/8.0	Poorly graded SAND (SP), light yellowish brown (10YR 6/4), fine grained, no odor, hand-augered from surface to 8 feet bgs		
					Dark yellowish brown (10YR 4/4)		
80 / 4					Yellowish brown (10YR 5/8), moist		
78 / 6							
76 / 8					Continuous Direct Push sampling beginning at 8 feet bgs		
				4.0/4.0	Yellowish brown (10YR 5/6), loose, slightly moist, fine grained, no odor		
74 / 10					Dark yellowish brown (10YR 4/6), 1-inch thick layer		
72 / 12					Silty SAND (SM), dark yellowish brown (10YR 4/4), very loose, dry, fine grained		
				4.0/3.0	Poorly graded SAND (SP), yellowish brown (10YR 5/8), loose, slightly moist, fine grained		
70 / 14					Yellowish brown (10YR 5/6), medium grained		
					Yellowish brown (10YR 5/8), very fine to fine grained		
68 / 16				4.0/4.0			
					Dark yellowish brown (10YR 4/4), medium dense		
66 / 18					Yellowish brown (10YR 6/6)		
64							

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DRILLING DATE: October 27, 2016
DEPTH TO GROUNDWATER: 53.0 ft
COMPLETION DEPTH: 56.0 ft
BACKFILLED WITH: Hydrated Bentonite Chips

DRILLING/SAMPLING METHOD: HSA/Direct Push
DRILLING COMPANY: Gregg Drilling
LOGGED BY: C. Swithenbank, S. McAlpin, M. McAlpin
CHECKED BY: A. Sellinger, P.G., C.Hg.

LOG OF SOIL BORING SBTB9-70

Guadalupe Restoration Project
Guadalupe, California

The log and data presented are a simplification of actual conditions encountered at the time of drilling at the drilled location. Subsurface conditions may differ at other locations and with the passage of time. Please refer to Key to Boring Log for symbol explanation.

December 2016
Project No. 1601-2193

padre associates, inc.
ENGINEERS, GEOLOGISTS & ENVIRONMENTAL SCIENTISTS

LOCATION: Tank Battery 9 (TB9) Area
SURFACE ELEVATION: 83.71 ft +/- (relative datum MSL)
NORTHING: 546168.042
EASTING: 1214418.227
COORDINATE SYSTEM: NAD27 Ca SP Zn 5, feet

ELEVATION, ft MSL / DEPTH, ft	USCS MATERIAL SYMBOL	SAMPLE ID	SAMPLE INTERVAL	RECOVERY (d/r), feet	MATERIAL DESCRIPTION	Gas Monitor: MultiRAE Lite (ppm)	TOTAL TPH (mg/Kg)
62 / 22				4.0/3.5	Dark brown (10YR 3/3), 1/2-inch thick lens of silty sand, slightly moist Brownish yellow (10YR 6/6)		
60 / 24				4.0/3.0			
58 / 26					Strong brown (7.5YR 4/6), 1-inch thick layer		
56 / 28				4.0/3.0	Brownish yellow (10YR 6/6), loose, fine to medium grained		
54 / 30							
52 / 32				4.0/3.0			
50 / 34					Medium grained Dark yellowish brown (10YR 4/4), very fine to fine grained		
48 / 36				4.0/4.0			
46 / 38							
44						0	

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DRILLING DATE: October 27, 2016
DEPTH TO GROUNDWATER: 53.0 ft
COMPLETION DEPTH: 56.0 ft
BACKFILLED WITH: Hydrated Bentonite Chips

DRILLING/SAMPLING METHOD: HSA/Direct Push
DRILLING COMPANY: Gregg Drilling
LOGGED BY: C. Swithenbank, S. McAlpin, M. McAlpin
CHECKED BY: A. Sellinger, P.G., C.Hg.

LOG OF SOIL BORING SBTB9-70

Guadalupe Restoration Project
Guadalupe, California

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December 2016
Project No. 1601-2193

padre associates, inc.
ENGINEERS, GEOLOGISTS & ENVIRONMENTAL SCIENTISTS

LOCATION: Tank Battery 9 (TB9) Area
SURFACE ELEVATION: 83.71 ft +/- (relative datum MSL)
NORTHING: 546168.042
EASTING: 1214418.227
COORDINATE SYSTEM: NAD27 Ca SP Zn 5, feet

ELEVATION, ft MSL / DEPTH, ft	USCS MATERIAL SYMBOL	SAMPLE ID	SAMPLE INTERVAL	RECOVERY (d/r), feet	MATERIAL DESCRIPTION	Gas Monitor: MultiRAE Lite (ppm)	TOTAL TPH (mg/Kg)
42 / 42				4.0/3.0	Stopped drilling at 40 feet bgs on 10/26/2016, continued on 10/27/2016 Yellowish brown (10YR 5/4), frequent laminated trace mafic minerals		
40 / 44				4.0/3.0			
38 / 46							
36 / 48				4.0/3.5	Trace laminated mafic minerals, strong brown (7.5YR 5/6) mottling		
34 / 50							
32 / 52				4.0/4.0	Strong brown (7.5YR 5/6) Yellowish brown (10YR 5/4), frequent laminated strong brown (7.5YR 5/6)	0	0*
		SBTB9-70-52.5-102716			Dark gray (10YR 4/1)	0	0*
30 / 54		SBTB9-70-53-102716			Silty SAND (SM), wet, very fine sand with silt		
28 / 56		SBTB9-70-55.5-102716			Clayey Sandy SILT (ML), brown (10YR 4/3), stiff, wet, micaceous	0	0*
26 / 58					*TPH was not detected at or above the Practical Quantitation Limits for gasoline, diesel or motor oil carbon chain ranges		
24							

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DRILLING DATE: October 27, 2016
DEPTH TO GROUNDWATER: 53.0 ft
COMPLETION DEPTH: 56.0 ft
BACKFILLED WITH: Hydrated Bentonite Chips

DRILLING/SAMPLING METHOD: HSA/Direct Push
DRILLING COMPANY: Gregg Drilling
LOGGED BY: C. Swithenbank, S. McAlpin, M. McAlpin
CHECKED BY: A. Sellinger, P.G., C.Hg.

LOG OF SOIL BORING SBTB9-70

Guadalupe Restoration Project
Guadalupe, California

The log and data presented are a simplification of actual conditions encountered at the time of drilling at the drilled location. Subsurface conditions may differ at other locations and with the passage of time. Please refer to Key to Boring Log for symbol explanation.

December 2016
Project No. 1601-2193

padre associates, inc.
ENGINEERS, GEOLOGISTS & ENVIRONMENTAL SCIENTISTS

LOCATION: Tank Battery 9 (TB9) Area
SURFACE ELEVATION: 85.57 ft +/- (relative datum MSL)
NORTHING: 546403.110
EASTING: 1214032.259
COORDINATE SYSTEM: NAD27 Ca SP Zn 5, feet

ELEVATION, ft MSL / DEPTH, ft	USCS MATERIAL SYMBOL	SAMPLE ID	SAMPLE INTERVAL	RECOVERY (d/r), feet	MATERIAL DESCRIPTION	Gas Monitor: MultiRAE Lite (ppm)	TOTAL TPH (mg/Kg)
84 / 2	SP	SBTB9-71-0.5-102616		8.0/8.0	Poorly graded SAND (SP), light yellowish brown (10YR 6/4), fine grained, no odor, hand-augered from surface to 8 feet bgs		20,906
					Black (10YR 2/1), moderate to strong odor		
		SBTB9-71-2.5-102616					28,001
82 / 4					Light yellowish brown (10YR 6/4), fine grained, no odor		
80 / 6					Moist		
78 / 8					Continuous Direct Push sampling beginning at 8 feet bgs		
				4.0/2.3	Moist, frequent laminated medium grained sand and trace mafic minerals		
76 / 10							
74 / 12				4.0/2.5			
72 / 14							
70 / 16				4.0/2.5	Frequent striated medium grained sand and trace mafic minerals		
68 / 18							
66							

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DRILLING DATE: October 27, 2016
DEPTH TO GROUNDWATER: 56.5 ft
COMPLETION DEPTH: 60.0 ft
BACKFILLED WITH: Hydrated Bentonite Chips

DRILLING/SAMPLING METHOD: HSA/Direct Push
DRILLING COMPANY: Gregg Drilling
LOGGED BY: C. Swithenbank, M. McAlpin
CHECKED BY: A. Sellinger, P.G., C.Hg.

LOG OF SOIL BORING SBTB9-71

Guadalupe Restoration Project
Guadalupe, California

The log and data presented are a simplification of actual conditions encountered at the time of drilling at the drilled location. Subsurface conditions may differ at other locations and with the passage of time. Please refer to Key to Boring Log for symbol explanation.

December 2016
Project No. 1601-2193

padre associates, inc.
ENGINEERS, GEOLOGISTS & ENVIRONMENTAL SCIENTISTS

ELEVATION, ft MSL / DEPTH, ft	USCS MATERIAL SYMBOL	SAMPLE ID	SAMPLE INTERVAL	RECOVERY (d/r), feet	MATERIAL DESCRIPTION	Gas Monitor: MultiRAE Lite (ppm)	TOTAL TPH (mg/Kg)
					LOCATION: Tank Battery 9 (TB9) Area SURFACE ELEVATION: 85.57 ft +/- (relative datum MSL) NORTHING: 546403.110 EASTING: 1214032.259 COORDINATE SYSTEM: NAD27 Ca SP Zn 5, feet		
64 / 22				4.0/3.0	Fine grained		
62 / 24				4.0/2.8	Occasional laminated yellowish brown (10YR 5/8) and trace mafic minerals		
60 / 26							
58 / 28				4.0/3.0	Frequent laminated trace mafic minerals		
56 / 30							
54 / 32				4.0/2.8			
52 / 34					Frequent laminated trace mafic minerals		
50 / 36				4.0/3.0	Frequent laminated medium grained sand and trace mafic minerals		
48 / 38							
46							

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DRILLING DATE: October 27, 2016
DEPTH TO GROUNDWATER: 56.5 ft
COMPLETION DEPTH: 60.0 ft
BACKFILLED WITH: Hydrated Bentonite Chips

DRILLING/SAMPLING METHOD: HSA/Direct Push
DRILLING COMPANY: Gregg Drilling
LOGGED BY: C. Swithenbank, M. McAlpin
CHECKED BY: A. Sellinger, P.G., C.Hg.

LOG OF SOIL BORING SBTB9-71

Guadalupe Restoration Project
Guadalupe, California

The log and data presented are a simplification of actual conditions encountered at the time of drilling at the drilled location. Subsurface conditions may differ at other locations and with the passage of time. Please refer to Key to Boring Log for symbol explanation.

December 2016
Project No. 1601-2193

padre associates, inc.
ENGINEERS, GEOLOGISTS & ENVIRONMENTAL SCIENTISTS

LOCATION: Tank Battery 9 (TB9) Area
SURFACE ELEVATION: 85.57 ft +/- (relative datum MSL)
NORTHING: 546403.110
EASTING: 1214032.259
COORDINATE SYSTEM: NAD27 Ca SP Zn 5, feet

ELEVATION, ft MSL / DEPTH, ft	USCS MATERIAL SYMBOL	SAMPLE ID	SAMPLE INTERVAL	RECOVERY (d/r), feet	MATERIAL DESCRIPTION	Gas Monitor: MultiRAE Lite (ppm)	TOTAL TPH (mg/Kg)
44 / 42				4.0/2.5	Yellowish brown (10YR 5/4)		
42 / 44				4.0/2.8	Frequent laminated medium grained sand		
40 / 46							
38 / 48				4.0/2.8			
36 / 50							
34 / 52				4.0/2.5			
32 / 54		SBTB9-71-53-102716			Dark grayish brown (10YR 4/2), moderate odor Dark greenish gray (10Y 4/1)	10.8	30,002
30 / 56		SBTB9-71-56-102716 SBTB9-71-56.5-102716		4.0/2.8	Black (N 2.5/0), strong odor Wet	12.8 325	12,620 44,240
28 / 58		SBTB9-71-58.5-102716			Clayey Sandy SILT (ML), stiff, wet, non-plastic, micaceous, no odor, trace carbon staining *TPH was not detected at or above the Practical Quantitation Limits for gasoline, diesel or motor oil carbon chain ranges	11.3	0*
26							

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DRILLING DATE: October 27, 2016
DEPTH TO GROUNDWATER: 56.5 ft
COMPLETION DEPTH: 60.0 ft
BACKFILLED WITH: Hydrated Bentonite Chips

DRILLING/SAMPLING METHOD: HSA/Direct Push
DRILLING COMPANY: Gregg Drilling
LOGGED BY: C. Swithenbank, M. McAlpin
CHECKED BY: A. Sellinger, P.G., C.Hg.

LOG OF SOIL BORING SBTB9-71

Guadalupe Restoration Project
Guadalupe, California

The log and data presented are a simplification of actual conditions encountered at the time of drilling at the drilled location. Subsurface conditions may differ at other locations and with the passage of time. Please refer to Key to Boring Log for symbol explanation.

December 2016
Project No. 1601-2193

padre associates, inc.
ENGINEERS, GEOLOGISTS & ENVIRONMENTAL SCIENTISTS

LOCATION: Tank Battery 9 (TB9) Area
SURFACE ELEVATION: 101.54 ft +/- (relative datum MSL)
NORTHING: 546557.620
EASTING: 1213958.532
COORDINATE SYSTEM: NAD27 Ca SP Zn 5, feet

ELEVATION, ft MSL / DEPTH, ft	USCS MATERIAL SYMBOL	SAMPLE ID	SAMPLE INTERVAL	RECOVERY (d/r), feet	MATERIAL DESCRIPTION	Gas Monitor: MultiRAE Lite (ppm)	TOTAL TPH (mg/Kg)
100 / 2				8.0/8.0	Asphalt, dark brown (10YR 3/3), fine grained sand with asphalt, no odor, hand-augered from surface to 8 feet bgs		
					Poorly graded SAND (SP), dark yellowish brown (10YR 3/4), fine grained, no odor		
98 / 4					Brownish yellow (10YR 6/6)		
96 / 6							
94 / 8					Continuous Direct Push sampling beginning at 8 feet bgs		
92 / 10				4.0/2.8	Yellowish brown (10YR 5/4), moist, fine grained, frequent laminated mafic minerals and yellowish brown (10YR 5/8)		
90 / 12				4.0/3.0			
88 / 14							
86 / 16				4.0/2.5			
84 / 18							
82							

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DRILLING DATE: October 31, 2016
DEPTH TO GROUNDWATER: 72.0 ft
COMPLETION DEPTH: 76.0 ft
BACKFILLED WITH: Hydrated Bentonite Chips

DRILLING/SAMPLING METHOD: HSA/Direct Push
DRILLING COMPANY: Gregg Drilling
LOGGED BY: C. Swithenbank, M. McAlpin
CHECKED BY: A. Sellinger, P.G., C.Hg.

LOG OF SOIL BORING SBTB9-72

Guadalupe Restoration Project
Guadalupe, California

The log and data presented are a simplification of actual conditions encountered at the time of drilling at the drilled location. Subsurface conditions may differ at other locations and with the passage of time. Please refer to Key to Boring Log for symbol explanation.

December 2016
Project No. 1601-2193

padre associates, inc.
ENGINEERS, GEOLOGISTS & ENVIRONMENTAL SCIENTISTS

LOCATION: Tank Battery 9 (TB9) Area
SURFACE ELEVATION: 101.54 ft +/- (relative datum MSL)
NORTHING: 546557.620
EASTING: 1213958.532
COORDINATE SYSTEM: NAD27 Ca SP Zn 5, feet

ELEVATION, ft MSL / DEPTH, ft	USCS MATERIAL SYMBOL	SAMPLE ID	SAMPLE INTERVAL	RECOVERY (d/r), feet	MATERIAL DESCRIPTION	Gas Monitor: MultiRAE Lite (ppm)	TOTAL TPH (mg/Kg)
-80 / 22				4.0/2.8			
-78 / 24				4.0/3.0	1-inch thick layer of medium grained sand		
-76 / 26							
-74 / 28				4.0/3.8			
-72 / 30							
-70 / 32				4.0/3.8			
-68 / 34							
-66 / 36				4.0/3.5			
-64 / 38					Frequent laminated trace mafic minerals		
-62							

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DRILLING DATE: October 31, 2016
DEPTH TO GROUNDWATER: 72.0 ft
COMPLETION DEPTH: 76.0 ft
BACKFILLED WITH: Hydrated Bentonite Chips

DRILLING/SAMPLING METHOD: HSA/Direct Push
DRILLING COMPANY: Gregg Drilling
LOGGED BY: C. Swithenbank, M. McAlpin
CHECKED BY: A. Sellinger, P.G., C.Hg.

LOG OF SOIL BORING SBTB9-72

Guadalupe Restoration Project
Guadalupe, California

The log and data presented are a simplification of actual conditions encountered at the time of drilling at the drilled location. Subsurface conditions may differ at other locations and with the passage of time. Please refer to Key to Boring Log for symbol explanation.

December 2016
Project No. 1601-2193

padre associates, inc.
ENGINEERS, GEOLOGISTS & ENVIRONMENTAL SCIENTISTS

LOCATION: Tank Battery 9 (TB9) Area
SURFACE ELEVATION: 101.54 ft +/- (relative datum MSL)
NORTHING: 546557.620
EASTING: 1213958.532
COORDINATE SYSTEM: NAD27 Ca SP Zn 5, feet

ELEVATION, ft MSL / DEPTH, ft	USCS MATERIAL SYMBOL	SAMPLE ID	SAMPLE INTERVAL	RECOVERY (d/r), feet	MATERIAL DESCRIPTION	Gas Monitor: MultiRAE Lite (ppm)	TOTAL TPH (mg/Kg)
60 / 42				4.0/3.0			
58 / 44				4.0/3.0	Occasional striated medium grained sand		
56 / 46							
54 / 48				4.0/3.0	Frequent laminated medium grained sand		
52 / 50							
50 / 52				4.0/2.5			
48 / 54							
46 / 56				4.0/3.0			
44 / 58							
42							

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DRILLING DATE: October 31, 2016
DEPTH TO GROUNDWATER: 72.0 ft
COMPLETION DEPTH: 76.0 ft
BACKFILLED WITH: Hydrated Bentonite Chips

DRILLING/SAMPLING METHOD: HSA/Direct Push
DRILLING COMPANY: Gregg Drilling
LOGGED BY: C. Swithenbank, M. McAlpin
CHECKED BY: A. Sellinger, P.G., C.Hg.

LOG OF SOIL BORING SBTB9-72

Guadalupe Restoration Project
Guadalupe, California

The log and data presented are a simplification of actual conditions encountered at the time of drilling at the drilled location. Subsurface conditions may differ at other locations and with the passage of time. Please refer to Key to Boring Log for symbol explanation.

December 2016
Project No. 1601-2193

padre associates, inc.
ENGINEERS, GEOLOGISTS & ENVIRONMENTAL SCIENTISTS

LOCATION: Tank Battery 9 (TB9) Area
SURFACE ELEVATION: 101.54 ft +/- (relative datum MSL)
NORTHING: 546557.620
EASTING: 1213958.532
COORDINATE SYSTEM: NAD27 Ca SP Zn 5, feet

ELEVATION, ft MSL / DEPTH, ft	USCS MATERIAL SYMBOL	SAMPLE ID	SAMPLE INTERVAL	RECOVERY (d/r), feet	MATERIAL DESCRIPTION	Gas Monitor: MultiRAE Lite (ppm)	TOTAL TPH (mg/Kg)
62 / 40				4.0/3.0			
64 / 38				4.0/3.0			
66 / 36							
68 / 34				4.0/3.0			
70 / 32		SBTB9-72-69-103116			Strong brown (7.5YR 5/8) mottling Brown (10YR 4/3), sheen on sand grains, moderate odor	1	12,300
72 / 30		SBTB9-72-70.5-103116			Dark gray (10YR 4/1)	4	14,110
74 / 28		SBTB9-72-72-103116		4.0/3.0	Very dark gray (10YR 3/1), wet, moderate odor Dark greenish gray (10Y 4/1), slight odor	55	83,320
76 / 26		SBTB9-72-74.5-103116			Clayey SILT (ML), dark gray (10YR 4/1), stiff, non-plastic, micaceous, trace yellowish brown (10YR 5/8) mottling	0	17
78 / 24							
22							

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DRILLING DATE: October 31, 2016
DEPTH TO GROUNDWATER: 72.0 ft
COMPLETION DEPTH: 76.0 ft
BACKFILLED WITH: Hydrated Bentonite Chips

DRILLING/SAMPLING METHOD: HSA/Direct Push
DRILLING COMPANY: Gregg Drilling
LOGGED BY: C. Swithenbank, M. McAlpin
CHECKED BY: A. Sellinger, P.G., C.Hg.

LOG OF SOIL BORING SBTB9-72

Guadalupe Restoration Project
Guadalupe, California

The log and data presented are a simplification of actual conditions encountered at the time of drilling at the drilled location. Subsurface conditions may differ at other locations and with the passage of time. Please refer to Key to Boring Log for symbol explanation.

December 2016
Project No. 1601-2193

padre associates, inc.
ENGINEERS, GEOLOGISTS & ENVIRONMENTAL SCIENTISTS

LOCATION: Tank Battery 9 (TB9) Area
SURFACE ELEVATION: 100.53 ft +/- (relative datum MSL)
NORTHING: 546670.301
EASTING: 1214053.336
COORDINATE SYSTEM: NAD27 Ca SP Zn 5, feet

ELEVATION, ft MSL / DEPTH, ft	USCS MATERIAL SYMBOL	SAMPLE ID	SAMPLE INTERVAL	RECOVERY (d/r), feet	MATERIAL DESCRIPTION	Gas Monitor: MultiRAE Lite (ppm)	TOTAL TPH (mg/Kg)
100 / 0				8.0/8.0	Asphalt, 16-inch thick layer, hand-augered from surface to 8 feet bgs Hand-augered from surface to 8 feet bgs		
2 / 98		SBTB9-73-1.5-103116			Sump material, poorly graded SAND (SP), black (N 2.5/0), firm to soft, moist, asphaltic, strong odor	999+	24,500
4 / 96							
6 / 94							
8 / 92				4.0/2.3	Continuous Direct Push sampling beginning at 8 feet bgs		
10 / 90							
12 / 88				4.0/3.0			
14 / 86		SBTB9-73-13-103116			Poorly graded SAND (SP), yellowish brown (10YR 5/4), moist, medium grained, no odor	0	0*
16 / 84				4.0/2.5	Trace dark yellowish brown (10YR 3/6) mottling		
18 / 82							

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DRILLING DATE: November 1, 2016
DEPTH TO GROUNDWATER: 71.5 ft
COMPLETION DEPTH: 80.0 ft
BACKFILLED WITH: Hydrated Bentonite Chips

DRILLING/SAMPLING METHOD: HSA/Direct Push
DRILLING COMPANY: Gregg Drilling
LOGGED BY: M. McAlpin
CHECKED BY: A. Sellinger, P.G., C.Hg.

LOG OF SOIL BORING SBTB9-73

Guadalupe Restoration Project
Guadalupe, California

The log and data presented are a simplification of actual conditions encountered at the time of drilling at the drilled location. Subsurface conditions may differ at other locations and with the passage of time. Please refer to Key to Boring Log for symbol explanation.

December 2016
Project No. 1601-2193

padre associates, inc.
ENGINEERS, GEOLOGISTS & ENVIRONMENTAL SCIENTISTS

LOCATION: Tank Battery 9 (TB9) Area
SURFACE ELEVATION: 100.53 ft +/- (relative datum MSL)
NORTHING: 546670.301
EASTING: 1214053.336
COORDINATE SYSTEM: NAD27 Ca SP Zn 5, feet

ELEVATION, ft MSL / DEPTH, ft	USCS MATERIAL SYMBOL	SAMPLE ID	SAMPLE INTERVAL	RECOVERY (d/r), feet	MATERIAL DESCRIPTION	Gas Monitor: MultiRAE Lite (ppm)	TOTAL TPH (mg/Kg)
-80 / 22				4.0/2.8	Fine to medium grained		
-78 / 24				4.0/3.0	Fine grained		
-76 / 26							
-74 / 28				4.0/3.0			
-72 / 30					Frequent striated medium grained sand		
-70					Laminated trace mafic minerals		
32 / -68				4.0/3.0	Frequent laminated medium grained sand with trace mafic minerals		
34 / -66							
36 / -64				4.0/2.5			
38 / -62							

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DRILLING DATE: November 1, 2016
DEPTH TO GROUNDWATER: 71.5 ft
COMPLETION DEPTH: 80.0 ft
BACKFILLED WITH: Hydrated Bentonite Chips

DRILLING/SAMPLING METHOD: HSA/Direct Push
DRILLING COMPANY: Gregg Drilling
LOGGED BY: M. McAlpin
CHECKED BY: A. Sellinger, P.G., C.Hg.

LOG OF SOIL BORING SBTB9-73

Guadalupe Restoration Project
Guadalupe, California

The log and data presented are a simplification of actual conditions encountered at the time of drilling at the drilled location. Subsurface conditions may differ at other locations and with the passage of time. Please refer to Key to Boring Log for symbol explanation.

December 2016
Project No. 1601-2193

padre associates, inc.
ENGINEERS, GEOLOGISTS & ENVIRONMENTAL SCIENTISTS

LOCATION: Tank Battery 9 (TB9) Area
SURFACE ELEVATION: 100.53 ft +/- (relative datum MSL)
NORTHING: 546670.301
EASTING: 1214053.336
COORDINATE SYSTEM: NAD27 Ca SP Zn 5, feet

ELEVATION, ft MSL / DEPTH, ft	USCS MATERIAL SYMBOL	SAMPLE ID	SAMPLE INTERVAL	RECOVERY (d/r), feet	MATERIAL DESCRIPTION	Gas Monitor: MultiRAE Lite (ppm)	TOTAL TPH (mg/Kg)
-60 / 42				4.0/2.8			
-58 / 44							
-56 / 46				4.0/2.8			
-54 / 48							
-52 / 50				4.0/2.8			
-50 / 52							
-48 / 54				4.0/3.0	Frequent laminated medium grained sand		
-46 / 56							
-44 / 58				4.0/3.0	Frequent laminated trace mafic minerals		
-42							

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DRILLING DATE: November 1, 2016
DEPTH TO GROUNDWATER: 71.5 ft
COMPLETION DEPTH: 80.0 ft
BACKFILLED WITH: Hydrated Bentonite Chips

DRILLING/SAMPLING METHOD: HSA/Direct Push
DRILLING COMPANY: Gregg Drilling
LOGGED BY: M. McAlpin
CHECKED BY: A. Sellinger, P.G., C.Hg.

LOG OF SOIL BORING SBTB9-73

Guadalupe Restoration Project
Guadalupe, California

The log and data presented are a simplification of actual conditions encountered at the time of drilling at the drilled location. Subsurface conditions may differ at other locations and with the passage of time. Please refer to Key to Boring Log for symbol explanation.

December 2016
Project No. 1601-2193

padre associates, inc.
ENGINEERS, GEOLOGISTS & ENVIRONMENTAL SCIENTISTS

LOCATION: Tank Battery 9 (TB9) Area
SURFACE ELEVATION: 100.53 ft +/- (relative datum MSL)
NORTHING: 546670.301
EASTING: 1214053.336
COORDINATE SYSTEM: NAD27 Ca SP Zn 5, feet

ELEVATION, ft MSL / DEPTH, ft	USCS MATERIAL SYMBOL	SAMPLE ID	SAMPLE INTERVAL	RECOVERY (d/r), feet	MATERIAL DESCRIPTION	Gas Monitor: MultiRAE Lite (ppm)	TOTAL TPH (mg/Kg)
-40 / 62				4.0/3.0			
-38 / 64				4.0/3.8			
-36 / 66							
-34 / 68		SBTB9-73-68-110116		4.0/3.8	Dark gray (N 4/0), sheen on sand grains, moderate odor Gray (2.5Y 5/1)	20	8,056
-32 / 70							
-30 / 72		SBTB9-73-71-110116				22	12,520
		SBTB9-73-71.5-110116			Dark gray (5Y 4/1)	31	20,060
		SBTB9-73-72-110116		4.0/2.3	Wet	30	38,130
-28 / 74					Very dark gray (N 3/0)		
-26 / 76				4.0/4.0	Possible slough, sheen, slight odor		
-24 / 78					*TPH was not detected at or above the Practical Quantitation Limits for gasoline, diesel or motor oil carbon chain ranges		
-22					Silty SAND (SM)		
		SBTB9-73-80-110116				0	0*

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DRILLING DATE: November 1, 2016
DEPTH TO GROUNDWATER: 71.5 ft
COMPLETION DEPTH: 80.0 ft
BACKFILLED WITH: Hydrated Bentonite Chips

DRILLING/SAMPLING METHOD: HSA/Direct Push
DRILLING COMPANY: Gregg Drilling
LOGGED BY: M. McAlpin
CHECKED BY: A. Sellinger, P.G., C.Hg.

LOG OF SOIL BORING SBTB9-73

Guadalupe Restoration Project
Guadalupe, California

The log and data presented are a simplification of actual conditions encountered at the time of drilling at the drilled location. Subsurface conditions may differ at other locations and with the passage of time. Please refer to Key to Boring Log for symbol explanation.

December 2016
Project No. 1601-2193

padre associates, inc.
ENGINEERS, GEOLOGISTS & ENVIRONMENTAL SCIENTISTS

LOCATION: Tank Battery 9 (TB9) Area
SURFACE ELEVATION: 100.97 ft +/- (relative datum MSL)
NORTHING: 546751.697
EASTING: 1214184.428
COORDINATE SYSTEM: NAD27 Ca SP Zn 5, feet

ELEVATION, ft MSL / DEPTH, ft	USCS MATERIAL SYMBOL	SAMPLE ID	SAMPLE INTERVAL	RECOVERY (d/r), feet	MATERIAL DESCRIPTION	Gas Monitor: MultiRAE Lite (ppm)	TOTAL TPH (mg/Kg)
100 / 0				8.0/8.0	Asphalt, 4-inch thick layer, hand-augered from surface to 8 feet bgs		
					Redrock, 3-inch thick layer		
					Poorly graded SAND (SP), yellowish brown (10YR 5/4), loose, dry, fine to medium grained		
98 / 2							
96 / 4							
94 / 6							
92 / 8					Continuous Direct Push sampling beginning at 8 feet bgs		
				4.0/2.0	Moist, fine grained		
90 / 10							
88 / 12				4.0/3.0			
86 / 14							
84 / 16				4.0/3.0	Frequent laminated medium grained sand		
					Fine grained		
82 / 18							

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DRILLING DATE: November 1, 2016
DEPTH TO GROUNDWATER: 70.5 ft
COMPLETION DEPTH: 76.0 ft
BACKFILLED WITH: Hydrated Bentonite Chips

DRILLING/SAMPLING METHOD: HSA/Direct Push
DRILLING COMPANY: Gregg Drilling
LOGGED BY: M. McAlpin, R. Robledo
CHECKED BY: A. Sellinger, P.G., C.Hg.

LOG OF SOIL BORING SBTB9-74

Guadalupe Restoration Project
Guadalupe, California

The log and data presented are a simplification of actual conditions encountered at the time of drilling at the drilled location. Subsurface conditions may differ at other locations and with the passage of time. Please refer to Key to Boring Log for symbol explanation.

December 2016
Project No. 1601-2193

padre associates, inc.
ENGINEERS, GEOLOGISTS & ENVIRONMENTAL SCIENTISTS

LOCATION: Tank Battery 9 (TB9) Area
SURFACE ELEVATION: 100.97 ft +/- (relative datum MSL)
NORTHING: 546751.697
EASTING: 1214184.428
COORDINATE SYSTEM: NAD27 Ca SP Zn 5, feet

ELEVATION, ft MSL / DEPTH, ft	USCS MATERIAL SYMBOL	SAMPLE ID	SAMPLE INTERVAL	RECOVERY (d/r), feet	MATERIAL DESCRIPTION	Gas Monitor: MultiRAE Lite (ppm)	TOTAL TPH (mg/Kg)
80 / 22				4.0/3.0	Frequent striated medium grained sand Frequent laminated trace mafic minerals		
78 / 24				4.0/2.8			
76 / 26							
74 / 28				4.0/2.5	Occasional laminated medium grained sand		
72 / 30							
70 / 32				4.0/3.0			
68 / 34							
66 / 36				4.0/2.0			
64 / 38							
62							

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DRILLING DATE: November 1, 2016
DEPTH TO GROUNDWATER: 70.5 ft
COMPLETION DEPTH: 76.0 ft
BACKFILLED WITH: Hydrated Bentonite Chips

DRILLING/SAMPLING METHOD: HSA/Direct Push
DRILLING COMPANY: Gregg Drilling
LOGGED BY: M. McAlpin, R. Robledo
CHECKED BY: A. Sellinger, P.G., C.Hg.

LOG OF SOIL BORING SBTB9-74

Guadalupe Restoration Project
Guadalupe, California

The log and data presented are a simplification of actual conditions encountered at the time of drilling at the drilled location. Subsurface conditions may differ at other locations and with the passage of time. Please refer to Key to Boring Log for symbol explanation.

December 2016
Project No. 1601-2193

padre associates, inc.
ENGINEERS, GEOLOGISTS & ENVIRONMENTAL SCIENTISTS

ELEVATION, ft MSL / DEPTH, ft	USCS MATERIAL SYMBOL	SAMPLE ID	SAMPLE INTERVAL	RECOVERY (d/r), feet	LOCATION: Tank Battery 9 (TB9) Area SURFACE ELEVATION: 100.97 ft +/- (relative datum MSL) NORTHING: 546751.697 EASTING: 1214184.428 COORDINATE SYSTEM: NAD27 Ca SP Zn 5, feet MATERIAL DESCRIPTION	Gas Monitor: MultiRAE Lite (ppm)	TOTAL TPH (mg/Kg)
60 / 42				4.0/3.8			
58 / 44				4.0/3.5			
56 / 46				4.0/3.0			
54 / 48				4.0/3.0			
52 / 50				4.0/2.8	Frequent laminated trace mafic minerals		
50 / 52							
48 / 54							
46 / 56							
44 / 58							
42							

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DRILLING DATE: November 1, 2016
DEPTH TO GROUNDWATER: 70.5 ft
COMPLETION DEPTH: 76.0 ft
BACKFILLED WITH: Hydrated Bentonite Chips

DRILLING/SAMPLING METHOD: HSA/Direct Push
DRILLING COMPANY: Gregg Drilling
LOGGED BY: M. McAlpin, R. Robledo
CHECKED BY: A. Sellinger, P.G., C.Hg.

LOG OF SOIL BORING SBTB9-74

Guadalupe Restoration Project
Guadalupe, California

The log and data presented are a simplification of actual conditions encountered at the time of drilling at the drilled location. Subsurface conditions may differ at other locations and with the passage of time. Please refer to Key to Boring Log for symbol explanation.

December 2016
Project No. 1601-2193

padre associates, inc.
ENGINEERS, GEOLOGISTS & ENVIRONMENTAL SCIENTISTS

LOCATION: Tank Battery 9 (TB9) Area
SURFACE ELEVATION: 100.97 ft +/- (relative datum MSL)
NORTHING: 546751.697
EASTING: 1214184.428
COORDINATE SYSTEM: NAD27 Ca SP Zn 5, feet

ELEVATION, ft MSL / DEPTH, ft	USCS MATERIAL SYMBOL	SAMPLE ID	SAMPLE INTERVAL	RECOVERY (d/r), feet	MATERIAL DESCRIPTION	Gas Monitor: MultiRAE Lite (ppm)	TOTAL TPH (mg/Kg)
40 / 62				4.0/2.5			
38 / 64				4.0/3.0			
36 / 66		SBTB9-74-64.5-110116			Frequent laminated strong brown (7.5YR 5/6) and dark grayish brown (10YR 4/2), sheen on sand grains, moderate odor	0	3,600
34 / 68		SBTB9-74-66-110116			Yellowish brown (10YR 5/4), no odor	0	1,480
32 / 70		SBTB9-74-68-110116		4.0/3.0	Brown (10YR 5/3), sheen on sand grains, moderate odor	1	5,001
30 / 72		SBTB9-74-70-110116			Black (N 2.5/0), strong odor	5	14,580
		SBTB9-74-70.5-110116			Wet	5	35,110
				4.0/3.0			
28 / 74		SBTB9-74-73-110116			Silty CLAY (CL), dark gray (5Y 4/1), soft, wet, non-plastic, slight odor	0	40
					Clayey Silt (ML), dark grayish brown (10YR 4/2), soft, wet, non-plastic, no odor		
26 / 76		SBTB9-74-74.5-110116				0	18
24 / 78							
22							

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DRILLING DATE: November 1, 2016
DEPTH TO GROUNDWATER: 70.5 ft
COMPLETION DEPTH: 76.0 ft
BACKFILLED WITH: Hydrated Bentonite Chips

DRILLING/SAMPLING METHOD: HSA/Direct Push
DRILLING COMPANY: Gregg Drilling
LOGGED BY: M. McAlpin, R. Robledo
CHECKED BY: A. Sellinger, P.G., C.Hg.

LOG OF SOIL BORING SBTB9-74

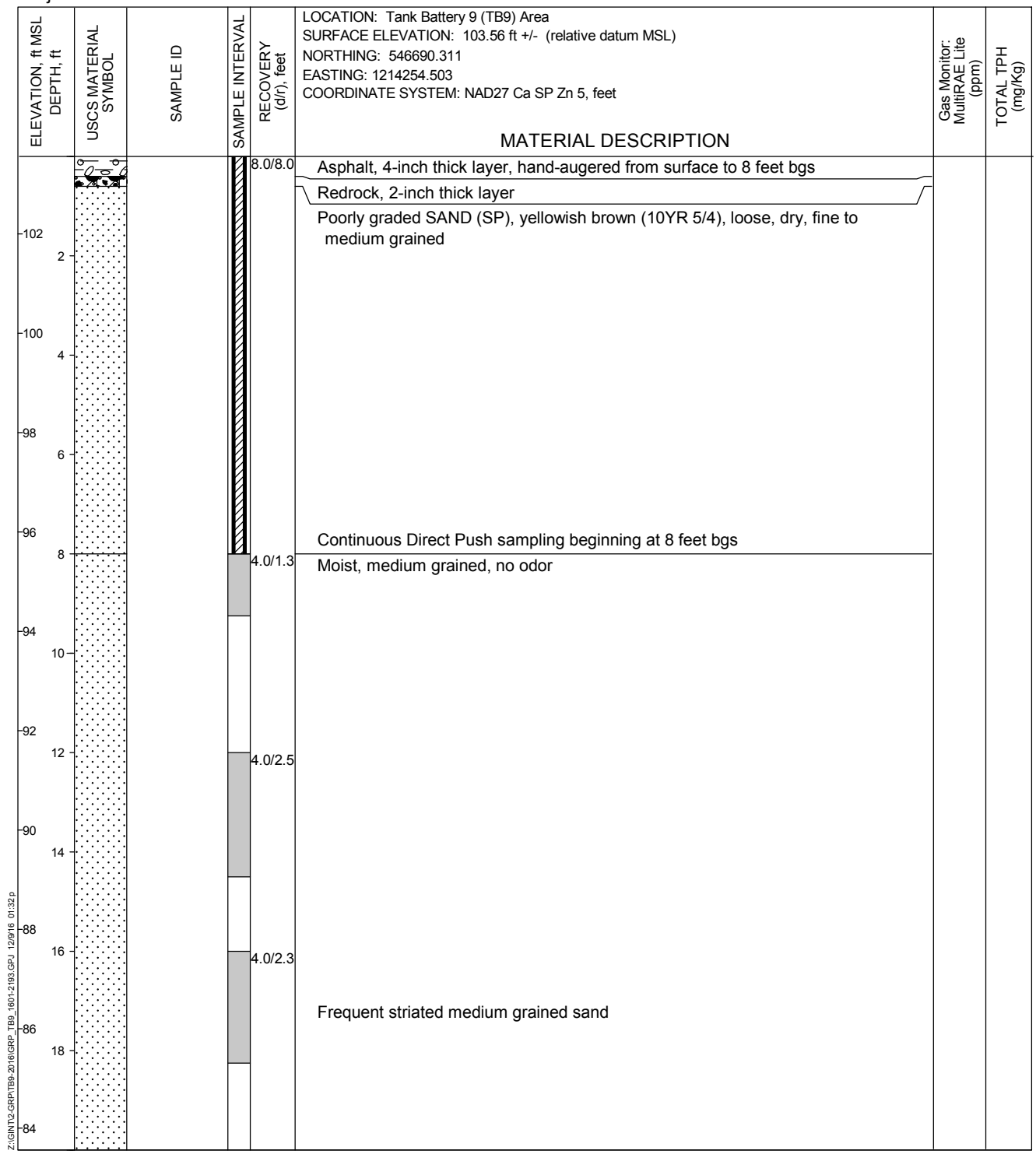
Guadalupe Restoration Project
Guadalupe, California

The log and data presented are a simplification of actual conditions encountered at the time of drilling at the drilled location. Subsurface conditions may differ at other locations and with the passage of time. Please refer to Key to Boring Log for symbol explanation.

December 2016
Project No. 1601-2193

padre associates, inc.
ENGINEERS, GEOLOGISTS & ENVIRONMENTAL SCIENTISTS

LOCATION: Tank Battery 9 (TB9) Area
SURFACE ELEVATION: 103.56 ft +/- (relative datum MSL)
NORTHING: 546690.311
EASTING: 1214254.503
COORDINATE SYSTEM: NAD27 Ca SP Zn 5, feet



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DRILLING DATE: November 2, 2016
DEPTH TO GROUNDWATER: 66.0 ft
COMPLETION DEPTH: 76.0 ft
BACKFILLED WITH: Hydrated Bentonite Chips

DRILLING/SAMPLING METHOD: HSA/Direct Push
DRILLING COMPANY: Gregg Drilling
LOGGED BY: M. McAlpin, R. Robledo
CHECKED BY: A. Sellinger, P.G., C.Hg.

LOG OF SOIL BORING SBTB9-75

Guadalupe Restoration Project
Guadalupe, California

The log and data presented are a simplification of actual conditions encountered at the time of drilling at the drilled location. Subsurface conditions may differ at other locations and with the passage of time. Please refer to Key to Boring Log for symbol explanation.

December 2016
Project No. 1601-2193

padre associates, inc.
ENGINEERS, GEOLOGISTS & ENVIRONMENTAL SCIENTISTS

LOCATION: Tank Battery 9 (TB9) Area
SURFACE ELEVATION: 103.56 ft +/- (relative datum MSL)
NORTHING: 546690.311
EASTING: 1214254.503
COORDINATE SYSTEM: NAD27 Ca SP Zn 5, feet

ELEVATION, ft MSL / DEPTH, ft	USCS MATERIAL SYMBOL	SAMPLE ID	SAMPLE INTERVAL	RECOVERY (d/r), feet	MATERIAL DESCRIPTION	Gas Monitor: MultiRAE Lite (ppm)	TOTAL TPH (mg/Kg)
-82 / 22				4.0/3.5	Frequent laminated trace mafic minerals		
-80 / 24				4.0/2.8			
-78 / 26					Trace strong brown (7.5YR 5/8)		
-76 / 28				4.0/3.0	Occasional laminated medium grained sand		
-74 / 30							
-72 / 32				4.0/2.8			
-70 / 34							
-68 / 36				4.0/2.8			
-66 / 38							
-64							

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DRILLING DATE: November 2, 2016
DEPTH TO GROUNDWATER: 66.0 ft
COMPLETION DEPTH: 76.0 ft
BACKFILLED WITH: Hydrated Bentonite Chips

DRILLING/SAMPLING METHOD: HSA/Direct Push
DRILLING COMPANY: Gregg Drilling
LOGGED BY: M. McAlpin, R. Robledo
CHECKED BY: A. Sellinger, P.G., C.Hg.

LOG OF SOIL BORING SBTB9-75

Guadalupe Restoration Project
Guadalupe, California

The log and data presented are a simplification of actual conditions encountered at the time of drilling at the drilled location. Subsurface conditions may differ at other locations and with the passage of time. Please refer to Key to Boring Log for symbol explanation.

December 2016
Project No. 1601-2193

padre associates, inc.
ENGINEERS, GEOLOGISTS & ENVIRONMENTAL SCIENTISTS

LOCATION: Tank Battery 9 (TB9) Area
SURFACE ELEVATION: 103.56 ft +/- (relative datum MSL)
NORTHING: 546690.311
EASTING: 1214254.503
COORDINATE SYSTEM: NAD27 Ca SP Zn 5, feet

ELEVATION, ft MSL / DEPTH, ft	USCS MATERIAL SYMBOL	SAMPLE ID	SAMPLE INTERVAL	RECOVERY (d/r), feet	MATERIAL DESCRIPTION	Gas Monitor: MultiRAE Lite (ppm)	TOTAL TPH (mg/Kg)
62 / 42				4.0/2.8			
60 / 44				4.0/3.0	Frequent laminated medium grained sand		
58 / 46							
56 / 48				4.0/3.0			
54 / 50							
52 / 52				4.0/2.5			
50 / 54							
48 / 56				4.0/3.8			
46 / 58					Frequent laminated strong brown (7.5YR 5/8)		
44							

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DRILLING DATE: November 2, 2016
DEPTH TO GROUNDWATER: 66.0 ft
COMPLETION DEPTH: 76.0 ft
BACKFILLED WITH: Hydrated Bentonite Chips

DRILLING/SAMPLING METHOD: HSA/Direct Push
DRILLING COMPANY: Gregg Drilling
LOGGED BY: M. McAlpin, R. Robledo
CHECKED BY: A. Sellinger, P.G., C.Hg.

LOG OF SOIL BORING SBTB9-75

Guadalupe Restoration Project
Guadalupe, California

The log and data presented are a simplification of actual conditions encountered at the time of drilling at the drilled location. Subsurface conditions may differ at other locations and with the passage of time. Please refer to Key to Boring Log for symbol explanation.

December 2016
Project No. 1601-2193

padre associates, inc.
ENGINEERS, GEOLOGISTS & ENVIRONMENTAL SCIENTISTS

LOCATION: Tank Battery 9 (TB9) Area
SURFACE ELEVATION: 103.56 ft +/- (relative datum MSL)
NORTHING: 546690.311
EASTING: 1214254.503
COORDINATE SYSTEM: NAD27 Ca SP Zn 5, feet

ELEVATION, ft MSL / DEPTH, ft	USCS MATERIAL SYMBOL	SAMPLE ID	SAMPLE INTERVAL	RECOVERY (d/r), feet	MATERIAL DESCRIPTION	Gas Monitor: MultiRAE Lite (ppm)	TOTAL TPH (mg/Kg)
42 / 62				4.0/3.2	Laminated medium grained sand		
40 / 64				4.0/3.0			
		SBTB9-75-65-110216			Sheen on sand grains, slight odor	3	4,100
38 / 66		SBTB9-75-66-110216			Dark gray (10YR 4/1), moderate odor Wet, medium grained Very dark gray (N 3/0)	7	5,925
36 / 68				4.0/3.0	Fine grained, sheen, moderate to strong odor		
34 / 70		SBTB9-75-70.5-110216			Mottled black (N 2.5/0) and very dark gray (N 3/0), moderate odor	460	2,033
32 / 72				4.0/4.0	Very dark gray (N 3/0), moderate odor		
30 / 74		SBTB9-75-73.5-110216			Silty CLAY (CL), very dark gray (10YR 3/1), soft to stiff, wet, trace yellowish brown (10YR 5/8) mottling, non-plastic, trace mafic minerals	9	42
28 / 76		SBTB9-75-75.5-110216			Clayey Silty SAND (SM-SC), wet, non-plastic	0	0*
26 / 78					*TPH was not detected at or above the Practical Quantitation Limits for gasoline, diesel or motor oil carbon chain ranges		
24							

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DRILLING DATE: November 2, 2016
DEPTH TO GROUNDWATER: 66.0 ft
COMPLETION DEPTH: 76.0 ft
BACKFILLED WITH: Hydrated Bentonite Chips

DRILLING/SAMPLING METHOD: HSA/Direct Push
DRILLING COMPANY: Gregg Drilling
LOGGED BY: M. McAlpin, R. Robledo
CHECKED BY: A. Sellinger, P.G., C.Hg.

LOG OF SOIL BORING SBTB9-75

Guadalupe Restoration Project
Guadalupe, California

The log and data presented are a simplification of actual conditions encountered at the time of drilling at the drilled location. Subsurface conditions may differ at other locations and with the passage of time. Please refer to Key to Boring Log for symbol explanation.

December 2016
Project No. 1601-2193

padre associates, inc.
ENGINEERS, GEOLOGISTS & ENVIRONMENTAL SCIENTISTS

LOCATION: Tank Battery 9 (TB9) Area
SURFACE ELEVATION: 90.33 ft +/- (relative datum MSL)
NORTHING: 546505.253
EASTING: 1214544.021
COORDINATE SYSTEM: NAD27 Ca SP Zn 5, feet

ELEVATION, ft MSL / DEPTH, ft	USCS MATERIAL SYMBOL	SAMPLE ID	SAMPLE INTERVAL	RECOVERY (d/r), feet	MATERIAL DESCRIPTION	Gas Monitor: MultiRAE Lite (ppm)	TOTAL TPH (mg/Kg)
90 / 0				8.0/8.0	Asphalt, 6 to 7-inch thick layer, hand-augered from surface to 8 feet bgs		
					Redrock, 1/2-inch thick layer		
					Poorly graded SAND (SP), brown (10YR 4/3), fine grained sand with trace fine gravel		
88 / 2					Light yellowish brown (10YR 6/4), fine grained		
		SBTB9-76-3.5-110216			Yellowish brown (10YR 5/4), fine grained, slight odor		540
86 / 4							
		SBTB9-76-5.5-110216					15
84 / 6					No odor		
					Continuous Direct Push sampling beginning at 8 feet bgs		
82 / 8				4.0/2.8	Poorly graded SAND (SP), yellowish brown (10YR 5/4), moist, medium grained		
80 / 10							
78 / 12				4.0/2.8	Frequent striated medium grained sand		
					Fine grained		
76 / 14							
74 / 16				4.0/2.8			
72 / 18							

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DRILLING DATE: November 2, 2016
DEPTH TO GROUNDWATER: 60.0 ft
COMPLETION DEPTH: 64.0 ft
BACKFILLED WITH: Hydrated Bentonite Chips

DRILLING/SAMPLING METHOD: HSA/Direct Push
DRILLING COMPANY: Gregg Drilling
LOGGED BY: C. Swithenbank, M. McAlpin
CHECKED BY: A. Sellinger, P.G., C.Hg.

LOG OF SOIL BORING SBTB9-76

Guadalupe Restoration Project
Guadalupe, California

The log and data presented are a simplification of actual conditions encountered at the time of drilling at the drilled location. Subsurface conditions may differ at other locations and with the passage of time. Please refer to Key to Boring Log for symbol explanation.

December 2016
Project No. 1601-2193

padre associates, inc.
ENGINEERS, GEOLOGISTS & ENVIRONMENTAL SCIENTISTS

LOCATION: Tank Battery 9 (TB9) Area
SURFACE ELEVATION: 90.33 ft +/- (relative datum MSL)
NORTHING: 546505.253
EASTING: 1214544.021
COORDINATE SYSTEM: NAD27 Ca SP Zn 5, feet

ELEVATION, ft MSL / DEPTH, ft	USCS MATERIAL SYMBOL	SAMPLE ID	SAMPLE INTERVAL	RECOVERY (d/r), feet	MATERIAL DESCRIPTION	Gas Monitor: MultiRAE Lite (ppm)	TOTAL TPH (mg/Kg)
-70 / 22				4.0/3.5	Striated medium grained sand		
-68 / 24				4.0/2.5			
-66 / 26							
-64 / 28				4.0/3.5			
-62 / 30							
-60 / 32				4.0/3.8			
-58 / 34							
-56 / 36				4.0/3.2			
-54 / 38					Laminated trace mafic minerals		
-52							

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DRILLING DATE: November 2, 2016
DEPTH TO GROUNDWATER: 60.0 ft
COMPLETION DEPTH: 64.0 ft
BACKFILLED WITH: Hydrated Bentonite Chips

DRILLING/SAMPLING METHOD: HSA/Direct Push
DRILLING COMPANY: Gregg Drilling
LOGGED BY: C. Swithenbank, M. McAlpin
CHECKED BY: A. Sellinger, P.G., C.Hg.

LOG OF SOIL BORING SBTB9-76

Guadalupe Restoration Project
Guadalupe, California

The log and data presented are a simplification of actual conditions encountered at the time of drilling at the drilled location. Subsurface conditions may differ at other locations and with the passage of time. Please refer to Key to Boring Log for symbol explanation.

December 2016
Project No. 1601-2193

padre associates, inc.
ENGINEERS, GEOLOGISTS & ENVIRONMENTAL SCIENTISTS

LOCATION: Tank Battery 9 (TB9) Area
SURFACE ELEVATION: 90.33 ft +/- (relative datum MSL)
NORTHING: 546505.253
EASTING: 1214544.021
COORDINATE SYSTEM: NAD27 Ca SP Zn 5, feet

ELEVATION, ft MSL / DEPTH, ft	USCS MATERIAL SYMBOL	SAMPLE ID	SAMPLE INTERVAL	RECOVERY (d/r), feet	MATERIAL DESCRIPTION	Gas Monitor: MultiRAE Lite (ppm)	TOTAL TPH (mg/Kg)
-50 / 42				4.0/3.0			
-48 / 44					Dark yellowish brown (10YR 4/4)		
-46 / 46				4.0/3.2	Yellowish brown (10YR 5/4), trace strong brown (7.5YR 5/8)		
-44 / 48							
-42 / 50				4.0/2.8	Frequent laminated yellowish brown (10YR 5/6)		
-40 / 52		SBTB9-76-50.5-110216			Brown (10YR 4/3), slight odor	0	1,870
-38 / 54				4.0/3.0	Sheen on sand grains, moderate to strong odor Little yellowish brown (10YR 5/8) mottling		
-36 / 56							
-34 / 58				4.0/2.8	Dark gray (N 4/0), sheen on sand grains, strong odor		
-32		SBTB9-76-58.5-110216				15	2,488

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DRILLING DATE: November 2, 2016
DEPTH TO GROUNDWATER: 60.0 ft
COMPLETION DEPTH: 64.0 ft
BACKFILLED WITH: Hydrated Bentonite Chips

DRILLING/SAMPLING METHOD: HSA/Direct Push
DRILLING COMPANY: Gregg Drilling
LOGGED BY: C. Swithenbank, M. McAlpin
CHECKED BY: A. Sellinger, P.G., C.Hg.

LOG OF SOIL BORING SBTB9-76

Guadalupe Restoration Project
Guadalupe, California

The log and data presented are a simplification of actual conditions encountered at the time of drilling at the drilled location. Subsurface conditions may differ at other locations and with the passage of time. Please refer to Key to Boring Log for symbol explanation.

December 2016
Project No. 1601-2193

padre associates, inc.
ENGINEERS, GEOLOGISTS & ENVIRONMENTAL SCIENTISTS

LOCATION: Tank Battery 9 (TB9) Area
SURFACE ELEVATION: 90.33 ft +/- (relative datum MSL)
NORTHING: 546505.253
EASTING: 1214544.021
COORDINATE SYSTEM: NAD27 Ca SP Zn 5, feet

ELEVATION, ft MSL / DEPTH, ft	USCS MATERIAL SYMBOL	SAMPLE ID	SAMPLE INTERVAL	RECOVERY (d/r), feet	MATERIAL DESCRIPTION	Gas Monitor: MultiRAE Lite (ppm)	TOTAL TPH (mg/Kg)
-30 / 62		SBTB9-76-60-110216		4.0/3.0	Black (N 2.5/0), wet, sheen on sand grains, moderate odor	99	37,140
-28 / 64		SBTB9-76-62.5-110216			Silty CLAY (CL), gray (10YR 5/1), stiff, wet, trace micaceous minerals, no odor	0	391
-26 / 66							
-24 / 68							
-22 / 70							
-20 / 72							
-18 / 74							
-16 / 76							
-14 / 78							
-12							

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DRILLING DATE: November 2, 2016
DEPTH TO GROUNDWATER: 60.0 ft
COMPLETION DEPTH: 64.0 ft
BACKFILLED WITH: Hydrated Bentonite Chips

DRILLING/SAMPLING METHOD: HSA/Direct Push
DRILLING COMPANY: Gregg Drilling
LOGGED BY: C. Swithenbank, M. McAlpin
CHECKED BY: A. Sellinger, P.G., C.Hg.

LOG OF SOIL BORING SBTB9-76

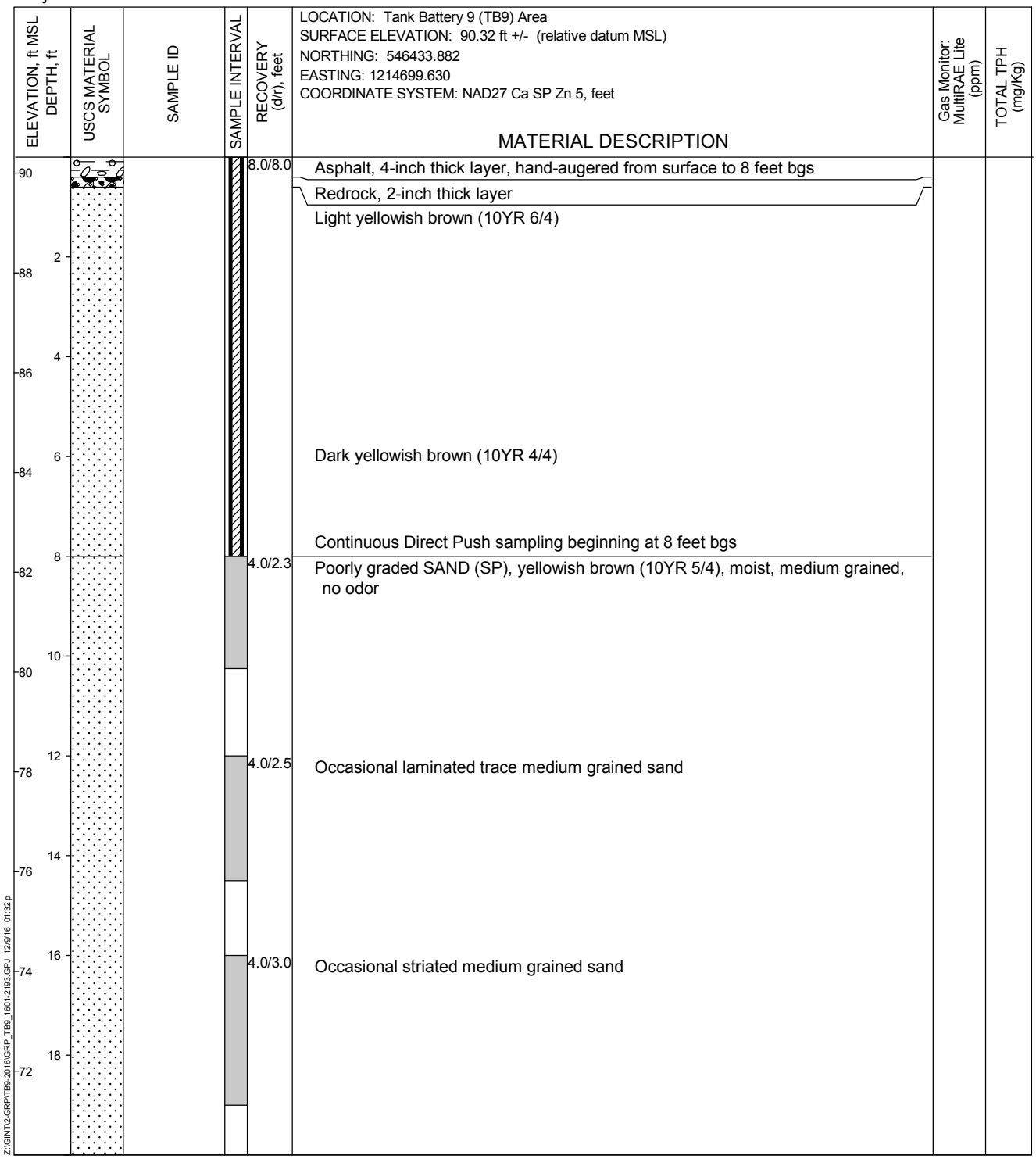
Guadalupe Restoration Project
Guadalupe, California

The log and data presented are a simplification of actual conditions encountered at the time of drilling at the drilled location. Subsurface conditions may differ at other locations and with the passage of time. Please refer to Key to Boring Log for symbol explanation.

December 2016
Project No. 1601-2193

padre associates, inc.
ENGINEERS, GEOLOGISTS & ENVIRONMENTAL SCIENTISTS

LOCATION: Tank Battery 9 (TB9) Area
SURFACE ELEVATION: 90.32 ft +/- (relative datum MSL)
NORTHING: 546433.882
EASTING: 1214699.630
COORDINATE SYSTEM: NAD27 Ca SP Zn 5, feet



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DRILLING DATE: November 3, 2016
DEPTH TO GROUNDWATER: 58.5 ft
COMPLETION DEPTH: 64.0 ft
BACKFILLED WITH: Hydrated Bentonite Chips

DRILLING/SAMPLING METHOD: HSA/Direct Push
DRILLING COMPANY: Gregg Drilling
LOGGED BY: M. McAlpin, R. Robledo
CHECKED BY: A. Sellinger, P.G., C.Hg.

LOG OF SOIL BORING SBTB9-77

Guadalupe Restoration Project
Guadalupe, California

The log and data presented are a simplification of actual conditions encountered at the time of drilling at the drilled location. Subsurface conditions may differ at other locations and with the passage of time. Please refer to Key to Boring Log for symbol explanation.

December 2016
Project No. 1601-2193

padre associates, inc.
ENGINEERS, GEOLOGISTS & ENVIRONMENTAL SCIENTISTS

LOCATION: Tank Battery 9 (TB9) Area
SURFACE ELEVATION: 90.32 ft +/- (relative datum MSL)
NORTHING: 546433.882
EASTING: 1214699.630
COORDINATE SYSTEM: NAD27 Ca SP Zn 5, feet

ELEVATION, ft MSL / DEPTH, ft	USCS MATERIAL SYMBOL	SAMPLE ID	SAMPLE INTERVAL	RECOVERY (d/r), feet	MATERIAL DESCRIPTION	Gas Monitor: MultiRAE Lite (ppm)	TOTAL TPH (mg/Kg)
-70				4.0/3.0	Fine grained		
22							
-68							
24				4.0/2.8			
-66							
26							
-64							
28				4.0/2.8	Occasional striated trace mafic minerals		
-62							
30							
-60					Striated medium grained sand		
32				4.0/2.0			
-58					Frequent laminated medium grained sand		
34							
-56							
36				4.0/3.0	Fine grained		
-54							
38							
-52							

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DRILLING DATE: November 3, 2016
DEPTH TO GROUNDWATER: 58.5 ft
COMPLETION DEPTH: 64.0 ft
BACKFILLED WITH: Hydrated Bentonite Chips

DRILLING/SAMPLING METHOD: HSA/Direct Push
DRILLING COMPANY: Gregg Drilling
LOGGED BY: M. McAlpin, R. Robledo
CHECKED BY: A. Sellinger, P.G., C.Hg.

LOG OF SOIL BORING SBTB9-77

Guadalupe Restoration Project
Guadalupe, California

The log and data presented are a simplification of actual conditions encountered at the time of drilling at the drilled location. Subsurface conditions may differ at other locations and with the passage of time. Please refer to Key to Boring Log for symbol explanation.

December 2016
Project No. 1601-2193

LOCATION: Tank Battery 9 (TB9) Area
SURFACE ELEVATION: 90.32 ft +/- (relative datum MSL)
NORTHING: 546433.882
EASTING: 1214699.630
COORDINATE SYSTEM: NAD27 Ca SP Zn 5, feet

ELEVATION, ft MSL / DEPTH, ft	USCS MATERIAL SYMBOL	SAMPLE ID	SAMPLE INTERVAL	RECOVERY (d/r), feet	MATERIAL DESCRIPTION	Gas Monitor: MultiRAE Lite (ppm)	TOTAL TPH (mg/Kg)
-50 / 42				4.0/3.0			
-48 / 44				4.0/3.0			
-46 / 46				4.0/3.0			
-44 / 48				4.0/3.0			
-42 / 50							
-40 / 52		SBTB9-77-52-110316		4.0/3.2	Brown (10YR 5/3), moist, fine grained, sheen on sand grains, strong odor	1	15,510
-38 / 54					Dark brown (10YR 3/3) Brown (10YR 5/3) Dark brown (10YR 3/3) Brown (10YR 5/3)		
-36 / 56				4.0/3.0	Frequent laminated strong brown (7.5YR 4/6) and dark brown (10YR 3/3), sheen, strong odor Dark gray (10YR 4/1)		
-34 / 58		SBTB9-77-58-110316				62	4,656
-32		SBTB9-77-58.5-110316			Very dark gray (N 3/0), wet	60	17,780

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DRILLING DATE: November 3, 2016
DEPTH TO GROUNDWATER: 58.5 ft
COMPLETION DEPTH: 64.0 ft
BACKFILLED WITH: Hydrated Bentonite Chips

DRILLING/SAMPLING METHOD: HSA/Direct Push
DRILLING COMPANY: Gregg Drilling
LOGGED BY: M. McAlpin, R. Robledo
CHECKED BY: A. Sellinger, P.G., C.Hg.

LOG OF SOIL BORING SBTB9-77

Guadalupe Restoration Project
Guadalupe, California

The log and data presented are a simplification of actual conditions encountered at the time of drilling at the drilled location. Subsurface conditions may differ at other locations and with the passage of time. Please refer to Key to Boring Log for symbol explanation.

December 2016
Project No. 1601-2193

padre associates, inc.
ENGINEERS, GEOLOGISTS & ENVIRONMENTAL SCIENTISTS

LOCATION: Tank Battery 9 (TB9) Area
SURFACE ELEVATION: 90.32 ft +/- (relative datum MSL)
NORTHING: 546433.882
EASTING: 1214699.630
COORDINATE SYSTEM: NAD27 Ca SP Zn 5, feet

ELEVATION, ft MSL / DEPTH, ft	USCS MATERIAL SYMBOL	SAMPLE ID	SAMPLE INTERVAL	RECOVERY (d/r), feet	MATERIAL DESCRIPTION	Gas Monitor: MultiRAE Lite (ppm)	TOTAL TPH (mg/Kg)
-30 / 60				4.0/3.0	Sheen, strong odor		
		SBTB9-77-60.5-110316				38	27
					Clayey SAND (SC), dark grayish brown (10YR 4/2), stiff, wet, fine grained sand, no odor Trace micaceous minerals, trace dark gray (10YR 4/1) and dark yellowish brown (10YR 3/6) mottling, trace carbon staining		
-28 / 62		SBTB9-77-62.5-110316				9	0*
-26 / 64							
-24 / 66					*TPH was not detected at or above the Practical Quantitation Limits for gasoline, diesel or motor oil carbon chain ranges		
-22 / 68							
-20 / 70							
-18 / 72							
-16 / 74							
-14 / 76							
-12 / 78							

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DRILLING DATE: November 3, 2016
DEPTH TO GROUNDWATER: 58.5 ft
COMPLETION DEPTH: 64.0 ft
BACKFILLED WITH: Hydrated Bentonite Chips

DRILLING/SAMPLING METHOD: HSA/Direct Push
DRILLING COMPANY: Gregg Drilling
LOGGED BY: M. McAlpin, R. Robledo
CHECKED BY: A. Sellinger, P.G., C.Hg.

LOG OF SOIL BORING SBTB9-77

Guadalupe Restoration Project
Guadalupe, California

The log and data presented are a simplification of actual conditions encountered at the time of drilling at the drilled location. Subsurface conditions may differ at other locations and with the passage of time. Please refer to Key to Boring Log for symbol explanation.

December 2016
Project No. 1601-2193

padre associates, inc.
ENGINEERS, GEOLOGISTS & ENVIRONMENTAL SCIENTISTS

LOCATION: Tank Battery 9 (TB9) Area
SURFACE ELEVATION: 87.01 ft +/- (relative datum MSL)
NORTHING: 546321.670
EASTING: 1214819.497
COORDINATE SYSTEM: NAD27 Ca SP Zn 5, feet

ELEVATION, ft MSL / DEPTH, ft	USCS MATERIAL SYMBOL	SAMPLE ID	SAMPLE INTERVAL	RECOVERY (d/r), feet	MATERIAL DESCRIPTION	Gas Monitor: MultiRAE Lite (ppm)	TOTAL TPH (mg/Kg)
87 / 0				8.0/8.0	Asphalt, 3-inch thick layer, hand-augered from surface to 8 feet bgs		
					Poorly graded SAND (SP), dark yellowish brown (10YR 4/4), fine grained sand with trace fine gravel, trace redrock, no odor		
86 / 2					Light yellowish brown (10YR 6/4), fine grained		
84 / 4							
82 / 6							
80 / 8					Continuous Direct Push sampling beginning at 8 feet bgs		
				4.0/2.5	Yellowish brown (10YR 5/4), moist, striations of medium grained sand		
78 / 10							
76 / 12				4.0/2.8			
74 / 14							
72 / 16				4.0/3.0			
70 / 18					Occasional 1/4-inch thick lenses of dark yellowish brown (10YR 4/4)		
68							

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DRILLING DATE: November 3, 2016
DEPTH TO GROUNDWATER: 54.5 ft
COMPLETION DEPTH: 60.0 ft
BACKFILLED WITH: Hydrated Bentonite Chips

DRILLING/SAMPLING METHOD: HSA/Direct Push
DRILLING COMPANY: Gregg Drilling
LOGGED BY: C. Swithenbank, M. McAlpin
CHECKED BY: A. Sellinger, P.G., C.Hg.

LOG OF SOIL BORING SBTB9-78

Guadalupe Restoration Project
Guadalupe, California

The log and data presented are a simplification of actual conditions encountered at the time of drilling at the drilled location. Subsurface conditions may differ at other locations and with the passage of time. Please refer to Key to Boring Log for symbol explanation.

December 2016
Project No. 1601-2193

padre associates, inc.
ENGINEERS, GEOLOGISTS & ENVIRONMENTAL SCIENTISTS

ELEVATION, ft MSL / DEPTH, ft	USCS MATERIAL SYMBOL	SAMPLE ID	SAMPLE INTERVAL	RECOVERY (d/r), feet	MATERIAL DESCRIPTION	Gas Monitor: MultiRAE Lite (ppm)	TOTAL TPH (mg/Kg)
					LOCATION: Tank Battery 9 (TB9) Area SURFACE ELEVATION: 87.01 ft +/- (relative datum MSL) NORTHING: 546321.670 EASTING: 1214819.497 COORDINATE SYSTEM: NAD27 Ca SP Zn 5, feet		
66 / 22				4.0/2.8			
64 / 24				4.0/2.5			
62 / 26							
60 / 28				4.0/2.5	Frequent striated medium grained sand		
58 / 30							
56 / 32				4.0/3.0	Dark yellowish brown (10YR 4/4) Yellowish brown (10YR 5/6)		
54 / 34							
52 / 36				4.0/2.8	Yellowish brown (10YR 5/4)		
50 / 38							
48							

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DRILLING DATE: November 3, 2016
DEPTH TO GROUNDWATER: 54.5 ft
COMPLETION DEPTH: 60.0 ft
BACKFILLED WITH: Hydrated Bentonite Chips

DRILLING/SAMPLING METHOD: HSA/Direct Push
DRILLING COMPANY: Gregg Drilling
LOGGED BY: C. Swithenbank, M. McAlpin
CHECKED BY: A. Sellinger, P.G., C.Hg.

LOG OF SOIL BORING SBTB9-78

Guadalupe Restoration Project
Guadalupe, California

The log and data presented are a simplification of actual conditions encountered at the time of drilling at the drilled location. Subsurface conditions may differ at other locations and with the passage of time. Please refer to Key to Boring Log for symbol explanation.

December 2016
Project No. 1601-2193

padre associates, inc.
ENGINEERS, GEOLOGISTS & ENVIRONMENTAL SCIENTISTS

LOCATION: Tank Battery 9 (TB9) Area
SURFACE ELEVATION: 87.01 ft +/- (relative datum MSL)
NORTHING: 546321.670
EASTING: 1214819.497
COORDINATE SYSTEM: NAD27 Ca SP Zn 5, feet

ELEVATION, ft MSL / DEPTH, ft	USCS MATERIAL SYMBOL	SAMPLE ID	SAMPLE INTERVAL	RECOVERY (d/r), feet	MATERIAL DESCRIPTION	Gas Monitor: MultiRAE Lite (ppm)	TOTAL TPH (mg/Kg)
-46 / 42				4.0/3.0			
-44 / 44				4.0/3.0	Trace mafic minerals		
-42 / 46							
-40 / 48				4.0/3.0	Frequent striated trace mafic minerals and medium grained sand		
-38 / 50							
-36 / 52				4.0/3.0			
-34 / 54		SBTB9-78-54-110316				0	0*
-32		SBTB9-78-54.5-110316			Fine to medium grained Wet, fine grained, laminated strong brown (7.5YR 4/6) and brown (10YR 4/3)	0	0*
56 / -30				4.0/3.5			
58					Silty sandy CLAY (CL), soft, wet, trace mafic minerals, trace strong brown (7.5YR 4/6), trace carbon staining		
-28		SBTB9-78-59-110316			*TPH was not detected at or above the Practical Quantitation Limits for gasoline, diesel or motor oil carbon chain ranges	0	0*

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DRILLING DATE: November 3, 2016
DEPTH TO GROUNDWATER: 54.5 ft
COMPLETION DEPTH: 60.0 ft
BACKFILLED WITH: Hydrated Bentonite Chips

DRILLING/SAMPLING METHOD: HSA/Direct Push
DRILLING COMPANY: Gregg Drilling
LOGGED BY: C. Swithenbank, M. McAlpin
CHECKED BY: A. Sellinger, P.G., C.Hg.

LOG OF SOIL BORING SBTB9-78

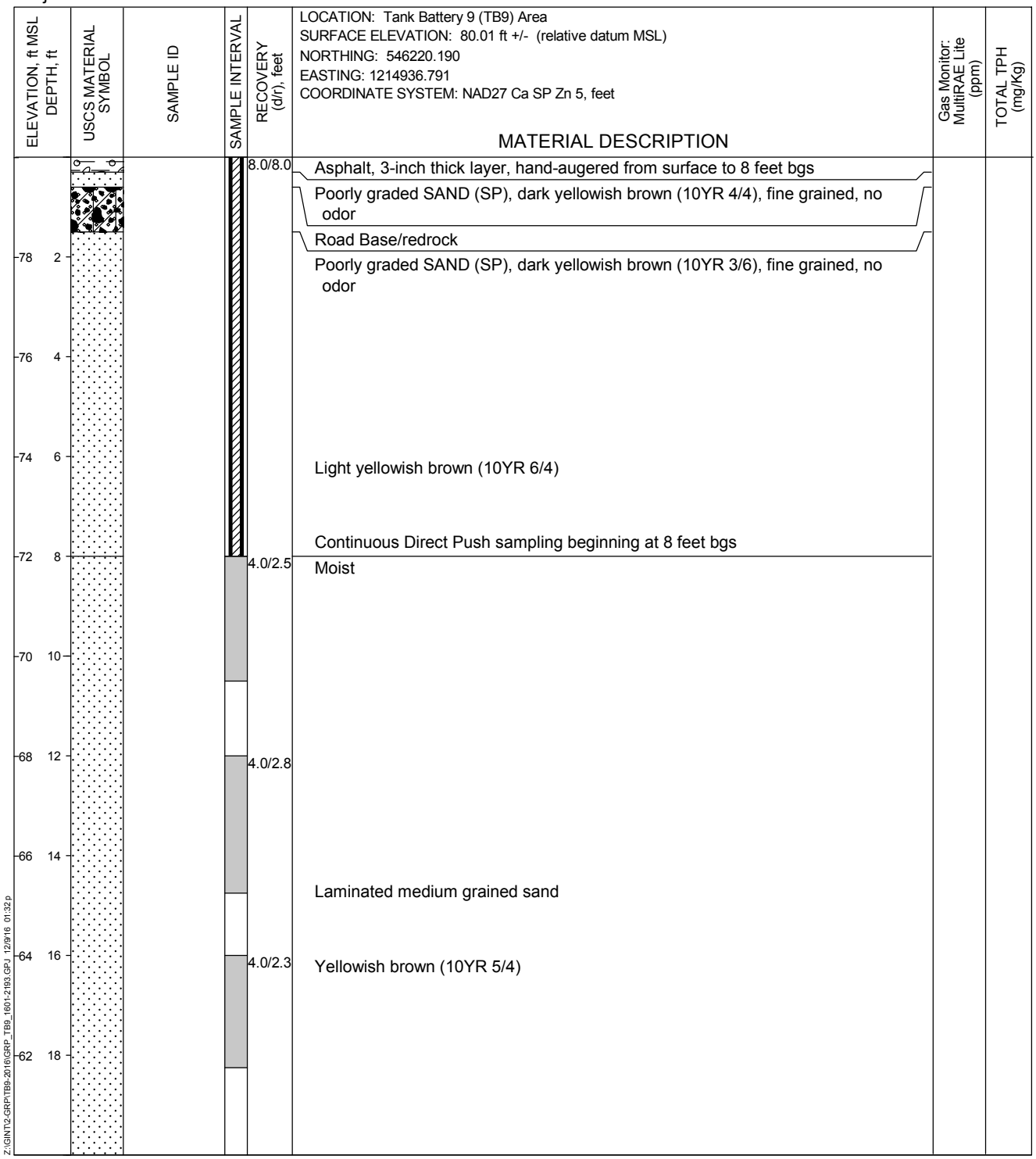
Guadalupe Restoration Project
Guadalupe, California

The log and data presented are a simplification of actual conditions encountered at the time of drilling at the drilled location. Subsurface conditions may differ at other locations and with the passage of time. Please refer to Key to Boring Log for symbol explanation.

December 2016
Project No. 1601-2193

padre associates, inc.
ENGINEERS, GEOLOGISTS & ENVIRONMENTAL SCIENTISTS

LOCATION: Tank Battery 9 (TB9) Area
SURFACE ELEVATION: 80.01 ft +/- (relative datum MSL)
NORTHING: 546220.190
EASTING: 1214936.791
COORDINATE SYSTEM: NAD27 Ca SP Zn 5, feet



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DRILLING DATE: November 4, 2016
DEPTH TO GROUNDWATER: 47.3 ft
COMPLETION DEPTH: 52.0 ft
BACKFILLED WITH: Hydrated Bentonite Chips

DRILLING/SAMPLING METHOD: HSA/Direct Push
DRILLING COMPANY: Gregg Drilling
LOGGED BY: C. Swithenbank, M. McAlpin
CHECKED BY: A. Sellinger, P.G., C.Hg.

LOG OF SOIL BORING SBTB9-79

Guadalupe Restoration Project
Guadalupe, California

The log and data presented are a simplification of actual conditions encountered at the time of drilling at the drilled location. Subsurface conditions may differ at other locations and with the passage of time. Please refer to Key to Boring Log for symbol explanation.

December 2016
Project No. 1601-2193

padre associates, inc.
ENGINEERS, GEOLOGISTS & ENVIRONMENTAL SCIENTISTS

LOCATION: Tank Battery 9 (TB9) Area
SURFACE ELEVATION: 80.01 ft +/- (relative datum MSL)
NORTHING: 546220.190
EASTING: 1214936.791
COORDINATE SYSTEM: NAD27 Ca SP Zn 5, feet

ELEVATION, ft MSL / DEPTH, ft	USCS MATERIAL SYMBOL	SAMPLE ID	SAMPLE INTERVAL	RECOVERY (d/r), feet	MATERIAL DESCRIPTION	Gas Monitor: MultiRAE Lite (ppm)	TOTAL TPH (mg/Kg)
-58 22				4.0/3.0	Frequent striated medium grained sand		
-56 24				4.0/2.8	Frequent laminated medium grained sand		
-54 26							
-52 28				4.0/2.8	Trace mafic minerals		
-50 30							
-48 32				4.0/3.2			
-46 34					Frequent laminated trace mafic minerals		
-44 36				4.0/2.8			
-42 38							

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DRILLING DATE: November 4, 2016
DEPTH TO GROUNDWATER: 47.3 ft
COMPLETION DEPTH: 52.0 ft
BACKFILLED WITH: Hydrated Bentonite Chips

DRILLING/SAMPLING METHOD: HSA/Direct Push
DRILLING COMPANY: Gregg Drilling
LOGGED BY: C. Swithenbank, M. McAlpin
CHECKED BY: A. Sellinger, P.G., C.Hg.

LOG OF SOIL BORING SBTB9-79

Guadalupe Restoration Project
Guadalupe, California

The log and data presented are a simplification of actual conditions encountered at the time of drilling at the drilled location. Subsurface conditions may differ at other locations and with the passage of time. Please refer to Key to Boring Log for symbol explanation.

December 2016
Project No. 1601-2193

padre associates, inc.
ENGINEERS, GEOLOGISTS & ENVIRONMENTAL SCIENTISTS

LOCATION: Tank Battery 9 (TB9) Area
SURFACE ELEVATION: 80.01 ft +/- (relative datum MSL)
NORTHING: 546220.190
EASTING: 1214936.791
COORDINATE SYSTEM: NAD27 Ca SP Zn 5, feet

ELEVATION, ft MSL / DEPTH, ft	USCS MATERIAL SYMBOL	SAMPLE ID	SAMPLE INTERVAL	RECOVERY (d/r), feet	MATERIAL DESCRIPTION	Gas Monitor: MultiRAE Lite (ppm)	TOTAL TPH (mg/Kg)
				4.0/2.8	1/2-inch thick layer medium grained sand		
38 42							
36 44				4.0/3.5			
34 46							
		SBTB9-79-46.5-110416				0	0*
		SBTB9-79-47-110416			Wet	0	0*
32 48				4.0/4.0			
					Sandy CLAY (CL), brown (10YR 4/3), soft, wet, non-plastic, trace micaceous minerals, trace gray (10YR 5/1) mottling, trace carbon staining		
30 50							
		SBTB9-79-51.5-110416			Clayey SAND (SC)	0	0*
28 52							
					*TPH was not detected at or above the Practical Quantitation Limits for gasoline, diesel or motor oil carbon chain ranges		
26 54							
24 56							
22 58							

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DRILLING DATE: November 4, 2016
DEPTH TO GROUNDWATER: 47.3 ft
COMPLETION DEPTH: 52.0 ft
BACKFILLED WITH: Hydrated Bentonite Chips

DRILLING/SAMPLING METHOD: HSA/Direct Push
DRILLING COMPANY: Gregg Drilling
LOGGED BY: C. Swithenbank, M. McAlpin
CHECKED BY: A. Sellinger, P.G., C.Hg.

LOG OF SOIL BORING SBTB9-79

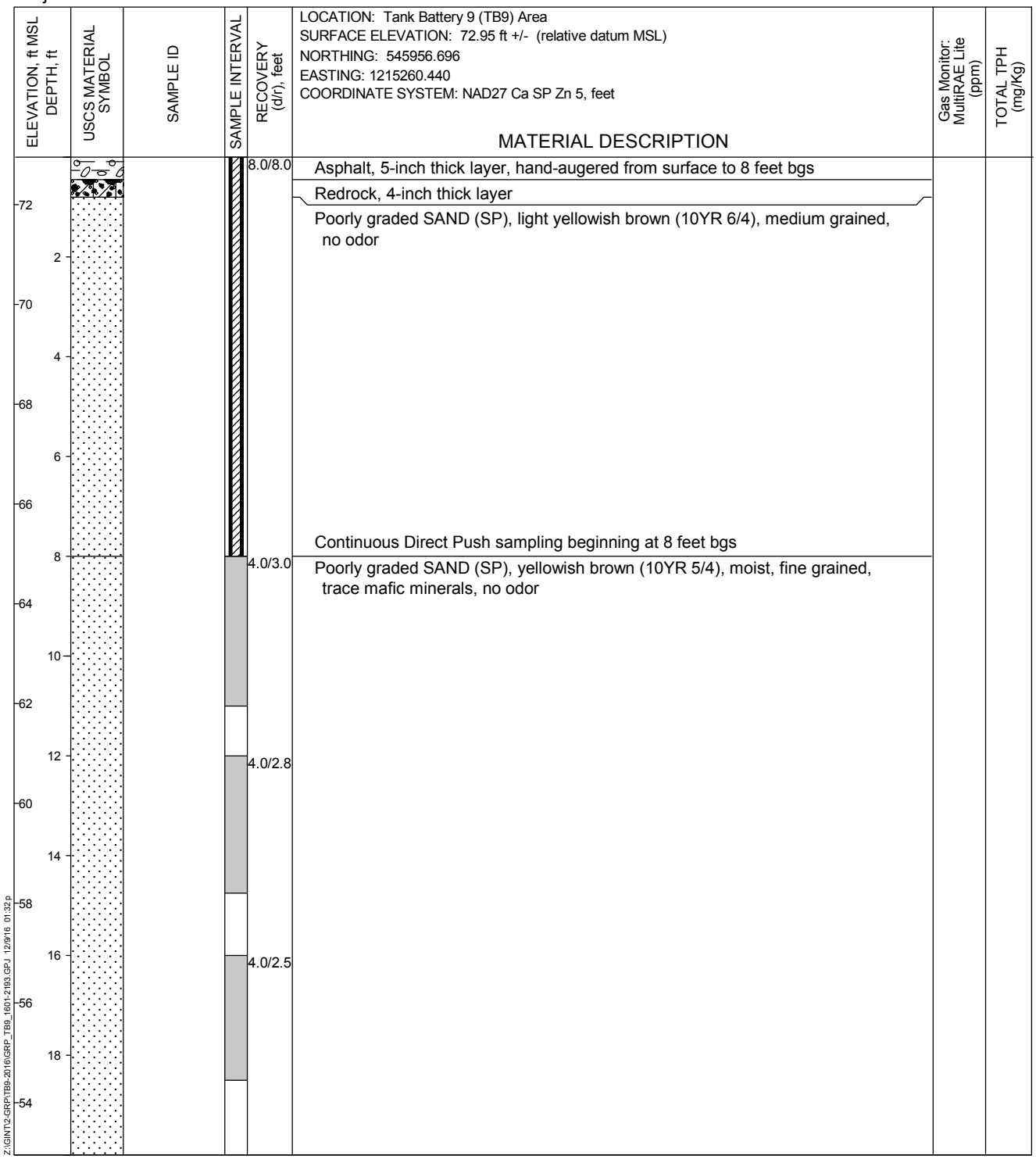
Guadalupe Restoration Project
Guadalupe, California

The log and data presented are a simplification of actual conditions encountered at the time of drilling at the drilled location. Subsurface conditions may differ at other locations and with the passage of time. Please refer to Key to Boring Log for symbol explanation.

December 2016
Project No. 1601-2193

padre associates, inc.
ENGINEERS, GEOLOGISTS & ENVIRONMENTAL SCIENTISTS

LOCATION: Tank Battery 9 (TB9) Area
SURFACE ELEVATION: 72.95 ft +/- (relative datum MSL)
NORTHING: 545956.696
EASTING: 1215260.440
COORDINATE SYSTEM: NAD27 Ca SP Zn 5, feet



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DRILLING DATE: November 4, 2016
DEPTH TO GROUNDWATER: 40.8 ft
COMPLETION DEPTH: 44.0 ft
BACKFILLED WITH: Hydrated Bentonite Chips

DRILLING/SAMPLING METHOD: HSA/Direct Push
DRILLING COMPANY: Gregg Drilling
LOGGED BY: M. McAlpin, R. Robledo
CHECKED BY: A. Sellinger, P.G., C.Hg.

LOG OF SOIL BORING SBTB9-80

Guadalupe Restoration Project
Guadalupe, California

The log and data presented are a simplification of actual conditions encountered at the time of drilling at the drilled location. Subsurface conditions may differ at other locations and with the passage of time. Please refer to Key to Boring Log for symbol explanation.

December 2016
Project No. 1601-2193

padre associates, inc.
ENGINEERS, GEOLOGISTS & ENVIRONMENTAL SCIENTISTS

LOCATION: Tank Battery 9 (TB9) Area
SURFACE ELEVATION: 72.95 ft +/- (relative datum MSL)
NORTHING: 545956.696
EASTING: 1215260.440
COORDINATE SYSTEM: NAD27 Ca SP Zn 5, feet

ELEVATION, ft MSL / DEPTH, ft	USCS MATERIAL SYMBOL	SAMPLE ID	SAMPLE INTERVAL	RECOVERY (d/r), feet	MATERIAL DESCRIPTION	Gas Monitor: MultiRAE Lite (ppm)	TOTAL TPH (mg/Kg)
52 / 22				4.0/2.5			
50 / 24				4.0/2.5			
48 / 26							
46 / 28				4.0/2.8	Frequent striated medium grained sand		
44 / 30							
42 / 32				4.0/3.0			
40 / 34							
38 / 36				4.0/2.8	Frequent striated yellowish brown (10YR 5/6)		
36 / 38							
34							

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DRILLING DATE: November 4, 2016
DEPTH TO GROUNDWATER: 40.8 ft
COMPLETION DEPTH: 44.0 ft
BACKFILLED WITH: Hydrated Bentonite Chips

DRILLING/SAMPLING METHOD: HSA/Direct Push
DRILLING COMPANY: Gregg Drilling
LOGGED BY: M. McAlpin, R. Robledo
CHECKED BY: A. Sellinger, P.G., C.Hg.

LOG OF SOIL BORING SBTB9-80

Guadalupe Restoration Project
Guadalupe, California

The log and data presented are a simplification of actual conditions encountered at the time of drilling at the drilled location. Subsurface conditions may differ at other locations and with the passage of time. Please refer to Key to Boring Log for symbol explanation.

December 2016
Project No. 1601-2193

padre associates, inc.
ENGINEERS, GEOLOGISTS & ENVIRONMENTAL SCIENTISTS

LOCATION: Tank Battery 9 (TB9) Area
SURFACE ELEVATION: 72.95 ft +/- (relative datum MSL)
NORTHING: 545956.696
EASTING: 1215260.440
COORDINATE SYSTEM: NAD27 Ca SP Zn 5, feet

ELEVATION, ft MSL / DEPTH, ft	USCS MATERIAL SYMBOL	SAMPLE ID	SAMPLE INTERVAL	RECOVERY (d/r), feet	MATERIAL DESCRIPTION	Gas Monitor: MultiRAE Lite (ppm)	TOTAL TPH (mg/Kg)
32 / 42		SBTB9-80-40-110416		4.0/2.8		0	0*
		SBTB9-80-40.5-110416			Wet	0	0*
30 / 44		SBTB9-80-42.5-110416			Sandy CLAY (CL), dark grayish brown (10YR 4/2), medium to stiff, wet, fine grained sand, non-plastic, trace micaceous minerals, trace dark gray (10YR 4/1) mottling, trace carbon staining	0	0*
28 / 46					*TPH was not detected at or above the Practical Quantitation Limits for gasoline, diesel or motor oil carbon chain ranges		
26 / 48							
24 / 50							
22 / 52							
20 / 54							
18 / 56							
16 / 58							
14							

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DRILLING DATE: November 4, 2016
DEPTH TO GROUNDWATER: 40.8 ft
COMPLETION DEPTH: 44.0 ft
BACKFILLED WITH: Hydrated Bentonite Chips

DRILLING/SAMPLING METHOD: HSA/Direct Push
DRILLING COMPANY: Gregg Drilling
LOGGED BY: M. McAlpin, R. Robledo
CHECKED BY: A. Sellinger, P.G., C.Hg.

LOG OF SOIL BORING SBTB9-80

Guadalupe Restoration Project
Guadalupe, California

The log and data presented are a simplification of actual conditions encountered at the time of drilling at the drilled location. Subsurface conditions may differ at other locations and with the passage of time. Please refer to Key to Boring Log for symbol explanation.

December 2016
Project No. 1601-2193

padre associates, inc.
ENGINEERS, GEOLOGISTS & ENVIRONMENTAL SCIENTISTS

LOCATION: Tank Battery 9 (TB9) Area
SURFACE ELEVATION: 71.11 ft +/- (relative datum MSL)
NORTHING: 546023.594
EASTING: 1215139.334
COORDINATE SYSTEM: NAD27 Ca SP Zn 5, feet

ELEVATION, ft MSL / DEPTH, ft	USCS MATERIAL SYMBOL	SAMPLE ID	SAMPLE INTERVAL	RECOVERY (d/r), feet	MATERIAL DESCRIPTION	Gas Monitor: MultiRAE Lite (ppm)	TOTAL TPH (mg/Kg)
70 / 2				8.0/8.0	Asphalt, 3-inch thick layer, hand-augered from surface to 8 feet bgs		
					Redrock, 3-inch thick layer		
					Poorly graded SAND (SP), light yellowish brown (10YR 6/4), medium grained, no odor		
68 / 4							
66 / 6		SBTB9-81-5.5-110316			Sump material, very dark brown (10YR 2/2), medium grained, strong hydrocarbon odor	999+	14,300
64 / 8					Continuous Direct Push sampling beginning at 8 feet bgs		
				4.0/2.8	Loose		
		SBTB9-81-8.5-110416				999+	16,631
62 / 10		SBTB9-81-9.5-110416			Poorly graded SAND (SP), yellowish brown (10YR 5/4), moist, fine grained, no odor	0	12
60 / 12				4.0/3.2	Trace strong brown (7.5YR 4/6) mottling		
58 / 14							
56 / 16				4.0/2.3			
54 / 18							
52							

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DRILLING DATE: November 4, 2016
DEPTH TO GROUNDWATER: 38.3 ft
COMPLETION DEPTH: 44.0 ft
BACKFILLED WITH: Hydrated Bentonite Chips

DRILLING/SAMPLING METHOD: HSA/Direct Push
DRILLING COMPANY: Gregg Drilling
LOGGED BY: M. McAlpin, R. Robledo
CHECKED BY: A. Sellinger, P.G., C.Hg.

LOG OF SOIL BORING SBTB9-81

Guadalupe Restoration Project
Guadalupe, California

The log and data presented are a simplification of actual conditions encountered at the time of drilling at the drilled location. Subsurface conditions may differ at other locations and with the passage of time. Please refer to Key to Boring Log for symbol explanation.

December 2016
Project No. 1601-2193

padre associates, inc.
ENGINEERS, GEOLOGISTS & ENVIRONMENTAL SCIENTISTS

LOCATION: Tank Battery 9 (TB9) Area
SURFACE ELEVATION: 71.11 ft +/- (relative datum MSL)
NORTHING: 546023.594
EASTING: 1215139.334
COORDINATE SYSTEM: NAD27 Ca SP Zn 5, feet

ELEVATION, ft MSL / DEPTH, ft	USCS MATERIAL SYMBOL	SAMPLE ID	SAMPLE INTERVAL	RECOVERY (d/r), feet	MATERIAL DESCRIPTION	Gas Monitor: MultiRAE Lite (ppm)	TOTAL TPH (mg/Kg)
50 / 22				4.0/2.8	Trace dark grayish brown (10YR 4/2) mottling		
48 / 24				4.0/2.8	Fine to medium grained		
46 / 26							
44 / 28				4.0/2.8	Medium grained		
42 / 30					Fine grained		
40 / 32				4.0/3.0	Occasional laminated strong brown (7.5YR 5/8)		
38 / 34							
36 / 36				4.0/3.0	Frequent laminated strong brown (7.5YR 5/8)		
34					Brown (10YR 5/3)		
38 / 32		SBTB9-81-37.5-110416			Yellowish brown (10YR 5/4)	0	0*
		SBTB9-81-38-110416			Wet	0	0*

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DRILLING DATE: November 4, 2016
DEPTH TO GROUNDWATER: 38.3 ft
COMPLETION DEPTH: 44.0 ft
BACKFILLED WITH: Hydrated Bentonite Chips

DRILLING/SAMPLING METHOD: HSA/Direct Push
DRILLING COMPANY: Gregg Drilling
LOGGED BY: M. McAlpin, R. Robledo
CHECKED BY: A. Sellinger, P.G., C.Hg.

LOG OF SOIL BORING SBTB9-81

Guadalupe Restoration Project
Guadalupe, California

The log and data presented are a simplification of actual conditions encountered at the time of drilling at the drilled location. Subsurface conditions may differ at other locations and with the passage of time. Please refer to Key to Boring Log for symbol explanation.

December 2016
Project No. 1601-2193

padre associates, inc.
ENGINEERS, GEOLOGISTS & ENVIRONMENTAL SCIENTISTS

LOCATION: Tank Battery 9 (TB9) Area
SURFACE ELEVATION: 71.11 ft +/- (relative datum MSL)
NORTHING: 546023.594
EASTING: 1215139.334
COORDINATE SYSTEM: NAD27 Ca SP Zn 5, feet

ELEVATION, ft MSL / DEPTH, ft	USCS MATERIAL SYMBOL	SAMPLE ID	SAMPLE INTERVAL	RECOVERY (d/r), feet	MATERIAL DESCRIPTION	Gas Monitor: MultiRAE Lite (ppm)	TOTAL TPH (mg/Kg)
				4.0/3.8			
-30 / 42					Clayey SAND (SC), brown (10YR 4/3), soft, wet, fine grained sand, non-plastic, trace dark gray (10YR 4/1) mottling, trace carbon staining		
					Silty CLAY (CL), stiff, few micaceous minerals, dark gray (10YR 4/1) and light gray (10YR 7/1) mottling		
-28					Sandy CLAY (CL), stiff		
44		SBTB9-81-43.5-110416				0	0*
-26 / 46					*TPH was not detected at or above the Practical Quantitation Limits for gasoline, diesel or motor oil carbon chain ranges		
-24 / 48							
-22 / 50							
-20 / 52							
-18 / 54							
-16 / 56							
-14 / 58							
-12							

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DRILLING DATE: November 4, 2016
DEPTH TO GROUNDWATER: 38.3 ft
COMPLETION DEPTH: 44.0 ft
BACKFILLED WITH: Hydrated Bentonite Chips

DRILLING/SAMPLING METHOD: HSA/Direct Push
DRILLING COMPANY: Gregg Drilling
LOGGED BY: M. McAlpin, R. Robledo
CHECKED BY: A. Sellinger, P.G., C.Hg.

LOG OF SOIL BORING SBTB9-81

Guadalupe Restoration Project
Guadalupe, California

The log and data presented are a simplification of actual conditions encountered at the time of drilling at the drilled location. Subsurface conditions may differ at other locations and with the passage of time. Please refer to Key to Boring Log for symbol explanation.

December 2016
Project No. 1601-2193

padre associates, inc.
ENGINEERS, GEOLOGISTS & ENVIRONMENTAL SCIENTISTS

LOCATION: Tank Battery 9 (TB9) Area
SURFACE ELEVATION: 98.53 ft +/- (relative datum MSL)
NORTHING: 546699.849
EASTING: 1213990.840
COORDINATE SYSTEM: NAD27 Ca SP Zn 5, feet

ELEVATION, ft MSL / DEPTH, ft	USCS MATERIAL SYMBOL	SAMPLE ID	SAMPLE INTERVAL	RECOVERY (d/r), feet	MATERIAL DESCRIPTION	Gas Monitor: MultiRAE Lite (ppm)	TOTAL TPH (mg/Kg)
98 / 0		SBTB9-82-0.5-110416		8.0/8.0	Asphalt, 4-inch thick layer, hand-augered from surface to 8 feet bgs		24,074
					Road Base, very dark brown (10YR 2/2), 6-inch thick layer, strong odor		
		SBTB9-82-1.5-110416			Dark brown (10YR 3/3), medium grained, 4-inch thick layer, moderate hydrocarbon odor		38,500
96 / 2		SBTB9-82-2-110416			Sump material, black (10YR 2/1), strong odor		69
					Poorly graded SAND (SP), yellowish brown (10YR 5/4), medium grained, no odor		
94 / 4							
92 / 6					Slightly moist		
90 / 8					Continuous Direct Push sampling beginning at 8 feet bgs		
				4.0/2.5	Loose		
88 / 10							
86 / 12				4.0/2.5			
84 / 14							
82 / 16				4.0/2.5			
80 / 18							

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DRILLING DATE: November 5, 2016
DEPTH TO GROUNDWATER: 68.5 ft
COMPLETION DEPTH: 76.0 ft
BACKFILLED WITH: Hydrated Bentonite Chips

DRILLING/SAMPLING METHOD: HSA/Direct Push
DRILLING COMPANY: Gregg Drilling
LOGGED BY: C. Swithenbank, R. Robledo
CHECKED BY: A. Sellinger, P.G., C.Hg.

LOG OF SOIL BORING SBTB9-82

Guadalupe Restoration Project
Guadalupe, California

The log and data presented are a simplification of actual conditions encountered at the time of drilling at the drilled location. Subsurface conditions may differ at other locations and with the passage of time. Please refer to Key to Boring Log for symbol explanation.

December 2016
Project No. 1601-2193

padre associates, inc.
ENGINEERS, GEOLOGISTS & ENVIRONMENTAL SCIENTISTS

LOCATION: Tank Battery 9 (TB9) Area
SURFACE ELEVATION: 98.53 ft +/- (relative datum MSL)
NORTHING: 546699.849
EASTING: 1213990.840
COORDINATE SYSTEM: NAD27 Ca SP Zn 5, feet

ELEVATION, ft MSL / DEPTH, ft	USCS MATERIAL SYMBOL	SAMPLE ID	SAMPLE INTERVAL	RECOVERY (d/r), feet	MATERIAL DESCRIPTION	Gas Monitor: MultiRAE Lite (ppm)	TOTAL TPH (mg/Kg)
78 / 22				4.0/2.5	Same as above		
76 / 24							
74 / 26				4.0/4.0			
72 / 28							
70 / 30				4.0/2.5			
68 / 32							
66 / 34				4.0/2.5			
64 / 36							
62 / 38				4.0/3.0			
60							

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DRILLING DATE: November 5, 2016
DEPTH TO GROUNDWATER: 68.5 ft
COMPLETION DEPTH: 76.0 ft
BACKFILLED WITH: Hydrated Bentonite Chips

DRILLING/SAMPLING METHOD: HSA/Direct Push
DRILLING COMPANY: Gregg Drilling
LOGGED BY: C. Swithenbank, R. Robledo
CHECKED BY: A. Sellinger, P.G., C.Hg.

LOG OF SOIL BORING SBTB9-82

Guadalupe Restoration Project
Guadalupe, California

The log and data presented are a simplification of actual conditions encountered at the time of drilling at the drilled location. Subsurface conditions may differ at other locations and with the passage of time. Please refer to Key to Boring Log for symbol explanation.

December 2016
Project No. 1601-2193

padre associates, inc.
ENGINEERS, GEOLOGISTS & ENVIRONMENTAL SCIENTISTS

LOCATION: Tank Battery 9 (TB9) Area
SURFACE ELEVATION: 98.53 ft +/- (relative datum MSL)
NORTHING: 546699.849
EASTING: 1213990.840
COORDINATE SYSTEM: NAD27 Ca SP Zn 5, feet

ELEVATION, ft MSL / DEPTH, ft	USCS MATERIAL SYMBOL	SAMPLE ID	SAMPLE INTERVAL	RECOVERY (d/r), feet	MATERIAL DESCRIPTION	Gas Monitor: MultiRAE Lite (ppm)	TOTAL TPH (mg/Kg)
-58 / 42				4.0/2.5	Same as above		
-56 / 44							
-54 / 46				4.0/3.0			
-52 / 48							
-50 / 50				4.0/3.5	Brownish yellow (10YR 6/6)		
-48 / 52							
-46 / 54				4.0/3.0			
-44 / 56							
-42 / 58				4.0/3.0	Light yellowish brown (10YR 6/4), fine to medium grained		
-40							

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DRILLING DATE: November 5, 2016
DEPTH TO GROUNDWATER: 68.5 ft
COMPLETION DEPTH: 76.0 ft
BACKFILLED WITH: Hydrated Bentonite Chips

DRILLING/SAMPLING METHOD: HSA/Direct Push
DRILLING COMPANY: Gregg Drilling
LOGGED BY: C. Swithenbank, R. Robledo
CHECKED BY: A. Sellinger, P.G., C.Hg.

LOG OF SOIL BORING SBTB9-82

Guadalupe Restoration Project
Guadalupe, California

The log and data presented are a simplification of actual conditions encountered at the time of drilling at the drilled location. Subsurface conditions may differ at other locations and with the passage of time. Please refer to Key to Boring Log for symbol explanation.

December 2016
Project No. 1601-2193

padre associates, inc.
ENGINEERS, GEOLOGISTS & ENVIRONMENTAL SCIENTISTS

LOCATION: Tank Battery 9 (TB9) Area
SURFACE ELEVATION: 98.53 ft +/- (relative datum MSL)
NORTHING: 546699.849
EASTING: 1213990.840
COORDINATE SYSTEM: NAD27 Ca SP Zn 5, feet

ELEVATION, ft MSL / DEPTH, ft	USCS MATERIAL SYMBOL	SAMPLE ID	SAMPLE INTERVAL	RECOVERY (d/r), feet	MATERIAL DESCRIPTION	Gas Monitor: MultiRAE Lite (ppm)	TOTAL TPH (mg/Kg)
38 / 62				4.0/3.0	Same as above		
36 / 64				4.0/4.0			
34 / 66					Dark brown (10YR 3/3), 2-inch thick layer Yellowish brown (10YR 5/8)		
32 / 68		SBTB9-82-67.5-110516		4.0/4.0	Brown (10YR 5/3), moderate odor Gray (10YR 5/1), slightly moist, moderate odor	31	16,402
30 / 70		SBTB9-82-68.5-110516			Very dark gray (N 3/0), dense, wet, moderate to strong odor	13	17,373
28 / 72					Dark gray (N 4/0), slight odor		
26 / 74				4.0/4.0	Dense Silty SAND (SM), dark gray (10YR 4/1), wet Very dark grayish brown (10YR 3/2)		
24 / 76		SBTB9-82-75.5-110516			Dark brown (10YR 3/3)	0	0*
22 / 78					*TPH was not detected at or above the Practical Quantitation Limits for gasoline, diesel or motor oil carbon chain ranges		
20							

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DRILLING DATE: November 5, 2016
DEPTH TO GROUNDWATER: 68.5 ft
COMPLETION DEPTH: 76.0 ft
BACKFILLED WITH: Hydrated Bentonite Chips

DRILLING/SAMPLING METHOD: HSA/Direct Push
DRILLING COMPANY: Gregg Drilling
LOGGED BY: C. Swithenbank, R. Robledo
CHECKED BY: A. Sellinger, P.G., C.Hg.

LOG OF SOIL BORING SBTB9-82

Guadalupe Restoration Project
Guadalupe, California

The log and data presented are a simplification of actual conditions encountered at the time of drilling at the drilled location. Subsurface conditions may differ at other locations and with the passage of time. Please refer to Key to Boring Log for symbol explanation.

December 2016
Project No. 1601-2193

padre associates, inc.
ENGINEERS, GEOLOGISTS & ENVIRONMENTAL SCIENTISTS

LOCATION: Tank Battery 9 (TB9) Area
SURFACE ELEVATION: 98.87 ft +/- (relative datum MSL)
NORTHING: 546650.507
EASTING: 1214156.724
COORDINATE SYSTEM: NAD27 Ca SP Zn 5, feet

ELEVATION, ft MSL / DEPTH, ft	USCS MATERIAL SYMBOL	SAMPLE ID	SAMPLE INTERVAL	RECOVERY (d/r), feet	MATERIAL DESCRIPTION	Gas Monitor: MultiRAE Lite (ppm)	TOTAL TPH (mg/Kg)
98 / 0				4.0/4.0	Poorly graded SAND (SP), light yellowish brown (10YR 6/4), slightly moist, fine grained, no odor, hand-augered from surface to 4 feet bgs		
96 / 2					Sump material, poorly graded SAND (SP), black (10YR 2/1), slightly moist, fine grained, moderate odor		
		SBTB9-83-3-110716			Asphaltic, black (N 2.5/0), strong odor	999+	36,530
94 / 4					Continuous Direct Push sampling beginning at 4 feet bgs		
				4.0/3.0			
92 / 6					Poorly graded SAND (SP), very dark brown (10YR 2/2), moist, fine grained, slight odor		
					Yellowish brown (10YR 5/4), no odor		
90 / 8		SBTB9-83-8-110716		4.0/2.8		0	0*
88 / 10					Very dark grayish brown (10YR 3/2)		
86 / 12				4.0/2.8	Yellowish brown (10YR 5/4)		
84 / 14							
82 / 16				4.0/3.0			
80 / 18					Fine to medium grained Fine grained		

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DRILLING DATE: November 7, 2016
DEPTH TO GROUNDWATER: Not Encountered
COMPLETION DEPTH: 28.0 ft
BACKFILLED WITH: Hydrated Bentonite Chips

DRILLING/SAMPLING METHOD: HSA/Direct Push
DRILLING COMPANY: Gregg Drilling
LOGGED BY: M. McAlpin
CHECKED BY: A. Sellinger, P.G., C.Hg.

LOG OF SOIL BORING SBTB9-83

Guadalupe Restoration Project
Guadalupe, California

The log and data presented are a simplification of actual conditions encountered at the time of drilling at the drilled location. Subsurface conditions may differ at other locations and with the passage of time. Please refer to Key to Boring Log for symbol explanation.

December 2016
Project No. 1601-2193

padre associates, inc.
ENGINEERS, GEOLOGISTS & ENVIRONMENTAL SCIENTISTS

LOCATION: Tank Battery 9 (TB9) Area
SURFACE ELEVATION: 98.87 ft +/- (relative datum MSL)
NORTHING: 546650.507
EASTING: 1214156.724
COORDINATE SYSTEM: NAD27 Ca SP Zn 5, feet

ELEVATION, ft MSL / DEPTH, ft	USCS MATERIAL SYMBOL	SAMPLE ID	SAMPLE INTERVAL	RECOVERY (d/r), feet	MATERIAL DESCRIPTION	Gas Monitor: MultiRAE Lite (ppm)	TOTAL TPH (mg/Kg)
78 / 22				4.0/2.8	Same as above		
76 / 24				4.0/3.0			
74 / 26		SBTB9-83-26.5-110716				0	0*
72 / 28							
70 / 30					*TPH was not detected at or above the Practical Quantitation Limits for gasoline, diesel or motor oil carbon chain ranges		
68 / 32							
66 / 34							
64 / 36							
62 / 38							
60							

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DRILLING DATE: November 7, 2016
DEPTH TO GROUNDWATER: Not Encountered
COMPLETION DEPTH: 28.0 ft
BACKFILLED WITH: Hydrated Bentonite Chips

DRILLING/SAMPLING METHOD: HSA/Direct Push
DRILLING COMPANY: Gregg Drilling
LOGGED BY: M. McAlpin
CHECKED BY: A. Sellinger, P.G., C.Hg.

LOG OF SOIL BORING SBTB9-83

Guadalupe Restoration Project
Guadalupe, California

The log and data presented are a simplification of actual conditions encountered at the time of drilling at the drilled location. Subsurface conditions may differ at other locations and with the passage of time. Please refer to Key to Boring Log for symbol explanation.

December 2016
Project No. 1601-2193

padre associates, inc.
ENGINEERS, GEOLOGISTS & ENVIRONMENTAL SCIENTISTS

LOCATION: Tank Battery 9 (TB9) Area
SURFACE ELEVATION: 98.76 ft +/- (relative datum MSL)
NORTHING: 546486.512
EASTING: 1214365.885
COORDINATE SYSTEM: NAD27 Ca SP Zn 5, feet

ELEVATION, ft MSL / DEPTH, ft	USCS MATERIAL SYMBOL	SAMPLE ID	SAMPLE INTERVAL	RECOVERY (d/r), feet	MATERIAL DESCRIPTION	Gas Monitor: MultiRAE Lite (ppm)	TOTAL TPH (mg/Kg)
98 / 0				8.0/8.0	Poorly graded SAND (SP), light yellowish brown (10YR 6/4), loose, fine grained, no odor, hand-augered from surface to 8 feet bgs		
96 / 2		SBTB9-84-2.5-110716			Sump material, dense Redrock fragments		35,012
94 / 4		SBTB9-84-4-110716			Poorly graded SAND (SP), light yellowish brown (10YR 6/4), loose, slightly moist, no odor	0	92
92 / 6							
90 / 8				4.0/2.8	Continuous Direct Push sampling beginning at 8 feet bgs Very dark brown (10YR 2/2), moist, fine grained, no odor, trace rootlets Yellowish brown (10YR 5/4)		
88 / 10							
86 / 12				4.0/2.8			
84 / 14					Trace strong brown (7.5YR 5/8) mottling		
82 / 16				4.0/2.8			
80 / 18							

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DRILLING DATE: November 7, 2016
DEPTH TO GROUNDWATER: Not Encountered
COMPLETION DEPTH: 24.0 ft
BACKFILLED WITH: Hydrated Bentonite Chips

DRILLING/SAMPLING METHOD: HSA/Direct Push
DRILLING COMPANY: Gregg Drilling
LOGGED BY: C. Swithenbank, M. McAlpin
CHECKED BY: A. Sellinger, P.G., C.Hg.

LOG OF SOIL BORING SBTB9-84

Guadalupe Restoration Project
Guadalupe, California

The log and data presented are a simplification of actual conditions encountered at the time of drilling at the drilled location. Subsurface conditions may differ at other locations and with the passage of time. Please refer to Key to Boring Log for symbol explanation.

December 2016
Project No. 1601-2193

padre associates, inc.
ENGINEERS, GEOLOGISTS & ENVIRONMENTAL SCIENTISTS

LOCATION: Tank Battery 9 (TB9) Area
SURFACE ELEVATION: 98.76 ft +/- (relative datum MSL)
NORTHING: 546486.512
EASTING: 1214365.885
COORDINATE SYSTEM: NAD27 Ca SP Zn 5, feet

ELEVATION, ft MSL / DEPTH, ft	USCS MATERIAL SYMBOL	SAMPLE ID	SAMPLE INTERVAL	RECOVERY (d/r), feet	MATERIAL DESCRIPTION	Gas Monitor: MultiRAE Lite (ppm)	TOTAL TPH (mg/Kg)
78 / 22		SBTB9-84-22-110716		4.0/2.5	Same as above	0	0*
76 / 24							
74 / 26					*TPH was not detected at or above the Practical Quantitation Limits for gasoline, diesel or motor oil carbon chain ranges		
72 / 28							
70 / 30							
68 / 32							
66 / 34							
64 / 36							
62 / 38							
60							

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DRILLING DATE: November 7, 2016
DEPTH TO GROUNDWATER: Not Encountered
COMPLETION DEPTH: 24.0 ft
BACKFILLED WITH: Hydrated Bentonite Chips

DRILLING/SAMPLING METHOD: HSA/Direct Push
DRILLING COMPANY: Gregg Drilling
LOGGED BY: C. Swithenbank, M. McAlpin
CHECKED BY: A. Sellinger, P.G., C.Hg.

LOG OF SOIL BORING SBTB9-84

Guadalupe Restoration Project
Guadalupe, California

The log and data presented are a simplification of actual conditions encountered at the time of drilling at the drilled location. Subsurface conditions may differ at other locations and with the passage of time. Please refer to Key to Boring Log for symbol explanation.

December 2016
Project No. 1601-2193

padre associates, inc.
ENGINEERS, GEOLOGISTS & ENVIRONMENTAL SCIENTISTS

LOCATION: Tank Battery 9 (TB9) Area
SURFACE ELEVATION: 76.81 ft +/- (relative datum MSL)
NORTHING: 546311.850
EASTING: 1214649.166
COORDINATE SYSTEM: NAD27 Ca SP Zn 5, feet

ELEVATION, ft MSL / DEPTH, ft	USCS MATERIAL SYMBOL	SAMPLE ID	SAMPLE INTERVAL	RECOVERY (d/r), feet	MATERIAL DESCRIPTION	Gas Monitor: MultiRAE Lite (ppm)	TOTAL TPH (mg/Kg)
76 / 0				8.0/8.0	Poorly graded SAND (SP), light yellowish brown (10YR 6/4), loose, fine grained, no odor, hand-augered from surface to 8 feet bgs		
					Dark brown (10YR 3/3)		
		SBTB9-85-1.5-110716			Sump material, dense, fine grained, 3-inch thick layer		7,259
74 / 2		SBTB9-85-2-110716			Poorly graded SAND (SP), light yellowish brown (10YR 6/4), loose, fine grained		820
					Brownish yellow (10YR 6/6), slightly moist		
72 / 4							
70 / 6							
					Continuous Direct Push sampling beginning at 8 feet bgs		
68 / 8				4.0/2.5	Poorly graded SAND (SP), yellowish brown (10YR 5/4), moist, fine grained		
66 / 10							
64 / 12				4.0/3.0	Trace mafic minerals		
62 / 14							
60 / 16				4.0/2.5	Laminated medium grained sand		
58 / 18							

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DRILLING DATE: November 7, 2016
DEPTH TO GROUNDWATER: Not Encountered
COMPLETION DEPTH: 24.0 ft
BACKFILLED WITH: Hydrated Bentonite Chips

DRILLING/SAMPLING METHOD: HSA/Direct Push
DRILLING COMPANY: Gregg Drilling
LOGGED BY: C. Swithenbank, M. McAlpin
CHECKED BY: A. Sellinger, P.G., C.Hg.

LOG OF SOIL BORING SBTB9-85

Guadalupe Restoration Project
Guadalupe, California

The log and data presented are a simplification of actual conditions encountered at the time of drilling at the drilled location. Subsurface conditions may differ at other locations and with the passage of time. Please refer to Key to Boring Log for symbol explanation.

December 2016
Project No. 1601-2193

padre associates, inc.
ENGINEERS, GEOLOGISTS & ENVIRONMENTAL SCIENTISTS

LOCATION: Tank Battery 9 (TB9) Area
SURFACE ELEVATION: 76.81 ft +/- (relative datum MSL)
NORTHING: 546311.850
EASTING: 1214649.166
COORDINATE SYSTEM: NAD27 Ca SP Zn 5, feet

ELEVATION, ft MSL / DEPTH, ft	USCS MATERIAL SYMBOL	SAMPLE ID	SAMPLE INTERVAL	RECOVERY (d/r), feet	MATERIAL DESCRIPTION	Gas Monitor: MultiRAE Lite (ppm)	TOTAL TPH (mg/Kg)
56 / 22				4.0/2.8	Frequent striated medium grained sand		
54 / 24		SBTB9-85-22.5-110716				0	0*
52 / 26					*TPH was not detected at or above the Practical Quantitation Limits for gasoline, diesel or motor oil carbon chain ranges		
50 / 28							
48 / 30							
46 / 32							
44 / 34							
42 / 36							
40 / 38							
38							

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DRILLING DATE: November 7, 2016
DEPTH TO GROUNDWATER: Not Encountered
COMPLETION DEPTH: 24.0 ft
BACKFILLED WITH: Hydrated Bentonite Chips

DRILLING/SAMPLING METHOD: HSA/Direct Push
DRILLING COMPANY: Gregg Drilling
LOGGED BY: C. Swithenbank, M. McAlpin
CHECKED BY: A. Sellinger, P.G., C.Hg.

LOG OF SOIL BORING SBTB9-85

Guadalupe Restoration Project
Guadalupe, California

The log and data presented are a simplification of actual conditions encountered at the time of drilling at the drilled location. Subsurface conditions may differ at other locations and with the passage of time. Please refer to Key to Boring Log for symbol explanation.

December 2016
Project No. 1601-2193

padre associates, inc.
ENGINEERS, GEOLOGISTS & ENVIRONMENTAL SCIENTISTS

LOCATION: Tank Battery 9 (TB9) Area
SURFACE ELEVATION: 67.16 ft +/- (relative datum MSL)
NORTHING: 546118.007
EASTING: 1214932.830
COORDINATE SYSTEM: NAD27 Ca SP Zn 5, feet

ELEVATION, ft MSL / DEPTH, ft	USCS MATERIAL SYMBOL	SAMPLE ID	SAMPLE INTERVAL	RECOVERY (d/r), feet	MATERIAL DESCRIPTION	Gas Monitor: MultiRAE Lite (ppm)	TOTAL TPH (mg/Kg)
66 / 2				8.0/8.0	Poorly graded SAND (SP), light yellowish brown (10YR 6/4), slightly moist, fine grained, no odor, hand-augered from surface to 8 feet bgs		
					Brown (10YR 4/3), moist, torn pieces of fabric liner		
64 / 4					Poorly graded SAND (SP) with crude oil, few fine gravel sized sump material clasts, hard, dry, no odor		
62 / 6					Clayey SAND (SC), brown (10YR 4/3), moist, fine grained sand, non-plastic, 1-inch thick layer		
60 / 8					Continuous Direct Push sampling beginning at 8 feet bgs		
				4.0/3.0	Very dark grayish brown (10YR 3/2)		
58 / 10					Yellowish brown (10YR 5/4)		
					Brown (10YR 4/3)		
56 / 12				4.0/3.0	Dark reddish brown (5YR 3/4)		
		SBTB9-86-12.5-110816			Sump material, sand with crude oil, black (N 2.5/0), hard, dry, slight odor	0	13,400
54 / 14		SBTB9-86-13-110816			Poorly graded SAND (SP), frequent laminated dark reddish brown (5YR 3/4) and yellowish brown (10YR 5/4)	0	0*
					Yellowish brown (10YR 5/4) with strong brown (7.5YR 4/6) mottling		
52 / 16				4.0/3.0	Strong brown (7.5YR 4/6)		
					Yellowish brown (10YR 5/4)		
50 / 18							
48							

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DRILLING DATE: November 8, 2016
DEPTH TO GROUNDWATER: Not Encountered
COMPLETION DEPTH: 32.0 ft
BACKFILLED WITH: Hydrated Bentonite Chips

DRILLING/SAMPLING METHOD: HSA/Direct Push
DRILLING COMPANY: Gregg Drilling
LOGGED BY: M. McAlpin
CHECKED BY: A. Sellinger, P.G., C.Hg.

LOG OF SOIL BORING SBTB9-86

Guadalupe Restoration Project
Guadalupe, California

The log and data presented are a simplification of actual conditions encountered at the time of drilling at the drilled location. Subsurface conditions may differ at other locations and with the passage of time. Please refer to Key to Boring Log for symbol explanation.

December 2016
Project No. 1601-2193

padre associates, inc.
ENGINEERS, GEOLOGISTS & ENVIRONMENTAL SCIENTISTS

LOCATION: Tank Battery 9 (TB9) Area
SURFACE ELEVATION: 67.16 ft +/- (relative datum MSL)
NORTHING: 546118.007
EASTING: 1214932.830
COORDINATE SYSTEM: NAD27 Ca SP Zn 5, feet

ELEVATION, ft MSL / DEPTH, ft	USCS MATERIAL SYMBOL	SAMPLE ID	SAMPLE INTERVAL	RECOVERY (d/r), feet	MATERIAL DESCRIPTION	Gas Monitor: MultiRAE Lite (ppm)	TOTAL TPH (mg/Kg)
46 / 22				4.0/3.0	Trace mafic minerals Yellowish red (5YR 4/6)		
44 / 24				4.0/3.0	Dark reddish brown (5YR 3/4) Yellowish brown (10YR 5/4) Medium to fine grained		
42 / 26							
40 / 28				4.0/3.0	Frequent laminated trace mafic minerals		
38 / 30		SBTB9-86-30.5-110816				0	0*
36 / 32							
34 / 34					*TPH was not detected at or above the Practical Quantitation Limits for gasoline, diesel or motor oil carbon chain ranges		
32 / 36							
30 / 38							
28							

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DRILLING DATE: November 8, 2016
DEPTH TO GROUNDWATER: Not Encountered
COMPLETION DEPTH: 32.0 ft
BACKFILLED WITH: Hydrated Bentonite Chips

DRILLING/SAMPLING METHOD: HSA/Direct Push
DRILLING COMPANY: Gregg Drilling
LOGGED BY: M. McAlpin
CHECKED BY: A. Sellinger, P.G., C.Hg.

LOG OF SOIL BORING SBTB9-86

Guadalupe Restoration Project
Guadalupe, California

The log and data presented are a simplification of actual conditions encountered at the time of drilling at the drilled location. Subsurface conditions may differ at other locations and with the passage of time. Please refer to Key to Boring Log for symbol explanation.

December 2016
Project No. 1601-2193

padre associates, inc.
ENGINEERS, GEOLOGISTS & ENVIRONMENTAL SCIENTISTS

LOCATION: Tank Battery 9 (TB9) Area
SURFACE ELEVATION: 71.14 ft +/- (relative datum MSL)
NORTHING: 546036.922
EASTING: 1214743.216
COORDINATE SYSTEM: NAD27 Ca SP Zn 5, feet

ELEVATION, ft MSL / DEPTH, ft	USCS MATERIAL SYMBOL	SAMPLE ID	SAMPLE INTERVAL	RECOVERY (d/r), feet	MATERIAL DESCRIPTION	Gas Monitor: MultiRAE Lite (ppm)	TOTAL TPH (mg/Kg)
70 / 2				8.0/8.0	Poorly graded SAND (SP), light yellowish brown (10YR 6/4), loose, fine grained, no odor, hand-augered from surface to 8 feet bgs		
					Felt liner		
68 / 4					Dark brown (10YR 3/3), hard		
66 / 6		SBTB9-87-5-110816			Sump material		13,400
64 / 8				4.0/2.5	Greenish gray (10GY 5/1), loose, fine grained, sulfur odor Continuous Direct Push sampling beginning at 8 feet bgs		
62 / 10		SBTB9-87-9-110816			Poorly graded SAND (SP), dark grayish brown (10YR 4/2), moist, fine grained, slight odor Yellowish brown (10YR 5/4), no odor Trace silt	0	0*
60 / 12				4.0/3.5			
58 / 14					Trace strong brown (7.5YR 5/8) Little strong brown (7.5YR 5/8) mottling		
56 / 16				4.0/3.0	Yellowish brown (10YR 5/4)		
54 / 18					Trace dark yellowish brown (10YR 3/6) mottling		
52							

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DRILLING DATE: November 8, 2016
DEPTH TO GROUNDWATER: Not Encountered
COMPLETION DEPTH: 32.0 ft
BACKFILLED WITH: Hydrated Bentonite Chips

DRILLING/SAMPLING METHOD: HSA/Direct Push
DRILLING COMPANY: Gregg Drilling
LOGGED BY: C. Swithenbank, M. McAlpin
CHECKED BY: A. Sellinger, P.G., C.Hg.

LOG OF SOIL BORING SBTB9-87

Guadalupe Restoration Project
Guadalupe, California

The log and data presented are a simplification of actual conditions encountered at the time of drilling at the drilled location. Subsurface conditions may differ at other locations and with the passage of time. Please refer to Key to Boring Log for symbol explanation.

December 2016
Project No. 1601-2193

padre associates, inc.
ENGINEERS, GEOLOGISTS & ENVIRONMENTAL SCIENTISTS

LOCATION: Tank Battery 9 (TB9) Area
SURFACE ELEVATION: 71.14 ft +/- (relative datum MSL)
NORTHING: 546036.922
EASTING: 1214743.216
COORDINATE SYSTEM: NAD27 Ca SP Zn 5, feet

ELEVATION, ft MSL / DEPTH, ft	USCS MATERIAL SYMBOL	SAMPLE ID	SAMPLE INTERVAL	RECOVERY (d/r), feet	MATERIAL DESCRIPTION	Gas Monitor: MultiRAE Lite (ppm)	TOTAL TPH (mg/Kg)
50 / 22				4.0/3.0			
48 / 24				4.0/2.5	Frequent laminated yellowish brown (10YR 5/8) Very dark brown (10YR 2/2) Very dark grayish brown (10YR 3/2)		
46 / 26							
44 / 28				4.0/2.5	Brown (10YR 4/3) Yellowish brown (10YR 5/4)		
42 / 30		SBTB9-87-30-110816				0	0*
40 / 32							
38 / 34					*TPH was not detected at or above the Practical Quantitation Limits for gasoline, diesel or motor oil carbon chain ranges		
36 / 36							
34 / 38							
32							

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DRILLING DATE: November 8, 2016
DEPTH TO GROUNDWATER: Not Encountered
COMPLETION DEPTH: 32.0 ft
BACKFILLED WITH: Hydrated Bentonite Chips

DRILLING/SAMPLING METHOD: HSA/Direct Push
DRILLING COMPANY: Gregg Drilling
LOGGED BY: C. Swithenbank, M. McAlpin
CHECKED BY: A. Sellinger, P.G., C.Hg.

LOG OF SOIL BORING SBTB9-87

Guadalupe Restoration Project
Guadalupe, California

The log and data presented are a simplification of actual conditions encountered at the time of drilling at the drilled location. Subsurface conditions may differ at other locations and with the passage of time. Please refer to Key to Boring Log for symbol explanation.

December 2016
Project No. 1601-2193

padre associates, inc.
ENGINEERS, GEOLOGISTS & ENVIRONMENTAL SCIENTISTS

LOCATION: Tank Battery 9 (TB9) Area
SURFACE ELEVATION: 79.77 ft +/- (relative datum MSL)
NORTHING: 546165.892
EASTING: 1214542.829
COORDINATE SYSTEM: NAD27 Ca SP Zn 5, feet

ELEVATION, ft MSL / DEPTH, ft	USCS MATERIAL SYMBOL	SAMPLE ID	SAMPLE INTERVAL	RECOVERY (d/r), feet	MATERIAL DESCRIPTION	Gas Monitor: MultiRAE Lite (ppm)	TOTAL TPH (mg/Kg)
78 / 2				8.0/8.0	Poorly graded SAND (SP), light yellowish brown (10YR 6/4), loose, fine grained, no odor, hand-augered from surface to 8 feet bgs		
					Felt liner		
		SBTB9-88-2.5-110816			Sump material, poorly graded SAND (SP), black (N 2.5/0), stiff, moist, strong odor, asphaltic		7,300
76 / 4							
					Gray (10YR 5/1), moderate odor		
74 / 6					Redrock clasts		
72 / 8					Continuous Direct Push sampling beginning at 8 feet bgs		
				4.0/3.3			
70 / 10							
68 / 12		SBTB9-88-12-110816		4.0/2.3	Sheen	999+	51,700
					Poorly graded SAND (SP), brown (10YR 4/3), moist, fine grained, slight odor		
66 / 14		SBTB9-88-14-110816			Yellowish brown (10YR 5/4), no odor	0	0*
64 / 16				4.0/2.8			
62 / 18							
60							

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DRILLING DATE: November 8, 2016
DEPTH TO GROUNDWATER: Not Encountered
COMPLETION DEPTH: 36.0 ft
BACKFILLED WITH: Hydrated Bentonite Chips

DRILLING/SAMPLING METHOD: HSA/Direct Push
DRILLING COMPANY: Gregg Drilling
LOGGED BY: C. Swithenbank, M. McAlpin
CHECKED BY: A. Sellinger, P.G., C.Hg.

LOG OF SOIL BORING SBTB9-88

Guadalupe Restoration Project
Guadalupe, California

The log and data presented are a simplification of actual conditions encountered at the time of drilling at the drilled location. Subsurface conditions may differ at other locations and with the passage of time. Please refer to Key to Boring Log for symbol explanation.

December 2016
Project No. 1601-2193

padre associates, inc.
ENGINEERS, GEOLOGISTS & ENVIRONMENTAL SCIENTISTS

LOCATION: Tank Battery 9 (TB9) Area
SURFACE ELEVATION: 79.77 ft +/- (relative datum MSL)
NORTHING: 546165.892
EASTING: 1214542.829
COORDINATE SYSTEM: NAD27 Ca SP Zn 5, feet

ELEVATION, ft MSL / DEPTH, ft	USCS MATERIAL SYMBOL	SAMPLE ID	SAMPLE INTERVAL	RECOVERY (d/r), feet	MATERIAL DESCRIPTION	Gas Monitor: MultiRAE Lite (ppm)	TOTAL TPH (mg/Kg)
-58 / 22				4.0/2.5			
-56 / 24				4.0/2.8	Frequent laminated strong brown (7.5YR 5/8) and yellowish brown (10YR 5/4)		
-54 / 26							
-52 / 28				4.0/3.3	Yellowish brown (10YR 5/4), trace strong brown (7.5YR 5/8)		
-50 / 30							
-48 / 32				4.0/2.5	Frequent laminated strong brown (7.5YR 5/8)		
-46 / 34		SBTB9-88-34-110816					0*
-44 / 36							
-42 / 38					*TPH was not detected at or above the Practical Quantitation Limits for gasoline, diesel or motor oil carbon chain ranges		
-40							

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DRILLING DATE: November 8, 2016
DEPTH TO GROUNDWATER: Not Encountered
COMPLETION DEPTH: 36.0 ft
BACKFILLED WITH: Hydrated Bentonite Chips

DRILLING/SAMPLING METHOD: HSA/Direct Push
DRILLING COMPANY: Gregg Drilling
LOGGED BY: C. Swithenbank, M. McAlpin
CHECKED BY: A. Sellinger, P.G., C.Hg.

LOG OF SOIL BORING SBTB9-88

Guadalupe Restoration Project
Guadalupe, California

The log and data presented are a simplification of actual conditions encountered at the time of drilling at the drilled location. Subsurface conditions may differ at other locations and with the passage of time. Please refer to Key to Boring Log for symbol explanation.

December 2016
Project No. 1601-2193

padre associates, inc.
ENGINEERS, GEOLOGISTS & ENVIRONMENTAL SCIENTISTS

LOCATION: Tank Battery 9 (TB9) Area
SURFACE ELEVATION: 88.27 ft +/- (relative datum MSL)
NORTHING: 546288.072
EASTING: 1214331.897
COORDINATE SYSTEM: NAD27 Ca SP Zn 5, feet

ELEVATION, ft MSL / DEPTH, ft	USCS MATERIAL SYMBOL	SAMPLE ID	SAMPLE INTERVAL	RECOVERY (d/r), feet	MATERIAL DESCRIPTION	Gas Monitor: MultiRAE Lite (ppm)	TOTAL TPH (mg/Kg)
88 / 0				8.0/8.0	Poorly graded SAND (SP), light yellowish brown (10YR 6/4), no odor, hand-augered from surface to 8 feet bgs Dark yellowish brown (10YR 4/4)		
86 / 2							
84 / 4							
82 / 6							
80 / 8				4.0/3.0	Continuous Direct Push sampling beginning at 8 feet bgs Yellowish brown (10YR 5/4), moist, fine grained, no odor		
78 / 10					Brown (10YR 4/3), 1/4-inch thick layer		
76 / 12				4.0/2.5	Occasional striated brown (10YR 4/3)		
74 / 14							
72 / 16				4.0/2.5	Frequent striated dark brown (10YR 3/3)		
70 / 18					Dark brown (10YR 3/3)		

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DRILLING DATE: November 9, 2016
DEPTH TO GROUNDWATER: Not Encountered
COMPLETION DEPTH: 24.0 ft
BACKFILLED WITH: Hydrated Bentonite Chips

DRILLING/SAMPLING METHOD: HSA/Direct Push
DRILLING COMPANY: Gregg Drilling
LOGGED BY: M. McAlpin, R. Robledo
CHECKED BY: A. Sellinger, P.G., C.Hg.

LOG OF SOIL BORING SBTB9-89

Guadalupe Restoration Project
Guadalupe, California

The log and data presented are a simplification of actual conditions encountered at the time of drilling at the drilled location. Subsurface conditions may differ at other locations and with the passage of time. Please refer to Key to Boring Log for symbol explanation.

December 2016
Project No. 1601-2193

padre associates, inc.
ENGINEERS, GEOLOGISTS & ENVIRONMENTAL SCIENTISTS

ELEVATION, ft MSL / DEPTH, ft	USCS MATERIAL SYMBOL	SAMPLE ID	SAMPLE INTERVAL	RECOVERY (d/r), feet	LOCATION: Tank Battery 9 (TB9) Area SURFACE ELEVATION: 88.27 ft +/- (relative datum MSL) NORTHING: 546288.072 EASTING: 1214331.897 COORDINATE SYSTEM: NAD27 Ca SP Zn 5, feet MATERIAL DESCRIPTION	Gas Monitor: MultiRAE Lite (ppm)	TOTAL TPH (mg/Kg)
68 / 0				4.0/3.5	Yellowish brown (10YR 5/4)		
66 / 2		SBTB9-89-23-110916				0	0*
64 / 4					*TPH was not detected at or above the Practical Quantitation Limits for gasoline, diesel or motor oil carbon chain ranges		
62 / 6							
60 / 8							
58 / 10							
56 / 12							
54 / 14							
52 / 16							
50 / 18							

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DRILLING DATE: November 9, 2016
DEPTH TO GROUNDWATER: Not Encountered
COMPLETION DEPTH: 24.0 ft
BACKFILLED WITH: Hydrated Bentonite Chips

DRILLING/SAMPLING METHOD: HSA/Direct Push
DRILLING COMPANY: Gregg Drilling
LOGGED BY: M. McAlpin, R. Robledo
CHECKED BY: A. Sellinger, P.G., C.Hg.

LOG OF SOIL BORING SBTB9-89

Guadalupe Restoration Project
Guadalupe, California

The log and data presented are a simplification of actual conditions encountered at the time of drilling at the drilled location. Subsurface conditions may differ at other locations and with the passage of time. Please refer to Key to Boring Log for symbol explanation.

December 2016
Project No. 1601-2193

padre associates, inc.
ENGINEERS, GEOLOGISTS & ENVIRONMENTAL SCIENTISTS

LOCATION: Tank Battery 9 (TB9) Area
SURFACE ELEVATION: 90.65 ft +/- (relative datum MSL)
NORTHING: 546408.385
EASTING: 1214178.577
COORDINATE SYSTEM: NAD27 Ca SP Zn 5, feet

ELEVATION, ft MSL / DEPTH, ft	USCS MATERIAL SYMBOL	SAMPLE ID	SAMPLE INTERVAL	RECOVERY (d/r), feet	MATERIAL DESCRIPTION	Gas Monitor: MultiRAE Lite (ppm)	TOTAL TPH (mg/Kg)
90 / 0				8.0/8.0	Poorly graded SAND (SP), light yellowish brown (2.5Y 6/3), no odor, hand-augered from surface to 8 feet bgs		
88 / 2							
86 / 4					Brown (10YR 4/3), moist, medium grained		
84 / 6		SBTB9-90-6-110916			Very dark grayish brown (10YR 3/2), medium grained, moderate hydrocarbon odor	999+	27,000
					Sump material, poorly graded SAND (SP), black (N 2.5/0), stiff, moist, fine grained, strong hydrocarbon odor, asphaltic		
82 / 8					Continuous Direct Push sampling beginning at 8 feet bgs		
				4.0/3.0			
80 / 10							
				4.0/2.5			
78 / 12		SBTB9-90-13-110916			Poorly graded SAND (SP), gray (5Y 5/1), moist, fine grained, moderate odor	7	14
76 / 14					Frequent laminated dark gray (2.5Y 4/1)		
				4.0/2.5			
74 / 16							
72 / 18		SBTB9-90-18-110916			Sump material, poorly graded SAND (SP), black (10YR 2/1), soft, moist, fine grained, strong odor, asphaltic	999+	14,000

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DRILLING DATE: November 9, 2016
DEPTH TO GROUNDWATER: Not Encountered
COMPLETION DEPTH: 44.0 ft
BACKFILLED WITH: Hydrated Bentonite Chips

DRILLING/SAMPLING METHOD: HSA/Direct Push
DRILLING COMPANY: Gregg Drilling
LOGGED BY: M. McAlpin, R. Robledo
CHECKED BY: A. Sellinger, P.G., C.Hg.

LOG OF SOIL BORING SBTB9-90

Guadalupe Restoration Project
Guadalupe, California

The log and data presented are a simplification of actual conditions encountered at the time of drilling at the drilled location. Subsurface conditions may differ at other locations and with the passage of time. Please refer to Key to Boring Log for symbol explanation.

December 2016
Project No. 1601-2193

padre associates, inc.
ENGINEERS, GEOLOGISTS & ENVIRONMENTAL SCIENTISTS

LOCATION: Tank Battery 9 (TB9) Area
SURFACE ELEVATION: 90.65 ft +/- (relative datum MSL)
NORTHING: 546408.385
EASTING: 1214178.577
COORDINATE SYSTEM: NAD27 Ca SP Zn 5, feet

ELEVATION, ft MSL / DEPTH, ft	USCS MATERIAL SYMBOL	SAMPLE ID	SAMPLE INTERVAL	RECOVERY (d/r), feet	MATERIAL DESCRIPTION	Gas Monitor: MultiRAE Lite (ppm)	TOTAL TPH (mg/Kg)
70 / 20				4.0/3.0	Same as above		
68 / 22		SBTB9-90-21.5-110916			Poorly graded SAND (SP), dark gray (5Y 4/1), moist, fine grained, moderate odor	557	1.0
66 / 24				4.0/2.8	1 1/2-inch thick layer black (N 2.5/0), moderate to slight odor		
64 / 26							
62 / 28		SBTB9-90-28-110916		4.0/3.0	Gray (5Y 5/1)	2	0*
60 / 30							
58 / 32				4.0/3.0			
56 / 34							
54 / 36				4.0/2.5	Gray (2.5Y 5/1)		
52 / 38							

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DRILLING DATE: November 9, 2016
DEPTH TO GROUNDWATER: Not Encountered
COMPLETION DEPTH: 44.0 ft
BACKFILLED WITH: Hydrated Bentonite Chips

DRILLING/SAMPLING METHOD: HSA/Direct Push
DRILLING COMPANY: Gregg Drilling
LOGGED BY: M. McAlpin, R. Robledo
CHECKED BY: A. Sellinger, P.G., C.Hg.

LOG OF SOIL BORING SBTB9-90

Guadalupe Restoration Project
Guadalupe, California

The log and data presented are a simplification of actual conditions encountered at the time of drilling at the drilled location. Subsurface conditions may differ at other locations and with the passage of time. Please refer to Key to Boring Log for symbol explanation.

December 2016
Project No. 1601-2193

padre associates, inc.
ENGINEERS, GEOLOGISTS & ENVIRONMENTAL SCIENTISTS

LOCATION: Tank Battery 9 (TB9) Area
SURFACE ELEVATION: 90.65 ft +/- (relative datum MSL)
NORTHING: 546408.385
EASTING: 1214178.577
COORDINATE SYSTEM: NAD27 Ca SP Zn 5, feet

ELEVATION, ft MSL / DEPTH, ft	USCS MATERIAL SYMBOL	SAMPLE ID	SAMPLE INTERVAL	RECOVERY (d/r), feet	MATERIAL DESCRIPTION	Gas Monitor: MultiRAE Lite (ppm)	TOTAL TPH (mg/Kg)
50 / 42				4.0/3.8	Same as above		
48 / 44		SBTB9-90-43.5-110916				1	0*
46 / 46					*TPH was not detected at or above the Practical Quantitation Limits for gasoline, diesel or motor oil carbon chain ranges		
44 / 48							
42 / 50							
40 / 52							
38 / 54							
36 / 56							
34 / 58							
32							

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DRILLING DATE: November 9, 2016
DEPTH TO GROUNDWATER: Not Encountered
COMPLETION DEPTH: 44.0 ft
BACKFILLED WITH: Hydrated Bentonite Chips

DRILLING/SAMPLING METHOD: HSA/Direct Push
DRILLING COMPANY: Gregg Drilling
LOGGED BY: M. McAlpin, R. Robledo
CHECKED BY: A. Sellinger, P.G., C.Hg.

LOG OF SOIL BORING SBTB9-90

Guadalupe Restoration Project
Guadalupe, California

The log and data presented are a simplification of actual conditions encountered at the time of drilling at the drilled location. Subsurface conditions may differ at other locations and with the passage of time. Please refer to Key to Boring Log for symbol explanation.

December 2016
Project No. 1601-2193

padre associates, inc.
ENGINEERS, GEOLOGISTS & ENVIRONMENTAL SCIENTISTS

LOCATION: Tank Battery 9 (TB9) Area
SURFACE ELEVATION: 93.30 ft +/- (relative datum MSL)
NORTHING: 546506.759
EASTING: 1214070.533
COORDINATE SYSTEM: NAD27 Ca SP Zn 5, feet

ELEVATION, ft MSL / DEPTH, ft	USCS MATERIAL SYMBOL	SAMPLE ID	SAMPLE INTERVAL	RECOVERY (d/r), feet	MATERIAL DESCRIPTION	Gas Monitor: MultiRAE Lite (ppm)	TOTAL TPH (mg/Kg)
92 / 2				8.0/8.0	Poorly graded SAND (SP), dark yellowish brown (10YR 4/4), medium grained, no odor, hand-augered from surface to 8 feet bgs		
90 / 4		SBTB9-91-3-110916			Poorly graded SAND (SP) with crude oil, few fine gravel-sized sump material, very dark brown (10YR 2/2), hard, dry, slight hydrocarbon odor	0	500
		SBTB9-91-4.5-110916			Poorly graded SAND (SP), dark yellowish brown (10YR 4/4), no odor	0	720
88 / 6		SBTB9-91-6-110916			Sump material, black (N 2.5/0), moist, fine grained, asphaltic, strong odor	999+	16,330
86 / 8		SBTB9-91-7-110916			Poorly graded SAND (SP), dark yellowish brown (10YR 4/4), dry, fine gravel, no odor	0	680
					Continuous Direct Push sampling beginning at 8 feet bgs		
84 / 10				4.0/2.0	Poorly graded SAND (SP), dark brown (10YR 3/3), moist, fine grained, no odor Sump material, asphaltic, hard, dry, 1-inch thick layer, trace fine gravel-sized redrock Trace asphaltic material, hard, dry, slight odor		
82 / 12				4.0/2.8			
80 / 14					Occasional laminated sump material, hard, dry, slight odor		
78 / 16				4.0/2.5	Brown (10YR 4/3)		
76 / 18		SBTB9-91-18-110916			Sump material, poorly graded SAND (SP), black (N 2.5/0), stiff, moist, fine grained, asphaltic	999+	26,290
74							

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DRILLING DATE: November 9, 2016
DEPTH TO GROUNDWATER: Not Encountered
COMPLETION DEPTH: 52.0 ft
BACKFILLED WITH: Hydrated Bentonite Chips

DRILLING/SAMPLING METHOD: HSA/Direct Push
DRILLING COMPANY: Gregg Drilling
LOGGED BY: M. McAlpin, R. Robledo
CHECKED BY: A. Sellinger, P.G., C.Hg.

LOG OF SOIL BORING SBTB9-91

Guadalupe Restoration Project
Guadalupe, California

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December 2016
Project No. 1601-2193

padre associates, inc.
ENGINEERS, GEOLOGISTS & ENVIRONMENTAL SCIENTISTS

LOCATION: Tank Battery 9 (TB9) Area
SURFACE ELEVATION: 93.30 ft +/- (relative datum MSL)
NORTHING: 546506.759
EASTING: 1214070.533
COORDINATE SYSTEM: NAD27 Ca SP Zn 5, feet

ELEVATION, ft MSL / DEPTH, ft	USCS MATERIAL SYMBOL	SAMPLE ID	SAMPLE INTERVAL	RECOVERY (d/r), feet	MATERIAL DESCRIPTION	Gas Monitor: MultiRAE Lite (ppm)	TOTAL TPH (mg/Kg)
72 / 22				4.0/2.0	Few fine angular gravel Sheen visible on sump material		
70 / 24				4.0/3.0			
68 / 26					Very dark brown (10YR 2/2)		
66 / 28				4.0/3.5	Frequent laminated light yellowish brown (2.5Y 6/4)		
64 / 30		SBTB9-91-29.5-110916			Poorly graded SAND (SP), light yellowish brown (2.5Y 6/4), moist, fine grained, few light gray (2.5Y 7/2) and olive yellow (2.5Y 6/6) mottling, moderate sulfur odor	0	43
62 / 32				4.0/3.5	Light gray (2.5Y 7/2), frequent laminated brownish yellow (10YR 6/8), slight sulfur odor		
60 / 34							
58 / 36				4.0/3.0	Light yellowish brown (10YR 6/4), frequent laminated yellowish brown (10YR 5/8) and very pale brown (10YR 7/4), no odor		
56 / 38							
54							

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DRILLING DATE: November 9, 2016
DEPTH TO GROUNDWATER: Not Encountered
COMPLETION DEPTH: 52.0 ft
BACKFILLED WITH: Hydrated Bentonite Chips

DRILLING/SAMPLING METHOD: HSA/Direct Push
DRILLING COMPANY: Gregg Drilling
LOGGED BY: M. McAlpin, R. Robledo
CHECKED BY: A. Sellinger, P.G., C.Hg.

LOG OF SOIL BORING SBTB9-91

Guadalupe Restoration Project
Guadalupe, California

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December 2016
Project No. 1601-2193

padre associates, inc.
ENGINEERS, GEOLOGISTS & ENVIRONMENTAL SCIENTISTS

LOCATION: Tank Battery 9 (TB9) Area
SURFACE ELEVATION: 93.30 ft +/- (relative datum MSL)
NORTHING: 546506.759
EASTING: 1214070.533
COORDINATE SYSTEM: NAD27 Ca SP Zn 5, feet

ELEVATION, ft MSL / DEPTH, ft	USCS MATERIAL SYMBOL	SAMPLE ID	SAMPLE INTERVAL	RECOVERY (d/r), feet	MATERIAL DESCRIPTION	Gas Monitor: MultiRAE Lite (ppm)	TOTAL TPH (mg/Kg)
52 / 42				4.0/3.0			
50 / 44				4.0/3.0	Yellowish brown (10YR 5/4)		
48 / 46					1/2-inch thick layer of medium grained		
46 / 48				4.0/3.0			
44 / 50					1-inch thick layer of brown (10YR 4/3)		
42 / 52		SBTB9-91-50.5-110916				0	0*
40 / 54					*TPH was not detected at or above the Practical Quantitation Limits for gasoline, diesel or motor oil carbon chain ranges		
38 / 56							
36 / 58							
34							

Z:\GINT\2-GRP\TB9-2016\GRP_TB9_1601-2193.GPJ 12/9/16 01:32 p

DRILLING DATE: November 9, 2016
DEPTH TO GROUNDWATER: Not Encountered
COMPLETION DEPTH: 52.0 ft
BACKFILLED WITH: Hydrated Bentonite Chips

DRILLING/SAMPLING METHOD: HSA/Direct Push
DRILLING COMPANY: Gregg Drilling
LOGGED BY: M. McAlpin, R. Robledo
CHECKED BY: A. Sellinger, P.G., C.Hg.

LOG OF SOIL BORING SBTB9-91

Guadalupe Restoration Project
Guadalupe, California

The log and data presented are a simplification of actual conditions encountered at the time of drilling at the drilled location. Subsurface conditions may differ at other locations and with the passage of time. Please refer to Key to Boring Log for symbol explanation.

APPENDIX B
LABORATORY ANALYTICAL REPORTS
(PROVIDED ON CD)

APPENDIX H

Static and Seismic Slope Stability Analyses

REPORT

Static and Seismic Slope Stability Analyses Tank Battery 9, Soil Management Area

Guadalupe Restoration Project

Submitted to:

Chevron Environmental Management Company
2184 West Thornberry Road
Guadalupe, California 93434

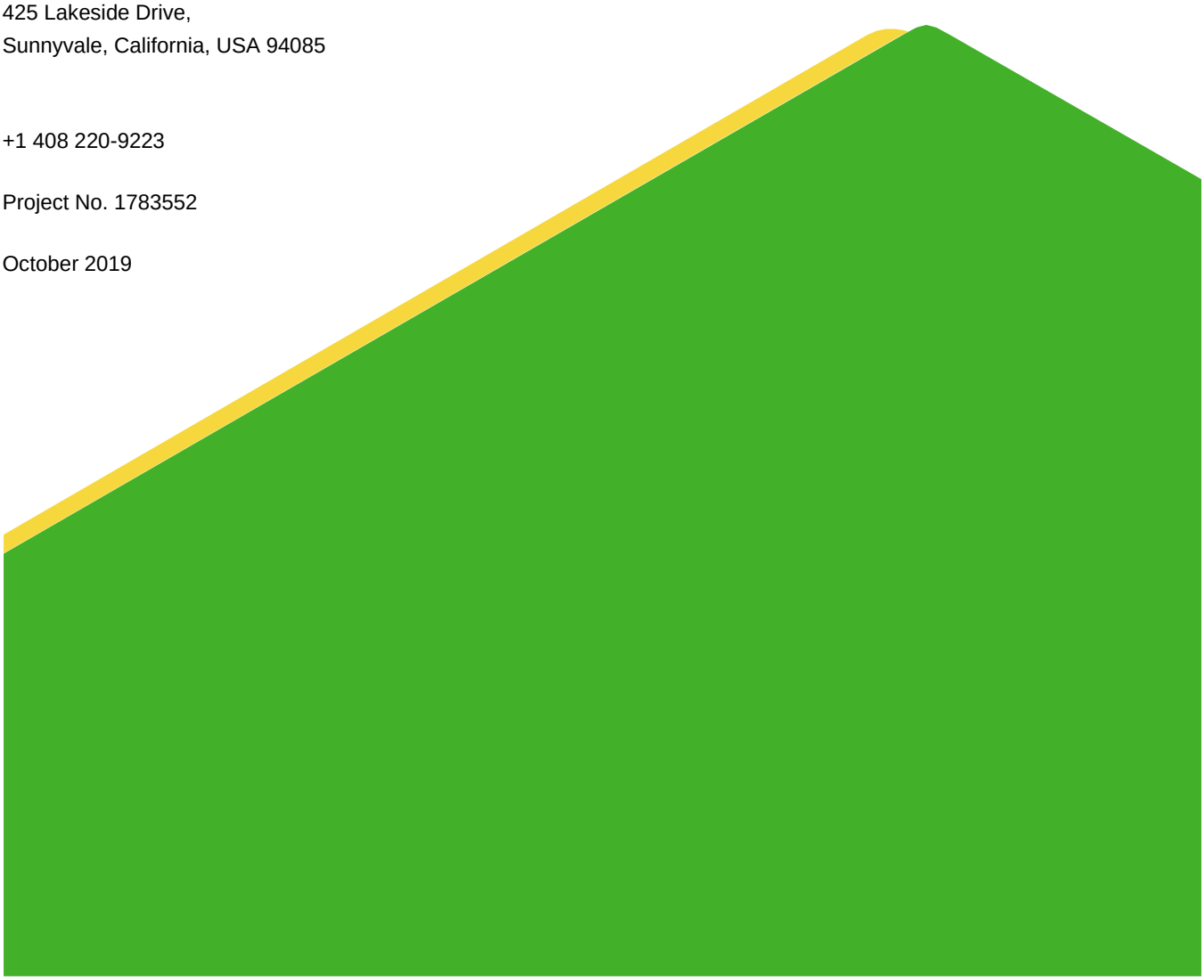
Submitted by:

Golder Associates Inc.
425 Lakeside Drive,
Sunnyvale, California, USA 94085

+1 408 220-9223

Project No. 1783552

October 2019



Distribution List

Chevron Environmental Management Company

Padre Associates, Inc.

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APPENDICES

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1.0 INTRODUCTION

This report presents the results of static and seismic slope stability analyses performed by Golder Associates Inc. (Golder) for the proposed Tank Battery 9 (TB9) Soil Management Area (SMA) at the Guadalupe Restoration Project (GRP). The project site (the site) is located at 2184 West Thornberry Road, Guadalupe, San Luis Obispo County, California (Figure 1). The work performed by Golder included the following tasks:

- Coordinating with Padre Associates, Inc. (Padre) who performed a geotechnical exploration of the site, which included both test borings and cone penetration tests (CPTs)
- Performing static slope stability analysis
- Performing a deterministic seismic hazard analysis (DSHA) to estimate the peak ground acceleration (PGA) anticipated at the site during the maximum credible earthquake (MCE)
- Selecting and spectrally matching acceleration time histories for use in the seismic response analysis for the site
- Seismic slope stability analysis, which included estimating yield acceleration, seismic response analysis, and Newmark-type permanent displacement analysis
- Liquefaction analysis using the CPT data
- Post-liquefaction slope stability analysis

Results of each of the above tasks is discussed in detail in the following sections.

2.0 GEOTECHNICAL EXPLORATION BY PADRE

In August 2018, Gregg Drilling, LLC, working as a subcontractor to Padre, performed three hollow-stem auger (HSA) borings to depths ranging from 40 to 61.5 feet below ground surface (bgs) and 14 CPTs pushed to depths from 31.82 to 59.88 feet bgs. The three HSA borings are designated as SBTB9-92, SBTB9-93, and SBTB9-94. The 14 CPTs are designated as TSAMACPT1 through TSAMCPT14. The locations of the HSA borings and the CPTs are shown Plate 3 in Appendix A.

During the field exploration, Padre also collected five, 5-gallon bucket bulk samples from borrow source material stockpiles at the site for laboratory testing.

The report prepared by Padre (2019) is presented Appendix B; the report presents the test boring and CPT logs, laboratory test results, and a description of the subsurface and ground water depths.

The CPT data was used in an assessment of the liquefaction potential of the dune sands, which is discussed subsequently in Section 5.0.

3.0 STATIC SLOPE STABILITY ANALYSIS

3.1 Design Criterion

Traditional geotechnical practice recommends a minimum static factor of safety (FS) of 1.5 for long-term slope stability of permanent slopes. Accordingly, a minimum FS of 1.5 has been used as the design criterion for the slope stability of permanent slopes of the SMA.

3.2 Critical Slope Stability Cross Sections

By examining the proposed base grading plan (Figure 2) in conjunction with the final grading plan (Figure 3) for the SMA, Golder identified two critical cross sections for analysis of slope stability. The cross sections are designated as A-A' and B-B', the locations of which are shown in both Figures 2 and 3. The cross-sectional profiles A-A' and B-B' used in the slope stability analysis are shown in Figure 4.

3.3 Analysis Method

The slope stability analysis was performed using the SLOPE/W computer program developed by GEO-SLOPE International Ltd. (2017). SLOPE/W performs two-dimensional limit equilibrium analysis using the method of slices to compute FSs against slope instability. The analysis was performed using the Morgenstern-Price procedure (Morgenstern and Price, 1965), which satisfies both force and moment equilibrium.

3.4 Material Parameters

Because the SMA will have geosynthetic components in its liner system, and the shear strength of the internal and interface shear planes within the liner system will control the factors of safety (FS) against slope stability of the SMA. The shear strength of the treated soil and the sand dune subgrade underlying the liner system would have insignificant impact on static slope stability.

3.4.1 Internal/Interface Shear Strength of the Liner System

This section lists the proposed liner system and presents a discussion of the selection of the shear strength of the liner system for use in the slope stability analysis.

The proposed liner system for the SMA will consists of the following components (listed in an ascending order):

Base Liner System

- Prepared subgrade
- 12-inch thick low-permeability clay liner
- 60-mil double-sided textured (DST) high-density polyethylene (HDPE) geomembrane
- Double-sided geocomposite drain
- Geosynthetic clay liner (GCL), needle-punched non-woven geotextile on both sides
- 60-mil DST HDPE geomembrane
- Geotextile cushion layer
- 12-inch thick leachate collection layer
- Geotextile filter layer
- 12-inch thick operations soil layer

Side Slopes Liner System:

- Prepared subgrade
- 12-inch thick low-permeability clay liner

- 60-mil DST HDPE geomembrane
- Double-sided geocomposite drain
- GCL, needle-punched non-woven geotextile on both sides
- 60-mil DST HDPE geomembrane
- Double-sided geocomposite drain
- 12-inch thick operations soil layer

The above liner system will consist of the following shear planes (starting from the bottom):

- Low permeability clay liner/lower surface of the DST HDPE geomembrane interface
- Upper surface DST HDPE geomembrane/lower surface of the geocomposite drain interface
- Upper surface of the DST geocomposite drain/lower surface of the primary GCL interface
- Internal shear plane within the secondary GCL
- Upper surface of the GCL/lower surface of the DST HDPE geomembrane interface
- Upper surface of the DST HDPE geomembrane/lower surface of the geotextile interface
- Geotextile/leachate collection layer interface
- Geotextile/operations layer interface

Of the above eight shear planes listed above, the following six represent the most critical for slope stability:

1) Low permeability clay liner/lower surface of the DST HDPE geomembrane interface
2) Upper surface DST HDPE geomembrane/lower surface of the geocomposite drain interface
3) Upper surface of the DST geocomposite drain/lower surface of the primary GCL interface
4) Internal shear plane within the secondary GCL
5) Upper surface of the GCL/lower surface of the DST HDPE geomembrane interface
6) Upper surface of the DST HDPE geomembrane/lower surface of the geotextile interface

Based on Golder's experience, the weakest of the above shear planes can achieve a maximum large-displacement (at a shear displacement level of 3 inches) shear strength envelope defined by a friction angle of 12 degrees. Accordingly, a large-displacement friction angle of 12 degrees was assigned to both the base and side slope liner systems. However, it is important to note that the actual shear strengths of the critical shear planes listed above will depend on the GCL, the textured HDPE geomembrane, geocomposite drain, and geotextile materials (manufacturer and product) used in the actual liner construction. Also, the shear strength envelope is often non-linear with a lower secant friction angle at higher normal stresses because of internal shearing of the GCL. Therefore, it is critical that the actual shear strengths of the critical shear planes listed above be tested in the laboratory and ascertained before installation of the liner system as recommended in Section 6.2 of this report.

3.4.2 Shear Strength of Treated Soils and Sand Dune

A typical unit weight of 120 pounds per cubic feet (pcf) and a conservative friction angle of 30 degrees was assigned to the treated soils. To restrict the failure surface search within the weaker liner system, the landfill subgrade was assumed as a high strength material. It should be noted that because the shear strength of the liner system is relatively low, the shear strength parameters assigned to the treated soils and the subgrade have very little impact on the results of the analysis.

3.5 Analysis Results

The results of the static slope stability analyses for cross sections A-A' and B-B', assuming a large-strain friction angle of 12 degrees for the liner system, are presented in Figures 5 and 6, respectively. The analyses show acceptable FSs of 1.51 and 1.90 for cross sections A-A' and B-B', respectively.

The detailed results of the static slope stability analysis are presented in Appendix B.

4.0 SEISMIC SLOPE STABILITY ANALYSIS

4.1 Design Criterion

The SMA will be permitted as a Class II landfill under the California Code of Regulations Title 27 (Title 27 CCR). Title 27 CCR requires that Class II landfills be designed to withstand ground motions from the MCE the site is likely to experience. Title 27 CCR defines the MCE as the "maximum earthquake that appears capable of occurring under the presently known geologic framework".

Section 21750(f)(5)(D) of Title 27 CCR requires that a dynamic factor of safety of 1.5 or greater must be achieved for the critical slope, unless a more rigorous method of analysis is used that provides a quantified estimate of the magnitude of slope movement. If a more rigorous method is used, it should be demonstrated that the predicted slope movement could be accommodated without jeopardizing the integrity of the landfill. As discussed in Section 4.2 below, a rigorous seismic slope stability analysis was performed to determine the potential for displacement along the critical slopes. Also, a permanent slope displacement of 6 inches was considered as the maximum acceptable limit, based on the *RCRA Subtitle D (Part 258) Seismic Design Guidance for Municipal Solid Waste Landfill Facilities* (U.S. EPA, 1995).

4.2 Analysis Method

The rigorous seismic slope stability analysis included performing the following tasks:

- DSHA to determine the magnitude of the MCE for the site and associated PGA and acceleration spectrum.
- Pseudo-static slope stability analyses to estimate the yield acceleration for each critical cross sections analyzed, where yield acceleration is the horizontal acceleration that results in a pseudo-static factor of safety of 1.
- Site response analyses using the SHAKE91 (Idriss ad Sun, 1992) computer program to estimate the time history of average horizontal equivalent acceleration (HEA) for the critical failure surface associated with the yield acceleration of each cross section.
- Newmark displacement analyses, which involved the double-integration of the average HEA values that are in excess of the yield acceleration, to estimate the likely magnitudes of permanent displacement during the MCE

Each of these tasks is discussed in detail in the following sections.

4.3 Deterministic Seismic Hazard Analysis

Golder performed a DSHA to determine the magnitude of the MCE for the site and associated PGA and acceleration spectrum. The DSHA included the following steps:

- Compiling the record of historical earthquakes with epicenters located within about a 62 mi (100 km) radius of the Site.
- Compiling information on the location and activity of faults mapped within about 62 mi of the Site. Fault locations and characteristics developed for the third Uniform California Earthquake Rupture Forecast (UCERF3) model were used to identify and characterize the potential MCE sources for the DSHA.
- DSHA to identify the controlling MCE and associated median horizontal PGA.

A Golder technical memorandum discussing the DSHA is presented in Appending C. The DSHA estimated that the Casmalia Fault controls the MCE at the site with a moment magnitude of 6.9. The PGA for 0.48g rock outcrop conditions is estimated to be 0.48g. The spectral accelerations are listed in Table 1.

Table 1: Target MCE Acceleration Response Spectrum

Period (sec)	Spectral Acceleration (g)	Period (sec)	Spectral Acceleration (g)
0.01	0.480	0.5	0.621
0.02	0.494	0.75	0.424
0.03	0.547	1	0.312
0.05	0.685	1.5	0.186
0.075	0.861	2	0.127
0.1	0.980	3	0.075
0.15	1.105	4	0.049
0.2	1.078	5	0.035
0.25	0.990	7.5	0.018
0.3	0.896	10	0.011
0.4	0.742		

The seismic response analysis discussed in Section 4.5 below accounts for attenuation (or amplification) of the ground motions through the overburden soils at the site.

As part of the DSHA, Golder also developed three spectrally matched acceleration time histories to be used as input in the seismic response analysis. The development of the three spectrally matched acceleration time histories involved the following steps:

- Selecting of three previously recorded single-horizontal-component acceleration time histories (seed) for the site MCE.
- Spectrally matching the seed acceleration time histories to the target acceleration response spectrum listed in Table 1.

A technical memorandum that describes the development of the acceleration time histories is also include in Appendix C. Table 2 lists the three acceleration time histories used.

Table 2: Selected Earthquake Acceleration Time Histories

ID	Earthquake Name	Year	Station Name	Designation
1	Loma Prieta	1989	San Jose - Santa Teresa Hills	Lompr.acc
2	Northridge-01	1994	Santa Susana Ground	Nridge.acc
3	Hector Mine	1999	Hector	HectorM.acc

4.4 Yield Acceleration

As noted in Section 4.2 above, yield acceleration is the horizontal acceleration (or seismic coefficient) that results in a pseudo-static FS of 1. It was estimated using an iterative pseudo-static slope stability analysis using SLOPE/W by varying the input horizontal acceleration.

The results of the pseudo-static analysis to estimate the yield accelerations for both cross sections A-A' and B-B' are presented in Figures 7 and 8; the estimated yield accelerations are 0.115g and 0.145g, respectively. Because the yield acceleration for cross section B-B' is significantly higher than that for cross section A-A', the seismic slope stability of cross section B-B' is consider less critical than that of cross section A-A'. Therefore, the seismic response and permanent displacement analyses discussed in the following sections were limited to cross section A-A'.

4.5 Seismic Response Analysis

It should be noted that the PGAs and acceleration time histories discussed in Section 4.3 correspond to outcropping bedrock conditions. The potential for seismically induced permanent displacement during the MCE along the critical SMA slope will depend on the magnitudes of the induced average accelerations with time (or HEA) within the slide mass associated with the yield acceleration. The local conditions (overburden and treated soil) will modify both the PGA and the acceleration time histories induced within the potential slope stability failure surface within the SMA. To estimate the time history of HEA induced within the critical failure surface, seismic response analyses were performed using the SHAKE91 computer program (Idriss and Sun, 1992).

SHAKE91 uses the one-dimensional (1-D) wave propagation theory to compute the response of a visco-elastic semi-infinite horizontally layered soil deposit overlying a uniform half-space subjected to vertically propagating shear waves. The computer program employs an equivalent-linear approximation to model non-linear behavior of soil and rock.

Since SHAKE91 can analyze only 1-D soil columns, a simplification was used to estimate the average response or the horizontal equivalent acceleration (HEA) of the two-dimensional (2-D) trial slip surface. It is assumed that the response of a 2-D trial slip surface can be approximated by the response of an average 1-D column located within the critical failure surface corresponding to the yield acceleration. It should be noted that the computed HEA time history based on a single 1-D column is conservative. In other words, averaging of HEA values from multiple 1-D soil columns, which is more representative of a 2-D response, would result in lower HEA values because of averaging of the spatial incoherence (i.e., at any instant of time, different points within the trial slip surface have different magnitudes, and the averaging results in lower HEA). Also, HEA values estimated based on SHAKE91 are conservative compared to those obtained from a 2-D seismic response analysis using computer programs such as QUAD4M, based on Golder's experience.

The average height of the most critical potential slide surface within cross section A-A′ is approximately 60 feet above the base liner. To account for the overburden below the bas liner, the soil column was extended to a depth 440 feet, to give total column height of 500 feet. The low-strain shear modulus of the treated soil and subgrade soils were estimated based on Tokimastu and Seed (1987) and the resulting values were calibrated against values presented in Taborda et al. (2015).

Three sets of SHAKE91 analyses were performed, one each for the three acceleration time histories listed in Table 2. The shear stress time history output files from the SHAKE91 analyses were used to compute the HEA time history within the trial surfaces using the following equation (Bray et al., 1998):

$$\text{HEA (t)} = \left[\frac{\tau(t)}{\sigma_v}\right] g$$

where, $\tau(t)$ = shear stress at the elevation of the trial surface at time t
σ_v = total vertical stress at the elevation of the trial plane with the 1-D column
g = acceleration due to gravity

The SHAKE91 analyses results are included in Attachment E.

4.6 Permanent Displacement Analysis

The magnitudes of the seismically induced permanent displacement for the critical failure surface along cross section A-A′ were estimated by numerically double integrating the average HEA values that are in excess of the yield acceleration, consistent with Newmark (1965). The numerical double integration was performed using the computer program DISPLMT developed by Houston et al. (1987). The DISPLMT results are presented in Attachment F.

The results of the DISPLMT analyses for interim slope stability cross section A-A′ are presented graphically in Figures 9, 10, and 11 for Lompr.acc, Nridge.acc, and HectorM.acc acceleration time histories, respectively. As can be seen from these figures, the estimated maximum permanent displacement is less than 0.1 inch. Therefore, the estimated seismically induced permanent displacement is significantly less than the maximum acceptable limit of 6 inches.

5.0 ANALYSIS OF LIQUEFACTION POTENTIAL

5.1 Analysis Method

The tip resistance and side friction measured in the CPTs were used to analyze the liquefaction potential of the sand dune soils. The liquefaction analysis was performed using the empirical procedure outlined in the Earthquake Engineering Research Institute's (EERI) monograph MNO-12 (Idriss and Boulanger, 2008) and subsequent updates in Boulanger and Idriss (2014). MNO-12 is an update of the original EERI monograph entitled "Ground Motions and Soil Liquefaction During Earthquakes" (Seed and Idriss, 1982).

5.2 Ground Water Depth

Gregg Drilling performed pore pressure dissipation tests at all the CPT locations to estimate the static ground water elevations. However, Golder's review showed that the estimated ground water levels from these dissipation tests were inconsistent and unreliable when compared to the 2018 ground water contours estimated by Padre. Therefore, Golder assumed a very conservative ground water table elevation of 37.3 feet, which is the estimated historic high elevation assumed in the design SMA base grading plan. This represents a conservative assumption because the 2018 ground water contours show the elevations to range from 29 to 32 feet under the SMA.

5.3 Analysis Results

The locations of the CPTs are shown in Plate 3 of Appendix A and Figure G-1 in Appendix G. The results of the liquefaction analyses are presented graphically in Figures G-2 through G-15, respectively, for SMACPT1 through SMACPT14. Liquefaction analyses spreadsheets are also included in Appendix G.

The results plotted in Figures G-2 through G-15 in Appendix G show minor potential for liquefaction at SMACP-2,SMACP-3, SMACP-4, SMACP-5, SMACP-6, SMACP-7, SMACP-11, SMACP-12, and SMACP-13. The liquefaction analyses predicted a maximum settlement of 1.5 inches, which is relatively small. The ratio residual undrained shear strength (S_r) to vertical effective stress (σ_{v0}') or S_r/σ_{v0}' of the liquefiable sand dunes is estimated to be between 0.08 and 0.1.

It should be noted that the liquefaction analysis is conservative because of conservatively higher ground water table elevation assumed in the analysis.

5.4 Post-Liquefaction Slope Stability

Because of the significant depth to the liquefiable materials below the ground surface, and because the liquefaction is unlikely to occur over the entire site, it is Golder's opinion that the post-liquefaction slope stability of SMA is not very critical. To demonstrate this, Golder performed a post-liquefication slope stability assuming relatively conservative assumptions. In the analysis, it was assumed that a 20-foot uniform thickness of sand dune below the ground water table will liquefy under the entire site. The S_r/σ_{v0}' of the liquefiable material is assumed to be 0.08.

The analysis was performed for cross section B-B' because of the shallower depth to ground water table along the eastern side of the SMA. The result of the post-liquefaction slope stability analysis is presented on Figure 12. Despite the very conservative assumptions, the analysis shows a FS of 1.28. A FS of greater than 1.1 is considered acceptable for post-liquefaction stability because it is a temporary condition lasting only a few seconds.

6.0 CONCLUSIONS AND RECOMMENDATIONS

6.1 Conclusions

The results of the static and seismic slope stability analyses presented in this report show that the SMA slope will be stable provided the baseliner and side slope liner systems meet a minimum large-displacement shear strength envelope defined a friction angle of 12 degrees. The computed minimum FS is 1.51, which satisfies the minimum requirement of 1.5. The estimated permanent displacement under seismic conditions less than 0.1 inch, which is significantly less than the maximum allowable limit of 6 inches.

The liquefaction analysis shows minor potential for liquefaction of saturated sand dunes. However, because the liquefaction would occur at significant depths below the ground surface and the liquefaction thickness is likely to be non-uniform, it is unlikely to have significant impact on the SMA. A post-liquefaction slope stability analysis, using conservative assumptions, shows more than adequate FS. The post-liquefaction settlement is estimated to be less than 1.5 inches.

6.2 Recommendations

As noted previously, the shear strength of the liner system will control the static and seismic slope stability of the SMA. To be consistent with assumptions used in the slope stability analyses discussed in tis report, the baseliner and side slope liner systems meet a minimum large-displacement shear strength envelope defined a friction angle of 12 degrees. Therefore, the shear strengths of the various shear planes (both internal and interface) within the liner systems should be verified during selection (i.e., before the materials are procured and shipped to the site) of the liner components by performing laboratory testing. The minimum shear strength requirements and laboratory testing requirements are summarized in Table 3.

It is also recommended the all HDPE geomembranes used shall be double-sided textured, the GCL shall be need-punched with non-woven geotextiles on both sides, and the cushion and filter geotextile layers shall be non-woven.

Table 3: Liner Internal/Interface Shear Strength and Testing Requirements

Test Configuration	ASTM Standard	Test Condition	Hydration Time Required Prior to Shearing	Strain Rate	Min. Shear Displacement	Normal Stress	Large Displ.[1] Shear Strength Required
				inch/minute	(inches)	(psf)	(psf)
Low permeability clay liner/lower surface of the DST HDPE geomembrane interface	D5321	Submerged	24 hours under corresponding normal load	0.04	3.0	3,000 6,000 9,000 12,000	638 1,275 1,913 2,550
Upper surface DST HDPE geomembrane/lower surface of the geocomposite drain interface[2]	D5321	Submerged	N/A	0.2	3.0	3,000 6,000 9,000 12,000	638 1,275 1,913 2,550
Upper surface of the DST geocomposite drain/lower surface of the primary GCL interface[2,3]	D6243	Submerged	48 hours under corresponding normal load	0.04	3.0	3,000 6,000 9,000 12,000	638 1,275 1,913 2,550
Upper surface of the GCL/lower surface of the DST HDPE geomembrane interface[3]	D6243	Submerged	48 hours under corresponding normal load	0.04	3.0	3,000 6,000 9,000 12,000	638 1,275 1,913 2,550
Upper surface of the DST HDPE geomembrane/lower surface of the geotextile interface	D5321	Submerged	N/A	0.2	3.0	3,000 6,000 9,000 12,000	638 1,275 1,913 2,550

(psf = pound per square foot; GCL = geosynthetic clay liner; DST HDPE = double-sided textured high-density polyethylene; N/A = not applicable)

Notes:
[1]Large Displacement shear strength as measured at a shear displacement of 3 inches; the listed values correspond to a large-displacement friction angle of 12°.
[2]The internal shear strength of the geocomposite drain should be tested simultaneously by allowing the required gap for internal shearing.
[3]The internal shear strength of the GCL should be tested simultaneously by allowing the required gap for internal shearing of GCL.

7.0 CLOSING

This report has been prepared for use exclusively by Chevron Environmental Management Company for the Tank Battery 9, Soils management Area at the Guadalupe Restoration project, Guadalupe, California. The conclusions and recommendations presented in this report are based on review of existing information, assumption, and analyses discussed in this report, and are not intended, nor should they be construed to represent a warranty, but are forwarded to assist in the planning, permitting, design, and construction of the SMA.

It has been our pleasure to provide our services to the Chevron Environmental Management Company on this project. Please contact us if you have any questions or need additional information.

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Signature Page

Golder Associates Inc.

Nagesh Koragappa, P.E., G.E.
Senior Consultant

Richard D. Haughey, P.E.
Associate / Practice Leader

NK/RDH

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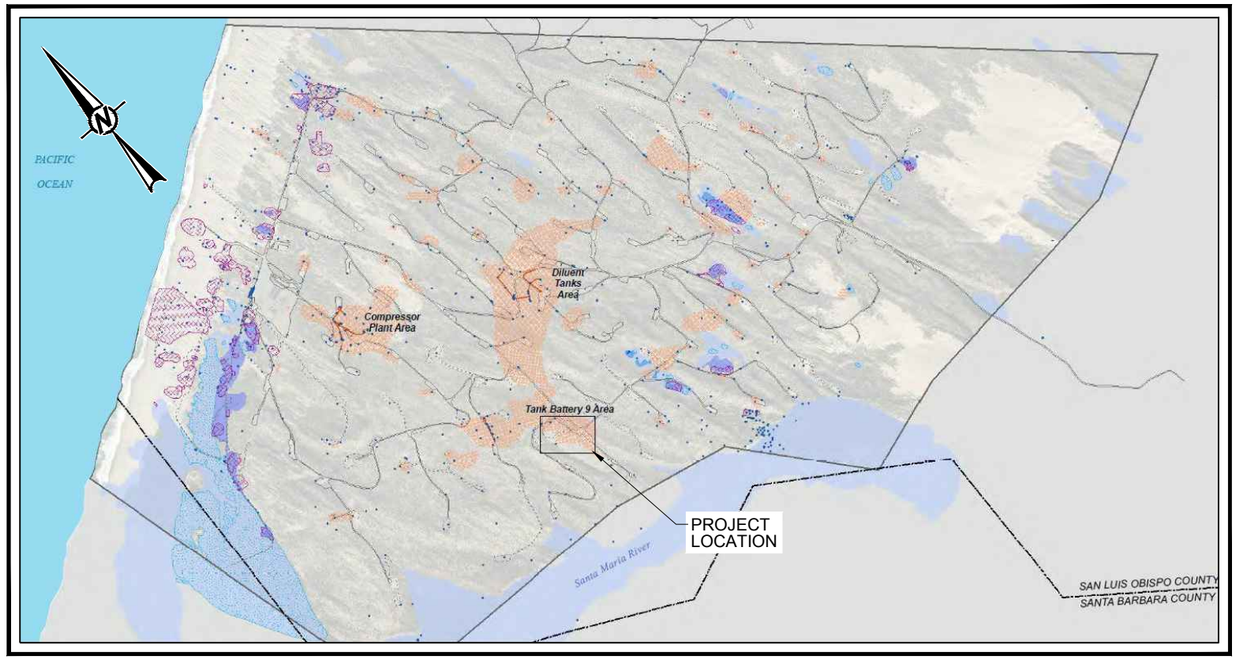
https://golderassociates.sharepoint.com/sites/15679g/technical work/slope stability/draft stabilty report_6-21-2019/chevron-guadalupe_stabil_rpt_draft_10-04-2019.docx

Figures



LOCATION MAP

CLIENT
CHEVRON ENVIRONMENTAL MANAGEMENT COMPANY
2184 WEST THORNBERRY ROAD
GUADALUPE, CA 93434

CONSULTANT
GOLDER

YYYY-MM-DD	2019-06-10
DESIGNED	CMN
PREPARED	CMN
REVIEWED	LMA
APPROVED	NK

PROJECT
CHEVRON ENVIRONMENTAL MANAGEMENT COMPANY
SOIL MANAGEMENT AREA

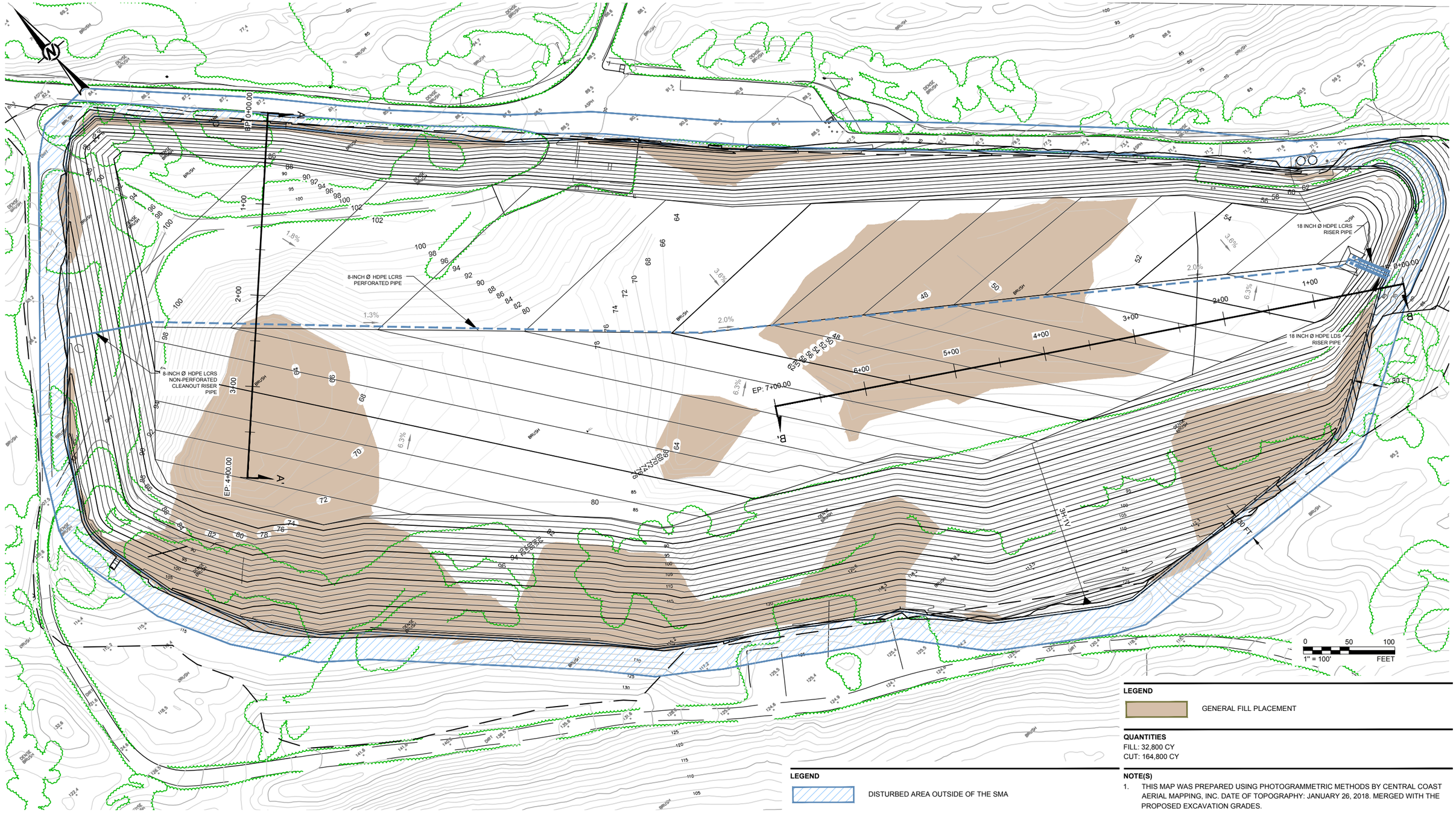
TITLE
SITE LOCATION

PROJECT NO.	REV.	FIGURE
1783552	0	1

IF THIS MEASUREMENT DOES NOT MATCH WHAT IS SHOWN, THE SHEET SIZE HAS BEEN MODIFIED FROM: ANSI B

0 1 in

Path: \\sacramento\acad\Sites\Chevron - Guadalupe\CIVIL 3D\2018 Treated Soil Management Area TBP\Figures for NK\ | File Name: Figures 1-3.dwg | Last Edited By: cnieuwenhuis Date: 2019-06-21 Time:10:13:37 AM | Printed By: CNieuwenhuis Date: 2019-06-21 Time:10:14:49 AM



LEGEND

GENERAL FILL PLACEMENT

QUANTITIES

FILL: 32,800 CY
CUT: 164,800 CY

LEGEND

DISTURBED AREA OUTSIDE OF THE SMA

NOTE(S)

1. THIS MAP WAS PREPARED USING PHOTOGRAMMETRIC METHODS BY CENTRAL COAST AERIAL MAPPING, INC. DATE OF TOPOGRAPHY: JANUARY 26, 2018. MERGED WITH THE PROPOSED EXCAVATION GRADES.

CLIENT
CHEVRON ENVIRONMENTAL MANAGEMENT COMPANY
2184 WEST THORNBERRY ROAD
GUADALUPE, CA 93434

CONSULTANT
GOLDER

YYYY-MM-DD	2019-06-10
DESIGNED	CMN
PREPARED	CMN
REVIEWED	LMA
APPROVED	NK

PROJECT
CHEVRON ENVIRONMENTAL MANAGEMENT COMPANY
SOIL MANAGEMENT AREA

TITLE
BASE GRADING, SLOPE STABILITY CROSS SECTION LOCATIONS

PROJECT NO.	REV.	FIGURE
1783552	0	2

IF THIS MEASUREMENT DOES NOT MATCH WHAT IS SHOWN, THE SHEET SIZE HAS BEEN MODIFIED FROM: ANSI B

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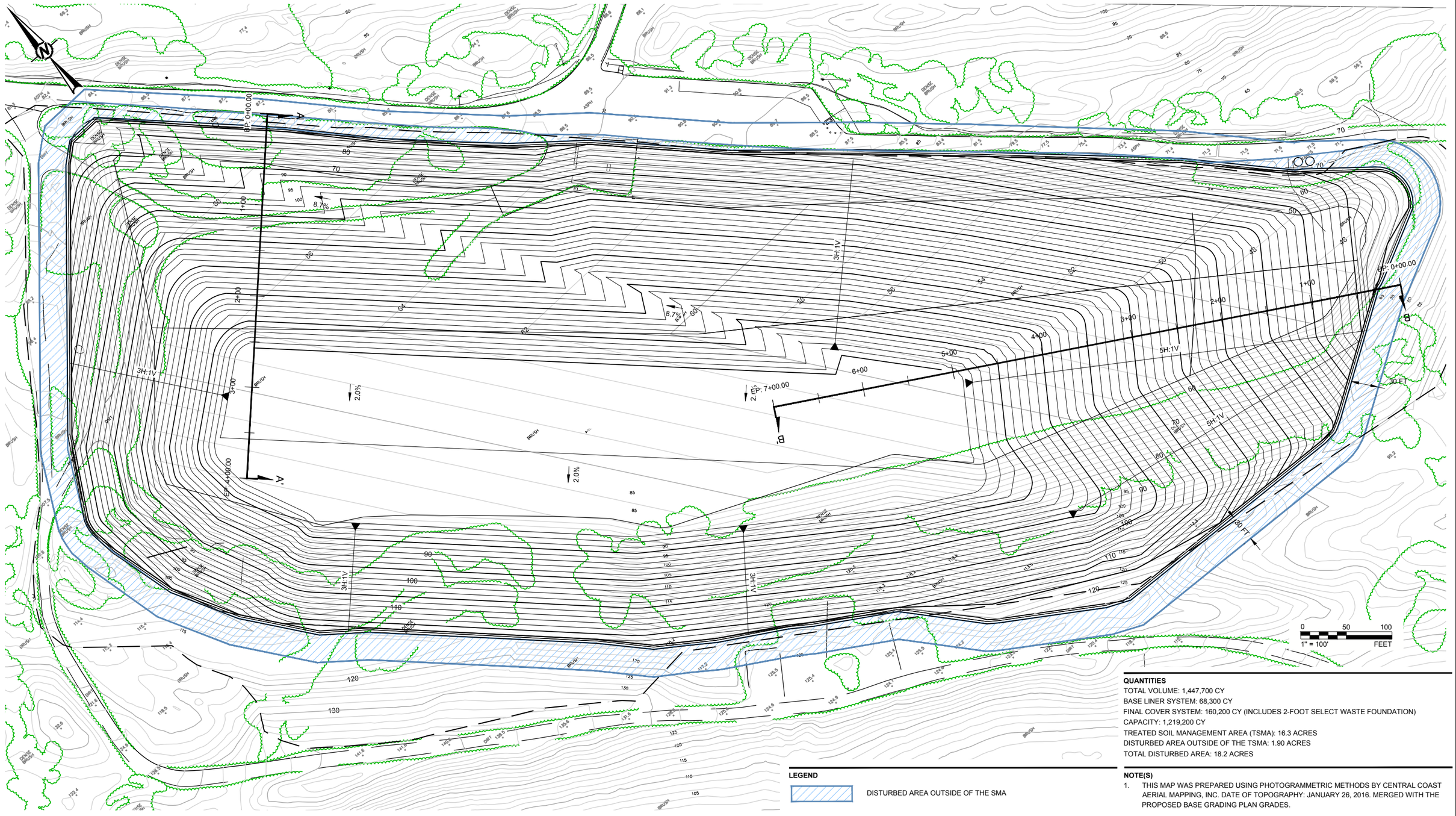

QUANTITIES

TOTAL VOLUME: 1,447,700 CY
BASE LINER SYSTEM: 68,300 CY
FINAL COVER SYSTEM: 160,200 CY (INCLUDES 2-FOOT SELECT WASTE FOUNDATION)
CAPACITY: 1,219,200 CY
TREATED SOIL MANAGEMENT AREA (TSMA): 16.3 ACRES
DISTURBED AREA OUTSIDE OF THE TSMA: 1.90 ACRES
TOTAL DISTURBED AREA: 18.2 ACRES

LEGEND

DISTURBED AREA OUTSIDE OF THE SMA

NOTE(S)

1. THIS MAP WAS PREPARED USING PHOTOGRAMMETRIC METHODS BY CENTRAL COAST AERIAL MAPPING, INC. DATE OF TOPOGRAPHY: JANUARY 26, 2016. MERGED WITH THE PROPOSED BASE GRADING PLAN GRADES.

CLIENT
CHEVRON ENVIRONMENTAL MANAGEMENT COMPANY
2184 WEST THRONBERRY ROAD
GUADALUPE, CA 93434

CONSULTANT
GOLDER

YYYY-MM-DD	2019-06-10
DESIGNED	CMN
PREPARED	CMN
REVIEWED	LMA
APPROVED	NK

PROJECT
CHEVRON ENVIRONMENTAL MANAGEMENT COMPANY
SOIL MANAGEMENT AREA

TITLE
FINAL GRADING, SLOPE STABILITY CROSS SECTION LOCATIONS

PROJECT NO.	REV.	FIGURE
1783552	0	3

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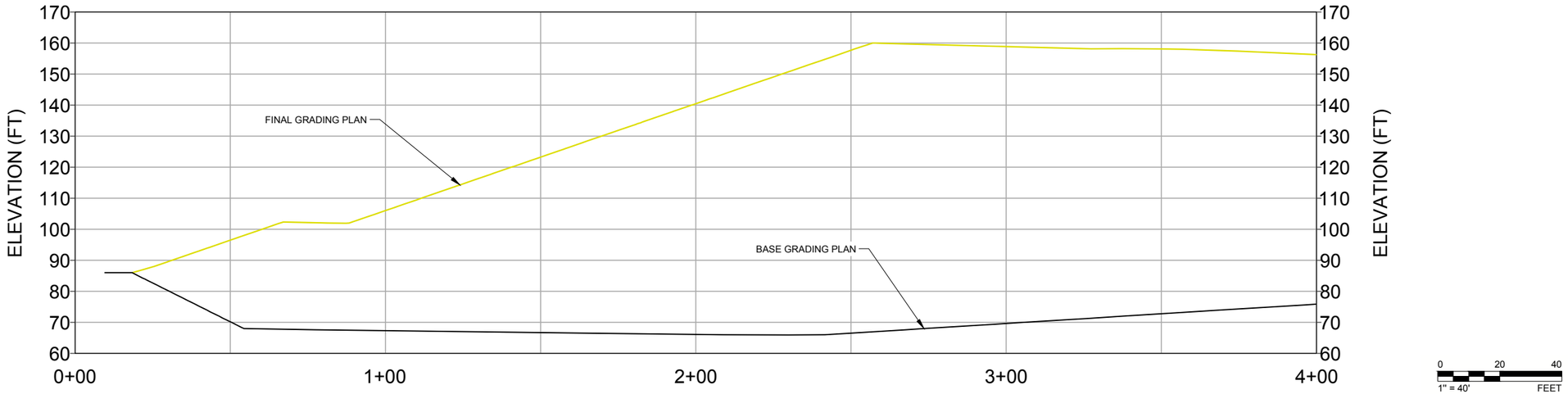
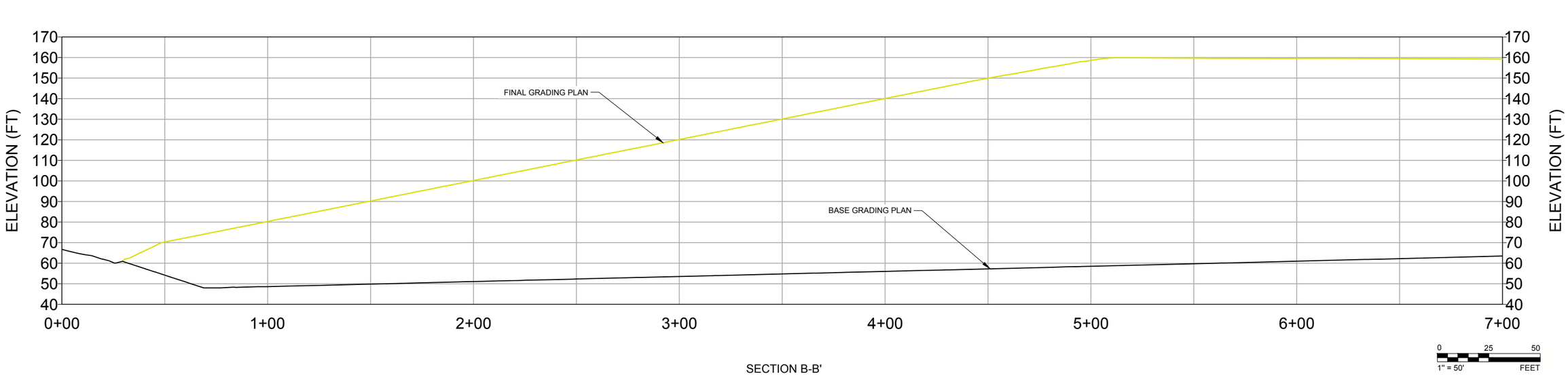


SECTION A-A'



SECTION B-B'

CLIENT
CHEVRON ENVIRONMENTAL MANAGEMENT COMPANY
2184 WEST THORNBERRY ROAD
GUADALUPE, CA 93434

CONSULTANT
GOLDER

YYYY-MM-DD	2019-06-10
DESIGNED	CMN
PREPARED	CMN
REVIEWED	LMA
APPROVED	NK

PROJECT
CHEVRON ENVIRONMENTAL MANAGEMENT COMPANY
SOIL MANAGEMENT AREA

TITLE
SLOPE STABILITY CROSS SECTIONS

PROJECT NO.	REV.	FIGURE
1783552	0	4

IF THIS MEASUREMENT DOES NOT MATCH WHAT IS SHOWN, THE SHEET SIZE HAS BEEN MODIFIED FROM: ANSI B

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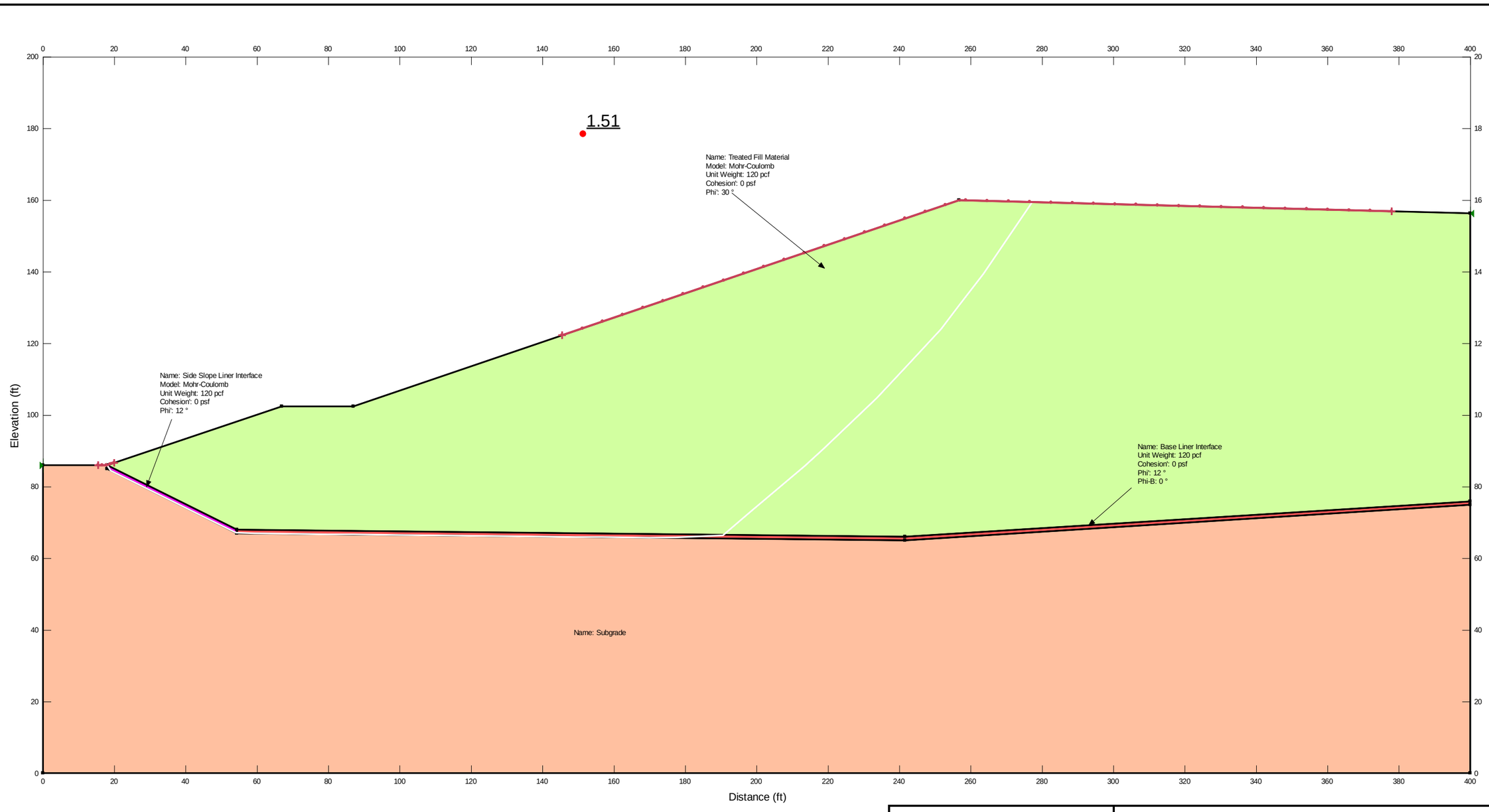
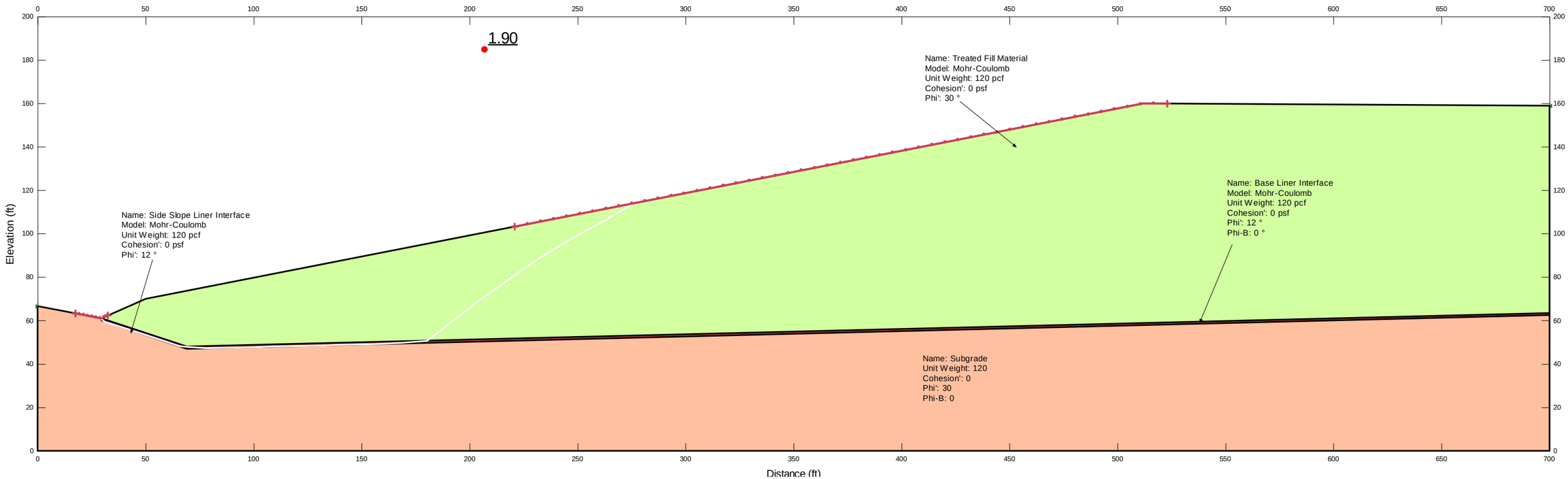


GOLDER

Chevron Environmental Management Company
Soil Management Area
Static Slope Stability
Cross Section A-A'

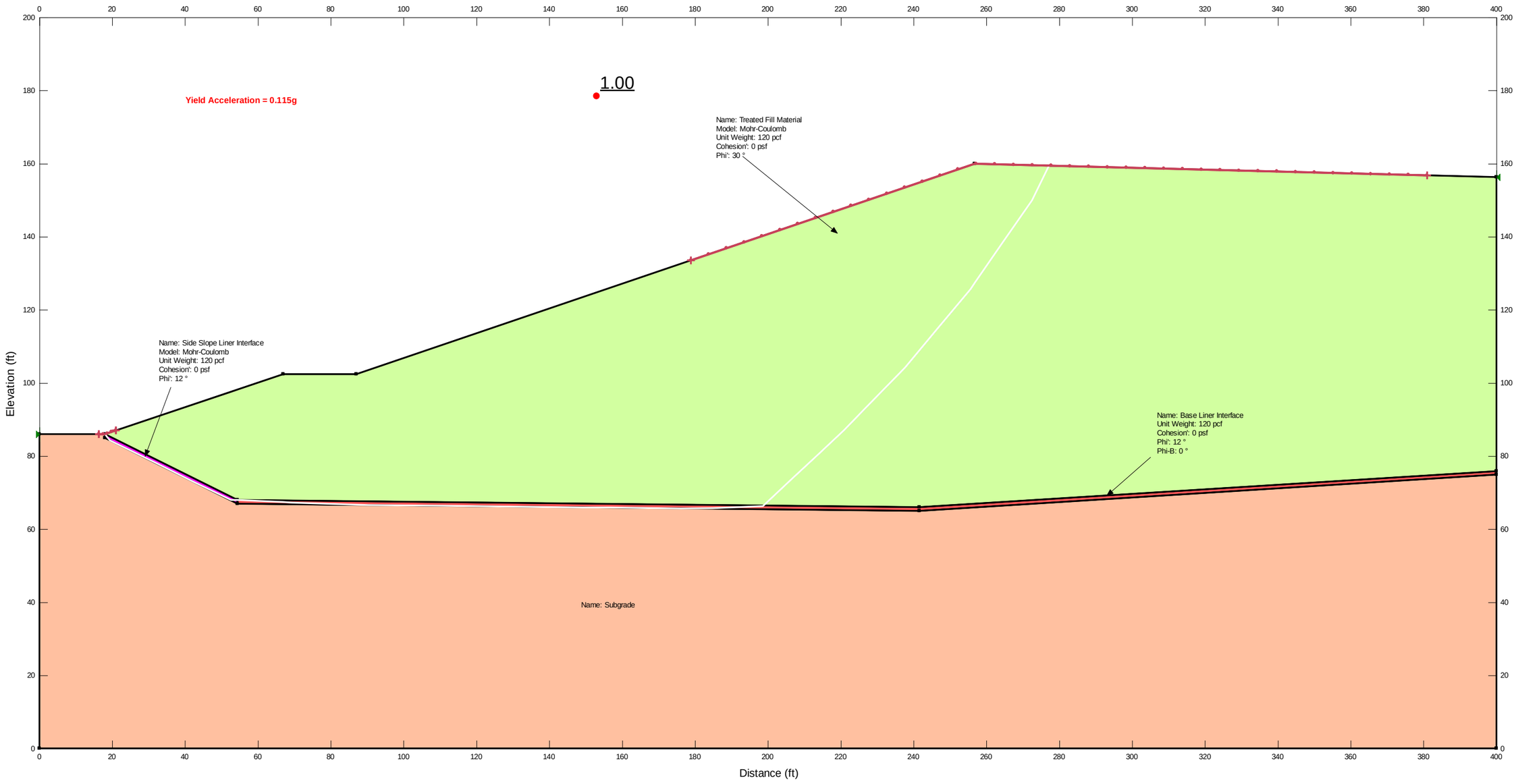
Project No. **1783552** | Date: **June 2019** | Figure: **5**



GOLDER

Chevron Environmental Management Company
Soil Management Area
Static Slope Stability
Cross Section B-B

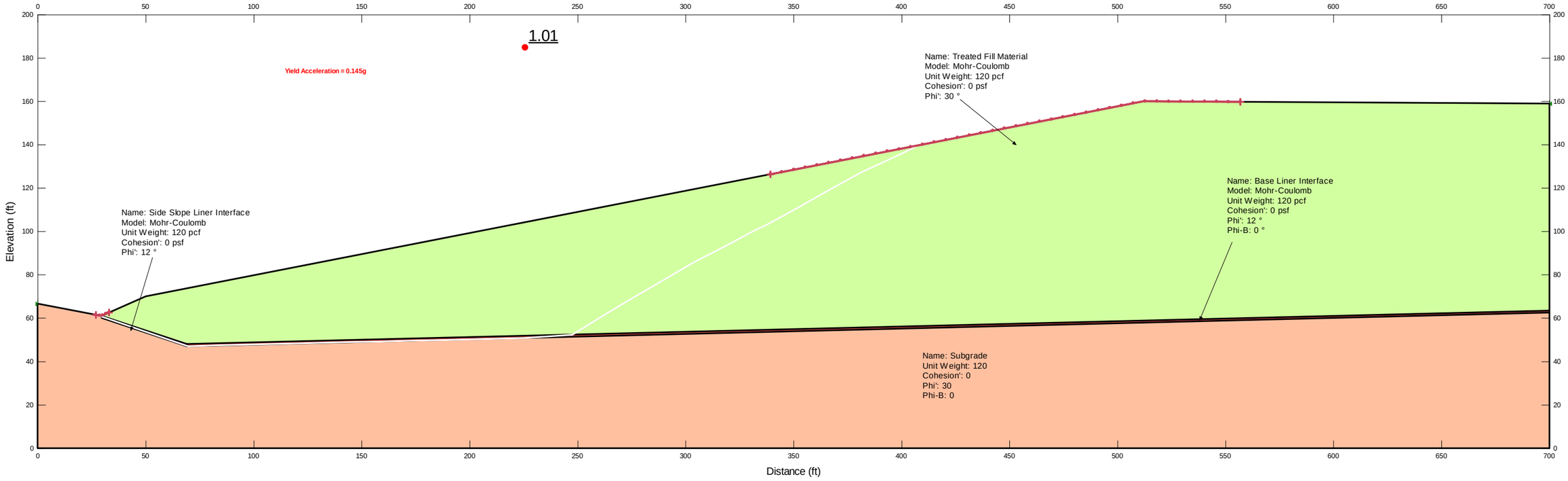
Project No. **1783552** | Date: **June 2019** | Figure: **6**



GOLDER

Chevron Environmental Management Company
Soil Management Area
Yield Acceleration
Cross Section A-A'

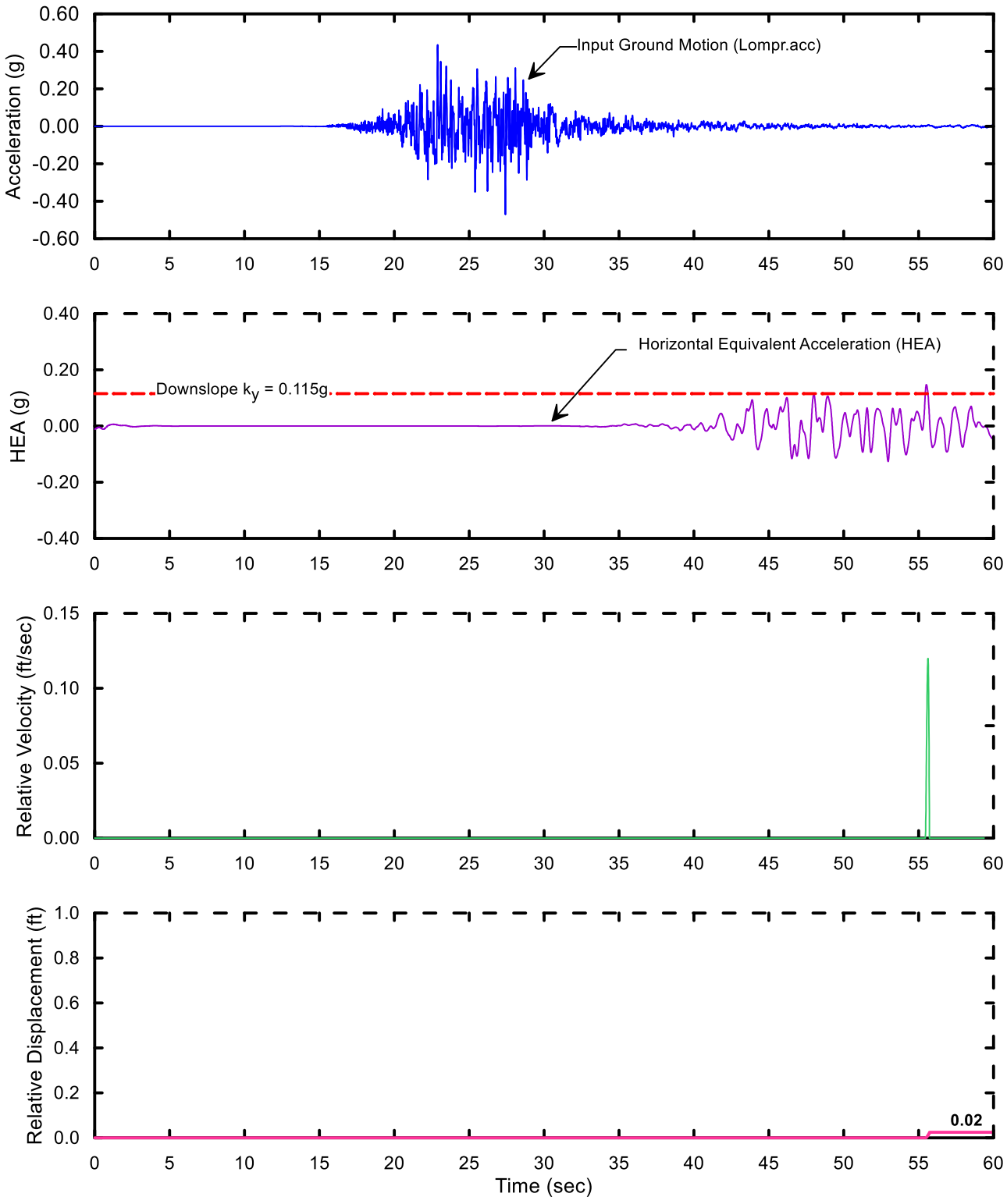
Project No. **1783552**	Date: **June 2019**	Figure: **7**



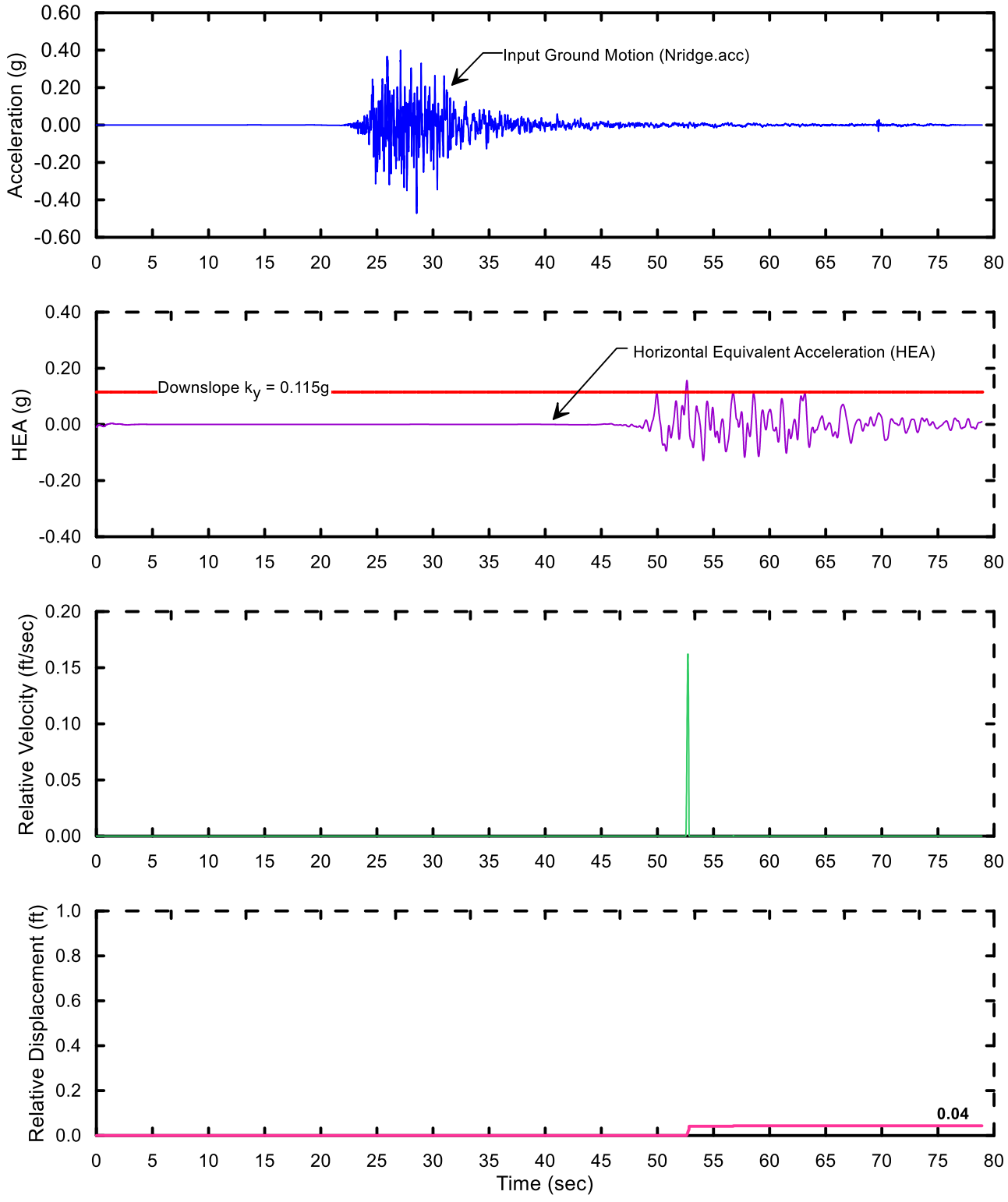
GOLDER

Chevron Environmental Management Company
Soil Management Area
Yield Acceleration
Cross Section B-B'

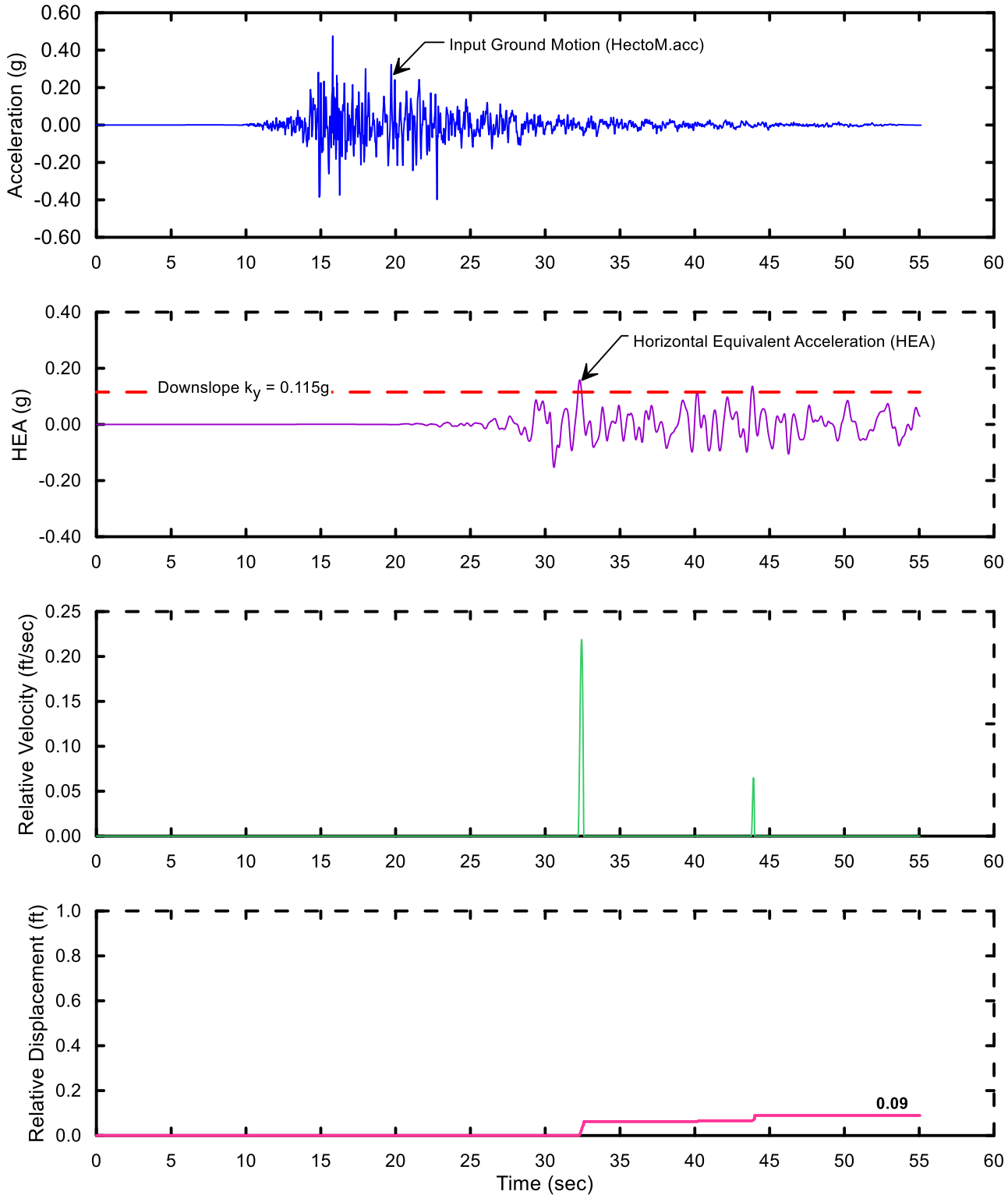
Project No. **1783552**	Date: **June 2019**	Figure: **8**



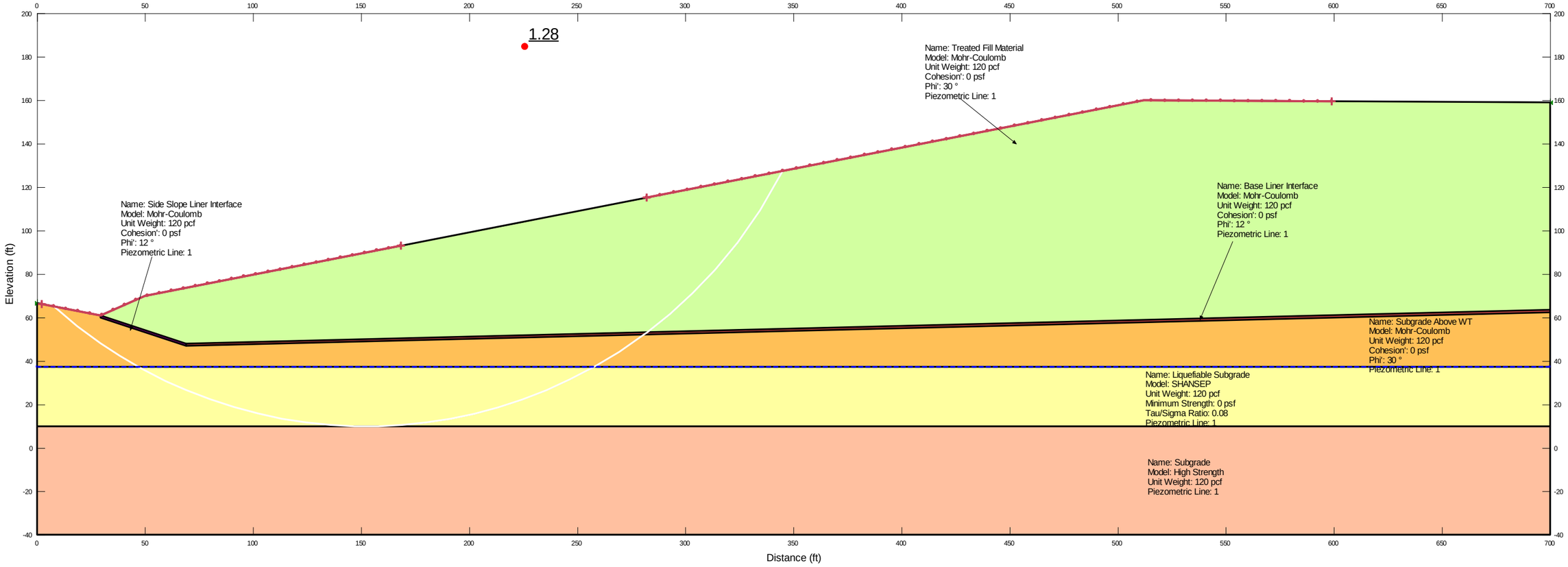
GOLDER	Chevron Environmental Management Company Soil Management Area **Seismic Slope Stability, Cross Section A-A'** **Permanent Displacement** **Time History = Lompr.acc**	
Project No.: **1662583**	Date: **January 2018**	Figure: **9**



GOLDER	Chevron Environmental Management Company Soil Management Area **Seismic Slope Stability, Cross Section A-A'** **Permanent Displacement** **Time History = Nridge.acc**	
Project No.: **1662583**	Date: **January 2018**	Figure: **10**



GOLDER	Chevron Environmental Management Company Soil Management Area **Seismic Slope Stability, Cross Section A-A'** **Permanent Displacement** **Time History = HectorM.acc**	
Project No.: **1662583**	Date: **January 2018**	Figure: **11**



GOLDER

Chevron Environmental Management Company
Soil Management Area
Post-Liquefaction Slope Stability
Cross Section B-B'

Project No. **1783552** | Date: **June 2019** | Figure: **12**

APPENDIX A

Geotechnical Assessment Report by Padre Associates, Inc.

padre associates, inc.
ENGINEERS, GEOLOGISTS & ENVIRONMENTAL SCIENTISTS

GEOTECHNICAL ASSESSMENT SERVICES DATA REPORT

TANK BATTERY 9 (TB9)
GUADALUPE RESTORATION PROJECT
2184 WEST THORNBERRY ROAD
GUADALUPE, SAN LUIS OBISPO COUNTY, CALIFORNIA

Prepared for:
CHEVRON ENVIRONMENTAL MANAGEMENT COMPANY

October 2018

1861 Knoll Drive ▪ Ventura, California 93003 ▪ 805-644-2220 ▪ www.padreinc.com

padre
associates, inc.
ENGINEERS, GEOLOGISTS & ENVIRONMENTAL SCIENTISTS

October 15, 2018
Project No. 1801-2191

Chevron Environmental Management Company
2184 West Thornberry Road
Guadalupe, California 93434

Attention: Ms. Danielle Wold
Project Manager

Subject: Geotechnical Assessment Data Report, Tank Battery 9 Area, Guadalupe Restoration Project, 2184 West Thornberry Road, Guadalupe, San Luis Obispo County, California

Dear Ms. Wold:

Padre Associates, Inc. (Padre), is pleased to present the attached geotechnical assessment data report to the Chevron Environmental Management Company (CEMC) describing the results of the geotechnical assessment for the design of the Tank Battery 9 (TB9) Area at the Guadalupe Restoration Project (Project Site). Services provided for this report were in general compliance with the site assessment plan for the Treated Soil Management Area (TSMA) presented in the CEMC letter to the Central Coast Regional Water Quality Control Board (CCRWQCB) dated July 25, 2018.

This data report provides a summary and findings from three hollow-stem auger (HSA) drill holes and fourteen cone penetrometer tests (CPTs) advanced within the area of the TSMA, as well as, the results of laboratory tests performed on soil samples collected from the site. We appreciate the opportunity to provide these services to CEMC on this project.

If you have any questions regarding this study, please contact us.

Sincerely,

PADRE ASSOCIATES, INC.

Eva E. von Thury, G.I.T.
Project Geologist

Jeffrey T. Damron, G.E.
Principal

REGISTERED PROFESSIONAL ENGINEER
JEFFREY T. DAMRON
No. 2546
GEOTECHNICAL
STATE OF CALIFORNIA

padre associates, inc. ENGINEERS, GEOLOGISTS & ENVIRONMENTAL SCIENTISTS

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APPENDIX A: SUBSURFACE EXPLORATION

APPENDIX B: LABORATORY TESTING

INTRODUCTION

Padre Associates, Inc. (Padre) is pleased to submit this summary geotechnical data report presenting the field methods and data collected during our field campaign for the proposed Tank Battery 9 (TB9) treated soil management area (TSMA) project at the Guadalupe Restoration Project (GRP), 2184 West Thornberry Road, Guadalupe, San Luis Obispo County, California (Project Site, Plate 1 - General Vicinity Map). The area of the Project Site where the TB9 Geotechnical Assessment was performed is shown on Plate 2 -Tank Battery 9 Area Site Location Map. The following sections present our project understanding, purpose, work performed, and a summary of the data collected.

PROJECT UNDERSTANDING AND STUDY PURPOSE

The Guadalupe Restoration Project (Project Site) is located in southwestern San Luis Obispo County, west of The City of Guadalupe. The Project Site was formerly part of the active Guadalupe Oil Field. Most of the aboveground infrastructure from the historical oil field operations have been abandoned and removed from the Project Site.

At the TB9 Area, a geotechnical site assessment was performed in support of preliminary TSMA design efforts at the Project Site. The geotechnical site assessment included 3 hollow-stem auger (has) drill holes to depths ranging from 40 (SBTB9-94) to 61.5 (SBTB9-92) feet below ground surface (ft bgs) and 14 cone penetration tests (CPTs) pushed to depths from 31.82 (TSMACPT-3) to 59.88 (TSMACPT-4) ft bgs.

WORK PERFORMED

The scope of work for this investigation was developed through written correspondence from Ms. Danielle Wold of CEMC and e-mail correspondence with Nagesh Koragappa of Golder Associates, Inc. (Golder). Field work was conducted in general accordance with the CEMC letter from Ms. Wold to Mr. Greg Bishop at CCRWQCB dated July 25, 2018. Work performed for this geotechnical data report included:

- Review of previous geoenvironmental studies conducted for the TB9 area and available geologic reports and maps relevant to the site;
- Marking of proposed exploration locations with GRP staff and notification of Underground Service Alert in an effort to locate underground utilities at the proposed exploration locations;
- Exploration of the site at 3 drill hole locations within the proposed improvements using a HSA limited access drill rig and 14 CPT locations. In addition, five, 5-gallon bucket bulk samples from one stockpile and the onsite borrow source material were collected for proctor testing. Approximate drill hole and CPT locations are shown on Plate 3 -

TB9 Geotechnical Exploration Location Map. The drill hole and CPT logs are presented in Appendix A - Subsurface Exploration;

- Laboratory testing of soil samples obtained from selected depth intervals within each exploration and of the soil samples collected from the potential borrow sources; a description of laboratory tests performed; and the results of those tests are presented in Appendix B - Laboratory Testing; and
- Preparation of this geotechnical data summary report.

HOLLOW-STEM AUGER DRILLING AND SAMPLING

Three hollow-stem auger drill holes were advanced using a Marl 5T track-mounted limited access drill rig supplied by Gregg Drilling, LLC (Gregg) of Signal Hill, California. The drill holes were excavated to depths ranging from 40 to 61.5 ft bgs, while a Padre field geologist logged the drill holes using the Unified Soil Classification System (USCS). The drill holes were sampled at approximately 5-foot intervals using a 2-inch outside diameter standard penetration test (SPT) split spoon sampler.

The split spoon samplers were driven into the materials below the bottom of the auger, at the bottom of the drill hole using a 140-pound automatic trip hammer with a 30-inch drop. Blow counts were recorded for each driven sample and an N-value recorded; where the N-value refers to the number of blows from the hammer that were needed to drive the sampler 1 foot after the sampler had been seated at least 6 inches into the material at the bottom of the hole. The sample intervals, N-values, and a description of the subsurface conditions encountered are presented on the logs of the drill holes (Appendix A).

Upon completion of drilling, the drill holes were abandoned by backfilling with a bentonite cement slurry until 1 foot from the ground surface. The last foot of each drill hole was backfilled with native materials.

CONE PENETROMETER TESTING (CPT)

Fourteen CPTs were pushed using a 20 Ton track-mounted CPT rig suited to traverse the Guadalupe Sand Dunes. The CPT rig used direct-push drilling methods to electronically, continuously log the downhole site lithology. Pore dissipation data was collected downhole at each of the 14 locations with the intention of assisting with creating a hydrogeologic profile. No physical samples were collected. Once the CPT was competed and the rods pulled from the hole, the hole was abandoned by backfilling with a bentonite cement slurry until one foot from the ground surface. The last foot of each CPT sounding hole was backfilled with native materials.

BORROW SOURCE MATERIAL BULK SAMPLES

Five, 5-gallon bucket bulk samples were collected from borrow source material stockpiles at the Project Site. Four bulk samples were collected from the Q4 dune sand stockpile, with one sample taken from each quadrant of the large stock pile (Plate 2). These samples were collected with the aid of a backhoe that cleared the top few feet of the pile and then collected the samples

for proctor testing from inside the pile. One bulk sample from the E4A red rock stockpile was also collected for proctor testing via hand shoveling and obtaining a sample from inside the pile (Plate 2). The red rock will be broken up and mixed as fines material with the sand for backfilling and compaction purposes.

LABORATORY TESTING

Laboratory testing was performed at the soil laboratories of Yeh & Associates, Inc., Grover Beach, California and Cal Poly Corporation GEO-E Laboratory, San Luis Obispo, California. Laboratory tests for moisture content, Atterberg Limits, sieve analyses, and hydrometer were performed on the SPT samples collected from the drill holes; modified proctor and flex wall permeability tests were performed on the bulk borrow source material samples. The tests were performed in general accordance with the applicable standards of ASTM. The results of the tests performed on samples collected from all three drill holes are presented in Appendix B - Laboratory Test Results.

FINDINGS

SITE LOCATION

The Project Site is located in the southwestern corner of San Luis Obispo County, approximately 3 miles west of The City of Guadalupe. Formerly, the Project Site was part of the active Guadalupe Oil Field. The Project Site is approximately 2,700 acres that are bordered to the south by the Santa Maria River and an estuary or lagoon system; to the west by the Pacific Ocean; to the north by the Guadalupe-Nipomo Dunes National Wildlife Refuge; and to the east by agricultural farmland. Oil production activities began in the late 1940s and continued through the early 1990s. In the 1950s, mid-range petroleum (referred to as diluent) was first used at the Guadalupe Oil Field to assist in the production of heavy crude oil.

SITE CONDITIONS

Topography

The Guadalupe Oil Field Site is located within the Guadalupe-Nipomo Dunes Complex at approximate elevations ranging from sea level to 180 feet above mean sea level (AMSL). The topography of the Project Site is mainly sand dunes, which form as narrow ridges separated by narrow valleys. At the TB9 Geotechnical Assessment Area, approximate elevations range from 60 to 105 ft AMSL.

Existing Land Uses

The Project Site is an active remediation/restoration project.

GEOLOGIC CONDITIONS

Regional Settings

The Project Site is located within the Coast Range Geomorphic Province of California. The province is characterized by a faulted network of northwest-trending mountains and intervening valleys located between the Great Valley of California and the Pacific Ocean.

Local Geology

The surficial sediments at the Project Site generally consist predominantly of Quaternary aeolian dune deposits of unconsolidated, well sorted, fine to medium grained sands, with less than two percent fines. The thickness of the dune sand varies in accordance with the topography. Surficial dune sand deposits are underlain by Quaternary alluvium, which may be informally divided into two members. The upper member consists of interbedded silt, clay, and sand, while the lower member is generally coarser grained. The Quaternary alluvium is underlain by the Paso Robles Formation of Pliocene and Pleistocene age (Worts, 1951; Eley and Knott, 1999). Near the Santa Maria River (SMR), riverbed deposits are encountered and likely lie directly on the upper member of the Quaternary alluvium.

Significant Faults

The State of California designates faults as active, potentially active, and inactive depending on the recency of the movement that can be substantiated for a fault. A fault is considered active if it can be substantiated that the fault has ruptured during the Holocene (the last 11,000 years). A fault is considered potentially active if it can be substantiated that it has ruptured during the Quaternary (the last 2-million years), but not the Holocene. A fault is considered inactive if it can be substantiated as not having ruptured within the Quaternary.

The California Division of Mines and Geology (CDMG) evaluate the activity rating of a fault in fault evaluation reports (FER). FERs compile available geologic and seismologic data and evaluate if a fault should be zoned as active, potentially active, or inactive. If a FER evaluates a fault as active, then it is typically incorporated into a Special Studies Zone in accordance with the Alquist-Priolo Earthquake Hazards Act (AP). An AP Special Studies Zone requires site-specific evaluation of a fault location and requires a structural setback if the fault is found traversing a project site. Our review of the regulatory required zone of study maps on the State of California, Department of Conservation web site indicates that there are currently no AP Special Studies Zones that cross the Project Site.

Local Faults

No active faults are known to project through the Project Site. However, there are active and potentially active faults in the vicinity of the Project Site that have the potential to generate strong ground motion. Local faults in the vicinity of the CEMC project site consist of the active Hosgri fault to the west and the potentially active Casmalia and San Luis fault systems, located south and north of the project site, respectively.

Hosgri Fault Zone. The Hosgri fault is a regional, active fault system made up of a complex zone of interlaced and parallel fault segments. This fault complex, includes the San Simeon Fault and has an estimated overall length of about 87 miles. The Hosgri fault zone is located entirely offshore, approximately 8 miles from the CEMC Project Site.

According to the Southern California Earthquake Data Center (2018) and Jennings (1994), the Hosgri fault zone is primarily a reverse and thrust fault with some right-lateral slip, dipping northeast. The probable maximum moment magnitude (Mw) for earthquakes on this fault will range from 6.5 to 7.5. The last major rupture of the Hosgri fault zone occurred on November 4, 1927, with a local magnitude (M_L) of 7.3.

Ground Water Conditions

Groundwater was encountered within two of the three drill holes advanced for this study at depths of approximately 53.9 (SBTB9-93) and 29.0 (SBTB9-94) ft bgs; groundwater was not encountered in SBTB9-92. Recent 2018 quarterly TB9 groundwater monitoring results generally agree with the depths to groundwater encountered during the geotechnical site investigation. Groundwater levels vary throughout the year, and from year to year. Groundwater conditions discussed herein represent only those conditions encountered at the time and location of our exploration and those previously documented by Padre in the GRP Semi-Annual Groundwater Report (January through June 2018).

Pore Pressure Dissipation tests were conducted on the 14 CPT soundings; however, the results from several of the soundings were viewed to be inconclusive when compared to recent groundwater measurements at adjacent drill holes and gauging wells. Therefore, groundwater elevations should be referenced from drill holes SBTB9-92, SBTB9-93, and SBTB9-94 and 2018, first (1Q18) and third (3Q18) quarters groundwater monitoring well gauging data.

EARTH MATERIALS

For this study, we advanced and collected soil samples from 3 hollow-stem-auger drill holes (SBTB9-92, SBTB9-93, and SBTB9-94) to depths ranging from 40 (SBTB9-94) to 61.5 (SBTB9-92) ft bgs. Two (SBTB9-93 and SBTB9-94) of the drill holes were advanced southeast of the existing TB9 stockpile and the third drill hole (SBTB9-92) was advanced northwest of the stockpile.

Fourteen CPTs were pushed in the TB9 site area to depths ranging from 31.82 (TSMACPT-3) to 59.88 (TSMACPT-4 and TSMACPT-8) ft bgs. Eleven CPTs were pushed southeast of the TB9 stockpile. The remaining three CPTs were pushed northeast (TSCMACPT-8), southwest (TSCMASCPT-9), and northwest (TSCMACPT-10) of the existing TB9 stockpile. Approximate drill hole and CPT locations are indicated on Plate 3. Earth materials encountered in the drill holes are described below.

Additionally, five, 5-gallon buckets of borrow source material were collected from the E4A stockpile and Q4 borrow source located at the project site for the generation of borrow source material proctor curves: one 5-gallon bucket of red rock and four 5-gallon buckets of dune sand, respectively.

Artificial Fill (af). Artificial fill was encountered in the upper 5 (SBTB9-94) to 20.5 (SBTB9-92) ft in all three of the drill holes advanced for this study. The artificial fill was primarily composed of loose to hard yellow (10YR 7/6) to dark yellowish brown (10YR 3/4) poorly graded sand (SBTB9-93) with silt (SBTB9-94) and angular gravel (SBTB9-92). The sand was slightly moist with a strong hydrocarbon odor in SBTB9-92 and SBTB9-94; a hydrocarbon odor was absent from the fill sand from SBTB9-93.

Sump material was encountered as soft lenses and pockets of material intermixed in the sand fill of SBTB9-92; however, in SBTB9-93 the sump material was encountered as a stiff 15-foot layer of fill. Sump material was observed to be black (2.5Y 2.5/1), slightly moist to moist, and contain a strong hydrocarbon odor. No sump material was encountered in SBTB9-94.

Guadalupe Sand Dune Complex (Qs and Qos). Dune sand deposits were encountered in all three drill holes, overlain by the artificial fill. The dune sand deposits extended to depths ranging from 35.75 (SBTB9-94) to greater than 61.5 (SBTB9-92) ft bgs before contact with the Confining Unit. The dune sand in the TB9 project area is generally comprised of medium dense to very dense, slightly moist to wet, yellowish brown (10YR 5/6) to brown (10YR 5/4) poorly graded sand (SP). Moderate to strong hydrocarbon odor was detected in the dune sand samples collected from SBTB9-93 and SBTB9-94; no hydrocarbon odors were detected in dune sand samples from SBTB9-92. Few to trace oxidation stains were observed in the dune sand samples of SBTB9-92 and SBTB9-94.

Confining Unit (CU). The confining unit was encountered in two of the three drill holes (SBTB9-93 and SBTB9-94) at 54 and 35.75 ft bgs, respectively. At TB9, the confining unit was generally comprised of stiff to very stiff, dark yellowish brown (10YR 4/6), moist to wet, lean clay with sand to lean clay (CL). A mild hydrocarbon odor was detected in SBTB9-93, but not in samples from SBTB9-94. Trace oxidation staining was observed only in SBTB9-94.

CLOSURE AND LIMITATIONS

This summary data report has been prepared for the exclusive use of CEMC, Golder, and their agents for specific application to the proposed TB9 TSMA project at the Project Site, as shown on Plates 1 through 3. Padre prepared the findings presented herein in accordance with generally accepted geotechnical engineering and geologic practices at the time and location that this report was prepared. No other warranty, express or implied, is made.

Soil and rock materials are typically not homogenous in type, strength, and other geotechnical properties and can vary between points of observation and exploration. In addition, groundwater and soil moisture conditions can vary seasonally and for other reasons. Padre does not and cannot have a complete knowledge of the subsurface conditions underlying a site. The

conclusions and recommendations presented in this report are based upon the findings at the points of exploration, interpolation and extrapolation of information between and beyond the points of observation, and are subject to confirmation of the conditions revealed by construction.

Findings of this report are valid as of the date of issuance; however, changes in condition of a property can and will occur with the passage of time. Furthermore, changes in applicable or appropriate standards occur whether they result from legislation or advancement in technology. Accordingly, findings of this report may be invalidated wholly or partially by changes outside of our control. This report is subject to our review and remains valid for a period of one year, unless we issue a written opinion of its continued applicability thereafter.

-- o --

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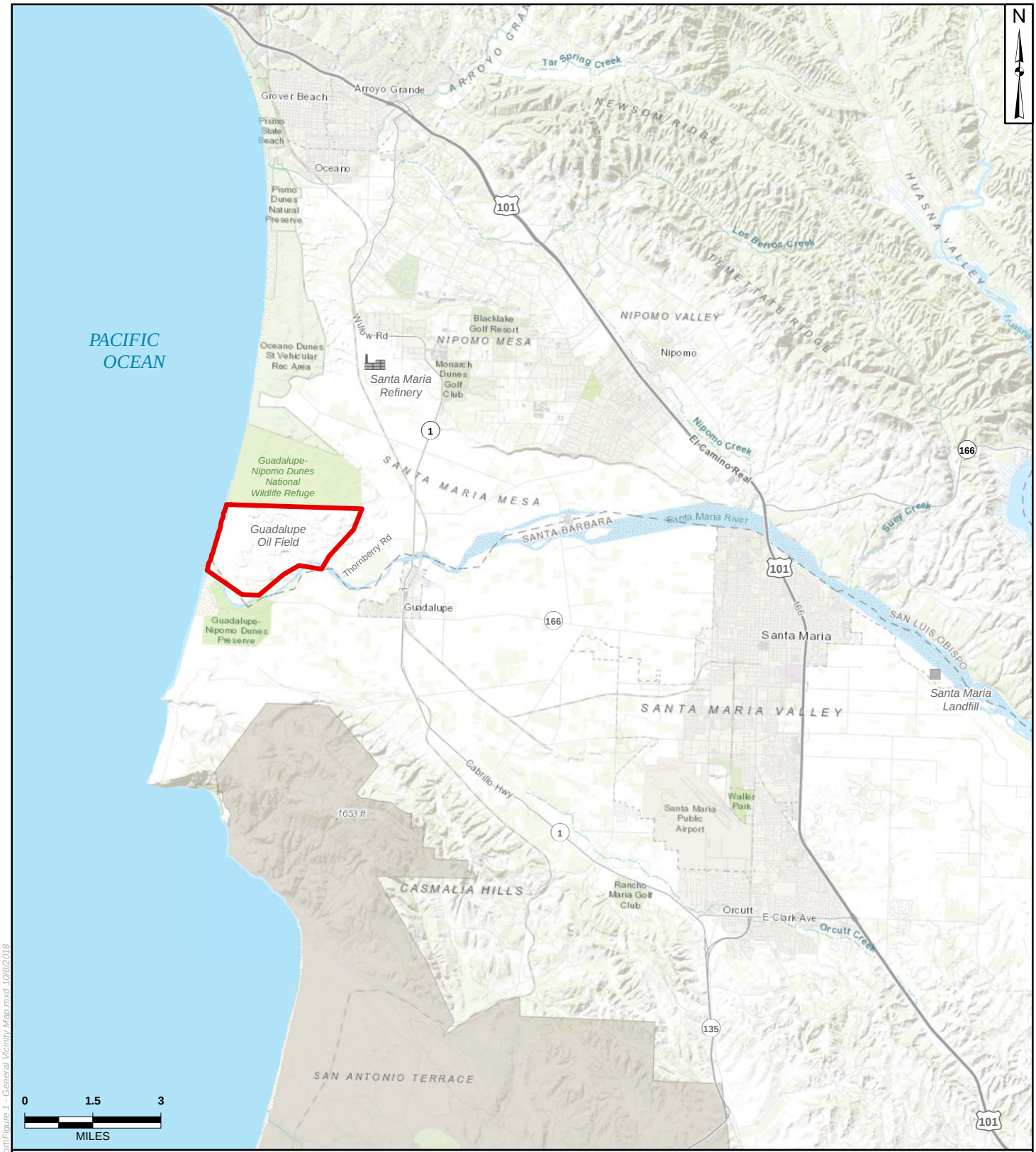
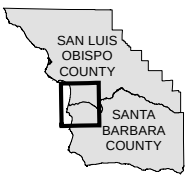
PLATES



LEGEND:

Guadalupe Restoration Project

MAP EXTENT:



Source: Esri Online Basemap
Coordinate System: NAD 1983 StatePlane California V FIPS 0405 Feet
Notes: This map was created for informational and display purposes only

padre associates, inc.
ENGINEERS, GEOLOGISTS & ENVIRONMENTAL SCIENTISTS

PROJECT NAME: CHEVRON ENVIRONMENTAL MANAGEMENT COMPANY GUADALUPE RESTORATION PROJECT

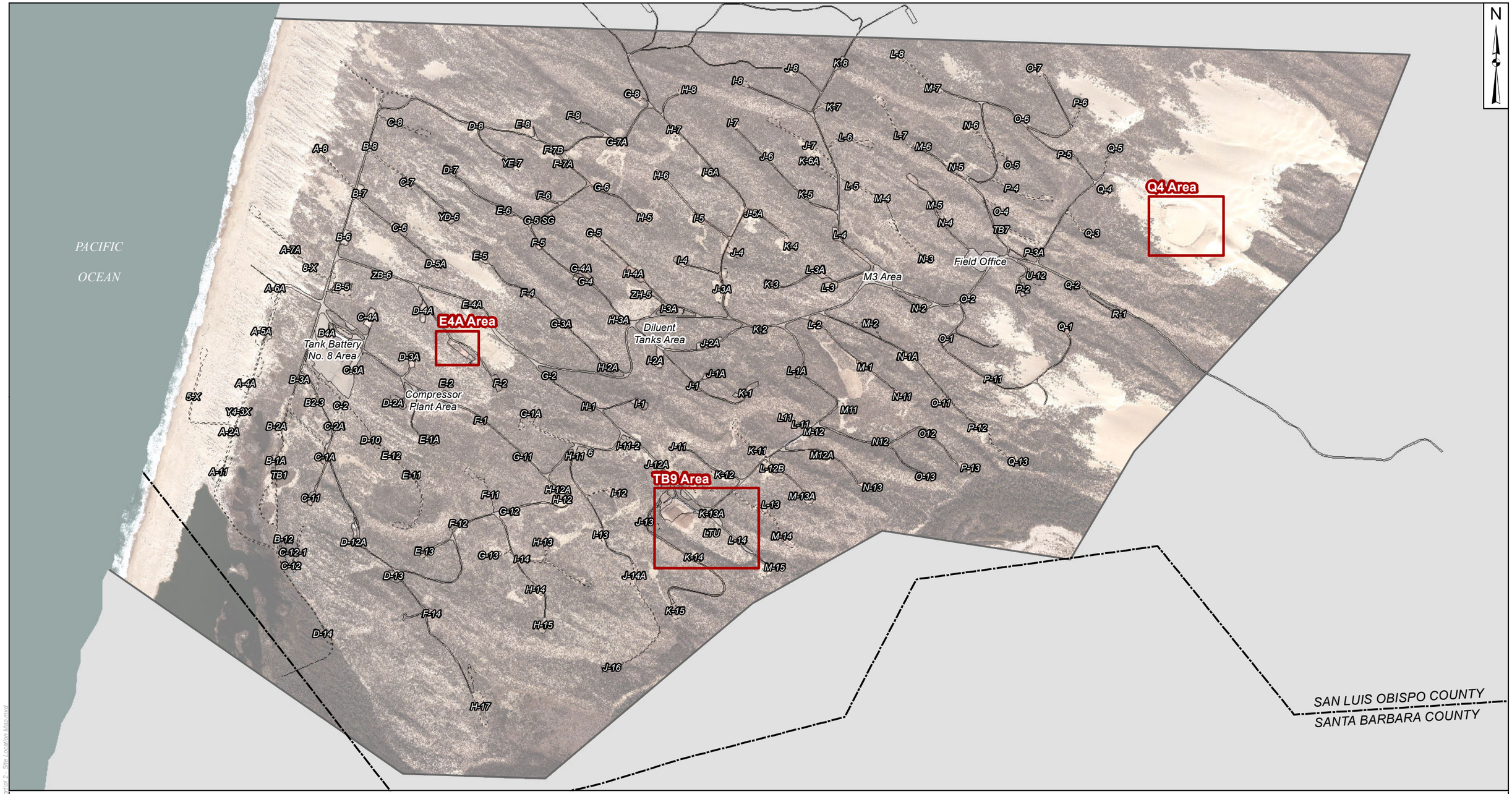
PROJECT NUMBER: 1801-2191

DATE: October 2018

GENERAL VICINITY MAP

PLATE 1

G:\Guadalupe\Assessment\T59\Geotechnical\Data\Report\Figure 1 - General Vicinity Map.mxd 10/8/2018



LEGEND:

Property Boundary | County Line | Existing Roadway or Well Pad Feature | Former Roadway or Well Pad Feature

0 650 1,300
FEET

Source: Cannon 2018 Image
Coordinate System: NAD 1927 StatePlane California V FIPS 0405
Abbreviation: TB = Tank Battery
Notes: This map was created for informational and display purposes only

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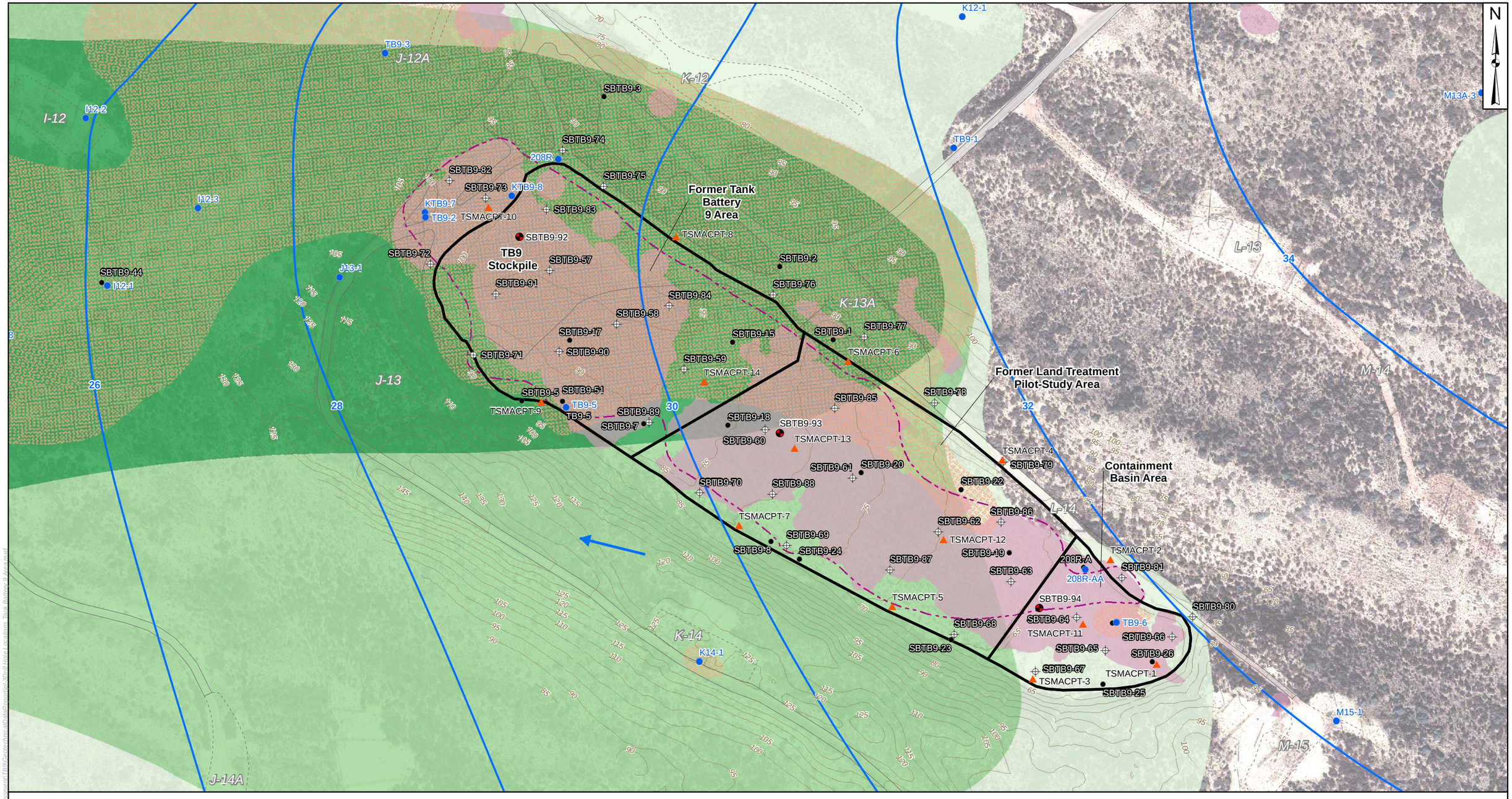
PROJECT NAME: CHEVRON ENVIRONMENTAL MANAGEMENT COMPANY GUADALUPE RESTORATION PROJECT
PROJECT NUMBER: 1801-2191
DATE: October 2018

TANK BATTERY 9 AREA SITE LOCATION MAP

FIGURE 2

G:\padre\Areas\main\TB9\Geotechnical\Data\Report\pl 2 - Site Location Map.mxd



LEGEND:

- 4Q16 Drill Hole Location
- Historical Drill Hole Location
- Groundwater Monitoring Well
- 2018 Cone Penetrometer Test (CPT)
- 2018 Drill Hole Location
- 5-ft Topographic Elevation Contour
- Existing Roadway or Well Pad Feature
- Former Roadway or Well Pad Feature
- LNAPL Source
- Approximate Extent of Sump based on Aerial Photo Review
- Approximate Extent of Sump material based on Assessment Results
- 1Q18 TPH Concentrations in Groundwater Above Laboratory Reporting Limit of 0.05 to 1
- 1Q18 TPH Concentrations in Groundwater Ranging from 1 to 10 mg/L
- 1Q18 TPH Concentrations in Groundwater Greater than 10 mg/L
- 1Q18 Groundwater Elevation Contour (feet msl)
- Ground Water Flow Direction

0 80 160
FEET

Source: Cannon 4/2018 Image, Cannon 2016 Contours
Coordinate System: NAD 1927 StatePlane California V FIPS 0405
Abbreviations: ft = foot
LNAPL = Light Non-Aqueous Phase Liquid
mg/L = Milligrams per Liter
TB = Tank Battery
TPH = Total Petroleum Hydrocarbons
Notes: This map was created for informational and display purposes only.

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PROJECT NAME: CHEVRON ENVIRONMENTAL MANAGEMENT COMPANY GUADALUPE RESTORATION PROJECT
PROJECT NUMBER: 1801-2191
DATE: October 2018

TB9 GEOTECHNICAL EXPLORATION LOCATION MAP

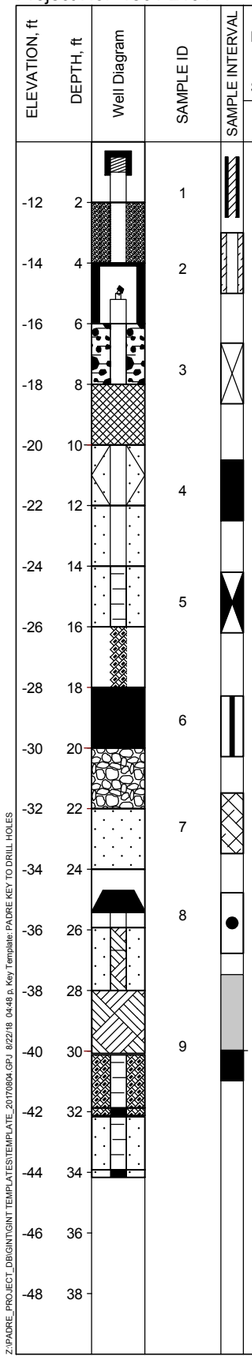
PLATE 3

z:\Kristin\GIS Maps\Maps Project\Guadalupe\Assessment\TB9\Geotechnical\Data Reporting\3 Drill Hole Locations, Tank Battery 9 Area.mxd

APPENDIX A
SUBSURFACE EXPLORATION

October 2018
Project No. 1801-2191

padre associates, inc.
ENGINEERS, GEOLOGISTS & ENVIRONMENTAL SCIENTISTS



LOCATION: The drill hole location referencing local landmarks or coordinates

SURFACE EL: Surface elevation based on MSL

MATERIAL DESCRIPTION

- Riser
- Solid Pipe Packed in Bentonite Chips
- Locking Well Cap in Traffic Box
- Solid Pipe in Concrete
- Native Backfill
- Centralizer with Solid Pipe in Sand
- Solid Pipe Packed in Sand
- Slotted Pipe Packed in Sand
- Abandoned Well
- Bentonite in Bottom of Hole
- Slough at Bottom of Hole
- Native Sand Backfill
- Well Cover for Vapor Probe Holes
- Grout Packed Slotted Pipe in Sand
- Grout / Neat Cement
- Slotted Pipe in Grout with Bottom Cap
- Slotted Pipe in Sand with Bottom Cap

WATER LEVEL SYMBOLS:

- Initial or perched water level
- Final groundwater level

CONTACT SYMBOLS:

- Inferred Contact
- Known Contact

GENERAL NOTES:

SAMPLE ID FOR:

1 Hand-Auger
2 Soil Core
3 Standard Penetration Test (SPT)
4 Environmental Jar Sample
5 Modified California
6 Shelby Tube
7 Bulk or Grab Bag
8 No Recovery
9 Direct Push Sample Interval:

Recovered Length of Driven Sampler

Soil Sample Retained for Laboratory Analysis

ABBREVIATIONS:

1) * = Sample collected but not sent for analysis
2) bgs = below ground surface
3) d/r = driven/recovered
4) El. = Elevation
5) ft = Feet
6) GP = Geoprobe
7) HA = Hand-Auger
8) HSA/DP = Hollow Stem Auger/Direct Push
9) J = J-Flagged (Estimated Value)
10) ksf = kips per square foot
11) m. = Mini Torvane
12) mg/Kg = milligrams per Kilogram
13) MSL = mean sea level
14) NA = not analyzed
15) NM = not measured
16) NR = no recovery
17) p. = pocket penetrometer
18) PID = Photoionization Detector
19) ppm = parts per million
20) ppmv = parts per million by volume
21) q. = Unconsolidated Undrained Triaxial
22) SB = Soil Boring
23) t. = Torvane
24) TD = Total Depth
25) tsf = tons per square foot
26) U. = Unconfined Compression
27) USCS = Unified Soil Classification System

NOTES:

1) All items in legend may not appear on logs.
2) Length of sample symbol approximates recovery length.
3) Classification of Soils per ASTM D2487 or D2488.
4) Geologic Formation noted in bold font at the top of interpretted interval.
5) Rock Quality Designation (RQD) is the sum of recovery core pieces grater than 4 inches divided by the length of the core interval.

SOIL AND ROCK TYPES:

- Asphalt or Concrete Pavement (AC)
- Artificial Fill (af)
- Base Material
- Top Soil
- Fat CLAY (CH)
- Gravelly Fat CLAY (CH)
- Silty Fat CLAY (CH)
- Sandy Fat CLAY (CH)
- Sandy Fat CLAY with gravel (CH)
- Fat CLAY with Sand (CH)
- Lean CLAY (CL)
- Lean CLAY with gravel (CL)
- Gravelly Lean CLAY with sand (CL)
- Silty CLAY (CL)
- Silty CLAY with sand (CL)
- Sandy Lean CLAY (CL)
- Lean CLAY with Sand and Gravel (CL)
- Lean CLAY with sand (CL)
- Clayey GRAVEL (GC)
- Silty, Clayey GRAVEL (with Sand, GC)
- Silty GRAVEL (GM)
- Silty GRAVEL with Sand (GM)
- Poorly Graded GRAVEL (GP)
- Poorly Graded GRAVEL with Clay (and Sand, GP)
- Poorly Graded GRAVEL with Silt (and Sand, GP)
- Sandy GRAVEL with Silt (GP)
- Poorly Graded GRAVEL with Sand (GP)
- Well Graded GRAVEL (GW)
- Well Graded GRAVEL with Clay (GW)
- Well Graded GRAVEL with Silt (and Sand, GW)
- Well Graded GRAVEL with Sand (GW)
- Elastic SILT (MH)
- Elastic SILT with Fat Clay (MH)
- Elastic SILT with Sand (MH)
- SILT (ML)
- Organic, Sandy SILT (ML)
- Sandy, Clayey SILT (ML)
- Clayey SILT (ML) to Clayey SAND (SC)
- SILT with gravel (ML)
- Sandy SILT (ML)
- Sandy SILT with gravel (ML)
- Sandy SILT with clay (ML)
- SILT with sand (ML)
- High Plasticity ORGANIC (OH)
- Low Plasticity ORGANIC (OL)
- Plastic ORGANIC (OH/OL)
- PEAT or ORGANIC MATTER (PT)
- Clayey SAND (SC)
- Clayey SAND and Basalt (SC)
- Clayey SAND with Gravel (SC)
- Silty, Clayey SAND (SC)
- Silty, Clayey SAND with Gravel (SC)
- Silty SAND (SM)
- Silty SAND with Gravel (SM)
- Silty SAND (SM) and Sandy SILT (ML)
- Poorly Graded SAND (SP)
- Poorly Graded SAND with CLAY (SP)
- Poorly Graded SAND with Gravel (SP)
- Gravelly SAND (SP)
- Poorly Graded SAND with (Silty) Clay (and Gravel, SP)
- Poorly Graded SAND with Silt (and Gravel, SP)
- Gravelly SAND with silt (SP)
- Well Graded SAND (SW)
- Well Graded SAND with gravel (SW)
- Well Graded SAND with (Silty) Clay (and Gravel, SW)
- Well Graded SAND with Silt (and Gravel, SW)
- BASALT
- BASE Material
- BEDROCK
- BOULDERS and COBBLES
- BRECCIA
- CHALK
- Chert
- CLAYSTONE
- CLAYSTONE and SILTSTONE
- CLAYSTONE and SANDSTONE
- COAL
- CONCRETE
- CONGLOMERATE
- CORAL or SHELLS
- DOLOMITE
- GYPSUM, ROCKSALT
- IGNEOUS ROCK
- LIMESTONE
- MELANGE
- METAMORPHIC ROCK
- MUDSTONE
- Rock Fragments
- Sand SLURRY (Cement Stabilized Sand)
- SANDSTONE
- SANDSTONE and SILTSTONE
- Interbedded SANDSTONE and SHALE
- SERPENTINITE
- SHALE
- SILTSTONE
- Tuff
- VEGETATION, SOD, or GROUNDCOVER

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KEY TO TERMS & SYMBOLS USED ON LOGS

Guadalupe Restoration Project
Guadalupe, California

PLATE A-1

October 2018
Project No. 1801-2191

padre associates, inc.
ENGINEERS, GEOLOGISTS & ENVIRONMENTAL SCIENTISTS

LOCATION: Tank Battery 9 Area
SURFACE ELEVATION: 99.37 ft +/- (relative datum MSL)
NORTHING: 546632.52
EASTING: 1214083.08
COORDINATE SYSTEM: NAD27 SP Ca Zn 5, ft

ELEVATION, ft / DEPTH, ft	USCS MATERIAL SYMBOL	SAMPLE ID	SAMPLE INTERVAL	SAMPLER BLOW COUNT/	MATERIAL DESCRIPTION	UNIT WET WEIGHT, pcf	UNIT DRY WEIGHT, pcf	WATER CONTENT, %	% PASSING #200 SIEVE	LIQUID LIMIT, %	PLASTICITY INDEX, %	UNDRAINED SHEAR STRENGTH, S_u, ksf	GAS MONITOR: MultiRAE Lite (ppm)
98 / 2		SBTB9-92a-0to5-081618			**ARTIFICIAL FILL (af)** Poorly graded SAND with gravel (SP), stiff, yellow (10YR 7/6), moist, medium grained								
96 / 4													
94 / 6		SBTB9-92a-5-081618		34	Hard, strong hydrocarbon odor								0.0
92 / 8													
90 / 10		SBTB9-92a-10,5-081618		29	Sump material (af), medium dense, black (10YR 2/1), mild hydrocarbon odor								0.0
88 / 12		SBTB9-92a-10-081618			Poorly graded GRAVEL (GP), yellow (10YR 7/6), medium grained, no hydrocarbon odor Dark brown (10YR 3/3)								
86 / 14													

U:\GINT\2-GRP\TB9\TB9-2018\GRP_TB9_1801-2191.GPJ 10/3/18 04:20 p, Template: PADRE_GEOW/ PIDNOWELL_APPA

DRILLING DATE: August 16, 2018
DEPTH TO GROUNDWATER: Not Encountered
COMPLETION DEPTH: 61.5 ft
BACKFILLED WITH: Bentonite Grout

DRILLING/SAMPLING METHOD: 8-in. dia. Hollow Stem Auger
HAMMER TYPE: Automatic Trip
DRILLING COMPANY: Gregg Drilling
LOGGED BY: E. von Thury
CHECKED BY: R. Zukor, P.G.

LOG OF WELL SBTB9-92

Guadalupe Restoration Project
Guadalupe, California

PLATE A-1a

The log and data presented are a simplification of actual conditions encountered at the time of drilling at the drilled location. Subsurface conditions may differ at other locations and with the passage of time. Please refer to Key to Boring Log for symbol explanation.

October 2018
Project No. 1801-2191

padre associates, inc.
ENGINEERS, GEOLOGISTS & ENVIRONMENTAL SCIENTISTS

LOCATION: Tank Battery 9 Area
SURFACE ELEVATION: 99.37 ft +/- (relative datum MSL)
NORTHING: 546632.52
EASTING: 1214083.08
COORDINATE SYSTEM: NAD27 SP Ca Zn 5, ft

ELEVATION, ft / DEPTH, ft	USCS MATERIAL SYMBOL	SAMPLE ID	SAMPLE INTERVAL	SAMPLER BLOW COUNT/	MATERIAL DESCRIPTION	UNIT WET WEIGHT, pcf	UNIT DRY WEIGHT, pcf	WATER CONTENT, %	% PASSING #200 SIEVE	LIQUID LIMIT, %	PLASTICITY INDEX, %	UNDRAINED SHEAR STRENGTH, S_u, ksf	GAS MONITOR: MultiRAE Lite (ppm)
84		SBTB9-92a-15.5-081618		30	Medium dense, mild hydrocarbon odor								0.0
16		SBTB9-92a-15-081618			**Guadalupe Sand Dune Complex** Poorly graded SAND (SP), medium dense, light yellowish brown (10YR 6/4), slightly moist, medium grained, no hydrocarbon odor								
82													
18													
80													
20		SBTB9-92a-20-081618		26	Yellowish brown (10YR 5/4), no hydrocarbon odor			4	2				0.0
78													
22													
76													
24													
74		SBTB9-92a-25-081618		26	Yellowish brown (10YR 5/6), fine grained, no hydrocarbon odor								0.0
26					Medium grained Fine grained								
72													
28													
70													

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DRILLING DATE: August 16, 2018
DEPTH TO GROUNDWATER: Not Encountered
COMPLETION DEPTH: 61.5 ft
BACKFILLED WITH: Bentonite Grout

DRILLING/SAMPLING METHOD: 8-in. dia. Hollow Stem Auger
HAMMER TYPE: Automatic Trip
DRILLING COMPANY: Gregg Drilling
LOGGED BY: E. von Thury
CHECKED BY: R. Zukor, P.G.

LOG OF WELL SBTB9-92

Guadalupe Restoration Project
Guadalupe, California

PLATE A-1b

The log and data presented are a simplification of actual conditions encountered at the time of drilling at the drilled location. Subsurface conditions may differ at other locations and with the passage of time. Please refer to Key to Boring Log for symbol explanation.

October 2018
Project No. 1801-2191

padre associates, inc.
ENGINEERS, GEOLOGISTS & ENVIRONMENTAL SCIENTISTS

LOCATION: Tank Battery 9 Area
SURFACE ELEVATION: 99.37 ft +/- (relative datum MSL)
NORTHING: 546632.52
EASTING: 1214083.08
COORDINATE SYSTEM: NAD27 SP Ca Zn 5, ft

ELEVATION, ft / DEPTH, ft	USCS MATERIAL SYMBOL	SAMPLE ID	SAMPLE INTERVAL	SAMPLER BLOW COUNT/	MATERIAL DESCRIPTION	UNIT WET WEIGHT, pcf	UNIT DRY WEIGHT, pcf	WATER CONTENT, %	% PASSING #200 SIEVE	LIQUID LIMIT, %	PLASTICITY INDEX, %	UNDRAINED SHEAR STRENGTH, S_u, ksf	GAS MONITOR: MultiRAE Lite (ppm)
68 / 32		SBTB9-92a-30-081618		30	No hydrocarbon odor								0.0
66 / 34													
64 / 36		SBTB9-92a-35-081618		26	No hydrocarbon odor 0.25 inched thick of oxidation staining								0.0
62 / 38													
60 / 40		SBTB9-92a-40-081618		19				3	1				0.0
58 / 42													
56 / 44													

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DRILLING DATE: August 16, 2018
DEPTH TO GROUNDWATER: Not Encountered
COMPLETION DEPTH: 61.5 ft
BACKFILLED WITH: Bentonite Grout

DRILLING/SAMPLING METHOD: 8-in. dia. Hollow Stem Auger
HAMMER TYPE: Automatic Trip
DRILLING COMPANY: Gregg Drilling
LOGGED BY: E. von Thury
CHECKED BY: R. Zukor, P.G.

LOG OF WELL SBTB9-92

Guadalupe Restoration Project
Guadalupe, California

PLATE A-1c

The log and data presented are a simplification of actual conditions encountered at the time of drilling at the drilled location. Subsurface conditions may differ at other locations and with the passage of time. Please refer to Key to Boring Log for symbol explanation.

October 2018
Project No. 1801-2191

padre associates, inc.
ENGINEERS, GEOLOGISTS & ENVIRONMENTAL SCIENTISTS

LOCATION: Tank Battery 9 Area
SURFACE ELEVATION: 99.37 ft +/- (relative datum MSL)
NORTHING: 546632.52
EASTING: 1214083.08
COORDINATE SYSTEM: NAD27 SP Ca Zn 5, ft

ELEVATION, ft DEPTH, ft	USCS MATERIAL SYMBOL	SAMPLE ID	SAMPLE INTERVAL	SAMPLER BLOW COUNT/	MATERIAL DESCRIPTION	UNIT WET WEIGHT, pcf	UNIT DRY WEIGHT, pcf	WATER CONTENT, %	% PASSING #200 SIEVE	LIQUID LIMIT, %	PLASTICITY INDEX, %	UNDRAINED SHEAR STRENGTH, S_u, ksf	GAS MONITOR: MultiRAE Lite (ppm)
54 / 46		SBTB9-92a-45-081618		42	Dense, no hydrocarbon odor								0.0
52 / 48													
50 / 50		SBTB9-92a-50-081618		50	Medium dense, no hydrocarbon odor								0.0
48 / 52													
46 / 54													
44 / 56		SBTB9-92a-55-081618		50/6"	Hard, no hydrocarbon odor								0.0
42 / 58													
40													

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DRILLING DATE: August 16, 2018
DEPTH TO GROUNDWATER: Not Encountered
COMPLETION DEPTH: 61.5 ft
BACKFILLED WITH: Bentonite Grout

DRILLING/SAMPLING METHOD: 8-in. dia. Hollow Stem Auger
HAMMER TYPE: Automatic Trip
DRILLING COMPANY: Gregg Drilling
LOGGED BY: E. von Thury
CHECKED BY: R. Zukor, P.G.

LOG OF WELL SBTB9-92

Guadalupe Restoration Project
Guadalupe, California

PLATE A-1d

The log and data presented are a simplification of actual conditions encountered at the time of drilling at the drilled location. Subsurface conditions may differ at other locations and with the passage of time. Please refer to Key to Boring Log for symbol explanation.

October 2018
Project No. 1801-2191

padre associates, inc.
ENGINEERS, GEOLOGISTS & ENVIRONMENTAL SCIENTISTS

LOCATION: Tank Battery 9 Area
SURFACE ELEVATION: 99.37 ft +/- (relative datum MSL)
NORTHING: 546632.52
EASTING: 1214083.08
COORDINATE SYSTEM: NAD27 SP Ca Zn 5, ft

ELEVATION, ft / DEPTH, ft	USCS MATERIAL SYMBOL	SAMPLE ID	SAMPLE INTERVAL	SAMPLER BLOW COUNT/	MATERIAL DESCRIPTION	UNIT WET WEIGHT, pcf	UNIT DRY WEIGHT, pcf	WATER CONTENT, %	% PASSING #200 SIEVE	LIQUID LIMIT, %	PLASTICITY INDEX, %	UNDRAINED SHEAR STRENGTH, S_u, ksf	GAS MONITOR: MultiRAE Lite (ppm)
38 / 62		SBTB9-92a-60-081618		49	Very dense, brownish yellow (10YR 6/6), no hydrocarbon odor			4	2				0.0
36 / 64													
34 / 66													
32 / 68													
30 / 70													
28 / 72													
26 / 74													

U:\GINT\2-GRP\TB9\TB9-2018\GRP_TB9_1801-2191.GPJ 10/3/18 04:20 p. Template: PADRE_GEOW/ PIDNOWELL_APPA

DRILLING DATE: August 16, 2018
DEPTH TO GROUNDWATER: Not Encountered
COMPLETION DEPTH: 61.5 ft
BACKFILLED WITH: Bentonite Grout

DRILLING/SAMPLING METHOD: 8-in. dia. Hollow Stem Auger
HAMMER TYPE: Automatic Trip
DRILLING COMPANY: Gregg Drilling
LOGGED BY: E. von Thury
CHECKED BY: R. Zukor, P.G.

LOG OF WELL SBTB9-92

Guadalupe Restoration Project
Guadalupe, California

PLATE A-1e

The log and data presented are a simplification of actual conditions encountered at the time of drilling at the drilled location. Subsurface conditions may differ at other locations and with the passage of time. Please refer to Key to Boring Log for symbol explanation.

October 2018
Project No. 1801-2191

padre associates, inc.
ENGINEERS, GEOLOGISTS & ENVIRONMENTAL SCIENTISTS

LOCATION: Tank Battery 9 Area
SURFACE ELEVATION: 81.94 ft +/- (relative datum MSL)
NORTHING: 546270.11
EASTING: 1214555.75
COORDINATE SYSTEM: NAD27 SP Ca Zn 5, ft

ELEVATION, ft / DEPTH, ft	USCS MATERIAL SYMBOL	SAMPLE ID	SAMPLE INTERVAL	SAMPLER BLOW COUNT/	MATERIAL DESCRIPTION	UNIT WET WEIGHT, pcf	UNIT DRY WEIGHT, pcf	WATER CONTENT, %	% PASSING #200 SIEVE	LIQUID LIMIT, %	PLASTICITY INDEX, %	UNDRAINED SHEAR STRENGTH, S_u, ksf	GAS MONITOR: MultiRAE Lite (ppm)
80 / 2		SBTB9-93-0to5-081418			**ARTIFICIAL FILL (af)** Poorly graded SAND (SP), loose, dark yellowish brown (10YR 4/6), slightly moist, medium grained, no hydrocarbon odor, few rootlets								
78 / 4		SBTB9-93-5-081418		35	Medium dense, no hydrocarbon odor								3.9
76 / 6		SBTB9-93-5.5-081418			Sump material (af), very dense, black (2.5Y 2.5/1), slightly moist, medium grained, strong hydrocarbon odor								
74 / 8													
72 / 10		SBTB9-93-10-081418		9	Stiff, strong hydrocarbon odor								394
70 / 12													
68 / 14		SBTB9-93-12.5-081418											

U:\GINT\2-GRP\TB9\TB9-2018\GRP_TB9_1801-2191.GPJ 10/3/18 04:20 p. Template: PADRE_GEOW/ PIDNOWELL_APPA

DRILLING DATE: August 15, 2018
DEPTH TO GROUNDWATER: 53.9 ft
COMPLETION DEPTH: 56.5 ft
BACKFILLED WITH: Bentonite Grout

DRILLING/SAMPLING METHOD: 8-in. dia. Hollow Stem Auger
HAMMER TYPE: Automatic Trip
DRILLING COMPANY: Gregg Drilling
LOGGED BY: E. von Thury
CHECKED BY: R. Zukor, P.G.

LOG OF WELL SBTB9-93

Guadalupe Restoration Project
Guadalupe, California

PLATE A-2a

The log and data presented are a simplification of actual conditions encountered at the time of drilling at the drilled location. Subsurface conditions may differ at other locations and with the passage of time. Please refer to Key to Boring Log for symbol explanation.

October 2018
Project No. 1801-2191

padre associates, inc.
ENGINEERS, GEOLOGISTS & ENVIRONMENTAL SCIENTISTS

LOCATION: Tank Battery 9 Area
SURFACE ELEVATION: 81.94 ft +/- (relative datum MSL)
NORTHING: 546270.11
EASTING: 1214555.75
COORDINATE SYSTEM: NAD27 SP Ca Zn 5, ft

ELEVATION, ft / DEPTH, ft	USCS MATERIAL SYMBOL	SAMPLE ID	SAMPLE INTERVAL	SAMPLER BLOW COUNT/	MATERIAL DESCRIPTION	UNIT WET WEIGHT, pcf	UNIT DRY WEIGHT, pcf	WATER CONTENT, %	% PASSING #200 SIEVE	LIQUID LIMIT, %	PLASTICITY INDEX, %	UNDRAINED SHEAR STRENGTH, S_u, ksf	GAS MONITOR: MultiRAE Lite (ppm)
66 / 16		SBTB9-93-16-081418		6	Strong hydrocarbon odor								359
		SBTB9-93-15-081418											
64 / 18													
62 / 20		SBTB9-93-20.5-081418		32	Dense, moist, strong hydrocarbon odor								291
		SBTB9-93-20-081418			**Guadalupe sand dune complex** Poorly graded SAND (SP), dense, dark grayish brown (10YR 4/2), slightly moist, medium grained, slight hydrocarbon odor								
60 / 22		SBTB9-93-21.5-081418											
		SBTB9-93-22.5-081418			Strong hydrocarbon odor End 8/14/18 and resume 8/15/18								
58 / 24													
		SBTB9-93-25-081418		38	Brown (10YR 5/3), slightly moist, strong hydrocarbon odor			3	1				6.0
56 / 26													
54 / 28													

U:\GINT\2-GRP\TB9\TB9-2018\GRP_TB9_1801-2191.GPJ 10/3/18 04:20 p. Template: PADRE_GEOW/ PIDNOWELL_APPA

DRILLING DATE: August 15, 2018
DEPTH TO GROUNDWATER: 53.9 ft
COMPLETION DEPTH: 56.5 ft
BACKFILLED WITH: Bentonite Grout

DRILLING/SAMPLING METHOD: 8-in. dia. Hollow Stem Auger
HAMMER TYPE: Automatic Trip
DRILLING COMPANY: Gregg Drilling
LOGGED BY: E. von Thury
CHECKED BY: R. Zukor, P.G.

LOG OF WELL SBTB9-93

Guadalupe Restoration Project
Guadalupe, California

PLATE A-2b

The log and data presented are a simplification of actual conditions encountered at the time of drilling at the drilled location. Subsurface conditions may differ at other locations and with the passage of time. Please refer to Key to Boring Log for symbol explanation.

October 2018
Project No. 1801-2191

padre associates, inc.
ENGINEERS, GEOLOGISTS & ENVIRONMENTAL SCIENTISTS

LOCATION: Tank Battery 9 Area
SURFACE ELEVATION: 81.94 ft +/- (relative datum MSL)
NORTHING: 546270.11
EASTING: 1214555.75
COORDINATE SYSTEM: NAD27 SP Ca Zn 5, ft

ELEVATION, ft / DEPTH, ft	USCS MATERIAL SYMBOL	SAMPLE ID	SAMPLE INTERVAL	SAMPLER BLOW COUNT/	MATERIAL DESCRIPTION	UNIT WET WEIGHT, pcf	UNIT DRY WEIGHT, pcf	WATER CONTENT, %	% PASSING #200 SIEVE	LIQUID LIMIT, %	PLASTICITY INDEX, %	UNDRAINED SHEAR STRENGTH, S_u, ksf	GAS MONITOR: MultiRAE Lite (ppm)
		SBTB9-93-30-081418		52	Very dense, moderate hydrocarbon odor, slightly indurated								0.0
-50 32													
-48 34													
		SBTB9-93-35-081418		45	Dense, grayish brown (10YR 5/2), moist, medium grained, moderate hydrocarbon odor			2	1				4.0
-46 36					Pale brown (10YR 6/3), slightly moist, fine grained								
-44 38													
-42 40		SBTB9-93-40.5-081418		45	Dark yellowish brown (10YR 3/4), moist, strong hydrocarbon odor								1.0
		SBTB9-93-40-081418			Brown (10YR 4/3)								
-40 42					Slight hydrocarbon odor								
-38 44													

U:\GINT\2-GRP\TB9\TB9-2018\GRP_TB9_1801-2191.GPJ 10/3/18 04:20 p. Template: PADRE_GEOW/ PIDNOWELL_APPA

DRILLING DATE: August 15, 2018
DEPTH TO GROUNDWATER: 53.9 ft
COMPLETION DEPTH: 56.5 ft
BACKFILLED WITH: Bentonite Grout

DRILLING/SAMPLING METHOD: 8-in. dia. Hollow Stem Auger
HAMMER TYPE: Automatic Trip
DRILLING COMPANY: Gregg Drilling
LOGGED BY: E. von Thury
CHECKED BY: R. Zukor, P.G.

LOG OF WELL SBTB9-93

Guadalupe Restoration Project
Guadalupe, California

PLATE A-2c

The log and data presented are a simplification of actual conditions encountered at the time of drilling at the drilled location. Subsurface conditions may differ at other locations and with the passage of time. Please refer to Key to Boring Log for symbol explanation.

October 2018
Project No. 1801-2191

padre associates, inc.
ENGINEERS, GEOLOGISTS & ENVIRONMENTAL SCIENTISTS

LOCATION: Tank Battery 9 Area
SURFACE ELEVATION: 81.94 ft +/- (relative datum MSL)
NORTHING: 546270.11
EASTING: 1214555.75
COORDINATE SYSTEM: NAD27 SP Ca Zn 5, ft

ELEVATION, ft / DEPTH, ft	USCS MATERIAL SYMBOL	SAMPLE ID	SAMPLE INTERVAL	SAMPLER BLOW COUNT/	MATERIAL DESCRIPTION	UNIT WET WEIGHT, pcf	UNIT DRY WEIGHT, pcf	WATER CONTENT, %	% PASSING #200 SIEVE	LIQUID LIMIT, %	PLASTICITY INDEX, %	UNDRAINED SHEAR STRENGTH, S_u, ksf	GAS MONITOR: MultiRAE Lite (ppm)
		SBTB9-93-45-081418		62	Very dense, gray (10YR 5/1), medium grained, mild hydrocarbon odor								0.0
-36 46													
-34 48													
-32 50		SBTB9-93-50-081418		65	Yellowish brown (10YR 5/4), moist, slight hydrocarbon odor Wet								0.0
-30 52													
-28 54					**CONFINING UNIT**								
		SBTB9-93-55-081418		24	Lean CLAY with sand (CL), very stiff, dark yellowish brown (10YR 4/6), wet, mild hydrocarbon odor			26	80	26	17		0.0
-26 56													
-24 58													

U:\GINT\2-GRP\TB9\TB9-2018\GRP_TB9_1801-2191.GPJ 10/3/18 04:20 p, Template: PADRE_GEOW/ PIDNOWELL_APPA

DRILLING DATE: August 15, 2018
DEPTH TO GROUNDWATER: 53.9 ft
COMPLETION DEPTH: 56.5 ft
BACKFILLED WITH: Bentonite Grout

DRILLING/SAMPLING METHOD: 8-in. dia. Hollow Stem Auger
HAMMER TYPE: Automatic Trip
DRILLING COMPANY: Gregg Drilling
LOGGED BY: E. von Thury
CHECKED BY: R. Zukor, P.G.

LOG OF WELL SBTB9-93

Guadalupe Restoration Project
Guadalupe, California

PLATE A-2d

The log and data presented are a simplification of actual conditions encountered at the time of drilling at the drilled location. Subsurface conditions may differ at other locations and with the passage of time. Please refer to Key to Boring Log for symbol explanation.

October 2018
Project No. 1801-2191

padre associates, inc.
ENGINEERS, GEOLOGISTS & ENVIRONMENTAL SCIENTISTS

LOCATION: Tank Battery 9 Area
SURFACE ELEVATION: 60.91 ft +/- (relative datum MSL)
NORTHING: 545957.51
EASTING: 1215062.03
COORDINATE SYSTEM: NAD27 SP Ca Zn 5, ft

ELEVATION, ft / DEPTH, ft	USCS MATERIAL SYMBOL	SAMPLE ID	SAMPLE INTERVAL	SAMPLER BLOW COUNT/	MATERIAL DESCRIPTION	UNIT WET WEIGHT, pcf	UNIT DRY WEIGHT, pcf	WATER CONTENT, %	% PASSING #200 SIEVE	LIQUID LIMIT, %	PLASTICITY INDEX, %	UNDRAINED SHEAR STRENGTH, S_u, ksf	GAS MONITOR: MultiRAE Lite (ppm)
60 / 0		SBTB9-94-0to5-081418			**GUADALUPE SAND DUNE COMPLEX** Poorly graded SAND (SP), loose, dark yellowish brown (10YR 3/4), slightly moist, medium grained, moderate HC odor								
58 / 2													
56 / 4		SBTB9-94-5-081418		27	Poorly graded SAND with silt (SP-SM), medium dense, dark yellowish brown (10YR 4/6), dry			2	7				0.7
54 / 6					Poorly graded SAND (SP), HTP liner encountered, no hydrocarbon odor Light brownish yellow (10YR 6/4), moderate hydrocarbon odor, few oxidation stains								
52 / 8													
50 / 10		SBTB9-94-10-081418		25	Brown (10YR 5/4), moderate hydrocarbon odor								0.0
48 / 12		SBTB9-94-12.5-081418			Yellowish brown (10YR 5/6), trace oxidation stains								
46 / 14													

U:\GINT\2-GRP\TB9\TB9-2018\GRP_TB9_1801-2191.GPJ 10/3/18 04:20 p. Template: PADRE_GEOW/ PIDNOWELL_APPA

DRILLING DATE: August 14, 2018
DEPTH TO GROUNDWATER: 29.0 ft
COMPLETION DEPTH: 40.0 ft
BACKFILLED WITH: Bentonite Grout

DRILLING/SAMPLING METHOD: 8-in. dia. Hollow Stem Auger
HAMMER TYPE: Automatic Trip
DRILLING COMPANY: Gregg Drilling
LOGGED BY: E. von Thury
CHECKED BY: R. Zukor, P.G.

LOG OF WELL SBTB9-94

Guadalupe Restoration Project
Guadalupe, California

PLATE A-3a

The log and data presented are a simplification of actual conditions encountered at the time of drilling at the drilled location. Subsurface conditions may differ at other locations and with the passage of time. Please refer to Key to Boring Log for symbol explanation.

October 2018
Project No. 1801-2191

padre associates, inc.
ENGINEERS, GEOLOGISTS & ENVIRONMENTAL SCIENTISTS

LOCATION: Tank Battery 9 Area
SURFACE ELEVATION: 60.91 ft +/- (relative datum MSL)
NORTHING: 545957.51
EASTING: 1215062.03
COORDINATE SYSTEM: NAD27 SP Ca Zn 5, ft

ELEVATION, ft / DEPTH, ft	USCS MATERIAL SYMBOL	SAMPLE ID	SAMPLE INTERVAL	SAMPLER BLOW COUNT/	MATERIAL DESCRIPTION	UNIT WET WEIGHT, pcf	UNIT DRY WEIGHT, pcf	WATER CONTENT, %	% PASSING #200 SIEVE	LIQUID LIMIT, %	PLASTICITY INDEX, %	UNDRAINED SHEAR STRENGTH, S_u, ksf	GAS MONITOR: MultiRAE Lite (ppm)
16 / 44		SBTB9-94-15-081418		30	Slightly moist, medium grained, no hydrocarbon odor								0.8
18 / 42		SBTB9-94-17.5-081418											
20 / 40		SBTB9-94-20-081418		34	Dense, light yellowish brown (10YR 6/4), no hydrocarbon odor, trace oxidation staining				3				0.1
22 / 38		SBTB9-94-22.5-081418											
24 / 36		SBTB9-94-25-081418		54	Very dense, light yellowish brown (10YR 5/6), moist, no hydrocarbon odor, trace oxidation staining				3				0.3
26 / 34													
28 / 32													

U:\GINT\2-GRP\TB9\TB9-2018\GRP_TB9_1801-2191.GPJ 10/3/18 04:20 p. Template: PADRE_GEOW/ PIDNOWELL_APPA

DRILLING DATE: August 14, 2018
DEPTH TO GROUNDWATER: 29.0 ft
COMPLETION DEPTH: 40.0 ft
BACKFILLED WITH: Bentonite Grout

DRILLING/SAMPLING METHOD: 8-in. dia. Hollow Stem Auger
HAMMER TYPE: Automatic Trip
DRILLING COMPANY: Gregg Drilling
LOGGED BY: E. von Thury
CHECKED BY: R. Zukor, P.G.

LOG OF WELL SBTB9-94

Guadalupe Restoration Project
Guadalupe, California

PLATE A-3b

The log and data presented are a simplification of actual conditions encountered at the time of drilling at the drilled location. Subsurface conditions may differ at other locations and with the passage of time. Please refer to Key to Boring Log for symbol explanation.

October 2018
Project No. 1801-2191

padre associates, inc.
ENGINEERS, GEOLOGISTS & ENVIRONMENTAL SCIENTISTS

LOCATION: Tank Battery 9 Area
SURFACE ELEVATION: 60.91 ft +/- (relative datum MSL)
NORTHING: 545957.51
EASTING: 1215062.03
COORDINATE SYSTEM: NAD27 SP Ca Zn 5, ft

ELEVATION, ft DEPTH, ft	USCS MATERIAL SYMBOL	SAMPLE ID	SAMPLE INTERVAL	SAMPLER BLOW COUNT/	MATERIAL DESCRIPTION	UNIT WET WEIGHT, pcf	UNIT DRY WEIGHT, pcf	WATER CONTENT, %	% PASSING #200 SIEVE	LIQUID LIMIT, %	PLASTICITY INDEX, %	UNDRAINED SHEAR STRENGTH, S_u, ksf	GAS MONITOR: MultiRAE Lite (ppm)
		SBTB9-94-30-081418		32	Dense, dark yellowish brown (10YR 4/6), wet, no hydrocarbon odor								0.1
-30													
32													
-28													
34													
-26		SBTB9-94-35-081418		13	Loose, no hydrocarbon odor, heaving sands			19	3				0.8
		SBTB9-94-35.75-081418			**CONFINING UNIT** Lean CLAY with sand (CL), stiff, dark yellowish brown (10YR 4/4), moist, no hydrocarbon odor			20	81	27	19		0.0
36		SBTB9-94-36.5-081418			Trace ocidation staining			31		46	14		0.3
-24					Lean CLAY (CL), stiff, dark yellowish brown (10YR 4/4), moist, no hydrocarbon odor								
38													
-22													
40													
-20													
42													
-18													
44													
-16													

U:\GINT\2-GRP\TB9\TB9-2018\GRP_TB9_1801-2191.GPJ 10/3/18 04:20 p. Template: PADRE_GEOW/ PIDNOWELL_APPA

DRILLING DATE: August 14, 2018
DEPTH TO GROUNDWATER: 29.0 ft
COMPLETION DEPTH: 40.0 ft
BACKFILLED WITH: Bentonite Grout

DRILLING/SAMPLING METHOD: 8-in. dia. Hollow Stem Auger
HAMMER TYPE: Automatic Trip
DRILLING COMPANY: Gregg Drilling
LOGGED BY: E. von Thury
CHECKED BY: R. Zukor, P.G.

LOG OF WELL SBTB9-94

Guadalupe Restoration Project
Guadalupe, California

PLATE A-3c

The log and data presented are a simplification of actual conditions encountered at the time of drilling at the drilled location. Subsurface conditions may differ at other locations and with the passage of time. Please refer to Key to Boring Log for symbol explanation.

GREGG DRILLING, INC.
www.greggdrilling.com

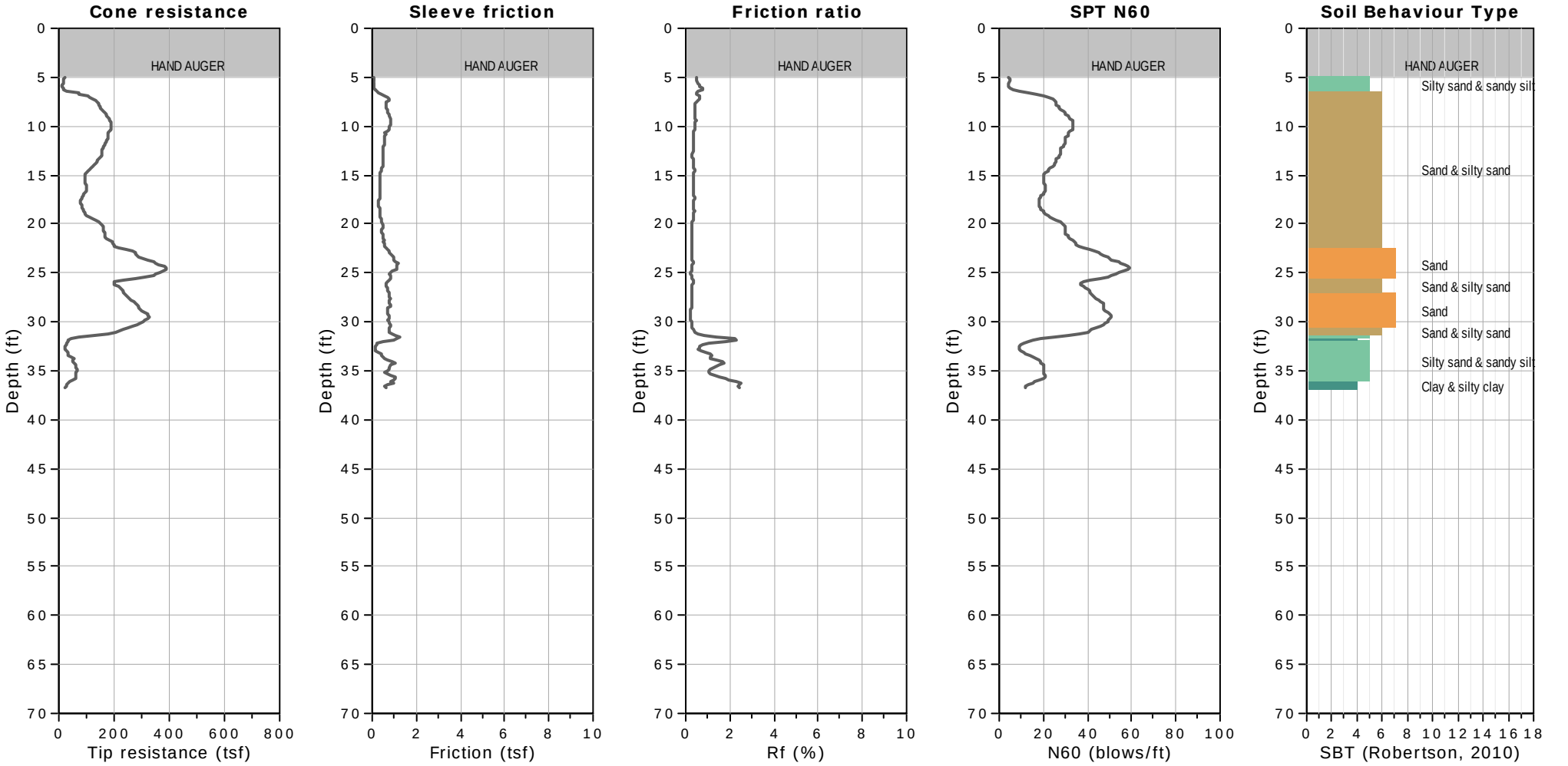
CPT: TSMACPT-1

CLIENT: PADRE ASSOCIATES, INC.

Field Rep: EVA

SITE: GUADALUPE RESTORATION PROJECT - SAN LUIS OBISPO, CA

Total depth: 36.75 ft, Date: 8/15/2018



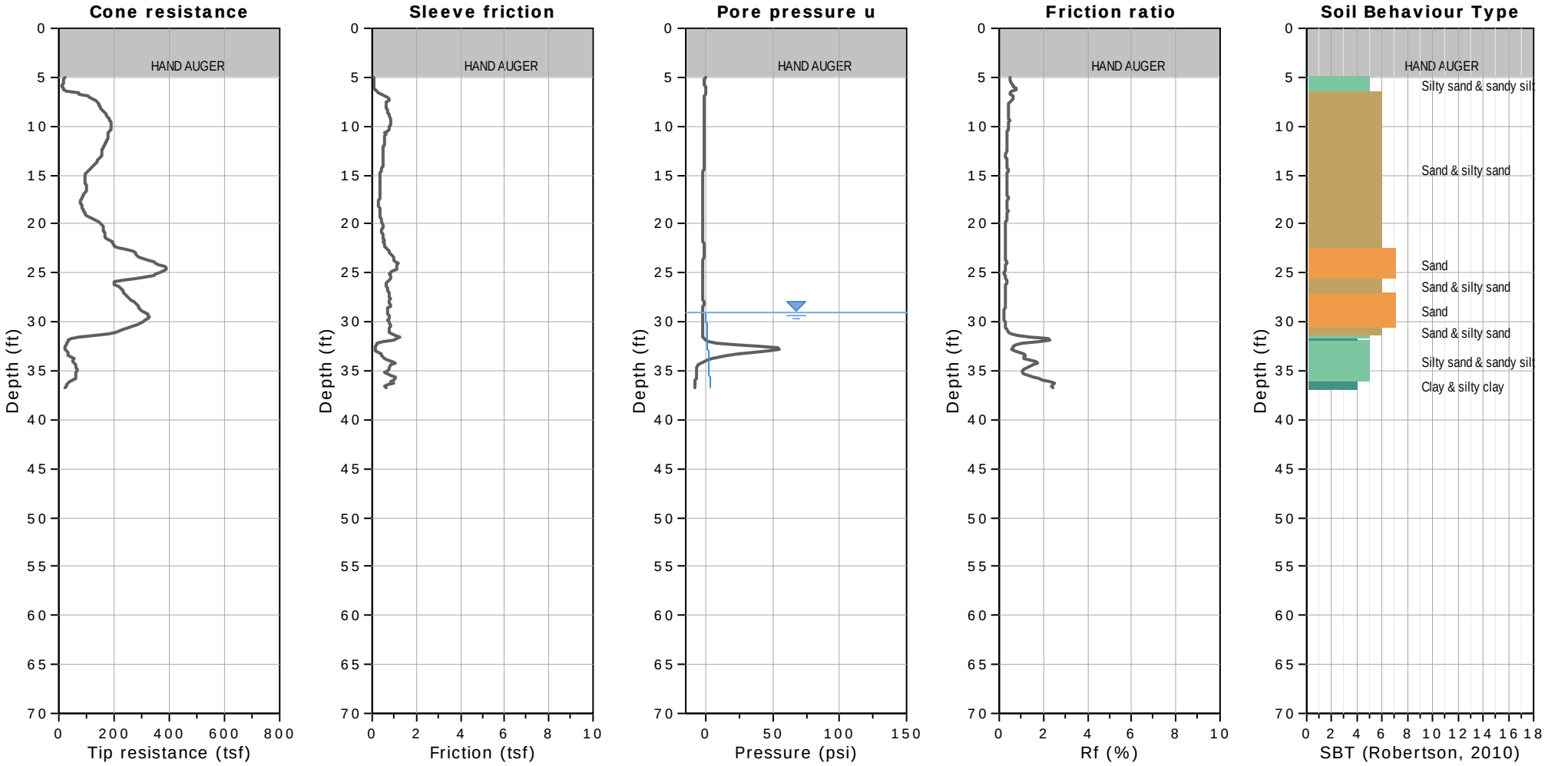
CPT: TSMACPT-1

CLIENT: PADRE ASSOCIATES, INC.

SITE: GUADALUPE RESTORATION PROJECT - SAN LUIS OBISPO, CA

Field Rep: EVA

Total depth: 36.75 ft, Date: 8/15/2018



SBTn legend

1. Sensitive fine grained
2. Organic material
3. Clay to silty clay
4. Clayey silt to silty clay
5. Silty sand to sandy silt
6. Clean sand to silty sand
7. Gravely sand to sand
8. Very stiff sand to clayey sand
9. Very stiff fine grained

WATER TABLE FOR ESTIMATING PURPOSES ONLY

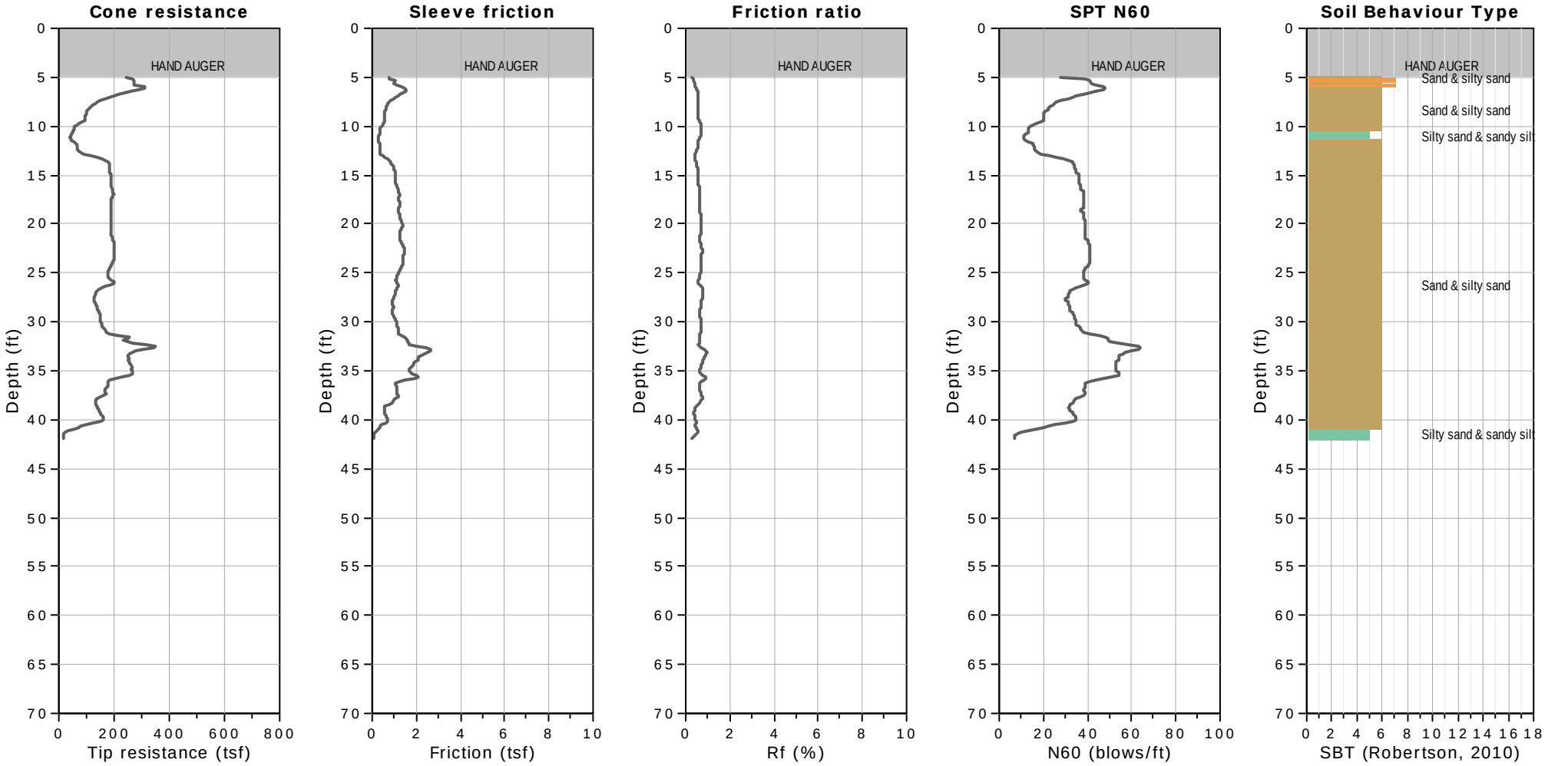
CPT: TSMACPT-2

CLIENT: PADRE ASSOCIATES, INC.

SITE: GUADALUPE RESTORATION PROJECT - SAN LUIS OBISPO, CA

Field Rep: EVA

Total depth: 41.83 ft, Date: 8/14/2018



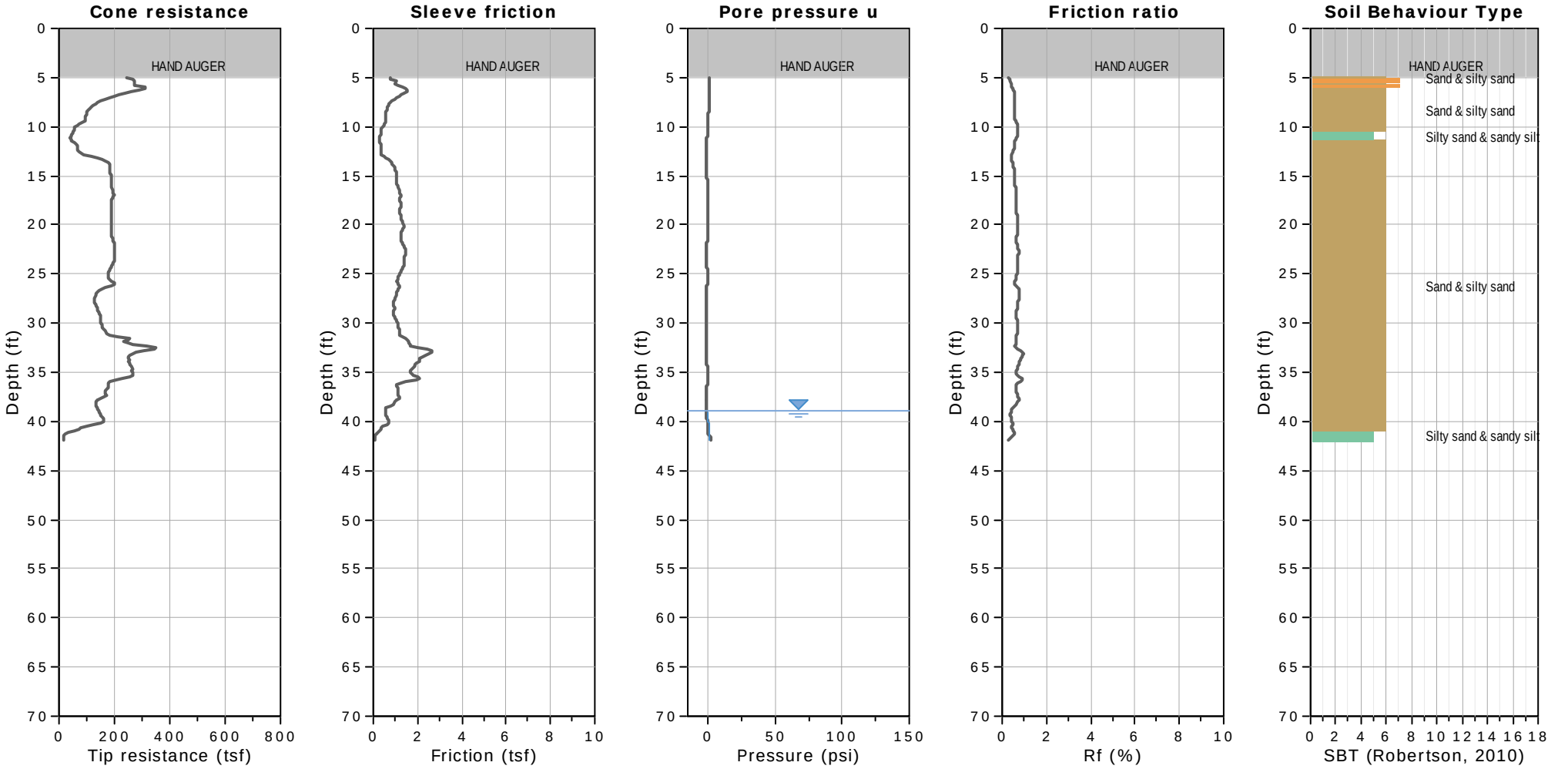
CPT: TSMACPT-2

CLIENT: PADRE ASSOCIATES, INC.

SITE: GUADALUPE RESTORATION PROJECT - SAN LUIS OBISPO, CA

Field Rep: EVA

Total depth: 41.83 ft, Date: 8/14/2018



SBTn legend

1. Sensitive fine grained
2. Organic material
3. Clay to silty clay
4. Clayey silt to silty clay
5. Silty sand to sandy silt
6. Clean sand to silty sand
7. Gravely sand to sand
8. Very stiff sand to clayey sand
9. Very stiff fine grained

WATER TABLE FOR ESTIMATING PURPOSES ONLY

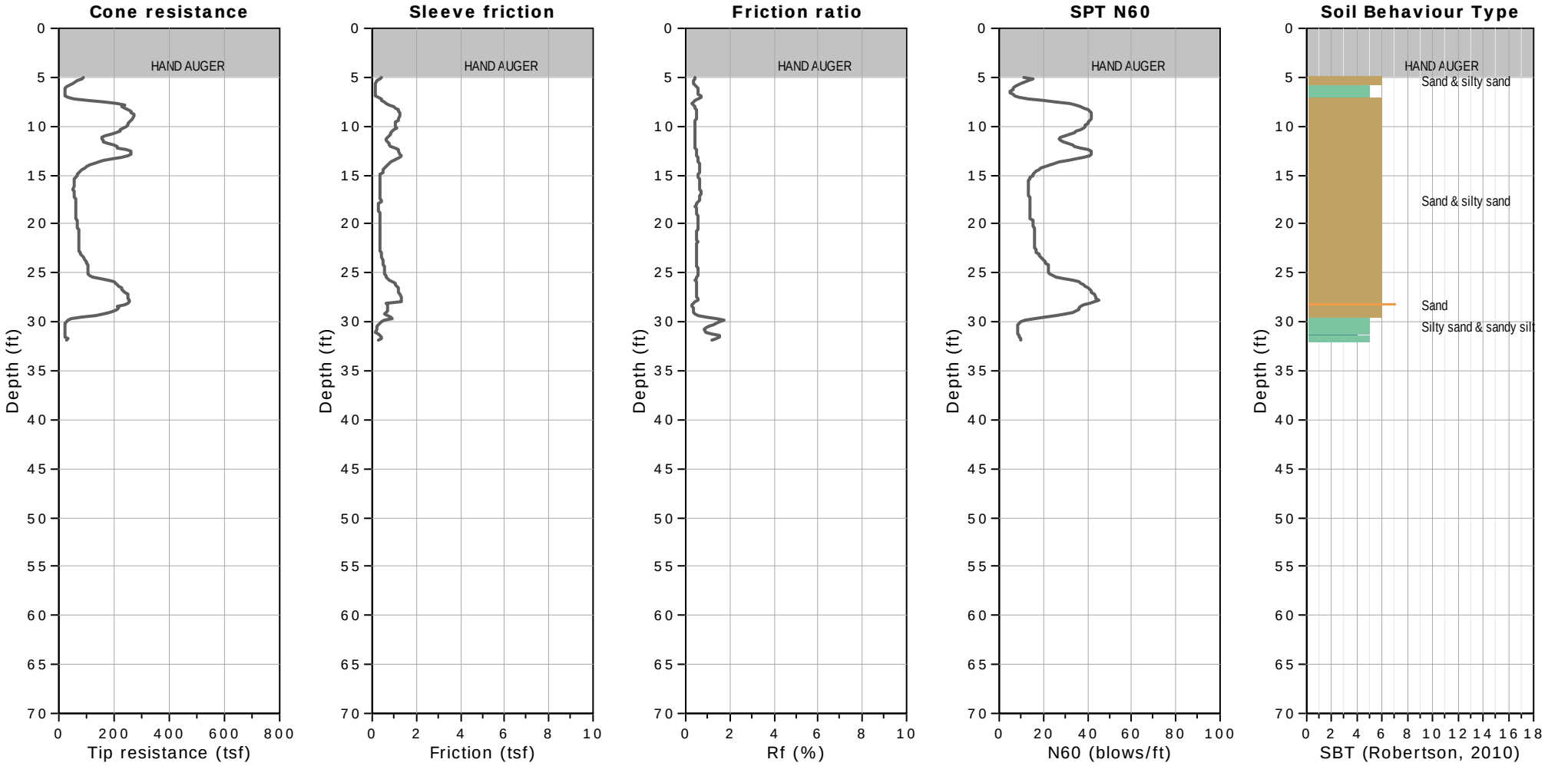
CPT: TSMACPT-3

CLIENT: PADRE ASSOCIATES, INC.

Field Rep: EVA

SITE: GUADALUPE RESTORATION PROJECT - SAN LUIS OBISPO, CA

Total depth: 31.82 ft, Date: 8/20/2018



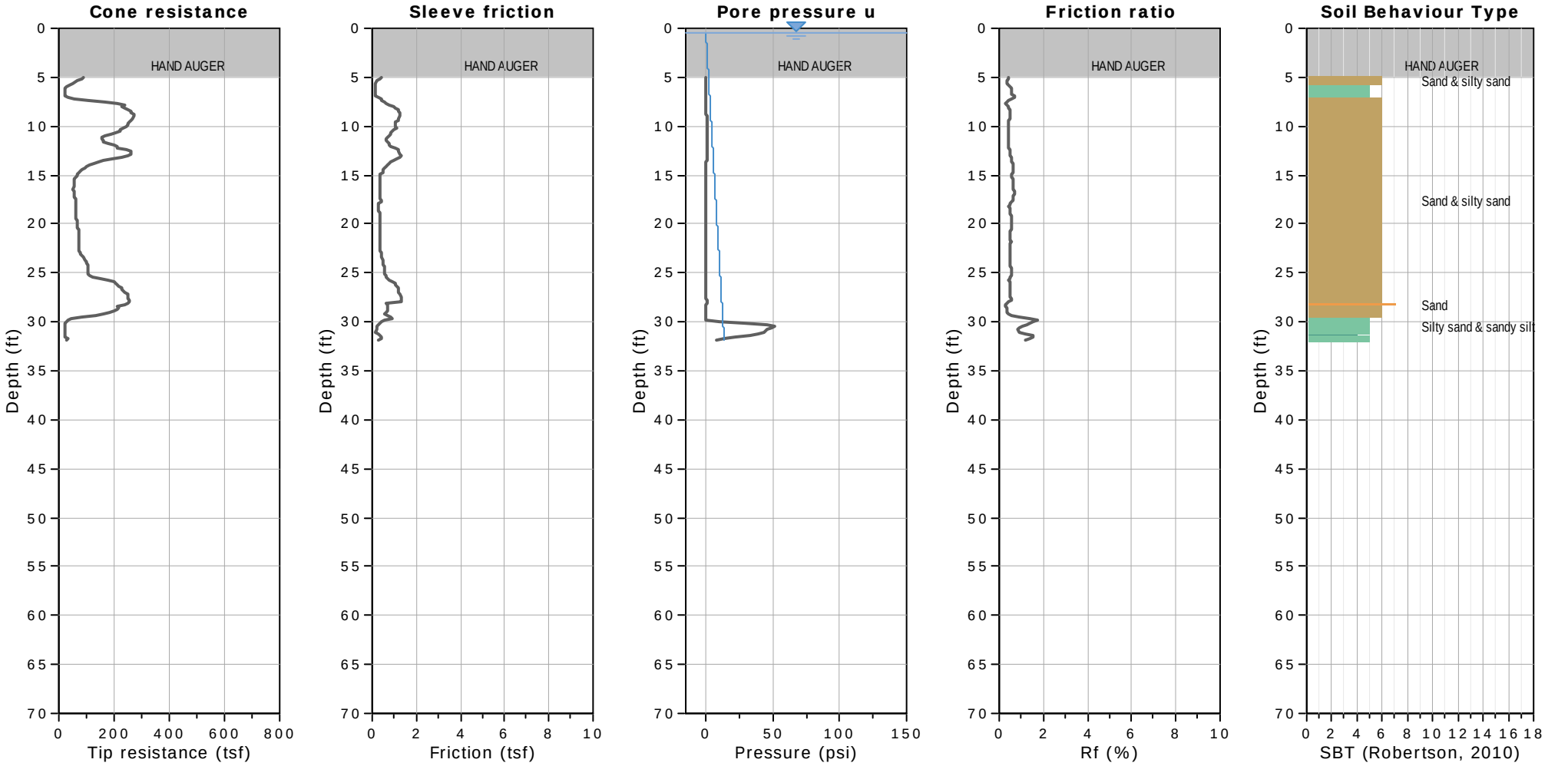
CPT: TSMACPT-3

CLIENT: PADRE ASSOCIATES, INC.

Field Rep: EVA

SITE: GUADALUPE RESTORATION PROJECT - SAN LUIS OBISPO, CA

Total depth: 31.82 ft, Date: 8/20/2018



WATER TABLE FOR ESTIMATING PURPOSES ONLY

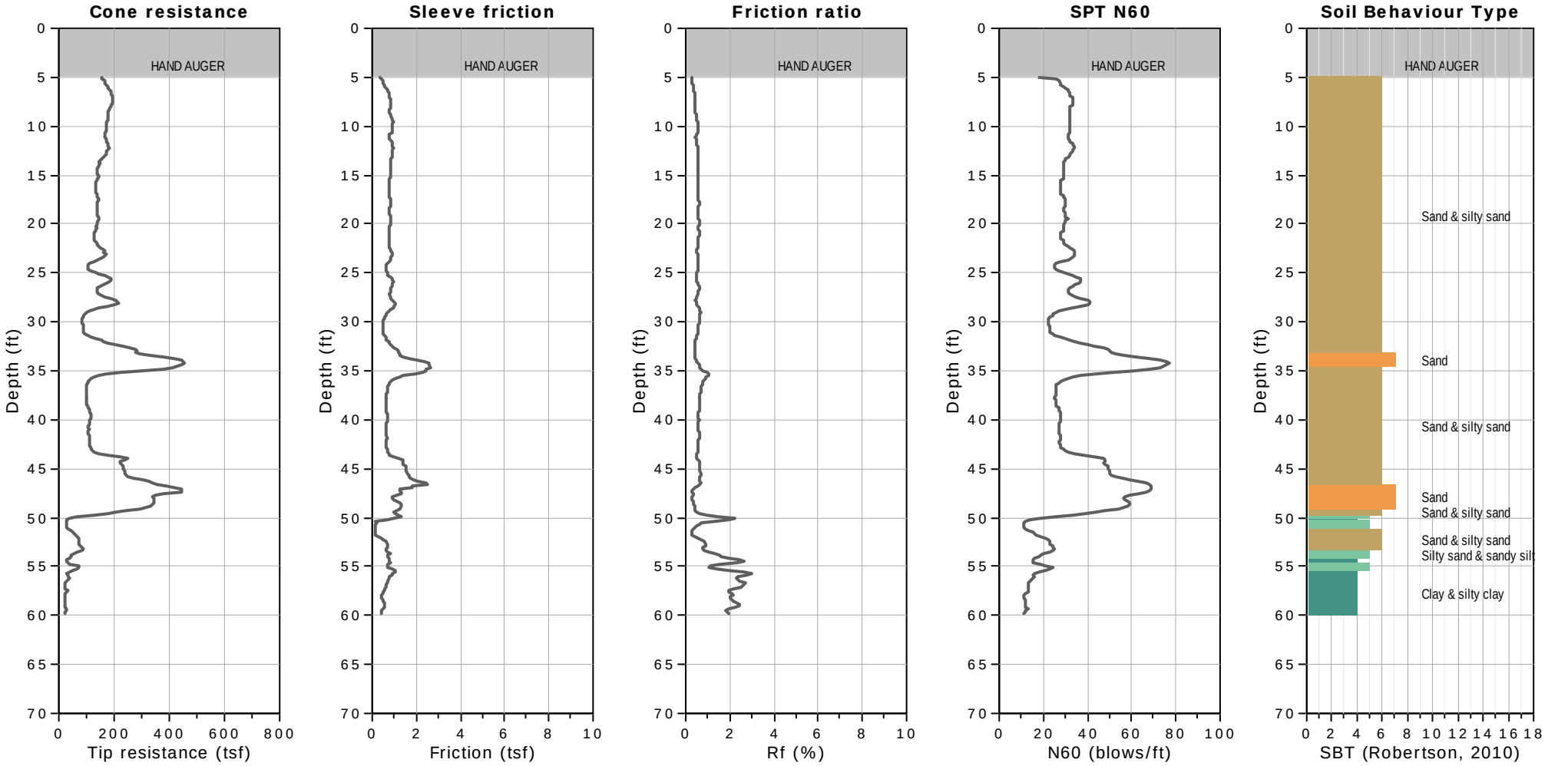
CPT: TSMACPT-4

CLIENT: PADRE ASSOCIATES, INC.

SITE: GUADALUPE RESTORATION PROJECT - SAN LUIS OBISPO, CA

Field Rep: EVA

Total depth: 59.88 ft, Date: 8/14/2018

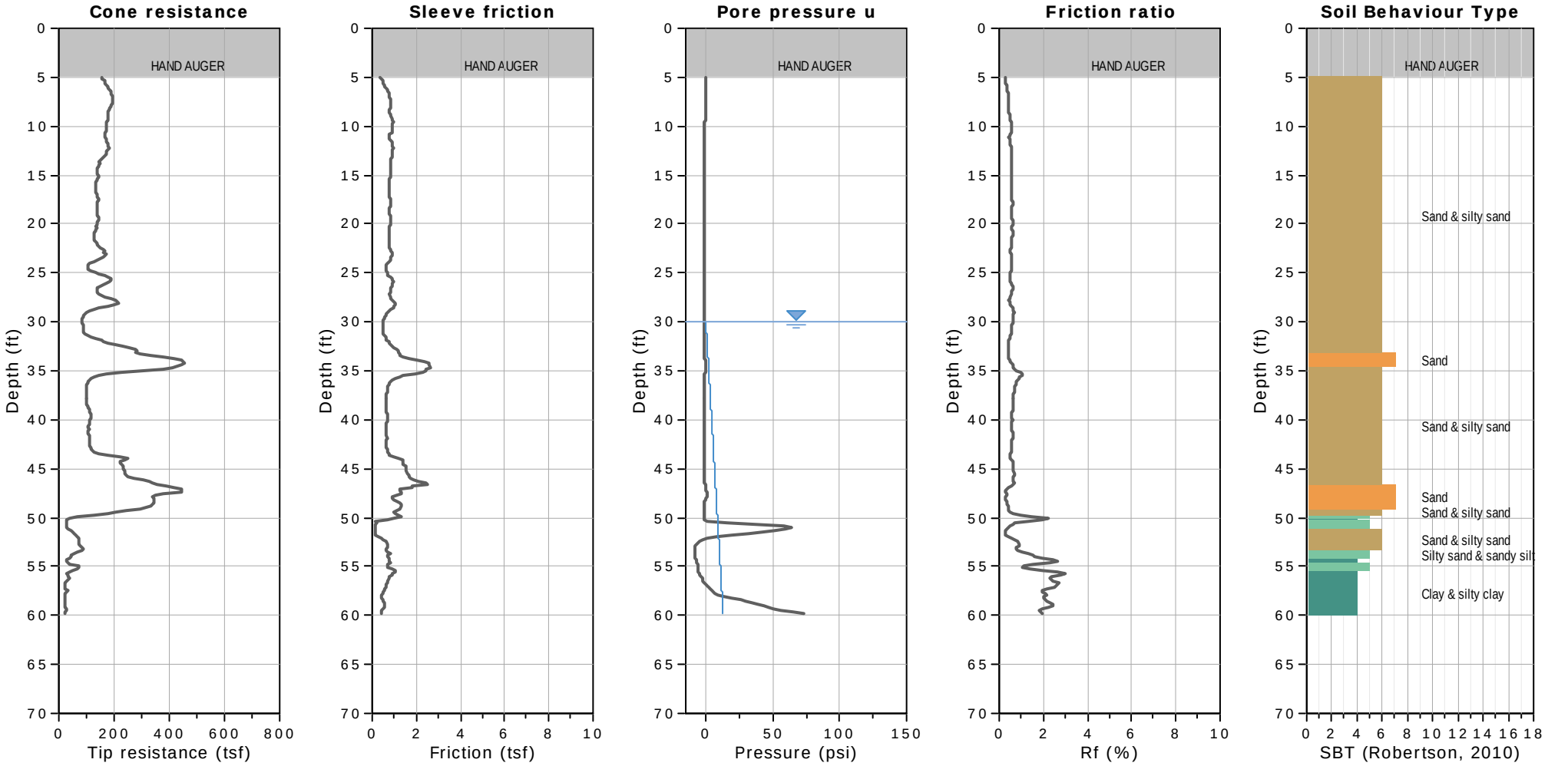


CLIENT: PADRE ASSOCIATES, INC.

SITE: GUADALUPE RESTORATION PROJECT - SAN LUIS OBISPO, CA

Field Rep: EVA

Total depth: 59.88 ft, Date: 8/14/2018



WATER TABLE FOR ESTIMATING PURPOSES ONLY

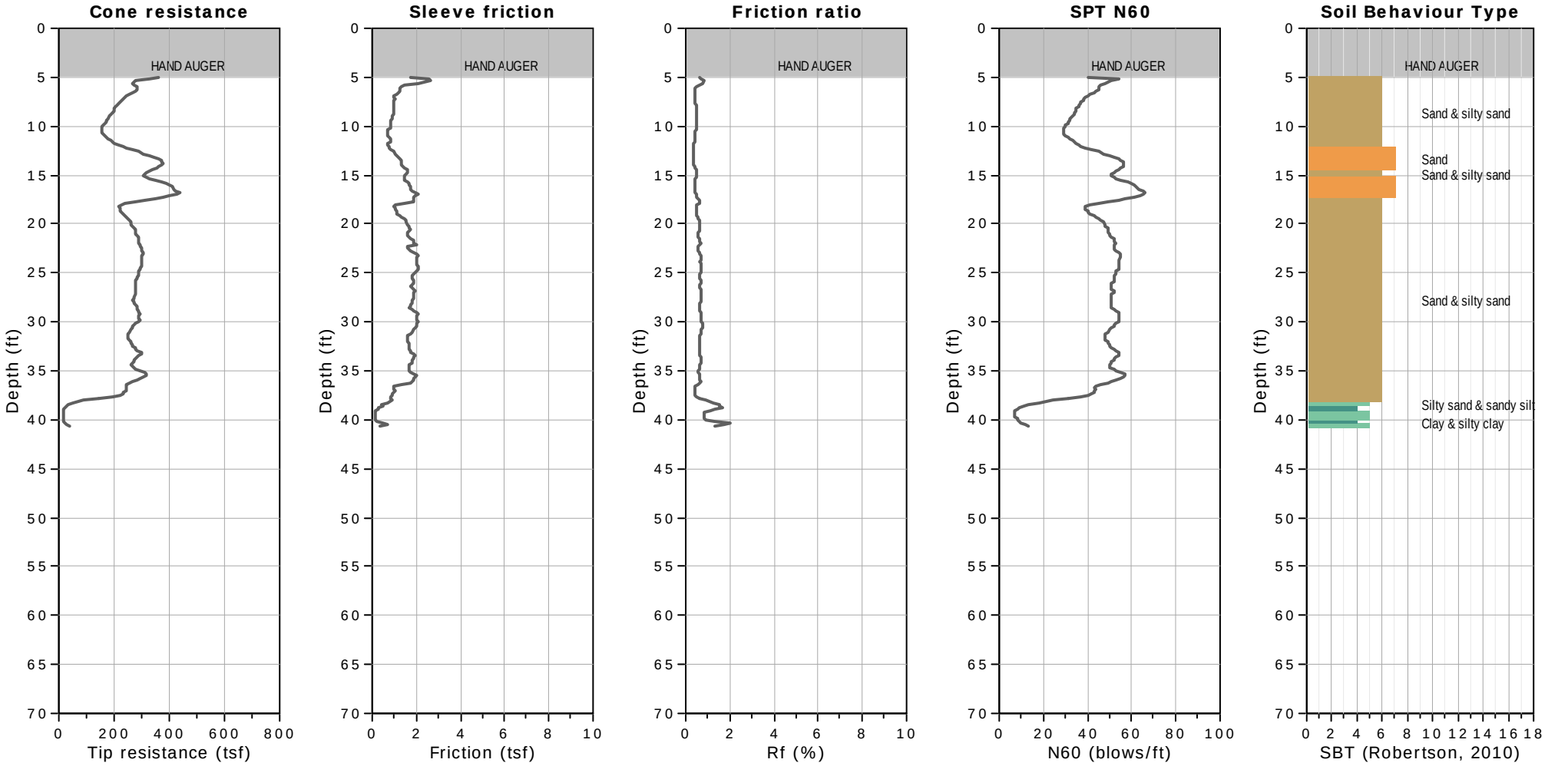
CPT: TSMACPT-5

CLIENT: PADRE ASSOCIATES, INC.

SITE: GUADALUPE RESTORATION PROJECT - SAN LUIS OBISPO, CA

Field Rep: EVA

Total depth: 40.68 ft, Date: 8/20/2018



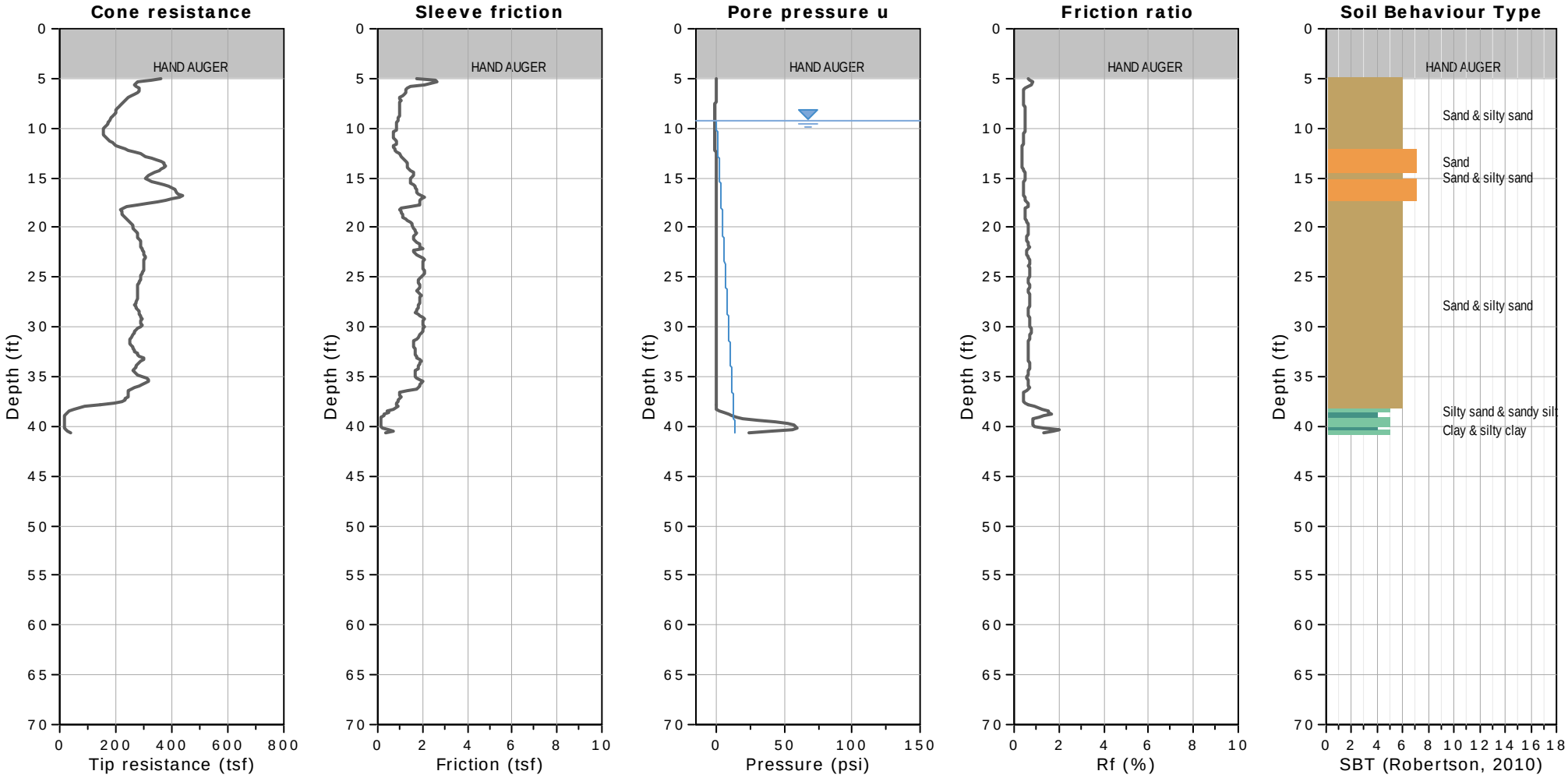
CPT: TSMACPT-5

CLIENT: PADRE ASSOCIATES, INC.

SITE: GUADALUPE RESTORATION PROJECT - SAN LUIS OBISPO, CA

Field Rep: EVA

Total depth: 40.68 ft, Date: 8/20/2018



SBTn legend

1. Sensitive fine grained
2. Organic material
3. Clay to silty clay
4. Clayey silt to silty clay
5. Silty sand to sandy silt
6. Clean sand to silty sand
7. Gravely sand to sand
8. Very stiff sand to clayey sand
9. Very stiff fine grained

WATER TABLE FOR ESTIMATING PURPOSES ONLY

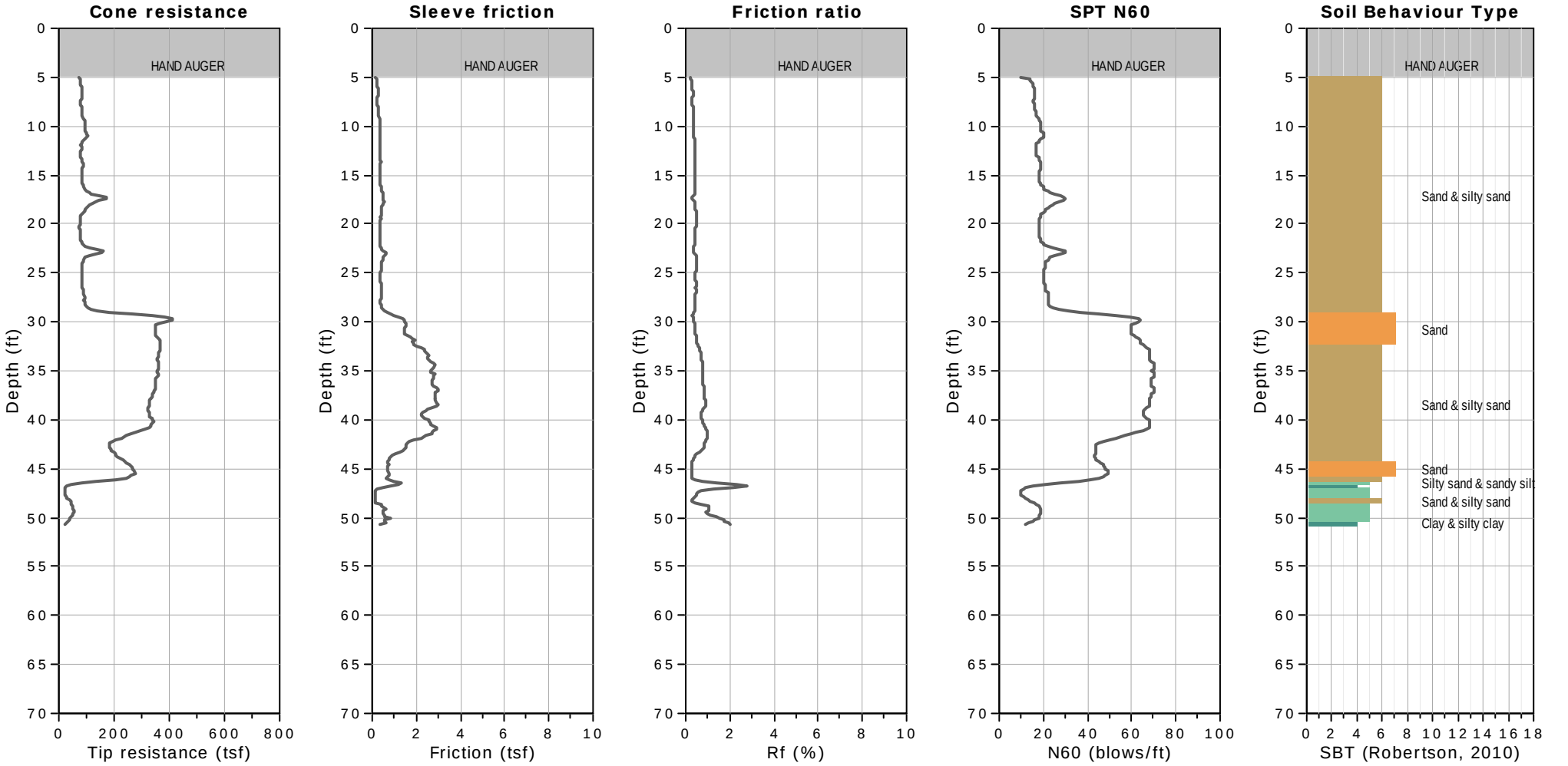
CPT: TSMACPT-6

CLIENT: PADRE ASSOCIATES, INC.

SITE: GUADALUPE RESTORATION PROJECT - SAN LUIS OBISPO, CA

Field Rep: EVA

Total depth: 50.69 ft, Date: 8/16/2018



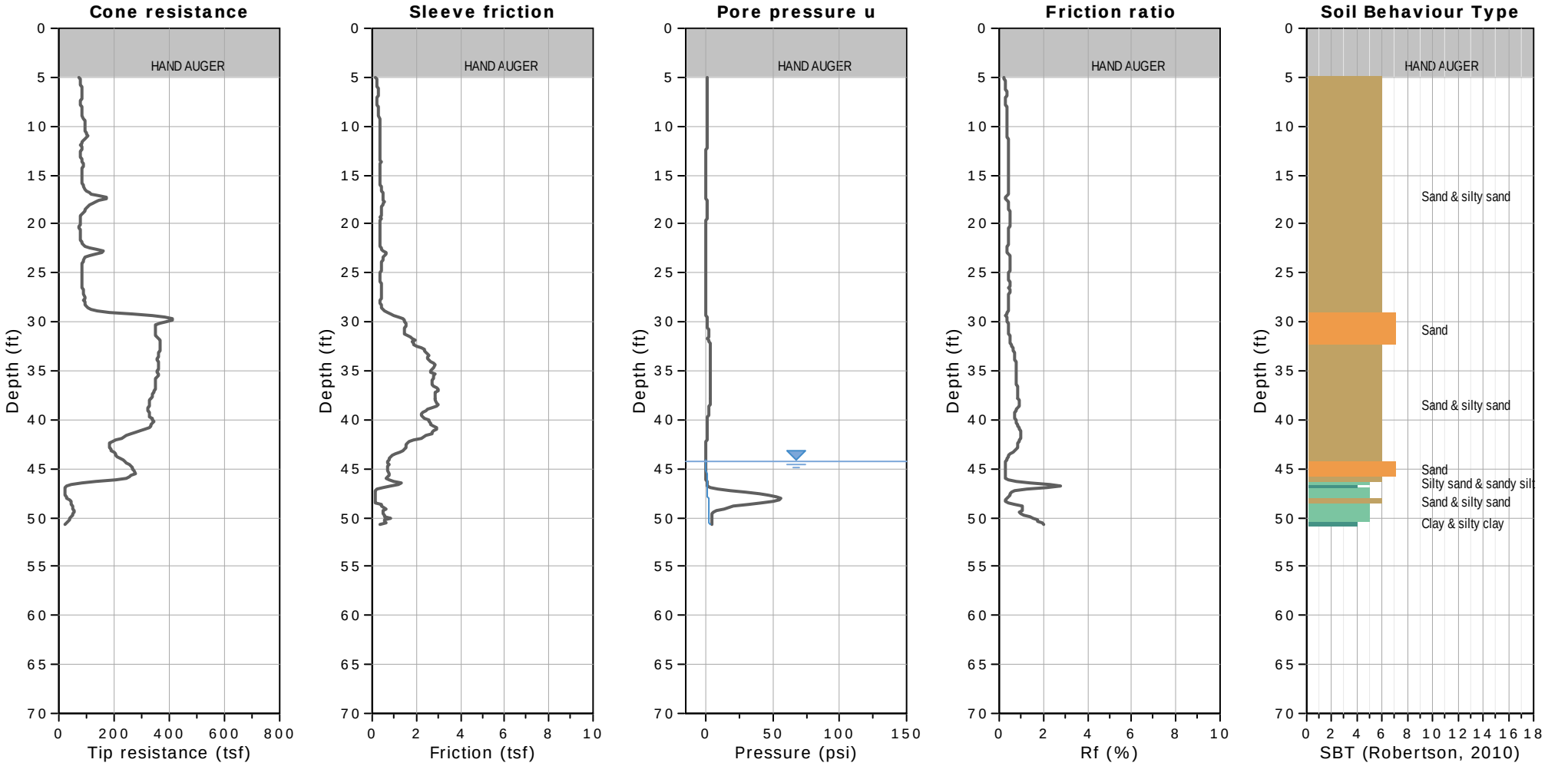
CPT: TSMACPT-6

CLIENT: PADRE ASSOCIATES, INC.

SITE: GUADALUPE RESTORATION PROJECT - SAN LUIS OBISPO, CA

Field Rep: EVA

Total depth: 50.69 ft, Date: 8/16/2018



WATER TABLE FOR ESTIMATING PURPOSES ONLY

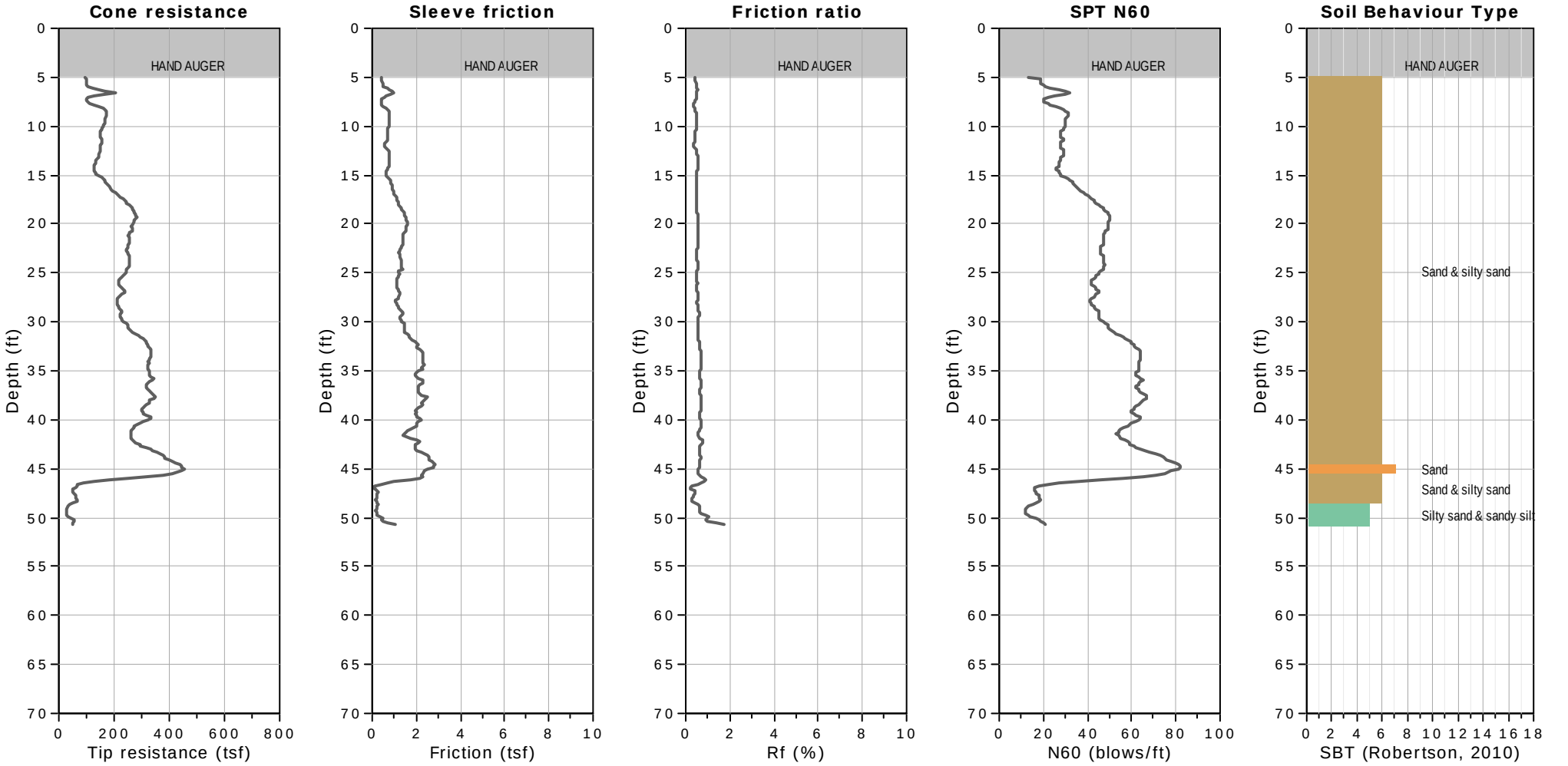
CPT: TSMACPT-7

CLIENT: PADRE ASSOCIATES, INC.

SITE: GUADALUPE RESTORATION PROJECT - SAN LUIS OBISPO, CA

Field Rep: EVA

Total depth: 50.69 ft, Date: 8/20/2018



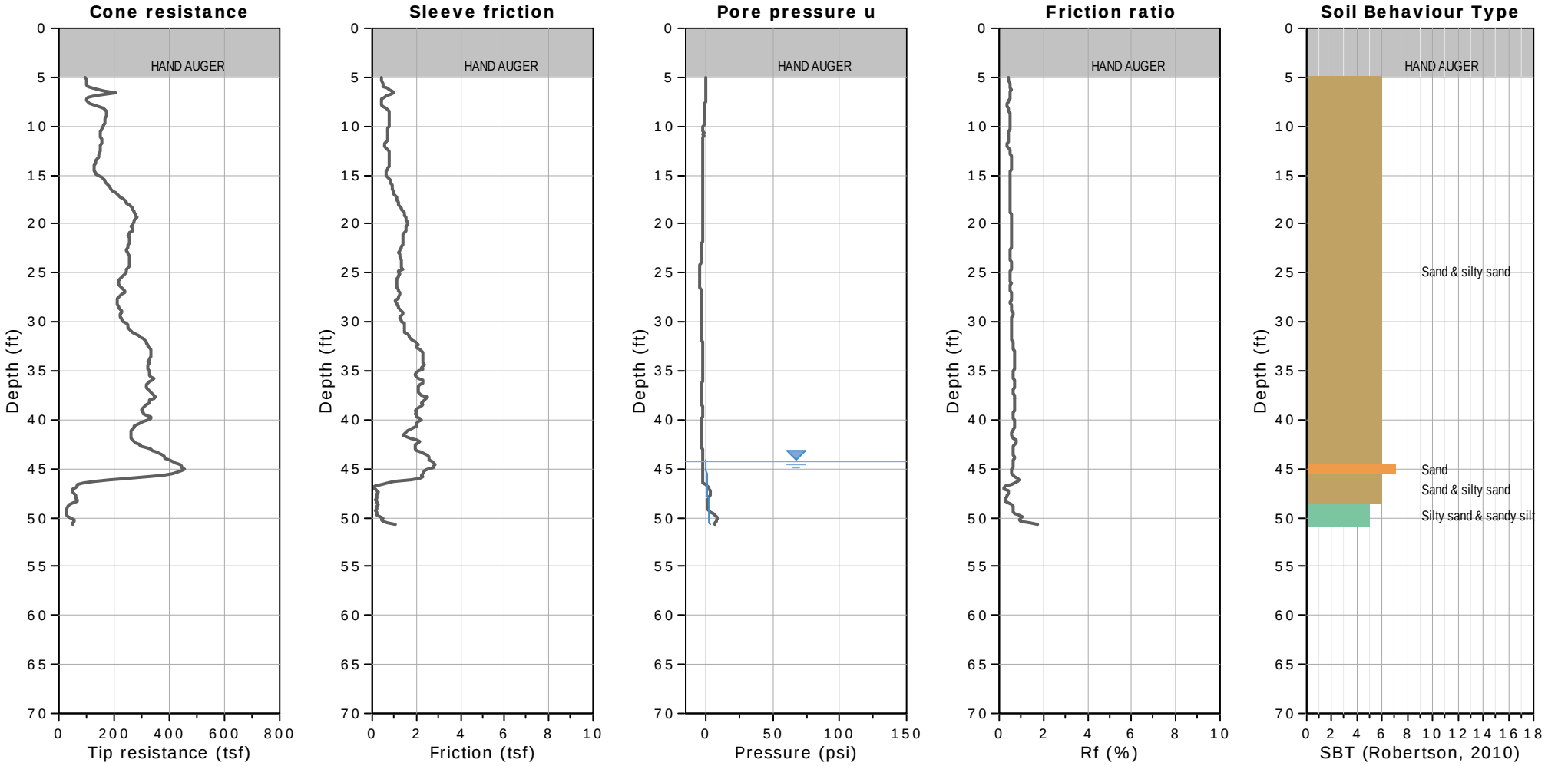
CPT: TSMACPT-7

CLIENT: PADRE ASSOCIATES, INC.

SITE: GUADALUPE RESTORATION PROJECT - SAN LUIS OBISPO, CA

Field Rep: EVA

Total depth: 50.69 ft, Date: 8/20/2018



WATER TABLE FOR ESTIMATING PURPOSES ONLY

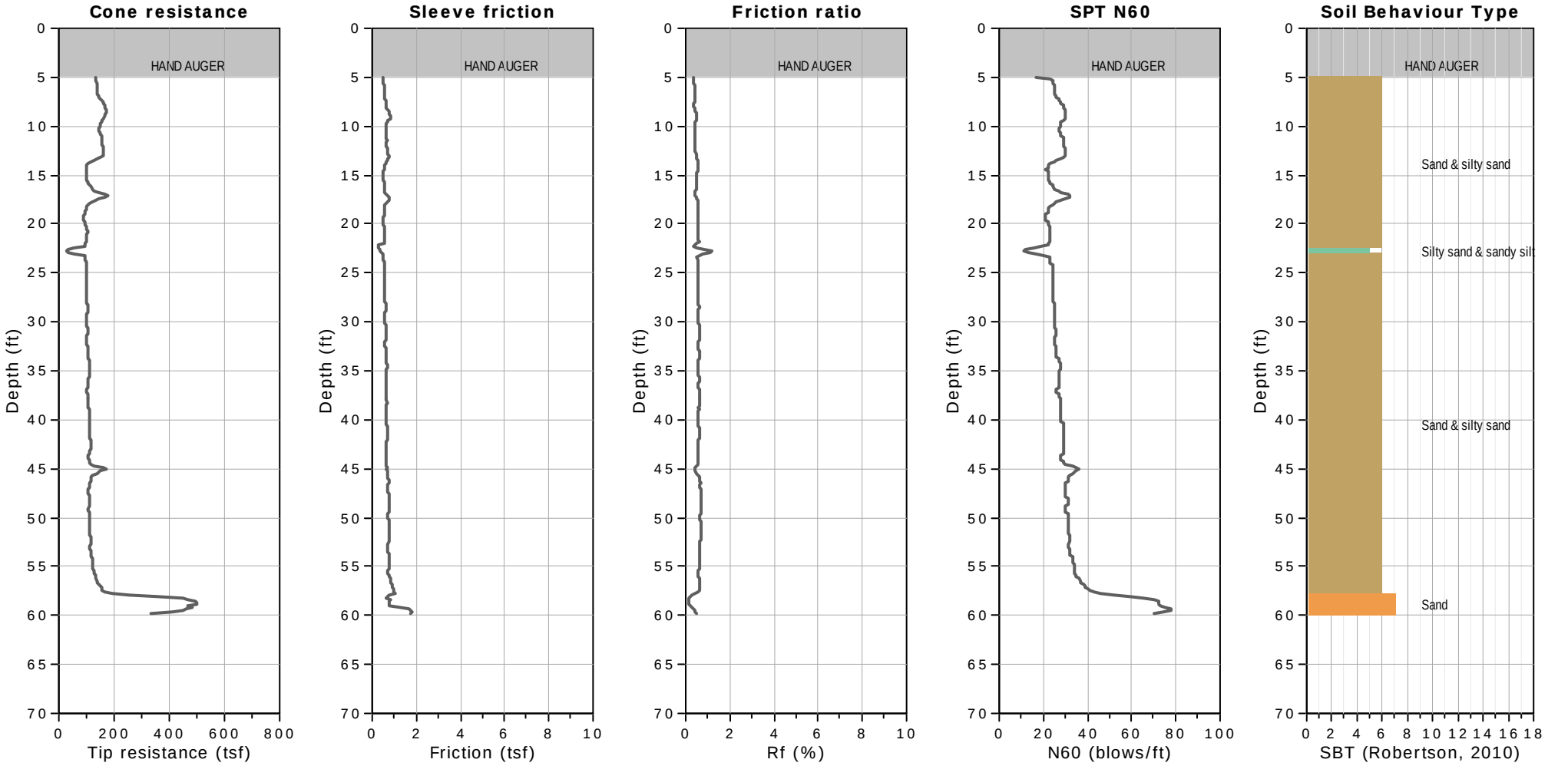
CPT: TSMACPT-8

CLIENT: PADRE ASSOCIATES, INC.

SITE: GUADALUPE RESTORATION PROJECT - SAN LUIS OBISPO, CA

Field Rep: EVA

Total depth: 59.88 ft, Date: 8/14/2018



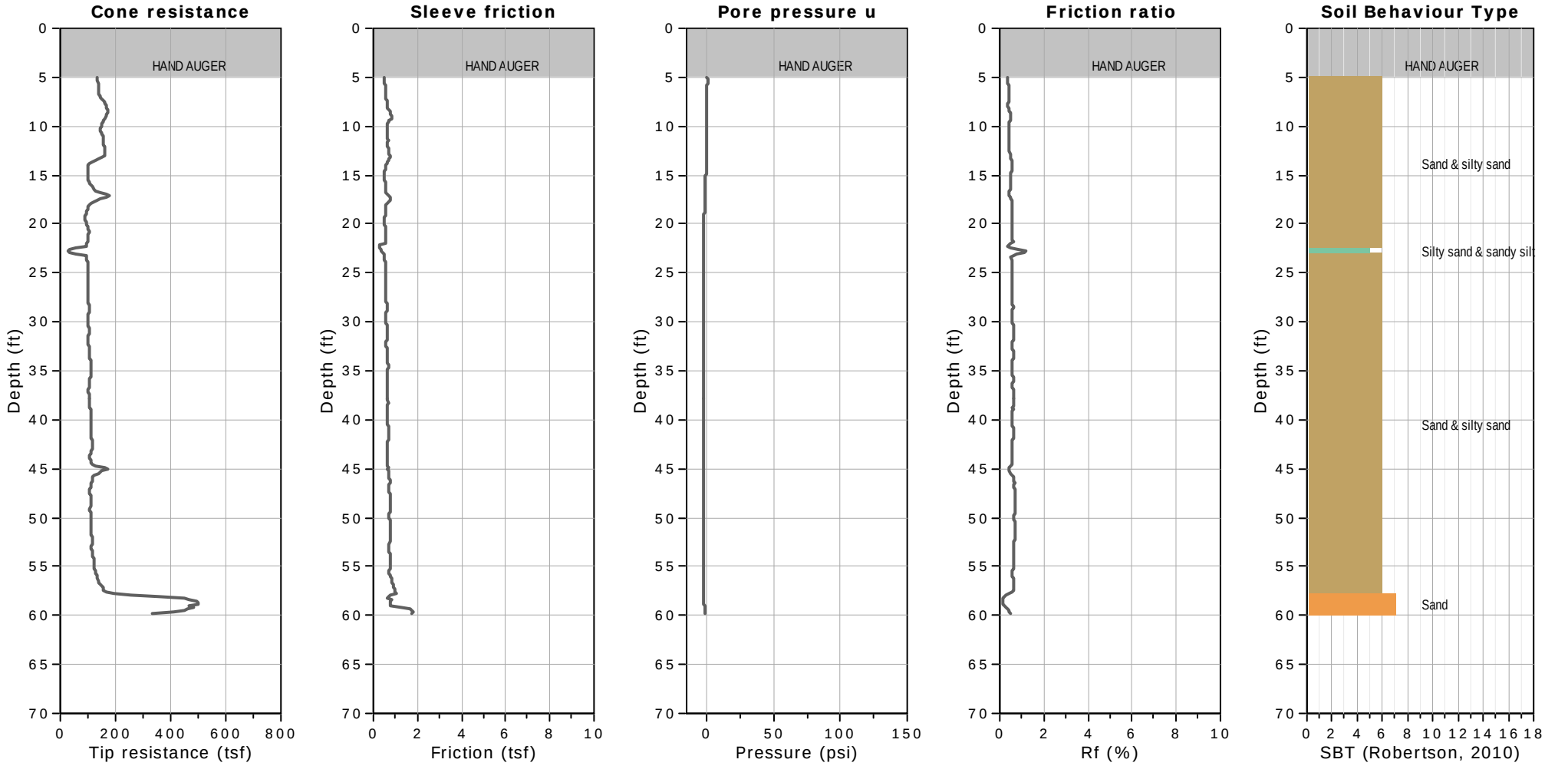
CPT: TSMACPT-8

CLIENT: PADRE ASSOCIATES, INC.

SITE: GUADALUPE RESTORATION PROJECT - SAN LUIS OBISPO, CA

Field Rep: EVA

Total depth: 59.88 ft, Date: 8/14/2018



WATER TABLE FOR ESTIMATING PURPOSES ONLY

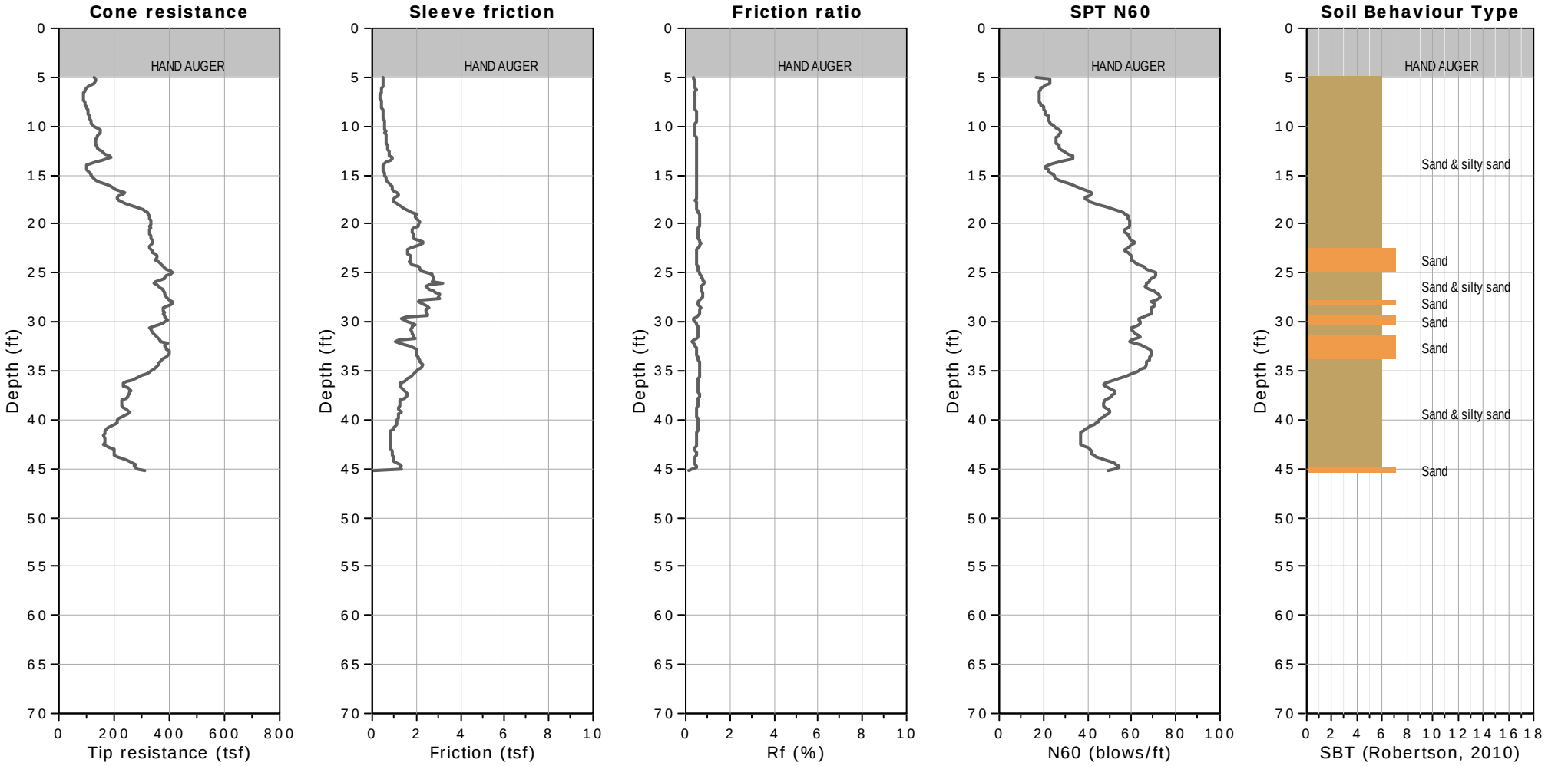
CPT: TSMACPT-9

CLIENT: PADRE ASSOCIATES, INC.

SITE: GUADALUPE RESTORATION PROJECT - SAN LUIS OBISPO, CA

Field Rep: EVA

Total depth: 45.28 ft, Date: 8/21/2018



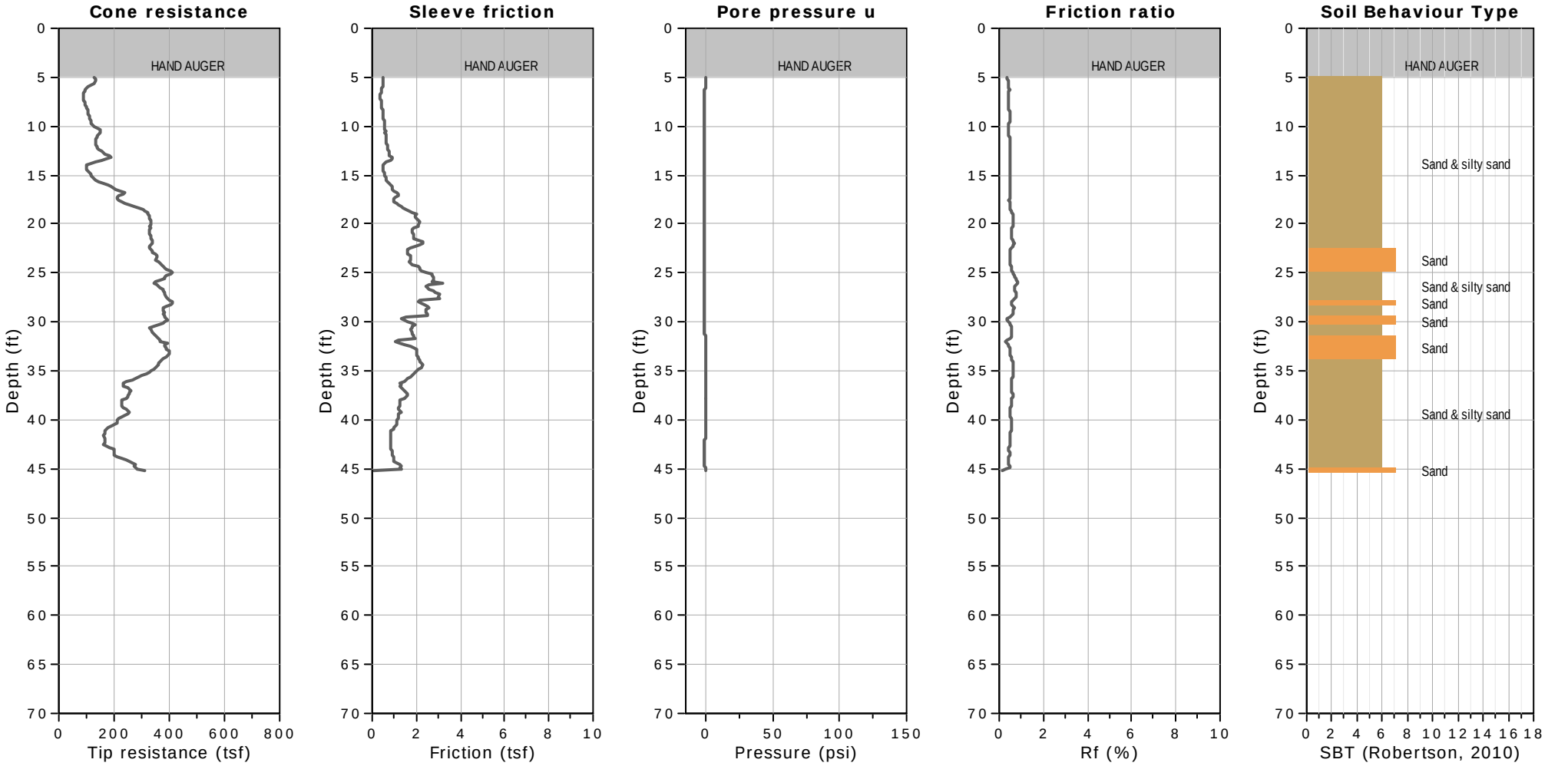
CPT: TSMACPT-9

CLIENT: PADRE ASSOCIATES, INC.

SITE: GUADALUPE RESTORATION PROJECT - SAN LUIS OBISPO, CA

Field Rep: EVA

Total depth: 45.28 ft, Date: 8/21/2018



WATER TABLE FOR ESTIMATING PURPOSES ONLY

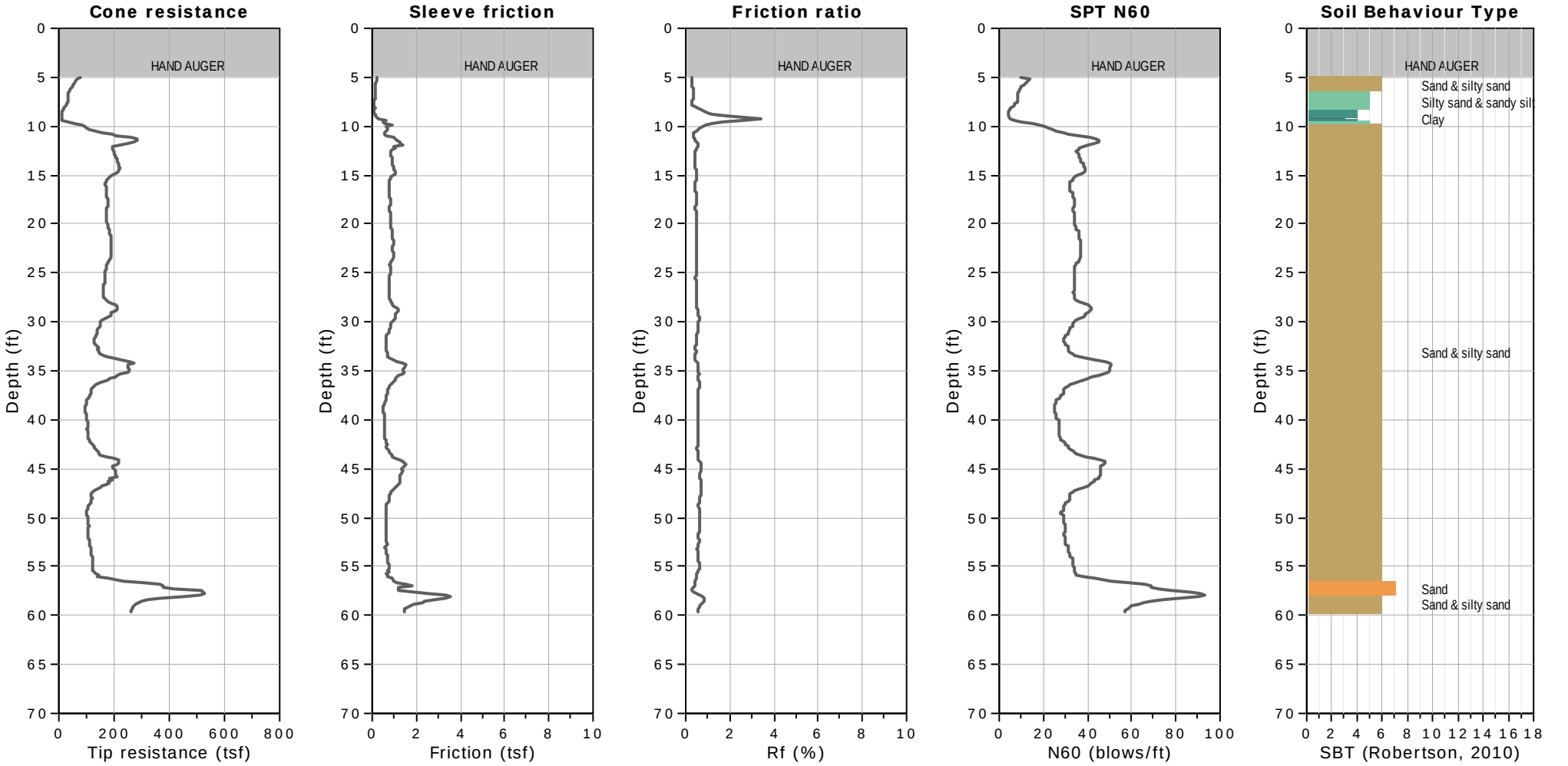
CPT: TSMACPT-10

CLIENT: PADRE ASSOCIATES, INC.

SITE: GUADALUPE RESTORATION PROJECT - SAN LUIS OBISPO, CA

Field Rep: EVA

Total depth: 59.71 ft, Date: 8/21/2018



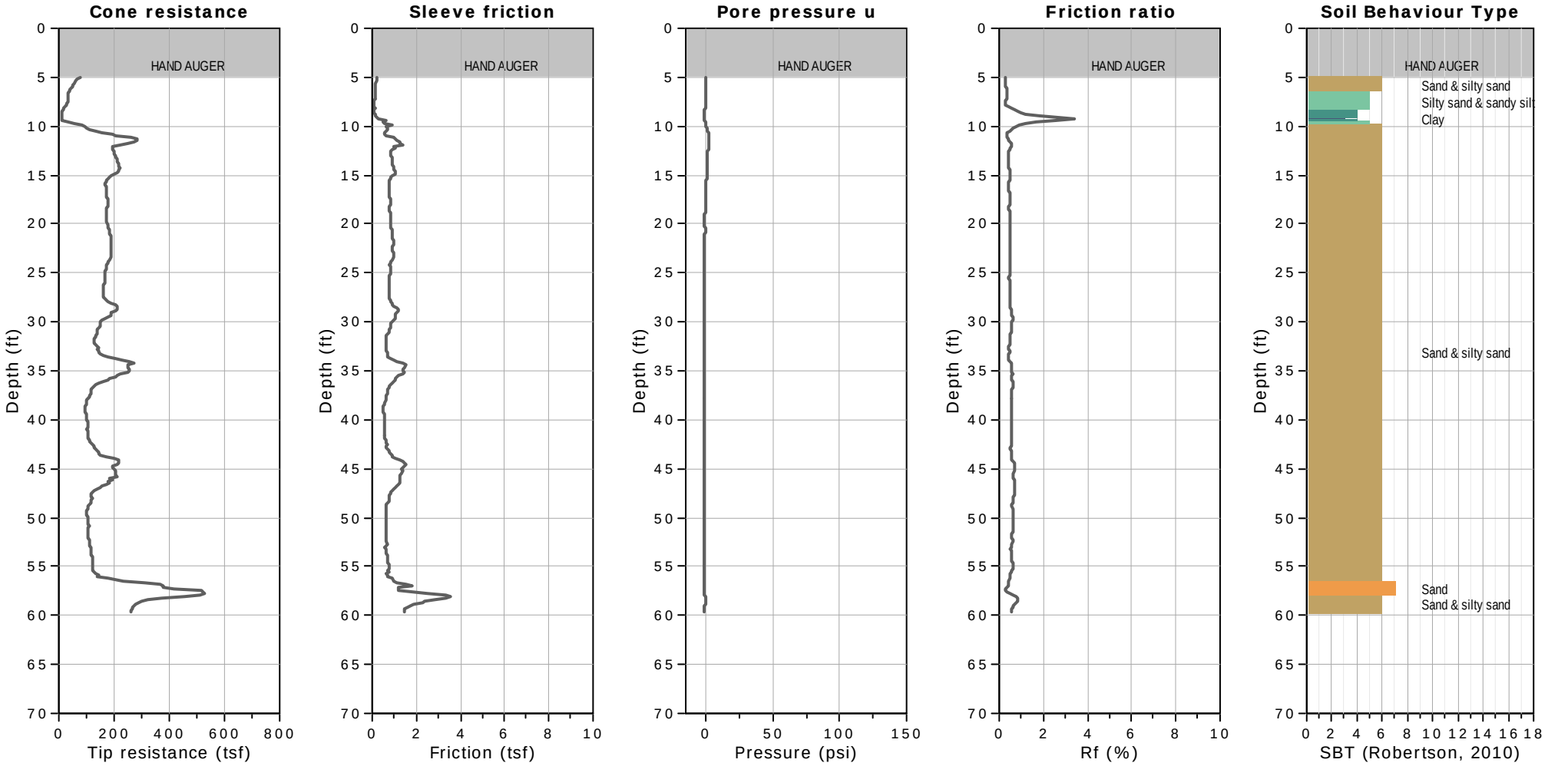
CPT: TSMACPT-10

CLIENT: PADRE ASSOCIATES, INC.

SITE: GUADALUPE RESTORATION PROJECT - SAN LUIS OBISPO, CA

Field Rep: EVA

Total depth: 59.71 ft, Date: 8/21/2018



WATER TABLE FOR ESTIMATING PURPOSES ONLY

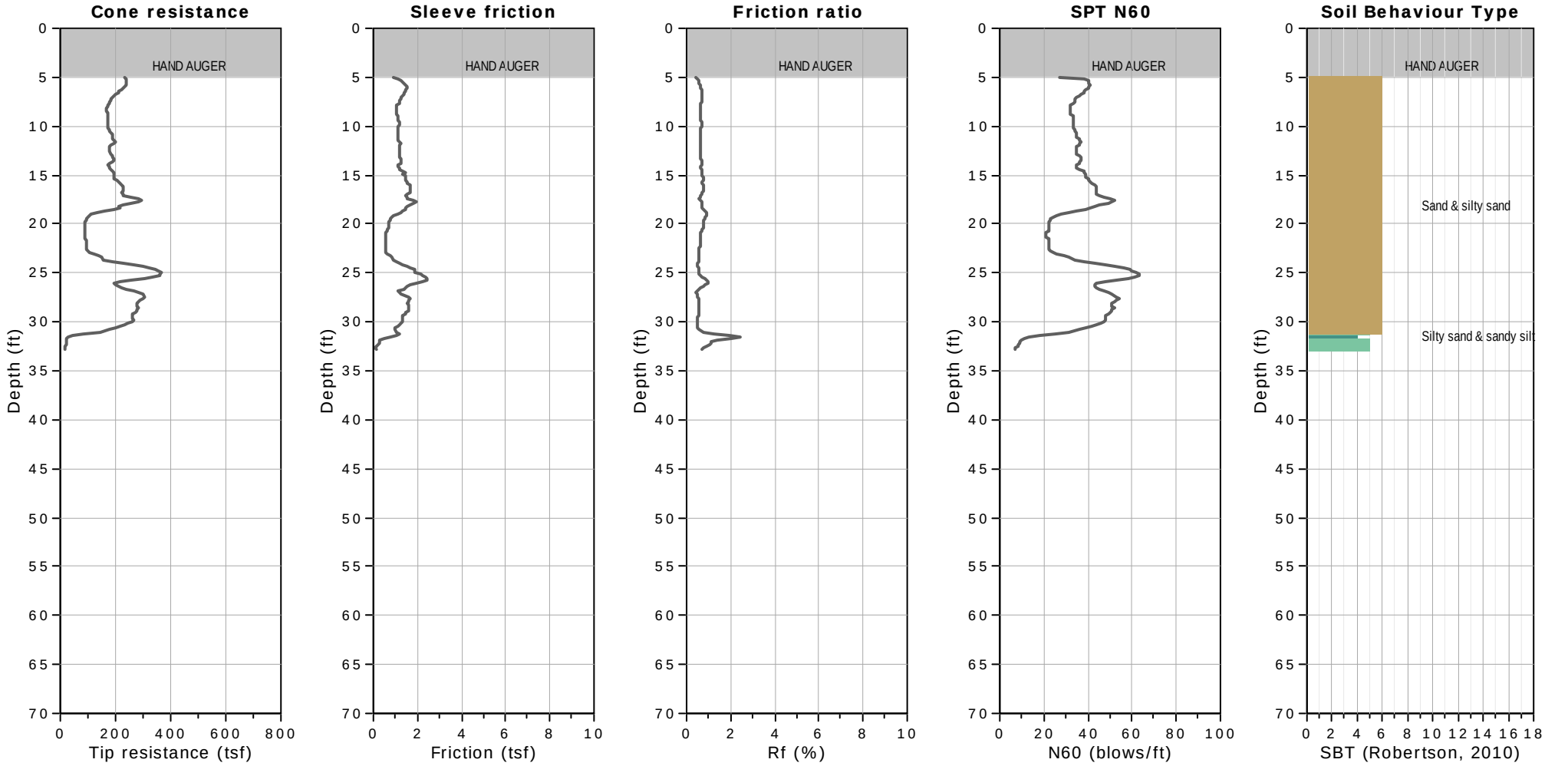
CPT: TSMACPT-11

CLIENT: PADRE ASSOCIATES, INC.

SITE: GUADALUPE RESTORATION PROJECT - SAN LUIS OBISPO, CA

Field Rep: EVA

Total depth: 32.81 ft, Date: 8/15/2018



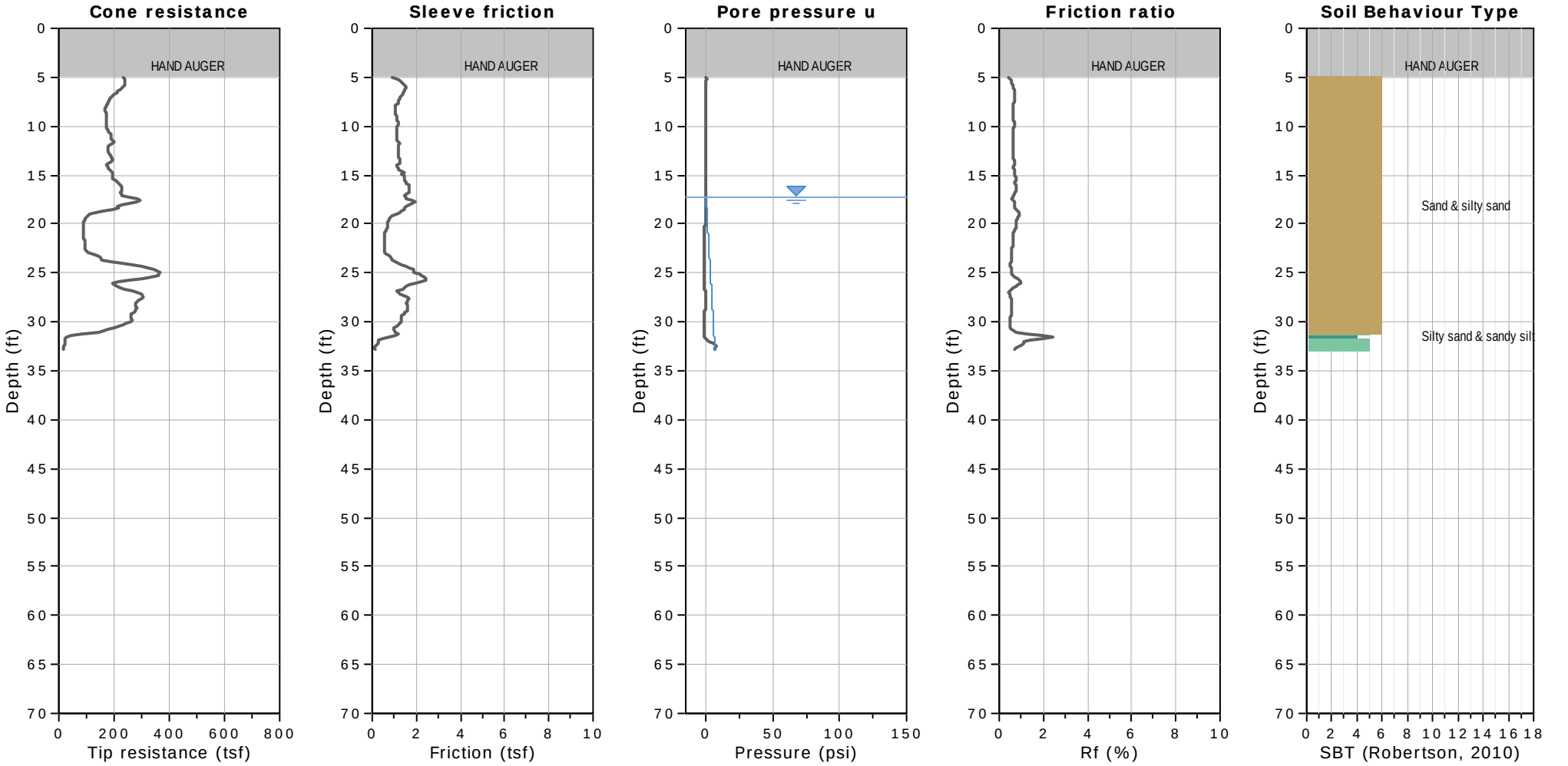
CPT: TSMACPT-11

CLIENT: PADRE ASSOCIATES, INC.

SITE: GUADALUPE RESTORATION PROJECT - SAN LUIS OBISPO, CA

Field Rep: EVA

Total depth: 32.81 ft, Date: 8/15/2018



WATER TABLE FOR ESTIMATING PURPOSES ONLY

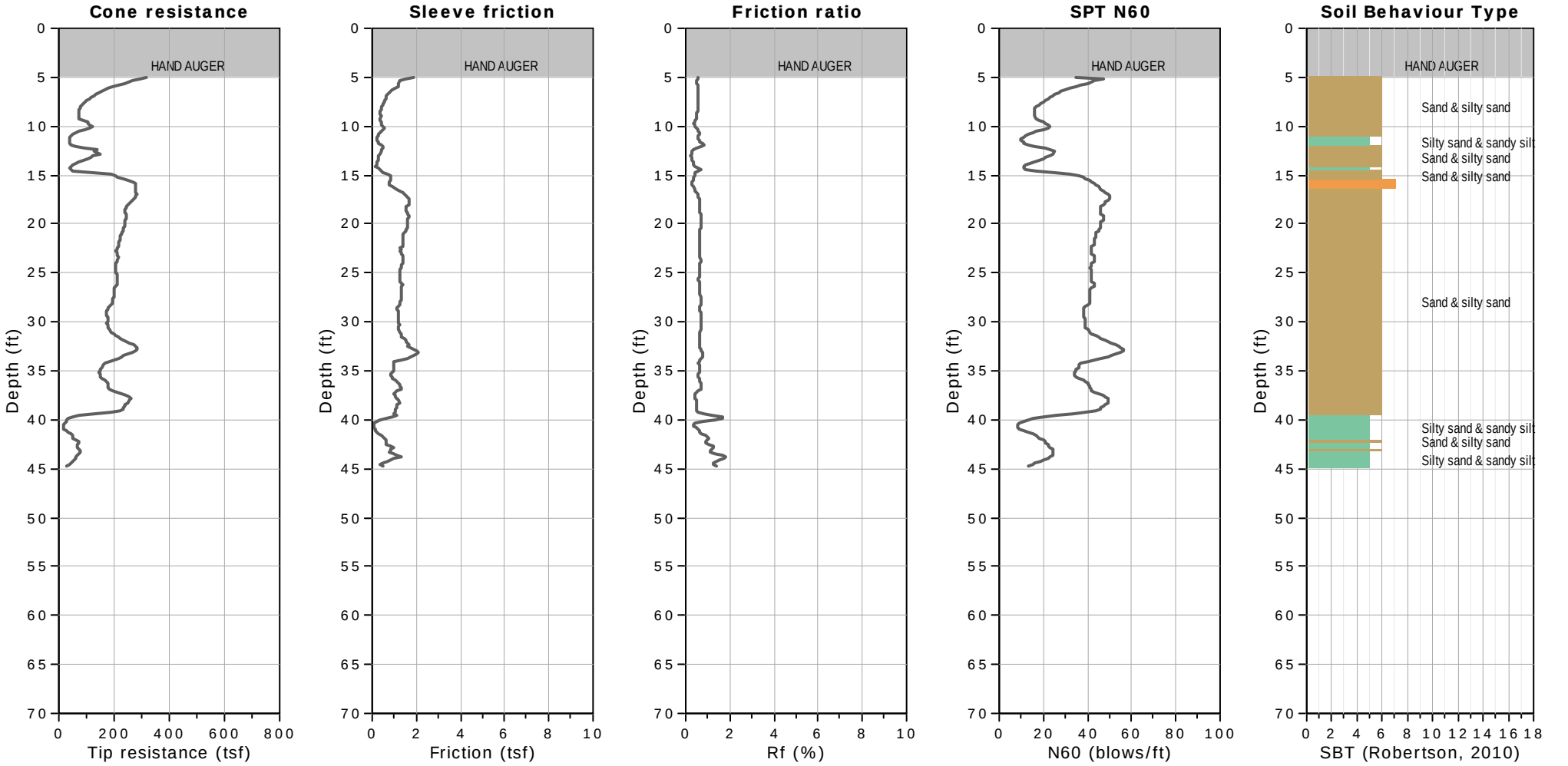
CPT: TSMACPT-12

CLIENT: PADRE ASSOCIATES, INC.

SITE: GUADALUPE RESTORATION PROJECT - SAN LUIS OBISPO, CA

Field Rep: EVA

Total depth: 44.78 ft, Date: 8/15/2018



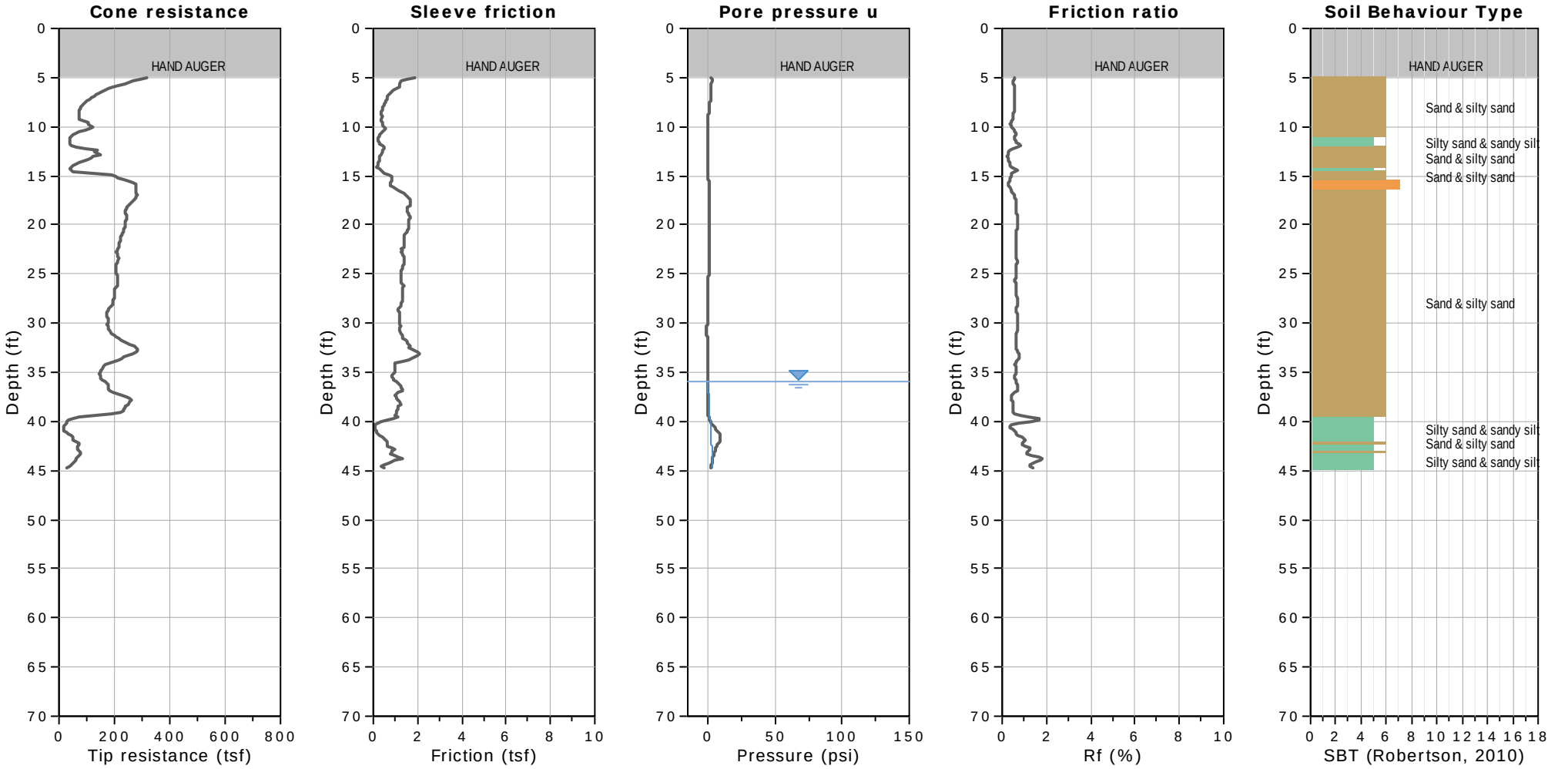
CPT: TSMACPT-12

CLIENT: PADRE ASSOCIATES, INC.

SITE: GUADALUPE RESTORATION PROJECT - SAN LUIS OBISPO, CA

Field Rep: EVA

Total depth: 44.78 ft, Date: 8/15/2018



SBTn legend

1. Sensitive fine grained
2. Organic material
3. Clay to silty clay
4. Clayey silt to silty clay
5. Silty sand to sandy silt
6. Clean sand to silty sand
7. Gravely sand to sand
8. Very stiff sand to clayey sand
9. Very stiff fine grained

WATER TABLE FOR ESTIMATING PURPOSES ONLY

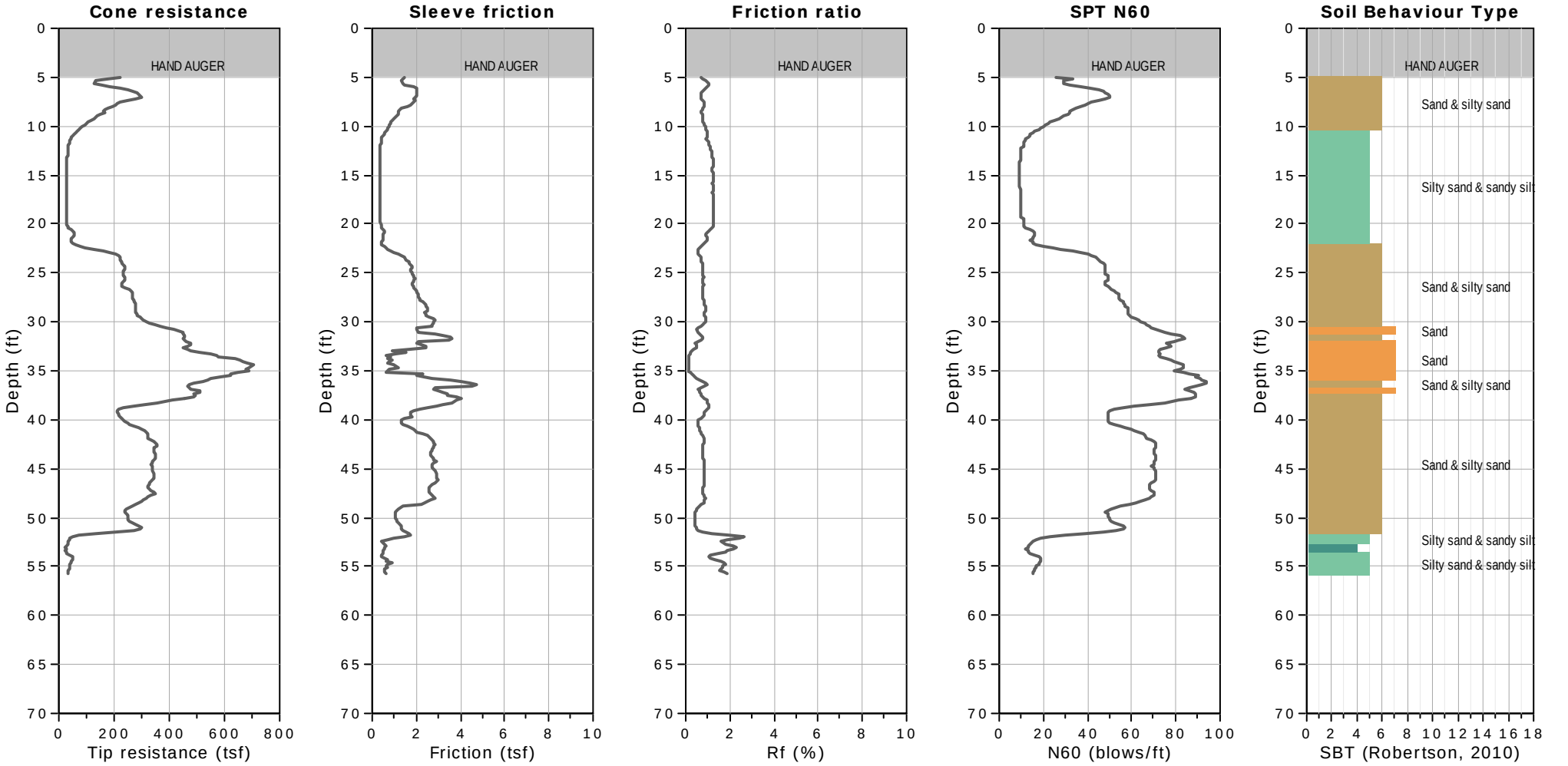
CPT: TSMACPT-13

CLIENT: PADRE ASSOCIATES, INC.

SITE: GUADALUPE RESTORATION PROJECT - SAN LUIS OBISPO, CA

Field Rep: EVA

Total depth: 55.77 ft, Date: 8/16/2018



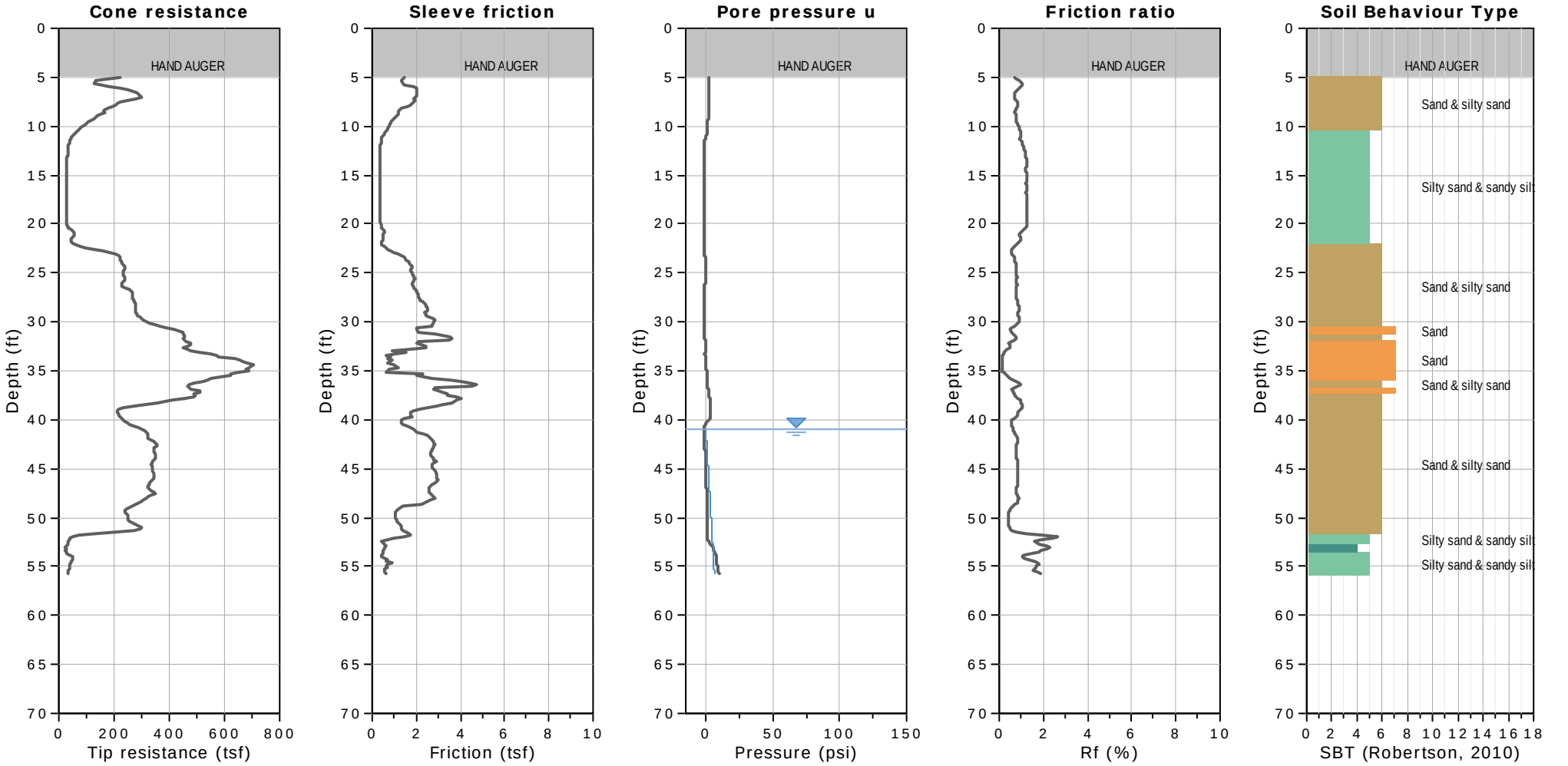
CPT: TSMACPT-13

CLIENT: PADRE ASSOCIATES, INC.

SITE: GUADALUPE RESTORATION PROJECT - SAN LUIS OBISPO, CA

Field Rep: EVA

Total depth: 55.77 ft, Date: 8/16/2018



WATER TABLE FOR ESTIMATING PURPOSES ONLY

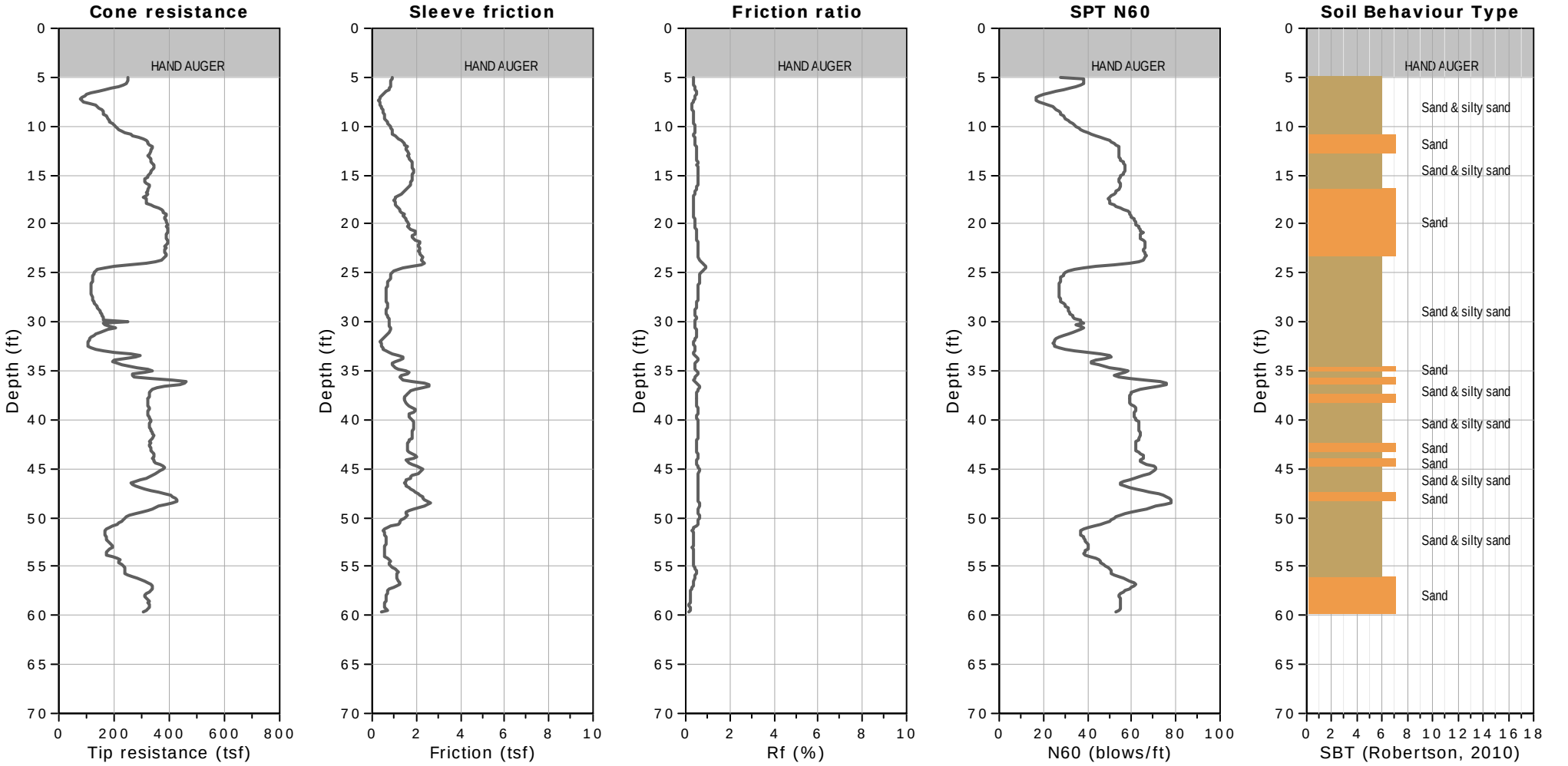
CPT: TSMACPT-14

CLIENT: PADRE ASSOCIATES, INC.

SITE: GUADALUPE RESTORATION PROJECT - SAN LUIS OBISPO, CA

Field Rep: EVA

Total depth: 59.71 ft, Date: 8/16/2018



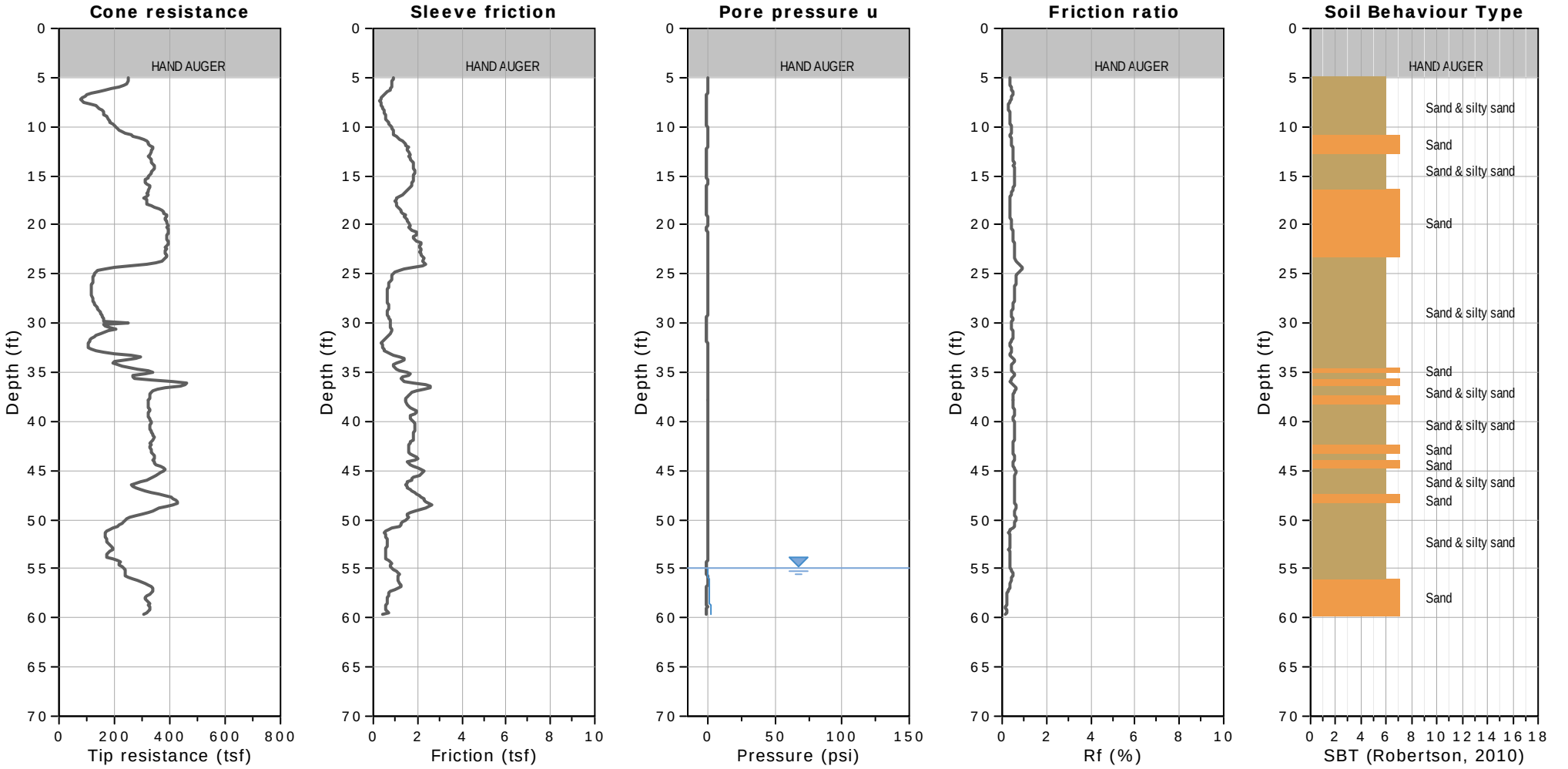
CPT: TSMACPT-14

CLIENT: PADRE ASSOCIATES, INC.

SITE: GUADALUPE RESTORATION PROJECT - SAN LUIS OBISPO, CA

Field Rep: EVA

Total depth: 59.71 ft, Date: 8/16/2018



SBTn legend

1. Sensitive fine grained
2. Organic material
3. Clay to silty clay
4. Clayey silt to silty clay
5. Silty sand to sandy silt
6. Clean sand to silty sand
7. Gravely sand to sand
8. Very stiff sand to clayey sand
9. Very stiff fine grained

WATER TABLE FOR ESTIMATING PURPOSES ONLY

APPENDIX B
LABORATORY TESTING

Yeh and Associates, Inc.
Consulting Engineers & Scientists

Summary of Laboratory Test Results

Project Name	Padre Misc. Lab Services - Guadalupe Restor.	Project No.	215-199.08	Date	9/17/2018	Project Manager	J. King	Checked By	J. King

Sample Location			Moisture Content (%)	Dry Unit Weight (pcf)	Gradation			Atterberg		Corrosion				Compaction		R-Value	USCS Classification
Sample I.D.	Depth (ft)	Sample Type			Gravel > #4 (%)	Sand (%)	Fines < #200 (%)	LL	PI	pH	R (ohm-cm)	SO_4^{2-} (mg/kg)	Cl^- (mg/kg)	Max. Unit Weight (pcf)	Optimum Water Content (%)		
SBTB9-92a-20-081618	20	SPT	4	--	0	98	2	--	--	--	--	--	--	--	--	--	Poorly graded SAND (SP)
SBTB9-92a-40-081618	40	SPT	3	--	0	99	1	--	--	--	--	--	--	--	--	--	Poorly graded SAND (SP)
SBTB9-92a-60-081618	60	SPT	4	--	0	98	2	--	--	--	--	--	--	--	--	--	Poorly graded SAND (SP)
SBTB9-93-25-081618	25	SPT	3	--	0	99	1	--	--	--	--	--	--	--	--	--	Poorly graded SAND (SP)
SBTB9-93-35-081618	35	SPT	2	--	0	99	1	--	--	--	--	--	--	--	--	--	Poorly graded SAND (SP)
SBTB9-93-55-081618	55	SPT	26	--	0	20	80	26	9	--	--	--	--	--	--	--	Lean CLAY with Sand (CL)
SBTB9-94-5-081418	5	SPT	2	--	2	91	7	--	--	--	--	--	--	--	--	--	Poorly graded SAND with silt (SP-SM)
SBTB9-94-20-081418	20	SPT	3	--	0	97	3	--	--	--	--	--	--	--	--	--	Poorly graded SAND (SP)
SBTB9-94-35-081418	35	SPT	19	--	0	97	3	--	--	--	--	--	--	--	--	--	Poorly graded SAND (SP)
SBTB9-94-35.75-081418	35.75	SPT	20	--	0	19	81	27	8	--	--	--	--	--	--	--	Lean CLAY with Sand (CL)
SBTB9-94-36.5-081418	36.5	SPT	31	--	0	8	92	46	32	--	--	--	--	--	--	--	Lean CLAY (CL)
GRPE4ATP-1-082918	--	Bulk	20	--	34	53	13	24	1	--	--	--	--	97	24	--	Clayey SAND with Gravel (SC)
GRPQ4TP-1-082918	--	Bulk	2	--	0	99	1	--	--	--	--	--	--	104	18	--	Poorly graded SAND (SP)
GRPQ4TP-2-082918	--	Bulk	2	--	0	99	1	--	--	--	--	--	--	105	14	--	Poorly graded SAND (SP)
GRPQ4TP-3-082918	--	Bulk	3	--	0	100	0	--	--	--	--	--	--	105	18	--	Poorly graded SAND (SP)
GRPQ4TP-4-082918	--	Bulk	3	--	0	99	1	--	--	--	--	--	--	105	17	--	Poorly graded SAND (SP)

Yeh and Associates, Inc.
Consulting Engineers & Scientists

Mechnical Sieve Analysis
Test Methods: ASTM D6913, D2487, D4718

Project Name	Padre Misc. Lab Services - Guadalupe Restoration	**Project No.**	215-199.08
Project Manager	J. King	**Tested By**	A. Limpert/N. Simon
Checked By	J. King	**Testing Date**	9/1/2018

SUMMARY OF RESULTS

Boring No.	Sample No.	Depth (ft)	Water Content (%)	Gravel (%)	Sand (%)	Fines (%)	D_{10} (mm)	D_{30} (mm)	D_{50} (mm)	D_{60} (mm)	C_u	C_c	USCS Classification & Soil Description	AASHTO Classification
GRPQ4TP-1-082918	--	--	2.1%	0%	99%	1%	0.18	0.25	0.31	0.34	1.90	1.00	Poorly graded SAND (SP) brown, moist	--
GRPQ4TP-2-082918	--	--	1.6%	0%	99%	1%	0.19	0.27	0.33	0.35	1.80	1.10	Poorly graded SAND (SP), brown, moist	--
GRPQ4TP-3-082918	--	--	2.5%	0%	100%	0%	0.19	0.27	0.32	0.35	1.90	1.10	Poorly graded SAND (SP), brown, moist	--
GRPQ4TP-4-082918	--	--	2.6%	0%	99%	1%	0.18	0.26	0.31	0.34	1.90	1.10	Poorly graded SAND (SP), brown, moist	--
SBTB9	92a	20	3.5%	0%	98%	2%	0.17	0.23	0.31	0.36	2.20	0.90	Poorly-Graded SAND (SP), yellowish-brown, moist	--

SUMMARY OF RESULTS														
Boring No.	**Sample No.**	**Depth (ft)**	**Water Content (%)**	**Gravel (%)**	**Sand (%)**	**Fines (%)**	**$D_{10\ (mm)}$**	**$D_{30\ (mm)}$**	**$D_{50\ (mm)}$**	**$D_{60\ (mm)}$**	**C_u**	**C_c**	**USCS Classification & Soil Description**	**AASHTO Classification**
SBTB9	92a	40	3.4%	0%	99%	1%	0.17	0.23	0.30	0.34	2.00	0.90	Poorly-Graded SAND (SP), yellowish-brown, moist	--
SBTB9	92a	60	3.9%	0%	98%	2%	0.20	0.29	0.35	0.38	1.90	1.10	Poorly-Graded SAND (SP), yellowish-brown, moist	--
SBTB9	93	25	3.1%	0%	99%	1%	0.20	0.30	0.38	0.42	2.10	1.10	Poorly-Graded SAND (SP), yellowish-brown, moist	--
SBTB9	93	35	2.2%	0%	99%	1%	0.20	0.31	0.41	0.49	2.50	1.00	Poorly-Graded SAND (SP), yellowish-brown, moist	--
SBTB9	94	5	2.1%	2%	91%	7%	0.13	0.26	0.34	0.39	3.00	1.40	Poorly-Graded SAND with Silt (SP-SM), yellowish-brown, moist	--
SBTB9	94	20	3.2%	0%	97%	3%	0.17	0.26	0.34	0.38	2.20	1.10	Poorly-Graded SAND (SP), yellowish-brown, moist	--
SBTB9	94	35	18.6%	0%	97%	3%	0.19	0.28	0.34	0.37	2.00	1.10	Poolry-Graded SAND (SP), yellowish-brown, moist	--

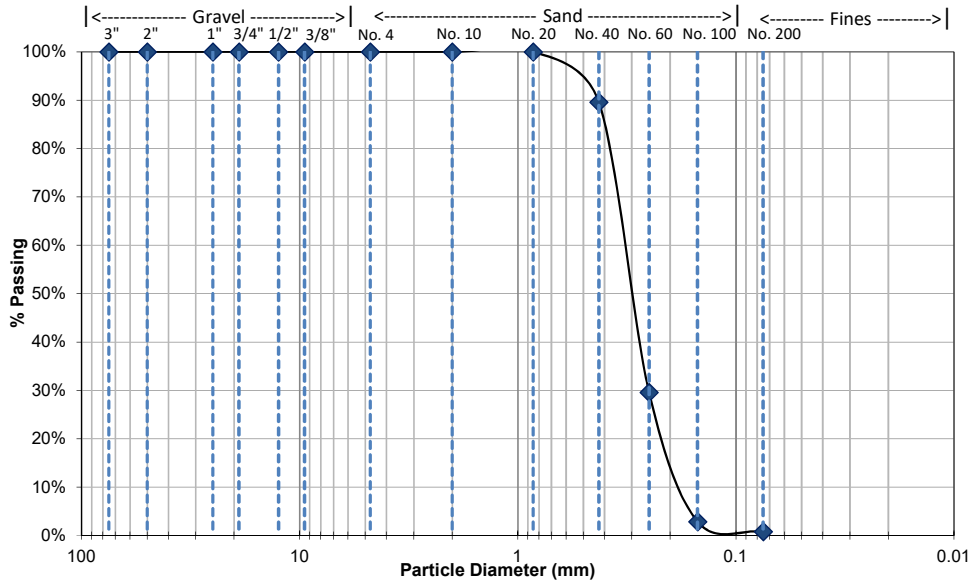
SUMMARY OF RESULTS														
Boring No.	**Sample No.**	**Depth (ft)**	**Water Content (%)**	**Gravel (%)**	**Sand (%)**	**Fines (%)**	**$D_{10\ (mm)}$**	**$D_{30\ (mm)}$**	**$D_{50\ (mm)}$**	**$D_{60\ (mm)}$**	**C_u**	**C_c**	**USCS Classification & Soil Description**	**AASHTO Classification**
SBTB9	94	36.5	30.8%	0%	8%	92%	--	--	--	--	--	--	Lean CLAY (CL), yellowish brown, moist	--

GRADATION CHARTS

Boring No.: GRPQ4TP-1-082918

Sample No.: --

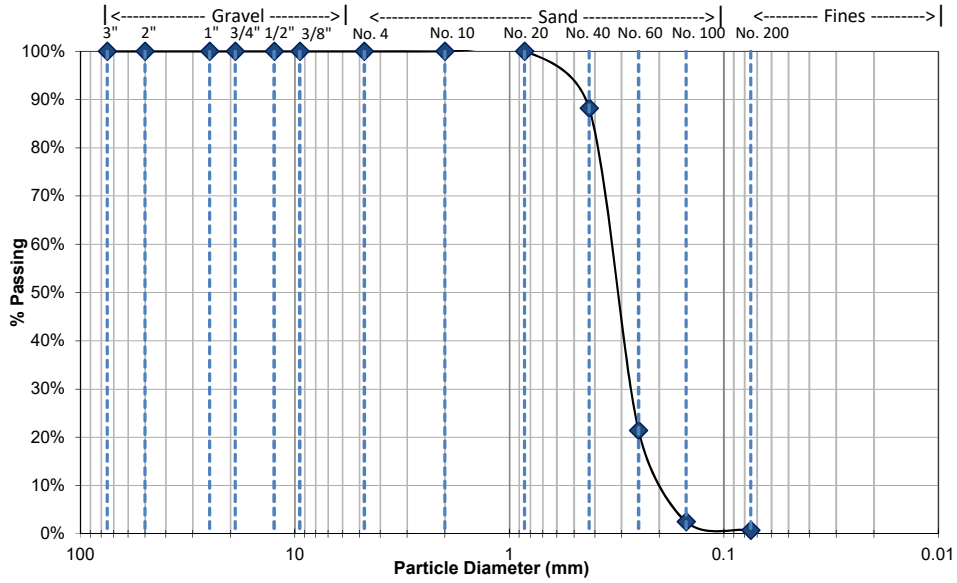
USCS Classification: Poorly graded SAND (SP)



Boring No.: GRPQ4TP-2-082918

Sample No.: --

USCS Classification: Poorly graded SAND (SP),

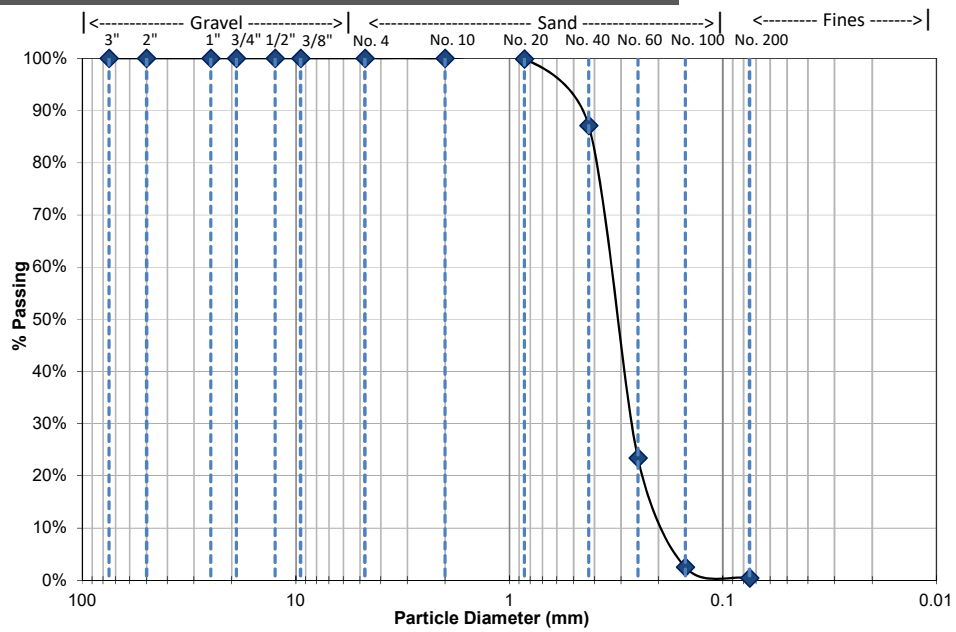


GRADATION CHARTS

Boring No.: GRPQ4TP-3-082918

Sample No.: --

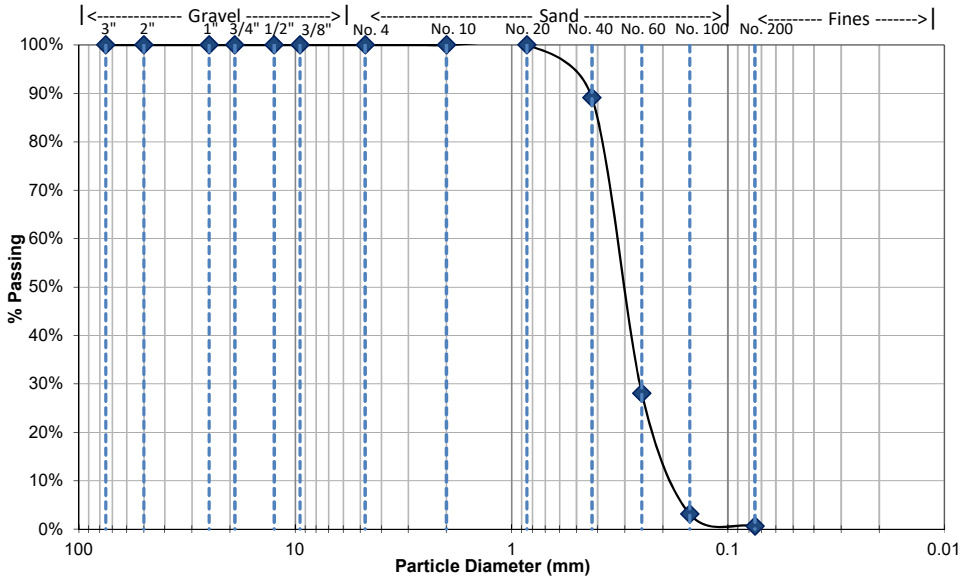
USCS Classification: Poorly graded SAND (SP),



Boring No.: GRPQ4TP-4-082918

Sample No.: --

USCS Classification: Poorly graded SAND (SP),

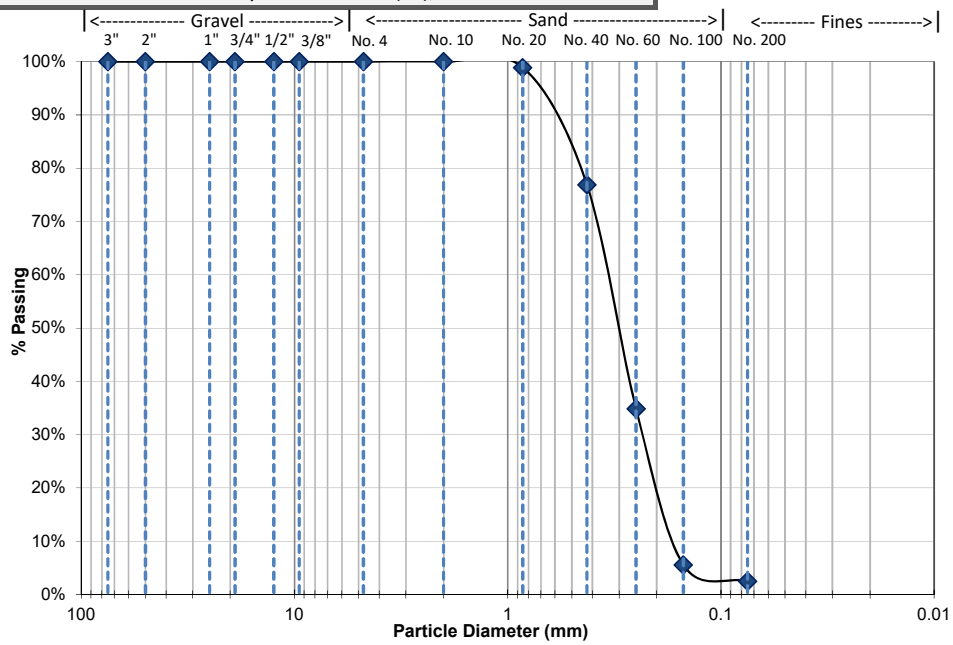


GRADATION CHARTS

Boring No.: SBTB9

Sample No.: 92a

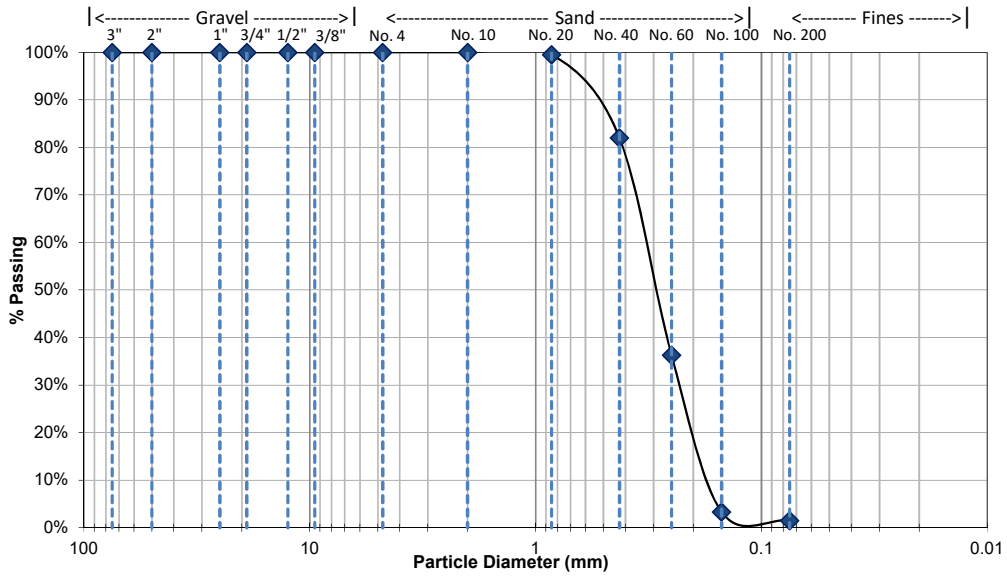
USCS Classification: Poorly-Graded SAND (SP),



Boring No.: SBTB9

Sample No.: 92a

USCS Classification: Poorly-Graded SAND (SP),

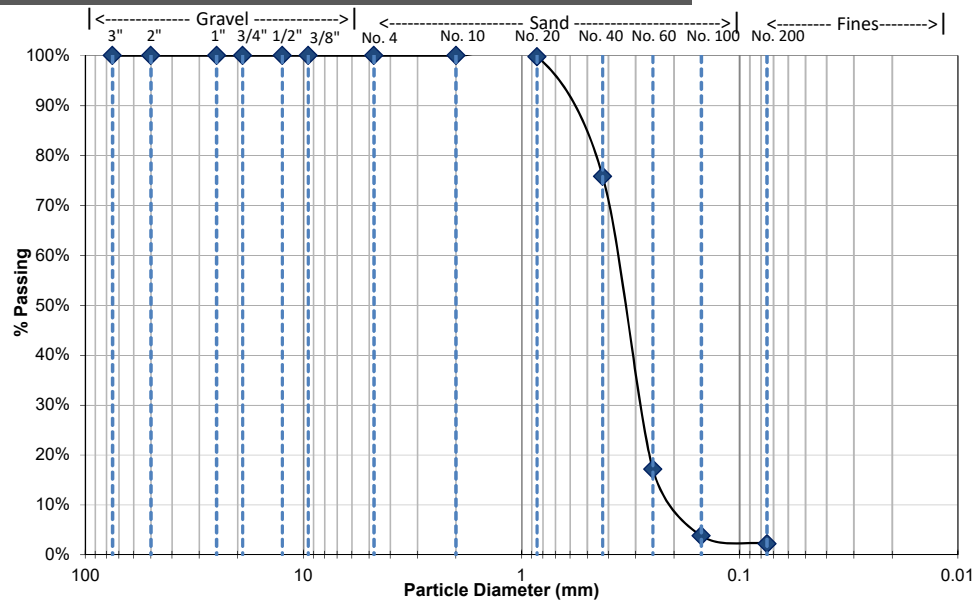


GRADATION CHARTS

Boring No.: SBTB9

Sample No.: 92a

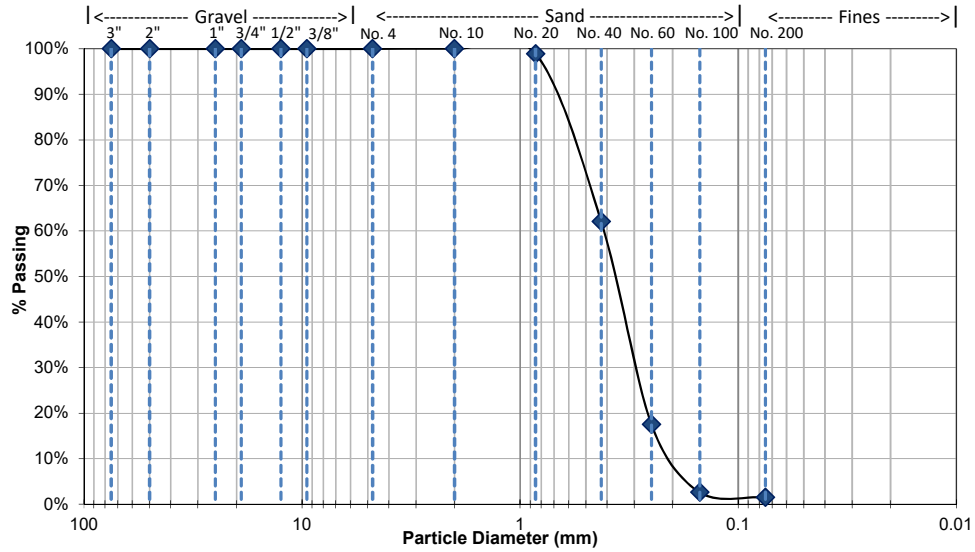
USCS Classification: Poorly-Graded SAND (SP),



Boring No.: SBTB9

Sample No.: 93

USCS Classification: Poorly-Graded SAND (SP),

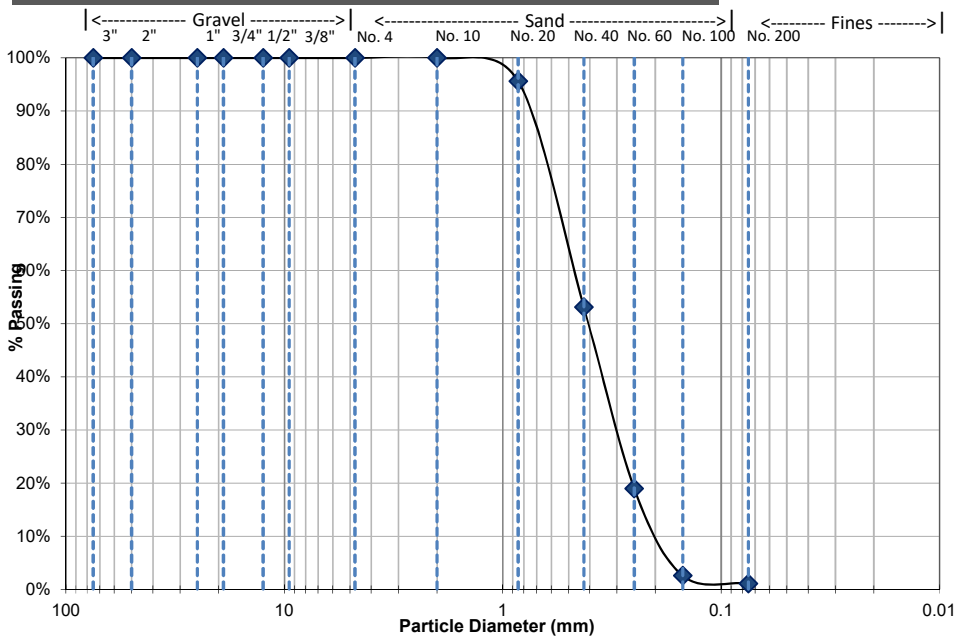


GRADATION CHARTS

Boring No.: SBTB9

Sample No.: 93

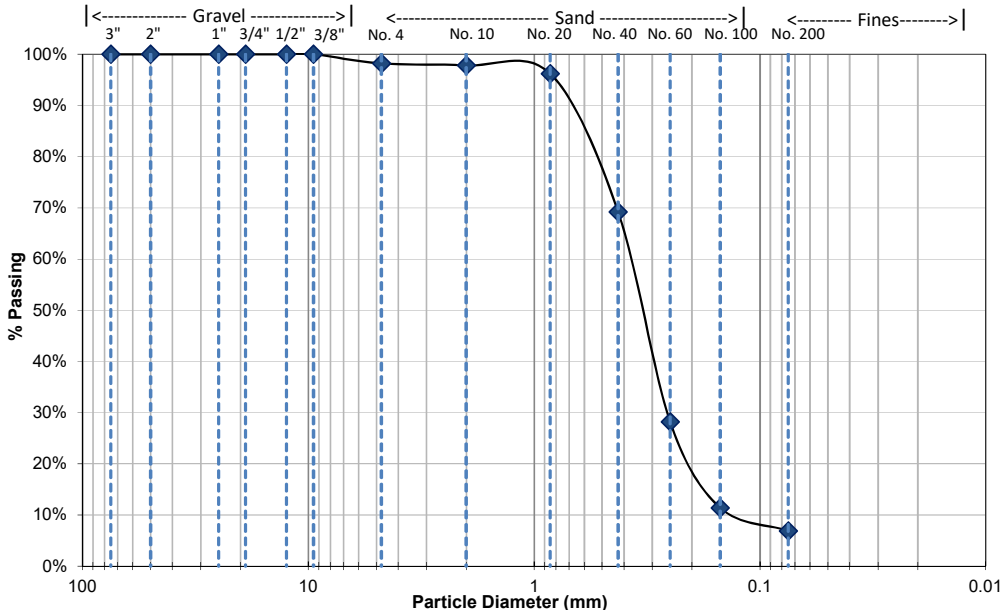
USCS Classification: Poorly-Graded SAND (SP),



Boring No.: SBTB9

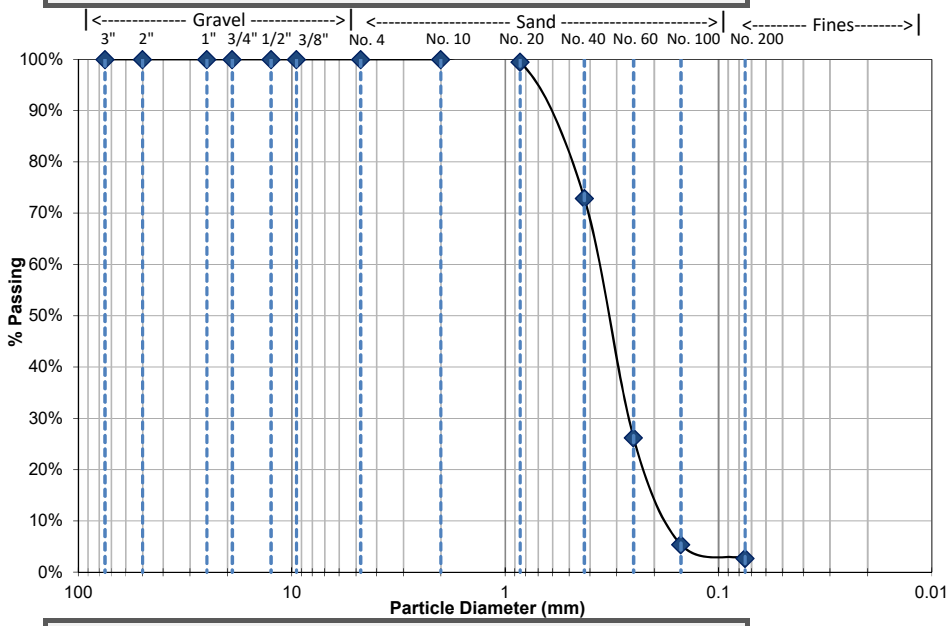
Sample No.: 94

USCS Classification: Poorly-Graded SAND with Silt (SP-SM),

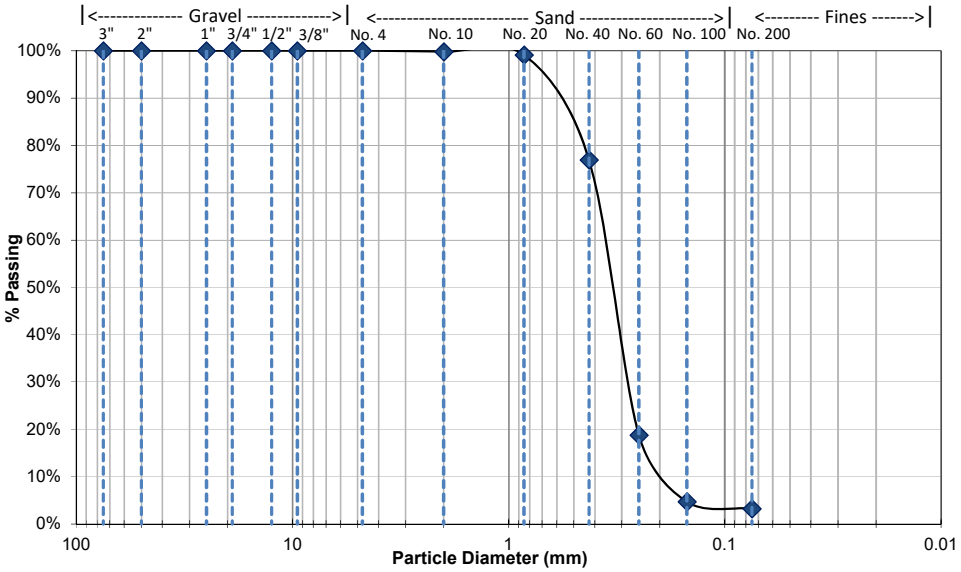


GRADATION CHARTS

Boring No.:	SBTB9
Sample No.:	94
USCS Classification:	Poorly-Graded SAND (SP),



Boring No.:	SBTB9
Sample No.:	94
USCS Classification:	Poolry-Graded SAND (SP),

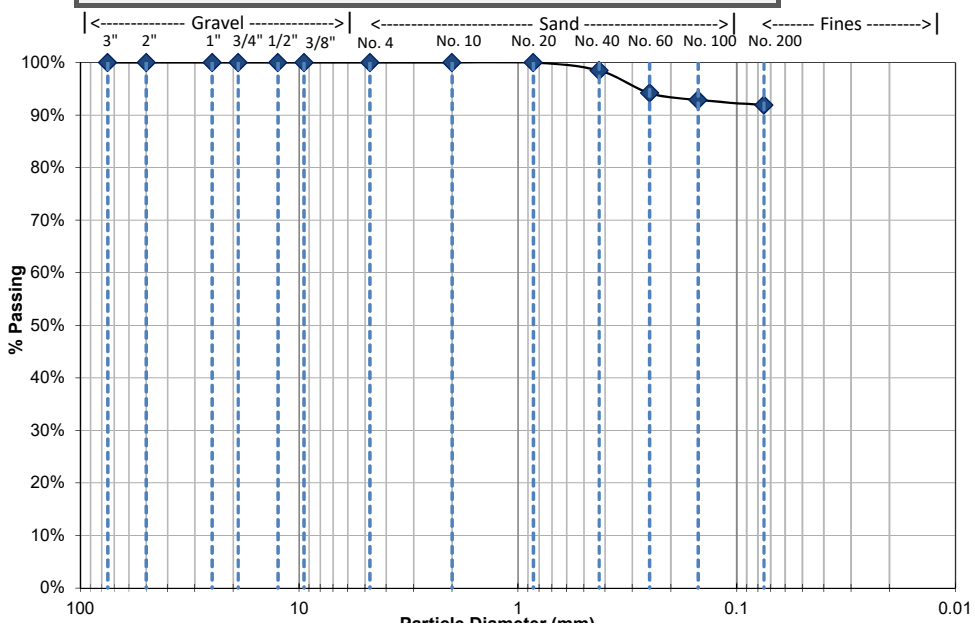


GRADATION CHARTS

Boring No.: SBTB9

Sample No.: 94

USCS Classification: Lean CLAY (CL),



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Mechnical Sieve Analysis with Hydrometer
Test Methods: ASTM D6913, D2487, D4718, D422

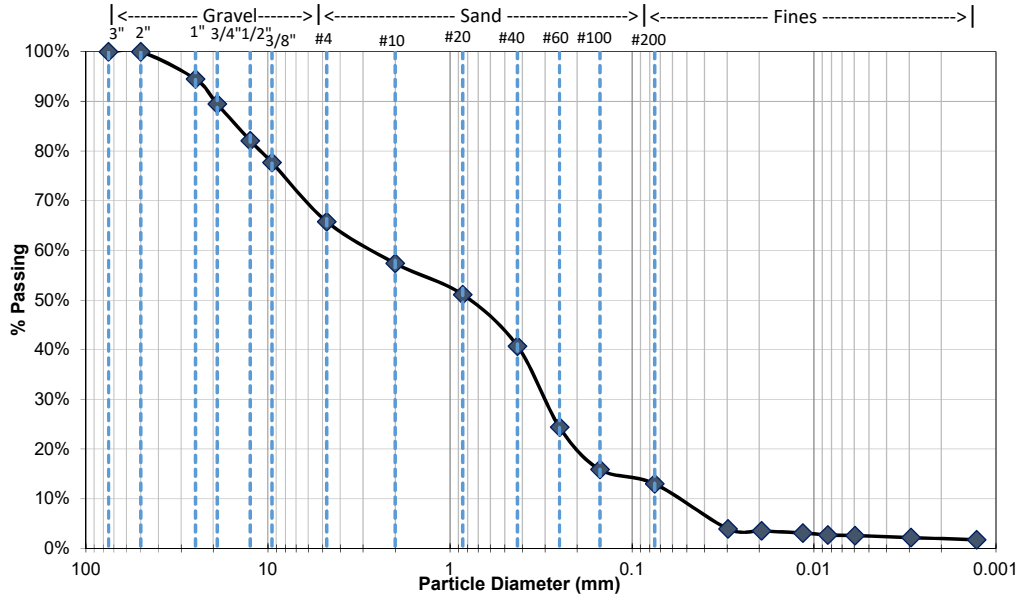
Project Name	217-199.08			**Project No.**	Guadalupe Restoration
Project Manager	J. King	**Tested By**		A. Limpert	
Checked By	N. Simon	**Testing Date**		9/7/2018	

SUMMARY OF RESULTS

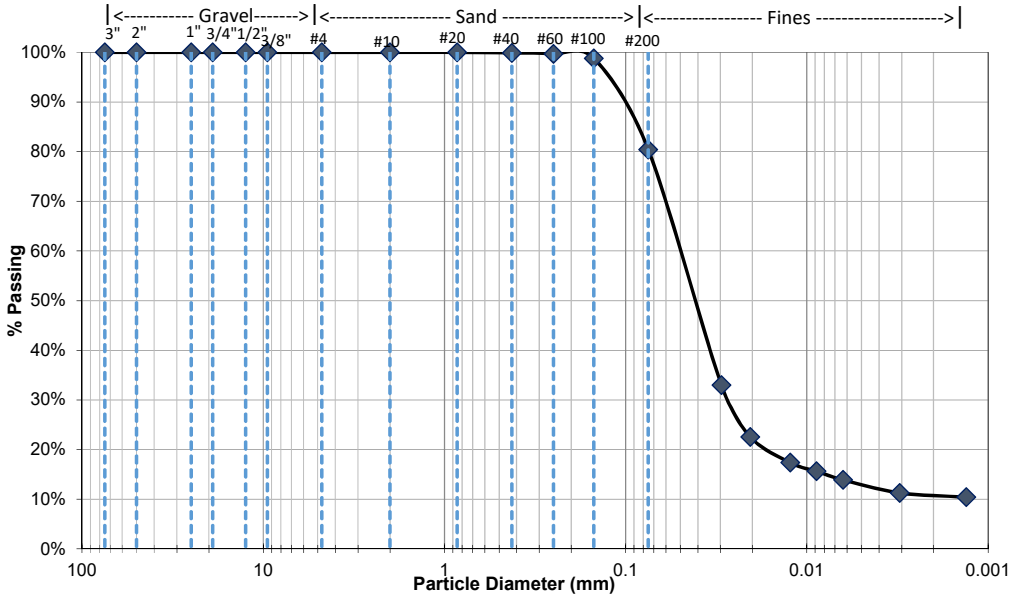
Boring No.	Sample No.	Depth (ft)	Water Content (%)	Gravel (%)	Sand (%)	Fines (%)	D_{10} (mm)	D_{30} (mm)	D_{50} (mm)	D_{60} (mm)	C_u	C_c	USCS Classification & Soil Description	AASHTO Classification
GRPE4ATP-1-082918	--	--	19.7%	34%	53%	13%	0.060	0.310	0.805	2.85	47.5	0.60	Clayey SAND with Gravel (SC) red, moist, subangular gravel	--
93	--	55	26.4%	0%	20%	80%	0.001	0.027	0.046	0.06	--	--	Lean CLAY with SAND (CL) yellowish brown, moist	--
94	--	35.75	20.3%	0%	19%	81%	0.001	0.008	0.020	0.03	--	--	Lean CLAY with SAND (CL) yellowish brown, moist	--

GRADATION CHARTS

Boring No.: GRPE4ATP-1-082918
Sample No.: --
USCS Classification: Clayey SAND with Gravel (SC)

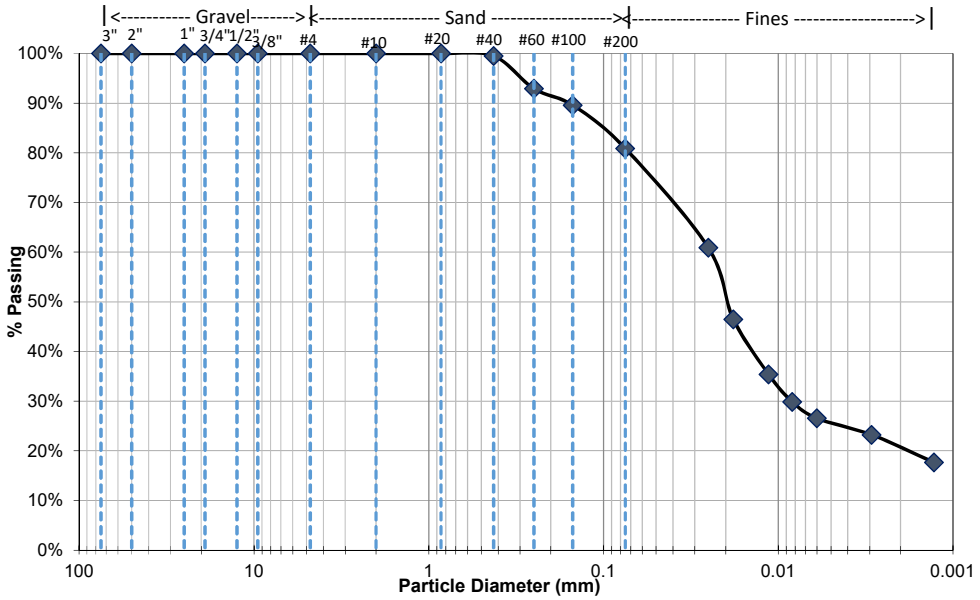


Boring No.: 93
Sample No.: --
USCS Classification: Lean CLAY with SAND (CL)



GRADATION CHARTS

Boring No.:	94
Sample No.:	--
USCS Classification:	Lean CLAY with SAND (CL)



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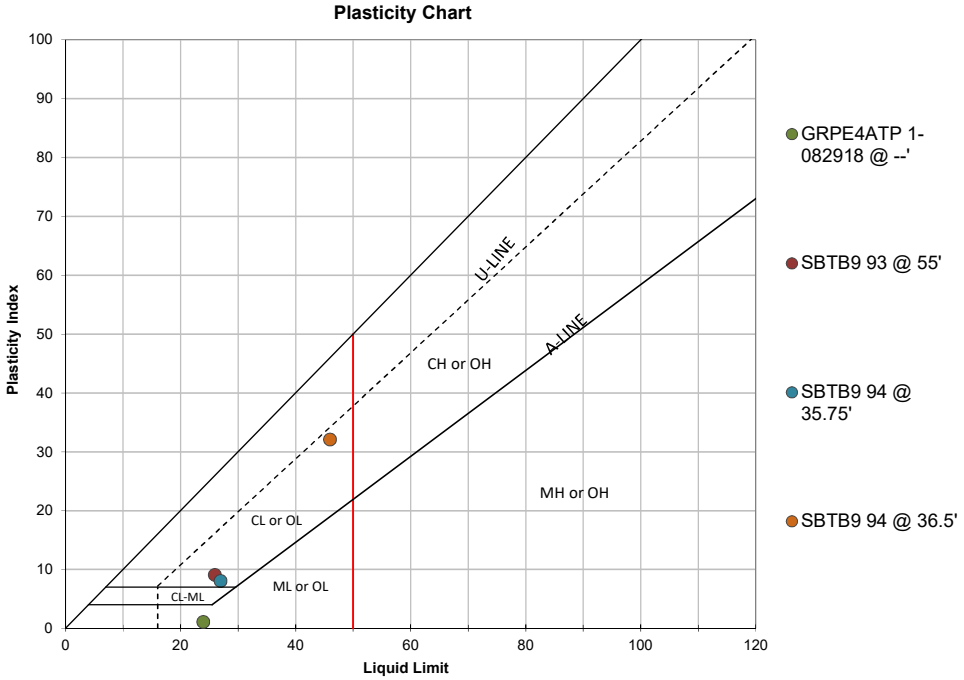
Atterberg Limits
Test Method: ASTM D4318

Project Name	Padre Misc. Lab Services - Guadalupe Restoration				
Project No.	215-199.08		**Project Manager**	J. King	
Tested By	N. Simon	**Checked By**	J. King	**Testing Date**	9/1/2018

SUMMARY OF RESULTS

Boring No.	Sample No.	Depth (ft)	Moisture Content (%)	Liquid Limit	Plastic Limit	Plasticity Index	USCS Classification & Soil Description	AASHTO Classification
GRPE4ATP	1-082918	--	18.8%	24	23	1	Clayey SAND with GRAVEL (SC), red, moist, subangular gravel	--
SBTB9	93	55.0	26.4%	26	17	9	Lean CLAY with SAND (CL), yellowish brown, moist	--
SBTB9	94	35.75	20.3%	27	19	8	Lean CLAY with SAND (CL), yellowish brown, moist	--
SBTB9	94	36.5	30.8%	46	14	32	Lean CLAY (CL), yellowish brown, moist	--



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Proctor Compaction

Test Method: ASTM D698, D1557

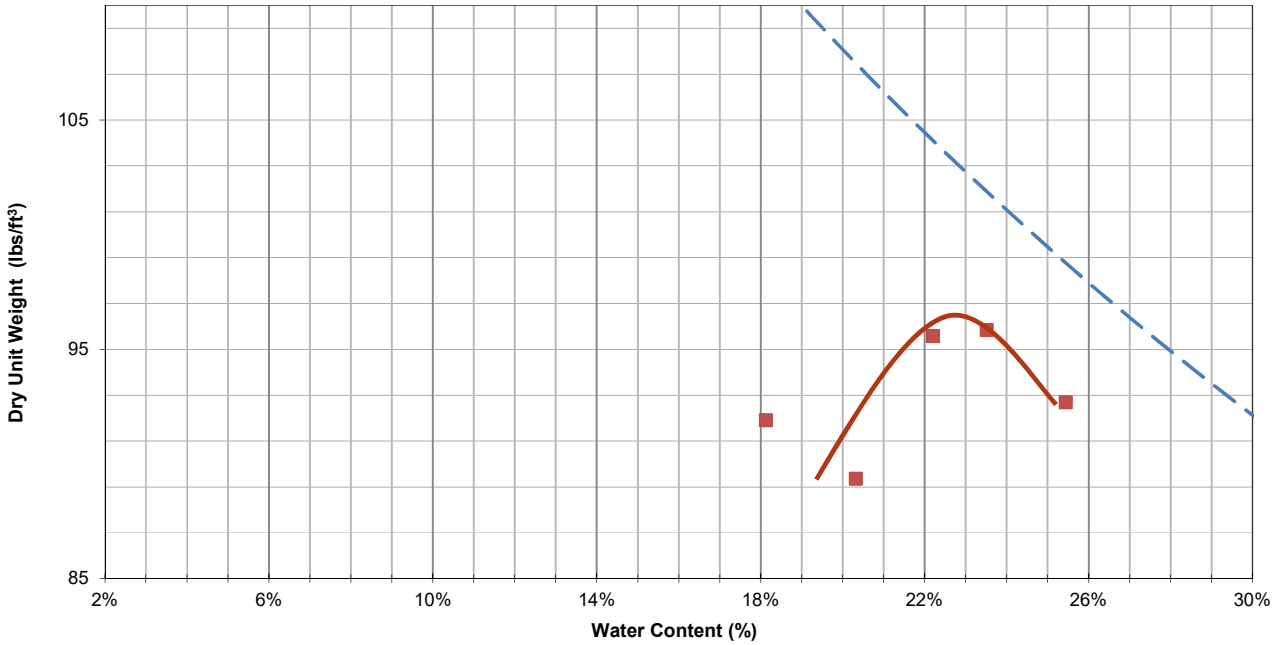
Project Name	Padre Misc. Lab Services - Guadalupe Restoration				
Project No.	215-199.08		**Project Manager**	J. King	
Tested By	A. Limpert	**Checked By**	J. King	**Testing Date**	9/1/2018

SPECIMEN ID AND CLASSIFICATION					
Boring No.	GRPE4ATP-1-082918	**Sample No.**	--	**Depth (ft)**	--
USCS Classification & Soil Description	Clayey SAND with Gravel (SC), red, moist, subangular gravel			**AASHTO Classification**	--

EQUIPMENT AND PROCEDURE					
Test Method (D698 or D1557)	1557B	**Ram. Mass (lbs)**	10	**# of Lifts**	5
Mold Volume (cm^3)	941	**Mold Mass(g)**	2010.8	**Blows/ Lift**	25

DENSITY AND MOISTURE MEASUREMENTS					
Mass of Soil + Mold (g)	3648	3632	3796	3764	3772
Dish ID	202A	106B	103A	108A	107A
Mass of Dish (g)	135.3	134.7	134.7	134.6	134.7
Mass of Moist Soil + Dish (g)	480.6	735.0	544.9	706.0	628.4
Mass of Dry Soil + Dish (g)	427.6	633.6	466.8	590.1	538.7

RESULTS					
Water Content	18.1%	20.3%	23.5%	25.4%	22.2%
Dry Density (Mg/m^3)	1.473	1.432	1.536	1.485	1.532
Dry Unit Weight (lbs/ft^3)	91.9	89.3	95.8	92.7	95.6
Lab Max. Dry Density (Mg/m^3)	1.536		**Optimum Water Content (%)**		23.6%
Lab Max. Dry Unit Wt. (lbs/ft^3)	96.5				



Yeh and Associates, Inc.
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Proctor Compaction

Test Method: ASTM D698, D1557

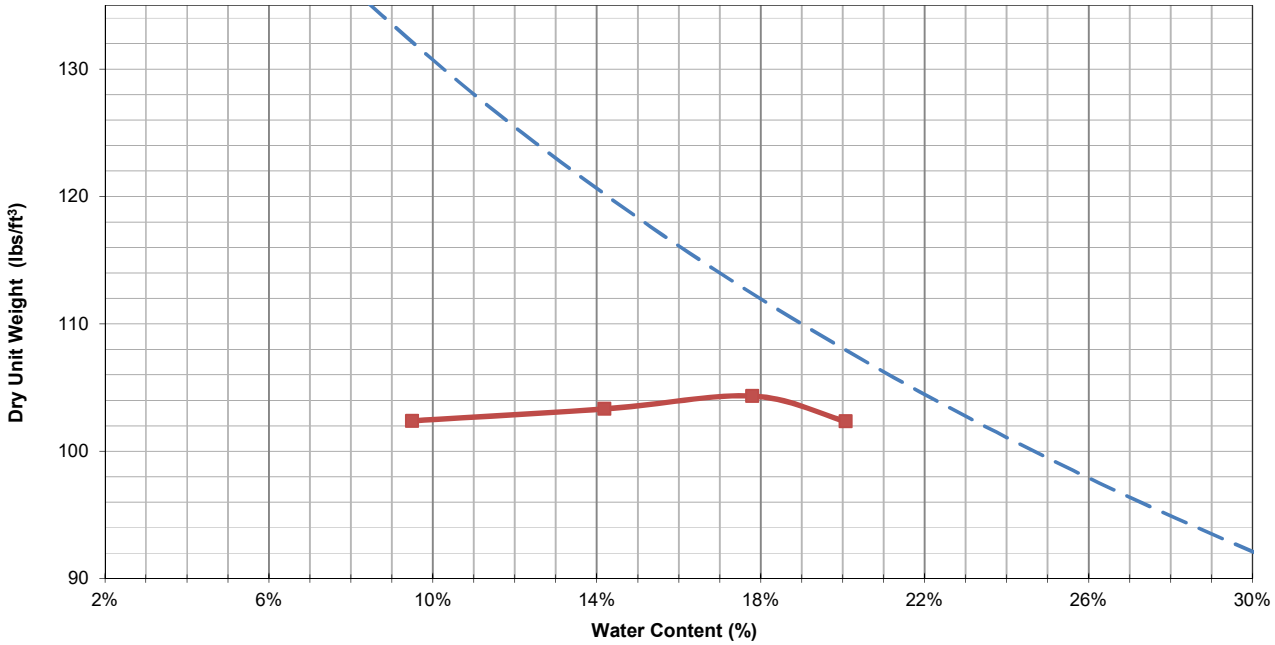
Project Name	Padre Misc. Lab Services - Guadalupe Restoration				
Project No.	215-199.08		**Project Manager**	J. King	
Tested By	A. Limpert	**Checked By**	J. King	**Testing Date**	9/1/2018

SPECIMEN ID AND CLASSIFICATION					
Boring No.	GRPQ4TP-1-082918	**Sample No.**	--	**Depth (ft)**	--
USCS Classification & Soil Description	Poorly graded SAND (SP), brown, moist			**AASHTO Classification**	--

EQUIPMENT AND PROCEDURE					
Test Method (D698 or D1557)	1557A	**Ram. Mass (lbs)**	10	**# of Lifts**	5
Mold Volume (cm^3)	914	**Mold Mass(g)**	2014	**Blows/ Lift**	25

DENSITY AND MOISTURE MEASUREMENTS					
Mass of Soil + Mold (g)	3602	3656	3742	3814	3814
Dish ID	101B	4A	107A	101B	102A
Mass of Dish (g)	135.0	134.8	135.7	134.9	134.7
Mass of Moist Soil + Dish (g)	560.9	750.5	708.8	765.8	812.9
Mass of Dry Soil + Dish (g)	536.7	697.1	637.6	670.5	699.5

RESULTS					
Water Content	6.0%	9.5%	14.2%	17.8%	20.1%
Dry Density (Mg/m^3)	1.639	1.641	1.656	1.672	1.640
Dry Unit Weight (lbs/ft^3)	102.3	102.4	103.3	104.3	102.3
Lab Max. Dry Density (Mg/m^3)	1.672		**Optimum Water Content (%)**		17.8%
Lab Max. Dry Unit Wt. (lbs/ft^3)	104.3				



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Proctor Compaction

Test Method: ASTM D698, D1557

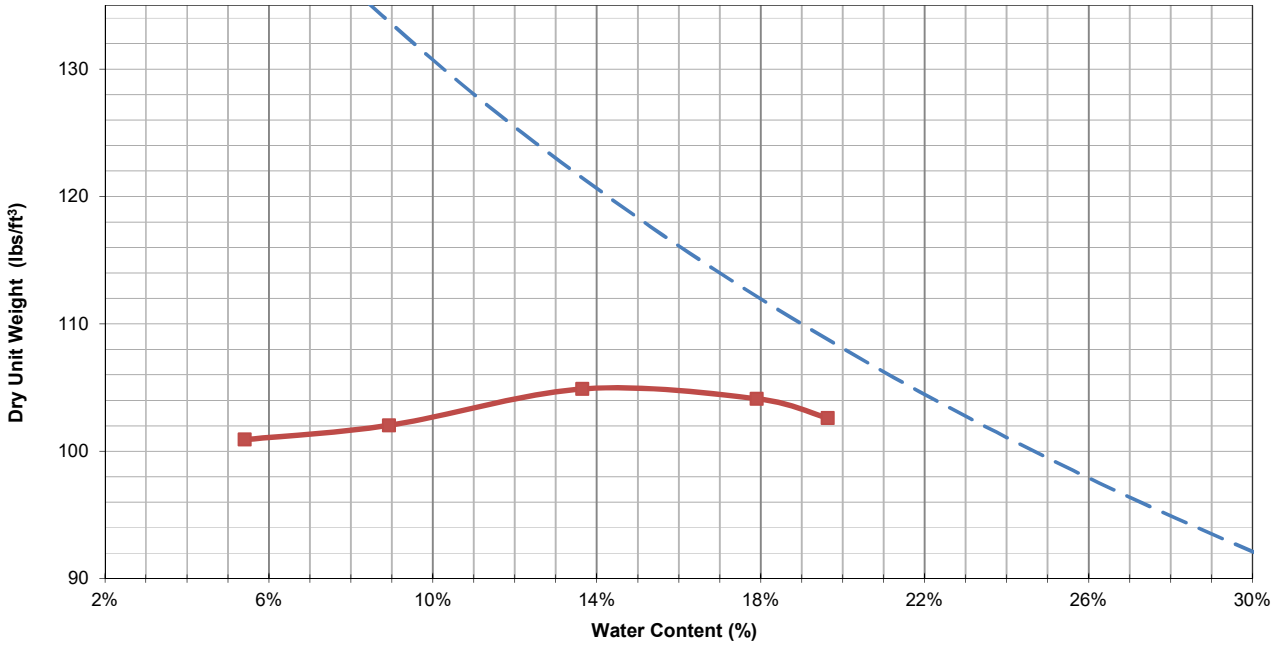
Project Name	Padre Misc. Lab Services - Guadalupe Restoration				
Project No.	215-199.08		**Project Manager**	J. King	
Tested By	A. Limpert	**Checked By**	J. King	**Testing Date**	9/1/2018

SPECIMEN ID AND CLASSIFICATION					
Boring No.	GRPQ4TP-2-082918	**Sample No.**	--	**Depth (ft)**	--
USCS Classification & Soil Description	Poorly graded SAND (SP), brown, moist			**AASHTO Classification**	--

EQUIPMENT AND PROCEDURE					
Test Method (D698 or D1557)	1557A	**Ram. Mass (lbs)**	10	**# of Lifts**	5
Mold Volume (cm^3)	914	**Mold Mass(g)**	2014	**Blows/ Lift**	25

DENSITY AND MOISTURE MEASUREMENTS					
Mass of Soil + Mold (g)	3572	3642	3760	3812	3812
Dish ID	104A	101R	202A	106B	102R
Mass of Dish (g)	136.2	136.0	135.3	134.6	134.8
Mass of Moist Soil + Dish (g)	669.7	611.5	718.2	676.0	650.2
Mass of Dry Soil + Dish (g)	642.3	572.5	648.2	593.8	565.6

RESULTS					
Water Content	5.4%	8.9%	13.6%	17.9%	19.6%
Dry Density (Mg/m^3)	1.617	1.635	1.681	1.669	1.644
Dry Unit Weight (lbs/ft^3)	100.9	102.0	104.9	104.1	102.6
Lab Max. Dry Density (Mg/m^3)	1.681		**Optimum Water Content (%)**		14.0%
Lab Max. Dry Unit Wt. (lbs/ft^3)	104.9				



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Proctor Compaction

Test Method: ASTM D698, D1557

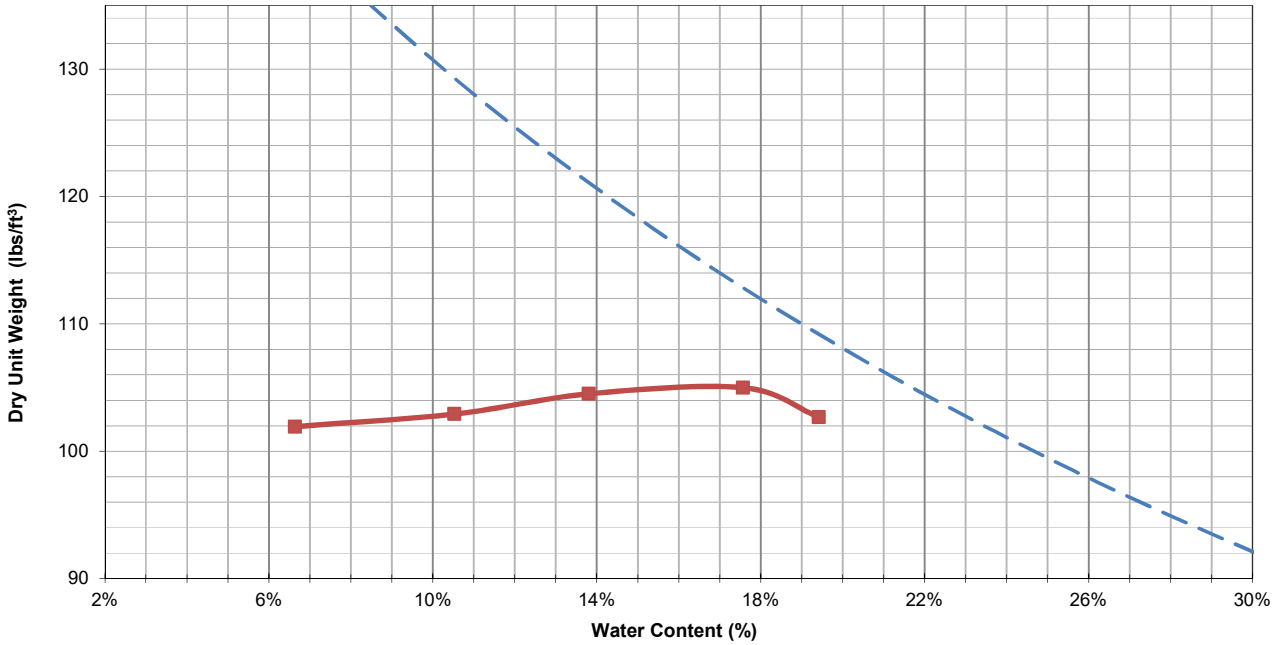
Project Name	Padre Misc. Lab Services - Guadalupe Restoration				
Project No.	215-199.08		**Project Manager**	J. King	
Tested By	A. Limpert	**Checked By**	J. King	**Testing Date**	9/1/2018

SPECIMEN ID AND CLASSIFICATION					
Boring No.	GRPQ4TP-3-082918	**Sample No.**	--	**Depth (ft)**	--
USCS Classification & Soil Description	Poorly Graded SAND (SP), brown, moist			**AASHTO Classification**	--

EQUIPMENT AND PROCEDURE					
Test Method (D698 or D1557)	1557A	**Ram. Mass (lbs)**	10	**# of Lifts**	5
Mold Volume (cm^3)	914	**Mold Mass(g)**	2014	**Blows/ Lift**	25

DENSITY AND MOISTURE MEASUREMENTS					
Mass of Soil + Mold (g)	3606	3680	3756	3822	3810
Dish ID	109B	105B	101B	101R	107C
Mass of Dish (g)	134.7	134.8	134.9	135.4	135.1
Mass of Moist Soil + Dish (g)	719.9	689.3	673.2	658.7	740.9
Mass of Dry Soil + Dish (g)	683.5	636.5	607.9	580.5	642.4

RESULTS					
Water Content	6.6%	10.5%	13.8%	17.6%	19.4%
Dry Density (Mg/m^3)	1.633	1.649	1.675	1.683	1.645
Dry Unit Weight (lbs/ft^3)	101.9	102.9	104.5	105.0	102.7
Lab Max. Dry Density (Mg/m^3)	1.683		**Optimum Water Content (%)**		17.5%
Lab Max. Dry Unit Wt. (lbs/ft^3)	105.0				



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Proctor Compaction

Test Method: ASTM D698, D1557

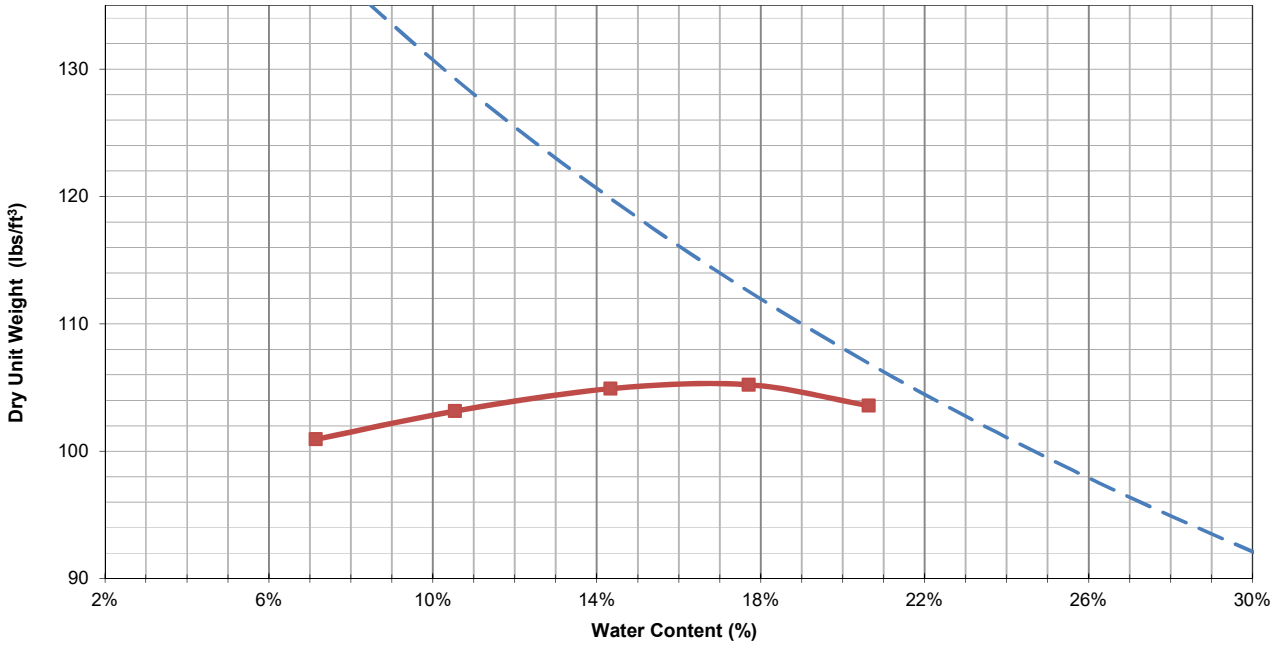
Project Name	Padre Misc. Lab Services - Guadalupe Restoration				
Project No.	215-199.08		**Project Manager**	J. King	
Tested By	A. Limpert	**Checked By**	J. King	**Testing Date**	9/1/2018

SPECIMEN ID AND CLASSIFICATION					
Boring No.	GRPQ4TP-4-082918	**Sample No.**	--	**Depth (ft)**	--
USCS Classification & Soil Description	Poorly Graded SAND (SP), brown, moist			**AASHTO Classification**	

EQUIPMENT AND PROCEDURE					
Test Method (D698 or D1557)	1557B	**Ram. Mass (lbs)**	10	**# of Lifts**	5
Mold Volume (cm^3)	914	**Mold Mass(g)**	2014	**Blows/ Lift**	25

DENSITY AND MOISTURE MEASUREMENTS					
Mass of Soil + Mold (g)	3598	3684	3771	3828	3844
Dish ID	103A	107C	101A	101B	107A
Mass of Dish (g)	134.9	137.2	134.8	135.0	134.8
Mass of Moist Soil + Dish (g)	638.6	788.5	732.1	771.8	725.8
Mass of Dry Soil + Dish (g)	605.0	726.4	657.2	676.0	624.7

RESULTS					
Water Content	7.1%	10.5%	14.3%	17.7%	20.6%
Dry Density (Mg/m^3)	1.617	1.653	1.681	1.686	1.660
Dry Unit Weight (lbs/ft^3)	100.9	103.1	104.9	105.2	103.6
Lab Max. Dry Density (Mg/m^3)	1.686		**Optimum Water Content (%)**		16.5%
Lab Max. Dry Unit Wt. (lbs/ft^3)	105.2				



SAMPLE ID

Boring Number	--
Sample Number	GRPE4ATP-1-082918
Sample Depth, ft	--
Classification	Silty SAND (SM): red

SAMPLE PROPERTIES

	Intial	Final
Mass, g	401.36	421.55
Water Content, %	27.6%	34.0%
Dry Density, pcf	86.8	86.8
Saturation, %	81%	100%
Void Ratio	0.90	0.90
Diameter, in	2.42	2.42
Height, in	3.00	3.00
Area, in^2	4.60	4.60
Volume, in^3	13.80	13.80

CLASSIFICATION

Sieve Size	% Passing
3/8-in. (9.5mm)	---
#4 (4.75mm)	---
#16 (1.18mm)	---
#30 (0.6mm)	---
#100 (0.150mm)	---
#200 (0.075mm)	---

Other Parameters	
Liquid Limit	---
Plastic Limit	---
Plasticity Index	---
Estimated Gs	2.65

TEST SUMMARY

Sample Type	RC = 90%
Permeant	Deaired Tap-Water
Pipette Area, cm^2	0.263
k_{avg} 20ºC, cm/s	1.6E-03
Tested By	ND

REMARKS

Test Method: ASTM D5084 (Method C)

Project: Guadalupe Restoration - TB9 Assessment
Project No. 1801-2191

PERMEATION DATA

Trial	Date	Time, sec	$Temp_{Avg}$, ºC	σ', ksf	μ, ksf	i_o	i_f	k_t, cm/s
1	9/17/18	85	21.1	0.3	13.0	5.0	0.7	1.6E-03
2	9/17/18	81	21.1	0.3	13.0	5.0	0.7	1.7E-03
3	9/17/18	82	21.1	0.3	13.0	5.0	0.7	1.7E-03
4	9/17/18	80	21.1	0.3	13.0	5.0	0.7	1.7E-03
5	9/17/18	80	21.1	0.3	13.0	5.0	0.7	1.7E-03
6	9/17/18	81	21.1	0.3	13.0	5.0	0.7	1.7E-03

SAMPLE IMAGES

SAMPLE ID

Boring Number	--
Sample Number	GRPQ4TP-1-082918
Sample Depth, ft	--
Classification	Poorly-graded SAND (SP): light brown, fine

SAMPLE PROPERTIES

	Intial	Final
Mass, g	405.31	439.88
Water Content, %	19.2%	29.4%
Dry Density, pcf	93.9	93.9
Saturation, %	65%	100%
Void Ratio	0.80	0.80
Diameter, in	2.42	2.42
Height, in	3.00	3.00
Area, in^2	4.60	4.60
Volume, in^3	13.80	13.80

CLASSIFICATION

Sieve Size	% Passing
3/8-in. (9.5mm)	---
#4 (4.75mm)	---
#16 (1.18mm)	---
#30 (0.6mm)	---
#100 (0.150mm)	---
#200 (0.075mm)	---

Other Parameters	
Liquid Limit	---
Plastic Limit	---
Plasticity Index	---
Estimated Gs	2.7

TEST SUMMARY

Sample Type	RC = 90%
Permeant	Deaired Tap-Water
Pipette Area, cm^2	0.263
k_{avg} 20ºC, cm/s	8.7E-03
Tested By	ND

REMARKS

Test Method: ASTM D5084 (Method C)

Project: Guadalupe Restoration - TB9 Assessment

Project No. 1801-2191

PERMEATION DATA

Trial	Date	Time, sec	$Temp_{Avg}$, ºC	σ', ksf	μ, ksf	i_o	i_f	k_t, cm/s
1	9/12/18	10	21.0	0.3	13.0	4.5	1.2	8.9E-03
2	9/12/18	10	21.0	0.3	13.0	4.5	1.2	8.9E-03
3	9/12/18	10	21.0	0.3	13.0	4.5	1.2	8.9E-03
4	9/12/18	10	21.0	0.3	13.0	4.5	1.2	8.8E-03
5	9/12/18	10	21.0	0.3	13.0	4.5	1.2	8.8E-03
6	9/12/18	10	21.0	0.3	13.0	4.5	1.2	8.8E-03

SAMPLE IMAGES

SAMPLE ID

Boring Number	--
Sample Number	GRPQ4TP-2-082918
Sample Depth, ft	--
Classification	Poorly-graded SAND (SP): light brown, fine

SAMPLE PROPERTIES

	Intial	Final
Mass, g	409.95	440.02
Water Content, %	19.0%	27.8%
Dry Density, pcf	95.1	95.1
Saturation, %	68%	100%
Void Ratio	0.74	0.74
Diameter, in	2.42	2.42
Height, in	3.00	3.00
Area, in^2	4.60	4.60
Volume, in^3	13.80	13.80

CLASSIFICATION

Sieve Size	% Passing
3/8-in. (9.5mm)	---
#4 (4.75mm)	---
#16 (1.18mm)	---
#30 (0.6mm)	---
#100 (0.150mm)	---
#200 (0.075mm)	---

Other Parameters	
Liquid Limit	---
Plastic Limit	---
Plasticity Index	---
Estimated Gs	2.65

TEST SUMMARY

Sample Type	RC = 90%
Permeant	Deaired Tap-Water
Pipette Area, cm^2	0.263
k_{avg} 20ºC, cm/s	8.8E-03
Tested By	ND

REMARKS

Test Method: ASTM D5084 (Method C)

Project: Guadalupe Restoration - TB9 Assessment
Project No. 1801-2191

PERMEATION DATA

Trial	Date	Time, sec	$Temp_{Avg}$, ºC	σ', ksf	μ, ksf	i_o	i_f	k_t, cm/s
1	9/12/18	14	21.0	0.3	13.0	5.0	0.7	9.2E-03
2	9/12/18	15	21.0	0.3	13.0	5.0	0.7	8.9E-03
3	9/12/18	15	21.0	0.3	13.0	5.0	0.7	8.9E-03
4	9/12/18	14	21.0	0.3	13.0	5.0	0.7	9.3E-03
5	9/12/18	15	21.0	0.3	13.0	5.0	0.7	8.7E-03
6	9/12/18	14	21.0	0.3	13.0	5.0	0.7	9.3E-03

SAMPLE IMAGES

SAMPLE ID

Boring Number	--
Sample Number	GRPQ4TP-3-082918
Sample Depth, ft	--
Classification	Poorly-graded SAND (SP): light brown, fine

SAMPLE PROPERTIES

	Intial	Final
Mass, g	386.65	438.89
Water Content, %	13.0%	28.2%
Dry Density, pcf	94.5	94.5
Saturation, %	46%	100%
Void Ratio	0.75	0.75
Diameter, in	2.42	2.42
Height, in	3.00	3.00
Area, in^2	4.60	4.60
Volume, in^3	13.80	13.80

CLASSIFICATION

Sieve Size	% Passing
3/8-in. (9.5mm)	---
#4 (4.75mm)	---
#16 (1.18mm)	---
#30 (0.6mm)	---
#100 (0.150mm)	---
#200 (0.075mm)	---

Other Parameters	
Liquid Limit	---
Plastic Limit	---
Plasticity Index	---
Estimated Gs	2.65

TEST SUMMARY

Sample Type	RC = 90%
Permeant	Deaired Tap-Water
Pipette Area, cm^2	0.263
k_{avg} 20ºC, cm/s	8.1E-03
Tested By	ND

REMARKS

Test Method: ASTM D5084 (Method C)

Project: Guadalupe Restoration - TB9 Assessment
Project No. 1801-2191

PERMEATION DATA

Trial	Date	Time, sec	$Temp_{Avg}$, ºC	σ', ksf	μ, ksf	i_o	i_f	k_t, cm/s
1	9/13/18	16	21.0	0.3	13.0	5.0	0.7	8.3E-03
2	9/13/18	16	21.0	0.3	13.0	5.0	0.7	8.3E-03
3	9/13/18	16	21.0	0.3	13.0	5.0	0.7	8.3E-03
4	9/13/18	16	21.0	0.3	13.0	5.0	0.7	8.3E-03
5	9/13/18	16	21.0	0.3	13.0	5.0	0.7	8.3E-03
6	9/13/18	16	21.0	0.3	13.0	5.0	0.7	8.3E-03

SAMPLE IMAGES

SAMPLE ID

Boring Number	--
Sample Number	GRPQ4TP-4-082918
Sample Depth, ft	--
Classification	Poorly-graded SAND (SP): light brown, fine

SAMPLE PROPERTIES

	Intial	Final
Mass, g	397.37	439.36
Water Content, %	15.9%	28.1%
Dry Density, pcf	94.7	94.7
Saturation, %	56%	100%
Void Ratio	0.75	0.75
Diameter, in	2.42	2.42
Height, in	3.00	3.00
Area, in^2	4.60	4.60
Volume, in^3	13.80	13.80

CLASSIFICATION

Sieve Size	% Passing
3/8-in. (9.5mm)	---
#4 (4.75mm)	---
#16 (1.18mm)	---
#30 (0.6mm)	---
#100 (0.150mm)	---
#200 (0.075mm)	---

Other Parameters	
Liquid Limit	---
Plastic Limit	---
Plasticity Index	---
Estimated Gs	2.65

TEST SUMMARY

Sample Type	RC = 90%
Permeant	Deaired Tap-Water
Pipette Area, cm^2	0.263
k_{avg} 20ºC, cm/s	8.5E-03
Tested By	ND

REMARKS

Test Method: ASTM D5084 (Method C)

Project: Guadalupe Restoration - TB9 Assessment
Project No. 1801-2191

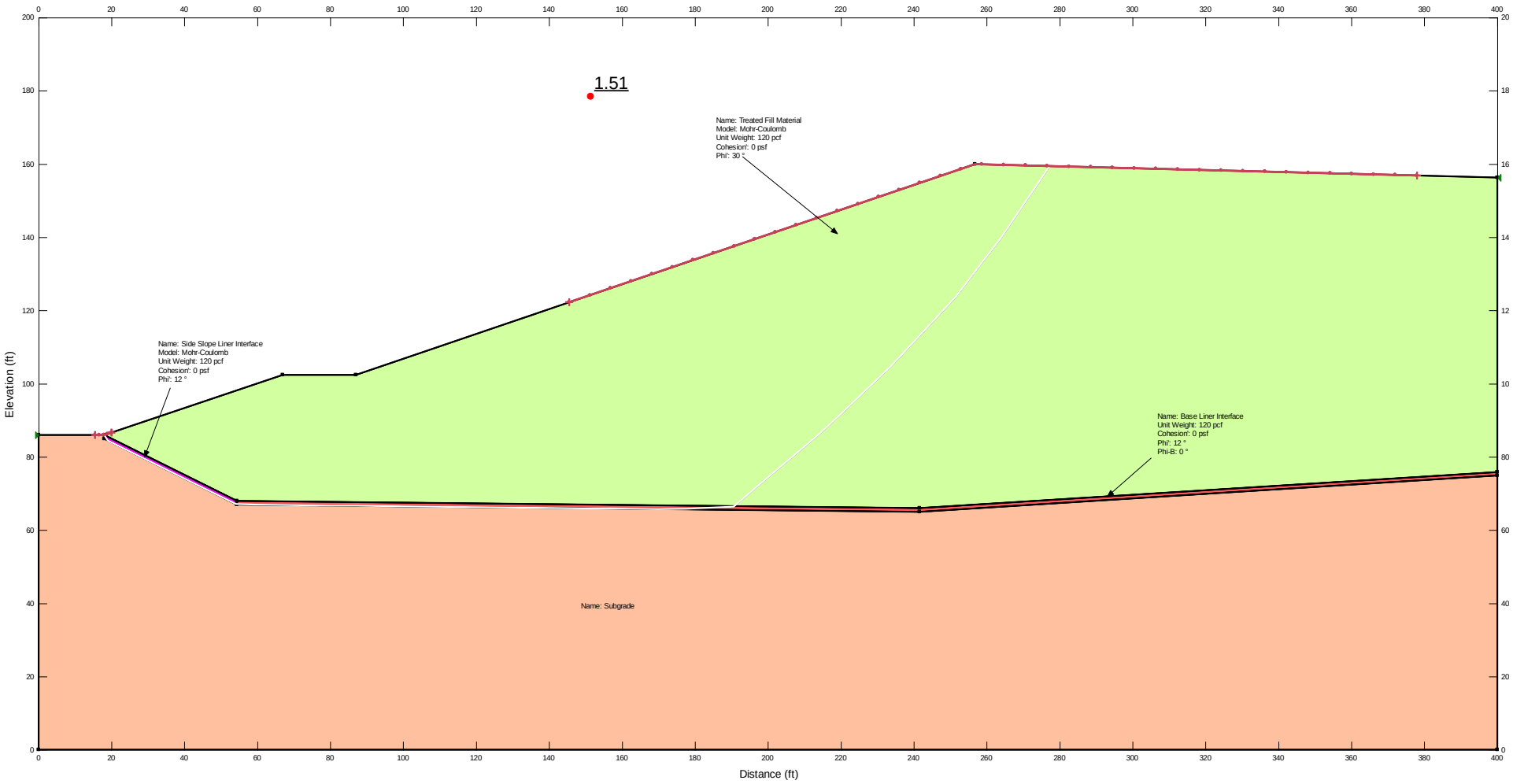
PERMEATION DATA

Trial	Date	Time, sec	$Temp_{Avg}$, ºC	σ', ksf	μ, ksf	i_o	i_f	k_t, cm/s
1	9/14/18	16	21.1	0.3	13.0	5.0	0.7	8.3E-03
2	9/14/18	15	21.1	0.3	13.0	5.0	0.7	8.9E-03
3	9/14/18	15	21.1	0.3	13.0	5.0	0.7	8.9E-03
4	9/14/18	15	21.1	0.3	13.0	5.0	0.7	8.9E-03
5	9/14/18	15	21.1	0.3	13.0	5.0	0.7	8.9E-03
6	9/14/18	15	21.1	0.3	13.0	5.0	0.7	8.9E-03

SAMPLE IMAGES

APPENDIX B

Static Slope Stability Analysis Results


1.51
Name: Treated Fill Material
Model: Mohr-Coulomb
Unit Weight: 120 pcf
Cohesion': 0 psf
Phi': 30 °
Name: Side Slope Liner Interface
Model: Mohr-Coulomb
Unit Weight: 120 pcf
Cohesion': 0 psf
Phi': 12 °
Name: Base Liner Interface
Unit Weight: 120 pcf
Cohesion': 0 psf
Phi': 12 °
Phi-B: 0 °
Name: Subgrade
Elevation (ft)
Distance (ft)

A-A', Static, Run 1

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File Information

Date: 06/10/2019
Time: 11:49:08 AM
Tool Version: 9.1.0.16306
File Name: A-A'_Rev5_1.gsz
Last Solved Date: 06/10/2019
Last Solved Time: 11:49:18 AM

Project Settings

Unit System: U.S. Customary Units

Analysis Settings

A-A', Static, Run 1

Description: Chevron, Guadalupe Restoration Project, Slope Stability, Cross Section
Kind: SLOPE/W
Method: Morgenstern-Price
Settings
- Side Function
  - Interslice force function option: Half-Sine
- PWP Conditions from: (none)
- Unit Weight of Water: 62.430189 pcf

Slip Surface
- Direction of movement: Right to Left
- Use Passive Mode: No
- Slip Surface Option: Entry and Exit

- Critical slip surfaces saved: 1
- Optimize Critical Slip Surface Location: Yes
- Optimizations Settings
  - Maximum Iterations: 5,000
  - Convergence Tolerance: 1e-07
  - Starting Points: 8
  - Ending Points: 16
  - Complete Passes per Insertion: 1
  - Driving Side Maximum Convex Angle: 5 °
  - Resisting Side Maximum Convex Angle: 1 °
- Tension Crack Option: (none)

Distribution
- F of S Calculation Option: Constant

Advanced
- Geometry Settings
  - Minimum Slip Surface Depth: 0.1 ft
  - Number of Slices: 30
- Factor of Safety Convergence Settings
  - Maximum Number of Iterations: 100
  - Tolerable difference in F of S: 0.001
- Solution Settings
  - Search Method: Root Finder
  - Tolerable difference between starting and converged F of S: 3
  - Maximum iterations to calculate converged lambda: 20
  - Max Absolute Lambda: 2

Materials

Treated Fill Material

- Model: Mohr-Coulomb
- Unit Weight: 120 pcf
- Cohesion': 0 psf
- Phi': 30 °

Phi-B: 0 °

Base Liner Interface

Model: Mohr-Coulomb
Unit Weight: 120 pcf
Cohesion': 0 psf
Phi': 12 °
Phi-B: 0 °

Subgrade

Model: Bedrock (Impenetrable)

Side Slope Liner Interface

Model: Mohr-Coulomb
Unit Weight: 120 pcf
Cohesion': 0 psf
Phi': 12 °
Phi-B: 0 °

Slip Surface Entry and Exit

Left Type: Range
Left-Zone Left Coordinate: (15.51969, 86) ft
Left-Zone Right Coordinate: (20, 86.66939) ft
Left-Zone Increment: 4
Right Type: Range
Right-Zone Left Coordinate: (145.56222, 122.26563) ft
Right-Zone Right Coordinate: (378, 156.86844) ft
Right-Zone Increment: 40
Radius Increments: 10

Slip Surface Limits

Left Coordinate: (0, 86) ft
Right Coordinate: (400, 156.3) ft

Points

	X	Y
Point 1	0 ft	86 ft
Point 2	18 ft	86 ft
Point 3	67 ft	102.4 ft
Point 4	87 ft	102.4 ft
Point 5	256.8 ft	160 ft
Point 6	400 ft	156.3 ft
Point 7	54.4 ft	68 ft
Point 8	241.6 ft	66 ft
Point 9	400 ft	75.9 ft
Point 10	18 ft	85 ft
Point 11	54.4 ft	67 ft
Point 12	241.6 ft	65 ft
Point 13	400 ft	74.9 ft
Point 14	0 ft	0 ft
Point 15	400 ft	0 ft

Regions

	Material	Points	Area
Region 1	Treated Fill Material	2,3,4,5,6,9,8,7	25,005 ft²

Region 2	Side Slope Liner Interface	2,7,11,10	36.4 ft²
Region 3	Base Liner Interface	7,8,9,13,12,11	345.6 ft²
Region 4	Subgrade	1,2,10,11,12,13,15,14	27,750 ft²

Slip Results

Slip Surfaces Analysed: 1003 of 2256 converged

Current Slip Surface

Slip Surface: 2,256
Factor of Safety: 1.51
Volume: 11,076.807 ft³
Weight: 1,329,216.8 lbf
Resisting Moment: 60,538,281 lbf·ft
Activating Moment: 40,191,776 lbf·ft
Resisting Force: 368,085.03 lbf
Activating Force: 244,530.02 lbf
Slip Rank: 1 of 2,256 slip surfaces
Exit: (18.000663, 86.000222) ft
Entry: (277.27405, 159.47099) ft
Radius: 135.36466 ft
Center: (120.27697, 194.96169) ft

Slip Slices

	X	Y	PWP	Base Normal Stress	Frictional Strength	Cohesive Strength	Suction Strength	Base Material
Slice 1	18.000933 ft	85.999813 ft	0 psf	0.14251834 psf	0.082283 psf	0 psf	0 psf	Treated Fill Material

Slice 2	18.492355 ft	85.256528 ft	0 psf	139.70179 psf	29.694533 psf	0 psf	0 psf	Side Slope Liner Interface
Slice 3	22.410982 ft	82.818745 ft	0 psf	614.61621 psf	130.64071 psf	0 psf	0 psf	Side Slope Liner Interface
Slice 4	29.265934 ft	79.428934 ft	0 psf	1,400.7417 psf	297.73684 psf	0 psf	0 psf	Side Slope Liner Interface
Slice 5	38.058838 ft	75.080795 ft	0 psf	2,476.471 psf	526.39015 psf	0 psf	0 psf	Side Slope Liner Interface
Slice 6	48.789693 ft	69.774328 ft	0 psf	3,886.1614 psf	826.0291 psf	0 psf	0 psf	Side Slope Liner Interface
Slice 7	56.740115 ft	67.034238 ft	0 psf	4,145.6148 psf	881.17762 psf	0 psf	0 psf	Base Liner Interface
Slice 8	63.162555 ft	66.906383 ft	0 psf	4,419.4862 psf	939.39079 psf	0 psf	0 psf	Base Liner Interface
Slice 9	73.407885 ft	66.796924 ft	0 psf	4,619.9965 psf	982.01057 psf	0 psf	0 psf	Base Liner Interface
Slice 10	83.407885 ft	66.690087 ft	0 psf	4,653.2494 psf	989.07869 psf	0 psf	0 psf	Base Liner Interface
Slice 11	93.40947 ft	66.58323 ft	0 psf	4,947.9805 psf	1,051.7257 psf	0 psf	0 psf	Base Liner Interface
Slice 12	104.21188 ft	66.467819 ft	0 psf	5,422.9021 psf	1,152.6734 psf	0 psf	0 psf	Base Liner Interface
Slice 13	112.99776 ft	66.373956 ft	0 psf	5,801.2339 psf	1,233.0903 psf	0 psf	0 psf	Base Liner Interface
Slice 14	121.78364 ft	66.280089 ft	0 psf	6,171.0374 psf	1,311.6945 psf	0 psf	0 psf	Base Liner Interface
Slice 15	130.56952 ft	66.186223 ft	0 psf	6,530.9761 psf	1,388.2018 psf	0 psf	0 psf	Base Liner Interface
Slice 16	138.56362 ft	66.100816 ft	0 psf	6,849.0919 psf	1,455.8194 psf	0 psf	0 psf	Base Liner Interface
Slice 17	145.76594 ft	66.023868 ft	0 psf	7,127.1618 psf	1,514.925 psf	0 psf	0 psf	Base Liner Interface
Slice 18	152.96826 ft	65.94692 ft	0 psf	7,396.8654 psf	1,572.2523 psf	0 psf	0 psf	Base Liner Interface
Slice 19	159.9234 ft	65.872613 ft	0 psf	7,649.1871 psf	1,625.8849 psf	0 psf	0 psf	Base Liner Interface
Slice 20	166.63137 ft	65.800947 ft	0 psf	7,884.7966 psf	1,675.9653 psf	0 psf	0 psf	Base Liner Interface
Slice 21	173.72627 ft	65.815892 ft	0 psf	8,023.9732 psf	1,705.5482 psf	0 psf	0 psf	Base Liner Interface
Slice 22	180.75481 ft	66.010267 ft	0 psf	8,113.9236 psf	1,724.6677 psf	0 psf	0 psf	Base Liner Interface
Slice 23	187.33006 ft	66.297462 ft	0 psf	8,286.0044 psf	1,761.2446 psf	0 psf	0 psf	Base Liner Interface
Slice 24	194.46279 ft	69.688751 ft	0 psf	5,490.8435 psf	3,170.14 psf	0 psf	0 psf	Treated Fill Material
Slice 25	202.09243 ft	76.132969 ft	0 psf	5,197.2991 psf	3,000.662 psf	0 psf	0 psf	Treated Fill Material
Slice 26	209.6615 ft	82.526023 ft	0 psf	4,913.8445 psf	2,837.0095 psf	0 psf	0 psf	Treated Fill Material
Slice 27	216.06581 ft	88.093085 ft	0 psf	4,550.8883 psf	2,627.4566 psf	0 psf	0 psf	Treated Fill Material

Slice 28	222.43394 ft	94.0273 ft	0 psf	4,209.2568 psf	2,430.2156 psf	0 psf	0 psf	Treated Fill Material
Slice 29	229.93064 ft	101.15466 ft	0 psf	3,896.8801 psf	2,249.8648 psf	0 psf	0 psf	Treated Fill Material
Slice 30	238.17826 ft	109.5345 ft	0 psf	3,363.2506 psf	1,941.7736 psf	0 psf	0 psf	Treated Fill Material
Slice 31	247.1768 ft	119.1668 ft	0 psf	2,922.8476 psf	1,687.5068 psf	0 psf	0 psf	Treated Fill Material
Slice 32	254.23803 ft	127.28769 ft	0 psf	2,359.0491 psf	1,361.9976 psf	0 psf	0 psf	Treated Fill Material
Slice 33	260.21001 ft	134.99106 ft	0 psf	1,882.1738 psf	1,086.6736 psf	0 psf	0 psf	Treated Fill Material
Slice 34	267.03354 ft	144.41003 ft	0 psf	1,127.4092 psf	650.91001 psf	0 psf	0 psf	Treated Fill Material
Slice 35	273.86055 ft	154.45067 ft	0 psf	384.88352 psf	222.21261 psf	0 psf	0 psf	Treated Fill Material

APPENDIX C

Seismic Hazard Analysis and Acceleration Time History Development

TECHNICAL MEMORANDUM

DATE May 28, 2019 **Reference No.** 1783552-1-TM-2

TO Danielle Wold
Chevron EMC

CC Richard Haughey, Nagesh Koragappa, Alan Hull

FROM Don Lowry **EMAIL DLowry@Golder.com**

REVISED DETERMINISTIC SEISMIC HAZARD ANALYSIS FOR THE GUADALUPE TANK BATTERY 9 SITE, GUADALUPE, SAN LUIS OBISPO COUNTY, CALIFORNIA

This revised technical memorandum presents the results of a deterministic seismic hazard analysis (DSHA) for the Guadalupe Tank Battery 9 (TB9) restoration project site (Site). The results incorporate readily available information on the location and activity of seismogenic faults within 62 mi (100 km) of the Site.

This technical memorandum revises Golder's technical memorandum of September 2018 by providing additional peak horizontal ground accelerations (PGA) for outcropping rock conditions (i.e. $V_{S,30}$ = 760 m/s) for the controlling maximum credible earthquake (MCE) at the site. The median acceleration response spectrum for the MCE is provided, along with three spectrally matched acceleration time histories in a separate technical memorandum.

1.0 PROJECT BACKGROUND

The proposed TB9 project is a Treated Soil Management Area (TSMA) encompassing approximately 750,000 to 800,000 cubic yards of available airspace, and with a leachate collection system. The unit will be permitted as a Class II landfill under California Code of Regulations Title 27 (Title 27 CCR). The Site is located about 3 miles west of Guadalupe, in San Luis Obispo County, California (Figure 1).

2.0 SCOPE OF WORK

Title 27 CCR requires that the maximum credible earthquake (MCE) ground motions are to be developed based on the recent, readily available, and relevant scientific information. Accordingly, Golder Associates Inc. (Golder) undertook the following scope of work to acquire and interpret the "the available science" to develop the PGA estimate for the Site:

- Compiled the record of historical earthquakes with epicenters located within about a 62 mi (100 km) radius of the Site.
- Compiled information on the location and activity of faults mapped within about 62 mi of the Site. Fault locations and characteristics developed for the third Uniform California Earthquake Rupture Forecast (UCERF3) model reported by Field et al. (2013) were used to identify and characterize the potential MCE sources for the DSHA.

Golder Associates Inc.
44 Union Boulevard, Suite 300, Lakewood, Colorado 80228 USA T: +1 303 980-0540 F: +1 303 985-2080

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- Completed a DSHA revision to identify the controlling MCE and associated median horizontal PGA for both a weak rock ($V_{S,30}$ = 760 m/s) and stiff soil site condition ($V_{S,30}$ = 259 m/s).
- Compared the PGA value developed from the DSHA to those available for selected return periods from the US Geological Survey (USGS) 2014 national probabilistic seismic hazard maps.
- Undertook a deaggregation to identify the earthquake sources for both the 475- and 2,475-year return PGA.
- Prepared this technical memorandum that presents the results of Golder's analysis, including the MCE PGA for the Site.

3.0 TECTONIC AND GEOLOGIC SETTING

3.1 Regional Geomorphic Province

The Site is located in San Luis Obispo County, California, near its boundary with Santa Barbara County, and within about 1.4 miles of the Pacific coastline. The Site is located in the Coast Ranges geomorphic province (CGS 2002) dominated by northwest-trending, moderately elevated mountains and valleys that extend parallel to the central California coastline. The Coast Ranges province extends from Humboldt County in the northwest to the Transverse Ranges, north of Los Angeles, in the southeast, a distance of about 600 mi (965 km). The Coast Ranges province is bounded on the east by the Great Valley province.

The Site is situated within coastal sand dune deposits that mantle the western extent of the Santa Maria River valley (Figure 2). The valley is bounded:

- On the northeast by low coastal mountains that include Temettate Ridge (1,800 ft/550 m), Newsome Ridge (1,600 ft/485 m) and Loma Pelona (1,785 ft/545 m) (Figure 1)
- On the southwest by the Casmalia Hills, with a maximum elevation of 1,660 ft (505 m) at Mount Lospe (Figure 1)

The Casmalia Hills are the northern and westernmost onshore extent of the Transverse Ranges and the southwestern edge of Santa Maria River valley forms the boundary between the Coastal Ranges and Transverse Ranges geomorphic provinces.

3.2 Tectonic Setting

The present-day tectonics surrounding the Site are largely controlled by deformation associated with the northwest-striking, right-lateral (dextral) strike-slip (RLSS) faults associated with the San Andreas fault system (SAF). The SAF marks the boundary between the Pacific and the North America tectonic plates and has among the highest average slip rates and shortest surface rupture recurrence intervals in the region (Field et al. 2013). There are two key sections of the SAF located within 62 mi (100 km) of the site—the Parkfield and Cholame-Carrizo sections (USGS 2006). Both sections, along with the Creeping section to the north and the Mojave section to the south, ruptured during the moment magnitude (**M)**7.9 1857 Fort Tejon earthquake. Nearby faults within the SAF system include the San Juan, Rinconada and West Huasna faults in westward progression from the SAF.

The western Coast Ranges expose many reverse-oblique, en echelon arranged faults. These faults were mostly active in the late-Pleistocene (last ca 130,000 years), and act to transfer strain between dextral strike-slip faults

parallel to the coastline, including the Hosgri and San Simeon faults to the west and Oceanic and West Huasna faults to the east (USGS 2006).

The Site is located within the coastal sand dune deposits (Qs) at the Guadalupe Oil Field (Figure 2). The dunes extend along the coastal portion of the Santa Maria Valley from near Oceano in the north to south of the Santa Maria River, a distance of about 12 miles (mi) (19 kilometers [km]). The dunes extend westward into the Santa Maria Valley up to 3.5 miles (Dibblee 1989). The Santa Maria Valley is more than 14 miles (22 km) wide along the coastline but narrows to less than 2 miles (3.2 km) southeast of the City of Santa Maria.

3.3 Regional Geology

Based on the cross section from Dibblee (1994), the generalized depositional sequence underlying the Santa Maria Valley and the project Site are:

- **Coastal Dune Deposits (Qs)**: Wind-blown sands, deposited mainly along the coastline (Holocene)
- **Valley Floodplain Alluvium (Qa)**: A thin veneer of surficial alluvium deposited on the valley floor (Holocene)
- **Orcutt Formation (Qo)**: Non-marine weakly-consolidated wind-blown sand and gravel deposit (Pleistocene)
- **Paso Robles Formation (QTp)**: Non-marine weakly-consolidated alluvial gravels, sands, and clay (Pleistocene)
- **Careaga Sand (Tca)**: Marine, weakly-indurated fossiliferous sand (Pliocene-Pleistocene)
- **Foxen Claystone (Tf)**: Marine claystone (Pliocene)
- **Sisquoc Formation (Tsq)**: Marine diatomaceous claystone (Miocene-Pliocene)
- **Monterey Shale (Tm)**: Marine (biogenic) thin-bedded siliceous shale (late-Miocene)

The weakly consolidated Quaternary units (including the Careaga Sand deposits) have a maximum thickness of about 8,000 feet (ft) (2.4 km) in the Santa Maria Valley. Neogene and older sedimentary rocks make up an additional 18,000 ft (5.5.km) before reaching the Jurassic Franciscan Formation rocks that form the local bedrock (Woodring and Bramlette 1950).

Southwest of the Site, the Casmalia Hills rise above the coastline exposing basement rocks composed of the Point Sal Ophiolite, a metamorphosed assemblage of Jurassic-aged mafic igneous and deep marine sedimentary rocks. The basement rocks are overlain by Cretaceous-aged Espada Formation marine sedimentary deposits, including shale, sandstone, and conglomerate. This entire assemblage has been unconformably buried by the Oligocene-aged non-marine Lospe Formation (claystone and sandstone), early- to mid-Miocene aged Point Sal formation (shale, sandstone, and dolomite) and mid- to late Miocene aged marine sediments of the Monterey Shale formation. A younger sequence of marine, shallow-marine, and non-marine sedimentary units are in fault contact with older rocks along the northern flank of the Casmalia Hills (Dibblee 1989).

North and northeast of the Site, the hills rising from Santa Maria Valley expose a moderately folded sequence of rocks that range from Miocene (Obispo Formation volcanic rocks (Tot/Tov)) through Quaternary (Paso Robles Formation (QTp)). Several prominent sets of northwest-trending hills are present between the Santa Maria Valley to the southwest and the Huasna Valley to the northeast, including Temettate Ridge and Newsome Ridge. The West Huasna fault dissects these hills with a steep down-to-the-west geometry (Dibblee 2006).

3.4 Seismotectonic Setting

This section summarizes information on the historical earthquake record (seismic history) of the region surrounding the Site. The section also includes descriptions of the major known active faults in the region surrounding the Site.

3.4.1 Historical Earthquakes

Figure 1 shows historical earthquake epicenters in the region surrounding the Site. Instrumental and reported historical records from the early 19th century through December 2011 reveal that there at least 633 earthquake epicenters with moment magnitudes greater than 3.0 located within about 62 mi (100 km) of the Site (Figure 1). Earthquake epicenter locations and magnitudes are from the UCERF3 Catalog of Field et al. (2013). Of these recorded earthquakes, eight have exceeded **M**[1]6.0—the most recent in September 2004 (i.e., 2004 Parkfield Earthquake). The largest earthquake recorded with an epicenter located within 62 mi of the Site was an estimated **M**7.1 event that occurred in November 1927 offshore, and west of Lompoc, California. It was located about 30 mi (49 km) southwest of the Site (Figure 1).

The closest recorded earthquakes to the Site greater than or equal to **M**3.0 are an **M**3.2 earthquake in October 2000 and a **M**3.8 earthquake in March 2000. Both earthquakes have epicenters located about 6 mi (9 to 10 km) east of the Site. The largest recorded earthquake within a 25 mi (40 km) radius of the Site was an estimated **M**5.8 earthquake on July 28, 1902, located about 17 mi (28 km) southeast of the Site (Figure 1).

3.4.2 Significant Faults within 62 mi (100 km) of the Site

Key sources of information on the location and activity of potential seismogenic faults in California are the following:

- Quaternary Fault and Fold Database of the United States (USGS 2006)
- Probabilistic Seismic Hazard Analysis for the State of California (Petersen et al. 1996)
- Uniform California Earthquake Rupture Forecast, Version 2 (UCERF2) (Field et al. 2007)
- Uniform California Earthquake Rupture Forecast, Version 3 (UCERF3) – The Time-Independent Model (Field et al. 2013)

Golder's review of these sources indicates that there are 22 major faults or distinct fault sections within about 62 mi (100 km) of the Site (Figure 1). Of those, two faults show surface fault rupture within historic time (since mid-19th century) and seven faults have one or more surface ruptures within the last 15,000 years (generally Holocene). The remaining 14 faults only have inferred surface rupture during the last 130,000 years (late Pleistocene). The locations of faults within USG. (2006) older than 130,000 years are not considered in this study because of the uncertainty in their seismogenic potential.

[1] **M** =moment magnitude

Table 1: Major Faults Mapped within about 62 mi (100 km) of the Guadalupe TB9 Site, San Luis Obispo County, California

Fault Number[1]	Major Fault or Fault Zone[1]	Age of Most Recent Displacement[2]	Approximate Distance from Project Site (mi/km)[3]	Total Length (mi/km)[4]	Fault Type[5]	Dip Angle (°), Direction[6]	Upper and (Lower) Seismogenic Depth (km)[7]	Estimated Average Slip Rate (mm/yr)[8]	Surface Rupture Recurrence Interval (years)[8]
n/a	Shoreline fault zone Northern Segment Central Segment Southern Segment San Luis Bay Segment	Late Pleistocene (< 130 ka) [a]	1.0/1.6 23/37 17/28 13/21 1.0/1.6	30.2/48.7 5.8/9.4 6.0/9.7 4.4/7.1 14/22.5	RLSS	90	0 (12) [d]	0.2±0.1 [e]	20-40k [d]
84 [b] 295 [c]	Casmalia fault zone	Late Pleistocene (< 130 ka)	2.8/4.5	30/47.9	R	75° NE[a]	0 (12) [a]	0.25 [a]	Unk
692 [a] 82 [b] 288 [c]	San Luis Range fault system Oceano fault	Late Pleistocene (< 130 ka)	6.3/10.2	13/21	R	45° NE[a]	0 (12) [a]	0.0276 [a]	Unk
681 [a] 296 [c]	Lions Head fault zone	Late Pleistocene (< 130 ka)	6.7/10.7	40/65.2	R	75° [c] NE[a]	0 (12) [a]	0.02 [a]	Unk
691 [a] 82 [b] 304 [c]	SAN LUIS RANGE 2011 CFM (UCERF3) Santa Maria River fault + Foxen Canyon Fault	Late Pleistocene (< 130 ka)	9.4/15	49/78.9	R	52° NE[a]	0 (12) [a]	0.0276 [a]	Unk
74 [a] 79a-d [b] 285 [c]	Los Osos fault zone	Holocene (< 15 ka) and Late Pleistocene (< 130 ka)	13.2/21	36/57.9	R	45, W? [a]	0 (12) [a]	0.39 [a] < 0.2 [b]	Unk
709 [a] 352 b 371 [b] 289 [c]	Oceanic/West Huasna fault (Note: UCERF3 combines these two faults) [a,b]	Late Pleistocene (<130 ka)	14.3/23	76/121.9 [b]	R	58, W [b]	0 (7) [a]	0.39 [b]	Unk
30 [a] 81a [b]	Hosgri fault zone, San Luis-Pismo section	Holocene (< 15 ka)	17/27.5	15/24	RLSS	60-90 E 80° E [a]	0 (12.2) [a]	1-5 [b]	Unk
262 [b]	Cambria Fault [b]	Late Pleistocene (<130 ka)	20/33	19/30.4 [b]	R	45 E	0 (12) assumed	Unk	Unk

Fault Number[1]	Major Fault or Fault Zone[1]	Age of Most Recent Displacement[2]	Approximate Distance from Project Site (mi/km)[3]	Total Length (mi/km)[4]	Fault Type[5]	Dip Angle (°), Direction[6]	Upper and (Lower) Seismogenic Depth (km)[7]	Estimated Average Slip Rate (mm/yr)[8]	Surface Rupture Recurrence Interval (years)[8]
683 [a] 85 [b] 302 [c]	Los Alamos fault	Holocene (< 15 ka) and Late Pleistocene (< 130 ka)	22/36	16.7/26.9	R	30 SW	0 (12) [a]	0.39 [a]	Unk
781 [a] 253 [b] 299/300 [c]	Santa Ynez River fault zone	Late Pleistocene (<130 ka)	23/37	45/72.8	R	70 SW	0 (12) [a]	0.39 [a]	Unk
31[a] 77[b]	San Juan FZ [a, b]	Holocene (<15 ka) to Early Quaternary (< 2.4 Ma)	37/59	51/82.1 [a] 51/81 [b]	RLSS	90° Assumed	0 (13) [a]	0.01 [a]	Unk
77 [a] 87a, b[b] 320 [c]	Santa Ynez (west)	Late Pleistocene (<130 ka)	38/61	49/79.6	R	70° S	0 (9.2) [a]	2.0 [a]	Unk
80 [b] 255 [c]	San Simeon fault zone	Holocene (< 15 ka) and Late Pleistocene (< 130 ka)	40/64	49/79	RLSS	90° Assumed	0 (12) Assumed	1-5 [b]	Unk
650 [a] 63c [b]	Rinconada fault zone, Rinconada section [a, b]	Late Pleistocene (<130 ka)	45/72	76/122.8 [a] 54/87 [b]	RLSS	82 [a], NE and SW 90 [b]	0 (8.5) [a]	0.39 [a]	1,883 [c]
285 & 300 [a] 1g [b]	San Andreas fault zone Cholame-Carrizo section	Recent (<150 years) (1857) and Holocene (< 15 ka)	47/76	75/121.7	RLSS	90° [a]	0 (12-15.1) [a]	34.0 [a]	100-450 [b]
79 [a] 87d [b] 321 [c]	Santa Ynez (east)	Late Pleistocene (<130 ka)	51/82	42/68.4	R	70° N	0 (13.3) [a]	2.0 [a]	Unk
432 [b]	San Pedro fault	Late Pleistocene (<130 ka)	53/85	6.2/10	R, LLSS	60° W Assumed	0 (12) Assumed	unk	Unk
263 [b]	San Jose fault	Late Pleistocene (<130 ka)	53/86	8/13	R, LLSS	60° W Assumed	0 (12) Assumed	unk	Unk

Fault Number[1]	Major Fault or Fault Zone[1]	Age of Most Recent Displacement[2]	Approximate Distance from Project Site (mi/km)[3]	Total Length (mi/km)[4]	Fault Type[5]	Dip Angle (°), Direction[6]	Upper and (Lower) Seismogenic Depth (km)[7]	Estimated Average Slip Rate (mm/yr)[8]	Surface Rupture Recurrence Interval (years)[8]
78 [a] 88a-c [b]	Mission Ridge fault system	Holocene (< 15 ka) and Late Pleistocene (< 130 ka)	55/89.5	31/50	R, LLSS	60° E[b]	0 (7.6) [a]	0.9 [a]	Unk
32[a] 1f [b]	San Andreas Fault, Parkfield section [a, b]	Recent (<150 years), including years 1857, 1881, 1901, 1922, 1934, 1966, 2004	56/90	26/36.5 [a] 20/32 [b]	RLSS	90° [a]	0 (10.2) [a]	35.0 [a] 26.3 ±3.9 [b]	25 ±15 [a]
118 [a] 90 [b]	Red Mountain fault zone	Late Pleistocene (<130 ka)	57/92	62/100.6	R	56° N[a, e] 60° N[b, e]	0 (14.1) [a]	2.0 [a]	Unk

Notes: ka = thousand years; Ma = million years; N = Normal Fault; RLSS = Right Lateral Strike Slip; LLSS = Left Lateral Strike Slip; unk = unknown; n/a = not applicable/appropriate; MCE = maximum credible earthquake

1. The names of faults, fault zones, and fault numbers were taken from:
   a. Field, et al. (2013)
   b. USGS (2006)
   c. Jennings (2010)
2. Age of most recent pre-historic surface displacement taken from the Quaternary Fault and Fold Database of the United States (USGS 2006), where available. Other sources include:
   a. Nishenko et al. (2018)
3. The fault-to-site distances are the closest approach of the mapped fault traces to the Site. Distances were measured from the fault traces as plotted on Google Earth™ (from USGS 2006) and using a Site location of 34.973°N, 120.624°W.
4. Length is based on:
   a. Field, et al. (2013); and
   b. The total lengths of the faults and fault segments as indicated in the Quaternary Fault and Fold Database of the United States (USGS 2006)
5. Fault type (R = reverse; RLSS = right-lateral strike-slip)
6. Fault dip and direction determined from Field, et al. (2013) and USG.S 2006. Dip assumed to be 90° for strike slip faults, 75º for normal faults and 60° for reverse faults where no other information is available.
7. Seismogenic Depth and Average fault slip rates taken from:
   a. Field, et al. (2013)
   b. USGS (2006).
   c. For USGS (2006) generalized value intervals (i.e., 0.2 to 1.0 mm/yr), mid-range values assumed used for MCE calculation.
   d. Nishenko et al. (2018)
8. Slip rate and recurrence interval as defined within studies noted below:
   a. Field, et al. (2013)
   b. USGS (2006)
   c. Wesnouski (1986)
   d. Nishenko et al. (2018)
   e. PG&E (2015)

3.4.3 Studies Relating to the Diablo Canyon Power Plant (DCPP) – Shoreline Fault Zone

Studies undertaken by Pacific Gas & Electric (PG&E), USGS, geoscience practitioners, and local universities have – over the last decade – increased understanding the earthquake shaking and fault rupture hazards in the region surrounding the Diablo Canyon Power Plant (DCPP), located about 21 mi (34 km) northwest of the Site. PG&E (2015) is a comprehensive characterization of seismic sources in the region. Of significance to the TP-9 Site is the Shoreline fault zone (SFZ) and its tectonic characterization by PG&E (2011, 2015) and Nishenko et al. (2018). The SFZ is not recognized as a fault source in the UCERF3 or the National Probabilistic Seismic Hazard Model (USGS 2014b).

The SFZ as mapped by both PG&E (2015) and Nishenko et al. (2018) is considered in this study. The SFZ is mapped to within 1 mi (1.6 km) of the Site, closer than any of the faults contained described above.

Golder's review of Nishenko et al. (2018) indicates that the SFZ is a dextral strike-slip fault made up of a northern, central, and southern segments. The southern segment is well-defined by PG&E (2015) north of its intersection with the Oceano (thrust) fault (OF; offshore south of Avila Beach), with earthquake hypocenters associated with the SFZ. South of the OF intersection, the SFZ is mapped through San Luis Obispo Bay and possibly onshore south of the TP-9 site, near the mouth of the Santa Maria River. Mapping by PG&E (2015) shows this SFZ extension as uncertain south of the OF. Marine sediments of Holocene age (i.e., less than about 11,700 years) bury the SFZ extension through San Luis Bay. Due to the lack of evidence for Holocene surface rupture and microseismicity along the SFZ south of the intersection with the OF, Holocene activity of this section of the SFZ is unlikely (PG&E 2015; Nishenko et al. 2018). Nishenko et al. (2018) estimated an **M**6.7 for the maximum credible earthquake (MCE), with a recurrence interval for the San Luis Bay section of the SFZ at 20 to 40,000 years.

3.4.4 Casmalia Fault Zone

The Casmalia fault zone is considered by Hanson et al. (2004) to be the source of a May 1980 earthquake (**M**5.1) and associated aftershocks; and several other earthquakes recorded between October 1987 and January 1997 (Hanson et al. 2004). Earthquake focal mechanisms constructed from p-wave data indicate that the fault motion was almost pure reverse associated with a relatively steep-dipping Casmalia fault plane (55° to 80° SW).

The Casmalia fault forms the boundary between structural blocks associated with the offshore Hosgri fault zone, including the Santa Maria Valley and Casmalia structural blocks (Willingham et al. (1995). The Casmalia structural block is bounded by the Casmalia fault zone on the northeast and the Lions Head fault on the southeast. The Casmalia Hills represent a horst developed between the two faults.

3.4.5 Oceanic – West Huasna Fault Zone

Rupture on the Oceanic fault produced the 2003 **M**6.6 San Simeon earthquake, although surface rupture is not known to have accompanied the 2003 earthquake. The fault links and transfers slip from the Hosgri fault system in the west to the West Huasna fault in the east (Graymer et al. 2014) (Figure 1). Its orientation relative to the Hosgri and West Huasna Faults results in a significant component of reverse (up to the northeast) slip. The Oceanic and West Huasna faults are combined within the current UCERF3 fault model (Field et al. 2013).

4.0 EVALUATION OF SEISMIC HAZARDS

This section presents the results of both a site-specific DSHA and comparison to probabilistic seismic hazard analyses (PSHA) results for the Site. Golder estimated fault lengths and fault trace-to-site based on mapped traces from USGS (2006), and as shown on Google Earth™ and/or ArcGIS Earth™. The probabilistic results are those based on the USGS national seismic hazard maps and related hazard mapping tools.

4.1 Seismic Source Parameters For Significant Faults

The development and estimation of the MCE magnitude for the 22 faults was based on the empirical fault rupture/earthquake magnitude relationships developed by Wells and Coppersmith (1994), and Hanks and Bakun (2002). Individual fault, geologic, and geometric data are taken from either Field et al. (2013) or CGS (2006).

4.1.1 Maximum Credible Earthquake Magnitude

California Code of Regulations Title 27 defines the MCE as "…the maximum earthquake that appears capable of occurring under the presently known geologic framework….little regard is given to its probability of occurrence except that its likelihood of occurring is great enough to be of concern." Estimation of the ground motions associated with the MCE requires that the magnitude of the MCE is established, as described below.

Table 2 presents two values for the MCE magnitude. The first column labeled "Calculated M" shows the value obtained using Wells and Coppersmith (1994) for reverse faults and Hanks and Bakun (2002) for strike-slip faults and the fault geometry data listed in Table 1. For the reverse faults, we used an average of values obtained using both surface rupture length (SRL) and rupture area (RA) equations.

The second column is labeled "MCE," which represents the median MCE (shown in first column as "Calculated M") after being reduced by the aseismicity factor (reducing the area of the fault by the provided factor) for each structure as provided in Field et al. (2013). In most cases, application of the aseismic factor reduced the area about 10%, but the San Andreas fault – Parkfield segment, which has an aseismic factor of 0.7, had a significant reduction in RA. Golder notes that in the absence of fault specific data all UCERF3 faults have an aseismicity factor of 0.10 (10%). As a result, the recalculated M results in a drop of up to 0.1 magnitude units for most faults within revised Table 2, with the SAF (Parkfield segment) being the lone variation with a drop of 0.6 magnitude units.

Title 27 defines the MCE as "the maximum earthquake that appears capable of occurring under the presently known geologic framework." However, Title 27 does not specify how the MCE should be determined. Based on recent landfill projects, the median earthquake magnitude calculated from the empirical relations representative of a reasonable MCE estimate has been used and accepted by the RWQCB.

4.2 Site Soil Condition

The site is situated on dune sand (Qs) deposited over valley floodplain alluvium (Qa). Review of Dibblee (1989) indicates that the site is about 80-foot above mean sea level (amsl), while exposures of alluvium about 4 mi (0.7 km) north of the site are shown at be at about 40-foot amsl. Golder assumed for the purposes of this evaluation that the Qa unit is unconsolidated and that the Qs (dune sand) deposits are poorly graded and unconsolidated. This analysis was used to assume a $V_{S,30}$ (average shear velocity in the upper 100 ft [30 m]) of 850 feet per second (ft/s) (259 meters per second [m/s]), which represents the mid-point of soil Site Class D as defined within ASCE 7-10 (ASCE 2010). This $V_{S,30}$ value is about 10% to 20% higher than the 200 to 250 m/s $V_{S,30}$ reported from similar site soil conditions (sand and alluvium) at 15 sites near Oceano, about 10 miles north of the TB9 site.

These $V_{S,30}$ measurements are from profiles generally less than 100 ft reported by the USGS (https://earthquake.usgs.gov/data/vs30/us/).

4.3 Deterministic Seismic Hazard Analysis

DSHA uses available historical and instrumental earthquake records and geologic data to generate discrete, single-valued estimates of earthquake ground motions at a site. These single-valued estimates are commonly the basis for seismic analysis and design of major structures such as landfills, dams, and mine infrastructure. Median (50th-percentile) PGA values are sometimes used for analysis and design of moderate to low failure consequence structures, while median + 1σ (84th-percentile) values are sometime used for high consequence failure structures such as major dams and impoundments. This study reports only median PGA values in accordance with the standard of practice for landfill design in California.

In DSHA, one or more MCEs are specified by magnitude and location with respect to the site of interest. In areas like central California, major earthquakes are assumed to be generated by movement along mapped faults, and on that part of the fault closest to the Site. Estimates of Site earthquake ground motions are based on displacement along a known fault, with a specified MCE magnitude, a source-to-site distance, and for the site soil conditions.

Site PGA (5%-damped) values were calculated for two site soil conditions.

- A $V_{S,30}$ of 259 m/s as the arithmetic mean PGA of four equally weights NGA-West2 ground motion models (GMM) developed by Abrahamson and Silva (2013), Boore et al. (2013), Campbell and Bozorgnia (2013) and Chiou and Youngs (2013)
- A $V_{S,30}$ of 760 m/s using the GMMs of Abrahamson and Silva (2013), Boore et al. (2013), Campbell and Bozorgnia (2013) and Chiou and Youngs (2013) weighted at 0.22 each and Idriss (2013) weighted at 0.12. This weighting corresponds to that used by the U.S. Geological Survey for the National Seismic Hazard Model (USGS 2014b).

Table 2 lists the distances for each fault as applied in the NGA-West2 NGA GMMs to calculate the MCE PGA. Table 2 also lists the median horizontal PGA (5%-damped) expected at the Site from individual and some combined fault sources.

Table 2: Fault Parameters used and Median PGA Values for Two Site Soil Conditions at the Guadalupe TB9 Site, San Luis Obispo County, California

Fault or Fault Zone[1]	Rrup	Rjb	Rx	Ry0	Calculated M[2]	MCE[3]	Median PGA[5] ($V_{S,30}$=259 m/s) (g)	Median PGA[4] ($V_{S,30}$=760 m/s) (g)
Casmalia fault zone	4.35	1.28	4.50	0.00	6.9	6.9	0.49	0.48
Lions Head fault zone	10.84	8.17	7.20	7.13	7.1	7.0	0.33	0.28
Los Osos fault zone	14.85	9.00	21.00	0.00	7.1	7.0	0.32	0.27
Oceano Fault	10.20	10.20	10.20	0.00	6.6	6.6	0.28	0.24
San Luis Range 2011 CFM (Santa Maria F. + Foxen Canyon F.)	14.91	14.91	14.91	0.00	7.2	7.2	0.27	0.22
Oceanic/West Huasna faults	19.90	18.63	23.00	0.00	7.1	7.1	0.22	0.17
Santa Ynez River fault zone	37.00	37.00	37.00	0.00	7.1	7.1	0.14	0.10
Cambria Fault	32.50	32.50	27.16	17.85	6.8	6.7	0.12	0.09
Hosgri fault zone, San Luis-Pismo section	27.40	27.40	7.30	26.40	6.4	6.4	0.12	0.08
Los Alamos fault	44.63	44.63	9.00	43.71	6.8	6.8	0.10	0.06
Santa Ynez (west)	58.20	58.20	55.72	16.80	7.1	7.1	0.09	0.06
San Juan fault zone	59.00	59.00	59.00	0.00	7.1	7.0	0.08	0.06
San Simeon fault zone	64.36	64.36	6.78	64.41	7.0	7.0	0.08	0.05
San Andreas fault zone – Cholame to Carrizo section	76.00	76.00	76.00	0.00	7.4	7.4	0.08	0.05
Santa Ynez (east) fault	79.20	78.08	51.76	62.41	7.1	7.1	0.07	0.04
Red Mountain fault zone	88.72	87.59	48.00	78.00	7.3	7.3	0.07	0.04

Fault or Fault Zone[1]	Rrup	Rjb	Rx	Ry0	Calculated M[2]	MCE[3]	Median PGA[5] ($V_{S,30}$=259 m/s) (g)	Median PGA[4] ($V_{S,30}$=760 m/s) (g)
Rinconada fault zone	70.13	70.13	44.93	53.85	7.1	7.0	0.07	0.04
Mission Ridge fault system	90.63	90.63	70.00	57.56	6.9	6.8	0.04	0.03
San Pedro fault	85.00	85.00	1.63	85.00	6.2	6.2	0.03	0.02
San Jose fault	86.12	86.12	4.50	86.00	6.3	6.3	0.03	0.02
San Andreas fault zone – Parkfield section	87.80	87.80	77.50	41.23	6.6	6.0	0.02	0.01

Notes: Rrup = Closest distance to coseismic rupture (km); Rjb = Closest distance to surface projection of coseismic rupture (km); Rx = Horizontal distance from top of rupture measured perpendicular to fault strike (km); Ry0 = Horizontal distance off the end of the rupture measured parallel to strike (km); MCE = maximum credible earthquake

1) Fault names as defined in Table 1.
2) Values calculated using applicable empirical length-magnitude scaling relations of Wells and Coppersmith (1994) and Hanks and Bakun (2002). For reverse faults, we used the median value of Wells and Coppersmith (1994) relations using surface rupture length (SRL) and rupture area (RA). For strike-slip faults, we applied Hanks and Bakun (2002).
3) MCE values obtained by reducing the calculated M value by the aseismicity factor for each structure as provided in Field et al. (2013). An aseismicity factor of 10% (0.10) was applied throughout UCERF3 where no data was available. Due to uncertainties built into the various equations (i.e. W&C SRL = standard deviation of 0.28, RA = 0.24 and H&B RA = 0.04), MCE values for reverse faults were increased by 0.3 after aseismicity factors were applied to account for the upper bound of uncertainty.
4) Median PGA calculated assuming $V_{S,30}$ = 259 m/s, and using the following NGA-West2 GMMs weighted equally: Abrahamson and Silva (2013), Boore et a. (2013), Campbell and Bozorgnia (2013), Chiou and Youngs (2013).
5) Median PGA calculated assuming $V_{S,30}$ = 760 m/s, and using the following NGA-West2 GMMs with relative weighting in brackets: Abrahamson and Silva (2013) [0.22], Boore et al. (2013) [0.22], Campbell and Bozorgnia (2013) [0.22], Chiou and Youngs (2013) [0.22], Idriss (2013) [0.12]

4.3.1 Hazard Deaggregation Analysis

Figure 2a shows the results of a deaggregation analysis for the Site for the 475-year return period PGA. The results shown in Figure 2a indicate that the primary contributors to the 475-year return period PGA hazard are **M**5.0 to **M**7.6 earthquakes with epicenters located within about 5 km (3.1 mi), **M**6.0 to **M**7.7 earthquakes with epicenters located about 25 km (15.5 mi) from the site and **M**7.3 to **M**8.3 earthquakes with epicenters located about 75 km (47 mi) from the Site. These sources generally equate to the Casmalia fault at a distance of 4.5 km (2.8 mi), the Oceanic/West Huasna fault system at 23 km (14.4.mi) and the San Andreas fault at a distance of 72 km. Hazard sources located beyond the San Andreas fault zone ore than about 75 km (42 mi) from the site.

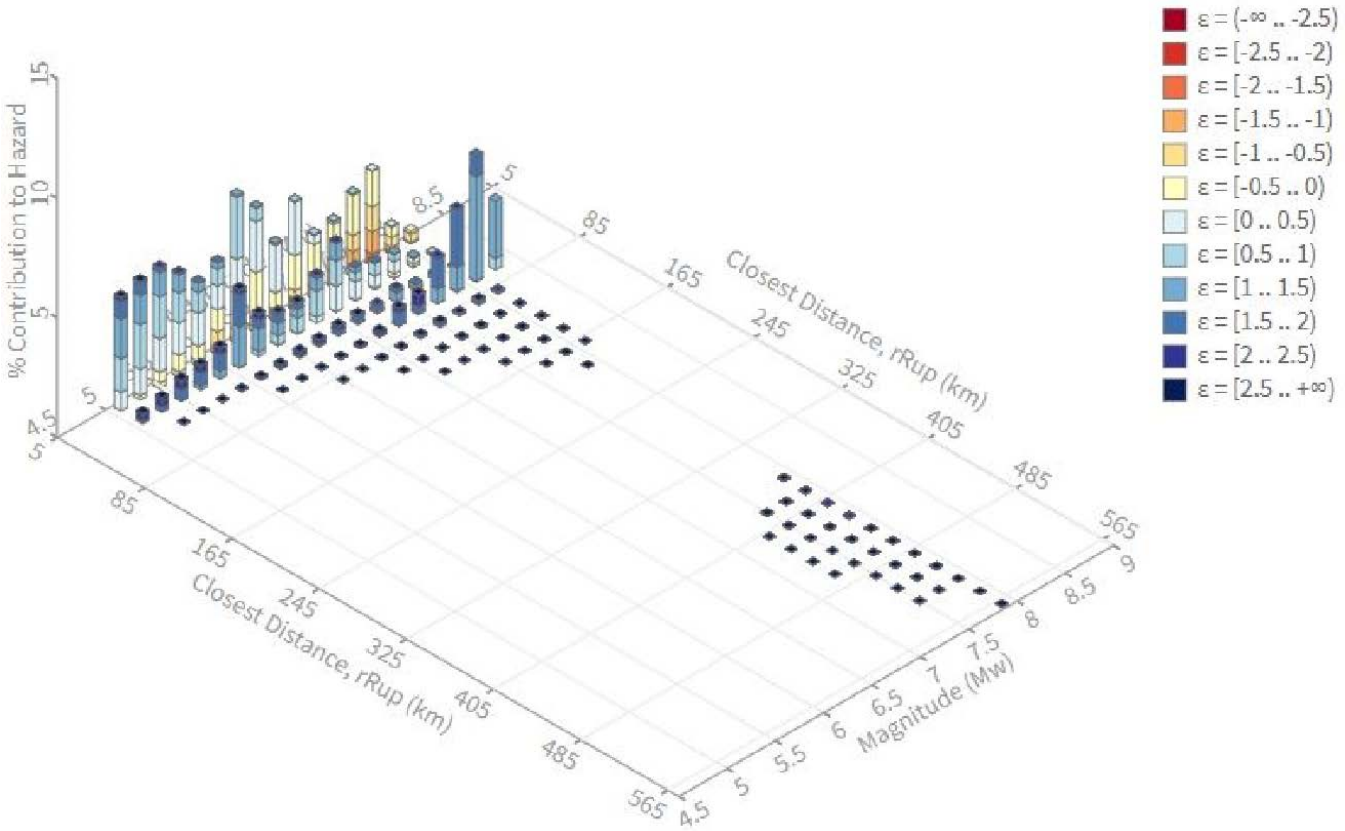

Figure 2a: Magnitude-Distance Deaggregation for the 475-year return period PGA for a site soil condition of VS,30 of 760 m/s.

Figure 2b shows the results of deaggregation analysis for the Site for a 2,475-year return period PGA. The results shown in Figure 2b indicate that the primary contributors to the 2,475-year return period PGA hazard are **M**5.0 to **M**7.9 earthquakes with epicenters located within about 5 km (3.1 mi) of the Site, with significantly smaller contributions from sources at 25 km (15.5.mi) and 75 km (42 mi) distances.

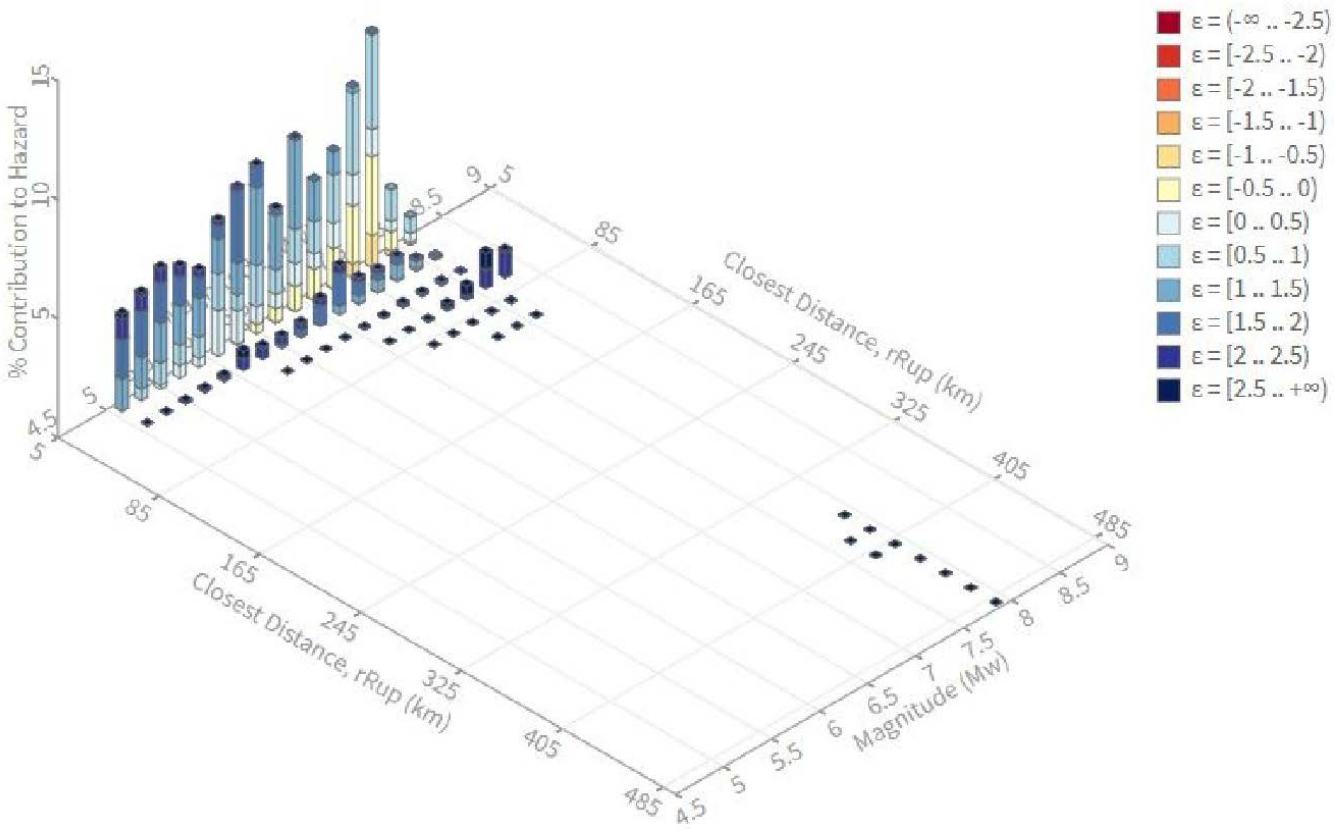

Figure 2b: Magnitude-Distance Deaggregation for the 2,475-year return period PGA for a site soil condition of VS,30 760 m/s.

4.3.2 Conclusion from Deterministic Seismic Hazard Analysis at the Guadalupe TB9 TSMA

Table 2 lists estimated median (5%-damped) PGAs at the Site for a site soil condition of $V_{S,30}$ = 259 m/s that range from 0.02 to 0.49 g. Table 2 also lists estimated median (5%-damped) PGAs at the Site for a site soil condition of $V_{S,30}$ = 760 m/s that range from 0.01 to 0.48 g. The largest estimated median PGA of 0.48 g arises from an **M**6.9 earthquake occurring on the Casmalia Fault about 2.8 mi (4.5 km) southwest of the Site (Figure 1).

4.4 Probabilistic Seismic Hazard Analysis

PSHA is used to estimate earthquake ground motions for regions and for sites (e.g., McGuire 2004). PSHA provides a probabilistic estimate (annual exceedance probability [AEP]) for a specified earthquake ground motion. The earthquake ground motions can be PGA estimates, as is usually required for landfills in California, or spectral accelerations (accelerations at a specified frequency), as commonly used in most modern building codes.

The USGS developed national probabilistic seismic hazard models in 1996, 2002, 2008, and 2014. Each update of the national probabilistic model and associated hazard maps has incorporated the latest information on fault locations, fault characteristics, historical earthquakes, and the number and weighting of ground motion models (GMM) developed from earthquake records in the US and around the world. The national hazard models are used to estimate PGA and spectral accelerations for sites in the conterminous United States based on the Unified Hazard Tool (USGS 2014b).

Table 3a lists PGA and selected spectral accelerations for three return periods and three spectral periods from the Conterminous US probabilistic seismic hazard model. PGA values listed in Table 3a were calculated assuming an ASCE 7-10 soil Site Class D soil condition of stiff soil with a $V_{S,30}$ of 259 m/s.

Table 3a: Outcropping Stiff Soil PGA and Spectral Accelerations (5%-damped) for Selected Return Periods at the Guadalupe TB9 TSMA, San Luis Obispo County, California

Probability of Exceedance (return period in years)[1]	Mean PGA (g)	Mean 0.2 Second (g)	Mean 1.0 Second (g)
10% in 50 years (475)	0.30	0.72	0.37
5% in 50 years (975)	0.40	0.96	0.51
2% in 50 years (2,475)	0.57	1.35	0.74

Notes: PGA = peak ground acceleration
1. Values from the 2014 USGS national seismic hazard model for a site with $V_{S,30}$ of 259 m/s at location 34.973°N, 120.624°W.

Table 3b lists PGA and selected spectral accelerations for three return periods and three spectral periods from the Conterminous US probabilistic seismic hazard model. PGA values listed in Table 3b were calculated assuming an ASCE 7-10 soil Site Class B/C boundary soil condition of rock with a $V_{S,30}$ of 760 m/s.

Table 3b: Outcropping Weak Rock PGA and Spectral Accelerations (5%-damped) for Selected Return Periods at the Guadalupe TB9 TSMA, San Luis Obispo County, California

Probability of Exceedance (return period in years)[2]	Mean PGA (g)	Mean 0.2 Second (g)	Mean 1.0 Second (g)
10% in 50 years (475)	0.20	0.44	0.13
5% in 50 years (975)	0.28	0.62	0.19
2% in 50 years (2,475)	0.40	0.92	0.29

Notes: PGA = peak ground acceleration
2. Values from the 2014 USGS national seismic hazard model for a site with $V_{S,30}$ of 760 m/s at location 34.973°N, 120.624°W.

4.4.1 Conclusion from Probabilistic Seismic Hazard Analysis Results for the Site

The 2014 USGS national probabilistic hazard model indicates a mean 475-year return period PGA (5%-damped) of about 0.30 g for a stiff soil site condition (Table 3a) and 0.20 g for a rock site (Table 3b). The 0.20 g value for the 475-year mean PGA (rock soil condition) indicates a moderate level of seismic hazard at the Site.

Comparison between mean probabilistic and median deterministic PGA ground motions indicates that the estimated median deterministic PGA value of 0.48 g has a mean return period of about 4,000 years.

5.0 SUMMARY OF CONCLUSIONS

The Guadalupe TB9 TSMA site is located in a region of moderate historical earthquake activity west of the SAF within the North America-Pacific plate boundary zone. More than 600 earthquakes greater than **M**3.0 have epicenters within about 62 mi (100 km) of the Site since the early 19th century. There are 22 significant faults mapped within 62 mi (100 km) of the Site, and of those, two fault sections (San Andreas fault: Cholame-Carrizo and Parkfield sections) have had surface fault rupture within historical time (i.e., since mid-19th century). Seven faults are considered to have had surface rupture within the last 15,000 years. The remaining 14 faults have inferred surface rupture less than 130,000 years ago (late Pleistocene). Faults older than late Pleistocene were not included in this study.

DSHA indicates that the Casmalia fault develops the highest MCE median PGA at the Site. The PGA arises from an **M**6.9 earthquake located about 2.8 mi (4.5 km) from the Site. Using the geometric mean of five NGA-West2 GMPEs with variable weightings, the strongest median PGA value for an assumed rock site (i.e., $V_{S,30}$ = 760 m/s) is 0.48 g. This PGA value has a return period estimated from the 2014 USGS national seismic hazard model at about 4,000 years.

6.0 CLOSING

This office-based analysis of fault activity and seismic hazard is for use by Chevron Environmental Management Company. The results of the assessment indicate a relatively moderate level of seismic hazard based on probabilistic analysis, and a higher deterministic median PGA value because of the Site's close proximity to the Casmalia fault. If you have any questions or concerns, then please contact us.

Donald Lowry, PG, CEG
Senior Engineering Geologist

Alan Hull, PG, CEG
Principal, Global Seismic Hazard Practice Leader

DL/AH/rjg

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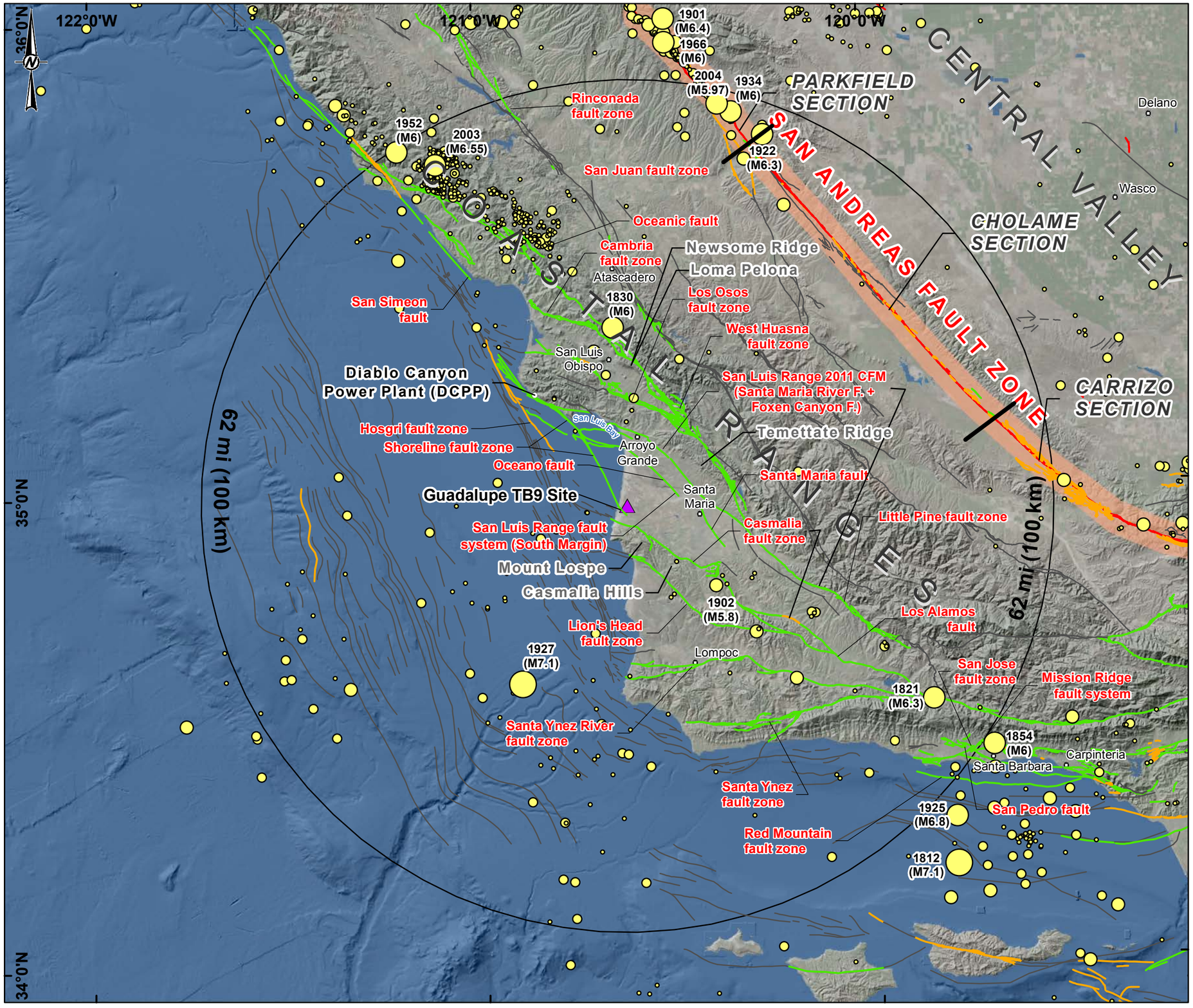
Figures



LEGEND

- Guadalupe TB9 Site

Historical Earthquake Epicenters

Magnitude

- 3.0 - 3.9
- 4.0 - 4.9
- 5.0 - 5.9
- 6.0 - 6.9
- 7.0 - 7.9

(Year and magnitude of significant events labeled)

Faults

Age of Most Recent Activity

- Historic (<150 years)
- Holocene (<15,000 years)
- Late Quaternary (<130,000 years)
- Undifferentiated Quaternary
- 1857 San Andreas Fault Rupture

0 5 10 20
MILES

0 12.5 25 50
KILOMETERS

REFERENCE(S)

1. EARTHQUAKE EPICENTERS (FIELD ET AL. 2013)
2. FAULT LOCATIONS: USGS (2018), NISHENKO ET AL. (2018), PG&E (2015)
3. COORDINATE SYSTEM: NAD 1983 UTM ZONE 10N
4. SERVICE LAYER CREDITS:
AIRBUS,USGS,NGA,NASA,CGIAR,GEBCO,NCEAS,NLS,OS,NMA,GEODATASTYRELSEN,GSA,GSI AND THE GIS USER COMMUNITY
SOURCE: ESRI, DIGITALGLOBE, GEOEYE, EARTHSTAR GEOGRAPHICS, CNES/AIRBUS DS, USDA, USGS, AEROGRID, IGN, AND THE GIS USER COMMUNITY

CLIENT
CHEVRON ENVIRONMENTAL MANAGEMENT COMPANY

PROJECT
SEISMIC HAZARD ASSESSMENT
GUADALUPE TANK BATTERY 9 SITE
SAN LUIS OBISPO COUNTY, CALIFORNIA

TITLE
HISTORICAL EARTHQUAKE EPICENTERS AND MAPPED FAULTS WITHIN ABOUT 62 MI (100 KM) OF THE GUADALUPE TANK BATTERY 9 SITE

CONSULTANT
GOLDER

YYYY-MM-DD	2018-09-07
PREPARED	HJ
REVIEWED	DL
APPROVED	AH

PROJECT NO.	PHASE	REV.	FIGURE
1783552	-	A	1

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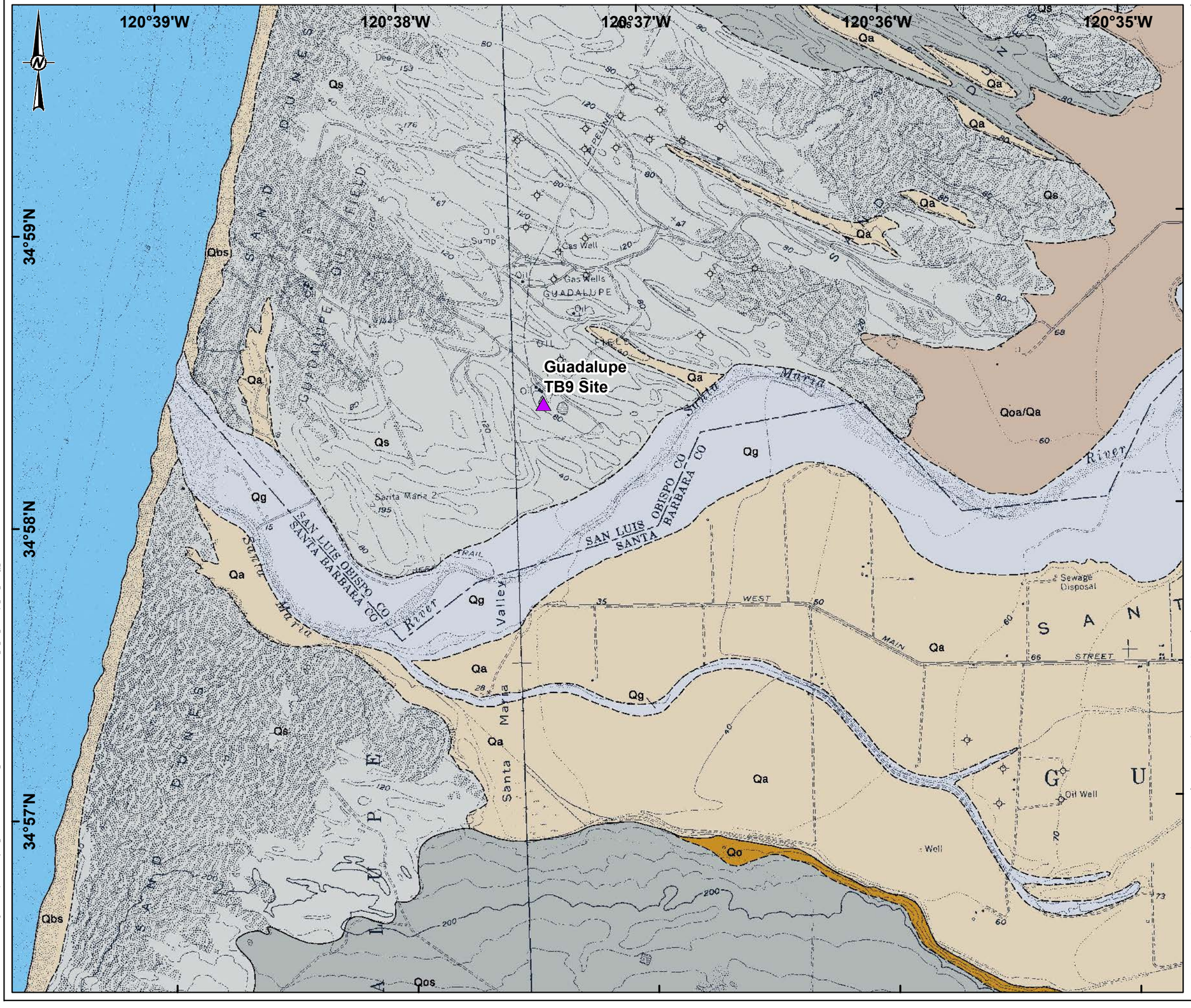

LEGEND

- Guadalupe TB9 Site

Surficial Geology

- Qa - Valley and floodplain alluvium
- Qbs - Beach sand deposits
- Qg - Stream channel deposits of sand and silt
- Qoa/Qa - Older dissected surficial sediments
- Qs - Dune sand deposits
- Qos - Older Dune sand deposits
- Qo - Orcutt sand

0 0.2 0.4 0.8
MILES

0 0.325 0.65 1.3
KILOMETERS

REFERENCE(S)

1. DIBBLEE (2009) - GEOLOGY
2. COORDINATE SYSTEM: NAD 1983 UTM ZONE 10N
3. SERVICE LAYER CREDITS:

CLIENT
CHEVRON ENVIRONMENTAL MANAGEMENT COMPANY

PROJECT
SEISMIC HAZARD ASSESSMENT
GUADALUPE TANK BATTERY 9 SITE
SAN LUIS OBISPO COUNTY, CALIFORNIA

TITLE
SURFICIAL GEOLOGY OF AREA SURROUNDING THE GUADALUPE TANK BATTERY 9 SITE

CONSULTANT
GOLDER

YYYY-MM-DD	2018-07-12
PREPARED	HJ
REVIEWED	DL
APPROVED	AH

PROJECT NO.	PHASE	REV.	FIGURE
1783552	-	A	2

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TECHNICAL MEMORANDUM

DATE June 7, 2019 **Project No.** 1783552

TO Danielle Wold
Chevron EMC

CC Richard Haughey, Nagesh Koragappa

FROM Feng Li, Jie Cao, and Alan Hull, Golder, Redmond, USA **EMAIL Feng_Li@golder.com**

EARTHQUAKE ACCELERATION TIME HISTORIES FOR THE GUADALUPE TANK BATTERY 9 SITE, GUADALUPE, SAN LUIS OBISPO COUNTY, CALIFORNIA

This technical memorandum presents earthquake acceleration time histories developed to support site response analysis for the Guadalupe Tank Battery 9 (TB9) restoration project site (the Site). The technical memorandum was prepared as a supplement to Golder Associates Inc (Golder) March 8, 2019 technical memorandum entitled "Deterministic Seismic Hazard Analysis for the Guadalupe Tank Battery 9 Site" (Golder 2019). The target is the median acceleration response spectrum for a maximum credible earthquake (MCE) developed by an **M**[1]6.9 earthquake on the Casmalia fault zone about 2.7 miles from the Site (Golder 2019). The target response spectrum was developed for an outcropping rock ground condition with an assumed average shear-wave velocity in the top 30 meters ($V_{S,30}$) of 760 m/s. Golder has spectrally matched three recorded, single-horizontal-component earthquake acceleration time histories to the target acceleration response spectrum.

1.0 INTRODUCTION

Preliminary seismic slope stability analyses performed by Golder for the proposed landfill slopes at TB9 using simplified methods resulted in seismic slope displacements that exceeded the acceptable limits. Therefore, more advanced analysis was performed to further assess seismic slope stability. The advanced seismic slope stability analysis required earthquake acceleration time histories developed for bedrock conditions beneath the TB9 site. To meet this need, Golder developed three single-horizontal-component earthquake acceleration time histories. This technical memorandum describes the input acceleration time histories, spectral matching procedure, and the resulting acceleration time histories.

2.0 WORK PERFORMED

The development of the three spectrally matched acceleration time histories involved the following:

- Selection of three previously recorded single-horizontal-component acceleration time histories (seed) for the site MCE as evaluated by Golder (2019)
- Spectrally matching the seed acceleration time histories to the target acceleration response spectrum

[1] **M** is moment magnitude. **M** is a measure of the earthquake magnitude based on the fault rupture area and average slip on the causative fault.

Golder Associates Inc.
18300 NE Union Hill Road, Suite 200, Redmond, Washington, USA 98052 T: +1 425 883-0777 F: +1 425 882-5498

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- Providing digital files of the modified acceleration time histories for use in the TB9 landfill seismic stability analysis
- Preparation of this technical memorandum that describes the data, procedures, and results of the acceleration time history development

3.0 TARGET SPECTRUM

For the MCE, the deterministic seismic hazard analysis (DSHA) indicates that the controlling seismic source is the Casmalia fault zone—a reverse fault located about [2]4.35 km (2.7 miles) away from the Site (Golder 2019). This fault has a maximum earthquake magnitude of **M**6.9. The target acceleration response spectrum for earthquake acceleration time history development is the MCE median acceleration response spectrum calculated for outcropping rock ground conditions with a $V_{S,30}$ of 760 m/s. The NGA-West2 spreadsheet developed and published by the Pacific Earthquake Engineering Research Center (PEER) was used to calculate the target acceleration response spectrum. The target response spectrum was calculated using the same set of ground motion models and the same weightings for the Casmalia fault assumed in Golder (2019). Table 1 lists the spectral acceleration values of the target MCE spectrum.

Table 1: Target MCE Acceleration Response Spectrum for the TB9 Site

Period (s)[1]	Spectral Acceleration (g)[2]	Period (s)	Spectral Acceleration (g)
0.01	0.480	0.5	0.621
0.02	0.494	0.75	0.424
0.03	0.547	1	0.312
0.05	0.685	1.5	0.186
0.075	0.861	2	0.127
0.1	0.980	3	0.075
0.15	1.105	4	0.049
0.2	1.078	5	0.035
0.25	0.990	7.5	0.018
0.3	0.896	10	0.011
0.4	0.742		

Notes:
1. All values assume 5%-damped
2. Site soil condition of $V_{S,30}$ = 760 m/s

The period range used for earthquake acceleration time history development in this study is from 0.04 to 10 seconds because it extends across the range of periods that are typically of engineering interest.

[2] Note the distance measures used in the NGA-West2 ground motion models are kilometers (km).

4.0 SPECTRAL-MATCHING PROCEDURE

The process of modifying the seed acceleration time history or earthquake strong motion record to closely match the target acceleration response spectrum is known as “spectral matching”. The objective of spectral matching is to reduce the individual spectral peaks and troughs of the seed acceleration time history while closely preserving its non-stationary characteristics (e.g., Abrahamson 1992).

This study used the time-domain spectral-matching method developed by Lilhanand and Tseng (1988) and subsequently modified by Abrahamson (1992), Hancock et al. (2006), and Al Atik and Abrahamson (2010). The time-domain spectral-matching adds wavelets in the seismic waveform to improve the spectral deficiencies of the seed motion. The wavelets introduce less energy into the acceleration time history and preserve the non-stationary characteristics of the seed acceleration time history (Hancock et al. 2006). Typically, several iterations are required to obtain reasonable convergence between the spectrally matched acceleration time history and the target response spectrum. A final baseline correction is sometimes necessary to remove permanent offset on the displacement time history introduced during the spectral matching procedure.

Spectral matching for this study used the computer program RSPMatch09 developed by Al Atik and Abrahamson (2010) and published by Fouad and Rathje (2012).

5.0 SELECTION OF SEED ACCELERATION TIME HISTORIES

Seed earthquake acceleration time histories are typically selected based on a scenario earthquake, and its magnitude and source-to-site distance. The scenario earthquake is selected either as the controlling MCE from Golder (2019), or the earthquake magnitude and source-to-site distance ranges that contribute most to the seismic hazard evaluated from a probabilistic analysis for the return period of interest.

Once the scenario earthquake is identified, recorded acceleration time histories are selected that have similar source, path, and site properties to the scenario earthquake. The selection criteria typically include earthquake magnitude, source-to-site distance, style of faulting, rupture directivity, and the site ground condition.

The principal earthquake acceleration time history selection criteria used in this study are that the:

- Overall shape of acceleration response spectrum of the seed acceleration time history is similar to the target response spectrum
- Scaling factor (ratio of the target PGA to the PGA of the seed) ranges between 0.5 and 4.0
- The main intensity parameters of the modified earthquake acceleration time histories are comparable to the anticipated intensity measures for the representative earthquake scenarios at the Site

Golder selected three single-horizontal-component seed acceleration time histories for the MCE target acceleration response spectrum from the PEER NGA-West2 database. Seed acceleration time histories were selected from earthquakes of magnitudes between **M**6.65 to **M**7.15. Source-to-site distances are less than 30 km for the selected seed records.

6.0 TIME HISTORY DEVELOPMENT RESULTS

Table 2 lists the key source parameters of the three seed earthquake acceleration time histories selected for the spectral matching. The record sequence number (RSN) for the real earthquake recording is as assigned by the PEER NGA-West2 database.

Figure 1 (left) shows a comparison between the acceleration response spectrum of individual spectrally matched time histories and the MCE target spectrum. Figure 1 (right) shows a comparison between the geometric mean acceleration response spectrum of the three spectrally matched time histories and the MCE target spectrum. Both the individual acceleration response spectra and the geometric mean spectrum agree well with the MCE target spectrum from PGA to 10.0 seconds. The acceleration response spectra of the matched time histories are generally within 90% to 110% of the MCE target spectrum.

Figures 2 to 4 (attached to the end of this technical memorandum) are comparisons between the spectrally matched acceleration, velocity, and displacement time histories and the input seed acceleration, velocity, and displacement time histories. These figures also show the target, seed, and spectrally matched acceleration response spectra, Fourier amplitude spectra, and normalized Arias intensity (AI) (Arias, 1970) for the seed and spectrally matched acceleration time histories. The seed acceleration response spectrum shown in Figures 2 to 4 has been scaled by the scale factor used in the spectral matching process.

Because the solution in spectral matching is not unique (i.e., there are an infinite number of time histories that will produce the target spectrum), the acceleration, velocity, and displacement time histories were reviewed as part of this study to confirm that the non-stationary characteristics of the seed time series have been maintained.

Earthquake magnitude and distance are causal parameters and only indirect measures of the characteristics of the earthquake acceleration time histories. Significant durations (SD_{5-75} and SD_{5-95}), Arias intensity (AI), cumulative absolute velocity (CAV), peak ground velocity (PGV), and peak ground displacement (PGD) are important measures of the intensity of earthquake acceleration time histories. Table 3 lists the main intensity parameters of the spectrally matched earthquake acceleration time histories.

Information listed in Tables 2 and 3 indicate that:

- No more than two seed acceleration time histories are from the same earthquake
- The seed acceleration time histories are records from California earthquakes
- The seed acceleration time histories were recorded from earthquakes with magnitudes and at distances that meet criteria described in Section 5.0
- Scale factors to the seed acceleration time history range from 1.3 to 2.0, which are well within the typically accepted range from 0.5 to 4.0

Golder further compared SD_{5-75}, SD_{5-95}, and AI of the spectrally matched acceleration time histories to predictions of these intensity parameters from the empirical relations listed in Table 4. Empirical relations considered are Abrahamson and Silva (1996) for SD_{5-75} and SD_{5-95}, and Abrahamson et al. (2016) for AI. The considered earthquake magnitude-distance pairs reflect the controlling seismic source (i.e., the Casmalia fault) of an **M**6.9 at 4.35 km.

The comparison of values listed in Tables 3 and 4 indicates that SD_{5-75}, SD_{5-95}, and AI of the three spectrally matched earthquake acceleration time histories are generally within 16th to 84th percentiles (i.e., ±1 standard deviation about the median) of the predicted reference values. The intensity parameters of the spectrally matched earthquake acceleration time histories, therefore, are judged to be acceptable.

Table 2: Key parameters of the selected seed earthquake acceleration time histories

ID	RSN[1]	Compo-nent	Earthquake Name	Year	Station Name	Earthquake Magnitude (M)[2]	Earthquake Mechanism	Rjb[3] (km)	Rrup[4] (km)	$V_{S,30}$ (m/s)
1	801	315	Loma Prieta	1989	San Jose - Santa Teresa Hills	6.93	Reverse Oblique	14.2	14.7	672
2	1078	0	Northridge-01	1994	Santa Susana Ground	6.69	Reverse	1.7	16.7	715
3	1787	0	Hector Mine	1999	Hector	7.13	Strike Slip	10.4	11.7	726

Notes:
1. Record Sequence Number
2. Moment magnitude
3. Rrup = rupture distance
4. Rjb = Joyner-Boore distance

Table 3: Key parameters of the spectrally matched time histories

ID	Scale Factor	Significant Duration (5-75, s)	Significant Duration (5-95, s)	Arias Intensity (m/s)	Cumulative Absolute Velocity (m/s)	Peak Ground Velocity (cm/s)	Peak Ground Displacement (cm)
1	1.3	5.9	9.2	2.2	12.6	42.3	14.1
2	1.9	5.2	9.3	2.3	12.1	25.9	16.4
3	2.0	6.8	13.4	2.3	13.7	24.8	15.4

Table 4: Predicted range of earthquake strong ground motion intensity measures from empirical relations

Intensity Parameters	Empirical Equation Source	Earthquake Magnitude (M)	Earthquake Distance (km)	Site Condition	Median	16th Percentile	84th Percentile
SD_{5-75} (s)	Abrahamson and Silva (1996)	6.9	4.35	Soil	5.5	3.2	9.5
		6.9	4.35	Rock	6.3	3.6	10.9
SD_{5-95} (s)		6.9	4.35	Soil	12.8	7.8	20.9
		6.9	4.35	Rock	14.7	9.0	24.0

Intensity Parameters	Empirical Equation Source	Earthquake Magnitude (M)	Earthquake Distance (km)	Site Condition	Median	16th Percentile	84th Percentile
Arias Intensity (m/s)	Abrahamson et al. (2016)	6.9	4.35	$V_{S,30}$ = 760 m/s	2.1	1.4	3.1

7.0 SUMMARY

Three seed earthquake acceleration time histories were selected from earthquake strong ground motion recordings in the PEER NGA-West2 database. These seed acceleration time history records were spectrally matched to the 5%-damped, median MCE response spectrum for an outcropping rock site condition with a $V_{S,30}$ of 760 m/s. The geometric mean response spectrum of the three spectrally matched earthquake acceleration time histories agrees well with the target response spectrum from PGA to 10.0 seconds. Comparisons between the earthquake intensity measures, including significant durations and AI, estimated for the spectrally matched motions and from empirical relations for representative earthquake scenarios indicate that the spectrally matched motions are acceptable because they fall within ±1 standard deviation of the predicted median values.

8.0 REFERENCES

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Lilhanand, K. and W.S. Tseng 1988. Development and application of realistic earthquake time histories comparable with multiple damping design spectra. Proceedings of the Ninth World Conference on Earthquake Engineering, Tokyo-Kyoto, Japan, Volume 2.

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Figures

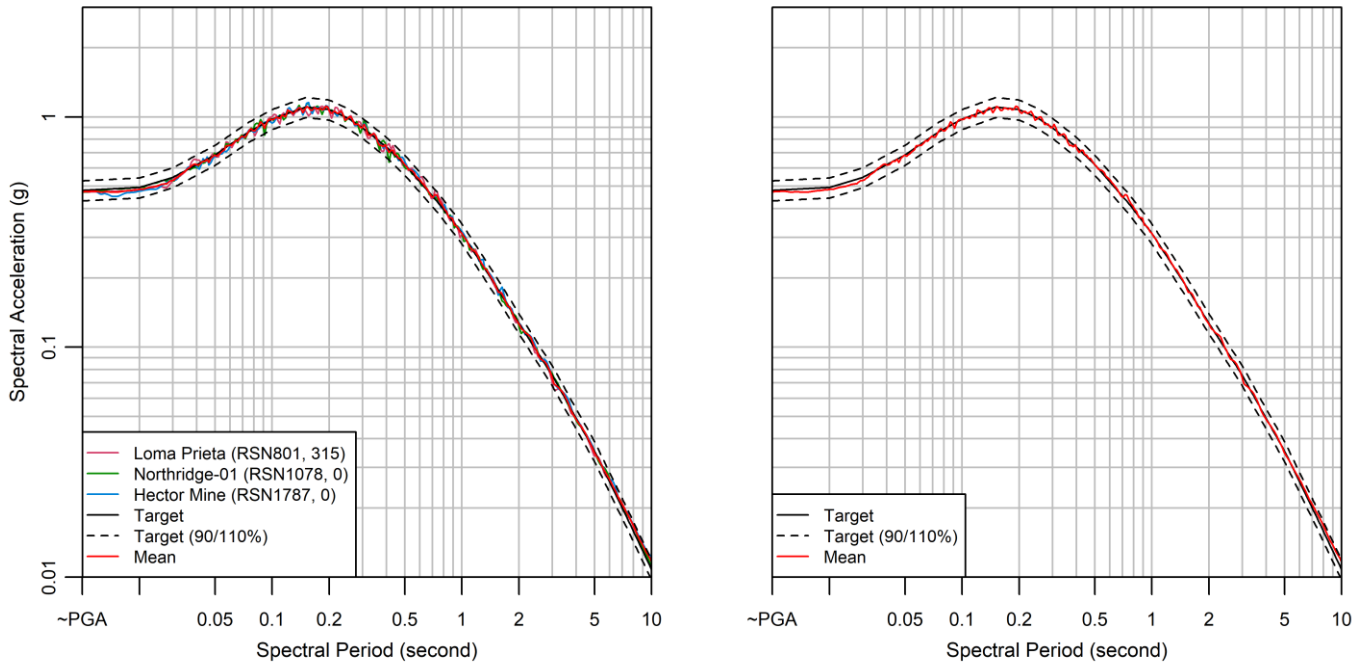
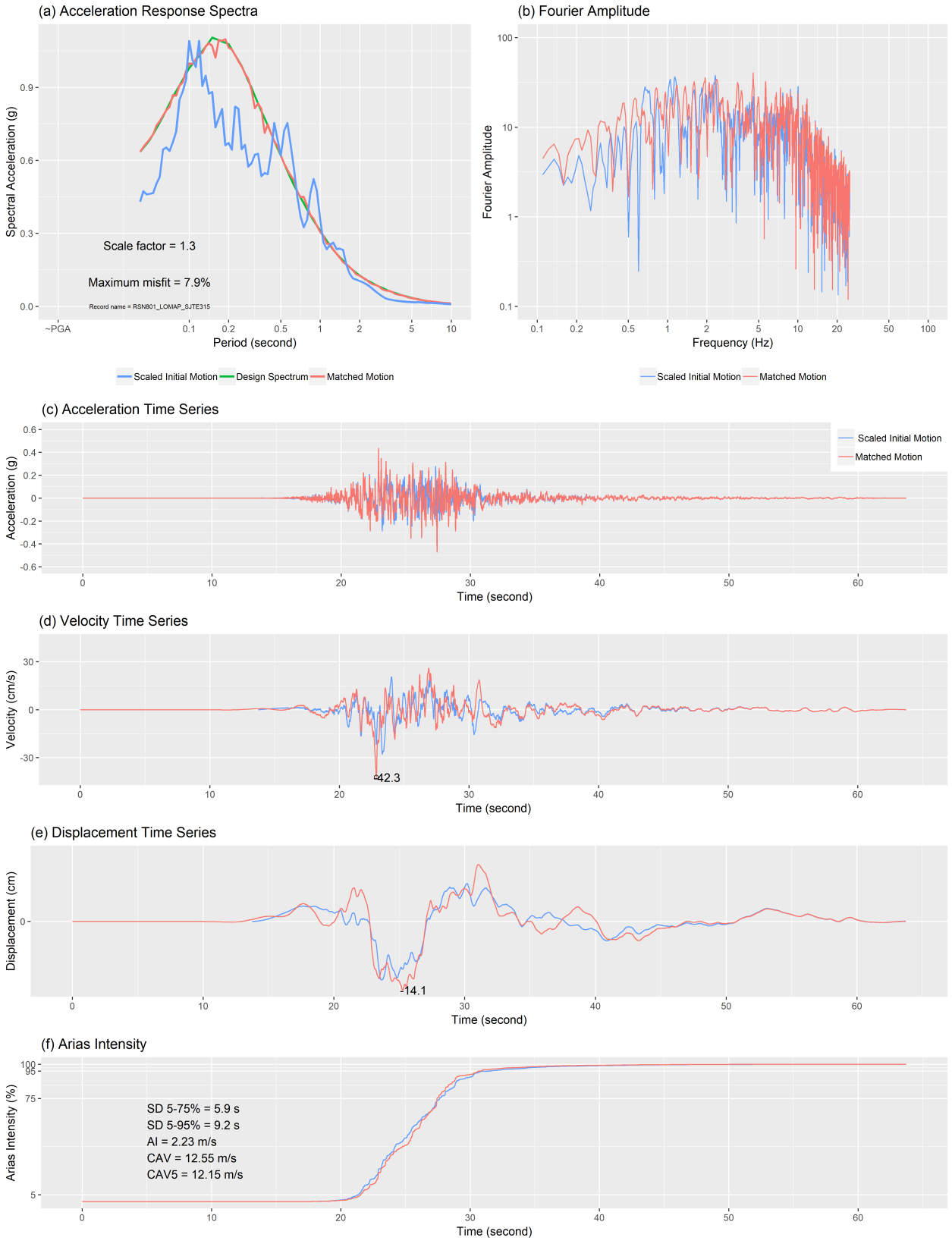


Figure 1: Target acceleration response spectrum compared to individual response spectra of spectrally matched time histories (left) and the geometric mean response spectrum (right)



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CHEVRON EMC

CONSULTANT

GOLDER

YYYY-MM-DD	6/5/2019
PREPARED	JC
DESIGN	--
REVIEW	FL
APPROVED	AH

PROJECT

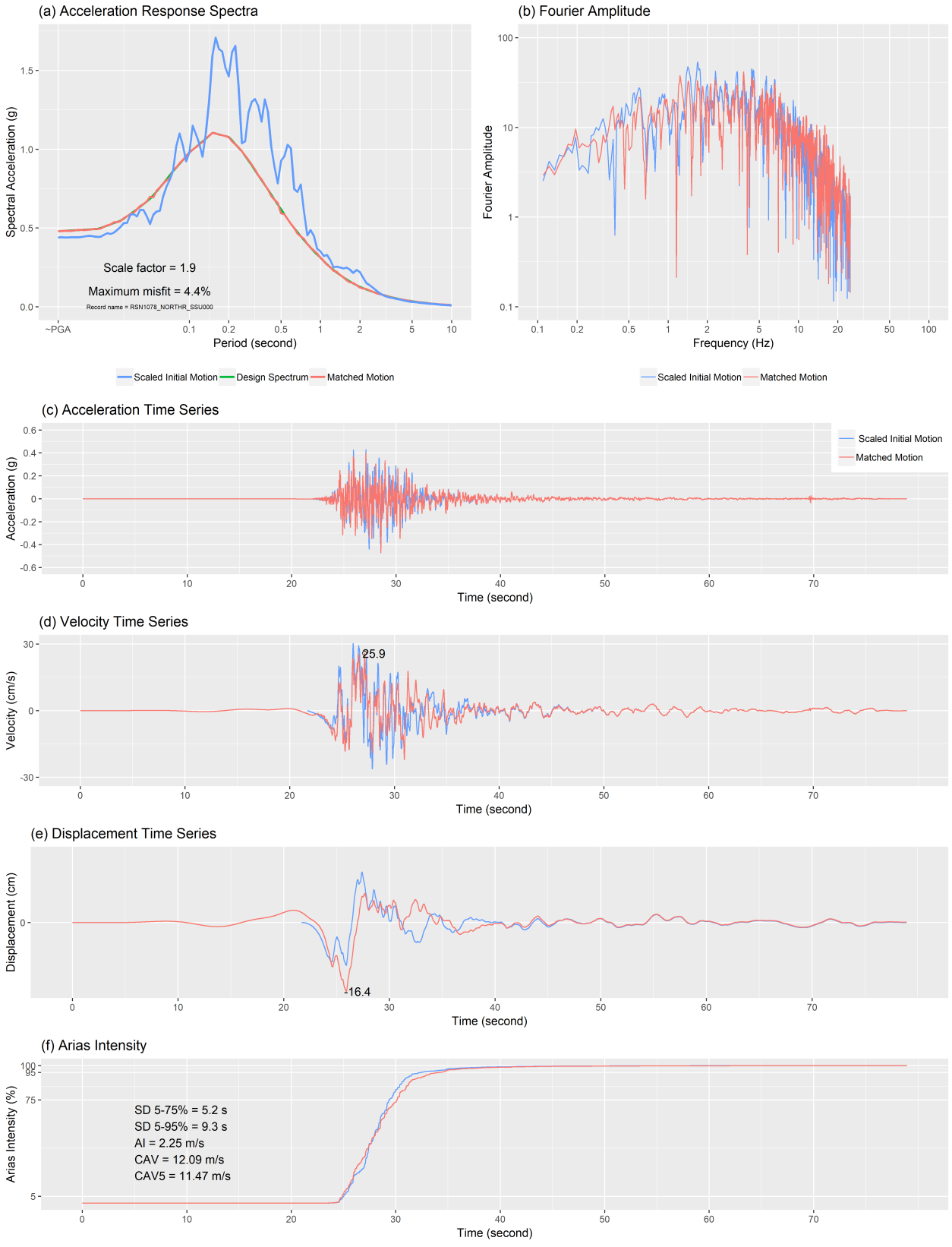
EARTHQUAKE ACCELERATION TIME HISTORIES FOR THE GUADALUPE TANK BATTERY 9 SITE

TITLE

Spectral Matching Results (LOMAP, RSN801-315)

PROJECT No.	PHASE	REV.	FIGURE
1783552	002	Rev0	2

2019-06-06 11:16:46 JCao



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GOLDER

YYYY-MM-DD	6/5/2019
PREPARED	JC
DESIGN	--
REVIEW	FL
APPROVED	AH

PROJECT

EARTHQUAKE ACCELERATION TIME HISTORIES FOR THE GUADALUPE TANK BATTERY 9 SITE

TITLE

Spectral Matching Results (NORTHR, RSN1078-0)

PROJECT No.	PHASE	REV.	FIGURE
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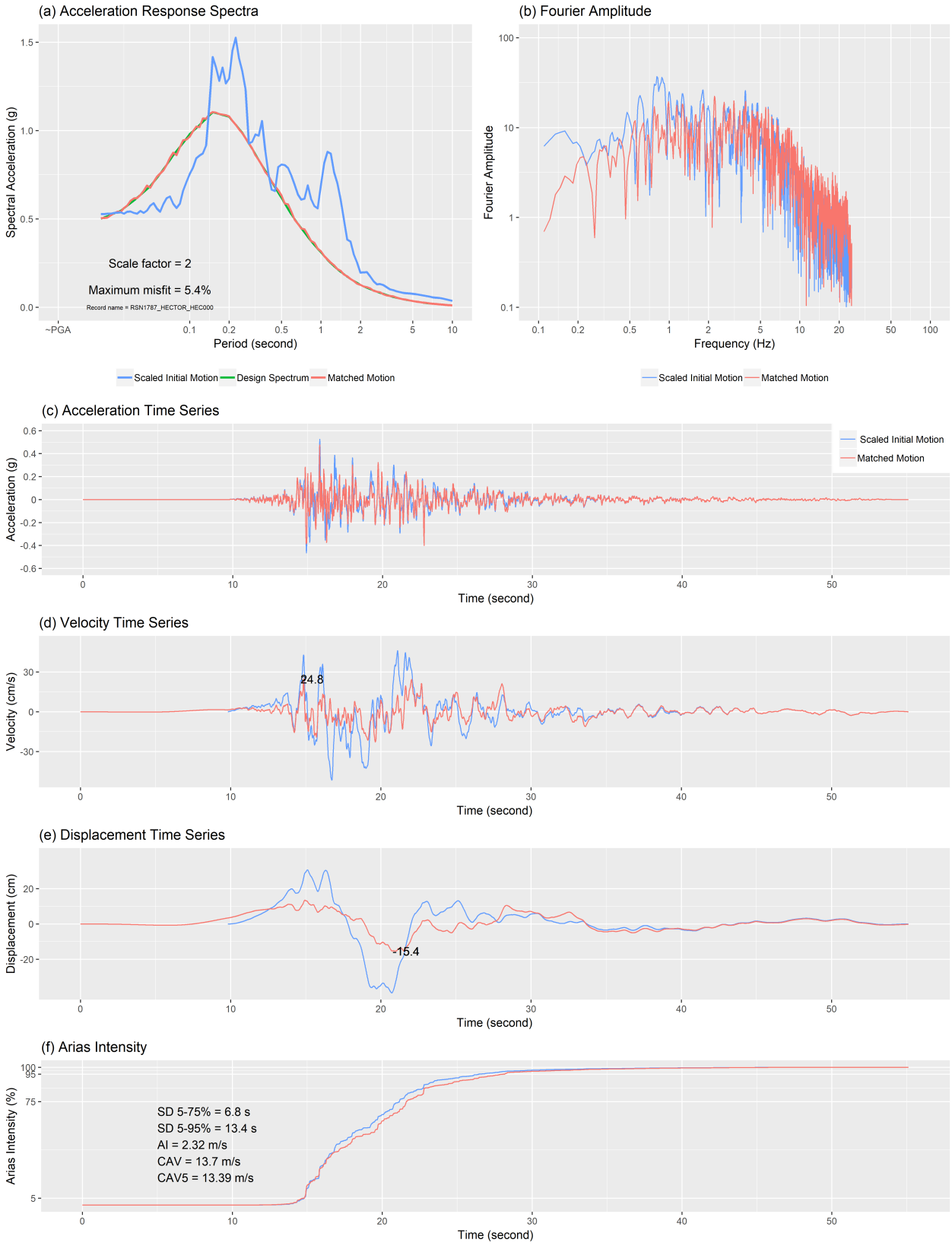

CLIENT

CHEVRON EMC

CONSULTANT

GOLDER

YYYY-MM-DD	6/5/2019
PREPARED	JC
DESIGN	--
REVIEW	FL
APPROVED	AH

PROJECT

EARTHQUAKE ACCELERATION TIME HISTORIES FOR THE GUADALUPE TANK BATTERY 9 SITE

TITLE

Spectral Matching Results (HECTOR, RSN1787-0)

PROJECT No.	PHASE	REV.	FIGURE
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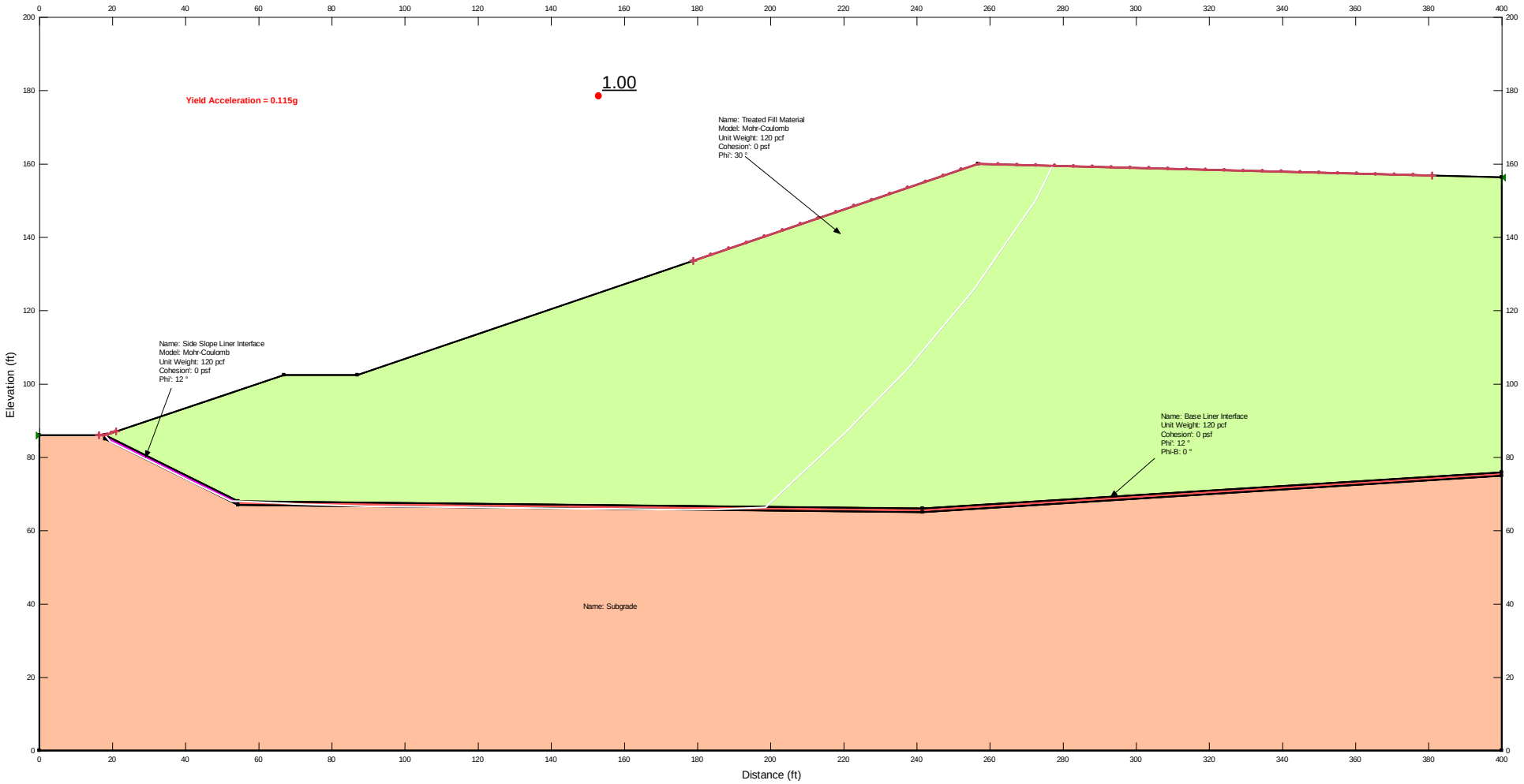
APPENDIX D

Yield Accelerations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Yield Acceleration = 0.115g
Name: Treated Fill Material
Model: Mohr-Coulomb
Unit Weight: 120 pcf
Cohesion': 0 psf
Phi': 30 °
Name: Side Slope Liner Interface
Model: Mohr-Coulomb
Unit Weight: 120 pcf
Cohesion': 0 psf
Phi': 12 °
Name: Base Liner Interface
Unit Weight: 120 pcf
Cohesion': 0 psf
Phi': 12 °
Phi-B: 0 °
Name: Subgrade
Elevation (ft)
Distance (ft)

A-A', Yield Acceleration, Run 1

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File Information

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Time: 11:53:47 AM
Tool Version: 9.1.0.16306
File Name: A-A'_Rev5_1.gsz
Last Solved Date: 06/10/2019
Last Solved Time: 11:58:14 AM

Project Settings

Unit System: U.S. Customary Units

Analysis Settings

A-A', Yield Acceleration, Run 1

Description: Chevron, Guadalupe Restoration Project, Slope Stability, Cross Section
Kind: SLOPE/W
Method: Morgenstern-Price
Settings
- Side Function
  - Interslice force function option: Half-Sine
- PWP Conditions from: (none)
- Unit Weight of Water: 62.430189 pcf

Slip Surface
- Direction of movement: Right to Left
- Use Passive Mode: No

Slip Surface Option: Entry and Exit
Critical slip surfaces saved: 1
Optimize Critical Slip Surface Location: Yes
Optimizations Settings
Maximum Iterations: 5,000
Convergence Tolerance: 1e-07
Starting Points: 8
Ending Points: 16
Complete Passes per Insertion: 1
Driving Side Maximum Convex Angle: 5 °
Resisting Side Maximum Convex Angle: 1 °
Tension Crack Option: (none)
Distribution
F of S Calculation Option: Constant
Advanced
Geometry Settings
Minimum Slip Surface Depth: 0.1 ft
Number of Slices: 30
Factor of Safety Convergence Settings
Maximum Number of Iterations: 100
Tolerable difference in F of S: 0.001
Solution Settings
Search Method: Root Finder
Tolerable difference between starting and converged F of S: 3
Maximum iterations to calculate converged lambda: 20
Max Absolute Lambda: 2

Materials

Treated Fill Material

Model: Mohr-Coulomb
Unit Weight: 120 pcf
Cohesion': 0 psf

Phi': 30 °
Phi-B: 0 °

Base Liner Interface

Model: Mohr-Coulomb
Unit Weight: 120 pcf
Cohesion': 0 psf
Phi': 12 °
Phi-B: 0 °

Subgrade

Model: Bedrock (Impenetrable)

Side Slope Liner Interface

Model: Mohr-Coulomb
Unit Weight: 120 pcf
Cohesion': 0 psf
Phi': 12 °
Phi-B: 0 °

Slip Surface Entry and Exit

Left Type: Range
Left-Zone Left Coordinate: (16.3352, 86) ft
Left-Zone Right Coordinate: (20.9878, 87) ft
Left-Zone Increment: 4
Right Type: Range
Right-Zone Left Coordinate: (178.87039, 133.56451) ft
Right-Zone Right Coordinate: (381, 156.79092) ft
Right-Zone Increment: 40
Radius Increments: 10

Slip Surface Limits

Left Coordinate: (0, 86) ft
Right Coordinate: (400, 156.3) ft

Seismic Coefficients

Horz Seismic Coef.: 0.115

Points

	X	Y
Point 1	0 ft	86 ft
Point 2	18 ft	86 ft
Point 3	67 ft	102.4 ft
Point 4	87 ft	102.4 ft
Point 5	256.8 ft	160 ft
Point 6	400 ft	156.3 ft
Point 7	54.4 ft	68 ft
Point 8	241.6 ft	66 ft
Point 9	400 ft	75.9 ft
Point 10	18 ft	85 ft
Point 11	54.4 ft	67 ft
Point 12	241.6 ft	65 ft
Point 13	400 ft	74.9 ft
Point 14	0 ft	0 ft
Point 15	400 ft	0 ft

Regions

	Material	Points	Area
Region 1	Treated Fill Material	2,3,4,5,6,9,8,7	25,005 ft²
Region 2	Side Slope Liner Interface	2,7,11,10	36.4 ft²
Region 3	Base Liner Interface	7,8,9,13,12,11	345.6 ft²
Region 4	Subgrade	1,2,10,11,12,13,15,14	27,750 ft²

Slip Results

Slip Surfaces Analysed: 1371 of 2256 converged

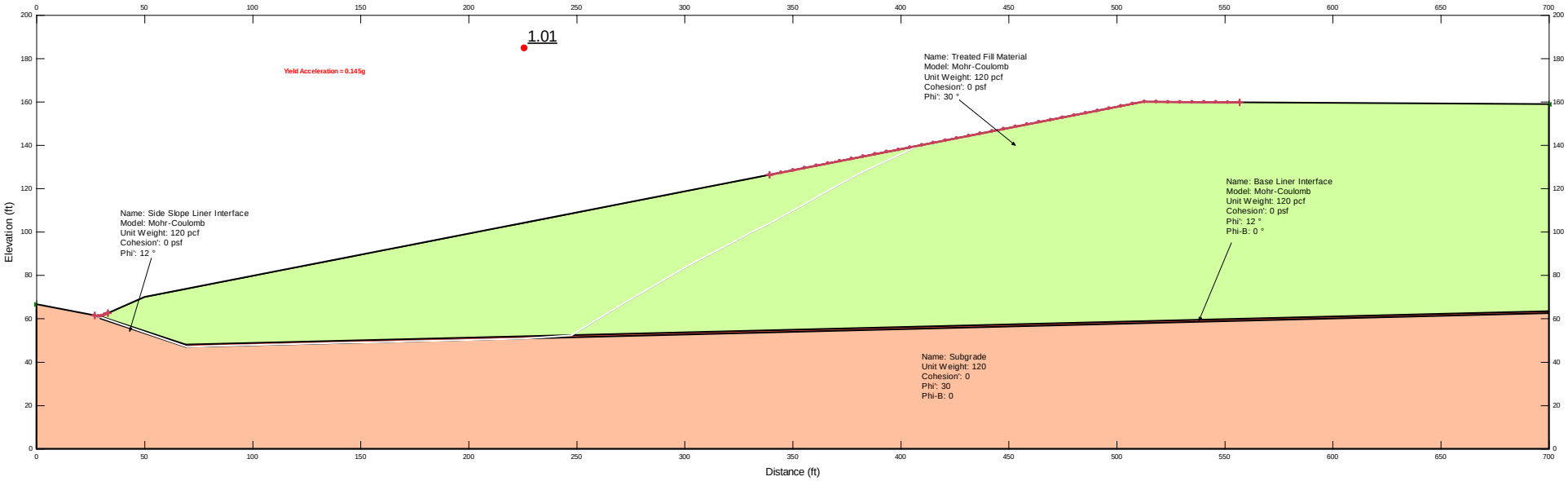
Current Slip Surface

Slip Surface: 2,256
Factor of Safety: 1.00
Volume: 11,428.568 ft³
Weight: 1,371,428.2 lbf
Resisting Moment: 56,188,508 lbf·ft
Activating Moment: 56,187,359 lbf·ft
Resisting Force: 345,460.34 lbf
Activating Force: 345,448.13 lbf
Slip Rank: 1 of 2,256 slip surfaces
Exit: (18.01315, 86.004401) ft
Entry: (277.25594, 159.47146) ft
Radius: 135.36229 ft
Center: (124.60237, 195.78363) ft

Slip Slices

	X	Y	PWP	Base Normal Stress	Frictional Strength	Cohesive Strength	Suction Strength	Base Material
Slice 1	18.020433 ft	85.995348 ft	0 psf	4.8984409 psf	2.8281162 psf	0 psf	0 psf	Treated Fill Material
Slice 2	18.695559 ft	85.156042 ft	0 psf	178.61731 psf	37.966281 psf	0 psf	0 psf	Side Slope Liner Interface
Slice 3	25.663111 ft	81.210549 ft	0 psf	1,054.075 psf	224.05057 psf	0 psf	0 psf	Side Slope Liner Interface
Slice 4	37.038788 ft	75.585215 ft	0 psf	2,589.5294 psf	550.42147 psf	0 psf	0 psf	Side Slope Liner Interface
Slice 5	47.346703 ft	70.560361 ft	0 psf	4,167.2532 psf	885.77701 psf	0 psf	0 psf	Side Slope Liner Interface
Slice 6	53.489325 ft	68.005237 ft	0 psf	4,074.6012 psf	866.08323 psf	0 psf	0 psf	Side Slope Liner Interface
Slice 7	60.7 ft	67.685645 ft	0 psf	4,463.3803 psf	948.72077 psf	0 psf	0 psf	Base Liner Interface
Slice 8	68.287575 ft	67.349348 ft	0 psf	4,818.4764 psf	1,024.1988 psf	0 psf	0 psf	Base Liner Interface
Slice 9	73.931363 ft	67.150253 ft	0 psf	4,837.6599 psf	1,028.2764 psf	0 psf	0 psf	Base Liner Interface
Slice 10	82.643788 ft	66.8662 ft	0 psf	4,904.665 psf	1,042.5187 psf	0 psf	0 psf	Base Liner Interface
Slice 11	88.652943 ft	66.670281 ft	0 psf	5,015.9557 psf	1,066.1743 psf	0 psf	0 psf	Base Liner Interface
Slice 12	95.53481 ft	66.560526 ft	0 psf	5,251.2525 psf	1,116.1882 psf	0 psf	0 psf	Base Liner Interface
Slice 13	105.99266 ft	66.448796 ft	0 psf	5,703.9136 psf	1,212.4043 psf	0 psf	0 psf	Base Liner Interface
Slice 14	114.91851 ft	66.353435 ft	0 psf	6,077.2769 psf	1,291.7651 psf	0 psf	0 psf	Base Liner Interface
Slice 15	122.31236 ft	66.274441 ft	0 psf	6,375.3332 psf	1,355.1189 psf	0 psf	0 psf	Base Liner Interface
Slice 16	129.85958 ft	66.193808 ft	0 psf	6,668.2122 psf	1,417.3723 psf	0 psf	0 psf	Base Liner Interface
Slice 17	137.56016 ft	66.111537 ft	0 psf	6,954.4562 psf	1,478.2153 psf	0 psf	0 psf	Base Liner Interface
Slice 18	145.26073 ft	66.029266 ft	0 psf	7,227.3773 psf	1,536.2265 psf	0 psf	0 psf	Base Liner Interface
Slice 19	152.96131 ft	65.946995 ft	0 psf	7,486.7339 psf	1,591.3544 psf	0 psf	0 psf	Base Liner Interface
Slice 20	160.07267 ft	65.871018 ft	0 psf	7,714.4432 psf	1,639.7555 psf	0 psf	0 psf	Base Liner Interface
Slice 21	166.59481 ft	65.801337 ft	0 psf	7,913.3508 psf	1,682.0346 psf	0 psf	0 psf	Base Liner Interface
Slice 22	173.01181 ft	65.73278 ft	0 psf	8,100.3957 psf	1,721.7923 psf	0 psf	0 psf	Base Liner Interface
Slice 23	180.4699 ft	65.746101 ft	0 psf	8,156.9217 psf	1,733.8072 psf	0 psf	0 psf	Base Liner Interface

Slice 24	188.24878 ft	65.91976 ft	0 psf	8,183.1798 psf	1,739.3886 psf	0 psf	0 psf	Base Liner Interface
Slice 25	195.20221 ft	66.173 ft	0 psf	8,339.0691 psf	1,772.5239 psf	0 psf	0 psf	Base Liner Interface
Slice 26	202.44356 ft	69.822855 ft	0 psf	4,482.693 psf	2,588.084 psf	0 psf	0 psf	Treated Fill Material
Slice 27	209.88887 ft	76.790752 ft	0 psf	4,239.7387 psf	2,447.8143 psf	0 psf	0 psf	Treated Fill Material
Slice 28	217.25022 ft	83.680077 ft	0 psf	4,007.4764 psf	2,313.7176 psf	0 psf	0 psf	Treated Fill Material
Slice 29	224.2088 ft	90.4632 ft	0 psf	3,613.844 psf	2,086.4538 psf	0 psf	0 psf	Treated Fill Material
Slice 30	232.58832 ft	99.01331 ft	0 psf	3,327.6793 psf	1,921.2366 psf	0 psf	0 psf	Treated Fill Material
Slice 31	242.17355 ft	109.58753 ft	0 psf	2,728.0408 psf	1,575.0351 psf	0 psf	0 psf	Treated Fill Material
Slice 32	251.14076 ft	120.31267 ft	0 psf	2,353.6637 psf	1,358.8884 psf	0 psf	0 psf	Treated Fill Material
Slice 33	256.21218 ft	126.51897 ft	0 psf	1,937.7153 psf	1,118.7405 psf	0 psf	0 psf	Treated Fill Material
Slice 34	260.72864 ft	133.00169 ft	0 psf	1,601.8951 psf	924.85458 psf	0 psf	0 psf	Treated Fill Material
Slice 35	268.58593 ft	144.27966 ft	0 psf	957.26597 psf	552.67777 psf	0 psf	0 psf	Treated Fill Material
Slice 36	274.88526 ft	154.69505 ft	0 psf	261.88294 psf	151.19819 psf	0 psf	0 psf	Treated Fill Material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Model: Mohr-Coulomb
Unit Weight: 120 pcf
Cohesion': 0 psf
Phi': 30 °
Name: Base Liner Interface
Model: Mohr-Coulomb
Unit Weight: 120 pcf
Cohesion': 0 psf
Phi': 12 °
Phi-B: 0 °
Name: Side Slope Liner Interface
Model: Mohr-Coulomb
Unit Weight: 120 pcf
Cohesion': 0 psf
Phi': 12 °
Name: Subgrade
Unit Weight: 120
Cohesion': 0
Phi': 30
Phi-B: 0
Elevation (ft)
Distance (ft)
0
50
100
150
200
250
300
350
400
450
500
550
600
650
700
0
20
40
60
80
100
120
140
160
180
200

B-B', Yield Acceleration, Rev-5

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File Information

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Project Settings

Unit System: U.S. Customary Units

Analysis Settings

B-B', Yield Acceleration, Rev-5

Description: Chevron, Guadalupe Restoration Project, Slope Stability, Cross Section
Kind: SLOPE/W
Method: Morgenstern-Price
Settings
- Side Function
  - Interslice force function option: Half-Sine
- PWP Conditions from: (none)
- Unit Weight of Water: 62.430189 pcf

Slip Surface
- Direction of movement: Right to Left
- Use Passive Mode: No

Slip Surface Option: Entry and Exit
Critical slip surfaces saved: 1
Optimize Critical Slip Surface Location: Yes
Optimizations Settings
Maximum Iterations: 5,000
Convergence Tolerance: 1e-07
Starting Points: 8
Ending Points: 16
Complete Passes per Insertion: 1
Driving Side Maximum Convex Angle: 5 °
Resisting Side Maximum Convex Angle: 1 °
Tension Crack Option: (none)
Distribution
F of S Calculation Option: Constant
Advanced
Geometry Settings
Minimum Slip Surface Depth: 0.1 ft
Number of Slices: 30
Factor of Safety Convergence Settings
Maximum Number of Iterations: 100
Tolerable difference in F of S: 0.001
Solution Settings
Search Method: Root Finder
Tolerable difference between starting and converged F of S: 3
Maximum iterations to calculate converged lambda: 20
Max Absolute Lambda: 2

Materials

Treated Fill Material

Model: Mohr-Coulomb
Unit Weight: 120 pcf
Cohesion': 0 psf

Phi': 30 °
Phi-B: 0 °

Base Liner Interface

Model: Mohr-Coulomb
Unit Weight: 120 pcf
Cohesion': 0 psf
Phi': 12 °
Phi-B: 0 °

Subgrade

Model: Mohr-Coulomb
Unit Weight: 120 pcf
Cohesion': 0 psf
Phi': 30 °
Phi-B: 0 °

Side Slope Liner Interface

Model: Mohr-Coulomb
Unit Weight: 120 pcf
Cohesion': 0 psf
Phi': 12 °
Phi-B: 0 °

Slip Surface Entry and Exit

Left Type: Range
Left-Zone Left Coordinate: (27, 61.48305) ft
Left-Zone Right Coordinate: (33, 62.53659) ft
Left-Zone Increment: 4
Right Type: Range
Right-Zone Left Coordinate: (339.29621, 126.3564) ft
Right-Zone Right Coordinate: (557.00052, 159.76064) ft
Right-Zone Increment: 40

Radius Increments: 10

Slip Surface Limits

Left Coordinate: (0, 66.7) ft
Right Coordinate: (700, 159) ft

Seismic Coefficients

Horz Seismic Coef.: 0.145

Points

	X	Y
Point 1	0 ft	66.7 ft
Point 2	29.5 ft	61 ft
Point 3	50 ft	70 ft
Point 4	512 ft	160 ft
Point 5	700 ft	159 ft
Point 6	69 ft	48 ft
Point 7	700 ft	63.5 ft
Point 8	29.5 ft	60 ft
Point 9	69 ft	47 ft
Point 10	700 ft	62.5 ft
Point 11	0 ft	0 ft
Point 12	700 ft	0 ft

Regions

	Material	Points	Area
Region 1	Treated Fill Material	2,3,4,5,7,6	47,128 ft²
Region 2	Side Slope Liner Interface	2,6,9,8	39.5 ft²
Region 3	Base Liner Interface	6,7,10,9	631 ft²
Region 4	Subgrade	1,2,8,9,10,12,11	38,544 ft²

Slip Results

Slip Surfaces Analysed: 2253 of 2256 converged

Current Slip Surface

Slip Surface: 2,256
Factor of Safety: 1.01
Volume: 12,290.318 ft³
Weight: 1,474,838.2 lbf
Resisting Moment: 3.0520925e+08 lbf·ft
Activating Moment: 3.021894e+08 lbf·ft
Resisting Force: 418,257.91 lbf
Activating Force: 413,757.38 lbf
Slip Rank: 1 of 2,256 slip surfaces
Exit: (27.232571, 61.438113) ft
Entry: (407.43136, 139.62949) ft
Radius: 171.80092 ft
Center: (156.20051, 754.55186) ft

Slip Slices

	X	Y	PWP	Base Normal Stress	Frictional Strength	Cohesive Strength	Suction Strength	Base Material

Slice 1	28.366286 ft	61.053711 ft	0 psf	24.879226 psf	14.364028 psf	0 psf	0 psf	Subgrade
Slice 2	34.625 ft	58.931604 ft	0 psf	573.87112 psf	121.98007 psf	0 psf	0 psf	Side Slope Liner Interface
Slice 3	44.875 ft	55.456195 ft	0 psf	1,685.4282 psf	358.24882 psf	0 psf	0 psf	Side Slope Liner Interface
Slice 4	59.86935 ft	50.372145 ft	0 psf	3,124.9235 psf	664.22299 psf	0 psf	0 psf	Side Slope Liner Interface
Slice 5	76.178422 ft	47.18314 ft	0 psf	3,537.5803 psf	751.9359 psf	0 psf	0 psf	Base Liner Interface
Slice 6	89.057868 ft	47.49782 ft	0 psf	3,814.0397 psf	810.69916 psf	0 psf	0 psf	Base Liner Interface
Slice 7	101.93731 ft	47.8125 ft	0 psf	4,088.8374 psf	869.10922 psf	0 psf	0 psf	Base Liner Interface
Slice 8	114.81676 ft	48.12718 ft	0 psf	4,361.2473 psf	927.01172 psf	0 psf	0 psf	Base Liner Interface
Slice 9	127.19793 ft	48.430818 ft	0 psf	4,619.4239 psf	981.88886 psf	0 psf	0 psf	Base Liner Interface
Slice 10	139.08083 ft	48.723415 ft	0 psf	4,864.1981 psf	1,033.9172 psf	0 psf	0 psf	Base Liner Interface
Slice 11	150.96373 ft	49.016012 ft	0 psf	5,105.1413 psf	1,085.1313 psf	0 psf	0 psf	Base Liner Interface
Slice 12	164.64871 ft	49.352018 ft	0 psf	5,377.7701 psf	1,143.0803 psf	0 psf	0 psf	Base Liner Interface
Slice 13	180.13578 ft	49.731432 ft	0 psf	5,678.2786 psf	1,206.9554 psf	0 psf	0 psf	Base Liner Interface
Slice 14	194.06724 ft	50.073933 ft	0 psf	5,940.0753 psf	1,262.602 psf	0 psf	0 psf	Base Liner Interface
Slice 15	206.44311 ft	50.37952 ft	0 psf	6,167.0359 psf	1,310.8439 psf	0 psf	0 psf	Base Liner Interface
Slice 16	218.81898 ft	50.685107 ft	0 psf	6,388.2378 psf	1,357.8619 psf	0 psf	0 psf	Base Liner Interface
Slice 17	232.06457 ft	51.26524 ft	0 psf	6,387.6327 psf	1,357.7332 psf	0 psf	0 psf	Base Liner Interface
Slice 18	243.39828 ft	52.02549 ft	0 psf	6,431.1792 psf	1,366.9893 psf	0 psf	0 psf	Base Liner Interface
Slice 19	254.19103 ft	56.331198 ft	0 psf	4,235.4227 psf	2,445.3224 psf	0 psf	0 psf	Treated Fill Material
Slice 20	267.1983 ft	64.260858 ft	0 psf	3,812.9243 psf	2,201.3929 psf	0 psf	0 psf	Treated Fill Material
Slice 21	281.33958 ft	72.643462 ft	0 psf	3,465.6504 psf	2,000.8942 psf	0 psf	0 psf	Treated Fill Material
Slice 22	296.64099 ft	81.494947 ft	0 psf	3,005.8569 psf	1,735.4323 psf	0 psf	0 psf	Treated Fill Material
Slice 23	312.57669 ft	90.13852 ft	0 psf	2,711.8986 psf	1,565.7154 psf	0 psf	0 psf	Treated Fill Material
Slice 24	325.66204 ft	96.960185 ft	0 psf	2,295.5428 psf	1,325.3323 psf	0 psf	0 psf	Treated Fill Material
Slice 25	334.60084 ft	101.57551 ft	0 psf	2,143.982 psf	1,237.8286 psf	0 psf	0 psf	Treated Fill Material
Slice 26	345.79805 ft	107.50166 ft	0 psf	1,736.2819 psf	1,002.4428 psf	0 psf	0 psf	Treated Fill Material

Slice 27	359.91555 ft	115.33095 ft	0 psf	1,314.0542 psf	758.66952 psf	0 psf	0 psf	Treated Fill Material
Slice 28	374.03306 ft	123.16024 ft	0 psf	882.05631 psf	509.25545 psf	0 psf	0 psf	Treated Fill Material
Slice 29	386.72581 ft	129.67435 ft	0 psf	557.08592 psf	321.63371 psf	0 psf	0 psf	Treated Fill Material
Slice 30	397.99381 ft	134.87328 ft	0 psf	275.71529 psf	159.18429 psf	0 psf	0 psf	Treated Fill Material
Slice 31	405.52959 ft	138.55111 ft	0 psf	63.989883 psf	36.944576 psf	0 psf	0 psf	Treated Fill Material

APPENDIX E

SHAKE Analysis Results

Estimation of Unit Weight (γ) and Shear Wave Velocity (V_s) of Soils
Cross Section A-A', Seismic Slope Stability
Tank Battery 9 Area, Chevron, Guadalupe

1. Treated Fill Material

Soil No.	Depth Increment	Refuse Thickness above Mid-Depth (z)		$(K_2)_{max}$	Unit Weight (γ)	σ_v at Mid-Depth	σ_v' at Mid-Depth	ϕ'	K_0	σ'_m	G_{max} (Note 1)
	(ft.)	(ft.)	(m)		(pcf)	(psf)	(psf)	(deg)		(psf)	(ksf)
1	5	2.5	0.76	30	120	600	600	30	0.50	400	600
2	10	10	3.05	30	120	1500	1500	30	0.50	1000	949
3	10	20	6.10	30	120	2700	2700	30	0.50	1800	1273
4	10	30	9.15	30	120	3900	3900	30	0.50	2600	1530
5	10	40	12.20	30	120	5100	5100	30	0.50	3400	1749
6	10	50	15.24	30	120	6300	6300	30	0.50	4200	1944
7	5	57.5	17.53	30	120	7200	7200	30	0.50	4800	2078
Total =	60										

Total vertical stress at slip plane= 7.20 ksf

2. Subgrade

Approximate depth to groundwater from top of the soil/waste column = 100 ft

Soil No.	Thickness	Mid-Depth (z)		$(K_2)_{max}$	Unit Weight (γ)	σ_v at Mid-Depth	σ_v' at Mid-Depth	ϕ'	K_0	σ'_m	G_{max} (Note 1)
	(ft)	(ft)	(m)		(pcf)	(psf)	(psf)	(deg)		(psf)	(ksf)
8	20	70	21.34	31	120	8700	8700	30	0.50	5800	2361
9	20	90	27.44	31	120	11100	11100	30	0.50	7400	2667
10	20	110	33.54	31	120	13500	12876	30	0.50	8584	2872
11	20	130	39.63	31	120	15900	14028	30	0.50	9352	2998
12	40	160	48.78	43	125	19600	15856	32	0.47	10254	4354
13	40	200	60.98	43	125	24600	18360	32	0.47	11874	4686
14	40	240	73.17	43	125	29600	20864	32	0.47	13493	4995
15	40	280	85.37	43	125	34600	23368	32	0.47	15113	5286
16	50	325	99.09	43	125	40225	26185	32	0.47	16934	5596
17	50	375	114.33	43	125	46475	29315	32	0.47	18959	5921
18	50	425	129.57	43	125	52725	32445	32	0.47	20983	6229
19	50	475	144.82	43	125	58975	35575	32	0.47	23007	6522
Subgrade =	500										

Note 1:
The maximum shear modulus (Gmax) for subgrade is based on the paper "Evaluation of Settlements in Sands Due to Earthquake Shaking" by Tokimatsu and Seed, in the *Journal of Geotechnical Engineering* , August 1987, pp 861-871:

$$G_{max} = 1000\,(K_2)_{max}\,(\sigma'_m)^{0.5}$$

where, $\sigma'_m = (\sigma'_v + 2\,K_o\,\sigma'_v)/3$

$K_o = 1 - \sin\phi'$

```
  ***************************************************
  * SHAKE  --   A COMPUTER PROGRAM FOR EARTHQUAKE RESPONSE  *
  *             ANALYSIS OF HORIZONTALLY LAYERED SITES      *
  *             by: Per B. Schnabel & John Lysmer -- 1970   *
  * ----------------------------------------------------- *
  * shake85     IBM-PC version of SHAKE                     *
  *             by: S.S. (Willie) Lai, January 1985         *
  * ----------------------------------------------------- *
  * shake88   : New modulus reduction curves for clays added*
  *             using results from Sun et al (1988)         *
  *             by: J. I. Sun & Ramin Golesorkhi            *
  *             February 26, 1988                           *
  * ----------------------------------------------------- *
  * SHAKE90/91: Adjust last iteration; Input now is either  *
  *             Gmax or max Vs; up to 13 material types can *
  *             be specified by user; up to 50 Layers can   *
  *             be specified; object motion can be read in  *
  *             from a separate file and can have user      *
  *             specified format; Different periods for     *
  *             response spectral calculations; options     *
  *             are renumbered; and general cleanup         *
  *             by: J. I. Sun, I. M. Idriss & P. Dirrim     *
  *             June 1990 - February 1991                   *
  * ----------------------------------------------------- *
  * SHAKE91   : General cleanup and finalization of input/  *
  *             output format ... etc                       *
  *             by: I. M. Idriss                            *
  *             December 1991                               *
  ***************************************************
   MAX. NUMBER OF TERMS IN FOURIER TRANSFORM =     32768
   NECESSARY LENGTH OF BLANK COMMON X        =    204819
      Option NO.    1   is started.

1******   OPTION  1  ***  READ RELATION BETWEEN SOIL PROPERTIES AND STRAIN

  **********************
   MATERIAL TYPE NO. 4
  **********************

  CURVE NO.  7:      #4 modulus for waste (Zekkos et al., 2006)
  CURVE NO.  8:        damping for waste (Zekkos et al., 2006)
```

CURVE NO. 7		CURVE NO. 8	
STRAIN	G/Gmax	STRAIN	DAMPING
0.0001	1.000	0.0001	4.00
0.0003	0.996	0.0003	4.10
0.0010	0.990	0.0010	4.10
0.0030	0.975	0.0030	4.20
0.0100	0.936	0.0100	4.50
0.0300	0.856	0.0300	5.20
0.1000	0.690	0.1000	7.20
0.3000	0.475	0.3000	10.50
1.0000	0.252	1.0000	14.00
3.0000	0.121	3.0000	23.50
8.0000	0.058	10.0000	28.00

```
  **********************
```

MATERIAL TYPE NO. 2
****

CURVE NO. 3: #2 modulus for sand (seed & idriss 1970) - upper Range
CURVE NO. 4: damping for sand (Idriss 1990) - (about LRng from SI

CURVE NO. 3		CURVE NO. 4	
STRAIN	G/Gmax	STRAIN	DAMPING
0.0001	1.000	0.0001	0.24
0.0003	1.000	0.0003	0.42
0.0010	0.990	0.0010	0.80
0.0030	0.960	0.0030	1.40
0.0100	0.850	0.0100	2.80
0.0300	0.640	0.0300	5.10
0.1000	0.370	0.1000	9.80
0.3000	0.180	0.3000	15.50
1.0000	0.080	1.0000	21.00
3.0000	0.050	3.0000	25.00
10.0000	0.035	10.0000	28.00

****
MATERIAL TYPE NO. 3
****

CURVE NO. 5: #3 ATTENUATION OF ROCK AVERAGE
CURVE NO. 6: DAMPING IN ROCK

CURVE NO. 5		CURVE NO. 6	
STRAIN	G/Gmax	STRAIN	DAMPING
0.0001	1.000	0.0001	0.40
0.0003	1.000	0.0010	0.80
0.0010	0.988	0.0100	1.50
0.0030	0.952	0.1000	3.00
0.0100	0.900	1.0000	4.60
0.0300	0.810	0.0000	0.00
0.1000	0.725	0.0000	0.00
1.0000	0.550	0.0000	0.00

Option NO. 1 has been concluded.
Option NO. 2 is started.

1****** OPTION 2 *** READ SOIL PROFILE
NEW SOIL PROFILE NO. 1 IDENTIFICATION Chevron Tank Battery 9, A-A', Lompr
NUMBER OF LAYERS 20 DEPTH TO BEDROCK 500.00

NO.	TYPE	THICKNESS (ft)	DEPTH (ft)	Tot. PRESS. (ksf)	MODULUS (ksf)	DAMPING	UNIT WT. (kcf)	SHEAR VEL (fps)
1	2	5.00	2.50	0.30	600.	0.050	0.120	401.2
2	2	10.00	10.00	1.20	949.	0.050	0.120	504.6
3	2	10.00	20.00	2.40	1273.	0.050	0.120	584.5
4	2	10.00	30.00	3.60	1530.	0.050	0.120	640.7
5	2	10.00	40.00	4.80	1749.	0.050	0.120	685.1
6	2	10.00	50.00	6.00	1944.	0.050	0.120	722.2
7	2	5.00	57.50	6.90	2078.	0.050	0.120	746.7
8	2	20.00	70.00	8.40	2361.	0.050	0.120	795.9

```
   9    2     20.00     90.00     10.80       2667.   0.050    0.120     846.0
  10    2     20.00    110.00     13.20       2872.   0.050    0.120     877.9
  11    2     20.00    130.00     15.60       2998.   0.050    0.120     896.9
  12    2     40.00    160.00     19.30       4354.   0.050    0.125    1059.1
  13    2     40.00    200.00     24.30       4686.   0.050    0.125    1098.7
  14    2     40.00    240.00     29.30       5995.   0.050    0.125    1242.7
  15    2     40.00    280.00     34.30       5286.   0.050    0.125    1166.9
  16    2     50.00    325.00     39.92       5596.   0.050    0.125    1200.6
  17    2     50.00    375.00     46.17       5921.   0.050    0.125    1235.0
  18    2     50.00    425.00     52.42       6229.   0.050    0.125    1266.7
  19    2     50.00    475.00     58.67       6522.   0.050    0.125    1296.2
  20   BASE                                 26203.   0.020    0.135    2500.0

  PERIOD = 1.86 FROM AVERAGE SHEAR VELOCITY =   1076.


  FREQUENCY    AMPLITUDE
 MAXIMUM AMPLIFICATION =  13.90
 FOR FREQUENCY         =   0.60 C/SEC.
     PERIOD            =   1.66 SEC.
     Option NO.    2   has been concluded.
     Option NO.    3   is started.

1******   OPTION  3  ***  READ INPUT MOTION

  FILE NAME FOR INPUT MOTION = Lompr.acc
    NO. OF INPUT ACC. POINTS = 12748
   NO. OF POINTS USED IN FFT = 16384
        NO. OF HEADING LINES =     2
      NO. OF POINTS PER LINE =     1
  TIME STEP FOR INPUT MOTION = 0.0050
  FORMAT FOR OF TIME HISTORY = (1E11.3)


  READING INPUT MOTION FROM ----> Lompr.acc
  FORMAT OF INPUT MOTION USED --> (1E11.3)

 ***** H E A D E R
Loma Prieta, 10/18/1989, San Jose - Santa Teresa Hills, 315
 12749   0.005
 **  FIRST & LAST 5 LINES OF INPUT MOTION *****

     1  0.000000
     2  0.000000
     3  0.000000
     4  0.000000
     5  0.000000
   ........ INPUT MOTION READ NOT ECHOED..........
 12744 -0.000361
 12745 -0.000362
 12746 -0.000363
 12747 -0.000365
 12748 -0.000366

 MAXIMUM ACCELERATION =  0.47140
 AT TIME              = 54.83 SEC
 THE VALUES WILL BE MULTIPLIED BY A FACTOR =  1.018
 TO GIVE NEW MAXIMUM ACCELERATION          =  0.48000
 MEAN SQUARE FREQUENCY =      50.00 C/SEC.
  MAX ACCELERATION =    0.48000 FOR FREQUENCIES REMOVED ABOVE     100.00 C/SEC.
```

```
     Option NO.    3   has been concluded.
     Option NO.    4   is started.
1******   OPTION  4  ***  READ WHERE OBJECT MOTION IS GIVEN
   OBJECT MOTION IN LAYER NUMBER  20 OUTCROPPING
     Option NO.    4   has been concluded.
     Option NO.    5   is started.

1******   OPTION  5  ***  OBTAIN STRAIN COMPATIBLE SOIL PROPERTIES
  MAXIMUM NUMBER OF ITERATIONS                =     6
  FACTOR FOR UNIFORM STRAIN IN TIME DOMAIN    =   0.65



+              ITERATION NUMBER  1
     EARTHQUAKE   - Lompr.acc
     SOIL PROFILE - Chevron Tank Battery 9, A-A', Lompr

  ITERATION NUMBER  1

  VALUES IN TIME DOMAIN
```

NO	TYPE	DEPTH (FT)	UNIFRM. STRAIN	<---- DAMPING ----> NEW	USED	ERROR	<---- SHEAR MODULUS -----> NEW	USED	ERROR	G/Go RATIO
1	2	2.5	0.00971	0.028	0.050	-80.8	511.6	600.0	-17.3	1.000
2	2	10.0	0.02367	0.046	0.050	-8.6	650.4	949.0	-45.9	1.000
3	2	20.0	0.03266	0.054	0.050	7.9	790.5	1273.0	-61.0	1.000
4	2	30.0	0.03745	0.060	0.050	16.2	903.1	1530.0	-69.4	1.000
5	2	40.0	0.04015	0.062	0.050	19.8	1005.0	1749.0	-74.0	1.000
6	2	50.0	0.04183	0.064	0.050	21.8	1099.3	1944.0	-76.8	1.000
7	2	57.5	0.04293	0.065	0.050	23.1	1162.9	2078.0	-78.7	1.000
8	2	70.0	0.04188	0.064	0.050	21.9	1334.3	2361.0	-76.9	1.000
9	2	90.0	0.04083	0.063	0.050	20.7	1522.5	2667.0	-75.2	1.000
10	2	110.0	0.04142	0.064	0.050	21.4	1630.3	2872.0	-76.2	1.000
11	2	130.0	0.04439	0.066	0.050	24.6	1655.3	2998.0	-81.1	1.000
12	2	160.0	0.03372	0.056	0.050	10.0	2672.5	4354.0	-62.9	1.000
13	2	200.0	0.03773	0.060	0.050	16.6	2758.2	4686.0	-69.9	1.000
14	2	240.0	0.03626	0.058	0.050	14.4	3581.9	5995.0	-67.4	1.000
15	2	280.0	0.04518	0.067	0.050	25.4	2897.7	5286.0	-82.4	1.000
16	2	325.0	0.04313	0.065	0.050	23.3	3125.8	5596.0	-79.0	1.000
17	2	375.0	0.03833	0.061	0.050	17.4	3464.1	5921.0	-70.9	1.000
18	2	425.0	0.03847	0.061	0.050	17.6	3639.2	6229.0	-71.2	1.000
19	2	475.0	0.03757	0.060	0.050	16.4	3845.0	6522.0	-69.6	1.000

```
+              ITERATION NUMBER  2
1
     EARTHQUAKE   - Lompr.acc
     SOIL PROFILE - Chevron Tank Battery 9, A-A', Lompr

  ITERATION NUMBER  2

  VALUES IN TIME DOMAIN
```

NO	TYPE	DEPTH (FT)	UNIFRM. STRAIN	<---- DAMPING ----> NEW	USED	ERROR	<---- SHEAR MODULUS -----> NEW	USED	ERROR	G/Go RATIO
1	2	2.5	0.01117	0.030	0.028	8.8	497.3	511.6	-2.9	0.853
2	2	10.0	0.03454	0.057	0.046	18.5	577.3	650.4	-12.6	0.685
3	2	20.0	0.05336	0.073	0.054	26.1	650.3	790.5	-21.6	0.621
4	2	30.0	0.06507	0.081	0.060	26.5	713.6	903.1	-26.6	0.590
5	2	40.0	0.07227	0.085	0.062	26.9	774.5	1005.0	-29.8	0.575

6	2	50.0	0.07568	0.087	0.064	26.6	840.8	1099.3	-30.7	0.565
7	2	57.5	0.07627	0.087	0.065	25.7	895.1	1162.9	-29.9	0.560
8	2	70.0	0.07020	0.084	0.064	23.9	1060.9	1334.3	-25.8	0.565
9	2	90.0	0.06215	0.079	0.063	20.6	1271.3	1522.5	-19.8	0.571
10	2	110.0	0.05989	0.078	0.064	18.5	1392.8	1630.3	-17.1	0.568
11	2	130.0	0.07481	0.087	0.066	23.5	1304.4	1655.3	-26.9	0.552
12	2	160.0	0.05983	0.078	0.056	28.7	2112.6	2672.5	-26.5	0.614
13	2	200.0	0.06683	0.082	0.060	27.1	2157.3	2758.2	-27.9	0.589
14	2	240.0	0.05182	0.072	0.058	19.3	3101.8	3581.9	-15.5	0.597
15	2	280.0	0.06055	0.078	0.067	14.6	2550.6	2897.7	-13.6	0.548
16	2	325.0	0.05847	0.077	0.065	15.4	2743.9	3125.8	-13.9	0.559
17	2	375.0	0.05823	0.077	0.061	21.2	2908.9	3464.1	-19.1	0.585
18	2	425.0	0.06028	0.078	0.061	22.4	3011.7	3639.2	-20.8	0.584
19	2	475.0	0.06468	0.081	0.060	26.2	3050.5	3845.0	-26.0	0.590

```
+              ITERATION NUMBER  3
1
     EARTHQUAKE   - Lompr.acc
     SOIL PROFILE - Chevron Tank Battery 9, A-A', Lompr

  ITERATION NUMBER  3

  VALUES IN TIME DOMAIN
```

NO	TYPE	DEPTH (FT)	UNIFRM. STRAIN	<---- DAMPING ----> NEW	USED	ERROR	<---- SHEAR MODULUS -----> NEW	USED	ERROR	G/Go RATIO
1	2	2.5	0.00965	0.028	0.030	-9.9	511.9	497.3	2.9	0.829
2	2	10.0	0.03290	0.055	0.057	-3.5	587.7	577.3	1.8	0.608
3	2	20.0	0.05545	0.075	0.073	2.0	639.4	650.3	-1.7	0.511
4	2	30.0	0.07043	0.084	0.081	3.7	686.4	713.6	-4.0	0.466
5	2	40.0	0.07935	0.089	0.085	4.1	737.9	774.5	-5.0	0.443
6	2	50.0	0.08255	0.091	0.087	3.7	802.9	840.8	-4.7	0.432
7	2	57.5	0.08188	0.090	0.087	3.1	862.0	895.1	-3.8	0.431
8	2	70.0	0.07239	0.085	0.084	1.4	1044.7	1060.9	-1.6	0.449
9	2	90.0	0.06375	0.080	0.079	1.2	1256.0	1271.3	-1.2	0.477
10	2	110.0	0.06828	0.083	0.078	6.2	1308.4	1392.8	-6.5	0.485
11	2	130.0	0.08960	0.094	0.087	7.5	1183.1	1304.4	-10.3	0.435
12	2	160.0	0.06554	0.082	0.078	4.4	2023.5	2112.6	-4.4	0.485
13	2	200.0	0.06854	0.083	0.082	1.2	2130.9	2157.3	-1.2	0.460
14	2	240.0	0.04649	0.068	0.072	-6.2	3247.8	3101.8	4.5	0.517
15	2	280.0	0.06066	0.078	0.078	0.1	2548.5	2550.6	-0.1	0.483
16	2	325.0	0.06003	0.078	0.077	1.3	2711.0	2743.9	-1.2	0.490
17	2	375.0	0.06447	0.081	0.077	4.9	2773.7	2908.9	-4.9	0.491
18	2	425.0	0.07629	0.087	0.078	10.5	2682.8	3011.7	-12.3	0.483
19	2	475.0	0.08640	0.092	0.081	12.3	2626.9	3050.5	-16.1	0.468

```
+              ITERATION NUMBER  4
1
     EARTHQUAKE   - Lompr.acc
     SOIL PROFILE - Chevron Tank Battery 9, A-A', Lompr

  ITERATION NUMBER  4

  VALUES IN TIME DOMAIN
```

NO	TYPE	DEPTH (FT)	UNIFRM. STRAIN	<---- DAMPING ----> NEW	USED	ERROR	<---- SHEAR MODULUS -----> NEW	USED	ERROR	G/Go RATIO
1	2	2.5	0.00886	0.027	0.028	-3.7	516.6	511.9	0.9	0.853
2	2	10.0	0.03058	0.052	0.055	-5.5	603.3	587.7	2.6	0.619
3	2	20.0	0.05349	0.074	0.075	-1.9	649.6	639.4	1.6	0.502

4	2	30.0	0.06946	0.084	0.084	-0.6	691.1	686.4	0.7	0.449
5	2	40.0	0.07882	0.089	0.089	-0.3	740.5	737.9	0.4	0.422
6	2	50.0	0.08164	0.090	0.091	-0.5	807.7	802.9	0.6	0.413
7	2	57.5	0.08028	0.089	0.090	-0.9	871.2	862.0	1.1	0.415
8	2	70.0	0.06961	0.084	0.085	-1.8	1065.4	1044.7	1.9	0.442
9	2	90.0	0.06216	0.079	0.080	-1.2	1271.1	1256.0	1.2	0.471
10	2	110.0	0.07083	0.085	0.083	1.7	1284.8	1308.4	-1.8	0.456
11	2	130.0	0.09525	0.096	0.094	2.5	1142.0	1183.1	-3.6	0.395
12	2	160.0	0.06515	0.081	0.082	-0.3	2029.3	2023.5	0.3	0.465
13	2	200.0	0.06545	0.081	0.083	-2.2	2179.2	2130.9	2.2	0.455
14	2	240.0	0.04243	0.065	0.068	-5.5	3370.7	3247.8	3.6	0.542
15	2	280.0	0.05916	0.078	0.078	-1.3	2578.0	2548.5	1.1	0.482
16	2	325.0	0.06024	0.078	0.078	0.2	2706.6	2711.0	-0.2	0.484
17	2	375.0	0.06823	0.083	0.081	2.7	2698.3	2773.7	-2.8	0.468
18	2	425.0	0.08564	0.092	0.087	4.9	2521.3	2682.8	-6.4	0.431
19	2	475.0	0.09824	0.097	0.092	5.2	2439.1	2626.9	-7.7	0.403

```
+              ITERATION NUMBER  5
1
     EARTHQUAKE   - Lompr.acc
     SOIL PROFILE - Chevron Tank Battery 9, A-A', Lompr

  ITERATION NUMBER  5

  VALUES IN TIME DOMAIN
```

NO	TYPE	DEPTH (FT)	UNIFRM. STRAIN	<---- DAMPING ----> NEW	USED	ERROR	<---- SHEAR MODULUS -----> NEW	USED	ERROR	G/Go RATIO
1	2	2.5	0.00861	0.026	0.027	-1.3	518.2	516.6	0.3	0.861
2	2	10.0	0.02916	0.050	0.052	-2.7	612.5	603.3	1.5	0.636
3	2	20.0	0.05166	0.072	0.074	-1.9	659.5	649.6	1.5	0.510
4	2	30.0	0.06774	0.083	0.084	-1.2	699.7	691.1	1.2	0.452
5	2	40.0	0.07719	0.088	0.089	-0.9	748.7	740.5	1.1	0.423
6	2	50.0	0.07983	0.089	0.090	-1.0	817.5	807.7	1.2	0.415
7	2	57.5	0.07820	0.088	0.089	-1.2	883.5	871.2	1.4	0.419
8	2	70.0	0.06734	0.083	0.084	-1.6	1082.9	1065.4	1.6	0.451
9	2	90.0	0.06080	0.079	0.079	-1.1	1284.4	1271.1	1.0	0.477
10	2	110.0	0.07045	0.084	0.085	-0.2	1288.2	1284.8	0.3	0.447
11	2	130.0	0.09640	0.097	0.096	0.5	1133.9	1142.0	-0.7	0.381
12	2	160.0	0.06362	0.080	0.081	-1.2	2052.6	2029.3	1.1	0.466
13	2	200.0	0.06290	0.080	0.081	-1.9	2221.0	2179.2	1.9	0.465
14	2	240.0	0.04059	0.063	0.065	-2.8	3430.5	3370.7	1.7	0.562
15	2	280.0	0.05811	0.077	0.078	-0.9	2599.2	2578.0	0.8	0.488
16	2	325.0	0.06046	0.078	0.078	0.2	2702.0	2706.6	-0.2	0.484
17	2	375.0	0.06991	0.084	0.083	1.1	2666.1	2698.3	-1.2	0.456
18	2	425.0	0.09028	0.094	0.092	2.2	2447.5	2521.3	-3.0	0.405
19	2	475.0	0.10446	0.100	0.097	3.0	2363.9	2439.1	-3.2	0.374

```
+              ITERATION NUMBER  6
1
     EARTHQUAKE   - Lompr.acc
     SOIL PROFILE - Chevron Tank Battery 9, A-A', Lompr

  ITERATION NUMBER  6

  VALUES IN TIME DOMAIN
```

NO	TYPE	DEPTH (FT)	UNIFRM. STRAIN	<---- DAMPING ----> NEW	USED	ERROR	<---- SHEAR MODULUS -----> NEW	USED	ERROR	G/Go RATIO
1	2	2.5	0.00852	0.026	0.026	-0.4	518.8	518.2	0.1	0.864

2	2	10.0	0.02853	0.050	0.050	-0.9	616.5	612.5	0.6	0.645
3	2	20.0	0.05058	0.071	0.072	-1.2	665.6	659.5	0.9	0.518
4	2	30.0	0.06657	0.082	0.083	-0.8	705.7	699.7	0.8	0.457
5	2	40.0	0.07605	0.087	0.088	-0.7	754.5	748.7	0.8	0.428
6	2	50.0	0.07867	0.089	0.089	-0.6	823.9	817.5	0.8	0.421
7	2	57.5	0.07697	0.088	0.088	-0.7	890.8	883.5	0.8	0.425
8	2	70.0	0.06619	0.082	0.083	-0.8	1092.0	1082.9	0.8	0.459
9	2	90.0	0.06012	0.078	0.079	-0.6	1291.1	1284.4	0.5	0.482
10	2	110.0	0.06914	0.084	0.084	-0.9	1300.3	1288.2	0.9	0.449
11	2	130.0	0.09576	0.096	0.097	-0.3	1138.4	1133.9	0.4	0.378
12	2	160.0	0.06230	0.080	0.080	-1.0	2073.0	2052.6	1.0	0.471
13	2	200.0	0.06141	0.079	0.080	-1.2	2246.3	2221.0	1.1	0.474
14	2	240.0	0.03973	0.062	0.063	-1.3	3459.2	3430.5	0.8	0.572
15	2	280.0	0.05751	0.076	0.077	-0.5	2611.6	2599.2	0.5	0.492
16	2	325.0	0.06057	0.078	0.078	0.1	2699.6	2702.0	-0.1	0.483
17	2	375.0	0.07047	0.084	0.084	0.4	2655.6	2666.1	-0.4	0.450
18	2	425.0	0.09232	0.095	0.094	0.9	2416.3	2447.5	-1.3	0.393
19	2	475.0	0.10711	0.102	0.100	1.3	2335.7	2363.9	-1.2	0.362

VALUES IN TIME DOMAIN

LAYER	TYPE	THICKNESS FT	DEPTH FT	MAX STRAIN PRCNT	MAX STRESS PSF	TIME SEC
1	2	5.0	2.5	0.01311	67.96	55.53
2	2	10.0	10.0	0.04389	268.81	55.53
3	2	10.0	20.0	0.07781	513.22	55.53
4	2	10.0	30.0	0.10241	716.63	55.53
5	2	10.0	40.0	0.11700	875.93	55.52
6	2	10.0	50.0	0.12103	989.38	55.51
7	2	5.0	57.5	0.11841	1046.14	55.51
8	2	20.0	70.0	0.10184	1102.79	55.52
9	2	20.0	90.0	0.09250	1188.06	55.56
10	2	20.0	110.0	0.10637	1370.28	46.72
11	2	20.0	130.0	0.14732	1670.44	46.72
12	2	40.0	160.0	0.09585	1967.33	46.70
13	2	40.0	200.0	0.09447	2098.21	46.68
14	2	40.0	240.0	0.06112	2096.78	45.98
15	2	40.0	280.0	0.08848	2299.71	45.94
16	2	50.0	325.0	0.09319	2518.04	47.26
17	2	50.0	375.0	0.10841	2890.29	47.19
18	2	50.0	425.0	0.14203	3476.30	47.13
19	2	50.0	475.0	0.16478	3895.20	47.08

PERIOD = 2.76 FROM AVERAGE SHEAR VELOCITY = 726.

FREQUENCY AMPLITUDE
MAXIMUM AMPLIFICATION = 7.98
FOR FREQUENCY = 0.40 C/SEC.
PERIOD = 2.50 SEC.
Option NO. 5 has been concluded.
Option NO. 6 is started.

1****** OPTION 6 *** COMPUTE MOTION IN NEW SUBLAYERS

EARTHQUAKE -Lompr.acc
SOIL DEPOSIT - Chevron Tank Battery 9, A-A', Lompr

LAYER	DEPTH FT	MAX. ACC. G	TIME SEC	MEAN SQ. FR. C/SEC	ACC. RATIO QUIET ZONE	TH SAVED ACC. RECORD

WITHIN	0.0	0.22437	55.53	1.29	0.195	0
WITHIN	5.0	0.22063	55.53	1.26	0.196	0
WITHIN	15.0	0.20044	55.51	1.13	0.202	0
WITHIN	25.0	0.17651	55.49	1.00	0.205	0
WITHIN	35.0	0.14681	55.48	0.96	0.224	0
WITHIN	45.0	0.11672	55.45	0.98	0.281	0
WITHIN	55.0	0.11897	46.76	1.01	0.272	0
WITHIN	60.0	0.12717	46.74	1.03	0.252	0
WITHIN	80.0	0.15530	46.72	1.08	0.192	0
WITHIN	100.0	0.16301	46.70	1.17	0.158	0
WITHIN	120.0	0.14101	46.69	1.31	0.180	0
WITHIN	140.0	0.14087	55.25	1.43	0.192	0
WITHIN	180.0	0.15825	55.21	1.36	0.174	0
WITHIN	220.0	0.13707	55.16	1.49	0.197	0

Option NO. 6 has been concluded.
Option NO. 6 is started.

1****** OPTION 6 *** COMPUTE MOTION IN NEW SUBLAYERS

EARTHQUAKE -Lompr.acc
SOIL DEPOSIT - Chevron Tank Battery 9, A-A', Lompr

LAYER	DEPTH FT	MAX. ACC. G	TIME SEC	MEAN SQ. FR. C/SEC	ACC. RATIO QUIET ZONE	TH SAVED , ACC. RECORD
OUTCR.	260.0	0.25380	55.11	1.76	0.179	0
WITHIN	300.0	0.15010	55.07	1.71	0.190	0
WITHIN	350.0	0.15186	55.01	1.87	0.173	0
WITHIN	400.0	0.15494	54.95	2.13	0.153	0
WITHIN	450.0	0.15578	54.90	2.55	0.164	0
WITHIN	500.0	0.36139	54.83	50.03	0.154	0
WITHIN	500.0	0.36139	54.83	50.03	0.154	0

Option NO. 6 has been concluded.
Option NO. 7 is started.

1****** OPTION 7 *** COMPUTE STRESS/STRAIN HISTORY

COMPUTE STRESS OR STRAIN HISTORY AT THE TOP OF LAYER 8
SCALE FOR PLOTTING 0.0000
IDENTIFICATION - -- Stress at the top of layer

COMPUTE STRESS OR STRAIN HISTORY AT THE TOP OF LAYER 8
SCALE FOR PLOTTING 0.0000
IDENTIFICATION - -- Strain not saved
Option NO. 7 has been concluded.

```
  ***************************************************
  * SHAKE  --   A COMPUTER PROGRAM FOR EARTHQUAKE RESPONSE  *
  *             ANALYSIS OF HORIZONTALLY LAYERED SITES      *
  *             by: Per B. Schnabel & John Lysmer -- 1970   *
  * ----------------------------------------------------- *
  * shake85     IBM-PC version of SHAKE                     *
  *             by: S.S. (Willie) Lai, January 1985         *
  * ----------------------------------------------------- *
  * shake88   : New modulus reduction curves for clays added*
  *             using results from Sun et al (1988)         *
  *             by: J. I. Sun & Ramin Golesorkhi            *
  *             February 26, 1988                           *
  * ----------------------------------------------------- *
  * SHAKE90/91: Adjust last iteration; Input now is either  *
  *             Gmax or max Vs; up to 13 material types can *
  *             be specified by user; up to 50 Layers can   *
  *             be specified; object motion can be read in  *
  *             from a separate file and can have user      *
  *             specified format; Different periods for     *
  *             response spectral calculations; options     *
  *             are renumbered; and general cleanup         *
  *             by: J. I. Sun, I. M. Idriss & P. Dirrim     *
  *             June 1990 - February 1991                   *
  * ----------------------------------------------------- *
  * SHAKE91   : General cleanup and finalization of input/  *
  *             output format ... etc                       *
  *             by: I. M. Idriss                            *
  *             December 1991                               *
  ***************************************************
   MAX. NUMBER OF TERMS IN FOURIER TRANSFORM =     32768
   NECESSARY LENGTH OF BLANK COMMON X        =    204819
      Option NO.    1   is started.

1******   OPTION  1  ***  READ RELATION BETWEEN SOIL PROPERTIES AND STRAIN

  **********************
   MATERIAL TYPE NO. 4
  **********************

  CURVE NO.  7:      #4 modulus for waste (Zekkos et al., 2006)
  CURVE NO.  8:        damping for waste (Zekkos et al., 2006)
```

CURVE NO. 7		CURVE NO. 8	
STRAIN	G/Gmax	STRAIN	DAMPING
0.0001	1.000	0.0001	4.00
0.0003	0.996	0.0003	4.10
0.0010	0.990	0.0010	4.10
0.0030	0.975	0.0030	4.20
0.0100	0.936	0.0100	4.50
0.0300	0.856	0.0300	5.20
0.1000	0.690	0.1000	7.20
0.3000	0.475	0.3000	10.50
1.0000	0.252	1.0000	14.00
3.0000	0.121	3.0000	23.50
8.0000	0.058	10.0000	28.00

```
  **********************
```

MATERIAL TYPE NO. 2
****

CURVE NO. 3: #2 modulus for sand (seed & idriss 1970) - upper Range
CURVE NO. 4: damping for sand (Idriss 1990) - (about LRng from SI

CURVE NO. 3		CURVE NO. 4	
STRAIN	G/Gmax	STRAIN	DAMPING
0.0001	1.000	0.0001	0.24
0.0003	1.000	0.0003	0.42
0.0010	0.990	0.0010	0.80
0.0030	0.960	0.0030	1.40
0.0100	0.850	0.0100	2.80
0.0300	0.640	0.0300	5.10
0.1000	0.370	0.1000	9.80
0.3000	0.180	0.3000	15.50
1.0000	0.080	1.0000	21.00
3.0000	0.050	3.0000	25.00
10.0000	0.035	10.0000	28.00

****
MATERIAL TYPE NO. 3
****

CURVE NO. 5: #3 ATTENUATION OF ROCK AVERAGE
CURVE NO. 6: DAMPING IN ROCK

CURVE NO. 5		CURVE NO. 6	
STRAIN	G/Gmax	STRAIN	DAMPING
0.0001	1.000	0.0001	0.40
0.0003	1.000	0.0010	0.80
0.0010	0.988	0.0100	1.50
0.0030	0.952	0.1000	3.00
0.0100	0.900	1.0000	4.60
0.0300	0.810	0.0000	0.00
0.1000	0.725	0.0000	0.00
1.0000	0.550	0.0000	0.00

Option NO. 1 has been concluded.
Option NO. 2 is started.

1****** OPTION 2 *** READ SOIL PROFILE
NEW SOIL PROFILE NO. 1 IDENTIFICATION Chevron Tank Battery 9, A-A', Nridge
NUMBER OF LAYERS 20 DEPTH TO BEDROCK 500.00

NO.	TYPE	THICKNESS (ft)	DEPTH (ft)	Tot. PRESS. (ksf)	MODULUS (ksf)	DAMPING	UNIT WT. (kcf)	SHEAR VEL (fps)
1	2	5.00	2.50	0.30	600.	0.050	0.120	401.2
2	2	10.00	10.00	1.20	949.	0.050	0.120	504.6
3	2	10.00	20.00	2.40	1273.	0.050	0.120	584.5
4	2	10.00	30.00	3.60	1530.	0.050	0.120	640.7
5	2	10.00	40.00	4.80	1749.	0.050	0.120	685.1
6	2	10.00	50.00	6.00	1944.	0.050	0.120	722.2
7	2	5.00	57.50	6.90	2078.	0.050	0.120	746.7
8	2	20.00	70.00	8.40	2361.	0.050	0.120	795.9

```
   9    2     20.00     90.00     10.80       2667.   0.050    0.120     846.0
  10    2     20.00    110.00     13.20       2872.   0.050    0.120     877.9
  11    2     20.00    130.00     15.60       2998.   0.050    0.120     896.9
  12    2     40.00    160.00     19.30       4354.   0.050    0.125    1059.1
  13    2     40.00    200.00     24.30       4686.   0.050    0.125    1098.7
  14    2     40.00    240.00     29.30       5995.   0.050    0.125    1242.7
  15    2     40.00    280.00     34.30       5286.   0.050    0.125    1166.9
  16    2     50.00    325.00     39.92       5596.   0.050    0.125    1200.6
  17    2     50.00    375.00     46.17       5921.   0.050    0.125    1235.0
  18    2     50.00    425.00     52.42       6229.   0.050    0.125    1266.7
  19    2     50.00    475.00     58.67       6522.   0.050    0.125    1296.2
  20   BASE                                 26203.   0.020    0.135    2500.0

  PERIOD = 1.86 FROM AVERAGE SHEAR VELOCITY =   1076.


  FREQUENCY    AMPLITUDE
 MAXIMUM AMPLIFICATION =  13.90
 FOR FREQUENCY         =   0.60 C/SEC.
     PERIOD            =   1.66 SEC.
     Option NO.    2   has been concluded.
     Option NO.    3   is started.

1******   OPTION  3  ***  READ INPUT MOTION

  FILE NAME FOR INPUT MOTION = Nridge.acc
    NO. OF INPUT ACC. POINTS = 15790
   NO. OF POINTS USED IN FFT = 16384
        NO. OF HEADING LINES =     2
      NO. OF POINTS PER LINE =     1
  TIME STEP FOR INPUT MOTION = 0.0050
  FORMAT FOR OF TIME HISTORY = (1E11.3)


  READING INPUT MOTION FROM ----> Nridge.acc
  FORMAT OF INPUT MOTION USED --> (1E11.3)

 ***** H E A D E R
Northridge-01, 1/17/1994, Santa Susana Ground, 0
 15791   0.005
 **  FIRST & LAST 5 LINES OF INPUT MOTION *****

     1 -0.000005
     2 -0.000005
     3 -0.000005
     4 -0.000005
     5 -0.000005
   ........ INPUT MOTION READ NOT ECHOED..........
 15786  0.000160
 15787  0.000161
 15788  0.000161
 15789  0.000162
 15790  0.000163

 MAXIMUM ACCELERATION =  0.47114
 AT TIME              = 57.09 SEC
 THE VALUES WILL BE MULTIPLIED BY A FACTOR =  1.019
 TO GIVE NEW MAXIMUM ACCELERATION          =  0.48000
 MEAN SQUARE FREQUENCY =      50.00 C/SEC.
  MAX ACCELERATION =    0.48000 FOR FREQUENCIES REMOVED ABOVE     100.00 C/SEC.
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     Option NO.    3   has been concluded.
     Option NO.    4   is started.
1******   OPTION  4  ***  READ WHERE OBJECT MOTION IS GIVEN
   OBJECT MOTION IN LAYER NUMBER  20 OUTCROPPING
     Option NO.    4   has been concluded.
     Option NO.    5   is started.

1******   OPTION  5  ***  OBTAIN STRAIN COMPATIBLE SOIL PROPERTIES
  MAXIMUM NUMBER OF ITERATIONS                =     6
  FACTOR FOR UNIFORM STRAIN IN TIME DOMAIN    =   0.65



+              ITERATION NUMBER  1
     EARTHQUAKE   - Nridge.acc
     SOIL PROFILE - Chevron Tank Battery 9, A-A', Nridge

  ITERATION NUMBER  1

  VALUES IN TIME DOMAIN
```

NO	TYPE	DEPTH (FT)	UNIFRM. STRAIN	<---- DAMPING ----> NEW	USED	ERROR	<---- SHEAR MODULUS -----> NEW	USED	ERROR	G/Go RATIO
1	2	2.5	0.01085	0.030	0.050	-68.3	500.7	600.0	-19.8	1.000
2	2	10.0	0.02658	0.048	0.050	-3.2	629.3	949.0	-50.8	1.000
3	2	20.0	0.03725	0.059	0.050	15.9	752.9	1273.0	-69.1	1.000
4	2	30.0	0.04335	0.065	0.050	23.5	852.9	1530.0	-79.4	1.000
5	2	40.0	0.04696	0.068	0.050	27.0	943.6	1749.0	-85.3	1.000
6	2	50.0	0.04900	0.070	0.050	28.7	1030.3	1944.0	-88.7	1.000
7	2	57.5	0.04968	0.071	0.050	29.3	1094.9	2078.0	-89.8	1.000
8	2	70.0	0.04807	0.069	0.050	28.0	1261.5	2361.0	-87.2	1.000
9	2	90.0	0.04712	0.069	0.050	27.1	1436.8	2667.0	-85.6	1.000
10	2	110.0	0.04782	0.069	0.050	27.8	1537.7	2872.0	-86.8	1.000
11	2	130.0	0.04815	0.069	0.050	28.0	1600.6	2998.0	-87.3	1.000
12	2	160.0	0.03434	0.056	0.050	11.1	2654.8	4354.0	-64.0	1.000
13	2	200.0	0.03477	0.057	0.050	11.9	2844.1	4686.0	-64.8	1.000
14	2	240.0	0.03025	0.051	0.050	2.6	3825.6	5995.0	-56.7	1.000
15	2	280.0	0.03829	0.061	0.050	17.4	3093.9	5286.0	-70.9	1.000
16	2	325.0	0.04052	0.063	0.050	20.3	3204.1	5596.0	-74.7	1.000
17	2	375.0	0.03881	0.061	0.050	18.1	3447.4	5921.0	-71.8	1.000
18	2	425.0	0.03687	0.059	0.050	15.3	3698.7	6229.0	-68.4	1.000
19	2	475.0	0.03707	0.059	0.050	15.6	3864.6	6522.0	-68.8	1.000

```
+              ITERATION NUMBER  2
1
     EARTHQUAKE   - Nridge.acc
     SOIL PROFILE - Chevron Tank Battery 9, A-A', Nridge

  ITERATION NUMBER  2

  VALUES IN TIME DOMAIN
```

NO	TYPE	DEPTH (FT)	UNIFRM. STRAIN	<---- DAMPING ----> NEW	USED	ERROR	<---- SHEAR MODULUS -----> NEW	USED	ERROR	G/Go RATIO
1	2	2.5	0.01171	0.031	0.030	5.1	491.9	500.7	-1.8	0.834
2	2	10.0	0.03651	0.059	0.048	17.4	565.5	629.3	-11.3	0.663
3	2	20.0	0.05731	0.076	0.059	22.0	629.9	752.9	-19.5	0.591
4	2	30.0	0.06977	0.084	0.065	22.1	689.6	852.9	-23.7	0.557
5	2	40.0	0.07635	0.087	0.068	21.7	753.0	943.6	-25.3	0.540

6	2	50.0	0.07858	0.089	0.070	20.8	824.4	1030.3	-25.0	0.530
7	2	57.5	0.07813	0.088	0.071	20.0	883.9	1094.9	-23.9	0.527
8	2	70.0	0.07208	0.085	0.069	18.6	1046.9	1261.5	-20.5	0.534
9	2	90.0	0.06812	0.083	0.069	17.3	1216.4	1436.8	-18.1	0.539
10	2	110.0	0.07312	0.086	0.069	19.3	1264.3	1537.7	-21.6	0.535
11	2	130.0	0.07447	0.086	0.069	19.7	1307.4	1600.6	-22.4	0.534
12	2	160.0	0.05122	0.072	0.056	21.7	2264.2	2654.8	-17.3	0.610
13	2	200.0	0.06102	0.079	0.057	27.9	2252.9	2844.1	-26.2	0.607
14	2	240.0	0.05030	0.071	0.051	27.9	3141.9	3825.6	-21.8	0.638
15	2	280.0	0.06351	0.080	0.061	24.6	2493.9	3093.9	-24.1	0.585
16	2	325.0	0.06070	0.079	0.063	20.1	2697.0	3204.1	-18.8	0.573
17	2	375.0	0.05705	0.076	0.061	19.8	2936.1	3447.4	-17.4	0.582
18	2	425.0	0.05537	0.075	0.059	21.2	3130.5	3698.7	-18.1	0.594
19	2	475.0	0.06113	0.079	0.059	24.8	3133.1	3864.6	-23.3	0.593

+ ITERATION NUMBER 3
1
EARTHQUAKE - Nridge.acc
SOIL PROFILE - Chevron Tank Battery 9, A-A', Nridge

ITERATION NUMBER 3

VALUES IN TIME DOMAIN

NO	TYPE	DEPTH (FT)	UNIFRM. STRAIN	<---- DAMPING ----> NEW	USED	ERROR	<---- SHEAR MODULUS -----> NEW	USED	ERROR	G/Go RATIO
1	2	2.5	0.00904	0.027	0.031	-16.7	515.5	491.9	4.6	0.820
2	2	10.0	0.03087	0.052	0.059	-12.6	601.3	565.5	5.9	0.596
3	2	20.0	0.05212	0.073	0.076	-5.1	657.0	629.9	4.1	0.495
4	2	30.0	0.06640	0.082	0.084	-2.4	706.6	689.6	2.4	0.451
5	2	40.0	0.07694	0.088	0.087	0.3	749.9	753.0	-0.4	0.431
6	2	50.0	0.08210	0.090	0.089	1.9	805.3	824.4	-2.4	0.424
7	2	57.5	0.08289	0.091	0.088	2.5	856.3	883.9	-3.2	0.425
8	2	70.0	0.07622	0.087	0.085	2.5	1017.3	1046.9	-2.9	0.443
9	2	90.0	0.07225	0.085	0.083	2.7	1181.2	1216.4	-3.0	0.456
10	2	110.0	0.07594	0.087	0.086	1.7	1239.9	1264.3	-2.0	0.440
11	2	130.0	0.08363	0.091	0.086	5.0	1229.4	1307.4	-6.3	0.436
12	2	160.0	0.06000	0.078	0.072	7.9	2109.8	2264.2	-7.3	0.520
13	2	200.0	0.07061	0.084	0.079	6.7	2099.5	2252.9	-7.3	0.481
14	2	240.0	0.05207	0.073	0.071	1.9	3095.6	3141.9	-1.5	0.524
15	2	280.0	0.06567	0.082	0.080	1.6	2454.3	2493.9	-1.6	0.472
16	2	325.0	0.06276	0.080	0.079	1.6	2655.1	2697.0	-1.6	0.482
17	2	375.0	0.06664	0.082	0.076	7.4	2729.6	2936.1	-7.6	0.496
18	2	425.0	0.07144	0.085	0.075	11.7	2774.5	3130.5	-12.8	0.503
19	2	475.0	0.07643	0.088	0.079	10.0	2806.2	3133.1	-11.6	0.480

+ ITERATION NUMBER 4
1
EARTHQUAKE - Nridge.acc
SOIL PROFILE - Chevron Tank Battery 9, A-A', Nridge

ITERATION NUMBER 4

VALUES IN TIME DOMAIN

NO	TYPE	DEPTH (FT)	UNIFRM. STRAIN	<---- DAMPING ----> NEW	USED	ERROR	<---- SHEAR MODULUS -----> NEW	USED	ERROR	G/Go RATIO
1	2	2.5	0.00777	0.025	0.027	-7.0	523.8	515.5	1.6	0.859
2	2	10.0	0.02619	0.048	0.052	-8.2	632.0	601.3	4.9	0.634
3	2	20.0	0.04613	0.068	0.073	-7.0	691.9	657.0	5.0	0.516

4	2	30.0	0.06242	0.080	0.082	-3.0	727.8	706.6	2.9	0.462
5	2	40.0	0.07488	0.087	0.088	-1.2	760.6	749.9	1.4	0.429
6	2	50.0	0.08201	0.090	0.090	0.0	805.8	805.3	0.1	0.414
7	2	57.5	0.08386	0.091	0.091	0.5	850.9	856.3	-0.6	0.412
8	2	70.0	0.07734	0.088	0.087	0.6	1009.6	1017.3	-0.8	0.431
9	2	90.0	0.07372	0.086	0.085	0.9	1169.2	1181.2	-1.0	0.443
10	2	110.0	0.07715	0.088	0.087	0.7	1229.8	1239.9	-0.8	0.432
11	2	130.0	0.08730	0.093	0.091	1.8	1200.6	1229.4	-2.4	0.410
12	2	160.0	0.06255	0.080	0.078	2.0	2069.2	2109.8	-2.0	0.485
13	2	200.0	0.07251	0.085	0.084	1.2	2071.7	2099.5	-1.3	0.448
14	2	240.0	0.05075	0.072	0.073	-1.4	3130.0	3095.6	1.1	0.516
15	2	280.0	0.06431	0.081	0.082	-1.0	2479.2	2454.3	1.0	0.464
16	2	325.0	0.06302	0.080	0.080	0.2	2649.9	2655.1	-0.2	0.474
17	2	375.0	0.07179	0.085	0.082	3.4	2630.9	2729.6	-3.8	0.461
18	2	425.0	0.07870	0.089	0.085	4.3	2639.4	2774.5	-5.1	0.445
19	2	475.0	0.08231	0.090	0.088	3.2	2697.9	2806.2	-4.0	0.430

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+              ITERATION NUMBER  5
1
     EARTHQUAKE   - Nridge.acc
     SOIL PROFILE - Chevron Tank Battery 9, A-A', Nridge

  ITERATION NUMBER  5

  VALUES IN TIME DOMAIN
```

NO	TYPE	DEPTH (FT)	UNIFRM. STRAIN	<---- DAMPING ----> NEW	USED	ERROR	<---- SHEAR MODULUS -----> NEW	USED	ERROR	G/Go RATIO
1	2	2.5	0.00733	0.024	0.025	-2.8	527.0	523.8	0.6	0.873
2	2	10.0	0.02389	0.046	0.048	-4.2	648.7	632.0	2.6	0.666
3	2	20.0	0.04315	0.065	0.068	-4.0	710.9	691.9	2.7	0.543
4	2	30.0	0.05989	0.078	0.080	-2.1	742.0	727.8	1.9	0.476
5	2	40.0	0.07325	0.086	0.087	-1.0	769.2	760.6	1.1	0.435
6	2	50.0	0.08160	0.090	0.090	-0.2	807.9	805.8	0.3	0.414
7	2	57.5	0.08426	0.091	0.091	0.2	848.7	850.9	-0.3	0.409
8	2	70.0	0.07801	0.088	0.088	0.4	1005.0	1009.6	-0.5	0.428
9	2	90.0	0.07452	0.087	0.086	0.5	1162.7	1169.2	-0.6	0.438
10	2	110.0	0.07776	0.088	0.088	0.4	1224.6	1229.8	-0.4	0.428
11	2	130.0	0.08904	0.093	0.093	0.8	1187.3	1200.6	-1.1	0.400
12	2	160.0	0.06303	0.080	0.080	0.4	2061.7	2069.2	-0.4	0.475
13	2	200.0	0.07329	0.086	0.085	0.5	2060.4	2071.7	-0.5	0.442
14	2	240.0	0.05022	0.071	0.072	-0.6	3144.1	3130.0	0.4	0.522
15	2	280.0	0.06386	0.080	0.081	-0.3	2487.4	2479.2	0.3	0.469
16	2	325.0	0.06321	0.080	0.080	0.1	2646.1	2649.9	-0.1	0.474
17	2	375.0	0.07405	0.086	0.085	1.4	2589.6	2630.9	-1.6	0.444
18	2	425.0	0.08165	0.090	0.089	1.6	2587.9	2639.4	-2.0	0.424
19	2	475.0	0.08417	0.091	0.090	1.0	2665.1	2697.9	-1.2	0.414

```
+              ITERATION NUMBER  6
1
     EARTHQUAKE   - Nridge.acc
     SOIL PROFILE - Chevron Tank Battery 9, A-A', Nridge

  ITERATION NUMBER  6

  VALUES IN TIME DOMAIN
```

NO	TYPE	DEPTH (FT)	UNIFRM. STRAIN	<---- DAMPING ----> NEW	USED	ERROR	<---- SHEAR MODULUS -----> NEW	USED	ERROR	G/Go RATIO
1	2	2.5	0.00717	0.024	0.024	-1.1	528.3	527.0	0.2	0.878

2	2	10.0	0.02308	0.046	0.046	-1.6	654.9	648.7	1.0	0.684
3	2	20.0	0.04171	0.064	0.065	-2.1	720.6	710.9	1.3	0.558
4	2	30.0	0.05845	0.077	0.078	-1.2	750.3	742.0	1.1	0.485
5	2	40.0	0.07217	0.085	0.086	-0.7	775.0	769.2	0.7	0.440
6	2	50.0	0.08128	0.090	0.090	-0.2	809.6	807.9	0.2	0.416
7	2	57.5	0.08447	0.091	0.091	0.1	847.5	848.7	-0.1	0.408
8	2	70.0	0.07850	0.089	0.088	0.3	1001.7	1005.0	-0.3	0.426
9	2	90.0	0.07500	0.087	0.087	0.3	1158.9	1162.7	-0.3	0.436
10	2	110.0	0.07808	0.088	0.088	0.2	1222.0	1224.6	-0.2	0.426
11	2	130.0	0.08985	0.094	0.093	0.4	1181.2	1187.3	-0.5	0.396
12	2	160.0	0.06298	0.080	0.080	0.0	2062.5	2061.7	0.0	0.474
13	2	200.0	0.07365	0.086	0.086	0.2	2055.2	2060.4	-0.3	0.440
14	2	240.0	0.05004	0.071	0.071	-0.2	3149.1	3144.1	0.2	0.524
15	2	280.0	0.06374	0.080	0.080	-0.1	2489.7	2487.4	0.1	0.471
16	2	325.0	0.06330	0.080	0.080	0.1	2644.4	2646.1	-0.1	0.473
17	2	375.0	0.07504	0.087	0.086	0.6	2572.1	2589.6	-0.7	0.437
18	2	425.0	0.08286	0.091	0.090	0.6	2567.3	2587.9	-0.8	0.415
19	2	475.0	0.08464	0.091	0.091	0.2	2657.0	2665.1	-0.3	0.409

VALUES IN TIME DOMAIN

LAYER	TYPE	THICKNESS FT	DEPTH FT	MAX STRAIN PRCNT	MAX STRESS PSF	TIME SEC
1	2	5.0	2.5	0.01102	58.10	57.80
2	2	10.0	10.0	0.03550	230.30	52.63
3	2	10.0	20.0	0.06417	456.21	52.63
4	2	10.0	30.0	0.08992	667.22	52.63
5	2	10.0	40.0	0.11103	854.13	52.63
6	2	10.0	50.0	0.12505	1010.33	52.63
7	2	5.0	57.5	0.12996	1102.91	52.63
8	2	20.0	70.0	0.12078	1213.82	52.62
9	2	20.0	90.0	0.11538	1341.55	52.59
10	2	20.0	110.0	0.12013	1471.17	52.55
11	2	20.0	130.0	0.13824	1641.33	52.50
12	2	40.0	160.0	0.09689	1997.56	52.45
13	2	40.0	200.0	0.11331	2334.64	52.42
14	2	40.0	240.0	0.07698	2420.25	52.41
15	2	40.0	280.0	0.09806	2439.18	52.38
16	2	50.0	325.0	0.09738	2576.82	52.26
17	2	50.0	375.0	0.11544	2989.46	52.19
18	2	50.0	425.0	0.12748	3299.07	52.14
19	2	50.0	475.0	0.13022	3470.41	52.07

PERIOD = 2.77 FROM AVERAGE SHEAR VELOCITY = 723.

FREQUENCY AMPLITUDE
MAXIMUM AMPLIFICATION = 8.11
FOR FREQUENCY = 0.40 C/SEC.
PERIOD = 2.49 SEC.
Option NO. 5 has been concluded.
Option NO. 6 is started.

1****** OPTION 6 *** COMPUTE MOTION IN NEW SUBLAYERS

EARTHQUAKE -Nridge.acc
SOIL DEPOSIT - Chevron Tank Battery 9, A-A', Nridge

LAYER	DEPTH FT	MAX. ACC. G	TIME SEC	MEAN SQ. FR. C/SEC	ACC. RATIO QUIET ZONE	TH SAVED ACC. RECORD

WITHIN	0.0	0.19336	57.79	1.35	0.433	0
WITHIN	5.0	0.18996	57.79	1.33	0.436	0
WITHIN	15.0	0.18207	52.61	1.21	0.432	0
WITHIN	25.0	0.16842	52.61	1.07	0.438	0
WITHIN	35.0	0.14561	52.61	0.97	0.516	0
WITHIN	45.0	0.13644	56.71	0.95	0.574	0
WITHIN	55.0	0.13526	56.70	1.02	0.586	0
WITHIN	60.0	0.13185	56.69	1.07	0.597	0
WITHIN	80.0	0.13546	52.39	1.24	0.523	0
WITHIN	100.0	0.14510	52.41	1.30	0.394	0
WITHIN	120.0	0.14557	52.40	1.38	0.322	0
WITHIN	140.0	0.12583	52.38	1.51	0.326	0
WITHIN	180.0	0.11093	61.15	1.48	0.308	0
WITHIN	220.0	0.10872	57.42	1.57	0.351	0

Option NO. 6 has been concluded.
Option NO. 6 is started.

1****** OPTION 6 *** COMPUTE MOTION IN NEW SUBLAYERS

EARTHQUAKE -Nridge.acc
SOIL DEPOSIT - Chevron Tank Battery 9, A-A', Nridge

LAYER	DEPTH FT	MAX. ACC. G	TIME SEC	MEAN SQ. FR. C/SEC	ACC. RATIO QUIET ZONE	TH SAVED , ACC. RECORD
OUTCR.	260.0	0.22840	57.38	1.79	0.353	0
WITHIN	300.0	0.13353	52.16	1.80	0.304	0
WITHIN	350.0	0.13480	52.11	1.93	0.330	0
WITHIN	400.0	0.12947	52.05	2.10	0.328	0
WITHIN	450.0	0.14815	57.15	2.48	0.317	0
WITHIN	500.0	0.36786	57.09	49.36	0.266	0
WITHIN	500.0	0.36786	57.09	49.36	0.266	0

Option NO. 6 has been concluded.
Option NO. 7 is started.

1****** OPTION 7 *** COMPUTE STRESS/STRAIN HISTORY

COMPUTE STRESS OR STRAIN HISTORY AT THE TOP OF LAYER 8
SCALE FOR PLOTTING 0.0000
IDENTIFICATION - -- Stress at the top of layer

COMPUTE STRESS OR STRAIN HISTORY AT THE TOP OF LAYER 8
SCALE FOR PLOTTING 0.0000
IDENTIFICATION - -- Strain not saved
Option NO. 7 has been concluded.

```
  ***************************************************
  * SHAKE  --   A COMPUTER PROGRAM FOR EARTHQUAKE RESPONSE  *
  *             ANALYSIS OF HORIZONTALLY LAYERED SITES      *
  *             by: Per B. Schnabel & John Lysmer -- 1970   *
  * ----------------------------------------------------- *
  * shake85     IBM-PC version of SHAKE                     *
  *             by: S.S. (Willie) Lai, January 1985         *
  * ----------------------------------------------------- *
  * shake88   : New modulus reduction curves for clays added*
  *             using results from Sun et al (1988)         *
  *             by: J. I. Sun & Ramin Golesorkhi            *
  *             February 26, 1988                           *
  * ----------------------------------------------------- *
  * SHAKE90/91: Adjust last iteration; Input now is either  *
  *             Gmax or max Vs; up to 13 material types can *
  *             be specified by user; up to 50 Layers can   *
  *             be specified; object motion can be read in  *
  *             from a separate file and can have user      *
  *             specified format; Different periods for     *
  *             response spectral calculations; options     *
  *             are renumbered; and general cleanup         *
  *             by: J. I. Sun, I. M. Idriss & P. Dirrim     *
  *             June 1990 - February 1991                   *
  * ----------------------------------------------------- *
  * SHAKE91   : General cleanup and finalization of input/  *
  *             output format ... etc                       *
  *             by: I. M. Idriss                            *
  *             December 1991                               *
  ***************************************************
  MAX. NUMBER OF TERMS IN FOURIER TRANSFORM =     32768
  NECESSARY LENGTH OF BLANK COMMON X        =    204819
     Option NO.    1   is started.

1******   OPTION  1  ***  READ RELATION BETWEEN SOIL PROPERTIES AND STRAIN

 **********************
  MATERIAL TYPE NO. 4
 **********************

 CURVE NO.  7:      #4 modulus for waste (Zekkos et al., 2006)
 CURVE NO.  8:        damping for waste (Zekkos et al., 2006)
```

CURVE NO. 7		CURVE NO. 8	
STRAIN	G/Gmax	STRAIN	DAMPING
0.0001	1.000	0.0001	4.00
0.0003	0.996	0.0003	4.10
0.0010	0.990	0.0010	4.10
0.0030	0.975	0.0030	4.20
0.0100	0.936	0.0100	4.50
0.0300	0.856	0.0300	5.20
0.1000	0.690	0.1000	7.20
0.3000	0.475	0.3000	10.50
1.0000	0.252	1.0000	14.00
3.0000	0.121	3.0000	23.50
8.0000	0.058	10.0000	28.00

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MATERIAL TYPE NO. 2
****

CURVE NO. 3: #2 modulus for sand (seed & idriss 1970) - upper Range
CURVE NO. 4: damping for sand (Idriss 1990) - (about LRng from SI

CURVE NO. 3		CURVE NO. 4	
STRAIN	G/Gmax	STRAIN	DAMPING
0.0001	1.000	0.0001	0.24
0.0003	1.000	0.0003	0.42
0.0010	0.990	0.0010	0.80
0.0030	0.960	0.0030	1.40
0.0100	0.850	0.0100	2.80
0.0300	0.640	0.0300	5.10
0.1000	0.370	0.1000	9.80
0.3000	0.180	0.3000	15.50
1.0000	0.080	1.0000	21.00
3.0000	0.050	3.0000	25.00
10.0000	0.035	10.0000	28.00

****
MATERIAL TYPE NO. 3
****

CURVE NO. 5: #3 ATTENUATION OF ROCK AVERAGE
CURVE NO. 6: DAMPING IN ROCK

CURVE NO. 5		CURVE NO. 6	
STRAIN	G/Gmax	STRAIN	DAMPING
0.0001	1.000	0.0001	0.40
0.0003	1.000	0.0010	0.80
0.0010	0.988	0.0100	1.50
0.0030	0.952	0.1000	3.00
0.0100	0.900	1.0000	4.60
0.0300	0.810	0.0000	0.00
0.1000	0.725	0.0000	0.00
1.0000	0.550	0.0000	0.00

Option NO. 1 has been concluded.
Option NO. 2 is started.

1****** OPTION 2 *** READ SOIL PROFILE
NEW SOIL PROFILE NO. 1 IDENTIFICATION Chevron Tank Battery 9, A-A', Hector
NUMBER OF LAYERS 20 DEPTH TO BEDROCK 500.00

NO.	TYPE	THICKNESS (ft)	DEPTH (ft)	Tot. PRESS. (ksf)	MODULUS (ksf)	DAMPING	UNIT WT. (kcf)	SHEAR VEL (fps)
1	2	5.00	2.50	0.30	600.	0.050	0.120	401.2
2	2	10.00	10.00	1.20	949.	0.050	0.120	504.6
3	2	10.00	20.00	2.40	1273.	0.050	0.120	584.5
4	2	10.00	30.00	3.60	1530.	0.050	0.120	640.7
5	2	10.00	40.00	4.80	1749.	0.050	0.120	685.1
6	2	10.00	50.00	6.00	1944.	0.050	0.120	722.2
7	2	5.00	57.50	6.90	2078.	0.050	0.120	746.7
8	2	20.00	70.00	8.40	2361.	0.050	0.120	795.9

```
   9    2     20.00     90.00     10.80       2667.   0.050    0.120     846.0
  10    2     20.00    110.00     13.20       2872.   0.050    0.120     877.9
  11    2     20.00    130.00     15.60       2998.   0.050    0.120     896.9
  12    2     40.00    160.00     19.30       4354.   0.050    0.125    1059.1
  13    2     40.00    200.00     24.30       4686.   0.050    0.125    1098.7
  14    2     40.00    240.00     29.30       5995.   0.050    0.125    1242.7
  15    2     40.00    280.00     34.30       5286.   0.050    0.125    1166.9
  16    2     50.00    325.00     39.92       5596.   0.050    0.125    1200.6
  17    2     50.00    375.00     46.17       5921.   0.050    0.125    1235.0
  18    2     50.00    425.00     52.42       6229.   0.050    0.125    1266.7
  19    2     50.00    475.00     58.67       6522.   0.050    0.125    1296.2
  20   BASE                                 26203.   0.020    0.135    2500.0

  PERIOD = 1.86 FROM AVERAGE SHEAR VELOCITY =   1076.


  FREQUENCY    AMPLITUDE
 MAXIMUM AMPLIFICATION =  13.90
 FOR FREQUENCY         =   0.60 C/SEC.
     PERIOD            =   1.66 SEC.
     Option NO.    2   has been concluded.
     Option NO.    3   is started.

1******   OPTION  3  ***  READ INPUT MOTION

  FILE NAME FOR INPUT MOTION = HectorM.acc
    NO. OF INPUT ACC. POINTS =  5513
   NO. OF POINTS USED IN FFT = 16384
        NO. OF HEADING LINES =     2
      NO. OF POINTS PER LINE =     1
  TIME STEP FOR INPUT MOTION = 0.0100
  FORMAT FOR OF TIME HISTORY = (1E11.3)


  READING INPUT MOTION FROM ----> HectorM.acc
  FORMAT OF INPUT MOTION USED --> (1E11.3)

 ***** H E A D E R
Hector Mine, 10/16/1999, Hector, 0
 5513   0.01
 **  FIRST & LAST 5 LINES OF INPUT MOTION *****

     1 -0.000023
     2 -0.000023
     3 -0.000023
     4 -0.000024
     5 -0.000024
   ........ INPUT MOTION READ NOT ECHOED..........
  5509 -0.000830
  5510 -0.000840
  5511 -0.000850
  5512 -0.000859
  5513 -0.000868

 MAXIMUM ACCELERATION =  0.47631
 AT TIME              = 31.60 SEC
 THE VALUES WILL BE MULTIPLIED BY A FACTOR =  1.008
 TO GIVE NEW MAXIMUM ACCELERATION          =  0.48000
 MEAN SQUARE FREQUENCY =      25.00 C/SEC.
  MAX ACCELERATION =    0.48000 FOR FREQUENCIES REMOVED ABOVE      50.00 C/SEC.
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     Option NO.    3   has been concluded.
     Option NO.    4   is started.
1******   OPTION  4  ***  READ WHERE OBJECT MOTION IS GIVEN
   OBJECT MOTION IN LAYER NUMBER  20 OUTCROPPING
     Option NO.    4   has been concluded.
     Option NO.    5   is started.

1******   OPTION  5  ***  OBTAIN STRAIN COMPATIBLE SOIL PROPERTIES
  MAXIMUM NUMBER OF ITERATIONS                =     6
  FACTOR FOR UNIFORM STRAIN IN TIME DOMAIN    =   0.65



+              ITERATION NUMBER  1
     EARTHQUAKE   - HectorM.acc
     SOIL PROFILE - Chevron Tank Battery 9, A-A', Hector

  ITERATION NUMBER  1

  VALUES IN TIME DOMAIN
```

NO	TYPE	DEPTH (FT)	UNIFRM. STRAIN	<---- DAMPING ----> NEW	USED	ERROR	<---- SHEAR MODULUS -----> NEW	USED	ERROR	G/Go RATIO
1	2	2.5	0.01023	0.028	0.050	-75.6	507.4	600.0	-18.3	1.000
2	2	10.0	0.02532	0.047	0.050	-5.4	638.1	949.0	-48.7	1.000
3	2	20.0	0.03716	0.059	0.050	15.8	753.6	1273.0	-68.9	1.000
4	2	30.0	0.04523	0.067	0.050	25.4	838.3	1530.0	-82.5	1.000
5	2	40.0	0.05074	0.072	0.050	30.1	913.2	1749.0	-91.5	1.000
6	2	50.0	0.05409	0.074	0.050	32.4	987.2	1944.0	-96.9	1.000
7	2	57.5	0.05535	0.075	0.050	33.3	1044.5	2078.0	-98.9	1.000
8	2	70.0	0.05370	0.074	0.050	32.2	1202.8	2361.0	-96.3	1.000
9	2	90.0	0.05037	0.071	0.050	29.8	1397.0	2667.0	-90.9	1.000
10	2	110.0	0.04889	0.070	0.050	28.6	1523.6	2872.0	-88.5	1.000
11	2	130.0	0.05246	0.073	0.050	31.3	1543.0	2998.0	-94.3	1.000
12	2	160.0	0.04008	0.062	0.050	19.8	2503.7	4354.0	-73.9	1.000
13	2	200.0	0.03892	0.061	0.050	18.2	2725.5	4686.0	-71.9	1.000
14	2	240.0	0.03138	0.053	0.050	5.2	3776.2	5995.0	-58.8	1.000
15	2	280.0	0.03911	0.061	0.050	18.5	3068.8	5286.0	-72.3	1.000
16	2	325.0	0.03737	0.060	0.050	16.1	3305.7	5596.0	-69.3	1.000
17	2	375.0	0.03650	0.059	0.050	14.8	3528.9	5921.0	-67.8	1.000
18	2	425.0	0.03707	0.059	0.050	15.6	3691.0	6229.0	-68.8	1.000
19	2	475.0	0.03958	0.062	0.050	19.1	3768.9	6522.0	-73.0	1.000

```
+              ITERATION NUMBER  2
1
     EARTHQUAKE   - HectorM.acc
     SOIL PROFILE - Chevron Tank Battery 9, A-A', Hector

  ITERATION NUMBER  2

  VALUES IN TIME DOMAIN
```

NO	TYPE	DEPTH (FT)	UNIFRM. STRAIN	<---- DAMPING ----> NEW	USED	ERROR	<---- SHEAR MODULUS -----> NEW	USED	ERROR	G/Go RATIO
1	2	2.5	0.01243	0.033	0.028	12.5	485.0	507.4	-4.6	0.846
2	2	10.0	0.03905	0.061	0.047	22.6	551.3	638.1	-15.8	0.672
3	2	20.0	0.06403	0.081	0.059	26.4	598.3	753.6	-26.0	0.592
4	2	30.0	0.08184	0.090	0.067	25.7	634.9	838.3	-32.0	0.548
5	2	40.0	0.09271	0.095	0.072	24.8	676.8	913.2	-34.9	0.522

6	2	50.0	0.09689	0.097	0.074	23.5	733.0	987.2	-34.7	0.508
7	2	57.5	0.09626	0.097	0.075	22.4	786.6	1044.5	-32.8	0.503
8	2	70.0	0.08605	0.092	0.074	20.0	953.1	1202.8	-26.2	0.509
9	2	90.0	0.07730	0.088	0.071	19.0	1140.8	1397.0	-22.5	0.524
10	2	110.0	0.07619	0.087	0.070	19.8	1237.8	1523.6	-23.1	0.530
11	2	130.0	0.08536	0.092	0.073	20.7	1215.7	1543.0	-26.9	0.515
12	2	160.0	0.06158	0.079	0.062	21.2	2084.3	2503.7	-20.1	0.575
13	2	200.0	0.06378	0.080	0.061	24.0	2206.5	2725.5	-23.5	0.582
14	2	240.0	0.04725	0.069	0.053	23.2	3226.2	3776.2	-17.0	0.630
15	2	280.0	0.06006	0.078	0.061	21.4	2560.1	3068.8	-19.9	0.581
16	2	325.0	0.05853	0.077	0.060	22.7	2742.7	3305.7	-20.5	0.591
17	2	375.0	0.05933	0.078	0.059	24.4	2883.9	3528.9	-22.4	0.596
18	2	425.0	0.05812	0.077	0.059	22.9	3062.7	3691.0	-20.5	0.593
19	2	475.0	0.06114	0.079	0.062	21.6	3132.6	3768.9	-20.3	0.578

+ ITERATION NUMBER 3
1

EARTHQUAKE - HectorM.acc
SOIL PROFILE - Chevron Tank Battery 9, A-A', Hector

ITERATION NUMBER 3

VALUES IN TIME DOMAIN

NO	TYPE	DEPTH (FT)	UNIFRM. STRAIN	<---- DAMPING ----> NEW	USED	ERROR	<---- SHEAR MODULUS -----> NEW	USED	ERROR	G/Go RATIO
1	2	2.5	0.01062	0.029	0.033	-11.3	503.1	485.0	3.6	0.808
2	2	10.0	0.03655	0.059	0.061	-4.4	565.3	551.3	2.5	0.581
3	2	20.0	0.06432	0.081	0.081	0.2	597.0	598.3	-0.2	0.470
4	2	30.0	0.08461	0.091	0.090	1.4	623.5	634.9	-1.8	0.415
5	2	40.0	0.09572	0.096	0.095	1.3	664.3	676.8	-1.9	0.387
6	2	50.0	0.09736	0.097	0.097	0.2	730.9	733.0	-0.3	0.377
7	2	57.5	0.09374	0.095	0.097	-1.1	799.0	786.6	1.5	0.379
8	2	70.0	0.08431	0.091	0.092	-0.9	963.9	953.1	1.1	0.404
9	2	90.0	0.07961	0.089	0.088	1.3	1123.2	1140.8	-1.6	0.428
10	2	110.0	0.08378	0.091	0.087	4.1	1176.6	1237.8	-5.2	0.431
11	2	130.0	0.09795	0.097	0.092	5.5	1123.2	1215.7	-8.2	0.406
12	2	160.0	0.06441	0.081	0.079	2.2	2040.5	2084.3	-2.1	0.479
13	2	200.0	0.06400	0.081	0.080	0.2	2202.8	2206.5	-0.2	0.471
14	2	240.0	0.04630	0.068	0.069	-1.2	3253.5	3226.2	0.8	0.538
15	2	280.0	0.06211	0.079	0.078	1.6	2520.4	2560.1	-1.6	0.484
16	2	325.0	0.06192	0.079	0.077	2.8	2672.1	2742.7	-2.6	0.490
17	2	375.0	0.06108	0.079	0.078	1.4	2845.3	2883.9	-1.4	0.487
18	2	425.0	0.06537	0.081	0.077	5.6	2898.5	3062.7	-5.7	0.492
19	2	475.0	0.06857	0.083	0.079	5.4	2965.0	3132.6	-5.7	0.480

+ ITERATION NUMBER 4
1

EARTHQUAKE - HectorM.acc
SOIL PROFILE - Chevron Tank Battery 9, A-A', Hector

ITERATION NUMBER 4

VALUES IN TIME DOMAIN

NO	TYPE	DEPTH (FT)	UNIFRM. STRAIN	<---- DAMPING ----> NEW	USED	ERROR	<---- SHEAR MODULUS -----> NEW	USED	ERROR	G/Go RATIO
1	2	2.5	0.00990	0.028	0.029	-5.0	510.6	503.1	1.5	0.839
2	2	10.0	0.03448	0.056	0.059	-4.0	577.7	565.3	2.1	0.596
3	2	20.0	0.06223	0.079	0.081	-1.6	606.4	597.0	1.6	0.469

4	2	30.0	0.08311	0.091	0.091	-0.8	629.6	623.5	1.0	0.407
5	2	40.0	0.09402	0.096	0.096	-0.7	671.3	664.3	1.0	0.380
6	2	50.0	0.09416	0.096	0.097	-1.4	745.5	730.9	2.0	0.376
7	2	57.5	0.09083	0.094	0.095	-1.3	813.7	799.0	1.8	0.385
8	2	70.0	0.08301	0.091	0.091	-0.7	972.2	963.9	0.8	0.408
9	2	90.0	0.08055	0.090	0.089	0.5	1116.1	1123.2	-0.6	0.421
10	2	110.0	0.08603	0.092	0.091	1.1	1159.5	1176.6	-1.5	0.410
11	2	130.0	0.10378	0.100	0.097	2.7	1090.0	1123.2	-3.0	0.375
12	2	160.0	0.06407	0.081	0.081	-0.3	2045.6	2040.5	0.3	0.469
13	2	200.0	0.06240	0.080	0.081	-1.2	2229.5	2202.8	1.2	0.470
14	2	240.0	0.04490	0.067	0.068	-1.8	3294.8	3253.5	1.3	0.543
15	2	280.0	0.06144	0.079	0.079	-0.5	2533.3	2520.4	0.5	0.477
16	2	325.0	0.06145	0.079	0.079	-0.4	2681.6	2672.1	0.4	0.478
17	2	375.0	0.06133	0.079	0.079	0.2	2839.9	2845.3	-0.2	0.481
18	2	425.0	0.06823	0.083	0.081	2.0	2838.8	2898.5	-2.1	0.465
19	2	475.0	0.07135	0.085	0.083	1.8	2906.8	2965.0	-2.0	0.455

+ ITERATION NUMBER 5

1

EARTHQUAKE - HectorM.acc
SOIL PROFILE - Chevron Tank Battery 9, A-A', Hector

ITERATION NUMBER 5

VALUES IN TIME DOMAIN

NO	TYPE	DEPTH (FT)	UNIFRM. STRAIN	<---- DAMPING ----> NEW	USED	ERROR	<---- SHEAR MODULUS -----> NEW	USED	ERROR	G/Go RATIO
1	2	2.5	0.00966	0.028	0.028	-1.0	511.9	510.6	0.3	0.851
2	2	10.0	0.03346	0.055	0.056	-2.1	584.1	577.7	1.1	0.609
3	2	20.0	0.06079	0.079	0.079	-1.2	613.1	606.4	1.1	0.476
4	2	30.0	0.08172	0.090	0.091	-0.7	635.4	629.6	0.9	0.411
5	2	40.0	0.09251	0.095	0.096	-0.7	677.6	671.3	0.9	0.384
6	2	50.0	0.09196	0.095	0.096	-1.0	755.8	745.5	1.4	0.383
7	2	57.5	0.08910	0.093	0.094	-0.8	822.6	813.7	1.1	0.392
8	2	70.0	0.08228	0.090	0.091	-0.4	976.9	972.2	0.5	0.412
9	2	90.0	0.08083	0.090	0.090	0.2	1114.0	1116.1	-0.2	0.418
10	2	110.0	0.08678	0.092	0.092	0.4	1154.0	1159.5	-0.5	0.404
11	2	130.0	0.10648	0.101	0.100	1.3	1076.7	1090.0	-1.2	0.364
12	2	160.0	0.06365	0.080	0.081	-0.3	2052.1	2045.6	0.3	0.470
13	2	200.0	0.06143	0.079	0.080	-0.8	2245.9	2229.5	0.7	0.476
14	2	240.0	0.04411	0.066	0.067	-1.0	3318.5	3294.8	0.7	0.550
15	2	280.0	0.06063	0.078	0.079	-0.7	2548.9	2533.3	0.6	0.479
16	2	325.0	0.06073	0.079	0.079	-0.6	2696.4	2681.6	0.5	0.479
17	2	375.0	0.06120	0.079	0.079	-0.1	2842.8	2839.9	0.1	0.480
18	2	425.0	0.06949	0.084	0.083	0.9	2813.1	2838.8	-0.9	0.456
19	2	475.0	0.07262	0.086	0.085	0.8	2881.1	2906.8	-0.9	0.446

+ ITERATION NUMBER 6

1

EARTHQUAKE - HectorM.acc
SOIL PROFILE - Chevron Tank Battery 9, A-A', Hector

ITERATION NUMBER 6

VALUES IN TIME DOMAIN

NO	TYPE	DEPTH (FT)	UNIFRM. STRAIN	<---- DAMPING ----> NEW	USED	ERROR	<---- SHEAR MODULUS -----> NEW	USED	ERROR	G/Go RATIO
1	2	2.5	0.00961	0.028	0.028	-0.2	512.2	511.9	0.1	0.853

2	2	10.0	0.03303	0.055	0.055	-0.9	586.9	584.1	0.5	0.615
3	2	20.0	0.06003	0.078	0.079	-0.6	616.7	613.1	0.6	0.482
4	2	30.0	0.08091	0.090	0.090	-0.4	638.8	635.4	0.5	0.415
5	2	40.0	0.09165	0.095	0.095	-0.4	681.3	677.6	0.5	0.387
6	2	50.0	0.09081	0.094	0.095	-0.5	761.3	755.8	0.7	0.389
7	2	57.5	0.08816	0.093	0.093	-0.4	827.6	822.6	0.6	0.396
8	2	70.0	0.08191	0.090	0.090	-0.2	979.2	976.9	0.2	0.414
9	2	90.0	0.08087	0.090	0.090	0.0	1113.8	1114.0	0.0	0.418
10	2	110.0	0.08703	0.093	0.092	0.1	1152.1	1154.0	-0.2	0.402
11	2	130.0	0.10768	0.102	0.101	0.6	1070.9	1076.7	-0.5	0.359
12	2	160.0	0.06345	0.080	0.080	-0.2	2055.1	2052.1	0.1	0.471
13	2	200.0	0.06100	0.079	0.079	-0.3	2253.3	2245.9	0.3	0.479
14	2	240.0	0.04375	0.066	0.066	-0.5	3329.5	3318.5	0.3	0.554
15	2	280.0	0.06010	0.078	0.078	-0.4	2559.3	2548.9	0.4	0.482
16	2	325.0	0.06026	0.078	0.079	-0.4	2706.1	2696.4	0.4	0.482
17	2	375.0	0.06100	0.079	0.079	-0.2	2847.0	2842.8	0.1	0.480
18	2	425.0	0.07009	0.084	0.084	0.4	2801.2	2813.1	-0.4	0.452
19	2	475.0	0.07327	0.086	0.086	0.4	2868.1	2881.1	-0.5	0.442

VALUES IN TIME DOMAIN

LAYER	TYPE	THICKNESS FT	DEPTH FT	MAX STRAIN PRCNT	MAX STRESS PSF	TIME SEC
1	2	5.0	2.5	0.01478	75.68	30.57
2	2	10.0	10.0	0.05081	296.77	30.57
3	2	10.0	20.0	0.09236	566.25	30.57
4	2	10.0	30.0	0.12447	790.84	30.57
5	2	10.0	40.0	0.14100	955.49	30.57
6	2	10.0	50.0	0.13971	1055.95	30.57
7	2	5.0	57.5	0.13564	1115.78	32.30
8	2	20.0	70.0	0.12602	1231.00	32.29
9	2	20.0	90.0	0.12441	1386.00	32.25
10	2	20.0	110.0	0.13389	1545.08	30.72
11	2	20.0	130.0	0.16567	1783.77	30.74
12	2	40.0	160.0	0.09762	2003.23	30.74
13	2	40.0	200.0	0.09385	2107.68	30.70
14	2	40.0	240.0	0.06731	2233.68	30.64
15	2	40.0	280.0	0.09247	2356.89	30.60
16	2	50.0	325.0	0.09271	2499.97	30.55
17	2	50.0	375.0	0.09385	2668.05	29.86
18	2	50.0	425.0	0.10783	3033.47	29.81
19	2	50.0	475.0	0.11272	3247.53	29.76

PERIOD = 2.72 FROM AVERAGE SHEAR VELOCITY = 734.

FREQUENCY AMPLITUDE
MAXIMUM AMPLIFICATION = 8.65
FOR FREQUENCY = 0.41 C/SEC.
PERIOD = 2.43 SEC.
Option NO. 5 has been concluded.
Option NO. 6 is started.

1****** OPTION 6 *** COMPUTE MOTION IN NEW SUBLAYERS

EARTHQUAKE -HectorM.acc
SOIL DEPOSIT - Chevron Tank Battery 9, A-A', Hector

LAYER	DEPTH FT	MAX. ACC. G	TIME SEC	MEAN SQ. FR. C/SEC	ACC. RATIO QUIET ZONE	TH SAVED ACC. RECORD

WITHIN	0.0	0.25473	30.56	1.23	0.000	0
WITHIN	5.0	0.25223	30.56	1.21	0.000	0
WITHIN	15.0	0.23402	30.56	1.11	0.000	0
WITHIN	25.0	0.19781	30.56	0.97	0.000	0
WITHIN	35.0	0.15969	32.24	0.87	0.000	0
WITHIN	45.0	0.15167	32.20	0.85	0.000	0
WITHIN	55.0	0.15400	32.18	0.89	0.000	0
WITHIN	60.0	0.15465	32.17	0.93	0.000	0
WITHIN	80.0	0.15249	30.74	1.04	0.000	0
WITHIN	100.0	0.14192	30.35	1.14	0.000	0
WITHIN	120.0	0.13908	30.32	1.20	0.000	0
WITHIN	140.0	0.12808	30.29	1.27	0.000	0
WITHIN	180.0	0.12054	31.97	1.26	0.000	0
WITHIN	220.0	0.13410	31.91	1.34	0.000	0

Option NO. 6 has been concluded.
Option NO. 6 is started.

1****** OPTION 6 *** COMPUTE MOTION IN NEW SUBLAYERS

EARTHQUAKE -HectorM.acc
SOIL DEPOSIT - Chevron Tank Battery 9, A-A', Hector

LAYER	DEPTH FT	MAX. ACC. G	TIME SEC	MEAN SQ. FR. C/SEC	ACC. RATIO QUIET ZONE	TH SAVED , ACC. RECORD
OUTCR.	260.0	0.25637	31.87	1.58	0.000	0
WITHIN	300.0	0.14947	31.83	1.60	0.000	0
WITHIN	350.0	0.15724	31.77	1.78	0.000	0
WITHIN	400.0	0.16793	31.72	2.06	0.000	0
WITHIN	450.0	0.19681	31.66	4.56	0.000	0
WITHIN	500.0	0.35789	31.60	24.73	0.000	0
WITHIN	500.0	0.35789	31.60	24.73	0.000	0

Option NO. 6 has been concluded.
Option NO. 7 is started.

1****** OPTION 7 *** COMPUTE STRESS/STRAIN HISTORY

COMPUTE STRESS OR STRAIN HISTORY AT THE TOP OF LAYER 8
SCALE FOR PLOTTING 0.0000
IDENTIFICATION - -- Stress at the top of layer

COMPUTE STRESS OR STRAIN HISTORY AT THE TOP OF LAYER 8
SCALE FOR PLOTTING 0.0000
IDENTIFICATION - -- Strain not saved
Option NO. 7 has been concluded.

APPENDIX F

Permanent Displacement Analysis

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          ***********
    **                 **
    **   D I S P L M T   **
          ***********
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Chevron, Tank 9 Battery, Cross Section A-A', Lompr.acc

YIELD ACCELERATION = 0.1150

DT = 0.0050 ACCN DUE GRAVITY = 32.200 NLINES = 1593

A max = 0.14719 Acc Factor = 1.00000 Static F.S.= 1.510

*** COMPUTATION WITH ORIGINAL RECORD ***

Vmax = 0.02051 Ft/S Dfinal = 0.00655 Ft

*** COMPUTATION WITH REVERSED RECORD ***

Vmax = 0.11985 Ft/S Dfinal = 0.02495 Ft

** SUMMARY OF RESULTS **

RUN	V max Ft/S	V ave Ft/S	D final Ft	D final ave Ft
1	0.02051		0.00655	
		0.07018		0.01575
2	0.11985		0.02495	

*** PROGRAM TERMINATED ***

Chevron, Tank 9 Battery, Cross Section A-A', Lompr.acc
0 0.
1
0.115
0.005 32.2 1593
0 1.51

0.011247	0.011193	0.011130	0.011059	0.010980	0.010892	0.010794	0.010688
0.010573	0.010450	0.010320	0.010182	0.010037	0.009885	0.009728	0.009566
0.009399	0.009228	0.009053	0.008874	0.008693	0.008510	0.008324	0.008138
0.007951	0.007765	0.007580	0.007397	0.007216	0.007038	0.006865	0.006696
0.006531	0.006372	0.006217	0.006068	0.005924	0.005784	0.005650	0.005521
0.005396	0.005276	0.005161	0.005051	0.004947	0.004849	0.004758	0.004673
0.004597	0.004529	0.004471	0.004422	0.004383	0.004356	0.004339	0.004334
0.004340	0.004358	0.004387	0.004426	0.004477	0.004537	0.004607	0.004686
0.004774	0.004869	0.004971	0.005080	0.005195	0.005316	0.005442	0.005572
0.005708	0.005847	0.005991	0.006138	0.006289	0.006444	0.006602	0.006763
0.006928	0.007095	0.007266	0.007439	0.007614	0.007792	0.007972	0.008154
0.008338	0.008523	0.008708	0.008895	0.009081	0.009266	0.009450	0.009632
0.009811	0.009985	0.010154	0.010316	0.010471	0.010618	0.010754	0.010881
0.010996	0.011098	0.011187	0.011263	0.011324	0.011371	0.011403	0.011421
0.011423	0.011411	0.011384	0.011344	0.011290	0.011224	0.011146	0.011057
0.010957	0.010848	0.010731	0.010606	0.010473	0.010333	0.010188	0.010035
0.009877	0.009713	0.009544	0.009369	0.009188	0.009002	0.008810	0.008612
0.008408	0.008198	0.007982	0.007760	0.007531	0.007296	0.007055	0.006808
0.006555	0.006297	0.006033	0.005764	0.005490	0.005213	0.004932	0.004649
0.004363	0.004077	0.003790	0.003503	0.003218	0.002934	0.002653	0.002376
0.002103	0.001835	0.001572	0.001316	0.001066	0.000823	0.000587	0.000358
0.000138	-0.000075	-0.000280	-0.000477	-0.000667	-0.000849	-0.001023	-0.001191
-0.001352	-0.001507	-0.001655	-0.001798	-0.001935	-0.002067	-0.002195	-0.002318
-0.002437	-0.002552	-0.002663	-0.002771	-0.002876	-0.002978	-0.003076	-0.003173
-0.003267	-0.003359	-0.003448	-0.003536	-0.003622	-0.003706	-0.003789	-0.003870
-0.003950	-0.004028	-0.004106	-0.004182	-0.004257	-0.004330	-0.004403	-0.004475
-0.004546	-0.004615	-0.004684	-0.004752	-0.004818	-0.004884	-0.004949	-0.005012
-0.005074	-0.005135	-0.005195	-0.005253	-0.005310	-0.005366	-0.005420	-0.005473
-0.005524	-0.005573	-0.005621	-0.005667	-0.005712	-0.005754	-0.005795	-0.005834
-0.005871	-0.005906	-0.005939	-0.005970	-0.005999	-0.006026	-0.006051	-0.006074
-0.006094	-0.006113	-0.006129	-0.006143	-0.006154	-0.006163	-0.006170	-0.006174
-0.006176	-0.006175	-0.006172	-0.006167	-0.006159	-0.006148	-0.006135	-0.006120
-0.006103	-0.006083	-0.006061	-0.006036	-0.006010	-0.005981	-0.005950	-0.005918
-0.005883	-0.005847	-0.005809	-0.005769	-0.005728	-0.005685	-0.005641	-0.005595
-0.005548	-0.005501	-0.005452	-0.005402	-0.005351	-0.005299	-0.005246	-0.005193
-0.005138	-0.005083	-0.005028	-0.004971	-0.004914	-0.004857	-0.004798	-0.004739
-0.004680	-0.004620	-0.004559	-0.004498	-0.004436	-0.004374	-0.004312	-0.004248
-0.004185	-0.004121	-0.004057	-0.003992	-0.003928	-0.003863	-0.003798	-0.003733
-0.003668	-0.003603	-0.003538	-0.003473	-0.003409	-0.003345	-0.003281	-0.003218
-0.003156	-0.003094	-0.003033	-0.002973	-0.002913	-0.002855	-0.002798	-0.002741
-0.002686	-0.002632	-0.002579	-0.002527	-0.002477	-0.002428	-0.002380	-0.002334
-0.002290	-0.002247	-0.002205	-0.002165	-0.002127	-0.002090	-0.002056	-0.002022
-0.001991	-0.001961	-0.001933	-0.001907	-0.001882	-0.001859	-0.001838	-0.001819
-0.001802	-0.001786	-0.001772	-0.001760	-0.001749	-0.001740	-0.001733	-0.001727
-0.001723	-0.001720	-0.001719	-0.001720	-0.001721	-0.001724	-0.001729	-0.001734
-0.001741	-0.001749	-0.001758	-0.001768	-0.001778	-0.001790	-0.001803	-0.001816
-0.001829	-0.001843	-0.001858	-0.001873	-0.001888	-0.001904	-0.001919	-0.001935

-0.001950	-0.001966	-0.001981	-0.001996	-0.002010	-0.002024	-0.002037	-0.002050
-0.002062	-0.002073	-0.002083	-0.002092	-0.002100	-0.002107	-0.002112	-0.002116
-0.002119	-0.002120	-0.002120	-0.002118	-0.002115	-0.002110	-0.002103	-0.002095
-0.002085	-0.002073	-0.002059	-0.002043	-0.002025	-0.002006	-0.001985	-0.001962
-0.001937	-0.001910	-0.001881	-0.001851	-0.001818	-0.001785	-0.001749	-0.001712
-0.001673	-0.001632	-0.001590	-0.001546	-0.001501	-0.001454	-0.001406	-0.001357
-0.001306	-0.001254	-0.001201	-0.001147	-0.001091	-0.001035	-0.000977	-0.000919
-0.000860	-0.000800	-0.000739	-0.000678	-0.000616	-0.000553	-0.000491	-0.000427
-0.000364	-0.000300	-0.000236	-0.000172	-0.000108	-0.000044	0.000019	0.000083
0.000146	0.000209	0.000272	0.000334	0.000395	0.000456	0.000517	0.000576
0.000635	0.000694	0.000751	0.000808	0.000863	0.000918	0.000972	0.001025
0.001077	0.001128	0.001178	0.001227	0.001275	0.001322	0.001368	0.001413
0.001457	0.001500	0.001542	0.001583	0.001623	0.001662	0.001700	0.001738
0.001774	0.001809	0.001843	0.001877	0.001910	0.001941	0.001972	0.002003
0.002032	0.002060	0.002088	0.002115	0.002141	0.002166	0.002191	0.002215
0.002238	0.002260	0.002282	0.002303	0.002323	0.002343	0.002361	0.002379
0.002397	0.002413	0.002429	0.002445	0.002459	0.002473	0.002486	0.002499
0.002511	0.002522	0.002532	0.002542	0.002551	0.002559	0.002566	0.002573
0.002579	0.002584	0.002589	0.002593	0.002596	0.002598	0.002600	0.002601
0.002601	0.002600	0.002598	0.002596	0.002593	0.002589	0.002585	0.002580
0.002574	0.002567	0.002559	0.002551	0.002542	0.002532	0.002522	0.002510
0.002498	0.002486	0.002472	0.002458	0.002443	0.002428	0.002412	0.002395
0.002378	0.002360	0.002341	0.002322	0.002302	0.002282	0.002261	0.002240
0.002218	0.002196	0.002173	0.002150	0.002126	0.002102	0.002078	0.002053
0.002028	0.002002	0.001976	0.001950	0.001924	0.001897	0.001870	0.001843
0.001816	0.001789	0.001761	0.001734	0.001706	0.001678	0.001650	0.001622
0.001594	0.001566	0.001538	0.001510	0.001482	0.001454	0.001426	0.001398
0.001371	0.001343	0.001316	0.001289	0.001262	0.001235	0.001208	0.001182
0.001156	0.001130	0.001104	0.001079	0.001054	0.001029	0.001005	0.000981
0.000957	0.000934	0.000911	0.000888	0.000866	0.000844	0.000823	0.000802
0.000782	0.000761	0.000742	0.000723	0.000704	0.000686	0.000668	0.000651
0.000634	0.000617	0.000601	0.000586	0.000571	0.000556	0.000542	0.000528
0.000515	0.000502	0.000490	0.000478	0.000467	0.000456	0.000445	0.000435
0.000425	0.000416	0.000407	0.000398	0.000390	0.000382	0.000375	0.000368
0.000361	0.000354	0.000348	0.000342	0.000336	0.000331	0.000326	0.000321
0.000316	0.000311	0.000307	0.000303	0.000298	0.000294	0.000290	0.000287
0.000283	0.000279	0.000276	0.000272	0.000269	0.000265	0.000262	0.000258
0.000254	0.000251	0.000247	0.000243	0.000239	0.000235	0.000231	0.000227
0.000222	0.000218	0.000213	0.000208	0.000203	0.000197	0.000192	0.000186
0.000180	0.000173	0.000167	0.000160	0.000153	0.000145	0.000138	0.000130
0.000122	0.000113	0.000105	0.000096	0.000087	0.000077	0.000067	0.000057
0.000047	0.000036	0.000026	0.000015	0.000003	-0.000008	-0.000020	-0.000032
-0.000044	-0.000057	-0.000069	-0.000082	-0.000095	-0.000109	-0.000122	-0.000136
-0.000149	-0.000163	-0.000177	-0.000191	-0.000206	-0.000220	-0.000234	-0.000249
-0.000263	-0.000278	-0.000293	-0.000307	-0.000322	-0.000337	-0.000352	-0.000366
-0.000381	-0.000395	-0.000410	-0.000425	-0.000439	-0.000453	-0.000468	-0.000482
-0.000496	-0.000510	-0.000524	-0.000538	-0.000551	-0.000564	-0.000578	-0.000591
-0.000604	-0.000616	-0.000629	-0.000641	-0.000653	-0.000665	-0.000677	-0.000688
-0.000700	-0.000711	-0.000722	-0.000732	-0.000743	-0.000753	-0.000763	-0.000772
-0.000782	-0.000791	-0.000800	-0.000808	-0.000817	-0.000825	-0.000833	-0.000840
-0.000848	-0.000855	-0.000862	-0.000868	-0.000875	-0.000881	-0.000887	-0.000893
-0.000898	-0.000903	-0.000908	-0.000912	-0.000917	-0.000921	-0.000924	-0.000928
-0.000931	-0.000934	-0.000937	-0.000940	-0.000942	-0.000944	-0.000946	-0.000947

-0.000948	-0.000949	-0.000950	-0.000950	-0.000951	-0.000951	-0.000950	-0.000950
-0.000949	-0.000948	-0.000947	-0.000945	-0.000943	-0.000941	-0.000939	-0.000936
-0.000934	-0.000931	-0.000927	-0.000924	-0.000920	-0.000916	-0.000912	-0.000907
-0.000903	-0.000898	-0.000892	-0.000887	-0.000881	-0.000875	-0.000869	-0.000863
-0.000857	-0.000850	-0.000843	-0.000836	-0.000828	-0.000821	-0.000813	-0.000805
-0.000797	-0.000789	-0.000781	-0.000772	-0.000763	-0.000754	-0.000745	-0.000736
-0.000726	-0.000717	-0.000707	-0.000697	-0.000688	-0.000677	-0.000667	-0.000657
-0.000647	-0.000636	-0.000626	-0.000615	-0.000604	-0.000593	-0.000583	-0.000572
-0.000561	-0.000550	-0.000539	-0.000528	-0.000517	-0.000506	-0.000494	-0.000483
-0.000472	-0.000461	-0.000450	-0.000439	-0.000428	-0.000417	-0.000406	-0.000395
-0.000384	-0.000373	-0.000362	-0.000351	-0.000340	-0.000330	-0.000319	-0.000309
-0.000298	-0.000288	-0.000278	-0.000268	-0.000258	-0.000248	-0.000238	-0.000228
-0.000218	-0.000209	-0.000199	-0.000190	-0.000181	-0.000172	-0.000163	-0.000155
-0.000146	-0.000138	-0.000129	-0.000121	-0.000113	-0.000105	-0.000097	-0.000090
-0.000082	-0.000075	-0.000068	-0.000061	-0.000054	-0.000047	-0.000041	-0.000034
-0.000028	-0.000022	-0.000016	-0.000010	-0.000004	0.000001	0.000007	0.000012
0.000017	0.000022	0.000027	0.000032	0.000037	0.000041	0.000045	0.000050
0.000054	0.000058	0.000062	0.000065	0.000069	0.000073	0.000076	0.000080
0.000083	0.000086	0.000089	0.000092	0.000095	0.000098	0.000101	0.000104
0.000106	0.000109	0.000111	0.000114	0.000116	0.000119	0.000121	0.000123
0.000125	0.000128	0.000130	0.000132	0.000134	0.000136	0.000138	0.000140
0.000142	0.000144	0.000146	0.000148	0.000150	0.000152	0.000154	0.000156
0.000158	0.000160	0.000163	0.000164	0.000167	0.000169	0.000171	0.000173
0.000175	0.000177	0.000179	0.000181	0.000183	0.000186	0.000188	0.000190
0.000193	0.000195	0.000197	0.000199	0.000202	0.000204	0.000207	0.000209
0.000212	0.000214	0.000217	0.000219	0.000222	0.000224	0.000227	0.000229
0.000232	0.000235	0.000237	0.000240	0.000243	0.000245	0.000248	0.000251
0.000253	0.000256	0.000259	0.000262	0.000264	0.000267	0.000270	0.000272
0.000275	0.000278	0.000280	0.000283	0.000286	0.000288	0.000291	0.000293
0.000296	0.000298	0.000301	0.000303	0.000305	0.000308	0.000310	0.000312
0.000315	0.000317	0.000319	0.000321	0.000323	0.000325	0.000327	0.000329
0.000331	0.000333	0.000334	0.000336	0.000338	0.000339	0.000341	0.000342
0.000344	0.000345	0.000346	0.000348	0.000349	0.000350	0.000351	0.000352
0.000353	0.000353	0.000354	0.000355	0.000355	0.000356	0.000356	0.000357
0.000357	0.000357	0.000358	0.000358	0.000358	0.000358	0.000357	0.000357
0.000357	0.000357	0.000356	0.000356	0.000355	0.000354	0.000354	0.000353
0.000352	0.000350	0.000349	0.000348	0.000346	0.000345	0.000347	0.000344
0.000342	0.000341	0.000339	0.000337	0.000336	0.000334	0.000332	0.000330
0.000328	0.000326	0.000323	0.000321	0.000319	0.000317	0.000314	0.000312
0.000309	0.000306	0.000304	0.000301	0.000298	0.000295	0.000292	0.000289
0.000286	0.000283	0.000280	0.000276	0.000273	0.000270	0.000266	0.000263
0.000259	0.000256	0.000252	0.000249	0.000245	0.000241	0.000238	0.000234
0.000230	0.000226	0.000222	0.000218	0.000214	0.000210	0.000206	0.000202
0.000198	0.000194	0.000190	0.000186	0.000182	0.000178	0.000173	0.000169
0.000165	0.000161	0.000157	0.000153	0.000148	0.000144	0.000140	0.000136
0.000132	0.000128	0.000123	0.000119	0.000115	0.000111	0.000107	0.000103
0.000099	0.000095	0.000091	0.000087	0.000083	0.000079	0.000075	0.000071
0.000067	0.000063	0.000059	0.000056	0.000052	0.000048	0.000044	0.000041
0.000037	0.000034	0.000030	0.000027	0.000023	0.000020	0.000017	0.000013
0.000010	0.000007	0.000004	0.000001	-0.000002	-0.000005	-0.000008	-0.000011
-0.000014	-0.000017	-0.000019	-0.000022	-0.000025	-0.000027	-0.000030	-0.000032
-0.000035	-0.000037	-0.000039	-0.000042	-0.000044	-0.000046	-0.000048	-0.000050
-0.000052	-0.000054	-0.000056	-0.000058	-0.000060	-0.000061	-0.000063	-0.000065

-0.000066	-0.000068	-0.000069	-0.000071	-0.000072	-0.000074	-0.000075	-0.000076
-0.000078	-0.000079	-0.000080	-0.000081	-0.000082	-0.000083	-0.000084	-0.000085
-0.000086	-0.000087	-0.000088	-0.000089	-0.000090	-0.000091	-0.000092	-0.000092
-0.000093	-0.000094	-0.000094	-0.000095	-0.000096	-0.000096	-0.000097	-0.000098
-0.000098	-0.000098	-0.000099	-0.000099	-0.000100	-0.000100	-0.000101	-0.000101
-0.000102	-0.000102	-0.000102	-0.000103	-0.000103	-0.000103	-0.000104	-0.000104
-0.000104	-0.000105	-0.000105	-0.000105	-0.000105	-0.000106	-0.000106	-0.000106
-0.000107	-0.000107	-0.000107	-0.000107	-0.000107	-0.000108	-0.000108	-0.000108
-0.000108	-0.000108	-0.000109	-0.000109	-0.000109	-0.000109	-0.000109	-0.000109
-0.000110	-0.000110	-0.000110	-0.000110	-0.000110	-0.000110	-0.000111	-0.000111
-0.000111	-0.000111	-0.000111	-0.000111	-0.000111	-0.000112	-0.000112	-0.000112
-0.000112	-0.000112	-0.000112	-0.000112	-0.000112	-0.000112	-0.000112	-0.000112
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0.000376	0.000383	0.000388	0.000392	0.000395	0.000396	0.000397	0.000396
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0.003243	0.003243	0.003236	0.003221	0.003198	0.003167	0.003129	0.003083
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0.001794	0.002146	0.002483	0.002810	0.003132	0.003454	0.003783	0.004123
0.004480	0.004859	0.005267	0.005708	0.006187	0.006707	0.007274	0.007889
0.008556	0.009274	0.010044	0.010864	0.011732	0.012642	0.013589	0.014566
0.015563	0.016573	0.017583	0.018585	0.019566	0.020516	0.021422	0.022276
0.023066	0.023785	0.024423	0.024975	0.025436	0.025801	0.026069	0.026238
0.026311	0.026287	0.026171	0.025966	0.025677	0.025310	0.024870	0.024362
0.023790	0.023158	0.022471	0.021729	0.020936	0.020091	0.019196	0.018250
0.017255	0.016209	0.015114	0.013970	0.012778	0.011540	0.010258	0.008933
0.007567	0.006163	0.004722	0.003244	0.001732	0.000184	-0.001398	-0.003015
-0.004668	-0.006359	-0.008087	-0.009853	-0.011658	-0.013502	-0.015386	-0.017307
-0.019266	-0.021260	-0.023287	-0.025344	-0.027426	-0.029528	-0.031645	-0.033768
-0.035889	-0.037999	-0.040088	-0.042144	-0.044155	-0.046109	-0.047992	-0.049792
-0.051494	-0.053087	-0.054559	-0.055900	-0.057100	-0.058153	-0.059053	-0.059798
-0.060386	-0.060818	-0.061098	-0.061231	-0.061225	-0.061087	-0.060830	-0.060466
-0.060008	-0.059473	-0.058878	-0.058240	-0.057576	-0.056907	-0.056250	-0.055622
-0.055039	-0.054518	-0.054069	-0.053705	-0.053433	-0.053259	-0.053186	-0.053213
-0.053340	-0.053561	-0.053870	-0.054260	-0.054723	-0.055248	-0.055825	-0.056446
-0.057099	-0.057777	-0.058470	-0.059173	-0.059879	-0.060584	-0.061287	-0.061985
-0.062680	-0.063373	-0.064070	-0.064774	-0.065492	-0.066230	-0.066995	-0.067794
-0.068633	-0.069519	-0.070456	-0.071449	-0.072498	-0.073607	-0.074772	-0.075990
-0.077258	-0.078567	-0.079908	-0.081269	-0.082638	-0.083999	-0.085335	-0.086630
-0.087866	-0.089023	-0.090085	-0.091034	-0.091853	-0.092529	-0.093047	-0.093398
-0.093570	-0.093559	-0.093358	-0.092963	-0.092373	-0.091588	-0.090606	-0.089430
-0.088060	-0.086501	-0.084753	-0.082822	-0.080710	-0.078422	-0.075962	-0.073335
-0.070547	-0.067602	-0.064508	-0.061271	-0.057898	-0.054399	-0.050781	-0.047055
-0.043231	-0.039320	-0.035335	-0.031286	-0.027186	-0.023046	-0.018878	-0.014691
-0.010498	-0.006307	-0.002129	0.002028	0.006154	0.010241	0.014277	0.018254
0.022161	0.025987	0.029721	0.033351	0.036866	0.040257	0.043512	0.046624
0.049587	0.052394	0.055043	0.057533	0.059864	0.062039	0.064062	0.065940
0.067679	0.069288	0.070774	0.072148	0.073417	0.074590	0.075676	0.076681
0.077613	0.078477	0.079277	0.080018	0.080704	0.081336	0.081915	0.082442
0.082914	0.083330	0.083687	0.083980	0.084204	0.084353	0.084422	0.084405

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0.084299	0.084099	0.083804	0.083414	0.082930	0.082355	0.081696	0.080958
0.080149	0.079279	0.078354	0.077385	0.076379	0.075344	0.074287	0.073215
0.072133	0.071045	0.069955	0.068869	0.067787	0.066713	0.065649	0.064597
0.063558	0.062533	0.061521	0.060524	0.059539	0.058566	0.057601	0.056641
0.055683	0.054721	0.053750	0.052764	0.051757	0.050723	0.049655	0.048548
0.047396	0.046193	0.044937	0.043623	0.042249	0.040814	0.039317	0.037758
0.036138	0.034459	0.032722	0.030931	0.029088	0.027196	0.025258	0.023276
0.021254	0.019194	0.017098	0.014969	0.012808	0.010618	0.008400	0.006158
0.003895	0.001615	-0.000678	-0.002978	-0.005280	-0.007577	-0.009862	-0.012127
-0.014367	-0.016574	-0.018743	-0.020866	-0.022939	-0.024957	-0.026915	-0.028810
-0.030639	-0.032398	-0.034085	-0.035698	-0.037237	-0.038700	-0.040089	-0.041405
-0.042649	-0.043825	-0.044936	-0.045986	-0.046980	-0.047921	-0.048815	-0.049665
-0.050478	-0.051255	-0.052003	-0.052724	-0.053423	-0.054101	-0.054763	-0.055408
-0.056039	-0.056655	-0.057256	-0.057838	-0.058399	-0.058931	-0.059429	-0.059883
-0.060283	-0.060617	-0.060872	-0.061034	-0.061090	-0.061024	-0.060825	-0.060480
-0.059978	-0.059310	-0.058470	-0.057453	-0.056259	-0.054888	-0.053344	-0.051635
-0.049768	-0.047756	-0.045611	-0.043349	-0.040988	-0.038544	-0.036038	-0.033489
-0.030918	-0.028345	-0.025792	-0.023278	-0.020824	-0.018448	-0.016169	-0.014004
-0.011968	-0.010077	-0.008342	-0.006774	-0.005381	-0.004167	-0.003134	-0.002281
-0.001602	-0.001088	-0.000724	-0.000496	-0.000384	-0.000364	-0.000414	-0.000508
-0.000621	-0.000727	-0.000805	-0.000833	-0.000796	-0.000680	-0.000478	-0.000187
0.000192	0.000653	0.001183	0.001769	0.002394	0.003038	0.003681	0.004300
0.004877	0.005392	0.005827	0.006168	0.006401	0.006518	0.006512	0.006381
0.006123	0.005743	0.005247	0.004644	0.003946	0.003168	0.002328	0.001444
0.000536	-0.000374	-0.001266	-0.002120	-0.002916	-0.003636	-0.004266	-0.004792
-0.005203	-0.005493	-0.005655	-0.005688	-0.005590	-0.005364	-0.005015	-0.004548
-0.003971	-0.003295	-0.002532	-0.001694	-0.000795	0.000149	0.001124	0.002113
0.003102	0.004076	0.005021	0.005926	0.006780	0.007575	0.008304	0.008964
0.009553	0.010068	0.010512	0.010886	0.011192	0.011434	0.011613	0.011732
0.011791	0.011791	0.011731	0.011610	0.011425	0.011175	0.010854	0.010462
0.009995	0.009450	0.008827	0.008125	0.007345	0.006486	0.005553	0.004546
0.003471	0.002328	0.001124	-0.000139	-0.001457	-0.002826	-0.004243	-0.005705
-0.007208	-0.008748	-0.010323	-0.011928	-0.013560	-0.015214	-0.016887	-0.018576
-0.020275	-0.021982	-0.023692	-0.025403	-0.027112	-0.028815	-0.030511	-0.032197
-0.033872	-0.035533	-0.037181	-0.038814	-0.040432	-0.042034	-0.043620	-0.045191
-0.046745	-0.048283	-0.049805	-0.051308	-0.052790	-0.054251	-0.055685	-0.057088
-0.058455	-0.059778	-0.061048	-0.062254	-0.063387	-0.064433	-0.065379	-0.066211
-0.066918	-0.067486	-0.067904	-0.068166	-0.068265	-0.068200	-0.067971	-0.067583
-0.067045	-0.066368	-0.065568	-0.064662	-0.063668	-0.062607	-0.061499	-0.060367
-0.059230	-0.058109	-0.057021	-0.055983	-0.055009	-0.054112	-0.053301	-0.052585
-0.051968	-0.051454	-0.051043	-0.050736	-0.050530	-0.050421	-0.050404	-0.050475
-0.050626	-0.050851	-0.051146	-0.051503	-0.051917	-0.052385	-0.052902	-0.053464
-0.054068	-0.054713	-0.055394	-0.056110	-0.056858	-0.057634	-0.058437	-0.059263
-0.060110	-0.060975	-0.061857	-0.062753	-0.063665	-0.064591	-0.065535	-0.066499
-0.067487	-0.068501	-0.069548	-0.070630	-0.071751	-0.072916	-0.074125	-0.075379
-0.076679	-0.078021	-0.079401	-0.080815	-0.082256	-0.083715	-0.085182	-0.086647
-0.088097	-0.089520	-0.090903	-0.092234	-0.093502	-0.094694	-0.095801	-0.096814
-0.097726	-0.098532	-0.099227	-0.099808	-0.100273	-0.100621	-0.100848	-0.100955
-0.100937	-0.100791	-0.100511	-0.100089	-0.099517	-0.098784	-0.097878	-0.096787
-0.095497	-0.093998	-0.092277	-0.090328	-0.088142	-0.085717	-0.083051	-0.080145
-0.077004	-0.073632	-0.070036	-0.066223	-0.062202	-0.057980	-0.053567	-0.048969
-0.044199	-0.039266	-0.034182	-0.028963	-0.023625	-0.018187	-0.012670	-0.007098
-0.001494	0.004118	0.009713	0.015270	0.020767	0.026185	0.031509	0.036724

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0.041819	0.046784	0.051612	0.056296	0.060831	0.065211	0.069433	0.073492
0.077386	0.081112	0.084668	0.088051	0.091262	0.094298	0.097158	0.099841
0.102344	0.104662	0.106792	0.108728	0.110462	0.111989	0.113301	0.114393
0.115259	0.115895	0.116300	0.116474	0.116420	0.116143	0.115649	0.114948
0.114050	0.112965	0.111707	0.110287	0.108720	0.107019	0.105198	0.103270
0.101251	0.099155	0.096997	0.094794	0.092563	0.090319	0.088082	0.085869
0.083699	0.081589	0.079556	0.077618	0.075789	0.074084	0.072516	0.071097
0.069835	0.068739	0.067818	0.067077	0.066522	0.066158	0.065987	0.066013
0.066237	0.066659	0.067279	0.068091	0.069091	0.070271	0.071618	0.073121
0.074763	0.076525	0.078389	0.080333	0.082335	0.084373	0.086425	0.088470
0.090487	0.092456	0.094360	0.096182	0.097906	0.099519	0.101008	0.102362
0.103570	0.104623	0.105513	0.106233	0.106775	0.107136	0.107311	0.107296
0.107088	0.106688	0.106093	0.105306	0.104328	0.103164	0.101819	0.100298
0.098611	0.096767	0.094776	0.092650	0.090401	0.088043	0.085588	0.083048
0.080434	0.077755	0.075018	0.072229	0.069389	0.066500	0.063560	0.060566
0.057516	0.054404	0.051228	0.047987	0.044681	0.041311	0.037885	0.034409
0.030896	0.027360	0.023819	0.020290	0.016796	0.013358	0.009997	0.006735
0.003592	0.000588	-0.002261	-0.004939	-0.007433	-0.009731	-0.011822	-0.013699
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-0.020206	-0.019777	-0.019137	-0.018297	-0.017270	-0.016071	-0.014716	-0.013223
-0.011613	-0.009904	-0.008120	-0.006281	-0.004410	-0.002528	-0.000656	0.001188
0.002984	0.004718	0.006376	0.007946	0.009420	0.010792	0.012060	0.013222
0.014280	0.015239	0.016104	0.016882	0.017581	0.018210	0.018777	0.019291
0.019760	0.020194	0.020599	0.020983	0.021353	0.021716	0.022080	0.022453
0.022842	0.023257	0.023705	0.024196	0.024740	0.025345	0.026020	0.026773
0.027609	0.028535	0.029554	0.030669	0.031881	0.033188	0.034588	0.036081
0.037661	0.039326	0.041071	0.042894	0.044791	0.046760	0.048797	0.050900
0.053068	0.055297	0.057583	0.059923	0.062312	0.064744	0.067211	0.069706
0.072220	0.074745	0.077270	0.079786	0.082284	0.084754	0.087189	0.089581
0.091920	0.094200	0.096414	0.098553	0.100612	0.102580	0.104450	0.106213
0.107859	0.109378	0.110759	0.111991	0.113063	0.113965	0.114687	0.115220
0.115556	0.115688	0.115612	0.115323	0.114819	0.114098	0.113160	0.112004
0.110632	0.109043	0.107240	0.105223	0.102994	0.100555	0.097907	0.095053
0.091995	0.088737	0.085283	0.081640	0.077812	0.073809	0.069639	0.065311
0.060838	0.056230	0.051500	0.046662	0.041728	0.036713	0.031631	0.026495
0.021317	0.016110	0.010887	0.005657	0.000432	-0.004778	-0.009964	-0.015117
-0.020228	-0.025290	-0.030290	-0.035224	-0.040080	-0.044851	-0.049526	-0.054095
-0.058550	-0.062878	-0.067068	-0.071111	-0.074995	-0.078710	-0.082246	-0.085593
-0.088745	-0.091694	-0.094437	-0.096971	-0.099296	-0.101413	-0.103324	-0.105036
-0.106553	-0.107881	-0.109027	-0.109994	-0.110788	-0.111411	-0.111866	-0.112151
-0.112265	-0.112205	-0.111969	-0.111551	-0.110949	-0.110158	-0.109175	-0.108000
-0.106631	-0.105069	-0.103317	-0.101378	-0.099258	-0.096961	-0.094495	-0.091869
-0.089090	-0.086170	-0.083119	-0.079949	-0.076672	-0.073303	-0.069856	-0.066349
-0.062800	-0.059229	-0.055656	-0.052104	-0.048597	-0.045159	-0.041814	-0.038586
-0.035499	-0.032576	-0.029835	-0.027296	-0.024973	-0.022877	-0.021019	-0.019403
-0.018033	-0.016906	-0.016020	-0.015367	-0.014938	-0.014720	-0.014700	-0.014862
-0.015186	-0.015655	-0.016247	-0.016942	-0.017719	-0.018558	-0.019439	-0.020342
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-0.027233	-0.027720	-0.028143	-0.028502	-0.028801	-0.029042	-0.029226	-0.029358
-0.029440	-0.029474	-0.029462	-0.029406	-0.029306	-0.029163	-0.028975	-0.028739
-0.028454	-0.028115	-0.027716	-0.027252	-0.026716	-0.026101	-0.025400	-0.024608
-0.023717	-0.022723	-0.021623	-0.020415	-0.019097	-0.017671	-0.016139	-0.014506
-0.012776	-0.010958	-0.009060	-0.007092	-0.005066	-0.002996	-0.000886	0.001218

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0.003329	0.005416	0.007462	0.009445	0.011346	0.013143	0.014818	0.016351
0.017726	0.018928	0.019942	0.020759	0.021371	0.021773	0.021960	0.021934
0.021694	0.021244	0.020588	0.019732	0.018681	0.017443	0.016024	0.014430
0.012671	0.010751	0.008680	0.006464	0.004110	0.001628	-0.000975	-0.003691
-0.006510	-0.009422	-0.012417	-0.015486	-0.018618	-0.021802	-0.025028	-0.028287
-0.031568	-0.034863	-0.038163	-0.041459	-0.044743	-0.048008	-0.051243	-0.054441
-0.057593	-0.060691	-0.063724	-0.066683	-0.069560	-0.072345	-0.075030	-0.077608
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-0.095331	-0.096688	-0.097934	-0.099073	-0.100112	-0.101056	-0.101910	-0.102679
-0.103370	-0.103984	-0.104526	-0.104997	-0.105399	-0.105731	-0.105991	-0.106178
-0.106289	-0.106320	-0.106267	-0.106126	-0.105896	-0.105573	-0.105156	-0.104645
-0.104043	-0.103352	-0.102577	-0.101724	-0.100800	-0.099813	-0.098771	-0.097684
-0.096559	-0.095406	-0.094233	-0.093048	-0.091858	-0.090668	-0.089485	-0.088313
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-0.066805	-0.064920	-0.062898	-0.060732	-0.058416	-0.055947	-0.053325	-0.050549
-0.047623	-0.044553	-0.041346	-0.038012	-0.034562	-0.031011	-0.027373	-0.023662
-0.019894	-0.016084	-0.012246	-0.008393	-0.004537	-0.000686	0.003152	0.006970
0.010764	0.014531	0.018266	0.021969	0.025636	0.029266	0.032856	0.036402
0.039903	0.043356	0.046757	0.050106	0.053398	0.056635	0.059813	0.062932
0.065992	0.068992	0.071930	0.074805	0.077615	0.080356	0.083024	0.085616
0.088124	0.090544	0.092869	0.095093	0.097210	0.099213	0.101097	0.102857
0.104489	0.105991	0.107359	0.108593	0.109693	0.110660	0.111496	0.112203
0.112787	0.113250	0.113600	0.113842	0.113983	0.114031	0.113992	0.113875
0.113687	0.113436	0.113127	0.112767	0.112360	0.111908	0.111415	0.110880
0.110305	0.109687	0.109026	0.108320	0.107566	0.106763	0.105909	0.105004
0.104046	0.103038	0.101980	0.100876	0.099731	0.098551	0.097344	0.096119
0.094885	0.093654	0.092435	0.091239	0.090077	0.088956	0.087883	0.086862
0.085898	0.084989	0.084133	0.083325	0.082558	0.081821	0.081103	0.080391
0.079671	0.078929	0.078150	0.077322	0.076431	0.075466	0.074418	0.073278
0.072040	0.070699	0.069252	0.067698	0.066036	0.064267	0.062393	0.060417
0.058342	0.056172	0.053913	0.051571	0.049152	0.046665	0.044117	0.041517
0.038876	0.036204	0.033511	0.030808	0.028105	0.025412	0.022738	0.020092
0.017483	0.014916	0.012398	0.009935	0.007528	0.005183	0.002899	0.000677
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0.004906	0.006436	0.007994	0.009578	0.011186	0.012815	0.014463	0.016123
0.017791	0.019461	0.021126	0.022780	0.024412	0.026013	0.027572	0.029075
0.030508	0.031856	0.033104	0.034235	0.035234	0.036085	0.036776	0.037293
0.037629	0.037775	0.037727	0.037483	0.037044	0.036415	0.035603	0.034615
0.033464	0.032164	0.030727	0.029170	0.027508	0.025758	0.023936	0.022057
0.020136	0.018187	0.016223	0.014255	0.012295	0.010350	0.008429	0.006538
0.004681	0.002862	0.001085	-0.000650	-0.002341	-0.003988	-0.005591	-0.007150
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0.003884	0.007221	0.010607	0.014033	0.017488	0.020963	0.024448	0.027935
0.031414	0.034878	0.038318	0.041729	0.045102	0.048432	0.051710	0.054929
0.058083	0.061162	0.064156	0.067056	0.069850	0.072528	0.075078	0.077488
0.079748	0.081849	0.083781	0.085537	0.087113	0.088503	0.089706	0.090719
0.091544	0.092182	0.092632	0.092897	0.092980	0.092880	0.092600	0.092140
0.091498	0.090672	0.089659	0.088455	0.087053	0.085448	0.083632	0.081600
0.079347	0.076872	0.074174	0.071260	0.068138	0.064822	0.061329	0.057683
0.053907	0.050029	0.046074	0.042069	0.038038	0.033999	0.029970	0.025961
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0.015142	0.019801	0.024412	0.028963	0.033445	0.037847	0.042161	0.046375
0.050481	0.054467	0.058324	0.062039	0.065602	0.069001	0.072225	0.075262
0.078102	0.080733	0.083147	0.085333	0.087286	0.088997	0.090462	0.091679
0.092646	0.093366	0.093842	0.094080	0.094090	0.093881	0.093464	0.092854
0.092062	0.091102	0.089987	0.088728	0.087338	0.085826	0.084200	0.082466
0.080631	0.078698	0.076671	0.074550	0.072337	0.070032	0.067634	0.065143
0.062558	0.059877	0.057100	0.054226	0.051257	0.048193	0.045037	0.041793
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0.009981	0.006379	0.002817	-0.000691	-0.004131	-0.007490	-0.010756	-0.013919
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0.005550	0.006660	0.007859	0.009153	0.010543	0.012030	0.013612	0.015283
0.017040	0.018874	0.020780	0.022750	0.024780	0.026864	0.028997	0.031178

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0.052756	0.055355	0.057988	0.060652	0.063345	0.066062	0.068802	0.071561
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0.096869	0.099657	0.102411	0.105117	0.107757	0.110316	0.112772	0.115104
0.117289	0.119303	0.121121	0.122718	0.124067	0.125144	0.125926	0.126392
0.126522	0.126301	0.125719	0.124768	0.123448	0.121761	0.119717	0.117329
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0.084639	0.080340	0.076022	0.071707	0.067415	0.063164	0.058964	0.054823
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0.097879	0.096770	0.095581	0.094323	0.093010	0.091650	0.090255	0.088834
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0.074321	0.073805	0.073274	0.072740	0.072211	0.071695	0.071197	0.070719
0.070263	0.069828	0.069410	0.069005	0.068608	0.068208	0.067799	0.067369
0.066908	0.066404	0.065846	0.065222	0.064523	0.063737	0.062858	0.061879
0.060795	0.059603	0.058303	0.056896	0.055385	0.053774	0.052070	0.050280
0.048414	0.046480	0.044489	0.042452	0.040381	0.038286	0.036179	0.034071
0.031972	0.029890	0.027835	0.025813	0.023828	0.021884	0.019983	0.018126
0.016310	0.014534	0.012794	0.011086	0.009406	0.007750	0.006114	0.004497
0.002896	0.001310	-0.000260	-0.001813	-0.003345	-0.004855	-0.006338	-0.007789
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0.005849	0.007830	0.010013	0.012397	0.014976	0.017741	0.020680	0.023775
0.027009	0.030360	0.033805	0.037320	0.040879	0.044456	0.048027	0.051566
0.055048	0.058452	0.061755	0.064938	0.067982	0.070872	0.073593	0.076135
0.078489	0.080648	0.082609	0.084371	0.085935	0.087304	0.088486	0.089489
0.090322	0.090997	0.091527	0.091926	0.092209	0.092389	0.092481	0.092499
0.092455	0.092359	0.092220	0.092045	0.091838	0.091601	0.091332	0.091028
0.090683	0.090290	0.089839	0.089320	0.088722	0.088036	0.087250	0.086355
0.085345	0.084213	0.082955	0.081572	0.080064	0.078434	0.076689	0.074836

0.072886	0.070850	0.068742	0.066575	0.064365	0.062125	0.059872	0.057619
0.055380	0.053164	0.050983	0.048843	0.046748	0.044700	0.042699	0.040741
0.038820	0.036927	0.035054	0.033188	0.031319	0.029433	0.027519	0.025565
0.023559	0.021494	0.019360	0.017151	0.014862	0.012491	0.010036	0.007500
0.004885	0.002197	-0.000558	-0.003369	-0.006227	-0.009119	-0.012029	-0.014944
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0.007228	0.009360	0.011542	0.013772	0.016048	0.018365	0.020720	0.023110
0.025528	0.027968	0.030424	0.032889	0.035352	0.037805	0.040237	0.042637
0.044994	0.047297	0.049534	0.051695	0.053770	0.055751	0.057630	0.059403
0.061066	0.062618	0.064060	0.065394	0.066625	0.067757	0.068796	0.069748
0.070620	0.071416	0.072140	0.072797	0.073387	0.073911	0.074367	0.074752
0.075063	0.075294	0.075440	0.075494	0.075452	0.075306	0.075053	0.074688
0.074206	0.073605	0.072882	0.072036	0.071066	0.069972	0.068755	0.067417
0.065960	0.064387	0.062705	0.060919	0.059038	0.057070	0.055028	0.052924
0.050772	0.048589	0.046391	0.044195	0.042019	0.039880	0.037794	0.035777
0.033842	0.032001	0.030263	0.028636	0.027122	0.025723	0.024437	0.023261
0.022186	0.021204	0.020303	0.019469	0.018688	0.017945	0.017222	0.016504
0.015773	0.015016	0.014217	0.013362	0.012439	0.011436	0.010345	0.009157
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0.001690	0.002286	0.002769	0.003131	0.003365	0.003468	0.003439	0.003282
0.003000	0.002599	0.002089	0.001479	0.000781	0.000007	-0.000830	-0.001715
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0.001691	0.001923	0.002153	0.002381	0.002607	0.002829	0.003045	0.003253
0.003450	0.003632	0.003796	0.003938	0.004056	0.004146	0.004206	0.004235
0.004230	0.004193	0.004123	0.004022	0.003892	0.003736	0.003555	0.003354
0.003136	0.002904	0.002661	0.002410	0.002155	0.001896	0.001638	0.001380
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0.006253	0.006750	0.007248	0.007748	0.008251	0.008761	0.009280	0.009810
0.010354	0.010916	0.011497	0.012100	0.012727	0.013379	0.014059	0.014766
0.015502	0.016266	0.017056	0.017873	0.018712	0.019572	0.020448	0.021337
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0.028969	0.029678	0.030346	0.030971	0.031553	0.032095	0.032597	0.033064
0.033500	0.033909	0.034297	0.034670	0.035034	0.035395	0.035758	0.036129
0.036512	0.036911	0.037329	0.037767	0.038225	0.038703	0.039199	0.039709
0.040228	0.040750	0.041270	0.041779	0.042272	0.042738	0.043172	0.043564
0.043908	0.044197	0.044424	0.044585	0.044673	0.044687	0.044622	0.044478
0.044253	0.043948	0.043564	0.043104	0.042570	0.041967	0.041301	0.040576
0.039800	0.038980	0.038123	0.037236	0.036325	0.035396	0.034455	0.033506
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0.044796	0.046338	0.047873	0.049399	0.050911	0.052403	0.053874	0.055318
0.056733	0.058116	0.059463	0.060771	0.062038	0.063261	0.064439	0.065569
0.066650	0.067682	0.068663	0.069594	0.070475	0.071306	0.072088	0.072822
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0.079228	0.079030	0.078793	0.078514	0.078195	0.077836	0.077439	0.077005
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0.044805	0.043899	0.043016	0.042154	0.041316	0.040500	0.039705	0.038927
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-0.071196	-0.071054	-0.070883	-0.070683	-0.070455	-0.070198	-0.069914	-0.069604
-0.069268	-0.068908	-0.068526	-0.068122	-0.067697	-0.067253	-0.066791	-0.066312
-0.065816	-0.065305	-0.064780	-0.064240	-0.063687	-0.063122	-0.062545	-0.061956
-0.061356	-0.060746	-0.060127	-0.059499	-0.058863	-0.058221	-0.057573	-0.056921
-0.056266	-0.055610	-0.054953	-0.054297	-0.053642	-0.052989	-0.052338	-0.051690
-0.051045	-0.050402	-0.049761	-0.049124	-0.048489	-0.047858	-0.047232	-0.046611
-0.045998	-0.045394	-0.044801	-0.044221	-0.043654	-0.043103	-0.042568	-0.042050
-0.041547	-0.041060	-0.040586	-0.040123	-0.039669	-0.039221	-0.038778	-0.038334
-0.037889	-0.037440	-0.036985	-0.036522	-0.036049	-0.035568	-0.035077	-0.034577
-0.034069	-0.033554	-0.033035	-0.032514	-0.031993	-0.031475	-0.030963	-0.030460
-0.029968	-0.029489	-0.029027	-0.028582	-0.028156	-0.027750	-0.027365	-0.026999
-0.026652	-0.026323	-0.026010	-0.025712	-0.025427	-0.025152	-0.024886	-0.024626
-0.024372	-0.024123	-0.023877	-0.023633	-0.023392	-0.023153	-0.022915	-0.022679
-0.022443	-0.022207	-0.021970	-0.021732	-0.021490	-0.021243	-0.020990	-0.020730
-0.020461	-0.020182	-0.019892	-0.019590	-0.019276	-0.018951	-0.018613	-0.018264
-0.017904	-0.017534	-0.017154	-0.016765	-0.016367	-0.015961	-0.015547	-0.015127
-0.014699	-0.014266	-0.013827	-0.013383	-0.012934	-0.012483	-0.012027	-0.011570
-0.011111	-0.010652	-0.010192	-0.009732	-0.009274	-0.008817	-0.008362	-0.007910

-0.007461	-0.007017	-0.006578	-0.006145	-0.005719	-0.005302	-0.004895	-0.004499
-0.004116	-0.003747	-0.003393	-0.003055	-0.002733	-0.002429	-0.002141	-0.001868
-0.001609	-0.001362	-0.001123	-0.000889	-0.000657	-0.000423	-0.000182	0.000071
0.000337	0.000622	0.000927	0.001254	0.001605	0.001978	0.002375	0.002792
0.003228	0.003679	0.004143	0.004615	0.005093	0.005573	0.006052	0.006526
0.006993	0.007450	0.007895	0.008326	0.008741	0.009139	0.009519	0.009881
0.010223	0.010544	0.010846	0.011128	0.011389	0.011629	0.011850	0.012050
0.012230	0.012390	0.012530	0.012651	0.012752	0.012833	0.012896	0.012940
0.012966	0.012974	0.012965	0.012938	0.012896	0.012837	0.012761	0.012669

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          ***********
    **                   **
    **   D I S P L M T   **
          ***********


Chevron, Tank 9 Battery, Cross Section A-A', Nridge.acc

 YIELD ACCELERATION =  0.1150

 DT = 0.0050    ACCN DUE GRAVITY =   32.200    NLINES = 1973

  A max =  0.15659    Acc Factor =  1.00000         Static F.S.=  1.510


 *** COMPUTATION WITH ORIGINAL RECORD ***

Vmax =  0.16226 Ft/S      Dfinal =  0.04334 Ft


 *** COMPUTATION WITH REVERSED RECORD ***

Vmax =  0.03577 Ft/S      Dfinal =  0.00961 Ft


 ** SUMMARY OF RESULTS **

 RUN       V max       V ave       D final      D final ave
            Ft/S        Ft/S         Ft             Ft

  1       0.16226                 0.04334
                     0.09902                     0.02648
  2       0.03577                 0.00961


***  PROGRAM TERMINATED  ***
```

Chevron, Tank 9 Battery, Cross Section A-A', Nridge.acc
0 0.
1
0.115
0.005 32.2 1973
0 1.51

-0.009608	-0.009423	-0.009226	-0.009021	-0.008808	-0.008590	-0.008368	-0.008143
-0.007916	-0.007688	-0.007461	-0.007235	-0.007009	-0.006784	-0.006560	-0.006338
-0.006116	-0.005895	-0.005675	-0.005455	-0.005237	-0.005019	-0.004801	-0.004585
-0.004370	-0.004156	-0.003944	-0.003734	-0.003527	-0.003323	-0.003124	-0.002930
-0.002741	-0.002559	-0.002385	-0.002220	-0.002065	-0.001921	-0.001789	-0.001670
-0.001564	-0.001473	-0.001398	-0.001337	-0.001293	-0.001264	-0.001251	-0.001254
-0.001272	-0.001303	-0.001349	-0.001406	-0.001474	-0.001553	-0.001640	-0.001734
-0.001834	-0.001939	-0.002047	-0.002157	-0.002269	-0.002380	-0.002491	-0.002600
-0.002706	-0.002810	-0.002909	-0.003005	-0.003096	-0.003182	-0.003263	-0.003338
-0.003408	-0.003473	-0.003532	-0.003586	-0.003636	-0.003681	-0.003722	-0.003760
-0.003797	-0.003832	-0.003866	-0.003900	-0.003936	-0.003974	-0.004015	-0.004059
-0.004108	-0.004161	-0.004220	-0.004286	-0.004357	-0.004436	-0.004521	-0.004614
-0.004714	-0.004820	-0.004934	-0.005053	-0.005179	-0.005310	-0.005445	-0.005585
-0.005728	-0.005873	-0.006019	-0.006166	-0.006312	-0.006456	-0.006597	-0.006734
-0.006865	-0.006989	-0.007105	-0.007212	-0.007308	-0.007394	-0.007468	-0.007531
-0.007583	-0.007625	-0.007657	-0.007680	-0.007696	-0.007705	-0.007708	-0.007705
-0.007698	-0.007687	-0.007671	-0.007652	-0.007628	-0.007601	-0.007569	-0.007533
-0.007492	-0.007445	-0.007392	-0.007333	-0.007268	-0.007194	-0.007113	-0.007024
-0.006926	-0.006819	-0.006703	-0.006578	-0.006443	-0.006300	-0.006147	-0.005984
-0.005814	-0.005635	-0.005448	-0.005254	-0.005053	-0.004847	-0.004636	-0.004421
-0.004203	-0.003982	-0.003761	-0.003540	-0.003320	-0.003103	-0.002888	-0.002678
-0.002473	-0.002274	-0.002082	-0.001898	-0.001721	-0.001552	-0.001392	-0.001240
-0.001097	-0.000961	-0.000834	-0.000713	-0.000600	-0.000493	-0.000392	-0.000297
-0.000208	-0.000123	-0.000042	0.000034	0.000106	0.000175	0.000240	0.000303
0.000362	0.000419	0.000474	0.000527	0.000578	0.000627	0.000674	0.000720
0.000765	0.000808	0.000851	0.000893	0.000934	0.000975	0.001015	0.001055
0.001094	0.001133	0.001172	0.001211	0.001250	0.001289	0.001329	0.001368
0.001408	0.001448	0.001489	0.001530	0.001571	0.001613	0.001655	0.001698
0.001741	0.001784	0.001828	0.001873	0.001917	0.001963	0.002008	0.002054
0.002101	0.002148	0.002195	0.002242	0.002290	0.002338	0.002386	0.002435
0.002483	0.002532	0.002581	0.002630	0.002679	0.002727	0.002775	0.002823
0.002871	0.002918	0.002964	0.003010	0.003055	0.003099	0.003142	0.003183
0.003223	0.003263	0.003300	0.003336	0.003370	0.003403	0.003433	0.003462
0.003489	0.003514	0.003536	0.003556	0.003574	0.003590	0.003603	0.003614
0.003623	0.003628	0.003632	0.003633	0.003631	0.003627	0.003621	0.003612
0.003600	0.003586	0.003570	0.003552	0.003531	0.003508	0.003483	0.003456
0.003426	0.003395	0.003362	0.003327	0.003290	0.003251	0.003211	0.003169
0.003126	0.003082	0.003036	0.002988	0.002940	0.002891	0.002841	0.002790
0.002739	0.002687	0.002634	0.002581	0.002528	0.002474	0.002421	0.002368
0.002315	0.002262	0.002209	0.002158	0.002106	0.002056	0.002006	0.001958
0.001910	0.001863	0.001818	0.001774	0.001731	0.001689	0.001650	0.001611
0.001574	0.001539	0.001505	0.001473	0.001443	0.001414	0.001388	0.001362
0.001339	0.001317	0.001297	0.001278	0.001261	0.001245	0.001231	0.001219
0.001207	0.001198	0.001189	0.001182	0.001175	0.001170	0.001166	0.001163
0.001161	0.001160	0.001159	0.001160	0.001161	0.001162	0.001165	0.001168
0.001171	0.001175	0.001179	0.001184	0.001189	0.001195	0.001201	0.001207
0.001214	0.001221	0.001228	0.001235	0.001243	0.001251	0.001259	0.001267

0.001276	0.001285	0.001294	0.001303	0.001312	0.001322	0.001331	0.001341
0.001351	0.001361	0.001371	0.001381	0.001391	0.001400	0.001410	0.001420
0.001429	0.001439	0.001448	0.001456	0.001465	0.001473	0.001480	0.001487
0.001493	0.001499	0.001504	0.001508	0.001512	0.001515	0.001517	0.001518
0.001519	0.001518	0.001516	0.001514	0.001510	0.001505	0.001500	0.001493
0.001485	0.001476	0.001466	0.001454	0.001442	0.001428	0.001414	0.001398
0.001381	0.001362	0.001343	0.001322	0.001301	0.001278	0.001254	0.001229
0.001203	0.001175	0.001147	0.001117	0.001087	0.001055	0.001023	0.000990
0.000956	0.000921	0.000885	0.000848	0.000811	0.000773	0.000735	0.000696
0.000656	0.000616	0.000576	0.000536	0.000495	0.000454	0.000413	0.000372
0.000331	0.000290	0.000250	0.000209	0.000169	0.000129	0.000090	0.000051
0.000012	-0.000026	-0.000064	-0.000101	-0.000138	-0.000174	-0.000209	-0.000244
-0.000278	-0.000311	-0.000344	-0.000376	-0.000407	-0.000438	-0.000468	-0.000497
-0.000526	-0.000554	-0.000581	-0.000608	-0.000634	-0.000660	-0.000685	-0.000709
-0.000733	-0.000756	-0.000779	-0.000801	-0.000823	-0.000844	-0.000865	-0.000885
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-0.001368	-0.001378	-0.001387	-0.001397	-0.001405	-0.001414	-0.001422	-0.001430
-0.001437	-0.001444	-0.001451	-0.001457	-0.001463	-0.001468	-0.001473	-0.001478
-0.001482	-0.001486	-0.001489	-0.001492	-0.001494	-0.001496	-0.001497	-0.001498
-0.001498	-0.001498	-0.001497	-0.001496	-0.001494	-0.001492	-0.001489	-0.001486
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-0.001432	-0.001423	-0.001414	-0.001404	-0.001394	-0.001384	-0.001373	-0.001362
-0.001350	-0.001337	-0.001325	-0.001312	-0.001298	-0.001284	-0.001270	-0.001256
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-0.000337	-0.000332	-0.000328	-0.000324	-0.000320	-0.000317	-0.000313	-0.000310
-0.000307	-0.000303	-0.000300	-0.000297	-0.000294	-0.000291	-0.000289	-0.000286
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-0.000026	-0.000018	-0.000009	0.000000	0.000008	0.000017	0.000026	0.000035
0.000044	0.000054	0.000063	0.000072	0.000082	0.000091	0.000100	0.000110
0.000119	0.000129	0.000138	0.000148	0.000157	0.000166	0.000176	0.000185
0.000195	0.000204	0.000213	0.000222	0.000231	0.000240	0.000249	0.000258
0.000267	0.000276	0.000284	0.000293	0.000301	0.000309	0.000318	0.000326
0.000333	0.000341	0.000349	0.000356	0.000364	0.000371	0.000378	0.000385
0.000392	0.000399	0.000405	0.000412	0.000418	0.000424	0.000430	0.000436
0.000442	0.000448	0.000453	0.000458	0.000464	0.000469	0.000474	0.000478
0.000483	0.000488	0.000492	0.000496	0.000500	0.000504	0.000508	0.000512

0.000515	0.000519	0.000522	0.000525	0.000528	0.000531	0.000533	0.000536
0.000538	0.000541	0.000543	0.000545	0.000547	0.000549	0.000550	0.000552
0.000553	0.000554	0.000555	0.000556	0.000557	0.000558	0.000558	0.000558
0.000559	0.000559	0.000559	0.000558	0.000558	0.000558	0.000557	0.000556
0.000555	0.000554	0.000553	0.000552	0.000550	0.000548	0.000547	0.000545
0.000543	0.000540	0.000538	0.000536	0.000533	0.000530	0.000527	0.000524
0.000521	0.000518	0.000514	0.000510	0.000507	0.000503	0.000499	0.000495
0.000490	0.000486	0.000482	0.000477	0.000472	0.000467	0.000463	0.000458
0.000452	0.000447	0.000442	0.000436	0.000431	0.000425	0.000420	0.000414
0.000408	0.000402	0.000396	0.000390	0.000384	0.000378	0.000372	0.000366
0.000359	0.000353	0.000347	0.000340	0.000334	0.000328	0.000321	0.000315
0.000308	0.000302	0.000295	0.000289	0.000283	0.000276	0.000270	0.000263
0.000257	0.000251	0.000245	0.000238	0.000232	0.000226	0.000220	0.000214
0.000208	0.000202	0.000196	0.000190	0.000184	0.000179	0.000173	0.000167
0.000162	0.000157	0.000151	0.000146	0.000141	0.000136	0.000131	0.000126
0.000121	0.000116	0.000111	0.000107	0.000102	0.000098	0.000093	0.000089
0.000085	0.000081	0.000077	0.000073	0.000069	0.000065	0.000061	0.000058
0.000054	0.000051	0.000047	0.000044	0.000041	0.000037	0.000034	0.000031
0.000028	0.000025	0.000023	0.000020	0.000017	0.000015	0.000012	0.000010
0.000007	0.000005	0.000003	0.000000	-0.000002	-0.000004	-0.000006	-0.000008
-0.000010	-0.000013	-0.000014	-0.000016	-0.000018	-0.000020	-0.000022	-0.000024
-0.000025	-0.000027	-0.000029	-0.000030	-0.000032	-0.000034	-0.000035	-0.000037
-0.000038	-0.000040	-0.000042	-0.000043	-0.000045	-0.000046	-0.000048	-0.000049
-0.000051	-0.000052	-0.000054	-0.000055	-0.000057	-0.000058	-0.000060	-0.000061
-0.000063	-0.000064	-0.000066	-0.000067	-0.000069	-0.000070	-0.000072	-0.000073
-0.000075	-0.000077	-0.000078	-0.000080	-0.000081	-0.000083	-0.000085	-0.000086
-0.000088	-0.000090	-0.000091	-0.000093	-0.000095	-0.000097	-0.000098	-0.000100
-0.000102	-0.000104	-0.000105	-0.000107	-0.000109	-0.000111	-0.000113	-0.000114
-0.000116	-0.000118	-0.000120	-0.000122	-0.000123	-0.000125	-0.000127	-0.000214
-0.000131	-0.000133	-0.000134	-0.000136	-0.000138	-0.000140	-0.000141	-0.000143
-0.000145	-0.000147	-0.000148	-0.000150	-0.000152	-0.000153	-0.000155	-0.000157
-0.000158	-0.000160	-0.000161	-0.000163	-0.000164	-0.000166	-0.000167	-0.000169
-0.000170	-0.000172	-0.000173	-0.000174	-0.000176	-0.000177	-0.000178	-0.000179
-0.000180	-0.000182	-0.000183	-0.000184	-0.000185	-0.000186	-0.000187	-0.000188
-0.000188	-0.000189	-0.000190	-0.000191	-0.000191	-0.000192	-0.000193	-0.000193
-0.000194	-0.000194	-0.000195	-0.000195	-0.000196	-0.000196	-0.000196	-0.000196
-0.000197	-0.000197	-0.000197	-0.000197	-0.000197	-0.000197	-0.000197	-0.000197
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0.001207	0.002101	0.002975	0.003825	0.004648	0.005439	0.006197	0.006919
0.007605	0.008255	0.008869	0.009450	0.010000	0.010522	0.011021	0.011500
0.011963	0.012416	0.012863	0.013308	0.013756	0.014213	0.014684	0.015176
0.015693	0.016242	0.016830	0.017462	0.018143	0.018877	0.019668	0.020518
0.021427	0.022394	0.023417	0.024493	0.025616	0.026781	0.027981	0.029209
0.030460	0.031726	0.033003	0.034285	0.035569	0.036854	0.038139	0.039426
0.040716	0.042016	0.043330	0.044667	0.046034	0.047440	0.048896	0.050408
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0.067240	0.069418	0.071626	0.073849	0.076075	0.078291	0.080486	0.082649
0.084770	0.086842	0.088859	0.090815	0.092708	0.094533	0.096290	0.097975
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0.109302	0.110014	0.110587	0.111009	0.111273	0.111369	0.111291	0.111033
0.110592	0.109949	0.109104	0.108152	0.107075	0.105628	0.104118	0.102557
0.100659	0.098738	0.096709	0.094588	0.092393	0.090138	0.087841	0.085516
0.083177	0.080836	0.078502	0.076183	0.073885	0.071611	0.069363	0.067140
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0.048038	0.046004	0.043991	0.042000	0.040032	0.038088	0.036171	0.034281
0.032420	0.030590	0.028793	0.027029	0.025303	0.023617	0.021973	0.020374
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0.038179	0.040336	0.042540	0.044786	0.047072	0.049389	0.051733	0.054092
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0.019002	0.018744	0.018399	0.017966	0.017441	0.016822	0.016103	0.015282
0.014353	0.013311	0.012152	0.010870	0.009460	0.007918	0.006239	0.004421
0.002461	0.000359	-0.001885	-0.004269	-0.006788	-0.009435	-0.012204	-0.015084
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0.018759	0.022139	0.025486	0.028789	0.032038	0.035225	0.038342	0.041383
0.044343	0.047220	0.050010	0.052711	0.055321	0.057839	0.060263	0.062594
0.064832	0.066976	0.069029	0.070993	0.072874	0.074676	0.076406	0.078072
0.079683	0.081249	0.082781	0.084287	0.085779	0.087266	0.088755	0.090255
0.091768	0.093300	0.094850	0.096417	0.097997	0.099584	0.101168	0.102741
0.104289	0.105798	0.107255	0.108644	0.109949	0.111156	0.112251	0.113219
0.114049	0.114731	0.115254	0.115612	0.115801	0.115815	0.115656	0.115322
0.114818	0.114149	0.113322	0.112346	0.111232	0.109993	0.108642	0.107195
0.105665	0.104069	0.102421	0.100737	0.099028	0.097308	0.095586	0.093870
0.092166	0.090478	0.088806	0.087149	0.085502	0.083860	0.082215	0.080558
0.078880	0.077170	0.075420	0.073619	0.071761	0.069839	0.067850	0.065790
0.063659	0.061461	0.059198	0.056880	0.054513	0.052111	0.049686	0.047253
0.044828	0.042428	0.040070	0.037770	0.035546	0.033412	0.031382	0.029470

0.027685	0.026038	0.024533	0.023177	0.021972	0.020919	0.020016	0.019260
0.018646	0.018165	0.017807	0.017562	0.017415	0.017351	0.017352	0.017398
0.017471	0.017549	0.017612	0.017639	0.017610	0.017506	0.017312	0.017013
0.016597	0.016057	0.015387	0.014585	0.013653	0.012597	0.011424	0.010148
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0.002397	0.003642	0.004913	0.006209	0.007529	0.008871	0.010234	0.011617
0.013019	0.014438	0.015871	0.017317	0.018770	0.020229	0.021690	0.023149
0.024603	0.026047	0.027480	0.028898	0.030298	0.031676	0.033029	0.034354
0.035645	0.036898	0.038104	0.039257	0.040347	0.041363	0.042293	0.043125
0.043843	0.044433	0.044881	0.045171	0.045290	0.045223	0.044960	0.044490
0.043805	0.042898	0.041766	0.040407	0.038820	0.037007	0.034973	0.032722
0.030261	0.027596	0.024735	0.021686	0.018457	0.015054	0.011485	0.007757
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0.001929	0.001044	0.000014	-0.001131	-0.002364	-0.003660	-0.004995	-0.006351
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0.022616	0.025653	0.028754	0.031926	0.035174	0.038503	0.041914	0.045404
0.048968	0.052596	0.056277	0.059993	0.063726	0.067453	0.071151	0.074795
0.078359	0.081818	0.085146	0.088319	0.091317	0.094120	0.096711	0.099077
0.101208	0.103098	0.104744	0.106147	0.107311	0.108245	0.108957	0.109460
0.109769	0.109899	0.109864	0.109682	0.109368	0.108934	0.108396	0.107764
0.107048	0.106256	0.105393	0.104464	0.103471	0.102414	0.101292	0.100104
0.098844	0.097509	0.096094	0.094591	0.092995	0.091300	0.089498	0.087583
0.085550	0.083394	0.081112	0.078700	0.076158	0.073486	0.070685	0.067759
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0.016796	0.020056	0.023129	0.026011	0.028700	0.031195	0.033498	0.035613
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0.047386	0.048070	0.048669	0.049190	0.049641	0.050028	0.050355	0.050624
0.050837	0.050992	0.051087	0.051117	0.051078	0.050963	0.050766	0.050480
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0.029552	0.027571	0.025557	0.023521	0.021470	0.019413	0.017360	0.015316
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0.039592	0.040436	0.041186	0.041850	0.042437	0.042959	0.043427	0.043853
0.044249	0.044628	0.045000	0.045375	0.045760	0.046161	0.046583	0.047027
0.047493	0.047978	0.048480	0.048993	0.049510	0.050025	0.050529	0.051014
0.051472	0.051895	0.052274	0.052604	0.052876	0.053085	0.053228	0.053299
0.053297	0.053220	0.053068	0.052840	0.052538	0.052162	0.051716	0.051200
0.050619	0.049974	0.049269	0.048506	0.047689	0.046818	0.045897	0.044926
0.043906	0.042837	0.041718	0.040547	0.039324	0.038047	0.036712	0.035319
0.033863	0.032344	0.030759	0.029107	0.027386	0.025596	0.023740	0.021817
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0.004337	0.005508	0.006635	0.007718	0.008758	0.009755	0.010708	0.011616
0.012478	0.013292	0.014056	0.014766	0.015419	0.016012	0.016538	0.016996
0.017378	0.017683	0.017906	0.018044	0.018094	0.018057	0.017929	0.017711
0.017402	0.017004	0.016515	0.015938	0.015272	0.014519	0.013681	0.012758
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0.033970	0.037630	0.041228	0.044762	0.048227	0.051620	0.054938	0.058177
0.061336	0.064410	0.067396	0.070291	0.073090	0.075788	0.078380	0.080859
0.083219	0.085454	0.087558	0.089522	0.091343	0.093014	0.094530	0.095888
0.097087	0.098124	0.099000	0.099717	0.100278	0.100688	0.100953	0.101079
0.101074	0.100947	0.100706	0.100362	0.099925	0.099404	0.098810	0.098152
0.097441	0.096685	0.095894	0.095076	0.094240	0.093395	0.092547	0.091705
0.090877	0.090070	0.089293	0.088552	0.087855	0.087210	0.086625	0.086105
0.085659	0.085290	0.085005	0.084808	0.084700	0.084685	0.084763	0.084933
0.085194	0.085543	0.085975	0.086485	0.087068	0.087718	0.088428	0.089190
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0.097365	0.098319	0.099265	0.100200	0.101121	0.102023	0.102903	0.103759
0.104587	0.105383	0.106144	0.106867	0.107548	0.108180	0.108761	0.109282
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0.025987	0.025948	0.025843	0.025673	0.025442	0.025152	0.024805	0.024405
0.023956	0.023461	0.022924	0.022348	0.021738	0.021097	0.020428	0.019736
0.019024	0.018295	0.017553	0.016799	0.016039	0.015273	0.014504	0.013734
0.012966	0.012199	0.011436	0.010678	0.009925	0.009178	0.008439	0.007706
0.006981	0.006264	0.005556	0.004856	0.004165	0.003484	0.002813	0.002154
0.001507	0.000874	0.000256	-0.000343	-0.000923	-0.001478	-0.002007	-0.002506
-0.002972	-0.003402	-0.003791	-0.004138	-0.004439	-0.004693	-0.004898	-0.005052
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0.003936	0.004579	0.005227	0.005879	0.006535	0.007193	0.007853	0.008516
0.009181	0.009848	0.010517	0.011190	0.011866	0.012547	0.013232	0.013921
0.014617	0.015317	0.016023	0.016734	0.017449	0.018168	0.018889	0.019613
0.020337	0.021061	0.021784	0.022504	0.023221	0.023934	0.024643	0.025348
0.026048	0.026743	0.027433	0.028118	0.028799	0.029476	0.030148	0.030815
0.031477	0.032132	0.032780	0.033418	0.034046	0.034660	0.035257	0.035835
0.036391	0.036920	0.037419	0.037885	0.038316	0.038707	0.039058	0.039365
0.039629	0.039849	0.040024	0.040156	0.040246	0.040296	0.040308	0.040285

0.040230	0.040145	0.040035	0.039903	0.039751	0.039584	0.039403	0.039211
0.039011	0.038805	0.038595	0.038381	0.038165	0.037947	0.037727	0.037507
0.037285	0.037061	0.036835	0.036606	0.036374	0.036138	0.035896	0.035649
0.035395	0.035134	0.034865	0.034588	0.034301	0.034006	0.033702	0.033389
0.033068	0.032738	0.032399	0.032053	0.031701	0.031342	0.030977	0.030607
0.030231	0.029850	0.029464	0.029071	0.028671	0.028262	0.027840	0.027405
0.026953	0.026479	0.025981	0.025454	0.024893	0.024294	0.023653	0.022964
0.022224	0.021428	0.020574	0.019656	0.018673	0.017623	0.016504	0.015314
0.014055	0.012726	0.011328	0.009863	0.008333	0.006741	0.005090	0.003383
0.001623	-0.000185	-0.002037	-0.003930	-0.005858	-0.007818	-0.009804	-0.011812
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0.004819	0.005986	0.007106	0.008180	0.009205	0.010182	0.011109	0.011985
0.012811	0.013586	0.014310	0.014983	0.015605	0.016179	0.016703	0.017181
0.017612	0.017999	0.018343	0.018646	0.018909	0.019134	0.019323	0.019478
0.019600	0.019691	0.019753	0.019786	0.019792	0.019773	0.019730	0.019663
0.019573	0.019462	0.019330	0.019178	0.019007	0.018817	0.018609	0.018383
0.018142	0.017884	0.017612	0.017324	0.017022	0.016707	0.016379	0.016039
0.015689	0.015328	0.014959	0.014583	0.014202	0.013816	0.013429	0.013040
0.012653	0.012268	0.011887	0.011512	0.011142	0.010780	0.010427	0.010082
0.009747	0.009421	0.009105	0.008800	0.008504	0.008218	0.007942	0.007675
0.007417	0.007167	0.006924	0.006690	0.006463	0.006242	0.006028	0.005820
0.005618	0.005421	0.005230	0.005044	0.004862	0.004685	0.004513	0.004345
0.004182	0.004024	0.003872	0.003725	0.003585	0.003453	0.003328	0.003213
0.003109	0.003017	0.002938	0.002873	0.002823	0.002788	0.002770	0.002768
0.002782	0.002810	0.002853	0.002907	0.002970	0.003041	0.003115	0.003190
0.003261	0.003325	0.003378	0.003416	0.003436	0.003433	0.003406	0.003353
0.003270	0.003158	0.003016	0.002845	0.002645	0.002419	0.002169	0.001898
0.001609	0.001305	0.000990	0.000668	0.000342	0.000017	-0.000305	-0.000619
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0.001594	0.002141	0.002725	0.003345	0.003998	0.004681	0.005390	0.006120
0.006869	0.007630	0.008401	0.009176	0.009951	0.010722	0.011484	0.012235
0.012971	0.013689	0.014387	0.015063	0.015713	0.016339	0.016938	0.017509
0.018053	0.018569	0.019058	0.019518	0.019952	0.020358	0.020738	0.021092
0.021420	0.021723	0.021999	0.022248	0.022471	0.022666	0.022833	0.022968
0.023071	0.023139	0.023170	0.023161	0.023110	0.023013	0.022868	0.022673

0.022425	0.022122	0.021763	0.021346	0.020871	0.020337	0.019745	0.019096
0.018390	0.017629	0.016814	0.015947	0.015030	0.014067	0.013058	0.012008
0.010918	0.009793	0.008634	0.007446	0.006232	0.004995	0.003738	0.002465
0.001178	-0.000117	-0.001419	-0.002725	-0.004030	-0.005332	-0.006628	-0.007915
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0.006016	0.006766	0.007490	0.008187	0.008856	0.009496	0.010107	0.010689
0.011243	0.011771	0.012272	0.012749	0.013203	0.013636	0.014048	0.014440
0.014814	0.015169	0.015507	0.015826	0.016128	0.016412	0.016678	0.016925
0.017153	0.017362	0.017552	0.017723	0.017875	0.018007	0.018121	0.018217
0.018295	0.018356	0.018400	0.018429	0.018443	0.018444	0.018434	0.018413
0.018383	0.018347	0.018305	0.018261	0.018215	0.018170	0.018128	0.018089
0.018056	0.018029	0.018009	0.017996	0.017990	0.017990	0.017996	0.018005
0.018017	0.018029	0.018038	0.018042	0.018037	0.018022	0.017992	0.017944
0.017876	0.017784	0.017666	0.017518	0.017339	0.017127	0.016878	0.016593
0.016269	0.015905	0.015501	0.015055	0.014568	0.014038	0.013468	0.012855
0.012202	0.011509	0.010778	0.010010	0.009207	0.008370	0.007503	0.006607
0.005686	0.004741	0.003774	0.002789	0.001788	0.000771	-0.000258	-0.001298
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0.014771	0.015511	0.016226	0.016913	0.017574	0.018206	0.018808	0.019379
0.019919	0.020423	0.020893	0.021324	0.021715	0.022065	0.022372	0.022634
0.022851	0.023021	0.023143	0.023218	0.023245	0.023224	0.023158	0.023045
0.022888	0.022689	0.022449	0.022172	0.021860	0.021517	0.021145	0.020748
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0.016682	0.016238	0.015807	0.015389	0.014986	0.014599	0.014229	0.013876
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0.011474	0.011297	0.011139	0.011002	0.010888	0.010797	0.010731	0.010690
0.010676	0.010689	0.010730	0.010799	0.010897	0.011023	0.011177	0.011358
0.011566	0.011800	0.012059	0.012341	0.012646	0.012971	0.013315	0.013677
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0.005191	0.005593	0.005987	0.006370	0.006740	0.007094	0.007428	0.007741
0.008030	0.008293	0.008528	0.008734	0.008908	0.009050	0.009160	0.009237
0.009282	0.009294	0.009275	0.009225	0.009147	0.009040	0.008908	0.008750
0.008570	0.008367	0.008144	0.007901	0.007640	0.007361	0.007064	0.006751
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0.003212	0.002743	0.002262	0.001768	0.001263	0.000747	0.000221	-0.000312
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0.003585	0.003901	0.004207	0.004501	0.004782	0.005049	0.005301	0.005538
0.005762	0.005972	0.006170	0.006357	0.006536	0.006707	0.006873	0.007034
0.007192	0.007349	0.007505	0.007661	0.007818	0.007975	0.008133	0.008292
0.008451	0.008611	0.008771	0.008931	0.009091	0.009251	0.009412	0.009572
0.009733	0.009895	0.010056	0.010218	0.010381	0.010543	0.010705	0.010867
0.011027	0.011185	0.011340	0.011491	0.011638	0.011779	0.011913	0.012039
0.012155	0.012260	0.012352	0.012431	0.012493	0.012538	0.012565	0.012570
0.012554	0.012515	0.012451	0.012361	0.012244	0.012100	0.011927	0.011725
0.011493	0.011231	0.010938	0.010615	0.010261	0.009877	0.009462	0.009019
0.008548	0.008050	0.007526	0.006978	0.006406	0.005813	0.005200	0.004568
0.003920	0.003256	0.002577	0.001886	0.001183	0.000471	-0.000250	-0.000977
-0.001709	-0.002445	-0.003183	-0.003919	-0.004654	-0.005384	-0.006107	-0.006822
-0.007526	-0.008218	-0.008896	-0.009559	-0.010206	-0.010837	-0.011450	-0.012047
-0.012627	-0.013191	-0.013738	-0.014271	-0.014789	-0.015294	-0.015784	-0.016261
-0.016725	-0.017175	-0.017610	-0.018029	-0.018432	-0.018816	-0.019179	-0.019521

-0.019838	-0.020128	-0.020391	-0.020623	-0.020823	-0.020990	-0.021123	-0.021220
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-0.013145	-0.012488	-0.011812	-0.011115	-0.010399	-0.009664	-0.008910	-0.008139
-0.007350	-0.006544	-0.005722	-0.004885	-0.004034	-0.003169	-0.002293	-0.001404
-0.000506	0.000402	0.001316	0.002237	0.003162	0.004090	0.005019	0.005947
0.006872	0.007791	0.008703	0.009604	0.010492	0.011365	0.012219	0.013052
0.013861	0.014642	0.015394	0.016113	0.016798	0.017446	0.018055	0.018623
0.019150	0.019634	0.020074	0.020471	0.020825	0.021135	0.021402	0.021628
0.021813	0.021959	0.022065	0.022136	0.022173	0.022177	0.022149	0.022093
0.022011	0.021903	0.021773	0.021623	0.021454	0.021270	0.021071	0.020860
0.020638	0.020408	0.020170	0.019926	0.019676	0.019421	0.019163	0.018900
0.018635	0.018366	0.018093	0.017818	0.017541	0.017261	0.016978	0.016695
0.016411	0.016128	0.015847	0.015569	0.015297	0.015032	0.014777	0.014533
0.014302	0.014087	0.013889	0.013709	0.013550	0.013411	0.013293	0.013197
0.013121	0.013064	0.013025	0.013003	0.012993	0.012996	0.013006	0.013022
0.013039	0.013056	0.013067	0.013071	0.013062	0.013039	0.012998	0.012936
0.012850	0.012738	0.012597	0.012426	0.012224	0.011989	0.011720	0.011418
0.011082	0.010714	0.010313	0.009880	0.009418	0.008928	0.008410	0.007868
0.007302	0.006714	0.006106	0.005480	0.004836	0.004178	0.003505	0.002821
0.002125	0.001420	0.000707	-0.000013	-0.000737	-0.001464	-0.002192	-0.002919
-0.003642	-0.004360	-0.005069	-0.005768	-0.006454	-0.007123	-0.007774	-0.008403
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-0.012806	-0.013137	-0.013436	-0.013704	-0.013942	-0.014150	-0.014330	-0.014483
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-0.013843	-0.013671	-0.013491	-0.013305	-0.013113	-0.012917	-0.012719	-0.012520
-0.012321	-0.012124	-0.011931	-0.011743	-0.011561	-0.011387	-0.011222	-0.011068
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-0.001644	-0.000987	-0.000315	0.000371	0.001069	0.001778	0.002496	0.003222
0.003952	0.004685	0.005420	0.006153	0.006884	0.007609	0.008327	0.009037
0.009735	0.010421	0.011093	0.011750	0.012391	0.013013	0.013617	0.014200
0.014762	0.015302	0.015819	0.016312	0.016780	0.017222	0.017637	0.018026
0.018386	0.018718	0.019020	0.019293	0.019535	0.019746	0.019925	0.020073
0.020187	0.020268	0.020315	0.020327	0.020304	0.020244	0.020147	0.020013
0.019841	0.019630	0.019381	0.019093	0.018767	0.018402	0.017998	0.017557
0.017079	0.016564	0.016014	0.015431	0.014814	0.014165	0.013487	0.012781
0.012049	0.011293	0.010515	0.009718	0.008904	0.008077	0.007238	0.006392
0.005540	0.004686	0.003833	0.002985	0.002144	0.001313	0.000495	-0.000306
-0.001088	-0.001848	-0.002585	-0.003295	-0.003977	-0.004629	-0.005250	-0.005839
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-0.010563	-0.010445	-0.010328	-0.010215	-0.010108	-0.010009	-0.009920	-0.009843
-0.009780	-0.009732	-0.009701	-0.009689	-0.009696	-0.009723	-0.009771	-0.009841
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-0.013421	-0.013679	-0.013930	-0.014174	-0.014408	-0.014633	-0.014847	-0.015048
-0.015237	-0.015410	-0.015569	-0.015711	-0.015837	-0.015944	-0.016032	-0.016100
-0.016147	-0.016171	-0.016173	-0.016151	-0.016103	-0.016030	-0.015930	-0.015802
-0.015645	-0.015459	-0.015244	-0.014998	-0.014723	-0.014416	-0.014080	-0.013713
-0.013318	-0.012894	-0.012443	-0.011967	-0.011465	-0.010942	-0.010398	-0.009835
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0.000333	0.000842	0.001330	0.001797	0.002241	0.002663	0.003061	0.003437
0.003788	0.004117	0.004423	0.004707	0.004968	0.005209	0.005429	0.005629
0.005810	0.005973	0.006118	0.006246	0.006358	0.006455	0.006537	0.006605
0.006659	0.006701	0.006730	0.006748	0.006756	0.006753	0.006742	0.006723
0.006697	0.006666	0.006631	0.006594	0.006556	0.006519	0.006485	0.006454
0.006428	0.006410	0.006399	0.006397	0.006404	0.006422	0.006450	0.006488
0.006538	0.006598	0.006669	0.006749	0.006840	0.006939	0.007047	0.007163
0.007285	0.007413	0.007546	0.007684	0.007824	0.007966	0.008109	0.008251
0.008393	0.008532	0.008668	0.008800	0.008927	0.009048	0.009162	0.009268
0.009365	0.009453	0.009530	0.009597	0.009652	0.009694	0.009724	0.009741

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    **                   **
    **   D I S P L M T   **
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Chevron, Tank 9 Battery, Cross Section A-A', HectorM.acc

YIELD ACCELERATION = 0.1150

DT = 0.0100 ACCN DUE GRAVITY = 32.200 NLINES = 688

A max = 0.15848 Acc Factor = 1.00000 Static F.S.= 1.510

*** COMPUTATION WITH ORIGINAL RECORD ***

Vmax = 0.21878 Ft/S Dfinal = 0.08933 Ft

*** COMPUTATION WITH REVERSED RECORD ***

Vmax = 0.14976 Ft/S Dfinal = 0.04740 Ft

** SUMMARY OF RESULTS **

RUN	V max Ft/S	V ave Ft/S	D final Ft	D final ave Ft
1	0.21878		0.08933	
		0.18427		0.06837
2	0.14976		0.04740	

*** PROGRAM TERMINATED ***

Chevron, Tank 9 Battery, Cross Section A-A', HectorM.acc
0 0.
1
0.115
0.01 32.2 688
0 1.51

0.000001	0.000001	0.000001	0.000001	0.000001	0.000001	0.000001	0.000001
0.000001	0.000001	0.000001	0.000001	0.000001	0.000001	0.000001	0.000001
0.000001	0.000001	0.000001	0.000001	0.000001	0.000001	0.000001	0.000001
0.000001	0.000001	0.000001	0.000001	0.000001	0.000001	0.000001	0.000001
0.000001	0.000001	0.000001	0.000001	0.000001	0.000001	0.000001	0.000001
0.000001	0.000001	0.000001	0.000001	0.000000	0.000000	0.000000	0.000000
0.000000	-0.000001	-0.000001	-0.000001	-0.000002	-0.000002	-0.000003	-0.000003
-0.000004	-0.000005	-0.000005	-0.000006	-0.000007	-0.000007	-0.000008	-0.000008
-0.000009	-0.000010	-0.000011	-0.000011	-0.000012	-0.000013	-0.000013	-0.000014
-0.000015	-0.000015	-0.000016	-0.000016	-0.000017	-0.000017	-0.000018	-0.000018
-0.000019	-0.000019	-0.000019	-0.000020	-0.000020	-0.000020	-0.000020	-0.000020
-0.000021	-0.000021	-0.000021	-0.000021	-0.000021	-0.000021	-0.000022	-0.000022
-0.000022	-0.000022	-0.000022	-0.000022	-0.000022	-0.000022	-0.000022	-0.000022
-0.000023	-0.000023	-0.000023	-0.000023	-0.000023	-0.000023	-0.000023	-0.000023
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0.000153	0.000396	0.000626	0.000839	0.001029	0.001194	0.001330	0.001437
0.001517	0.001570	0.001599	0.001605	0.001588	0.001551	0.001497	0.001429
0.001353	0.001274	0.001196	0.001122	0.001052	0.000987	0.000923	0.000860
0.000796	0.000732	0.000668	0.000603	0.000541	0.000479	0.000419	0.000362
0.000307	0.000255	0.000209	0.000168	0.000132	0.000099	0.000067	0.000032
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0.002794	0.003169	0.003506	0.003802	0.004060	0.004281	0.004471	0.004636
0.004783	0.004920	0.005051	0.005181	0.005313	0.005449	0.005595	0.005753
0.005927	0.006118	0.006323	0.006536	0.006745	0.006937	0.007098	0.007212
0.007270	0.007267	0.007206	0.007096	0.006950	0.006782	0.006607	0.006433
0.006265	0.006101	0.005935	0.005759	0.005563	0.005337	0.005075	0.004768
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0.004643	0.004392	0.004058	0.003650	0.003179	0.002662	0.002112	0.001541
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0.004624	0.004926	0.005191	0.005404	0.005553	0.005632	0.005640	0.005588
0.005487	0.005353	0.005203	0.005048	0.004898	0.004759	0.004635	0.004523
0.004421	0.004319	0.004212	0.004093	0.003964	0.003828	0.003695	0.003574
0.003475	0.003402	0.003353	0.003320	0.003296	0.003270	0.003238	0.003196
0.003140	0.003068	0.002978	0.002867	0.002735	0.002586	0.002423	0.002253
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0.010000	0.010515	0.010990	0.011415	0.011787	0.012110	0.012399	0.012670
0.012941	0.013222	0.013519	0.013831	0.014156	0.014492	0.014840	0.015207
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0.019500	0.019918	0.020276	0.020560	0.020756	0.020844	0.020803	0.020611
0.020251	0.019706	0.018967	0.018036	0.016921	0.015643	0.014231	0.012725
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0.029015	0.029277	0.029388	0.029360	0.029203	0.028920	0.028513	0.027985
0.027341	0.026589	0.025741	0.024818	0.023844	0.022844	0.021840	0.020842
0.019851	0.018853	0.017832	0.016770	0.015662	0.014512	0.013340	0.012178
0.011058	0.010013	0.009063	0.008219	0.007478	0.006827	0.006251	0.005733
0.005262	0.004828	0.004427	0.004058	0.003723	0.003425	0.003170	0.002959
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0.032480	0.036687	0.041049	0.045474	0.049848	0.054037	0.057898	0.061290
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0.017444	0.021247	0.024764	0.027915	0.030631	0.032863	0.034588	0.035803
0.036535	0.036832	0.036758	0.036393	0.035827	0.035154	0.034470	0.033864
0.033415	0.033182	0.033205	0.033498	0.034046	0.034807	0.035716	0.036691
0.037645	0.038491	0.039154	0.039578	0.039725	0.039580	0.039149	0.038456
0.037538	0.036435	0.035190	0.033832	0.032377	0.030824	0.029154	0.027334
0.025316	0.023049	0.020473	0.017534	0.014184	0.010388	0.006129	0.001413
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0.030469	0.034676	0.038240	0.041205	0.043619	0.045522	0.046949	0.047931
0.048497	0.048675	0.048491	0.047971	0.047131	0.045982	0.044528	0.042773
0.040724	0.038402	0.035846	0.033114	0.030286	0.027460	0.024752	0.022285
0.020188	0.018584	0.017584	0.017270	0.017689	0.018851	0.020723	0.023242
0.026319	0.029853	0.033730	0.037835	0.042052	0.046265	0.050361	0.054230
0.057771	0.060887	0.063493	0.065520	0.066918	0.067661	0.067753	0.067224
0.066128	0.064533	0.062514	0.060140	0.057472	0.054558	0.051432	0.048114
0.044618	0.040949	0.037108	0.033099	0.028927	0.024608	0.020169	0.015650
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0.009397	0.008936	0.008222	0.007243	0.005994	0.004473	0.002686	0.000644
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0.003696	0.005658	0.007772	0.010042	0.012470	0.015058	0.017806	0.020715
0.023784	0.027012	0.030394	0.033922	0.037579	0.041343	0.045183	0.049063
0.052943	0.056781	0.060537	0.064170	0.067642	0.070917	0.073958	0.076727
0.079191	0.081317	0.083081	0.084468	0.085473	0.086105	0.086381	0.086327
0.085972	0.085347	0.084482	0.083405	0.082141	0.080717	0.079162	0.077506
0.075780	0.074016	0.072240	0.070476	0.068741	0.067043	0.065387	0.063777
0.062213	0.060700	0.059242	0.057844	0.056507	0.055227	0.053991	0.052778
0.051552	0.050267	0.048866	0.047283	0.045453	0.043311	0.040803	0.037886
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0.031818	0.041915	0.051670	0.060968	0.069702	0.077788	0.085156	0.091758
0.097565	0.102562	0.106746	0.110122	0.112703	0.114502	0.115536	0.115813
0.115341	0.114116	0.112132	0.109379	0.105853	0.101561	0.096523	0.090779
0.084393	0.077450	0.070057	0.062338	0.054432	0.046485	0.038643	0.031045
0.023818	0.017070	0.010894	0.005364	0.000540	-0.003532	-0.006815	-0.009288
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0.001894	0.005679	0.009593	0.013508	0.017304	0.020865	0.024089	0.026894
0.029218	0.031021	0.032290	0.033030	0.033265	0.033033	0.032375	0.031334
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0.008150	0.012867	0.017514	0.022109	0.026670	0.031214	0.035756	0.040307
0.044870	0.049442	0.054008	0.058545	0.063024	0.067409	0.071662	0.075743
0.079609	0.083216	0.086515	0.089459	0.092001	0.094095	0.095701	0.096788
0.097339	0.097353	0.096840	0.095826	0.094344	0.092433	0.090136	0.087494
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0.055291	0.051674	0.048223	0.044964	0.041911	0.039068	0.036431	0.033987
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0.110136	0.116011	0.121192	0.125650	0.129363	0.132308	0.134459	0.135792
0.136283	0.135916	0.134680	0.132580	0.129632	0.125865	0.121320	0.116047
0.110101	0.103543	0.096438	0.088855	0.080873	0.072577	0.064065	0.055443
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0.022341	0.024751	0.026690	0.028168	0.029210	0.029850	0.030131	0.030093
0.029775	0.029206	0.028414	0.027420	0.026251	0.024931	0.023495	0.021977
0.020416	0.018851	0.017313	0.015831	0.014422	0.013100	0.011872	0.010743
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0.034195	0.035523	0.036485	0.037088	0.037343	0.037262	0.036859	0.036156
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0.008018	0.008217	0.008675	0.009351	0.010193	0.011142	0.012138	0.013118
0.014023	0.014800	0.015406	0.015808	0.015991	0.015956	0.015718	0.015309
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0.026428	0.024963	0.023286	0.021437	0.019457	0.017390	0.015280	0.013165
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0.010237	0.009486	0.008667	0.007827	0.007005	0.006234	0.005543	0.004952
0.004473	0.004110	0.003861	0.003713	0.003651	0.003649	0.003678	0.003707
0.003702	0.003634	0.003478	0.003217	0.002845	0.002365	0.001790	0.001138
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0.009244	0.010594	0.011945	0.013350	0.014858	0.016509	0.018332	0.020343
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0.059921	0.056149	0.052293	0.048402	0.044527	0.040723	0.037043	0.033534

0.030238	0.027190	0.024412	0.021920	0.019718	0.017801	0.016157	0.014770
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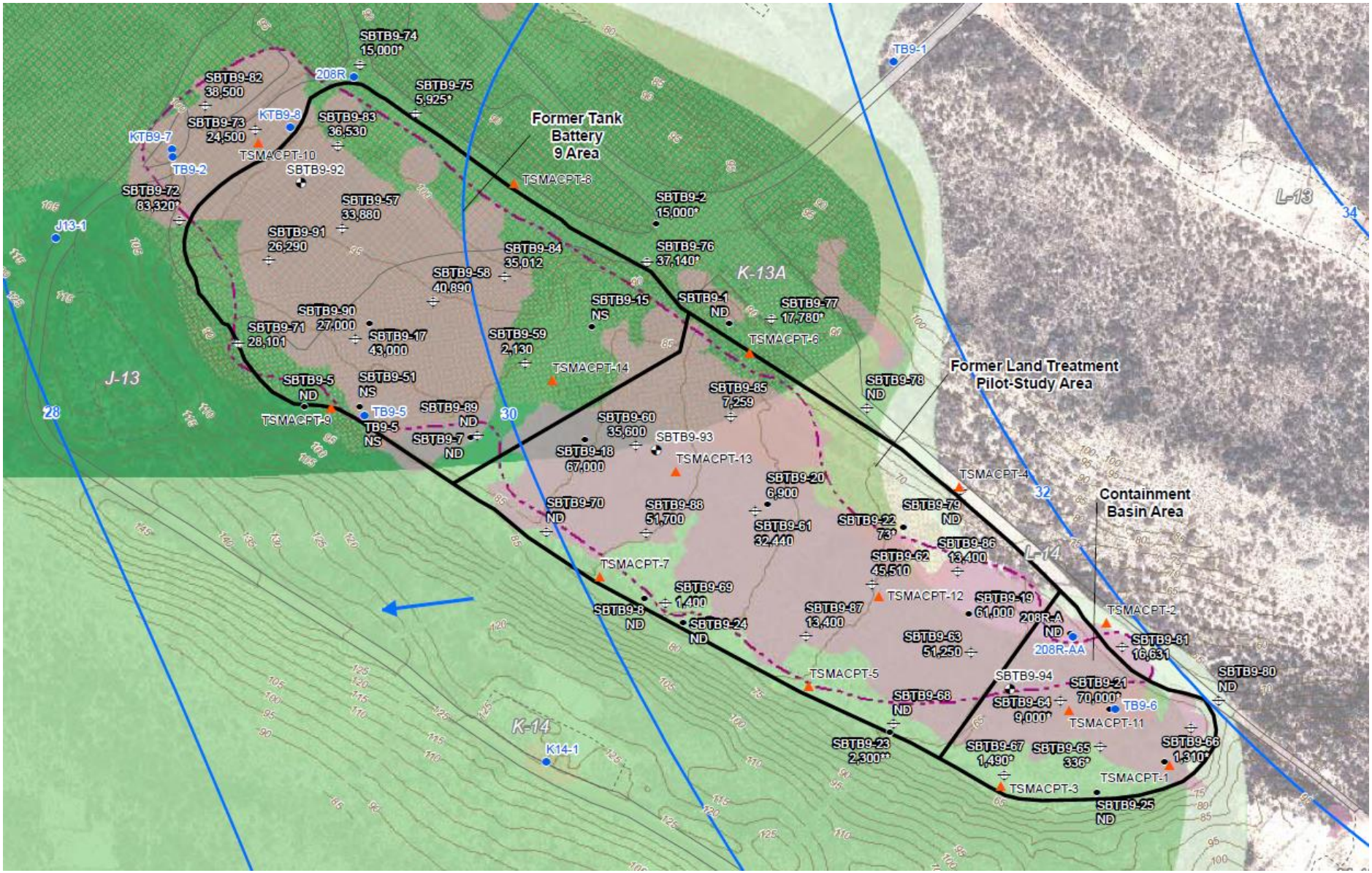
APPENDIX G

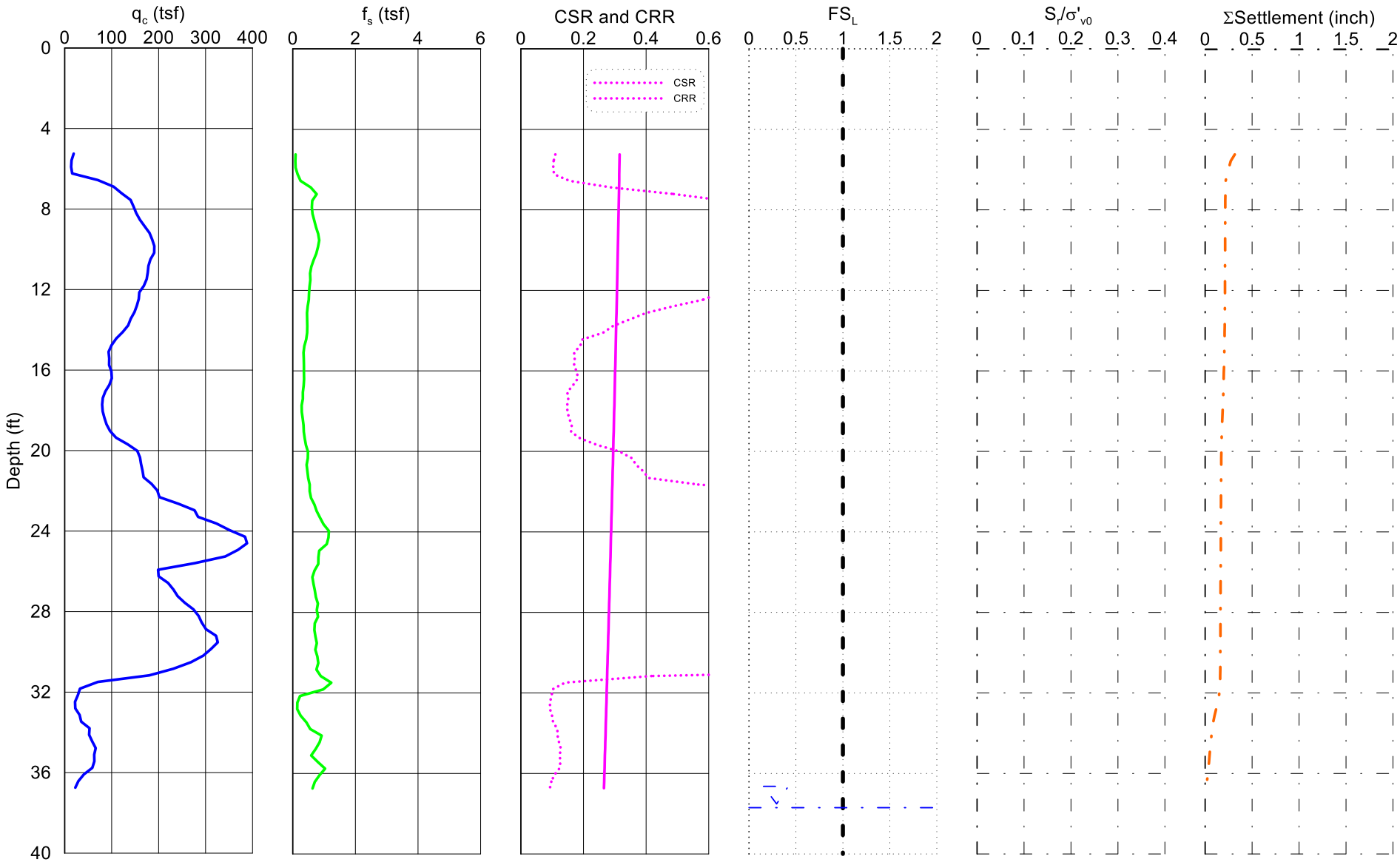
Liquefaction Analysis Results



Source:

padre associates, inc. ENGINEERS, GEOLOGISTS & ENVIRONMENTAL SCIENTISTS	PROJECT NAME: CHEVRON ENVIRONMENTAL MANAGEMENT COMPANY GUADALUPE RESTORATION PROJECT	
	PROJECT NUMBER: 1601-2193	DATE: October 2018

GOLDER	Chevron Environmental Management Company Tank Battery 9 Area **2018 Cone Penetration and Test Boring Locations**	
Project No.: **1783552**	Date: **October 2018**	Figure: **G-1**

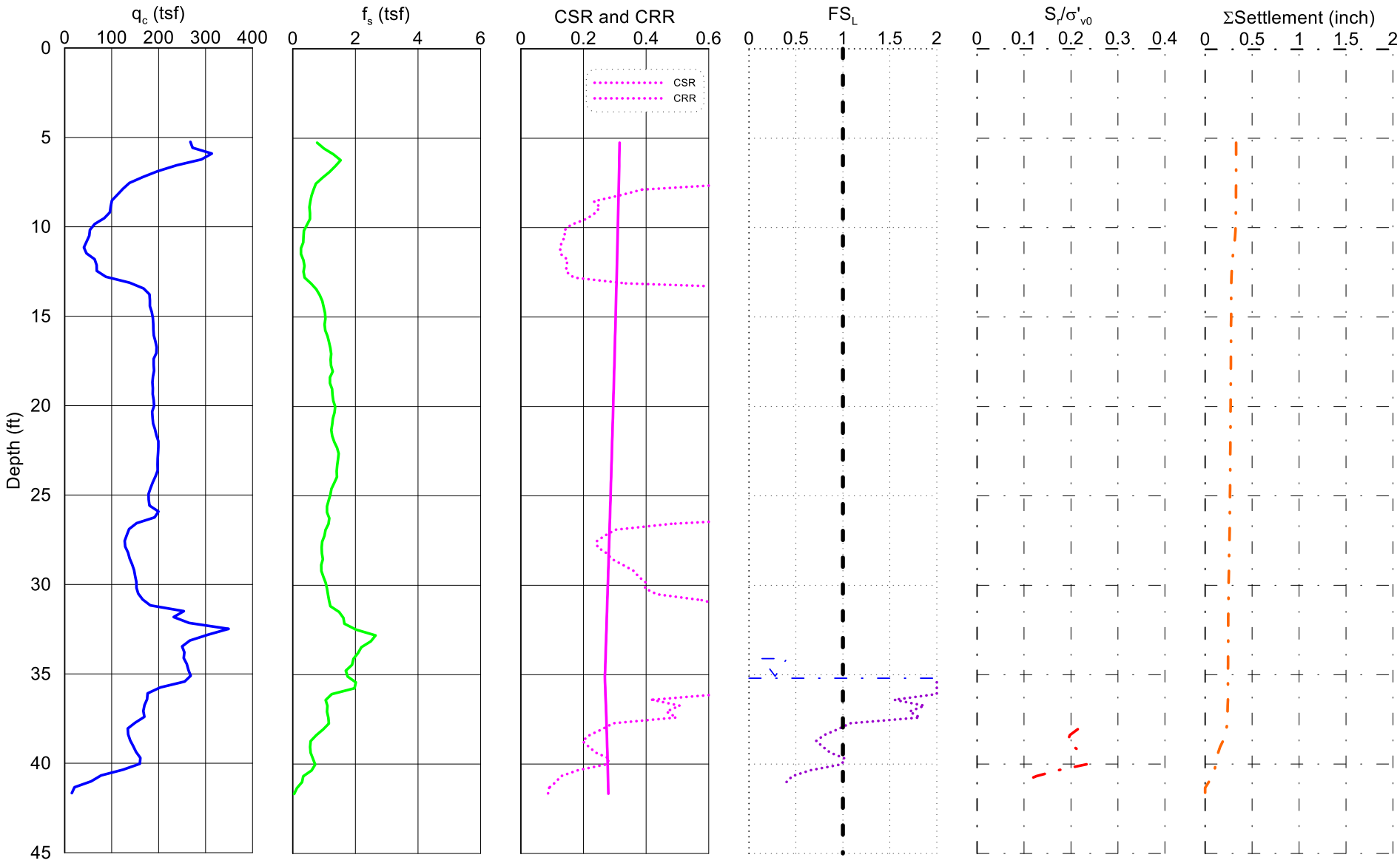


q_c=tip resistance, f_s=sleeve friction
CSR=cyclic stress ratio, CRR=cyclic resistance ratio
F_{SL}=factor of safety against liquefaction=CRR/CSR
S_r/σ'_{vo}=residual shear strength normalized by effective vertical stress
ΣSettlement=cumulative settlement with depth

GOLDER

Chevron Environmental Management Company
Tank Battery 9 Area
Liquefaction Analysis for TSMACPT-1

Project No.: **1783552** | Date: **October 2018** | Figure: **G-2**

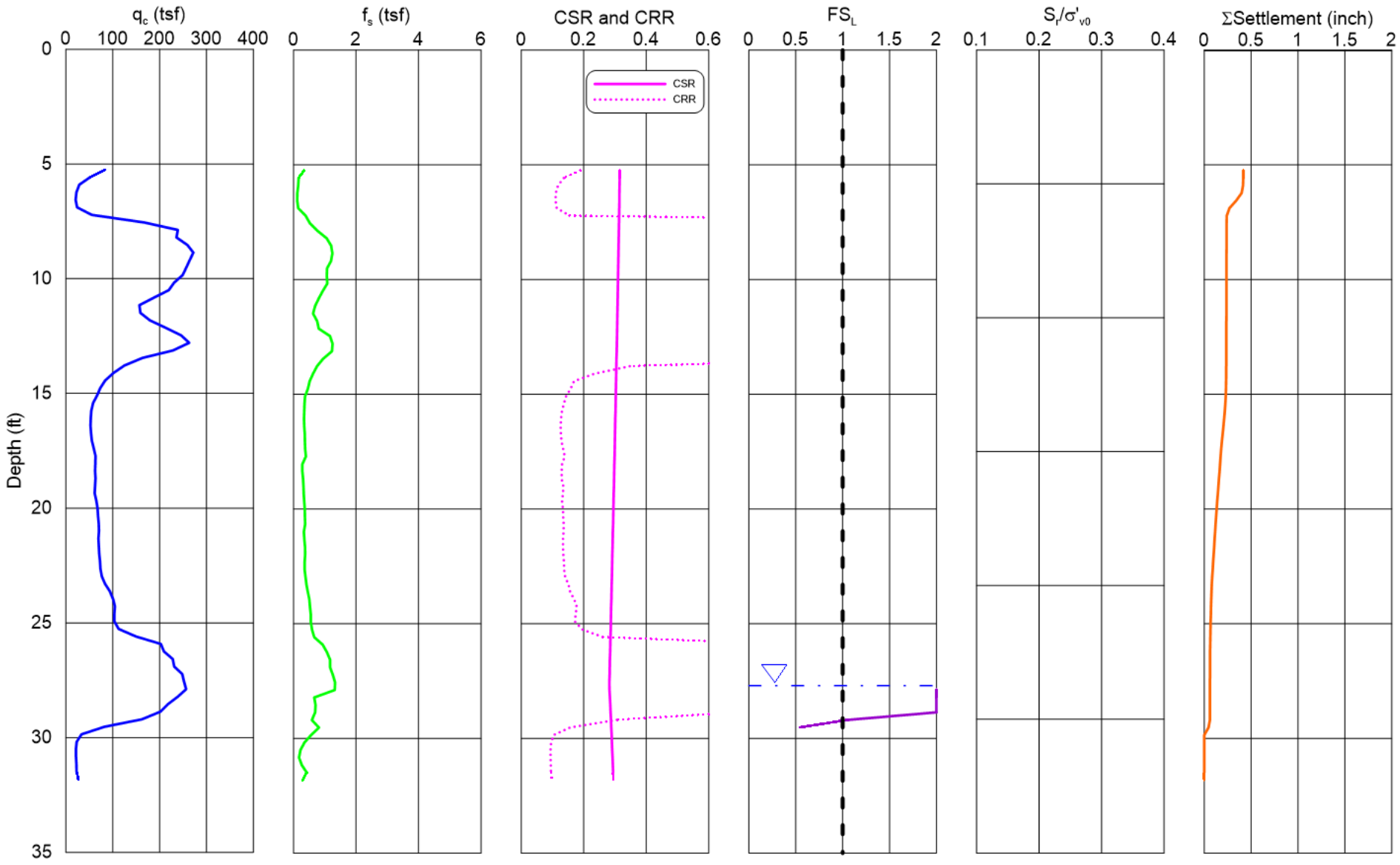


q_c=tip resistance, f_s=sleeve friction
CSR=cyclic stress ratio, CRR=cyclic resistance ratio
F_{SL}=factor of safety against liquefaction=CRR/CSR
S_r/σ'_{vo}=residual shear strength normalized by effective vertical stress
ΣSettlement=cumulative settlement with depth

GOLDER

Chevron Environmental Management Company
Tank Battery 9 Area
Liquefaction Analysis for TSMACPT-2

Project No.: **1783552** | Date: **October 2018** | Figure: **G-3**

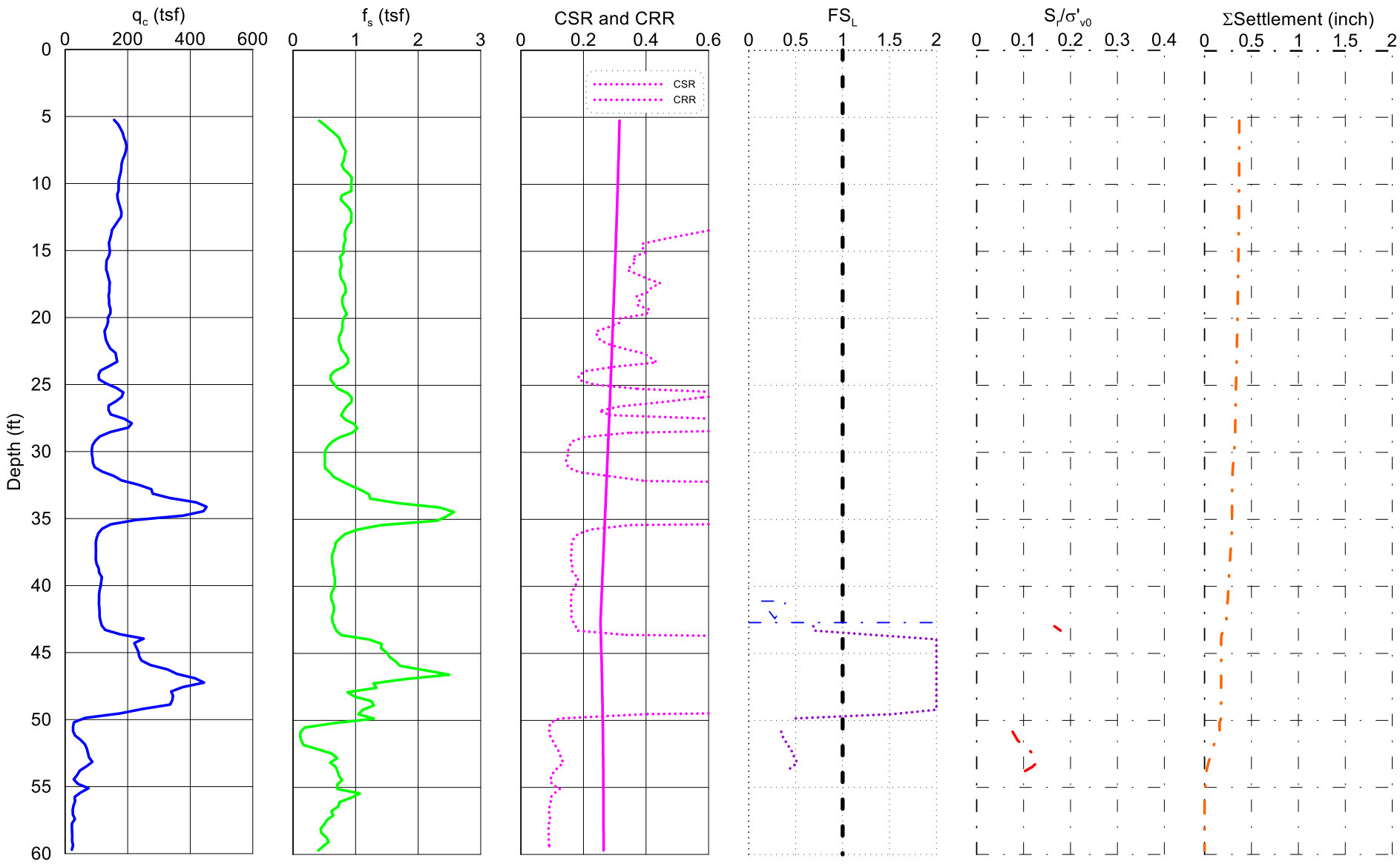


q_c=tip resistance, f_s=sleeve friction
CSR=cyclic stress ratio, CRR=cyclic resistance ratio
F_{SL}=factor of safety against liquefaction=CRR/CSR
S_r/σ'_{vo}=residual shear strength normalized by effective vertical stress
ΣSettlement=cumulative settlement with depth

GOLDER

Chevron Environmental Management Company
Tank Battery 9 Area
Liquefaction Analysis for TSMACPT-3

Project No.: **1783552** | Date: **October 2018** | Figure: **G-4**

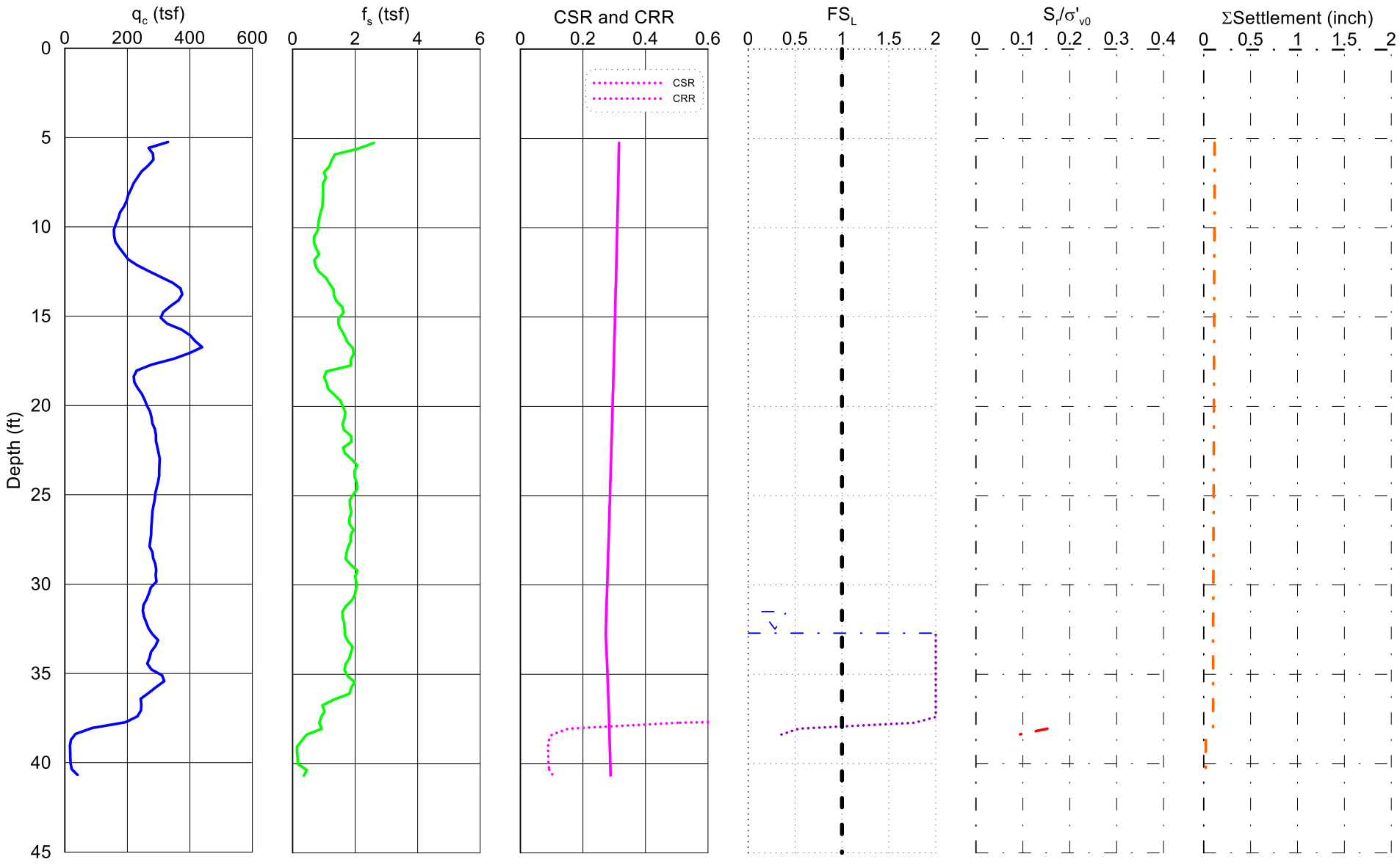


q_c=tip resistance, f_s=sleeve friction
CSR=cyclic stress ratio, CRR=cyclic resistance ratio
F_{SL}=factor of safety against liquefaction=CRR/CSR
S_r/σ'_{vo}=residual shear strength normalized by effective vertical stress
ΣSettlement=cumulative settlement with depth

GOLDER

Chevron Environmental Management Company
Tank Battery 9 Area
Liquefaction Analysis for TSMACPT-4

Project No.: **1783552** | Date: **October 2018** | Figure: **G-5**

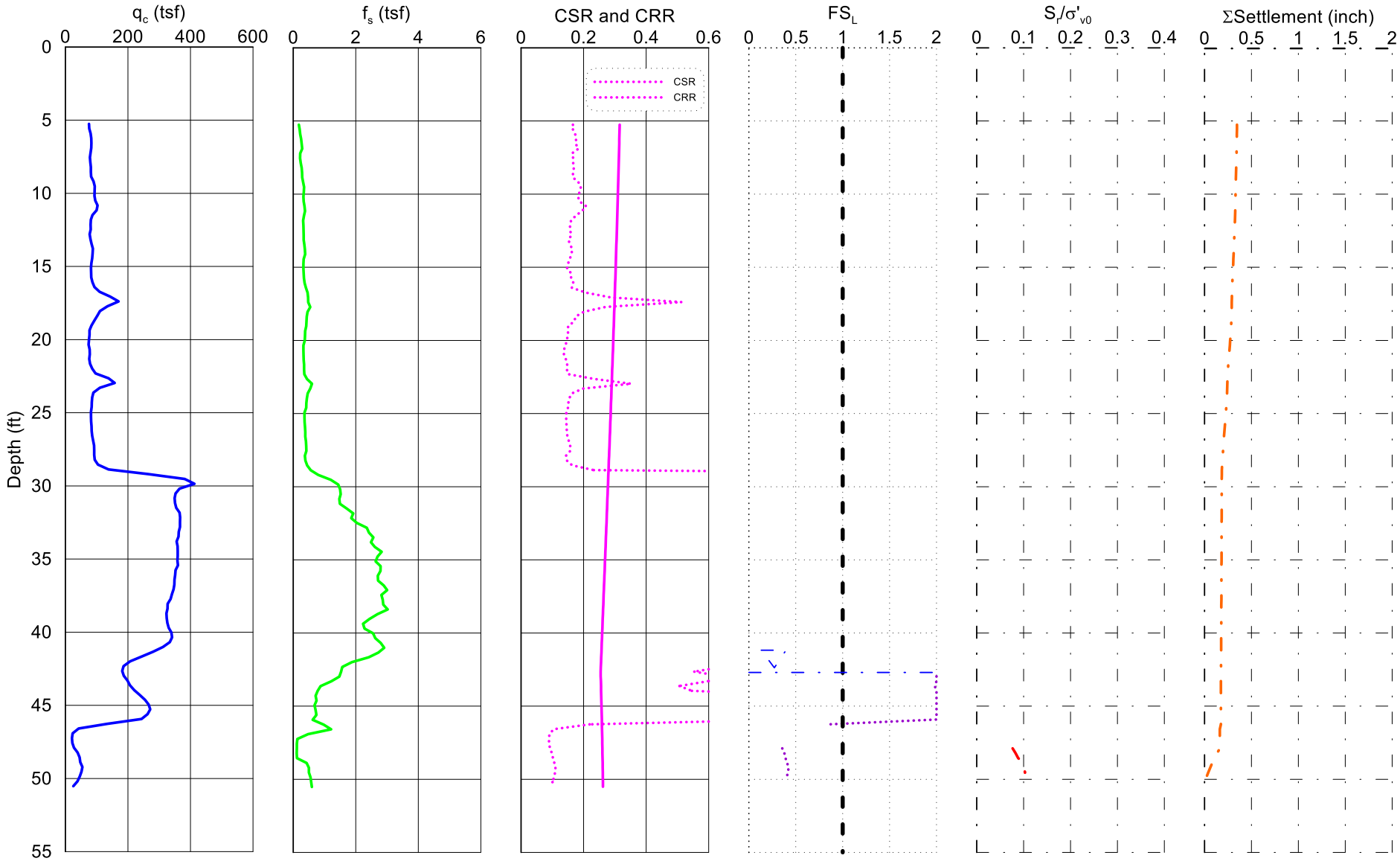


q_c=tip resistance, f_s=sleeve friction
CSR=cyclic stress ratio, CRR=cyclic resistance ratio
F_{SL}=factor of safety against liquefaction=CRR/CSR
S_r/σ'_{vo}=residual shear strength normalized by effective vertical stress
ΣSettlement=cumulative settlement with depth

GOLDER

Chevron Environmental Management Company
Tank Battery 9 Area
Liquefaction Analysis for TSMACPT-5

Project No.: **1783552** | Date: **October 2018** | Figure: **G-6**

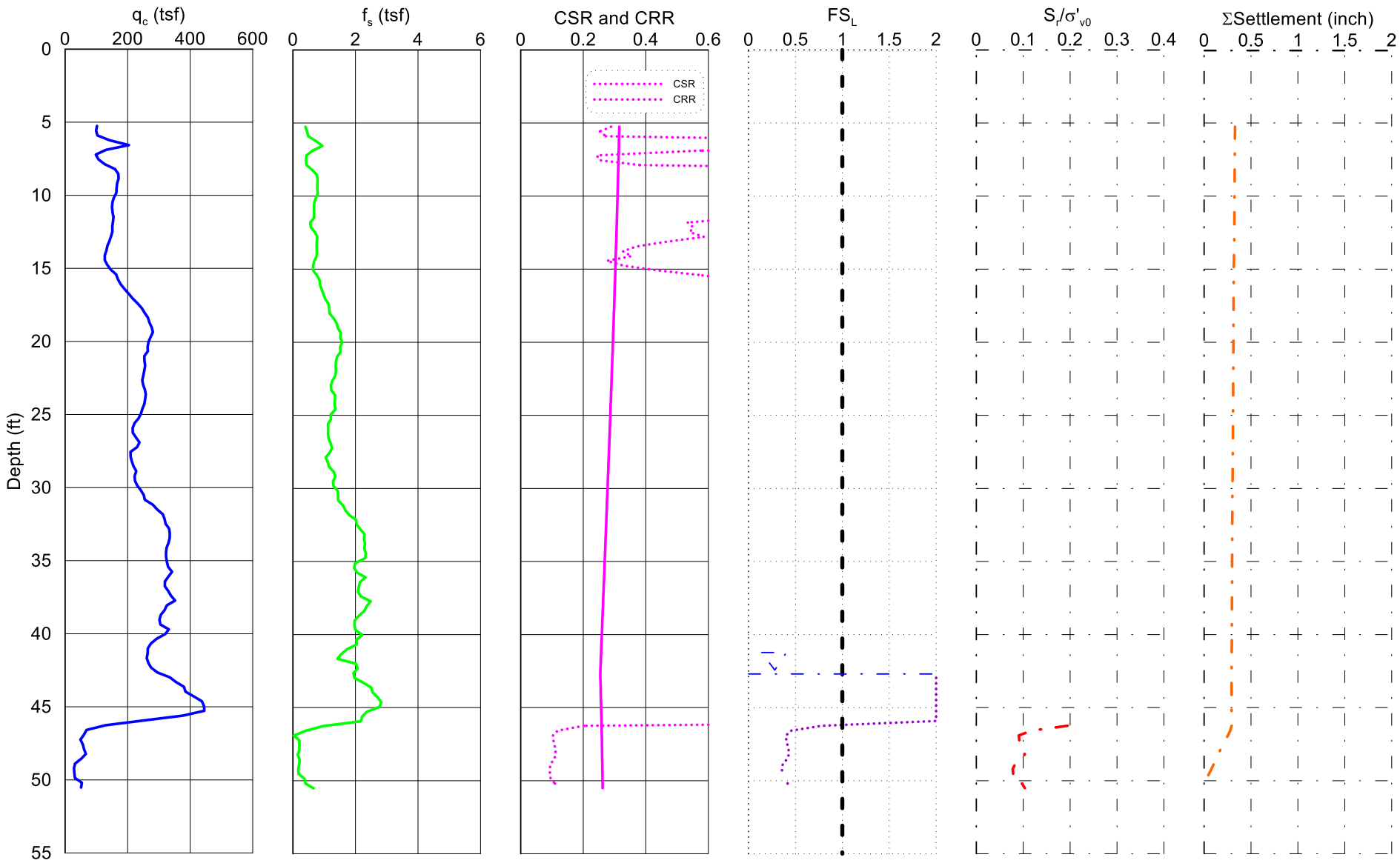


q_c=tip resistance, f_s=sleeve friction
CSR=cyclic stress ratio, CRR=cyclic resistance ratio
F_{SL}=factor of safety against liquefaction=CRR/CSR
S_r/σ'_{vo}=residual shear strength normalized by effective vertical stress
ΣSettlement=cumulative settlement with depth

GOLDER

Chevron Environmental Management Company
Tank Battery 9 Area
Liquefaction Analysis for TSMACPT-6

Project No.: **1783552** | Date: **October 2018** | Figure: **G-7**

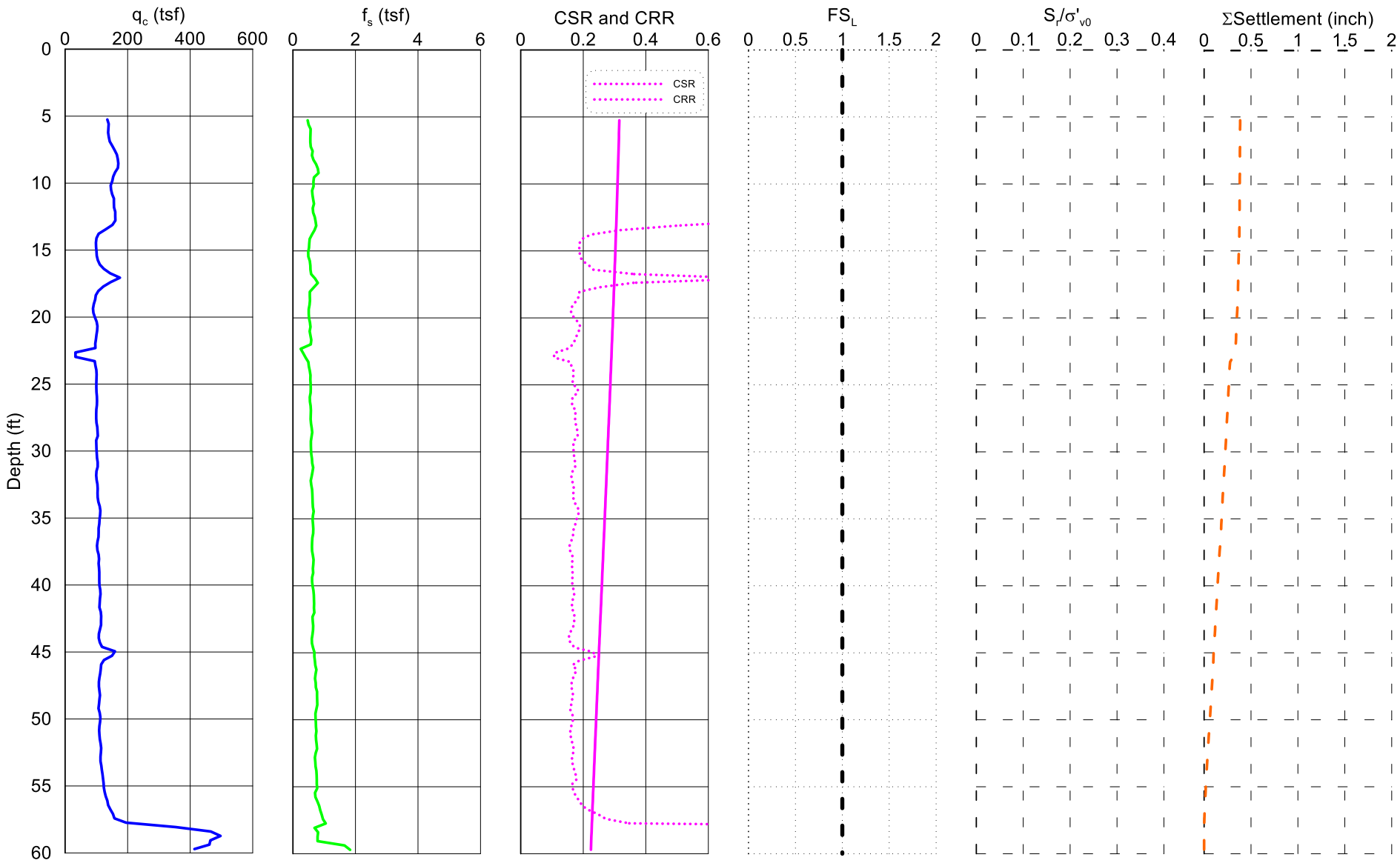


q_c=tip resistance, f_s=sleeve friction
CSR=cyclic stress ratio, CRR=cyclic resistance ratio
F_{SL}=factor of safety against liquefaction=CRR/CSR
S_r/σ'_{vo}=residual shear strength normalized by effective vertical stress
ΣSettlement=cumulative settlement with depth

GOLDER

Chevron Environmental Management Company
Tank Battery 9 Area
Liquefaction Analysis for TSMACPT-7

Project No.: **1783552** | Date: **October 2018** | Figure: **G-8**

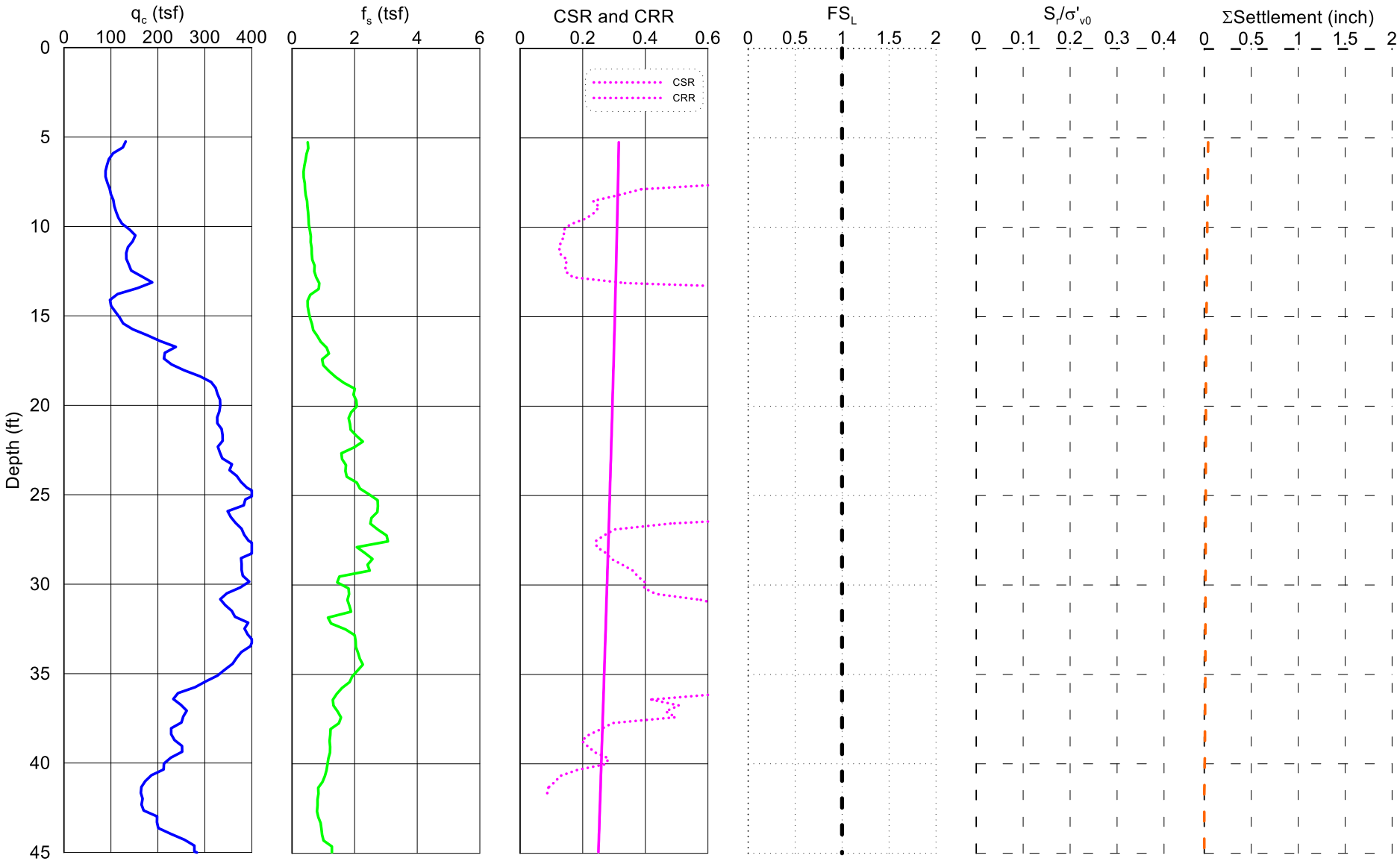


q_c=tip resistance, f_s=sleeve friction
CSR=cyclic stress ratio, CRR=cyclic resistance ratio
F_{SL}=factor of safety against liquefaction=CRR/CSR
S_r/σ'_{vo}=residual shear strength normalized by effective vertical stress
ΣSettlement=cumulative settlement with depth

GOLDER

Chevron Environmental Management Company
Tank Battery 9 Area
Liquefaction Analysis for TSMACPT-8

Project No.: **1783552** | Date: **October 2018** | Figure: **G-9**

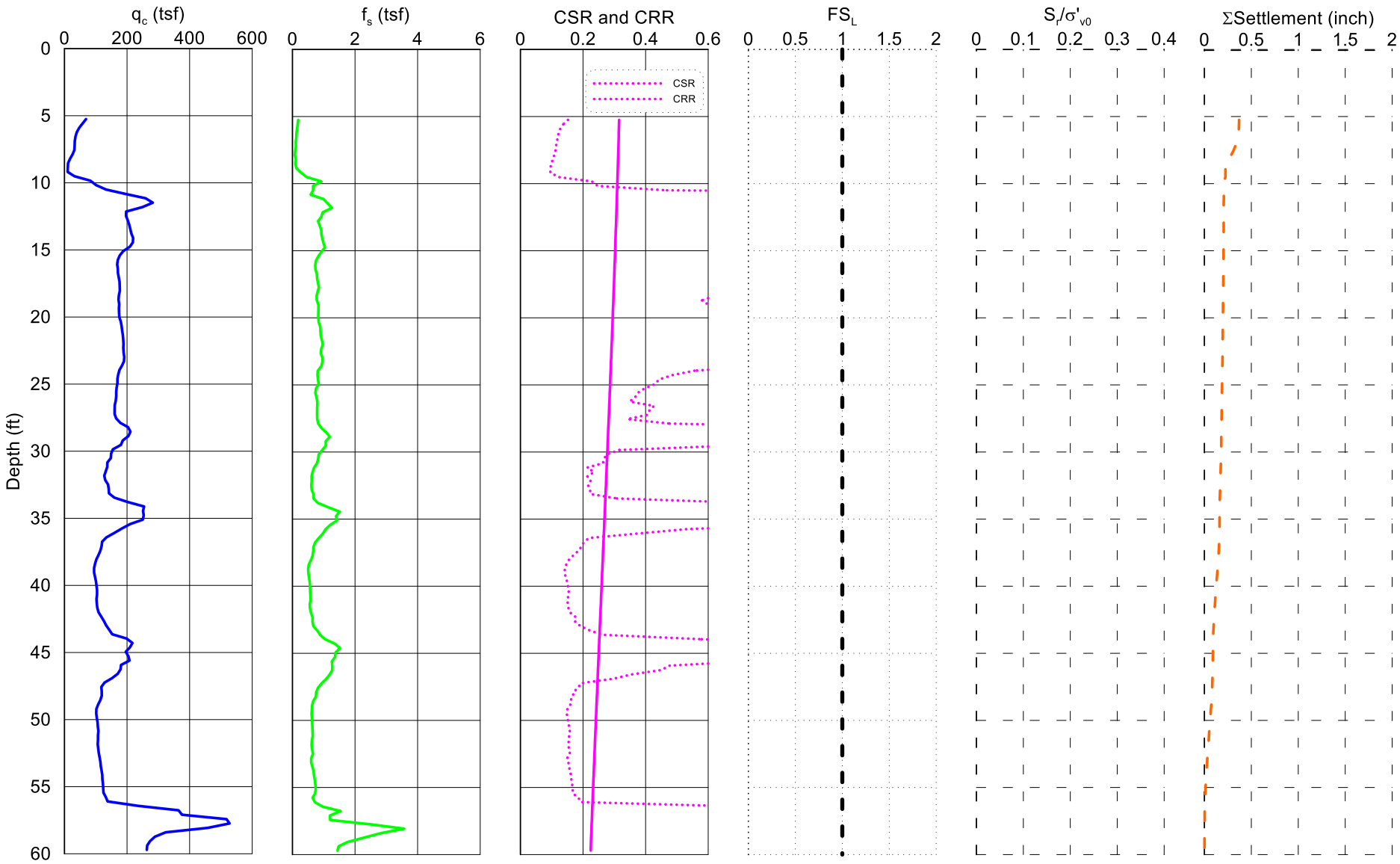


q_c=tip resistance, f_s=sleeve friction
CSR=cyclic stress ratio, CRR=cyclic resistance ratio
F_{SL}=factor of safety against liquefaction=CRR/CSR
S_r/σ'_{vo}=residual shear strength normalized by effective vertical stress
ΣSettlement=cumulative settlement with depth

GOLDER

Chevron Environmental Management Company
Tank Battery 9 Area
Liquefaction Analysis for TSMACPT-9

Project No.: **1783552** | Date: **October 2018** | Figure: **G-10**

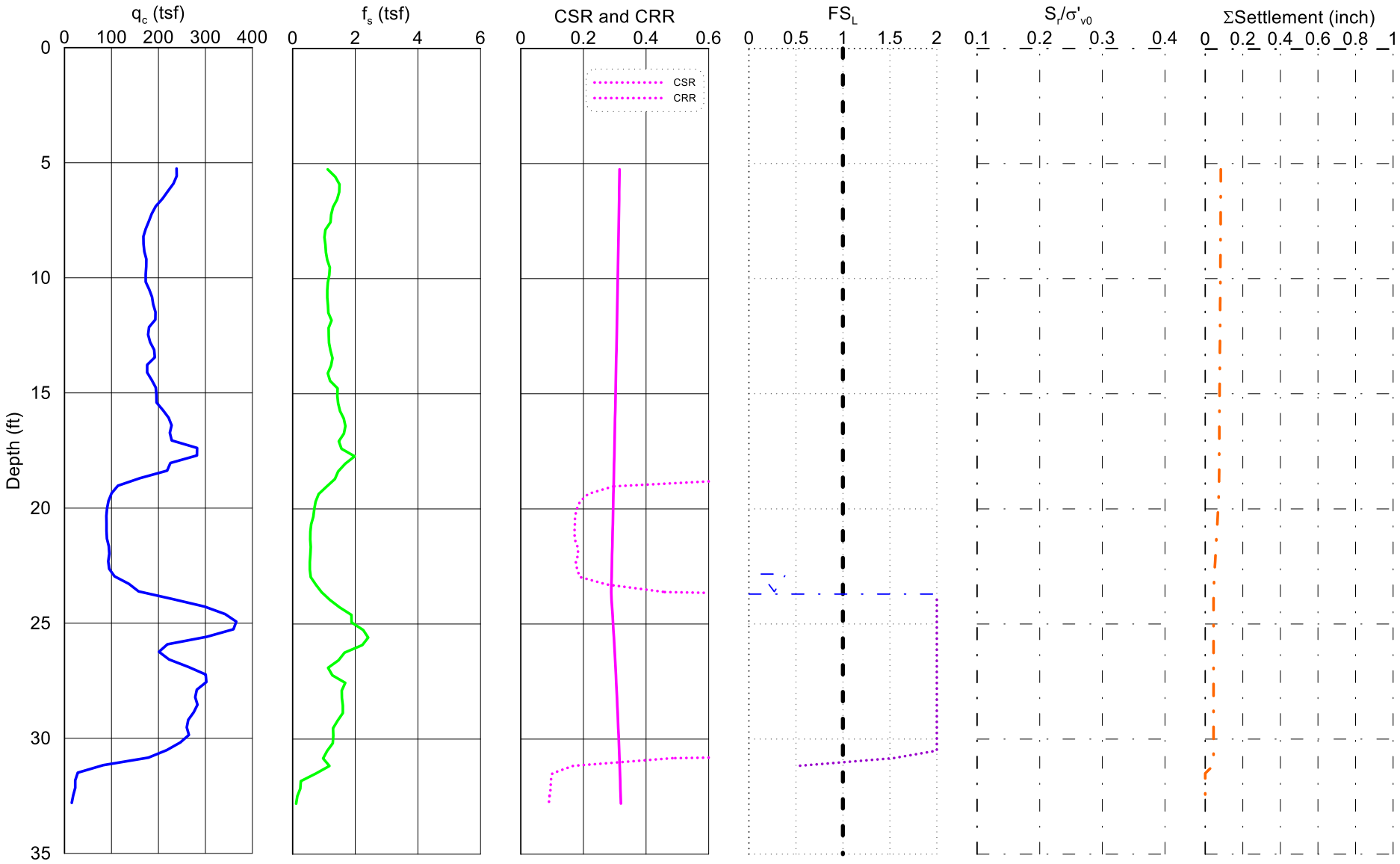


q_c=tip resistance, f_s=sleeve friction
CSR=cyclic stress ratio, CRR=cyclic resistance ratio
F_{SL}=factor of safety against liquefaction=CRR/CSR
S_r/σ'_{vo}=residual shear strength normalized by effective vertical stress
ΣSettlement=cumulative settlement with depth

GOLDER

Chevron Environmental Management Company
Tank Battery 9 Area
Liquefaction Analysis for TSMACPT-10

Project No.: **1783552** | Date: **October 2018** | Figure: **G-11**

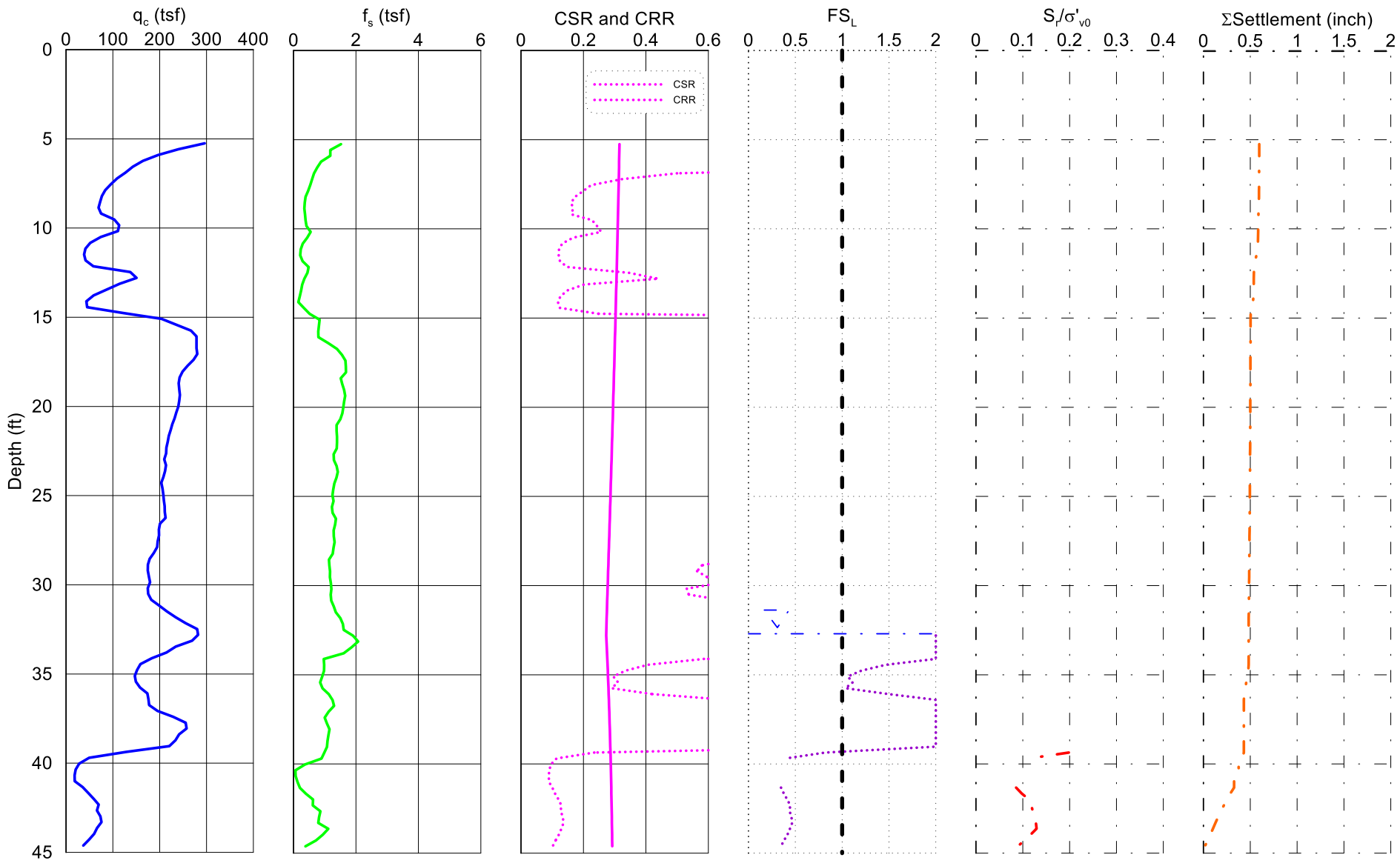


q_c=tip resistance, f_s=sleeve friction
CSR=cyclic stress ratio, CRR=cyclic resistance ratio
F_{SL}=factor of safety against liquefaction=CRR/CSR
S_r/σ'_{vo}=residual shear strength normalized by effective vertical stress
ΣSettlement=cumulative settlement with depth

GOLDER

Chevron Environmental Management Company
Tank Battery 9 Area
Liquefaction Analysis for TSMACPT-11

Project No.: **1783552** | Date: **October 2018** | Figure: **G-12**

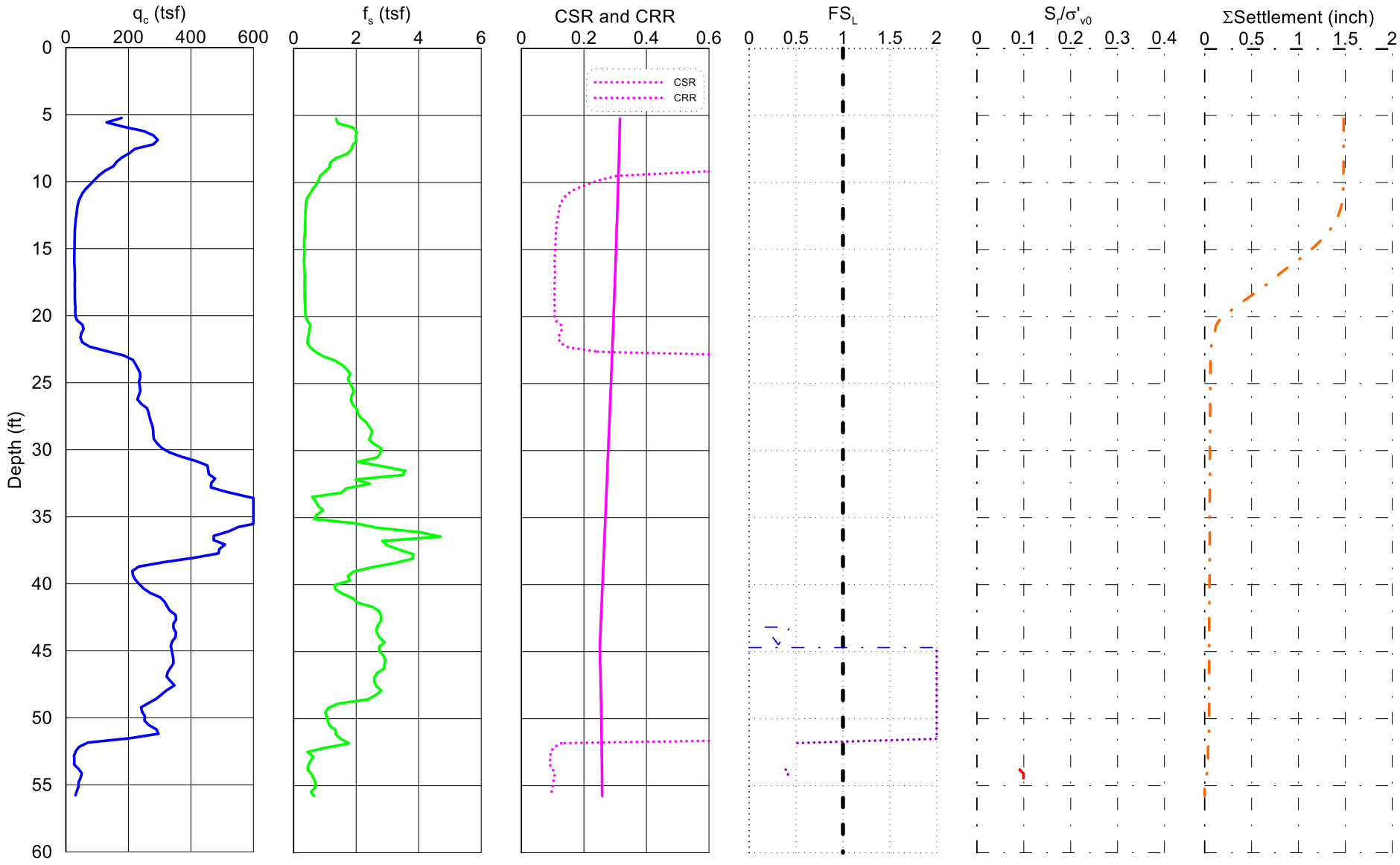


q_c=tip resistance, f_s=sleeve friction
CSR=cyclic stress ratio, CRR=cyclic resistance ratio
F_{SL}=factor of safety against liquefaction=CRR/CSR
S_r/σ'_{vo}=residual shear strength normalized by effective vertical stress
ΣSettlement=cumulative settlement with depth

GOLDER

Chevron Environmental Management Company
Tank Battery 9 Area
Liquefaction Analysis for TSMACPT-12

Project No.: **1783552** | Date: **October 2018** | Figure: **G-13**

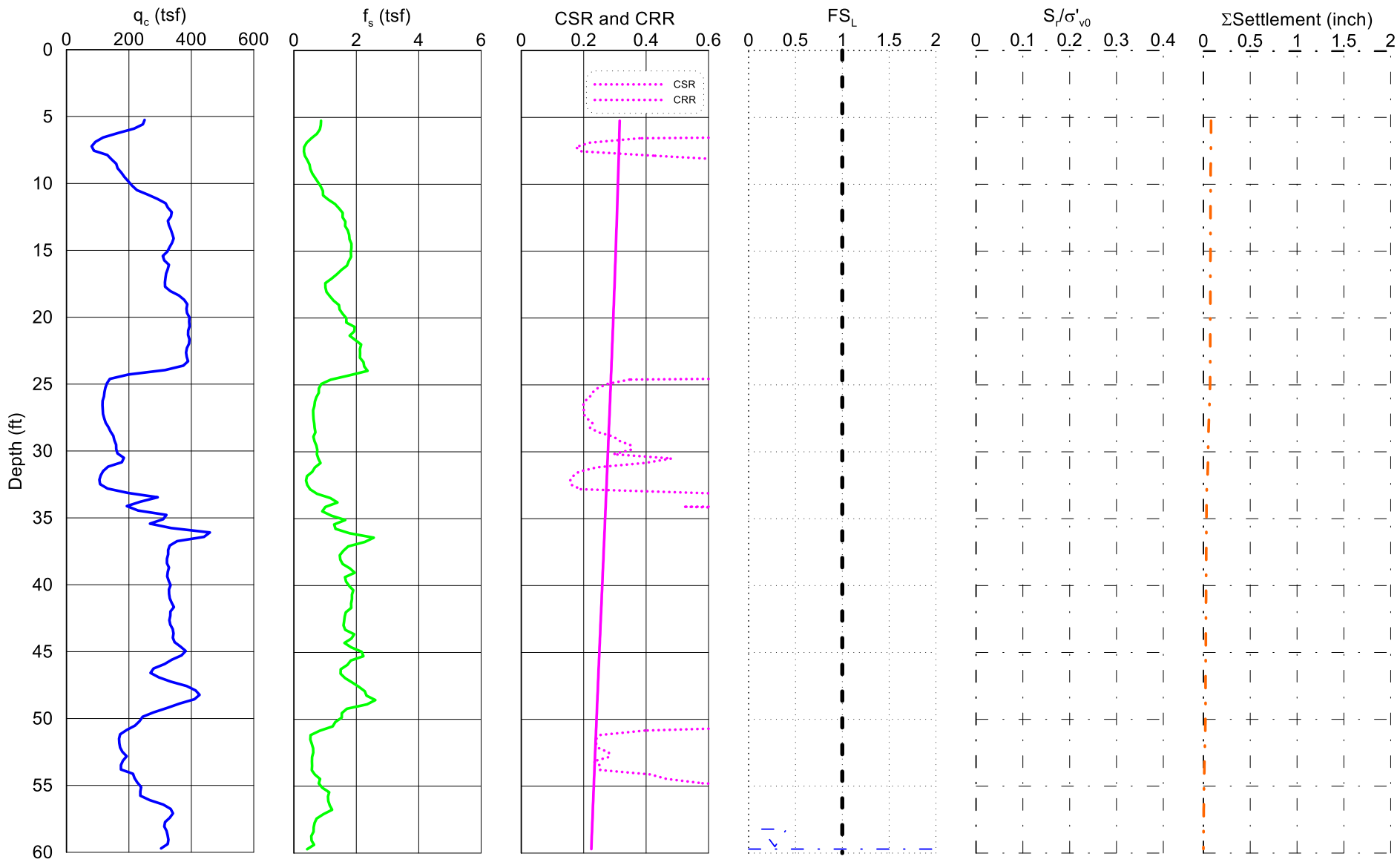


q_c=tip resistance, f_s=sleeve friction
CSR=cyclic stress ratio, CRR=cyclic resistance ratio
F_{SL}=factor of safety against liquefaction=CRR/CSR
S_r/σ'_{vo}=residual shear strength normalized by effective vertical stress
ΣSettlement=cumulative settlement with depth

GOLDER

Chevron Environmental Management Company
Tank Battery 9 Area
Liquefaction Analysis for TSMACPT-13

Project No.: **1783552** | Date: **October 2018** | Figure: **G-14**



q_c=tip resistance, f_s=sleeve friction
CSR=cyclic stress ratio, CRR=cyclic resistance ratio
F_{SL}=factor of safety against liquefaction=CRR/CSR
S_r/σ'_{vo}=residual shear strength normalized by effective vertical stress
ΣSettlement=cumulative settlement with depth

GOLDER

Chevron Environmental Management Company
Tank Battery 9 Area
Liquefaction Analysis for TSMACPT-14

Project No.: **1783552** | Date: **October 2018** | Figure: **G-15**

CONE PENETRATION TEST-BASED LIQUEFACTION ANALYSIS BASED ON IDRISS & BOULANGER (2008)

References:

1 - Idriss, I.M. and Boulanger, R.W. (2008). *Soil Liquefaction During Earthquakes*, Earthquake Engineering Research Institute, EERI Publication MNO-12.

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3 - Tokimatsu, K. and Seed H.B. (1987). "Evaluation of Settlements in Sands Due to Earthquake Shaking," Journal of Geotechnical Engineering, Vol. 113, No. 8, August.

4 - Pradel, D. (1998). "Procedure to Evaluate Earthquake-Induced Settlements in Sand," Journal of Geotechnical and Geoenvironmental Engineering, Vol. 124, No. 4, April.

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6 - Boulanger, R.W. and Idriss, I.M. (2014). "CPT and SPT Based Liquefaction Triggering Procedures," Report No. UCD/CGM-14/01, University of California at Davis

Project	Chevron Guadalupe Tank Battery 9 Site
Test Boring No	TSMACPT-1

Test Boring Information:

Approx. depth to ground water table		37.7 ft	11.49 m
Moist unit weight of soil	γ_m	115 pcf	18.08 kN/m^3
Saturated unit weight of soil	γ_{sat}	125 pcf	19.65 kN/m^3

Earthquake Information:

Earthquake magnitude	M_w	6.9
Peak horizontal ground surface acceleratio	a_{max}	0.490 g
Number of equivalent cycle	N	10.1

Atmospheric pressure	P_a	101.3 kPa

N/L = Non-liquefiable clay-like soil
N.A. = Not Applicable

Sum
0.00

Sum	Total
0.32	0.32

Factor of Safety Agaist Liquefaction (Idriss & Boulanger, 2008 and Boulanger & Idriss, 2014)

Depth, Z (m)	Depth, Z (ft)	q_c (kPa)	f_s (kPa)	σ_{vc} (kPa)	σ'_{vc} (kPa)	Q	F	I_c	Soil Type	Fines (%)	Interpreted q_c	C_N	q_{c1N}	q_{c1N-cs}	Stress Reduction Factor (r_d)	CSR	K_σ for sand	$CRR_{M=7.5}$ at σ'_{vc}=1	MSF_{max}	MSF	CRR	$(FS)_L$
1.60	5.25	1820	9	28.9	28.9	33	0.49	2.2	Unsaturated	22	1820	1.39	25.1	58.1	0.99	0.315	1.1	0.098	1.12	1.026	0.110	N/L
1.70	5.58	1407	8	30.7	30.7	25	0.56	2.3	Unsaturated	24	1407	1.37	19.1	52.2	0.99	0.315	1.1	0.094	1.11	1.025	0.104	N/L
1.80	5.90	1304	9	32.5	32.5	22	0.67	2.4	Unsaturated	27	1304	1.35	17.4	51.3	0.99	0.315	1.1	0.093	1.11	1.024	0.103	N/L
1.90	6.23	1522	15	34.3	34.3	25	1.00	2.4	Unsaturated	27	1522	1.33	20.0	54.8	0.99	0.314	1.1	0.096	1.12	1.025	0.106	N/L
2.00	6.56	6762	24	36.2	36.2	111	0.35	1.6	Unsaturated	10	6762	1.31	87.8	97.9	0.99	0.314	1.1	0.135	1.25	1.054	0.156	N/L
2.10	6.89	9948	55	38.0	38.0	160	0.56	1.6	Unsaturated	10	9948	1.29	127.5	139.9	0.98	0.314	1.1	0.234	1.56	1.120	0.288	N/L
2.20	7.22	11621	73	39.8	39.8	182	0.63	1.6	Unsaturated	10	11621	1.28	147.1	160.7	0.98	0.313	1.1	0.378	1.80	1.172	0.488	N/L
2.30	7.54	13421	60	41.6	41.6	206	0.45	1.4	Unsaturated	7	13421	1.26	167.9	169.4	0.98	0.313	1.1	0.494	1.92	1.198	0.651	N/L
2.40	7.87	14029	58	43.4	43.4	211	0.42	1.4	Unsaturated	7	14029	1.25	173.6	175.1	0.98	0.312	1.1	0.602	2.01	1.217	0.805	N/L
2.50	8.20	14589	60	45.2	45.2	215	0.42	1.4	Unsaturated	7	14589	1.24	178.6	180.1	0.98	0.312	1.1	0.730	2.09	1.234	0.991	N/L
2.60	8.53	15324	66	47.0	47.0	221	0.43	1.4	Unsaturated	7	15324	1.22	185.6	187.2	0.98	0.312	1.1	0.988	2.20	1.257	1.367	N/L
2.70	8.86	16294	71	48.8	48.8	231	0.44	1.4	Unsaturated	7	16294	1.21	195.4	197.1	0.98	0.311	1.1	1.610	2.20	1.257	2.000	N/L
2.80	9.18	17303	77	50.6	50.6	241	0.45	1.4	Unsaturated	7	17303	1.20	205.6	207.3	0.98	0.311	1.1	2.918	2.20	1.257	2.000	N/L
2.90	9.51	17846	81	52.4	52.4	244	0.45	1.4	Unsaturated	7	17846	1.19	210.1	211.8	0.97	0.310	1.1	2.000	2.20	1.257	2.000	N/L
3.00	9.84	18280	77	54.2	54.2	246	0.42	1.4	Unsaturated	7	18280	1.18	213.3	215.0	0.97	0.310	1.1	2.000	2.20	1.257	2.000	N/L
3.10	10.17	18239	72	56.0	56.0	241	0.40	1.4	Unsaturated	7	18239	1.17	210.9	212.7	0.97	0.309	1.1	2.000	2.20	1.257	2.000	N/L
3.20	10.50	17486	64	57.8	57.8	228	0.37	1.4	Unsaturated	7	17486	1.16	200.6	202.2	0.97	0.309	1.1	2.146	2.20	1.257	2.000	N/L
3.30	10.82	17063	57	59.7	59.7	219	0.33	1.4	Unsaturated	7	17063	1.15	194.1	195.7	0.97	0.309	1.1	1.499	2.20	1.257	2.000	N/L
3.40	11.15	16932	53	61.5	61.5	214	0.31	1.3	Unsaturated	6	16932	1.14	191.1	191.3	0.97	0.308	1.1	1.196	2.20	1.257	1.654	N/L
3.50	11.48	16707	54	63.3	63.3	208	0.32	1.4	Unsaturated	7	16707	1.13	187.1	188.7	0.97	0.308	1.1	1.059	2.20	1.257	1.465	N/L
3.60	11.81	16129	51	65.1	65.1	198	0.32	1.4	Unsaturated	7	16129	1.12	179.3	180.9	0.96	0.307	1.1	0.752	2.10	1.237	1.017	N/L
3.70	12.14	15209	50	66.9	66.9	184	0.33	1.4	Unsaturated	7	15209	1.11	167.9	169.3	0.96	0.307	1.1	0.493	1.92	1.198	0.637	N/L
3.80	12.46	15097	49	68.7	68.7	180	0.32	1.4	Unsaturated	7	15097	1.11	165.5	166.9	0.96	0.306	1.1	0.456	1.89	1.190	0.581	N/L
3.90	12.79	14716	45	70.5	70.5	173	0.31	1.4	Unsaturated	7	14716	1.10	160.2	161.6	0.96	0.306	1.1	0.389	1.81	1.175	0.486	N/L
4.00	13.12	14235	43	72.3	72.3	165	0.31	1.4	Unsaturated	7	14235	1.09	153.9	155.3	0.96	0.305	1.1	0.328	1.73	1.157	0.401	N/L
4.10	13.45	13465	44	74.1	74.1	155	0.33	1.5	Unsaturated	8	13465	1.09	144.7	150.1	0.96	0.305	1.0	0.289	1.67	1.144	0.347	N/L
4.20	13.78	12931	44	75.9	75.9	147	0.34	1.5	Unsaturated	8	12931	1.08	138.0	143.3	0.96	0.304	1.0	0.250	1.60	1.128	0.294	N/L
4.30	14.10	11857	44	77.7	77.7	133	0.37	1.6	Unsaturated	10	11857	1.07	125.8	138.1	0.95	0.304	1.0	0.226	1.54	1.116	0.262	N/L
4.40	14.43	10500	41	79.5	79.5	116	0.39	1.6	Unsaturated	10	10500	1.07	110.7	122.2	0.95	0.303	1.0	0.176	1.40	1.086	0.197	N/L
4.50	14.76	9553	35	81.4	81.4	104	0.37	1.7	Unsaturated	11	9553	1.06	100.1	119.6	0.95	0.303	1.0	0.170	1.38	1.082	0.189	N/L
4.60	15.09	8935	33	83.2	83.2	96	0.37	1.7	Unsaturated	11	8935	1.05	93.1	111.9	0.95	0.303	1.0	0.155	1.33	1.071	0.170	N/L
4.70	15.42	9072	34	85.0	85.0	97	0.38	1.7	Unsaturated	11	9072	1.05	94.0	112.9	0.95	0.302	1.0	0.157	1.34	1.072	0.172	N/L
4.80	15.74	9069	34	86.8	86.8	96	0.38	1.7	Unsaturated	11	9069	1.04	93.5	112.2	0.95	0.302	1.0	0.156	1.33	1.071	0.170	N/L
4.90	16.07	9518	34	88.6	88.6	100	0.36	1.7	Unsaturated	11	9518	1.04	97.6	116.8	0.95	0.301	1.0	0.164	1.36	1.078	0.180	N/L
5.00	16.40	9609	34	90.4	90.4	99	0.36	1.7	Unsaturated	11	9609	1.03	98.0	117.2	0.94	0.301	1.0	0.165	1.37	1.079	0.181	N/L
5.10	16.73	9099	33	92.2	92.2	93	0.37	1.7	Unsaturated	11	9099	1.02	92.3	110.9	0.94	0.300	1.0	0.154	1.32	1.069	0.166	N/L
5.20	17.06	8290	31	94.0	94.0	84	0.38	1.7	Unsaturated	11	8290	1.02	83.7	101.4	0.94	0.300	1.0	0.139	1.27	1.058	0.148	N/L
5.30	17.38	7762	31	95.8	95.8	78	0.40	1.8	Unsaturated	13	7762	1.01	77.9	103.3	0.94	0.299	1.0	0.142	1.28	1.060	0.151	N/L
5.40	17.71	7641	27	97.6	97.6	76	0.36	1.8	Unsaturated	13	7641	1.01	76.3	101.5	0.94	0.299	1.0	0.139	1.27	1.058	0.148	N/L
5.50	18.04	7741	28	99.4	99.4	76	0.36	1.8	Unsaturated	13	7741	1.00	77.0	102.2	0.94	0.298	1.0	0.140	1.27	1.059	0.149	N/L
5.60	18.37	8110	30	101.2	101.2	79	0.38	1.8	Unsaturated	13	8110	1.00	80.3	106.0	0.93	0.297	1.0	0.146	1.29	1.063	0.155	N/L
5.70	18.70	8526	33	103.0	103.0	82	0.39	1.8	Unsaturated	13	8526	0.99	84.0	110.3	0.93	0.297	1.0	0.152	1.32	1.069	0.163	N/L
5.80	19.02	9255	34	104.9	104.9	89	0.37	1.7	Unsaturated	11	9255	0.99	90.7	109.2	0.93	0.296	1.0	0.151	1.31	1.067	0.160	N/L
5.90	19.35	10479	36	106.7	106.7	100	0.35	1.7	Unsaturated	11	10479	0.99	102.3	122.0	0.93	0.296	1.0	0.176	1.40	1.086	0.190	N/L
6.00	19.68	12825	40	108.5	108.5	121	0.32	1.6	Unsaturated	10	12825	0.98	124.6	136.9	0.93	0.295	1.0	0.221	1.53	1.114	0.244	N/L
6.10	20.01	14807	46	110.3	110.3	139	0.32	1.5	Unsaturated	8	14807	0.98	143.2	148.7	0.93	0.295	1.0	0.280	1.65	1.140	0.315	N/L
6.20	20.34	15350	46	112.1	112.1	143	0.30	1.5	Unsaturated	8	15350	0.97	147.9	153.4	0.92	0.294	1.0	0.313	1.71	1.152	0.354	N/L
6.30	20.66	15575	42	113.9	113.9	144	0.27	1.5	Unsaturated	8	15575	0.97	149.4	155.0	0.92	0.294	1.0	0.325	1.73	1.156	0.368	N/L
6.40	20.99	15873	45	115.7	115.7	146	0.29	1.5	Unsaturated	8	15873	0.96	151.6	157.2	0.92	0.293	1.0	0.345	1.76	1.162	0.391	N/L
6.50	21.32	16092	47	117.5	117.5	146	0.30	1.5	Unsaturated	8	16092	0.96	153.1	158.8	0.92	0.293	1.0	0.359	1.78	1.166	0.408	N/L
6.60	21.65	17693	52	119.3	119.3	160	0.29	1.4	Unsaturated	7	17693	0.96	167.6	169.1	0.92	0.292	1.0	0.489	1.92	1.197	0.567	N/L
6.70	21.98	18876	52	121.1	121.1	169	0.28	1.4	Unsaturated	7	18876	0.95	178.1	179.7	0.92	0.292	1.0	0.717	2.08	1.233	0.850	N/L
6.80	22.30	19304	56	122.9	122.9	172	0.29	1.4	Unsaturated	7	19304	0.95	181.5	183.0	0.91	0.291	1.0	0.822	2.14	1.245	0.979	N/L
6.90	22.63	23168	66	124.7	124.7	205	0.29	1.3	Unsaturated	6	23168	0.95	217.0	217.1	0.91	0.291	0.9	2.000	2.20	1.257	2.000	N/L
7.00	22.96	26485	73	126.5	126.5	233	0.28	1.3	Unsaturated	6	26485	0.94	247.1	247.3	0.91	0.290	0.9	2.000	2.20	1.257	2.000	N/L
7.10	23.29	27206	84	128.4	128.4	237	0.31	1.3	Unsaturated	6	27206	0.94	252.9	253.1	0.91	0.289	0.9	2.000	2.20	1.257	2.000	N/L
7.20	23.62	30922	94	130.2	130.2	268	0.31	1.3	Unsaturated	6	30922	0.94	286.3	286.6	0.91	0.289	0.9	2.000	2.20	1.257	2.000	N/L
7.30	23.94	33627	110	132.0	132.0	290	0.33	1.2	Unsaturated	4	33627	0.93	310.3	310.3	0.91	0.288	0.9	2.000	2.20	1.257	2.000	N/L
7.40	24.27	36763	109	133.8	133.8	315	0.30	1.2	Unsaturated	4	36763	0.93	338.0	338.0	0.90	0.288	0.9	2.000	2.20	1.257	2.000	N/L
7.50	24.60	37188	104	135.6	135.6	316	0.28	1.2	Unsaturated	4	37188	0.93	340.7	340.7	0.90	0.287	0.9	2.000	2.20	1.257	2.000	N/L
7.60	24.93	35321	81	137.4	137.4	298	0.23	1.2	Unsaturated	4	35321	0.92	322.4	322.4	0.90	0.287	0.9	2.000	2.20	1.257	2.000	N/L
7.70	25.26	32748	79	139.2	139.2	275	0.24	1.2	Unsaturated	4	32748	0.92	297.9	297.9	0.90	0.286	0.9	2.000	2.20	1.257	2.000	N/L
7.80	25.58	26505	78	141.0	141.0	221	0.30	1.3	Unsaturated	6	26505	0.92	240.3	240.5	0.90	0.286	0.9	2.000	2.20	1.257	2.000	N/L
7.90	25.91	19053	66	142.8	142.8	157	0.35	1.5	Unsaturated	8	19053	0.91	172.2	178.3	0.89	0.285	0.9	0.678	2.06	1.228	0.773	N/L
8.00	26.24	19141	60	144.6	144.6	157	0.32	1.5	Unsaturated	8	19141	0.91	172.4	178.5	0.89	0.284	0.9	0.685	2.07	1.228	0.778	N/L
8.10	26.57	21071	63	146.4	146.4	172	0.30	1.4	Unsaturated	7	21071	0.91	189.1	190.7	0.89	0.284	0.9	1.165	2.20	1.257	1.336	N/L
8.20	26.90	22171	67	148.2	148.2	180	0.31	1.4	Unsaturated	7	22171	0.90	198.4	200.0	0.89	0.283	0.9	1.893	2.20	1.257	2.000	N/L
8.30	27.22	23030	71	150.0	150.0	186	0.31	1.4	Unsaturated	7	23030	0.90	205.4	207.1	0.89	0.283	0.9	2.888	2.20	1.257	2.000	N/L
8.40	27.55	24490	77	151.9	151.9	196	0.32	1.4	Unsaturated	7	24490	0.90	217.7	219.5	0.89	0.282	0.9	2.000	2.20	1.257	2.000	N/L
8.50	27.88	26228	74	153.7	153.7	209	0.28	1.3	Unsaturated	6	26228	0.90	232.5	232.7	0.88	0.281	0.9	2.000	2.20	1.257	2.000	N/L
8.60	28.21	27311	77	155.5	155.5	216	0.28	1.3	Unsaturated	6	27311	0.89	241.3	241.5	0.88	0.281	0.9	2.000	2.20	1.257	2.000	N/L
8.70	28.54	27924	67	157.3	157.3	220	0.24	1.3	Unsaturated	6	27924	0.89	246.0	246.2	0.88	0.280	0.9	2.000	2.20	1.257	2.000	N/L
8.80	28.86	28818	66	159.1	159.1	226	0.23	1.3	Unsaturated	6	28818	0.89	253.1	253.3	0.88	0.280	0.9	2.000	2.20	1.257	2.000	N/L

Settelemnt of Liquefiable Soil (Idriss and Boulnager, 2008)

Depth, Z (m)	q_t (kPa)	N_{60}	$N_{1,60}$	$\Delta(N_1)_{60}$	$N_{1,60-CS}$	Limiting Shear Strain γ_{lim}	Parameter F_α	Max. Shear Strain γ_{max}	ΔHi (m)	ΔLDI_i (m)	Vert. Recon. Strain ε_v	DF_i	ΔSi (inch)
1.60	1850	4.1	5.7	4.7	N.A.	0.000	0.000	0.000	0.05	0.0000	0.0000	0.91	0.00
1.70	1432	3.3	4.6	5.0	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.91	0.00
1.80	1343	3.3	4.4	5.2	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.90	0.00
1.90	1793	4.4	5.8	5.2	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.90	0.00
2.00	5396	9.6	12.6	0.9	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.89	0.00
2.10	9200	16.4	21.2	0.9	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.89	0.00
2.20	11658	20.8	26.5	0.9	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.88	0.00
2.30	13301	22.2	28.1	0.1	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.87	0.00
2.40	14028	23.4	29.3	0.1	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.87	0.00
2.50	14617	24.4	30.2	0.1	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.86	0.00
2.60	15373	25.7	31.4	0.1	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.86	0.00
2.70	16272	27.2	32.9	0.1	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.85	0.00
2.80	17197	28.7	34.4	0.1	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.85	0.00
2.90	17861	29.8	35.4	0.1	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.84	0.00
3.00	18241	30.5	35.9	0.1	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.84	0.00
3.10	18216	30.4	35.5	0.1	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.83	0.00
3.20	17549	29.3	33.9	0.1	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.83	0.00
3.30	17062	28.5	32.7	0.1	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.82	0.00
3.40	16954	27.4	31.3	0.0	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.81	0.00
3.50	16613	27.7	31.4	0.1	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.81	0.00
3.60	16082	26.8	30.1	0.1	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.80	0.00
3.70	15401	25.7	28.7	0.1	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.80	0.00
3.80	15038	25.1	27.8	0.1	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.79	0.00
3.90	14737	24.6	27.1	0.1	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.79	0.00
4.00	14170	23.7	25.8	0.1	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.78	0.00
4.10	13432	23.1	25.1	0.4	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.78	0.00
4.20	12851	22.1	23.9	0.4	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.77	0.00
4.30	11784	21.0	22.5	0.9	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.76	0.00
4.40	10527	18.7	20.0	0.9	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.76	0.00
4.50	9526	17.5	18.6	1.7	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.75	0.00
4.60	8994	16.6	17.4	1.7	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.75	0.00
4.70	9036	16.6	17.4	1.7	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.74	0.00
4.80	9114	16.8	17.5	1.7	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.74	0.00
4.90	9472	17.4	18.1	1.7	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.73	0.00
5.00	9568	17.6	18.1	1.7	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.73	0.00
5.10	9085	16.7	17.1	1.7	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.72	0.00
5.20	8304	15.3	15.6	1.7	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.72	0.00
5.30	7768	14.8	15.0	2.5	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.71	0.00
5.40	7633	14.6	14.7	2.5	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.70	0.00
5.50	7739	14.8	14.8	2.5	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.70	0.00
5.60	8094	15.4	15.4	2.5	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.69	0.00
5.70	8560	16.3	16.2	2.5	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.69	0.00
5.80	9250	17.0	16.9	1.7	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.68	0.00
5.90	10549	19.4	19.2	1.7	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.68	0.00
6.00	12763	22.7	22.3	0.9	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.67	0.00
6.10	14712	25.4	24.8	0.4	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.67	0.00
6.20	15357	26.5	25.7	0.4	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.66	0.00
6.30	15572	26.8	26.0	0.4	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.66	0.00
6.40	15826	27.3	26.3	0.4	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.65	0.00
6.50	16090	27.7	26.6	0.4	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.64	0.00
6.60	17606	29.4	28.1	0.1	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.64	0.00
6.70	18905	31.6	30.1	0.1	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.63	0.00
6.80	19718	32.9	31.3	0.1	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.63	0.00
6.90	23156	37.5	35.5	0.0	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.62	0.00
7.00	26182	42.4	39.9	0.0	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.62	0.00
7.10	27204	44.0	41.3	0.0	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.61	0.00
7.20	30616	49.6	46.4	0.0	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.61	0.00
7.30	33783	53.1	49.5	0.0	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.60	0.00
7.40	36247	57.0	52.9	0.0	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.60	0.00
7.50	36827	57.9	53.5	0.0	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.59	0.00
7.60	34958	54.9	50.6	0.0	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.58	0.00
7.70	32081	50.4	46.3	0.0	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.58	0.00
7.80	26209	42.4	38.9	0.0	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.57	0.00
7.90	20110	34.7	31.6	0.4	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.57	0.00
8.00	19573	33.7	30.7	0.4	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.56	0.00
8.10	21059	35.2	31.9	0.1	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.56	0.00
8.20	22110	36.9	33.4	0.1	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.55	0.00
8.30	23094	38.6	34.7	0.1	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.55	0.00
8.40	24439	40.8	36.6	0.1	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.54	0.00
8.50	26022	42.1	37.7	0.0	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.54	0.00
8.60	27291	44.2	39.4	0.0	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.53	0.00
8.70	27918	45.2	40.2	0.0	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.52	0.00
8.80	28816	46.6	41.4	0.0	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.52	0.00

Settlement of Unsaturated Sand (Tokimatsu & Seed, 1987, and Pradel, 1998) / Cumulative / S_r (Idriss & Boulanger, 2008)

Depth, Z (m)	$p = \sigma_m$ (tsf)	τ_{ave} (psf)	G_{max} (tsf)	τ_{ave}/G_{max}	a	b	γ_{eff} (%)	ε_{15} (%)	ε_{Nc} (%)	Settlement (inch)	Cumulative Settlement (inch)	$\Delta(N_1)_{60-Sr}$	$(N_1)_{60-Sr}$	S_r/σ_{v0}'
1.60	0.202	192	384	0.00025	0.20272	16691	0.29504	1.323	1.106	0.04	0.32	N/A	N/A	N/A
1.70	0.215	204	314	0.00032	0.20764	16095	0.05000	0.295	0.247	0.02	0.27	N/A	N/A	N/A
1.80	0.228	216	312	0.00035	0.21256	15552	0.05000	0.308	0.258	0.02	0.25	N/A	N/A	N/A
1.90	0.240	228	422	0.00027	0.21749	15056	0.05000	0.221	0.185	0.01	0.23	N/A	N/A	N/A
2.00	0.253	239	943	0.00013	0.22241	14600	0.02512	0.044	0.037	0.00	0.22	N/A	N/A	N/A
2.10	0.266	251	1627	0.00008	0.22733	14178	0.01057	0.010	0.008	0.00	0.22	N/A	N/A	N/A
2.20	0.278	263	2084	0.00006	0.23225	13788	0.00796	0.006	0.005	0.00	0.22	N/A	N/A	N/A
2.30	0.291	275	2253	0.00006	0.23717	13425	0.00759	0.005	0.004	0.00	0.21	N/A	N/A	N/A
2.40	0.304	287	2400	0.00006	0.24209	13087	0.00736	0.005	0.004	0.00	0.21	N/A	N/A	N/A
2.50	0.316	299	2525	0.00006	0.24701	12770	0.00723	0.004	0.004	0.00	0.21	N/A	N/A	N/A
2.60	0.329	310	2681	0.00006	0.25193	12473	0.00702	0.004	0.003	0.00	0.21	N/A	N/A	N/A
2.70	0.342	322	2863	0.00006	0.25685	12194	0.00676	0.004	0.003	0.00	0.21	N/A	N/A	N/A
2.80	0.354	334	3052	0.00005	0.26177	11931	0.00652	0.003	0.003	0.00	0.21	N/A	N/A	N/A
2.90	0.367	346	3196	0.00005	0.26669	11682	0.00641	0.003	0.003	0.00	0.21	N/A	N/A	N/A
3.00	0.379	357	3290	0.00005	0.27161	11447	0.00643	0.003	0.003	0.00	0.21	N/A	N/A	N/A
3.10	0.392	369	3311	0.00006	0.27653	11224	0.00662	0.003	0.003	0.00	0.21	N/A	N/A	N/A
3.20	0.405	381	3214	0.00006	0.28145	11012	0.00712	0.004	0.003	0.00	0.21	N/A	N/A	N/A
3.30	0.417	392	3147	0.00006	0.28637	10811	0.00756	0.004	0.004	0.00	0.21	N/A	N/A	N/A
3.40	0.430	404	3054	0.00007	0.29129	10619	0.00813	0.005	0.004	0.00	0.21	N/A	N/A	N/A
3.50	0.443	415	3107	0.00007	0.29621	10436	0.00822	0.005	0.004	0.00	0.21	N/A	N/A	N/A
3.60	0.455	427	3028	0.00007	0.30113	10261	0.00878	0.005	0.004	0.00	0.21	N/A	N/A	N/A
3.70	0.468	438	2919	0.00008	0.30605	10093	0.00951	0.006	0.005	0.00	0.21	N/A	N/A	N/A
3.80	0.481	450	2868	0.00008	0.31097	9933	0.01004	0.007	0.006	0.00	0.21	N/A	N/A	N/A
3.90	0.493	461	2828	0.00008	0.31589	9780	0.01055	0.007	0.006	0.00	0.21	N/A	N/A	N/A
4.00	0.506	473	2735	0.00009	0.32081	9632	0.01137	0.008	0.007	0.00	0.21	N/A	N/A	N/A
4.10	0.519	484	2692	0.00009	0.32573	9490	0.01197	0.009	0.008	0.00	0.21	N/A	N/A	N/A
4.20	0.531	496	2590	0.00010	0.33065	9354	0.01301	0.011	0.009	0.00	0.21	N/A	N/A	N/A
4.30	0.544	507	2468	0.00010	0.33557	9223	0.01434	0.012	0.010	0.00	0.21	N/A	N/A	N/A
4.40	0.557	518	2217	0.00012	0.34049	9097	0.01732	0.017	0.015	0.00	0.21	N/A	N/A	N/A
4.50	0.569	530	2087	0.00013	0.34541	8975	0.01961	0.021	0.018	0.00	0.21	N/A	N/A	N/A
4.60	0.582	541	1980	0.00014	0.35033	8857	0.02199	0.026	0.022	0.00	0.20	N/A	N/A	N/A
4.70	0.594	552	2000	0.00014	0.35525	8744	0.02228	0.026	0.022	0.00	0.20	N/A	N/A	N/A
4.80	0.607	563	2027	0.00014	0.36017	8634	0.02243	0.026	0.022	0.00	0.20	N/A	N/A	N/A
4.90	0.620	574	2117	0.00014	0.36509	8528	0.02148	0.024	0.020	0.00	0.20	N/A	N/A	N/A
5.00	0.632	586	2148	0.00014	0.37001	8425	0.02155	0.024	0.020	0.00	0.20	N/A	N/A	N/A
5.10	0.645	597	2050	0.00015	0.37493	8326	0.02392	0.029	0.024	0.00	0.20	N/A	N/A	N/A
5.20	0.658	608	1882	0.00016	0.37985	8229	0.02848	0.038	0.032	0.00	0.19	N/A	N/A	N/A
5.30	0.670	619	1832	0.00017	0.38477	8136	0.03074	0.043	0.036	0.00	0.19	N/A	N/A	N/A
5.40	0.683	630	1808	0.00017	0.38969	8045	0.03236	0.047	0.039	0.00	0.19	N/A	N/A	N/A
5.50	0.696	641	1841	0.00017	0.39461	7957	0.03213	0.046	0.038	0.00	0.19	N/A	N/A	N/A
5.60	0.708	651	1934	0.00017	0.39953	7871	0.03015	0.041	0.034	0.00	0.18	N/A	N/A	N/A
5.70	0.721	662	2053	0.00016	0.40446	7788	0.02779	0.036	0.030	0.00	0.18	N/A	N/A	N/A
5.80	0.734	673	2151	0.00016	0.40938	7707	0.02628	0.032	0.027	0.00	0.18	N/A	N/A	N/A
5.90	0.746	684	2463	0.00014	0.41430	7629	0.02154	0.023	0.019	0.00	0.18	N/A	N/A	N/A
6.00	0.759	695	2892	0.00012	0.41922	7552	0.01725	0.015	0.013	0.00	0.17	N/A	N/A	N/A
6.10	0.772	705	3239	0.00011	0.42414	7478	0.01496	0.012	0.010	0.00	0.17	N/A	N/A	N/A
6.20	0.784	716	3394	0.00011	0.42906	7405	0.01430	0.011	0.009	0.00	0.17	N/A	N/A	N/A
6.30	0.797	727	3455	0.00011	0.43398	7334	0.01422	0.010	0.009	0.00	0.17	N/A	N/A	N/A
6.40	0.810	737	3524	0.00010	0.43890	7265	0.01409	0.010	0.008	0.00	0.17	N/A	N/A	N/A
6.50	0.822	748	3596	0.00010	0.44382	7198	0.01395	0.010	0.008	0.00	0.17	N/A	N/A	N/A
6.60	0.835	758	3826	0.00010	0.44874	7132	0.01306	0.009	0.007	0.00	0.17	N/A	N/A	N/A
6.70	0.847	769	4122	0.00009	0.45366	7068	0.01204	0.007	0.006	0.00	0.17	N/A	N/A	N/A
6.80	0.860	779	4315	0.00009	0.45858	7006	0.01153	0.007	0.006	0.00	0.17	N/A	N/A	N/A
6.90	0.873	789	4931	0.00008	0.46350	6945	0.00989	0.005	0.004	0.00	0.17	N/A	N/A	N/A
7.00	0.885	800	5594	0.00007	0.46842	6885	0.00860	0.004	0.003	0.00	0.17	N/A	N/A	N/A
7.10	0.898	810	5832	0.00007	0.47334	6827	0.00830	0.003	0.003	0.00	0.17	N/A	N/A	N/A
7.20	0.911	820	6585	0.00006	0.47826	6770	0.00728	0.003	0.002	0.00	0.17	N/A	N/A	N/A
7.30	0.923	830	7075	0.00006	0.48318	6714	0.00679	0.002	0.002	0.00	0.17	N/A	N/A	N/A
7.40	0.936	840	7616	0.00006	0.48810	6659	0.00632	0.002	0.002	0.00	0.17	N/A	N/A	N/A
7.50	0.949	850	7762	0.00005	0.49302	6606	0.00627	0.002	0.002	0.00	0.17	N/A	N/A	N/A
7.60	0.961	860	7391	0.00006	0.49794	6553	0.00672	0.002	0.002	0.00	0.17	N/A	N/A	N/A
7.70	0.974	870	6804	0.00006	0.50286	6502	0.00750	0.003	0.002	0.00	0.17	N/A	N/A	N/A
7.80	0.987	880	5745	0.00008	0.50778	6452	0.00931	0.004	0.004	0.00	0.17	N/A	N/A	N/A
7.90	0.999	890	4706	0.00009	0.51270	6403	0.01213	0.007	0.006	0.00	0.17	N/A	N/A	N/A
8.00	1.012	900	4594	0.00010	0.51762	6355	0.01268	0.008	0.006	0.00	0.17	N/A	N/A	N/A
8.10	1.025	910	4803	0.00009	0.52254	6308	0.01213	0.007	0.006	0.00	0.16	N/A	N/A	N/A
8.20	1.037	920	5057	0.00009	0.52746	6261	0.01150	0.006	0.005	0.00	0.16	N/A	N/A	N/A
8.30	1.050	929	5297	0.00009	0.53238	6216	0.01098	0.006	0.005	0.00	0.16	N/A	N/A	N/A
8.40	1.062	939	5621	0.00008	0.53730	6171	0.01032	0.005	0.004	0.00	0.16	N/A	N/A	N/A
8.50	1.075	948	5821	0.00008	0.54222	6128	0.01000	0.005	0.004	0.00	0.16	N/A	N/A	N/A
8.60	1.088	958	6121	0.00008	0.54714	6085	0.00951	0.004	0.004	0.00	0.16	N/A	N/A	N/A
8.70	1.100	967	6279	0.00008	0.55206	6043	0.00933	0.004	0.003	0.00	0.16	N/A	N/A	N/A
8.80	1.113	977	6498	0.00008	0.55698	6002	0.00905	0.004	0.003	0.00	0.16	N/A	N/A	N/A

Depth, Z (m)	Depth, Z (ft)	q_c (kPa)	f_s (kPa)	σ_{vc} (kPa)	σ'_{vc} (kPa)	Q	F	I_c	Soil Type	Fines (%)	Interpreted q_c	C_N	q_{c1N}	q_{c1N-cs}	Stress Reduction Factor (r_d)	CSR	K_σ for sand	$CRR_{M=7.5}$ at σ'_{vc}=1	MSF_{max}	MSF	CRR	$(FS)_L$	q_t (kPa)	N_{60}	$N_{1,60}$	$\Delta(N_1)_{60}$	$N_{1,60\text{-}CS}$	Limiting Shear Strain γ_{lim}	Parameter F_α	Max. Shear Strain γ_{max}	ΔHi (m)	ΔLDI (m)	Vert. Recon. Strain ε_v	DF_i	ΔSi (inch)	p = σ_m (tsf)	τ_{ave} (psf)	G_{max} (tsf)	τ_{ave}/G_{max}	a	b	γ_{eff} (%)	ε_{15} (%)	ε_{NC} (%)	Settlement (inch)	Settlement (inch)	$\Delta(N_1)_{60\text{-}Sr}$	$(N_1)_{60\text{-}Sr}$	S_r/σ_{vo}'
8.90	29.19	30866	69	160.9	160.9	241	0.23	1.2	Unsaturated	4	30866	0.88	270.3	270.3	0.88	0.279	0.9	2.000	2.20	1.257	2.000	**N/L**	30513	47.9	42.4	0.0	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.51	0.00	1.126	986	6697	0.00007	0.56190	5961	0.00882	0.004	0.003	0.00	0.16	N/A	N/A	N/A
9.00	29.52	31214	74	162.7	162.7	242	0.24	1.2	Unsaturated	4	31214	0.88	272.5	272.5	0.87	0.279	0.9	2.000	2.20	1.257	2.000	**N/L**	31014	48.7	43.0	0.0	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.51	0.00	1.138	996	6825	0.00007	0.56682	5921	0.00872	0.003	0.003	0.00	0.16	N/A	N/A	N/A
9.10	29.85	29860	69	164.5	164.5	230	0.23	1.3	Unsaturated	6	29860	0.88	259.9	260.1	0.87	0.278	0.9	2.000	2.20	1.257	2.000	**N/L**	29903	48.4	42.6	0.0	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.50	0.00	1.151	1005	6797	0.00007	0.57174	5882	0.00886	0.004	0.003	0.00	0.16	N/A	N/A	N/A
9.20	30.18	28261	75	166.3	166.3	216	0.27	1.3	Unsaturated	6	28261	0.88	245.3	245.5	0.87	0.277	0.9	2.000	2.20	1.257	2.000	**N/L**	28198	45.6	40.0	0.0	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.50	0.00	1.164	1014	6426	0.00008	0.57666	5844	0.00958	0.004	0.003	0.00	0.16	N/A	N/A	N/A
9.30	30.50	25732	78	168.1	168.1	196	0.31	1.4	Unsaturated	7	25732	0.87	222.7	224.5	0.87	0.277	0.8	2.000	2.20	1.257	2.000	**N/L**	25690	42.9	37.5	0.1	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.49	0.00	1.176	1023	6053	0.00008	0.58158	5806	0.01042	0.005	0.004	0.00	0.16	N/A	N/A	N/A
9.40	30.83	22133	72	169.9	169.9	167	0.33	1.4	Unsaturated	7	22133	0.87	191.0	192.6	0.87	0.276	0.9	1.279	2.20	1.257	1.406	**N/L**	22029	36.8	32.1	0.1	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.49	0.00	1.189	1032	5204	0.00010	0.58650	5769	0.01275	0.007	0.006	0.00	0.16	N/A	N/A	N/A
9.50	31.16	17227	86	171.7	171.7	129	0.50	1.6	Unsaturated	10	17227	0.87	148.3	161.9	0.87	0.276	0.9	0.392	1.82	1.175	0.417	**N/L**	16412	29.2	25.4	0.9	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.48	0.00	1.202	1041	4146	0.00013	0.59143	5732	0.01748	0.013	0.011	0.00	0.16	N/A	N/A	N/A
9.60	31.49	6765	118	173.5	173.5	50	1.79	2.3	Unsaturated	24	6765	0.87	58.1	103.4	0.86	0.275	0.9	0.142	1.28	1.060	0.142	**N/L**	7698	17.9	15.5	5.0	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.48	0.00	1.214	1050	2542	0.00021	0.59635	5696	0.03796	0.052	0.043	0.00	0.16	N/A	N/A	N/A
9.70	31.82	3107	93	175.4	175.4	22	3.16	2.7	Unsaturated	37	3107	0.86	26.6	65.7	0.86	0.274	1.0	0.104	1.14	1.030	0.102	**N/L**	3484	9.8	8.5	5.5	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.47	0.00	1.227	1059	1396	0.00038	0.60127	5661	0.05000	0.140	0.117	0.01	0.16	N/A	N/A	N/A
9.80	32.14	2685	22	177.2	177.2	19	0.88	2.5	Unsaturated	30	2685	0.86	22.9	59.6	0.86	0.274	1.0	0.099	1.13	1.027	0.098	**N/L**	2747	7.0	6.0	5.4	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.46	0.00	1.240	1068	998	0.00053	0.60619	5626	0.05000	0.211	0.176	0.01	0.15	N/A	N/A	N/A
9.90	32.47	2112	14	179.0	179.0	14	0.72	2.6	Unsaturated	34	2112	0.86	18.0	53.7	0.86	0.273	1.0	0.095	1.12	1.025	0.093	**N/L**	2256	6.0	5.2	5.5	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.46	0.00	1.252	1077	863	0.00062	0.61111	5592	0.05000	0.253	0.211	0.02	0.13	N/A	N/A	N/A
10.00	32.80	2154	14	180.8	180.8	15	0.68	2.5	Unsaturated	30	2154	0.86	18.3	53.5	0.86	0.273	1.0	0.095	1.12	1.025	0.093	**N/L**	2329	5.9	5.1	5.4	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.45	0.00	1.265	1086	850	0.00064	0.61603	5558	0.05000	0.259	0.216	0.02	0.12	N/A	N/A	N/A
10.10	33.13	3030	24	182.6	182.6	21	0.85	2.4	Unsaturated	27	3030	0.86	25.7	62.3	0.85	0.272	1.0	0.101	1.13	1.028	0.099	**N/L**	2909	7.1	6.0	5.2	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.45	0.00	1.277	1094	1017	0.00054	0.62095	5525	0.05000	0.210	0.176	0.01	0.10	N/A	N/A	N/A
10.20	33.46	3366	42	184.4	184.4	23	1.31	2.5	Unsaturated	30	3366	0.85	28.4	67.0	0.85	0.271	1.0	0.105	1.14	1.030	0.103	**N/L**	3588	9.1	7.8	5.4	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.44	0.00	1.290	1103	1317	0.00042	0.62587	5493	0.05000	0.155	0.130	0.01	0.09	N/A	N/A	N/A
10.30	33.78	5057	53	186.2	186.2	35	1.10	2.3	Unsaturated	24	5057	0.85	42.6	83.1	0.85	0.271	0.9	0.119	1.19	1.040	0.116	**N/L**	4771	11.1	9.4	5.0	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.44	0.00	1.303	1112	1602	0.00035	0.63079	5461	0.05000	0.123	0.103	0.01	0.08	N/A	N/A	N/A
10.40	34.11	4992	88	188.0	188.0	35	1.84	2.4	Unsaturated	27	4992	0.85	42.0	83.9	0.85	0.270	0.9	0.119	1.19	1.041	0.117	**N/L**	5057	12.3	10.4	5.2	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.43	0.00	1.315	1120	1780	0.00031	0.63571	5429	0.05000	0.109	0.091	0.01	0.07	N/A	N/A	N/A
10.50	34.44	5600	82	189.8	189.8	39	1.52	2.3	Unsaturated	24	5600	0.85	46.9	88.8	0.85	0.270	0.9	0.124	1.21	1.045	0.122	**N/L**	5630	13.1	11.1	5.0	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.43	0.00	1.328	1129	1899	0.00030	0.64063	5398	0.05000	0.102	0.085	0.01	0.06	N/A	N/A	N/A
10.60	34.77	6314	70	191.6	191.6	44	1.14	2.2	Unsaturated	22	6314	0.84	52.8	94.0	0.84	0.269	0.9	0.130	1.23	1.050	0.128	**N/L**	6274	14.0	11.8	4.7	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.42	0.00	1.341	1137	2033	0.00028	0.64555	5368	0.05000	0.094	0.079	0.01	0.05	N/A	N/A	N/A
10.70	35.10	6024	56	193.4	193.4	42	0.97	2.2	Unsaturated	22	6024	0.84	50.3	90.7	0.84	0.268	0.9	0.126	1.22	1.047	0.124	**N/L**	6164	13.7	11.6	4.7	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.42	0.00	1.353	1146	2002	0.00029	0.65047	5337	0.05000	0.097	0.081	0.01	0.05	N/A	N/A	N/A
10.80	35.42	6048	77	195.2	195.2	42	1.31	2.3	Unsaturated	24	6048	0.84	50.3	93.2	0.84	0.268	0.9	0.129	1.23	1.049	0.126	**N/L**	6052	14.1	11.8	5.0	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.41	0.00	1.366	1154	2055	0.00028	0.65539	5308	0.05000	0.094	0.079	0.01	0.04	N/A	N/A	N/A
10.90	35.75	5623	99	197.1	197.1	38	1.82	2.4	Unsaturated	27	5623	0.84	46.7	90.2	0.84	0.267	0.9	0.126	1.22	1.046	0.123	**N/L**	5450	13.2	11.1	5.2	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.40	0.00	1.379	1162	1939	0.00030	0.66031	5278	0.05000	0.101	0.085	0.01	0.03	N/A	N/A	N/A
11.00	36.08	3900	82	198.9	198.9	26	2.21	2.6	Unsaturated	34	3900	0.84	32.3	72.9	0.84	0.267	0.9	0.110	1.16	1.034	0.107	**N/L**	3876	10.4	8.7	5.5	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.40	0.00	1.391	1170	1520	0.00038	0.66523	5250	0.05000	0.137	0.114	0.01	0.03	N/A	N/A	N/A
11.10	36.41	2788	67	200.7	200.7	18	2.59	2.7	Unsaturated	37	2788	0.83	23.0	60.9	0.84	0.266	0.9	0.100	1.13	1.028	0.097	**N/L**	2862	8.0	6.7	5.5	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.39	0.00	1.404	1179	1184	0.00050	0.67015	5221	0.05000	0.185	0.155	0.01	0.02	N/A	N/A	N/A
11.20	36.74	2157	61	202.5	202.5	14	3.10	2.9	Unsaturated	45	2157	0.83	17.8	54.3	0.83	0.265	0.9	0.095	1.12	1.025	0.093	**N/L**	2338	7.3	6.1	5.6	N.A.	0.000	0.000	0.000	0.05	0.0000	0.0000	0.39	0.00	1.417	1187	1084	0.00055	0.67507	5193	0.05000	0.207	0.173	0.01	0.01	N/A	N/A	N/A

CONE PENETRATION TEST-BASED LIQUEFACTION ANALYSIS BASED ON IDRISS & BOULANGER (2008)

References:

1 - Idriss, I.M. and Boulanger, R.W. (2008). *Soil Liquefaction During Earthquakes* , Earthquake Engineering Research Institute, EERI Publication MNO-12.

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3 - Tokimatsu, K. and Seed H.B. (1987). "Evaluation of Settlements in Sands Due to Earthquake Shaking," Journal of Geotechnical Engineering, Vol. 113, No. 8, August.

4 - Pradel, D. (1998). "Procedure to Evaluate Earthquake-Induced Settlements in Sand," Journal of Geotechnical and Geoenvironmental Engineering, Vol. 124, No. 4, April.

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6 - Boulanger, R.W. and Idriss, I.M. (2014). "CPT and SPT Based Liquefaction Triggering Procedures," Report No. UCD/CGM-14/01, University of California at Davis

Project	Chevron Guadalupe Tank Battery 9 Site
Test Boring No	TSMACPT-2

Test Boring Information:

Approx. depth to ground water table		35.2	ft	10.73	m
Moist unit weight of soil	γ_m	115	pcf	18.08	kN/m^3
Saturated unit weight of soil	γ_{sat}	125	pcf	19.65	kN/m^3

Earthquake Information:

Earthquake magnitude	M_w	6.9	
Peak horizontal ground surface acceleratio	a_{max}	0.490	g
Number of equivalent cycle	N	10.1	
Atmospheric pressure	P_a	101.3	kPa

N/L = Non-liquefiable clay-like soil

N.A. = Not Applicable

Sum
0.24

Sum	Total
0.09	0.33

Factor of Safety Agaist Liquefaction (Idriss & Boulanger, 2008 and Boulanger & Idriss, 2014)

Depth, Z (m)	Depth, Z (ft)	q_c (kPa)	f_s (kPa)	σ_{vc} (kPa)	σ'_{vc} (kPa)	Q	F	I_c	Soil Type	Fines (%)	Interpreted q_c	C_N	q_{c1N}	q_{c1N-cs}	Stress Reduction Factor (r_d)	CSR	K_σ for sand	$CRR_{M=7.5}$ at σ'_{vc}=1	MSF_{max}	MSF	CRR	$(FS)_L$
1.60	5.25	25650	74	28.9	28.9	473	0.29	1.0	Unsaturated	3	25650	1.39	353.2	353.2	0.99	0.315	1.1	2.000	2.20	1.257	2.000	N/L
1.70	5.58	26061	96	30.7	30.7	467	0.37	1.1	Unsaturated	4	26061	1.37	353.2	353.2	0.99	0.315	1.1	2.000	2.20	1.257	2.000	N/L
1.80	5.90	30010	124	32.5	32.5	522	0.41	1.1	Unsaturated	4	30010	1.35	400.6	400.6	0.99	0.315	1.1	2.000	2.20	1.257	2.000	N/L
1.90	6.23	27883	146	34.3	34.3	472	0.53	1.2	Unsaturated	4	27883	1.33	366.9	366.9	0.99	0.314	1.1	2.000	2.20	1.257	2.000	N/L
2.00	6.56	22800	130	36.2	36.2	376	0.57	1.3	Unsaturated	6	22800	1.31	296.0	296.2	0.99	0.314	1.1	2.000	2.20	1.257	2.000	N/L
2.10	6.89	18941	112	38.0	38.0	305	0.59	1.4	Unsaturated	7	18941	1.29	242.8	244.7	0.98	0.314	1.1	2.000	2.20	1.257	2.000	N/L
2.20	7.22	15940	91	39.8	39.8	251	0.57	1.4	Unsaturated	7	15940	1.28	201.8	203.5	0.98	0.313	1.1	2.313	2.20	1.257	2.000	N/L
2.30	7.54	13223	71	41.6	41.6	203	0.54	1.5	Unsaturated	8	13223	1.26	165.5	171.4	0.98	0.313	1.1	0.528	1.95	1.204	0.700	N/L
2.40	7.87	11875	64	43.4	43.4	178	0.54	1.5	Unsaturated	8	11875	1.25	146.9	152.4	0.98	0.312	1.1	0.306	1.70	1.150	0.386	N/L
2.50	8.20	10742	57	45.2	45.2	158	0.54	1.6	Unsaturated	10	10742	1.24	131.5	144.1	0.98	0.312	1.1	0.254	1.60	1.129	0.316	N/L
2.60	8.53	9639	54	47.0	47.0	139	0.56	1.6	Unsaturated	10	9639	1.22	116.8	128.6	0.98	0.312	1.1	0.193	1.45	1.097	0.233	N/L
2.70	8.86	9373	51	48.8	48.8	133	0.54	1.7	Unsaturated	11	9373	1.21	112.4	133.2	0.98	0.311	1.1	0.208	1.50	1.106	0.253	N/L
2.80	9.18	9217	53	50.6	50.6	128	0.57	1.7	Unsaturated	11	9217	1.20	109.5	130.0	0.98	0.311	1.1	0.197	1.47	1.100	0.237	N/L
2.90	9.51	8081	52	52.4	52.4	110	0.65	1.8	Unsaturated	13	8081	1.19	95.1	123.1	0.97	0.310	1.1	0.179	1.41	1.088	0.210	N/L
3.00	9.84	6125	44	54.2	54.2	82	0.72	1.9	Unsaturated	15	6125	1.18	71.5	103.2	0.97	0.310	1.1	0.142	1.28	1.060	0.160	N/L
3.10	10.17	5148	34	56.0	56.0	68	0.67	1.9	Unsaturated	15	5148	1.17	59.5	88.8	0.97	0.309	1.1	0.124	1.21	1.045	0.137	N/L
3.20	10.50	5010	33	57.8	57.8	65	0.67	2.0	Unsaturated	17	5010	1.16	57.5	92.0	0.97	0.309	1.1	0.128	1.22	1.048	0.141	N/L
3.30	10.82	4464	32	59.7	59.7	57	0.73	2.0	Unsaturated	17	4464	1.15	50.8	83.7	0.97	0.309	1.0	0.119	1.19	1.041	0.130	N/L
3.40	11.15	3902	25	61.5	61.5	49	0.65	2.1	Unsaturated	19	3902	1.14	44.0	79.5	0.97	0.308	1.0	0.115	1.18	1.038	0.125	N/L
3.50	11.48	4425	25	63.3	63.3	54	0.58	2.0	Unsaturated	17	4425	1.13	49.6	82.2	0.97	0.308	1.0	0.118	1.19	1.040	0.128	N/L
3.60	11.81	6092	32	65.1	65.1	74	0.54	1.9	Unsaturated	15	6092	1.12	67.7	98.7	0.96	0.307	1.0	0.136	1.25	1.055	0.150	N/L
3.70	12.14	6505	36	66.9	66.9	78	0.56	1.8	Unsaturated	13	6505	1.11	71.8	96.2	0.96	0.307	1.0	0.133	1.24	1.052	0.145	N/L
3.80	12.46	6538	33	68.7	68.7	78	0.51	1.8	Unsaturated	13	6538	1.11	71.7	96.1	0.96	0.306	1.0	0.132	1.24	1.052	0.145	N/L
3.90	12.79	8399	36	70.5	70.5	99	0.44	1.7	Unsaturated	11	8399	1.10	91.4	110.0	0.96	0.306	1.0	0.152	1.32	1.068	0.169	N/L
4.00	13.12	13238	56	72.3	72.3	154	0.43	1.5	Unsaturated	8	13238	1.09	143.1	148.6	0.96	0.305	1.1	0.279	1.65	1.140	0.335	N/L
4.10	13.45	16079	72	74.1	74.1	185	0.45	1.5	Unsaturated	8	16079	1.09	172.7	178.9	0.96	0.305	1.1	0.694	2.07	1.230	0.909	N/L
4.20	13.78	17297	83	75.9	75.9	196	0.48	1.5	Unsaturated	8	17297	1.08	184.7	191.1	0.96	0.304	1.1	1.183	2.20	1.257	1.588	N/L
4.30	14.10	17383	90	77.7	77.7	195	0.52	1.5	Unsaturated	8	17383	1.07	184.4	190.8	0.95	0.304	1.1	1.169	2.20	1.257	1.562	N/L
4.40	14.43	17386	94	79.5	79.5	193	0.55	1.5	Unsaturated	8	17386	1.07	183.3	189.7	0.95	0.303	1.1	1.109	2.20	1.257	1.472	N/L
4.50	14.76	17758	99	81.4	81.4	195	0.56	1.5	Unsaturated	8	17758	1.06	186.1	192.6	0.95	0.303	1.1	1.275	2.20	1.257	1.687	N/L
4.60	15.09	17979	100	83.2	83.2	195	0.56	1.5	Unsaturated	8	17979	1.05	187.4	193.8	0.95	0.303	1.0	1.359	2.20	1.257	1.790	N/L
4.70	15.42	18059	97	85.0	85.0	194	0.54	1.5	Unsaturated	8	18059	1.05	187.1	193.6	0.95	0.302	1.0	1.342	2.20	1.257	1.759	N/L
4.80	15.74	18087	99	86.8	86.8	192	0.55	1.5	Unsaturated	8	18087	1.04	186.4	192.8	0.95	0.302	1.0	1.292	2.20	1.257	1.684	N/L
4.90	16.07	18159	106	88.6	88.6	191	0.59	1.5	Unsaturated	8	18159	1.04	186.1	192.6	0.95	0.301	1.0	1.274	2.20	1.257	1.653	N/L
5.00	16.40	18483	111	90.4	90.4	192	0.60	1.6	Unsaturated	10	18483	1.03	188.4	204.4	0.94	0.301	1.0	2.443	2.20	1.257	2.000	N/L
5.10	16.73	18749	115	92.2	92.2	193	0.62	1.6	Unsaturated	10	18749	1.02	190.2	206.2	0.94	0.300	1.0	2.730	2.20	1.257	2.000	N/L
5.20	17.06	18690	117	94.0	94.0	191	0.63	1.6	Unsaturated	10	18690	1.02	188.6	204.5	0.94	0.300	1.0	2.465	2.20	1.257	2.000	N/L
5.30	17.38	18132	116	95.8	95.8	183	0.64	1.6	Unsaturated	10	18132	1.01	182.0	197.6	0.94	0.299	1.0	1.657	2.20	1.257	2.000	N/L
5.40	17.71	18151	117	97.6	97.6	182	0.65	1.6	Unsaturated	10	18151	1.01	181.3	196.9	0.94	0.299	1.0	1.591	2.20	1.257	2.000	N/L
5.50	18.04	18224	122	99.4	99.4	181	0.67	1.6	Unsaturated	10	18224	1.00	181.2	196.7	0.94	0.298	1.0	1.578	2.20	1.257	1.992	N/L
5.60	18.37	18006	114	101.2	101.2	177	0.63	1.6	Unsaturated	10	18006	1.00	178.2	193.5	0.93	0.297	1.0	1.337	2.20	1.257	1.679	N/L
5.70	18.70	17893	114	103.0	103.0	174	0.64	1.6	Unsaturated	10	17893	0.99	176.2	191.5	0.93	0.297	1.0	1.207	2.20	1.257	1.511	N/L
5.80	19.02	17988	120	104.9	104.9	174	0.67	1.6	Unsaturated	10	17988	0.99	176.3	191.6	0.93	0.296	1.0	1.215	2.20	1.257	1.514	N/L
5.90	19.35	17936	121	106.7	106.7	172	0.68	1.6	Unsaturated	10	17936	0.99	175.1	190.2	0.93	0.296	1.0	1.137	2.20	1.257	1.411	N/L
6.00	19.68	18129	124	108.5	108.5	172	0.69	1.6	Unsaturated	10	18129	0.98	176.2	191.4	0.93	0.295	1.0	1.202	2.20	1.257	1.486	N/L
6.10	20.01	18215	130	110.3	110.3	171	0.72	1.6	Unsaturated	10	18215	0.98	176.2	191.5	0.93	0.295	1.0	1.206	2.20	1.257	1.485	N/L
6.20	20.34	17843	127	112.1	112.1	166	0.72	1.6	Unsaturated	10	17843	0.97	171.9	186.9	0.92	0.294	1.0	0.972	2.20	1.257	1.194	N/L
6.30	20.66	17914	123	113.9	113.9	166	0.69	1.6	Unsaturated	10	17914	0.97	171.8	186.8	0.92	0.294	1.0	0.970	2.20	1.257	1.187	N/L
6.40	20.99	18041	120	115.7	115.7	166	0.67	1.6	Unsaturated	10	18041	0.96	172.3	187.4	0.92	0.293	1.0	0.994	2.20	1.257	1.211	N/L
6.50	21.32	18401	118	117.5	117.5	168	0.64	1.6	Unsaturated	10	18401	0.96	175.1	190.2	0.92	0.293	1.0	1.137	2.20	1.257	1.378	N/L
6.60	21.65	18687	121	119.3	119.3	169	0.65	1.6	Unsaturated	10	18687	0.96	177.1	192.4	0.92	0.292	1.0	1.261	2.20	1.257	1.521	N/L
6.70	21.98	19094	127	121.1	121.1	171	0.67	1.6	Unsaturated	10	19094	0.95	180.2	195.7	0.92	0.292	1.0	1.494	2.20	1.257	1.793	N/L
6.80	22.30	19088	135	122.9	122.9	170	0.71	1.6	Unsaturated	10	19088	0.95	179.4	194.9	0.91	0.291	1.0	1.433	2.20	1.257	1.713	N/L
6.90	22.63	19029	140	124.7	124.7	168	0.74	1.7	Unsaturated	11	19029	0.95	178.2	205.8	0.91	0.291	0.9	2.668	2.20	1.257	2.000	N/L
7.00	22.96	18953	138	126.5	126.5	166	0.73	1.7	Unsaturated	11	18953	0.94	176.8	204.3	0.91	0.290	0.9	2.428	2.20	1.257	2.000	N/L
7.10	23.29	18920	136	128.4	128.4	165	0.72	1.7	Unsaturated	11	18920	0.94	175.8	203.2	0.91	0.289	0.9	2.279	2.20	1.257	2.000	N/L
7.20	23.62	18956	134	130.2	130.2	164	0.71	1.7	Unsaturated	11	18956	0.94	175.5	202.9	0.91	0.289	0.9	2.231	2.20	1.257	2.000	N/L
7.30	23.94	18525	135	132.0	132.0	159	0.73	1.7	Unsaturated	11	18525	0.93	170.9	197.8	0.91	0.288	0.9	1.672	2.20	1.257	1.958	N/L
7.40	24.27	17970	127	133.8	133.8	153	0.71	1.7	Unsaturated	11	17970	0.93	165.2	191.5	0.90	0.288	0.9	1.208	2.20	1.257	1.417	N/L
7.50	24.60	17498	118	135.6	135.6	148	0.68	1.7	Unsaturated	11	17498	0.93	160.3	186.1	0.90	0.287	0.9	0.938	2.19	1.256	1.100	N/L
7.60	24.93	17094	115	137.4	137.4	144	0.68	1.7	Unsaturated	11	17094	0.92	156.0	181.4	0.90	0.287	0.9	0.767	2.11	1.239	0.888	N/L
7.70	25.26	17115	110	139.2	139.2	143	0.65	1.7	Unsaturated	11	17115	0.92	155.7	181.0	0.90	0.286	0.9	0.756	2.11	1.237	0.871	N/L
7.80	25.58	17292	105	141.0	141.0	143	0.61	1.7	Unsaturated	11	17292	0.92	156.8	182.2	0.90	0.286	0.9	0.793	2.13	1.242	0.914	N/L
7.90	25.91	19115	105	142.8	142.8	158	0.55	1.6	Unsaturated	10	19115	0.91	172.7	187.8	0.89	0.285	0.9	1.013	2.20	1.257	1.172	N/L
8.00	26.24	18321	112	144.6	144.6	150	0.61	1.6	Unsaturated	10	18321	0.91	165.0	179.6	0.89	0.284	0.9	0.715	2.08	1.232	0.814	N/L
8.10	26.57	14678	109	146.4	146.4	119	0.75	1.8	Unsaturated	13	14678	0.91	131.8	165.4	0.89	0.284	0.9	0.435	1.87	1.186	0.480	N/L
8.20	26.90	13132	100	148.2	148.2	106	0.77	1.8	Unsaturated	13	13132	0.90	117.5	149.0	0.89	0.283	0.9	0.282	1.66	1.141	0.302	N/L
8.30	27.22	12677	97	150.0	150.0	102	0.77	1.8	Unsaturated	13	12677	0.90	113.1	143.9	0.89	0.283	0.9	0.253	1.60	1.129	0.268	N/L
8.40	27.55	12221	90	151.9	151.9	97	0.75	1.8	Unsaturated	13	12221	0.90	108.7	138.8	0.89	0.282	0.9	0.229	1.55	1.118	0.241	N/L
8.50	27.88	12353	88	153.7	153.7	98	0.72	1.8	Unsaturated	13	12353	0.90	109.5	139.7	0.88	0.281	0.9	0.233	1.56	1.120	0.245	N/L
8.60	28.21	12913	89	155.5	155.5	102	0.70	1.8	Unsaturated	13	12913	0.89	114.1	145.0	0.88	0.281	0.9	0.259	1.61	1.131	0.274	N/L
8.70	28.54	13229	92	157.3	157.3	104	0.70	1.8	Unsaturated	13	13229	0.89	116.5	147.9	0.88	0.280	0.9	0.275	1.64	1.138	0.291	N/L
8.80	28.86	13739	87	159.1	159.1	107	0.64	1.8	Unsaturated	13	13739	0.89	120.7	152.6	0.88	0.280	0.9	0.307	1.70	1.150	0.327	N/L

Settelemnt of Liquefiable Soil (Idriss and Boulnager, 2008) / Settlement of Unsaturated Sand (Tokimatsu & Seed, 1987, and Pradel, 1998) / Cumulative / S_r (Idriss & Boulanger, 2008)

Depth, Z (m)	q_t (kPa)	N_{60}	$N_{1,60}$	$\Delta(N_1)_{60}$	$N_{1,60-CS}$	Limiting Shear Strain γ_{lim}	Parameter F_α	Max. Shear Strain γ_{max}	ΔHi (m)	ΔLDI_i (m)	Vert. Recon. Strain ε_v	DF_i	ΔSi (inch)	p = σ_m (tsf)	τ_{ave} (psf)	G_{max} (tsf)	τ_{ave}/G_{max}	a	b	γ_{eff} (%)	ε_{15} (%)	ε_{Nc} (%)	Settlement (inch)	Cumulative Settlement (inch)	$\Delta(N_1)_{60-Sr}$	$(N_1)_{60-Sr}$	S_r/σ_{vo}'
1.60	25008	37.1	51.6	0.0	N.A.	0.000	0.000	0.000	0.05	0.0000	0.0000	0.91	0.00	0.202	192	3456	0.00003	0.20272	16691	0.00305	0.001	0.001	0.00	0.33	N/A	N/A	N/A
1.70	26063	39.8	54.5	0.0	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.91	0.00	0.215	204	3758	0.00003	0.20764	16095	0.00297	0.001	0.001	0.00	0.33	N/A	N/A	N/A
1.80	28708	43.8	59.1	0.0	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.90	0.00	0.228	216	4196	0.00003	0.21256	15552	0.00279	0.001	0.001	0.00	0.33	N/A	N/A	N/A
1.90	27660	43.5	57.8	0.0	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.90	0.00	0.240	228	4215	0.00003	0.21749	15056	0.00294	0.001	0.001	0.00	0.33	N/A	N/A	N/A
2.00	22940	37.1	48.7	0.0	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.89	0.00	0.253	239	3646	0.00003	0.22241	14600	0.00365	0.001	0.001	0.00	0.33	N/A	N/A	N/A
2.10	19032	31.8	41.1	0.1	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.89	0.00	0.266	251	3155	0.00004	0.22733	14178	0.00454	0.002	0.002	0.00	0.33	N/A	N/A	N/A
2.20	15870	26.5	33.9	0.1	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.88	0.00	0.278	263	2660	0.00005	0.23225	13788	0.00586	0.003	0.003	0.00	0.33	N/A	N/A	N/A
2.30	13352	23.0	29.1	0.4	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.87	0.00	0.291	275	2335	0.00006	0.23717	13425	0.00725	0.005	0.004	0.00	0.33	N/A	N/A	N/A
2.40	11911	20.5	25.7	0.4	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.87	0.00	0.304	287	2104	0.00007	0.24209	13087	0.00873	0.006	0.005	0.00	0.33	N/A	N/A	N/A
2.50	10706	19.1	23.6	0.9	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.86	0.00	0.316	299	1973	0.00008	0.24701	12770	0.01001	0.008	0.007	0.00	0.33	N/A	N/A	N/A
2.60	9723	17.3	21.2	0.9	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.86	0.00	0.329	310	1808	0.00009	0.25193	12473	0.01189	0.011	0.009	0.00	0.33	N/A	N/A	N/A
2.70	9373	17.3	20.9	1.7	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.85	0.00	0.342	322	1820	0.00009	0.25685	12194	0.01237	0.012	0.010	0.00	0.33	N/A	N/A	N/A
2.80	9097	16.8	20.1	1.7	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.85	0.00	0.354	334	1781	0.00009	0.26177	11931	0.01338	0.013	0.011	0.00	0.33	N/A	N/A	N/A
2.90	7999	15.3	18.1	2.5	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.84	0.00	0.367	346	1636	0.00011	0.26669	11682	0.01598	0.018	0.015	0.00	0.33	N/A	N/A	N/A
3.00	6217	12.3	14.5	3.2	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.84	0.00	0.379	357	1329	0.00013	0.27161	11447	0.02395	0.035	0.029	0.00	0.32	N/A	N/A	N/A
3.10	5217	10.3	12.1	3.2	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.83	0.00	0.392	369	1124	0.00016	0.27653	11224	0.03531	0.065	0.054	0.00	0.32	N/A	N/A	N/A
3.20	4967	10.2	11.8	3.8	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.83	0.00	0.405	381	1120	0.00017	0.28145	11012	0.03754	0.071	0.059	0.00	0.32	N/A	N/A	N/A
3.30	4414	9.1	10.4	3.8	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.82	0.00	0.417	392	1002	0.00020	0.28637	10811	0.05135	0.112	0.094	0.01	0.31	N/A	N/A	N/A
3.40	4018	8.6	9.8	4.3	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.81	0.00	0.430	404	956	0.00021	0.29129	10619	0.06132	0.145	0.121	0.01	0.31	N/A	N/A	N/A
3.50	4655	9.6	10.8	3.8	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.81	0.00	0.443	415	1072	0.00019	0.29621	10436	0.04843	0.101	0.085	0.01	0.30	N/A	N/A	N/A
3.60	5949	11.8	13.2	3.2	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.80	0.00	0.455	427	1328	0.00016	0.30113	10261	0.03173	0.052	0.044	0.00	0.29	N/A	N/A	N/A
3.70	6460	12.3	13.7	2.5	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.80	0.00	0.468	438	1399	0.00016	0.30605	10093	0.02985	0.047	0.039	0.00	0.29	N/A	N/A	N/A
3.80	6568	12.5	13.9	2.5	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.79	0.00	0.481	450	1432	0.00016	0.31097	9933	0.02974	0.046	0.039	0.00	0.28	N/A	N/A	N/A
3.90	8679	16.0	17.6	1.7	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.79	0.00	0.493	461	1838	0.00013	0.31589	9780	0.01983	0.023	0.019	0.00	0.28	N/A	N/A	N/A
4.00	13042	22.5	24.5	0.4	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.78	0.00	0.506	473	2599	0.00009	0.32081	9632	0.01219	0.010	0.008	0.00	0.28	N/A	N/A	N/A
4.10	15954	27.5	29.8	0.4	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.78	0.00	0.519	484	3198	0.00008	0.32573	9490	0.00953	0.006	0.005	0.00	0.28	N/A	N/A	N/A
4.20	17178	29.6	31.9	0.4	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.77	0.00	0.531	496	3463	0.00007	0.33065	9354	0.00885	0.005	0.004	0.00	0.28	N/A	N/A	N/A
4.30	17381	30.0	32.1	0.4	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.76	0.00	0.544	507	3523	0.00007	0.33557	9223	0.00890	0.005	0.004	0.00	0.28	N/A	N/A	N/A
4.40	17445	30.1	32.0	0.4	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.76	0.00	0.557	518	3555	0.00007	0.34049	9097	0.00903	0.005	0.004	0.00	0.28	N/A	N/A	N/A
4.50	17724	30.5	32.3	0.4	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.75	0.00	0.569	530	3632	0.00007	0.34541	8975	0.00902	0.005	0.004	0.00	0.28	N/A	N/A	N/A
4.60	17921	30.9	32.5	0.4	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.75	0.00	0.582	541	3691	0.00007	0.35033	8857	0.00906	0.005	0.004	0.00	0.28	N/A	N/A	N/A
4.70	18012	31.0	32.5	0.4	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.74	0.00	0.594	552	3729	0.00007	0.35525	8744	0.00917	0.005	0.004	0.00	0.28	N/A	N/A	N/A
4.80	18087	31.2	32.4	0.4	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.74	0.00	0.607	563	3763	0.00007	0.36017	8634	0.00928	0.005	0.004	0.00	0.28	N/A	N/A	N/A
4.90	18170	31.3	32.4	0.4	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.73	0.00	0.620	574	3799	0.00008	0.36509	8528	0.00939	0.005	0.004	0.00	0.28	N/A	N/A	N/A
5.00	18438	32.8	33.8	0.9	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.73	0.00	0.632	586	4002	0.00007	0.37001	8425	0.00900	0.005	0.004	0.00	0.28	N/A	N/A	N/A
5.10	18747	33.4	34.2	0.9	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.72	0.00	0.645	597	4088	0.00007	0.37493	8326	0.00896	0.005	0.004	0.00	0.27	N/A	N/A	N/A
5.20	18655	33.2	33.9	0.9	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.72	0.00	0.658	608	4087	0.00007	0.37985	8229	0.00916	0.005	0.004	0.00	0.27	N/A	N/A	N/A
5.30	18213	32.4	32.9	0.9	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.71	0.00	0.670	619	4008	0.00008	0.38477	8136	0.00959	0.005	0.004	0.00	0.27	N/A	N/A	N/A
5.40	18150	32.3	32.6	0.9	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.70	0.00	0.683	630	4012	0.00008	0.38969	8045	0.00978	0.005	0.005	0.00	0.27	N/A	N/A	N/A
5.50	18181	32.4	32.5	0.9	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.70	0.00	0.696	641	4036	0.00008	0.39461	7957	0.00991	0.006	0.005	0.00	0.27	N/A	N/A	N/A
5.60	18011	32.1	32.1	0.9	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.69	0.00	0.708	651	4016	0.00008	0.39953	7871	0.01018	0.006	0.005	0.00	0.27	N/A	N/A	N/A
5.70	17893	31.9	31.7	0.9	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.69	0.00	0.721	662	4006	0.00008	0.40446	7788	0.01042	0.006	0.005	0.00	0.27	N/A	N/A	N/A
5.80	17933	31.9	31.6	0.9	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.68	0.00	0.734	673	4031	0.00008	0.40938	7707	0.01054	0.006	0.005	0.00	0.27	N/A	N/A	N/A
5.90	17936	31.9	31.5	0.9	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.68	0.00	0.746	684	4048	0.00008	0.41430	7629	0.01068	0.006	0.005	0.00	0.27	N/A	N/A	N/A
6.00	18112	32.3	31.7	0.9	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.67	0.00	0.759	695	4104	0.00008	0.41922	7552	0.01070	0.006	0.005	0.00	0.27	N/A	N/A	N/A
6.10	18195	32.4	31.7	0.9	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.67	0.00	0.772	705	4139	0.00009	0.42414	7478	0.01078	0.006	0.005	0.00	0.27	N/A	N/A	N/A
6.20	17946	32.0	31.1	0.9	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.66	0.00	0.784	716	4098	0.00009	0.42906	7405	0.01112	0.007	0.005	0.00	0.27	N/A	N/A	N/A
6.30	17923	31.9	30.9	0.9	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.66	0.00	0.797	727	4109	0.00009	0.43398	7334	0.01128	0.007	0.006	0.00	0.27	N/A	N/A	N/A
6.40	18060	32.2	31.0	0.9	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.65	0.00	0.810	737	4155	0.00009	0.43890	7265	0.01132	0.007	0.006	0.00	0.27	N/A	N/A	N/A
6.50	18309	32.6	31.3	0.9	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.64	0.00	0.822	748	4228	0.00009	0.44382	7198	0.01126	0.007	0.005	0.00	0.27	N/A	N/A	N/A
6.60	18660	33.2	31.8	0.9	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.64	0.00	0.835	758	4325	0.00009	0.44874	7132	0.01112	0.006	0.005	0.00	0.27	N/A	N/A	N/A
6.70	19041	33.9	32.3	0.9	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.63	0.00	0.847	769	4429	0.00009	0.45366	7068	0.01097	0.006	0.005	0.00	0.27	N/A	N/A	N/A
6.80	19105	34.0	32.3	0.9	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.63	0.00	0.860	779	4459	0.00009	0.45858	7006	0.01105	0.006	0.005	0.00	0.27	N/A	N/A	N/A
6.90	19040	35.1	33.2	1.7	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.62	0.00	0.873	789	4613	0.00009	0.46350	6945	0.01075	0.006	0.005	0.00	0.27	N/A	N/A	N/A
7.00	18937	34.9	32.9	1.7	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.62	0.00	0.885	800	4604	0.00009	0.46842	6885	0.01095	0.006	0.005	0.00	0.27	N/A	N/A	N/A
7.10	18919	34.9	32.7	1.7	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.61	0.00	0.898	810	4615	0.00009	0.47334	6827	0.01109	0.006	0.005	0.00	0.27	N/A	N/A	N/A
7.20	18906	34.8	32.6	1.7	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.61	0.00	0.911	820	4627	0.00009	0.47826	6770	0.01122	0.006	0.005	0.00	0.27	N/A	N/A	N/A
7.30	18497	34.1	31.8	1.7	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.60	0.00	0.923	830	4542	0.00009	0.48318	6714	0.01166	0.007	0.006	0.00	0.27	N/A	N/A	N/A
7.40	17951	33.1	30.7	1.7	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.60	0.00	0.936	840	4422	0.00010	0.48810	6659	0.01225	0.007	0.006	0.00	0.27	N/A	N/A	N/A
7.50	17500	32.2	29.8	1.7	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.59	0.00	0.949	850	4325	0.00010	0.49302	6606	0.01280	0.008	0.007	0.00	0.27	N/A	N/A	N/A
7.60	17152	31.6	29.1	1.7	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.58	0.00	0.961	860	4252	0.00010	0.49794	6553	0.01328	0.008	0.007	0.00	0.26	N/A	N/A	N/A
7.70	17115	31.5	29.0	1.7	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.58	0.00	0.974	870	4256	0.00010	0.50286	6502	0.01346	0.009	0.007	0.00	0.26	N/A	N/A	N/A
7.80	17458	32.2	29.5	1.7	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.57	0.00	0.987	880	4354	0.00010	0.50778	6452	0.01324	0.008	0.007	0.00	0.26	N/A	N/A	N/A
7.90	18758	33.4	30.5	0.9	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.57	0.00	0.999	890	4536	0.00010	0.51270	6403	0.01272	0.008	0.006	0.00	0.26	N/A	N/A	N/A
8.00	17905	31.9	29.0	0.9	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.56	0.00	1.012	900	4343	0.00010	0.51762	6355	0.01366	0.009	0.007	0.00	0.26	N/A	N/A	N/A
8.10	14854	28.3	25.7	2.5	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.56	0.00	1.025	910	3871	0.00012	0.52254	6308	0.01618	0.012	0.010	0.00	0.26	N/A	N/A	N/A
8.20	13248	25.3	22.8	2.5	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.55	0.00	1.037	920	3463	0.00013	0.52746	6261	0.01922	0.016	0.014	0.00	0.26	N/A	N/A	N/A
8.30	12612	24.1	21.7	2.5	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.55	0.00	1.050	929	3306	0.00014	0.53238	6216	0.02087	0.019	0.016	0.00	0.26	N/A	N/A	N/A
8.40	12252	23.4	21.0	2.5	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.54	0.00	1.062	939	3221	0.00015	0.53730	6171	0.02200	0.021	0.017	0.00	0.26	N/A	N/A	N/A
8.50	12392	23.6	21.2	2.5	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.54	0.00	1.075	948	3267	0.00015	0.54222	6128	0.02184	0.020	0.017	0.00	0.26	N/A	N/A	N/A
8.60	12857	24.5	21.9	2.5	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.53	0.00	1.088	958	3399	0.00014	0.54714	6085	0.02086	0.019	0.016	0.00	0.26	N/A	N/A	N/A
8.70	13254	25.3	22.5	2.5	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.52	0.00	1.100	967	3513	0.00014	0.55206	6043	0.02012	0.017	0.015	0.00	0.25	N/A	N/A	N/A
8.80	13698	26.1	23.2	2.5	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.52	0.00	1.113	977	3641	0.00013	0.55698	6002	0.01935	0.016	0.014	0.00	0.25	N/A	N/A	N/A

Depth, Z (m)	Depth, Z (ft)	q_c (kPa)	f_s (kPa)	σ_{vc} (kPa)	σ'_{vc} (kPa)	Q	F	I_c	Soil Type	Fines (%)	Interpreted q_c	C_N	q_{c1N}	q_{c1N-cs}	Stress Reduction Factor (r_d)	CSR	K_σ for sand	$CRR_{M=7.5}$ at σ'_{vc}=1	MSF_{max}	MSF	CRR	$(FS)_L$	q_L (kPa)	N_{60}	$N_{1,60}$	$\Delta(N_1)_{60}$	$N_{1,60\text{-}CS}$	Limiting Shear Strain γ_{lim}	Parameter F_{ru}	Max. Shear Strain γ_{max}	ΔHi (m)	ΔLDI (m)	Vert. Recon. Strain ε_v	DF_i	ΔSi (inch)	p = σ_m (tsf)	τ_{ave} (psf)	G_{max} (tsf)	τ_{ave}/G_{max}	a	b	γ_{eff} (%)	$\varepsilon_{1\%}$ (%)	ε_{NC} (%)	Settlement (inch)	Settlement (inch)	$\Delta(N_1)_{60\text{-}Sr}$	$(N_1)_{60\text{-}Sr}$	S_r/σ_{vo}'
8.90	29.19	14147	88	160.9	160.9	110	0.63	1.8	Unsaturated	13	14147	0.88	123.9	156.3	0.88	0.279	0.9	0.336	1.75	1.160	0.360	**N/L**	14120	26.9	23.8	2.5	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.51	0.00	1.126	986	3763	0.00013	0.56190	5961	0.01869	0.015	0.013	0.00	0.25	N/A	N/A	N/A
9.00	29.52	14357	93	162.7	162.7	111	0.66	1.8	Unsaturated	13	14357	0.88	125.4	158.0	0.87	0.279	0.9	0.352	1.77	1.164	0.376	**N/L**	14356	27.4	24.2	2.5	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.51	0.00	1.138	996	3836	0.00013	0.56682	5921	0.01840	0.015	0.012	0.00	0.25	N/A	N/A	N/A
9.10	29.85	14610	100	164.5	164.5	112	0.70	1.8	Unsaturated	13	14610	0.88	127.2	160.1	0.87	0.278	0.9	0.373	1.79	1.170	0.399	**N/L**	14545	27.8	24.4	2.5	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.50	0.00	1.151	1005	3897	0.00013	0.57174	5882	0.01821	0.014	0.012	0.00	0.25	N/A	N/A	N/A
9.20	30.18	14639	105	166.3	166.3	112	0.72	1.8	Unsaturated	13	14639	0.88	127.1	160.0	0.87	0.277	0.9	0.371	1.79	1.170	0.397	**N/L**	14638	27.9	24.5	2.5	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.50	0.00	1.164	1014	3932	0.00013	0.57666	5844	0.01820	0.014	0.012	0.00	0.25	N/A	N/A	N/A
9.30	30.50	14987	107	168.1	168.1	114	0.73	1.8	Unsaturated	13	14987	0.87	129.7	163.1	0.87	0.277	0.9	0.405	1.83	1.179	0.434	**N/L**	15001	28.6	25.0	2.5	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.49	0.00	1.176	1023	4039	0.00013	0.58158	5806	0.01772	0.014	0.011	0.00	0.25	N/A	N/A	N/A
9.40	30.83	15893	111	169.9	169.9	120	0.70	1.8	Unsaturated	13	15893	0.87	137.2	171.7	0.87	0.276	0.9	0.533	1.96	1.205	0.577	**N/L**	15866	30.3	26.4	2.5	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.49	0.00	1.189	1032	4283	0.00012	0.58650	5769	0.01652	0.012	0.010	0.00	0.25	N/A	N/A	N/A
9.50	31.16	17466	115	171.7	171.7	131	0.66	1.7	Unsaturated	11	17466	0.87	150.3	175.0	0.87	0.276	0.9	0.601	2.01	1.216	0.653	**N/L**	17968	33.1	28.8	1.7	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.48	0.00	1.202	1041	4695	0.00011	0.59143	5732	0.01475	0.010	0.008	0.00	0.25	N/A	N/A	N/A
9.60	31.49	24290	142	173.5	173.5	182	0.59	1.6	Unsaturated	10	24290	0.87	208.5	225.6	0.86	0.275	0.8	2.000	2.20	1.257	2.000	**N/L**	22751	40.5	35.1	0.9	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.48	0.00	1.214	1050	5761	0.00009	0.59635	5696	0.01143	0.006	0.005	0.00	0.25	N/A	N/A	N/A
9.70	31.82	22224	155	175.4	175.4	165	0.70	1.6	Unsaturated	10	22224	0.86	190.2	206.3	0.86	0.274	0.8	2.745	2.20	1.257	2.000	**N/L**	23309	41.5	35.9	0.9	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.47	0.00	1.227	1059	5917	0.00009	0.60127	5661	0.01117	0.006	0.005	0.00	0.25	N/A	N/A	N/A
9.80	32.14	25375	158	177.2	177.2	188	0.63	1.6	Unsaturated	10	25375	0.86	216.6	234.2	0.86	0.274	0.8	2.000	2.20	1.257	2.000	**N/L**	26420	47.0	40.6	0.9	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.46	0.00	1.240	1068	6723	0.00008	0.60619	5626	0.00963	0.004	0.003	0.00	0.25	N/A	N/A	N/A
9.90	32.47	33432	194	179.0	179.0	247	0.58	1.5	Unsaturated	8	33432	0.86	284.6	293.4	0.86	0.273	0.8	2.000	2.20	1.257	2.000	**N/L**	32247	55.6	47.8	0.4	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.46	0.00	1.252	1077	7960	0.00007	0.61111	5592	0.00794	0.003	0.002	0.00	0.25	N/A	N/A	N/A
10.00	32.80	29279	253	180.8	180.8	215	0.87	1.6	Unsaturated	10	29279	0.86	248.6	268.1	0.86	0.273	0.8	2.000	2.20	1.257	2.000	**N/L**	29789	53.0	45.5	0.9	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.45	0.00	1.265	1086	7616	0.00007	0.61603	5558	0.00845	0.003	0.003	0.00	0.25	N/A	N/A	N/A
10.10	33.13	25538	239	182.6	182.6	186	0.94	1.7	Unsaturated	11	25538	0.86	216.3	247.9	0.85	0.272	0.8	2.000	2.20	1.257	2.000	**N/L**	25537	47.0	40.2	1.7	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.45	0.00	1.277	1094	6770	0.00008	0.62095	5525	0.00983	0.004	0.004	0.00	0.25	N/A	N/A	N/A
10.20	33.46	23953	210	184.4	184.4	174	0.88	1.7	Unsaturated	11	23953	0.85	202.3	232.5	0.85	0.271	0.8	2.000	2.20	1.257	2.000	**N/L**	24114	44.4	37.9	1.7	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.44	0.00	1.290	1103	6408	0.00009	0.62587	5493	0.01061	0.005	0.004	0.00	0.24	N/A	N/A	N/A
10.30	33.78	24411	200	186.2	186.2	176	0.82	1.7	Unsaturated	11	24411	0.85	205.7	236.2	0.85	0.271	0.8	2.000	2.20	1.257	2.000	**N/L**	24261	44.7	38.0	1.7	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.44	0.00	1.303	1112	6462	0.00009	0.63079	5461	0.01060	0.005	0.004	0.00	0.24	N/A	N/A	N/A
10.40	34.11	24272	186	188.0	188.0	175	0.77	1.7	Unsaturated	11	24272	0.85	204.0	234.3	0.85	0.270	0.8	2.000	2.20	1.257	2.000	**N/L**	24271	44.7	38.0	1.7	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.43	0.00	1.315	1120	6479	0.00009	0.63571	5429	0.01066	0.005	0.004	0.00	0.24	N/A	N/A	N/A
10.50	34.44	24906	181	189.8	189.8	178	0.73	1.6	Unsaturated	10	24906	0.85	208.8	225.9	0.85	0.270	0.8	2.000	2.20	1.257	2.000	**N/L**	24846	44.2	37.5	0.9	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.43	0.00	1.328	1129	6426	0.00009	0.64063	5398	0.01086	0.005	0.004	0.00	0.24	N/A	N/A	N/A
10.60	34.77	25216	162	191.6	191.6	180	0.65	1.6	Unsaturated	10	25216	0.84	210.9	228.1	0.84	0.269	0.8	2.000	2.20	1.257	2.000	**N/L**	25318	45.1	38.1	0.9	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.42	0.00	1.341	1137	6563	0.00009	0.64555	5368	0.01068	0.005	0.004	0.00	0.24	N/A	N/A	N/A
10.70	35.10	25703	168	193.4	193.4	182	0.66	1.6	Unsaturated	10	25703	0.84	214.4	231.8	0.84	0.268	0.8	2.000	2.20	1.257	2.000	**N/L**	25600	45.6	38.4	0.9	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.42	0.00	1.353	1146	6650	0.00009	0.65047	5337	0.01059	0.005	0.004	0.00	0.24	N/A	N/A	N/A
10.80	35.42	24458	193	195.3	194.7	173	0.79	1.7		11	24458	0.84	203.7	233.9	0.84	0.269	0.8	2.000	2.20	1.257	2.000	**2.00**	24035	44.3	37.2	1.7	38.9	0.011	-0.722	0.000	0.10	0.0000	0.0000	0.41	0.00	1.362	1155	6469	0.00009	0.65386	5317	0.01107	0.005	0.004	0.00	0.24	1.0	38	N/A
10.90	35.75	19478	189	197.3	195.7	137	0.98	1.8		13	19478	0.84	162.0	200.3	0.84	0.269	0.8	1.922	2.20	1.257	1.995	**2.00**	19763	37.7	31.7	2.5	34.1	0.025	-0.375	0.000	0.10	0.0000	0.0000	0.40	0.00	1.369	1164	5516	0.00011	0.65654	5301	0.01368	0.008	0.007	0.00	0.24	1.2	33	N/A
11.00	36.08	16920	119	199.3	196.6	118	0.71	1.8		13	16920	0.84	140.5	175.5	0.84	0.270	0.9	0.612	2.02	1.218	0.644	**2.00**	17195	32.8	27.5	2.5	30.0	0.047	-0.088	0.000	0.10	0.0000	0.0000	0.40	0.00	1.376	1173	4805	0.00012	0.65921	5285	0.01660	0.011	0.009	0.00	0.24	1.2	29	N/A
11.10	36.41	16811	100	201.2	197.6	117	0.60	1.7		11	16811	0.84	139.4	163.0	0.84	0.271	0.9	0.405	1.83	1.179	0.419	**1.55**	16820	31.0	26.0	1.7	27.6	0.064	0.067	0.010	0.10	0.0010	0.0022	0.39	0.00	1.383	1182	4543	0.00013	0.66189	5269	0.01811	0.013	0.011	0.00	0.24	1.0	27	N/A
11.20	36.74	16277	106	203.2	198.6	113	0.66	1.8		13	16277	0.84	134.8	169.0	0.83	0.272	0.9	0.486	1.92	1.197	0.507	**1.87**	16371	31.2	26.1	2.5	28.6	0.056	0.004	0.002	0.10	0.0002	0.0005	0.39	0.00	1.390	1191	4585	0.00013	0.66457	5253	0.01806	0.013	0.011	0.00	0.24	1.2	27	N/A
11.30	37.06	16026	105	205.2	199.6	111	0.66	1.8		13	16026	0.84	132.6	166.4	0.83	0.272	0.9	0.448	1.88	1.189	0.465	**1.71**	16025	30.6	25.5	2.5	28.0	0.061	0.042	0.006	0.10	0.0006	0.0013	0.38	0.00	1.397	1200	4494	0.00013	0.66725	5238	0.01876	0.014	0.012	0.00	0.24	1.2	27	N/A
11.40	37.39	16259	109	207.1	200.6	113	0.68	1.8		13	16259	0.83	134.3	168.4	0.83	0.273	0.9	0.477	1.91	1.195	0.497	**1.82**	15980	30.5	25.4	2.5	27.9	0.062	0.049	0.003	0.10	0.0003	0.0007	0.38	0.00	1.403	1209	4486	0.00013	0.66993	5222	0.01899	0.014	0.012	0.00	0.24	1.2	27	N/A
11.50	37.72	14374	110	209.1	201.6	99	0.78	1.8		13	14374	0.83	118.6	150.2	0.83	0.273	0.9	0.290	1.67	1.144	0.295	**1.08**	14474	27.6	23.0	2.5	25.5	0.084	0.202	0.029	0.10	0.0029	0.0068	0.37	0.01	1.410	1218	4068	0.00015	0.67260	5207	0.02207	0.019	0.016	0.00	0.24	1.2	24	N/A
11.60	38.05	12869	93	211.1	202.6	88	0.74	1.9		15	12869	0.83	106.0	144.7	0.83	0.274	0.9	0.257	1.61	1.131	0.260	**0.95**	13048	25.8	21.5	3.2	24.7	0.092	0.250	0.040	0.10	0.0040	0.0095	0.37	0.01	1.417	1226	3808	0.00016	0.67528	5192	0.02459	0.023	0.019	0.00	0.23	1.3	23	0.21
11.70	38.38	12952	72	213.0	203.5	89	0.56	1.8		13	12952	0.83	106.6	136.4	0.82	0.275	0.9	0.219	1.52	1.113	0.220	**0.80**	12973	24.8	20.6	2.5	23.0	0.112	0.349	0.061	0.10	0.0061	0.0155	0.36	0.02	1.424	1235	3655	0.00017	0.67796	5177	0.02645	0.026	0.021	0.00	0.21	1.2	22	0.20
11.80	38.70	13338	54	215.0	204.5	91	0.41	1.7		11	13338	0.83	109.6	130.1	0.82	0.275	0.9	0.198	1.47	1.100	0.197	**0.72**	13327	24.6	20.4	1.7	22.1	0.126	0.405	0.086	0.10	0.0086	0.0212	0.35	0.03	1.431	1244	3629	0.00017	0.68064	5162	0.02701	0.026	0.022	0.00	0.19	1.0	21	0.19
11.90	39.03	13973	53	217.0	205.5	95	0.39	1.7		11	13973	0.83	114.7	135.7	0.82	0.276	0.9	0.217	1.52	1.111	0.217	**0.79**	13941	25.7	21.3	1.7	23.0	0.113	0.353	0.064	0.10	0.0064	0.0163	0.35	0.02	1.438	1252	3800	0.00016	0.68332	5147	0.02541	0.024	0.020	0.00	0.16	1.0	22	0.21
12.00	39.36	14560	55	218.9	206.5	99	0.38	1.7		11	14560	0.83	119.4	140.9	0.82	0.276	0.9	0.238	1.57	1.122	0.239	**0.87**	14608	26.9	22.3	1.7	24.0	0.101	0.295	0.049	0.10	0.0049	0.0121	0.34	0.02	1.445	1261	3987	0.00016	0.68599	5132	0.02387	0.021	0.018	0.00	0.14	1.0	23	0.22
12.10	39.69	15442	62	220.9	207.5	105	0.41	1.7		11	15442	0.83	126.4	148.7	0.82	0.277	0.9	0.280	1.65	1.140	0.283	**1.02**	15355	28.3	23.4	1.7	25.1	0.088	0.228	0.033	0.10	0.0033	0.0079	0.34	0.01	1.452	1269	4196	0.00015	0.68867	5118	0.02234	0.019	0.015	0.00	0.12	1.0	24	N/A
12.20	40.02	15309	69	222.9	208.5	104	0.46	1.7		11	15309	0.83	125.2	147.3	0.81	0.277	0.9	0.272	1.64	1.137	0.274	**0.99**	15030	27.7	22.9	1.7	24.5	0.094	0.260	0.036	0.10	0.0036	0.0087	0.33	0.01	1.458	1278	4111	0.00016	0.69135	5103	0.02323	0.020	0.017	0.00	0.11	1.0	24	0.23
12.30	40.34	11898	58	224.8	209.4	80	0.49	1.8		13	11898	0.82	97.2	125.5	0.81	0.278	0.9	0.185	1.43	1.092	0.182	**0.66**	11868	22.6	18.7	2.5	21.2	0.140	0.456	0.127	0.10	0.0127	0.0220	0.33	0.03	1.465	1286	3366	0.00019	0.69403	5089	0.03197	0.035	0.029	0.00	0.10	1.2	20	0.17
12.40	40.67	7420	32	226.8	210.4	49	0.44	2.0		17	7420	0.82	60.5	95.8	0.81	0.278	0.9	0.132	1.24	1.052	0.128	**0.46**	7911	16.3	13.4	3.8	17.2	0.216	0.656	0.216	0.10	0.0216	0.0259	0.32	0.03	1.472	1294	2419	0.00027	0.69671	5074	0.05847	0.095	0.079	0.00	0.07	1.5	15	0.13
12.50	41.00	5393	28	228.8	211.4	35	0.55	2.1		19	5393	0.82	43.9	79.4	0.81	0.279	0.9	0.115	1.18	1.038	0.112	**0.40**	5166	11.0	9.1	4.3	13.4	0.326	0.815	0.326	0.10	0.0326	0.0310	0.32	0.04	1.479	1303	1645	0.00040	0.69939	5060	0.14424	0.372	0.311	0.00	0.04	1.7	11	0.10
12.60	41.33	1989	13	230.7	212.4	12	0.72	2.6	Clay-Like	34	1989	0.82	16.2	51.3	0.81	0.279	0.9	0.093	1.11	1.024	0.090	**N/L**	2285	6.1	5.0	5.5	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.31	0.00	1.486	1311	910	0.00072	0.70206	5046	1.16613	6.131	5.126	0.00	0.00	N/A	N/A	N/A
12.70	41.66	1457	4	232.7	213.4	8	0.32	2.7	Clay-Like	37	1457	0.82	11.8	45.9	0.80	0.280	0.9	0.089	1.11	1.023	0.087	**N/L**	1450	4.1	3.3	5.5	N.A.	0.000	0.000	0.000	0.05	0.0000	0.0000	0.31	0.00	1.493	1319	609	0.00108	0.70474	5032	10.52391	89.944	75.208	0.00	0.00	N/A	N/A	N/A

CONE PENETRATION TEST-BASED LIQUEFACTION ANALYSIS BASED ON IDRISS & BOULANGER (2008)

References:

1 - Idriss, I.M. and Boulanger, R.W. (2008). *Soil Liquefaction During Earthquakes* , Earthquake Engineering Research Institute, EERI Publication MNO-12.

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3 - Tokimatsu, K. and Seed H.B. (1987). "Evaluation of Settlements in Sands Due to Earthquake Shaking," Journal of Geotechnical Engineering, Vol. 113, No. 8, August.

4 - Pradel, D. (1998). "Procedure to Evaluate Earthquake-Induced Settlements in Sand," Journal of Geotechnical and Geoenvironmental Engineering, Vol. 124, No. 4, April.

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6 - Boulanger, R.W. and Idriss, I.M. (2014). "CPT and SPT Based Liquefaction Triggering Procedures," Report No. UCD/CGM-14/01, University of California at Davis

Project	Chevron Guadalupe Tank Battery 9 Site
Test Boring No	TSMACPT-3

Test Boring Information:

Approx. depth to ground water table		27.7 ft	8.45 m
Moist unit weight of soil	γ_m	115 pcf	18.08 kN/m^3
Saturated unit weight of soil	γ_{sat}	125 pcf	19.65 kN/m^3

Earthquake Information:

Earthquake magnitude	M_w	6.9
Peak horizontal ground surface acceleratio	a_{max}	0.490 g
Number of equivalent cycle	N	10.1
Atmospheric pressure	P_a	101.3 kPa

N/L = Non-liquefiable clay-like soil
N.A. = Not Applicable

Sum (ΔSi)	Sum (Settlement)	Total
0.06	0.36	0.42

Factor of Safety Agaist Liquefaction (Idriss & Boulanger, 2008 and Boulanger & Idriss, 2014)

Depth, Z (m)	Depth, Z (ft)	q_c (kPa)	f_s (kPa)	σ_{vc} (kPa)	σ'_{vc} (kPa)	Q	F	I_c	Soil Type	Fines (%)	Interpreted q_c	C_N	q_{c1N}	q_{c1N-cs}	Stress Reduction Factor (r_d)	CSR	K_σ for sand	$CRR_{M=7.5}$ at σ'_{vc}=1	MSF_{max}	MSF	CRR	$(FS)_L$
1.60	5.25	7989	33	28.9	28.9	147	0.41	1.5	Unsaturated	8	7989	1.39	110.0	114.7	0.99	0.315	1.1	0.160	1.35	1.075	0.189	N/L
1.70	5.58	4965	15	30.7	30.7	88	0.31	1.7	Unsaturated	11	4965	1.37	67.3	83.3	0.99	0.315	1.1	0.119	1.19	1.041	0.136	N/L
1.80	5.90	2744	14	32.5	32.5	47	0.53	2.0	Unsaturated	17	2744	1.35	36.6	66.2	0.99	0.315	1.1	0.104	1.14	1.030	0.117	N/L
1.90	6.23	2174	12	34.3	34.3	36	0.54	2.1	Unsaturated	19	2174	1.33	28.6	59.9	0.99	0.314	1.1	0.099	1.13	1.027	0.111	N/L
2.00	6.56	2009	11	36.2	36.2	33	0.56	2.2	Unsaturated	22	2009	1.31	26.1	59.4	0.99	0.314	1.1	0.099	1.13	1.027	0.110	N/L
2.10	6.89	2301	14	38.0	38.0	36	0.64	2.2	Unsaturated	22	2301	1.29	29.5	63.8	0.98	0.314	1.1	0.102	1.13	1.029	0.114	N/L
2.20	7.22	5284	37	39.8	39.8	83	0.70	1.9	Unsaturated	15	5284	1.28	66.9	97.7	0.98	0.313	1.1	0.134	1.25	1.054	0.155	N/L
2.30	7.54	16047	50	41.6	41.6	247	0.31	1.3	Unsaturated	6	16047	1.26	200.8	201.0	0.98	0.313	1.1	1.996	2.20	1.257	2.000	N/L
2.40	7.87	22870	73	43.4	43.4	344	0.32	1.2	Unsaturated	4	22870	1.25	283.0	283.0	0.98	0.312	1.1	2.000	2.20	1.257	2.000	N/L
2.50	8.20	22611	101	45.2	45.2	334	0.45	1.3	Unsaturated	6	22611	1.24	276.8	277.0	0.98	0.312	1.1	2.000	2.20	1.257	2.000	N/L
2.60	8.53	24824	115	47.0	47.0	359	0.47	1.3	Unsaturated	6	24824	1.22	300.7	301.0	0.98	0.312	1.1	2.000	2.20	1.257	2.000	N/L
2.70	8.86	26051	119	48.8	48.8	370	0.46	1.3	Unsaturated	6	26051	1.21	312.5	312.7	0.98	0.311	1.1	2.000	2.20	1.257	2.000	N/L
2.80	9.18	25316	115	50.6	50.6	353	0.45	1.3	Unsaturated	6	25316	1.20	300.8	301.0	0.98	0.311	1.1	2.000	2.20	1.257	2.000	N/L
2.90	9.51	24602	103	52.4	52.4	337	0.42	1.3	Unsaturated	6	24602	1.19	289.6	289.8	0.97	0.310	1.1	2.000	2.20	1.257	2.000	N/L
3.00	9.84	23868	102	54.2	54.2	321	0.43	1.3	Unsaturated	6	23868	1.18	278.4	278.7	0.97	0.310	1.1	2.000	2.20	1.257	2.000	N/L
3.10	10.17	22115	103	56.0	56.0	293	0.47	1.3	Unsaturated	6	22115	1.17	255.8	256.0	0.97	0.309	1.1	2.000	2.20	1.257	2.000	N/L
3.20	10.50	21024	90	57.8	57.8	274	0.43	1.3	Unsaturated	6	21024	1.16	241.1	241.3	0.97	0.309	1.1	2.000	2.20	1.257	2.000	N/L
3.30	10.82	17976	77	59.7	59.7	230	0.43	1.4	Unsaturated	7	17976	1.15	204.5	206.2	0.97	0.309	1.1	2.727	2.20	1.257	2.000	N/L
3.40	11.15	15020	66	61.5	61.5	190	0.44	1.5	Unsaturated	8	15020	1.14	169.5	175.6	0.97	0.308	1.1	0.613	2.02	1.218	0.821	N/L
3.50	11.48	15199	60	63.3	63.3	189	0.40	1.4	Unsaturated	7	15199	1.13	170.2	171.7	0.97	0.308	1.1	0.534	1.96	1.206	0.702	N/L
3.60	11.81	17147	72	65.1	65.1	210	0.42	1.4	Unsaturated	7	17147	1.12	190.6	192.3	0.96	0.307	1.1	1.254	2.20	1.257	1.735	N/L
3.70	12.14	20389	77	66.9	66.9	247	0.38	1.3	Unsaturated	6	20389	1.11	225.1	225.2	0.96	0.307	1.1	2.000	2.20	1.257	2.000	N/L
3.80	12.46	23543	112	68.7	68.7	281	0.48	1.4	Unsaturated	7	23543	1.11	258.0	260.0	0.96	0.306	1.1	2.000	2.20	1.257	2.000	N/L
3.90	12.79	25201	120	70.5	70.5	297	0.48	1.3	Unsaturated	6	25201	1.10	274.3	274.6	0.96	0.306	1.1	2.000	2.20	1.257	2.000	N/L
4.00	13.12	21882	118	72.3	72.3	255	0.54	1.4	Unsaturated	7	21882	1.09	236.6	238.5	0.96	0.305	1.1	2.000	2.20	1.257	2.000	N/L
4.10	13.45	15663	91	74.1	74.1	180	0.58	1.6	Unsaturated	10	15663	1.09	168.3	183.1	0.96	0.305	1.1	0.823	2.14	1.245	1.094	N/L
4.20	13.78	11978	72	75.9	75.9	136	0.60	1.7	Unsaturated	11	11978	1.08	127.9	150.2	0.96	0.304	1.0	0.290	1.67	1.144	0.347	N/L
4.30	14.10	9712	60	77.7	77.7	109	0.62	1.8	Unsaturated	13	9712	1.07	103.0	132.3	0.95	0.304	1.0	0.205	1.49	1.104	0.234	N/L
4.40	14.43	8016	49	79.5	79.5	88	0.62	1.8	Unsaturated	13	8016	1.07	84.5	110.9	0.95	0.303	1.0	0.154	1.32	1.069	0.169	N/L
4.50	14.76	7019	44	81.4	81.4	76	0.63	1.9	Unsaturated	15	7019	1.06	73.6	105.7	0.95	0.303	1.0	0.145	1.29	1.063	0.158	N/L
4.60	15.09	6373	35	83.2	83.2	69	0.56	1.9	Unsaturated	15	6373	1.05	66.4	97.1	0.95	0.303	1.0	0.134	1.25	1.053	0.144	N/L
4.70	15.42	5561	34	85.0	85.0	59	0.61	2.0	Unsaturated	17	5561	1.05	57.6	92.2	0.95	0.302	1.0	0.128	1.22	1.048	0.136	N/L
4.80	15.74	5210	33	86.8	86.8	55	0.64	2.0	Unsaturated	17	5210	1.04	53.7	87.4	0.95	0.302	1.0	0.123	1.20	1.044	0.130	N/L
4.90	16.07	5080	32	88.6	88.6	53	0.64	2.0	Unsaturated	17	5080	1.04	52.1	85.3	0.95	0.301	1.0	0.121	1.20	1.042	0.127	N/L
5.00	16.40	5024	33	90.4	90.4	52	0.66	2.0	Unsaturated	17	5024	1.03	51.2	84.3	0.94	0.301	1.0	0.120	1.19	1.041	0.126	N/L
5.10	16.73	5133	35	92.2	92.2	52	0.69	2.0	Unsaturated	17	5133	1.02	52.1	85.3	0.94	0.300	1.0	0.121	1.20	1.042	0.127	N/L
5.20	17.06	5313	35	94.0	94.0	53	0.67	2.0	Unsaturated	17	5313	1.02	53.6	87.3	0.94	0.300	1.0	0.123	1.20	1.044	0.129	N/L
5.30	17.38	5691	36	95.8	95.8	57	0.64	2.0	Unsaturated	17	5691	1.01	57.1	91.6	0.94	0.299	1.0	0.127	1.22	1.048	0.134	N/L
5.40	17.71	6042	38	97.6	97.6	60	0.63	2.0	Unsaturated	17	6042	1.01	60.4	95.6	0.94	0.299	1.0	0.132	1.24	1.051	0.139	N/L
5.50	18.04	6027	27	99.4	99.4	59	0.46	1.9	Unsaturated	15	6027	1.00	59.9	89.3	0.94	0.298	1.0	0.125	1.21	1.045	0.131	N/L
5.60	18.37	5978	27	101.2	101.2	58	0.46	1.9	Unsaturated	15	5978	1.00	59.2	88.4	0.93	0.297	1.0	0.124	1.21	1.045	0.129	N/L
5.70	18.70	6039	29	103.0	103.0	58	0.49	1.9	Unsaturated	15	6039	0.99	59.5	88.8	0.93	0.297	1.0	0.124	1.21	1.045	0.130	N/L
5.80	19.02	5974	30	104.9	104.9	57	0.52	2.0	Unsaturated	17	5974	0.99	58.6	93.4	0.93	0.296	1.0	0.129	1.23	1.049	0.135	N/L
5.90	19.35	5890	31	106.7	106.7	56	0.54	2.0	Unsaturated	17	5890	0.99	57.5	92.1	0.93	0.296	1.0	0.128	1.22	1.048	0.133	N/L
6.00	19.68	6240	33	108.5	108.5	58	0.53	1.9	Unsaturated	15	6240	0.98	60.6	90.2	0.93	0.295	1.0	0.126	1.22	1.046	0.131	N/L
6.10	20.01	6494	34	110.3	110.3	60	0.54	1.9	Unsaturated	15	6494	0.98	62.8	92.8	0.93	0.295	1.0	0.129	1.23	1.049	0.134	N/L
6.20	20.34	6564	35	112.1	112.1	61	0.54	1.9	Unsaturated	15	6564	0.97	63.2	93.3	0.92	0.294	1.0	0.129	1.23	1.049	0.134	N/L
6.30	20.66	6712	36	113.9	113.9	61	0.54	1.9	Unsaturated	15	6712	0.97	64.4	94.7	0.92	0.294	1.0	0.131	1.24	1.050	0.136	N/L
6.40	20.99	6747	32	115.7	115.7	61	0.48	1.9	Unsaturated	15	6747	0.96	64.5	94.7	0.92	0.293	1.0	0.131	1.24	1.051	0.136	N/L
6.50	21.32	6652	33	117.5	117.5	60	0.51	1.9	Unsaturated	15	6652	0.96	63.3	93.3	0.92	0.293	1.0	0.129	1.23	1.049	0.134	N/L
6.60	21.65	6718	35	119.3	119.3	60	0.53	1.9	Unsaturated	15	6718	0.96	63.7	93.8	0.92	0.292	1.0	0.130	1.23	1.050	0.134	N/L
6.70	21.98	6806	36	121.1	121.1	60	0.53	1.9	Unsaturated	15	6806	0.95	64.2	94.5	0.92	0.292	1.0	0.131	1.23	1.050	0.135	N/L
6.80	22.30	6983	34	122.9	122.9	61	0.49	1.9	Unsaturated	15	6983	0.95	65.6	96.2	0.91	0.291	1.0	0.133	1.24	1.052	0.137	N/L
6.90	22.63	7050	34	124.7	124.7	62	0.49	1.9	Unsaturated	15	7050	0.95	66.0	96.6	0.91	0.291	1.0	0.133	1.24	1.052	0.137	N/L
7.00	22.96	7320	37	126.5	126.5	64	0.51	1.9	Unsaturated	15	7320	0.94	68.3	99.3	0.91	0.290	1.0	0.136	1.26	1.055	0.141	N/L
7.10	23.29	7980	39	128.4	128.4	69	0.50	1.9	Unsaturated	15	7980	0.94	74.2	106.4	0.91	0.289	1.0	0.146	1.30	1.064	0.151	N/L
7.20	23.62	8987	44	130.2	130.2	77	0.50	1.8	Unsaturated	13	8987	0.94	83.2	109.4	0.91	0.289	1.0	0.151	1.31	1.067	0.156	N/L
7.30	23.94	9641	48	132.0	132.0	82	0.51	1.8	Unsaturated	13	9641	0.93	89.0	116.0	0.91	0.288	1.0	0.163	1.36	1.077	0.170	N/L
7.40	24.27	10010	51	133.8	133.8	85	0.51	1.8	Unsaturated	13	10010	0.93	92.0	119.6	0.90	0.288	1.0	0.170	1.38	1.082	0.178	N/L
7.50	24.60	9895	53	135.6	135.6	83	0.54	1.8	Unsaturated	13	9895	0.93	90.6	118.0	0.90	0.287	1.0	0.167	1.37	1.080	0.174	N/L
7.60	24.93	9904	53	137.4	137.4	83	0.54	1.8	Unsaturated	13	9904	0.92	90.4	117.7	0.90	0.287	1.0	0.166	1.37	1.079	0.173	N/L
7.70	25.26	10780	57	139.2	139.2	90	0.53	1.8	Unsaturated	13	10780	0.92	98.1	126.5	0.90	0.286	1.0	0.187	1.44	1.094	0.196	N/L
7.80	25.58	14303	64	141.0	141.0	118	0.45	1.6	Unsaturated	10	14303	0.92	129.7	142.2	0.90	0.286	1.0	0.245	1.58	1.125	0.261	N/L
7.90	25.91	19407	90	142.8	142.8	160	0.47	1.5	Unsaturated	8	19407	0.91	175.4	181.5	0.89	0.285	0.9	0.773	2.12	1.239	0.887	N/L
8.00	26.24	20032	102	144.6	144.6	164	0.51	1.6	Unsaturated	10	20032	0.91	180.4	195.9	0.89	0.284	0.9	1.512	2.20	1.257	1.729	N/L
8.10	26.57	21835	112	146.4	146.4	178	0.52	1.5	Unsaturated	8	21835	0.91	196.0	202.7	0.89	0.284	0.9	2.205	2.20	1.257	2.000	N/L
8.20	26.90	22148	112	148.2	148.2	180	0.51	1.5	Unsaturated	8	22148	0.90	198.2	204.9	0.89	0.283	0.9	2.519	2.20	1.257	2.000	N/L
8.30	27.22	23776	120	150.0	150.0	192	0.51	1.5	Unsaturated	8	23776	0.90	212.1	219.1	0.89	0.283	0.9	2.000	2.20	1.257	2.000	N/L
8.40	27.55	24127	127	151.9	151.9	193	0.53	1.5	Unsaturated	8	24127	0.90	214.5	221.6	0.89	0.282	0.9	2.000	2.20	1.257	2.000	N/L
8.50	27.88	24567	126	153.7	153.2	196	0.52	1.5		8	24567	0.90	217.9	225.1	0.88	0.282	0.9	2.000	2.20	1.257	2.000	2.00
8.60	28.21	22867	63	155.7	154.2	182	0.28	1.4		7	22867	0.89	202.5	204.2	0.88	0.284	0.9	2.410	2.20	1.257	2.000	2.00
8.70	28.54	20855	67	157.7	155.2	165	0.33	1.5		8	20855	0.89	184.4	190.8	0.88	0.285	0.9	1.167	2.20	1.257	1.318	2.00
8.80	28.86	19304	66	159.6	156.2	152	0.35	1.5		8	19304	0.89	170.4	176.4	0.88	0.286	0.9	0.632	2.03	1.221	0.704	2.00

Settelemnt of Liquefiable Soil (Idriss and Boulnager, 2008) / Settlement of Unsaturated Sand (Tokimatsu & Seed, 1987, and Pradel, 1998) / Cumulative / S_r (Idriss & Boulanger, 2008)

Depth, Z (m)	q_t (kPa)	N_{60}	$N_{1,60}$	$\Delta(N_1)_{60}$	$N_{1,60-CS}$	Limiting Shear Strain γ_{lim}	Parameter F_α	Max. Shear Strain γ_{max}	ΔHi (m)	ΔLDI_i (m)	Vert. Recon. Strain ε_v	DF_i	ΔSi (inch)	$p = \sigma_m$ (tsf)	τ_{ave} (psf)	G_{max} (tsf)	τ_{ave}/G_{max}	a	b	γ_{eff} (%)	ε_{15} (%)	ε_{Nc} (%)	Settlement (inch)	Cumulative Settlement (inch)	$\Delta(N_1)_{60-Sr}$	$(N_1)_{60-Sr}$	S_r/σ_{v0}'
1.60	7686	13.2	18.4	0.4	N.A.	0.000	0.000	0.000	0.05	0.0000	0.0000	0.91	0.00	0.202	192	1234	0.00008	0.20272	16691	0.01127	0.012	0.010	0.00	0.42	N/A	N/A	N/A
1.70	5026	9.3	12.7	1.7	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.91	0.00	0.215	204	875	0.00012	0.20764	16095	0.02270	0.039	0.033	0.00	0.42	N/A	N/A	N/A
1.80	2902	6.0	8.0	3.8	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.90	0.00	0.228	216	571	0.00019	0.21256	15552	0.07806	0.233	0.195	0.02	0.41	N/A	N/A	N/A
1.90	2185	4.7	6.2	4.3	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.90	0.00	0.240	228	453	0.00025	0.21749	15056	0.21795	0.888	0.742	0.06	0.40	N/A	N/A	N/A
2.00	2064	4.6	6.0	4.7	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.89	0.00	0.253	239	451	0.00027	0.22241	14600	0.25486	1.076	0.900	0.07	0.34	N/A	N/A	N/A
2.10	2480	5.5	7.1	4.7	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.89	0.00	0.266	251	548	0.00023	0.22733	14178	0.12809	0.440	0.368	0.03	0.27	N/A	N/A	N/A
2.20	6078	12.0	15.4	3.2	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.88	0.00	0.278	263	1208	0.00011	0.23225	13788	0.01807	0.025	0.021	0.00	0.24	N/A	N/A	N/A
2.30	15377	24.9	31.5	0.0	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.87	0.00	0.291	275	2526	0.00005	0.23717	13425	0.00657	0.004	0.003	0.00	0.24	N/A	N/A	N/A
2.40	21601	33.9	42.4	0.0	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.87	0.00	0.304	287	3479	0.00004	0.24209	13087	0.00470	0.002	0.002	0.00	0.24	N/A	N/A	N/A
2.50	22729	36.8	45.5	0.0	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.86	0.00	0.316	299	3808	0.00004	0.24701	12770	0.00443	0.002	0.001	0.00	0.24	N/A	N/A	N/A
2.60	24544	39.7	48.6	0.0	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.86	0.00	0.329	310	4150	0.00004	0.25193	12473	0.00419	0.001	0.001	0.00	0.24	N/A	N/A	N/A
2.70	25708	41.6	50.4	0.0	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.85	0.00	0.342	322	4386	0.00004	0.25685	12194	0.00410	0.001	0.001	0.00	0.24	N/A	N/A	N/A
2.80	25393	41.1	49.3	0.0	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.85	0.00	0.354	334	4369	0.00004	0.26177	11931	0.00428	0.001	0.001	0.00	0.24	N/A	N/A	N/A
2.90	24504	39.7	47.2	0.0	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.84	0.00	0.367	346	4252	0.00004	0.26669	11682	0.00458	0.002	0.001	0.00	0.24	N/A	N/A	N/A
3.00	23710	38.4	45.2	0.0	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.84	0.00	0.379	357	4147	0.00004	0.27161	11447	0.00489	0.002	0.002	0.00	0.24	N/A	N/A	N/A
3.10	22239	36.0	42.1	0.0	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.83	0.00	0.392	369	3920	0.00005	0.27653	11224	0.00542	0.002	0.002	0.00	0.24	N/A	N/A	N/A
3.20	20728	33.6	38.9	0.0	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.83	0.00	0.405	381	3681	0.00005	0.28145	11012	0.00604	0.003	0.002	0.00	0.24	N/A	N/A	N/A
3.30	17945	30.0	34.4	0.1	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.82	0.00	0.417	392	3310	0.00006	0.28637	10811	0.00711	0.004	0.003	0.00	0.24	N/A	N/A	N/A
3.40	15294	26.4	30.0	0.4	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.81	0.00	0.430	404	2933	0.00007	0.29129	10619	0.00856	0.005	0.004	0.00	0.24	N/A	N/A	N/A
3.50	15200	25.4	28.7	0.1	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.81	0.00	0.443	415	2843	0.00007	0.29621	10436	0.00921	0.006	0.005	0.00	0.24	N/A	N/A	N/A
3.60	17251	28.8	32.3	0.1	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.80	0.00	0.455	427	3248	0.00007	0.30113	10261	0.00804	0.005	0.004	0.00	0.24	N/A	N/A	N/A
3.70	19889	32.2	35.9	0.0	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.80	0.00	0.468	438	3655	0.00006	0.30605	10093	0.00717	0.004	0.003	0.00	0.24	N/A	N/A	N/A
3.80	22937	38.3	42.4	0.1	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.79	0.00	0.481	450	4375	0.00005	0.31097	9933	0.00596	0.002	0.002	0.00	0.24	N/A	N/A	N/A
3.90	24749	40.1	44.1	0.0	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.79	0.00	0.493	461	4605	0.00005	0.31589	9780	0.00577	0.002	0.002	0.00	0.24	N/A	N/A	N/A
4.00	21486	35.9	39.2	0.1	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.78	0.00	0.506	473	4148	0.00006	0.32081	9632	0.00671	0.003	0.003	0.00	0.24	N/A	N/A	N/A
4.10	15951	28.4	30.8	0.9	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.78	0.00	0.519	484	3304	0.00007	0.32573	9490	0.00914	0.005	0.005	0.00	0.24	N/A	N/A	N/A
4.20	12119	22.3	24.1	1.7	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.77	0.00	0.531	496	2612	0.00009	0.33065	9354	0.01286	0.010	0.009	0.00	0.23	N/A	N/A	N/A
4.30	9751	18.6	19.9	2.5	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.76	0.00	0.544	507	2188	0.00012	0.33557	9223	0.01715	0.017	0.014	0.00	0.23	N/A	N/A	N/A
4.40	8088	15.4	16.4	2.5	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.76	0.00	0.557	518	1825	0.00014	0.34049	9097	0.02372	0.030	0.025	0.00	0.23	N/A	N/A	N/A
4.50	6992	13.8	14.6	3.2	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.75	0.00	0.569	530	1645	0.00016	0.34541	8975	0.02949	0.043	0.036	0.00	0.23	N/A	N/A	N/A
4.60	6264	12.4	13.0	3.2	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.75	0.00	0.582	541	1481	0.00018	0.35033	8857	0.03738	0.062	0.052	0.00	0.23	N/A	N/A	N/A
4.70	5591	11.5	12.0	3.8	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.74	0.00	0.594	552	1380	0.00020	0.35525	8744	0.04491	0.083	0.069	0.01	0.22	N/A	N/A	N/A
4.80	5243	10.8	11.2	3.8	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.74	0.00	0.607	563	1301	0.00022	0.36017	8634	0.05310	0.106	0.089	0.01	0.22	N/A	N/A	N/A
4.90	5105	10.5	10.9	3.8	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.73	0.00	0.620	574	1272	0.00023	0.36509	8528	0.05791	0.121	0.101	0.01	0.21	N/A	N/A	N/A
5.00	5062	10.4	10.7	3.8	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.73	0.00	0.632	586	1268	0.00023	0.37001	8425	0.06050	0.128	0.107	0.01	0.20	N/A	N/A	N/A
5.10	5150	10.6	10.8	3.8	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.72	0.00	0.645	597	1296	0.00023	0.37493	8326	0.05940	0.124	0.104	0.01	0.20	N/A	N/A	N/A
5.20	5350	11.0	11.2	3.8	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.72	0.00	0.658	608	1353	0.00022	0.37985	8229	0.05555	0.111	0.093	0.01	0.19	N/A	N/A	N/A
5.30	5700	11.7	11.9	3.8	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.71	0.00	0.670	619	1447	0.00021	0.38477	8136	0.04921	0.092	0.077	0.01	0.18	N/A	N/A	N/A
5.40	5999	12.3	12.4	3.8	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.70	0.00	0.683	630	1530	0.00021	0.38969	8045	0.04500	0.080	0.067	0.01	0.17	N/A	N/A	N/A
5.50	6021	11.9	12.0	3.2	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.70	0.00	0.696	641	1485	0.00022	0.39461	7957	0.04939	0.091	0.077	0.01	0.17	N/A	N/A	N/A
5.60	5993	11.9	11.9	3.2	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.69	0.00	0.708	651	1485	0.00022	0.39953	7871	0.05090	0.095	0.080	0.01	0.16	N/A	N/A	N/A
5.70	6044	12.0	11.9	3.2	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.69	0.00	0.721	662	1504	0.00022	0.40446	7788	0.05093	0.095	0.079	0.01	0.16	N/A	N/A	N/A
5.80	5972	12.3	12.2	3.8	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.68	0.00	0.734	673	1549	0.00022	0.40938	7707	0.04909	0.089	0.075	0.01	0.15	N/A	N/A	N/A
5.90	5890	12.1	11.9	3.8	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.68	0.00	0.746	684	1534	0.00022	0.41430	7629	0.05153	0.096	0.080	0.01	0.14	N/A	N/A	N/A
6.00	6195	12.3	12.0	3.2	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.67	0.00	0.759	695	1560	0.00022	0.41922	7552	0.05103	0.094	0.079	0.01	0.14	N/A	N/A	N/A
6.10	6469	12.8	12.5	3.2	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.67	0.00	0.772	705	1635	0.00022	0.42414	7478	0.04735	0.083	0.070	0.01	0.13	N/A	N/A	N/A
6.20	6581	13.0	12.7	3.2	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.66	0.00	0.784	716	1670	0.00021	0.42906	7405	0.04647	0.080	0.067	0.01	0.13	N/A	N/A	N/A
6.30	6706	13.3	12.9	3.2	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.66	0.00	0.797	727	1708	0.00021	0.43398	7334	0.04545	0.077	0.065	0.01	0.12	N/A	N/A	N/A
6.40	6713	13.3	12.8	3.2	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.65	0.00	0.810	737	1716	0.00021	0.43890	7265	0.04611	0.079	0.066	0.01	0.12	N/A	N/A	N/A
6.50	6669	13.2	12.7	3.2	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.64	0.00	0.822	748	1711	0.00022	0.44382	7198	0.04748	0.082	0.069	0.01	0.11	N/A	N/A	N/A
6.60	6723	13.3	12.7	3.2	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.64	0.00	0.835	758	1731	0.00022	0.44874	7132	0.04744	0.082	0.068	0.01	0.11	N/A	N/A	N/A
6.70	6825	13.5	12.9	3.2	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.63	0.00	0.847	769	1764	0.00022	0.45366	7068	0.04670	0.079	0.066	0.01	0.10	N/A	N/A	N/A
6.80	6948	13.7	13.1	3.2	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.63	0.00	0.860	779	1802	0.00022	0.45858	7006	0.04571	0.076	0.064	0.01	0.09	N/A	N/A	N/A
6.90	7050	13.9	13.2	3.2	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.62	0.00	0.873	789	1835	0.00022	0.46350	6945	0.04504	0.074	0.062	0.00	0.09	N/A	N/A	N/A
7.00	7341	14.5	13.7	3.2	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.62	0.00	0.885	800	1917	0.00021	0.46842	6885	0.04217	0.066	0.056	0.00	0.08	N/A	N/A	N/A
7.10	8014	15.9	14.9	3.2	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.61	0.00	0.898	810	2100	0.00019	0.47334	6827	0.03621	0.052	0.043	0.00	0.08	N/A	N/A	N/A
7.20	8932	17.0	15.9	2.5	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.61	0.00	0.911	820	2264	0.00018	0.47826	6770	0.03222	0.042	0.035	0.00	0.08	N/A	N/A	N/A
7.30	9610	18.3	17.1	2.5	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.60	0.00	0.923	830	2444	0.00017	0.48318	6714	0.02876	0.035	0.029	0.00	0.07	N/A	N/A	N/A
7.40	9955	19.0	17.6	2.5	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.60	0.00	0.936	840	2540	0.00017	0.48810	6659	0.02745	0.032	0.027	0.00	0.07	N/A	N/A	N/A
7.50	9924	18.9	17.5	2.5	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.59	0.00	0.949	850	2540	0.00017	0.49302	6606	0.02792	0.033	0.027	0.00	0.07	N/A	N/A	N/A
7.60	9997	19.1	17.6	2.5	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.58	0.00	0.961	860	2567	0.00017	0.49794	6553	0.02791	0.033	0.027	0.00	0.07	N/A	N/A	N/A
7.70	10846	20.7	19.0	2.5	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.58	0.00	0.974	870	2793	0.00016	0.50286	6502	0.02473	0.026	0.022	0.00	0.07	N/A	N/A	N/A
7.80	14369	25.6	23.4	0.9	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.57	0.00	0.987	880	3464	0.00013	0.50778	6452	0.01814	0.015	0.013	0.00	0.06	N/A	N/A	N/A
7.90	18788	32.4	29.6	0.4	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.57	0.00	0.999	890	4397	0.00010	0.51270	6403	0.01325	0.008	0.007	0.00	0.06	N/A	N/A	N/A
8.00	20159	35.9	32.7	0.9	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.56	0.00	1.012	900	4889	0.00009	0.51762	6355	0.01170	0.006	0.005	0.00	0.06	N/A	N/A	N/A
8.10	21533	37.1	33.6	0.4	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.56	0.00	1.025	910	5069	0.00009	0.52254	6308	0.01132	0.006	0.005	0.00	0.06	N/A	N/A	N/A
8.20	22429	38.7	34.9	0.4	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.55	0.00	1.037	920	5295	0.00009	0.52746	6261	0.01085	0.006	0.005	0.00	0.06	N/A	N/A	N/A
8.30	23611	40.7	36.7	0.4	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.55	0.00	1.050	929	5590	0.00008	0.53238	6216	0.01026	0.005	0.004	0.00	0.06	N/A	N/A	N/A
8.40	24162	41.6	37.4	0.4	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.54	0.00	1.062	939	5737	0.00008	0.53730	6171	0.01006	0.005	0.004	0.00	0.06	N/A	N/A	N/A
8.50	24279	41.8	37.5	0.4	37.9	0.013	-0.644	0.000	0.10	0.0000	0.0000	0.54	0.00	1.072	949	5777	0.00008	0.54099	6139	0.01010	0.005	0.004	0.00	0.06	0.7	38	N/A
8.60	22343	37.3	33.4	0.1	33.5	0.028	-0.326	0.000	0.10	0.0000	0.0000	0.53	0.00	1.079	959	5158	0.00009	0.54367	6115	0.01181	0.006	0.005	0.00	0.06	0.6	34	N/A
8.70	20465	35.3	31.5	0.4	31.9	0.036	-0.216	0.000	0.10	0.0000	0.0000	0.52	0.00	1.086	970	4884	0.00010	0.54635	6092	0.01284	0.007	0.006	0.00	0.06	0.7	32	N/A
8.80	19117	32.9	29.4	0.4	29.7	0.048	-0.072	0.000	0.10	0.0000	0.0000	0.52	0.00	1.093	980	4569	0.00011	0.54903	6069	0.01422	0.009	0.007	0.00	0.06	0.7	30	N/A

Depth, Z (m)	Depth, Z (ft)	q_c (kPa)	f_s (kPa)	σ_{vc} (kPa)	σ'_{vc} (kPa)	Q	F	I_c	Soil Type	Fines (%)	Interpreted q_c	C_N	q_{c1N}	q_{c1N-cs}	Stress Reduction Factor (r_d)	CSR	K_σ for sand	$CRR_{M=7.5}$ at σ'_{vc}=1	MSF_{max}	MSF	CRR	$(FS)_L$	q_t (kPa)	N_{60}	$N_{1,60}$	$\Delta(N_1)_{60}$	$N_{1,60\text{-}CS}$	Limiting Shear Strain γ_{lim}	Parameter F_α	Max. Shear Strain γ_{max}	ΔHi (m)	ΔLDI_i (m)	Vert. Recon. Strain ε_v	DF_i	ΔSi (inch)	p = σ_m (tsf)	τ_{ave} (psf)	G_{max} (tsf)	τ_{ave}/G_{max}	a	b	γ_{eff} (%)	ε_{15} (%)	ε_{NC} (%)	Settlement (inch)	Settlement (inch)	$\Delta(N_1)_{60\text{-}Sr}$	$(N_1)_{60\text{-}Sr}$	S_r/σ_{vo}'
8.90	29.19	15542	56	161.6	157.1	122	0.37	1.6		10	15542	0.89	136.9	149.9	0.88	0.287	0.9	0.288	1.67	1.143	0.306	**1.07**	15335	27.3	24.3	0.9	25.2	0.086	0.218	0.030	0.10	0.0030	0.0071	0.51	0.01	1.099	991	3793	0.00013	0.55170	6046	0.01864	0.015	0.012	0.00	0.06	0.9	25	N/A
9.00	29.52	7868	78	163.6	158.1	61	1.01	2.1		19	7868	0.89	69.2	111.5	0.87	0.288	0.9	0.155	1.33	1.070	0.157	**0.54**	8298	17.7	15.8	4.3	20.1	0.157	0.512	0.157	0.10	0.0157	0.0229	0.51	0.05	1.106	1001	2467	0.00020	0.55438	6023	0.03761	0.050	0.042	0.00	0.05	1.7	17	0.15
9.10	29.85	3204	54	165.5	159.1	24	1.77	2.6	Clay-Like	34	3204	0.89	28.1	67.3	0.87	0.289	1.0	0.105	1.14	1.031	0.104	**N/L**	3434	9.2	8.1	5.5	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.50	0.00	1.113	1011	1278	0.00040	0.55706	6001	0.17740	0.522	0.436	0.00	0.00	N/A	N/A	N/A
9.20	30.18	2204	33	167.5	160.1	16	1.63	2.7	Clay-Like	37	2204	0.89	19.3	55.9	0.87	0.290	1.0	0.097	1.12	1.026	0.096	**N/L**	2342	6.6	5.8	5.5	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.50	0.00	1.120	1021	919	0.00056	0.55974	5979	0.58853	2.582	2.159	0.00	0.00	N/A	N/A	N/A
9.30	30.50	2045	21	169.5	161.1	15	1.11	2.6	Clay-Like	34	2045	0.88	17.9	53.6	0.87	0.291	1.0	0.095	1.12	1.025	0.094	**N/L**	2098	5.6	5.0	5.5	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.49	0.00	1.127	1031	783	0.00066	0.56242	5957	1.24030	6.617	5.533	0.00	0.00	N/A	N/A	N/A
9.40	30.83	2071	17	171.4	162.1	15	0.88	2.6	Clay-Like	34	2071	0.88	18.1	53.9	0.87	0.292	1.0	0.095	1.12	1.025	0.094	**N/L**	2132	5.7	5.0	5.5	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.49	0.00	1.134	1041	797	0.00065	0.56510	5935	1.18174	6.196	5.181	0.00	0.00	N/A	N/A	N/A
9.50	31.16	2173	25	173.4	163.1	16	1.27	2.6	Clay-Like	34	2173	0.88	19.0	55.0	0.87	0.293	1.0	0.096	1.12	1.025	0.095	**N/L**	2213	5.9	5.2	5.5	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.48	0.00	1.141	1051	828	0.00063	0.56777	5914	1.02160	5.134	4.292	0.00	0.00	N/A	N/A	N/A
9.60	31.49	2189	41	175.4	164.0	16	2.02	2.7	Clay-Like	37	2189	0.88	19.1	55.6	0.86	0.294	1.0	0.096	1.12	1.026	0.095	**N/L**	2482	7.0	6.1	5.5	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.48	0.00	1.148	1061	979	0.00054	0.57045	5892	0.51367	2.118	1.771	0.00	0.00	N/A	N/A	N/A
9.70	31.82	2567	28	177.3	165.0	18	1.16	2.6	Clay-Like	34	2567	0.88	22.3	59.5	0.86	0.295	1.0	0.099	1.13	1.027	0.098	**N/L**	2696	7.2	6.3	5.5	N.A.	0.000	0.000	0.000	0.05	0.0000	0.0000	0.47	0.00	1.155	1071	1012	0.00053	0.57313	5871	0.46496	1.850	1.547	0.00	0.00	N/A	N/A	N/A

CONE PENETRATION TEST-BASED LIQUEFACTION ANALYSIS BASED ON IDRISS & BOULANGER (2008)

References:

1 - Idriss, I.M. and Boulanger, R.W. (2008). *Soil Liquefaction During Earthquakes* , Earthquake Engineering Research Institute, EERI Publication MNO-12.

2 - Ishihara, K. and Yoshimine, M. (1992). "Evaluation of Settlements in Sand Deposits Following Liquefaction During Earthquakes," *Soils and Foundations* , Vol. 32, No. 1, pp. 173-188, March 1992.

3 - Tokimatsu, K. and Seed H.B. (1987). "Evaluation of Settlements in Sands Due to Earthquake Shaking," Journal of Geotechnical Engineering, Vol. 113, No. 8, August.

4 - Pradel, D. (1998). "Procedure to Evaluate Earthquake-Induced Settlements in Sand," Journal of Geotechnical and Geoenvironmental Engineering, Vol. 124, No. 4, April.

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6 - Boulanger, R.W. and Idriss, I.M. (2014). "CPT and SPT Based Liquefaction Triggering Procedures," Report No. UCD/CGM-14/01, University of California at Davis

Project	**Chevron Guadalupe Tank Battery 9 Site**
Test Boring No	**TSMACPT-4**

Test Boring Information:

Approx. depth to ground water table		42.7 ft	13.02 m
Moist unit weight of soil	γ_m	115 pcf	18.08 kN/m^3
Saturated unit weight of soil	γ_{sat}	125 pcf	19.65 kN/m^3

Earthquake Information:

Earthquake magnitude	M_w	6.9
Peak horizontal ground surface acceleratio	a_{max}	0.490 g
Number of equivalent cycle	N	10.1

Atmospheric pressure	P_a	101.3 kPa

N/L = Non-liquefiable clay-like soil

N.A. = Not Applicable

Sum
0.23

Sum	Total
0.14	0.37

Factor of Safety Agaist Liquefaction (Idriss & Boulanger, 2008 and Boulanger & Idriss, 2014)

Depth, Z (m)	Depth, Z (ft)	q_c (kPa)	f_s (kPa)	σ_{vc} (kPa)	σ'_{vc} (kPa)	Q	F	I_c	Soil Type	Fines (%)	Interpreted q_c	C_N	q_{c1N}	q_{c1N-cs}	Stress Reduction Factor (r_d)	CSR	K_σ for sand	$CRR_{M=7.5}$ at σ'_{vc}=1	MSF_{max}	MSF	CRR	$(FS)_L$
1.60	5.25	14996	40	28.9	28.9	277	0.27	1.2	Unsaturated	4	14996	1.39	206.5	206.5	0.99	0.315	1.1	2.783	2.20	1.257	2.000	**N/L**
1.70	5.58	16203	49	30.7	30.7	290	0.30	1.2	Unsaturated	4	16203	1.37	219.6	219.6	0.99	0.315	1.1	2.000	2.20	1.257	2.000	**N/L**
1.80	5.90	16949	56	32.5	32.5	295	0.33	1.2	Unsaturated	4	16949	1.35	226.3	226.3	0.99	0.315	1.1	2.000	2.20	1.257	2.000	**N/L**
1.90	6.23	17657	64	34.3	34.3	299	0.36	1.3	Unsaturated	6	17657	1.33	232.4	232.6	0.99	0.314	1.1	2.000	2.20	1.257	2.000	**N/L**
2.00	6.56	17991	71	36.2	36.2	297	0.40	1.3	Unsaturated	6	17991	1.31	233.6	233.8	0.99	0.314	1.1	2.000	2.20	1.257	2.000	**N/L**
2.10	6.89	18528	73	38.0	38.0	298	0.40	1.3	Unsaturated	6	18528	1.29	237.5	237.7	0.98	0.314	1.1	2.000	2.20	1.257	2.000	**N/L**
2.20	7.22	18796	77	39.8	39.8	296	0.41	1.3	Unsaturated	6	18796	1.28	238.0	238.2	0.98	0.313	1.1	2.000	2.20	1.257	2.000	**N/L**
2.30	7.54	18575	81	41.6	41.6	286	0.44	1.3	Unsaturated	6	18575	1.26	232.4	232.6	0.98	0.313	1.1	2.000	2.20	1.257	2.000	**N/L**
2.40	7.87	18230	79	43.4	43.4	274	0.43	1.3	Unsaturated	6	18230	1.25	225.6	225.8	0.98	0.312	1.1	2.000	2.20	1.257	2.000	**N/L**
2.50	8.20	17638	78	45.2	45.2	260	0.44	1.4	Unsaturated	7	17638	1.24	215.9	217.7	0.98	0.312	1.1	2.000	2.20	1.257	2.000	**N/L**
2.60	8.53	17275	75	47.0	47.0	250	0.43	1.4	Unsaturated	7	17275	1.22	209.3	211.0	0.98	0.312	1.1	2.000	2.20	1.257	2.000	**N/L**
2.70	8.86	17191	77	48.8	48.8	244	0.45	1.4	Unsaturated	7	17191	1.21	206.2	207.9	0.98	0.311	1.1	3.040	2.20	1.257	2.000	**N/L**
2.80	9.18	17005	85	50.6	50.6	237	0.50	1.4	Unsaturated	7	17005	1.20	202.0	203.7	0.98	0.311	1.1	2.343	2.20	1.257	2.000	**N/L**
2.90	9.51	16672	90	52.4	52.4	228	0.54	1.5	Unsaturated	8	16672	1.19	196.2	202.9	0.97	0.310	1.1	2.237	2.20	1.257	2.000	**N/L**
3.00	9.84	16392	89	54.2	54.2	220	0.55	1.5	Unsaturated	8	16392	1.18	191.2	197.8	0.97	0.310	1.1	1.672	2.20	1.257	2.000	**N/L**
3.10	10.17	16381	89	56.0	56.0	217	0.55	1.5	Unsaturated	8	16381	1.17	189.5	196.0	0.97	0.309	1.1	1.517	2.20	1.257	2.000	**N/L**
3.20	10.50	16365	89	57.8	57.8	213	0.55	1.5	Unsaturated	8	16365	1.16	187.7	194.2	0.97	0.309	1.1	1.382	2.20	1.257	1.911	**N/L**
3.30	10.82	15973	75	59.7	59.7	205	0.47	1.5	Unsaturated	8	15973	1.15	181.7	188.0	0.97	0.309	1.1	1.026	2.20	1.257	1.419	**N/L**
3.40	11.15	16095	73	61.5	61.5	203	0.46	1.5	Unsaturated	8	16095	1.14	181.7	188.0	0.97	0.308	1.1	1.024	2.20	1.257	1.416	**N/L**
3.50	11.48	16445	80	63.3	63.3	205	0.49	1.5	Unsaturated	8	16445	1.13	184.2	190.6	0.97	0.308	1.1	1.157	2.20	1.257	1.600	**N/L**
3.60	11.81	16881	86	65.1	65.1	207	0.51	1.5	Unsaturated	8	16881	1.12	187.7	194.2	0.96	0.307	1.1	1.381	2.20	1.257	1.911	**N/L**
3.70	12.14	17235	90	66.9	66.9	209	0.52	1.5	Unsaturated	8	17235	1.11	190.2	196.8	0.96	0.307	1.1	1.584	2.20	1.257	2.000	**N/L**
3.80	12.46	17150	89	68.7	68.7	205	0.52	1.5	Unsaturated	8	17150	1.11	188.0	194.5	0.96	0.306	1.1	1.402	2.20	1.257	1.931	**N/L**
3.90	12.79	16226	89	70.5	70.5	191	0.55	1.5	Unsaturated	8	16226	1.10	176.6	182.9	0.96	0.306	1.1	0.816	2.14	1.244	1.095	**N/L**
4.00	13.12	15324	84	72.3	72.3	178	0.55	1.6	Unsaturated	10	15324	1.09	165.7	180.3	0.96	0.305	1.1	0.736	2.10	1.235	0.973	**N/L**
4.10	13.45	14356	80	74.1	74.1	165	0.56	1.6	Unsaturated	10	14356	1.09	154.2	168.2	0.96	0.305	1.1	0.475	1.91	1.194	0.600	**N/L**
4.20	13.78	14111	79	75.9	75.9	160	0.56	1.6	Unsaturated	10	14111	1.08	150.6	164.4	0.96	0.304	1.1	0.422	1.85	1.183	0.524	**N/L**
4.30	14.10	13801	80	77.7	77.7	155	0.59	1.6	Unsaturated	10	13801	1.07	146.4	159.9	0.95	0.304	1.0	0.371	1.79	1.170	0.453	**N/L**
4.40	14.43	13419	78	79.5	79.5	149	0.59	1.6	Unsaturated	10	13419	1.07	141.5	154.7	0.95	0.303	1.0	0.323	1.73	1.156	0.388	**N/L**
4.50	14.76	13527	77	81.4	81.4	148	0.57	1.6	Unsaturated	10	13527	1.06	141.8	155.0	0.95	0.303	1.0	0.326	1.73	1.156	0.390	**N/L**
4.60	15.09	13689	78	83.2	83.2	148	0.57	1.6	Unsaturated	10	13689	1.05	142.7	156.0	0.95	0.303	1.0	0.333	1.74	1.159	0.399	**N/L**
4.70	15.42	13397	72	85.0	85.0	143	0.54	1.6	Unsaturated	10	13397	1.05	138.8	151.9	0.95	0.302	1.0	0.302	1.69	1.148	0.356	**N/L**
4.80	15.74	12671	74	86.8	86.8	134	0.58	1.7	Unsaturated	11	12671	1.04	130.6	153.2	0.95	0.302	1.0	0.311	1.71	1.152	0.368	**N/L**
4.90	16.07	12609	74	88.6	88.6	132	0.59	1.7	Unsaturated	11	12609	1.04	129.2	151.8	0.95	0.301	1.0	0.301	1.69	1.148	0.352	**N/L**
5.00	16.40	12568	72	90.4	90.4	130	0.58	1.7	Unsaturated	11	12568	1.03	128.1	150.5	0.94	0.301	1.0	0.292	1.67	1.145	0.340	**N/L**
5.10	16.73	12963	72	92.2	92.2	133	0.56	1.7	Unsaturated	11	12963	1.02	131.5	154.2	0.94	0.300	1.0	0.319	1.72	1.154	0.374	**N/L**
5.20	17.06	13306	74	94.0	94.0	135	0.56	1.7	Unsaturated	11	13306	1.02	134.3	157.3	0.94	0.300	1.0	0.345	1.76	1.162	0.406	**N/L**
5.30	17.38	13663	79	95.8	95.8	138	0.58	1.7	Unsaturated	11	13663	1.01	137.2	160.5	0.94	0.299	1.0	0.377	1.80	1.171	0.445	**N/L**
5.40	17.71	13545	80	97.6	97.6	135	0.60	1.7	Unsaturated	11	13545	1.01	135.3	158.5	0.94	0.299	1.0	0.356	1.77	1.166	0.417	**N/L**
5.50	18.04	13536	81	99.4	99.4	134	0.60	1.7	Unsaturated	11	13536	1.00	134.6	157.6	0.94	0.298	1.0	0.348	1.76	1.163	0.406	**N/L**
5.60	18.37	13297	76	101.2	101.2	130	0.58	1.7	Unsaturated	11	13297	1.00	131.6	154.3	0.93	0.297	1.0	0.320	1.72	1.154	0.369	**N/L**
5.70	18.70	13464	75	103.0	103.0	131	0.56	1.7	Unsaturated	11	13464	0.99	132.6	155.5	0.93	0.297	1.0	0.329	1.73	1.157	0.380	**N/L**
5.80	19.02	13477	76	104.9	104.9	130	0.57	1.7	Unsaturated	11	13477	0.99	132.1	154.9	0.93	0.296	1.0	0.325	1.73	1.156	0.373	**N/L**
5.90	19.35	13866	79	106.7	106.7	132	0.57	1.7	Unsaturated	11	13866	0.99	135.3	158.5	0.93	0.296	1.0	0.356	1.77	1.166	0.411	**N/L**
6.00	19.68	13860	83	108.5	108.5	131	0.60	1.7	Unsaturated	11	13860	0.98	134.7	157.8	0.93	0.295	1.0	0.349	1.76	1.164	0.402	**N/L**
6.10	20.01	13084	77	110.3	110.3	123	0.60	1.7	Unsaturated	11	13084	0.98	126.6	148.8	0.93	0.295	1.0	0.281	1.66	1.140	0.316	**N/L**
6.20	20.34	13140	75	112.1	112.1	122	0.58	1.7	Unsaturated	11	13140	0.97	126.6	148.8	0.92	0.294	1.0	0.281	1.66	1.140	0.315	**N/L**
6.30	20.66	12719	76	113.9	113.9	117	0.60	1.7	Unsaturated	11	12719	0.97	122.0	143.8	0.92	0.294	1.0	0.252	1.60	1.129	0.279	**N/L**
6.40	20.99	12075	74	115.7	115.7	110	0.62	1.7	Unsaturated	11	12075	0.96	115.3	136.4	0.92	0.293	1.0	0.220	1.53	1.113	0.240	**N/L**
6.50	21.32	12235	71	117.5	117.5	111	0.58	1.7	Unsaturated	11	12235	0.96	116.4	137.6	0.92	0.293	1.0	0.224	1.54	1.115	0.244	**N/L**
6.60	21.65	12491	70	119.3	119.3	113	0.57	1.7	Unsaturated	11	12491	0.96	118.4	139.7	0.92	0.292	1.0	0.233	1.56	1.120	0.255	**N/L**
6.70	21.98	13064	72	121.1	121.1	117	0.56	1.7	Unsaturated	11	13064	0.95	123.3	145.2	0.92	0.292	1.0	0.260	1.61	1.132	0.286	**N/L**
6.80	22.30	13772	74	122.9	122.9	122	0.54	1.7	Unsaturated	11	13772	0.95	129.5	152.0	0.91	0.291	1.0	0.302	1.69	1.148	0.336	**N/L**
6.90	22.63	15439	80	124.7	124.7	136	0.52	1.6	Unsaturated	10	15439	0.95	144.6	158.0	0.91	0.291	1.0	0.351	1.77	1.164	0.394	**N/L**
7.00	22.96	15690	84	126.5	126.5	137	0.54	1.6	Unsaturated	10	15690	0.94	146.4	159.9	0.91	0.290	1.0	0.370	1.79	1.170	0.416	**N/L**
7.10	23.29	15905	85	128.4	128.4	138	0.54	1.6	Unsaturated	10	15905	0.94	147.8	161.4	0.91	0.289	1.0	0.386	1.81	1.174	0.434	**N/L**
7.20	23.62	13527	77	130.2	130.2	117	0.58	1.7	Unsaturated	11	13527	0.94	125.3	147.4	0.91	0.289	1.0	0.272	1.64	1.137	0.297	**N/L**
7.30	23.94	10872	63	132.0	132.0	93	0.59	1.8	Unsaturated	13	10872	0.93	100.3	129.1	0.91	0.288	1.0	0.195	1.46	1.098	0.206	**N/L**
7.40	24.27	10231	58	133.8	133.8	87	0.57	1.8	Unsaturated	13	10231	0.93	94.1	121.9	0.90	0.288	1.0	0.176	1.40	1.086	0.184	**N/L**
7.50	24.60	10367	58	135.6	135.6	87	0.57	1.8	Unsaturated	13	10367	0.93	95.0	123.0	0.90	0.287	1.0	0.178	1.41	1.088	0.186	**N/L**
7.60	24.93	12618	63	137.4	137.4	106	0.51	1.7	Unsaturated	11	12618	0.92	115.2	136.2	0.90	0.287	1.0	0.219	1.52	1.112	0.233	**N/L**
7.70	25.26	15760	69	139.2	139.2	132	0.44	1.6	Unsaturated	10	15760	0.92	143.4	156.7	0.90	0.286	0.9	0.340	1.75	1.161	0.373	**N/L**
7.80	25.58	17831	84	141.0	141.0	148	0.47	1.6	Unsaturated	10	17831	0.92	161.7	176.1	0.90	0.286	0.9	0.624	2.03	1.220	0.709	**N/L**
7.90	25.91	17321	90	142.8	142.8	143	0.52	1.6	Unsaturated	10	17321	0.91	156.5	170.6	0.89	0.285	0.9	0.514	1.94	1.202	0.576	**N/L**
8.00	26.24	15551	90	144.6	144.6	127	0.58	1.7	Unsaturated	11	15551	0.91	140.1	163.7	0.89	0.284	0.9	0.413	1.84	1.181	0.456	**N/L**
8.10	26.57	13282	82	146.4	146.4	108	0.63	1.8	Unsaturated	13	13282	0.91	119.2	151.0	0.89	0.284	0.9	0.295	1.68	1.146	0.318	**N/L**
8.20	26.90	13306	77	148.2	148.2	107	0.59	1.7	Unsaturated	11	13306	0.90	119.1	140.5	0.89	0.283	0.9	0.237	1.57	1.121	0.250	**N/L**
8.30	27.22	13952	74	150.0	150.0	112	0.53	1.7	Unsaturated	11	13952	0.90	124.4	146.5	0.89	0.283	0.9	0.267	1.63	1.135	0.284	**N/L**
8.40	27.55	18171	80	151.9	151.9	145	0.44	1.6	Unsaturated	10	18171	0.90	161.6	175.9	0.89	0.282	0.9	0.621	2.02	1.220	0.695	**N/L**
8.50	27.88	20410	94	153.7	153.7	162	0.46	1.5	Unsaturated	8	20410	0.90	180.9	187.2	0.88	0.281	0.9	0.988	2.20	1.257	1.123	**N/L**
8.60	28.21	19366	98	155.5	155.5	153	0.51	1.6	Unsaturated	10	19366	0.89	171.1	186.1	0.88	0.281	0.9	0.938	2.19	1.256	1.064	**N/L**
8.70	28.54	13875	90	157.3	157.3	109	0.66	1.8	Unsaturated	13	13875	0.89	122.2	154.4	0.88	0.280	0.9	0.321	1.72	1.155	0.343	**N/L**
8.80	28.86	10633	72	159.1	159.1	83	0.68	1.9	Unsaturated	15	10633	0.89	93.4	129.5	0.88	0.280	0.9	0.196	1.46	1.099	0.202	**N/L**

Settelemnt of Liquefiable Soil (Idriss and Boulnager, 2008)

Depth, Z (m)	q_t (kPa)	N_{60}	$N_{1,60}$	$\Delta(N_1)_{60}$	$N_{1,60-CS}$	Limiting Shear Strain γ_{lim}	Parameter F_α	Max. Shear Strain γ_{max}	ΔHi (m)	ΔLDI_i (m)	Vert. Recon. Strain ε_v	DF_i	ΔSi (inch)
1.60	15183	23.9	33.2	0.0	N.A.	0.000	0.000	0.000	0.05	0.0000	0.0000	0.91	0.00
1.70	16166	25.4	34.8	0.0	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.91	0.00
1.80	16942	26.6	35.9	0.0	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.90	0.00
1.90	17600	28.5	37.9	0.0	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.90	0.00
2.00	18035	29.2	38.3	0.0	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.89	0.00
2.10	18499	29.9	38.8	0.0	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.89	0.00
2.20	18720	30.3	38.8	0.0	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.88	0.00
2.30	18584	30.1	38.0	0.0	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.87	0.00
2.40	18234	29.5	36.9	0.0	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.87	0.00
2.50	17638	29.4	36.4	0.1	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.86	0.00
2.60	17275	28.8	35.3	0.1	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.86	0.00
2.70	17183	28.7	34.8	0.1	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.85	0.00
2.80	16993	28.4	34.0	0.1	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.85	0.00
2.90	16654	28.7	34.1	0.4	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.84	0.00
3.00	16406	28.3	33.3	0.4	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.84	0.00
3.10	16380	28.2	33.0	0.4	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.83	0.00
3.20	16313	28.1	32.6	0.4	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.83	0.00
3.30	16103	27.8	31.9	0.4	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.82	0.00
3.40	16171	27.9	31.8	0.4	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.81	0.00
3.50	16444	28.3	32.1	0.4	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.81	0.00
3.60	16853	29.0	32.6	0.4	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.80	0.00
3.70	17234	29.7	33.1	0.4	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.80	0.00
3.80	17083	29.4	32.6	0.4	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.79	0.00
3.90	16226	28.0	30.7	0.4	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.79	0.00
4.00	15317	27.3	29.8	0.9	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.78	0.00
4.10	14438	25.7	27.9	0.9	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.78	0.00
4.20	14094	25.1	27.1	0.9	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.77	0.00
4.30	13774	24.5	26.3	0.9	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.76	0.00
4.40	13443	23.9	25.5	0.9	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.76	0.00
4.50	13495	24.0	25.4	0.9	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.75	0.00
4.60	13623	24.3	25.5	0.9	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.75	0.00
4.70	13412	23.9	25.0	0.9	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.74	0.00
4.80	12869	23.7	24.7	1.7	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.74	0.00
4.90	12639	23.3	24.1	1.7	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.73	0.00
5.00	12567	23.2	23.8	1.7	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.73	0.00
5.10	12929	23.8	24.4	1.7	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.72	0.00
5.20	13351	24.6	25.1	1.7	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.72	0.00
5.30	13615	25.1	25.4	1.7	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.71	0.00
5.40	13576	25.0	25.2	1.7	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.70	0.00
5.50	13519	24.9	25.0	1.7	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.70	0.00
5.60	13382	24.7	24.6	1.7	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.69	0.00
5.70	13462	24.8	24.7	1.7	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.69	0.00
5.80	13518	24.9	24.7	1.7	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.68	0.00
5.90	13826	25.5	25.1	1.7	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.68	0.00
6.00	13700	25.2	24.8	1.7	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.67	0.00
6.10	13083	24.1	23.5	1.7	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.67	0.00
6.20	13015	24.0	23.3	1.7	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.66	0.00
6.30	12669	23.3	22.6	1.7	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.66	0.00
6.40	12209	22.5	21.7	1.7	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.65	0.00
6.50	12288	22.6	21.7	1.7	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.64	0.00
6.60	12616	23.2	22.2	1.7	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.64	0.00
6.70	13092	24.1	23.0	1.7	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.63	0.00
6.80	13834	25.5	24.2	1.7	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.63	0.00
6.90	15306	27.3	25.8	0.9	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.62	0.00
7.00	16044	28.6	26.9	0.9	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.62	0.00
7.10	15825	28.2	26.5	0.9	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.61	0.00
7.20	13595	25.0	23.4	1.7	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.61	0.00
7.30	11057	21.1	19.7	2.5	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.60	0.00
7.40	10259	19.6	18.2	2.5	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.60	0.00
7.50	10684	20.4	18.9	2.5	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.59	0.00
7.60	12651	23.3	21.5	1.7	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.58	0.00
7.70	15617	27.8	25.6	0.9	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.58	0.00
7.80	17605	31.4	28.7	0.9	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.57	0.00
7.90	17236	30.7	28.0	0.9	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.57	0.00
8.00	15440	28.4	25.9	1.7	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.56	0.00
8.10	13599	25.9	23.5	2.5	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.56	0.00
8.20	13308	24.5	22.2	1.7	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.55	0.00
8.30	14405	26.5	23.9	1.7	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.55	0.00
8.40	17977	32.0	28.7	0.9	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.54	0.00
8.50	20249	34.9	31.2	0.4	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.54	0.00
8.60	18974	33.8	30.2	0.9	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.53	0.00
8.70	14309	27.3	24.3	2.5	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.52	0.00
8.80	10809	21.4	19.0	3.2	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.52	0.00

Settlement of Unsaturated Sand (Tokimatsu & Seed, 1987, and Pradel, 1998) / Cumulative / S_r (Idriss & Boulanger, 2008)

Depth, Z (m)	p = σ_m (tsf)	τ_{ave} (psf)	G_{max} (tsf)	τ_{ave}/G_{max}	a	b	γ_{eff} (%)	ε_{15} (%)	ε_{Nc} (%)	Settlement (inch)	Cumulative Settlement (inch)	$\Delta(N_1)_{60-Sr}$	$(N_1)_{60-Sr}$	S_r/σ_{v0}'
1.60	0.202	192	2222	0.00004	0.20272	16691	0.00509	0.003	0.002	0.00	0.37	N/A	N/A	N/A
1.70	0.215	204	2400	0.00004	0.20764	16095	0.00496	0.003	0.002	0.00	0.37	N/A	N/A	N/A
1.80	0.228	216	2549	0.00004	0.21256	15552	0.00492	0.002	0.002	0.00	0.37	N/A	N/A	N/A
1.90	0.240	228	2763	0.00004	0.21749	15056	0.00475	0.002	0.002	0.00	0.37	N/A	N/A	N/A
2.00	0.253	239	2866	0.00004	0.22241	14600	0.00482	0.002	0.002	0.00	0.37	N/A	N/A	N/A
2.10	0.266	251	2974	0.00004	0.22733	14178	0.00487	0.002	0.002	0.00	0.37	N/A	N/A	N/A
2.20	0.278	263	3043	0.00004	0.23225	13788	0.00499	0.002	0.002	0.00	0.37	N/A	N/A	N/A
2.30	0.291	275	3053	0.00005	0.23717	13425	0.00522	0.002	0.002	0.00	0.37	N/A	N/A	N/A
2.40	0.304	287	3025	0.00005	0.24209	13087	0.00553	0.003	0.002	0.00	0.37	N/A	N/A	N/A
2.50	0.316	299	3047	0.00005	0.24701	12770	0.00574	0.003	0.002	0.00	0.37	N/A	N/A	N/A
2.60	0.329	310	3012	0.00005	0.25193	12473	0.00609	0.003	0.003	0.00	0.37	N/A	N/A	N/A
2.70	0.342	322	3023	0.00005	0.25685	12194	0.00632	0.003	0.003	0.00	0.37	N/A	N/A	N/A
2.80	0.354	334	3015	0.00006	0.26177	11931	0.00661	0.003	0.003	0.00	0.37	N/A	N/A	N/A
2.90	0.367	346	3076	0.00006	0.26669	11682	0.00672	0.004	0.003	0.00	0.37	N/A	N/A	N/A
3.00	0.379	357	3055	0.00006	0.27161	11447	0.00704	0.004	0.003	0.00	0.37	N/A	N/A	N/A
3.10	0.392	369	3073	0.00006	0.27653	11224	0.00725	0.004	0.003	0.00	0.37	N/A	N/A	N/A
3.20	0.405	381	3084	0.00006	0.28145	11012	0.00749	0.004	0.003	0.00	0.37	N/A	N/A	N/A
3.30	0.417	392	3066	0.00006	0.28637	10811	0.00781	0.004	0.004	0.00	0.37	N/A	N/A	N/A
3.40	0.430	404	3101	0.00007	0.29129	10619	0.00797	0.005	0.004	0.00	0.37	N/A	N/A	N/A
3.50	0.443	415	3175	0.00007	0.29621	10436	0.00801	0.005	0.004	0.00	0.37	N/A	N/A	N/A
3.60	0.455	427	3276	0.00007	0.30113	10261	0.00795	0.004	0.004	0.00	0.37	N/A	N/A	N/A
3.70	0.468	438	3372	0.00007	0.30605	10093	0.00792	0.004	0.004	0.00	0.37	N/A	N/A	N/A
3.80	0.481	450	3363	0.00007	0.31097	9933	0.00819	0.005	0.004	0.00	0.37	N/A	N/A	N/A
3.90	0.493	461	3214	0.00007	0.31589	9780	0.00893	0.005	0.004	0.00	0.37	N/A	N/A	N/A
4.00	0.506	473	3154	0.00007	0.32081	9632	0.00942	0.006	0.005	0.00	0.36	N/A	N/A	N/A
4.10	0.519	484	2990	0.00008	0.32573	9490	0.01040	0.007	0.006	0.00	0.36	N/A	N/A	N/A
4.20	0.531	496	2936	0.00008	0.33065	9354	0.01096	0.008	0.006	0.00	0.36	N/A	N/A	N/A
4.30	0.544	507	2885	0.00009	0.33557	9223	0.01154	0.008	0.007	0.00	0.36	N/A	N/A	N/A
4.40	0.557	518	2831	0.00009	0.34049	9097	0.01218	0.009	0.008	0.00	0.36	N/A	N/A	N/A
4.50	0.569	530	2857	0.00009	0.34541	8975	0.01235	0.009	0.008	0.00	0.36	N/A	N/A	N/A
4.60	0.582	541	2899	0.00009	0.35033	8857	0.01243	0.009	0.008	0.00	0.36	N/A	N/A	N/A
4.70	0.594	552	2869	0.00010	0.35525	8744	0.01295	0.010	0.008	0.00	0.36	N/A	N/A	N/A
4.80	0.607	563	2862	0.00010	0.36017	8634	0.01333	0.010	0.009	0.00	0.36	N/A	N/A	N/A
4.90	0.620	574	2825	0.00010	0.36509	8528	0.01392	0.011	0.009	0.00	0.36	N/A	N/A	N/A
5.00	0.632	586	2822	0.00010	0.37001	8425	0.01429	0.012	0.010	0.00	0.36	N/A	N/A	N/A
5.10	0.645	597	2917	0.00010	0.37493	8326	0.01397	0.011	0.009	0.00	0.36	N/A	N/A	N/A
5.20	0.658	608	3026	0.00010	0.37985	8229	0.01359	0.010	0.009	0.00	0.36	N/A	N/A	N/A
5.30	0.670	619	3100	0.00010	0.38477	8136	0.01345	0.010	0.008	0.00	0.36	N/A	N/A	N/A
5.40	0.683	630	3104	0.00010	0.38969	8045	0.01373	0.010	0.009	0.00	0.36	N/A	N/A	N/A
5.50	0.696	641	3105	0.00010	0.39461	7957	0.01403	0.011	0.009	0.00	0.36	N/A	N/A	N/A
5.60	0.708	651	3086	0.00011	0.39953	7871	0.01445	0.011	0.009	0.00	0.35	N/A	N/A	N/A
5.70	0.721	662	3118	0.00011	0.40446	7788	0.01456	0.011	0.009	0.00	0.35	N/A	N/A	N/A
5.80	0.734	673	3144	0.00011	0.40938	7707	0.01469	0.011	0.010	0.00	0.35	N/A	N/A	N/A
5.90	0.746	684	3228	0.00011	0.41430	7629	0.01445	0.011	0.009	0.00	0.35	N/A	N/A	N/A
6.00	0.759	695	3212	0.00011	0.41922	7552	0.01485	0.011	0.010	0.00	0.35	N/A	N/A	N/A
6.10	0.772	705	3079	0.00011	0.42414	7478	0.01607	0.013	0.011	0.00	0.35	N/A	N/A	N/A
6.20	0.784	716	3075	0.00012	0.42906	7405	0.01642	0.014	0.011	0.00	0.35	N/A	N/A	N/A
6.30	0.797	727	3004	0.00012	0.43398	7334	0.01732	0.015	0.012	0.00	0.35	N/A	N/A	N/A
6.40	0.810	737	2906	0.00013	0.43890	7265	0.01854	0.017	0.014	0.00	0.35	N/A	N/A	N/A
6.50	0.822	748	2935	0.00013	0.44382	7198	0.01861	0.017	0.014	0.00	0.35	N/A	N/A	N/A
6.60	0.835	758	3025	0.00013	0.44874	7132	0.01814	0.016	0.013	0.00	0.35	N/A	N/A	N/A
6.70	0.847	769	3150	0.00012	0.45366	7068	0.01741	0.015	0.012	0.00	0.35	N/A	N/A	N/A
6.80	0.860	779	3340	0.00012	0.45858	7006	0.01629	0.013	0.011	0.00	0.34	N/A	N/A	N/A
6.90	0.873	789	3585	0.00011	0.46350	6945	0.01501	0.011	0.009	0.00	0.34	N/A	N/A	N/A
7.00	0.885	800	3771	0.00011	0.46842	6885	0.01424	0.010	0.008	0.00	0.34	N/A	N/A	N/A
7.10	0.898	810	3732	0.00011	0.47334	6827	0.01468	0.010	0.009	0.00	0.34	N/A	N/A	N/A
7.20	0.911	820	3327	0.00012	0.47826	6770	0.01752	0.014	0.012	0.00	0.34	N/A	N/A	N/A
7.30	0.923	830	2812	0.00015	0.48318	6714	0.02291	0.023	0.020	0.00	0.34	N/A	N/A	N/A
7.40	0.936	840	2617	0.00016	0.48810	6659	0.02613	0.029	0.025	0.00	0.34	N/A	N/A	N/A
7.50	0.949	850	2734	0.00016	0.49302	6606	0.02476	0.027	0.022	0.00	0.34	N/A	N/A	N/A
7.60	0.961	860	3136	0.00014	0.49794	6553	0.02036	0.019	0.016	0.00	0.34	N/A	N/A	N/A
7.70	0.974	870	3754	0.00012	0.50286	6502	0.01596	0.012	0.010	0.00	0.33	N/A	N/A	N/A
7.80	0.987	880	4244	0.00010	0.50778	6452	0.01370	0.009	0.007	0.00	0.33	N/A	N/A	N/A
7.90	0.999	890	4168	0.00011	0.51270	6403	0.01423	0.009	0.008	0.00	0.33	N/A	N/A	N/A
8.00	1.012	900	3874	0.00012	0.51762	6355	0.01594	0.012	0.010	0.00	0.33	N/A	N/A	N/A
8.10	1.025	910	3544	0.00013	0.52254	6308	0.01833	0.015	0.013	0.00	0.33	N/A	N/A	N/A
8.20	1.037	920	3359	0.00014	0.52746	6261	0.02010	0.018	0.015	0.00	0.33	N/A	N/A	N/A
8.30	1.050	929	3646	0.00013	0.53238	6216	0.01809	0.015	0.012	0.00	0.33	N/A	N/A	N/A
8.40	1.062	939	4411	0.00011	0.53730	6171	0.01410	0.009	0.008	0.00	0.33	N/A	N/A	N/A
8.50	1.075	948	4821	0.00010	0.54222	6128	0.01270	0.007	0.006	0.00	0.33	N/A	N/A	N/A
8.60	1.088	958	4681	0.00010	0.54714	6085	0.01336	0.008	0.007	0.00	0.33	N/A	N/A	N/A
8.70	1.100	967	3793	0.00013	0.55206	6043	0.01802	0.014	0.012	0.00	0.33	N/A	N/A	N/A
8.80	1.113	977	2979	0.00016	0.55698	6002	0.02622	0.028	0.023	0.00	0.33	N/A	N/A	N/A

Depth, Z (m)	Depth, Z (ft)	q_c (kPa)	f_s (kPa)	σ_{vc} (kPa)	σ'_{vc} (kPa)	Q	F	I_c	Soil Type	Fines (%)	Interpreted q_c	C_N	q_{c1N}	$q_{c1N\text{-}cs}$	Stress Reduction Factor (r_d)	CSR	K_σ for sand	$CRR_{M=7.5}$ at σ'_{vc}=1	MSF_{max}	MSF	CRR	$(FS)_L$	q_t (kPa)	N_{60}	$N_{1,60}$	$\Delta(N_1)_{60}$	$N_{1,60\text{-}CS}$
8.90	29.19	9246	60	160.9	160.9	71	0.66	1.9	Unsaturated	15	9246	0.88	81.0	114.6	0.88	0.279	0.9	0.160	1.35	1.075	0.162	N/L	9242	18.3	16.2	3.2	N.A.
9.00	29.52	8355	54	162.7	162.7	64	0.65	2.0	Unsaturated	17	8355	0.88	72.9	111.2	0.87	0.279	0.9	0.154	1.33	1.070	0.156	N/L	8428	17.3	15.3	3.8	N.A.
9.10	29.85	8166	50	164.5	164.5	62	0.62	2.0	Unsaturated	17	8166	0.88	71.1	108.9	0.87	0.278	0.9	0.150	1.31	1.067	0.151	N/L	8192	16.8	14.8	3.8	N.A.
9.20	30.18	8184	49	166.3	166.3	62	0.61	2.0	Unsaturated	17	8184	0.88	71.0	108.9	0.87	0.277	0.9	0.150	1.31	1.067	0.151	N/L	8221	16.9	14.8	3.8	N.A.
9.30	30.50	8411	49	168.1	168.1	63	0.59	1.9	Unsaturated	15	8411	0.87	72.8	104.8	0.87	0.277	0.9	0.144	1.29	1.062	0.144	N/L	8439	16.7	14.6	3.2	N.A.
9.40	30.83	8512	49	169.9	169.9	64	0.58	1.9	Unsaturated	15	8512	0.87	73.5	105.6	0.87	0.276	0.9	0.145	1.29	1.063	0.145	N/L	8575	17.0	14.8	3.2	N.A.
9.50	31.16	9013	49	171.7	171.7	67	0.55	1.9	Unsaturated	15	9013	0.87	77.6	110.5	0.87	0.276	0.9	0.153	1.32	1.069	0.153	N/L	9189	18.2	15.8	3.2	N.A.
9.60	31.49	11353	57	173.5	173.5	84	0.51	1.8	Unsaturated	13	11353	0.87	97.4	125.8	0.86	0.275	0.9	0.185	1.43	1.093	0.188	N/L	11403	21.8	18.9	2.5	N.A.
9.70	31.82	14881	62	175.4	175.4	110	0.42	1.7	Unsaturated	11	14881	0.86	127.4	149.7	0.86	0.274	0.9	0.287	1.67	1.143	0.299	N/L	14348	26.4	22.9	1.7	N.A.
9.80	32.14	17235	75	177.2	177.2	127	0.44	1.6	Unsaturated	10	17235	0.86	147.1	160.7	0.86	0.274	0.9	0.378	1.80	1.172	0.400	N/L	17355	30.9	26.6	0.9	N.A.
9.90	32.47	22478	88	179.0	179.0	166	0.40	1.5	Unsaturated	8	22478	0.86	191.4	197.9	0.86	0.273	0.9	1.686	2.20	1.257	1.808	N/L	22202	38.3	32.9	0.4	N.A.
10.00	32.80	26375	104	180.8	180.8	194	0.40	1.4	Unsaturated	7	26375	0.86	224.0	225.8	0.86	0.273	0.8	2.000	2.20	1.257	2.000	N/L	26080	43.5	37.3	0.1	N.A.
10.10	33.13	26783	116	182.6	182.6	196	0.44	1.5	Unsaturated	8	26783	0.86	226.8	234.2	0.85	0.272	0.8	2.000	2.20	1.257	2.000	N/L	27457	47.3	40.5	0.4	N.A.
10.20	33.46	31919	118	184.4	184.4	232	0.37	1.4	Unsaturated	7	31919	0.85	269.6	271.7	0.85	0.271	0.8	2.000	2.20	1.257	2.000	N/L	32132	53.6	45.8	0.1	N.A.
10.30	33.78	40094	161	186.2	186.2	291	0.40	1.3	Unsaturated	6	40094	0.85	337.8	338.1	0.85	0.271	0.8	2.000	2.20	1.257	2.000	N/L	39655	64.2	54.6	0.0	N.A.
10.40	34.11	43298	225	188.0	188.0	312	0.52	1.4	Unsaturated	7	43298	0.85	363.9	366.5	0.85	0.270	0.8	2.000	2.20	1.257	2.000	N/L	43114	72.0	61.1	0.1	N.A.
10.50	34.44	42404	246	189.8	189.8	304	0.58	1.4	Unsaturated	7	42404	0.85	355.5	358.0	0.85	0.270	0.8	2.000	2.20	1.257	2.000	N/L	41729	69.7	59.0	0.1	N.A.
10.60	34.77	36144	235	191.6	191.6	258	0.65	1.5	Unsaturated	8	36144	0.84	302.2	311.4	0.84	0.269	0.8	2.000	2.20	1.257	2.000	N/L	34749	59.9	50.6	0.4	N.A.
10.70	35.10	21788	221	193.4	193.4	154	1.02	1.8	Unsaturated	13	21788	0.84	181.7	223.1	0.84	0.268	0.8	2.000	2.20	1.257	2.000	N/L	22387	42.7	36.0	2.5	N.A.
10.80	35.42	13970	135	195.2	195.2	98	0.98	1.9	Unsaturated	15	13970	0.84	116.2	156.9	0.84	0.268	0.9	0.342	1.75	1.161	0.353	N/L	14337	28.4	23.8	3.2	N.A.
10.90	35.75	11329	99	197.1	197.1	79	0.89	2.0	Unsaturated	17	11329	0.84	94.0	137.4	0.84	0.267	0.9	0.223	1.53	1.115	0.225	N/L	11457	23.5	19.7	3.8	N.A.
11.00	36.08	10175	80	198.9	198.9	70	0.80	2.0	Unsaturated	17	10175	0.84	84.3	125.3	0.84	0.267	0.9	0.184	1.43	1.092	0.183	N/L	10233	21.0	17.6	3.8	N.A.
11.10	36.41	9668	72	200.7	200.7	66	0.76	2.0	Unsaturated	17	9668	0.83	79.9	119.8	0.84	0.266	0.9	0.171	1.38	1.083	0.169	N/L	9652	19.8	16.5	3.8	N.A.
11.20	36.74	9410	65	202.5	202.5	64	0.71	2.0	Unsaturated	17	9410	0.83	77.5	116.9	0.83	0.265	0.9	0.165	1.36	1.078	0.163	N/L	9419	19.4	16.1	3.8	N.A.
11.30	37.06	9417	64	204.3	204.3	64	0.70	2.0	Unsaturated	17	9417	0.83	77.4	116.8	0.83	0.265	0.9	0.164	1.36	1.078	0.162	N/L	9420	19.4	16.1	3.8	N.A.
11.40	37.39	9447	62	206.1	206.1	64	0.67	2.0	Unsaturated	17	9447	0.83	77.5	116.9	0.83	0.264	0.9	0.165	1.36	1.078	0.162	N/L	9455	19.4	16.1	3.8	N.A.
11.50	37.72	9391	60	207.9	207.9	63	0.65	2.0	Unsaturated	17	9391	0.83	76.9	116.1	0.83	0.264	0.9	0.163	1.36	1.077	0.160	N/L	9427	19.4	16.0	3.8	N.A.
11.60	38.05	9414	60	209.7	209.7	63	0.65	2.0	Unsaturated	17	9414	0.82	76.9	116.1	0.83	0.263	0.9	0.163	1.36	1.077	0.160	N/L	9453	19.4	16.0	3.8	N.A.
11.70	38.38	9659	61	211.5	211.5	65	0.64	2.0	Unsaturated	17	9659	0.82	78.7	118.4	0.82	0.262	0.9	0.168	1.37	1.080	0.165	N/L	9719	20.0	16.4	3.8	N.A.
11.80	38.70	10270	62	213.3	213.3	68	0.62	1.9	Unsaturated	15	10270	0.82	83.5	117.6	0.82	0.262	0.9	0.166	1.37	1.079	0.163	N/L	10252	20.3	16.7	3.2	N.A.
11.90	39.03	10435	62	215.1	215.1	69	0.61	1.9	Unsaturated	15	10435	0.82	84.6	119.0	0.82	0.261	0.9	0.169	1.38	1.081	0.166	N/L	10550	20.9	17.1	3.2	N.A.
12.00	39.36	11243	64	216.9	216.9	74	0.58	1.9	Unsaturated	15	11243	0.82	91.0	126.6	0.82	0.261	0.9	0.188	1.44	1.094	0.185	N/L	11046	21.9	17.9	3.2	N.A.
12.10	39.69	11058	64	218.7	218.7	73	0.59	1.9	Unsaturated	15	11058	0.82	89.3	124.6	0.82	0.260	0.9	0.182	1.42	1.090	0.179	N/L	11084	21.9	17.9	3.2	N.A.
12.20	40.02	10869	64	220.6	220.6	71	0.60	1.9	Unsaturated	15	10869	0.81	87.6	122.5	0.81	0.259	0.9	0.177	1.41	1.087	0.173	N/L	10826	21.4	17.4	3.2	N.A.
12.30	40.34	10547	60	222.4	222.4	69	0.58	1.9	Unsaturated	15	10547	0.81	84.8	119.2	0.81	0.259	0.9	0.169	1.38	1.082	0.165	N/L	10520	20.8	16.9	3.2	N.A.
12.40	40.67	10363	58	224.2	224.2	67	0.57	1.9	Unsaturated	15	10363	0.81	83.1	117.2	0.81	0.258	0.9	0.165	1.37	1.078	0.161	N/L	10361	20.5	16.6	3.2	N.A.
12.50	41.00	10382	59	226.0	226.0	67	0.58	1.9	Unsaturated	15	10382	0.81	83.1	117.2	0.81	0.258	0.9	0.165	1.37	1.078	0.161	N/L	10345	20.5	16.6	3.2	N.A.
12.60	41.33	10333	62	227.8	227.8	67	0.61	1.9	Unsaturated	15	10333	0.81	82.6	116.5	0.81	0.257	0.9	0.164	1.36	1.077	0.159	N/L	10332	20.4	16.5	3.2	N.A.
12.70	41.66	10462	63	229.6	229.6	67	0.61	1.9	Unsaturated	15	10462	0.81	83.4	117.5	0.80	0.256	0.9	0.166	1.37	1.079	0.161	N/L	10459	20.7	16.7	3.2	N.A.
12.80	41.98	10553	62	231.4	231.4	67	0.60	1.9	Unsaturated	15	10553	0.80	84.0	118.2	0.80	0.256	0.9	0.167	1.37	1.080	0.162	N/L	10540	20.9	16.8	3.2	N.A.
12.90	42.31	10531	60	233.2	233.2	67	0.58	1.9	Unsaturated	15	10531	0.80	83.6	117.8	0.80	0.255	0.9	0.166	1.37	1.079	0.161	N/L	10530	20.8	16.7	3.2	N.A.
13.00	42.64	10836	61	235.0	235.0	69	0.57	1.9	Unsaturated	15	10836	0.80	85.9	120.5	0.80	0.255	0.9	0.172	1.39	1.084	0.167	N/L	10815	21.4	17.1	3.2	N.A.
13.10	42.97	11217	63	237.0	236.1	71	0.58	1.9		15	11217	0.80	88.8	123.9	0.80	0.255	0.9	0.181	1.42	1.089	0.175	0.69	11277	22.3	17.8	3.2	21.0
13.20	43.30	12282	67	238.9	237.1	78	0.55	1.8		13	12282	0.80	97.1	125.4	0.80	0.255	0.9	0.184	1.43	1.092	0.179	0.70	12565	24.0	19.1	2.5	21.6
13.30	43.62	16943	74	240.9	238.1	108	0.44	1.7		11	16943	0.80	133.8	156.8	0.79	0.256	0.9	0.341	1.75	1.161	0.338	1.32	17269	31.8	25.4	1.7	27.0
13.40	43.95	24051	116	242.8	239.1	153	0.49	1.6		10	24051	0.80	189.7	205.7	0.79	0.256	0.8	2.650	2.20	1.257	2.000	2.00	22649	40.3	32.1	0.9	33.1
13.50	44.28	21159	135	244.8	240.1	134	0.65	1.7		11	21159	0.80	166.7	193.1	0.79	0.256	0.8	1.312	2.20	1.257	1.302	2.00	21837	40.2	32.0	1.7	33.7
13.60	44.61	21788	135	246.8	241.1	138	0.62	1.7		11	21788	0.79	171.5	198.4	0.79	0.257	0.8	1.729	2.20	1.257	1.686	2.00	21944	40.4	32.1	1.7	33.8
13.70	44.94	22434	144	248.7	242.1	142	0.65	1.7		11	22434	0.79	176.4	203.8	0.79	0.257	0.8	2.359	2.20	1.257	2.000	2.00	22493	41.4	32.9	1.7	34.6
13.80	45.26	22664	148	250.7	243.0	143	0.66	1.7		11	22664	0.79	178.0	205.6	0.78	0.258	0.8	2.630	2.20	1.257	2.000	2.00	22663	41.7	33.1	1.7	34.8
13.90	45.59	23378	157	252.7	244.0	147	0.68	1.7		11	23378	0.79	183.4	211.6	0.78	0.258	0.7	2.000	2.20	1.257	1.848	2.00	23457	43.2	34.2	1.7	35.9
14.00	45.92	26122	164	254.6	245.0	164	0.63	1.6		10	26122	0.79	204.7	221.6	0.78	0.258	0.7	2.000	2.20	1.257	1.845	2.00	26420	47.0	37.2	0.9	38.2
14.10	46.25	31406	202	256.6	246.0	197	0.65	1.6		10	31406	0.79	245.9	265.1	0.78	0.259	0.7	2.000	2.20	1.257	1.842	2.00	31035	55.3	43.7	0.9	44.6
14.20	46.58	34197	239	258.6	247.0	215	0.70	1.6		10	34197	0.79	267.4	288.0	0.78	0.259	0.7	2.000	2.20	1.257	1.839	2.00	34680	61.8	48.8	0.9	49.7
14.30	46.90	39799	171	260.5	248.0	249	0.43	1.4		7	39799	0.79	310.9	313.2	0.77	0.259	0.7	2.000	2.20	1.257	1.836	2.00	39784	66.4	52.4	0.1	52.5
14.40	47.23	42505	123	262.5	248.9	266	0.29	1.2		4	42505	0.79	331.7	331.7	0.77	0.260	0.7	2.000	2.20	1.257	1.833	2.00	42407	66.6	52.5	0.0	52.5
14.50	47.56	36082	128	264.5	249.9	225	0.36	1.4		7	36082	0.79	281.3	283.4	0.77	0.260	0.7	2.000	2.20	1.257	1.830	2.00	37249	62.2	49.0	0.1	49.1
14.60	47.89	32474	83	266.4	250.9	202	0.26	1.3		6	32474	0.79	252.9	253.1	0.77	0.260	0.7	2.000	2.20	1.257	1.827	2.00	32916	53.3	41.9	0.0	41.9
14.70	48.22	33031	95	268.4	251.9	205	0.29	1.3		6	33031	0.79	257.0	257.2	0.77	0.260	0.7	2.000	2.20	1.257	1.824	2.00	33031	53.5	42.0	0.0	42.0
14.80	48.54	32808	120	270.4	252.9	203	0.37	1.4		7	32808	0.78	255.0	257.0	0.77	0.261	0.7	2.000	2.20	1.257	1.821	2.00	32807	54.8	43.0	0.1	43.1
14.90	48.87	32152	124	272.3	253.9	199	0.39	1.4		7	32152	0.78	249.6	251.6	0.76	0.261	0.7	2.000	2.20	1.257	1.818	2.00	30865	51.5	40.4	0.1	40.5
15.00	49.20	23593	107	274.3	254.8	145	0.46	1.6		10	23593	0.78	183.0	198.6	0.76	0.261	0.8	1.750	2.20	1.257	1.674	2.00	23834	42.4	33.2	0.9	34.2
15.10	49.53	16778	100	276.3	255.8	103	0.61	1.8		13	16778	0.78	130.0	163.4	0.76	0.261	0.8	0.409	1.84	1.180	0.402	1.54	16287	31.1	24.3	2.5	26.8
15.20	49.86	6190	124	278.2	256.8	37	2.10	2.5		30	6190	0.78	47.9	93.0	0.76	0.262	0.9	0.129	1.23	1.049	0.122	0.47	7381	18.8	14.7	5.4	20.1
15.30	50.18	2711	64	280.2	257.8	15	2.62	2.8	Clay-Like	41	2711	0.78	21.0	58.4	0.76	0.262	0.9	0.098	1.12	1.027	0.094	N/L	2987	8.9	6.9	5.6	N.A.
15.40	50.51	2416	18	282.1	258.8	13	0.83	2.6	Clay-Like	34	2416	0.78	18.7	54.6	0.75	0.262	0.9	0.096	1.12	1.025	0.091	N/L	2499	6.7	5.2	5.5	N.A.
15.50	50.84	2430	12	284.1	259.8	13	0.54	2.5		30	2430	0.78	18.7	54.1	0.75	0.262	0.9	0.095	1.12	1.025	0.091	0.35	2636	6.7	5.2	5.4	10.6
15.60	51.17	2992	11	286.1	260.7	17	0.40	2.4		27	2992	0.78	23.1	58.8	0.75	0.262	0.9	0.099	1.12	1.027	0.094	0.36	3321	8.1	6.3	5.2	11.5
15.70	51.50	4700	13	288.0	261.7	27	0.29	2.1		19	4700	0.78	36.2	69.5	0.75	0.262	0.9	0.107	1.15	1.032	0.101	0.39	4694	10.0	7.8	4.3	12.2
15.80	51.82	6019	16	290.0	262.7	35	0.28	2.0		17	6019	0.78	46.3	78.2	0.75	0.263	0.9	0.114	1.17	1.037	0.108	0.41	5917	12.2	9.4	3.8	13.3
15.90	52.15	6653	39	292.0	263.7	39	0.62	2.1		19	6653	0.78	51.1	88.5	0.75	0.263	0.9	0.124	1.21	1.045	0.117	0.45	6666	14.2	11.1	4.3	15.4
16.00	52.48	6991	60	293.9	264.7	41	0.89	2.2		22	6991	0.78	53.7	95.1	0.74	0.263	0.9	0.131	1.24	1.051	0.124	0.47	6985	15.5	12.1	4.7	16.8
16.10	52.81	7296	68	295.9	265.7	43	0.97	2.2		22	7296	0.77	56.0	98.1	0.74	0.263	0.9	0.135	1.25	1.054	0.128	0.49	7490	16.7	12.9	4.7	17.7
16.20	53.14	8317	57	297.9	266.7	49	0.71	2.1		19	8317	0.77	63.7	104.6	0.74	0.263	0.9	0.144	1.29	1.061	0.136	0.52	8132	17.4	13.5	4.3	17.8
16.30	53.46	6579	65	299.8	267.6	38	1.04	2.3		24	6579	0.77	50.4	93.3	0.74	0.263	0.9	0.129	1.23	1.049	0.122	0.46	6570	15.3	11.8	5.0	16.8
16.40	53.79	4490	68	301.8	268.6	25	1.63	2.5		30	4490	0.77	34.3	74.9	0.74	0.263	0.9	0.111	1.16	1.035	0.105	0.40	4641	11.8	9.1	5.4	14.5
16.50	54.12	3685	70	303.8	269.6	20	2.08	2.7	Clay-Like	37	3685	0.77	28.2	67.8	0.73	0.263	0.9	0.106	1.14	1.031	0.100	N/L	3583	10.1	7.8	5.5	N.A.
16.60	54.45	2615	75	305.7	270.6	14	3.25	2.9	Clay-Like	45	2615	0.77	20.0	57.2	0.73	0.264	0.9	0.097	1.12	1.026	0.093	N/L	2855	9.0	6.9	5.6	N.A.
16.70	54.78	3838	68	307.7	271.6	21	1.92	2.6	Clay-Like	34	3838	0.77	29.3	68.9	0.73	0.264	0.9	0.106	1.15	1.031	0.101	N/L	4673	12.5	9.6	5.5	N.A.
16.80	55.10	7166	68	309.7	272.6	41	0.99	2.2		22	7166	0.77	54.6	96.3	0.73	0.264	0.9	0.133	1.24	1.052	0.125	0.48	6909	15.4	11.8	4.7	16.6
16.90	55.43	4685	102	311.6	273.5	26	2.34	2.6	Clay-Like	34	4685	0.77	35.7	77.4	0.73	0.264	0.9	0.114	1.17	1.036	0.107	N/L	4912	13.1	10.1	5.5	N.A.
17.00	55.76	2900	89	313.6	274.5	16	3.43	2.9	Clay-Like	45	2900	0.77	22.1	60.0	0.73	0.264	0.9	0.100	1.13	1.027	0.094	N/L	3109	9.8	7.5	5.6	N.A.
17.10	56.09	3056	71	315.6	275.5	16	2.59	2.8	Clay-Like	41	3056	0.77	23.2	61.5	0.72	0.264	0.9	0.101	1.13	1.028	0.095	N/L	3175	9.4	7.2	5.6	N.A.
17.20	56.42	2552	69	317.5	276.5	13	3.10	2.9	Clay-Like	45	2552	0.77	19.4	56.4	0.72	0.264	0.9	0.097	1.12	1.026	0.092	N/L	2787	8.8	6.7	5.6	N.A.
17.30	56.74	2300	59	319.5	277.5	12	2.96	2.9	Clay-Like	45	2300	0.77	17.4	53.8	0.72	0.264	0.9	0.095	1.12	1.025	0.090	N/L	2315	7.3	5.6	5.6	N.A.
17.40	57.07	2366	61	321.4	278.5	12	3.01	2.9	Clay-Like	45	2366	0.77	17.9	54.5	0.72	0.264	0.9	0.095	1.12	1.025	0.091	N/L	2359	7.4	5.7	5.6	N.A.
17.50	57.40	3003	52	323.4	279.4	16	1.94	2.7	Clay-Like	37	3003	0.76	22.7	60.5	0.72	0.264	0.9	0.100	1.13	1.027	0.095	N/L	2646	7.4	5.7	5.5	N.A.
17.60	57.73	2092	48	325.4	280.4	10	2.73	3.0	Clay-Like	49	2092	0.76	15.8	51.7	0.71	0.264	0.9	0.093	1.11	1.024	0.089	N/L	2233	7.5	5.7	5.6	N.A.
17.70	58.06	2062	42	327.3	281.4	10	2.43	2.9	Clay-Like	45	2062	0.76	15.6	51.3	0.71	0.264	0.9	0.093	1.11	1.024	0.088	N/L	2076	6.5	5.0	5.6	N.A.
17.80	58.38	2133	43	329.3	282.4	11	2.40	2.9	Clay-Like	45	2133	0.76	16.1	52.0	0.71	0.264	0.9	0.094	1.11	1.024	0.089	N/L	2162	6.8	5.2	5.6	N.A.
17.90	58.71	2170	51	331.3	283.4	11	2.78	2.9	Clay-Like	45	2170	0.76	16.4	52.4	0.71	0.264	0.9	0.094	1.11	1.025	0.089	N/L	2205	6.9	5.3	5.6	N.A.
18.00	59.04	2143	55	333.2	284.4	11	3.02	3.0	Clay-Like	49	2143	0.76	16.2	52.1	0.71	0.264	0.9	0.094	1.11	1.025	0.089	N/L	2241	7.5	5.7	5.6	N.A.

Depth, Z (m)	Limiting Shear Strain γ_{lim}	Parameter F_α	Max. Shear Strain γ_{max}	ΔHi (m)	ΔLDI_i (m)	Vert. Recon. Strain ε_v	DF_i	ΔSi (inch)	$p = \sigma_m$ (tsf)	τ_{ave} (psf)	G_{max} (tsf)	τ_{ave}/G_{max}	a	b	γ_{eff} (%)	ε_{15} (%)	ε_{Nc} (%)	Settlement (inch)	Settlement (inch)	$\Delta(N_1)_{60\text{-}Sr}$	$(N_1)_{60\text{-}Sr}$	S_r/σ_{v0}'
8.90	0.000	0.000	0.000	0.10	0.0000	0.0000	0.51	0.00	1.126	986	2554	0.00019	0.56190	5961	0.03431	0.044	0.037	0.00	0.32	N/A	N/A	N/A
9.00	0.000	0.000	0.000	0.10	0.0000	0.0000	0.51	0.00	1.138	996	2425	0.00021	0.56682	5921	0.03814	0.053	0.044	0.00	0.32	N/A	N/A	N/A
9.10	0.000	0.000	0.000	0.10	0.0000	0.0000	0.50	0.00	1.151	1005	2363	0.00021	0.57174	5882	0.04053	0.058	0.049	0.00	0.32	N/A	N/A	N/A
9.20	0.000	0.000	0.000	0.10	0.0000	0.0000	0.50	0.00	1.164	1014	2378	0.00021	0.57666	5844	0.04063	0.058	0.049	0.00	0.31	N/A	N/A	N/A
9.30	0.000	0.000	0.000	0.10	0.0000	0.0000	0.49	0.00	1.176	1023	2357	0.00022	0.58158	5806	0.04187	0.061	0.051	0.00	0.31	N/A	N/A	N/A
9.40	0.000	0.000	0.000	0.10	0.0000	0.0000	0.49	0.00	1.189	1032	2401	0.00021	0.58650	5769	0.04102	0.059	0.049	0.00	0.31	N/A	N/A	N/A
9.50	0.000	0.000	0.000	0.10	0.0000	0.0000	0.48	0.00	1.202	1041	2579	0.00020	0.59143	5732	0.03655	0.048	0.041	0.00	0.30	N/A	N/A	N/A
9.60	0.000	0.000	0.000	0.10	0.0000	0.0000	0.48	0.00	1.214	1050	3094	0.00017	0.59635	5696	0.02731	0.029	0.024	0.00	0.30	N/A	N/A	N/A
9.70	0.000	0.000	0.000	0.10	0.0000	0.0000	0.47	0.00	1.227	1059	3768	0.00014	0.60127	5661	0.02048	0.017	0.015	0.00	0.30	N/A	N/A	N/A
9.80	0.000	0.000	0.000	0.10	0.0000	0.0000	0.46	0.00	1.240	1068	4416	0.00012	0.60619	5626	0.01654	0.012	0.010	0.00	0.30	N/A	N/A	N/A
9.90	0.000	0.000	0.000	0.10	0.0000	0.0000	0.46	0.00	1.252	1077	5480	0.00010	0.61111	5592	0.01255	0.007	0.006	0.00	0.29	N/A	N/A	N/A
10.00	0.000	0.000	0.000	0.10	0.0000	0.0000	0.45	0.00	1.265	1086	6251	0.00009	0.61603	5558	0.01074	0.005	0.004	0.00	0.29	N/A	N/A	N/A
10.10	0.000	0.000	0.000	0.10	0.0000	0.0000	0.45	0.00	1.277	1094	6809	0.00008	0.62095	5525	0.00976	0.004	0.004	0.00	0.29	N/A	N/A	N/A
10.20	0.000	0.000	0.000	0.10	0.0000	0.0000	0.44	0.00	1.290	1103	7738	0.00007	0.62587	5493	0.00844	0.003	0.003	0.00	0.29	N/A	N/A	N/A
10.30	0.000	0.000	0.000	0.10	0.0000	0.0000	0.44	0.00	1.303	1112	9281	0.00006	0.63079	5461	0.00689	0.002	0.002	0.00	0.29	N/A	N/A	N/A
10.40	0.000	0.000	0.000	0.10	0.0000	0.0000	0.43	0.00	1.315	1120	10430	0.00005	0.63571	5429	0.00608	0.002	0.001	0.00	0.29	N/A	N/A	N/A
10.50	0.000	0.000	0.000	0.10	0.0000	0.0000	0.43	0.00	1.328	1129	10118	0.00006	0.64063	5398	0.00634	0.002	0.001	0.00	0.29	N/A	N/A	N/A
10.60	0.000	0.000	0.000	0.10	0.0000	0.0000	0.42	0.00	1.341	1137	8717	0.00007	0.64555	5368	0.00760	0.002	0.002	0.00	0.29	N/A	N/A	N/A
10.70	0.000	0.000	0.000	0.10	0.0000	0.0000	0.42	0.00	1.353	1146	6231	0.00009	0.65047	5337	0.01149	0.006	0.005	0.00	0.29	N/A	N/A	N/A
10.80	0.000	0.000	0.000	0.10	0.0000	0.0000	0.41	0.00	1.366	1154	4148	0.00014	0.65539	5308	0.01993	0.016	0.013	0.00	0.29	N/A	N/A	N/A
10.90	0.000	0.000	0.000	0.10	0.0000	0.0000	0.40	0.00	1.379	1162	3449	0.00017	0.66031	5278	0.02645	0.027	0.022	0.00	0.29	N/A	N/A	N/A
11.00	0.000	0.000	0.000	0.10	0.0000	0.0000	0.40	0.00	1.391	1170	3087	0.00019	0.66523	5250	0.03186	0.037	0.031	0.00	0.29	N/A	N/A	N/A
11.10	0.000	0.000	0.000	0.10	0.0000	0.0000	0.39	0.00	1.404	1179	2918	0.00020	0.67015	5221	0.03534	0.044	0.037	0.00	0.29	N/A	N/A	N/A
11.20	0.000	0.000	0.000	0.10	0.0000	0.0000	0.39	0.00	1.417	1187	2854	0.00021	0.67507	5193	0.03707	0.048	0.040	0.00	0.28	N/A	N/A	N/A
11.30	0.000	0.000	0.000	0.10	0.0000	0.0000	0.38	0.00	1.429	1195	2860	0.00021	0.67999	5165	0.03730	0.048	0.041	0.00	0.28	N/A	N/A	N/A
11.40	0.000	0.000	0.000	0.10	0.0000	0.0000	0.38	0.00	1.442	1203	2877	0.00021	0.68491	5138	0.03728	0.048	0.040	0.00	0.28	N/A	N/A	N/A
11.50	0.000	0.000	0.000	0.10	0.0000	0.0000	0.37	0.00	1.455	1211	2874	0.00021	0.68983	5111	0.03769	0.049	0.041	0.00	0.27	N/A	N/A	N/A
11.60	0.000	0.000	0.000	0.10	0.0000	0.0000	0.37	0.00	1.467	1219	2888	0.00021	0.69475	5085	0.03773	0.049	0.041	0.00	0.27	N/A	N/A	N/A
11.70	0.000	0.000	0.000	0.10	0.0000	0.0000	0.36	0.00	1.480	1226	2975	0.00021	0.69967	5059	0.03619	0.046	0.038	0.00	0.27	N/A	N/A	N/A
11.80	0.000	0.000	0.000	0.10	0.0000	0.0000	0.35	0.00	1.493	1234	3028	0.00020	0.70459	5033	0.03544	0.044	0.037	0.00	0.27	N/A	N/A	N/A
11.90	0.000	0.000	0.000	0.10	0.0000	0.0000	0.35	0.00	1.505	1242	3123	0.00020	0.70951	5008	0.03397	0.041	0.034	0.00	0.26	N/A	N/A	N/A
12.00	0.000	0.000	0.000	0.10	0.0000	0.0000	0.34	0.00	1.518	1249	3276	0.00019	0.71443	4983	0.03167	0.036	0.030	0.00	0.26	N/A	N/A	N/A
12.10	0.000	0.000	0.000	0.10	0.0000	0.0000	0.34	0.00	1.530	1257	3294	0.00019	0.71935	4958	0.03166	0.036	0.030	0.00	0.26	N/A	N/A	N/A
12.20	0.000	0.000	0.000	0.10	0.0000	0.0000	0.33	0.00	1.543	1265	3223	0.00020	0.72427	4933	0.03306	0.039	0.033	0.00	0.25	N/A	N/A	N/A
12.30	0.000	0.000	0.000	0.10	0.0000	0.0000	0.33	0.00	1.556	1272	3138	0.00020	0.72919	4909	0.03484	0.043	0.036	0.00	0.25	N/A	N/A	N/A
12.40	0.000	0.000	0.000	0.10	0.0000	0.0000	0.32	0.00	1.568	1279	3097	0.00021	0.73411	4885	0.03591	0.045	0.038	0.00	0.25	N/A	N/A	N/A
12.50	0.000	0.000	0.000	0.10	0.0000	0.0000	0.32	0.00	1.581	1287	3098	0.00021	0.73903	4862	0.03617	0.045	0.038	0.00	0.25	N/A	N/A	N/A
12.60	0.000	0.000	0.000	0.10	0.0000	0.0000	0.31	0.00	1.594	1294	3100	0.00021	0.74395	4839	0.03642	0.046	0.038	0.00	0.24	N/A	N/A	N/A
12.70	0.000	0.000	0.000	0.10	0.0000	0.0000	0.31	0.00	1.606	1301	3144	0.00021	0.74887	4816	0.03585	0.045	0.037	0.00	0.24	N/A	N/A	N/A
12.80	0.000	0.000	0.000	0.10	0.0000	0.0000	0.30	0.00	1.619	1309	3174	0.00021	0.75379	4793	0.03555	0.044	0.037	0.00	0.24	N/A	N/A	N/A
12.90	0.000	0.000	0.000	0.10	0.0000	0.0000	0.29	0.00	1.632	1316	3177	0.00021	0.75871	4771	0.03577	0.044	0.037	0.00	0.23	N/A	N/A	N/A
13.00	0.000	0.000	0.000	0.10	0.0000	0.0000	0.29	0.00	1.644	1323	3269	0.00020	0.76363	4749	0.03437	0.041	0.035	0.00	0.23	N/A	N/A	N/A
13.10	0.141	0.461	0.109	0.10	0.0109	0.0221	0.28	0.02	1.652	1331	3412	0.00019	0.76672	4735	0.03233	0.037	0.031	0.00	0.23	1.3	19	0.17
13.20	0.132	0.430	0.096	0.10	0.0096	0.0216	0.28	0.02	1.659	1338	3670	0.00018	0.76940	4723	0.02907	0.031	0.026	0.00	0.20	1.2	20	0.18
13.30	0.069	0.105	0.017	0.10	0.0017	0.0038	0.27	0.00	1.666	1346	4874	0.00014	0.77208	4712	0.01932	0.015	0.012	0.00	0.18	1.0	26	N/A
13.40	0.030	-0.298	0.000	0.10	0.0000	0.0000	0.27	0.00	1.673	1354	6186	0.00011	0.77476	4700	0.01416	0.008	0.007	0.00	0.18	0.9	33	N/A
13.50	0.027	-0.342	0.000	0.10	0.0000	0.0000	0.26	0.00	1.680	1361	6176	0.00011	0.77744	4688	0.01428	0.008	0.007	0.00	0.18	1.0	33	N/A
13.60	0.027	-0.351	0.000	0.10	0.0000	0.0000	0.26	0.00	1.687	1369	6212	0.00011	0.78011	4677	0.01428	0.008	0.007	0.00	0.18	1.0	33	N/A
13.70	0.024	-0.405	0.000	0.10	0.0000	0.0000	0.25	0.00	1.694	1377	6374	0.00011	0.78279	4666	0.01391	0.008	0.006	0.00	0.18	1.0	34	N/A
13.80	0.023	-0.421	0.000	0.10	0.0000	0.0000	0.25	0.00	1.700	1384	6428	0.00011	0.78547	4654	0.01385	0.008	0.006	0.00	0.18	1.0	34	N/A
13.90	0.019	-0.501	0.000	0.10	0.0000	0.0000	0.24	0.00	1.707	1391	6659	0.00010	0.78815	4643	0.01332	0.007	0.006	0.00	0.18	1.0	35	N/A
14.00	0.013	-0.667	0.000	0.10	0.0000	0.0000	0.23	0.00	1.714	1399	7257	0.00010	0.79083	4632	0.01203	0.006	0.005	0.00	0.18	0.9	38	N/A
14.10	0.003	-1.160	0.000	0.10	0.0000	0.0000	0.23	0.00	1.721	1406	8533	0.00008	0.79350	4621	0.00993	0.004	0.003	0.00	0.18	0.9	45	N/A
14.20	0.000	-1.565	0.000	0.10	0.0000	0.0000	0.22	0.00	1.728	1413	9545	0.00007	0.79618	4610	0.00874	0.003	0.003	0.00	0.18	0.9	50	N/A
14.30	0.000	-1.793	0.000	0.10	0.0000	0.0000	0.22	0.00	1.735	1421	10275	0.00007	0.79886	4599	0.00806	0.003	0.002	0.00	0.18	0.6	53	N/A
14.40	0.000	-1.795	0.000	0.10	0.0000	0.0000	0.21	0.00	1.742	1428	10318	0.00007	0.80154	4588	0.00807	0.003	0.002	0.00	0.18	0.4	53	N/A
14.50	0.001	-1.513	0.000	0.10	0.0000	0.0000	0.21	0.00	1.749	1435	9638	0.00007	0.80422	4577	0.00879	0.003	0.003	0.00	0.18	0.6	50	N/A
14.60	0.006	-0.950	0.000	0.10	0.0000	0.0000	0.20	0.00	1.756	1442	8266	0.00009	0.80689	4566	0.01062	0.004	0.004	0.00	0.18	0.5	42	N/A
14.70	0.006	-0.958	0.000	0.10	0.0000	0.0000	0.20	0.00	1.762	1449	8303	0.00009	0.80957	4555	0.01063	0.004	0.004	0.00	0.18	0.5	43	N/A
14.80	0.004	-1.040	0.000	0.10	0.0000	0.0000	0.19	0.00	1.769	1455	8512	0.00009	0.81225	4545	0.01037	0.004	0.003	0.00	0.18	0.6	44	N/A
14.90	0.008	-0.842	0.000	0.10	0.0000	0.0000	0.19	0.00	1.776	1462	8016	0.00009	0.81493	4534	0.01122	0.005	0.004	0.00	0.18	0.6	41	N/A
15.00	0.025	-0.377	0.000	0.10	0.0000	0.0000	0.18	0.00	1.783	1469	6608	0.00011	0.81761	4524	0.01438	0.008	0.007	0.00	0.18	0.9	34	N/A
15.10	0.071	0.121	0.010	0.10	0.0010	0.0022	0.17	0.00	1.790	1476	4843	0.00015	0.82029	4513	0.02202	0.017	0.015	0.00	0.18	1.2	25	N/A
15.20	0.158	0.515	0.158	0.10	0.0158	0.0230	0.17	0.02	1.797	1482	2929	0.00025	0.82296	4503	0.04957	0.072	0.060	0.00	0.17	2.6	17	0.15
15.30	0.000	0.000	0.000	0.10	0.0000	0.0000	0.16	0.00	1.804	1489	1384	0.00054	0.82564	4492	0.30207	1.079	0.902	0.00	0.16	N/A	N/A	N/A
15.40	0.000	0.000	0.000	0.10	0.0000	0.0000	0.16	0.00	1.811	1495	1043	0.00072	0.82832	4482	0.84598	4.252	3.555	0.00	0.16	N/A	N/A	N/A
15.50	0.443	0.900	0.443	0.10	0.0443	0.0361	0.15	0.02	1.817	1502	1049	0.00072	0.83100	4472	0.83776	4.193	3.506	0.00	0.16	2.6	8	0.08
15.60	0.401	0.877	0.401	0.10	0.0401	0.0343	0.15	0.02	1.824	1508	1262	0.00060	0.83368	4462	0.42289	1.698	1.420	0.00	0.14	2.4	9	0.08
15.70	0.374	0.858	0.374	0.10	0.0374	0.0332	0.14	0.02	1.831	1514	1572	0.00048	0.83635	4452	0.21365	0.661	0.553	0.00	0.12	1.7	10	0.09
15.80	0.331	0.820	0.331	0.10	0.0331	0.0313	0.14	0.02	1.838	1521	1907	0.00040	0.83903	4442	0.12863	0.316	0.265	0.00	0.10	1.5	11	0.10
15.90	0.263	0.737	0.263	0.10	0.0263	0.0282	0.13	0.01	1.845	1527	2236	0.00034	0.84171	4432	0.08941	0.182	0.152	0.00	0.08	1.7	13	0.11
16.00	0.227	0.676	0.227	0.10	0.0227	0.0265	0.13	0.01	1.852	1533	2443	0.00031	0.84439	4422	0.07455	0.137	0.114	0.00	0.07	1.9	14	0.12
16.10	0.206	0.636	0.206	0.10	0.0206	0.0255	0.12	0.01	1.859	1539	2621	0.00029	0.84707	4412	0.06506	0.110	0.092	0.00	0.06	1.9	15	0.13
16.20	0.203	0.629	0.203	0.10	0.0203	0.0253	0.11	0.01	1.866	1545	2735	0.00028	0.84974	4402	0.06028	0.097	0.081	0.00	0.04	1.7	15	0.13
16.30	0.226	0.675	0.226	0.10	0.0226	0.0264	0.11	0.01	1.873	1551	2404	0.00032	0.85242	4393	0.07866	0.148	0.124	0.00	0.03	2.1	14	0.12
16.40	0.290	0.775	0.290	0.10	0.0290	0.0294	0.10	0.01	1.879	1557	1861	0.00042	0.85510	4383	0.14311	0.367	0.307	0.00	0.02	2.6	12	0.10
16.50	0.000	0.000	0.000	0.10	0.0000	0.0000	0.10	0.00	1.886	1563	1590	0.00049	0.85778	4373	0.22120	0.687	0.575	0.00	0.01	N/A	N/A	N/A
16.60	0.000	0.000	0.000	0.10	0.0000	0.0000	0.09	0.00	1.893	1569	1417	0.00055	0.86046	4364	0.31651	1.132	0.946	0.00	0.01	N/A	N/A	N/A
16.70	0.000	0.000	0.000	0.10	0.0000	0.0000	0.09	0.00	1.900	1574	1973	0.00040	0.86314	4354	0.12642	0.304	0.255	0.00	0.01	N/A	N/A	N/A
16.80	0.232	0.687	0.232	0.10	0.0232	0.0267	0.08	0.01	1.907	1580	2433	0.00032	0.86581	4345	0.07917	0.149	0.124	0.00	0.01	1.9	14	0.12
16.90	0.000	0.000	0.000	0.10	0.0000	0.0000	0.08	0.00	1.914	1586	2077	0.00038	0.86849	4335	0.11321	0.257	0.215	0.00	0.00	N/A	N/A	N/A
17.00	0.000	0.000	0.000	0.10	0.0000	0.0000	0.07	0.00	1.921	1591	1548	0.00051	0.87117	4326	0.24851	0.806	0.674	0.00	0.00	N/A	N/A	N/A
17.10	0.000	0.000	0.000	0.10	0.0000	0.0000	0.07	0.00	1.928	1597	1495	0.00053	0.87385	4317	0.27844	0.944	0.789	0.00	0.00	N/A	N/A	N/A
17.20	0.000	0.000	0.000	0.10	0.0000	0.0000	0.06	0.00	1.935	1602	1390	0.00058	0.87653	4308	0.35291	1.308	1.093	0.00	0.00	N/A	N/A	N/A
17.30	0.000	0.000	0.000	0.10	0.0000	0.0000	0.05	0.00	1.941	1608	1156	0.00070	0.87920	4298	0.68351	3.167	2.648	0.00	0.00	N/A	N/A	N/A
17.40	0.000	0.000	0.000	0.10	0.0000	0.0000	0.05	0.00	1.948	1613	1179	0.00068	0.88188	4289	0.63933	2.899	2.424	0.00	0.00	N/A	N/A	N/A
17.50	0.000	0.000	0.000	0.10	0.0000	0.0000	0.04	0.00	1.955	1618	1184	0.00068	0.88456	4280	0.63406	2.867	2.397	0.00	0.00	N/A	N/A	N/A
17.60	0.000	0.000	0.000	0.10	0.0000	0.0000	0.04	0.00	1.962	1623	1188	0.00068	0.88724	4271	0.63147	2.850	2.383	0.00	0.00	N/A	N/A	N/A
17.70	0.000	0.000	0.000	0.10	0.0000	0.0000	0.03	0.00	1.969	1629	1040	0.00078	0.88992	4262	1.07848	5.720	4.783	0.00	0.00	N/A	N/A	N/A
17.80	0.000	0.000	0.000	0.10	0.0000	0.0000	0.03	0.00	1.976	1634	1084	0.00075	0.89260	4253	0.91638	4.635	3.876	0.00	0.00	N/A	N/A	N/A
17.90	0.000	0.000	0.000	0.10	0.0000	0.0000	0.02	0.00	1.983	1639	1107	0.00074	0.89527	4244	0.84961	4.201	3.513	0.00	0.00	N/A	N/A	N/A
18.00	0.000	0.000	0.000	0.10	0.0000	0.0000	0.02	0.00	1.990	1644	1196	0.00069	0.89795	4236	0.63409	2.863	2.394	0.00	0.00	N/A	N/A	N/A

Depth, Z (m)	Depth, Z (ft)	q_c (kPa)	f_s (kPa)	σ_{vc} (kPa)	σ'_{vc} (kPa)	Q	F	I_c	Soil Type	Fines (%)	Interpreted q_c	C_N	q_{c1N}	q_{c1N-cs}	Stress Reduction Factor (r_d)
18.10	59.37	2440	46	335.2	285.3	12	2.21	2.8	Clay-Like	41	2440	0.76	18.4	54.9	0.71
18.20	59.70	2068	39	337.2	286.3	10	2.24	2.9	Clay-Like	45	2068	0.76	15.6	51.3	0.70

Depth, Z (m)	CSR	K_σ for sand	$CRR_{M=7.5}$ at $\sigma'_{vc}=1$	MSF_{max}	MSF	CRR	$(FS)_L$	q_t (kPa)	N_{60}	$N_{1,60}$	$\Delta(N_1)_{60}$	$N_{1,60-CS}$	Limiting Shear Strain γ_{lim}	Parameter F_α	Max. Shear Strain γ_{max}	ΔHi (m)	ΔLDI_i (m)
18.10	0.264	0.9	0.096	1.12	1.025	0.091	**N/L**	2432	7.2	5.5	5.6	N.A.	0.000	0.000	0.000	0.10	0.0000
18.20	0.264	0.9	0.093	1.11	1.024	0.088	**N/L**	2212	7.0	5.3	5.6	N.A.	0.000	0.000	0.000	0.05	0.0000

Depth, Z (m)	Vert. Recon. Strain ε_v	DF_i	ΔSi (inch)	$p = \sigma_m$ (tsf)	τ_{ave} (psf)	G_{max} (tsf)	τ_{ave}/G_{max}	a	b	γ_{eff} (%)	ε_{15} (%)	ε_{Nc} (%)	Settlement (inch)	Settlement (inch)	$\Delta(N_1)_{60-Sr}$	$(N_1)_{60-Sr}$	S_r/σ_{v0}'
18.10	0.0000	0.01	0.00	1.996	1649	1154	0.00071	0.90063	4227	0.72994	3.445	2.881	0.00	0.00	N/A	N/A	N/A
18.20	0.0000	0.01	0.00	2.003	1654	1113	0.00074	0.90331	4218	0.84897	4.196	3.508	0.00	0.00	N/A	N/A	N/A

CONE PENETRATION TEST-BASED LIQUEFACTION ANALYSIS BASED ON IDRISS & BOULANGER (2008)

References:

1 - Idriss, I.M. and Boulanger, R.W. (2008). *Soil Liquefaction During Earthquakes* , Earthquake Engineering Research Institute, EERI Publication MNO-12.
2 - Ishihara, K. and Yoshimine, M. (1992). "Evaluation of Settlements in Sand Deposits Following Liquefaction During Earthquakes," *Soils and Foundations* , Vol. 32, No. 1, pp. 173-188, March 1992.
3 - Tokimatsu, K. and Seed H.B. (1987). "Evaluation of Settlements in Sands Due to Earthquake Shaking," Journal of Geotechnical Engineering, Vol. 113, No. 8, August.
4 - Pradel, D. (1998). "Procedure to Evaluate Earthquake-Induced Settlements in Sand," Journal of Geotechnical and Geoenvironmental Engineering, Vol. 124, No. 4, April.
5 - Cetin, K.O., Bilge, H.T., Wu, J., Kammerer, A.M., and Seed R.B. (2009). "Procedure to Evaluate Earthquake-Induced Settlements in Sand," Journal of Geotechnical and Geoenvironmental Engineering, Vol. 135, No. 3, March.
6 - Boulanger, R.W. and Idriss, I.M. (2014). "CPT and SPT Based Liquefaction Triggering Procedures," Report No. UCD/CGM-14/01, University of California at Davis

Project	**Chevron Guadalupe Tank Battery 9 Site**
Test Boring No	**TSMACPT-5**

Test Boring Information:

Approx. depth to ground water table		32.7 ft	9.97 m
Moist unit weight of soil	γ_m	115 pcf	18.08 kN/m^3
Saturated unit weight of soil	γ_{sat}	125 pcf	19.65 kN/m^3

Earthquake Information:

Earthquake magnitude	M_w	6.9
Peak horizontal ground surface acceleratio	a_{max}	0.490 g
Number of equivalent cycle	N	10.1
Atmospheric pressure	P_a	101.3 kPa

N/L = Non-liquefiable clay-like soil
N.A. = Not Applicable

Settlement of Liquefiable Soil	Settlement of Unsaturated Sand	Total
Sum 0.10	Sum **0.02**	**0.12**

Factor of Safety Agaist Liquefaction (Idriss & Boulanger, 2008 and Boulanger & Idriss, 2014)

Depth, Z (m)	Depth, Z (ft)	q_c (kPa)	f_s (kPa)	σ_{vc} (kPa)	σ'_{vc} (kPa)	Q	F	I_c	Soil Type	Fines (%)	Interpreted q_c	C_N	q_{c1N}	q_{c1N-cs}	Stress Reduction Factor (r_d)	CSR	K_σ for sand	$CRR_{M=7.5}$ at σ'_{vc}=1	MSF_{max}	MSF	CRR	$(FS)_L$
1.60	5.25	31586	249	28.9	28.9	583	0.79	1.3	Unsaturated	6	31586	1.39	434.9	435.3	0.99	0.315	1.1	2.000	2.20	1.257	2.000	**N/L**
1.70	5.58	25670	200	30.7	30.7	460	0.78	1.4	Unsaturated	7	25670	1.37	347.9	350.4	0.99	0.315	1.1	2.000	2.20	1.257	2.000	**N/L**
1.80	5.90	26948	129	32.5	32.5	469	0.48	1.2	Unsaturated	4	26948	1.35	359.7	359.7	0.99	0.315	1.1	2.000	2.20	1.257	2.000	**N/L**
1.90	6.23	27116	119	34.3	34.3	459	0.44	1.2	Unsaturated	4	27116	1.33	356.8	356.9	0.99	0.314	1.1	2.000	2.20	1.257	2.000	**N/L**
2.00	6.56	25570	113	36.2	36.2	422	0.44	1.2	Unsaturated	4	25570	1.31	332.0	332.0	0.99	0.314	1.1	2.000	2.20	1.257	2.000	**N/L**
2.10	6.89	23499	96	38.0	38.0	378	0.41	1.2	Unsaturated	4	23499	1.29	301.2	301.2	0.98	0.314	1.1	2.000	2.20	1.257	2.000	**N/L**
2.20	7.22	22307	102	39.8	39.8	351	0.46	1.3	Unsaturated	6	22307	1.28	282.4	282.6	0.98	0.313	1.1	2.000	2.20	1.257	2.000	**N/L**
2.30	7.54	21077	93	41.6	41.6	324	0.44	1.3	Unsaturated	6	21077	1.26	263.7	264.0	0.98	0.313	1.1	2.000	2.20	1.257	2.000	**N/L**
2.40	7.87	20321	94	43.4	43.4	306	0.46	1.3	Unsaturated	6	20321	1.25	251.4	251.7	0.98	0.312	1.1	2.000	2.20	1.257	2.000	**N/L**
2.50	8.20	19404	93	45.2	45.2	286	0.48	1.4	Unsaturated	7	19404	1.24	237.5	239.4	0.98	0.312	1.1	2.000	2.20	1.257	2.000	**N/L**
2.60	8.53	18958	92	47.0	47.0	274	0.49	1.4	Unsaturated	7	18958	1.22	229.7	231.5	0.98	0.312	1.1	2.000	2.20	1.257	2.000	**N/L**
2.70	8.86	18129	91	48.8	48.8	257	0.50	1.4	Unsaturated	7	18129	1.21	217.5	219.2	0.98	0.311	1.1	2.000	2.20	1.257	2.000	**N/L**
2.80	9.18	16893	85	50.6	50.6	235	0.50	1.4	Unsaturated	7	16893	1.20	200.7	202.4	0.98	0.311	1.1	2.164	2.20	1.257	2.000	**N/L**
2.90	9.51	16389	81	52.4	52.4	224	0.50	1.4	Unsaturated	7	16389	1.19	192.9	194.5	0.97	0.310	1.1	1.407	2.20	1.257	1.946	**N/L**
3.00	9.84	15619	78	54.2	54.2	210	0.50	1.5	Unsaturated	8	15619	1.18	182.2	188.6	0.97	0.310	1.1	1.051	2.20	1.257	1.453	**N/L**
3.10	10.17	15037	77	56.0	56.0	199	0.51	1.5	Unsaturated	8	15037	1.17	173.9	180.1	0.97	0.309	1.1	0.728	2.09	1.234	0.988	**N/L**
3.20	10.50	15108	66	57.8	57.8	197	0.44	1.5	Unsaturated	8	15108	1.16	173.3	179.4	0.97	0.309	1.1	0.709	2.08	1.232	0.961	**N/L**
3.30	10.82	15485	66	59.7	59.7	198	0.43	1.4	Unsaturated	7	15485	1.15	176.2	177.7	0.97	0.309	1.1	0.663	2.05	1.226	0.894	**N/L**
3.40	11.15	16639	72	61.5	61.5	210	0.43	1.4	Unsaturated	7	16639	1.14	187.8	189.4	0.97	0.308	1.1	1.093	2.20	1.257	1.512	**N/L**
3.50	11.48	18035	81	63.3	63.3	224	0.45	1.4	Unsaturated	7	18035	1.13	202.0	203.7	0.97	0.308	1.1	2.341	2.20	1.257	2.000	**N/L**
3.60	11.81	19369	67	65.1	65.1	238	0.35	1.3	Unsaturated	6	19369	1.12	215.3	215.5	0.96	0.307	1.1	2.000	2.20	1.257	2.000	**N/L**
3.70	12.14	22127	70	66.9	66.9	268	0.32	1.3	Unsaturated	6	22127	1.11	244.2	244.4	0.96	0.307	1.1	2.000	2.20	1.257	2.000	**N/L**
3.80	12.46	25582	80	68.7	68.7	306	0.31	1.2	Unsaturated	4	25582	1.11	280.4	280.4	0.96	0.306	1.1	2.000	2.20	1.257	2.000	**N/L**
3.90	12.79	29273	102	70.5	70.5	346	0.35	1.2	Unsaturated	4	29273	1.10	318.7	318.7	0.96	0.306	1.1	2.000	2.20	1.257	2.000	**N/L**
4.00	13.12	32978	112	72.3	72.3	384	0.34	1.2	Unsaturated	4	32978	1.09	356.6	356.6	0.96	0.305	1.1	2.000	2.20	1.257	2.000	**N/L**
4.10	13.45	35415	125	74.1	74.1	408	0.35	1.2	Unsaturated	4	35415	1.09	380.5	380.5	0.96	0.305	1.1	2.000	2.20	1.257	2.000	**N/L**
4.20	13.78	35934	126	75.9	75.9	409	0.35	1.2	Unsaturated	4	35934	1.08	383.6	383.6	0.96	0.304	1.1	2.000	2.20	1.257	2.000	**N/L**
4.30	14.10	34840	134	77.7	77.7	392	0.38	1.2	Unsaturated	4	34840	1.07	369.6	369.6	0.95	0.304	1.1	2.000	2.20	1.257	2.000	**N/L**
4.40	14.43	32320	152	79.5	79.5	359	0.47	1.3	Unsaturated	6	32320	1.07	340.8	341.1	0.95	0.303	1.1	2.000	2.20	1.257	2.000	**N/L**
4.50	14.76	30178	155	81.4	81.4	332	0.52	1.3	Unsaturated	6	30178	1.06	316.3	316.6	0.95	0.303	1.1	2.000	2.20	1.257	2.000	**N/L**
4.60	15.09	29402	140	83.2	83.2	319	0.48	1.3	Unsaturated	6	29402	1.05	306.4	306.7	0.95	0.303	1.1	2.000	2.20	1.257	2.000	**N/L**
4.70	15.42	31364	140	85.0	85.0	337	0.45	1.3	Unsaturated	6	31364	1.05	325.0	325.3	0.95	0.302	1.1	2.000	2.20	1.257	2.000	**N/L**
4.80	15.74	35766	150	86.8	86.8	381	0.42	1.2	Unsaturated	4	35766	1.04	368.6	368.6	0.95	0.302	1.0	2.000	2.20	1.257	2.000	**N/L**
4.90	16.07	38377	160	88.6	88.6	404	0.42	1.2	Unsaturated	4	38377	1.04	393.4	393.4	0.95	0.301	1.0	2.000	2.20	1.257	2.000	**N/L**
5.00	16.40	39967	167	90.4	90.4	417	0.42	1.2	Unsaturated	4	39967	1.03	407.5	407.5	0.94	0.301	1.0	2.000	2.20	1.257	2.000	**N/L**
5.10	16.73	42086	184	92.2	92.2	435	0.44	1.2	Unsaturated	4	42086	1.02	426.8	426.8	0.94	0.300	1.0	2.000	2.20	1.257	2.000	**N/L**
5.20	17.06	38203	187	94.0	94.0	391	0.49	1.3	Unsaturated	6	38203	1.02	385.5	385.8	0.94	0.300	1.0	2.000	2.20	1.257	2.000	**N/L**
5.30	17.38	33370	178	95.8	95.8	338	0.54	1.3	Unsaturated	6	33370	1.01	335.0	335.3	0.94	0.299	1.0	2.000	2.20	1.257	2.000	**N/L**
5.40	17.71	26520	179	97.6	97.6	266	0.68	1.5	Unsaturated	8	26520	1.01	264.9	273.2	0.94	0.299	1.0	2.000	2.20	1.257	2.000	**N/L**
5.50	18.04	22009	103	99.4	99.4	218	0.47	1.4	Unsaturated	7	22009	1.00	218.8	220.6	0.94	0.298	1.0	2.000	2.20	1.257	2.000	**N/L**
5.60	18.37	21097	97	101.2	101.2	207	0.46	1.5	Unsaturated	8	21097	1.00	208.8	215.7	0.93	0.297	1.0	2.000	2.20	1.257	2.000	**N/L**
5.70	18.70	21292	104	103.0	103.0	207	0.49	1.5	Unsaturated	8	21292	0.99	209.7	216.7	0.93	0.297	1.0	2.000	2.20	1.257	2.000	**N/L**
5.80	19.02	22342	109	104.9	104.9	216	0.49	1.5	Unsaturated	8	22342	0.99	219.0	226.3	0.93	0.296	1.0	2.000	2.20	1.257	2.000	**N/L**
5.90	19.35	23614	128	106.7	106.7	226	0.55	1.5	Unsaturated	8	23614	0.99	230.5	237.9	0.93	0.296	1.0	2.000	2.20	1.257	2.000	**N/L**
6.00	19.68	24464	146	108.5	108.5	232	0.60	1.5	Unsaturated	8	24464	0.98	237.7	245.4	0.93	0.295	1.0	2.000	2.20	1.257	2.000	**N/L**
6.10	20.01	25172	154	110.3	110.3	237	0.62	1.5	Unsaturated	8	25172	0.98	243.5	251.3	0.93	0.295	1.0	2.000	2.20	1.257	2.000	**N/L**
6.20	20.34	26083	161	112.1	112.1	244	0.62	1.5	Unsaturated	8	26083	0.97	251.3	259.2	0.92	0.294	1.0	2.000	2.20	1.257	2.000	**N/L**
6.30	20.66	26561	159	113.9	113.9	246	0.60	1.5	Unsaturated	8	26561	0.97	254.8	262.8	0.92	0.294	1.0	2.000	2.20	1.257	2.000	**N/L**
6.40	20.99	26812	153	115.7	115.7	247	0.57	1.5	Unsaturated	8	26812	0.96	256.1	264.2	0.92	0.293	1.0	2.000	2.20	1.257	2.000	**N/L**
6.50	21.32	27594	157	117.5	117.5	252	0.57	1.4	Unsaturated	7	27594	0.96	262.5	264.5	0.92	0.293	1.0	2.000	2.20	1.257	2.000	**N/L**
6.60	21.65	27924	179	119.3	119.3	253	0.64	1.5	Unsaturated	8	27924	0.96	264.6	272.9	0.92	0.292	0.9	2.000	2.20	1.257	2.000	**N/L**
6.70	21.98	27927	181	121.1	121.1	251	0.65	1.5	Unsaturated	8	27927	0.95	263.6	271.8	0.92	0.292	0.9	2.000	2.20	1.257	2.000	**N/L**
6.80	22.30	28317	155	122.9	122.9	253	0.55	1.4	Unsaturated	7	28317	0.95	266.2	268.2	0.91	0.291	0.9	2.000	2.20	1.257	2.000	**N/L**
6.90	22.63	28697	160	124.7	124.7	254	0.56	1.4	Unsaturated	7	28697	0.95	268.7	270.8	0.91	0.291	0.9	2.000	2.20	1.257	2.000	**N/L**
7.00	22.96	29037	181	126.5	126.5	255	0.63	1.5	Unsaturated	8	29037	0.94	270.9	279.3	0.91	0.290	0.9	2.000	2.20	1.257	2.000	**N/L**
7.10	23.29	28983	198	128.4	128.4	253	0.68	1.5	Unsaturated	8	28983	0.94	269.4	277.8	0.91	0.289	0.9	2.000	2.20	1.257	2.000	**N/L**
7.20	23.62	28876	190	130.2	130.2	250	0.66	1.5	Unsaturated	8	28876	0.94	267.4	275.8	0.91	0.289	0.9	2.000	2.20	1.257	2.000	**N/L**
7.30	23.94	28880	190	132.0	132.0	249	0.66	1.5	Unsaturated	8	28880	0.93	266.5	274.8	0.91	0.288	0.9	2.000	2.20	1.257	2.000	**N/L**
7.40	24.27	28559	196	133.8	133.8	244	0.69	1.5	Unsaturated	8	28559	0.93	262.6	270.8	0.90	0.288	0.9	2.000	2.20	1.257	2.000	**N/L**
7.50	24.60	28116	198	135.6	135.6	239	0.71	1.5	Unsaturated	8	28116	0.93	257.6	265.7	0.90	0.287	0.9	2.000	2.20	1.257	2.000	**N/L**
7.60	24.93	27688	186	137.4	137.4	234	0.67	1.5	Unsaturated	8	27688	0.92	252.8	260.8	0.90	0.287	0.9	2.000	2.20	1.257	2.000	**N/L**
7.70	25.26	27520	175	139.2	139.2	231	0.64	1.5	Unsaturated	8	27520	0.92	250.4	258.3	0.90	0.286	0.9	2.000	2.20	1.257	2.000	**N/L**
7.80	25.58	27166	176	141.0	141.0	226	0.65	1.5	Unsaturated	8	27166	0.92	246.3	254.2	0.90	0.286	0.9	2.000	2.20	1.257	2.000	**N/L**
7.90	25.91	26844	180	142.8	142.8	222	0.67	1.5	Unsaturated	8	26844	0.91	242.6	250.3	0.89	0.285	0.9	2.000	2.20	1.257	2.000	**N/L**
8.00	26.24	26709	174	144.6	144.6	219	0.66	1.5	Unsaturated	8	26709	0.91	240.5	248.3	0.89	0.284	0.9	2.000	2.20	1.257	2.000	**N/L**
8.10	26.57	26576	173	146.4	146.4	217	0.66	1.5	Unsaturated	8	26576	0.91	238.6	246.2	0.89	0.284	0.9	2.000	2.20	1.257	2.000	**N/L**
8.20	26.90	26476	186	148.2	148.2	215	0.71	1.6	Unsaturated	10	26476	0.90	236.9	255.7	0.89	0.283	0.9	2.000	2.20	1.257	2.000	**N/L**
8.30	27.22	26414	178	150.0	150.0	213	0.68	1.6	Unsaturated	10	26414	0.90	235.6	254.3	0.89	0.283	0.9	2.000	2.20	1.257	2.000	**N/L**
8.40	27.55	26181	178	151.9	151.9	210	0.68	1.6	Unsaturated	10	26181	0.90	232.8	251.3	0.89	0.282	0.9	2.000	2.20	1.257	2.000	**N/L**
8.50	27.88	25927	170	153.7	153.7	207	0.66	1.6	Unsaturated	10	25927	0.90	229.8	248.2	0.88	0.281	0.9	2.000	2.20	1.257	2.000	**N/L**
8.60	28.21	26836	165	155.5	155.5	213	0.62	1.5	Unsaturated	8	26836	0.89	237.1	244.8	0.88	0.281	0.9	2.000	2.20	1.257	2.000	**N/L**
8.70	28.54	27036	162	157.3	157.3	213	0.60	1.5	Unsaturated	8	27036	0.89	238.2	245.8	0.88	0.280	0.9	2.000	2.20	1.257	2.000	**N/L**
8.80	28.86	27691	178	159.1	159.1	217	0.65	1.5	Unsaturated	8	27691	0.89	243.2	251.0	0.88	0.280	0.9	2.000	2.20	1.257	2.000	**N/L**

Settelemnt of Liquefiable Soil (Idriss and Boulnager, 2008) / Settlement of Unsaturated Sand (Tokimatsu & Seed, 1987, and Pradel, 1998) / Cumulative / S_r (Idriss & Boulanger, 2008)

Depth, Z (m)	q_t (kPa)	N_{60}	$N_{1,60}$	$\Delta(N_1)_{60}$	$N_{1,60-CS}$	Limiting Shear Strain γ_{lim}	Parameter F_α	Max. Shear Strain γ_{max}	ΔHi (m)	ΔLDI_i (m)	Vert. Recon. Strain ε_v	DF_i	ΔSi (inch)	$p = \sigma_m$ (tsf)	τ_{ave} (psf)	G_{max} (tsf)	τ_{ave}/G_{max}	a	b	γ_{eff} (%)	ε_{15} (%)	ε_{Nc} (%)	Settlement (inch)	Cumulative Settlement (inch)	$\Delta(N_1)_{60-Sr}$	$(N_1)_{60-Sr}$	S_r/σ_{v0}'
1.60	30869	50.0	69.5	0.0	N.A.	0.000	0.000	0.000	0.05	0.0000	0.0000	0.91	0.00	0.202	192	4654	0.00002	0.20272	16691	0.00220	0.000	0.000	0.00	0.12	N/A	N/A	N/A
1.70	26200	43.7	59.9	0.1	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.91	0.00	0.215	204	4132	0.00002	0.20764	16095	0.00267	0.001	0.001	0.00	0.12	N/A	N/A	N/A
1.80	26869	42.2	56.9	0.0	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.90	0.00	0.228	216	4043	0.00003	0.21256	15552	0.00291	0.001	0.001	0.00	0.12	N/A	N/A	N/A
1.90	26974	42.4	56.3	0.0	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.90	0.00	0.240	228	4111	0.00003	0.21749	15056	0.00302	0.001	0.001	0.00	0.12	N/A	N/A	N/A
2.00	25516	40.1	52.6	0.0	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.89	0.00	0.253	239	3936	0.00003	0.22241	14600	0.00335	0.001	0.001	0.00	0.12	N/A	N/A	N/A
2.10	23599	37.1	48.0	0.0	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.89	0.00	0.266	251	3683	0.00003	0.22733	14178	0.00381	0.001	0.001	0.00	0.12	N/A	N/A	N/A
2.20	22268	36.0	46.1	0.0	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.88	0.00	0.278	263	3620	0.00004	0.23225	13788	0.00408	0.001	0.001	0.00	0.12	N/A	N/A	N/A
2.30	21166	34.3	43.3	0.0	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.87	0.00	0.291	275	3477	0.00004	0.23717	13425	0.00449	0.002	0.001	0.00	0.12	N/A	N/A	N/A
2.40	20310	32.9	41.1	0.0	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.87	0.00	0.304	287	3370	0.00004	0.24209	13087	0.00487	0.002	0.002	0.00	0.12	N/A	N/A	N/A
2.50	19523	32.6	40.3	0.1	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.86	0.00	0.316	299	3373	0.00004	0.24701	12770	0.00509	0.002	0.002	0.00	0.12	N/A	N/A	N/A
2.60	18938	31.6	38.7	0.1	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.86	0.00	0.329	310	3302	0.00005	0.25193	12473	0.00545	0.002	0.002	0.00	0.12	N/A	N/A	N/A
2.70	18056	30.1	36.5	0.1	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.85	0.00	0.342	322	3177	0.00005	0.25685	12194	0.00596	0.003	0.002	0.00	0.11	N/A	N/A	N/A
2.80	16975	28.3	34.0	0.1	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.85	0.00	0.354	334	3012	0.00006	0.26177	11931	0.00662	0.004	0.003	0.00	0.11	N/A	N/A	N/A
2.90	16358	27.3	32.5	0.1	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.84	0.00	0.367	346	2927	0.00006	0.26669	11682	0.00714	0.004	0.003	0.00	0.11	N/A	N/A	N/A
3.00	15602	26.9	31.7	0.4	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.84	0.00	0.379	357	2905	0.00006	0.27161	11447	0.00749	0.004	0.004	0.00	0.11	N/A	N/A	N/A
3.10	15037	25.9	30.3	0.4	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.83	0.00	0.392	369	2821	0.00007	0.27653	11224	0.00807	0.005	0.004	0.00	0.11	N/A	N/A	N/A
3.20	15064	26.0	30.1	0.4	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.83	0.00	0.405	381	2848	0.00007	0.28145	11012	0.00828	0.005	0.004	0.00	0.11	N/A	N/A	N/A
3.30	15484	25.9	29.7	0.1	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.82	0.00	0.417	392	2856	0.00007	0.28637	10811	0.00855	0.005	0.004	0.00	0.11	N/A	N/A	N/A
3.40	16582	27.7	31.6	0.1	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.81	0.00	0.430	404	3081	0.00007	0.29129	10619	0.00804	0.005	0.004	0.00	0.11	N/A	N/A	N/A
3.50	18006	30.1	34.0	0.1	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.81	0.00	0.443	415	3368	0.00006	0.29621	10436	0.00744	0.004	0.003	0.00	0.11	N/A	N/A	N/A
3.60	19630	31.8	35.7	0.0	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.80	0.00	0.455	427	3584	0.00006	0.30113	10261	0.00712	0.004	0.003	0.00	0.11	N/A	N/A	N/A
3.70	22126	35.8	39.9	0.0	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.80	0.00	0.468	438	4066	0.00005	0.30605	10093	0.00631	0.003	0.002	0.00	0.11	N/A	N/A	N/A
3.80	25570	40.2	44.5	0.0	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.79	0.00	0.481	450	4590	0.00005	0.31097	9933	0.00563	0.002	0.002	0.00	0.11	N/A	N/A	N/A
3.90	29463	46.3	50.9	0.0	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.79	0.00	0.493	461	5321	0.00004	0.31589	9780	0.00489	0.002	0.001	0.00	0.11	N/A	N/A	N/A
4.00	33014	51.9	56.7	0.0	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.78	0.00	0.506	473	5998	0.00004	0.32081	9632	0.00438	0.001	0.001	0.00	0.11	N/A	N/A	N/A
4.10	35194	55.3	60.0	0.0	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.78	0.00	0.519	484	6432	0.00004	0.32573	9490	0.00416	0.001	0.001	0.00	0.11	N/A	N/A	N/A
4.20	35687	56.1	60.5	0.0	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.77	0.00	0.531	496	6559	0.00004	0.33065	9354	0.00418	0.001	0.001	0.00	0.11	N/A	N/A	N/A
4.30	34782	54.7	58.6	0.0	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.76	0.00	0.544	507	6429	0.00004	0.33557	9223	0.00438	0.001	0.001	0.00	0.11	N/A	N/A	N/A
4.40	32550	52.7	56.1	0.0	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.76	0.00	0.557	518	6232	0.00004	0.34049	9097	0.00464	0.001	0.001	0.00	0.11	N/A	N/A	N/A
4.50	30393	49.2	52.1	0.0	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.75	0.00	0.569	530	5850	0.00005	0.34541	8975	0.00511	0.002	0.001	0.00	0.11	N/A	N/A	N/A
4.60	29799	48.2	50.8	0.0	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.75	0.00	0.582	541	5766	0.00005	0.35033	8857	0.00532	0.002	0.001	0.00	0.11	N/A	N/A	N/A
4.70	31820	51.5	53.9	0.0	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.74	0.00	0.594	552	6188	0.00004	0.35525	8744	0.00502	0.002	0.001	0.00	0.11	N/A	N/A	N/A
4.80	35628	56.0	58.3	0.0	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.74	0.00	0.607	563	6758	0.00004	0.36017	8634	0.00464	0.001	0.001	0.00	0.11	N/A	N/A	N/A
4.90	38326	60.2	62.3	0.0	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.73	0.00	0.620	574	7305	0.00004	0.36509	8528	0.00435	0.001	0.001	0.00	0.11	N/A	N/A	N/A
5.00	39889	62.7	64.5	0.0	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.73	0.00	0.632	586	7640	0.00004	0.37001	8425	0.00423	0.001	0.001	0.00	0.11	N/A	N/A	N/A
5.10	41189	64.7	66.3	0.0	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.72	0.00	0.645	597	7926	0.00004	0.37493	8326	0.00414	0.001	0.001	0.00	0.11	N/A	N/A	N/A
5.20	38529	62.4	63.6	0.0	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.72	0.00	0.658	608	7674	0.00004	0.37985	8229	0.00438	0.001	0.001	0.00	0.11	N/A	N/A	N/A
5.30	33128	53.6	54.4	0.0	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.71	0.00	0.670	619	6628	0.00005	0.38477	8136	0.00527	0.002	0.001	0.00	0.11	N/A	N/A	N/A
5.40	26389	45.5	45.9	0.4	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.70	0.00	0.683	630	5645	0.00006	0.38969	8045	0.00646	0.002	0.002	0.00	0.11	N/A	N/A	N/A
5.50	22009	36.7	36.9	0.1	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.70	0.00	0.696	641	4581	0.00007	0.39461	7957	0.00846	0.004	0.003	0.00	0.11	N/A	N/A	N/A
5.60	21097	36.4	36.3	0.4	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.69	0.00	0.708	651	4552	0.00007	0.39953	7871	0.00870	0.004	0.004	0.00	0.11	N/A	N/A	N/A
5.70	21402	36.9	36.7	0.4	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.69	0.00	0.721	662	4637	0.00007	0.40446	7788	0.00867	0.004	0.004	0.00	0.11	N/A	N/A	N/A
5.80	22350	38.5	38.1	0.4	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.68	0.00	0.734	673	4862	0.00007	0.40938	7707	0.00834	0.004	0.003	0.00	0.11	N/A	N/A	N/A
5.90	23568	40.6	40.0	0.4	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.68	0.00	0.746	684	5148	0.00007	0.41430	7629	0.00793	0.003	0.003	0.00	0.11	N/A	N/A	N/A
6.00	24439	42.1	41.3	0.4	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.67	0.00	0.759	695	5359	0.00006	0.41922	7552	0.00769	0.003	0.003	0.00	0.11	N/A	N/A	N/A
6.10	25189	43.4	42.4	0.4	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.67	0.00	0.772	705	5546	0.00006	0.42414	7478	0.00751	0.003	0.003	0.00	0.11	N/A	N/A	N/A
6.20	26028	44.9	43.6	0.4	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.66	0.00	0.784	716	5752	0.00006	0.42906	7405	0.00732	0.003	0.002	0.00	0.11	N/A	N/A	N/A
6.30	26599	45.8	44.4	0.4	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.66	0.00	0.797	727	5901	0.00006	0.43398	7334	0.00722	0.003	0.002	0.00	0.11	N/A	N/A	N/A
6.40	26948	46.4	44.8	0.4	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.65	0.00	0.810	737	6000	0.00006	0.43890	7265	0.00720	0.003	0.002	0.00	0.11	N/A	N/A	N/A
6.50	27536	46.0	44.2	0.1	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.64	0.00	0.822	748	5962	0.00006	0.44382	7198	0.00737	0.003	0.002	0.00	0.11	N/A	N/A	N/A
6.60	27878	48.0	46.0	0.4	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.64	0.00	0.835	758	6253	0.00006	0.44874	7132	0.00708	0.003	0.002	0.00	0.11	N/A	N/A	N/A
6.70	27967	48.2	45.9	0.4	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.63	0.00	0.847	769	6295	0.00006	0.45366	7068	0.00713	0.003	0.002	0.00	0.11	N/A	N/A	N/A
6.80	28309	47.3	44.9	0.1	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.63	0.00	0.860	779	6195	0.00006	0.45858	7006	0.00738	0.003	0.002	0.00	0.11	N/A	N/A	N/A
6.90	28648	47.8	45.2	0.1	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.62	0.00	0.873	789	6291	0.00006	0.46350	6945	0.00736	0.003	0.002	0.00	0.11	N/A	N/A	N/A
7.00	29008	50.0	47.1	0.4	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.62	0.00	0.885	800	6597	0.00006	0.46842	6885	0.00706	0.003	0.002	0.00	0.11	N/A	N/A	N/A
7.10	29030	50.0	47.0	0.4	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.61	0.00	0.898	810	6625	0.00006	0.47334	6827	0.00713	0.003	0.002	0.00	0.11	N/A	N/A	N/A
7.20	28875	49.8	46.5	0.4	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.61	0.00	0.911	820	6611	0.00006	0.47826	6770	0.00725	0.003	0.002	0.00	0.11	N/A	N/A	N/A
7.30	28807	49.6	46.3	0.4	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.60	0.00	0.923	830	6617	0.00006	0.48318	6714	0.00734	0.003	0.002	0.00	0.11	N/A	N/A	N/A
7.40	28512	49.1	45.6	0.4	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.60	0.00	0.936	840	6570	0.00006	0.48810	6659	0.00751	0.003	0.002	0.00	0.11	N/A	N/A	N/A
7.50	28064	48.4	44.7	0.4	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.59	0.00	0.949	850	6487	0.00007	0.49302	6606	0.00773	0.003	0.002	0.00	0.11	N/A	N/A	N/A
7.60	27669	47.7	44.0	0.4	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.58	0.00	0.961	860	6416	0.00007	0.49794	6553	0.00794	0.003	0.003	0.00	0.11	N/A	N/A	N/A
7.70	27478	47.4	43.5	0.4	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.58	0.00	0.974	870	6392	0.00007	0.50286	6502	0.00808	0.003	0.003	0.00	0.11	N/A	N/A	N/A
7.80	27118	46.7	42.8	0.4	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.57	0.00	0.987	880	6327	0.00007	0.50778	6452	0.00828	0.003	0.003	0.00	0.11	N/A	N/A	N/A
7.90	26785	46.2	42.1	0.4	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.57	0.00	0.999	890	6268	0.00007	0.51270	6403	0.00849	0.003	0.003	0.00	0.11	N/A	N/A	N/A
8.00	26659	45.9	41.8	0.4	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.56	0.00	1.012	900	6257	0.00007	0.51762	6355	0.00861	0.004	0.003	0.00	0.11	N/A	N/A	N/A
8.10	26629	45.9	41.6	0.4	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.56	0.00	1.025	910	6269	0.00007	0.52254	6308	0.00870	0.004	0.003	0.00	0.11	N/A	N/A	N/A
8.20	26624	47.4	42.8	0.9	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.55	0.00	1.037	920	6495	0.00007	0.52746	6261	0.00844	0.003	0.003	0.00	0.10	N/A	N/A	N/A
8.30	26466	47.1	42.5	0.9	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.55	0.00	1.050	929	6475	0.00007	0.53238	6216	0.00858	0.003	0.003	0.00	0.10	N/A	N/A	N/A
8.40	26072	46.4	41.7	0.9	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.54	0.00	1.062	939	6397	0.00007	0.53730	6171	0.00881	0.004	0.003	0.00	0.10	N/A	N/A	N/A
8.50	25927	46.2	41.3	0.9	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.54	0.00	1.075	948	6379	0.00007	0.54222	6128	0.00894	0.004	0.003	0.00	0.10	N/A	N/A	N/A
8.60	26628	45.9	41.0	0.4	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.53	0.00	1.088	958	6358	0.00008	0.54714	6085	0.00908	0.004	0.003	0.00	0.10	N/A	N/A	N/A
8.70	27063	46.6	41.5	0.4	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.52	0.00	1.100	967	6479	0.00007	0.55206	6043	0.00898	0.004	0.003	0.00	0.10	N/A	N/A	N/A
8.80	27611	47.6	42.2	0.4	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.52	0.00	1.113	977	6628	0.00007	0.55698	6002	0.00883	0.004	0.003	0.00	0.10	N/A	N/A	N/A

Depth, Z (m)	Depth, Z (ft)	q_c (kPa)	f_s (kPa)	σ_{vc} (kPa)	σ'_{vc} (kPa)	Q	F	I_c	Soil Type	Fines (%)	Interpreted q_c	C_N	q_{c1N}	q_{c1N-cs}	Stress Reduction Factor (r_d)	CSR	K_σ for sand
8.90	29.19	27986	198	160.9	160.9	218	0.71	1.6	Unsaturated	10	27986	0.88	245.1	264.3	0.88	0.279	0.9
9.00	29.52	27842	192	162.7	162.7	216	0.69	1.6	Unsaturated	10	27842	0.88	243.1	262.2	0.87	0.279	0.9
9.10	29.85	28072	196	164.5	164.5	216	0.70	1.6	Unsaturated	10	28072	0.88	244.4	263.6	0.87	0.278	0.9
9.20	30.18	26364	194	166.3	166.3	202	0.74	1.6	Unsaturated	10	26364	0.88	228.8	247.1	0.87	0.277	0.9
9.30	30.50	25791	191	168.1	168.1	196	0.75	1.6	Unsaturated	10	25791	0.87	223.2	241.2	0.87	0.277	0.8
9.40	30.83	25080	183	169.9	169.9	190	0.73	1.6	Unsaturated	10	25080	0.87	216.5	234.0	0.87	0.276	0.8
9.50	31.16	24089	164	171.7	171.7	181	0.68	1.6	Unsaturated	10	24089	0.87	207.3	224.4	0.87	0.276	0.8
9.60	31.49	23902	153	173.5	173.5	179	0.64	1.6	Unsaturated	10	23902	0.87	205.2	222.1	0.86	0.275	0.8
9.70	31.82	24254	153	175.4	175.4	181	0.64	1.6	Unsaturated	10	24254	0.86	207.6	224.7	0.86	0.274	0.8
9.80	32.14	24965	158	177.2	177.2	185	0.64	1.6	Unsaturated	10	24965	0.86	213.1	230.5	0.86	0.274	0.8
9.90	32.47	25644	160	179.0	179.0	189	0.63	1.6	Unsaturated	10	25644	0.86	218.3	236.0	0.86	0.273	0.8
10.00	32.80	26849	160	180.8	180.5	197	0.60	1.5		8	26849	0.86	228.1	235.5	0.86	0.273	0.8
10.10	33.13	28576	169	182.8	181.5	209	0.59	1.5		8	28576	0.86	242.4	250.2	0.85	0.274	0.8
10.20	33.46	27762	184	184.8	182.5	203	0.67	1.6		10	27762	0.86	235.2	253.8	0.85	0.275	0.8
10.30	33.78	26390	178	186.7	183.5	192	0.68	1.6		10	26390	0.85	223.2	241.2	0.85	0.276	0.8
10.40	34.11	25980	174	188.7	184.5	189	0.67	1.6		10	25980	0.85	219.4	237.2	0.85	0.276	0.8
10.50	34.44	25220	162	190.7	185.4	183	0.65	1.6		10	25220	0.85	212.7	230.1	0.85	0.277	0.8
10.60	34.77	26499	159	192.6	186.4	191	0.60	1.6		10	26499	0.85	223.2	241.2	0.84	0.278	0.8
10.70	35.10	29804	169	194.6	187.4	215	0.57	1.5		8	29804	0.85	250.7	258.6	0.84	0.279	0.8
10.80	35.42	30435	190	196.5	188.4	219	0.63	1.5		8	30435	0.85	255.6	263.7	0.84	0.279	0.8
10.90	35.75	27977	179	198.5	189.4	201	0.65	1.6		10	27977	0.85	234.7	253.3	0.84	0.280	0.8
11.00	36.08	25706	174	200.5	190.4	184	0.68	1.6		10	25706	0.85	215.3	232.8	0.84	0.281	0.8
11.10	36.41	23248	126	202.4	191.4	166	0.55	1.6		10	23248	0.84	194.5	210.8	0.84	0.281	0.8
11.20	36.74	23430	91	204.4	192.3	166	0.39	1.5		8	23430	0.84	195.7	202.4	0.83	0.282	0.8
11.30	37.06	23310	98	206.4	193.3	165	0.42	1.5		8	23310	0.84	194.5	201.1	0.83	0.283	0.8
11.40	37.39	22242	87	208.3	194.3	157	0.40	1.5		8	22242	0.84	185.3	191.7	0.83	0.283	0.8
11.50	37.72	18584	82	210.3	195.3	131	0.45	1.6		10	18584	0.84	154.6	168.6	0.83	0.284	0.9
11.60	38.05	8352	89	212.3	196.3	58	1.10	2.1		19	8352	0.84	69.4	111.8	0.83	0.284	0.9
11.70	38.38	3272	42	214.2	197.3	22	1.38	2.5		30	3272	0.84	27.2	65.3	0.82	0.285	0.9
11.80	38.70	1870	28	216.2	198.2	12	1.71	2.8	Clay-Like	41	1870	0.84	15.5	51.1	0.82	0.286	1.0
11.90	39.03	1559	13	218.2	199.2	9	1.00	2.8	Clay-Like	41	1559	0.84	12.9	47.5	0.82	0.286	1.0
12.00	39.36	1626	14	220.1	200.2	10	0.97	2.8	Clay-Like	41	1626	0.83	13.4	48.3	0.82	0.287	1.0
12.10	39.69	1670	15	222.1	201.2	10	1.06	2.8	Clay-Like	41	1670	0.83	13.8	48.7	0.82	0.287	1.0
12.20	40.02	1785	16	224.1	202.2	11	1.04	2.7	Clay-Like	37	1785	0.83	14.7	49.7	0.81	0.287	1.0
12.30	40.34	2106	44	226.0	203.2	13	2.32	2.8	Clay-Like	41	2106	0.83	17.3	53.5	0.81	0.288	0.9
12.40	40.67	3891	34	228.0	204.1	25	0.94	2.4		27	3891	0.83	32.0	70.7	0.81	0.288	0.9

Depth, Z (m)	$CRR_{M=7.5}$ at σ'_{vc}=1	MSF_{max}	MSF	CRR	$(FS)_L$	q_t (kPa)	N_{60}	$N_{1,60}$	$\Delta(N_1)_{60}$	$N_{1,60-CS}$	Limiting Shear Strain γ_{lim}	Parameter F_α	Max. Shear Strain γ_{max}	ΔHi (m)	ΔLDI_i (m)	Vert. Recon. Strain ε_v	DF_i
8.90	2.000	2.20	1.257	2.000	**N/L**	27891	49.7	43.9	0.9	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.51
9.00	2.000	2.20	1.257	2.000	**N/L**	27841	49.6	43.7	0.9	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.51
9.10	2.000	2.20	1.257	2.000	**N/L**	27821	49.5	43.6	0.9	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.50
9.20	2.000	2.20	1.257	2.000	**N/L**	26550	47.3	41.5	0.9	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.50
9.30	2.000	2.20	1.257	2.000	**N/L**	25741	45.8	40.1	0.9	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.49
9.40	2.000	2.20	1.257	2.000	**N/L**	25008	44.5	38.8	0.9	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.49
9.50	2.000	2.20	1.257	2.000	**N/L**	24126	43.0	37.3	0.9	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.48
9.60	2.000	2.20	1.257	2.000	**N/L**	23979	42.7	37.0	0.9	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.48
9.70	2.000	2.20	1.257	2.000	**N/L**	24458	43.6	37.7	0.9	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.47
9.80	2.000	2.20	1.257	2.000	**N/L**	25115	44.7	38.6	0.9	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.46
9.90	2.000	2.20	1.257	2.000	**N/L**	25790	45.9	39.5	0.9	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.46
10.00	2.000	2.20	1.257	2.000	**2.00**	26849	46.3	39.7	0.4	40.1	0.009	-0.810	0.000	0.10	0.0000	0.0000	0.45
10.10	2.000	2.20	1.257	2.000	**2.00**	28200	48.6	41.6	0.4	42.0	0.006	-0.957	0.000	0.10	0.0000	0.0000	0.45
10.20	2.000	2.20	1.257	2.000	**2.00**	27791	49.5	42.3	0.9	43.3	0.004	-1.054	0.000	0.10	0.0000	0.0000	0.44
10.30	2.000	2.20	1.257	2.000	**2.00**	26459	47.1	40.3	0.9	41.2	0.007	-0.894	0.000	0.10	0.0000	0.0000	0.44
10.40	2.000	2.20	1.257	2.000	**2.00**	25809	46.0	39.2	0.9	40.1	0.008	-0.814	0.000	0.10	0.0000	0.0000	0.43
10.50	2.000	2.20	1.257	2.000	**2.00**	25479	45.4	38.7	0.9	39.6	0.010	-0.772	0.000	0.10	0.0000	0.0000	0.43
10.60	2.000	2.20	1.257	2.000	**2.00**	26881	47.9	40.7	0.9	41.6	0.006	-0.929	0.000	0.10	0.0000	0.0000	0.42
10.70	2.000	2.20	1.257	2.000	**2.00**	29481	50.8	43.2	0.4	43.5	0.004	-1.075	0.000	0.10	0.0000	0.0000	0.42
10.80	2.000	2.20	1.257	2.000	**2.00**	30090	51.9	44.0	0.4	44.4	0.003	-1.140	0.000	0.10	0.0000	0.0000	0.41
10.90	2.000	2.20	1.257	2.000	**2.00**	28195	50.2	42.5	0.9	43.5	0.004	-1.069	0.000	0.10	0.0000	0.0000	0.40
11.00	2.000	2.20	1.257	2.000	**2.00**	25706	45.8	38.7	0.9	39.7	0.009	-0.778	0.000	0.10	0.0000	0.0000	0.40
11.10	3.668	2.20	1.257	2.000	**2.00**	23572	42.0	35.5	0.9	36.4	0.017	-0.537	0.000	0.10	0.0000	0.0000	0.39
11.20	2.168	2.20	1.257	2.000	**2.00**	23429	40.4	34.1	0.4	34.4	0.024	-0.396	0.000	0.10	0.0000	0.0000	0.39
11.30	2.012	2.20	1.257	2.000	**2.00**	23168	39.9	33.6	0.4	34.0	0.026	-0.366	0.000	0.10	0.0000	0.0000	0.38
11.40	1.222	2.20	1.257	1.296	**2.00**	22024	38.0	31.9	0.4	32.3	0.033	-0.247	0.000	0.10	0.0000	0.0000	0.38
11.50	0.481	1.91	1.196	0.503	**1.77**	17996	32.0	26.9	0.9	27.9	0.062	0.052	0.004	0.10	0.0004	0.0009	0.37
11.60	0.155	1.33	1.071	0.153	**0.54**	9023	19.3	16.2	4.3	20.5	0.150	0.489	0.150	0.10	0.0150	0.0225	0.37
11.70	0.104	1.14	1.030	0.101	**0.35**	3534	9.0	7.5	5.4	12.9	0.345	0.833	0.345	0.10	0.0345	0.0319	0.36
11.80	0.093	1.11	1.024	0.091	**N/L**	2053	6.1	5.1	5.6	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.35
11.90	0.091	1.11	1.023	0.088	**N/L**	1574	4.7	3.9	5.6	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.35
12.00	0.091	1.11	1.023	0.089	**N/L**	1618	4.8	4.0	5.6	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.34
12.10	0.091	1.11	1.024	0.089	**N/L**	1748	5.2	4.3	5.6	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.34
12.20	0.092	1.11	1.024	0.090	**N/L**	1859	5.2	4.4	5.5	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.33
12.30	0.095	1.12	1.025	0.092	**N/L**	2164	6.4	5.3	5.6	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.33
12.40	0.108	1.15	1.032	0.105	**0.36**	3434	8.3	6.9	5.2	12.2	0.374	0.857	0.374	0.05	0.0187	0.0331	0.32

Depth, Z (m)	ΔSi (inch)	$p = \sigma_m$ (tsf)	τ_{ave} (psf)	G_{max} (tsf)	τ_{ave}/G_{max}	a	b	γ_{eff} (%)	ε_{15} (%)	ε_{Nc} (%)	Settlement (inch)	Settlement (inch)	$\Delta(N_1)_{60-Sr}$	$(N_1)_{60-Sr}$	S_r/σ_{v0}'
8.90	0.00	1.126	986	6937	0.00007	0.56190	5961	0.00846	0.003	0.003	0.00	0.10	N/A	N/A	N/A
9.00	0.00	1.138	996	6943	0.00007	0.56682	5921	0.00854	0.003	0.003	0.00	0.10	N/A	N/A	N/A
9.10	0.00	1.151	1005	6956	0.00007	0.57174	5882	0.00861	0.003	0.003	0.00	0.10	N/A	N/A	N/A
9.20	0.00	1.164	1014	6656	0.00008	0.57666	5844	0.00918	0.004	0.003	0.00	0.10	N/A	N/A	N/A
9.30	0.00	1.176	1023	6469	0.00008	0.58158	5806	0.00960	0.004	0.003	0.00	0.10	N/A	N/A	N/A
9.40	0.00	1.189	1032	6301	0.00008	0.58650	5769	0.01002	0.005	0.004	0.00	0.10	N/A	N/A	N/A
9.50	0.00	1.202	1041	6094	0.00009	0.59143	5732	0.01055	0.005	0.004	0.00	0.10	N/A	N/A	N/A
9.60	0.00	1.214	1050	6072	0.00009	0.59635	5696	0.01071	0.005	0.004	0.00	0.10	N/A	N/A	N/A
9.70	0.00	1.227	1059	6208	0.00009	0.60127	5661	0.01052	0.005	0.004	0.00	0.10	N/A	N/A	N/A
9.80	0.00	1.240	1068	6391	0.00008	0.60619	5626	0.01025	0.005	0.004	0.00	0.10	N/A	N/A	N/A
9.90	0.00	1.252	1077	6578	0.00008	0.61111	5592	0.00999	0.004	0.004	0.00	0.10	N/A	N/A	N/A
10.00	0.00	1.263	1086	6641	0.00008	0.61534	5563	0.00997	0.004	0.004	0.00	0.10	0.7	40	N/A
10.10	0.00	1.270	1096	6984	0.00008	0.61802	5545	0.00948	0.004	0.003	0.00	0.10	0.7	42	N/A
10.20	0.00	1.277	1105	7121	0.00008	0.62070	5527	0.00935	0.004	0.003	0.00	0.10	0.9	43	N/A
10.30	0.00	1.284	1115	6788	0.00008	0.62338	5509	0.01001	0.004	0.004	0.00	0.10	0.9	41	N/A
10.40	0.00	1.291	1124	6630	0.00008	0.62606	5492	0.01041	0.005	0.004	0.00	0.10	0.9	40	N/A
10.50	0.00	1.298	1134	6554	0.00009	0.62873	5474	0.01067	0.005	0.004	0.00	0.10	0.9	40	N/A
10.60	0.00	1.304	1143	6923	0.00008	0.63141	5457	0.01007	0.004	0.004	0.00	0.10	0.9	42	N/A
10.70	0.00	1.311	1152	7357	0.00008	0.63409	5440	0.00945	0.004	0.003	0.00	0.10	0.7	44	N/A
10.80	0.00	1.318	1162	7518	0.00008	0.63677	5422	0.00929	0.004	0.003	0.00	0.10	0.7	45	N/A
10.90	0.00	1.325	1171	7288	0.00008	0.63945	5406	0.00974	0.004	0.003	0.00	0.10	0.9	43	N/A
11.00	0.00	1.332	1180	6653	0.00009	0.64212	5389	0.01099	0.005	0.004	0.00	0.10	0.9	40	N/A
11.10	0.00	1.339	1189	6108	0.00010	0.64480	5372	0.01235	0.006	0.005	0.00	0.10	0.9	36	N/A
11.20	0.00	1.346	1198	5882	0.00010	0.64748	5356	0.01309	0.007	0.006	0.00	0.10	0.7	35	N/A
11.30	0.00	1.353	1207	5824	0.00010	0.65016	5339	0.01338	0.007	0.006	0.00	0.10	0.7	34	N/A
11.40	0.00	1.359	1216	5543	0.00011	0.65284	5323	0.01440	0.008	0.007	0.00	0.10	0.7	33	N/A
11.50	0.00	1.366	1225	4686	0.00013	0.65551	5307	0.01825	0.013	0.011	0.00	0.10	0.9	28	N/A
11.60	0.03	1.373	1233	2822	0.00022	0.65819	5291	0.04074	0.053	0.044	0.00	0.10	1.7	18	0.15
11.70	0.05	1.380	1242	1317	0.00047	0.66087	5275	0.25386	0.819	0.685	0.00	0.07	2.6	10	0.09
11.80	0.00	1.387	1251	894	0.00070	0.66355	5259	1.14805	5.919	4.949	0.00	0.02	N/A	N/A	N/A
11.90	0.00	1.394	1259	686	0.00092	0.66623	5244	4.56304	32.399	27.091	0.00	0.02	N/A	N/A	N/A
12.00	0.00	1.401	1268	706	0.00090	0.66891	5228	3.98335	27.410	22.919	0.00	0.02	N/A	N/A	N/A
12.10	0.00	1.408	1276	764	0.00084	0.67158	5213	2.65958	16.699	13.963	0.00	0.02	N/A	N/A	N/A
12.20	0.00	1.415	1285	770	0.00083	0.67426	5198	2.60969	16.272	13.606	0.00	0.02	N/A	N/A	N/A
12.30	0.00	1.421	1293	948	0.00068	0.67694	5183	0.98474	4.802	4.015	0.00	0.02	N/A	N/A	N/A
12.40	0.02	1.428	1301	1232	0.00053	0.67962	5168	0.35878	1.281	1.071	0.00	0.02	2.4	9	0.09

CONE PENETRATION TEST-BASED LIQUEFACTION ANALYSIS BASED ON IDRISS & BOULANGER (2008)

References:

1 - Idriss, I.M. and Boulanger, R.W. (2008). *Soil Liquefaction During Earthquakes* , Earthquake Engineering Research Institute, EERI Publication MNO-12.

2 - Ishihara, K. and Yoshimine, M. (1992). "Evaluation of Settlements in Sand Deposits Following Liquefaction During Earthquakes," *Soils and Foundations* , Vol. 32, No. 1, pp. 173-188, March 1992.

3 - Tokimatsu, K. and Seed H.B. (1987). "Evaluation of Settlements in Sands Due to Earthquake Shaking," Journal of Geotechnical Engineering, Vol. 113, No. 8, August.

4 - Pradel, D. (1998). "Procedure to Evaluate Earthquake-Induced Settlements in Sand," Journal of Geotechnical and Geoenvironmental Engineering, Vol. 124, No. 4, April.

5 - Cetin, K.O., Bilge, H.T., Wu, J., Kammerer, A.M., and Seed R.B. (2009). "Procedure to Evaluate Earthquake-Induced Settlements in Sand," Journal of Geotechnical and Geoenvironmental Engineering, Vol. 135, No. 3, March.

6 - Boulanger, R.W. and Idriss, I.M. (2014). "CPT and SPT Based Liquefaction Triggering Procedures," Report No. UCD/CGM-14/01, University of California at Davis

Project	Chevron Guadalupe Tank Battery 9 Site
Test Boring No	TSMACPT-6

Test Boring Information:

Approx. depth to ground water table		42.7 ft	13.02 m
Moist unit weight of soil	γ_m	115 pcf	18.08 kN/m^3
Saturated unit weight of soil	γ_{sat}	125 pcf	19.65 kN/m^3

Earthquake Information:

Earthquake magnitude	M_w	6.9
Peak horizontal ground surface acceleratio	a_{max}	0.490 g
Number of equivalent cycle	N	10.1

Atmospheric pressure	P_a	101.3 kPa

N/L = Non-liquefiable clay-like soil

N.A. = Not Applicable

Sum (Liquefiable Soil)	Sum (Unsaturated Sand)	Total
0.17	0.17	0.35

Factor of Safety Agaist Liquefaction (Idriss & Boulanger, 2008 and Boulanger & Idriss, 2014)

Depth, Z (m)	Depth, Z (ft)	q_c (kPa)	f_s (kPa)	σ_{vc} (kPa)	σ'_{vc} (kPa)	Q	F	I_c	Soil Type	Fines (%)	Interpreted q_c	C_N	q_{c1N}	q_{c1N-cs}	Stress Reduction Factor (r_d)	CSR	K_σ for sand	$CRR_{M=7.5}$ at σ'_{vc}=1	MSF_{max}	MSF	CRR	$(FS)_L$
1.60	5.25	7210	17	28.9	28.9	133	0.24	1.5	Unsaturated	8	7210	1.39	99.3	103.7	0.99	0.315	1.1	0.142	1.28	1.060	0.166	**N/L**
1.70	5.58	7323	20	30.7	30.7	131	0.27	1.5	Unsaturated	8	7323	1.37	99.2	103.6	0.99	0.315	1.1	0.142	1.28	1.060	0.166	**N/L**
1.80	5.90	7718	21	32.5	32.5	134	0.28	1.5	Unsaturated	8	7718	1.35	103.0	107.5	0.99	0.315	1.1	0.148	1.30	1.065	0.173	**N/L**
1.90	6.23	7927	24	34.3	34.3	134	0.30	1.5	Unsaturated	8	7927	1.33	104.3	108.8	0.99	0.314	1.1	0.150	1.31	1.067	0.176	**N/L**
2.00	6.56	7969	26	36.2	36.2	131	0.32	1.5	Unsaturated	8	7969	1.31	103.5	107.9	0.99	0.314	1.1	0.149	1.31	1.066	0.174	**N/L**
2.10	6.89	7927	28	38.0	38.0	127	0.35	1.6	Unsaturated	10	7927	1.29	101.6	112.5	0.98	0.314	1.1	0.156	1.33	1.072	0.184	**N/L**
2.20	7.22	7715	22	39.8	39.8	121	0.28	1.5	Unsaturated	8	7715	1.28	97.7	102.0	0.98	0.313	1.1	0.140	1.27	1.058	0.163	**N/L**
2.30	7.54	7503	21	41.6	41.6	115	0.28	1.6	Unsaturated	10	7503	1.26	93.9	104.3	0.98	0.313	1.1	0.143	1.28	1.061	0.167	**N/L**
2.40	7.87	7618	23	43.4	43.4	114	0.30	1.6	Unsaturated	10	7618	1.25	94.3	104.7	0.98	0.312	1.1	0.144	1.29	1.062	0.167	**N/L**
2.50	8.20	7798	26	45.2	45.2	115	0.33	1.6	Unsaturated	10	7798	1.24	95.4	106.0	0.98	0.312	1.1	0.146	1.29	1.063	0.169	**N/L**
2.60	8.53	7806	27	47.0	47.0	112	0.35	1.6	Unsaturated	10	7806	1.22	94.6	105.1	0.98	0.312	1.1	0.144	1.29	1.062	0.166	**N/L**
2.70	8.86	7883	28	48.8	48.8	111	0.35	1.6	Unsaturated	10	7883	1.21	94.6	105.1	0.98	0.311	1.1	0.144	1.29	1.062	0.166	**N/L**
2.80	9.18	8624	30	50.6	50.6	120	0.35	1.6	Unsaturated	10	8624	1.20	102.5	113.4	0.98	0.311	1.1	0.158	1.34	1.073	0.183	**N/L**
2.90	9.51	8972	33	52.4	52.4	122	0.37	1.6	Unsaturated	10	8972	1.19	105.6	116.7	0.97	0.310	1.1	0.164	1.36	1.078	0.191	**N/L**
3.00	9.84	8957	33	54.2	54.2	120	0.37	1.6	Unsaturated	10	8957	1.18	104.5	115.6	0.97	0.310	1.1	0.162	1.35	1.076	0.187	**N/L**
3.10	10.17	8892	31	56.0	56.0	117	0.35	1.6	Unsaturated	10	8892	1.17	102.8	113.8	0.97	0.309	1.1	0.159	1.34	1.074	0.182	**N/L**
3.20	10.50	9140	32	57.8	57.8	119	0.35	1.6	Unsaturated	10	9140	1.16	104.8	115.9	0.97	0.309	1.1	0.163	1.36	1.077	0.187	**N/L**
3.30	10.82	9833	34	59.7	59.7	126	0.35	1.6	Unsaturated	10	9833	1.15	111.9	123.4	0.97	0.309	1.1	0.179	1.41	1.088	0.208	**N/L**
3.40	11.15	9568	36	61.5	61.5	120	0.38	1.6	Unsaturated	10	9568	1.14	108.0	119.3	0.97	0.308	1.1	0.170	1.38	1.082	0.195	**N/L**
3.50	11.48	8302	33	63.3	63.3	103	0.40	1.7	Unsaturated	11	8302	1.13	93.0	111.7	0.97	0.308	1.1	0.155	1.33	1.071	0.175	**N/L**
3.60	11.81	7789	31	65.1	65.1	95	0.40	1.7	Unsaturated	11	7789	1.12	86.6	104.7	0.96	0.307	1.0	0.144	1.29	1.061	0.160	**N/L**
3.70	12.14	7719	31	66.9	66.9	93	0.41	1.7	Unsaturated	11	7719	1.11	85.2	103.1	0.96	0.307	1.0	0.142	1.28	1.060	0.157	**N/L**
3.80	12.46	7759	32	68.7	68.7	92	0.41	1.7	Unsaturated	11	7759	1.11	85.0	103.0	0.96	0.306	1.0	0.141	1.28	1.059	0.156	**N/L**
3.90	12.79	7410	32	70.5	70.5	87	0.44	1.8	Unsaturated	13	7410	1.10	80.7	106.4	0.96	0.306	1.0	0.146	1.30	1.064	0.162	**N/L**
4.00	13.12	7668	32	72.3	72.3	89	0.42	1.7	Unsaturated	11	7668	1.09	82.9	100.6	0.96	0.305	1.0	0.138	1.26	1.057	0.151	**N/L**
4.10	13.45	8010	34	74.1	74.1	92	0.43	1.7	Unsaturated	11	8010	1.09	86.1	104.1	0.96	0.305	1.0	0.143	1.28	1.061	0.157	**N/L**
4.20	13.78	8426	36	75.9	75.9	95	0.43	1.7	Unsaturated	11	8426	1.08	89.9	108.4	0.96	0.304	1.0	0.149	1.31	1.066	0.164	**N/L**
4.30	14.10	8337	36	77.7	77.7	93	0.44	1.7	Unsaturated	11	8337	1.07	88.5	106.7	0.95	0.304	1.0	0.147	1.30	1.064	0.161	**N/L**
4.40	14.43	8190	32	79.5	79.5	90	0.40	1.7	Unsaturated	11	8190	1.07	86.4	104.4	0.95	0.303	1.0	0.143	1.29	1.061	0.156	**N/L**
4.50	14.76	7947	31	81.4	81.4	87	0.40	1.7	Unsaturated	11	7947	1.06	83.3	101.0	0.95	0.303	1.0	0.139	1.27	1.057	0.150	**N/L**
4.60	15.09	7853	31	83.2	83.2	85	0.40	1.7	Unsaturated	11	7853	1.05	81.8	99.4	0.95	0.303	1.0	0.137	1.26	1.055	0.147	**N/L**
4.70	15.42	7877	32	85.0	85.0	84	0.41	1.8	Unsaturated	13	7877	1.05	81.6	107.6	0.95	0.302	1.0	0.148	1.30	1.065	0.161	**N/L**
4.80	15.74	7905	33	86.8	86.8	83	0.42	1.8	Unsaturated	13	7905	1.04	81.5	107.4	0.95	0.302	1.0	0.148	1.30	1.065	0.160	**N/L**
4.90	16.07	8287	35	88.6	88.6	87	0.42	1.8	Unsaturated	13	8287	1.04	84.9	111.4	0.95	0.301	1.0	0.154	1.33	1.070	0.168	**N/L**
5.00	16.40	8886	39	90.4	90.4	92	0.44	1.7	Unsaturated	11	8886	1.03	90.6	109.1	0.94	0.301	1.0	0.150	1.31	1.067	0.163	**N/L**
5.10	16.73	10468	44	92.2	92.2	107	0.42	1.7	Unsaturated	11	10468	1.02	106.2	126.3	0.94	0.300	1.0	0.187	1.44	1.093	0.206	**N/L**
5.20	17.06	13692	45	94.0	94.0	139	0.33	1.5	Unsaturated	8	13692	1.02	138.2	143.5	0.94	0.300	1.0	0.251	1.60	1.128	0.286	**N/L**
5.30	17.38	16288	46	95.8	95.8	164	0.28	1.4	Unsaturated	7	16288	1.01	163.5	165.0	0.94	0.299	1.0	0.429	1.86	1.184	0.513	**N/L**
5.40	17.71	12884	52	97.6	97.6	129	0.41	1.6	Unsaturated	10	12884	1.01	128.7	141.2	0.94	0.299	1.0	0.240	1.57	1.123	0.271	**N/L**
5.50	18.04	10586	44	99.4	99.4	104	0.42	1.7	Unsaturated	11	10586	1.00	105.2	125.3	0.94	0.298	1.0	0.184	1.43	1.092	0.201	**N/L**
5.60	18.37	9759	42	101.2	101.2	95	0.43	1.7	Unsaturated	11	9759	1.00	96.6	115.7	0.93	0.297	1.0	0.162	1.36	1.076	0.175	**N/L**
5.70	18.70	8845	41	103.0	103.0	86	0.47	1.8	Unsaturated	13	8845	0.99	87.1	113.9	0.93	0.297	1.0	0.159	1.34	1.074	0.170	**N/L**
5.80	19.02	7983	40	104.9	104.9	76	0.50	1.8	Unsaturated	13	7983	0.99	78.3	103.7	0.93	0.296	1.0	0.142	1.28	1.060	0.150	**N/L**
5.90	19.35	7383	36	106.7	106.7	70	0.50	1.9	Unsaturated	15	7383	0.99	72.1	103.9	0.93	0.296	1.0	0.143	1.28	1.061	0.150	**N/L**
6.00	19.68	7402	36	108.5	108.5	70	0.50	1.9	Unsaturated	15	7402	0.98	71.9	103.7	0.93	0.295	1.0	0.142	1.28	1.060	0.150	**N/L**
6.10	20.01	7222	35	110.3	110.3	67	0.49	1.9	Unsaturated	15	7222	0.98	69.9	101.3	0.93	0.295	1.0	0.139	1.27	1.057	0.146	**N/L**
6.20	20.34	7107	31	112.1	112.1	66	0.45	1.9	Unsaturated	15	7107	0.97	68.5	99.6	0.92	0.294	1.0	0.137	1.26	1.056	0.143	**N/L**
6.30	20.66	7417	31	113.9	113.9	68	0.43	1.8	Unsaturated	13	7417	0.97	71.1	95.5	0.92	0.294	1.0	0.132	1.24	1.051	0.137	**N/L**
6.40	20.99	7482	32	115.7	115.7	68	0.43	1.8	Unsaturated	13	7482	0.96	71.5	95.8	0.92	0.293	1.0	0.132	1.24	1.052	0.137	**N/L**
6.50	21.32	7315	32	117.5	117.5	66	0.44	1.9	Unsaturated	15	7315	0.96	69.6	100.9	0.92	0.293	1.0	0.139	1.27	1.057	0.144	**N/L**
6.60	21.65	7541	33	119.3	119.3	68	0.45	1.9	Unsaturated	15	7541	0.96	71.5	103.1	0.92	0.292	1.0	0.142	1.28	1.060	0.147	**N/L**
6.70	21.98	8222	33	121.1	121.1	73	0.41	1.8	Unsaturated	13	8222	0.95	77.6	102.9	0.92	0.292	1.0	0.141	1.28	1.059	0.147	**N/L**
6.80	22.30	9243	34	122.9	122.9	82	0.37	1.7	Unsaturated	11	9243	0.95	86.9	105.0	0.91	0.291	1.0	0.144	1.29	1.062	0.150	**N/L**
6.90	22.63	13197	42	124.7	124.7	116	0.32	1.6	Unsaturated	10	13197	0.95	123.6	135.8	0.91	0.291	1.0	0.217	1.52	1.111	0.234	**N/L**
7.00	22.96	15094	57	126.5	126.5	132	0.38	1.6	Unsaturated	10	15094	0.94	140.8	154.0	0.91	0.290	1.0	0.317	1.72	1.154	0.352	**N/L**
7.10	23.29	10535	52	128.4	128.4	91	0.50	1.8	Unsaturated	13	10535	0.94	97.9	126.4	0.91	0.289	1.0	0.187	1.44	1.093	0.198	**N/L**
7.20	23.62	8582	44	130.2	130.2	74	0.52	1.9	Unsaturated	15	8582	0.94	79.5	112.8	0.91	0.289	1.0	0.157	1.34	1.072	0.163	**N/L**
7.30	23.94	8214	42	132.0	132.0	70	0.52	1.9	Unsaturated	15	8214	0.93	75.8	108.3	0.91	0.288	1.0	0.149	1.31	1.066	0.154	**N/L**
7.40	24.27	8101	40	133.8	133.8	68	0.51	1.9	Unsaturated	15	8101	0.93	74.5	106.8	0.90	0.288	1.0	0.147	1.30	1.064	0.151	**N/L**
7.50	24.60	8063	40	135.6	135.6	68	0.50	1.9	Unsaturated	15	8063	0.93	73.9	106.0	0.90	0.287	1.0	0.146	1.29	1.063	0.150	**N/L**
7.60	24.93	7830	34	137.4	137.4	65	0.45	1.9	Unsaturated	15	7830	0.92	71.5	103.2	0.90	0.287	1.0	0.142	1.28	1.060	0.145	**N/L**
7.70	25.26	7846	34	139.2	139.2	65	0.45	1.9	Unsaturated	15	7846	0.92	71.4	103.1	0.90	0.286	1.0	0.141	1.28	1.060	0.145	**N/L**
7.80	25.58	7877	35	141.0	141.0	65	0.45	1.9	Unsaturated	15	7877	0.92	71.4	103.1	0.90	0.286	1.0	0.141	1.28	1.060	0.144	**N/L**
7.90	25.91	8007	36	142.8	142.8	65	0.46	1.9	Unsaturated	15	8007	0.91	72.4	104.2	0.89	0.285	1.0	0.143	1.28	1.061	0.146	**N/L**
8.00	26.24	8048	37	144.6	144.6	65	0.47	1.9	Unsaturated	15	8048	0.91	72.5	104.4	0.89	0.284	1.0	0.143	1.29	1.061	0.146	**N/L**
8.10	26.57	8216	37	146.4	146.4	66	0.46	1.9	Unsaturated	15	8216	0.91	73.8	105.9	0.89	0.284	1.0	0.146	1.29	1.063	0.148	**N/L**
8.20	26.90	8503	39	148.2	148.2	68	0.47	1.9	Unsaturated	15	8503	0.90	76.1	108.7	0.89	0.283	1.0	0.150	1.31	1.067	0.153	**N/L**
8.30	27.22	8771	40	150.0	150.0	70	0.46	1.9	Unsaturated	15	8771	0.90	78.2	111.3	0.89	0.283	1.0	0.154	1.33	1.070	0.157	**N/L**
8.40	27.55	8812	40	151.9	151.9	70	0.46	1.9	Unsaturated	15	8812	0.90	78.4	111.4	0.89	0.282	1.0	0.154	1.33	1.070	0.157	**N/L**
8.50	27.88	8827	36	153.7	153.7	70	0.41	1.8	Unsaturated	13	8827	0.90	78.2	103.6	0.88	0.281	1.0	0.142	1.28	1.060	0.144	**N/L**
8.60	28.21	9007	37	155.5	155.5	71	0.42	1.8	Unsaturated	13	9007	0.89	79.6	105.2	0.88	0.281	1.0	0.144	1.29	1.062	0.146	**N/L**
8.70	28.54	9969	43	157.3	157.3	78	0.44	1.8	Unsaturated	13	9969	0.89	87.8	114.7	0.88	0.280	0.9	0.160	1.35	1.075	0.163	**N/L**
8.80	28.86	13226	54	159.1	159.1	103	0.41	1.7	Unsaturated	11	13226	0.89	116.2	137.3	0.88	0.280	0.9	0.223	1.53	1.114	0.232	**N/L**

Settelemnt of Liquefiable Soil (Idriss and Boulnager, 2008)

Depth, Z (m)	q_t (kPa)	N_{60}	$N_{1,60}$	$\Delta(N_1)_{60}$	$N_{1,60-CS}$	Limiting Shear Strain γ_{lim}	Parameter F_α	Max. Shear Strain γ_{max}	ΔHi (m)	ΔLDI_i (m)	Vert. Recon. Strain ε_v	DF_i	ΔSi (inch)
1.60	7203	12.4	17.3	0.4	N.A.	0.000	0.000	0.000	0.05	0.0000	0.0000	0.91	0.00
1.70	7349	12.7	17.3	0.4	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.91	0.00
1.80	7700	13.3	17.9	0.4	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.90	0.00
1.90	7932	13.7	18.2	0.4	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.90	0.00
2.00	7955	13.7	18.0	0.4	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.89	0.00
2.10	7917	14.1	18.2	0.9	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.89	0.00
2.20	7707	13.3	17.0	0.4	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.88	0.00
2.30	7503	13.4	16.9	0.9	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.87	0.00
2.40	7621	13.6	17.0	0.9	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.87	0.00
2.50	7797	13.9	17.2	0.9	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.86	0.00
2.60	7835	14.0	17.1	0.9	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.86	0.00
2.70	7973	14.2	17.2	0.9	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.85	0.00
2.80	8575	15.3	18.3	0.9	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.85	0.00
2.90	8969	16.0	19.0	0.9	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.84	0.00
3.00	8954	15.9	18.8	0.9	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.84	0.00
3.10	8929	15.9	18.6	0.9	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.83	0.00
3.20	9187	16.4	19.0	0.9	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.83	0.00
3.30	9782	17.4	20.0	0.9	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.82	0.00
3.40	9508	16.9	19.3	0.9	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.81	0.00
3.50	8380	15.4	17.5	1.7	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.81	0.00
3.60	7789	14.3	16.1	1.7	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.80	0.00
3.70	7720	14.2	15.9	1.7	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.80	0.00
3.80	7683	14.2	15.7	1.7	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.79	0.00
3.90	7462	14.2	15.7	2.5	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.79	0.00
4.00	7663	14.1	15.4	1.7	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.78	0.00
4.10	8004	14.7	16.0	1.7	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.78	0.00
4.20	8414	15.5	16.7	1.7	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.77	0.00
4.30	8370	15.4	16.5	1.7	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.76	0.00
4.40	8162	15.0	16.0	1.7	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.76	0.00
4.50	7977	14.7	15.6	1.7	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.75	0.00
4.60	7854	14.5	15.2	1.7	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.75	0.00
4.70	7863	15.0	15.7	2.5	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.74	0.00
4.80	7905	15.1	15.7	2.5	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.74	0.00
4.90	8247	15.7	16.3	2.5	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.73	0.00
5.00	8988	16.6	17.0	1.7	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.73	0.00
5.10	10468	19.3	19.8	1.7	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.72	0.00
5.20	13809	23.8	24.3	0.4	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.72	0.00
5.30	15579	26.0	26.4	0.1	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.71	0.00
5.40	12934	23.0	23.2	0.9	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.70	0.00
5.50	10858	20.0	20.1	1.7	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.70	0.00
5.60	9743	17.9	17.9	1.7	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.69	0.00
5.70	8854	16.9	16.8	2.5	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.69	0.00
5.80	7948	15.2	15.0	2.5	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.68	0.00
5.90	7384	14.6	14.4	3.2	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.68	0.00
6.00	7323	14.5	14.2	3.2	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.67	0.00
6.10	7210	14.3	13.9	3.2	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.67	0.00
6.20	7215	14.3	13.9	3.2	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.66	0.00
6.30	7417	14.2	13.7	2.5	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.66	0.00
6.40	7427	14.2	13.7	2.5	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.65	0.00
6.50	7360	14.6	14.0	3.2	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.64	0.00
6.60	7586	15.0	14.4	3.2	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.64	0.00
6.70	8094	15.4	14.7	2.5	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.63	0.00
6.80	9428	17.4	16.5	1.7	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.63	0.00
6.90	13185	23.5	22.2	0.9	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.62	0.00
7.00	14451	25.7	24.2	0.9	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.62	0.00
7.10	10828	20.7	19.4	2.5	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.61	0.00
7.20	8717	17.2	16.1	3.2	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.61	0.00
7.30	8208	16.2	15.1	3.2	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.60	0.00
7.40	8102	16.0	14.9	3.2	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.60	0.00
7.50	8042	15.9	14.7	3.2	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.59	0.00
7.60	7876	15.6	14.4	3.2	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.58	0.00
7.70	7846	15.5	14.3	3.2	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.58	0.00
7.80	7898	15.6	14.3	3.2	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.57	0.00
7.90	7982	15.8	14.4	3.2	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.57	0.00
8.00	8044	15.9	14.5	3.2	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.56	0.00
8.10	8225	16.3	14.8	3.2	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.56	0.00
8.20	8512	16.8	15.2	3.2	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.55	0.00
8.30	8771	17.4	15.6	3.2	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.55	0.00
8.40	8810	17.4	15.7	3.2	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.54	0.00
8.50	8829	16.8	15.1	2.5	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.54	0.00
8.60	9087	17.3	15.5	2.5	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.53	0.00
8.70	10176	19.4	17.3	2.5	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.52	0.00
8.80	14004	25.8	22.9	1.7	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.52	0.00

Settlement of Unsaturated Sand (Tokimatsu & Seed, 1987, and Pradel, 1998); Cumulative; S_r (Idriss & Boulanger, 2008)

Depth, Z (m)	$p = \sigma_m$ (tsf)	τ_{ave} (psf)	G_{max} (tsf)	τ_{ave}/G_{max}	a	b	γ_{eff} (%)	ε_{15} (%)	ε_{Nc} (%)	Settlement (inch)	Cumulative Settlement (inch)	$\Delta(N_1)_{60-Sr}$	$(N_1)_{60-Sr}$	S_r/σ_{v0}'
1.60	0.202	192	1156	0.00008	0.20272	16691	0.01249	0.015	0.012	0.00	0.35	N/A	N/A	N/A
1.70	0.215	204	1197	0.00009	0.20764	16095	0.01282	0.015	0.013	0.00	0.35	N/A	N/A	N/A
1.80	0.228	216	1271	0.00008	0.21256	15552	0.01257	0.014	0.012	0.00	0.34	N/A	N/A	N/A
1.90	0.240	228	1326	0.00009	0.21749	15056	0.01263	0.014	0.012	0.00	0.34	N/A	N/A	N/A
2.00	0.253	239	1346	0.00009	0.22241	14600	0.01321	0.015	0.013	0.00	0.34	N/A	N/A	N/A
2.10	0.266	251	1400	0.00009	0.22733	14178	0.01325	0.015	0.012	0.00	0.34	N/A	N/A	N/A
2.20	0.278	263	1334	0.00010	0.23225	13788	0.01526	0.019	0.016	0.00	0.34	N/A	N/A	N/A
2.30	0.291	275	1356	0.00010	0.23717	13425	0.01579	0.019	0.016	0.00	0.34	N/A	N/A	N/A
2.40	0.304	287	1391	0.00010	0.24209	13087	0.01605	0.020	0.016	0.00	0.34	N/A	N/A	N/A
2.50	0.316	299	1437	0.00010	0.24701	12770	0.01609	0.019	0.016	0.00	0.34	N/A	N/A	N/A
2.60	0.329	310	1457	0.00011	0.25193	12473	0.01660	0.020	0.017	0.00	0.34	N/A	N/A	N/A
2.70	0.342	322	1496	0.00011	0.25685	12194	0.01674	0.020	0.017	0.00	0.33	N/A	N/A	N/A
2.80	0.354	334	1623	0.00010	0.26177	11931	0.01543	0.017	0.014	0.00	0.33	N/A	N/A	N/A
2.90	0.367	346	1712	0.00010	0.26669	11682	0.01488	0.016	0.013	0.00	0.33	N/A	N/A	N/A
3.00	0.379	357	1723	0.00010	0.27161	11447	0.01542	0.017	0.014	0.00	0.33	N/A	N/A	N/A
3.10	0.392	369	1731	0.00011	0.27653	11224	0.01598	0.017	0.015	0.00	0.33	N/A	N/A	N/A
3.20	0.405	381	1795	0.00011	0.28145	11012	0.01576	0.017	0.014	0.00	0.33	N/A	N/A	N/A
3.30	0.417	392	1925	0.00010	0.28637	10811	0.01475	0.015	0.012	0.00	0.33	N/A	N/A	N/A
3.40	0.430	404	1884	0.00011	0.29129	10619	0.01584	0.017	0.014	0.00	0.33	N/A	N/A	N/A
3.50	0.443	415	1730	0.00012	0.29621	10436	0.01887	0.022	0.019	0.00	0.33	N/A	N/A	N/A
3.60	0.455	427	1619	0.00013	0.30113	10261	0.02195	0.028	0.024	0.00	0.32	N/A	N/A	N/A
3.70	0.468	438	1614	0.00014	0.30605	10093	0.02293	0.030	0.025	0.00	0.32	N/A	N/A	N/A
3.80	0.481	450	1617	0.00014	0.31097	9933	0.02376	0.032	0.027	0.00	0.32	N/A	N/A	N/A
3.90	0.493	461	1637	0.00014	0.31589	9780	0.02415	0.032	0.027	0.00	0.32	N/A	N/A	N/A
4.00	0.506	473	1632	0.00014	0.32081	9632	0.02517	0.034	0.029	0.00	0.32	N/A	N/A	N/A
4.10	0.519	484	1715	0.00014	0.32573	9490	0.02390	0.031	0.026	0.00	0.31	N/A	N/A	N/A
4.20	0.531	496	1813	0.00014	0.33065	9354	0.02247	0.028	0.023	0.00	0.31	N/A	N/A	N/A
4.30	0.544	507	1814	0.00014	0.33557	9223	0.02321	0.029	0.024	0.00	0.31	N/A	N/A	N/A
4.40	0.557	518	1778	0.00015	0.34049	9097	0.02481	0.032	0.027	0.00	0.31	N/A	N/A	N/A
4.50	0.569	530	1747	0.00015	0.34541	8975	0.02643	0.036	0.030	0.00	0.31	N/A	N/A	N/A
4.60	0.582	541	1729	0.00016	0.35033	8857	0.02780	0.039	0.032	0.00	0.30	N/A	N/A	N/A
4.70	0.594	552	1802	0.00015	0.35525	8744	0.02662	0.036	0.030	0.00	0.30	N/A	N/A	N/A
4.80	0.607	563	1821	0.00015	0.36017	8634	0.02694	0.036	0.030	0.00	0.30	N/A	N/A	N/A
4.90	0.620	574	1909	0.00015	0.36509	8528	0.02554	0.033	0.027	0.00	0.30	N/A	N/A	N/A
5.00	0.632	586	2018	0.00015	0.37001	8425	0.02389	0.029	0.024	0.00	0.29	N/A	N/A	N/A
5.10	0.645	597	2362	0.00013	0.37493	8326	0.01905	0.019	0.016	0.00	0.29	N/A	N/A	N/A
5.20	0.658	608	2928	0.00010	0.37985	8229	0.01423	0.011	0.009	0.00	0.29	N/A	N/A	N/A
5.30	0.670	619	3214	0.00010	0.38477	8136	0.01280	0.009	0.008	0.00	0.29	N/A	N/A	N/A
5.40	0.683	630	2859	0.00011	0.38969	8045	0.01541	0.013	0.011	0.00	0.29	N/A	N/A	N/A
5.50	0.696	641	2494	0.00013	0.39461	7957	0.01931	0.019	0.016	0.00	0.29	N/A	N/A	N/A
5.60	0.708	651	2247	0.00014	0.39953	7871	0.02331	0.027	0.022	0.00	0.29	N/A	N/A	N/A
5.70	0.721	662	2124	0.00016	0.40446	7788	0.02622	0.032	0.027	0.00	0.29	N/A	N/A	N/A
5.80	0.734	673	1914	0.00018	0.40938	7707	0.03227	0.046	0.038	0.00	0.28	N/A	N/A	N/A
5.90	0.746	684	1852	0.00018	0.41430	7629	0.03518	0.052	0.044	0.00	0.28	N/A	N/A	N/A
6.00	0.759	695	1844	0.00019	0.41922	7552	0.03635	0.055	0.046	0.00	0.28	N/A	N/A	N/A
6.10	0.772	705	1823	0.00019	0.42414	7478	0.03807	0.059	0.049	0.00	0.27	N/A	N/A	N/A
6.20	0.784	716	1831	0.00020	0.42906	7405	0.03865	0.060	0.050	0.00	0.27	N/A	N/A	N/A
6.30	0.797	727	1822	0.00020	0.43398	7334	0.03996	0.063	0.053	0.00	0.27	N/A	N/A	N/A
6.40	0.810	737	1831	0.00020	0.43890	7265	0.04049	0.064	0.053	0.00	0.26	N/A	N/A	N/A
6.50	0.822	748	1889	0.00020	0.44382	7198	0.03900	0.060	0.050	0.00	0.26	N/A	N/A	N/A
6.60	0.835	758	1954	0.00019	0.44874	7132	0.03738	0.056	0.046	0.00	0.25	N/A	N/A	N/A
6.70	0.847	769	2017	0.00019	0.45366	7068	0.03597	0.052	0.043	0.00	0.25	N/A	N/A	N/A
6.80	0.860	779	2277	0.00017	0.45858	7006	0.02956	0.037	0.031	0.00	0.25	N/A	N/A	N/A
6.90	0.873	789	3088	0.00013	0.46350	6945	0.01856	0.016	0.014	0.00	0.24	N/A	N/A	N/A
7.00	0.885	800	3396	0.00012	0.46842	6885	0.01646	0.013	0.011	0.00	0.24	N/A	N/A	N/A
7.10	0.898	810	2736	0.00015	0.47334	6827	0.02311	0.024	0.020	0.00	0.24	N/A	N/A	N/A
7.20	0.911	820	2291	0.00018	0.47826	6770	0.03154	0.041	0.034	0.00	0.24	N/A	N/A	N/A
7.30	0.923	830	2165	0.00019	0.48318	6714	0.03557	0.050	0.042	0.00	0.24	N/A	N/A	N/A
7.40	0.936	840	2143	0.00020	0.48810	6659	0.03689	0.053	0.044	0.00	0.23	N/A	N/A	N/A
7.50	0.949	850	2135	0.00020	0.49302	6606	0.03786	0.055	0.046	0.00	0.23	N/A	N/A	N/A
7.60	0.961	860	2097	0.00021	0.49794	6553	0.03986	0.059	0.050	0.00	0.23	N/A	N/A	N/A
7.70	0.974	870	2095	0.00021	0.50286	6502	0.04064	0.061	0.051	0.00	0.22	N/A	N/A	N/A
7.80	0.987	880	2116	0.00021	0.50778	6452	0.04062	0.061	0.051	0.00	0.22	N/A	N/A	N/A
7.90	0.999	890	2145	0.00021	0.51270	6403	0.04028	0.060	0.050	0.00	0.22	N/A	N/A	N/A
8.00	1.012	900	2168	0.00021	0.51762	6355	0.04016	0.059	0.049	0.00	0.21	N/A	N/A	N/A
8.10	1.025	910	2223	0.00020	0.52254	6308	0.03897	0.056	0.047	0.00	0.21	N/A	N/A	N/A
8.20	1.037	920	2307	0.00020	0.52746	6261	0.03700	0.051	0.043	0.00	0.20	N/A	N/A	N/A
8.30	1.050	929	2384	0.00019	0.53238	6216	0.03545	0.048	0.040	0.00	0.20	N/A	N/A	N/A
8.40	1.062	939	2402	0.00020	0.53730	6171	0.03553	0.048	0.040	0.00	0.20	N/A	N/A	N/A
8.50	1.075	948	2327	0.00020	0.54222	6128	0.03818	0.054	0.045	0.00	0.19	N/A	N/A	N/A
8.60	1.088	958	2402	0.00020	0.54714	6085	0.03661	0.050	0.042	0.00	0.19	N/A	N/A	N/A
8.70	1.100	967	2697	0.00018	0.55206	6043	0.03040	0.036	0.030	0.00	0.19	N/A	N/A	N/A
8.80	1.113	977	3594	0.00014	0.55698	6002	0.01972	0.017	0.014	0.00	0.18	N/A	N/A	N/A

Depth, Z (m)	Depth, Z (ft)	q_c (kPa)	f_s (kPa)	σ_{vc} (kPa)	σ'_{vc} (kPa)	Q	F	I_c	Soil Type	Fines (%)	Interpreted q_c	C_N	q_{c1N}	$q_{c1N\text{-}cs}$	Stress Reduction Factor (r_d)	CSR	K_σ for sand	$CRR_{M=7.5}$ at σ'_{vc}=1	MSF_{max}	MSF	CRR	$(FS)_L$	q_t (kPa)	N_{60}	$N_{1,60}$	$\Delta(N_1)_{60}$
8.90	29.19	25470	77	160.9	160.9	198	0.30	1.4	Unsaturated	7	25470	0.88	223.0	224.8	0.88	0.279	0.9	2.000	2.20	1.257	2.000	**N/L**	25088	41.9	37.0	0.1
9.00	29.52	36513	115	162.7	162.7	283	0.32	1.2	Unsaturated	4	36513	0.88	318.8	318.8	0.87	0.279	0.9	2.000	2.20	1.257	2.000	**N/L**	36011	56.6	49.9	0.0
9.10	29.85	39531	138	164.5	164.5	305	0.35	1.2	Unsaturated	4	39531	0.88	344.1	344.1	0.87	0.278	0.9	2.000	2.20	1.257	2.000	**N/L**	38687	60.8	53.4	0.0
9.20	30.18	34958	144	166.3	166.3	268	0.41	1.3	Unsaturated	6	34958	0.88	303.4	303.7	0.87	0.277	0.9	2.000	2.20	1.257	2.000	**N/L**	35324	57.2	50.1	0.0
9.30	30.50	33725	145	168.1	168.1	257	0.43	1.4	Unsaturated	7	33725	0.87	291.9	294.1	0.87	0.277	0.8	2.000	2.20	1.257	2.000	**N/L**	33726	56.3	49.2	0.1
9.40	30.83	33459	141	169.9	169.9	254	0.42	1.4	Unsaturated	7	33459	0.87	288.8	291.0	0.87	0.276	0.8	2.000	2.20	1.257	2.000	**N/L**	33551	56.0	48.8	0.1
9.50	31.16	33556	143	171.7	171.7	253	0.43	1.4	Unsaturated	7	33556	0.87	288.8	291.0	0.87	0.276	0.8	2.000	2.20	1.257	2.000	**N/L**	33588	56.1	48.7	0.1
9.60	31.49	33934	164	173.5	173.5	255	0.49	1.4	Unsaturated	7	33934	0.87	291.3	293.5	0.86	0.275	0.8	2.000	2.20	1.257	2.000	**N/L**	34074	56.9	49.3	0.1
9.70	31.82	34981	184	175.4	175.4	261	0.53	1.4	Unsaturated	7	34981	0.86	299.4	301.7	0.86	0.274	0.8	2.000	2.20	1.257	2.000	**N/L**	34894	58.3	50.4	0.1
9.80	32.14	35132	178	177.2	177.2	261	0.51	1.4	Unsaturated	7	35132	0.86	299.9	302.2	0.86	0.274	0.8	2.000	2.20	1.257	2.000	**N/L**	35088	58.6	50.5	0.1
9.90	32.47	35095	195	179.0	179.0	259	0.56	1.4	Unsaturated	7	35095	0.86	298.8	301.0	0.86	0.273	0.8	2.000	2.20	1.257	2.000	**N/L**	35099	58.6	50.4	0.1
10.00	32.80	35079	225	180.8	180.8	258	0.65	1.5	Unsaturated	8	35079	0.86	297.9	306.9	0.86	0.273	0.8	2.000	2.20	1.257	2.000	**N/L**	35101	60.5	51.9	0.4
10.10	33.13	34713	232	182.6	182.6	254	0.67	1.5	Unsaturated	8	34713	0.86	294.0	303.0	0.85	0.272	0.8	2.000	2.20	1.257	2.000	**N/L**	34809	60.0	51.3	0.4
10.20	33.46	34651	245	184.4	184.4	252	0.71	1.5	Unsaturated	8	34651	0.85	292.7	301.7	0.85	0.271	0.8	2.000	2.20	1.257	2.000	**N/L**	34576	59.6	50.8	0.4
10.30	33.78	34067	238	186.2	186.2	247	0.70	1.5	Unsaturated	8	34067	0.85	287.0	295.8	0.85	0.271	0.8	2.000	2.20	1.257	2.000	**N/L**	34228	59.0	50.2	0.4
10.40	34.11	34341	250	188.0	188.0	247	0.73	1.5	Unsaturated	8	34341	0.85	288.6	297.5	0.85	0.270	0.8	2.000	2.20	1.257	2.000	**N/L**	34305	59.1	50.2	0.4
10.50	34.44	34376	271	189.8	189.8	247	0.79	1.6	Unsaturated	10	34376	0.85	288.2	309.9	0.85	0.270	0.8	2.000	2.20	1.257	2.000	**N/L**	34424	61.3	51.9	0.9
10.60	34.77	34376	258	191.6	191.6	245	0.75	1.5	Unsaturated	8	34376	0.84	287.4	296.3	0.84	0.269	0.8	2.000	2.20	1.257	2.000	**N/L**	34397	59.3	50.1	0.4
10.70	35.10	34298	252	193.4	193.4	244	0.74	1.5	Unsaturated	8	34298	0.84	286.1	294.9	0.84	0.268	0.8	2.000	2.20	1.257	2.000	**N/L**	34302	59.1	49.8	0.4
10.80	35.42	34474	268	195.2	195.2	244	0.78	1.6	Unsaturated	10	34474	0.84	286.8	308.5	0.84	0.268	0.8	2.000	2.20	1.257	2.000	**N/L**	34269	61.0	51.3	0.9
10.90	35.75	33716	267	197.1	197.1	237	0.80	1.6	Unsaturated	10	33716	0.84	279.9	301.1	0.84	0.267	0.8	2.000	2.20	1.257	2.000	**N/L**	33719	60.0	50.3	0.9
11.00	36.08	33606	259	198.9	198.9	235	0.78	1.6	Unsaturated	10	33606	0.84	278.3	299.4	0.84	0.267	0.8	2.000	2.20	1.257	2.000	**N/L**	33517	59.7	49.9	0.9
11.10	36.41	33403	260	200.7	200.7	233	0.78	1.6	Unsaturated	10	33403	0.83	275.9	297.0	0.84	0.266	0.8	2.000	2.20	1.257	1.996	**N/L**	33433	59.5	49.7	0.9
11.20	36.74	33362	277	202.5	202.5	232	0.84	1.6	Unsaturated	10	33362	0.83	274.9	295.9	0.83	0.265	0.8	2.000	2.20	1.257	1.989	**N/L**	33429	59.5	49.5	0.9
11.30	37.06	33108	288	204.3	204.3	229	0.87	1.6	Unsaturated	10	33108	0.83	272.2	293.0	0.83	0.265	0.8	2.000	2.20	1.257	1.982	**N/L**	33171	59.1	49.1	0.9
11.40	37.39	32621	270	206.1	206.1	224	0.83	1.6	Unsaturated	10	32621	0.83	267.6	288.1	0.83	0.264	0.8	2.000	2.20	1.257	1.976	**N/L**	32695	58.2	48.2	0.9
11.50	37.72	32218	274	207.9	207.9	221	0.86	1.6	Unsaturated	10	32218	0.83	263.7	284.0	0.83	0.264	0.8	2.000	2.20	1.257	1.969	**N/L**	32222	57.4	47.4	0.9
11.60	38.05	31308	276	209.7	209.7	213	0.89	1.6	Unsaturated	10	31308	0.82	255.6	275.5	0.83	0.263	0.8	2.000	2.20	1.257	1.963	**N/L**	31460	56.0	46.2	0.9
11.70	38.38	31258	289	211.5	211.5	212	0.93	1.6	Unsaturated	10	31258	0.82	254.7	274.4	0.82	0.262	0.8	2.000	2.20	1.257	1.956	**N/L**	31228	55.6	45.8	0.9
11.80	38.70	30960	258	213.3	213.3	209	0.84	1.6	Unsaturated	10	30960	0.82	251.7	271.3	0.82	0.262	0.8	2.000	2.20	1.257	1.950	**N/L**	31054	55.3	45.4	0.9
11.90	39.03	31025	233	215.1	215.1	209	0.76	1.6	Unsaturated	10	31025	0.82	251.6	271.2	0.82	0.261	0.8	2.000	2.20	1.257	1.943	**N/L**	31094	55.4	45.4	0.9
12.00	39.36	31230	214	216.9	216.9	209	0.69	1.6	Unsaturated	10	31230	0.82	252.7	272.4	0.82	0.261	0.8	2.000	2.20	1.257	1.937	**N/L**	31307	55.8	45.6	0.9
12.10	39.69	31627	218	218.7	218.7	211	0.69	1.6	Unsaturated	10	31627	0.82	255.4	275.2	0.82	0.260	0.8	2.000	2.20	1.257	1.931	**N/L**	31870	56.8	46.3	0.9
12.20	40.02	32465	245	220.6	220.6	216	0.76	1.6	Unsaturated	10	32465	0.81	261.6	281.8	0.81	0.259	0.8	2.000	2.20	1.257	1.925	**N/L**	32618	58.1	47.3	0.9
12.30	40.34	32674	251	222.4	222.4	216	0.77	1.6	Unsaturated	10	32674	0.81	262.7	283.0	0.81	0.259	0.8	2.000	2.20	1.257	1.918	**N/L**	32455	57.8	46.9	0.9
12.40	40.67	31969	268	224.2	224.2	211	0.84	1.6	Unsaturated	10	31969	0.81	256.5	276.4	0.81	0.258	0.8	2.000	2.20	1.257	1.912	**N/L**	31704	56.5	45.7	0.9
12.50	41.00	29866	279	226.0	226.0	196	0.94	1.7	Unsaturated	11	29866	0.81	239.1	273.1	0.81	0.258	0.8	2.000	2.20	1.257	1.906	**N/L**	29836	55.0	44.4	1.7
12.60	41.33	26806	261	227.8	227.8	175	0.98	1.7	Unsaturated	11	26806	0.81	214.2	245.5	0.81	0.257	0.8	2.000	2.20	1.257	1.900	**N/L**	26771	49.3	39.8	1.7
12.70	41.66	23390	231	229.6	229.6	152	1.00	1.8	Unsaturated	13	23390	0.81	186.5	228.6	0.80	0.256	0.8	2.000	2.20	1.257	1.894	**N/L**	23394	44.6	35.9	2.5
12.80	41.98	19823	180	231.4	231.4	128	0.92	1.8	Unsaturated	13	19823	0.80	157.7	195.4	0.80	0.256	0.8	1.471	2.20	1.257	1.467	**N/L**	20010	38.2	30.7	2.5
12.90	42.31	17820	150	233.2	233.2	114	0.85	1.8	Unsaturated	13	17820	0.80	141.5	176.6	0.80	0.255	0.8	0.637	2.04	1.222	0.645	**N/L**	17902	34.2	27.4	2.5
13.00	42.64	17411	146	235.0	235.0	111	0.85	1.8	Unsaturated	13	17411	0.80	138.0	172.6	0.80	0.255	0.8	0.550	1.97	1.208	0.554	**N/L**	17411	33.2	26.6	2.5
13.10	42.97	17887	141	237.0	236.1	114	0.80	1.8		13	17887	0.80	141.6	176.7	0.80	0.255	0.8	0.639	2.04	1.222	0.645	**2.00**	17900	34.2	27.3	2.5
13.20	43.30	18982	117	238.9	237.1	121	0.62	1.7		11	18982	0.80	150.0	174.7	0.80	0.255	0.8	0.594	2.00	1.215	0.598	**2.00**	18921	34.9	27.8	1.7
13.30	43.62	19761	84	240.9	238.1	126	0.43	1.6		10	19761	0.80	156.0	170.1	0.79	0.256	0.8	0.505	1.93	1.200	0.507	**1.98**	19787	35.2	28.1	0.9
13.40	43.95	21086	75	242.8	239.1	134	0.36	1.5		8	21086	0.80	166.3	172.3	0.79	0.256	0.8	0.544	1.97	1.207	0.546	**2.00**	21137	36.4	29.0	0.4
13.50	44.28	22773	68	244.8	240.1	144	0.30	1.5		8	22773	0.80	179.4	185.7	0.79	0.256	0.8	0.923	2.19	1.255	0.933	**2.00**	22773	39.2	31.2	0.4
13.60	44.61	24384	71	246.8	241.1	154	0.30	1.5		8	24384	0.79	191.9	198.5	0.79	0.257	0.8	1.737	2.20	1.257	1.694	**2.00**	24295	41.9	33.3	0.4
13.70	44.94	25505	65	248.7	242.1	161	0.26	1.4		7	25505	0.79	200.5	202.2	0.79	0.257	0.8	2.142	2.20	1.257	2.000	**2.00**	25468	42.5	33.8	0.1
13.80	45.26	25995	68	250.7	243.0	164	0.27	1.4		7	25995	0.79	204.2	205.8	0.78	0.258	0.8	2.669	2.20	1.257	2.000	**2.00**	26029	43.5	34.5	0.1
13.90	45.59	25178	71	252.7	244.0	159	0.29	1.4		7	25178	0.79	197.5	199.2	0.78	0.258	0.8	1.804	2.20	1.257	1.747	**2.00**	25395	42.4	33.6	0.1
14.00	45.92	23307	59	254.6	245.0	146	0.26	1.4		7	23307	0.79	182.7	184.2	0.78	0.258	0.8	0.865	2.16	1.249	0.869	**2.00**	22544	37.6	29.8	0.1
14.10	46.25	12831	93	256.6	246.0	80	0.74	1.9		15	12831	0.79	100.4	138.0	0.78	0.259	0.9	0.226	1.54	1.116	0.220	**0.85**	13437	26.6	21.0	3.2
14.20	46.58	4068	116	258.6	247.0	24	3.04	2.7	Clay-Like	37	4068	0.79	31.8	72.8	0.78	0.259	0.9	0.110	1.16	1.033	0.105	**N/L**	4782	13.4	10.6	5.5
14.30	46.90	2208	46	260.5	248.0	12	2.35	2.9	Clay-Like	45	2208	0.79	17.3	53.6	0.77	0.259	0.9	0.095	1.12	1.025	0.091	**N/L**	2264	7.1	5.6	5.6
14.40	47.23	2027	13	262.5	248.9	11	0.71	2.7	Clay-Like	37	2027	0.79	15.8	51.2	0.77	0.260	0.9	0.093	1.11	1.024	0.089	**N/L**	2063	5.8	4.6	5.5
14.50	47.56	2130	11	264.5	249.9	12	0.60	2.6	Clay-Like	34	2130	0.79	16.6	51.9	0.77	0.260	0.9	0.094	1.11	1.024	0.090	**N/L**	2172	5.8	4.6	5.5
14.60	47.89	2626	11	266.4	250.9	15	0.46	2.5		30	2626	0.79	20.4	56.3	0.77	0.260	0.9	0.097	1.12	1.026	0.093	**0.36**	2621	6.7	5.2	5.4
14.70	48.22	3717	11	268.4	251.9	22	0.31	2.3		24	3717	0.79	28.9	65.1	0.77	0.260	0.9	0.103	1.14	1.029	0.099	**0.38**	3649	8.5	6.7	5.0
14.80	48.54	4363	11	270.4	252.9	26	0.28	2.2		22	4363	0.78	33.9	69.5	0.77	0.261	0.9	0.107	1.15	1.032	0.102	**0.39**	4410	9.8	7.7	4.7
14.90	48.87	4551	41	272.3	253.9	27	0.96	2.4		27	4551	0.78	35.3	75.1	0.76	0.261	0.9	0.112	1.16	1.035	0.106	**0.41**	4572	11.1	8.7	5.2
15.00	49.20	5204	48	274.3	254.8	31	0.98	2.3		24	5204	0.78	40.4	80.2	0.76	0.261	0.9	0.116	1.18	1.038	0.110	**0.42**	5021	11.7	9.1	5.0
15.10	49.53	4921	48	276.3	255.8	29	1.03	2.4		27	4921	0.78	38.1	78.8	0.76	0.261	0.9	0.115	1.17	1.037	0.109	**0.42**	4956	12.0	9.4	5.2
15.20	49.86	4381	53	278.2	256.8	25	1.29	2.5		30	4381	0.78	33.9	74.3	0.76	0.262	0.9	0.111	1.16	1.034	0.105	**0.40**	4361	11.1	8.7	5.4
15.30	50.18	3711	55	280.2	257.8	21	1.60	2.6	Clay-Like	34	3711	0.78	28.7	68.1	0.76	0.262	0.9	0.106	1.14	1.031	0.101	**N/L**	3606	9.6	7.5	5.5
15.40	50.51	2413	57	282.1	258.8	13	2.68	2.9	Clay-Like	45	2413	0.78	18.6	55.4	0.75	0.262	0.9	0.096	1.12	1.026	0.092	**N/L**	2515	7.9	6.2	5.6

Depth, Z (m)	$N_{1,60\text{-}CS}$	Limiting Shear Strain γ_{lim}	Parameter F_α	Max. Shear Strain γ_{max}	ΔHi (m)	ΔLDI_i (m)	Vert. Recon. Strain ε_v	DF_i	ΔSi (inch)	$p = \sigma_m$ (tsf)	τ_{ave} (psf)	G_{max} (tsf)	τ_{ave}/G_{max}	a	b	γ_{eff} (%)	ε_{15} (%)	ε_{Nc} (%)	Settlement (inch)	Settlement (inch)	$\Delta(N_1)_{60\text{-}Sr}$	$(N_1)_{60\text{-}Sr}$	S_r/σ_{v0}'
8.90	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.51	0.00	1.126	986	5850	0.00008	0.56190	5961	0.01041	0.005	0.004	0.00	0.18	N/A	N/A	N/A
9.00	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.51	0.00	1.138	996	7924	0.00006	0.56682	5921	0.00731	0.002	0.002	0.00	0.18	N/A	N/A	N/A
9.10	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.50	0.00	1.151	1005	8535	0.00006	0.57174	5882	0.00677	0.002	0.002	0.00	0.18	N/A	N/A	N/A
9.20	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.50	0.00	1.164	1014	8050	0.00006	0.57666	5844	0.00732	0.002	0.002	0.00	0.18	N/A	N/A	N/A
9.30	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.49	0.00	1.176	1023	7946	0.00006	0.58158	5806	0.00751	0.003	0.002	0.00	0.18	N/A	N/A	N/A
9.40	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.49	0.00	1.189	1032	7925	0.00007	0.58650	5769	0.00761	0.003	0.002	0.00	0.18	N/A	N/A	N/A
9.50	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.48	0.00	1.202	1041	7954	0.00007	0.59143	5732	0.00765	0.003	0.002	0.00	0.18	N/A	N/A	N/A
9.60	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.48	0.00	1.214	1050	8089	0.00006	0.59635	5696	0.00758	0.003	0.002	0.00	0.18	N/A	N/A	N/A
9.70	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.47	0.00	1.227	1059	8304	0.00006	0.60127	5661	0.00742	0.002	0.002	0.00	0.18	N/A	N/A	N/A
9.80	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.46	0.00	1.240	1068	8370	0.00006	0.60619	5626	0.00742	0.002	0.002	0.00	0.18	N/A	N/A	N/A
9.90	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.46	0.00	1.252	1077	8393	0.00006	0.61111	5592	0.00747	0.002	0.002	0.00	0.18	N/A	N/A	N/A
10.00	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.45	0.00	1.265	1086	8685	0.00006	0.61603	5558	0.00724	0.002	0.002	0.00	0.18	N/A	N/A	N/A
10.10	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.45	0.00	1.277	1094	8633	0.00006	0.62095	5525	0.00736	0.002	0.002	0.00	0.18	N/A	N/A	N/A
10.20	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.44	0.00	1.290	1103	8595	0.00006	0.62587	5493	0.00746	0.002	0.002	0.00	0.18	N/A	N/A	N/A
10.30	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.44	0.00	1.303	1112	8528	0.00007	0.63079	5461	0.00760	0.003	0.002	0.00	0.18	N/A	N/A	N/A
10.40	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.43	0.00	1.315	1120	8567	0.00007	0.63571	5429	0.00762	0.003	0.002	0.00	0.18	N/A	N/A	N/A
10.50	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.43	0.00	1.328	1129	8903	0.00006	0.64063	5398	0.00735	0.002	0.002	0.00	0.18	N/A	N/A	N/A
10.60	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.42	0.00	1.341	1137	8628	0.00007	0.64555	5368	0.00769	0.003	0.002	0.00	0.18	N/A	N/A	N/A
10.70	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.42	0.00	1.353	1146	8624	0.00007	0.65047	5337	0.00776	0.003	0.002	0.00	0.18	N/A	N/A	N/A
10.80	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.41	0.00	1.366	1154	8922	0.00006	0.65539	5308	0.00752	0.002	0.002	0.00	0.18	N/A	N/A	N/A
10.90	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.40	0.00	1.379	1162	8798	0.00007	0.66031	5278	0.00770	0.003	0.002	0.00	0.18	N/A	N/A	N/A
11.00	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.40	0.00	1.391	1170	8764	0.00007	0.66523	5250	0.00780	0.003	0.002	0.00	0.18	N/A	N/A	N/A
11.10	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.39	0.00	1.404	1179	8761	0.00007	0.67015	5221	0.00786	0.003	0.002	0.00	0.18	N/A	N/A	N/A
11.20	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.39	0.00	1.417	1187	8779	0.00007	0.67507	5193	0.00790	0.003	0.002	0.00	0.18	N/A	N/A	N/A
11.30	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.38	0.00	1.429	1195	8729	0.00007	0.67999	5165	0.00802	0.003	0.002	0.00	0.18	N/A	N/A	N/A
11.40	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.38	0.00	1.442	1203	8622	0.00007	0.68491	5138	0.00820	0.003	0.002	0.00	0.18	N/A	N/A	N/A
11.50	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.37	0.00	1.455	1211	8515	0.00007	0.68983	5111	0.00838	0.003	0.002	0.00	0.18	N/A	N/A	N/A
11.60	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.37	0.00	1.467	1219	8330	0.00007	0.69475	5085	0.00866	0.003	0.003	0.00	0.18	N/A	N/A	N/A
11.70	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.36	0.00	1.480	1226	8285	0.00007	0.69967	5059	0.00878	0.003	0.003	0.00	0.18	N/A	N/A	N/A
11.80	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.35	0.00	1.493	1234	8256	0.00007	0.70459	5033	0.00888	0.003	0.003	0.00	0.18	N/A	N/A	N/A
11.90	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.35	0.00	1.505	1242	8283	0.00007	0.70951	5008	0.00891	0.003	0.003	0.00	0.18	N/A	N/A	N/A
12.00	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.34	0.00	1.518	1249	8357	0.00007	0.71443	4983	0.00888	0.003	0.003	0.00	0.18	N/A	N/A	N/A
12.10	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.34	0.00	1.530	1257	8523	0.00007	0.71935	4958	0.00874	0.003	0.003	0.00	0.18	N/A	N/A	N/A
12.20	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.33	0.00	1.543	1265	8740	0.00007	0.72427	4933	0.00854	0.003	0.003	0.00	0.18	N/A	N/A	N/A
12.30	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.33	0.00	1.556	1272	8714	0.00007	0.72919	4909	0.00863	0.003	0.003	0.00	0.18	N/A	N/A	N/A
12.40	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.32	0.00	1.568	1279	8528	0.00008	0.73411	4885	0.00891	0.003	0.003	0.00	0.18	N/A	N/A	N/A
12.50	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.32	0.00	1.581	1287	8318	0.00008	0.73903	4862	0.00924	0.004	0.003	0.00	0.18	N/A	N/A	N/A
12.60	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.31	0.00	1.594	1294	7478	0.00009	0.74395	4839	0.01057	0.005	0.004	0.00	0.18	N/A	N/A	N/A
12.70	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.31	0.00	1.606	1301	6780	0.00010	0.74887	4816	0.01201	0.006	0.005	0.00	0.18	N/A	N/A	N/A
12.80	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.30	0.00	1.619	1309	5811	0.00011	0.75379	4793	0.01472	0.009	0.007	0.00	0.18	N/A	N/A	N/A
12.90	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.29	0.00	1.632	1316	5208	0.00013	0.75871	4771	0.01714	0.012	0.010	0.00	0.18	N/A	N/A	N/A
13.00	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.29	0.00	1.644	1323	5074	0.00013	0.76363	4749	0.01787	0.013	0.011	0.00	0.17	N/A	N/A	N/A
13.10	29.8	0.048	-0.073	0.000	0.10	0.0000	0.0000	0.28	0.00	1.652	1331	5223	0.00013	0.76672	4735	0.01731	0.012	0.010	0.00	0.17	1.2	28	N/A
13.20	29.5	0.050	-0.055	0.000	0.10	0.0000	0.0000	0.28	0.00	1.659	1338	5335	0.00013	0.76940	4723	0.01695	0.011	0.010	0.00	0.17	1.0	29	N/A
13.30	29.0	0.053	-0.024	0.000	0.10	0.0000	0.0001	0.27	0.00	1.666	1346	5399	0.00012	0.77208	4712	0.01681	0.011	0.009	0.00	0.17	0.9	29	N/A
13.40	29.4	0.050	-0.048	0.000	0.10	0.0000	0.0000	0.27	0.00	1.673	1354	5587	0.00012	0.77476	4700	0.01618	0.010	0.009	0.00	0.17	0.7	30	N/A
13.50	31.6	0.037	-0.198	0.000	0.10	0.0000	0.0000	0.26	0.00	1.680	1361	6025	0.00011	0.77744	4688	0.01475	0.009	0.007	0.00	0.17	0.7	32	N/A
13.60	33.7	0.027	-0.341	0.000	0.10	0.0000	0.0000	0.26	0.00	1.687	1369	6434	0.00011	0.78011	4677	0.01365	0.007	0.006	0.00	0.17	0.7	34	N/A
13.70	33.9	0.026	-0.354	0.000	0.10	0.0000	0.0000	0.25	0.00	1.694	1377	6540	0.00011	0.78279	4666	0.01345	0.007	0.006	0.00	0.17	0.6	34	N/A
13.80	34.6	0.024	-0.405	0.000	0.10	0.0000	0.0000	0.25	0.00	1.700	1384	6690	0.00010	0.78547	4654	0.01316	0.007	0.006	0.00	0.17	0.6	35	N/A
13.90	33.7	0.027	-0.343	0.000	0.10	0.0000	0.0000	0.24	0.00	1.707	1391	6534	0.00011	0.78815	4643	0.01365	0.007	0.006	0.00	0.17	0.6	34	N/A
14.00	29.9	0.047	-0.081	0.000	0.10	0.0000	0.0000	0.23	0.00	1.714	1399	5806	0.00012	0.79083	4632	0.01602	0.010	0.008	0.00	0.17	0.6	30	N/A
14.10	24.2	0.097	0.278	0.051	0.10	0.0051	0.0124	0.23	0.01	1.721	1406	4105	0.00017	0.79350	4621	0.02627	0.025	0.021	0.00	0.17	1.3	22	0.21
14.20	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.22	0.00	1.728	1413	2078	0.00034	0.79618	4610	0.09120	0.195	0.163	0.00	0.16	N/A	N/A	N/A
14.30	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.22	0.00	1.735	1421	1100	0.00065	0.79886	4599	0.59354	2.727	2.280	0.00	0.16	N/A	N/A	N/A
14.40	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.21	0.00	1.742	1428	898	0.00079	0.80154	4588	1.39914	8.222	6.875	0.00	0.16	N/A	N/A	N/A
14.50	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.21	0.00	1.749	1435	899	0.00080	0.80422	4577	1.41494	8.325	6.961	0.00	0.16	N/A	N/A	N/A
14.60	10.6	0.442	0.900	0.442	0.10	0.0442	0.0361	0.20	0.03	1.756	1442	1034	0.00070	0.80689	4566	0.78887	3.932	3.288	0.00	0.16	2.6	8	0.08
14.70	11.7	0.394	0.872	0.394	0.10	0.0394	0.0340	0.20	0.03	1.762	1449	1316	0.00055	0.80957	4555	0.33257	1.245	1.041	0.00	0.13	2.1	9	0.08
14.80	12.4	0.363	0.848	0.363	0.10	0.0363	0.0327	0.19	0.02	1.769	1455	1526	0.00048	0.81225	4545	0.21318	0.670	0.560	0.00	0.11	1.9	10	0.09
14.90	13.9	0.309	0.796	0.309	0.10	0.0309	0.0303	0.19	0.02	1.776	1462	1727	0.00042	0.81493	4534	0.15288	0.415	0.347	0.00	0.08	2.4	11	0.10
15.00	14.2	0.301	0.788	0.301	0.10	0.0301	0.0299	0.18	0.02	1.783	1469	1816	0.00040	0.81761	4524	0.13565	0.347	0.290	0.00	0.06	2.1	11	0.10
15.10	14.6	0.286	0.769	0.286	0.10	0.0286	0.0292	0.17	0.02	1.790	1476	1876	0.00039	0.82029	4513	0.12622	0.312	0.261	0.00	0.04	2.4	12	0.10
15.20	14.0	0.305	0.792	0.305	0.10	0.0305	0.0301	0.17	0.02	1.797	1482	1730	0.00043	0.82296	4503	0.15649	0.427	0.357	0.00	0.02	2.6	11	0.10
15.30	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.16	0.00	1.804	1489	1504	0.00050	0.82564	4492	0.23409	0.757	0.633	0.00	0.00	N/A	N/A	N/A
15.40	N.A.	0.000	0.000	0.000	0.05	0.0000	0.0000	0.16	0.00	1.811	1495	1235	0.00061	0.82832	4482	0.44641	1.832	1.532	0.00	0.00	N/A	N/A	N/A

CONE PENETRATION TEST-BASED LIQUEFACTION ANALYSIS BASED ON IDRISS & BOULANGER (2008)

References:

1 - Idriss, I.M. and Boulanger, R.W. (2008). *Soil Liquefaction During Earthquakes* , Earthquake Engineering Research Institute, EERI Publication MNO-12.

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3 - Tokimatsu, K. and Seed H.B. (1987). "Evaluation of Settlements in Sands Due to Earthquake Shaking," Journal of Geotechnical Engineering, Vol. 113, No. 8, August.

4 - Pradel, D. (1998). "Procedure to Evaluate Earthquake-Induced Settlements in Sand," Journal of Geotechnical and Geoenvironmental Engineering, Vol. 124, No. 4, April.

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6 - Boulanger, R.W. and Idriss, I.M. (2014). "CPT and SPT Based Liquefaction Triggering Procedures," Report No. UCD/CGM-14/01, University of California at Davis

Project	**Chevron Guadalupe Tank Battery 9 Site**
Test Boring No	**TSMACPT-7**

Test Boring Information:

Approx. depth to ground water table		42.7 ft	13.02 m
Moist unit weight of soil	γ_m	115 pcf	18.08 kN/m^3
Saturated unit weight of soil	γ_{sat}	125 pcf	19.65 kN/m^3

Earthquake Information:

Earthquake magnitude	M_w	6.9
Peak horizontal ground surface acceleratio	a_{max}	0.490 g
Number of equivalent cycle	N	10.1

Atmospheric pressure	P_a	101.3 kPa

N/L = Non-liquefiable clay-like soil

N.A. = Not Applicable

Sum
0.29

Sum	Total
0.04	**0.33**

Factor of Safety Agaist Liquefaction (Idriss & Boulanger, 2008 and Boulanger & Idriss, 2014)

Depth, Z (m)	Depth, Z (ft)	q_c (kPa)	f_s (kPa)	σ_{vc} (kPa)	σ'_{vc} (kPa)	Q	F	I_c	Soil Type	Fines (%)	Interpreted q_c	C_N	q_{c1N}	q_{c1N-cs}	Stress Reduction Factor (r_d)	CSR	K_σ for sand
1.60	5.25	9786	38	28.9	28.9	180	0.39	1.5	Unsaturated	8	9786	1.39	134.8	140.0	0.99	0.315	1.1
1.70	5.58	9464	43	30.7	30.7	169	0.46	1.5	Unsaturated	8	9464	1.37	128.3	133.3	0.99	0.315	1.1
1.80	5.90	9883	47	32.5	32.5	172	0.48	1.5	Unsaturated	8	9883	1.35	131.9	137.1	0.99	0.315	1.1
1.90	6.23	13633	71	34.3	34.3	231	0.52	1.5	Unsaturated	8	13633	1.33	179.4	185.7	0.99	0.314	1.1
2.00	6.56	19554	90	36.2	36.2	323	0.46	1.3	Unsaturated	6	19554	1.31	253.9	254.1	0.99	0.314	1.1
2.10	6.89	12486	60	38.0	38.0	201	0.48	1.5	Unsaturated	8	12486	1.29	160.0	165.9	0.98	0.314	1.1
2.20	7.22	9414	41	39.8	39.8	148	0.44	1.6	Unsaturated	10	9414	1.28	119.2	131.1	0.98	0.313	1.1
2.30	7.54	10236	40	41.6	41.6	157	0.40	1.5	Unsaturated	8	10236	1.26	128.1	133.2	0.98	0.313	1.1
2.40	7.87	12167	41	43.4	43.4	183	0.34	1.4	Unsaturated	7	12167	1.25	150.5	151.9	0.98	0.312	1.1
2.50	8.20	15262	59	45.2	45.2	225	0.39	1.4	Unsaturated	7	15262	1.24	186.8	188.4	0.98	0.312	1.1
2.60	8.53	16297	73	47.0	47.0	236	0.45	1.4	Unsaturated	7	16297	1.22	197.4	199.1	0.98	0.312	1.1
2.70	8.86	16389	76	48.8	48.8	232	0.46	1.4	Unsaturated	7	16389	1.21	196.6	198.2	0.98	0.311	1.1
2.80	9.18	15914	75	50.6	50.6	222	0.47	1.4	Unsaturated	7	15914	1.20	189.1	190.7	0.98	0.311	1.1
2.90	9.51	15769	75	52.4	52.4	216	0.47	1.4	Unsaturated	7	15769	1.19	185.6	187.2	0.97	0.310	1.1
3.00	9.84	15663	76	54.2	54.2	211	0.49	1.5	Unsaturated	8	15663	1.18	182.7	189.1	0.97	0.310	1.1
3.10	10.17	14905	69	56.0	56.0	197	0.47	1.5	Unsaturated	8	14905	1.17	172.4	178.5	0.97	0.309	1.1
3.20	10.50	14475	65	57.8	57.8	188	0.45	1.5	Unsaturated	8	14475	1.16	166.0	172.0	0.97	0.309	1.1
3.30	10.82	14359	64	59.7	59.7	184	0.45	1.5	Unsaturated	8	14359	1.15	163.3	169.3	0.97	0.309	1.1
3.40	11.15	14509	65	61.5	61.5	183	0.45	1.5	Unsaturated	8	14509	1.14	163.8	169.7	0.97	0.308	1.1
3.50	11.48	14813	65	63.3	63.3	184	0.44	1.5	Unsaturated	8	14813	1.13	165.9	171.9	0.97	0.308	1.1
3.60	11.81	14636	53	65.1	65.1	179	0.36	1.4	Unsaturated	7	14636	1.12	162.7	164.2	0.96	0.307	1.1
3.70	12.14	14448	55	66.9	66.9	175	0.38	1.5	Unsaturated	8	14448	1.11	159.5	165.3	0.96	0.307	1.1
3.80	12.46	14506	67	68.7	68.7	173	0.46	1.5	Unsaturated	8	14506	1.11	159.0	164.8	0.96	0.306	1.1
3.90	12.79	14088	75	70.5	70.5	166	0.53	1.6	Unsaturated	10	14088	1.10	153.4	167.3	0.96	0.306	1.1
4.00	13.12	13598	73	72.3	72.3	158	0.54	1.6	Unsaturated	10	13598	1.09	147.0	160.6	0.96	0.305	1.1
4.10	13.45	12975	73	74.1	74.1	149	0.56	1.6	Unsaturated	10	12975	1.09	139.4	152.5	0.96	0.305	1.1
4.20	13.78	12645	73	75.9	75.9	143	0.58	1.6	Unsaturated	10	12645	1.08	135.0	147.8	0.96	0.304	1.0
4.30	14.10	12134	72	77.7	77.7	136	0.60	1.7	Unsaturated	11	12134	1.07	128.7	151.2	0.95	0.304	1.0
4.40	14.43	12161	65	79.5	79.5	135	0.54	1.6	Unsaturated	10	12161	1.07	128.2	140.7	0.95	0.303	1.0
4.50	14.76	12931	62	81.4	81.4	142	0.48	1.6	Unsaturated	10	12931	1.06	135.6	148.4	0.95	0.303	1.0
4.60	15.09	13990	62	83.2	83.2	152	0.45	1.6	Unsaturated	10	13990	1.05	145.8	159.3	0.95	0.303	1.0
4.70	15.42	15645	74	85.0	85.0	168	0.47	1.5	Unsaturated	8	15645	1.05	162.1	168.0	0.95	0.302	1.0
4.80	15.74	16176	82	86.8	86.8	172	0.51	1.5	Unsaturated	8	16176	1.04	166.7	172.7	0.95	0.302	1.0
4.90	16.07	16988	83	88.6	88.6	178	0.49	1.5	Unsaturated	8	16988	1.04	174.1	180.3	0.95	0.301	1.0
5.00	16.40	18171	89	90.4	90.4	189	0.49	1.5	Unsaturated	8	18171	1.03	185.3	191.7	0.94	0.301	1.0
5.10	16.73	19436	93	92.2	92.2	200	0.48	1.5	Unsaturated	8	19436	1.02	197.1	203.8	0.94	0.300	1.0
5.20	17.06	20678	99	94.0	94.0	211	0.48	1.5	Unsaturated	8	20678	1.02	208.7	215.6	0.94	0.300	1.0
5.30	17.38	22165	110	95.8	95.8	224	0.50	1.4	Unsaturated	7	22165	1.01	222.5	224.3	0.94	0.299	1.0
5.40	17.71	23458	111	97.6	97.6	235	0.48	1.4	Unsaturated	7	23458	1.01	234.3	236.2	0.94	0.299	1.0
5.50	18.04	24372	113	99.4	99.4	242	0.47	1.4	Unsaturated	7	24372	1.00	242.3	244.2	0.94	0.298	1.0
5.60	18.37	25343	125	101.2	101.2	249	0.50	1.4	Unsaturated	7	25343	1.00	250.8	252.7	0.93	0.297	1.0
5.70	18.70	25821	134	103.0	103.0	252	0.52	1.4	Unsaturated	7	25821	0.99	254.3	256.3	0.93	0.297	1.0
5.80	19.02	26520	138	104.9	104.9	256	0.52	1.4	Unsaturated	7	26520	0.99	260.0	262.0	0.93	0.296	1.0
5.90	19.35	26874	146	106.7	106.7	258	0.55	1.4	Unsaturated	7	26874	0.99	262.3	264.3	0.93	0.296	1.0
6.00	19.68	26231	145	108.5	108.5	249	0.56	1.4	Unsaturated	7	26231	0.98	254.9	256.8	0.93	0.295	1.0
6.10	20.01	25588	151	110.3	110.3	241	0.59	1.5	Unsaturated	8	25588	0.98	247.5	255.4	0.93	0.295	1.0
6.20	20.34	25291	145	112.1	112.1	236	0.57	1.5	Unsaturated	8	25291	0.97	243.6	251.4	0.92	0.294	1.0
6.30	20.66	25325	146	113.9	113.9	235	0.58	1.5	Unsaturated	8	25325	0.97	242.9	250.7	0.92	0.294	1.0
6.40	20.99	24262	135	115.7	115.7	223	0.56	1.5	Unsaturated	8	24262	0.96	231.8	239.3	0.92	0.293	1.0
6.50	21.32	24306	132	117.5	117.5	222	0.55	1.5	Unsaturated	8	24306	0.96	231.2	238.7	0.92	0.293	1.0
6.60	21.65	24496	131	119.3	119.3	222	0.54	1.5	Unsaturated	8	24496	0.96	232.1	239.6	0.92	0.292	0.9
6.70	21.98	24242	132	121.1	121.1	218	0.55	1.5	Unsaturated	8	24242	0.95	228.8	236.2	0.92	0.292	0.9
6.80	22.30	23965	129	122.9	122.9	214	0.54	1.5	Unsaturated	8	23965	0.95	225.3	232.7	0.91	0.291	0.9
6.90	22.63	23638	120	124.7	124.7	209	0.51	1.5	Unsaturated	8	23638	0.95	221.4	228.6	0.91	0.291	0.9
7.00	22.96	23874	116	126.5	126.5	210	0.49	1.5	Unsaturated	8	23874	0.94	222.7	230.0	0.91	0.290	0.9
7.10	23.29	24428	118	128.4	128.4	213	0.48	1.5	Unsaturated	8	24428	0.94	227.0	234.5	0.91	0.289	0.9
7.20	23.62	24700	129	130.2	130.2	214	0.53	1.5	Unsaturated	8	24700	0.94	228.7	236.2	0.91	0.289	0.9
7.30	23.94	24504	129	132.0	132.0	211	0.53	1.5	Unsaturated	8	24504	0.93	226.1	233.5	0.91	0.288	0.9
7.40	24.27	24275	128	133.8	133.8	207	0.53	1.5	Unsaturated	8	24275	0.93	223.2	230.5	0.90	0.288	0.9
7.50	24.60	23664	130	135.6	135.6	201	0.55	1.5	Unsaturated	8	23664	0.93	216.8	223.9	0.90	0.287	0.9
7.60	24.93	23239	116	137.4	137.4	196	0.50	1.5	Unsaturated	8	23239	0.92	212.1	219.2	0.90	0.287	0.9
7.70	25.26	22496	116	139.2	139.2	188	0.52	1.5	Unsaturated	8	22496	0.92	204.7	211.5	0.90	0.286	0.9
7.80	25.58	21277	107	141.0	141.0	177	0.51	1.5	Unsaturated	8	21277	0.92	192.9	199.5	0.90	0.286	0.9
7.90	25.91	20675	108	142.8	142.8	171	0.53	1.6	Unsaturated	10	20675	0.91	186.8	202.7	0.89	0.285	0.9
8.00	26.24	20705	107	144.6	144.6	170	0.52	1.6	Unsaturated	10	20705	0.91	186.5	202.3	0.89	0.284	0.9
8.10	26.57	21693	109	146.4	146.4	177	0.51	1.5	Unsaturated	8	21693	0.91	194.7	201.4	0.89	0.284	0.9
8.20	26.90	22782	115	148.2	148.2	185	0.51	1.5	Unsaturated	8	22782	0.90	203.8	210.7	0.89	0.283	0.9
8.30	27.22	22038	120	150.0	150.0	178	0.55	1.6	Unsaturated	10	22038	0.90	196.6	213.0	0.89	0.283	0.9
8.40	27.55	20012	112	151.9	151.9	160	0.57	1.6	Unsaturated	10	20012	0.90	177.9	193.3	0.89	0.282	0.9
8.50	27.88	20063	100	153.7	153.7	160	0.50	1.6	Unsaturated	10	20063	0.90	177.8	193.2	0.88	0.281	0.9
8.60	28.21	20457	107	155.5	155.5	162	0.53	1.6	Unsaturated	10	20457	0.89	180.8	196.3	0.88	0.281	0.9
8.70	28.54	20976	112	157.3	157.3	165	0.54	1.6	Unsaturated	10	20976	0.89	184.8	200.5	0.88	0.280	0.9
8.80	28.86	21794	126	159.1	159.1	170	0.58	1.6	Unsaturated	10	21794	0.89	191.4	207.5	0.88	0.280	0.9

Factor of Safety Agaist Liquefaction (continued) / Settelemnt of Liquefiable Soil (Idriss and Boulnager, 2008)

Depth, Z (m)	$CRR_{M=7.5}$ at σ'_{vc}=1	MSF_{max}	MSF	CRR	$(FS)_L$	q_t (kPa)	N_{60}	$N_{1,60}$	$\Delta(N_1)_{60}$	$N_{1,60-CS}$	Limiting Shear Strain γ_{lim}	Parameter F_α	Max. Shear Strain γ_{max}	ΔHi (m)	ΔLDI_i (m)	Vert. Recon. Strain ε_v	DF_i	ΔSi (inch)
1.60	0.234	1.56	1.120	0.289	**N/L**	9416	16.2	22.6	0.4	N.A.	0.000	0.000	0.000	0.05	0.0000	0.0000	0.91	0.00
1.70	0.208	1.50	1.106	0.253	**N/L**	9589	16.5	22.6	0.4	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.91	0.00
1.80	0.222	1.53	1.114	0.272	**N/L**	10390	17.9	24.1	0.4	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.90	0.00
1.90	0.923	2.19	1.255	1.274	**N/L**	13734	23.7	31.5	0.4	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.90	0.00
2.00	2.000	2.20	1.257	2.000	**N/L**	17164	27.8	36.4	0.0	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.89	0.00
2.10	0.441	1.87	1.187	0.575	**N/L**	12920	22.3	28.8	0.4	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.89	0.00
2.20	0.201	1.48	1.102	0.244	**N/L**	9813	17.5	22.3	0.9	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.88	0.00
2.30	0.208	1.49	1.106	0.253	**N/L**	10235	17.6	22.3	0.4	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.87	0.00
2.40	0.302	1.69	1.148	0.381	**N/L**	12287	20.5	25.6	0.1	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.87	0.00
2.50	1.043	2.20	1.257	1.443	**N/L**	15059	25.1	31.1	0.1	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.86	0.00
2.60	1.796	2.20	1.257	2.000	**N/L**	16182	27.0	33.1	0.1	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.86	0.00
2.70	1.712	2.20	1.257	2.000	**N/L**	16310	27.2	33.0	0.1	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.85	0.00
2.80	1.161	2.20	1.257	1.605	**N/L**	16002	26.7	32.1	0.1	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.85	0.00
2.90	0.987	2.20	1.257	1.365	**N/L**	15819	26.4	31.4	0.1	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.84	0.00
3.00	1.077	2.20	1.257	1.489	**N/L**	15613	26.9	31.7	0.4	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.84	0.00
3.10	0.684	2.07	1.228	0.925	**N/L**	15004	25.9	30.2	0.4	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.83	0.00
3.20	0.539	1.96	1.206	0.715	**N/L**	14546	25.1	29.0	0.4	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.83	0.00
3.30	0.491	1.92	1.198	0.647	**N/L**	14390	24.8	28.5	0.4	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.82	0.00
3.40	0.498	1.93	1.199	0.654	**N/L**	14551	25.1	28.6	0.4	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.81	0.00
3.50	0.537	1.96	1.206	0.707	**N/L**	14720	25.4	28.7	0.4	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.81	0.00
3.60	0.419	1.85	1.182	0.534	**N/L**	14557	24.3	27.3	0.1	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.80	0.00
3.70	0.433	1.86	1.185	0.552	**N/L**	14445	24.9	27.8	0.4	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.80	0.00
3.80	0.427	1.86	1.184	0.541	**N/L**	14449	24.9	27.6	0.4	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.79	0.00
3.90	0.461	1.89	1.191	0.586	**N/L**	14122	25.1	27.6	0.9	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.79	0.00
4.00	0.377	1.80	1.172	0.468	**N/L**	13598	24.2	26.4	0.9	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.78	0.00
4.10	0.306	1.70	1.150	0.370	**N/L**	13037	23.2	25.2	0.9	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.78	0.00
4.20	0.275	1.64	1.138	0.327	**N/L**	12658	22.5	24.3	0.9	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.77	0.00
4.30	0.297	1.68	1.146	0.354	**N/L**	12249	22.6	24.2	1.7	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.76	0.00
4.40	0.237	1.57	1.122	0.276	**N/L**	12266	21.8	23.3	0.9	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.76	0.00
4.50	0.279	1.65	1.140	0.328	**N/L**	12788	22.8	24.1	0.9	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.75	0.00
4.60	0.364	1.78	1.168	0.439	**N/L**	13909	24.8	26.1	0.9	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.75	0.00
4.70	0.472	1.90	1.194	0.581	**N/L**	15488	26.7	27.9	0.4	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.74	0.00
4.80	0.552	1.97	1.209	0.687	**N/L**	16233	28.0	29.1	0.4	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.74	0.00
4.90	0.734	2.09	1.235	0.932	**N/L**	17017	29.3	30.4	0.4	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.73	0.00
5.00	1.219	2.20	1.257	1.574	**N/L**	18186	31.3	32.3	0.4	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.73	0.00
5.10	2.360	2.20	1.257	2.000	**N/L**	19428	33.5	34.3	0.4	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.72	0.00
5.20	2.000	2.20	1.257	2.000	**N/L**	20699	35.7	36.4	0.4	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.72	0.00
5.30	2.000	2.20	1.257	2.000	**N/L**	22097	36.9	37.4	0.1	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.71	0.00
5.40	2.000	2.20	1.257	2.000	**N/L**	23179	38.7	39.0	0.1	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.70	0.00
5.50	2.000	2.20	1.257	2.000	**N/L**	24210	40.4	40.6	0.1	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.70	0.00
5.60	2.000	2.20	1.257	2.000	**N/L**	25207	42.1	42.1	0.1	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.69	0.00
5.70	2.000	2.20	1.257	2.000	**N/L**	25779	43.0	42.8	0.1	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.69	0.00
5.80	2.000	2.20	1.257	2.000	**N/L**	26484	44.2	43.8	0.1	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.68	0.00
5.90	2.000	2.20	1.257	2.000	**N/L**	26735	44.6	44.0	0.1	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.68	0.00
6.00	2.000	2.20	1.257	2.000	**N/L**	26274	43.9	43.0	0.1	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.67	0.00
6.10	2.000	2.20	1.257	2.000	**N/L**	25600	44.1	43.1	0.4	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.67	0.00
6.20	2.000	2.20	1.257	2.000	**N/L**	25289	43.6	42.4	0.4	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.66	0.00
6.30	2.000	2.20	1.257	2.000	**N/L**	25038	43.1	41.8	0.4	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.66	0.00
6.40	2.000	2.20	1.257	2.000	**N/L**	24259	41.8	40.3	0.4	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.65	0.00
6.50	2.000	2.20	1.257	2.000	**N/L**	24304	41.9	40.2	0.4	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.64	0.00
6.60	2.000	2.20	1.257	2.000	**N/L**	24493	42.2	40.4	0.4	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.64	0.00
6.70	2.000	2.20	1.257	2.000	**N/L**	24239	41.8	39.8	0.4	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.63	0.00
6.80	2.000	2.20	1.257	2.000	**N/L**	23912	41.2	39.1	0.4	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.63	0.00
6.90	2.000	2.20	1.257	2.000	**N/L**	23687	40.8	38.6	0.4	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.62	0.00
7.00	2.000	2.20	1.257	2.000	**N/L**	23870	41.1	38.8	0.4	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.62	0.00
7.10	2.000	2.20	1.257	2.000	**N/L**	24403	42.1	39.5	0.4	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.61	0.00
7.20	2.000	2.20	1.257	2.000	**N/L**	24550	42.3	39.6	0.4	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.61	0.00
7.30	2.000	2.20	1.257	2.000	**N/L**	24500	42.2	39.3	0.4	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.60	0.00
7.40	2.000	2.20	1.257	2.000	**N/L**	24345	42.0	39.0	0.4	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.60	0.00
7.50	2.000	2.20	1.257	2.000	**N/L**	23752	40.9	37.9	0.4	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.59	0.00
7.60	2.000	2.20	1.257	2.000	**N/L**	23235	40.0	36.9	0.4	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.58	0.00
7.70	2.000	2.20	1.257	2.000	**N/L**	22420	38.6	35.5	0.4	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.58	0.00
7.80	1.839	2.20	1.257	2.000	**N/L**	21340	36.8	33.7	0.4	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.57	0.00
7.90	2.206	2.20	1.257	2.000	**N/L**	20755	37.0	33.7	0.9	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.57	0.00
8.00	2.158	2.20	1.257	2.000	**N/L**	20865	37.2	33.8	0.9	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.56	0.00
8.10	2.044	2.20	1.257	2.000	**N/L**	21762	37.5	34.0	0.4	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.56	0.00
8.20	3.652	2.20	1.257	2.000	**N/L**	22690	39.1	35.3	0.4	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.55	0.00
8.30	2.000	2.20	1.257	2.000	**N/L**	21855	38.9	35.1	0.9	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.55	0.00
8.40	1.320	2.20	1.257	1.494	**N/L**	20206	36.0	32.3	0.9	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.54	0.00
8.50	1.313	2.20	1.257	1.482	**N/L**	20059	35.7	32.0	0.9	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.54	0.00
8.60	1.541	2.20	1.257	1.727	**N/L**	20418	36.4	32.4	0.9	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.53	0.00
8.70	1.946	2.20	1.257	2.000	**N/L**	21023	37.4	33.3	0.9	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.52	0.00
8.80	2.968	2.20	1.257	2.000	**N/L**	21626	38.5	34.2	0.9	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.52	0.00

Settlement of Unsaturated Sand (Tokimatsu & Seed, 1987, and Pradel, 1998) / Cumulative / S_r (Idriss & Boulanger, 2008)

Depth, Z (m)	$p = \sigma_m$ (tsf)	τ_{ave} (psf)	G_{max} (tsf)	τ_{ave}/G_{max}	a	b	γ_{eff} (%)	ε_{15} (%)	ε_{Nc} (%)	Settlement (inch)	Cumulative Settlement (inch)	$\Delta(N_1)_{60-Sr}$	$(N_1)_{60-Sr}$	S_r/σ_{v0}'
1.60	0.202	192	1511	0.00006	0.20272	16691	0.00836	0.007	0.006	0.00	0.33	N/A	N/A	N/A
1.70	0.215	204	1561	0.00007	0.20764	16095	0.00861	0.007	0.006	0.00	0.33	N/A	N/A	N/A
1.80	0.228	216	1715	0.00006	0.21256	15552	0.00812	0.006	0.005	0.00	0.33	N/A	N/A	N/A
1.90	0.240	228	2296	0.00005	0.21749	15056	0.00594	0.003	0.003	0.00	0.33	N/A	N/A	N/A
2.00	0.253	239	2728	0.00004	0.22241	14600	0.00511	0.002	0.002	0.00	0.33	N/A	N/A	N/A
2.10	0.266	251	2211	0.00006	0.22733	14178	0.00699	0.005	0.004	0.00	0.33	N/A	N/A	N/A
2.20	0.278	263	1755	0.00007	0.23225	13788	0.01006	0.009	0.007	0.00	0.33	N/A	N/A	N/A
2.30	0.291	275	1790	0.00008	0.23717	13425	0.01034	0.009	0.008	0.00	0.33	N/A	N/A	N/A
2.40	0.304	287	2102	0.00007	0.24209	13087	0.00874	0.006	0.005	0.00	0.33	N/A	N/A	N/A
2.50	0.316	299	2602	0.00006	0.24701	12770	0.00697	0.004	0.003	0.00	0.33	N/A	N/A	N/A
2.60	0.329	310	2822	0.00006	0.25193	12473	0.00659	0.004	0.003	0.00	0.33	N/A	N/A	N/A
2.70	0.342	322	2870	0.00006	0.25685	12194	0.00674	0.004	0.003	0.00	0.33	N/A	N/A	N/A
2.80	0.354	334	2840	0.00006	0.26177	11931	0.00712	0.004	0.003	0.00	0.33	N/A	N/A	N/A
2.90	0.367	346	2831	0.00006	0.26669	11682	0.00744	0.004	0.004	0.00	0.33	N/A	N/A	N/A
3.00	0.379	357	2907	0.00006	0.27161	11447	0.00749	0.004	0.004	0.00	0.32	N/A	N/A	N/A
3.10	0.392	369	2815	0.00007	0.27653	11224	0.00810	0.005	0.004	0.00	0.32	N/A	N/A	N/A
3.20	0.405	381	2750	0.00007	0.28145	11012	0.00866	0.006	0.005	0.00	0.32	N/A	N/A	N/A
3.30	0.417	392	2740	0.00007	0.28637	10811	0.00902	0.006	0.005	0.00	0.32	N/A	N/A	N/A
3.40	0.430	404	2791	0.00007	0.29129	10619	0.00912	0.006	0.005	0.00	0.32	N/A	N/A	N/A
3.50	0.443	415	2842	0.00007	0.29621	10436	0.00922	0.006	0.005	0.00	0.32	N/A	N/A	N/A
3.60	0.455	427	2741	0.00008	0.30113	10261	0.00999	0.007	0.006	0.00	0.32	N/A	N/A	N/A
3.70	0.468	438	2826	0.00008	0.30605	10093	0.00992	0.007	0.006	0.00	0.32	N/A	N/A	N/A
3.80	0.481	450	2845	0.00008	0.31097	9933	0.01015	0.007	0.006	0.00	0.32	N/A	N/A	N/A
3.90	0.493	461	2891	0.00008	0.31589	9780	0.01025	0.007	0.006	0.00	0.32	N/A	N/A	N/A
4.00	0.506	473	2800	0.00008	0.32081	9632	0.01102	0.008	0.007	0.00	0.32	N/A	N/A	N/A
4.10	0.519	484	2700	0.00009	0.32573	9490	0.01192	0.009	0.008	0.00	0.32	N/A	N/A	N/A
4.20	0.531	496	2637	0.00009	0.33065	9354	0.01269	0.010	0.008	0.00	0.32	N/A	N/A	N/A
4.30	0.544	507	2654	0.00010	0.33557	9223	0.01294	0.010	0.009	0.00	0.32	N/A	N/A	N/A
4.40	0.557	518	2583	0.00010	0.34049	9097	0.01383	0.012	0.010	0.00	0.32	N/A	N/A	N/A
4.50	0.569	530	2708	0.00010	0.34541	8975	0.01331	0.011	0.009	0.00	0.32	N/A	N/A	N/A
4.60	0.582	541	2960	0.00009	0.35033	8857	0.01209	0.009	0.007	0.00	0.32	N/A	N/A	N/A
4.70	0.594	552	3206	0.00009	0.35525	8744	0.01114	0.007	0.006	0.00	0.32	N/A	N/A	N/A
4.80	0.607	563	3377	0.00008	0.36017	8634	0.01067	0.007	0.006	0.00	0.32	N/A	N/A	N/A
4.90	0.620	574	3557	0.00008	0.36509	8528	0.01021	0.006	0.005	0.00	0.32	N/A	N/A	N/A
5.00	0.632	586	3820	0.00008	0.37001	8425	0.00954	0.005	0.004	0.00	0.31	N/A	N/A	N/A
5.10	0.645	597	4100	0.00007	0.37493	8326	0.00893	0.005	0.004	0.00	0.31	N/A	N/A	N/A
5.20	0.658	608	4389	0.00007	0.37985	8229	0.00839	0.004	0.003	0.00	0.31	N/A	N/A	N/A
5.30	0.670	619	4559	0.00007	0.38477	8136	0.00817	0.004	0.003	0.00	0.31	N/A	N/A	N/A
5.40	0.683	630	4803	0.00007	0.38969	8045	0.00783	0.004	0.003	0.00	0.31	N/A	N/A	N/A
5.50	0.696	641	5039	0.00006	0.39461	7957	0.00754	0.003	0.003	0.00	0.31	N/A	N/A	N/A
5.60	0.708	651	5269	0.00006	0.39953	7871	0.00729	0.003	0.002	0.00	0.31	N/A	N/A	N/A
5.70	0.721	662	5411	0.00006	0.40446	7788	0.00720	0.003	0.002	0.00	0.31	N/A	N/A	N/A
5.80	0.734	673	5582	0.00006	0.40938	7707	0.00707	0.003	0.002	0.00	0.31	N/A	N/A	N/A
5.90	0.746	684	5657	0.00006	0.41430	7629	0.00708	0.003	0.002	0.00	0.31	N/A	N/A	N/A
6.00	0.759	695	5582	0.00006	0.41922	7552	0.00732	0.003	0.002	0.00	0.31	N/A	N/A	N/A
6.10	0.772	705	5636	0.00006	0.42414	7478	0.00737	0.003	0.002	0.00	0.31	N/A	N/A	N/A
6.20	0.784	716	5589	0.00006	0.42906	7405	0.00757	0.003	0.003	0.00	0.31	N/A	N/A	N/A
6.30	0.797	727	5554	0.00007	0.43398	7334	0.00776	0.003	0.003	0.00	0.31	N/A	N/A	N/A
6.40	0.810	737	5402	0.00007	0.43890	7265	0.00816	0.004	0.003	0.00	0.31	N/A	N/A	N/A
6.50	0.822	748	5432	0.00007	0.44382	7198	0.00824	0.004	0.003	0.00	0.31	N/A	N/A	N/A
6.60	0.835	758	5494	0.00007	0.44874	7132	0.00826	0.004	0.003	0.00	0.31	N/A	N/A	N/A
6.70	0.847	769	5456	0.00007	0.45366	7068	0.00846	0.004	0.003	0.00	0.31	N/A	N/A	N/A
6.80	0.860	779	5401	0.00007	0.45858	7006	0.00870	0.004	0.003	0.00	0.31	N/A	N/A	N/A
6.90	0.873	789	5369	0.00007	0.46350	6945	0.00890	0.004	0.003	0.00	0.31	N/A	N/A	N/A
7.00	0.885	800	5429	0.00007	0.46842	6885	0.00892	0.004	0.003	0.00	0.31	N/A	N/A	N/A
7.10	0.898	810	5569	0.00007	0.47334	6827	0.00877	0.004	0.003	0.00	0.31	N/A	N/A	N/A
7.20	0.911	820	5621	0.00007	0.47826	6770	0.00880	0.004	0.003	0.00	0.31	N/A	N/A	N/A
7.30	0.923	830	5628	0.00007	0.48318	6714	0.00892	0.004	0.003	0.00	0.31	N/A	N/A	N/A
7.40	0.936	840	5610	0.00007	0.48810	6659	0.00908	0.004	0.003	0.00	0.31	N/A	N/A	N/A
7.50	0.949	850	5491	0.00008	0.49302	6606	0.00945	0.004	0.004	0.00	0.31	N/A	N/A	N/A
7.60	0.961	860	5388	0.00008	0.49794	6553	0.00981	0.005	0.004	0.00	0.31	N/A	N/A	N/A
7.70	0.974	870	5215	0.00008	0.50286	6502	0.01036	0.005	0.004	0.00	0.31	N/A	N/A	N/A
7.80	0.987	880	4979	0.00009	0.50778	6452	0.01113	0.006	0.005	0.00	0.31	N/A	N/A	N/A
7.90	0.999	890	5019	0.00009	0.51270	6403	0.01117	0.006	0.005	0.00	0.31	N/A	N/A	N/A
8.00	1.012	900	5061	0.00009	0.51762	6355	0.01120	0.006	0.005	0.00	0.31	N/A	N/A	N/A
8.10	1.025	910	5123	0.00009	0.52254	6308	0.01117	0.006	0.005	0.00	0.31	N/A	N/A	N/A
8.20	1.037	920	5357	0.00009	0.52746	6261	0.01069	0.005	0.005	0.00	0.31	N/A	N/A	N/A
8.30	1.050	929	5347	0.00009	0.53238	6216	0.01085	0.006	0.005	0.00	0.31	N/A	N/A	N/A
8.40	1.062	939	4958	0.00009	0.53730	6171	0.01210	0.007	0.006	0.00	0.31	N/A	N/A	N/A
8.50	1.075	948	4935	0.00010	0.54222	6128	0.01232	0.007	0.006	0.00	0.31	N/A	N/A	N/A
8.60	1.088	958	5038	0.00010	0.54714	6085	0.01214	0.007	0.006	0.00	0.30	N/A	N/A	N/A
8.70	1.100	967	5201	0.00009	0.55206	6043	0.01180	0.006	0.005	0.00	0.30	N/A	N/A	N/A
8.80	1.113	977	5365	0.00009	0.55698	6002	0.01147	0.006	0.005	0.00	0.30	N/A	N/A	N/A

Depth, Z (m)	Depth, Z (ft)	q_c (kPa)	f_s (kPa)	σ_{vc} (kPa)	σ'_{vc} (kPa)	Q	F	I_c	Soil Type	Fines (%)	Interpreted q_c	C_N	q_{c1N}	$q_{c1N\text{-}cs}$	Stress Reduction Factor (r_d)	CSR	K_σ for sand
8.90	29.19	21289	130	160.9	160.9	165	0.62	1.6	Unsaturated	10	21289	0.88	186.4	202.3	0.88	0.279	0.9
9.00	29.52	21393	123	162.7	162.7	165	0.58	1.6	Unsaturated	10	21393	0.88	186.8	202.6	0.87	0.279	0.9
9.10	29.85	22071	124	164.5	164.5	170	0.57	1.6	Unsaturated	10	22071	0.88	192.1	208.3	0.87	0.278	0.9
9.20	30.18	23198	138	166.3	166.3	177	0.60	1.6	Unsaturated	10	23198	0.88	201.4	218.1	0.87	0.277	0.9
9.30	30.50	24080	138	168.1	168.1	183	0.58	1.6	Unsaturated	10	24080	0.87	208.4	225.5	0.87	0.277	0.8
9.40	30.83	24422	139	169.9	169.9	185	0.57	1.6	Unsaturated	10	24422	0.87	210.8	228.0	0.87	0.276	0.8
9.50	31.16	26842	154	171.7	171.7	202	0.58	1.5	Unsaturated	8	26842	0.87	231.0	238.5	0.87	0.276	0.8
9.60	31.49	28205	161	173.5	173.5	211	0.57	1.5	Unsaturated	8	28205	0.87	242.1	249.9	0.86	0.275	0.8
9.70	31.82	29933	173	175.4	175.4	223	0.58	1.5	Unsaturated	8	29933	0.86	256.2	264.3	0.86	0.274	0.8
9.80	32.14	30466	193	177.2	177.2	226	0.64	1.5	Unsaturated	8	30466	0.86	260.1	268.3	0.86	0.274	0.8
9.90	32.47	30798	195	179.0	179.0	227	0.64	1.5	Unsaturated	8	30798	0.86	262.2	270.4	0.86	0.273	0.8
10.00	32.80	31857	207	180.8	180.8	234	0.65	1.5	Unsaturated	8	31857	0.86	270.5	278.9	0.86	0.273	0.8
10.10	33.13	32072	219	182.6	182.6	234	0.69	1.5	Unsaturated	8	32072	0.86	271.6	280.1	0.85	0.272	0.8
10.20	33.46	32025	217	184.4	184.4	233	0.68	1.5	Unsaturated	8	32025	0.85	270.5	279.0	0.85	0.271	0.8
10.30	33.78	31639	221	186.2	186.2	229	0.70	1.5	Unsaturated	8	31639	0.85	266.6	274.9	0.85	0.271	0.8
10.40	34.11	31052	219	188.0	188.0	224	0.71	1.5	Unsaturated	8	31052	0.85	261.0	269.2	0.85	0.270	0.8
10.50	34.44	30898	223	189.8	189.8	221	0.73	1.6	Unsaturated	10	30898	0.85	259.0	279.1	0.85	0.270	0.8
10.60	34.77	30948	221	191.6	191.6	221	0.72	1.6	Unsaturated	10	30948	0.84	258.8	278.8	0.84	0.269	0.8
10.70	35.10	31208	191	193.4	193.4	222	0.61	1.5	Unsaturated	8	31208	0.84	260.3	268.5	0.84	0.268	0.8
10.80	35.42	31541	188	195.2	195.2	223	0.60	1.5	Unsaturated	8	31541	0.84	262.4	270.7	0.84	0.268	0.8
10.90	35.75	32736	196	197.1	197.1	230	0.60	1.5	Unsaturated	8	32736	0.84	271.7	280.2	0.84	0.267	0.8
11.00	36.08	31639	223	198.9	198.9	222	0.71	1.6	Unsaturated	10	31639	0.84	262.0	282.2	0.84	0.267	0.8
11.10	36.41	30571	205	200.7	200.7	213	0.68	1.6	Unsaturated	10	30571	0.83	252.5	272.2	0.84	0.266	0.8
11.20	36.74	30549	202	202.5	202.5	212	0.66	1.5	Unsaturated	8	30549	0.83	251.8	259.8	0.83	0.265	0.8
11.30	37.06	31556	199	204.3	204.3	218	0.63	1.5	Unsaturated	8	31556	0.83	259.5	267.6	0.83	0.265	0.8
11.40	37.39	32426	208	206.1	206.1	223	0.65	1.5	Unsaturated	8	32426	0.83	266.0	274.3	0.83	0.264	0.8
11.50	37.72	33695	239	207.9	207.9	231	0.71	1.5	Unsaturated	8	33695	0.83	275.8	284.3	0.83	0.264	0.8
11.60	38.05	31143	226	209.7	209.7	212	0.73	1.6	Unsaturated	10	31143	0.82	254.3	274.1	0.83	0.263	0.8
11.70	38.38	30470	218	211.5	211.5	207	0.72	1.6	Unsaturated	10	30470	0.82	248.2	267.7	0.82	0.262	0.8
11.80	38.70	29290	202	213.3	213.3	198	0.70	1.6	Unsaturated	10	29290	0.82	238.1	256.9	0.82	0.262	0.8
11.90	39.03	28889	189	215.1	215.1	194	0.66	1.6	Unsaturated	10	28889	0.82	234.3	252.9	0.82	0.261	0.8
12.00	39.36	29193	188	216.9	216.9	195	0.65	1.6	Unsaturated	10	29193	0.82	236.2	255.0	0.82	0.261	0.8
12.10	39.69	31757	192	218.7	218.7	212	0.61	1.5	Unsaturated	8	31757	0.82	256.4	264.5	0.82	0.260	0.8
12.20	40.02	30650	212	220.6	220.6	204	0.70	1.6	Unsaturated	10	30650	0.81	247.0	266.3	0.81	0.259	0.8
12.30	40.34	28007	195	222.4	222.4	185	0.70	1.6	Unsaturated	10	28007	0.81	225.2	243.3	0.81	0.259	0.8
12.40	40.67	26204	196	224.2	224.2	172	0.75	1.7	Unsaturated	11	26204	0.81	210.2	241.2	0.81	0.258	0.8
12.50	41.00	25304	165	226.0	226.0	166	0.66	1.6	Unsaturated	10	25304	0.81	202.6	219.4	0.81	0.258	0.8
12.60	41.33	25269	148	227.8	227.8	165	0.59	1.6	Unsaturated	10	25269	0.81	201.9	218.6	0.81	0.257	0.8
12.70	41.66	25008	136	229.6	229.6	162	0.55	1.6	Unsaturated	10	25008	0.81	199.4	216.0	0.80	0.256	0.8
12.80	41.98	25487	193	231.4	231.4	165	0.77	1.7	Unsaturated	11	25487	0.80	202.8	233.0	0.80	0.256	0.8
12.90	42.31	26346	198	233.2	233.2	170	0.76	1.7	Unsaturated	11	26346	0.80	209.2	240.0	0.80	0.255	0.7
13.00	42.64	28290	185	235.0	235.0	182	0.66	1.6	Unsaturated	10	28290	0.80	224.2	242.2	0.80	0.255	0.7
13.10	42.97	32052	189	237.0	236.1	206	0.59	1.5		8	32052	0.80	253.6	261.7	0.80	0.255	0.7
13.20	43.30	33958	216	238.9	237.1	218	0.64	1.5		8	33958	0.80	268.4	276.8	0.80	0.255	0.7
13.30	43.62	36400	240	240.9	238.1	233	0.66	1.5		8	36400	0.80	287.4	296.3	0.79	0.256	0.7
13.40	43.95	36870	244	242.8	239.1	235	0.67	1.5		8	36870	0.80	290.8	299.7	0.79	0.256	0.7
13.50	44.28	39457	260	244.8	240.1	251	0.66	1.5		8	39457	0.80	310.9	320.3	0.79	0.256	0.7
13.60	44.61	41897	270	246.8	241.1	267	0.65	1.5		8	41897	0.79	329.7	339.6	0.79	0.257	0.7
13.70	44.94	42499	266	248.7	242.1	270	0.63	1.5		8	42499	0.79	334.1	344.1	0.79	0.257	0.7
13.80	45.26	42637	227	250.7	243.0	270	0.54	1.4		7	42637	0.79	334.9	337.3	0.78	0.258	0.7
13.90	45.59	36094	212	252.7	244.0	228	0.59	1.5		8	36094	0.79	283.2	291.9	0.78	0.258	0.7
14.00	45.92	24133	208	254.6	245.0	152	0.87	1.7		11	24133	0.79	189.1	217.9	0.78	0.258	0.7
14.10	46.25	12335	93	256.6	246.0	77	0.77	1.9		15	12335	0.79	96.6	133.3	0.78	0.259	0.9
14.20	46.58	6555	39	258.6	247.0	40	0.62	2.1		19	6555	0.79	51.3	88.7	0.78	0.259	0.9
14.30	46.90	5747	3	260.5	248.0	35	0.10	1.9		15	5747	0.79	44.9	71.3	0.77	0.259	0.9
14.40	47.23	4670	20	262.5	248.9	28	0.45	2.2		22	4670	0.79	36.4	72.8	0.77	0.260	0.9
14.50	47.56	5434	20	264.5	249.9	32	0.38	2.1		19	5434	0.79	42.4	77.4	0.77	0.260	0.9
14.60	47.89	5794	20	266.4	250.9	35	0.36	2.1		19	5794	0.79	45.1	80.9	0.77	0.260	0.9
14.70	48.22	6353	15	268.4	251.9	38	0.24	2.0		17	6353	0.79	49.4	82.1	0.77	0.260	0.9
14.80	48.54	4930	20	270.4	252.9	29	0.44	2.2		22	4930	0.78	38.3	75.2	0.77	0.261	0.9
14.90	48.87	3027	19	272.3	253.9	17	0.70	2.5		30	3027	0.78	23.5	60.4	0.76	0.261	0.9
15.00	49.20	2717	17	274.3	254.8	15	0.68	2.5		30	2717	0.78	21.1	57.2	0.76	0.261	0.9
15.10	49.53	2815	17	276.3	255.8	16	0.68	2.5		30	2815	0.78	21.8	58.2	0.76	0.261	0.9
15.20	49.86	3015	35	278.2	256.8	17	1.29	2.6	Clay-Like	34	3015	0.78	23.3	60.9	0.76	0.262	0.9
15.30	50.18	5116	38	280.2	257.8	30	0.79	2.3		24	5116	0.78	39.6	79.1	0.76	0.262	0.9
15.40	50.51	4865	63	282.1	258.8	28	1.38	2.4		27	4865	0.78	37.6	78.1	0.75	0.262	0.9

Depth, Z (m)	$CRR_{M=7.5}$ at σ'_{vc}=1	MSF_{max}	MSF	CRR	$(FS)_L$	q_t (kPa)	N_{60}	$N_{1,60}$	$\Delta(N_1)_{60}$	$N_{1,60\text{-}CS}$	Limiting Shear Strain γ_{lim}	Parameter F_α	Max. Shear Strain γ_{max}	ΔHi (m)	ΔLDI_i (m)	Vert. Recon. Strain ε_v	DF_i
8.90	2.151	2.20	1.257	2.000	**N/L**	21368	38.1	33.7	0.9	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.51
9.00	2.199	2.20	1.257	2.000	**N/L**	21389	38.1	33.6	0.9	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.51
9.10	3.118	2.20	1.257	2.000	**N/L**	22089	39.3	34.6	0.9	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.50
9.20	2.000	2.20	1.257	2.000	**N/L**	23210	41.3	36.2	0.9	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.50
9.30	2.000	2.20	1.257	2.000	**N/L**	23980	42.7	37.3	0.9	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.49
9.40	2.000	2.20	1.257	2.000	**N/L**	24710	44.0	38.4	0.9	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.49
9.50	2.000	2.20	1.257	2.000	**N/L**	26744	46.1	40.1	0.4	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.48
9.60	2.000	2.20	1.257	2.000	**N/L**	28306	48.8	42.3	0.4	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.48
9.70	2.000	2.20	1.257	2.000	**N/L**	29810	51.4	44.4	0.4	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.47
9.80	2.000	2.20	1.257	2.000	**N/L**	30523	52.6	45.4	0.4	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.46
9.90	2.000	2.20	1.257	2.000	**N/L**	30932	53.3	45.8	0.4	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.46
10.00	2.000	2.20	1.257	2.000	**N/L**	31757	54.7	46.9	0.4	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.45
10.10	2.000	2.20	1.257	2.000	**N/L**	32059	55.2	47.3	0.4	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.45
10.20	2.000	2.20	1.257	2.000	**N/L**	31946	55.1	47.0	0.4	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.44
10.30	2.000	2.20	1.257	2.000	**N/L**	31525	54.3	46.2	0.4	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.44
10.40	2.000	2.20	1.257	2.000	**N/L**	31123	53.6	45.5	0.4	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.43
10.50	2.000	2.20	1.257	2.000	**N/L**	30983	55.2	46.7	0.9	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.43
10.60	2.000	2.20	1.257	2.000	**N/L**	31061	55.3	46.7	0.9	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.42
10.70	2.000	2.20	1.257	2.000	**N/L**	31297	53.9	45.4	0.4	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.42
10.80	2.000	2.20	1.257	2.000	**N/L**	31662	54.6	45.9	0.4	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.41
10.90	2.000	2.20	1.257	2.000	**N/L**	32401	55.8	46.8	0.4	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.40
11.00	2.000	2.20	1.257	2.000	**N/L**	31568	56.2	47.0	0.9	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.40
11.10	2.000	2.20	1.257	1.996	**N/L**	30562	54.4	45.4	0.9	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.39
11.20	2.000	2.20	1.257	1.989	**N/L**	30546	52.6	43.8	0.4	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.39
11.30	2.000	2.20	1.257	1.982	**N/L**	31382	54.1	44.9	0.4	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.38
11.40	2.000	2.20	1.257	1.976	**N/L**	32477	56.0	46.4	0.4	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.38
11.50	2.000	2.20	1.257	1.969	**N/L**	33245	57.3	47.4	0.4	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.37
11.60	2.000	2.20	1.257	1.963	**N/L**	31808	56.6	46.7	0.9	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.37
11.70	2.000	2.20	1.257	1.956	**N/L**	30468	54.3	44.6	0.9	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.36
11.80	2.000	2.20	1.257	1.950	**N/L**	29298	52.2	42.8	0.9	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.35
11.90	2.000	2.20	1.257	1.943	**N/L**	28965	51.6	42.3	0.9	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.35
12.00	2.000	2.20	1.257	1.937	**N/L**	29585	52.7	43.1	0.9	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.34
12.10	2.000	2.20	1.257	1.931	**N/L**	31400	54.1	44.1	0.4	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.34
12.20	2.000	2.20	1.257	1.925	**N/L**	30582	54.5	44.3	0.9	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.33
12.30	2.000	2.20	1.257	1.918	**N/L**	28062	50.0	40.6	0.9	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.33
12.40	2.000	2.20	1.257	1.912	**N/L**	26337	48.5	39.3	1.7	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.32
12.50	2.000	2.20	1.257	1.906	**N/L**	25392	45.2	36.6	0.9	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.32
12.60	2.000	2.20	1.257	1.900	**N/L**	25130	44.8	36.1	0.9	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.31
12.70	2.000	2.20	1.257	1.894	**N/L**	25102	44.7	36.0	0.9	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.31
12.80	2.000	2.20	1.257	1.888	**N/L**	25525	47.0	37.8	1.7	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.30
12.90	2.000	2.20	1.257	1.882	**N/L**	26726	49.2	39.5	1.7	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.29
13.00	2.000	2.20	1.257	1.877	**N/L**	28814	51.3	41.1	0.9	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.29
13.10	2.000	2.20	1.257	1.873	**2.00**	31637	54.5	43.6	0.4	44.0	0.003	-1.108	0.000	0.10	0.0000	0.0000	0.28
13.20	2.000	2.20	1.257	1.870	**2.00**	34007	58.6	46.8	0.4	47.2	0.001	-1.361	0.000	0.10	0.0000	0.0000	0.28
13.30	2.000	2.20	1.257	1.867	**2.00**	36104	62.2	49.6	0.4	50.0	0.000	-1.589	0.000	0.10	0.0000	0.0000	0.27
13.40	2.000	2.20	1.257	1.864	**2.00**	37269	64.2	51.2	0.4	51.5	0.000	-1.715	0.000	0.10	0.0000	0.0000	0.27
13.50	2.000	2.20	1.257	1.860	**2.00**	39514	68.1	54.2	0.4	54.6	0.000	-1.965	0.000	0.10	0.0000	0.0000	0.26
13.60	2.000	2.20	1.257	1.857	**2.00**	41724	71.9	57.2	0.4	57.5	0.000	-2.214	0.000	0.10	0.0000	0.0000	0.26
13.70	2.000	2.20	1.257	1.854	**2.00**	42894	73.9	58.7	0.4	59.1	0.000	-2.344	0.000	0.10	0.0000	0.0000	0.25
13.80	2.000	2.20	1.257	1.851	**2.00**	41854	69.9	55.4	0.1	55.5	0.000	-2.044	0.000	0.10	0.0000	0.0000	0.25
13.90	2.000	2.20	1.257	1.848	**2.00**	35335	60.9	48.3	0.4	48.6	0.001	-1.478	0.000	0.10	0.0000	0.0000	0.24
14.00	2.000	2.20	1.257	1.845	**2.00**	24123	44.4	35.2	1.7	36.8	0.016	-0.570	0.000	0.10	0.0000	0.0000	0.23
14.10	0.208	1.50	1.106	0.202	**0.78**	12901	25.5	20.2	3.2	23.4	0.108	0.328	0.063	0.10	0.0063	0.0160	0.23
14.20	0.124	1.21	1.045	0.118	**0.46**	7140	15.3	12.1	4.3	16.4	0.236	0.694	0.236	0.10	0.0236	0.0269	0.22
14.30	0.108	1.15	1.033	0.103	**0.40**	5503	10.9	8.6	3.2	11.8	0.388	0.868	0.388	0.10	0.0388	0.0338	0.22
14.40	0.110	1.16	1.033	0.104	**0.40**	4674	10.4	8.2	4.7	12.9	0.344	0.832	0.344	0.10	0.0344	0.0318	0.21
14.50	0.113	1.17	1.036	0.108	**0.42**	5302	11.3	8.9	4.3	13.3	0.332	0.820	0.332	0.10	0.0332	0.0313	0.21
14.60	0.117	1.18	1.039	0.111	**0.43**	5871	12.5	9.9	4.3	14.2	0.299	0.785	0.299	0.10	0.0299	0.0298	0.20
14.70	0.118	1.18	1.040	0.112	**0.43**	6355	13.1	10.3	3.8	14.1	0.303	0.790	0.303	0.10	0.0303	0.0300	0.20
14.80	0.112	1.16	1.035	0.106	**0.41**	5061	11.3	8.8	4.7	13.6	0.321	0.809	0.321	0.10	0.0321	0.0308	0.19
14.90	0.100	1.13	1.027	0.095	**0.37**	3113	7.9	6.2	5.4	11.6	0.398	0.874	0.398	0.10	0.0398	0.0342	0.19
15.00	0.097	1.12	1.026	0.093	**0.36**	2720	6.9	5.4	5.4	10.8	0.434	0.896	0.434	0.10	0.0434	0.0357	0.18
15.10	0.098	1.12	1.027	0.094	**0.36**	2790	7.1	5.6	5.4	10.9	0.427	0.892	0.427	0.10	0.0427	0.0354	0.17
15.20	0.100	1.13	1.028	0.095	**N/L**	3327	8.9	6.9	5.5	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.17
15.30	0.115	1.17	1.037	0.109	**0.42**	4833	11.2	8.8	5.0	13.8	0.313	0.802	0.313	0.10	0.0313	0.0305	0.16
15.40	0.114	1.17	1.037	0.108	**0.41**	4990	12.1	9.5	5.2	14.7	0.285	0.767	0.285	0.05	0.0142	0.0292	0.16

Depth, Z (m)	ΔSi (inch)	$p = \sigma_m$ (tsf)	τ_{ave} (psf)	G_{max} (tsf)	τ_{ave}/G_{max}	a	b	γ_{eff} (%)	ε_{15} (%)	ε_{Nc} (%)	Settlement (inch)	Settlement (inch)	$\Delta(N_1)_{60\text{-}Sr}$	$(N_1)_{60\text{-}Sr}$	S_r/σ_{v0}'
8.90	0.00	1.126	986	5315	0.00009	0.56190	5961	0.01174	0.006	0.005	0.00	0.30	N/A	N/A	N/A
9.00	0.00	1.138	996	5334	0.00009	0.56682	5921	0.01182	0.006	0.005	0.00	0.30	N/A	N/A	N/A
9.10	0.00	1.151	1005	5523	0.00009	0.57174	5882	0.01144	0.006	0.005	0.00	0.30	N/A	N/A	N/A
9.20	0.00	1.164	1014	5818	0.00009	0.57666	5844	0.01083	0.005	0.004	0.00	0.30	N/A	N/A	N/A
9.30	0.00	1.176	1023	6027	0.00008	0.58158	5806	0.01048	0.005	0.004	0.00	0.30	N/A	N/A	N/A
9.40	0.00	1.189	1032	6226	0.00008	0.58650	5769	0.01017	0.005	0.004	0.00	0.30	N/A	N/A	N/A
9.50	0.00	1.202	1041	6537	0.00008	0.59143	5732	0.00968	0.004	0.004	0.00	0.30	N/A	N/A	N/A
9.60	0.00	1.214	1050	6936	0.00008	0.59635	5696	0.00910	0.004	0.003	0.00	0.30	N/A	N/A	N/A
9.70	0.00	1.227	1059	7323	0.00007	0.60127	5661	0.00861	0.003	0.003	0.00	0.30	N/A	N/A	N/A
9.80	0.00	1.240	1068	7516	0.00007	0.60619	5626	0.00842	0.003	0.003	0.00	0.30	N/A	N/A	N/A
9.90	0.00	1.252	1077	7635	0.00007	0.61111	5592	0.00835	0.003	0.003	0.00	0.30	N/A	N/A	N/A
10.00	0.00	1.265	1086	7857	0.00007	0.61603	5558	0.00814	0.003	0.002	0.00	0.30	N/A	N/A	N/A
10.10	0.00	1.277	1094	7951	0.00007	0.62095	5525	0.00810	0.003	0.002	0.00	0.30	N/A	N/A	N/A
10.20	0.00	1.290	1103	7941	0.00007	0.62587	5493	0.00819	0.003	0.002	0.00	0.30	N/A	N/A	N/A
10.30	0.00	1.303	1112	7855	0.00007	0.63079	5461	0.00837	0.003	0.003	0.00	0.30	N/A	N/A	N/A
10.40	0.00	1.315	1120	7772	0.00007	0.63571	5429	0.00855	0.003	0.003	0.00	0.30	N/A	N/A	N/A
10.50	0.00	1.328	1129	8013	0.00007	0.64063	5398	0.00832	0.003	0.003	0.00	0.30	N/A	N/A	N/A
10.60	0.00	1.341	1137	8051	0.00007	0.64555	5368	0.00834	0.003	0.003	0.00	0.30	N/A	N/A	N/A
10.70	0.00	1.353	1146	7868	0.00007	0.65047	5337	0.00864	0.003	0.003	0.00	0.30	N/A	N/A	N/A
10.80	0.00	1.366	1154	7977	0.00007	0.65539	5308	0.00857	0.003	0.003	0.00	0.30	N/A	N/A	N/A
10.90	0.00	1.379	1162	8181	0.00007	0.66031	5278	0.00839	0.003	0.003	0.00	0.30	N/A	N/A	N/A
11.00	0.00	1.391	1170	8255	0.00007	0.66523	5250	0.00837	0.003	0.003	0.00	0.30	N/A	N/A	N/A
11.10	0.00	1.404	1179	8009	0.00007	0.67015	5221	0.00874	0.003	0.003	0.00	0.30	N/A	N/A	N/A
11.20	0.00	1.417	1187	7763	0.00008	0.67507	5193	0.00914	0.004	0.003	0.00	0.30	N/A	N/A	N/A
11.30	0.00	1.429	1195	7992	0.00007	0.67999	5165	0.00890	0.003	0.003	0.00	0.30	N/A	N/A	N/A
11.40	0.00	1.442	1203	8288	0.00007	0.68491	5138	0.00859	0.003	0.003	0.00	0.30	N/A	N/A	N/A
11.50	0.00	1.455	1211	8502	0.00007	0.68983	5111	0.00840	0.003	0.002	0.00	0.30	N/A	N/A	N/A
11.60	0.00	1.467	1219	8422	0.00007	0.69475	5085	0.00855	0.003	0.003	0.00	0.30	N/A	N/A	N/A
11.70	0.00	1.480	1226	8084	0.00008	0.69967	5059	0.00905	0.003	0.003	0.00	0.30	N/A	N/A	N/A
11.80	0.00	1.493	1234	7789	0.00008	0.70459	5033	0.00953	0.004	0.003	0.00	0.30	N/A	N/A	N/A
11.90	0.00	1.505	1242	7716	0.00008	0.70951	5008	0.00970	0.004	0.003	0.00	0.30	N/A	N/A	N/A
12.00	0.00	1.518	1249	7897	0.00008	0.71443	4983	0.00950	0.004	0.003	0.00	0.30	N/A	N/A	N/A
12.10	0.00	1.530	1257	8127	0.00008	0.71935	4958	0.00925	0.004	0.003	0.00	0.30	N/A	N/A	N/A
12.20	0.00	1.543	1265	8195	0.00008	0.72427	4933	0.00922	0.004	0.003	0.00	0.30	N/A	N/A	N/A
12.30	0.00	1.556	1272	7534	0.00008	0.72919	4909	0.01027	0.004	0.004	0.00	0.30	N/A	N/A	N/A
12.40	0.00	1.568	1279	7329	0.00009	0.73411	4885	0.01069	0.005	0.004	0.00	0.30	N/A	N/A	N/A
12.50	0.00	1.581	1287	6843	0.00009	0.73903	4862	0.01172	0.006	0.005	0.00	0.29	N/A	N/A	N/A
12.60	0.00	1.594	1294	6785	0.00010	0.74395	4839	0.01192	0.006	0.005	0.00	0.29	N/A	N/A	N/A
12.70	0.00	1.606	1301	6790	0.00010	0.74887	4816	0.01199	0.006	0.005	0.00	0.29	N/A	N/A	N/A
12.80	0.00	1.619	1309	7156	0.00009	0.75379	4793	0.01130	0.005	0.004	0.00	0.29	N/A	N/A	N/A
12.90	0.00	1.632	1316	7507	0.00009	0.75871	4771	0.01073	0.005	0.004	0.00	0.29	N/A	N/A	N/A
13.00	0.00	1.644	1323	7838	0.00008	0.76363	4749	0.01024	0.004	0.004	0.00	0.29	N/A	N/A	N/A
13.10	0.00	1.652	1331	8338	0.00008	0.76672	4735	0.00957	0.004	0.003	0.00	0.29	0.7	44	N/A
13.20	0.00	1.659	1338	8971	0.00007	0.76940	4723	0.00883	0.003	0.003	0.00	0.29	0.7	48	N/A
13.30	0.00	1.666	1346	9533	0.00007	0.77208	4712	0.00827	0.003	0.002	0.00	0.29	0.7	50	N/A
13.40	0.00	1.673	1354	9851	0.00007	0.77476	4700	0.00802	0.003	0.002	0.00	0.29	0.7	52	N/A
13.50	0.00	1.680	1361	10454	0.00007	0.77744	4688	0.00753	0.002	0.002	0.00	0.29	0.7	55	N/A
13.60	0.00	1.687	1369	11050	0.00006	0.78011	4677	0.00711	0.002	0.002	0.00	0.29	0.7	58	N/A
13.70	0.00	1.694	1377	11370	0.00006	0.78279	4666	0.00692	0.002	0.002	0.00	0.29	0.7	59	N/A
13.80	0.00	1.700	1384	10758	0.00006	0.78547	4654	0.00742	0.002	0.002	0.00	0.29	0.6	56	N/A
13.90	0.00	1.707	1391	9385	0.00007	0.78815	4643	0.00876	0.003	0.003	0.00	0.29	0.7	49	N/A
14.00	0.00	1.714	1399	6855	0.00010	0.79083	4632	0.01292	0.007	0.005	0.00	0.29	1.0	36	N/A
14.10	0.01	1.721	1406	3941	0.00018	0.79350	4621	0.02794	0.028	0.023	0.00	0.29	1.3	22	0.19
14.20	0.02	1.728	1413	2358	0.00030	0.79618	4610	0.06956	0.128	0.107	0.00	0.28	1.7	14	0.12
14.30	0.03	1.735	1421	1684	0.00042	0.79886	4599	0.15360	0.423	0.354	0.00	0.25	1.3	10	0.09
14.40	0.03	1.742	1428	1611	0.00044	0.80154	4588	0.17514	0.511	0.427	0.00	0.23	1.9	10	0.09
14.50	0.03	1.749	1435	1756	0.00041	0.80422	4577	0.14074	0.371	0.310	0.00	0.20	1.7	11	0.10
14.60	0.02	1.756	1442	1946	0.00037	0.80689	4566	0.11021	0.257	0.215	0.00	0.17	1.7	12	0.10
14.70	0.02	1.762	1449	2027	0.00036	0.80957	4555	0.10109	0.225	0.188	0.00	0.15	1.5	12	0.10
14.80	0.02	1.769	1455	1751	0.00042	0.81225	4545	0.14608	0.389	0.325	0.00	0.13	1.9	11	0.10
14.90	0.02	1.776	1462	1232	0.00059	0.81493	4534	0.42546	1.731	1.448	0.00	0.10	2.6	9	0.08
15.00	0.03	1.783	1469	1077	0.00068	0.81761	4524	0.70770	3.391	2.835	0.00	0.08	2.6	8	0.08
15.10	0.02	1.790	1476	1106	0.00067	0.82029	4513	0.64629	3.006	2.514	0.00	0.05	2.6	8	0.08
15.20	0.00	1.797	1482	1386	0.00053	0.82296	4503	0.29728	1.057	0.884	0.00	0.03	N/A	N/A	N/A
15.30	0.02	1.804	1489	1753	0.00042	0.82564	4492	0.15271	0.411	0.343	0.00	0.03	2.1	11	0.10
15.40	0.01	1.811	1495	1893	0.00039	0.82832	4482	0.12659	0.311	0.260	0.00	0.01	2.4	12	0.10

CONE PENETRATION TEST-BASED LIQUEFACTION ANALYSIS BASED ON IDRISS & BOULANGER (2008)

References:

1 - Idriss, I.M. and Boulanger, R.W. (2008). *Soil Liquefaction During Earthquakes* , Earthquake Engineering Research Institute, EERI Publication MNO-12.
2 - Ishihara, K. and Yoshimine, M. (1992). "Evaluation of Settlements in Sand Deposits Following Liquefaction During Earthquakes," *Soils and Foundations* , Vol. 32, No. 1, pp. 173-188, March 1992.
3 - Tokimatsu, K. and Seed H.B. (1987). "Evaluation of Settlements in Sands Due to Earthquake Shaking," Journal of Geotechnical Engineering, Vol. 113, No. 8, August.
4 - Pradel, D. (1998). "Procedure to Evaluate Earthquake-Induced Settlements in Sand," Journal of Geotechnical and Geoenvironmental Engineering, Vol. 124, No. 4, April.
5 - Cetin, K.O., Bilge, H.T., Wu, J., Kammerer, A.M., and Seed R.B. (2009). "Procedure to Evaluate Earthquake-Induced Settlements in Sand," Journal of Geotechnical and Geoenvironmental Engineering, Vol. 135, No. 3, March.
6 - Boulanger, R.W. and Idriss, I.M. (2014). "CPT and SPT Based Liquefaction Triggering Procedures," Report No. UCD/CGM-14/01, University of California at Davis

Project	**Chevron Guadalupe Tank Battery 9 Site**
Test Boring No	**TSMACPT-8**

Test Boring Information:

Approx. depth to ground water table		62.7 ft	19.12 m
Moist unit weight of soil	γ_m	115 pcf	18.08 kN/m^3
Saturated unit weight of soil	γ_{sat}	125 pcf	19.65 kN/m^3

Earthquake Information:

Earthquake magnitude	M_w	6.9
Peak horizontal ground surface acceleratio	a_{max}	0.490 g
Number of equivalent cycle	N	10.1

Atmospheric pressure	P_a	101.3 kPa

N/L = Non-liquefiable clay-like soil
N.A. = Not Applicable

Sum
0.00

Sum	Total
0.38	0.38

Factor of Safety Agaist Liquefaction (Idriss & Boulanger, 2008 and Boulanger & Idriss, 2014)

Depth, Z (m)	Depth, Z (ft)	q_c (kPa)	f_s (kPa)	σ_{vc} (kPa)	σ'_{vc} (kPa)	Q	F	I_c	Soil Type	Fines (%)	Interpreted q_c	C_N	q_{c1N}	q_{c1N-cs}	Stress Reduction Factor (r_d)	CSR	K_σ for sand	$CRR_{M=7.5}$ at σ'_{vc}=1	MSF_{max}	MSF	CRR	$(FS)_L$
1.60	5.25	12910	45	28.9	28.9	238	0.35	1.3	Unsaturated	6	12910	1.39	177.8	177.9	0.99	0.315	1.1	0.669	2.06	1.226	0.903	**N/L**
1.70	5.58	13332	48	30.7	30.7	238	0.36	1.3	Unsaturated	6	13332	1.37	180.7	180.8	0.99	0.315	1.1	0.751	2.10	1.237	1.022	**N/L**
1.80	5.90	13256	54	32.5	32.5	230	0.41	1.4	Unsaturated	7	13256	1.35	177.0	178.5	0.99	0.315	1.1	0.684	2.06	1.228	0.924	**N/L**
1.90	6.23	13183	54	34.3	34.3	223	0.41	1.4	Unsaturated	7	13183	1.33	173.5	175.0	0.99	0.314	1.1	0.600	2.01	1.216	0.802	**N/L**
2.00	6.56	13374	53	36.2	36.2	220	0.40	1.4	Unsaturated	7	13374	1.31	173.6	175.1	0.99	0.314	1.1	0.603	2.01	1.217	0.807	**N/L**
2.10	6.89	13683	53	38.0	38.0	220	0.39	1.4	Unsaturated	7	13683	1.29	175.4	176.9	0.98	0.314	1.1	0.644	2.04	1.223	0.866	**N/L**
2.20	7.22	14450	55	39.8	39.8	227	0.38	1.4	Unsaturated	7	14450	1.28	183.0	184.5	0.98	0.313	1.1	0.876	2.17	1.250	1.205	**N/L**
2.30	7.54	15197	60	41.6	41.6	234	0.40	1.4	Unsaturated	7	15197	1.26	190.2	191.8	0.98	0.313	1.1	1.225	2.20	1.257	1.694	**N/L**
2.40	7.87	15822	58	43.4	43.4	238	0.37	1.3	Unsaturated	6	15822	1.25	195.8	195.9	0.98	0.312	1.1	1.515	2.20	1.257	2.000	**N/L**
2.50	8.20	16123	63	45.2	45.2	238	0.39	1.4	Unsaturated	7	16123	1.24	197.4	199.0	0.98	0.312	1.1	1.788	2.20	1.257	2.000	**N/L**
2.60	8.53	16286	71	47.0	47.0	235	0.44	1.4	Unsaturated	7	16286	1.22	197.3	198.9	0.98	0.312	1.1	1.781	2.20	1.257	2.000	**N/L**
2.70	8.86	16153	76	48.8	48.8	229	0.47	1.4	Unsaturated	7	16153	1.21	193.7	195.4	0.98	0.311	1.1	1.470	2.20	1.257	2.000	**N/L**
2.80	9.18	15288	78	50.6	50.6	213	0.51	1.5	Unsaturated	8	15288	1.20	181.6	188.0	0.98	0.311	1.1	1.022	2.20	1.257	1.414	**N/L**
2.90	9.51	14716	64	52.4	52.4	201	0.44	1.5	Unsaturated	8	14716	1.19	173.2	179.4	0.97	0.310	1.1	0.708	2.08	1.231	0.959	**N/L**
3.00	9.84	14465	63	54.2	54.2	194	0.44	1.5	Unsaturated	8	14465	1.18	168.8	174.8	0.97	0.310	1.1	0.595	2.01	1.216	0.795	**N/L**
3.10	10.17	13964	63	56.0	56.0	185	0.45	1.5	Unsaturated	8	13964	1.17	161.5	167.4	0.97	0.309	1.1	0.462	1.89	1.192	0.605	**N/L**
3.20	10.50	14073	59	57.8	57.8	183	0.42	1.5	Unsaturated	8	14073	1.16	161.4	167.3	0.97	0.309	1.1	0.460	1.89	1.191	0.603	**N/L**
3.30	10.82	14409	60	59.7	59.7	185	0.42	1.5	Unsaturated	8	14409	1.15	163.9	169.8	0.97	0.309	1.1	0.501	1.93	1.199	0.661	**N/L**
3.40	11.15	14937	62	61.5	61.5	189	0.42	1.5	Unsaturated	8	14937	1.14	168.6	174.6	0.97	0.308	1.1	0.591	2.00	1.215	0.790	**N/L**
3.50	11.48	14933	64	63.3	63.3	186	0.43	1.5	Unsaturated	8	14933	1.13	167.3	173.3	0.97	0.308	1.1	0.563	1.98	1.211	0.745	**N/L**
3.60	11.81	14993	61	65.1	65.1	184	0.41	1.5	Unsaturated	8	14993	1.12	166.7	172.7	0.96	0.307	1.1	0.552	1.97	1.209	0.725	**N/L**
3.70	12.14	15359	62	66.9	66.9	186	0.41	1.5	Unsaturated	8	15359	1.11	169.5	175.6	0.96	0.307	1.1	0.613	2.02	1.218	0.809	**N/L**
3.80	12.46	15330	67	68.7	68.7	183	0.44	1.5	Unsaturated	8	15330	1.11	168.0	174.0	0.96	0.306	1.1	0.579	1.99	1.213	0.756	**N/L**
3.90	12.79	15380	69	70.5	70.5	181	0.45	1.5	Unsaturated	8	15380	1.10	167.4	173.4	0.96	0.306	1.1	0.566	1.98	1.211	0.735	**N/L**
4.00	13.12	14495	72	72.3	72.3	169	0.50	1.5	Unsaturated	8	14495	1.09	156.7	162.5	0.96	0.305	1.1	0.398	1.83	1.177	0.497	**N/L**
4.10	13.45	12453	66	74.1	74.1	143	0.53	1.6	Unsaturated	10	12453	1.09	133.8	146.6	0.96	0.305	1.0	0.267	1.63	1.135	0.318	**N/L**
4.20	13.78	10243	58	75.9	75.9	116	0.57	1.7	Unsaturated	11	10243	1.08	109.3	129.8	0.96	0.304	1.0	0.197	1.46	1.100	0.225	**N/L**
4.30	14.10	9609	51	77.7	77.7	107	0.54	1.7	Unsaturated	11	9609	1.07	101.9	121.6	0.95	0.304	1.0	0.175	1.40	1.085	0.196	**N/L**
4.40	14.43	9434	50	79.5	79.5	104	0.54	1.7	Unsaturated	11	9434	1.07	99.5	118.9	0.95	0.303	1.0	0.169	1.38	1.081	0.188	**N/L**
4.50	14.76	9485	49	81.4	81.4	104	0.52	1.7	Unsaturated	11	9485	1.06	99.4	118.8	0.95	0.303	1.0	0.169	1.38	1.081	0.187	**N/L**
4.60	15.09	9606	47	83.2	83.2	104	0.49	1.7	Unsaturated	11	9606	1.05	100.1	119.6	0.95	0.303	1.0	0.170	1.38	1.082	0.189	**N/L**
4.70	15.42	9698	47	85.0	85.0	104	0.49	1.7	Unsaturated	11	9698	1.05	100.5	120.0	0.95	0.302	1.0	0.171	1.39	1.083	0.189	**N/L**
4.80	15.74	10016	52	86.8	86.8	106	0.52	1.7	Unsaturated	11	10016	1.04	103.2	123.0	0.95	0.302	1.0	0.178	1.41	1.088	0.198	**N/L**
4.90	16.07	10615	53	88.6	88.6	111	0.51	1.7	Unsaturated	11	10615	1.04	108.8	129.2	0.95	0.301	1.0	0.195	1.46	1.099	0.218	**N/L**
5.00	16.40	11848	54	90.4	90.4	123	0.46	1.6	Unsaturated	10	11848	1.03	120.8	132.8	0.94	0.301	1.0	0.207	1.49	1.105	0.232	**N/L**
5.10	16.73	13798	56	92.2	92.2	142	0.41	1.6	Unsaturated	10	13798	1.02	139.9	153.1	0.94	0.300	1.0	0.310	1.71	1.151	0.363	**N/L**
5.20	17.06	16802	68	94.0	94.0	171	0.41	1.5	Unsaturated	8	16802	1.02	169.5	175.6	0.94	0.300	1.0	0.613	2.02	1.218	0.757	**N/L**
5.30	17.38	13946	76	95.8	95.8	141	0.55	1.6	Unsaturated	10	13946	1.01	140.0	153.2	0.94	0.299	1.0	0.311	1.71	1.151	0.361	**N/L**
5.40	17.71	11704	64	97.6	97.6	117	0.55	1.7	Unsaturated	11	11704	1.01	116.9	138.2	0.94	0.299	1.0	0.226	1.54	1.116	0.254	**N/L**
5.50	18.04	10167	52	99.4	99.4	100	0.51	1.7	Unsaturated	11	10167	1.00	101.1	120.7	0.94	0.298	1.0	0.173	1.39	1.084	0.188	**N/L**
5.60	18.37	9379	52	101.2	101.2	92	0.56	1.8	Unsaturated	13	9379	1.00	92.8	120.5	0.93	0.297	1.0	0.172	1.39	1.084	0.187	**N/L**
5.70	18.70	9190	52	103.0	103.0	89	0.57	1.8	Unsaturated	13	9190	0.99	90.5	117.8	0.93	0.297	1.0	0.167	1.37	1.079	0.179	**N/L**
5.80	19.02	8789	51	104.9	104.9	84	0.59	1.8	Unsaturated	13	8789	0.99	86.2	112.8	0.93	0.296	1.0	0.157	1.34	1.072	0.167	**N/L**
5.90	19.35	8517	49	106.7	106.7	81	0.58	1.8	Unsaturated	13	8517	0.99	83.1	109.3	0.93	0.296	1.0	0.151	1.31	1.067	0.160	**N/L**
6.00	19.68	8668	48	108.5	108.5	82	0.57	1.8	Unsaturated	13	8668	0.98	84.2	110.6	0.93	0.295	1.0	0.153	1.32	1.069	0.162	**N/L**
6.10	20.01	9119	49	110.3	110.3	85	0.55	1.8	Unsaturated	13	9119	0.98	88.2	115.2	0.93	0.295	1.0	0.161	1.35	1.075	0.172	**N/L**
6.20	20.34	9641	52	112.1	112.1	89	0.55	1.8	Unsaturated	13	9641	0.97	92.9	120.5	0.92	0.294	1.0	0.172	1.39	1.084	0.184	**N/L**
6.30	20.66	9898	54	113.9	113.9	91	0.55	1.8	Unsaturated	13	9898	0.97	94.9	122.9	0.92	0.294	1.0	0.178	1.41	1.088	0.191	**N/L**
6.40	20.99	9789	51	115.7	115.7	89	0.53	1.8	Unsaturated	13	9789	0.96	93.5	121.3	0.92	0.293	1.0	0.174	1.40	1.085	0.186	**N/L**
6.50	21.32	9621	54	117.5	117.5	87	0.57	1.8	Unsaturated	13	9621	0.96	91.5	119.0	0.92	0.293	1.0	0.169	1.38	1.081	0.179	**N/L**
6.60	21.65	9456	56	119.3	119.3	85	0.60	1.8	Unsaturated	13	9456	0.96	89.6	116.8	0.92	0.292	1.0	0.164	1.36	1.078	0.174	**N/L**
6.70	21.98	9243	55	121.1	121.1	82	0.60	1.8	Unsaturated	13	9243	0.95	87.2	114.0	0.92	0.292	1.0	0.159	1.34	1.074	0.167	**N/L**
6.80	22.30	9264	24	122.9	122.9	82	0.26	1.7	Unsaturated	11	9264	0.95	87.1	105.2	0.91	0.291	1.0	0.144	1.29	1.062	0.150	**N/L**
6.90	22.63	3150	32	124.7	124.7	27	1.05	2.4	Unsaturated	27	3150	0.95	29.5	67.4	0.91	0.291	1.0	0.105	1.14	1.031	0.107	**N/L**
7.00	22.96	3179	39	126.5	126.5	27	1.28	2.4	Unsaturated	27	3179	0.94	29.7	67.6	0.91	0.290	1.0	0.105	1.14	1.031	0.107	**N/L**
7.10	23.29	9054	47	128.4	128.4	78	0.53	1.8	Unsaturated	13	9054	0.94	84.2	110.5	0.91	0.289	1.0	0.153	1.32	1.069	0.159	**N/L**
7.20	23.62	9270	49	130.2	130.2	80	0.53	1.8	Unsaturated	13	9270	0.94	85.8	112.4	0.91	0.289	1.0	0.156	1.33	1.072	0.162	**N/L**
7.30	23.94	9580	52	132.0	132.0	82	0.55	1.8	Unsaturated	13	9580	0.93	88.4	115.4	0.91	0.288	1.0	0.162	1.35	1.076	0.168	**N/L**
7.40	24.27	9633	54	133.8	133.8	82	0.56	1.8	Unsaturated	13	9633	0.93	88.6	115.6	0.90	0.288	1.0	0.162	1.35	1.076	0.168	**N/L**
7.50	24.60	9618	54	135.6	135.6	81	0.56	1.8	Unsaturated	13	9618	0.93	88.1	115.0	0.90	0.287	1.0	0.161	1.35	1.075	0.167	**N/L**
7.60	24.93	9566	54	137.4	137.4	80	0.57	1.8	Unsaturated	13	9566	0.92	87.3	114.1	0.90	0.287	1.0	0.159	1.34	1.074	0.165	**N/L**
7.70	25.26	9562	54	139.2	139.2	79	0.58	1.9	Unsaturated	15	9562	0.92	87.0	121.8	0.90	0.286	1.0	0.175	1.40	1.086	0.183	**N/L**
7.80	25.58	9612	54	141.0	141.0	79	0.57	1.9	Unsaturated	15	9612	0.92	87.1	122.0	0.90	0.286	1.0	0.176	1.40	1.086	0.183	**N/L**
7.90	25.91	9727	52	142.8	142.8	80	0.54	1.8	Unsaturated	13	9727	0.91	87.9	114.8	0.89	0.285	1.0	0.161	1.35	1.075	0.165	**N/L**
8.00	26.24	9754	52	144.6	144.6	79	0.54	1.8	Unsaturated	13	9754	0.91	87.8	114.7	0.89	0.284	1.0	0.160	1.35	1.075	0.165	**N/L**
8.10	26.57	9742	54	146.4	146.4	79	0.56	1.8	Unsaturated	13	9742	0.91	87.4	114.3	0.89	0.284	1.0	0.160	1.35	1.074	0.164	**N/L**
8.20	26.90	9559	55	148.2	148.2	77	0.58	1.9	Unsaturated	15	9559	0.90	85.5	120.1	0.89	0.283	1.0	0.171	1.39	1.083	0.177	**N/L**
8.30	27.22	9518	55	150.0	150.0	76	0.58	1.9	Unsaturated	15	9518	0.90	84.9	119.3	0.89	0.283	1.0	0.170	1.38	1.082	0.175	**N/L**
8.40	27.55	9538	54	151.9	151.9	76	0.58	1.9	Unsaturated	15	9538	0.90	84.8	119.2	0.89	0.282	0.9	0.169	1.38	1.082	0.174	**N/L**
8.50	27.88	9624	55	153.7	153.7	76	0.59	1.9	Unsaturated	15	9624	0.90	85.3	119.8	0.88	0.281	0.9	0.171	1.38	1.082	0.175	**N/L**
8.60	28.21	9848	57	155.5	155.5	77	0.59	1.9	Unsaturated	15	9848	0.89	87.0	121.8	0.88	0.281	0.9	0.175	1.40	1.086	0.180	**N/L**
8.70	28.54	9919	59	157.3	157.3	77	0.61	1.9	Unsaturated	15	9919	0.89	87.4	122.3	0.88	0.280	0.9	0.176	1.40	1.087	0.181	**N/L**
8.80	28.86	10016	57	159.1	159.1	78	0.58	1.9	Unsaturated	15	10016	0.89	88.0	123.0	0.88	0.280	0.9	0.178	1.41	1.088	0.183	**N/L**

Settelemnt of Liquefiable Soil (Idriss and Boulnager, 2008) / Settlement of Unsaturated Sand (Tokimatsu & Seed, 1987, and Pradel, 1998) / Cumulative / S_r (Idriss & Boulanger, 2008)

Depth, Z (m)	q_t (kPa)	N_{60}	$N_{1,60}$	$\Delta(N_1)_{60}$	$N_{1,60-CS}$	Limiting Shear Strain γ_{lim}	Parameter F_α	Max. Shear Strain γ_{max}	ΔHi (m)	ΔLDI_i (m)	Vert. Recon. Strain ε_v	DF_i	ΔSi (inch)	$p = \sigma_m$ (tsf)	τ_{ave} (psf)	G_{max} (tsf)	τ_{ave}/G_{max}	a	b	γ_{eff} (%)	ε_{15} (%)	ε_{Nc} (%)	Settlement (inch)	Cumulative Settlement (inch)	$\Delta(N_1)_{60-Sr}$	$(N_1)_{60-Sr}$	S_r/σ_{v0}'
1.60	12910	20.9	29.1	0.0	N.A.	0.000	0.000	0.000	0.05	0.0000	0.0000	0.91	0.00	0.202	192	1946	0.00005	0.20272	16691	0.00599	0.004	0.003	0.00	0.38	N/A	N/A	N/A
1.70	13254	21.5	29.4	0.0	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.91	0.00	0.215	204	2027	0.00005	0.20764	16095	0.00610	0.004	0.003	0.00	0.38	N/A	N/A	N/A
1.80	13298	22.2	29.9	0.1	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.90	0.00	0.228	216	2126	0.00005	0.21256	15552	0.00614	0.004	0.003	0.00	0.38	N/A	N/A	N/A
1.90	13184	22.0	29.3	0.1	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.90	0.00	0.240	228	2135	0.00005	0.21749	15056	0.00650	0.004	0.003	0.00	0.38	N/A	N/A	N/A
2.00	13362	22.3	29.3	0.1	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.89	0.00	0.253	239	2190	0.00005	0.22241	14600	0.00668	0.004	0.004	0.00	0.38	N/A	N/A	N/A
2.10	13732	22.9	29.7	0.1	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.89	0.00	0.266	251	2277	0.00006	0.22733	14178	0.00673	0.004	0.004	0.00	0.38	N/A	N/A	N/A
2.20	14484	24.2	30.9	0.1	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.88	0.00	0.278	263	2428	0.00005	0.23225	13788	0.00656	0.004	0.003	0.00	0.38	N/A	N/A	N/A
2.30	15199	25.4	32.1	0.1	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.87	0.00	0.291	275	2575	0.00005	0.23717	13425	0.00641	0.004	0.003	0.00	0.38	N/A	N/A	N/A
2.40	15734	25.5	31.8	0.0	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.87	0.00	0.304	287	2611	0.00005	0.24209	13087	0.00662	0.004	0.003	0.00	0.38	N/A	N/A	N/A
2.50	16131	26.9	33.3	0.1	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.86	0.00	0.316	299	2787	0.00005	0.24701	12770	0.00640	0.003	0.003	0.00	0.38	N/A	N/A	N/A
2.60	16309	27.2	33.3	0.1	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.86	0.00	0.329	310	2844	0.00005	0.25193	12473	0.00653	0.004	0.003	0.00	0.38	N/A	N/A	N/A
2.70	16126	26.9	32.6	0.1	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.85	0.00	0.342	322	2837	0.00006	0.25685	12194	0.00684	0.004	0.003	0.00	0.38	N/A	N/A	N/A
2.80	15309	26.4	31.7	0.4	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.85	0.00	0.354	334	2804	0.00006	0.26177	11931	0.00723	0.004	0.003	0.00	0.38	N/A	N/A	N/A
2.90	14689	25.3	30.1	0.4	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.84	0.00	0.367	346	2713	0.00006	0.26669	11682	0.00785	0.005	0.004	0.00	0.38	N/A	N/A	N/A
3.00	14469	24.9	29.4	0.4	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.84	0.00	0.379	357	2694	0.00007	0.27161	11447	0.00824	0.005	0.004	0.00	0.38	N/A	N/A	N/A
3.10	14079	24.3	28.3	0.4	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.83	0.00	0.392	369	2642	0.00007	0.27653	11224	0.00878	0.006	0.005	0.00	0.38	N/A	N/A	N/A
3.20	14073	24.3	28.1	0.4	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.83	0.00	0.405	381	2660	0.00007	0.28145	11012	0.00904	0.006	0.005	0.00	0.38	N/A	N/A	N/A
3.30	14423	24.9	28.6	0.4	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.82	0.00	0.417	392	2746	0.00007	0.28637	10811	0.00899	0.006	0.005	0.00	0.38	N/A	N/A	N/A
3.40	14820	25.5	29.1	0.4	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.81	0.00	0.430	404	2842	0.00007	0.29129	10619	0.00891	0.006	0.005	0.00	0.38	N/A	N/A	N/A
3.50	14933	25.7	29.1	0.4	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.81	0.00	0.443	415	2883	0.00007	0.29621	10436	0.00905	0.006	0.005	0.00	0.38	N/A	N/A	N/A
3.60	15034	25.9	29.1	0.4	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.80	0.00	0.455	427	2922	0.00007	0.30113	10261	0.00919	0.006	0.005	0.00	0.38	N/A	N/A	N/A
3.70	15268	26.3	29.3	0.4	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.80	0.00	0.468	438	2987	0.00007	0.30605	10093	0.00923	0.006	0.005	0.00	0.38	N/A	N/A	N/A
3.80	15329	26.4	29.2	0.4	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.79	0.00	0.481	450	3018	0.00007	0.31097	9933	0.00939	0.006	0.005	0.00	0.38	N/A	N/A	N/A
3.90	15317	26.4	29.0	0.4	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.79	0.00	0.493	461	3034	0.00008	0.31589	9780	0.00962	0.006	0.005	0.00	0.38	N/A	N/A	N/A
4.00	14385	24.8	27.1	0.4	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.78	0.00	0.506	473	2867	0.00008	0.32081	9632	0.01068	0.007	0.006	0.00	0.38	N/A	N/A	N/A
4.10	12332	22.0	23.8	0.9	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.78	0.00	0.519	484	2554	0.00009	0.32573	9490	0.01288	0.010	0.009	0.00	0.38	N/A	N/A	N/A
4.20	10392	19.1	20.6	1.7	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.77	0.00	0.531	496	2239	0.00011	0.33065	9354	0.01606	0.015	0.013	0.00	0.38	N/A	N/A	N/A
4.30	9607	17.7	19.0	1.7	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.76	0.00	0.544	507	2082	0.00012	0.33557	9223	0.01853	0.020	0.017	0.00	0.37	N/A	N/A	N/A
4.40	9433	17.4	18.5	1.7	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.76	0.00	0.557	518	2055	0.00013	0.34049	9097	0.01949	0.021	0.018	0.00	0.37	N/A	N/A	N/A
4.50	9524	17.5	18.6	1.7	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.75	0.00	0.569	530	2086	0.00013	0.34541	8975	0.01962	0.021	0.018	0.00	0.37	N/A	N/A	N/A
4.60	9604	17.7	18.6	1.7	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.75	0.00	0.582	541	2115	0.00013	0.35033	8857	0.01977	0.022	0.018	0.00	0.37	N/A	N/A	N/A
4.70	9696	17.9	18.7	1.7	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.74	0.00	0.594	552	2146	0.00013	0.35525	8744	0.01988	0.022	0.018	0.00	0.37	N/A	N/A	N/A
4.80	10012	18.4	19.2	1.7	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.74	0.00	0.607	563	2227	0.00013	0.36017	8634	0.01928	0.020	0.017	0.00	0.37	N/A	N/A	N/A
4.90	10645	19.6	20.3	1.7	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.73	0.00	0.620	574	2379	0.00012	0.36509	8528	0.01788	0.018	0.015	0.00	0.37	N/A	N/A	N/A
5.00	11738	20.9	21.5	0.9	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.73	0.00	0.632	586	2548	0.00011	0.37001	8425	0.01656	0.015	0.013	0.00	0.36	N/A	N/A	N/A
5.10	13967	24.9	25.5	0.9	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.72	0.00	0.645	597	3046	0.00010	0.37493	8326	0.01316	0.010	0.008	0.00	0.36	N/A	N/A	N/A
5.20	16262	28.0	28.6	0.4	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.72	0.00	0.658	608	3448	0.00009	0.37985	8229	0.01140	0.007	0.006	0.00	0.36	N/A	N/A	N/A
5.30	14279	25.4	25.8	0.9	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.71	0.00	0.670	619	3142	0.00010	0.38477	8136	0.01320	0.010	0.008	0.00	0.36	N/A	N/A	N/A
5.40	11756	21.7	21.9	1.7	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.70	0.00	0.683	630	2688	0.00012	0.38969	8045	0.01685	0.015	0.013	0.00	0.36	N/A	N/A	N/A
5.50	10258	18.9	19.0	1.7	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.70	0.00	0.696	641	2356	0.00014	0.39461	7957	0.02110	0.022	0.019	0.00	0.36	N/A	N/A	N/A
5.60	9497	18.1	18.1	2.5	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.69	0.00	0.708	651	2269	0.00014	0.39953	7871	0.02295	0.026	0.022	0.00	0.36	N/A	N/A	N/A
5.70	9187	17.5	17.4	2.5	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.69	0.00	0.721	662	2204	0.00015	0.40446	7788	0.02464	0.029	0.024	0.00	0.36	N/A	N/A	N/A
5.80	8787	16.8	16.6	2.5	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.68	0.00	0.734	673	2116	0.00016	0.40938	7707	0.02702	0.034	0.028	0.00	0.36	N/A	N/A	N/A
5.90	8549	16.3	16.1	2.5	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.68	0.00	0.746	684	2067	0.00017	0.41430	7629	0.02880	0.037	0.031	0.00	0.35	N/A	N/A	N/A
6.00	8709	16.6	16.3	2.5	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.67	0.00	0.759	695	2115	0.00016	0.41922	7552	0.02834	0.036	0.030	0.00	0.35	N/A	N/A	N/A
6.10	9150	17.5	17.1	2.5	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.67	0.00	0.772	705	2230	0.00016	0.42414	7478	0.02646	0.032	0.027	0.00	0.35	N/A	N/A	N/A
6.20	9619	18.4	17.9	2.5	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.66	0.00	0.784	716	2354	0.00015	0.42906	7405	0.02473	0.028	0.024	0.00	0.35	N/A	N/A	N/A
6.30	9852	18.8	18.2	2.5	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.66	0.00	0.797	727	2420	0.00015	0.43398	7334	0.02414	0.027	0.023	0.00	0.34	N/A	N/A	N/A
6.40	9798	18.7	18.0	2.5	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.65	0.00	0.810	737	2415	0.00015	0.43890	7265	0.02471	0.028	0.023	0.00	0.34	N/A	N/A	N/A
6.50	9640	18.4	17.7	2.5	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.64	0.00	0.822	748	2385	0.00016	0.44382	7198	0.02574	0.030	0.025	0.00	0.34	N/A	N/A	N/A
6.60	9468	18.1	17.3	2.5	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.64	0.00	0.835	758	2351	0.00016	0.44874	7132	0.02690	0.032	0.027	0.00	0.34	N/A	N/A	N/A
6.70	9277	17.7	16.9	2.5	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.63	0.00	0.847	769	2312	0.00017	0.45366	7068	0.02823	0.035	0.029	0.00	0.34	N/A	N/A	N/A
6.80	7895	14.5	13.8	1.7	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.63	0.00	0.860	779	1906	0.00020	0.45858	7006	0.04088	0.064	0.053	0.00	0.34	N/A	N/A	N/A
6.90	3625	8.8	8.3	5.2	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.62	0.00	0.873	789	1158	0.00034	0.46350	6945	0.13849	0.396	0.332	0.03	0.33	N/A	N/A	N/A
7.00	3600	8.7	8.2	5.2	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.62	0.00	0.885	800	1154	0.00035	0.46842	6885	0.14371	0.417	0.348	0.03	0.30	N/A	N/A	N/A
7.10	7778	14.8	13.9	2.5	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.61	0.00	0.898	810	1965	0.00021	0.47334	6827	0.04102	0.063	0.053	0.00	0.28	N/A	N/A	N/A
7.20	9296	17.7	16.6	2.5	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.61	0.00	0.911	820	2356	0.00017	0.47826	6770	0.03006	0.038	0.031	0.00	0.27	N/A	N/A	N/A
7.30	9548	18.2	17.0	2.5	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.60	0.00	0.923	830	2428	0.00017	0.48318	6714	0.02908	0.035	0.030	0.00	0.27	N/A	N/A	N/A
7.40	9644	18.4	17.1	2.5	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.60	0.00	0.936	840	2460	0.00017	0.48810	6659	0.02894	0.035	0.029	0.00	0.27	N/A	N/A	N/A
7.50	9613	18.3	17.0	2.5	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.59	0.00	0.949	850	2460	0.00017	0.49302	6606	0.02945	0.036	0.030	0.00	0.27	N/A	N/A	N/A
7.60	9564	18.2	16.8	2.5	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.58	0.00	0.961	860	2455	0.00018	0.49794	6553	0.03006	0.037	0.031	0.00	0.26	N/A	N/A	N/A
7.70	9570	18.9	17.4	3.2	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.58	0.00	0.974	870	2556	0.00017	0.50286	6502	0.02857	0.034	0.028	0.00	0.26	N/A	N/A	N/A
7.80	9610	19.0	17.4	3.2	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.57	0.00	0.987	880	2574	0.00017	0.50778	6452	0.02869	0.034	0.028	0.00	0.26	N/A	N/A	N/A
7.90	9720	18.5	16.9	2.5	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.57	0.00	0.999	890	2518	0.00018	0.51270	6403	0.03026	0.037	0.031	0.00	0.26	N/A	N/A	N/A
8.00	9765	18.6	16.9	2.5	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.56	0.00	1.012	900	2538	0.00018	0.51762	6355	0.03035	0.037	0.031	0.00	0.25	N/A	N/A	N/A
8.10	9746	18.6	16.9	2.5	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.56	0.00	1.025	910	2540	0.00018	0.52254	6308	0.03078	0.038	0.032	0.00	0.25	N/A	N/A	N/A
8.20	9608	19.0	17.2	3.2	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.55	0.00	1.037	920	2604	0.00018	0.52746	6261	0.02997	0.036	0.030	0.00	0.25	N/A	N/A	N/A
8.30	9516	18.8	17.0	3.2	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.55	0.00	1.050	929	2587	0.00018	0.53238	6216	0.03078	0.038	0.031	0.00	0.25	N/A	N/A	N/A
8.40	9536	18.9	16.9	3.2	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.54	0.00	1.062	939	2600	0.00018	0.53730	6171	0.03098	0.038	0.032	0.00	0.24	N/A	N/A	N/A
8.50	9624	19.0	17.0	3.2	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.54	0.00	1.075	948	2631	0.00018	0.54222	6128	0.03081	0.037	0.031	0.00	0.24	N/A	N/A	N/A
8.60	9810	19.4	17.3	3.2	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.53	0.00	1.088	958	2689	0.00018	0.54714	6085	0.03013	0.036	0.030	0.00	0.24	N/A	N/A	N/A
8.70	9961	19.7	17.5	3.2	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.52	0.00	1.100	967	2738	0.00018	0.55206	6043	0.02966	0.035	0.029	0.00	0.24	N/A	N/A	N/A
8.80	9989	19.8	17.5	3.2	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.52	0.00	1.113	977	2753	0.00018	0.55698	6002	0.02980	0.035	0.029	0.00	0.23	N/A	N/A	N/A

Depth, Z (m)	Depth, Z (ft)	q_c (kPa)	f_s (kPa)	σ_{vc} (kPa)	σ'_{vc} (kPa)	Q	F	I_c	Soil Type	Fines (%)	Interpreted q_c	C_N	q_{c1N}	q_{c1N-cs}	Stress Reduction Factor (r_d)	CSR	K_σ for sand	$CRR_{M=7.5}$ at σ'_{vc}=1	MSF_{max}	MSF	CRR	$(FS)_L$
8.90	29.19	9529	55	160.9	160.9	73	0.59	1.9	Unsaturated	15	9529	0.88	83.4	117.6	0.88	0.279	0.9	0.166	1.37	1.079	0.169	N/L
9.00	29.52	9547	55	162.7	162.7	73	0.59	1.9	Unsaturated	15	9547	0.88	83.4	117.4	0.87	0.279	0.9	0.166	1.37	1.079	0.168	N/L
9.10	29.85	9597	55	164.5	164.5	73	0.59	1.9	Unsaturated	15	9597	0.88	83.5	117.7	0.87	0.278	0.9	0.166	1.37	1.079	0.169	N/L
9.20	30.18	9695	56	166.3	166.3	73	0.59	1.9	Unsaturated	15	9695	0.88	84.2	118.4	0.87	0.277	0.9	0.168	1.37	1.080	0.170	N/L
9.30	30.50	9771	58	168.1	168.1	74	0.61	1.9	Unsaturated	15	9771	0.87	84.6	118.9	0.87	0.277	0.9	0.169	1.38	1.081	0.171	N/L
9.40	30.83	9963	59	169.9	169.9	75	0.60	1.9	Unsaturated	15	9963	0.87	86.0	120.6	0.87	0.276	0.9	0.173	1.39	1.084	0.175	N/L
9.50	31.16	9963	62	171.7	171.7	74	0.63	1.9	Unsaturated	15	9963	0.87	85.8	120.3	0.87	0.276	0.9	0.172	1.39	1.083	0.174	N/L
9.60	31.49	9624	60	173.5	173.5	71	0.63	1.9	Unsaturated	15	9624	0.87	82.6	116.5	0.86	0.275	0.9	0.164	1.36	1.077	0.165	N/L
9.70	31.82	9526	57	175.4	175.4	70	0.61	1.9	Unsaturated	15	9526	0.86	81.5	115.3	0.86	0.274	0.9	0.161	1.35	1.076	0.162	N/L
9.80	32.14	9656	55	177.2	177.2	71	0.58	1.9	Unsaturated	15	9656	0.86	82.4	116.3	0.86	0.274	0.9	0.164	1.36	1.077	0.164	N/L
9.90	32.47	9886	56	179.0	179.0	72	0.58	1.9	Unsaturated	15	9886	0.86	84.2	118.4	0.86	0.273	0.9	0.168	1.37	1.080	0.169	N/L
10.00	32.80	9990	59	180.8	180.8	72	0.60	1.9	Unsaturated	15	9990	0.86	84.8	119.2	0.86	0.273	0.9	0.169	1.38	1.082	0.170	N/L
10.10	33.13	9939	60	182.6	182.6	72	0.61	1.9	Unsaturated	15	9939	0.86	84.2	118.4	0.85	0.272	0.9	0.168	1.37	1.080	0.168	N/L
10.20	33.46	9993	60	184.4	184.4	72	0.61	1.9	Unsaturated	15	9993	0.85	84.4	118.7	0.85	0.271	0.9	0.168	1.38	1.081	0.169	N/L
10.30	33.78	10167	61	186.2	186.2	73	0.61	1.9	Unsaturated	15	10167	0.85	85.7	120.2	0.85	0.271	0.9	0.172	1.39	1.083	0.172	N/L
10.40	34.11	10591	61	188.0	188.0	75	0.59	1.9	Unsaturated	15	10591	0.85	89.0	124.2	0.85	0.270	0.9	0.181	1.42	1.090	0.182	N/L
10.50	34.44	10789	64	189.8	189.8	76	0.60	1.9	Unsaturated	15	10789	0.85	90.4	126.0	0.85	0.270	0.9	0.186	1.43	1.093	0.186	N/L
10.60	34.77	10715	61	191.6	191.6	76	0.58	1.9	Unsaturated	15	10715	0.84	89.6	124.9	0.84	0.269	0.9	0.183	1.42	1.091	0.183	N/L
10.70	35.10	10535	60	193.4	193.4	74	0.58	1.9	Unsaturated	15	10535	0.84	87.9	122.9	0.84	0.268	0.9	0.178	1.41	1.088	0.177	N/L
10.80	35.42	10450	62	195.2	195.2	73	0.60	1.9	Unsaturated	15	10450	0.84	86.9	121.8	0.84	0.268	0.9	0.175	1.40	1.086	0.174	N/L
10.90	35.75	10273	62	197.1	197.1	71	0.62	1.9	Unsaturated	15	10273	0.84	85.3	119.7	0.84	0.267	0.9	0.171	1.38	1.082	0.169	N/L
11.00	36.08	10255	62	198.9	198.9	71	0.62	1.9	Unsaturated	15	10255	0.84	84.9	119.3	0.84	0.267	0.9	0.170	1.38	1.082	0.168	N/L
11.10	36.41	10202	59	200.7	200.7	70	0.59	1.9	Unsaturated	15	10202	0.83	84.3	118.6	0.84	0.266	0.9	0.168	1.38	1.081	0.166	N/L
11.20	36.74	9928	59	202.5	202.5	68	0.60	1.9	Unsaturated	15	9928	0.83	81.8	115.6	0.83	0.265	0.9	0.162	1.35	1.076	0.160	N/L
11.30	37.06	9749	58	204.3	204.3	66	0.61	1.9	Unsaturated	15	9749	0.83	80.2	113.6	0.83	0.265	0.9	0.158	1.34	1.073	0.156	N/L
11.40	37.39	9910	59	206.1	206.1	67	0.60	1.9	Unsaturated	15	9910	0.83	81.3	115.0	0.83	0.264	0.9	0.161	1.35	1.075	0.158	N/L
11.50	37.72	10273	61	207.9	207.9	69	0.61	1.9	Unsaturated	15	10273	0.83	84.1	118.3	0.83	0.264	0.9	0.168	1.37	1.080	0.165	N/L
11.60	38.05	10367	63	209.7	209.7	70	0.62	1.9	Unsaturated	15	10367	0.82	84.7	119.0	0.83	0.263	0.9	0.169	1.38	1.081	0.166	N/L
11.70	38.38	10240	62	211.5	211.5	69	0.62	1.9	Unsaturated	15	10240	0.82	83.4	117.5	0.82	0.262	0.9	0.166	1.37	1.079	0.163	N/L
11.80	38.70	10367	61	213.3	213.3	69	0.60	1.9	Unsaturated	15	10367	0.82	84.3	118.5	0.82	0.262	0.9	0.168	1.38	1.081	0.165	N/L
11.90	39.03	10450	62	215.1	215.1	69	0.61	1.9	Unsaturated	15	10450	0.82	84.8	119.1	0.82	0.261	0.9	0.169	1.38	1.081	0.166	N/L
12.00	39.36	10462	59	216.9	216.9	69	0.57	1.9	Unsaturated	15	10462	0.82	84.7	119.0	0.82	0.261	0.9	0.169	1.38	1.081	0.166	N/L
12.10	39.69	10447	59	218.7	218.7	69	0.58	1.9	Unsaturated	15	10447	0.82	84.4	118.6	0.82	0.260	0.9	0.168	1.38	1.081	0.165	N/L
12.20	40.02	10524	60	220.6	220.6	69	0.58	1.9	Unsaturated	15	10524	0.81	84.8	119.2	0.81	0.259	0.9	0.169	1.38	1.082	0.166	N/L
12.30	40.34	10742	63	222.4	222.4	70	0.60	1.9	Unsaturated	15	10742	0.81	86.4	121.1	0.81	0.259	0.9	0.174	1.39	1.085	0.170	N/L
12.40	40.67	10839	64	224.2	224.2	70	0.60	1.9	Unsaturated	15	10839	0.81	87.0	121.8	0.81	0.258	0.9	0.175	1.40	1.086	0.171	N/L
12.50	41.00	10671	64	226.0	226.0	69	0.62	1.9	Unsaturated	15	10671	0.81	85.4	119.9	0.81	0.258	0.9	0.171	1.39	1.083	0.167	N/L
12.60	41.33	10594	65	227.8	227.8	68	0.63	1.9	Unsaturated	15	10594	0.81	84.6	119.0	0.81	0.257	0.9	0.169	1.38	1.081	0.164	N/L
12.70	41.66	10522	65	229.6	229.6	67	0.63	1.9	Unsaturated	15	10522	0.81	83.9	118.1	0.80	0.256	0.9	0.167	1.37	1.080	0.162	N/L
12.80	41.98	10934	66	231.4	231.4	70	0.61	1.9	Unsaturated	15	10934	0.80	87.0	121.8	0.80	0.256	0.9	0.175	1.40	1.086	0.170	N/L
12.90	42.31	11022	60	233.2	233.2	70	0.55	1.9	Unsaturated	15	11022	0.80	87.5	122.4	0.80	0.255	0.9	0.177	1.40	1.087	0.172	N/L
13.00	42.64	11010	61	235.0	235.0	70	0.56	1.9	Unsaturated	15	11010	0.80	87.2	122.1	0.80	0.255	0.9	0.176	1.40	1.086	0.171	N/L
13.10	42.97	10981	62	236.8	236.8	69	0.58	1.9	Unsaturated	15	10981	0.80	86.8	121.6	0.80	0.254	0.9	0.175	1.40	1.085	0.169	N/L
13.20	43.30	10671	62	238.6	238.6	67	0.59	1.9	Unsaturated	15	10671	0.80	84.2	118.5	0.80	0.253	0.9	0.168	1.38	1.080	0.162	N/L
13.30	43.62	10323	60	240.4	240.4	65	0.59	1.9	Unsaturated	15	10323	0.80	81.3	115.0	0.79	0.253	0.9	0.161	1.35	1.075	0.155	N/L
13.40	43.95	10298	58	242.2	242.2	64	0.58	1.9	Unsaturated	15	10298	0.79	80.9	114.6	0.79	0.252	0.9	0.160	1.35	1.075	0.154	N/L
13.50	44.28	10609	58	244.1	244.1	66	0.56	1.9	Unsaturated	15	10609	0.79	83.2	117.3	0.79	0.252	0.9	0.165	1.37	1.079	0.159	N/L
13.60	44.61	11282	61	245.9	245.9	70	0.56	1.9	Unsaturated	15	11282	0.79	88.3	123.4	0.79	0.251	0.9	0.179	1.41	1.088	0.173	N/L
13.70	44.94	15256	66	247.7	247.7	95	0.44	1.7	Unsaturated	11	15256	0.79	119.2	140.7	0.79	0.250	0.9	0.237	1.57	1.122	0.231	N/L
13.80	45.26	14377	66	249.5	249.5	89	0.47	1.8	Unsaturated	13	14377	0.79	112.1	142.8	0.78	0.250	0.9	0.247	1.59	1.126	0.241	N/L
13.90	45.59	11916	67	251.3	251.3	73	0.58	1.9	Unsaturated	15	11916	0.79	92.8	128.7	0.78	0.249	0.9	0.194	1.46	1.098	0.187	N/L
14.00	45.92	11058	68	253.1	253.1	67	0.63	1.9	Unsaturated	15	11058	0.78	85.9	120.5	0.78	0.249	0.9	0.172	1.39	1.084	0.165	N/L
14.10	46.25	10931	72	254.9	254.9	66	0.67	2.0	Unsaturated	17	10931	0.78	84.8	125.9	0.78	0.248	0.9	0.186	1.43	1.093	0.178	N/L
14.20	46.58	10751	69	256.7	256.7	65	0.66	2.0	Unsaturated	17	10751	0.78	83.2	124.0	0.78	0.247	0.9	0.181	1.42	1.089	0.173	N/L
14.30	46.90	10513	68	258.5	258.5	63	0.66	2.0	Unsaturated	17	10513	0.78	81.2	121.5	0.77	0.247	0.9	0.175	1.40	1.085	0.167	N/L
14.40	47.23	10338	70	260.3	260.3	62	0.69	2.0	Unsaturated	17	10338	0.78	79.7	119.7	0.77	0.246	0.9	0.170	1.38	1.082	0.163	N/L
14.50	47.56	10357	70	262.1	262.1	62	0.69	2.0	Unsaturated	17	10357	0.78	79.7	119.7	0.77	0.246	0.9	0.170	1.38	1.082	0.163	N/L
14.60	47.89	10491	74	263.9	263.9	63	0.72	2.0	Unsaturated	17	10491	0.78	80.6	120.8	0.77	0.245	0.9	0.173	1.39	1.084	0.165	N/L
14.70	48.22	10659	74	265.7	265.7	63	0.71	2.0	Unsaturated	17	10659	0.77	81.8	122.2	0.77	0.244	0.9	0.176	1.40	1.086	0.168	N/L
14.80	48.54	10491	74	267.6	267.6	62	0.73	2.0	Unsaturated	17	10491	0.77	80.3	120.4	0.77	0.244	0.9	0.172	1.39	1.083	0.164	N/L
14.90	48.87	10403	75	269.4	269.4	61	0.74	2.0	Unsaturated	17	10403	0.77	79.5	119.4	0.76	0.243	0.9	0.170	1.38	1.082	0.161	N/L
15.00	49.20	10215	72	271.2	271.2	60	0.72	2.0	Unsaturated	17	10215	0.77	77.9	117.4	0.76	0.243	0.9	0.166	1.37	1.079	0.157	N/L
15.10	49.53	10603	69	273.0	273.0	62	0.67	2.0	Unsaturated	17	10603	0.77	80.8	120.9	0.76	0.242	0.9	0.173	1.39	1.084	0.164	N/L
15.20	49.86	10778	69	274.8	274.8	63	0.66	2.0	Unsaturated	17	10778	0.77	82.0	122.4	0.76	0.241	0.9	0.177	1.40	1.087	0.168	N/L
15.30	50.18	10710	70	276.6	276.6	62	0.67	2.0	Unsaturated	17	10710	0.77	81.3	121.6	0.76	0.241	0.9	0.175	1.40	1.085	0.166	N/L
15.40	50.51	10518	71	278.4	278.4	61	0.69	2.0	Unsaturated	17	10518	0.77	79.7	119.6	0.75	0.240	0.9	0.170	1.38	1.082	0.161	N/L
15.50	50.84	10409	72	280.2	280.2	60	0.71	2.0	Unsaturated	17	10409	0.76	78.7	118.4	0.75	0.240	0.9	0.168	1.37	1.080	0.159	N/L
15.60	51.17	10486	70	282.0	282.0	60	0.69	2.0	Unsaturated	17	10486	0.76	79.2	119.0	0.75	0.239	0.9	0.169	1.38	1.081	0.160	N/L
15.70	51.50	10639	71	283.8	283.8	61	0.69	2.0	Unsaturated	17	10639	0.76	80.2	120.2	0.75	0.238	0.9	0.172	1.39	1.083	0.162	N/L
15.80	51.82	10875	72	285.6	285.6	62	0.68	2.0	Unsaturated	17	10875	0.76	81.8	122.3	0.75	0.238	0.9	0.176	1.40	1.087	0.166	N/L
15.90	52.15	11037	74	287.4	287.4	63	0.69	2.0	Unsaturated	17	11037	0.76	82.9	123.6	0.75	0.237	0.9	0.180	1.41	1.089	0.169	N/L
16.00	52.48	10978	70	289.2	289.2	62	0.65	2.0	Unsaturated	17	10978	0.76	82.3	122.9	0.74	0.237	0.9	0.178	1.41	1.088	0.168	N/L
16.10	52.81	10835	67	291.1	291.1	61	0.64	2.0	Unsaturated	17	10835	0.76	81.1	121.4	0.74	0.236	0.9	0.174	1.40	1.085	0.164	N/L
16.20	53.14	10854	68	292.9	292.9	61	0.65	2.0	Unsaturated	17	10854	0.76	81.2	121.4	0.74	0.236	0.9	0.174	1.40	1.085	0.164	N/L
16.30	53.46	11096	69	294.7	294.7	63	0.64	2.0	Unsaturated	17	11096	0.75	82.8	123.5	0.74	0.235	0.9	0.179	1.41	1.089	0.169	N/L
16.40	53.79	11258	72	296.5	296.5	63	0.66	2.0	Unsaturated	17	11258	0.75	83.9	124.8	0.74	0.234	0.9	0.183	1.42	1.091	0.172	N/L
16.50	54.12	11468	73	298.3	298.3	64	0.65	2.0	Unsaturated	17	11468	0.75	85.3	126.6	0.73	0.234	0.9	0.187	1.44	1.094	0.176	N/L
16.60	54.45	11606	73	300.1	300.1	65	0.65	2.0	Unsaturated	17	11606	0.75	86.2	127.7	0.73	0.233	0.9	0.191	1.45	1.096	0.179	N/L
16.70	54.78	11792	73	301.9	301.9	66	0.64	1.9	Unsaturated	15	11792	0.75	87.5	122.4	0.73	0.233	0.9	0.177	1.40	1.087	0.165	N/L
16.80	55.10	11841	74	303.7	303.7	66	0.64	1.9	Unsaturated	15	11841	0.75	87.7	122.6	0.73	0.232	0.9	0.177	1.41	1.087	0.166	N/L
16.90	55.43	12090	68	305.5	305.5	67	0.58	1.9	Unsaturated	15	12090	0.75	89.4	124.7	0.73	0.232	0.9	0.182	1.42	1.091	0.170	N/L
17.00	55.76	12446	69	307.3	307.3	69	0.57	1.9	Unsaturated	15	12446	0.75	91.9	127.7	0.73	0.231	0.9	0.191	1.45	1.096	0.178	N/L
17.10	56.09	12907	75	309.1	309.1	71	0.60	1.9	Unsaturated	15	12907	0.74	95.1	131.6	0.72	0.230	0.8	0.202	1.48	1.103	0.189	N/L
17.20	56.42	13188	81	310.9	310.9	73	0.63	1.9	Unsaturated	15	13188	0.74	97.1	133.9	0.72	0.230	0.8	0.210	1.50	1.108	0.196	N/L
17.30	56.74	13869	84	312.7	312.7	76	0.62	1.9	Unsaturated	15	13869	0.74	101.9	139.7	0.72	0.229	0.8	0.233	1.56	1.120	0.218	N/L
17.40	57.07	14636	88	314.6	314.6	80	0.62	1.9	Unsaturated	15	14636	0.74	107.4	146.3	0.72	0.229	0.8	0.266	1.63	1.134	0.249	N/L
17.50	57.40	15123	92	316.4	316.4	83	0.62	1.9	Unsaturated	15	15123	0.74	110.8	150.4	0.72	0.228	0.8	0.291	1.67	1.144	0.272	N/L
17.60	57.73	18687	101	318.2	318.2	102	0.55	1.7	Unsaturated	11	18687	0.74	136.7	160.0	0.71	0.228	0.8	0.371	1.79	1.170	0.347	N/L
17.70	58.06	33872	66	320.0	320.0	186	0.20	1.3	Unsaturated	6	33872	0.74	247.4	247.6	0.71	0.227	0.7	2.000	2.20	1.257	1.643	N/L
17.80	58.38	44620	77	321.8	321.8	245	0.17	1.2	Unsaturated	4	44620	0.74	325.4	325.4	0.71	0.227	0.7	2.000	2.20	1.257	1.639	N/L
17.90	58.71	47620	75	323.6	323.6	261	0.16	1.1	Unsaturated	4	47620	0.74	346.8	346.8	0.71	0.226	0.7	2.000	2.20	1.257	1.635	N/L
18.00	59.04	44484	75	325.4	325.4	243	0.17	1.2	Unsaturated	4	44484	0.73	323.5	323.5	0.71	0.225	0.6	2.000	2.20	1.257	1.631	N/L

Depth, Z (m)	q_t (kPa)	N_{60}	$N_{1,60}$	$\Delta(N_1)_{60}$	$N_{1,60-CS}$	Limiting Shear Strain γ_{lim}	Parameter F_α	Max. Shear Strain γ_{max}	ΔHi (m)	ΔLDI_i (m)	Vert. Recon. Strain ε_v	DF_i	ΔSi (inch)	$p = \sigma_m$ (tsf)	τ_{ave} (psf)	G_{max} (tsf)	τ_{ave}/G_{max}	a	b	γ_{eff} (%)	ε_{15} (%)	ε_{Nc} (%)	Settlement (inch)	Settlement (inch)	$\Delta(N_1)_{60-Sr}$	$(N_1)_{60-Sr}$	S_r/σ_{v0}'
8.90	9646	19.1	16.9	3.2	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.51	0.00	1.126	986	2666	0.00018	0.56190	5961	0.03188	0.039	0.033	0.00	0.23	N/A	N/A	N/A
9.00	9560	18.9	16.7	3.2	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.51	0.00	1.138	996	2649	0.00019	0.56682	5921	0.03267	0.041	0.034	0.00	0.23	N/A	N/A	N/A
9.10	9612	19.0	16.7	3.2	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.50	0.00	1.151	1005	2671	0.00019	0.57174	5882	0.03266	0.040	0.034	0.00	0.23	N/A	N/A	N/A
9.20	9689	19.2	16.8	3.2	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.50	0.00	1.164	1014	2699	0.00019	0.57666	5844	0.03251	0.040	0.033	0.00	0.22	N/A	N/A	N/A
9.30	9792	19.4	16.9	3.2	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.49	0.00	1.176	1023	2734	0.00019	0.58158	5806	0.03221	0.039	0.033	0.00	0.22	N/A	N/A	N/A
9.40	9957	19.7	17.2	3.2	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.49	0.00	1.189	1032	2788	0.00019	0.58650	5769	0.03159	0.038	0.032	0.00	0.22	N/A	N/A	N/A
9.50	9942	19.7	17.1	3.2	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.48	0.00	1.202	1041	2790	0.00019	0.59143	5732	0.03193	0.039	0.032	0.00	0.22	N/A	N/A	N/A
9.60	9675	19.1	16.6	3.2	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.48	0.00	1.214	1050	2722	0.00019	0.59635	5696	0.03371	0.042	0.035	0.00	0.21	N/A	N/A	N/A
9.70	9552	18.9	16.3	3.2	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.47	0.00	1.227	1059	2694	0.00020	0.60127	5661	0.03474	0.044	0.037	0.00	0.21	N/A	N/A	N/A
9.80	9654	19.1	16.5	3.2	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.46	0.00	1.240	1068	2729	0.00020	0.60619	5626	0.03439	0.043	0.036	0.00	0.21	N/A	N/A	N/A
9.90	9848	19.5	16.8	3.2	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.46	0.00	1.252	1077	2791	0.00019	0.61111	5592	0.03350	0.041	0.035	0.00	0.21	N/A	N/A	N/A
10.00	9945	19.7	16.9	3.2	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.45	0.00	1.265	1086	2825	0.00019	0.61603	5558	0.03320	0.041	0.034	0.00	0.20	N/A	N/A	N/A
10.10	9946	19.7	16.8	3.2	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.45	0.00	1.277	1094	2832	0.00019	0.62095	5525	0.03345	0.041	0.034	0.00	0.20	N/A	N/A	N/A
10.20	10008	19.8	16.9	3.2	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.44	0.00	1.290	1103	2856	0.00019	0.62587	5493	0.03334	0.041	0.034	0.00	0.20	N/A	N/A	N/A
10.30	10209	20.2	17.2	3.2	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.44	0.00	1.303	1112	2920	0.00019	0.63079	5461	0.03249	0.039	0.033	0.00	0.20	N/A	N/A	N/A
10.40	10566	20.9	17.7	3.2	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.43	0.00	1.315	1120	3029	0.00018	0.63571	5429	0.03091	0.036	0.030	0.00	0.19	N/A	N/A	N/A
10.50	10748	21.3	18.0	3.2	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.43	0.00	1.328	1129	3089	0.00018	0.64063	5398	0.03027	0.034	0.029	0.00	0.19	N/A	N/A	N/A
10.60	10709	21.2	17.9	3.2	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.42	0.00	1.341	1137	3084	0.00018	0.64555	5368	0.03066	0.035	0.029	0.00	0.19	N/A	N/A	N/A
10.70	10584	20.9	17.6	3.2	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.42	0.00	1.353	1146	3055	0.00019	0.65047	5337	0.03146	0.037	0.031	0.00	0.19	N/A	N/A	N/A
10.80	10455	20.7	17.4	3.2	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.41	0.00	1.366	1154	3024	0.00019	0.65539	5308	0.03231	0.038	0.032	0.00	0.18	N/A	N/A	N/A
10.90	10302	20.4	17.1	3.2	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.40	0.00	1.379	1162	2987	0.00019	0.66031	5278	0.03332	0.040	0.034	0.00	0.18	N/A	N/A	N/A
11.00	10263	20.3	17.0	3.2	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.40	0.00	1.391	1170	2982	0.00020	0.66523	5250	0.03375	0.041	0.034	0.00	0.18	N/A	N/A	N/A
11.10	10178	20.1	16.8	3.2	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.39	0.00	1.404	1179	2964	0.00020	0.67015	5221	0.03444	0.042	0.035	0.00	0.18	N/A	N/A	N/A
11.20	9907	19.6	16.3	3.2	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.39	0.00	1.417	1187	2891	0.00021	0.67507	5193	0.03627	0.046	0.039	0.00	0.17	N/A	N/A	N/A
11.30	9747	19.3	16.0	3.2	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.38	0.00	1.429	1195	2850	0.00021	0.67999	5165	0.03753	0.049	0.041	0.00	0.17	N/A	N/A	N/A
11.40	9946	19.7	16.3	3.2	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.38	0.00	1.442	1203	2914	0.00021	0.68491	5138	0.03646	0.047	0.039	0.00	0.17	N/A	N/A	N/A
11.50	10268	20.3	16.8	3.2	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.37	0.00	1.455	1211	3015	0.00020	0.68983	5111	0.03476	0.043	0.036	0.00	0.16	N/A	N/A	N/A
11.60	10324	20.4	16.8	3.2	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.37	0.00	1.467	1219	3037	0.00020	0.69475	5085	0.03464	0.043	0.036	0.00	0.16	N/A	N/A	N/A
11.70	10261	20.3	16.7	3.2	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.36	0.00	1.480	1226	3025	0.00020	0.69967	5059	0.03519	0.044	0.037	0.00	0.16	N/A	N/A	N/A
11.80	10348	20.5	16.8	3.2	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.35	0.00	1.493	1234	3057	0.00020	0.70459	5033	0.03489	0.043	0.036	0.00	0.15	N/A	N/A	N/A
11.90	10434	20.6	16.9	3.2	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.35	0.00	1.505	1242	3088	0.00020	0.70951	5008	0.03460	0.042	0.035	0.00	0.15	N/A	N/A	N/A
12.00	10451	20.7	16.9	3.2	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.34	0.00	1.518	1249	3099	0.00020	0.71443	4983	0.03469	0.042	0.035	0.00	0.15	N/A	N/A	N/A
12.10	10445	20.7	16.9	3.2	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.34	0.00	1.530	1257	3104	0.00020	0.71935	4958	0.03490	0.043	0.036	0.00	0.15	N/A	N/A	N/A
12.20	10526	20.8	16.9	3.2	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.33	0.00	1.543	1265	3134	0.00020	0.72427	4933	0.03463	0.042	0.035	0.00	0.14	N/A	N/A	N/A
12.30	10705	21.2	17.2	3.2	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.33	0.00	1.556	1272	3193	0.00020	0.72919	4909	0.03385	0.041	0.034	0.00	0.14	N/A	N/A	N/A
12.40	10811	21.4	17.3	3.2	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.32	0.00	1.568	1279	3231	0.00020	0.73411	4885	0.03346	0.040	0.033	0.00	0.14	N/A	N/A	N/A
12.50	10693	21.2	17.1	3.2	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.32	0.00	1.581	1287	3202	0.00020	0.73903	4862	0.03424	0.041	0.035	0.00	0.14	N/A	N/A	N/A
12.60	10546	20.9	16.8	3.2	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.31	0.00	1.594	1294	3164	0.00020	0.74395	4839	0.03520	0.043	0.036	0.00	0.13	N/A	N/A	N/A
12.70	10520	20.8	16.8	3.2	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.31	0.00	1.606	1301	3162	0.00021	0.74887	4816	0.03551	0.044	0.037	0.00	0.13	N/A	N/A	N/A
12.80	10878	21.5	17.3	3.2	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.30	0.00	1.619	1309	3276	0.00020	0.75379	4793	0.03375	0.040	0.034	0.00	0.13	N/A	N/A	N/A
12.90	11047	21.9	17.5	3.2	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.29	0.00	1.632	1316	3333	0.00020	0.75871	4771	0.03306	0.039	0.032	0.00	0.12	N/A	N/A	N/A
13.00	11023	21.8	17.5	3.2	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.29	0.00	1.644	1323	3332	0.00020	0.76363	4749	0.03332	0.039	0.033	0.00	0.12	N/A	N/A	N/A
13.10	10948	21.7	17.3	3.2	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.28	0.00	1.657	1330	3315	0.00020	0.76855	4727	0.03384	0.040	0.034	0.00	0.12	N/A	N/A	N/A
13.20	10657	21.1	16.8	3.2	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.28	0.00	1.670	1337	3233	0.00021	0.77347	4706	0.03552	0.044	0.037	0.00	0.12	N/A	N/A	N/A
13.30	10339	20.5	16.3	3.2	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.27	0.00	1.682	1344	3142	0.00021	0.77840	4684	0.03751	0.048	0.040	0.00	0.11	N/A	N/A	N/A
13.40	10296	20.4	16.2	3.2	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.27	0.00	1.695	1350	3134	0.00022	0.78332	4663	0.03793	0.049	0.041	0.00	0.11	N/A	N/A	N/A
13.50	10623	21.0	16.7	3.2	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.26	0.00	1.708	1357	3239	0.00021	0.78824	4643	0.03614	0.045	0.038	0.00	0.11	N/A	N/A	N/A
13.60	11520	22.8	18.0	3.2	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.26	0.00	1.720	1364	3519	0.00019	0.79316	4622	0.03181	0.036	0.030	0.00	0.10	N/A	N/A	N/A
13.70	14784	27.2	21.5	1.7	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.25	0.00	1.733	1371	4212	0.00016	0.79808	4602	0.02432	0.022	0.019	0.00	0.10	N/A	N/A	N/A
13.80	14740	28.1	22.2	2.5	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.25	0.00	1.745	1377	4357	0.00016	0.80300	4582	0.02329	0.021	0.017	0.00	0.10	N/A	N/A	N/A
13.90	12134	24.0	18.9	3.2	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.24	0.00	1.758	1384	3726	0.00019	0.80792	4562	0.02963	0.032	0.027	0.00	0.10	N/A	N/A	N/A
14.00	11119	22.0	17.3	3.2	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.23	0.00	1.771	1390	3420	0.00020	0.81284	4542	0.03416	0.041	0.034	0.00	0.10	N/A	N/A	N/A
14.10	10900	22.4	17.5	3.8	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.23	0.00	1.783	1397	3487	0.00020	0.81776	4523	0.03331	0.039	0.033	0.00	0.09	N/A	N/A	N/A
14.20	10738	22.1	17.2	3.8	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.22	0.00	1.796	1403	3441	0.00020	0.82268	4504	0.03424	0.041	0.034	0.00	0.09	N/A	N/A	N/A
14.30	10511	21.6	16.9	3.8	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.22	0.00	1.809	1410	3374	0.00021	0.82760	4485	0.03556	0.044	0.037	0.00	0.09	N/A	N/A	N/A
14.40	10340	21.2	16.6	3.8	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.21	0.00	1.821	1416	3325	0.00021	0.83252	4466	0.03665	0.046	0.038	0.00	0.09	N/A	N/A	N/A
14.50	10355	21.3	16.5	3.8	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.21	0.00	1.834	1422	3335	0.00021	0.83744	4448	0.03669	0.046	0.039	0.00	0.08	N/A	N/A	N/A
14.60	10511	21.6	16.8	3.8	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.20	0.00	1.847	1428	3391	0.00021	0.84236	4429	0.03590	0.044	0.037	0.00	0.08	N/A	N/A	N/A
14.70	10627	21.8	16.9	3.8	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.20	0.00	1.859	1434	3434	0.00021	0.84728	4411	0.03538	0.043	0.036	0.00	0.08	N/A	N/A	N/A
14.80	10526	21.6	16.7	3.8	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.19	0.00	1.872	1440	3406	0.00021	0.85220	4393	0.03604	0.045	0.037	0.00	0.07	N/A	N/A	N/A
14.90	10382	21.3	16.5	3.8	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.19	0.00	1.885	1446	3365	0.00021	0.85712	4376	0.03697	0.047	0.039	0.00	0.07	N/A	N/A	N/A
15.00	10283	21.1	16.3	3.8	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.18	0.00	1.897	1452	3338	0.00022	0.86204	4358	0.03766	0.048	0.040	0.00	0.07	N/A	N/A	N/A
15.10	10583	21.7	16.7	3.8	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.17	0.00	1.910	1458	3441	0.00021	0.86696	4341	0.03602	0.045	0.037	0.00	0.07	N/A	N/A	N/A
15.20	10776	22.1	17.0	3.8	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.17	0.00	1.923	1464	3509	0.00021	0.87188	4324	0.03508	0.043	0.036	0.00	0.06	N/A	N/A	N/A
15.30	10703	22.0	16.9	3.8	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.16	0.00	1.935	1470	3491	0.00021	0.87680	4307	0.03556	0.044	0.037	0.00	0.06	N/A	N/A	N/A
15.40	10522	21.6	16.5	3.8	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.16	0.00	1.948	1475	3437	0.00021	0.88172	4290	0.03666	0.046	0.038	0.00	0.06	N/A	N/A	N/A
15.50	10423	21.4	16.4	3.8	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.15	0.00	1.961	1481	3410	0.00022	0.88664	4273	0.03732	0.047	0.040	0.00	0.05	N/A	N/A	N/A
15.60	10484	21.5	16.4	3.8	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.15	0.00	1.973	1487	3435	0.00022	0.89156	4257	0.03706	0.047	0.039	0.00	0.05	N/A	N/A	N/A
15.70	10624	21.8	16.6	3.8	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.14	0.00	1.986	1492	3486	0.00021	0.89648	4240	0.03636	0.045	0.038	0.00	0.05	N/A	N/A	N/A
15.80	10863	22.3	17.0	3.8	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.14	0.00	1.998	1498	3570	0.00021	0.90140	4224	0.03515	0.043	0.036	0.00	0.04	N/A	N/A	N/A
15.90	11017	22.6	17.2	3.8	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.13	0.00	2.011	1503	3626	0.00021	0.90632	4208	0.03445	0.041	0.035	0.00	0.04	N/A	N/A	N/A
16.00	10951	22.5	17.0	3.8	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.13	0.00	2.024	1509	3610	0.00021	0.91124	4193	0.03486	0.042	0.035	0.00	0.04	N/A	N/A	N/A
16.10	10861	22.3	16.9	3.8	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.12	0.00	2.036	1514	3585	0.00021	0.91616	4177	0.03540	0.043	0.036	0.00	0.04	N/A	N/A	N/A
16.20	10929	22.5	17.0	3.8	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.11	0.00	2.049	1519	3613	0.00021	0.92108	4161	0.03512	0.043	0.036	0.00	0.03	N/A	N/A	N/A
16.30	11121	22.9	17.2	3.8	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.11	0.00	2.062	1524	3682	0.00021	0.92600	4146	0.03423	0.041	0.034	0.00	0.03	N/A	N/A	N/A
16.40	11266	23.1	17.4	3.8	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.10	0.00	2.074	1530	3735	0.00020	0.93092	4131	0.03360	0.040	0.033	0.00	0.03	N/A	N/A	N/A
16.50	11460	23.5	17.7	3.8	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.10	0.00	2.087	1535	3805	0.00020	0.93584	4116	0.03278	0.038	0.032	0.00	0.03	N/A	N/A	N/A
16.60	11640	23.9	17.9	3.8	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.09	0.00	2.100	1540	3871	0.00020	0.94076	4101	0.03205	0.036	0.031	0.00	0.02	N/A	N/A	N/A
16.70	11765	23.3	17.4	3.2	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.09	0.00	2.112	1545	3773	0.00020	0.94568	4086	0.03349	0.039	0.033	0.00	0.02	N/A	N/A	N/A
16.80	11839	23.4	17.5	3.2	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.08	0.00	2.125	1550	3801	0.00020	0.95060	4072	0.03323	0.039	0.033	0.00	0.02	N/A	N/A	N/A
16.90	12123	24.0	17.9	3.2	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.08	0.00	2.138	1555	3898	0.00020	0.95552	4057	0.03207	0.037	0.031	0.00	0.02	N/A	N/A	N/A
17.00	12443	24.6	18.4	3.2	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.07	0.00	2.150	1559	4007	0.00019	0.96044	4043	0.03086	0.034	0.029	0.00	0.01	N/A	N/A	N/A
17.10	12813	25.4	18.9	3.2	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.07	0.00	2.163	1564	4131	0.00019	0.96537	4029	0.02957	0.032	0.027	0.00	0.01	N/A	N/A	N/A
17.20	13227	26.2	19.5	3.2	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.06	0.00	2.176	1569	4271	0.00018	0.97029	4015	0.02823	0.029	0.024	0.00	0.01	N/A	N/A	N/A
17.30	13868	27.4	20.4	3.2	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.05	0.00	2.188	1574	4484	0.00018	0.97521	4001	0.02637	0.026	0.022	0.00	0.01	N/A	N/A	N/A
17.40	14564	28.8	21.4	3.2	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.05	0.00	2.201	1578	4716	0.00017	0.98013	3987	0.02459	0.023	0.019	0.00	0.00	N/A	N/A	N/A
17.50	15363	30.4	22.5	3.2	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.04	0.00	2.213	1583	4981	0.00016	0.98505	3973	0.02283	0.020	0.017	0.00	0.00	N/A	N/A	N/A
17.60	19680	36.3	26.8	1.7	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.04	0.00	2.226	1587	5949	0.00013	0.98997	3960	0.01796	0.013	0.011	0.00	0.00	N/A	N/A	N/A
17.70	33733	54.6	40.3	0.0	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.03	0.00	2.239	1592	8972	0.00009	0.99489	3946	0.01073	0.005	0.004	0.00	0.00	N/A	N/A	N/A
17.80	45037	70.8	52.1	0.0	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.03	0.00	2.251	1596	11642	0.00007	0.99981	3933	0.00792	0.003	0.002	0.00	0.00	N/A	N/A	N/A
17.90	47618	72.7	53.5	0.0	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.02	0.00	2.264	1601	11973	0.00007	1.00473	3920	0.00769	0.002	0.002	0.00	0.00	N/A	N/A	N/A
18.00	46274	72.7	53.4	0.0	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.02	0.00	2.277	1605	11994	0.00007	1.00965	3907	0.00770	0.002	0.002	0.00	0.00	N/A	N/A	N/A

Depth, Z (m)	Depth, Z (ft)	q_c (kPa)	f_s (kPa)	σ_{vc} (kPa)	σ'_{vc} (kPa)	Q	F	I_c	Soil Type	Fines (%)	Interpreted q_c	C_N	q_{c1N}	q_{c1N-cs}	Stress Reduction Factor (r_d)	CSR	K_σ for sand	$CRR_{M=7.5}$ at σ'_{vc}=1	MSF_{max}	MSF	CRR	$(FS)_L$	q_t (kPa)	N_{60}	$N_{1,60}$	$\Delta(N_1)_{60}$	$N_{1,60-CS}$	Limiting Shear Strain γ_{lim}	Parameter F_α	Max. Shear Strain γ_{max}	ΔHi (m)	ΔLDI_i (m)	Vert. Recon. Strain ε_v	DF_i	ΔSi (inch)	$p = \sigma_m$ (tsf)	τ_{ave} (psf)	G_{max} (tsf)	τ_{ave}/G_{max}	a	b	γ_{eff} (%)	ε_{15} (%)	ε_{Nc} (%)	Settlement (inch)	Settlement (inch)	$\Delta(N_1)_{60-Sr}$	$(N_1)_{60-Sr}$	S_r/σ_{v0}'
18.10	59.37	44180	158	327.2	327.2	241	0.36	1.3	Unsaturated	6	44180	0.73	320.8	321.0	0.71	0.225	0.6	2.000	2.20	1.257	1.627	**N/L**	44555	72.1	52.9	0.0	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.01	0.00	2.289	1609	11914	0.00007	1.01457	3894	0.00778	0.002	0.002	0.00	0.00	N/A	N/A	N/A
18.20	59.70	39590	175	329.0	329.0	215	0.45	1.4	Unsaturated	7	39590	0.73	287.0	289.2	0.70	0.224	0.6	2.000	2.20	1.257	1.622	**N/L**	38177	63.7	46.7	0.1	N.A.	0.000	0.000	0.000	0.05	0.0000	0.0000	0.01	0.00	2.302	1614	10541	0.00008	1.01949	3881	0.00899	0.003	0.003	0.00	0.00	N/A	N/A	N/A

CONE PENETRATION TEST-BASED LIQUEFACTION ANALYSIS BASED ON IDRISS & BOULANGER (2008)

References:

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3 - Tokimatsu, K. and Seed H.B. (1987). "Evaluation of Settlements in Sands Due to Earthquake Shaking," Journal of Geotechnical Engineering, Vol. 113, No. 8, August.

4 - Pradel, D. (1998). "Procedure to Evaluate Earthquake-Induced Settlements in Sand," Journal of Geotechnical and Geoenvironmental Engineering, Vol. 124, No. 4, April.

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6 - Boulanger, R.W. and Idriss, I.M. (2014). "CPT and SPT Based Liquefaction Triggering Procedures," Report No. UCD/CGM-14/01, University of California at Davis

Project	**Chevron Guadalupe Tank Battery 9 Site**
Test Boring No	**TSMACPT-9**

Test Boring Information:

Approx. depth to ground water table		52.7 ft	16.07 m
Moist unit weight of soil	γ_m	115 pcf	18.08 kN/m^3
Saturated unit weight of soil	γ_{sat}	125 pcf	19.65 kN/m^3

Earthquake Information:

Earthquake magnitude	M_w	6.9
Peak horizontal ground surface acceleratio	a_{max}	0.490 g
Number of equivalent cycle	N	10.1

Atmospheric pressure	P_a	101.3 kPa

N/L = Non-liquefiable clay-like soil

N.A. = Not Applicable

Sum
0.00

Sum	Total
0.04	**0.04**

Factor of Safety Agaist Liquefaction (Idriss & Boulanger, 2008 and Boulanger & Idriss, 2014)

Depth, Z (m)	Depth, Z (ft)	q_c (kPa)	f_s (kPa)	σ_{vc} (kPa)	σ'_{vc} (kPa)	Q	F	I_c	Soil Type	Fines (%)	Interpreted q_c	C_N	q_{c1N}	q_{c1N-cs}	Stress Reduction Factor (r_d)	CSR	K_σ for sand	$CRR_{M=7.5}$ at σ'_{vc}=1	MSF_{max}	MSF	CRR	$(FS)_L$
1.60	5.25	12583	48	28.9	28.9	232	0.38	1.4	Unsaturated	7	12583	1.39	173.3	174.8	0.99	0.315	1.1	0.595	2.01	1.216	0.795	**N/L**
1.70	5.58	12008	50	30.7	30.7	215	0.41	1.4	Unsaturated	7	12008	1.37	162.7	164.2	0.99	0.315	1.1	0.419	1.85	1.182	0.544	**N/L**
1.80	5.90	10043	44	32.5	32.5	174	0.44	1.5	Unsaturated	8	10043	1.35	134.1	139.3	0.99	0.315	1.1	0.231	1.55	1.119	0.284	**N/L**
1.90	6.23	9161	41	34.3	34.3	155	0.45	1.6	Unsaturated	10	9161	1.33	120.6	132.6	0.99	0.314	1.1	0.206	1.49	1.105	0.250	**N/L**
2.00	6.56	8774	38	36.2	36.2	144	0.43	1.6	Unsaturated	10	8774	1.31	113.9	125.5	0.99	0.314	1.1	0.185	1.43	1.092	0.222	**N/L**
2.10	6.89	8488	35	38.0	38.0	136	0.42	1.6	Unsaturated	10	8488	1.29	108.8	120.1	0.98	0.314	1.1	0.171	1.39	1.083	0.204	**N/L**
2.20	7.22	8494	36	39.8	39.8	133	0.42	1.6	Unsaturated	10	8494	1.28	107.5	118.8	0.98	0.313	1.1	0.169	1.38	1.081	0.200	**N/L**
2.30	7.54	8848	39	41.6	41.6	136	0.44	1.6	Unsaturated	10	8848	1.26	110.7	122.2	0.98	0.313	1.1	0.176	1.40	1.086	0.211	**N/L**
2.40	7.87	9302	40	43.4	43.4	140	0.43	1.6	Unsaturated	10	9302	1.25	115.1	126.8	0.98	0.312	1.1	0.188	1.44	1.094	0.226	**N/L**
2.50	8.20	9574	42	45.2	45.2	141	0.44	1.6	Unsaturated	10	9574	1.24	117.2	129.0	0.98	0.312	1.1	0.194	1.46	1.098	0.235	**N/L**
2.60	8.53	10072	46	47.0	47.0	145	0.46	1.6	Unsaturated	10	10072	1.22	122.0	134.1	0.98	0.312	1.1	0.211	1.50	1.108	0.257	**N/L**
2.70	8.86	10273	47	48.8	48.8	145	0.46	1.6	Unsaturated	10	10273	1.21	123.2	135.4	0.98	0.311	1.1	0.216	1.52	1.111	0.263	**N/L**
2.80	9.18	10653	49	50.6	50.6	148	0.47	1.6	Unsaturated	10	10653	1.20	126.6	138.9	0.98	0.311	1.1	0.230	1.55	1.118	0.282	**N/L**
2.90	9.51	11096	50	52.4	52.4	152	0.46	1.6	Unsaturated	10	11096	1.19	130.6	143.2	0.97	0.310	1.1	0.249	1.59	1.127	0.309	**N/L**
3.00	9.84	11822	51	54.2	54.2	159	0.44	1.5	Unsaturated	8	11822	1.18	137.9	143.2	0.97	0.310	1.1	0.249	1.59	1.127	0.308	**N/L**
3.10	10.17	13388	54	56.0	56.0	177	0.41	1.5	Unsaturated	8	13388	1.17	154.8	160.5	0.97	0.309	1.1	0.377	1.80	1.171	0.486	**N/L**
3.20	10.50	14560	58	57.8	57.8	189	0.40	1.4	Unsaturated	7	14560	1.16	167.0	168.5	0.97	0.309	1.1	0.479	1.91	1.195	0.629	**N/L**
3.30	10.82	14011	57	59.7	59.7	179	0.41	1.5	Unsaturated	8	14011	1.15	159.4	165.2	0.97	0.309	1.1	0.432	1.86	1.185	0.561	**N/L**
3.40	11.15	13055	60	61.5	61.5	165	0.46	1.5	Unsaturated	8	13055	1.14	147.4	152.9	0.97	0.308	1.1	0.309	1.70	1.151	0.384	**N/L**
3.50	11.48	12704	60	63.3	63.3	158	0.48	1.6	Unsaturated	10	12704	1.13	142.3	155.6	0.97	0.308	1.1	0.330	1.74	1.158	0.412	**N/L**
3.60	11.81	12710	62	65.1	65.1	156	0.49	1.6	Unsaturated	10	12710	1.12	141.3	154.5	0.96	0.307	1.1	0.321	1.72	1.155	0.398	**N/L**
3.70	12.14	13232	69	66.9	66.9	160	0.52	1.6	Unsaturated	10	13232	1.11	146.1	159.5	0.96	0.307	1.1	0.367	1.79	1.169	0.459	**N/L**
3.80	12.46	13710	68	68.7	68.7	164	0.50	1.6	Unsaturated	10	13710	1.11	150.3	164.0	0.96	0.306	1.1	0.417	1.85	1.181	0.527	**N/L**
3.90	12.79	15869	74	70.5	70.5	187	0.47	1.5	Unsaturated	8	15869	1.10	172.8	178.9	0.96	0.306	1.1	0.694	2.07	1.230	0.918	**N/L**
4.00	13.12	18011	84	72.3	72.3	210	0.47	1.5	Unsaturated	8	18011	1.09	194.8	201.4	0.96	0.305	1.1	2.048	2.20	1.257	2.000	**N/L**
4.10	13.45	14987	82	74.1	74.1	172	0.55	1.6	Unsaturated	10	14987	1.09	161.0	175.4	0.96	0.305	1.1	0.608	2.01	1.218	0.786	**N/L**
4.20	13.78	10951	56	75.9	75.9	124	0.52	1.7	Unsaturated	11	10951	1.08	116.9	138.1	0.96	0.304	1.0	0.226	1.54	1.116	0.263	**N/L**
4.30	14.10	9394	47	77.7	77.7	105	0.51	1.7	Unsaturated	11	9394	1.07	99.7	119.1	0.95	0.304	1.0	0.169	1.38	1.081	0.189	**N/L**
4.40	14.43	9591	48	79.5	79.5	106	0.51	1.7	Unsaturated	11	9591	1.07	101.1	120.7	0.95	0.303	1.0	0.173	1.39	1.084	0.193	**N/L**
4.50	14.76	10479	51	81.4	81.4	115	0.49	1.7	Unsaturated	11	10479	1.06	109.8	130.3	0.95	0.303	1.0	0.198	1.47	1.101	0.225	**N/L**
4.60	15.09	11364	56	83.2	83.2	123	0.49	1.7	Unsaturated	11	11364	1.05	118.4	139.8	0.95	0.303	1.0	0.234	1.56	1.120	0.269	**N/L**
4.70	15.42	12067	61	85.0	85.0	129	0.51	1.6	Unsaturated	10	12067	1.05	125.0	137.3	0.95	0.302	1.0	0.223	1.53	1.114	0.255	**N/L**
4.80	15.74	14028	65	86.8	86.8	149	0.47	1.6	Unsaturated	10	14028	1.04	144.6	158.0	0.95	0.302	1.0	0.351	1.77	1.164	0.420	**N/L**
4.90	16.07	16902	77	88.6	88.6	177	0.46	1.5	Unsaturated	8	16902	1.04	173.2	179.4	0.95	0.301	1.0	0.708	2.08	1.231	0.896	**N/L**
5.00	16.40	19581	88	90.4	90.4	204	0.45	1.5	Unsaturated	8	19581	1.03	199.6	206.4	0.94	0.301	1.0	2.762	2.20	1.257	2.000	**N/L**
5.10	16.73	22811	106	92.2	92.2	235	0.47	1.4	Unsaturated	7	22811	1.02	231.4	233.2	0.94	0.300	1.0	2.000	2.20	1.257	2.000	**N/L**
5.20	17.06	20587	113	94.0	94.0	210	0.55	1.5	Unsaturated	8	20587	1.02	207.7	214.7	0.94	0.300	1.0	2.000	2.20	1.257	2.000	**N/L**
5.30	17.38	20379	92	95.8	95.8	206	0.45	1.5	Unsaturated	8	20379	1.01	204.6	211.5	0.94	0.299	1.0	2.000	2.20	1.257	2.000	**N/L**
5.40	17.71	21947	95	97.6	97.6	220	0.44	1.4	Unsaturated	7	21947	1.01	219.3	221.0	0.94	0.299	1.0	2.000	2.20	1.257	2.000	**N/L**
5.50	18.04	24546	113	99.4	99.4	244	0.46	1.4	Unsaturated	7	24546	1.00	244.0	246.0	0.94	0.298	1.0	2.000	2.20	1.257	2.000	**N/L**
5.60	18.37	27721	134	101.2	101.2	273	0.49	1.4	Unsaturated	7	27721	1.00	274.3	276.4	0.93	0.297	1.0	2.000	2.20	1.257	2.000	**N/L**
5.70	18.70	30025	158	103.0	103.0	293	0.53	1.4	Unsaturated	7	30025	0.99	295.7	297.9	0.93	0.297	1.0	2.000	2.20	1.257	2.000	**N/L**
5.80	19.02	30951	192	104.9	104.9	299	0.62	1.4	Unsaturated	7	30951	0.99	303.4	305.7	0.93	0.296	1.0	2.000	2.20	1.257	2.000	**N/L**
5.90	19.35	31299	188	106.7	106.7	300	0.60	1.4	Unsaturated	7	31299	0.99	305.5	307.7	0.93	0.296	1.0	2.000	2.20	1.257	2.000	**N/L**
6.00	19.68	31810	196	108.5	108.5	302	0.62	1.4	Unsaturated	7	31810	0.98	309.1	311.4	0.93	0.295	1.0	2.000	2.20	1.257	2.000	**N/L**
6.10	20.01	31886	198	110.3	110.3	301	0.62	1.4	Unsaturated	7	31886	0.98	308.5	310.8	0.93	0.295	1.0	2.000	2.20	1.257	2.000	**N/L**
6.20	20.34	31692	181	112.1	112.1	296	0.57	1.4	Unsaturated	7	31692	0.97	305.3	307.6	0.92	0.294	1.0	2.000	2.20	1.257	2.000	**N/L**
6.30	20.66	31237	173	113.9	113.9	290	0.56	1.4	Unsaturated	7	31237	0.97	299.6	301.9	0.92	0.294	1.0	2.000	2.20	1.257	2.000	**N/L**
6.40	20.99	31261	177	115.7	115.7	288	0.57	1.4	Unsaturated	7	31261	0.96	298.6	300.9	0.92	0.293	1.0	2.000	2.20	1.257	2.000	**N/L**
6.50	21.32	32161	179	117.5	117.5	294	0.56	1.4	Unsaturated	7	32161	0.96	306.0	308.2	0.92	0.293	1.0	2.000	2.20	1.257	2.000	**N/L**
6.60	21.65	32335	196	119.3	119.3	293	0.61	1.4	Unsaturated	7	32335	0.96	306.4	308.7	0.92	0.292	0.9	2.000	2.20	1.257	2.000	**N/L**
6.70	21.98	32370	217	121.1	121.1	291	0.67	1.5	Unsaturated	8	32370	0.95	305.5	314.8	0.92	0.292	0.9	2.000	2.20	1.257	2.000	**N/L**
6.80	22.30	31386	189	122.9	122.9	280	0.60	1.4	Unsaturated	7	31386	0.95	295.1	297.3	0.91	0.291	0.9	2.000	2.20	1.257	2.000	**N/L**
6.90	22.63	31779	151	124.7	124.7	282	0.48	1.4	Unsaturated	7	31779	0.95	297.6	299.8	0.91	0.291	0.9	2.000	2.20	1.257	2.000	**N/L**
7.00	22.96	32285	153	126.5	126.5	284	0.48	1.4	Unsaturated	7	32285	0.94	301.2	303.4	0.91	0.290	0.9	2.000	2.20	1.257	2.000	**N/L**
7.10	23.29	34261	165	128.4	128.4	299	0.48	1.3	Unsaturated	6	34261	0.94	318.4	318.7	0.91	0.289	0.9	2.000	2.20	1.257	2.000	**N/L**
7.20	23.62	33757	163	130.2	130.2	293	0.49	1.4	Unsaturated	7	33757	0.94	312.6	314.9	0.91	0.289	0.9	2.000	2.20	1.257	2.000	**N/L**
7.30	23.94	35232	167	132.0	132.0	304	0.48	1.3	Unsaturated	6	35232	0.93	325.1	325.3	0.91	0.288	0.9	2.000	2.20	1.257	2.000	**N/L**
7.40	24.27	36094	198	133.8	133.8	309	0.55	1.4	Unsaturated	7	36094	0.93	331.8	334.2	0.90	0.288	0.9	2.000	2.20	1.257	2.000	**N/L**
7.50	24.60	37333	208	135.6	135.6	317	0.56	1.4	Unsaturated	7	37333	0.93	342.0	344.5	0.90	0.287	0.9	2.000	2.20	1.257	2.000	**N/L**
7.60	24.93	39413	236	137.4	137.4	333	0.60	1.4	Unsaturated	7	39413	0.92	359.8	362.4	0.90	0.287	0.9	2.000	2.20	1.257	2.000	**N/L**
7.70	25.26	36985	262	139.2	139.2	310	0.71	1.5	Unsaturated	8	36985	0.92	336.5	346.5	0.90	0.286	0.9	2.000	2.20	1.257	2.000	**N/L**
7.80	25.58	36654	263	141.0	141.0	306	0.72	1.5	Unsaturated	8	36654	0.92	332.3	342.2	0.90	0.286	0.9	2.000	2.20	1.257	2.000	**N/L**
7.90	25.91	33385	261	142.8	142.8	276	0.78	1.5	Unsaturated	8	33385	0.91	301.7	310.8	0.89	0.285	0.9	2.000	2.20	1.257	2.000	**N/L**
8.00	26.24	34037	243	144.6	144.6	280	0.72	1.5	Unsaturated	8	34037	0.91	306.5	315.8	0.89	0.284	0.9	2.000	2.20	1.257	2.000	**N/L**
8.10	26.57	34996	240	146.4	146.4	286	0.69	1.5	Unsaturated	8	34996	0.91	314.2	323.6	0.89	0.284	0.9	2.000	2.20	1.257	2.000	**N/L**
8.20	26.90	36235	263	148.2	148.2	294	0.73	1.5	Unsaturated	8	36235	0.90	324.2	333.9	0.89	0.283	0.9	2.000	2.20	1.257	2.000	**N/L**
8.30	27.22	36746	289	150.0	150.0	297	0.79	1.5	Unsaturated	8	36746	0.90	327.7	337.5	0.89	0.283	0.9	2.000	2.20	1.257	2.000	**N/L**
8.40	27.55	37610	294	151.9	151.9	302	0.78	1.5	Unsaturated	8	37610	0.90	334.4	344.3	0.89	0.282	0.9	2.000	2.20	1.257	2.000	**N/L**
8.50	27.88	39424	198	153.7	153.7	315	0.50	1.3	Unsaturated	6	39424	0.90	349.4	349.7	0.88	0.281	0.9	2.000	2.20	1.257	2.000	**N/L**
8.60	28.21	38884	223	155.5	155.5	309	0.58	1.4	Unsaturated	7	38884	0.89	343.6	346.1	0.88	0.281	0.9	2.000	2.20	1.257	2.000	**N/L**
8.70	28.54	36102	246	157.3	157.3	285	0.69	1.5	Unsaturated	8	36102	0.89	318.0	327.6	0.88	0.280	0.9	2.000	2.20	1.257	2.000	**N/L**
8.80	28.86	36231	231	159.1	159.1	284	0.64	1.4	Unsaturated	7	36231	0.89	318.2	320.6	0.88	0.280	0.9	2.000	2.20	1.257	2.000	**N/L**

Settelemnt of Liquefiable Soil (Idriss and Boulnager, 2008) | Settlement of Unsaturated Sand (Tokimatsu & Seed, 1987, and Pradel, 1998) | Cumulative | S_r (Idriss & Boulanger, 2008)

Depth, Z (m)	q_t (kPa)	N_{60}	$N_{1,60}$	$\Delta(N_1)_{60}$	$N_{1,60-CS}$	Limiting Shear Strain γ_{lim}	Parameter F_α	Max. Shear Strain γ_{max}	ΔHi (m)	ΔLDI_i (m)	Vert. Recon. Strain ε_v	DF_i	ΔSi (inch)	$p = \sigma_m$ (tsf)	τ_{ave} (psf)	G_{max} (tsf)	τ_{ave}/G_{max}	a	b	γ_{eff} (%)	ε_{15} (%)	ε_{Nc} (%)	Settlement (inch)	Cumulative Settlement (inch)	$\Delta(N_1)_{60-Sr}$	$(N_1)_{60-Sr}$	S_r/σ_{v0}'
1.60	12592	21.0	29.2	0.1	N.A.	0.000	0.000	0.000	0.05	0.0000	0.0000	0.91	0.00	0.202	192	1958	0.00005	0.20272	16691	0.00595	0.004	0.003	0.00	0.04	N/A	N/A	N/A
1.70	11968	20.0	27.3	0.1	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.91	0.00	0.215	204	1888	0.00005	0.20764	16095	0.00668	0.005	0.004	0.00	0.04	N/A	N/A	N/A
1.80	10178	17.5	23.6	0.4	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.90	0.00	0.228	216	1680	0.00006	0.21256	15552	0.00835	0.007	0.006	0.00	0.04	N/A	N/A	N/A
1.90	9176	16.3	21.7	0.9	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.90	0.00	0.240	228	1585	0.00007	0.21749	15056	0.00968	0.009	0.007	0.00	0.04	N/A	N/A	N/A
2.00	8765	15.6	20.5	0.9	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.89	0.00	0.253	239	1532	0.00008	0.22241	14600	0.01084	0.011	0.009	0.00	0.04	N/A	N/A	N/A
2.10	8520	15.2	19.6	0.9	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.89	0.00	0.266	251	1507	0.00008	0.22733	14178	0.01184	0.012	0.010	0.00	0.04	N/A	N/A	N/A
2.20	8533	15.2	19.4	0.9	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.88	0.00	0.278	263	1526	0.00009	0.23225	13788	0.01234	0.013	0.011	0.00	0.04	N/A	N/A	N/A
2.30	8835	15.7	19.9	0.9	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.87	0.00	0.291	275	1596	0.00009	0.23717	13425	0.01221	0.012	0.010	0.00	0.04	N/A	N/A	N/A
2.40	9287	16.5	20.7	0.9	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.87	0.00	0.304	287	1695	0.00008	0.24209	13087	0.01180	0.011	0.009	0.00	0.04	N/A	N/A	N/A
2.50	9667	17.2	21.3	0.9	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.86	0.00	0.316	299	1781	0.00008	0.24701	12770	0.01156	0.011	0.009	0.00	0.04	N/A	N/A	N/A
2.60	10032	17.9	21.9	0.9	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.86	0.00	0.329	310	1866	0.00008	0.25193	12473	0.01137	0.010	0.009	0.00	0.03	N/A	N/A	N/A
2.70	10276	18.3	22.2	0.9	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.85	0.00	0.342	322	1928	0.00008	0.25685	12194	0.01137	0.010	0.008	0.00	0.03	N/A	N/A	N/A
2.80	10669	19.0	22.8	0.9	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.85	0.00	0.354	334	2019	0.00008	0.26177	11931	0.01115	0.010	0.008	0.00	0.03	N/A	N/A	N/A
2.90	11119	19.8	23.5	0.9	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.84	0.00	0.367	346	2122	0.00008	0.26669	11682	0.01087	0.009	0.007	0.00	0.03	N/A	N/A	N/A
3.00	11864	20.4	24.1	0.4	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.84	0.00	0.379	357	2209	0.00008	0.27161	11447	0.01072	0.009	0.007	0.00	0.03	N/A	N/A	N/A
3.10	13346	23.0	26.9	0.4	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.83	0.00	0.392	369	2504	0.00007	0.27653	11224	0.00942	0.007	0.006	0.00	0.03	N/A	N/A	N/A
3.20	14413	24.1	27.9	0.1	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.83	0.00	0.405	381	2640	0.00007	0.28145	11012	0.00913	0.006	0.005	0.00	0.03	N/A	N/A	N/A
3.30	13999	24.1	27.7	0.4	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.82	0.00	0.417	392	2666	0.00007	0.28637	10811	0.00935	0.006	0.005	0.00	0.03	N/A	N/A	N/A
3.40	13091	22.6	25.7	0.4	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.81	0.00	0.430	404	2511	0.00008	0.29129	10619	0.01049	0.008	0.006	0.00	0.03	N/A	N/A	N/A
3.50	12699	22.6	25.6	0.9	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.81	0.00	0.443	415	2534	0.00008	0.29621	10436	0.01073	0.008	0.007	0.00	0.03	N/A	N/A	N/A
3.60	12814	22.8	25.6	0.9	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.80	0.00	0.455	427	2574	0.00008	0.30113	10261	0.01087	0.008	0.007	0.00	0.03	N/A	N/A	N/A
3.70	13161	23.4	26.1	0.9	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.80	0.00	0.468	438	2661	0.00008	0.30605	10093	0.01074	0.008	0.007	0.00	0.03	N/A	N/A	N/A
3.80	13855	24.7	27.3	0.9	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.79	0.00	0.481	450	2819	0.00008	0.31097	9933	0.01027	0.007	0.006	0.00	0.03	N/A	N/A	N/A
3.90	15962	27.5	30.2	0.4	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.79	0.00	0.493	461	3162	0.00007	0.31589	9780	0.00912	0.006	0.005	0.00	0.03	N/A	N/A	N/A
4.00	17267	29.8	32.5	0.4	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.78	0.00	0.506	473	3441	0.00007	0.32081	9632	0.00844	0.005	0.004	0.00	0.03	N/A	N/A	N/A
4.10	14716	26.2	28.4	0.9	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.78	0.00	0.519	484	3048	0.00008	0.32573	9490	0.01014	0.007	0.006	0.00	0.03	N/A	N/A	N/A
4.20	11081	20.4	22.0	1.7	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.77	0.00	0.531	496	2388	0.00010	0.33065	9354	0.01461	0.013	0.011	0.00	0.03	N/A	N/A	N/A
4.30	9473	17.5	18.7	1.7	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.76	0.00	0.544	507	2053	0.00012	0.33557	9223	0.01894	0.021	0.017	0.00	0.03	N/A	N/A	N/A
4.40	9717	17.9	19.1	1.7	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.76	0.00	0.557	518	2117	0.00012	0.34049	9097	0.01860	0.020	0.016	0.00	0.02	N/A	N/A	N/A
4.50	10517	19.4	20.5	1.7	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.75	0.00	0.569	530	2304	0.00011	0.34541	8975	0.01682	0.016	0.014	0.00	0.02	N/A	N/A	N/A
4.60	11340	20.9	22.0	1.7	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.75	0.00	0.582	541	2497	0.00011	0.35033	8857	0.01535	0.014	0.011	0.00	0.02	N/A	N/A	N/A
4.70	12203	21.7	22.7	0.9	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.74	0.00	0.594	552	2610	0.00011	0.35525	8744	0.01479	0.013	0.011	0.00	0.02	N/A	N/A	N/A
4.80	14132	25.2	26.2	0.9	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.74	0.00	0.607	563	3038	0.00009	0.36017	8634	0.01228	0.009	0.007	0.00	0.02	N/A	N/A	N/A
4.90	16886	29.1	30.1	0.4	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.73	0.00	0.620	574	3530	0.00008	0.36509	8528	0.01031	0.006	0.005	0.00	0.02	N/A	N/A	N/A
5.00	19708	34.0	35.0	0.4	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.73	0.00	0.632	586	4140	0.00007	0.37001	8425	0.00863	0.004	0.004	0.00	0.02	N/A	N/A	N/A
5.10	22192	37.0	38.0	0.1	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.72	0.00	0.645	597	4537	0.00007	0.37493	8326	0.00788	0.004	0.003	0.00	0.02	N/A	N/A	N/A
5.20	21031	36.2	36.9	0.4	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.72	0.00	0.658	608	4459	0.00007	0.37985	8229	0.00822	0.004	0.003	0.00	0.02	N/A	N/A	N/A
5.30	20378	35.1	35.6	0.4	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.71	0.00	0.670	619	4340	0.00007	0.38477	8136	0.00868	0.004	0.004	0.00	0.02	N/A	N/A	N/A
5.40	21891	36.5	36.9	0.1	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.70	0.00	0.683	630	4536	0.00007	0.38969	8045	0.00839	0.004	0.003	0.00	0.02	N/A	N/A	N/A
5.50	24537	41.0	41.1	0.1	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.70	0.00	0.696	641	5107	0.00006	0.39461	7957	0.00742	0.003	0.003	0.00	0.02	N/A	N/A	N/A
5.60	27601	46.1	46.1	0.1	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.69	0.00	0.708	651	5769	0.00006	0.39953	7871	0.00655	0.002	0.002	0.00	0.02	N/A	N/A	N/A
5.70	29885	49.9	49.6	0.1	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.69	0.00	0.721	662	6273	0.00005	0.40446	7788	0.00605	0.002	0.002	0.00	0.02	N/A	N/A	N/A
5.80	30976	51.7	51.2	0.1	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.68	0.00	0.734	673	6528	0.00005	0.40938	7707	0.00589	0.002	0.002	0.00	0.02	N/A	N/A	N/A
5.90	31401	52.4	51.7	0.1	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.68	0.00	0.746	684	6645	0.00005	0.41430	7629	0.00587	0.002	0.002	0.00	0.02	N/A	N/A	N/A
6.00	31828	53.1	52.1	0.1	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.67	0.00	0.759	695	6762	0.00005	0.41922	7552	0.00586	0.002	0.002	0.00	0.02	N/A	N/A	N/A
6.10	31846	53.2	51.9	0.1	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.67	0.00	0.772	705	6792	0.00005	0.42414	7478	0.00593	0.002	0.002	0.00	0.02	N/A	N/A	N/A
6.20	31496	52.6	51.2	0.1	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.66	0.00	0.784	716	6743	0.00005	0.42906	7405	0.00608	0.002	0.002	0.00	0.02	N/A	N/A	N/A
6.30	31251	52.2	50.5	0.1	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.66	0.00	0.797	727	6716	0.00005	0.43398	7334	0.00621	0.002	0.002	0.00	0.02	N/A	N/A	N/A
6.40	31437	52.5	50.6	0.1	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.65	0.00	0.810	737	6781	0.00005	0.43890	7265	0.00624	0.002	0.002	0.00	0.02	N/A	N/A	N/A
6.50	31974	53.4	51.3	0.1	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.64	0.00	0.822	748	6923	0.00005	0.44382	7198	0.00619	0.002	0.002	0.00	0.02	N/A	N/A	N/A
6.60	32217	53.8	51.5	0.1	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.64	0.00	0.835	758	7000	0.00005	0.44874	7132	0.00621	0.002	0.002	0.00	0.02	N/A	N/A	N/A
6.70	32169	55.4	52.8	0.4	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.63	0.00	0.847	769	7241	0.00005	0.45366	7068	0.00606	0.002	0.002	0.00	0.02	N/A	N/A	N/A
6.80	31506	52.6	49.9	0.1	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.63	0.00	0.860	779	6894	0.00006	0.45858	7006	0.00651	0.002	0.002	0.00	0.02	N/A	N/A	N/A
6.90	31778	53.1	50.2	0.1	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.62	0.00	0.873	789	6978	0.00006	0.46350	6945	0.00652	0.002	0.002	0.00	0.02	N/A	N/A	N/A
7.00	32664	54.5	51.4	0.1	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.62	0.00	0.885	800	7197	0.00006	0.46842	6885	0.00638	0.002	0.002	0.00	0.02	N/A	N/A	N/A
7.10	33967	55.0	51.6	0.0	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.61	0.00	0.898	810	7281	0.00006	0.47334	6827	0.00639	0.002	0.002	0.00	0.02	N/A	N/A	N/A
7.20	34127	57.0	53.3	0.1	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.61	0.00	0.911	820	7569	0.00005	0.47826	6770	0.00619	0.002	0.002	0.00	0.02	N/A	N/A	N/A
7.30	35128	56.9	53.0	0.0	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.60	0.00	0.923	830	7580	0.00005	0.48318	6714	0.00627	0.002	0.002	0.00	0.02	N/A	N/A	N/A
7.40	36155	60.4	56.0	0.1	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.60	0.00	0.936	840	8071	0.00005	0.48810	6659	0.00591	0.002	0.001	0.00	0.02	N/A	N/A	N/A
7.50	37606	62.8	58.1	0.1	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.59	0.00	0.949	850	8422	0.00005	0.49302	6606	0.00571	0.002	0.001	0.00	0.02	N/A	N/A	N/A
7.60	38965	65.1	60.0	0.1	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.58	0.00	0.961	860	8753	0.00005	0.49794	6553	0.00554	0.001	0.001	0.00	0.02	N/A	N/A	N/A
7.70	37532	64.7	59.4	0.4	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.58	0.00	0.974	870	8730	0.00005	0.50286	6502	0.00562	0.002	0.001	0.00	0.02	N/A	N/A	N/A
7.80	36149	62.3	57.0	0.4	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.57	0.00	0.987	880	8434	0.00005	0.50778	6452	0.00592	0.002	0.001	0.00	0.01	N/A	N/A	N/A
7.90	33759	58.2	53.1	0.4	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.57	0.00	0.999	890	7900	0.00006	0.51270	6403	0.00646	0.002	0.002	0.00	0.01	N/A	N/A	N/A
8.00	33852	58.3	53.1	0.4	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.56	0.00	1.012	900	7946	0.00006	0.51762	6355	0.00650	0.002	0.002	0.00	0.01	N/A	N/A	N/A
8.10	35155	60.6	54.9	0.4	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.56	0.00	1.025	910	8276	0.00005	0.52254	6308	0.00628	0.002	0.002	0.00	0.01	N/A	N/A	N/A
8.20	36329	62.6	56.6	0.4	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.55	0.00	1.037	920	8577	0.00005	0.52746	6261	0.00610	0.002	0.001	0.00	0.01	N/A	N/A	N/A
8.30	36907	63.6	57.3	0.4	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.55	0.00	1.050	929	8738	0.00005	0.53238	6216	0.00604	0.002	0.001	0.00	0.01	N/A	N/A	N/A
8.40	37740	65.0	58.4	0.4	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.54	0.00	1.062	939	8961	0.00005	0.53730	6171	0.00594	0.002	0.001	0.00	0.01	N/A	N/A	N/A
8.50	39050	63.2	56.6	0.0	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.54	0.00	1.075	948	8734	0.00005	0.54222	6128	0.00618	0.002	0.001	0.00	0.01	N/A	N/A	N/A
8.60	38462	64.2	57.3	0.1	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.53	0.00	1.088	958	8896	0.00005	0.54714	6085	0.00612	0.002	0.001	0.00	0.01	N/A	N/A	N/A
8.70	36425	62.8	55.8	0.4	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.52	0.00	1.100	967	8721	0.00006	0.55206	6043	0.00633	0.002	0.002	0.00	0.01	N/A	N/A	N/A
8.80	36231	60.5	53.7	0.1	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.52	0.00	1.113	977	8426	0.00006	0.55698	6002	0.00666	0.002	0.002	0.00	0.01	N/A	N/A	N/A

Depth, Z (m)	Depth, Z (ft)	q_c (kPa)	f_s (kPa)	σ_{vc} (kPa)	σ'_{vc} (kPa)	Q	F	I_c	Soil Type	Fines (%)	Interpreted q_c	C_N	q_{c1N}	q_{c1N-cs}	Stress Reduction Factor (r_d)	CSR	K_σ for sand	$CRR_{M=7.5}$ at σ'_{vc}=1	MSF_{max}	MSF	CRR	$(FS)_L$	q_t (kPa)	N_{60}	$N_{1,60}$	$\Delta(N_1)_{60}$	$N_{1,60-CS}$	Limiting Shear Strain γ_{lim}	Parameter F_α	Max. Shear Strain γ_{max}	ΔHi (m)	ΔLDI_i (m)	Vert. Recon. Strain ε_v	DF_i	ΔSi (inch)	$p = \sigma_m$ (tsf)	τ_{ave} (psf)	G_{max} (tsf)	τ_{ave}/G_{max}	a	b	γ_{eff} (%)	ε_{15} (%)	ε_{Nc} (%)	Settlement (inch)	Settlement (inch)	$\Delta(N_1)_{60-Sr}$	$(N_1)_{60-Sr}$	S_r/σ_{v0}'
8.90	29.19	36232	238	160.9	160.9	283	0.66	1.5	Unsaturated	8	36232	0.88	317.3	326.8	0.88	0.279	0.9	2.000	2.20	1.257	2.000	N/L	36414	62.8	55.5	0.4	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.51	0.00	1.126	986	8765	0.00006	0.56190	5961	0.00643	0.002	0.002	0.00	0.01	N/A	N/A	N/A
9.00	29.52	36462	145	162.7	162.7	283	0.40	1.3	Unsaturated	6	36462	0.88	318.3	318.6	0.87	0.279	0.9	2.000	2.20	1.257	2.000	N/L	36697	59.4	52.4	0.0	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.51	0.00	1.138	996	8320	0.00006	0.56682	5921	0.00690	0.002	0.002	0.00	0.01	N/A	N/A	N/A
9.10	29.85	37772	138	164.5	164.5	291	0.37	1.3	Unsaturated	6	37772	0.88	328.8	329.1	0.87	0.278	0.9	2.000	2.20	1.257	2.000	N/L	37245	60.3	53.0	0.0	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.50	0.00	1.151	1005	8466	0.00006	0.57174	5882	0.00684	0.002	0.002	0.00	0.01	N/A	N/A	N/A
9.20	30.18	35922	173	166.3	166.3	275	0.48	1.4	Unsaturated	7	35922	0.88	311.8	314.1	0.87	0.277	0.9	2.000	2.20	1.257	2.000	N/L	35775	59.7	52.4	0.1	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.50	0.00	1.164	1014	8408	0.00006	0.57666	5844	0.00696	0.002	0.002	0.00	0.01	N/A	N/A	N/A
9.30	30.50	33214	174	168.1	168.1	253	0.53	1.4	Unsaturated	7	33214	0.87	287.5	289.7	0.87	0.277	0.8	2.000	2.20	1.257	2.000	N/L	32965	55.0	48.1	0.1	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.49	0.00	1.176	1023	7767	0.00007	0.58158	5806	0.00771	0.003	0.002	0.00	0.01	N/A	N/A	N/A
9.40	30.83	31882	169	169.9	169.9	242	0.53	1.4	Unsaturated	7	31882	0.87	275.2	277.3	0.87	0.276	0.8	2.000	2.20	1.257	2.000	N/L	31881	53.2	46.4	0.1	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.49	0.00	1.189	1032	7531	0.00007	0.58650	5769	0.00808	0.003	0.002	0.00	0.01	N/A	N/A	N/A
9.50	31.16	32893	176	171.7	171.7	248	0.54	1.4	Unsaturated	7	32893	0.87	283.1	285.3	0.87	0.276	0.8	2.000	2.20	1.257	2.000	N/L	33062	55.2	48.0	0.1	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.48	0.00	1.202	1041	7829	0.00007	0.59143	5732	0.00780	0.003	0.002	0.00	0.01	N/A	N/A	N/A
9.60	31.49	34214	181	173.5	173.5	257	0.53	1.4	Unsaturated	7	34214	0.87	293.7	295.9	0.86	0.275	0.8	2.000	2.20	1.257	2.000	N/L	34157	57.0	49.4	0.1	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.48	0.00	1.214	1050	8109	0.00006	0.59635	5696	0.00756	0.003	0.002	0.00	0.01	N/A	N/A	N/A
9.70	31.82	34890	110	175.4	175.4	260	0.32	1.3	Unsaturated	6	34890	0.86	298.7	298.9	0.86	0.274	0.8	2.000	2.20	1.257	2.000	N/L	34911	56.5	48.9	0.0	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.47	0.00	1.227	1059	8056	0.00007	0.60127	5661	0.00769	0.003	0.002	0.00	0.01	N/A	N/A	N/A
9.80	32.14	37566	119	177.2	177.2	279	0.32	1.3	Unsaturated	6	37566	0.86	320.7	320.9	0.86	0.274	0.8	2.000	2.20	1.257	2.000	N/L	36475	59.0	50.9	0.0	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.46	0.00	1.240	1068	8437	0.00006	0.60619	5626	0.00735	0.002	0.002	0.00	0.01	N/A	N/A	N/A
9.90	32.47	36813	164	179.0	179.0	272	0.45	1.4	Unsaturated	7	36813	0.86	313.4	315.7	0.86	0.273	0.8	2.000	2.20	1.257	2.000	N/L	36813	61.5	52.8	0.1	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.46	0.00	1.252	1077	8803	0.00006	0.61111	5592	0.00706	0.002	0.002	0.00	0.01	N/A	N/A	N/A
10.00	32.80	37448	192	180.8	180.8	275	0.51	1.4	Unsaturated	7	37448	0.86	318.0	320.3	0.86	0.273	0.8	2.000	2.20	1.257	2.000	N/L	37520	62.6	53.7	0.1	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.45	0.00	1.265	1086	8993	0.00006	0.61603	5558	0.00695	0.002	0.002	0.00	0.01	N/A	N/A	N/A
10.10	33.13	38507	194	182.6	182.6	282	0.51	1.4	Unsaturated	7	38507	0.86	326.1	328.5	0.85	0.272	0.8	2.000	2.20	1.257	2.000	N/L	38360	64.0	54.8	0.1	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.45	0.00	1.277	1094	9216	0.00006	0.62095	5525	0.00682	0.002	0.002	0.00	0.01	N/A	N/A	N/A
10.20	33.46	38032	195	184.4	184.4	277	0.52	1.4	Unsaturated	7	38032	0.85	321.3	323.6	0.85	0.271	0.8	2.000	2.20	1.257	2.000	N/L	37872	63.2	53.9	0.1	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.44	0.00	1.290	1103	9120	0.00006	0.62587	5493	0.00696	0.002	0.002	0.00	0.01	N/A	N/A	N/A
10.30	33.78	36164	202	186.2	186.2	262	0.56	1.4	Unsaturated	7	36164	0.85	304.7	307.0	0.85	0.271	0.8	2.000	2.20	1.257	2.000	N/L	36324	60.6	51.6	0.1	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.44	0.00	1.303	1112	8767	0.00006	0.63079	5461	0.00735	0.002	0.002	0.00	0.01	N/A	N/A	N/A
10.40	34.11	35217	207	188.0	188.0	254	0.59	1.5	Unsaturated	8	35217	0.85	296.0	305.0	0.85	0.270	0.8	2.000	2.20	1.257	2.000	N/L	35197	60.7	51.5	0.4	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.43	0.00	1.315	1120	8789	0.00006	0.63571	5429	0.00740	0.002	0.002	0.00	0.01	N/A	N/A	N/A
10.50	34.44	34385	217	189.8	189.8	247	0.63	1.5	Unsaturated	8	34385	0.85	288.2	297.1	0.85	0.270	0.8	2.000	2.20	1.257	2.000	N/L	34252	59.0	50.0	0.4	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.43	0.00	1.328	1129	8573	0.00007	0.64063	5398	0.00768	0.003	0.002	0.00	0.01	N/A	N/A	N/A
10.60	34.77	32801	201	191.6	191.6	234	0.62	1.5	Unsaturated	8	32801	0.84	274.3	282.8	0.84	0.269	0.8	2.000	2.20	1.257	2.000	N/L	32887	56.7	47.9	0.4	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.42	0.00	1.341	1137	8250	0.00007	0.64555	5368	0.00810	0.003	0.002	0.00	0.01	N/A	N/A	N/A
10.70	35.10	31332	184	193.4	193.4	222	0.59	1.5	Unsaturated	8	31332	0.84	261.3	269.6	0.84	0.268	0.8	2.000	2.20	1.257	2.000	N/L	31276	53.9	45.4	0.4	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.42	0.00	1.353	1146	7863	0.00007	0.65047	5337	0.00865	0.003	0.003	0.00	0.01	N/A	N/A	N/A
10.80	35.42	28954	176	195.2	195.2	204	0.61	1.5	Unsaturated	8	28954	0.84	240.9	248.7	0.84	0.268	0.8	2.000	2.20	1.257	2.000	N/L	28933	49.9	41.9	0.4	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.41	0.00	1.366	1154	7290	0.00008	0.65539	5308	0.00955	0.004	0.003	0.00	0.01	N/A	N/A	N/A
10.90	35.75	26732	153	197.1	197.1	188	0.58	1.5	Unsaturated	8	26732	0.84	221.9	229.2	0.84	0.267	0.8	2.000	2.20	1.257	2.000	N/L	26526	45.7	38.3	0.4	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.40	0.00	1.379	1162	6698	0.00009	0.66031	5278	0.01068	0.005	0.004	0.00	0.01	N/A	N/A	N/A
11.00	36.08	23254	137	198.9	198.9	162	0.59	1.6	Unsaturated	10	23254	0.84	192.6	208.7	0.84	0.267	0.8	3.209	2.20	1.257	2.000	N/L	23576	42.0	35.1	0.9	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.40	0.00	1.391	1170	6165	0.00009	0.66523	5250	0.01194	0.006	0.005	0.00	0.01	N/A	N/A	N/A
11.10	36.41	22301	125	200.7	200.7	155	0.56	1.6	Unsaturated	10	22301	0.83	184.2	199.9	0.84	0.266	0.8	1.882	2.20	1.257	1.940	N/L	22301	39.7	33.1	0.9	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.39	0.00	1.404	1179	5844	0.00010	0.67015	5221	0.01289	0.007	0.006	0.00	0.01	N/A	N/A	N/A
11.20	36.74	23826	127	202.5	202.5	165	0.54	1.6	Unsaturated	10	23826	0.83	196.4	212.8	0.83	0.265	0.8	2.000	2.20	1.257	1.989	N/L	23649	42.1	35.1	0.9	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.39	0.00	1.417	1187	6210	0.00010	0.67507	5193	0.01203	0.006	0.005	0.00	0.01	N/A	N/A	N/A
11.30	37.06	25036	140	204.3	204.3	173	0.56	1.6	Unsaturated	10	25036	0.83	205.8	222.8	0.83	0.265	0.8	2.000	2.20	1.257	1.982	N/L	24801	44.2	36.7	0.9	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.38	0.00	1.429	1195	6526	0.00009	0.67999	5165	0.01139	0.006	0.005	0.00	0.01	N/A	N/A	N/A
11.40	37.39	24316	150	206.1	206.1	167	0.62	1.6	Unsaturated	10	24316	0.83	199.5	216.1	0.83	0.264	0.8	2.000	2.20	1.257	1.976	N/L	24344	43.4	35.9	0.9	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.38	0.00	1.442	1203	6420	0.00009	0.68491	5138	0.01172	0.006	0.005	0.00	0.01	N/A	N/A	N/A
11.50	37.72	23959	143	207.9	207.9	164	0.60	1.6	Unsaturated	10	23959	0.83	196.1	212.5	0.83	0.264	0.8	2.000	2.20	1.257	1.969	N/L	23774	42.3	35.0	0.9	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.37	0.00	1.455	1211	6282	0.00010	0.68983	5111	0.01214	0.006	0.005	0.00	0.01	N/A	N/A	N/A
11.60	38.05	21870	118	209.7	209.7	149	0.54	1.6	Unsaturated	10	21870	0.82	178.6	194.0	0.83	0.263	0.8	1.367	2.20	1.257	1.410	N/L	22282	39.7	32.7	0.9	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.37	0.00	1.467	1219	5900	0.00010	0.69475	5085	0.01325	0.007	0.006	0.00	0.01	N/A	N/A	N/A
11.70	38.38	21850	117	211.5	211.5	148	0.54	1.6	Unsaturated	10	21850	0.82	178.0	193.4	0.82	0.262	0.8	1.325	2.20	1.257	1.366	N/L	21849	38.9	32.0	0.9	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.36	0.00	1.480	1226	5797	0.00011	0.69967	5059	0.01366	0.008	0.006	0.00	0.01	N/A	N/A	N/A
11.80	38.70	22555	115	213.3	213.3	152	0.51	1.6	Unsaturated	10	22555	0.82	183.3	199.0	0.82	0.262	0.8	1.786	2.20	1.257	1.810	N/L	22695	40.4	33.2	0.9	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.35	0.00	1.493	1234	6034	0.00010	0.70459	5033	0.01307	0.007	0.006	0.00	0.01	N/A	N/A	N/A
11.90	39.03	24068	117	215.1	215.1	162	0.49	1.6	Unsaturated	10	24068	0.82	195.2	211.6	0.82	0.261	0.8	2.000	2.20	1.257	1.943	N/L	23946	42.6	34.9	0.9	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.35	0.00	1.505	1242	6379	0.00010	0.70951	5008	0.01227	0.006	0.005	0.00	0.01	N/A	N/A	N/A
12.00	39.36	24115	116	216.9	216.9	161	0.49	1.6	Unsaturated	10	24115	0.82	195.2	211.5	0.82	0.261	0.8	2.000	2.20	1.257	1.937	N/L	23771	42.3	34.6	0.9	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.34	0.00	1.518	1249	6345	0.00010	0.71443	4983	0.01244	0.006	0.005	0.00	0.01	N/A	N/A	N/A
12.10	39.69	21817	111	218.7	218.7	145	0.51	1.6	Unsaturated	10	21817	0.82	176.2	191.4	0.82	0.260	0.8	1.204	2.20	1.257	1.234	N/L	21875	39.0	31.8	0.9	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.34	0.00	1.530	1257	5850	0.00011	0.71935	4958	0.01391	0.008	0.007	0.00	0.01	N/A	N/A	N/A
12.20	40.02	20372	108	220.6	220.6	135	0.54	1.6	Unsaturated	10	20372	0.81	164.1	178.7	0.81	0.259	0.8	0.689	2.07	1.229	0.709	N/L	20564	36.6	29.8	0.9	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.33	0.00	1.543	1265	5510	0.00011	0.72427	4933	0.01514	0.009	0.008	0.00	0.00	N/A	N/A	N/A
12.30	40.34	20333	106	222.4	222.4	134	0.52	1.6	Unsaturated	10	20333	0.81	163.5	178.0	0.81	0.259	0.8	0.671	2.06	1.227	0.688	N/L	19921	35.5	28.8	0.9	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.33	0.00	1.556	1272	5348	0.00012	0.72919	4909	0.01587	0.010	0.009	0.00	0.00	N/A	N/A	N/A
12.40	40.67	17837	101	224.2	224.2	117	0.57	1.7	Unsaturated	11	17837	0.81	143.1	167.1	0.81	0.258	0.9	0.458	1.89	1.191	0.464	N/L	18040	33.2	26.9	1.7	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.32	0.00	1.568	1279	5020	0.00013	0.73411	4885	0.01740	0.012	0.010	0.00	0.00	N/A	N/A	N/A
12.50	41.00	16583	93	226.0	226.0	108	0.57	1.7	Unsaturated	11	16583	0.81	132.8	155.7	0.81	0.258	0.9	0.331	1.74	1.158	0.331	N/L	16639	30.7	24.8	1.7	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.32	0.00	1.581	1287	4639	0.00014	0.73903	4862	0.01955	0.015	0.013	0.00	0.00	N/A	N/A	N/A
12.60	41.33	15784	80	227.8	227.8	102	0.51	1.7	Unsaturated	11	15784	0.81	126.1	148.3	0.81	0.257	0.9	0.278	1.65	1.139	0.276	N/L	15859	29.2	23.6	1.7	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.31	0.00	1.594	1294	4430	0.00015	0.74395	4839	0.02101	0.017	0.014	0.00	0.00	N/A	N/A	N/A
12.70	41.66	15687	81	229.6	229.6	101	0.52	1.7	Unsaturated	11	15687	0.81	125.1	147.1	0.80	0.256	0.9	0.271	1.64	1.136	0.268	N/L	15757	29.0	23.4	1.7	N.A.	0.000	0.000	0.000	0.05	0.0000	0.0000	0.31	0.00	1.606	1301	4409	0.00015	0.74887	4816	0.02130	0.018	0.015	0.00	0.00	N/A	N/A	N/A
12.80	41.98	16041	78	231.4	231.4	103	0.49	1.7	Unsaturated	11	16041	0.80	127.6	150.0	0.80	0.256	0.9	0.288	1.67	1.143	0.286	N/L	16009	29.5	23.7	1.7	N.A.	0.000	0.000	0.000	0.05	0.0000	0.0000	0.30	0.00	1.619	1309	4488	0.00015	0.75379	4793	0.02091	0.017	0.014	0.00	0.00	N/A	N/A	N/A
12.90	42.31	15813	78	233.2	233.2	101	0.50	1.7	Unsaturated	11	15813	0.80	125.6	147.7	0.80	0.255	0.9	0.274	1.64	1.138	0.271	N/L	15856	29.2	23.4	1.7	N.A.	0.000	0.000	0.000	0.05	0.0000	0.0000	0.29	0.00	1.632	1316	4454	0.00015	0.75871	4771	0.02129	0.018	0.015	0.00	0.00	N/A	N/A	N/A
13.00	42.64	16256	77	235.0	235.0	104	0.48	1.7	Unsaturated	11	16256	0.80	128.8	151.3	0.80	0.255	0.9	0.297	1.68	1.147	0.294	N/L	16503	30.4	24.3	1.7	N.A.	0.000	0.000	0.000	0.05	0.0000	0.0000	0.29	0.00	1.644	1323	4644	0.00014	0.76363	4749	0.02020	0.016	0.013	0.00	0.00	N/A	N/A	N/A
13.10	42.97	18994	80	236.8	236.8	121	0.43	1.6	Unsaturated	10	18994	0.80	150.2	163.9	0.80	0.254	0.8	0.416	1.85	1.181	0.415	N/L	18668	33.2	26.5	0.9	N.A.	0.000	0.000	0.000	0.05	0.0000	0.0000	0.28	0.00	1.657	1330	5087	0.00013	0.76855	4727	0.01793	0.013	0.011	0.00	0.00	N/A	N/A	N/A
13.20	43.30	18955	87	238.6	238.6	120	0.47	1.6	Unsaturated	10	18955	0.80	149.6	163.3	0.80	0.253	0.8	0.408	1.84	1.179	0.406	N/L	19144	34.1	27.2	0.9	N.A.	0.000	0.000	0.000	0.05	0.0000	0.0000	0.28	0.00	1.670	1337	5226	0.00013	0.77347	4706	0.01739	0.012	0.010	0.00	0.00	N/A	N/A	N/A
13.30	43.62	19233	90	240.4	240.4	122	0.47	1.6	Unsaturated	10	19233	0.80	151.5	165.3	0.79	0.253	0.8	0.433	1.86	1.185	0.432	N/L	19556	34.8	27.7	0.9	N.A.	0.000	0.000	0.000	0.05	0.0000	0.0000	0.27	0.00	1.682	1344	5348	0.00013	0.77840	4684	0.01697	0.011	0.010	0.00	0.00	N/A	N/A	N/A
13.40	43.95	21823	92	242.2	242.2	138	0.43	1.6	Unsaturated	10	21823	0.79	171.5	186.5	0.79	0.252	0.8	0.957	2.20	1.257	0.965	N/L	21919	39.0	31.0	0.9	N.A.	0.000	0.000	0.000	0.05	0.0000	0.0000	0.27	0.00	1.695	1350	6005	0.00011	0.78332	4663	0.01465	0.009	0.007	0.00	0.00	N/A	N/A	N/A
13.50	44.28	24557	96	244.1	244.1	155	0.40	1.5	Unsaturated	8	24557	0.79	192.6	199.2	0.79	0.252	0.8	1.811	2.20	1.257	1.753	N/L	24556	42.3	33.5	0.4	N.A.	0.000	0.000	0.000	0.05	0.0000	0.0000	0.26	0.00	1.708	1357	6522	0.00010	0.78824	4643	0.01325	0.007	0.006	0.00	0.00	N/A	N/A	N/A
13.60	44.61	26582	122	245.9	245.9	167	0.46	1.5	Unsaturated	8	26582	0.79	208.1	215.1	0.79	0.251	0.7	2.000	2.20	1.257	1.842	N/L	26093	45.0	35.6	0.4	N.A.	0.000	0.000	0.000	0.05	0.0000	0.0000	0.26	0.00	1.720	1364	6942	0.00010	0.79316	4622	0.01232	0.006	0.005	0.00	0.00	N/A	N/A	N/A
13.70	44.94	26597	122	247.7	247.7	166	0.46	1.5	Unsaturated	8	26597	0.79	207.8	214.8	0.79	0.250	0.7	2.000	2.20	1.257	1.837	N/L	26596	45.8	36.2	0.4	N.A.	0.000	0.000	0.000	0.05	0.0000	0.0000	0.25	0.00	1.733	1371	7088	0.00010	0.79808	4602	0.01207	0.006	0.005	0.00	0.00	N/A	N/A	N/A
13.80	45.26	29869	7	249.5	249.5	186	0.10	1.2	Unsaturated	4	29869	0.79	233.0	233.0	0.78	0.250	0.7	2.000	2.20	1.257	1.831	N/L	28917	45.4	35.8	0.0	N.A.	0.000	0.000	0.000	0.05	0.0000	0.0000	0.25	0.00	1.745	1377	7039	0.00010	0.80300	4582	0.01225	0.006	0.005	0.00	0.00	N/A	N/A	N/A

CONE PENETRATION TEST-BASED LIQUEFACTION ANALYSIS BASED ON IDRISS & BOULANGER (2008)

References:

1 - Idriss, I.M. and Boulanger, R.W. (2008). *Soil Liquefaction During Earthquakes* , Earthquake Engineering Research Institute, EERI Publication MNO-12.

2 - Ishihara, K. and Yoshimine, M. (1992). "Evaluation of Settlements in Sand Deposits Following Liquefaction During Earthquakes," *Soils and Foundations* , Vol. 32, No. 1, pp. 173-188, March 1992.

3 - Tokimatsu, K. and Seed H.B. (1987). "Evaluation of Settlements in Sands Due to Earthquake Shaking," Journal of Geotechnical Engineering, Vol. 113, No. 8, August.

4 - Pradel, D. (1998). "Procedure to Evaluate Earthquake-Induced Settlements in Sand," Journal of Geotechnical and Geoenvironmental Engineering, Vol. 124, No. 4, April.

5 - Cetin, K.O., Bilge, H.T., Wu, J., Kammerer, A.M., and Seed R.B. (2009). "Procedure to Evaluate Earthquake-Induced Settlements in Sand," Journal of Geotechnical and Geoenvironmental Engineering, Vol. 135, No. 3, March.

6 - Boulanger, R.W. and Idriss, I.M. (2014). "CPT and SPT Based Liquefaction Triggering Procedures," Report No. UCD/CGM-14/01, University of California at Davis

Project	**Chevron Guadalupe Tank Battery 9 Site**
Test Boring No	**TSMACPT-10**

Test Boring Information:

Approx. depth to ground water table		63.2 ft	19.27 m
Moist unit weight of soil	γ_m	115 pcf	18.08 kN/m^3
Saturated unit weight of soil	γ_{sat}	125 pcf	19.65 kN/m^3

Earthquake Information:

Earthquake magnitude	M_w	6.9
Peak horizontal ground surface acceleratio	a_{max}	0.490 g
Number of equivalent cycle	N	10.1

Atmospheric pressure	P_a	101.3 kPa

N/L = Non-liquefiable clay-like soil

N.A. = Not Applicable

Sum
0.00

Sum	Total
0.37	**0.37**

Factor of Safety Agaist Liquefaction (Idriss & Boulanger, 2008 and Boulanger & Idriss, 2014)

Depth, Z (m)	Depth, Z (ft)	q_c (kPa)	f_s (kPa)	σ_{vc} (kPa)	σ'_{vc} (kPa)	Q	F	I_c	Soil Type	Fines (%)	Interpreted q_c	C_N	q_{c1N}	q_{c1N-cs}	Stress Reduction Factor (r_d)	CSR	K_σ for sand	$CRR_{M=7.5}$ at σ'_{vc}=1	MSF_{max}	MSF	CRR	$(FS)_L$
1.60	5.25	6620	18	28.9	28.9	122	0.27	1.5	Unsaturated	8	6620	1.39	91.2	95.4	0.99	0.315	1.1	0.132	1.24	1.051	0.152	**N/L**
1.70	5.58	5529	16	30.7	30.7	99	0.29	1.6	Unsaturated	10	5529	1.37	74.9	84.3	0.99	0.315	1.1	0.120	1.19	1.041	0.137	**N/L**
1.80	5.90	4529	14	32.5	32.5	78	0.32	1.7	Unsaturated	11	4529	1.35	60.5	75.8	0.99	0.315	1.1	0.112	1.16	1.035	0.128	**N/L**
1.90	6.23	3791	12	34.3	34.3	64	0.33	1.8	Unsaturated	13	3791	1.33	49.9	70.9	0.99	0.314	1.1	0.108	1.15	1.032	0.122	**N/L**
2.00	6.56	3363	12	36.2	36.2	55	0.36	1.9	Unsaturated	15	3363	1.31	43.7	69.8	0.99	0.314	1.1	0.107	1.15	1.032	0.120	**N/L**
2.10	6.89	3148	10	38.0	38.0	50	0.34	1.9	Unsaturated	15	3148	1.29	40.3	65.8	0.98	0.314	1.1	0.104	1.14	1.030	0.116	**N/L**
2.20	7.22	3111	11	39.8	39.8	48	0.34	1.9	Unsaturated	15	3111	1.28	39.4	64.6	0.98	0.313	1.1	0.103	1.14	1.029	0.114	**N/L**
2.30	7.54	3033	8	41.6	41.6	46	0.28	1.9	Unsaturated	15	3033	1.26	38.0	62.9	0.98	0.313	1.1	0.102	1.13	1.028	0.112	**N/L**
2.40	7.87	2505	7	43.4	43.4	37	0.30	2.0	Unsaturated	17	2505	1.25	31.0	59.2	0.98	0.312	1.1	0.099	1.13	1.027	0.108	**N/L**
2.50	8.20	1738	11	45.2	45.2	25	0.62	2.3	Unsaturated	24	1738	1.24	21.3	55.1	0.98	0.312	1.1	0.096	1.12	1.025	0.104	**N/L**
2.60	8.53	1127	9	47.0	47.0	16	0.83	2.5	Unsaturated	30	1127	1.22	13.7	47.3	0.98	0.312	1.1	0.090	1.11	1.023	0.097	**N/L**
2.70	8.86	1019	12	48.8	48.8	14	1.27	2.7	Unsaturated	37	1019	1.21	12.2	46.4	0.98	0.311	1.1	0.090	1.11	1.023	0.096	**N/L**
2.80	9.18	971	27	50.6	50.6	13	2.90	2.9	Unsaturated	45	971	1.20	11.5	45.8	0.98	0.311	1.0	0.089	1.11	1.023	0.096	**N/L**
2.90	9.51	3090	43	52.4	52.4	42	1.43	2.3	Unsaturated	24	3090	1.19	36.4	74.9	0.97	0.310	1.1	0.111	1.16	1.035	0.122	**N/L**
3.00	9.84	7930	89	54.2	54.2	106	1.13	1.9	Unsaturated	15	7930	1.18	92.5	128.4	0.97	0.310	1.1	0.193	1.45	1.097	0.229	**N/L**
3.10	10.17	9692	63	56.0	56.0	128	0.66	1.7	Unsaturated	11	9692	1.17	112.1	132.8	0.97	0.309	1.1	0.206	1.49	1.105	0.247	**N/L**
3.20	10.50	12724	63	57.8	57.8	165	0.50	1.6	Unsaturated	10	12724	1.16	145.9	159.4	0.97	0.309	1.1	0.365	1.78	1.168	0.468	**N/L**
3.30	10.82	18716	56	59.7	59.7	240	0.30	1.3	Unsaturated	6	18716	1.15	212.9	213.1	0.97	0.309	1.1	2.000	2.20	1.257	2.000	**N/L**
3.40	11.15	24847	95	61.5	61.5	314	0.38	1.3	Unsaturated	6	24847	1.14	280.5	280.7	0.97	0.308	1.1	2.000	2.20	1.257	2.000	**N/L**
3.50	11.48	27048	108	63.3	63.3	337	0.40	1.3	Unsaturated	6	27048	1.13	303.0	303.2	0.97	0.308	1.1	2.000	2.20	1.257	2.000	**N/L**
3.60	11.81	23826	121	65.1	65.1	293	0.51	1.4	Unsaturated	7	23826	1.12	264.9	266.9	0.96	0.307	1.1	2.000	2.20	1.257	2.000	**N/L**
3.70	12.14	18861	92	66.9	66.9	228	0.49	1.4	Unsaturated	7	18861	1.11	208.2	209.9	0.96	0.307	1.1	3.461	2.20	1.257	2.000	**N/L**
3.80	12.46	18842	89	68.7	68.7	225	0.47	1.4	Unsaturated	7	18842	1.11	206.5	208.2	0.96	0.306	1.1	3.102	2.20	1.257	2.000	**N/L**
3.90	12.79	19369	78	70.5	70.5	228	0.41	1.4	Unsaturated	7	19369	1.10	210.8	212.6	0.96	0.306	1.1	2.000	2.20	1.257	2.000	**N/L**
4.00	13.12	19841	83	72.3	72.3	231	0.42	1.4	Unsaturated	7	19841	1.09	214.5	216.3	0.96	0.305	1.1	2.000	2.20	1.257	2.000	**N/L**
4.10	13.45	20171	88	74.1	74.1	232	0.44	1.4	Unsaturated	7	20171	1.09	216.7	218.5	0.96	0.305	1.1	2.000	2.20	1.257	2.000	**N/L**
4.20	13.78	20484	89	75.9	75.9	233	0.43	1.4	Unsaturated	7	20484	1.08	218.7	220.4	0.96	0.304	1.1	2.000	2.20	1.257	2.000	**N/L**
4.30	14.10	21009	91	77.7	77.7	236	0.44	1.4	Unsaturated	7	21009	1.07	222.9	224.7	0.95	0.304	1.1	2.000	2.20	1.257	2.000	**N/L**
4.40	14.43	20917	95	79.5	79.5	232	0.46	1.4	Unsaturated	7	20917	1.07	220.6	222.4	0.95	0.303	1.1	2.000	2.20	1.257	2.000	**N/L**
4.50	14.76	20041	99	81.4	81.4	220	0.50	1.5	Unsaturated	8	20041	1.06	210.1	217.1	0.95	0.303	1.1	2.000	2.20	1.257	2.000	**N/L**
4.60	15.09	17991	89	83.2	83.2	195	0.49	1.5	Unsaturated	8	17991	1.05	187.5	194.0	0.95	0.303	1.0	1.368	2.20	1.257	1.801	**N/L**
4.70	15.42	16914	79	85.0	85.0	181	0.47	1.5	Unsaturated	8	16914	1.05	175.3	181.5	0.95	0.302	1.0	0.770	2.11	1.239	0.990	**N/L**
4.80	15.74	16339	72	86.8	86.8	173	0.44	1.5	Unsaturated	8	16339	1.04	168.4	174.4	0.95	0.302	1.0	0.587	2.00	1.214	0.734	**N/L**
4.90	16.07	16135	70	88.6	88.6	169	0.44	1.5	Unsaturated	8	16135	1.04	165.4	171.3	0.95	0.301	1.0	0.527	1.95	1.204	0.650	**N/L**
5.00	16.40	16342	70	90.4	90.4	170	0.43	1.5	Unsaturated	8	16342	1.03	166.6	172.6	0.94	0.301	1.0	0.550	1.97	1.208	0.679	**N/L**
5.10	16.73	16392	75	92.2	92.2	169	0.46	1.5	Unsaturated	8	16392	1.02	166.2	172.2	0.94	0.300	1.0	0.543	1.97	1.207	0.667	**N/L**
5.20	17.06	16613	75	94.0	94.0	169	0.46	1.5	Unsaturated	8	16613	1.02	167.6	173.6	0.94	0.300	1.0	0.571	1.99	1.212	0.701	**N/L**
5.30	17.38	16861	78	95.8	95.8	170	0.46	1.5	Unsaturated	8	16861	1.01	169.3	175.3	0.94	0.299	1.0	0.607	2.01	1.217	0.746	**N/L**
5.40	17.71	16907	81	97.6	97.6	169	0.48	1.5	Unsaturated	8	16907	1.01	168.9	174.9	0.94	0.299	1.0	0.598	2.01	1.216	0.732	**N/L**
5.50	18.04	16970	77	99.4	99.4	168	0.46	1.5	Unsaturated	8	16970	1.00	168.7	174.7	0.94	0.298	1.0	0.594	2.00	1.215	0.724	**N/L**
5.60	18.37	16654	74	101.2	101.2	163	0.45	1.5	Unsaturated	8	16654	1.00	164.8	170.7	0.93	0.297	1.0	0.516	1.94	1.202	0.620	**N/L**
5.70	18.70	16558	75	103.0	103.0	161	0.45	1.5	Unsaturated	8	16558	0.99	163.1	169.0	0.93	0.297	1.0	0.487	1.92	1.197	0.580	**N/L**
5.80	19.02	16743	79	104.9	104.9	161	0.48	1.5	Unsaturated	8	16743	0.99	164.1	170.1	0.93	0.296	1.0	0.505	1.93	1.200	0.601	**N/L**
5.90	19.35	16654	80	106.7	106.7	159	0.48	1.6	Unsaturated	10	16654	0.99	162.5	177.0	0.93	0.296	1.0	0.646	2.04	1.223	0.781	**N/L**
6.00	19.68	16710	79	108.5	108.5	158	0.48	1.6	Unsaturated	10	16710	0.98	162.4	176.8	0.93	0.295	1.0	0.641	2.04	1.222	0.772	**N/L**
6.10	20.01	16805	79	110.3	110.3	158	0.47	1.6	Unsaturated	10	16805	0.98	162.6	177.0	0.93	0.295	1.0	0.647	2.04	1.223	0.777	**N/L**
6.20	20.34	17244	81	112.1	112.1	161	0.47	1.5	Unsaturated	8	17244	0.97	166.1	172.1	0.92	0.294	1.0	0.540	1.96	1.207	0.639	**N/L**
6.30	20.66	17498	85	113.9	113.9	162	0.49	1.6	Unsaturated	10	17498	0.97	167.8	182.6	0.92	0.294	1.0	0.808	2.13	1.243	0.978	**N/L**
6.40	20.99	17666	86	115.7	115.7	162	0.49	1.6	Unsaturated	10	17666	0.96	168.8	183.6	0.92	0.293	1.0	0.841	2.15	1.247	1.017	**N/L**
6.50	21.32	17858	87	117.5	117.5	163	0.49	1.6	Unsaturated	10	17858	0.96	169.9	184.8	0.92	0.293	1.0	0.886	2.17	1.251	1.071	**N/L**
6.60	21.65	17991	90	119.3	119.3	163	0.50	1.6	Unsaturated	10	17991	0.96	170.5	185.4	0.92	0.292	1.0	0.910	2.18	1.253	1.098	**N/L**
6.70	21.98	18059	93	121.1	121.1	162	0.52	1.6	Unsaturated	10	18059	0.95	170.4	185.3	0.92	0.292	1.0	0.908	2.18	1.253	1.092	**N/L**
6.80	22.30	18002	88	122.9	122.9	160	0.49	1.6	Unsaturated	10	18002	0.95	169.2	184.1	0.91	0.291	1.0	0.860	2.16	1.249	1.027	**N/L**
6.90	22.63	18079	86	124.7	124.7	160	0.48	1.6	Unsaturated	10	18079	0.95	169.3	184.1	0.91	0.291	1.0	0.862	2.16	1.249	1.027	**N/L**
7.00	22.96	18324	92	126.5	126.5	161	0.50	1.6	Unsaturated	10	18324	0.94	170.9	185.9	0.91	0.290	0.9	0.931	2.19	1.255	1.109	**N/L**
7.10	23.29	18203	92	128.4	128.4	159	0.51	1.6	Unsaturated	10	18203	0.94	169.2	184.0	0.91	0.289	0.9	0.858	2.16	1.248	1.014	**N/L**
7.20	23.62	17601	88	130.2	130.2	152	0.50	1.6	Unsaturated	10	17601	0.94	163.0	177.5	0.91	0.289	0.9	0.658	2.05	1.225	0.763	**N/L**
7.30	23.94	16814	77	132.0	132.0	144	0.46	1.6	Unsaturated	10	16814	0.93	155.1	169.1	0.91	0.288	0.9	0.489	1.92	1.197	0.556	**N/L**
7.40	24.27	16465	77	133.8	133.8	140	0.47	1.6	Unsaturated	10	16465	0.93	151.4	165.2	0.90	0.288	0.9	0.432	1.86	1.185	0.485	**N/L**
7.50	24.60	16231	79	135.6	135.6	137	0.49	1.6	Unsaturated	10	16231	0.93	148.7	162.3	0.90	0.287	0.9	0.397	1.82	1.177	0.442	**N/L**
7.60	24.93	16212	80	137.4	137.4	136	0.50	1.6	Unsaturated	10	16212	0.92	148.0	161.6	0.90	0.287	0.9	0.388	1.81	1.174	0.431	**N/L**
7.70	25.26	15985	72	139.2	139.2	133	0.46	1.6	Unsaturated	10	15985	0.92	145.4	158.9	0.90	0.286	0.9	0.360	1.78	1.167	0.397	**N/L**
7.80	25.58	15849	70	141.0	141.0	131	0.45	1.6	Unsaturated	10	15849	0.92	143.7	157.1	0.90	0.286	0.9	0.343	1.75	1.162	0.376	**N/L**
7.90	25.91	15822	74	142.8	142.8	130	0.47	1.6	Unsaturated	10	15822	0.91	143.0	156.3	0.89	0.285	0.9	0.336	1.74	1.160	0.367	**N/L**
8.00	26.24	15692	76	144.6	144.6	128	0.49	1.6	Unsaturated	10	15692	0.91	141.3	154.5	0.89	0.284	0.9	0.322	1.72	1.155	0.349	**N/L**
8.10	26.57	15394	76	146.4	146.4	125	0.50	1.7	Unsaturated	11	15394	0.91	138.2	161.6	0.89	0.284	0.9	0.389	1.81	1.175	0.427	**N/L**
8.20	26.90	15335	75	148.2	148.2	124	0.50	1.7	Unsaturated	11	15335	0.90	137.2	160.6	0.89	0.283	0.9	0.377	1.80	1.172	0.412	**N/L**
8.30	27.22	15347	75	150.0	150.0	123	0.50	1.7	Unsaturated	11	15347	0.90	136.9	160.2	0.89	0.283	0.9	0.373	1.79	1.170	0.407	**N/L**
8.40	27.55	15840	76	151.9	151.9	126	0.48	1.6	Unsaturated	10	15840	0.90	140.8	154.0	0.89	0.282	0.9	0.318	1.72	1.154	0.342	**N/L**
8.50	27.88	17109	79	153.7	153.7	136	0.47	1.6	Unsaturated	10	17109	0.90	151.6	165.5	0.88	0.281	0.9	0.435	1.87	1.186	0.476	**N/L**
8.60	28.21	19460	89	155.5	155.5	154	0.46	1.6	Unsaturated	10	19460	0.89	171.9	186.9	0.88	0.281	0.9	0.976	2.20	1.257	1.106	**N/L**
8.70	28.54	20177	103	157.3	157.3	159	0.52	1.6	Unsaturated	10	20177	0.89	177.7	193.1	0.88	0.280	0.9	1.307	2.20	1.257	1.466	**N/L**
8.80	28.86	19575	115	159.1	159.1	153	0.59	1.6	Unsaturated	10	19575	0.89	171.9	186.9	0.88	0.280	0.9	0.974	2.20	1.257	1.099	**N/L**

	Settelemnt of Liquefiable Soil (Idriss and Boulnager, 2008)													Settlement of Unsaturated Sand (Tokimatsu & Seed, 1987, and Pradel, 1998)										Cumulative	S_r (Idriss & Boulanger, 2008)		
Depth, Z (m)	q_t (kPa)	N_{60}	$N_{1,60}$	$\Delta(N_1)_{60}$	$N_{1,60-CS}$	Limiting Shear Strain γ_{lim}	Parameter F_α	Max. Shear Strain γ_{max}	ΔHi (m)	ΔLDI_i (m)	Vert. Recon. Strain ε_v	DF_i	ΔSi (inch)	$p = \sigma_m$ (tsf)	τ_{ave} (psf)	G_{max} (tsf)	τ_{ave}/G_{max}	a	b	γ_{eff} (%)	ε_{15} (%)	ε_{Nc} (%)	Settlement (inch)	Settlement (inch)	$\Delta(N_1)_{60-Sr}$	$(N_1)_{60-Sr}$	S_r/σ_{v0}'
1.60	6699	11.5	16.1	0.4	N.A.	0.000	0.000	0.000	0.05	0.0000	0.0000	0.91	0.00	0.202	192	1075	0.00009	0.20272	16691	0.01409	0.018	0.015	0.00	0.37	N/A	N/A	N/A
1.70	5544	9.9	13.5	0.9	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.91	0.00	0.215	204	933	0.00011	0.20764	16095	0.01995	0.032	0.027	0.00	0.37	N/A	N/A	N/A
1.80	4559	8.4	11.3	1.7	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.90	0.00	0.228	216	804	0.00013	0.21256	15552	0.02998	0.059	0.050	0.00	0.37	N/A	N/A	N/A
1.90	3812	7.3	9.7	2.5	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.90	0.00	0.240	228	705	0.00016	0.21749	15056	0.04595	0.110	0.092	0.01	0.36	N/A	N/A	N/A
2.00	3378	6.7	8.8	3.2	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.89	0.00	0.253	239	656	0.00018	0.22241	14600	0.06259	0.168	0.141	0.01	0.36	N/A	N/A	N/A
2.10	3172	6.3	8.1	3.2	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.89	0.00	0.266	251	623	0.00020	0.22733	14178	0.08152	0.240	0.201	0.02	0.34	N/A	N/A	N/A
2.20	3111	6.2	7.9	3.2	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.88	0.00	0.278	263	618	0.00021	0.23225	13788	0.09287	0.284	0.238	0.02	0.33	N/A	N/A	N/A
2.30	2993	5.9	7.5	3.2	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.87	0.00	0.291	275	601	0.00023	0.23717	13425	0.11317	0.368	0.308	0.02	0.31	N/A	N/A	N/A
2.40	2444	5.0	6.3	3.8	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.87	0.00	0.304	287	515	0.00028	0.24209	13087	0.23050	0.926	0.774	0.06	0.29	N/A	N/A	N/A
2.50	1685	3.9	4.8	5.0	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.86	0.00	0.316	299	405	0.00037	0.24701	12770		0.000	0.000	0.00	0.22	N/A	N/A	N/A
2.60	1149	2.9	3.6	5.4	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.86	0.00	0.329	310	305	0.00051	0.25193	12473		0.000	0.000	0.00	0.22	N/A	N/A	N/A
2.70	1019	2.9	3.5	5.5	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.85	0.00	0.342	322	302	0.00053	0.25685	12194		0.000	0.000	0.00	0.22	N/A	N/A	N/A
2.80	976	3.1	3.7	5.6	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.85	0.00	0.354	334	326	0.00051	0.26177	11931		0.000	0.000	0.00	0.22	N/A	N/A	N/A
2.90	3089	7.2	8.5	5.0	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.84	0.00	0.367	346	769	0.00022	0.26669	11682	0.08305	0.231	0.193	0.02	0.22	N/A	N/A	N/A
3.00	7349	14.5	17.1	3.2	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.84	0.00	0.379	357	1571	0.00011	0.27161	11447	0.01787	0.022	0.018	0.00	0.21	N/A	N/A	N/A
3.10	9734	17.9	20.9	1.7	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.83	0.00	0.392	369	1952	0.00009	0.27653	11224	0.01331	0.013	0.011	0.00	0.21	N/A	N/A	N/A
3.20	12750	22.7	26.3	0.9	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.83	0.00	0.405	381	2491	0.00008	0.28145	11012	0.00986	0.007	0.006	0.00	0.21	N/A	N/A	N/A
3.30	17762	28.8	33.0	0.0	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.82	0.00	0.417	392	3177	0.00006	0.28637	10811	0.00748	0.004	0.003	0.00	0.21	N/A	N/A	N/A
3.40	23867	38.6	44.0	0.0	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.81	0.00	0.430	404	4300	0.00005	0.29129	10619	0.00538	0.002	0.002	0.00	0.21	N/A	N/A	N/A
3.50	26658	43.2	48.8	0.0	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.81	0.00	0.443	415	4835	0.00004	0.29621	10436	0.00485	0.002	0.001	0.00	0.21	N/A	N/A	N/A
3.60	23737	39.6	44.5	0.1	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.80	0.00	0.455	427	4470	0.00005	0.30113	10261	0.00547	0.002	0.002	0.00	0.21	N/A	N/A	N/A
3.70	19636	32.8	36.5	0.1	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.80	0.00	0.468	438	3722	0.00006	0.30605	10093	0.00701	0.003	0.003	0.00	0.21	N/A	N/A	N/A
3.80	18844	31.5	34.8	0.1	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.79	0.00	0.481	450	3594	0.00006	0.31097	9933	0.00754	0.004	0.003	0.00	0.21	N/A	N/A	N/A
3.90	19357	32.3	35.5	0.1	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.79	0.00	0.493	461	3715	0.00006	0.31589	9780	0.00746	0.004	0.003	0.00	0.21	N/A	N/A	N/A
4.00	19825	33.1	36.1	0.1	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.78	0.00	0.506	473	3827	0.00006	0.32081	9632	0.00740	0.004	0.003	0.00	0.21	N/A	N/A	N/A
4.10	20164	33.7	36.5	0.1	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.78	0.00	0.519	484	3915	0.00006	0.32573	9490	0.00740	0.004	0.003	0.00	0.21	N/A	N/A	N/A
4.20	20519	34.3	36.9	0.1	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.77	0.00	0.531	496	4007	0.00006	0.33065	9354	0.00739	0.004	0.003	0.00	0.20	N/A	N/A	N/A
4.30	20953	35.0	37.5	0.1	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.76	0.00	0.544	507	4115	0.00006	0.33557	9223	0.00735	0.003	0.003	0.00	0.20	N/A	N/A	N/A
4.40	20825	34.8	37.0	0.1	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.76	0.00	0.557	518	4112	0.00006	0.34049	9097	0.00754	0.004	0.003	0.00	0.20	N/A	N/A	N/A
4.50	19860	34.2	36.2	0.4	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.75	0.00	0.569	530	4069	0.00007	0.34541	8975	0.00783	0.004	0.003	0.00	0.20	N/A	N/A	N/A
4.60	18118	31.2	32.9	0.4	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.75	0.00	0.582	541	3732	0.00007	0.35033	8857	0.00894	0.005	0.004	0.00	0.20	N/A	N/A	N/A
4.70	16914	29.1	30.5	0.4	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.74	0.00	0.594	552	3501	0.00008	0.35525	8744	0.00993	0.006	0.005	0.00	0.20	N/A	N/A	N/A
4.80	16321	28.1	29.3	0.4	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.74	0.00	0.607	563	3396	0.00008	0.36017	8634	0.01059	0.007	0.006	0.00	0.20	N/A	N/A	N/A
4.90	16175	27.9	28.9	0.4	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.73	0.00	0.620	574	3381	0.00008	0.36509	8528	0.01091	0.007	0.006	0.00	0.20	N/A	N/A	N/A
5.00	16298	28.1	28.9	0.4	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.73	0.00	0.632	586	3424	0.00009	0.37001	8425	0.01099	0.007	0.006	0.00	0.20	N/A	N/A	N/A
5.10	16354	28.2	28.9	0.4	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.72	0.00	0.645	597	3451	0.00009	0.37493	8326	0.01113	0.007	0.006	0.00	0.20	N/A	N/A	N/A
5.20	16561	28.5	29.1	0.4	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.72	0.00	0.658	608	3511	0.00009	0.37985	8229	0.01113	0.007	0.006	0.00	0.20	N/A	N/A	N/A
5.30	16811	29.0	29.4	0.4	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.71	0.00	0.670	619	3580	0.00009	0.38477	8136	0.01109	0.007	0.006	0.00	0.20	N/A	N/A	N/A
5.40	16907	29.1	29.4	0.4	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.70	0.00	0.683	630	3617	0.00009	0.38969	8045	0.01118	0.007	0.006	0.00	0.20	N/A	N/A	N/A
5.50	16946	29.2	29.3	0.4	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.70	0.00	0.696	641	3641	0.00009	0.39461	7957	0.01132	0.007	0.006	0.00	0.20	N/A	N/A	N/A
5.60	16701	28.8	28.8	0.4	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.69	0.00	0.708	651	3603	0.00009	0.39953	7871	0.01172	0.008	0.006	0.00	0.20	N/A	N/A	N/A
5.70	16558	28.5	28.4	0.4	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.69	0.00	0.721	662	3587	0.00009	0.40446	7788	0.01203	0.008	0.007	0.00	0.20	N/A	N/A	N/A
5.80	16650	28.7	28.4	0.4	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.68	0.00	0.734	673	3622	0.00009	0.40938	7707	0.01212	0.008	0.007	0.00	0.20	N/A	N/A	N/A
5.90	16653	29.7	29.2	0.9	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.68	0.00	0.746	684	3759	0.00009	0.41430	7629	0.01177	0.007	0.006	0.00	0.20	N/A	N/A	N/A
6.00	16710	29.8	29.2	0.9	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.67	0.00	0.759	695	3787	0.00009	0.41922	7552	0.01188	0.008	0.006	0.00	0.20	N/A	N/A	N/A
6.10	16874	30.0	29.4	0.9	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.67	0.00	0.772	705	3839	0.00009	0.42414	7478	0.01189	0.008	0.006	0.00	0.20	N/A	N/A	N/A
6.20	17243	29.7	28.9	0.4	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.66	0.00	0.784	716	3811	0.00009	0.42906	7405	0.01223	0.008	0.007	0.00	0.20	N/A	N/A	N/A
6.30	17490	31.1	30.2	0.9	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.66	0.00	0.797	727	4009	0.00009	0.43398	7334	0.01165	0.007	0.006	0.00	0.20	N/A	N/A	N/A
6.40	17684	31.5	30.4	0.9	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.65	0.00	0.810	737	4069	0.00009	0.43890	7265	0.01163	0.007	0.006	0.00	0.20	N/A	N/A	N/A
6.50	17857	31.8	30.6	0.9	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.64	0.00	0.822	748	4124	0.00009	0.44382	7198	0.01163	0.007	0.006	0.00	0.20	N/A	N/A	N/A
6.60	18018	32.1	30.7	0.9	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.64	0.00	0.835	758	4176	0.00009	0.44874	7132	0.01164	0.007	0.006	0.00	0.19	N/A	N/A	N/A
6.70	18087	32.2	30.7	0.9	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.63	0.00	0.847	769	4207	0.00009	0.45366	7068	0.01172	0.007	0.006	0.00	0.19	N/A	N/A	N/A
6.80	18034	32.1	30.5	0.9	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.63	0.00	0.860	779	4209	0.00009	0.45858	7006	0.01191	0.007	0.006	0.00	0.19	N/A	N/A	N/A
6.90	18078	32.2	30.4	0.9	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.62	0.00	0.873	789	4234	0.00009	0.46350	6945	0.01201	0.007	0.006	0.00	0.19	N/A	N/A	N/A
7.00	18184	32.4	30.5	0.9	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.62	0.00	0.885	800	4273	0.00009	0.46842	6885	0.01205	0.007	0.006	0.00	0.19	N/A	N/A	N/A
7.10	18117	32.3	30.3	0.9	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.61	0.00	0.898	810	4272	0.00009	0.47334	6827	0.01225	0.007	0.006	0.00	0.19	N/A	N/A	N/A
7.20	17591	31.3	29.3	0.9	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.61	0.00	0.911	820	4162	0.00010	0.47826	6770	0.01288	0.008	0.007	0.00	0.19	N/A	N/A	N/A
7.30	16860	30.0	28.0	0.9	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.60	0.00	0.923	830	4002	0.00010	0.48318	6714	0.01378	0.009	0.008	0.00	0.19	N/A	N/A	N/A
7.40	16453	29.3	27.2	0.9	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.60	0.00	0.936	840	3918	0.00011	0.48810	6659	0.01439	0.010	0.008	0.00	0.19	N/A	N/A	N/A
7.50	16230	28.9	26.7	0.9	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.59	0.00	0.949	850	3877	0.00011	0.49302	6606	0.01482	0.010	0.009	0.00	0.19	N/A	N/A	N/A
7.60	16157	28.8	26.5	0.9	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.58	0.00	0.961	860	3872	0.00011	0.49794	6553	0.01507	0.011	0.009	0.00	0.19	N/A	N/A	N/A
7.70	16001	28.5	26.2	0.9	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.58	0.00	0.974	870	3846	0.00011	0.50286	6502	0.01543	0.011	0.009	0.00	0.19	N/A	N/A	N/A
7.80	15869	28.3	25.9	0.9	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.57	0.00	0.987	880	3826	0.00012	0.50778	6452	0.01577	0.012	0.010	0.00	0.19	N/A	N/A	N/A
7.90	15840	28.2	25.7	0.9	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.57	0.00	0.999	890	3831	0.00012	0.51270	6403	0.01597	0.012	0.010	0.00	0.19	N/A	N/A	N/A
8.00	15699	28.0	25.4	0.9	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.56	0.00	1.012	900	3808	0.00012	0.51762	6355	0.01633	0.012	0.010	0.00	0.19	N/A	N/A	N/A
8.10	15464	28.5	25.8	1.7	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.56	0.00	1.025	910	3892	0.00012	0.52254	6308	0.01606	0.012	0.010	0.00	0.19	N/A	N/A	N/A
8.20	15378	28.3	25.6	1.7	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.55	0.00	1.037	920	3881	0.00012	0.52746	6261	0.01635	0.012	0.010	0.00	0.18	N/A	N/A	N/A
8.30	15397	28.4	25.6	1.7	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.55	0.00	1.050	929	3897	0.00012	0.53238	6216	0.01647	0.012	0.010	0.00	0.18	N/A	N/A	N/A
8.40	15883	28.3	25.4	0.9	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.54	0.00	1.062	939	3897	0.00012	0.53730	6171	0.01669	0.013	0.010	0.00	0.18	N/A	N/A	N/A
8.50	17199	30.6	27.4	0.9	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.54	0.00	1.075	948	4232	0.00011	0.54222	6128	0.01510	0.010	0.009	0.00	0.18	N/A	N/A	N/A
8.60	19320	34.4	30.7	0.9	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.53	0.00	1.088	958	4767	0.00010	0.54714	6085	0.01304	0.008	0.007	0.00	0.18	N/A	N/A	N/A
8.70	20217	36.0	32.0	0.9	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.52	0.00	1.100	967	5002	0.00010	0.55206	6043	0.01240	0.007	0.006	0.00	0.18	N/A	N/A	N/A
8.80	19344	34.4	30.6	0.9	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.52	0.00	1.113	977	4798	0.00010	0.55698	6002	0.01324	0.008	0.007	0.00	0.18	N/A	N/A	N/A

Depth, Z (m)	Depth, Z (ft)	q_c (kPa)	f_s (kPa)	σ_{vc} (kPa)	σ'_{vc} (kPa)	Q	F	I_c	Soil Type	Fines (%)	Interpreted q_c	C_N	q_{c1N}	$q_{c1N\text{-}cs}$	Stress Reduction Factor (r_d)	CSR	K_σ for sand	$CRR_{M=7.5}$ at σ'_{vc}=1	MSF_{max}	MSF	CRR	$(FS)_L$	q_t (kPa)	N_{60}	$N_{1,60}$	$\Delta(N_1)_{60}$	$N_{1,60\text{-}CS}$	Limiting Shear Strain γ_{lim}	Parameter F_α	Max. Shear Strain γ_{max}	ΔHi (m)	ΔLDI_i (m)	Vert. Recon. Strain ε_v	DF_i	ΔSi (inch)	$p = \sigma_m$ (tsf)	τ_{ave} (psf)	G_{max} (tsf)	τ_{ave}/G_{max}	a	b	γ_{eff} (%)	ε_{15} (%)	ε_{Nc} (%)	Settlement (inch)	Settlement (inch)	$\Delta(N_1)_{60\text{-}Sr}$	$(N_1)_{60\text{-}Sr}$	S_r/σ_{v0}'
8.90	29.19	17867	102	160.9	160.9	139	0.58	1.7	Unsaturated	11	17867	0.88	156.4	181.8	0.88	0.279	0.9	0.782	2.12	1.240	0.872	N/L	18004	33.2	29.3	1.7	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.51	0.00	1.126	986	4633	0.00011	0.56190	5961	0.01404	0.009	0.007	0.00	0.18	N/A	N/A	N/A
9.00	29.52	17283	102	162.7	162.7	133	0.60	1.7	Unsaturated	11	17283	0.88	150.9	175.7	0.87	0.279	0.9	0.615	2.02	1.219	0.677	N/L	17028	31.4	27.7	1.7	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.51	0.00	1.138	996	4393	0.00011	0.56682	5921	0.01525	0.010	0.009	0.00	0.18	N/A	N/A	N/A
9.10	29.85	14834	91	164.5	164.5	114	0.62	1.7	Unsaturated	11	14834	0.88	129.1	151.6	0.87	0.278	0.9	0.300	1.69	1.147	0.317	N/L	15044	27.7	24.4	1.7	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.50	0.00	1.151	1005	3891	0.00013	0.57174	5882	0.01825	0.014	0.012	0.00	0.18	N/A	N/A	N/A
9.20	30.18	14273	80	166.3	166.3	109	0.57	1.7	Unsaturated	11	14273	0.88	123.9	145.9	0.87	0.277	0.9	0.263	1.62	1.133	0.276	N/L	14301	26.3	23.1	1.7	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.50	0.00	1.164	1014	3709	0.00014	0.57666	5844	0.01979	0.017	0.014	0.00	0.18	N/A	N/A	N/A
9.30	30.50	14185	79	168.1	168.1	107	0.56	1.7	Unsaturated	11	14185	0.87	122.8	144.6	0.87	0.277	0.9	0.257	1.61	1.131	0.268	N/L	14075	25.9	22.7	1.7	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.49	0.00	1.176	1023	3659	0.00014	0.58158	5806	0.02041	0.018	0.015	0.00	0.18	N/A	N/A	N/A
9.40	30.83	13117	75	169.9	169.9	99	0.58	1.8	Unsaturated	13	13117	0.87	113.2	144.0	0.87	0.276	0.9	0.254	1.60	1.129	0.264	N/L	13323	25.4	22.2	2.5	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.49	0.00	1.189	1032	3597	0.00014	0.58650	5769	0.02118	0.019	0.016	0.00	0.18	N/A	N/A	N/A
9.50	31.16	13076	66	171.7	171.7	98	0.51	1.7	Unsaturated	11	13076	0.87	112.5	133.3	0.87	0.276	0.9	0.208	1.50	1.106	0.213	N/L	13062	24.1	20.9	1.7	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.48	0.00	1.202	1041	3413	0.00015	0.59143	5732	0.02318	0.022	0.018	0.00	0.17	N/A	N/A	N/A
9.60	31.49	12634	62	173.5	173.5	94	0.49	1.8	Unsaturated	13	12634	0.87	108.4	138.5	0.86	0.275	0.9	0.228	1.55	1.117	0.235	N/L	12633	24.1	20.9	2.5	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.48	0.00	1.214	1050	3427	0.00015	0.59635	5696	0.02330	0.022	0.018	0.00	0.17	N/A	N/A	N/A
9.70	31.82	12170	59	175.4	175.4	90	0.49	1.8	Unsaturated	13	12170	0.86	104.2	133.6	0.86	0.274	0.9	0.209	1.50	1.107	0.214	N/L	12246	23.4	20.2	2.5	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.47	0.00	1.227	1059	3331	0.00016	0.60127	5661	0.02462	0.024	0.020	0.00	0.17	N/A	N/A	N/A
9.80	32.14	12477	59	177.2	177.2	92	0.48	1.8	Unsaturated	13	12477	0.86	106.5	136.3	0.86	0.274	0.9	0.219	1.52	1.112	0.224	N/L	12560	24.0	20.7	2.5	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.46	0.00	1.240	1068	3424	0.00016	0.60619	5626	0.02387	0.023	0.019	0.00	0.17	N/A	N/A	N/A
9.90	32.47	13329	58	179.0	179.0	98	0.44	1.7	Unsaturated	11	13329	0.86	113.5	134.4	0.86	0.273	0.9	0.212	1.51	1.108	0.216	N/L	13272	24.4	21.0	1.7	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.46	0.00	1.252	1077	3502	0.00015	0.61111	5592	0.02333	0.022	0.018	0.00	0.17	N/A	N/A	N/A
10.00	32.80	13540	59	180.8	180.8	99	0.44	1.7	Unsaturated	11	13540	0.86	115.0	136.0	0.86	0.273	0.9	0.218	1.52	1.112	0.222	N/L	13576	25.0	21.4	1.7	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.45	0.00	1.265	1086	3591	0.00015	0.61603	5558	0.02271	0.021	0.017	0.00	0.17	N/A	N/A	N/A
10.10	33.13	13633	64	182.6	182.6	99	0.48	1.7	Unsaturated	11	13633	0.86	115.5	136.5	0.85	0.272	0.9	0.220	1.53	1.113	0.224	N/L	13817	25.5	21.8	1.7	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.45	0.00	1.277	1094	3663	0.00015	0.62095	5525	0.02228	0.020	0.017	0.00	0.17	N/A	N/A	N/A
10.20	33.46	15259	65	184.4	184.4	110	0.43	1.7	Unsaturated	11	15259	0.85	128.9	151.4	0.85	0.271	0.9	0.298	1.68	1.147	0.308	N/L	15477	28.5	24.3	1.7	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.44	0.00	1.290	1103	4113	0.00013	0.62587	5493	0.01903	0.015	0.013	0.00	0.16	N/A	N/A	N/A
10.30	33.78	19419	77	186.2	186.2	140	0.40	1.6	Unsaturated	10	19419	0.85	163.6	178.1	0.85	0.271	0.9	0.674	2.06	1.227	0.722	N/L	19394	34.5	29.4	0.9	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.44	0.00	1.303	1112	4993	0.00011	0.63079	5461	0.01474	0.009	0.008	0.00	0.16	N/A	N/A	N/A
10.40	34.11	24363	110	188.0	188.0	175	0.45	1.5	Unsaturated	8	24363	0.85	204.7	211.6	0.85	0.270	0.8	2.000	2.20	1.257	2.000	N/L	24149	41.6	35.3	0.4	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.43	0.00	1.315	1120	6030	0.00009	0.63571	5429	0.01166	0.006	0.005	0.00	0.16	N/A	N/A	N/A
10.50	34.44	24030	145	189.8	189.8	172	0.61	1.6	Unsaturated	10	24030	0.85	201.4	218.1	0.85	0.270	0.8	2.000	2.20	1.257	2.000	N/L	24715	44.0	37.3	0.9	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.43	0.00	1.328	1129	6392	0.00009	0.64063	5398	0.01093	0.005	0.004	0.00	0.16	N/A	N/A	N/A
10.60	34.77	24266	133	191.6	191.6	173	0.55	1.6	Unsaturated	10	24266	0.84	202.9	219.7	0.84	0.269	0.8	2.000	2.20	1.257	2.000	N/L	24265	43.2	36.5	0.9	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.42	0.00	1.341	1137	6290	0.00009	0.64555	5368	0.01126	0.005	0.005	0.00	0.16	N/A	N/A	N/A
10.70	35.10	23956	137	193.4	193.4	170	0.58	1.6	Unsaturated	10	23956	0.84	199.8	216.4	0.84	0.268	0.8	2.000	2.20	1.257	2.000	N/L	23380	41.6	35.1	0.9	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.42	0.00	1.353	1146	6074	0.00009	0.65047	5337	0.01186	0.006	0.005	0.00	0.16	N/A	N/A	N/A
10.80	35.42	20109	116	195.2	195.2	142	0.58	1.6	Unsaturated	10	20109	0.84	167.3	182.0	0.84	0.268	0.9	0.789	2.12	1.241	0.840	N/L	20349	36.2	30.5	0.9	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.41	0.00	1.366	1154	5298	0.00011	0.65539	5308	0.01426	0.009	0.007	0.00	0.16	N/A	N/A	N/A
10.90	35.75	17578	101	197.1	197.1	123	0.58	1.7	Unsaturated	11	17578	0.84	145.9	170.2	0.84	0.267	0.9	0.506	1.93	1.200	0.530	N/L	18037	33.2	27.9	1.7	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.40	0.00	1.379	1162	4869	0.00012	0.66031	5278	0.01610	0.011	0.009	0.00	0.16	N/A	N/A	N/A
11.00	36.08	15247	93	198.9	198.9	106	0.62	1.8	Unsaturated	13	15247	0.84	126.3	159.1	0.84	0.267	0.9	0.362	1.78	1.167	0.373	N/L	15387	29.4	24.6	2.5	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.40	0.00	1.391	1170	4311	0.00014	0.66523	5250	0.01921	0.015	0.013	0.00	0.16	N/A	N/A	N/A
11.10	36.41	12860	80	200.7	200.7	89	0.63	1.8	Unsaturated	13	12860	0.83	106.2	136.0	0.84	0.266	0.9	0.218	1.52	1.112	0.219	N/L	12901	24.6	20.5	2.5	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.39	0.00	1.404	1179	3622	0.00016	0.67015	5221	0.02500	0.024	0.020	0.00	0.16	N/A	N/A	N/A
11.20	36.74	11539	70	202.5	202.5	79	0.62	1.9	Unsaturated	15	11539	0.83	95.1	131.5	0.83	0.265	0.9	0.202	1.48	1.103	0.202	N/L	11638	23.0	19.2	3.2	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.39	0.00	1.417	1187	3396	0.00017	0.67507	5193	0.02788	0.029	0.025	0.00	0.16	N/A	N/A	N/A
11.30	37.06	11361	65	204.3	204.3	78	0.58	1.9	Unsaturated	15	11361	0.83	93.4	129.5	0.83	0.265	0.9	0.196	1.46	1.099	0.195	N/L	11344	22.4	18.6	3.2	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.38	0.00	1.429	1195	3317	0.00018	0.67999	5165	0.02920	0.032	0.027	0.00	0.16	N/A	N/A	N/A
11.40	37.39	11016	63	206.1	206.1	75	0.59	1.9	Unsaturated	15	11016	0.83	90.4	125.9	0.83	0.264	0.9	0.186	1.43	1.093	0.184	N/L	11056	21.9	18.1	3.2	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.38	0.00	1.442	1203	3240	0.00019	0.68491	5138	0.03060	0.034	0.029	0.00	0.15	N/A	N/A	N/A
11.50	37.72	10429	61	207.9	207.9	70	0.60	1.9	Unsaturated	15	10429	0.83	85.4	119.8	0.83	0.264	0.9	0.171	1.39	1.083	0.168	N/L	10418	20.6	17.0	3.2	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.37	0.00	1.455	1211	3059	0.00020	0.68983	5111	0.03393	0.041	0.034	0.00	0.15	N/A	N/A	N/A
11.60	38.05	9777	57	209.7	209.7	66	0.59	1.9	Unsaturated	15	9777	0.82	79.8	113.2	0.83	0.263	0.9	0.158	1.34	1.073	0.154	N/L	9786	19.4	16.0	3.2	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.37	0.00	1.467	1219	2879	0.00021	0.69475	5085	0.03793	0.050	0.042	0.00	0.15	N/A	N/A	N/A
11.70	38.38	9341	50	211.5	211.5	62	0.55	1.9	Unsaturated	15	9341	0.82	76.1	108.7	0.82	0.262	0.9	0.150	1.31	1.067	0.146	N/L	9353	18.5	15.2	3.2	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.36	0.00	1.480	1226	2757	0.00022	0.69967	5059	0.04128	0.057	0.048	0.00	0.14	N/A	N/A	N/A
11.80	38.70	9063	48	213.3	213.3	60	0.54	1.9	Unsaturated	15	9063	0.82	73.7	105.8	0.82	0.262	0.9	0.145	1.29	1.063	0.142	N/L	9086	18.0	14.8	3.2	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.35	0.00	1.493	1234	2684	0.00023	0.70459	5033	0.04371	0.063	0.053	0.00	0.14	N/A	N/A	N/A
11.90	39.03	9063	49	215.1	215.1	60	0.55	1.9	Unsaturated	15	9063	0.82	73.5	105.6	0.82	0.261	0.9	0.145	1.29	1.063	0.141	N/L	9107	18.0	14.8	3.2	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.35	0.00	1.505	1242	2695	0.00023	0.70951	5008	0.04377	0.063	0.053	0.00	0.14	N/A	N/A	N/A
12.00	39.36	9370	51	216.9	216.9	62	0.56	1.9	Unsaturated	15	9370	0.82	75.8	108.4	0.82	0.261	0.9	0.149	1.31	1.066	0.145	N/L	9402	18.6	15.2	3.2	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.34	0.00	1.518	1249	2788	0.00022	0.71443	4983	0.04158	0.058	0.048	0.00	0.13	N/A	N/A	N/A
12.10	39.69	9653	53	218.7	218.7	63	0.56	1.9	Unsaturated	15	9653	0.82	77.9	111.0	0.82	0.260	0.9	0.154	1.32	1.070	0.150	N/L	9653	19.1	15.6	3.2	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.34	0.00	1.530	1257	2868	0.00022	0.71935	4958	0.03991	0.054	0.045	0.00	0.13	N/A	N/A	N/A
12.20	40.02	9824	54	220.6	220.6	64	0.56	1.9	Unsaturated	15	9824	0.81	79.2	112.4	0.81	0.259	0.9	0.156	1.33	1.072	0.152	N/L	9810	19.4	15.8	3.2	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.33	0.00	1.543	1265	2921	0.00022	0.72427	4933	0.03901	0.052	0.043	0.00	0.13	N/A	N/A	N/A
12.30	40.34	9990	54	222.4	222.4	65	0.55	1.9	Unsaturated	15	9990	0.81	80.3	113.8	0.81	0.259	0.9	0.159	1.34	1.073	0.154	N/L	9979	19.7	16.0	3.2	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.33	0.00	1.556	1272	2977	0.00021	0.72919	4909	0.03808	0.050	0.042	0.00	0.12	N/A	N/A	N/A
12.40	40.67	9993	55	224.2	224.2	65	0.56	1.9	Unsaturated	15	9993	0.81	80.2	113.6	0.81	0.258	0.9	0.158	1.34	1.073	0.154	N/L	9963	19.7	16.0	3.2	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.32	0.00	1.568	1279	2978	0.00021	0.73411	4885	0.03837	0.050	0.042	0.00	0.12	N/A	N/A	N/A
12.50	41.00	9824	56	226.0	226.0	63	0.58	1.9	Unsaturated	15	9824	0.81	78.7	111.8	0.81	0.258	0.9	0.155	1.33	1.071	0.150	N/L	9857	19.5	15.8	3.2	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.32	0.00	1.581	1287	2952	0.00022	0.73903	4862	0.03927	0.052	0.044	0.00	0.12	N/A	N/A	N/A
12.60	41.33	9895	53	227.8	227.8	64	0.55	1.9	Unsaturated	15	9895	0.81	79.1	112.3	0.81	0.257	0.9	0.156	1.33	1.071	0.151	N/L	9907	19.6	15.8	3.2	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.31	0.00	1.594	1294	2972	0.00022	0.74395	4839	0.03911	0.052	0.043	0.00	0.11	N/A	N/A	N/A
12.70	41.66	10069	54	229.6	229.6	65	0.55	1.9	Unsaturated	15	10069	0.81	80.3	113.7	0.80	0.256	0.9	0.159	1.34	1.073	0.154	N/L	10067	19.9	16.0	3.2	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.31	0.00	1.606	1301	3026	0.00022	0.74887	4816	0.03823	0.050	0.042	0.00	0.11	N/A	N/A	N/A
12.80	41.98	10441	57	231.4	231.4	67	0.56	1.9	Unsaturated	15	10441	0.80	83.1	117.1	0.80	0.256	0.9	0.165	1.37	1.078	0.160	N/L	10459	20.7	16.6	3.2	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.30	0.00	1.619	1309	3149	0.00021	0.75379	4793	0.03601	0.045	0.038	0.00	0.11	N/A	N/A	N/A
12.90	42.31	11258	62	233.2	233.2	72	0.56	1.9	Unsaturated	15	11258	0.80	89.4	124.7	0.80	0.255	0.9	0.182	1.42	1.091	0.177	N/L	11264	22.3	17.9	3.2	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.29	0.00	1.632	1316	3398	0.00019	0.75871	4771	0.03204	0.037	0.031	0.00	0.10	N/A	N/A	N/A
13.00	42.64	12078	61	235.0	235.0	77	0.52	1.8	Unsaturated	13	12078	0.80	95.7	123.8	0.80	0.255	0.9	0.180	1.42	1.089	0.175	N/L	12047	23.0	18.4	2.5	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.29	0.00	1.644	1323	3511	0.00019	0.76363	4749	0.03063	0.034	0.028	0.00	0.10	N/A	N/A	N/A
13.10	42.97	12764	64	236.8	236.8	81	0.51	1.8	Unsaturated	13	12764	0.80	100.9	129.8	0.80	0.254	0.9	0.197	1.47	1.100	0.192	N/L	12763	24.4	19.4	2.5	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.28	0.00	1.657	1330	3726	0.00018	0.76855	4727	0.02811	0.029	0.024	0.00	0.10	N/A	N/A	N/A
13.20	43.30	13716	76	238.6	238.6	87	0.57	1.8	Unsaturated	13	13716	0.80	108.2	138.3	0.80	0.253	0.9	0.227	1.54	1.116	0.222	N/L	13601	26.0	20.7	2.5	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.28	0.00	1.670	1337	3978	0.00017	0.77347	4706	0.02563	0.025	0.021	0.00	0.10	N/A	N/A	N/A
13.30	43.62	14627	85	240.4	240.4	92	0.59	1.8	Unsaturated	13	14627	0.80	115.2	146.3	0.79	0.253	0.9	0.266	1.63	1.134	0.261	N/L	14911	28.4	22.6	2.5	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.27	0.00	1.682	1344	4369	0.00015	0.77840	4684	0.02248	0.019	0.016	0.00	0.09	N/A	N/A	N/A
13.40	43.95	19003	101	242.2	242.2	120	0.54	1.7	Unsaturated	11	19003	0.79	149.4	174.0	0.79	0.252	0.8	0.578	1.99	1.213	0.579	N/L	18622	34.3	27.2	1.7	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.27	0.00	1.695	1350	5278	0.00013	0.78332	4663	0.01738	0.012	0.010	0.00	0.09	N/A	N/A	N/A
13.50	44.28	20802	130	244.1	244.1	131	0.63	1.7	Unsaturated	11	20802	0.79	163.2	189.3	0.79	0.252	0.8	1.086	2.20	1.257	1.084	N/L	20706	38.1	30.2	1.7	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.26	0.00	1.708	1357	5879	0.00012	0.78824	4643	0.01515	0.009	0.008	0.00	0.09	N/A	N/A	N/A
13.60	44.61	20009	146	245.9	245.9	125	0.74	1.8	Unsaturated	13	20009	0.79	156.7	194.2	0.79	0.251	0.8	1.382	2.20	1.257	1.357	N/L	19834	37.8	29.9	2.5	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.26	0.00	1.720	1364	5842	0.00012	0.79316	4622	0.01537	0.009	0.008	0.00	0.09	N/A	N/A	N/A
13.70	44.94	18749	132	247.7	247.7	117	0.71	1.8	Unsaturated	13	18749	0.79	146.5	182.5	0.79	0.250	0.8	0.803	2.13	1.243	0.803	N/L	18902	36.1	28.5	2.5	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.25	0.00	1.733	1371	5577	0.00012	0.79808	4602	0.01643	0.011	0.009	0.00	0.09	N/A	N/A	N/A
13.80	45.26	19566	131	249.5	249.5	122	0.68	1.7	Unsaturated	11	19566	0.79	152.6	177.6	0.78	0.250	0.8	0.660	2.05	1.225	0.658	N/L	19484	35.9	28.3	1.7	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.25	0.00	1.745	1377	5560	0.00012	0.80300	4582	0.01660	0.011	0.009	0.00	0.09	N/A	N/A	N/A
13.90	45.59	19897	121	251.3	251.3	123	0.61	1.7	Unsaturated	11	19897	0.79	154.9	180.1	0.78	0.249	0.8	0.729	2.09	1.234	0.725	N/L	19939	36.7	28.9	1.7	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.24	0.00	1.758	1384	5700	0.00012	0.80792	4562	0.01615	0.010	0.009	0.00	0.09	N/A	N/A	N/A
14.00	45.92	17327	122	253.1	253.1	107	0.71	1.8	Unsaturated	13	17327	0.78	134.6	168.7	0.78	0.249	0.8	0.483	1.91	1.196	0.477	N/L	18639	35.6	27.9	2.5	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.23	0.00	1.771	1390	5528	0.00013	0.81284	4542	0.01692	0.011	0.009	0.00	0.09	N/A	N/A	N/A
14.10	46.25	17162	122	254.9	254.9	105	0.72	1.8	Unsaturated	13	17162	0.78	133.1	167.0	0.78	0.248	0.8	0.456	1.89	1.190	0.449	N/L	17619	33.6	26.3	2.5	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.23	0.00	1.783	1397	5234	0.00013	0.81776	4523	0.01832	0.013	0.011	0.00	0.09	N/A	N/A	N/A
14.20	46.58	16306	114	256.7	256.7	100	0.71	1.8	Unsaturated	13	16306	0.78	126.2	159.0	0.78	0.247	0.8	0.362	1.78	1.167	0.354	N/L	16234	31.0	24.2	2.5	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.22	0.00	1.796	1403	4831	0.00015	0.82268	4504	0.02058	0.016	0.014	0.00	0.09	N/A	N/A	N/A
14.30	46.90	14542	103	258.5	258.5	88	0.72	1.9	Unsaturated	15	14542	0.78	112.4	152.3	0.77	0.247	0.8	0.304	1.70	1.149	0.296	N/L	14228	28.2	22.0	3.2	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.22	0.00	1.809	1410	4398	0.00016	0.82760	4485	0.02366	0.021	0.018	0.00	0.09	N/A	N/A	N/A
14.40	47.23	12270	89	260.3	260.3	74	0.74	1.9	Unsaturated	15	12270	0.78	94.6	131.0	0.77	0.246	0.9	0.200	1.48	1.102	0.192	N/L	12370	24.5	19.1	3.2	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.21	0.00	1.821	1416	3830	0.00018	0.83252	4466	0.02926	0.031	0.026	0.00	0.08	N/A	N/A	N/A
14.50	47.56	11297	78	262.1	262.1	68	0.71	2.0	Unsaturated	17	11297	0.78	87.0	128.6	0.77	0.246	0.9	0.193	1.45	1.098	0.185	N/L	11428	23.5	18.3	3.8	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.21	0.00	1.834	1422	3681	0.00019	0.83744	4448	0.03130	0.035	0.029	0.00	0.08	N/A	N/A	N/A
14.60	47.89	11392	73	263.9	263.9	68	0.65	1.9	Unsaturated	15	11392	0.78	87.5	122.5	0.77	0.245	0.9	0.177	1.40	1.087	0.169	N/L	11390	22.5	17.5	3.2	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.20	0.00	1.847	1428	3538	0.00020	0.84236	4429	0.03351	0.039	0.033	0.00	0.08	N/A	N/A	N/A
14.70	48.22	11406	72	265.7	265.7	68	0.64	1.9	Unsaturated	15	11406	0.77	87.5	122.4	0.77	0.244	0.9	0.177	1.40	1.087	0.169	N/L	11360	22.5	17.4	3.2	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.20	0.00	1.859	1434	3535	0.00020	0.84728	4411	0.03376	0.040	0.033	0.00	0.08	N/A	N/A	N/A
14.80	48.54	10957	64	267.6	267.6	65	0.60	1.9	Unsaturated	15	10957	0.77	83.9	118.1	0.77	0.244	0.9	0.167	1.37	1.080	0.159	N/L	10906	21.6	16.7	3.2	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.19	0.00	1.872	1440	3399	0.00021	0.85220	4393	0.03617	0.045	0.038	0.00	0.08	N/A	N/A	N/A
14.90	48.87	10310	60	269.4	269.4	61	0.60	2.0	Unsaturated	17	10310	0.77	78.8	118.5	0.76	0.243	0.9	0.168	1.38	1.080	0.160	N/L	10308	21.2	16.4	3.8	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.19	0.00	1.885	1446	3341	0.00022	0.85712	4376	0.03741	0.048	0.040	0.00	0.07	N/A	N/A	N/A
15.00	49.20	9768	60	271.2	271.2	57	0.63	2.0	Unsaturated	17	9768	0.77	74.5	113.2	0.76	0.243	0.9	0.158	1.34	1.073	0.149	N/L	9804	20.1	15.5	3.8	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.18	0.00	1.897	1452	3183	0.00023	0.86204	4358	0.04080	0.055	0.046	0.00	0.07	N/A	N/A	N/A
15.10	49.53	9737	59	273.0	273.0	57	0.62	2.0	Unsaturated	17	9737	0.77	74.2	112.7	0.76	0.242	0.9	0.157	1.34	1.072	0.148	N/L	9736	20.0	15.4	3.8	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.17	0.00	1.910	1458	3166	0.00023	0.86696	4341	0.04140	0.057	0.047	0.00	0.07	N/A	N/A	N/A
15.20	49.86	9872	60	274.8	274.8	58	0.62	2.0	Unsaturated	17	9872	0.77	75.1	113.9	0.76	0.241	0.9	0.159	1.34	1.074	0.150	N/L	9874	20.3	15.6	3.8	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.17	0.00	1.923	1464	3216	0.00023	0.87188	4324	0.04053	0.055	0.046	0.00	0.06	N/A	N/A	N/A
15.30	50.18	10119	60	276.6	276.6	59	0.61	2.0	Unsaturated	17	10119	0.77	76.8	116.0	0.76	0.241	0.9	0.163	1.36	1.077	0.154	N/L	10089	20.7	15.9	3.8	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.16	0.00	1.935	1470	3291	0.00022	0.87680	4307	0.03919	0.052	0.043	0.00	0.06	N/A	N/A	N/A
15.40	50.51	10199	61	278.4	278.4	59	0.62	2.0	Unsaturated	17	10199	0.77	77.3	116.6	0.75	0.240	0.9	0.164	1.36	1.078	0.155	N/L	10220	21.0	16.1	3.8	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.16	0.00	1.948	1475	3339	0.00022	0.88172	4290	0.03846	0.050	0.042	0.00	0.05	N/A	N/A	N/A
15.50	50.84	10391	61	280.2	280.2	60	0.61	2.0	Unsaturated	17	10391	0.76	78.6	118.2	0.75	0.240	0.9	0.167	1.37	1.080	0.158	N/L	10331	21.2	16.2	3.8	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.15	0.00	1.961	1481	3380	0.00022	0.88664	4273	0.03787	0.049	0.041	0.00	0.05	N/A	N/A	N/A
15.60	51.17	10270	62	282.0	282.0	59	0.62	2.0	Unsaturated	17	10270	0.76	77.6	117.0	0.75	0.239	0.9	0.165	1.36	1.078	0.155	N/L	10268	21.1	16.1	3.8	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.15	0.00	1.973	1487	3365	0.00022	0.89156	4257	0.03835	0.050	0.042	0.00	0.05	N/A	N/A	N/A
15.70	51.50	10243	59	283.8	283.8	59	0.60	2.0	Unsaturated	17	10243	0.76	77.2	116.5	0.75	0.238	0.9	0.164	1.36	1.077	0.155	N/L	10211	21.0	16.0	3.8	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.14	0.00	1.986	1492	3351	0.00022	0.89648	4240	0.03880	0.051	0.042	0.00	0.05	N/A	N/A	N/A
15.80	51.82	10162	59	285.6	285.6	58	0.59	2.0	Unsaturated	17	10162	0.76	76.5	115.6	0.75	0.238	0.9	0.162	1.36	1.076	0.153	N/L	10192	20.9	15.9	3.8	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.14	0.00	1.998	1498	3350	0.00022	0.90140	4224	0.03901	0.051	0.043	0.00	0.04	N/A	N/A	N/A
15.90	52.15	10347	60	287.4	287.4	59	0.60	2.0	Unsaturated	17	10347	0.76	77.7	117.2	0.75	0.237	0.9	0.165	1.37	1.078	0.156	N/L	10340	21.2	16.1	3.8	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.13	0.00	2.011	1503	3403	0.00022	0.90632	4208	0.03818	0.049	0.041	0.00	0.04	N/A	N/A	N/A
16.00	52.48	10509	63	289.2	289.2	60	0.61	2.0	Unsaturated	17	10509	0.76	78.8	118.5	0.74	0.237	0.9	0.168	1.38	1.081	0.158	N/L	10485	21.5	16.3	3.8	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.13	0.00	2.024	1509	3456	0.00022	0.91124	4193	0.03740	0.048	0.040	0.00	0.04	N/A	N/A	N/A
16.10	52.81	10763	57	291.1	291.1	61	0.55	1.9	Unsaturated	15	10763	0.76	80.6	114.1	0.74	0.236	0.9	0.159	1.34	1.074	0.150	N/L	10767	21.3	16.1	3.2	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.12	0.00	2.036	1514	3423	0.00022	0.91616	4177	0.03818	0.049	0.041	0.00	0.03	N/A	N/A	N/A
16.20	53.14	11019	57	292.9	292.9	62	0.53	1.9	Unsaturated	15	11019	0.76	82.4	116.3	0.74	0.236	0.9	0.163	1.36	1.077	0.153	N/L	11017	21.8	16.5	3.2	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.11	0.00	2.049	1519	3508	0.00022	0.92108	4161	0.03684	0.047	0.039	0.00	0.03	N/A	N/A	N/A
16.30	53.46	11137	62	294.7	294.7	63	0.57	1.9	Unsaturated	15	11137	0.75	83.1	117.2	0.74	0.235	0.9	0.165	1.37	1.078	0.155	N/L	11143	22.0	16.6	3.2	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.11	0.00	2.062	1524	3553	0.00021	0.92600	4146	0.03624	0.045	0.038	0.00	0.03	N/A	N/A	N/A
16.40	53.79	11388	65	296.5	296.5	64	0.58	1.9	Unsaturated	15	11388	0.75	84.9	119.3	0.74	0.234	0.9	0.170	1.38	1.082	0.159	N/L	11378	22.5	16.9	3.2	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.10	0.00	2.074	1530	3633	0.00021	0.93092	4131	0.03512	0.043	0.036	0.00	0.02	N/A	N/A	N/A
16.50	54.12	11556	66	298.3	298.3	65	0.59	1.9	Unsaturated	15	11556	0.75	86.0	120.6	0.73	0.234	0.9	0.173	1.39	1.084	0.162	N/L	11564	22.9	17.2	3.2	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.10	0.00	2.087	1535	3698	0.00021	0.93584	4116	0.03429	0.041	0.034	0.00	0.02	N/A	N/A	N/A
16.60	54.45	11633	68	300.1	300.1	65	0.60	1.9	Unsaturated	15	11633	0.75	86.4	121.1	0.73	0.233	0.9	0.174	1.39	1.085	0.163	N/L	11661	23.1	17.3	3.2	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.09	0.00	2.100	1540	3734	0.00021	0.94076	4101	0.03391	0.040	0.034	0.00	0.02	N/A	N/A	N/A
16.70	54.78	11792	70	301.9	301.9	66	0.61	1.9	Unsaturated	15	11792	0.75	87.5	122.4	0.73	0.233	0.9	0.177	1.40	1.087	0.165	N/L	11777	23.3	17.5	3.2	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.09	0.00	2.112	1545	3776	0.00020	0.94568	4086	0.03344	0.039	0.033	0.00	0.01	N/A	N/A	N/A
16.80	55.10	11878	71	303.7	303.7	66	0.62	1.9	Unsaturated	15	11878	0.75	88.0	123.0	0.73	0.232	0.9	0.178	1.41	1.088	0.167	N/L	11834	23.4	17.5	3.2	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.08	0.00	2.125	1550	3800	0.00020	0.95060	4072	0.03325	0.039	0.033	0.00	0.01	N/A	N/A	N/A
16.90	55.43	11952	69	305.5	305.5	66	0.60	1.9	Unsaturated	15	11952	0.75	88.4	123.5	0.73	0.232	0.9	0.179	1.41	1.088	0.168	N/L	11950	23.6	17.7	3.2	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.08	0.00	2.138	1555	3843	0.00020	0.95552	4057	0.03280	0.038	0.032	0.00	0.01	N/A	N/A	N/A
17.00	55.76	12660	62	307.3	307.3	70	0.50	1.9	Unsaturated	15	12660	0.75	93.5	129.6	0.73	0.231	0.9	0.196	1.46	1.099	0.183	N/L	12799	25.3	18.9	3.2	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.07	0.00	2.150	1559	4121	0.00019	0.96044	4043	0.02957	0.032	0.026	0.00	0.01	N/A	N/A	N/A
17.10	56.09	13217	69	309.1	309.1	73	0.53	1.9	Unsaturated	15	13217	0.74	97.4	134.3	0.72	0.230	0.8	0.212	1.51	1.108	0.198	N/L	14622	28.9	21.5	3.2	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.07	0.00	2.163	1564	4715	0.00017	0.96537	4029	0.02434	0.022	0.019	0.00	0.00	N/A	N/A	N/A
17.20	56.42	22581	93	310.9	310.9	125	0.42	1.6	Unsaturated	10	22581	0.74	166.2	180.8	0.72	0.230	0.8	0.751	2.10	1.237	0.706	N/L	23171	41.3	30.7	0.9	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.06	0.00	2.176	1569	6734	0.00012	0.97029	4015	0.01507	0.009	0.008	0.00	0.00	N/A	N/A	N/A
17.30	56.74	34925	148	312.7	312.7	194	0.43	1.5	Unsaturated	8	34925	0.74	256.6	264.7	0.72	0.229	0.7	2.000	2.20	1.257	1.661	N/L	33739	58.1	43.2	0.4	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.05	0.00	2.188	1574	9501	0.00008	0.97521	4001	0.00989	0.004	0.003	0.00	0.00	N/A	N/A	N/A
17.40	57.07	35952	115	314.6	314.6	200	0.32	1.4	Unsaturated	7	35952	0.74	263.8	265.8	0.72	0.229	0.7	2.000	2.20	1.257	1.656	N/L	37417	62.5	46.3	0.1	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.05	0.00	2.201	1578	10222	0.00008	0.98013	3987	0.00910	0.003	0.003	0.00	0.00	N/A	N/A	N/A
17.50	57.40	49624	115	316.4	316.4	275	0.23	1.2	Unsaturated	4	49624	0.74	363.5	363.5	0.72	0.228	0.7	2.000	2.20	1.257	1.652	N/L	46565	73.2	54.1	0.0	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.04	0.00	2.213	1583	11989	0.00007	0.98505	3973	0.00758	0.002	0.002	0.00	0.00	N/A	N/A	N/A
17.60	57.73	50532	237	318.2	318.2	280	0.47	1.4	Unsaturated	7	50532	0.74	369.6	372.3	0.71	0.228	0.7	2.000	2.20	1.257	1.648	N/L	49836	83.2	61.5	0.1	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.04	0.00	2.226	1587	13651	0.00006	0.98997	3960	0.00656	0.002	0.001	0.00	0.00	N/A	N/A	N/A
17.70	58.06	43817	342	320.0	320.0	242	0.79	1.6	Unsaturated	10	43817	0.74	320.0	343.6	0.71	0.227	0.7	2.000	2.20	1.257	1.643	N/L	42826	76.3	56.3	0.9	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.03	0.00	2.239	1592	12530	0.00006	0.99489	3946	0.00725	0.002	0.002	0.00	0.00	N/A	N/A	N/A
17.80	58.38	31004	271	321.8	321.8	170	0.88	1.7	Unsaturated	11	31004	0.74	226.1	258.8	0.71	0.227	0.7	2.000	2.20	1.257	1.639	N/L	31927	58.8	43.3	1.7	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.03	0.00	2.251	1596	9676	0.00008	0.99981	3933	0.00983	0.004	0.003	0.00	0.00	N/A	N/A	N/A
17.90	58.71	27679	220	323.6	323.6	151	0.80	1.7	Unsaturated	11	27679	0.74	201.6	231.6	0.71	0.226	0.7	2.000	2.20	1.257	1.635	N/L	27755	51.1	37.6	1.7	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.02	0.00	2.264	1601	8423	0.00010	1.00473	3920	0.01165	0.005	0.005	0.00	0.00	N/A	N/A	N/A
18.00	59.04	26179	169	325.4	325.4	142	0.65	1.7	Unsaturated	11	26179	0.73	190.4	219.3	0.71	0.225	0.6	2.000	2.20	1.257	1.631	N/L	26178	48.2	35.4	1.7	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.02	0.00	2.277	1605	7955	0.00010	1.00965	3907	0.01254	0.006	0.005	0.00	0.00	N/A	N/A	N/A

Depth, Z (m)	Depth, Z (ft)	q_c (kPa)	f_s (kPa)	σ_{vc} (kPa)	σ'_{vc} (kPa)	Q	F	I_c	Soil Type	Fines (%)	Interpreted q_c	C_N	q_{c1N}	$q_{c1N\text{-}cs}$	Stress Reduction Factor (r_d)	CSR	K_σ for sand	$CRR_{M=7.5}$ at σ'_{vc}=1	MSF_{max}	MSF	CRR	$(FS)_L$
18.10	59.37	25334	142	327.2	327.2	137	0.57	1.6	Unsaturated	10	25334	0.73	183.9	199.6	0.71	0.225	0.7	1.852	2.20	1.257	1.612	**N/L**
18.20	59.70	25204	138	329.0	329.0	136	0.55	1.6	Unsaturated	10	25204	0.73	182.7	198.4	0.70	0.224	0.7	1.725	2.20	1.257	1.508	**N/L**

Depth, Z (m)	q_t (kPa)	N_{60}	$N_{1,60}$	$\Delta(N_1)_{60}$	$N_{1,60\text{-}CS}$	Limiting Shear Strain γ_{lim}	Parameter F_α	Max. Shear Strain γ_{max}	ΔHi (m)	ΔLDI_i (m)	Vert. Recon. Strain ε_v	DF_i	ΔSi (inch)
18.10	25383	45.2	33.1	0.9	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.01	0.00
18.20	25176	44.8	32.8	0.9	N.A.	0.000	0.000	0.000	0.05	0.0000	0.0000	0.01	0.00

Depth, Z (m)	$p = \sigma_m$ (tsf)	τ_{ave} (psf)	G_{max} (tsf)	τ_{ave}/G_{max}	a	b	γ_{eff} (%)	ε_{15} (%)	ε_{Nc} (%)	Settlement (inch)	Settlement (inch)	$\Delta(N_1)_{60\text{-}Sr}$	$(N_1)_{60\text{-}Sr}$	S_r/σ_{v0}'
18.10	2.289	1609	7466	0.00011	1.01457	3894	0.01361	0.007	0.006	0.00	0.00	N/A	N/A	N/A
18.20	2.302	1614	7414	0.00011	1.01949	3881	0.01377	0.008	0.006	0.00	0.00	N/A	N/A	N/A

CONE PENETRATION TEST-BASED LIQUEFACTION ANALYSIS BASED ON IDRISS & BOULANGER (2008)

References:

1 - Idriss, I.M. and Boulanger, R.W. (2008). *Soil Liquefaction During Earthquakes* , Earthquake Engineering Research Institute, EERI Publication MNO-12.

2 - Ishihara, K. and Yoshimine, M. (1992). "Evaluation of Settlements in Sand Deposits Following Liquefaction During Earthquakes," *Soils and Foundations* , Vol. 32, No. 1, pp. 173-188, March 1992.

3 - Tokimatsu, K. and Seed H.B. (1987). "Evaluation of Settlements in Sands Due to Earthquake Shaking," Journal of Geotechnical Engineering, Vol. 113, No. 8, August.

4 - Pradel, D. (1998). "Procedure to Evaluate Earthquake-Induced Settlements in Sand," Journal of Geotechnical and Geoenvironmental Engineering, Vol. 124, No. 4, April.

5 - Cetin, K.O., Bilge, H.T., Wu, J., Kammerer, A.M., and Seed R.B. (2009). "Procedure to Evaluate Earthquake-Induced Settlements in Sand," Journal of Geotechnical and Geoenvironmental Engineering, Vol. 135, No. 3, March.

6 - Boulanger, R.W. and Idriss, I.M. (2014). "CPT and SPT Based Liquefaction Triggering Procedures," Report No. UCD/CGM-14/01, University of California at Davis

Project	**Chevron Guadalupe Tank Battery 9 Site**
Test Boring No	**TSMACPT-11**

Test Boring Information:

Approx. depth to ground water table		23.7 ft	7.23 m
Moist unit weight of soil	γ_m	115 pcf	18.08 kN/m^3
Saturated unit weight of soil	γ_{sat}	125 pcf	19.65 kN/m^3

Earthquake Information:

Earthquake magnitude	M_w	6.9
Peak horizontal ground surface acceleratio	a_{max}	0.490 g
Number of equivalent cycle	N	10.1

Atmospheric pressure	P_a	101.3 kPa

N/L = Non-liquefiable clay-like soil

N.A. = Not Applicable

Sum
0.04

Sum	Total
0.04	**0.08**

Factor of Safety Agaist Liquefaction (Idriss & Boulanger, 2008 and Boulanger & Idriss, 2014)

Depth, Z (m)	Depth, Z (ft)	q_c (kPa)	f_s (kPa)	σ_{vc} (kPa)	σ'_{vc} (kPa)	Q	F	I_c	Soil Type	Fines (%)	Interpreted q_c	C_N	q_{c1N}	$q_{c1N\text{-}cs}$	Stress Reduction Factor (r_d)	CSR
1.60	5.25	22856	107	28.9	28.9	422	0.47	1.2	Unsaturated	4	22856	1.39	314.7	314.7	0.99	0.315
1.70	5.58	22865	131	30.7	30.7	409	0.57	1.3	Unsaturated	6	22865	1.37	309.9	310.1	0.99	0.315
1.80	5.90	22204	143	32.5	32.5	386	0.65	1.4	Unsaturated	7	22204	1.35	296.4	298.6	0.99	0.315
1.90	6.23	21077	142	34.3	34.3	357	0.68	1.4	Unsaturated	7	21077	1.33	277.4	279.5	0.99	0.314
2.00	6.56	19979	136	36.2	36.2	330	0.68	1.4	Unsaturated	7	19979	1.31	259.4	261.4	0.99	0.314
2.10	6.89	18613	124	38.0	38.0	300	0.67	1.4	Unsaturated	7	18613	1.29	238.6	240.5	0.98	0.314
2.20	7.22	17784	118	39.8	39.8	280	0.66	1.5	Unsaturated	8	17784	1.28	225.2	232.5	0.98	0.313
2.30	7.54	17176	116	41.6	41.6	264	0.67	1.5	Unsaturated	8	17176	1.26	214.9	222.1	0.98	0.313
2.40	7.87	16548	100	43.4	43.4	249	0.61	1.5	Unsaturated	8	16548	1.25	204.8	211.6	0.98	0.312
2.50	8.20	16089	97	45.2	45.2	237	0.61	1.5	Unsaturated	8	16089	1.24	196.9	203.6	0.98	0.312
2.60	8.53	16120	100	47.0	47.0	233	0.62	1.5	Unsaturated	8	16120	1.22	195.3	202.0	0.98	0.312
2.70	8.86	16277	102	48.8	48.8	231	0.63	1.5	Unsaturated	8	16277	1.21	195.2	201.9	0.98	0.311
2.80	9.18	16687	106	50.6	50.6	232	0.64	1.5	Unsaturated	8	16687	1.20	198.2	205.0	0.98	0.311
2.90	9.51	16663	114	52.4	52.4	228	0.68	1.5	Unsaturated	8	16663	1.19	196.1	202.8	0.97	0.310
3.00	9.84	16564	112	54.2	54.2	223	0.68	1.5	Unsaturated	8	16564	1.18	193.2	199.8	0.97	0.310
3.10	10.17	16566	108	56.0	56.0	219	0.65	1.5	Unsaturated	8	16566	1.17	191.6	198.2	0.97	0.309
3.20	10.50	17277	106	57.8	57.8	225	0.62	1.5	Unsaturated	8	17277	1.16	198.1	204.9	0.97	0.309
3.30	10.82	17840	106	59.7	59.7	229	0.60	1.5	Unsaturated	8	17840	1.15	203.0	209.8	0.97	0.309
3.40	11.15	18097	108	61.5	61.5	229	0.60	1.5	Unsaturated	8	18097	1.14	204.3	211.1	0.97	0.308
3.50	11.48	18542	109	63.3	63.3	231	0.59	1.5	Unsaturated	8	18542	1.13	207.7	214.6	0.97	0.308
3.60	11.81	18531	119	65.1	65.1	227	0.65	1.5	Unsaturated	8	18531	1.12	206.0	212.9	0.96	0.307
3.70	12.14	17230	110	66.9	66.9	208	0.64	1.5	Unsaturated	8	17230	1.11	190.2	196.7	0.96	0.307
3.80	12.46	17036	110	68.7	68.7	203	0.65	1.6	Unsaturated	10	17036	1.11	186.7	202.6	0.96	0.306
3.90	12.79	17457	111	70.5	70.5	206	0.64	1.5	Unsaturated	8	17457	1.10	190.0	196.6	0.96	0.306
4.00	13.12	18277	116	72.3	72.3	213	0.64	1.5	Unsaturated	8	18277	1.09	197.6	204.3	0.96	0.305
4.10	13.45	18410	122	74.1	74.1	212	0.66	1.5	Unsaturated	8	18410	1.09	197.8	204.5	0.96	0.305
4.20	13.78	16867	117	75.9	75.9	191	0.70	1.6	Unsaturated	10	16867	1.08	180.1	195.5	0.96	0.304
4.30	14.10	16856	108	77.7	77.7	189	0.64	1.6	Unsaturated	10	16856	1.07	178.8	194.2	0.95	0.304
4.40	14.43	17772	115	79.5	79.5	197	0.65	1.6	Unsaturated	10	17772	1.07	187.4	203.3	0.95	0.303
4.50	14.76	18610	137	81.4	81.4	204	0.74	1.6	Unsaturated	10	18610	1.06	195.1	211.4	0.95	0.303
4.60	15.09	18728	137	83.2	83.2	203	0.73	1.6	Unsaturated	10	18728	1.05	195.2	211.5	0.95	0.303
4.70	15.42	18761	139	85.0	85.0	201	0.74	1.6	Unsaturated	10	18761	1.05	194.4	210.7	0.95	0.302
4.80	15.74	20074	145	86.8	86.8	213	0.72	1.6	Unsaturated	10	20074	1.04	206.9	223.9	0.95	0.302
4.90	16.07	21239	157	88.6	88.6	223	0.74	1.6	Unsaturated	10	21239	1.04	217.7	235.3	0.95	0.301
5.00	16.40	21841	161	90.4	90.4	227	0.74	1.6	Unsaturated	10	21841	1.03	222.7	240.6	0.94	0.301
5.10	16.73	21469	157	92.2	92.2	221	0.73	1.6	Unsaturated	10	21469	1.02	217.7	235.4	0.94	0.300
5.20	17.06	21850	141	94.0	94.0	223	0.65	1.5	Unsaturated	8	21850	1.02	220.5	227.7	0.94	0.300
5.30	17.38	27042	149	95.8	95.8	274	0.55	1.4	Unsaturated	7	27042	1.01	271.5	273.6	0.94	0.299
5.40	17.71	27004	189	97.6	97.6	271	0.70	1.5	Unsaturated	8	27004	1.01	269.8	278.2	0.94	0.299
5.50	18.04	21587	160	99.4	99.4	214	0.75	1.6	Unsaturated	10	21587	1.00	214.6	232.1	0.94	0.298
5.60	18.37	20929	139	101.2	101.2	206	0.67	1.6	Unsaturated	10	20929	1.00	207.1	224.1	0.93	0.297
5.70	18.70	15368	129	103.0	103.0	149	0.85	1.7	Unsaturated	11	15368	0.99	151.4	176.2	0.93	0.297
5.80	19.02	10895	104	104.9	104.9	105	0.97	1.9	Unsaturated	15	10895	0.99	106.8	145.6	0.93	0.296
5.90	19.35	9615	80	106.7	106.7	91	0.84	1.9	Unsaturated	15	9615	0.99	93.8	130.0	0.93	0.296
6.00	19.68	8969	70	108.5	108.5	85	0.79	1.9	Unsaturated	15	8969	0.98	87.1	122.0	0.93	0.295
6.10	20.01	8686	66	110.3	110.3	81	0.77	1.9	Unsaturated	15	8686	0.98	84.0	118.2	0.93	0.295
6.20	20.34	8526	63	112.1	112.1	79	0.75	1.9	Unsaturated	15	8526	0.97	82.1	116.0	0.92	0.294
6.30	20.66	8568	57	113.9	113.9	79	0.67	1.9	Unsaturated	15	8568	0.97	82.2	116.0	0.92	0.294
6.40	20.99	8557	54	115.7	115.7	78	0.64	1.9	Unsaturated	15	8557	0.96	81.7	115.5	0.92	0.293
6.50	21.32	8645	54	117.5	117.5	78	0.63	1.9	Unsaturated	15	8645	0.96	82.2	116.1	0.92	0.293
6.60	21.65	9016	56	119.3	119.3	81	0.62	1.9	Unsaturated	15	9016	0.96	85.4	119.9	0.92	0.292
6.70	21.98	9131	54	121.1	121.1	81	0.60	1.9	Unsaturated	15	9131	0.95	86.2	120.8	0.92	0.292
6.80	22.30	8910	52	122.9	122.9	79	0.60	1.9	Unsaturated	15	8910	0.95	83.8	117.9	0.91	0.291
6.90	22.63	9108	53	124.7	124.7	80	0.59	1.9	Unsaturated	15	9108	0.95	85.3	119.8	0.91	0.291
7.00	22.96	10199	55	126.5	126.5	89	0.55	1.8	Unsaturated	13	10199	0.94	95.1	123.2	0.91	0.290
7.10	23.29	13146	71	128.4	128.4	114	0.55	1.7	Unsaturated	11	13146	0.94	122.2	144.0	0.91	0.289
7.20	23.62	15091	89	130.2	130.2	130	0.59	1.7	Unsaturated	11	15091	0.94	139.7	163.4	0.91	0.289
7.30	23.94	22030	114	132.1	131.4	190	0.52	1.5		8	22030	0.93	203.5	210.4	0.91	0.290
7.40	24.27	28538	144	134.1	132.3	245	0.51	1.4		7	28538	0.93	263.1	265.1	0.90	0.291
7.50	24.60	32754	180	136.0	133.3	281	0.55	1.4		7	32754	0.93	301.4	303.6	0.90	0.293
7.60	24.93	35008	180	138.0	134.3	299	0.52	1.4		7	35008	0.93	321.5	323.9	0.90	0.294
7.70	25.26	34435	216	139.9	135.3	293	0.63	1.4		7	34435	0.93	315.6	318.0	0.90	0.296
7.80	25.58	29010	231	141.9	136.3	246	0.80	1.6		10	29010	0.92	265.4	285.8	0.90	0.297
7.90	25.91	20997	213	143.9	137.3	177	1.02	1.7		11	20997	0.92	191.7	220.8	0.89	0.299
8.00	26.24	19251	159	145.8	138.2	161	0.83	1.7		11	19251	0.92	175.5	202.8	0.89	0.300
8.10	26.57	21310	140	147.8	139.2	178	0.66	1.6		10	21310	0.92	193.9	210.1	0.89	0.301
8.20	26.90	25278	108	149.8	140.2	211	0.43	1.4		7	25278	0.92	229.5	231.4	0.89	0.303
8.30	27.22	28783	122	151.7	141.2	239	0.42	1.4		7	28783	0.92	260.9	262.9	0.89	0.304
8.40	27.55	28930	161	153.7	142.2	240	0.56	1.5		8	28930	0.91	261.7	270.0	0.89	0.305
8.50	27.88	26986	150	155.7	143.2	223	0.56	1.5		8	26986	0.91	243.7	251.5	0.88	0.306
8.60	28.21	26650	151	157.6	144.1	219	0.57	1.5		8	26650	0.91	240.2	247.9	0.88	0.307
8.70	28.54	27119	153	159.6	145.1	222	0.57	1.5		8	27119	0.91	244.0	251.8	0.88	0.308
8.80	28.86	26349	153	161.6	146.1	215	0.59	1.5		8	26349	0.91	236.7	244.3	0.88	0.309

Factor of Safety Agaist Liquefaction (continued) / Settelemnt of Liquefiable Soil (Idriss and Boulnager, 2008)

Depth, Z (m)	K_σ for sand	$CRR_{M=7.5}$ at σ'_{vc}=1	MSF_{max}	MSF	CRR	$(FS)_L$	q_t (kPa)	N_{60}	$N_{1,60}$	$\Delta(N_1)_{60}$	$N_{1,60\text{-}CS}$	Limiting Shear Strain γ_{lim}	Parameter F_α	Max. Shear Strain γ_{max}	ΔHi (m)	ΔLDI_i (m)	Vert. Recon. Strain ε_v	DF_i	ΔSi (inch)
1.60	1.1	2.000	2.20	1.257	2.000	**N/L**	22676	35.6	49.6	0.0	N.A.	0.000	0.000	0.000	0.05	0.0000	0.0000	0.91	0.00
1.70	1.1	2.000	2.20	1.257	2.000	**N/L**	22811	36.9	50.5	0.0	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.91	0.00
1.80	1.1	2.000	2.20	1.257	2.000	**N/L**	22238	37.1	50.1	0.1	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.90	0.00
1.90	1.1	2.000	2.20	1.257	2.000	**N/L**	21119	35.3	46.9	0.1	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.90	0.00
2.00	1.1	2.000	2.20	1.257	2.000	**N/L**	19914	33.2	43.6	0.1	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.89	0.00
2.10	1.1	2.000	2.20	1.257	2.000	**N/L**	18667	31.2	40.3	0.1	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.89	0.00
2.20	1.1	2.000	2.20	1.257	2.000	**N/L**	17811	30.7	39.3	0.4	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.88	0.00
2.30	1.1	2.000	2.20	1.257	2.000	**N/L**	17208	29.7	37.5	0.4	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.87	0.00
2.40	1.1	2.000	2.20	1.257	2.000	**N/L**	16558	28.5	35.7	0.4	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.87	0.00
2.50	1.1	2.335	2.20	1.257	2.000	**N/L**	16154	27.8	34.4	0.4	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.86	0.00
2.60	1.1	2.113	2.20	1.257	2.000	**N/L**	16172	27.9	34.1	0.4	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.86	0.00
2.70	1.1	2.106	2.20	1.257	2.000	**N/L**	16350	28.2	34.1	0.4	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.85	0.00
2.80	1.1	2.530	2.20	1.257	2.000	**N/L**	16641	28.7	34.4	0.4	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.85	0.00
2.90	1.1	2.223	2.20	1.257	2.000	**N/L**	16694	28.8	34.2	0.4	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.84	0.00
3.00	1.1	1.874	2.20	1.257	2.000	**N/L**	16598	28.6	33.7	0.4	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.84	0.00
3.10	1.1	1.706	2.20	1.257	2.000	**N/L**	16694	28.8	33.6	0.4	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.83	0.00
3.20	1.1	2.515	2.20	1.257	2.000	**N/L**	17256	29.7	34.4	0.4	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.83	0.00
3.30	1.1	3.437	2.20	1.257	2.000	**N/L**	17795	30.7	35.2	0.4	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.82	0.00
3.40	1.1	2.000	2.20	1.257	2.000	**N/L**	18097	31.2	35.6	0.4	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.81	0.00
3.50	1.1	2.000	2.20	1.257	2.000	**N/L**	18545	32.0	36.2	0.4	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.81	0.00
3.60	1.1	2.000	2.20	1.257	2.000	**N/L**	18353	31.6	35.5	0.4	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.80	0.00
3.70	1.1	1.578	2.20	1.257	2.000	**N/L**	17297	29.8	33.2	0.4	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.80	0.00
3.80	1.1	2.193	2.20	1.257	2.000	**N/L**	17106	30.5	33.7	0.9	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.79	0.00
3.90	1.1	1.565	2.20	1.257	2.000	**N/L**	17528	30.2	33.2	0.4	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.79	0.00
4.00	1.1	2.436	2.20	1.257	2.000	**N/L**	18198	31.4	34.3	0.4	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.78	0.00
4.10	1.1	2.458	2.20	1.257	2.000	**N/L**	18304	31.5	34.2	0.4	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.78	0.00
4.20	1.1	1.481	2.20	1.257	1.995	**N/L**	17212	30.7	33.0	0.9	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.77	0.00
4.30	1.1	1.385	2.20	1.257	1.853	**N/L**	16855	30.0	32.2	0.9	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.76	0.00
4.40	1.1	2.288	2.20	1.257	2.000	**N/L**	17699	31.5	33.6	0.9	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.76	0.00
4.50	1.1	2.000	2.20	1.257	2.000	**N/L**	18564	33.1	35.0	0.9	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.75	0.00
4.60	1.1	2.000	2.20	1.257	2.000	**N/L**	18745	33.4	35.1	0.9	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.75	0.00
4.70	1.1	3.654	2.20	1.257	2.000	**N/L**	18990	33.8	35.4	0.9	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.74	0.00
4.80	1.0	2.000	2.20	1.257	2.000	**N/L**	20069	35.7	37.2	0.9	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.74	0.00
4.90	1.0	2.000	2.20	1.257	2.000	**N/L**	21191	37.7	39.1	0.9	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.73	0.00
5.00	1.0	2.000	2.20	1.257	2.000	**N/L**	21831	38.9	40.0	0.9	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.73	0.00
5.10	1.0	2.000	2.20	1.257	2.000	**N/L**	21704	38.7	39.6	0.9	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.72	0.00
5.20	1.0	2.000	2.20	1.257	2.000	**N/L**	22591	38.9	39.7	0.4	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.72	0.00
5.30	1.0	2.000	2.20	1.257	2.000	**N/L**	26436	44.1	44.8	0.1	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.71	0.00
5.40	1.0	2.000	2.20	1.257	2.000	**N/L**	26508	45.7	46.1	0.4	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.70	0.00
5.50	1.0	2.000	2.20	1.257	2.000	**N/L**	22159	39.5	39.6	0.9	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.70	0.00
5.60	1.0	2.000	2.20	1.257	2.000	**N/L**	19959	35.5	35.5	0.9	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.69	0.00
5.70	1.0	0.626	2.03	1.220	0.761	**N/L**	15492	28.5	28.4	1.7	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.69	0.00
5.80	1.0	0.262	1.62	1.133	0.295	**N/L**	11172	22.1	21.9	3.2	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.68	0.00
5.90	1.0	0.197	1.47	1.100	0.216	**N/L**	9645	19.1	18.8	3.2	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.68	0.00
6.00	1.0	0.176	1.40	1.086	0.189	**N/L**	8991	17.8	17.5	3.2	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.67	0.00
6.10	1.0	0.167	1.37	1.080	0.179	**N/L**	8686	17.2	16.8	3.2	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.67	0.00
6.20	1.0	0.163	1.36	1.077	0.173	**N/L**	8557	16.9	16.5	3.2	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.66	0.00
6.30	1.0	0.163	1.36	1.077	0.173	**N/L**	8577	17.0	16.4	3.2	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.66	0.00
6.40	1.0	0.162	1.35	1.076	0.171	**N/L**	8576	17.0	16.4	3.2	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.65	0.00
6.50	1.0	0.163	1.36	1.077	0.172	**N/L**	8644	17.1	16.4	3.2	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.64	0.00
6.60	1.0	0.171	1.39	1.083	0.181	**N/L**	9011	17.8	17.1	3.2	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.64	0.00
6.70	1.0	0.173	1.39	1.084	0.183	**N/L**	9154	18.1	17.3	3.2	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.63	0.00
6.80	1.0	0.167	1.37	1.080	0.176	**N/L**	8939	17.7	16.8	3.2	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.63	0.00
6.90	1.0	0.171	1.38	1.082	0.180	**N/L**	9107	18.0	17.0	3.2	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.62	0.00
7.00	1.0	0.179	1.41	1.088	0.189	**N/L**	10402	19.8	18.7	2.5	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.62	0.00
7.10	1.0	0.253	1.60	1.129	0.276	**N/L**	12973	23.9	22.4	1.7	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.61	0.00
7.20	1.0	0.409	1.84	1.180	0.460	**N/L**	15841	29.2	27.3	1.7	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.61	0.00
7.30	0.9	3.568	2.20	1.257	2.000	**2.00**	21878	37.7	35.2	0.4	35.6	0.020	-0.476	0.000	0.10	0.0000	0.0000	0.60	0.00
7.40	0.9	2.000	2.20	1.257	2.000	**2.00**	28303	47.3	44.0	0.1	44.1	0.003	-1.118	0.000	0.10	0.0000	0.0000	0.60	0.00
7.50	0.9	2.000	2.20	1.257	2.000	**2.00**	32576	54.4	50.5	0.1	50.6	0.000	-1.641	0.000	0.10	0.0000	0.0000	0.59	0.00
7.60	0.9	2.000	2.20	1.257	2.000	**2.00**	34468	57.5	53.4	0.1	53.5	0.000	-1.873	0.000	0.10	0.0000	0.0000	0.58	0.00
7.70	0.9	2.000	2.20	1.257	2.000	**2.00**	33701	56.3	52.1	0.1	52.2	0.000	-1.767	0.000	0.10	0.0000	0.0000	0.58	0.00
7.80	0.9	2.000	2.20	1.257	2.000	**2.00**	28579	50.9	47.0	0.9	48.0	0.001	-1.424	0.000	0.10	0.0000	0.0000	0.57	0.00
7.90	0.9	2.000	2.20	1.257	2.000	**2.00**	21351	39.3	36.3	1.7	37.9	0.013	-0.651	0.000	0.10	0.0000	0.0000	0.57	0.00
8.00	0.9	2.220	2.20	1.257	2.000	**2.00**	19250	35.5	32.6	1.7	34.3	0.025	-0.387	0.000	0.10	0.0000	0.0000	0.56	0.00
8.10	0.9	3.513	2.20	1.257	2.000	**2.00**	21420	38.1	35.0	0.9	36.0	0.019	-0.506	0.000	0.10	0.0000	0.0000	0.56	0.00
8.20	0.9	2.000	2.20	1.257	2.000	**2.00**	25153	42.0	38.5	0.1	38.6	0.012	-0.699	0.000	0.10	0.0000	0.0000	0.55	0.00
8.30	0.9	2.000	2.20	1.257	2.000	**2.00**	28361	47.3	43.3	0.1	43.4	0.004	-1.067	0.000	0.10	0.0000	0.0000	0.55	0.00
8.40	0.9	2.000	2.20	1.257	2.000	**2.00**	28621	49.3	45.1	0.4	45.4	0.002	-1.224	0.000	0.10	0.0000	0.0000	0.54	0.00
8.50	0.9	2.000	2.20	1.257	2.000	**2.00**	27113	46.7	42.6	0.4	43.0	0.004	-1.033	0.000	0.10	0.0000	0.0000	0.54	0.00
8.60	0.9	2.000	2.20	1.257	2.000	**2.00**	26650	45.9	41.8	0.4	42.2	0.005	-0.971	0.000	0.10	0.0000	0.0000	0.53	0.00
8.70	0.9	2.000	2.20	1.257	2.000	**2.00**	26882	46.3	42.1	0.4	42.5	0.005	-0.993	0.000	0.10	0.0000	0.0000	0.52	0.00
8.80	0.9	2.000	2.20	1.257	2.000	**2.00**	26295	45.3	41.1	0.4	41.5	0.006	-0.917	0.000	0.10	0.0000	0.0000	0.52	0.00

Settlement of Unsaturated Sand (Tokimatsu & Seed, 1987, and Pradel, 1998) / Cumulative / S_r (Idriss & Boulanger, 2008)

Depth, Z (m)	$p = \sigma_m$ (tsf)	τ_{ave} (psf)	G_{max} (tsf)	τ_{ave}/G_{max}	a	b	γ_{eff} (%)	ε_{15} (%)	ε_{Nc} (%)	Settlement (inch)	Cumulative Settlement (inch)	$\Delta(N_1)_{60\text{-}Sr}$	$(N_1)_{60\text{-}Sr}$	S_r/σ_{v0}'
1.60	0.202	192	3318	0.00003	0.20272	16691	0.00319	0.001	0.001	0.00	0.08	N/A	N/A	N/A
1.70	0.215	204	3489	0.00003	0.20764	16095	0.00322	0.001	0.001	0.00	0.08	N/A	N/A	N/A
1.80	0.228	216	3555	0.00003	0.21256	15552	0.00335	0.001	0.001	0.00	0.08	N/A	N/A	N/A
1.90	0.240	228	3420	0.00003	0.21749	15056	0.00371	0.001	0.001	0.00	0.08	N/A	N/A	N/A
2.00	0.253	239	3264	0.00004	0.22241	14600	0.00414	0.002	0.001	0.00	0.08	N/A	N/A	N/A
2.10	0.266	251	3095	0.00004	0.22733	14178	0.00465	0.002	0.002	0.00	0.08	N/A	N/A	N/A
2.20	0.278	263	3082	0.00004	0.23225	13788	0.00491	0.002	0.002	0.00	0.08	N/A	N/A	N/A
2.30	0.291	275	3009	0.00005	0.23717	13425	0.00531	0.002	0.002	0.00	0.08	N/A	N/A	N/A
2.40	0.304	287	2925	0.00005	0.24209	13087	0.00576	0.003	0.002	0.00	0.08	N/A	N/A	N/A
2.50	0.316	299	2881	0.00005	0.24701	12770	0.00615	0.003	0.003	0.00	0.08	N/A	N/A	N/A
2.60	0.329	310	2911	0.00005	0.25193	12473	0.00635	0.003	0.003	0.00	0.08	N/A	N/A	N/A
2.70	0.342	322	2969	0.00005	0.25685	12194	0.00646	0.003	0.003	0.00	0.08	N/A	N/A	N/A
2.80	0.354	334	3048	0.00005	0.26177	11931	0.00652	0.003	0.003	0.00	0.08	N/A	N/A	N/A
2.90	0.367	346	3083	0.00006	0.26669	11682	0.00670	0.004	0.003	0.00	0.08	N/A	N/A	N/A
3.00	0.379	357	3090	0.00006	0.27161	11447	0.00694	0.004	0.003	0.00	0.08	N/A	N/A	N/A
3.10	0.392	369	3132	0.00006	0.27653	11224	0.00708	0.004	0.003	0.00	0.08	N/A	N/A	N/A
3.20	0.405	381	3262	0.00006	0.28145	11012	0.00699	0.004	0.003	0.00	0.08	N/A	N/A	N/A
3.30	0.417	392	3389	0.00006	0.28637	10811	0.00691	0.004	0.003	0.00	0.08	N/A	N/A	N/A
3.40	0.430	404	3470	0.00006	0.29129	10619	0.00694	0.003	0.003	0.00	0.08	N/A	N/A	N/A
3.50	0.443	415	3581	0.00006	0.29621	10436	0.00690	0.003	0.003	0.00	0.08	N/A	N/A	N/A
3.60	0.455	427	3567	0.00006	0.30113	10261	0.00716	0.004	0.003	0.00	0.08	N/A	N/A	N/A
3.70	0.468	438	3384	0.00006	0.30605	10093	0.00788	0.004	0.004	0.00	0.08	N/A	N/A	N/A
3.80	0.481	450	3480	0.00006	0.31097	9933	0.00785	0.004	0.004	0.00	0.08	N/A	N/A	N/A
3.90	0.493	461	3472	0.00007	0.31589	9780	0.00810	0.004	0.004	0.00	0.08	N/A	N/A	N/A
4.00	0.506	473	3626	0.00007	0.32081	9632	0.00790	0.004	0.003	0.00	0.08	N/A	N/A	N/A
4.10	0.519	484	3669	0.00007	0.32573	9490	0.00801	0.004	0.004	0.00	0.08	N/A	N/A	N/A
4.20	0.531	496	3585	0.00007	0.33065	9354	0.00847	0.005	0.004	0.00	0.08	N/A	N/A	N/A
4.30	0.544	507	3531	0.00007	0.33557	9223	0.00887	0.005	0.004	0.00	0.08	N/A	N/A	N/A
4.40	0.557	518	3728	0.00007	0.34049	9097	0.00851	0.005	0.004	0.00	0.08	N/A	N/A	N/A
4.50	0.569	530	3930	0.00007	0.34541	8975	0.00817	0.004	0.003	0.00	0.08	N/A	N/A	N/A
4.60	0.582	541	3990	0.00007	0.35033	8857	0.00823	0.004	0.003	0.00	0.08	N/A	N/A	N/A
4.70	0.594	552	4062	0.00007	0.35525	8744	0.00824	0.004	0.003	0.00	0.08	N/A	N/A	N/A
4.80	0.607	563	4314	0.00007	0.36017	8634	0.00784	0.004	0.003	0.00	0.08	N/A	N/A	N/A
4.90	0.620	574	4578	0.00006	0.36509	8528	0.00746	0.003	0.003	0.00	0.08	N/A	N/A	N/A
5.00	0.632	586	4739	0.00006	0.37001	8425	0.00732	0.003	0.003	0.00	0.08	N/A	N/A	N/A
5.10	0.645	597	4733	0.00006	0.37493	8326	0.00749	0.003	0.003	0.00	0.08	N/A	N/A	N/A
5.20	0.658	608	4790	0.00006	0.37985	8229	0.00754	0.003	0.003	0.00	0.07	N/A	N/A	N/A
5.30	0.670	619	5454	0.00006	0.38477	8136	0.00660	0.003	0.002	0.00	0.07	N/A	N/A	N/A
5.40	0.683	630	5670	0.00006	0.38969	8045	0.00643	0.002	0.002	0.00	0.07	N/A	N/A	N/A
5.50	0.696	641	4919	0.00007	0.39461	7957	0.00776	0.003	0.003	0.00	0.07	N/A	N/A	N/A
5.60	0.708	651	4450	0.00007	0.39953	7871	0.00895	0.004	0.004	0.00	0.07	N/A	N/A	N/A
5.70	0.721	662	3588	0.00009	0.40446	7788	0.01202	0.008	0.007	0.00	0.07	N/A	N/A	N/A
5.80	0.734	673	2791	0.00012	0.40938	7707	0.01743	0.016	0.013	0.00	0.07	N/A	N/A	N/A
5.90	0.746	684	2419	0.00014	0.41430	7629	0.02217	0.024	0.020	0.00	0.07	N/A	N/A	N/A
6.00	0.759	695	2264	0.00015	0.41922	7552	0.02525	0.030	0.025	0.00	0.07	N/A	N/A	N/A
6.10	0.772	705	2196	0.00016	0.42414	7478	0.02718	0.034	0.028	0.00	0.07	N/A	N/A	N/A
6.20	0.784	716	2171	0.00016	0.42906	7405	0.02832	0.036	0.030	0.00	0.07	N/A	N/A	N/A
6.30	0.797	727	2185	0.00017	0.43398	7334	0.02864	0.036	0.030	0.00	0.06	N/A	N/A	N/A
6.40	0.810	737	2193	0.00017	0.43890	7265	0.02907	0.037	0.031	0.00	0.06	N/A	N/A	N/A
6.50	0.822	748	2218	0.00017	0.44382	7198	0.02910	0.037	0.031	0.00	0.06	N/A	N/A	N/A
6.60	0.835	758	2321	0.00016	0.44874	7132	0.02750	0.033	0.028	0.00	0.06	N/A	N/A	N/A
6.70	0.847	769	2366	0.00016	0.45366	7068	0.02716	0.032	0.027	0.00	0.05	N/A	N/A	N/A
6.80	0.860	779	2318	0.00017	0.45858	7006	0.02866	0.035	0.030	0.00	0.05	N/A	N/A	N/A
6.90	0.873	789	2370	0.00017	0.46350	6945	0.02814	0.034	0.029	0.00	0.05	N/A	N/A	N/A
7.00	0.885	800	2619	0.00015	0.46842	6885	0.02432	0.026	0.022	0.00	0.05	N/A	N/A	N/A
7.10	0.898	810	3164	0.00013	0.47334	6827	0.01853	0.016	0.014	0.00	0.05	N/A	N/A	N/A
7.20	0.911	820	3877	0.00011	0.47826	6770	0.01416	0.010	0.008	0.00	0.05	N/A	N/A	N/A
7.30	0.919	831	5020	0.00008	0.48151	6732	0.01028	0.005	0.004	0.00	0.04	0.7	36	N/A
7.40	0.926	842	6302	0.00007	0.48419	6702	0.00791	0.003	0.003	0.00	0.04	0.6	45	N/A
7.50	0.933	853	7266	0.00006	0.48687	6673	0.00679	0.002	0.002	0.00	0.04	0.6	51	N/A
7.60	0.940	864	7702	0.00006	0.48955	6643	0.00644	0.002	0.002	0.00	0.04	0.6	54	N/A
7.70	0.947	875	7543	0.00006	0.49222	6614	0.00670	0.002	0.002	0.00	0.04	0.6	53	N/A
7.80	0.953	886	6835	0.00006	0.49490	6586	0.00762	0.003	0.002	0.00	0.04	0.9	48	N/A
7.90	0.960	897	5291	0.00008	0.49758	6557	0.01057	0.005	0.004	0.00	0.04	1.0	37	N/A
8.00	0.967	908	4779	0.00009	0.50026	6529	0.01222	0.007	0.006	0.00	0.04	1.0	34	N/A
8.10	0.974	918	5149	0.00009	0.50294	6501	0.01126	0.006	0.005	0.00	0.04	0.9	36	N/A
8.20	0.981	929	5678	0.00008	0.50561	6474	0.01010	0.005	0.004	0.00	0.04	0.6	39	N/A
8.30	0.988	940	6412	0.00007	0.50829	6447	0.00882	0.003	0.003	0.00	0.04	0.6	44	N/A
8.40	0.995	950	6691	0.00007	0.51097	6420	0.00849	0.003	0.003	0.00	0.04	0.7	46	N/A
8.50	1.002	961	6349	0.00008	0.51365	6394	0.00916	0.004	0.003	0.00	0.04	0.7	43	N/A
8.60	1.009	971	6250	0.00008	0.51633	6367	0.00946	0.004	0.003	0.00	0.04	0.7	43	N/A
8.70	1.015	982	6315	0.00008	0.51901	6341	0.00946	0.004	0.003	0.00	0.04	0.7	43	N/A
8.80	1.022	992	6187	0.00008	0.52168	6316	0.00983	0.004	0.003	0.00	0.04	0.7	42	N/A

Depth, Z (m)	Depth, Z (ft)	q_c (kPa)	f_s (kPa)	σ_{vc} (kPa)	σ'_{vc} (kPa)	Q	F	I_c	Soil Type	Fines (%)	Interpreted q_c	C_N	q_{c1N}	q_{c1N-cs}	Stress Reduction Factor (r_d)	CSR	K_σ for sand	$CRR_{M=7.5}$ at σ'_{vc}=1	MSF_{max}	MSF	CRR	$(FS)_L$	q_t (kPa)	N_{60}	$N_{1,60}$	$\Delta(N_1)_{60}$	$N_{1,60\text{-}CS}$	Limiting Shear Strain γ_{lim}	Parameter F_{ru}	Max. Shear Strain γ_{max}	ΔHi (m)	ΔLDI_i (m)	Vert. Recon. Strain ε_v	DF_i	ΔSi (inch)	p = σ_m (tsf)	τ_{ave} (psf)	G_{max} (tsf)	τ_{ave}/G_{max}	a	b	γ_{eff} (%)	ε_{15} (%)	ε_{NC} (%)	Settlement (inch)	Settlement (inch)	$\Delta(N_1)_{60\text{-}Sr}$	$(N_1)_{60\text{-}Sr}$	S_r/σ_{vo}'
8.90	29.19	25237	138	163.5	147.1	205	0.55	1.5		8	25237	0.91	226.3	233.7	0.88	0.310	0.9	2.000	2.20	1.257	2.000	**2.00**	25274	43.6	39.4	0.4	39.8	0.009	-0.791	0.000	0.10	0.0000	0.0000	0.51	0.00	1.029	1002	5956	0.00008	0.52436	6290	0.01043	0.005	0.004	0.00	0.04	0.7	40	N/A
9.00	29.52	24915	123	165.5	148.1	202	0.50	1.5		8	24915	0.90	223.0	230.3	0.87	0.311	0.9	2.000	2.20	1.257	2.000	**2.00**	24914	42.9	38.8	0.4	39.2	0.010	-0.743	0.000	0.10	0.0000	0.0000	0.51	0.00	1.036	1013	5881	0.00009	0.52704	6265	0.01073	0.005	0.004	0.00	0.04	0.7	40	N/A
9.10	29.85	25369	124	167.5	149.1	205	0.49	1.5		8	25369	0.90	226.7	234.1	0.87	0.312	0.9	2.000	2.20	1.257	2.000	**2.00**	25121	43.3	39.1	0.4	39.4	0.010	-0.762	0.000	0.10	0.0000	0.0000	0.50	0.00	1.043	1023	5939	0.00009	0.52972	6240	0.01073	0.005	0.004	0.00	0.04	0.7	40	N/A
9.20	30.18	23602	123	169.4	150.1	190	0.52	1.5		8	23602	0.90	210.5	217.5	0.87	0.313	0.9	2.000	2.20	1.257	2.000	**2.00**	23584	40.6	36.6	0.4	37.0	0.016	-0.580	0.000	0.10	0.0000	0.0000	0.50	0.00	1.050	1033	5584	0.00009	0.53240	6216	0.01175	0.006	0.005	0.00	0.04	0.7	37	N/A
9.30	30.50	20861	106	171.4	151.0	167	0.51	1.6		10	20861	0.90	185.7	201.5	0.87	0.314	0.9	2.063	2.20	1.257	2.000	**2.00**	20791	37.0	33.3	0.9	34.2	0.025	-0.380	0.000	0.10	0.0000	0.0000	0.49	0.00	1.057	1043	5095	0.00010	0.53507	6192	0.01339	0.007	0.006	0.00	0.04	0.9	34	N/A
9.40	30.83	17106	93	173.4	152.0	136	0.55	1.6		10	17106	0.90	152.0	165.9	0.87	0.315	0.9	0.441	1.87	1.187	0.484	**1.54**	16699	29.7	26.7	0.9	27.6	0.064	0.067	0.010	0.10	0.0010	0.0022	0.49	0.00	1.064	1053	4098	0.00013	0.53775	6167	0.01828	0.013	0.011	0.00	0.04	0.9	28	N/A
9.50	31.16	7907	113	175.3	153.0	62	1.46	2.2		22	7907	0.90	70.2	116.5	0.87	0.316	0.9	0.164	1.36	1.077	0.168	**0.53**	8601	19.1	17.2	4.7	21.9	0.128	0.414	0.128	0.10	0.0128	0.0213	0.48	0.04	1.071	1063	2643	0.00020	0.54043	6144	0.03733	0.045	0.038	0.00	0.04	1.9	19	0.16
9.60	31.49	2717	71	177.3	154.0	20	2.81	2.7	Clay-Like	37	2717	0.89	24.1	62.3	0.86	0.317	1.0	0.101	1.13	1.028	0.101	**N/L**	3067	8.6	7.7	5.5	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.48	0.00	1.077	1073	1192	0.00045	0.54311	6120	0.27806	0.872	0.729	0.00	0.00	N/A	N/A	N/A
9.70	31.82	2201	25	179.2	155.0	16	1.24	2.6	Clay-Like	34	2201	0.89	19.5	55.7	0.86	0.317	1.0	0.096	1.12	1.026	0.096	**N/L**	2253	6.0	5.4	5.5	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.47	0.00	1.084	1083	833	0.00065	0.54579	6097	1.24686	6.033	5.045	0.00	0.00	N/A	N/A	N/A
9.80	32.14	2189	23	181.2	156.0	16	1.17	2.6	Clay-Like	34	2189	0.89	19.3	55.5	0.86	0.318	1.0	0.096	1.12	1.026	0.095	**N/L**	2145	5.7	5.1	5.5	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.46	0.00	1.091	1093	794	0.00069	0.54846	6074	1.63051	8.386	7.012	0.00	0.00	N/A	N/A	N/A
9.90	32.47	1767	15	183.2	156.9	13	0.92	2.6	Clay-Like	34	1767	0.89	15.6	50.5	0.86	0.319	1.0	0.093	1.11	1.024	0.092	**N/L**	1767	4.7	4.2	5.5	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.46	0.00	1.098	1102	655	0.00084	0.55114	6051	4.90062	31.874	26.651	0.00	0.00	N/A	N/A	N/A
10.00	32.80	1484	11	185.1	157.9	10	0.83	2.7	Clay-Like	37	1484	0.89	13.1	47.5	0.86	0.320	1.0	0.091	1.11	1.023	0.090	**N/L**	1511	4.2	3.8	5.5	N.A.	0.000	0.000	0.000	0.05	0.0000	0.0000	0.45	0.00	1.105	1112	591	0.00094	0.55382	6028	9.81666	72.578	60.687	0.00	0.00	N/A	N/A	N/A

CONE PENETRATION TEST-BASED LIQUEFACTION ANALYSIS BASED ON IDRISS & BOULANGER (2008)

References:

1 - Idriss, I.M. and Boulanger, R.W. (2008). *Soil Liquefaction During Earthquakes* , Earthquake Engineering Research Institute, EERI Publication MNO-12.

2 - Ishihara, K. and Yoshimine, M. (1992). "Evaluation of Settlements in Sand Deposits Following Liquefaction During Earthquakes," *Soils and Foundations* , Vol. 32, No. 1, pp. 173-188, March 1992.

3 - Tokimatsu, K. and Seed H.B. (1987). "Evaluation of Settlements in Sands Due to Earthquake Shaking," Journal of Geotechnical Engineering, Vol. 113, No. 8, August.

4 - Pradel, D. (1998). "Procedure to Evaluate Earthquake-Induced Settlements in Sand," Journal of Geotechnical and Geoenvironmental Engineering, Vol. 124, No. 4, April.

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6 - Boulanger, R.W. and Idriss, I.M. (2014). "CPT and SPT Based Liquefaction Triggering Procedures," Report No. UCD/CGM-14/01, University of California at Davis

Project	**Chevron Guadalupe Tank Battery 9 Site**
Test Boring No	**TSMACPT-12**

Test Boring Information:

Approx. depth to ground water table		32.7 ft	9.97 m
Moist unit weight of soil	γ_m	115 pcf	18.08 kN/m^3
Saturated unit weight of soil	γ_{sat}	125 pcf	19.65 kN/m^3

Earthquake Information:

Earthquake magnitude	M_w	6.9
Peak horizontal ground surface acceleratio	a_{max}	0.490 g
Number of equivalent cycle	N	10.1

Atmospheric pressure	P_a	101.3 kPa

N/L = Non-liquefiable clay-like soil
N.A. = Not Applicable

Sum
0.48

Sum	Total
0.11	0.60

Factor of Safety Agaist Liquefaction (Idriss & Boulanger, 2008 and Boulanger & Idriss, 2014)

Depth, Z (m)	Depth, Z (ft)	q_c (kPa)	f_s (kPa)	σ_{vc} (kPa)	σ'_{vc} (kPa)	Q	F	I_c	Soil Type	Fines (%)	Interpreted q_c	C_N	q_{c1N}	q_{c1N-cs}	Stress Reduction Factor (r_d)	CSR	K_σ for sand	$CRR_{M=7.5}$ at σ'_{vc}=1	MSF_{max}	MSF	CRR	$(FS)_L$
1.60	5.25	28358	146	28.9	28.9	523	0.51	1.2	Unsaturated	4	28358	1.39	390.5	390.5	0.99	0.315	1.1	2.000	2.20	1.257	2.000	N/L
1.70	5.58	22986	113	30.7	30.7	411	0.49	1.3	Unsaturated	6	22986	1.37	311.5	311.7	0.99	0.315	1.1	2.000	2.20	1.257	2.000	N/L
1.80	5.90	18861	113	32.5	32.5	328	0.60	1.4	Unsaturated	7	18861	1.35	251.8	253.7	0.99	0.315	1.1	2.000	2.20	1.257	2.000	N/L
1.90	6.23	15722	85	34.3	34.3	266	0.54	1.4	Unsaturated	7	15722	1.33	206.9	208.6	0.99	0.314	1.1	3.180	2.20	1.257	2.000	N/L
2.00	6.56	13657	73	36.2	36.2	225	0.53	1.5	Unsaturated	8	13657	1.31	177.3	183.5	0.99	0.314	1.1	0.840	2.15	1.247	1.152	N/L
2.10	6.89	12152	63	38.0	38.0	195	0.52	1.5	Unsaturated	8	12152	1.29	155.8	161.5	0.98	0.314	1.1	0.387	1.81	1.174	0.500	N/L
2.20	7.22	10456	57	39.8	39.8	164	0.55	1.6	Unsaturated	10	10456	1.28	132.4	145.1	0.98	0.313	1.1	0.259	1.61	1.132	0.323	N/L
2.30	7.54	9172	51	41.6	41.6	141	0.56	1.6	Unsaturated	10	9172	1.26	114.8	126.5	0.98	0.313	1.1	0.187	1.44	1.094	0.225	N/L
2.40	7.87	8013	45	43.4	43.4	120	0.56	1.7	Unsaturated	11	8013	1.25	99.1	118.5	0.98	0.312	1.1	0.168	1.38	1.081	0.200	N/L
2.50	8.20	7340	37	45.2	45.2	108	0.51	1.7	Unsaturated	11	7340	1.24	89.9	108.3	0.98	0.312	1.1	0.149	1.31	1.066	0.173	N/L
2.60	8.53	6966	34	47.0	47.0	100	0.50	1.7	Unsaturated	11	6966	1.22	84.4	102.2	0.98	0.312	1.1	0.140	1.27	1.059	0.161	N/L
2.70	8.86	6662	33	48.8	48.8	94	0.50	1.8	Unsaturated	13	6662	1.21	79.9	105.6	0.98	0.311	1.1	0.145	1.29	1.063	0.167	N/L
2.80	9.18	7178	35	50.6	50.6	100	0.49	1.7	Unsaturated	11	7178	1.20	85.3	103.2	0.98	0.311	1.1	0.142	1.28	1.060	0.161	N/L
2.90	9.51	9860	37	52.4	52.4	135	0.37	1.6	Unsaturated	10	9860	1.19	116.1	127.8	0.97	0.310	1.1	0.191	1.45	1.096	0.227	N/L
3.00	9.84	10869	40	54.2	54.2	146	0.37	1.5	Unsaturated	8	10869	1.18	126.8	131.8	0.97	0.310	1.1	0.203	1.48	1.104	0.243	N/L
3.10	10.17	10612	53	56.0	56.0	140	0.50	1.6	Unsaturated	10	10612	1.17	122.7	134.9	0.97	0.309	1.1	0.214	1.51	1.110	0.257	N/L
3.20	10.50	7101	42	57.8	57.8	92	0.59	1.8	Unsaturated	13	7101	1.16	81.4	107.3	0.97	0.309	1.1	0.148	1.30	1.065	0.167	N/L
3.30	10.82	4965	28	59.7	59.7	63	0.58	1.9	Unsaturated	15	4965	1.15	56.5	85.2	0.97	0.309	1.0	0.121	1.20	1.042	0.132	N/L
3.40	11.15	3977	22	61.5	61.5	50	0.57	2.0	Unsaturated	17	3977	1.14	44.9	76.4	0.97	0.308	1.0	0.113	1.17	1.036	0.122	N/L
3.50	11.48	3688	20	63.3	63.3	45	0.57	2.1	Unsaturated	19	3688	1.13	41.3	76.0	0.97	0.308	1.0	0.112	1.17	1.035	0.121	N/L
3.60	11.81	3989	28	65.1	65.1	48	0.71	2.1	Unsaturated	19	3989	1.12	44.3	79.9	0.96	0.307	1.0	0.116	1.18	1.038	0.125	N/L
3.70	12.14	5594	46	66.9	66.9	67	0.84	2.0	Unsaturated	17	5594	1.11	61.7	97.3	0.96	0.307	1.0	0.134	1.25	1.053	0.147	N/L
3.80	12.46	13143	43	68.7	68.7	157	0.33	1.5	Unsaturated	8	13143	1.11	144.1	149.5	0.96	0.306	1.1	0.285	1.66	1.142	0.346	N/L
3.90	12.79	14424	33	70.5	70.5	170	0.23	1.4	Unsaturated	7	14424	1.10	157.0	158.4	0.96	0.306	1.1	0.356	1.77	1.165	0.440	N/L
4.00	13.12	10931	27	72.3	72.3	127	0.25	1.5	Unsaturated	8	10931	1.09	118.2	123.0	0.96	0.305	1.0	0.178	1.41	1.088	0.202	N/L
4.10	13.45	8329	23	74.1	74.1	95	0.28	1.6	Unsaturated	10	8329	1.09	89.5	99.7	0.96	0.305	1.0	0.137	1.26	1.056	0.149	N/L
4.20	13.78	5626	19	75.9	75.9	63	0.35	1.8	Unsaturated	13	5626	1.08	60.1	82.7	0.96	0.304	1.0	0.118	1.19	1.040	0.126	N/L
4.30	14.10	4148	15	77.7	77.7	46	0.36	2.0	Unsaturated	17	4148	1.07	44.0	75.3	0.95	0.304	1.0	0.112	1.16	1.035	0.118	N/L
4.40	14.43	4332	32	79.5	79.5	47	0.75	2.1	Unsaturated	19	4332	1.07	45.7	81.6	0.95	0.303	1.0	0.117	1.18	1.039	0.125	N/L
4.50	14.76	11786	50	81.4	81.4	129	0.43	1.6	Unsaturated	10	11786	1.06	123.6	135.7	0.95	0.303	1.0	0.217	1.52	1.111	0.248	N/L
4.60	15.09	19528	80	83.2	83.2	212	0.41	1.4	Unsaturated	7	19528	1.05	203.5	205.2	0.95	0.303	1.1	2.566	2.20	1.257	2.000	N/L
4.70	15.42	22555	78	85.0	85.0	242	0.35	1.3	Unsaturated	6	22555	1.05	233.7	233.9	0.95	0.302	1.1	2.000	2.20	1.257	2.000	N/L
4.80	15.74	25552	76	86.8	86.8	272	0.30	1.2	Unsaturated	4	25552	1.04	263.3	263.3	0.95	0.302	1.0	2.000	2.20	1.257	2.000	N/L
4.90	16.07	26673	76	88.6	88.6	281	0.29	1.2	Unsaturated	4	26673	1.04	273.4	273.4	0.95	0.301	1.0	2.000	2.20	1.257	2.000	N/L
5.00	16.40	26665	106	90.4	90.4	278	0.40	1.3	Unsaturated	6	26665	1.03	271.9	272.1	0.94	0.301	1.0	2.000	2.20	1.257	2.000	N/L
5.10	16.73	26667	133	92.2	92.2	275	0.50	1.4	Unsaturated	7	26667	1.02	270.5	272.5	0.94	0.300	1.0	2.000	2.20	1.257	2.000	N/L
5.20	17.06	26844	149	94.0	94.0	274	0.56	1.4	Unsaturated	7	26844	1.02	270.9	272.9	0.94	0.300	1.0	2.000	2.20	1.257	2.000	N/L
5.30	17.38	26063	159	95.8	95.8	264	0.61	1.5	Unsaturated	8	26063	1.01	261.7	269.9	0.94	0.299	1.0	2.000	2.20	1.257	2.000	N/L
5.40	17.71	24877	160	97.6	97.6	249	0.65	1.5	Unsaturated	8	24877	1.01	248.5	256.4	0.94	0.299	1.0	2.000	2.20	1.257	2.000	N/L
5.50	18.04	23841	161	99.4	99.4	237	0.68	1.5	Unsaturated	8	23841	1.00	237.0	244.7	0.94	0.298	1.0	2.000	2.20	1.257	2.000	N/L
5.60	18.37	23236	145	101.2	101.2	228	0.63	1.5	Unsaturated	8	23236	1.00	229.9	237.4	0.93	0.297	1.0	2.000	2.20	1.257	2.000	N/L
5.70	18.70	23046	150	103.0	103.0	225	0.65	1.5	Unsaturated	8	23046	0.99	227.0	234.4	0.93	0.297	1.0	2.000	2.20	1.257	2.000	N/L
5.80	19.02	23151	155	104.9	104.9	224	0.67	1.5	Unsaturated	8	23151	0.99	227.0	234.4	0.93	0.296	1.0	2.000	2.20	1.257	2.000	N/L
5.90	19.35	23275	158	106.7	106.7	223	0.68	1.5	Unsaturated	8	23275	0.99	227.2	234.6	0.93	0.296	1.0	2.000	2.20	1.257	2.000	N/L
6.00	19.68	23140	155	108.5	108.5	220	0.67	1.5	Unsaturated	8	23140	0.98	224.8	232.2	0.93	0.295	1.0	2.000	2.20	1.257	2.000	N/L
6.10	20.01	22956	153	110.3	110.3	216	0.67	1.5	Unsaturated	8	22956	0.98	222.1	229.4	0.93	0.295	1.0	2.000	2.20	1.257	2.000	N/L
6.20	20.34	22549	150	112.1	112.1	211	0.67	1.6	Unsaturated	10	22549	0.97	217.2	234.8	0.92	0.294	1.0	2.000	2.20	1.257	2.000	N/L
6.30	20.66	22177	144	113.9	113.9	205	0.65	1.6	Unsaturated	10	22177	0.97	212.7	230.1	0.92	0.294	1.0	2.000	2.20	1.257	2.000	N/L
6.40	20.99	21729	132	115.7	115.7	200	0.61	1.5	Unsaturated	8	21729	0.96	207.6	214.5	0.92	0.293	1.0	2.000	2.20	1.257	2.000	N/L
6.50	21.32	21409	132	117.5	117.5	195	0.62	1.6	Unsaturated	10	21409	0.96	203.7	220.5	0.92	0.293	1.0	2.000	2.20	1.257	2.000	N/L
6.60	21.65	21021	134	119.3	119.3	190	0.64	1.6	Unsaturated	10	21021	0.96	199.2	215.7	0.92	0.292	0.9	2.000	2.20	1.257	2.000	N/L
6.70	21.98	20799	134	121.1	121.1	187	0.65	1.6	Unsaturated	10	20799	0.95	196.3	212.7	0.92	0.292	0.9	2.000	2.20	1.257	2.000	N/L
6.80	22.30	20516	133	122.9	122.9	183	0.65	1.6	Unsaturated	10	20516	0.95	192.9	209.1	0.91	0.291	0.9	3.279	2.20	1.257	2.000	N/L
6.90	22.63	20460	123	124.7	124.7	181	0.61	1.6	Unsaturated	10	20460	0.95	191.6	207.7	0.91	0.291	0.9	3.007	2.20	1.257	2.000	N/L
7.00	22.96	20094	124	126.5	126.5	176	0.62	1.6	Unsaturated	10	20094	0.94	187.5	203.4	0.91	0.290	0.9	2.296	2.20	1.257	2.000	N/L
7.10	23.29	20439	132	128.4	128.4	178	0.65	1.6	Unsaturated	10	20439	0.94	190.0	206.0	0.91	0.289	0.9	2.698	2.20	1.257	2.000	N/L
7.20	23.62	20245	136	130.2	130.2	175	0.68	1.6	Unsaturated	10	20245	0.94	187.5	203.4	0.91	0.289	0.9	2.296	2.20	1.257	2.000	N/L
7.30	23.94	19914	132	132.0	132.0	171	0.67	1.6	Unsaturated	10	19914	0.93	183.7	199.4	0.91	0.288	0.9	1.829	2.20	1.257	2.000	N/L
7.40	24.27	19472	125	133.8	133.8	166	0.65	1.6	Unsaturated	10	19472	0.93	179.0	194.4	0.90	0.288	0.9	1.399	2.20	1.257	1.637	N/L
7.50	24.60	19717	122	135.6	135.6	167	0.62	1.6	Unsaturated	10	19717	0.93	180.6	196.1	0.90	0.287	0.9	1.529	2.20	1.257	1.780	N/L
7.60	24.93	19882	120	137.4	137.4	167	0.61	1.6	Unsaturated	10	19882	0.92	181.5	197.1	0.90	0.287	0.9	1.607	2.20	1.257	1.862	N/L
7.70	25.26	20000	123	139.2	139.2	167	0.62	1.6	Unsaturated	10	20000	0.92	181.9	197.5	0.90	0.286	0.9	1.648	2.20	1.257	1.902	N/L
7.80	25.58	20159	118	141.0	141.0	167	0.59	1.6	Unsaturated	10	20159	0.92	182.8	198.4	0.90	0.286	0.9	1.729	2.20	1.257	1.986	N/L
7.90	25.91	20181	120	142.8	142.8	167	0.60	1.6	Unsaturated	10	20181	0.91	182.4	198.0	0.89	0.285	0.9	1.687	2.20	1.257	1.933	N/L
8.00	26.24	20354	130	144.6	144.6	167	0.64	1.6	Unsaturated	10	20354	0.91	183.3	199.0	0.89	0.284	0.9	1.784	2.20	1.257	2.000	N/L
8.10	26.57	19194	128	146.4	146.4	156	0.67	1.6	Unsaturated	10	19194	0.91	172.3	187.3	0.89	0.284	0.9	0.993	2.20	1.257	1.142	N/L
8.20	26.90	18985	123	148.2	148.2	154	0.65	1.6	Unsaturated	10	18985	0.90	169.9	184.7	0.89	0.283	0.9	0.885	2.17	1.251	1.013	N/L
8.30	27.22	19006	124	150.0	150.0	153	0.66	1.7	Unsaturated	11	19006	0.90	169.5	196.2	0.89	0.283	0.9	1.539	2.20	1.257	1.742	N/L
8.40	27.55	18740	126	151.9	151.9	150	0.68	1.7	Unsaturated	11	18740	0.90	166.6	193.0	0.89	0.282	0.9	1.305	2.20	1.257	1.478	N/L
8.50	27.88	18643	123	153.7	153.7	148	0.66	1.7	Unsaturated	11	18643	0.90	165.2	191.5	0.88	0.281	0.9	1.210	2.20	1.257	1.368	N/L
8.60	28.21	17944	120	155.5	155.5	142	0.68	1.7	Unsaturated	11	17944	0.89	158.5	184.1	0.88	0.281	0.9	0.862	2.16	1.249	0.974	N/L
8.70	28.54	17097	109	157.3	157.3	134	0.64	1.7	Unsaturated	11	17097	0.89	150.6	175.4	0.88	0.280	0.9	0.608	2.01	1.218	0.673	N/L
8.80	28.86	16741	110	159.1	159.1	131	0.66	1.7	Unsaturated	11	16741	0.89	147.0	171.4	0.88	0.280	0.9	0.528	1.95	1.204	0.580	N/L

Settelemnt of Liquefiable Soil (Idriss and Boulnager, 2008)

Depth, Z (m)	q_t (kPa)	N_{60}	$N_{1,60}$	$\Delta(N_1)_{60}$	$N_{1,60-CS}$	Limiting Shear Strain γ_{lim}	Parameter F_α	Max. Shear Strain γ_{max}	ΔHi (m)	ΔLDI_i (m)	Vert. Recon. Strain ε_v	DF_i	ΔSi (inch)
1.60	28091	44.1	61.4	0.0	N.A.	0.000	0.000	0.000	0.05	0.0000	0.0000	0.91	0.00
1.70	23235	37.6	51.5	0.0	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.91	0.00
1.80	18975	31.7	42.7	0.1	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.90	0.00
1.90	15846	26.5	35.2	0.1	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.90	0.00
2.00	13733	23.7	31.0	0.4	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.89	0.00
2.10	12096	20.8	27.0	0.4	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.89	0.00
2.20	10502	18.7	23.9	0.9	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.88	0.00
2.30	9172	16.3	20.6	0.9	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.87	0.00
2.40	8058	14.8	18.6	1.7	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.87	0.00
2.50	7257	13.4	16.5	1.7	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.86	0.00
2.60	6847	12.6	15.4	1.7	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.86	0.00
2.70	6771	12.9	15.7	2.5	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.85	0.00
2.80	7618	14.0	16.8	1.7	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.85	0.00
2.90	9569	17.0	20.3	0.9	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.84	0.00
3.00	10909	18.8	22.2	0.4	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.84	0.00
3.10	10495	18.7	21.8	0.9	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.83	0.00
3.20	7289	13.9	16.1	2.5	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.83	0.00
3.30	5032	10.0	11.4	3.2	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.82	0.00
3.40	4038	8.3	9.5	3.8	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.81	0.00
3.50	3688	7.9	8.9	4.3	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.81	0.00
3.60	3988	8.5	9.6	4.3	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.80	0.00
3.70	6380	13.1	14.6	3.8	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.80	0.00
3.80	11494	19.8	21.9	0.4	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.79	0.00
3.90	12733	21.3	23.4	0.1	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.79	0.00
4.00	10839	18.7	20.4	0.4	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.78	0.00
4.10	8319	14.8	16.1	0.9	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.78	0.00
4.20	5735	10.9	11.8	2.5	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.77	0.00
4.30	4208	8.6	9.3	3.8	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.76	0.00
4.40	4332	9.3	9.9	4.3	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.76	0.00
4.50	11710	20.9	22.1	0.9	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.75	0.00
4.60	19379	32.4	34.1	0.1	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.75	0.00
4.70	22207	36.0	37.6	0.0	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.74	0.00
4.80	25235	39.7	41.3	0.0	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.74	0.00
4.90	26559	41.7	43.2	0.0	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.73	0.00
5.00	26671	43.2	44.5	0.0	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.73	0.00
5.10	26774	44.7	45.8	0.1	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.72	0.00
5.20	26797	44.7	45.6	0.1	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.72	0.00
5.30	26100	45.0	45.6	0.4	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.71	0.00
5.40	24912	42.9	43.3	0.4	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.70	0.00
5.50	23824	41.1	41.2	0.4	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.70	0.00
5.60	23237	40.0	40.0	0.4	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.69	0.00
5.70	23070	39.8	39.5	0.4	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.69	0.00
5.80	23172	39.9	39.5	0.4	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.68	0.00
5.90	23239	40.0	39.5	0.4	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.68	0.00
6.00	23141	39.9	39.1	0.4	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.67	0.00
6.10	22956	39.6	38.7	0.4	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.67	0.00
6.20	22565	40.2	39.1	0.9	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.66	0.00
6.30	22161	39.5	38.2	0.9	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.66	0.00
6.40	21725	37.4	36.1	0.4	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.65	0.00
6.50	21410	38.1	36.6	0.9	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.64	0.00
6.60	21082	37.5	35.9	0.9	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.64	0.00
6.70	20793	37.0	35.3	0.9	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.63	0.00
6.80	20535	36.6	34.7	0.9	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.63	0.00
6.90	20244	36.0	34.1	0.9	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.62	0.00
7.00	20095	35.8	33.7	0.9	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.62	0.00
7.10	20429	36.4	34.2	0.9	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.61	0.00
7.20	20276	36.1	33.8	0.9	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.61	0.00
7.30	19919	35.5	33.1	0.9	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.60	0.00
7.40	19621	34.9	32.4	0.9	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.60	0.00
7.50	19718	35.1	32.5	0.9	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.59	0.00
7.60	19919	35.5	32.7	0.9	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.58	0.00
7.70	20072	35.7	32.8	0.9	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.58	0.00
7.80	20147	35.9	32.9	0.9	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.57	0.00
7.90	20181	35.9	32.8	0.9	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.57	0.00
8.00	20189	36.0	32.7	0.9	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.56	0.00
8.10	19390	34.5	31.3	0.9	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.56	0.00
8.20	19002	33.8	30.6	0.9	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.55	0.00
8.30	19006	35.0	31.5	1.7	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.55	0.00
8.40	18832	34.7	31.2	1.7	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.54	0.00
8.50	18606	34.3	30.7	1.7	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.54	0.00
8.60	17940	33.0	29.5	1.7	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.53	0.00
8.70	17131	31.6	28.1	1.7	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.52	0.00
8.80	16760	30.9	27.4	1.7	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.52	0.00

Settlement of Unsaturated Sand (Tokimatsu & Seed, 1987, and Pradel, 1998) / Cumulative / S_r (Idriss & Boulanger, 2008)

Depth, Z (m)	$p = \sigma_m$ (tsf)	τ_{ave} (psf)	G_{max} (tsf)	τ_{ave}/G_{max}	a	b	γ_{eff} (%)	ε_{15} (%)	ε_{Nc} (%)	Settlement (inch)	Cumulative Settlement (inch)	$\Delta(N_1)_{60-Sr}$	$(N_1)_{60-Sr}$	S_r/σ_{v0}'
1.60	0.202	192	4111	0.00002	0.20272	16691	0.00252	0.001	0.001	0.00	0.60	N/A	N/A	N/A
1.70	0.215	204	3554	0.00003	0.20764	16095	0.00316	0.001	0.001	0.00	0.60	N/A	N/A	N/A
1.80	0.228	216	3033	0.00004	0.21256	15552	0.00402	0.002	0.001	0.00	0.60	N/A	N/A	N/A
1.90	0.240	228	2566	0.00004	0.21749	15056	0.00519	0.003	0.002	0.00	0.60	N/A	N/A	N/A
2.00	0.253	239	2323	0.00005	0.22241	14600	0.00621	0.004	0.003	0.00	0.59	N/A	N/A	N/A
2.10	0.266	251	2070	0.00006	0.22733	14178	0.00760	0.005	0.004	0.00	0.59	N/A	N/A	N/A
2.20	0.278	263	1878	0.00007	0.23225	13788	0.00916	0.007	0.006	0.00	0.59	N/A	N/A	N/A
2.30	0.291	275	1657	0.00008	0.23717	13425	0.01155	0.011	0.009	0.00	0.59	N/A	N/A	N/A
2.40	0.304	287	1521	0.00009	0.24209	13087	0.01390	0.015	0.013	0.00	0.59	N/A	N/A	N/A
2.50	0.316	299	1383	0.00011	0.24701	12770	0.01714	0.022	0.018	0.00	0.59	N/A	N/A	N/A
2.60	0.329	310	1317	0.00012	0.25193	12473	0.01971	0.027	0.022	0.00	0.59	N/A	N/A	N/A
2.70	0.342	322	1361	0.00012	0.25685	12194	0.01965	0.026	0.022	0.00	0.59	N/A	N/A	N/A
2.80	0.354	334	1492	0.00011	0.26177	11931	0.01770	0.022	0.018	0.00	0.59	N/A	N/A	N/A
2.90	0.367	346	1826	0.00009	0.26669	11682	0.01349	0.013	0.011	0.00	0.59	N/A	N/A	N/A
3.00	0.379	357	2031	0.00009	0.27161	11447	0.01206	0.011	0.009	0.00	0.58	N/A	N/A	N/A
3.10	0.392	369	2035	0.00009	0.27653	11224	0.01254	0.011	0.009	0.00	0.58	N/A	N/A	N/A
3.20	0.405	381	1526	0.00012	0.28145	11012	0.02056	0.027	0.022	0.00	0.58	N/A	N/A	N/A
3.30	0.417	392	1100	0.00018	0.28637	10811	0.04112	0.080	0.067	0.01	0.58	N/A	N/A	N/A
3.40	0.430	404	923	0.00022	0.29129	10619	0.06726	0.165	0.138	0.01	0.58	N/A	N/A	N/A
3.50	0.443	415	883	0.00024	0.29621	10436	0.08075	0.213	0.178	0.01	0.57	N/A	N/A	N/A
3.60	0.455	427	961	0.00022	0.30113	10261	0.06728	0.163	0.136	0.01	0.55	N/A	N/A	N/A
3.70	0.468	438	1488	0.00015	0.30605	10093	0.02655	0.039	0.032	0.00	0.54	N/A	N/A	N/A
3.80	0.481	450	2263	0.00010	0.31097	9933	0.01391	0.012	0.010	0.00	0.54	N/A	N/A	N/A
3.90	0.493	461	2443	0.00009	0.31589	9780	0.01288	0.011	0.009	0.00	0.54	N/A	N/A	N/A
4.00	0.506	473	2160	0.00011	0.32081	9632	0.01592	0.016	0.013	0.00	0.54	N/A	N/A	N/A
4.10	0.519	484	1723	0.00014	0.32573	9490	0.02370	0.031	0.026	0.00	0.54	N/A	N/A	N/A
4.20	0.531	496	1280	0.00019	0.33065	9354	0.04398	0.083	0.069	0.01	0.53	N/A	N/A	N/A
4.30	0.544	507	1017	0.00025	0.33557	9223	0.08107	0.204	0.171	0.01	0.53	N/A	N/A	N/A
4.40	0.557	518	1095	0.00024	0.34049	9097	0.06944	0.162	0.136	0.01	0.51	N/A	N/A	N/A
4.50	0.569	530	2479	0.00011	0.34541	8975	0.01509	0.013	0.011	0.00	0.50	N/A	N/A	N/A
4.60	0.582	541	3867	0.00007	0.35033	8857	0.00855	0.005	0.004	0.00	0.50	N/A	N/A	N/A
4.70	0.594	552	4319	0.00006	0.35525	8744	0.00765	0.004	0.003	0.00	0.50	N/A	N/A	N/A
4.80	0.607	563	4787	0.00006	0.36017	8634	0.00691	0.003	0.002	0.00	0.50	N/A	N/A	N/A
4.90	0.620	574	5062	0.00006	0.36509	8528	0.00662	0.003	0.002	0.00	0.50	N/A	N/A	N/A
5.00	0.632	586	5263	0.00006	0.37001	8425	0.00646	0.002	0.002	0.00	0.50	N/A	N/A	N/A
5.10	0.645	597	5474	0.00005	0.37493	8326	0.00630	0.002	0.002	0.00	0.50	N/A	N/A	N/A
5.20	0.658	608	5504	0.00006	0.37985	8229	0.00639	0.002	0.002	0.00	0.50	N/A	N/A	N/A
5.30	0.670	619	5558	0.00006	0.38477	8136	0.00645	0.002	0.002	0.00	0.50	N/A	N/A	N/A
5.40	0.683	630	5329	0.00006	0.38969	8045	0.00692	0.003	0.002	0.00	0.50	N/A	N/A	N/A
5.50	0.696	641	5118	0.00006	0.39461	7957	0.00740	0.003	0.003	0.00	0.50	N/A	N/A	N/A
5.60	0.708	651	5014	0.00006	0.39953	7871	0.00773	0.003	0.003	0.00	0.50	N/A	N/A	N/A
5.70	0.721	662	4998	0.00007	0.40446	7788	0.00791	0.003	0.003	0.00	0.50	N/A	N/A	N/A
5.80	0.734	673	5041	0.00007	0.40938	7707	0.00798	0.004	0.003	0.00	0.50	N/A	N/A	N/A
5.90	0.746	684	5076	0.00007	0.41430	7629	0.00806	0.004	0.003	0.00	0.50	N/A	N/A	N/A
6.00	0.759	695	5075	0.00007	0.41922	7552	0.00821	0.004	0.003	0.00	0.50	N/A	N/A	N/A
6.10	0.772	705	5054	0.00007	0.42414	7478	0.00840	0.004	0.003	0.00	0.50	N/A	N/A	N/A
6.20	0.784	716	5153	0.00007	0.42906	7405	0.00835	0.004	0.003	0.00	0.50	N/A	N/A	N/A
6.30	0.797	727	5080	0.00007	0.43398	7334	0.00864	0.004	0.003	0.00	0.50	N/A	N/A	N/A
6.40	0.810	737	4837	0.00008	0.43890	7265	0.00934	0.005	0.004	0.00	0.50	N/A	N/A	N/A
6.50	0.822	748	4944	0.00008	0.44382	7198	0.00924	0.004	0.004	0.00	0.50	N/A	N/A	N/A
6.60	0.835	758	4886	0.00008	0.44874	7132	0.00953	0.005	0.004	0.00	0.50	N/A	N/A	N/A
6.70	0.847	769	4836	0.00008	0.45366	7068	0.00981	0.005	0.004	0.00	0.50	N/A	N/A	N/A
6.80	0.860	779	4793	0.00008	0.45858	7006	0.01009	0.005	0.004	0.00	0.50	N/A	N/A	N/A
6.90	0.873	789	4741	0.00008	0.46350	6945	0.01039	0.005	0.005	0.00	0.50	N/A	N/A	N/A
7.00	0.885	800	4723	0.00008	0.46842	6885	0.01060	0.006	0.005	0.00	0.50	N/A	N/A	N/A
7.10	0.898	810	4817	0.00008	0.47334	6827	0.01050	0.006	0.005	0.00	0.50	N/A	N/A	N/A
7.20	0.911	820	4797	0.00009	0.47826	6770	0.01072	0.006	0.005	0.00	0.50	N/A	N/A	N/A
7.30	0.923	830	4728	0.00009	0.48318	6714	0.01108	0.006	0.005	0.00	0.50	N/A	N/A	N/A
7.40	0.936	840	4672	0.00009	0.48810	6659	0.01141	0.006	0.005	0.00	0.50	N/A	N/A	N/A
7.50	0.949	850	4710	0.00009	0.49302	6606	0.01146	0.006	0.005	0.00	0.50	N/A	N/A	N/A
7.60	0.961	860	4773	0.00009	0.49794	6553	0.01143	0.006	0.005	0.00	0.50	N/A	N/A	N/A
7.70	0.974	870	4825	0.00009	0.50286	6502	0.01143	0.006	0.005	0.00	0.49	N/A	N/A	N/A
7.80	0.987	880	4857	0.00009	0.50778	6452	0.01149	0.006	0.005	0.00	0.49	N/A	N/A	N/A
7.90	0.999	890	4880	0.00009	0.51270	6403	0.01157	0.006	0.005	0.00	0.49	N/A	N/A	N/A
8.00	1.012	900	4897	0.00009	0.51762	6355	0.01168	0.006	0.005	0.00	0.49	N/A	N/A	N/A
8.10	1.025	910	4717	0.00010	0.52254	6308	0.01242	0.007	0.006	0.00	0.49	N/A	N/A	N/A
8.20	1.037	920	4636	0.00010	0.52746	6261	0.01287	0.008	0.006	0.00	0.49	N/A	N/A	N/A
8.30	1.050	929	4810	0.00010	0.53238	6216	0.01242	0.007	0.006	0.00	0.49	N/A	N/A	N/A
8.40	1.062	939	4780	0.00010	0.53730	6171	0.01268	0.007	0.006	0.00	0.49	N/A	N/A	N/A
8.50	1.075	948	4736	0.00010	0.54222	6128	0.01300	0.008	0.007	0.00	0.49	N/A	N/A	N/A
8.60	1.088	958	4579	0.00010	0.54714	6085	0.01375	0.009	0.007	0.00	0.49	N/A	N/A	N/A
8.70	1.100	967	4384	0.00011	0.55206	6043	0.01475	0.010	0.008	0.00	0.49	N/A	N/A	N/A
8.80	1.113	977	4301	0.00011	0.55698	6002	0.01533	0.011	0.009	0.00	0.49	N/A	N/A	N/A

Depth, Z (m)	Depth, Z (ft)	q_c (kPa)	f_s (kPa)	σ_{vc} (kPa)	σ'_{vc} (kPa)	Q	F	I_c	Soil Type	Fines (%)	Interpreted q_c	C_N	q_{c1N}	q_{c1N-cs}	Stress Reduction Factor (r_d)	CSR	K_σ for sand
8.90	29.19	16718	112	160.9	160.9	130	0.68	1.7	Unsaturated	11	16718	0.88	146.4	170.7	0.88	0.279	0.9
9.00	29.52	16934	112	162.7	162.7	131	0.67	1.7	Unsaturated	11	16934	0.88	147.8	172.3	0.87	0.279	0.9
9.10	29.85	17179	115	164.5	164.5	132	0.67	1.7	Unsaturated	11	17179	0.88	149.6	174.2	0.87	0.278	0.9
9.20	30.18	16707	116	166.3	166.3	127	0.70	1.7	Unsaturated	11	16707	0.88	145.0	169.2	0.87	0.277	0.9
9.30	30.50	16797	114	168.1	168.1	127	0.69	1.7	Unsaturated	11	16797	0.87	145.4	169.6	0.87	0.277	0.9
9.40	30.83	17418	116	169.9	169.9	131	0.67	1.7	Unsaturated	11	17418	0.87	150.3	175.1	0.87	0.276	0.9
9.50	31.16	19079	124	171.7	171.7	143	0.65	1.7	Unsaturated	11	19079	0.87	164.2	190.4	0.87	0.276	0.9
9.60	31.49	20628	130	173.5	173.5	154	0.63	1.6	Unsaturated	10	20628	0.87	177.1	192.3	0.86	0.275	0.9
9.70	31.82	22443	144	175.4	175.4	167	0.64	1.6	Unsaturated	10	22443	0.86	192.1	208.3	0.86	0.274	0.8
9.80	32.14	24461	151	177.2	177.2	181	0.62	1.6	Unsaturated	10	24461	0.86	208.8	225.9	0.86	0.274	0.8
9.90	32.47	26803	154	179.0	179.0	198	0.58	1.5	Unsaturated	8	26803	0.86	228.2	235.6	0.86	0.273	0.8
10.00	32.80	27001	182	180.8	180.5	198	0.68	1.6		10	27001	0.86	229.4	247.7	0.86	0.273	0.8
10.10	33.13	25765	198	182.8	181.5	189	0.78	1.6		10	25765	0.86	218.5	236.2	0.85	0.274	0.8
10.20	33.46	22431	178	184.8	182.5	164	0.80	1.7		11	22431	0.86	190.0	218.9	0.85	0.275	0.8
10.30	33.78	20537	154	186.7	183.5	149	0.76	1.7		11	20537	0.85	173.7	200.9	0.85	0.276	0.8
10.40	34.11	17533	93	188.7	184.5	127	0.54	1.7		11	17533	0.85	148.1	172.6	0.85	0.276	0.9
10.50	34.44	15223	94	190.7	185.4	110	0.62	1.8		13	15223	0.85	128.4	161.5	0.85	0.277	0.9
10.60	34.77	14536	93	192.6	186.4	104	0.65	1.8		13	14536	0.85	122.4	154.7	0.84	0.278	0.9
10.70	35.10	14051	88	194.6	187.4	101	0.63	1.8		13	14051	0.85	118.2	149.7	0.84	0.279	0.9
10.80	35.42	14288	82	196.5	188.4	102	0.58	1.8		13	14288	0.85	120.0	151.9	0.84	0.279	0.9
10.90	35.75	15117	89	198.5	189.4	108	0.60	1.7		11	15117	0.85	126.8	149.1	0.84	0.280	0.9
11.00	36.08	16628	108	200.5	190.4	118	0.66	1.7		11	16628	0.85	139.3	162.8	0.84	0.281	0.9
11.10	36.41	16852	120	202.4	191.4	120	0.72	1.8		13	16852	0.84	141.0	176.1	0.84	0.281	0.9
11.20	36.74	16985	124	204.4	192.3	120	0.74	1.8		13	16985	0.84	141.9	177.1	0.83	0.282	0.9
11.30	37.06	18725	108	206.4	193.3	132	0.58	1.7		11	18725	0.84	156.2	181.5	0.83	0.283	0.9
11.40	37.39	21906	96	208.3	194.3	155	0.44	1.5		8	21906	0.84	182.5	188.9	0.83	0.283	0.8
11.50	37.72	24455	103	210.3	195.3	172	0.42	1.5		8	24455	0.84	203.5	210.3	0.83	0.284	0.8
11.60	38.05	24641	111	212.3	196.3	173	0.45	1.5		8	24641	0.84	204.7	211.6	0.83	0.284	0.8
11.70	38.38	23127	107	214.2	197.3	162	0.47	1.5		8	23127	0.84	191.9	198.5	0.82	0.285	0.8
11.80	38.70	22384	104	216.2	198.2	156	0.47	1.6		10	22384	0.84	185.5	201.3	0.82	0.286	0.8
11.90	39.03	21130	103	218.2	199.2	147	0.49	1.6		10	21130	0.84	174.9	190.0	0.82	0.286	0.8
12.00	39.36	12326	94	220.1	200.2	85	0.78	1.9		15	12326	0.83	101.9	139.7	0.82	0.287	0.9
12.10	39.69	4741	86	222.1	201.2	32	1.90	2.5		30	4741	0.83	39.1	81.3	0.82	0.287	0.9
12.20	40.02	2688	35	224.1	202.2	17	1.44	2.6	Clay-Like	34	2688	0.83	22.2	59.3	0.81	0.287	0.9
12.30	40.34	1983	6	226.0	203.2	12	0.32	2.5		30	1983	0.83	16.3	50.8	0.81	0.288	0.9
12.40	40.67	1741	7	228.0	204.1	11	0.44	2.6	Clay-Like	34	1741	0.83	14.3	48.8	0.81	0.288	1.0
12.50	41.00	1779	12	230.0	205.1	11	0.79	2.7	Clay-Like	37	1779	0.83	14.6	49.6	0.81	0.289	0.9
12.60	41.33	3390	20	231.9	206.1	22	0.62	2.4		27	3390	0.83	27.8	65.1	0.81	0.289	0.9
12.70	41.66	4555	38	233.9	207.1	30	0.89	2.3		24	4555	0.83	37.3	76.2	0.80	0.289	0.9
12.80	41.98	5650	60	235.8	208.1	37	1.11	2.3		24	5650	0.83	46.2	87.9	0.80	0.290	0.9
12.90	42.31	6685	59	237.8	209.1	44	0.92	2.2		22	6685	0.83	54.6	96.4	0.80	0.290	0.9
13.00	42.64	6317	83	239.8	210.0	42	1.36	2.3		24	6317	0.82	51.6	94.9	0.80	0.291	0.9
13.10	42.97	7039	78	241.7	211.0	46	1.15	2.2		22	7039	0.82	57.4	99.9	0.80	0.291	0.9
13.20	43.30	7240	76	243.7	212.0	48	1.09	2.2		22	7240	0.82	58.9	102.0	0.80	0.291	0.9
13.30	43.62	6340	107	245.7	213.0	41	1.75	2.4		27	6340	0.82	51.6	96.6	0.79	0.291	0.9
13.40	43.95	5741	90	247.6	214.0	37	1.64	2.4		27	5741	0.82	46.6	90.1	0.79	0.292	0.9
13.50	44.28	4706	69	249.6	215.0	30	1.55	2.4		27	4706	0.82	38.2	78.9	0.79	0.292	0.9
13.60	44.61	3517	37	251.6	216.0	22	1.12	2.5		30	3517	0.82	28.5	67.1	0.79	0.292	0.9

Depth, Z (m)	$CRR_{M=7.5}$ at $\sigma'_{vc}=1$	MSF_{max}	MSF	CRR	$(FS)_L$	q_t (kPa)	N_{60}	$N_{1,60}$	$\Delta(N_1)_{60}$	$N_{1,60-CS}$	Limiting Shear Strain γ_{lim}	Parameter F_α	Max. Shear Strain γ_{max}	ΔHi (m)	ΔLDI_i (m)	Vert. Recon. Strain ε_v	DF_i
8.90	0.515	1.94	1.202	0.564	**N/L**	16717	30.8	27.2	1.7	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.51
9.00	0.545	1.97	1.207	0.596	**N/L**	16928	31.2	27.5	1.7	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.51
9.10	0.582	2.00	1.214	0.638	**N/L**	17017	31.3	27.6	1.7	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.50
9.20	0.490	1.92	1.197	0.531	**N/L**	16746	30.8	27.0	1.7	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.50
9.30	0.497	1.93	1.199	0.537	**N/L**	16797	30.9	27.0	1.7	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.49
9.40	0.601	2.01	1.217	0.654	**N/L**	17461	32.2	28.0	1.7	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.49
9.50	1.145	2.20	1.257	1.260	**N/L**	19024	35.0	30.5	1.7	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.48
9.60	1.261	2.20	1.257	1.378	**N/L**	20671	36.8	31.9	0.9	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.48
9.70	3.112	2.20	1.257	2.000	**N/L**	22384	39.9	34.5	0.9	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.47
9.80	2.000	2.20	1.257	2.000	**N/L**	24512	43.7	37.6	0.9	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.46
9.90	2.000	2.20	1.257	2.000	**N/L**	26551	45.8	39.3	0.4	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.46
10.00	2.000	2.20	1.257	2.000	**2.00**	26928	48.0	41.1	0.9	42.1	0.006	-0.962	0.000	0.10	0.0000	0.0000	0.45
10.10	2.000	2.20	1.257	2.000	**2.00**	25471	45.4	38.9	0.9	39.8	0.009	-0.788	0.000	0.10	0.0000	0.0000	0.45
10.20	2.000	2.20	1.257	2.000	**2.00**	22607	41.6	35.6	1.7	37.3	0.015	-0.603	0.000	0.10	0.0000	0.0000	0.44
10.30	1.985	2.20	1.257	2.000	**2.00**	20382	37.5	32.1	1.7	33.7	0.027	-0.347	0.000	0.10	0.0000	0.0000	0.44
10.40	0.550	1.97	1.208	0.586	**2.00**	17471	32.2	27.5	1.7	29.1	0.052	-0.031	0.000	0.10	0.0000	0.0000	0.43
10.50	0.388	1.81	1.174	0.406	**1.47**	15291	29.2	24.9	2.5	27.3	0.066	0.087	0.012	0.10	0.0012	0.0027	0.43
10.60	0.323	1.72	1.155	0.335	**1.20**	14533	27.7	23.6	2.5	26.1	0.078	0.167	0.022	0.10	0.0022	0.0051	0.42
10.70	0.287	1.67	1.143	0.296	**1.06**	14156	27.0	22.9	2.5	25.4	0.084	0.207	0.031	0.10	0.0031	0.0071	0.42
10.80	0.301	1.69	1.148	0.311	**1.11**	14285	27.3	23.1	2.5	25.6	0.083	0.196	0.027	0.10	0.0027	0.0063	0.41
10.90	0.282	1.66	1.141	0.290	**1.04**	15142	27.9	23.6	1.7	25.3	0.086	0.213	0.032	0.10	0.0032	0.0076	0.40
11.00	0.403	1.83	1.178	0.420	**1.50**	16497	30.4	25.7	1.7	27.4	0.066	0.083	0.011	0.10	0.0011	0.0025	0.40
11.10	0.623	2.03	1.220	0.662	**2.00**	16906	32.3	27.3	2.5	29.7	0.048	-0.070	0.000	0.10	0.0000	0.0000	0.39
11.20	0.649	2.04	1.224	0.689	**2.00**	17218	32.9	27.7	2.5	30.2	0.045	-0.101	0.000	0.10	0.0000	0.0000	0.39
11.30	0.773	2.12	1.239	0.824	**2.00**	18840	34.7	29.2	1.7	30.9	0.041	-0.150	0.000	0.10	0.0000	0.0000	0.38
11.40	1.065	2.20	1.257	1.136	**2.00**	21738	37.5	31.5	0.4	31.9	0.035	-0.218	0.000	0.10	0.0000	0.0000	0.38
11.50	3.558	2.20	1.257	2.000	**2.00**	24206	41.7	35.1	0.4	35.4	0.020	-0.467	0.000	0.10	0.0000	0.0000	0.37
11.60	2.000	2.20	1.257	2.000	**2.00**	24479	42.2	35.4	0.4	35.8	0.019	-0.492	0.000	0.10	0.0000	0.0000	0.37
11.70	1.737	2.20	1.257	1.807	**2.00**	23261	40.1	33.6	0.4	34.0	0.026	-0.363	0.000	0.10	0.0000	0.0000	0.36
11.80	2.033	2.20	1.257	2.000	**2.00**	22489	40.0	33.5	0.9	34.4	0.024	-0.397	0.000	0.10	0.0000	0.0000	0.35
11.90	1.127	2.20	1.257	1.191	**2.00**	20451	36.4	30.4	0.9	31.4	0.038	-0.182	0.000	0.10	0.0000	0.0000	0.35
12.00	0.233	1.56	1.120	0.235	**0.82**	12378	24.5	20.4	3.2	23.7	0.104	0.313	0.056	0.10	0.0056	0.0140	0.34
12.10	0.117	1.18	1.039	0.114	**0.40**	5000	12.7	10.6	5.4	16.0	0.247	0.713	0.247	0.10	0.0247	0.0275	0.34
12.20	0.099	1.13	1.027	0.096	**N/L**	2899	7.7	6.4	5.5	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.33
12.30	0.093	1.11	1.024	0.090	**0.31**	2139	5.4	4.5	5.4	9.9	0.478	0.916	0.478	0.10	0.0478	0.0376	0.33
12.40	0.091	1.11	1.024	0.089	**N/L**	1760	4.7	3.9	5.5	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.32
12.50	0.092	1.11	1.024	0.089	**N/L**	1991	5.6	4.6	5.5	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.32
12.60	0.103	1.14	1.029	0.100	**0.35**	3414	8.3	6.9	5.2	12.1	0.376	0.859	0.376	0.10	0.0376	0.0332	0.31
12.70	0.112	1.17	1.036	0.109	**0.38**	4605	10.7	8.9	5.0	13.9	0.311	0.798	0.311	0.10	0.0311	0.0304	0.31
12.80	0.123	1.21	1.044	0.120	**0.41**	5732	13.3	11.0	5.0	16.0	0.246	0.711	0.246	0.10	0.0246	0.0274	0.30
12.90	0.133	1.24	1.052	0.129	**0.45**	6508	14.5	12.0	4.7	16.7	0.229	0.681	0.229	0.10	0.0229	0.0266	0.29
13.00	0.131	1.24	1.051	0.127	**0.44**	6323	14.7	12.1	5.0	17.1	0.218	0.661	0.218	0.10	0.0218	0.0261	0.29
13.10	0.137	1.26	1.056	0.134	**0.46**	6926	15.4	12.7	4.7	17.4	0.211	0.647	0.211	0.10	0.0211	0.0257	0.28
13.20	0.140	1.27	1.058	0.136	**0.47**	7209	16.0	13.2	4.7	17.9	0.200	0.623	0.200	0.10	0.0200	0.0252	0.28
13.30	0.133	1.24	1.052	0.129	**0.44**	6486	15.7	12.9	5.2	18.2	0.195	0.611	0.195	0.10	0.0195	0.0249	0.27
13.40	0.126	1.22	1.046	0.122	**0.42**	5699	13.8	11.4	5.2	16.6	0.232	0.686	0.232	0.10	0.0232	0.0267	0.27
13.50	0.115	1.17	1.037	0.111	**0.38**	4764	11.6	9.5	5.2	14.7	0.284	0.766	0.284	0.10	0.0284	0.0291	0.26
13.60	0.105	1.14	1.030	0.101	**0.35**	3473	8.8	7.2	5.4	12.6	0.356	0.843	0.356	0.05	0.0178	0.0324	0.26

Depth, Z (m)	ΔSi (inch)	$p = \sigma_m$ (tsf)	τ_{ave} (psf)	G_{max} (tsf)	τ_{ave}/G_{max}	a	b	γ_{eff} (%)	ε_{15} (%)	ε_{Nc} (%)	Settlement (inch)	Settlement (inch)	$\Delta(N_1)_{60-Sr}$	$(N_1)_{60-Sr}$	S_r/σ_{v0}'
8.90	0.00	1.126	986	4301	0.00011	0.56190	5961	0.01551	0.011	0.009	0.00	0.49	N/A	N/A	N/A
9.00	0.00	1.138	996	4367	0.00011	0.56682	5921	0.01537	0.010	0.009	0.00	0.49	N/A	N/A	N/A
9.10	0.00	1.151	1005	4401	0.00011	0.57174	5882	0.01539	0.010	0.009	0.00	0.49	N/A	N/A	N/A
9.20	0.00	1.164	1014	4343	0.00012	0.57666	5844	0.01585	0.011	0.009	0.00	0.49	N/A	N/A	N/A
9.30	0.00	1.176	1023	4367	0.00012	0.58158	5806	0.01591	0.011	0.009	0.00	0.49	N/A	N/A	N/A
9.40	0.00	1.189	1032	4551	0.00011	0.58650	5769	0.01521	0.010	0.008	0.00	0.49	N/A	N/A	N/A
9.50	0.00	1.202	1041	4971	0.00010	0.59143	5732	0.01368	0.008	0.007	0.00	0.48	N/A	N/A	N/A
9.60	0.00	1.214	1050	5234	0.00010	0.59635	5696	0.01292	0.007	0.006	0.00	0.48	N/A	N/A	N/A
9.70	0.00	1.227	1059	5682	0.00009	0.60127	5661	0.01175	0.006	0.005	0.00	0.48	N/A	N/A	N/A
9.80	0.00	1.240	1068	6237	0.00009	0.60619	5626	0.01056	0.005	0.004	0.00	0.48	N/A	N/A	N/A
9.90	0.00	1.252	1077	6554	0.00008	0.61111	5592	0.01003	0.004	0.004	0.00	0.48	N/A	N/A	N/A
10.00	0.00	1.263	1086	6882	0.00008	0.61534	5563	0.00955	0.004	0.003	0.00	0.48	0.9	42	N/A
10.10	0.00	1.270	1096	6518	0.00008	0.61802	5545	0.01031	0.005	0.004	0.00	0.48	0.9	40	N/A
10.20	0.00	1.277	1105	5993	0.00009	0.62070	5527	0.01157	0.006	0.005	0.00	0.48	1.0	37	N/A
10.30	0.00	1.284	1115	5410	0.00010	0.62338	5509	0.01333	0.008	0.006	0.00	0.48	1.0	33	N/A
10.40	0.00	1.291	1124	4643	0.00012	0.62606	5492	0.01651	0.011	0.009	0.00	0.48	1.0	28	N/A
10.50	0.00	1.298	1134	4214	0.00013	0.62873	5474	0.01910	0.015	0.012	0.00	0.48	1.2	26	N/A
10.60	0.01	1.304	1143	4010	0.00014	0.63141	5457	0.02074	0.017	0.014	0.00	0.48	1.2	25	N/A
10.70	0.01	1.311	1152	3911	0.00015	0.63409	5440	0.02176	0.018	0.015	0.00	0.47	1.2	24	N/A
10.80	0.01	1.318	1162	3951	0.00015	0.63677	5422	0.02167	0.018	0.015	0.00	0.46	1.2	24	N/A
10.90	0.01	1.325	1171	4049	0.00014	0.63945	5406	0.02114	0.017	0.014	0.00	0.45	1.0	25	N/A
11.00	0.00	1.332	1180	4417	0.00013	0.64212	5389	0.01886	0.014	0.012	0.00	0.44	1.0	27	N/A
11.10	0.00	1.339	1189	4694	0.00013	0.64480	5372	0.01751	0.012	0.010	0.00	0.43	1.2	28	N/A
11.20	0.00	1.346	1198	4786	0.00013	0.64748	5356	0.01721	0.012	0.010	0.00	0.43	1.2	29	N/A
11.30	0.00	1.353	1207	5062	0.00012	0.65016	5339	0.01610	0.010	0.009	0.00	0.43	1.0	30	N/A
11.40	0.00	1.359	1216	5471	0.00011	0.65284	5323	0.01465	0.008	0.007	0.00	0.43	0.7	32	N/A
11.50	0.00	1.366	1225	6099	0.00010	0.65551	5307	0.01284	0.007	0.005	0.00	0.43	0.7	36	N/A
11.60	0.00	1.373	1233	6175	0.00010	0.65819	5291	0.01275	0.006	0.005	0.00	0.43	0.7	36	N/A
11.70	0.00	1.380	1242	5875	0.00011	0.66087	5275	0.01371	0.007	0.006	0.00	0.43	0.7	34	N/A
11.80	0.00	1.387	1251	5876	0.00011	0.66355	5259	0.01383	0.007	0.006	0.00	0.43	0.9	34	N/A
11.90	0.00	1.394	1259	5350	0.00012	0.66623	5244	0.01579	0.010	0.008	0.00	0.43	0.9	31	N/A
12.00	0.02	1.401	1268	3602	0.00018	0.66891	5228	0.02825	0.028	0.023	0.00	0.43	1.3	22	0.20
12.10	0.04	1.408	1276	1873	0.00034	0.67158	5213	0.10126	0.217	0.181	0.00	0.41	2.6	13	0.11
12.20	0.00	1.415	1285	1142	0.00056	0.67426	5198	0.45575	1.773	1.482	0.00	0.38	N/A	N/A	N/A
12.30	0.05	1.421	1293	803	0.00080	0.67694	5183	2.15362	12.810	10.711	0.00	0.38	2.6	7	0.07
12.40	0.00	1.428	1301	695	0.00094	0.67962	5168	4.84821	34.425	28.785	0.00	0.33	N/A	N/A	N/A
12.50	0.00	1.435	1309	828	0.00079	0.68230	5153	1.93083	11.134	9.310	0.00	0.33	N/A	N/A	N/A
12.60	0.04	1.442	1318	1228	0.00054	0.68497	5138	0.37560	1.354	1.133	0.00	0.33	2.4	9	0.09
12.70	0.04	1.449	1326	1586	0.00042	0.68765	5123	0.16971	0.451	0.377	0.00	0.29	2.1	11	0.10
12.80	0.03	1.456	1334	1976	0.00034	0.69033	5109	0.09726	0.199	0.167	0.00	0.25	2.1	13	0.11
12.90	0.03	1.463	1342	2152	0.00031	0.69301	5094	0.08083	0.150	0.125	0.00	0.22	1.9	14	0.12
13.00	0.03	1.470	1350	2185	0.00031	0.69569	5080	0.07907	0.144	0.121	0.00	0.19	2.1	14	0.12
13.10	0.03	1.477	1357	2296	0.00030	0.69837	5066	0.07176	0.124	0.104	0.00	0.16	1.9	15	0.12
13.20	0.03	1.483	1365	2392	0.00029	0.70104	5052	0.06647	0.109	0.092	0.00	0.13	1.9	15	0.13
13.30	0.03	1.490	1373	2350	0.00029	0.70372	5038	0.06967	0.118	0.098	0.00	0.10	2.4	15	0.13
13.40	0.03	1.497	1381	2068	0.00033	0.70640	5024	0.09351	0.184	0.154	0.00	0.07	2.4	14	0.12
13.50	0.03	1.504	1388	1730	0.00040	0.70908	5010	0.14766	0.362	0.303	0.00	0.05	2.4	12	0.10
13.60	0.02	1.511	1396	1323	0.00053	0.71176	4996	0.33671	1.142	0.954	0.00	0.02	2.6	10	0.09

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CONE PENETRATION TEST-BASED LIQUEFACTION ANALYSIS BASED ON IDRISS & BOULANGER (2008)

References:

1 - Idriss, I.M. and Boulanger, R.W. (2008). *Soil Liquefaction During Earthquakes* , Earthquake Engineering Research Institute, EERI Publication MNO-12.

2 - Ishihara, K. and Yoshimine, M. (1992). "Evaluation of Settlements in Sand Deposits Following Liquefaction During Earthquakes," *Soils and Foundations* , Vol. 32, No. 1, pp. 173-188, March 1992.

3 - Tokimatsu, K. and Seed H.B. (1987). "Evaluation of Settlements in Sands Due to Earthquake Shaking," Journal of Geotechnical Engineering, Vol. 113, No. 8, August.

4 - Pradel, D. (1998). "Procedure to Evaluate Earthquake-Induced Settlements in Sand," Journal of Geotechnical and Geoenvironmental Engineering, Vol. 124, No. 4, April.

5 - Cetin, K.O., Bilge, H.T., Wu, J., Kammerer, A.M., and Seed R.B. (2009). "Procedure to Evaluate Earthquake-Induced Settlements in Sand," Journal of Geotechnical and Geoenvironmental Engineering, Vol. 135, No. 3, March.

6 - Boulanger, R.W. and Idriss, I.M. (2014). "CPT and SPT Based Liquefaction Triggering Procedures," Report No. UCD/CGM-14/01, University of California at Davis

Project	**Chevron Guadalupe Tank Battery 9 Site**
Test Boring No	**TSMACPT-13**

Test Boring Information:

Approx. depth to ground water table		44.7 ft	13.63 m
Moist unit weight of soil	γ_m	115 pcf	18.08 kN/m^3
Saturated unit weight of soil	γ_{sat}	125 pcf	19.65 kN/m^3

Earthquake Information:

Earthquake magnitude	M_w	6.9
Peak horizontal ground surface acceleratio	a_{max}	0.490 g
Number of equivalent cycle	N	10.1

Atmospheric pressure	P_a	101.3 kPa

N/L = Non-liquefiable clay-like soil

N.A. = Not Applicable

Sum
0.05

Sum	Total
1.43	1.48

Factor of Safety Agaist Liquefaction (Idriss & Boulanger, 2008 and Boulanger & Idriss, 2014)

Depth, Z (m)	Depth, Z (ft)	q_c (kPa)	f_s (kPa)	σ_{vc} (kPa)	σ'_{vc} (kPa)	Q	F	I_c	Soil Type	Fines (%)	Interpreted q_c	C_N	q_{c1N}	q_{c1N-cs}	Stress Reduction Factor (r_d)	CSR	K_σ for sand	$CRR_{M=7.5}$ at σ'_{vc}=1	MSF_{max}	MSF	CRR	$(FS)_L$
1.60	5.25	17091	130	28.9	28.9	315	0.76	1.5	Unsaturated	8	17091	1.39	235.3	243.0	0.99	0.315	1.1	2.000	2.20	1.257	2.000	N/L
1.70	5.58	12490	135	30.7	30.7	223	1.09	1.7	Unsaturated	11	12490	1.37	169.3	196.0	0.99	0.315	1.1	1.516	2.20	1.257	2.000	N/L
1.80	5.90	17563	182	32.5	32.5	305	1.04	1.6	Unsaturated	10	17563	1.35	234.5	253.1	0.99	0.315	1.1	2.000	2.20	1.257	2.000	N/L
1.90	6.23	23877	193	34.3	34.3	404	0.81	1.4	Unsaturated	7	23877	1.33	314.2	316.5	0.99	0.314	1.1	2.000	2.20	1.257	2.000	N/L
2.00	6.56	26886	191	36.2	36.2	444	0.71	1.4	Unsaturated	7	26886	1.31	349.1	351.6	0.99	0.314	1.1	2.000	2.20	1.257	2.000	N/L
2.10	6.89	28172	192	38.0	38.0	454	0.68	1.3	Unsaturated	6	28172	1.29	361.1	361.4	0.98	0.314	1.1	2.000	2.20	1.257	2.000	N/L
2.20	7.22	26786	181	39.8	39.8	421	0.68	1.3	Unsaturated	6	26786	1.28	339.1	339.4	0.98	0.313	1.1	2.000	2.20	1.257	2.000	N/L
2.30	7.54	21195	176	41.6	41.6	326	0.83	1.5	Unsaturated	8	21195	1.26	265.2	273.5	0.98	0.313	1.1	2.000	2.20	1.257	2.000	N/L
2.40	7.87	19501	163	43.4	43.4	294	0.84	1.5	Unsaturated	8	19501	1.25	241.3	249.0	0.98	0.312	1.1	2.000	2.20	1.257	2.000	N/L
2.50	8.20	17168	129	45.2	45.2	253	0.75	1.5	Unsaturated	8	17168	1.24	210.1	217.2	0.98	0.312	1.1	2.000	2.20	1.257	2.000	N/L
2.60	8.53	15498	112	47.0	47.0	224	0.72	1.6	Unsaturated	10	15498	1.22	187.8	203.7	0.98	0.312	1.1	2.338	2.20	1.257	2.000	N/L
2.70	8.86	14530	110	48.8	48.8	206	0.76	1.6	Unsaturated	10	14530	1.21	174.3	189.4	0.98	0.311	1.1	1.094	2.20	1.257	1.513	N/L
2.80	9.18	11993	96	50.6	50.6	167	0.80	1.7	Unsaturated	11	11993	1.20	142.5	166.4	0.98	0.311	1.1	0.448	1.88	1.189	0.586	N/L
2.90	9.51	10273	81	52.4	52.4	140	0.79	1.7	Unsaturated	11	10273	1.19	120.9	142.6	0.97	0.310	1.1	0.246	1.59	1.126	0.305	N/L
3.00	9.84	8886	76	54.2	54.2	119	0.86	1.8	Unsaturated	13	8886	1.18	103.7	133.0	0.97	0.310	1.1	0.207	1.49	1.106	0.249	N/L
3.10	10.17	7579	69	56.0	56.0	100	0.92	1.9	Unsaturated	15	7579	1.17	87.7	122.6	0.97	0.309	1.1	0.177	1.41	1.087	0.207	N/L
3.20	10.50	6243	58	57.8	57.8	81	0.94	2.0	Unsaturated	17	6243	1.16	71.6	109.6	0.97	0.309	1.1	0.151	1.32	1.068	0.172	N/L
3.30	10.82	5178	51	59.7	59.7	66	1.00	2.1	Unsaturated	19	5178	1.15	58.9	98.4	0.97	0.309	1.1	0.135	1.25	1.054	0.150	N/L
3.40	11.15	4490	41	61.5	61.5	56	0.92	2.1	Unsaturated	19	4490	1.14	50.7	87.9	0.97	0.308	1.0	0.123	1.21	1.044	0.135	N/L
3.50	11.48	3886	38	63.3	63.3	48	1.00	2.2	Unsaturated	22	3886	1.13	43.5	82.0	0.97	0.308	1.0	0.118	1.18	1.040	0.128	N/L
3.60	11.81	3591	37	65.1	65.1	43	1.05	2.2	Unsaturated	22	3591	1.12	39.9	77.3	0.96	0.307	1.0	0.113	1.17	1.036	0.122	N/L
3.70	12.14	3354	36	66.9	66.9	40	1.10	2.3	Unsaturated	24	3354	1.11	37.0	75.8	0.96	0.307	1.0	0.112	1.16	1.035	0.120	N/L
3.80	12.46	3245	36	68.7	68.7	38	1.13	2.3	Unsaturated	24	3245	1.11	35.6	73.9	0.96	0.306	1.0	0.110	1.16	1.034	0.118	N/L
3.90	12.79	3018	36	70.5	70.5	35	1.22	2.3	Unsaturated	24	3018	1.10	32.9	70.3	0.96	0.306	1.0	0.107	1.15	1.032	0.114	N/L
4.00	13.12	2912	35	72.3	72.3	33	1.24	2.3	Unsaturated	24	2912	1.09	31.5	68.5	0.96	0.305	1.0	0.106	1.15	1.031	0.112	N/L
4.10	13.45	2797	34	74.1	74.1	31	1.27	2.4	Unsaturated	27	2797	1.09	30.0	68.1	0.96	0.305	1.0	0.106	1.14	1.031	0.112	N/L
4.20	13.78	2725	34	75.9	75.9	30	1.29	2.4	Unsaturated	27	2725	1.08	29.1	66.8	0.96	0.304	1.0	0.105	1.14	1.030	0.110	N/L
4.30	14.10	2729	33	77.7	77.7	30	1.24	2.4	Unsaturated	27	2729	1.07	29.0	66.7	0.95	0.304	1.0	0.105	1.14	1.030	0.110	N/L
4.40	14.43	2670	32	79.5	79.5	29	1.24	2.4	Unsaturated	27	2670	1.07	28.2	65.6	0.95	0.303	1.0	0.104	1.14	1.030	0.109	N/L
4.50	14.76	2688	32	81.4	81.4	29	1.24	2.4	Unsaturated	27	2688	1.06	28.2	65.6	0.95	0.303	1.0	0.104	1.14	1.030	0.109	N/L
4.60	15.09	2646	33	83.2	83.2	28	1.30	2.4	Unsaturated	27	2646	1.05	27.6	64.8	0.95	0.303	1.0	0.103	1.14	1.029	0.108	N/L
4.70	15.42	2581	33	85.0	85.0	27	1.32	2.4	Unsaturated	27	2581	1.05	26.8	63.7	0.95	0.302	1.0	0.102	1.13	1.029	0.107	N/L
4.80	15.74	2579	32	86.8	86.8	27	1.27	2.4	Unsaturated	27	2579	1.04	26.6	63.5	0.95	0.302	1.0	0.102	1.13	1.029	0.106	N/L
4.90	16.07	2605	32	88.6	88.6	27	1.27	2.4	Unsaturated	27	2605	1.04	26.7	63.7	0.95	0.301	1.0	0.102	1.13	1.029	0.106	N/L
5.00	16.40	2670	33	90.4	90.4	27	1.28	2.4	Unsaturated	27	2670	1.03	27.2	64.4	0.94	0.301	1.0	0.103	1.14	1.029	0.107	N/L
5.10	16.73	2764	34	92.2	92.2	28	1.26	2.4	Unsaturated	27	2764	1.02	28.0	65.4	0.94	0.300	1.0	0.104	1.14	1.030	0.108	N/L
5.20	17.06	2764	34	94.0	94.0	27	1.27	2.4	Unsaturated	27	2764	1.02	27.9	65.3	0.94	0.300	1.0	0.104	1.14	1.030	0.107	N/L
5.30	17.38	2741	33	95.8	95.8	27	1.26	2.4	Unsaturated	27	2741	1.01	27.5	64.8	0.94	0.299	1.0	0.103	1.14	1.029	0.107	N/L
5.40	17.71	2697	34	97.6	97.6	26	1.30	2.4	Unsaturated	27	2697	1.01	26.9	64.0	0.94	0.299	1.0	0.103	1.13	1.029	0.106	N/L
5.50	18.04	2732	34	99.4	99.4	26	1.28	2.4	Unsaturated	27	2732	1.00	27.2	64.3	0.94	0.298	1.0	0.103	1.14	1.029	0.106	N/L
5.60	18.37	2758	34	101.2	101.2	26	1.27	2.4	Unsaturated	27	2758	1.00	27.3	64.5	0.93	0.297	1.0	0.103	1.14	1.029	0.106	N/L
5.70	18.70	2750	34	103.0	103.0	26	1.28	2.4	Unsaturated	27	2750	0.99	27.1	64.2	0.93	0.297	1.0	0.103	1.14	1.029	0.105	N/L
5.80	19.02	2794	35	104.9	104.9	26	1.29	2.4	Unsaturated	27	2794	0.99	27.4	64.6	0.93	0.296	1.0	0.103	1.14	1.029	0.106	N/L
5.90	19.35	2897	36	106.7	106.7	27	1.29	2.4	Unsaturated	27	2897	0.99	28.3	65.8	0.93	0.296	1.0	0.104	1.14	1.030	0.107	N/L
6.00	19.68	2891	36	108.5	108.5	27	1.29	2.4	Unsaturated	27	2891	0.98	28.1	65.5	0.93	0.295	1.0	0.104	1.14	1.030	0.106	N/L
6.10	20.01	2906	37	110.3	110.3	26	1.31	2.4	Unsaturated	27	2906	0.98	28.1	65.5	0.93	0.295	1.0	0.104	1.14	1.030	0.106	N/L
6.20	20.34	3387	43	112.1	112.1	31	1.30	2.4	Unsaturated	27	3387	0.97	32.6	71.5	0.92	0.294	1.0	0.109	1.15	1.033	0.111	N/L
6.30	20.66	5030	52	113.9	113.9	46	1.05	2.2	Unsaturated	22	5030	0.97	48.3	88.1	0.92	0.294	1.0	0.124	1.21	1.044	0.128	N/L
6.40	20.99	5432	48	115.7	115.7	49	0.90	2.1	Unsaturated	19	5432	0.96	51.9	89.5	0.92	0.293	1.0	0.125	1.21	1.046	0.129	N/L
6.50	21.32	4715	46	117.5	117.5	42	1.01	2.2	Unsaturated	22	4715	0.96	44.9	83.7	0.92	0.293	1.0	0.119	1.19	1.041	0.122	N/L
6.60	21.65	4459	44	119.3	119.3	39	1.00	2.2	Unsaturated	22	4459	0.96	42.3	80.3	0.92	0.292	1.0	0.116	1.18	1.038	0.119	N/L
6.70	21.98	4989	42	121.1	121.1	44	0.86	2.2	Unsaturated	22	4989	0.95	47.1	86.6	0.92	0.292	1.0	0.122	1.20	1.043	0.125	N/L
6.80	22.30	7246	51	122.9	122.9	64	0.72	2.0	Unsaturated	17	7246	0.95	68.1	105.2	0.91	0.291	1.0	0.145	1.29	1.062	0.150	N/L
6.90	22.63	12468	67	124.7	124.7	110	0.54	1.7	Unsaturated	11	12468	0.95	116.8	138.0	0.91	0.291	1.0	0.226	1.54	1.116	0.244	N/L
7.00	22.96	17770	91	126.5	126.5	156	0.52	1.6	Unsaturated	10	17770	0.94	165.8	180.4	0.91	0.290	1.0	0.738	2.10	1.235	0.868	N/L
7.10	23.29	20516	127	128.4	128.4	179	0.62	1.6	Unsaturated	10	20516	0.94	190.7	206.8	0.91	0.289	0.9	2.828	2.20	1.257	2.000	N/L
7.20	23.62	21342	149	130.2	130.2	185	0.70	1.6	Unsaturated	10	21342	0.94	197.6	214.1	0.91	0.289	0.9	2.000	2.20	1.257	2.000	N/L
7.30	23.94	22068	163	132.0	132.0	190	0.74	1.6	Unsaturated	10	22068	0.93	203.6	220.4	0.91	0.288	0.9	2.000	2.20	1.257	2.000	N/L
7.40	24.27	22732	174	133.8	133.8	194	0.77	1.6	Unsaturated	10	22732	0.93	209.0	226.1	0.90	0.288	0.9	2.000	2.20	1.257	2.000	N/L
7.50	24.60	22758	167	135.6	135.6	193	0.74	1.6	Unsaturated	10	22758	0.93	208.5	225.6	0.90	0.287	0.9	2.000	2.20	1.257	2.000	N/L
7.60	24.93	22416	171	137.4	137.4	189	0.77	1.6	Unsaturated	10	22416	0.92	204.6	221.5	0.90	0.287	0.9	2.000	2.20	1.257	2.000	N/L
7.70	25.26	22595	179	139.2	139.2	189	0.80	1.6	Unsaturated	10	22595	0.92	205.6	222.5	0.90	0.286	0.9	2.000	2.20	1.257	2.000	N/L
7.80	25.58	22823	185	141.0	141.0	190	0.81	1.6	Unsaturated	10	22823	0.92	206.9	224.0	0.90	0.286	0.9	2.000	2.20	1.257	2.000	N/L
7.90	25.91	22354	177	142.8	142.8	185	0.80	1.6	Unsaturated	10	22354	0.91	202.0	218.7	0.89	0.285	0.9	2.000	2.20	1.257	2.000	N/L
8.00	26.24	21929	175	144.6	144.6	180	0.80	1.7	Unsaturated	11	21929	0.91	197.5	227.1	0.89	0.284	0.9	2.000	2.20	1.257	2.000	N/L
8.10	26.57	23062	181	146.4	146.4	188	0.79	1.6	Unsaturated	10	23062	0.91	207.0	224.1	0.89	0.284	0.9	2.000	2.20	1.257	2.000	N/L
8.20	26.90	24865	194	148.2	148.2	202	0.79	1.6	Unsaturated	10	24865	0.90	222.5	240.4	0.89	0.283	0.9	2.000	2.20	1.257	2.000	N/L
8.30	27.22	25331	197	150.0	150.0	204	0.78	1.6	Unsaturated	10	25331	0.90	225.9	244.1	0.89	0.283	0.9	2.000	2.20	1.257	2.000	N/L
8.40	27.55	25635	206	151.9	151.9	205	0.81	1.6	Unsaturated	10	25635	0.90	227.9	246.2	0.89	0.282	0.9	2.000	2.20	1.257	2.000	N/L
8.50	27.88	26033	223	153.7	153.7	207	0.86	1.6	Unsaturated	10	26033	0.90	230.7	249.1	0.88	0.281	0.9	2.000	2.20	1.257	2.000	N/L
8.60	28.21	26511	231	155.5	155.5	210	0.88	1.6	Unsaturated	10	26511	0.89	234.3	252.9	0.88	0.281	0.9	2.000	2.20	1.257	2.000	N/L
8.70	28.54	26727	240	157.3	157.3	210	0.90	1.6	Unsaturated	10	26727	0.89	235.4	254.1	0.88	0.280	0.9	2.000	2.20	1.257	2.000	N/L
8.80	28.86	26800	237	159.1	159.1	210	0.89	1.6	Unsaturated	10	26800	0.89	235.4	254.1	0.88	0.280	0.9	2.000	2.20	1.257	2.000	N/L

Settelemnt of Liquefiable Soil (Idriss and Boulnager, 2008)

Depth, Z (m)	q_t (kPa)	N_{60}	$N_{1,60}$	$\Delta(N_1)_{60}$	$N_{1,60-CS}$	Limiting Shear Strain γ_{lim}	Parameter F_α	Max. Shear Strain γ_{max}	ΔHi (m)	ΔLDI_i (m)	Vert. Recon. Strain ε_v	DF_i	ΔSi (inch)
1.60	16915	29.1	40.5	0.4	N.A.	0.000	0.000	0.000	0.05	0.0000	0.0000	0.91	0.00
1.70	13379	24.6	33.7	1.7	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.91	0.00
1.80	17994	32.0	43.2	0.9	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.90	0.00
1.90	23532	39.3	52.2	0.1	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.90	0.00
2.00	26542	44.3	58.1	0.1	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.89	0.00
2.10	28043	45.4	58.8	0.0	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.89	0.00
2.20	26375	42.7	54.6	0.0	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.88	0.00
2.30	21740	37.5	47.4	0.4	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.87	0.00
2.40	19417	33.5	41.8	0.4	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.87	0.00
2.50	17140	29.5	36.5	0.4	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.86	0.00
2.60	15815	28.2	34.5	0.9	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.86	0.00
2.70	14692	26.2	31.7	0.9	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.85	0.00
2.80	12171	22.4	26.9	1.7	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.85	0.00
2.90	10333	19.0	22.6	1.7	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.84	0.00
3.00	8868	16.9	19.9	2.5	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.84	0.00
3.10	7532	14.9	17.4	3.2	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.83	0.00
3.20	6234	12.8	14.8	3.8	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.83	0.00
3.30	5204	11.1	12.8	4.3	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.82	0.00
3.40	4501	9.6	11.0	4.3	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.81	0.00
3.50	3942	8.8	9.9	4.7	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.81	0.00
3.60	3591	8.0	9.0	4.7	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.80	0.00
3.70	3373	7.8	8.7	5.0	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.80	0.00
3.80	3230	7.5	8.3	5.0	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.79	0.00
3.90	3023	7.0	7.7	5.0	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.79	0.00
4.00	2900	6.7	7.4	5.0	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.78	0.00
4.10	2795	6.8	7.4	5.2	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.78	0.00
4.20	2723	6.6	7.1	5.2	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.77	0.00
4.30	2716	6.6	7.1	5.2	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.76	0.00
4.40	2682	6.5	6.9	5.2	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.76	0.00
4.50	2675	6.5	6.9	5.2	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.75	0.00
4.60	2662	6.5	6.8	5.2	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.75	0.00
4.70	2615	6.4	6.6	5.2	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.74	0.00
4.80	2597	6.3	6.6	5.2	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.74	0.00
4.90	2621	6.4	6.6	5.2	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.73	0.00
5.00	2684	6.5	6.7	5.2	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.73	0.00
5.10	2764	6.7	6.9	5.2	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.72	0.00
5.20	2766	6.7	6.8	5.2	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.72	0.00
5.30	2730	6.6	6.7	5.2	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.71	0.00
5.40	2702	6.6	6.6	5.2	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.70	0.00
5.50	2745	6.7	6.7	5.2	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.70	0.00
5.60	2766	6.7	6.7	5.2	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.69	0.00
5.70	2756	6.7	6.7	5.2	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.69	0.00
5.80	2799	6.8	6.7	5.2	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.68	0.00
5.90	2881	7.0	6.9	5.2	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.68	0.00
6.00	2900	7.0	6.9	5.2	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.67	0.00
6.10	2953	7.2	7.0	5.2	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.67	0.00
6.20	3501	8.5	8.3	5.2	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.66	0.00
6.30	4853	10.8	10.5	4.7	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.66	0.00
6.40	5334	11.4	11.0	4.3	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.65	0.00
6.50	4752	10.6	10.2	4.7	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.64	0.00
6.60	4458	9.9	9.5	4.7	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.64	0.00
6.70	5028	11.2	10.7	4.7	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.63	0.00
6.80	7370	15.1	14.4	3.8	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.63	0.00
6.90	12311	22.7	21.5	1.7	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.62	0.00
7.00	17502	31.2	29.4	0.9	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.62	0.00
7.10	20361	36.3	34.0	0.9	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.61	0.00
7.20	21353	38.0	35.6	0.9	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.61	0.00
7.30	22094	39.3	36.7	0.9	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.60	0.00
7.40	22676	40.4	37.5	0.9	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.60	0.00
7.50	22697	40.4	37.4	0.9	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.59	0.00
7.60	22503	40.1	36.9	0.9	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.58	0.00
7.70	22594	40.2	37.0	0.9	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.58	0.00
7.80	22784	40.6	37.2	0.9	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.57	0.00
7.90	22368	39.8	36.4	0.9	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.57	0.00
8.00	21929	40.4	36.7	1.7	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.56	0.00
8.10	23083	41.1	37.3	0.9	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.56	0.00
8.20	24811	44.2	39.9	0.9	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.55	0.00
8.30	25430	45.3	40.8	0.9	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.55	0.00
8.40	25738	45.8	41.2	0.9	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.54	0.00
8.50	26139	46.5	41.7	0.9	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.54	0.00
8.60	26593	47.4	42.3	0.9	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.53	0.00
8.70	26777	47.7	42.4	0.9	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.52	0.00
8.80	26806	47.7	42.3	0.9	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.52	0.00

Settlement of Unsaturated Sand (Tokimatsu & Seed, 1987, and Pradel, 1998) / Cumulative / S_r (Idriss & Boulanger, 2008)

Depth, Z (m)	$p = \sigma_m$ (tsf)	τ_{ave} (psf)	G_{max} (tsf)	τ_{ave}/G_{max}	a	b	γ_{eff} (%)	ε_{15} (%)	ε_{Nc} (%)	Settlement (inch)	Cumulative Settlement (inch)	$\Delta(N_1)_{60-Sr}$	$(N_1)_{60-Sr}$	S_r/σ_{v0}'
1.60	0.202	192	2715	0.00004	0.20272	16691	0.00401	0.002	0.001	0.00	1.48	N/A	N/A	N/A
1.70	0.215	204	2329	0.00004	0.20764	16095	0.00515	0.003	0.002	0.00	1.48	N/A	N/A	N/A
1.80	0.228	216	3068	0.00004	0.21256	15552	0.00396	0.002	0.001	0.00	1.48	N/A	N/A	N/A
1.90	0.240	228	3810	0.00003	0.21749	15056	0.00329	0.001	0.001	0.00	1.48	N/A	N/A	N/A
2.00	0.253	239	4350	0.00003	0.22241	14600	0.00300	0.001	0.001	0.00	1.48	N/A	N/A	N/A
2.10	0.266	251	4508	0.00003	0.22733	14178	0.00304	0.001	0.001	0.00	1.48	N/A	N/A	N/A
2.20	0.278	263	4287	0.00003	0.23225	13788	0.00337	0.001	0.001	0.00	1.48	N/A	N/A	N/A
2.30	0.291	275	3802	0.00004	0.23717	13425	0.00405	0.001	0.001	0.00	1.48	N/A	N/A	N/A
2.40	0.304	287	3430	0.00004	0.24209	13087	0.00478	0.002	0.002	0.00	1.48	N/A	N/A	N/A
2.50	0.316	299	3057	0.00005	0.24701	12770	0.00572	0.003	0.002	0.00	1.48	N/A	N/A	N/A
2.60	0.329	310	2942	0.00005	0.25193	12473	0.00626	0.003	0.003	0.00	1.48	N/A	N/A	N/A
2.70	0.342	322	2757	0.00006	0.25685	12194	0.00708	0.004	0.003	0.00	1.48	N/A	N/A	N/A
2.80	0.354	334	2383	0.00007	0.26177	11931	0.00890	0.006	0.005	0.00	1.48	N/A	N/A	N/A
2.90	0.367	346	2040	0.00008	0.26669	11682	0.01148	0.010	0.008	0.00	1.48	N/A	N/A	N/A
3.00	0.379	357	1828	0.00010	0.27161	11447	0.01408	0.014	0.012	0.00	1.48	N/A	N/A	N/A
3.10	0.392	369	1623	0.00011	0.27653	11224	0.01773	0.021	0.018	0.00	1.48	N/A	N/A	N/A
3.20	0.405	381	1405	0.00014	0.28145	11012	0.02379	0.034	0.028	0.00	1.48	N/A	N/A	N/A
3.30	0.417	392	1229	0.00016	0.28637	10811	0.03236	0.055	0.046	0.00	1.47	N/A	N/A	N/A
3.40	0.430	404	1070	0.00019	0.29129	10619	0.04615	0.095	0.079	0.01	1.47	N/A	N/A	N/A
3.50	0.443	415	983	0.00021	0.29621	10436	0.06008	0.139	0.116	0.01	1.47	N/A	N/A	N/A
3.60	0.455	427	902	0.00024	0.30113	10261	0.08038	0.210	0.176	0.01	1.46	N/A	N/A	N/A
3.70	0.468	438	889	0.00025	0.30605	10093	0.08839	0.239	0.200	0.02	1.44	N/A	N/A	N/A
3.80	0.481	450	857	0.00026	0.31097	9933	0.10443	0.300	0.251	0.02	1.43	N/A	N/A	N/A
3.90	0.493	461	807	0.00029	0.31589	9780	0.13409	0.420	0.351	0.03	1.41	N/A	N/A	N/A
4.00	0.506	473	779	0.00030	0.32081	9632	0.16022	0.532	0.445	0.04	1.38	N/A	N/A	N/A
4.10	0.519	484	789	0.00031	0.32573	9490	0.16171	0.536	0.449	0.04	1.34	N/A	N/A	N/A
4.20	0.531	496	774	0.00032	0.33065	9354	0.18349	0.633	0.529	0.04	1.31	N/A	N/A	N/A
4.30	0.544	507	776	0.00033	0.33557	9223	0.19173	0.668	0.559	0.04	1.27	N/A	N/A	N/A
4.40	0.557	518	770	0.00034	0.34049	9097	0.20744	0.739	0.618	0.05	1.22	N/A	N/A	N/A
4.50	0.569	530	772	0.00034	0.34541	8975	0.21639	0.779	0.651	0.05	1.17	N/A	N/A	N/A
4.60	0.582	541	772	0.00035	0.35033	8857	0.22773	0.831	0.695	0.05	1.12	N/A	N/A	N/A
4.70	0.594	552	763	0.00036	0.35525	8744	0.25110	0.942	0.787	0.06	1.07	N/A	N/A	N/A
4.80	0.607	563	761	0.00037	0.36017	8634	0.26622	1.014	0.848	0.07	1.01	N/A	N/A	N/A
4.90	0.620	574	772	0.00037	0.36509	8528	0.26450	1.002	0.838	0.07	0.94	N/A	N/A	N/A
5.00	0.632	586	794	0.00037	0.37001	8425	0.24882	0.922	0.771	0.06	0.87	N/A	N/A	N/A
5.10	0.645	597	822	0.00036	0.37493	8326	0.22953	0.827	0.691	0.05	0.81	N/A	N/A	N/A
5.20	0.658	608	826	0.00037	0.37985	8229	0.23527	0.852	0.712	0.06	0.76	N/A	N/A	N/A
5.30	0.670	619	819	0.00038	0.38477	8136	0.25351	0.938	0.784	0.06	0.70	N/A	N/A	N/A
5.40	0.683	630	814	0.00039	0.38969	8045	0.27075	1.020	0.853	0.07	0.64	N/A	N/A	N/A
5.50	0.696	641	831	0.00039	0.39461	7957	0.26168	0.973	0.814	0.06	0.57	N/A	N/A	N/A
5.60	0.708	651	841	0.00039	0.39953	7871	0.26074	0.966	0.808	0.06	0.51	N/A	N/A	N/A
5.70	0.721	662	842	0.00039	0.40446	7788	0.27083	1.014	0.848	0.07	0.45	N/A	N/A	N/A
5.80	0.734	673	858	0.00039	0.40938	7707	0.26195	0.968	0.809	0.06	0.38	N/A	N/A	N/A
5.90	0.746	684	887	0.00039	0.41430	7629	0.24126	0.866	0.724	0.06	0.32	N/A	N/A	N/A
6.00	0.759	695	896	0.00039	0.41922	7552	0.24094	0.862	0.721	0.06	0.26	N/A	N/A	N/A
6.10	0.772	705	916	0.00038	0.42414	7478	0.23084	0.813	0.679	0.05	0.20	N/A	N/A	N/A
6.20	0.784	716	1090	0.00033	0.42906	7405	0.13513	0.390	0.326	0.03	0.15	N/A	N/A	N/A
6.30	0.797	727	1391	0.00026	0.43398	7334	0.07193	0.156	0.131	0.01	0.12	N/A	N/A	N/A
6.40	0.810	737	1473	0.00025	0.43890	7265	0.06442	0.132	0.110	0.01	0.11	N/A	N/A	N/A
6.50	0.822	748	1372	0.00027	0.44382	7198	0.07845	0.177	0.148	0.01	0.10	N/A	N/A	N/A
6.60	0.835	758	1292	0.00029	0.44874	7132	0.09399	0.230	0.192	0.02	0.09	N/A	N/A	N/A
6.70	0.847	769	1462	0.00026	0.45366	7068	0.07068	0.150	0.126	0.01	0.08	N/A	N/A	N/A
6.80	0.860	779	1985	0.00020	0.45858	7006	0.03785	0.056	0.047	0.00	0.07	N/A	N/A	N/A
6.90	0.873	789	2983	0.00013	0.46350	6945	0.01954	0.018	0.015	0.00	0.06	N/A	N/A	N/A
7.00	0.885	800	4113	0.00010	0.46842	6885	0.01267	0.008	0.007	0.00	0.06	N/A	N/A	N/A
7.10	0.898	810	4801	0.00008	0.47334	6827	0.01054	0.006	0.005	0.00	0.06	N/A	N/A	N/A
7.20	0.911	820	5052	0.00008	0.47826	6770	0.01004	0.005	0.004	0.00	0.06	N/A	N/A	N/A
7.30	0.923	830	5244	0.00008	0.48318	6714	0.00972	0.005	0.004	0.00	0.06	N/A	N/A	N/A
7.40	0.936	840	5400	0.00008	0.48810	6659	0.00951	0.004	0.004	0.00	0.06	N/A	N/A	N/A
7.50	0.949	850	5422	0.00008	0.49302	6606	0.00960	0.005	0.004	0.00	0.06	N/A	N/A	N/A
7.60	0.961	860	5392	0.00008	0.49794	6553	0.00980	0.005	0.004	0.00	0.06	N/A	N/A	N/A
7.70	0.974	870	5431	0.00008	0.50286	6502	0.00985	0.005	0.004	0.00	0.06	N/A	N/A	N/A
7.80	0.987	880	5493	0.00008	0.50778	6452	0.00984	0.005	0.004	0.00	0.06	N/A	N/A	N/A
7.90	0.999	890	5409	0.00008	0.51270	6403	0.01016	0.005	0.004	0.00	0.06	N/A	N/A	N/A
8.00	1.012	900	5502	0.00008	0.51762	6355	0.01008	0.005	0.004	0.00	0.06	N/A	N/A	N/A
8.10	1.025	910	5615	0.00008	0.52254	6308	0.00996	0.005	0.004	0.00	0.06	N/A	N/A	N/A
8.20	1.037	920	6053	0.00008	0.52746	6261	0.00919	0.004	0.003	0.00	0.06	N/A	N/A	N/A
8.30	1.050	929	6222	0.00007	0.53238	6216	0.00900	0.004	0.003	0.00	0.06	N/A	N/A	N/A
8.40	1.062	939	6315	0.00007	0.53730	6171	0.00895	0.004	0.003	0.00	0.06	N/A	N/A	N/A
8.50	1.075	948	6431	0.00007	0.54222	6128	0.00885	0.004	0.003	0.00	0.06	N/A	N/A	N/A
8.60	1.088	958	6561	0.00007	0.54714	6085	0.00874	0.004	0.003	0.00	0.06	N/A	N/A	N/A
8.70	1.100	967	6624	0.00007	0.55206	6043	0.00874	0.004	0.003	0.00	0.06	N/A	N/A	N/A
8.80	1.113	977	6650	0.00007	0.55698	6002	0.00880	0.004	0.003	0.00	0.06	N/A	N/A	N/A

Depth, Z (m)	Depth, Z (ft)	q_c (kPa)	f_s (kPa)	σ_{vc} (kPa)	σ'_{vc} (kPa)	Q	F	I_c	Soil Type	Fines (%)	Interpreted q_c	C_N	q_{c1N}	q_{c1N-cs}	Stress Reduction Factor (r_d)	CSR	K_σ for sand	$CRR_{M=7.5}$ at $\sigma'_{vc}=1$	MSF_{max}	MSF	CRR	$(FS)_L$	q_t (kPa)	N_{60}	$N_{1,60}$	$\Delta(N_1)_{60}$
8.90	29.19	26915	231	160.9	160.9	210	0.86	1.6	Unsaturated	10	26915	0.88	235.7	254.4	0.88	0.279	0.9	2.000	2.20	1.257	2.000	**N/L**	27026	48.1	42.6	0.9
9.00	29.52	27980	248	162.7	162.7	217	0.89	1.6	Unsaturated	10	27980	0.88	244.3	263.5	0.87	0.279	0.9	2.000	2.20	1.257	2.000	**N/L**	27961	49.8	43.9	0.9
9.10	29.85	29355	270	164.5	164.5	226	0.92	1.6	Unsaturated	10	29355	0.88	255.5	275.4	0.87	0.278	0.9	2.000	2.20	1.257	2.000	**N/L**	29453	52.4	46.1	0.9
9.20	30.18	31594	266	166.3	166.3	242	0.85	1.6	Unsaturated	10	31594	0.88	274.2	295.2	0.87	0.277	0.9	2.000	2.20	1.257	2.000	**N/L**	31764	56.6	49.6	0.9
9.30	30.50	35276	257	168.1	168.1	269	0.73	1.5	Unsaturated	8	35276	0.87	305.3	314.6	0.87	0.277	0.8	2.000	2.20	1.257	2.000	**N/L**	35334	60.9	53.2	0.4
9.40	30.83	39849	195	169.9	169.9	302	0.49	1.3	Unsaturated	6	39849	0.87	343.9	344.2	0.87	0.276	0.8	2.000	2.20	1.257	2.000	**N/L**	40142	65.0	56.7	0.0
9.50	31.16	43348	272	171.7	171.7	327	0.63	1.4	Unsaturated	7	43348	0.87	373.1	375.8	0.87	0.276	0.8	2.000	2.20	1.257	2.000	**N/L**	43376	72.4	63.0	0.1
9.60	31.49	43599	342	173.5	173.5	328	0.79	1.5	Unsaturated	8	43599	0.87	374.2	385.1	0.86	0.275	0.8	2.000	2.20	1.257	2.000	**N/L**	43525	75.0	65.0	0.4
9.70	31.82	43794	335	175.4	175.4	327	0.77	1.5	Unsaturated	8	43794	0.86	374.9	385.8	0.86	0.274	0.8	2.000	2.20	1.257	2.000	**N/L**	43793	75.5	65.2	0.4
9.80	32.14	45700	190	177.2	177.2	340	0.42	1.3	Unsaturated	6	45700	0.86	390.1	390.4	0.86	0.274	0.8	2.000	2.20	1.257	2.000	**N/L**	45241	73.2	63.1	0.0
9.90	32.47	44520	234	179.0	179.0	329	0.53	1.3	Unsaturated	6	44520	0.86	379.0	379.3	0.86	0.273	0.8	2.000	2.20	1.257	2.000	**N/L**	44501	72.0	61.9	0.0
10.00	32.80	44458	162	180.8	180.8	327	0.37	1.2	Unsaturated	4	44458	0.86	377.5	377.5	0.86	0.273	0.8	2.000	2.20	1.257	2.000	**N/L**	44458	69.9	59.9	0.0
10.10	33.13	49152	146	182.6	182.6	360	0.30	1.1	Unsaturated	4	49152	0.86	416.3	416.3	0.85	0.272	0.8	2.000	2.20	1.257	2.000	**N/L**	49261	75.2	64.3	0.0
10.20	33.46	54816	57	184.4	184.4	400	0.10	0.9	Unsaturated	2	54816	0.85	463.0	463.0	0.85	0.271	0.8	2.000	2.20	1.257	2.000	**N/L**	54353	78.5	67.0	0.0
10.30	33.78	61315	68	186.2	186.2	445	0.11	0.9	Unsaturated	2	61315	0.85	516.6	516.6	0.85	0.271	0.8	2.000	2.20	1.257	2.000	**N/L**	59720	86.2	73.4	0.0
10.40	34.11	63741	75	188.0	188.0	461	0.12	0.9	Unsaturated	2	63741	0.85	535.7	535.7	0.85	0.270	0.8	2.000	2.20	1.257	2.000	**N/L**	63972	92.4	78.4	0.0
10.50	34.44	67387	90	189.8	189.8	485	0.13	0.9	Unsaturated	2	67387	0.85	564.9	564.9	0.85	0.270	0.8	2.000	2.20	1.257	2.000	**N/L**	66352	95.8	81.1	0.0
10.60	34.77	65065	70	191.6	191.6	466	0.11	0.8	Unsaturated	2	65065	0.84	544.1	544.1	0.84	0.269	0.8	2.000	2.20	1.257	2.000	**N/L**	65605	92.2	77.9	0.0
10.70	35.10	62215	63	193.4	193.4	443	0.10	0.9	Unsaturated	2	62215	0.84	518.9	518.9	0.84	0.268	0.8	2.000	2.20	1.257	2.000	**N/L**	62435	90.1	75.9	0.0
10.80	35.42	59504	190	195.2	195.2	422	0.32	1.1	Unsaturated	4	59504	0.84	495.1	495.1	0.84	0.268	0.8	2.000	2.20	1.257	2.000	**N/L**	58328	89.0	74.8	0.0
10.90	35.75	52798	257	197.1	197.1	372	0.49	1.3	Unsaturated	6	52798	0.84	438.2	438.6	0.84	0.267	0.8	2.000	2.20	1.257	2.000	**N/L**	53517	86.6	72.6	0.0
11.00	36.08	49868	387	198.9	198.9	350	0.78	1.4	Unsaturated	7	49868	0.84	412.9	415.8	0.84	0.267	0.8	2.000	2.20	1.257	2.000	**N/L**	49523	82.7	69.1	0.1
11.10	36.41	45295	450	200.7	200.7	316	1.00	1.6	Unsaturated	10	45295	0.83	374.2	400.9	0.84	0.266	0.8	2.000	2.20	1.257	1.996	**N/L**	45652	81.3	67.8	0.9
11.20	36.74	45253	271	202.5	202.5	315	0.60	1.4	Unsaturated	7	45253	0.83	372.9	375.6	0.83	0.265	0.8	2.000	2.20	1.257	1.989	**N/L**	45254	75.6	62.9	0.1
11.30	37.06	48768	287	204.3	204.3	338	0.59	1.4	Unsaturated	7	48768	0.83	401.0	403.8	0.83	0.265	0.8	2.000	2.20	1.257	1.982	**N/L**	47882	79.9	66.4	0.1
11.40	37.39	47042	325	206.1	206.1	324	0.69	1.4	Unsaturated	7	47042	0.83	385.9	388.6	0.83	0.264	0.8	2.000	2.20	1.257	1.976	**N/L**	47846	79.9	66.2	0.1
11.50	37.72	46747	367	207.9	207.9	321	0.79	1.5	Unsaturated	8	46747	0.83	382.6	393.7	0.83	0.264	0.8	2.000	2.20	1.257	1.969	**N/L**	45951	79.2	65.5	0.4
11.60	38.05	39171	364	209.7	209.7	267	0.93	1.6	Unsaturated	10	39171	0.82	319.8	343.4	0.83	0.263	0.8	2.000	2.20	1.257	1.963	**N/L**	38869	69.2	57.1	0.9
11.70	38.38	29845	309	211.5	211.5	202	1.04	1.7	Unsaturated	11	29845	0.82	243.1	277.6	0.82	0.262	0.8	2.000	2.20	1.257	1.956	**N/L**	29861	55.0	45.3	1.7
11.80	38.70	22381	238	213.3	213.3	151	1.07	1.8	Unsaturated	13	22381	0.82	181.9	223.3	0.82	0.262	0.8	2.000	2.20	1.257	1.950	**N/L**	23089	44.1	36.2	2.5
11.90	39.03	20360	182	215.1	215.1	136	0.91	1.8	Unsaturated	13	20360	0.82	165.1	203.9	0.82	0.261	0.8	2.377	2.20	1.257	2.000	**N/L**	20609	39.3	32.2	2.5
12.00	39.36	20552	166	216.9	216.9	137	0.82	1.7	Unsaturated	11	20552	0.82	166.3	192.7	0.82	0.261	0.8	1.283	2.20	1.257	1.315	**N/L**	20610	38.0	31.0	1.7
12.10	39.69	21301	173	218.7	218.7	142	0.82	1.7	Unsaturated	11	21301	0.82	172.0	199.0	0.82	0.260	0.8	1.785	2.20	1.257	1.794	**N/L**	21363	39.4	32.1	1.7
12.20	40.02	22531	125	220.6	220.6	149	0.56	1.6	Unsaturated	10	22531	0.81	181.5	197.1	0.81	0.259	0.8	1.610	2.20	1.257	1.623	**N/L**	22515	40.1	32.6	0.9
12.30	40.34	23809	127	222.4	222.4	157	0.54	1.6	Unsaturated	10	23809	0.81	191.4	207.5	0.81	0.259	0.8	2.971	2.20	1.257	2.000	**N/L**	23817	42.4	34.4	0.9
12.40	40.67	25856	150	224.2	224.2	170	0.58	1.6	Unsaturated	10	25856	0.81	207.4	224.5	0.81	0.258	0.8	2.000	2.20	1.257	1.912	**N/L**	26006	46.3	37.5	0.9
12.50	41.00	28922	181	226.0	226.0	190	0.63	1.6	Unsaturated	10	28922	0.81	231.5	250.0	0.81	0.258	0.8	2.000	2.20	1.257	1.906	**N/L**	28689	51.1	41.3	0.9
12.60	41.33	30228	196	227.8	227.8	197	0.65	1.6	Unsaturated	10	30228	0.81	241.5	260.5	0.81	0.257	0.8	2.000	2.20	1.257	1.900	**N/L**	30248	53.9	43.5	0.9
12.70	41.66	30984	243	229.6	229.6	202	0.79	1.6	Unsaturated	10	30984	0.81	247.0	266.4	0.80	0.256	0.8	2.000	2.20	1.257	1.894	**N/L**	31005	55.2	44.5	0.9
12.80	41.98	31830	263	231.4	231.4	206	0.83	1.6	Unsaturated	10	31830	0.80	253.2	273.0	0.80	0.256	0.8	2.000	2.20	1.257	1.888	**N/L**	31932	56.9	45.7	0.9
12.90	42.31	33595	268	233.2	233.2	217	0.80	1.6	Unsaturated	10	33595	0.80	266.7	287.2	0.80	0.255	0.7	2.000	2.20	1.257	1.882	**N/L**	33435	59.5	47.7	0.9
13.00	42.64	33795	269	235.0	235.0	218	0.80	1.6	Unsaturated	10	33795	0.80	267.8	288.3	0.80	0.255	0.7	2.000	2.20	1.257	1.877	**N/L**	33569	59.8	47.8	0.9
13.10	42.97	32946	260	236.8	236.8	211	0.79	1.6	Unsaturated	10	32946	0.80	260.5	280.7	0.80	0.254	0.7	2.000	2.20	1.257	1.871	**N/L**	32988	58.7	46.9	0.9
13.20	43.30	32949	253	238.6	238.6	210	0.77	1.6	Unsaturated	10	32949	0.80	260.0	280.1	0.80	0.253	0.7	2.000	2.20	1.257	1.865	**N/L**	33051	58.9	46.9	0.9
13.30	43.62	33722	256	240.4	240.4	215	0.76	1.6	Unsaturated	10	33722	0.80	265.6	286.0	0.79	0.253	0.7	2.000	2.20	1.257	1.859	**N/L**	33551	59.7	47.5	0.9
13.40	43.95	33606	263	242.2	242.2	213	0.79	1.6	Unsaturated	10	33606	0.79	264.2	284.5	0.79	0.252	0.7	2.000	2.20	1.257	1.854	**N/L**	33430	59.5	47.3	0.9
13.50	44.28	32600	279	244.1	244.1	206	0.86	1.6	Unsaturated	10	32600	0.79	255.7	275.6	0.79	0.252	0.7	2.000	2.20	1.257	1.848	**N/L**	32648	58.1	46.1	0.9
13.60	44.61	32130	262	245.9	245.9	202	0.82	1.6	Unsaturated	10	32130	0.79	251.6	271.2	0.79	0.251	0.7	2.000	2.20	1.257	1.842	**N/L**	32244	57.4	45.4	0.9
13.70	44.94	32409	262	247.8	247.1	203	0.81	1.6		10	32409	0.79	253.4	273.1	0.79	0.251	0.7	2.000	2.20	1.257	1.839	**2.00**	32409	57.7	45.6	0.9
13.80	45.26	32686	275	249.7	248.1	205	0.85	1.6		10	32686	0.79	255.3	275.2	0.78	0.251	0.7	2.000	2.20	1.257	1.836	**2.00**	32665	58.2	45.9	0.9
13.90	45.59	32922	281	251.7	249.0	206	0.86	1.6		10	32922	0.79	256.9	276.8	0.78	0.252	0.7	2.000	2.20	1.257	1.833	**2.00**	32885	58.6	46.2	0.9
14.00	45.92	32972	278	253.7	250.0	206	0.85	1.6		10	32972	0.79	257.0	277.0	0.78	0.252	0.7	2.000	2.20	1.257	1.830	**2.00**	32875	58.5	46.1	0.9
14.10	46.25	32040	278	255.6	251.0	199	0.87	1.6		10	32040	0.79	249.5	269.0	0.78	0.252	0.7	2.000	2.20	1.257	1.827	**2.00**	32072	57.1	44.9	0.9
14.20	46.58	31192	256	257.6	252.0	194	0.83	1.6		10	31192	0.79	242.6	261.7	0.78	0.253	0.7	2.000	2.20	1.257	1.824	**2.00**	31192	55.5	43.6	0.9
14.30	46.90	30866	247	259.6	253.0	191	0.81	1.6		10	30866	0.78	239.9	258.8	0.77	0.253	0.7	2.000	2.20	1.257	1.821	**2.00**	31061	55.3	43.4	0.9
14.40	47.23	31990	247	261.5	254.0	198	0.78	1.6		10	31990	0.78	248.3	267.8	0.77	0.253	0.7	2.000	2.20	1.257	1.818	**2.00**	32123	57.2	44.9	0.9
14.50	47.56	33264	253	263.5	254.9	205	0.77	1.6		10	33264	0.78	258.0	278.0	0.77	0.254	0.7	2.000	2.20	1.257	1.815	**2.00**	32773	58.4	45.7	0.9
14.60	47.89	31102	269	265.5	255.9	192	0.87	1.7		11	31102	0.78	241.0	275.1	0.77	0.254	0.7	2.000	2.20	1.257	1.812	**2.00**	31115	57.3	44.9	1.7
14.70	48.22	29399	252	267.4	256.9	181	0.86	1.7		11	29399	0.78	227.5	260.3	0.77	0.254	0.7	2.000	2.20	1.257	1.809	**2.00**	29494	54.3	42.5	1.7
14.80	48.54	27797	227	269.4	257.9	170	0.82	1.7		11	27797	0.78	214.9	246.4	0.77	0.255	0.7	2.000	2.20	1.257	1.806	**2.00**	27744	51.1	39.9	1.7
14.90	48.87	25425	135	271.4	258.9	155	0.54	1.6		10	25425	0.78	196.4	212.8	0.76	0.255	0.7	2.000	2.20	1.257	1.803	**2.00**	25170	44.8	35.0	0.9
15.00	49.20	23022	105	273.3	259.9	140	0.46	1.6		10	23022	0.78	177.6	193.0	0.76	0.255	0.8	1.300	2.20	1.257	1.260	**2.00**	23209	41.3	32.2	0.9
15.10	49.53	23355	97	275.3	260.9	142	0.42	1.6		10	23355	0.78	180.0	195.5	0.76	0.255	0.8	1.480	2.20	1.257	1.420	**2.00**	23356	41.6	32.4	0.9
15.20	49.86	24163	102	277.3	261.8	147	0.43	1.6		10	24163	0.78	186.1	201.9	0.76	0.256	0.7	2.105	2.20	1.257	1.969	**2.00**	23944	42.6	33.2	0.9
15.30	50.18	24101	105	279.2	262.8	146	0.44	1.6		10	24101	0.78	185.4	201.2	0.76	0.256	0.7	2.022	2.20	1.257	1.894	**2.00**	24225	43.1	33.5	0.9
15.40	50.51	25361	110	281.2	263.8	153	0.44	1.5		8	25361	0.78	194.9	201.6	0.75	0.256	0.7	2.065	2.20	1.257	1.929	**2.00**	25518	44.0	34.1	0.4
15.50	50.84	27715	129	283.2	264.8	167	0.47	1.5		8	27715	0.78	212.8	219.9	0.75	0.256	0.7	2.000	2.20	1.257	1.786	**2.00**	27667	47.7	37.0	0.4
15.60	51.17	28382	129	285.1	265.8	171	0.46	1.5		8	28382	0.77	217.7	224.9	0.75	0.256	0.7	2.000	2.20	1.257	1.784	**2.00**	27692	47.7	37.0	0.4
15.70	51.50	19770	145	287.1	266.8	119	0.74	1.8		13	19770	0.77	151.5	188.2	0.75	0.257	0.8	1.034	2.20	1.257	1.009	**2.00**	19470	37.1	28.8	2.5
15.80	51.82	6741	170	289.0	267.7	39	2.63	2.5		30	6741	0.77	51.6	98.0	0.75	0.257	0.9	0.135	1.25	1.054	0.128	**0.50**	7974	20.3	15.7	5.4
15.90	52.15	3977	96	291.0	268.7	22	2.62	2.7	Clay-Like	37	3977	0.77	30.4	70.9	0.75	0.257	0.9	0.108	1.15	1.032	0.102	**N/L**	4099	11.5	8.9	5.5
16.00	52.48	3021	42	293.0	269.7	17	1.56	2.7	Clay-Like	37	3021	0.77	23.1	61.0	0.74	0.257	0.9	0.100	1.13	1.028	0.095	**N/L**	3261	9.2	7.1	5.5
16.10	52.81	2508	60	294.9	270.7	13	2.72	2.9	Clay-Like	45	2508	0.77	19.1	56.1	0.74	0.257	0.9	0.097	1.12	1.026	0.092	**N/L**	2518	7.9	6.1	5.6
16.20	53.14	2584	52	296.9	271.7	14	2.26	2.8	Clay-Like	41	2584	0.77	19.7	56.7	0.74	0.257	0.9	0.097	1.12	1.026	0.092	**N/L**	2324	6.9	5.3	5.6
16.30	53.46	2545	45	298.9	272.7	14	1.98	2.8	Clay-Like	41	2545	0.77	19.4	56.3	0.74	0.258	0.9	0.097	1.12	1.026	0.092	**N/L**	2552	7.6	5.8	5.6
16.40	53.79	3912	43	300.8	273.6	22	1.19	2.5		30	3912	0.77	29.8	68.8	0.74	0.258	0.9	0.106	1.15	1.031	0.101	**0.39**	3814	9.7	7.5	5.4
16.50	54.12	4865	55	302.8	274.6	27	1.20	2.4		27	4865	0.77	37.0	77.3	0.73	0.258	0.9	0.113	1.17	1.036	0.107	**0.42**	4789	11.6	8.9	5.2
16.60	54.45	4499	62	304.8	275.6	25	1.47	2.5		30	4499	0.77	34.2	74.7	0.73	0.258	0.9	0.111	1.16	1.035	0.105	**0.41**	4423	11.3	8.6	5.4
16.70	54.78	3902	68	306.7	276.6	21	1.88	2.6	Clay-Like	34	3902	0.77	29.6	69.3	0.73	0.258	0.9	0.107	1.15	1.032	0.101	**N/L**	3911	10.4	8.0	5.5
16.80	55.10	3844	66	308.7	277.6	21	1.86	2.6	Clay-Like	34	3844	0.77	29.2	68.7	0.73	0.258	0.9	0.106	1.15	1.031	0.100	**N/L**	3724	9.9	7.6	5.5
16.90	55.43	3381	53	310.7	278.6	18	1.72	2.6	Clay-Like	34	3381	0.77	25.6	63.9	0.73	0.258	0.9	0.103	1.13	1.029	0.097	**N/L**	3409	9.1	7.0	5.5
17.00	55.76	2971	62	312.6	279.5	16	2.33	2.8	Clay-Like	41	2971	0.76	22.5	60.5	0.73	0.258	0.9	0.100	1.13	1.027	0.095	**N/L**	3098	9.2	7.0	5.6

Depth, Z (m)	$N_{1,60-CS}$	Limiting Shear Strain γ_{lim}	Parameter F_α	Max. Shear Strain γ_{max}	ΔHi (m)	ΔLDI_i (m)	Vert. Recon. Strain ε_v	DF_i	ΔSi (inch)	$p = \sigma_m$ (tsf)	τ_{ave} (psf)	G_{max} (tsf)	τ_{ave}/G_{max}	a	b	γ_{eff} (%)	ε_{15} (%)	ε_{Nc} (%)	Settlement (inch)	Settlement (inch)	$\Delta(N_1)_{60-Sr}$	$(N_1)_{60-Sr}$	S_r/σ_{v0}'
8.90	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.51	0.00	1.126	986	6722	0.00007	0.56190	5961	0.00878	0.004	0.003	0.00	0.06	N/A	N/A	N/A
9.00	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.51	0.00	1.138	996	6973	0.00007	0.56682	5921	0.00850	0.003	0.003	0.00	0.06	N/A	N/A	N/A
9.10	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.50	0.00	1.151	1005	7364	0.00007	0.57174	5882	0.00805	0.003	0.002	0.00	0.06	N/A	N/A	N/A
9.20	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.50	0.00	1.164	1014	7963	0.00006	0.57666	5844	0.00742	0.002	0.002	0.00	0.06	N/A	N/A	N/A
9.30	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.49	0.00	1.176	1023	8594	0.00006	0.58158	5806	0.00686	0.002	0.002	0.00	0.06	N/A	N/A	N/A
9.40	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.49	0.00	1.189	1032	9195	0.00006	0.58650	5769	0.00641	0.002	0.002	0.00	0.06	N/A	N/A	N/A
9.50	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.48	0.00	1.202	1041	10272	0.00005	0.59143	5732	0.00570	0.001	0.001	0.00	0.06	N/A	N/A	N/A
9.60	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.48	0.00	1.214	1050	10666	0.00005	0.59635	5696	0.00552	0.001	0.001	0.00	0.06	N/A	N/A	N/A
9.70	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.47	0.00	1.227	1059	10758	0.00005	0.60127	5661	0.00552	0.001	0.001	0.00	0.06	N/A	N/A	N/A
9.80	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.46	0.00	1.240	1068	10465	0.00005	0.60619	5626	0.00574	0.001	0.001	0.00	0.06	N/A	N/A	N/A
9.90	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.46	0.00	1.252	1077	10319	0.00005	0.61111	5592	0.00589	0.002	0.001	0.00	0.05	N/A	N/A	N/A
10.00	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.45	0.00	1.265	1086	10029	0.00005	0.61603	5558	0.00614	0.002	0.001	0.00	0.05	N/A	N/A	N/A
10.10	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.45	0.00	1.277	1094	10821	0.00005	0.62095	5525	0.00568	0.001	0.001	0.00	0.05	N/A	N/A	N/A
10.20	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.44	0.00	1.290	1103	11320	0.00005	0.62587	5493	0.00545	0.001	0.001	0.00	0.05	N/A	N/A	N/A
10.30	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.44	0.00	1.303	1112	12467	0.00004	0.63079	5461	0.00493	0.001	0.001	0.00	0.05	N/A	N/A	N/A
10.40	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.43	0.00	1.315	1120	13385	0.00004	0.63571	5429	0.00460	0.001	0.001	0.00	0.05	N/A	N/A	N/A
10.50	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.43	0.00	1.328	1129	13914	0.00004	0.64063	5398	0.00444	0.001	0.001	0.00	0.05	N/A	N/A	N/A
10.60	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.42	0.00	1.341	1137	13425	0.00004	0.64555	5368	0.00466	0.001	0.001	0.00	0.05	N/A	N/A	N/A
10.70	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.42	0.00	1.353	1146	13151	0.00004	0.65047	5337	0.00480	0.001	0.001	0.00	0.05	N/A	N/A	N/A
10.80	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.41	0.00	1.366	1154	13017	0.00004	0.65539	5308	0.00490	0.001	0.001	0.00	0.05	N/A	N/A	N/A
10.90	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.40	0.00	1.379	1162	12695	0.00005	0.66031	5278	0.00508	0.001	0.001	0.00	0.05	N/A	N/A	N/A
11.00	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.40	0.00	1.391	1170	12140	0.00005	0.66523	5250	0.00537	0.001	0.001	0.00	0.05	N/A	N/A	N/A
11.10	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.39	0.00	1.404	1179	11963	0.00005	0.67015	5221	0.00551	0.001	0.001	0.00	0.05	N/A	N/A	N/A
11.20	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.39	0.00	1.417	1187	11141	0.00005	0.67507	5193	0.00601	0.002	0.001	0.00	0.05	N/A	N/A	N/A
11.30	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.38	0.00	1.429	1195	11813	0.00005	0.67999	5165	0.00567	0.001	0.001	0.00	0.05	N/A	N/A	N/A
11.40	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.38	0.00	1.442	1203	11829	0.00005	0.68491	5138	0.00570	0.001	0.001	0.00	0.05	N/A	N/A	N/A
11.50	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.37	0.00	1.455	1211	11751	0.00005	0.68983	5111	0.00578	0.001	0.001	0.00	0.05	N/A	N/A	N/A
11.60	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.37	0.00	1.467	1219	10292	0.00006	0.69475	5085	0.00677	0.002	0.002	0.00	0.05	N/A	N/A	N/A
11.70	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.36	0.00	1.480	1226	8196	0.00007	0.69967	5059	0.00890	0.003	0.003	0.00	0.05	N/A	N/A	N/A
11.80	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.35	0.00	1.493	1234	6577	0.00009	0.70459	5033	0.01172	0.006	0.005	0.00	0.05	N/A	N/A	N/A
11.90	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.35	0.00	1.505	1242	5882	0.00011	0.70951	5008	0.01361	0.008	0.006	0.00	0.05	N/A	N/A	N/A
12.00	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.34	0.00	1.518	1249	5691	0.00011	0.71443	4983	0.01431	0.008	0.007	0.00	0.05	N/A	N/A	N/A
12.10	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.34	0.00	1.530	1257	5910	0.00011	0.71935	4958	0.01372	0.008	0.007	0.00	0.05	N/A	N/A	N/A
12.20	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.33	0.00	1.543	1265	6033	0.00010	0.72427	4933	0.01346	0.007	0.006	0.00	0.05	N/A	N/A	N/A
12.30	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.33	0.00	1.556	1272	6394	0.00010	0.72919	4909	0.01259	0.007	0.005	0.00	0.05	N/A	N/A	N/A
12.40	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.32	0.00	1.568	1279	6995	0.00009	0.73411	4885	0.01133	0.005	0.004	0.00	0.05	N/A	N/A	N/A
12.50	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.32	0.00	1.581	1287	7732	0.00008	0.73903	4862	0.01009	0.004	0.004	0.00	0.05	N/A	N/A	N/A
12.60	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.31	0.00	1.594	1294	8167	0.00008	0.74395	4839	0.00950	0.004	0.003	0.00	0.05	N/A	N/A	N/A
12.70	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.31	0.00	1.606	1301	8387	0.00008	0.74887	4816	0.00926	0.004	0.003	0.00	0.05	N/A	N/A	N/A
12.80	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.30	0.00	1.619	1309	8654	0.00008	0.75379	4793	0.00898	0.003	0.003	0.00	0.05	N/A	N/A	N/A
12.90	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.29	0.00	1.632	1316	9078	0.00007	0.75871	4771	0.00854	0.003	0.003	0.00	0.05	N/A	N/A	N/A
13.00	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.29	0.00	1.644	1323	9131	0.00007	0.76363	4749	0.00853	0.003	0.003	0.00	0.05	N/A	N/A	N/A
13.10	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.28	0.00	1.657	1330	8989	0.00007	0.76855	4727	0.00874	0.003	0.003	0.00	0.05	N/A	N/A	N/A
13.20	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.28	0.00	1.670	1337	9023	0.00007	0.77347	4706	0.00876	0.003	0.003	0.00	0.05	N/A	N/A	N/A
13.30	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.27	0.00	1.682	1344	9176	0.00007	0.77840	4684	0.00863	0.003	0.003	0.00	0.05	N/A	N/A	N/A
13.40	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.27	0.00	1.695	1350	9159	0.00007	0.78332	4663	0.00870	0.003	0.003	0.00	0.05	N/A	N/A	N/A
13.50	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.26	0.00	1.708	1357	8960	0.00008	0.78824	4643	0.00898	0.003	0.003	0.00	0.05	N/A	N/A	N/A
13.60	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.26	0.00	1.720	1364	8865	0.00008	0.79316	4622	0.00915	0.003	0.003	0.00	0.05	N/A	N/A	N/A
13.70	46.5	0.002	-1.309	0.000	0.10	0.0000	0.0000	0.25	0.00	1.729	1371	8921	0.00008	0.79646	4608	0.00913	0.003	0.003	0.00	0.05	0.9	46	N/A
13.80	46.8	0.001	-1.333	0.000	0.10	0.0000	0.0000	0.25	0.00	1.736	1379	8999	0.00008	0.79914	4597	0.00910	0.003	0.003	0.00	0.05	0.9	47	N/A
13.90	47.1	0.001	-1.354	0.000	0.10	0.0000	0.0000	0.24	0.00	1.742	1386	9068	0.00008	0.80182	4587	0.00907	0.003	0.003	0.00	0.05	0.9	47	N/A
14.00	47.0	0.001	-1.349	0.000	0.10	0.0000	0.0000	0.23	0.00	1.749	1394	9074	0.00008	0.80450	4576	0.00912	0.003	0.003	0.00	0.05	0.9	47	N/A
14.10	45.8	0.002	-1.256	0.000	0.10	0.0000	0.0000	0.23	0.00	1.756	1401	8861	0.00008	0.80718	4565	0.00944	0.004	0.003	0.00	0.05	0.9	46	N/A
14.20	44.6	0.003	-1.156	0.000	0.10	0.0000	0.0000	0.22	0.00	1.763	1408	8626	0.00008	0.80985	4554	0.00981	0.004	0.003	0.00	0.05	0.9	45	N/A
14.30	44.3	0.003	-1.138	0.000	0.10	0.0000	0.0000	0.22	0.00	1.770	1415	8597	0.00008	0.81253	4544	0.00990	0.004	0.003	0.00	0.05	0.9	44	N/A
14.40	45.8	0.002	-1.251	0.000	0.10	0.0000	0.0000	0.21	0.00	1.777	1422	8899	0.00008	0.81521	4533	0.00956	0.004	0.003	0.00	0.05	0.9	46	N/A
14.50	46.6	0.001	-1.319	0.000	0.10	0.0000	0.0000	0.21	0.00	1.784	1429	9088	0.00008	0.81789	4522	0.00938	0.003	0.003	0.00	0.05	0.9	47	N/A
14.60	46.5	0.002	-1.310	0.000	0.10	0.0000	0.0000	0.20	0.00	1.791	1436	8934	0.00008	0.82057	4512	0.00962	0.004	0.003	0.00	0.05	1.0	46	N/A
14.70	44.1	0.003	-1.122	0.000	0.10	0.0000	0.0000	0.20	0.00	1.798	1443	8476	0.00009	0.82324	4502	0.01031	0.004	0.003	0.00	0.05	1.0	43	N/A
14.80	41.6	0.006	-0.924	0.000	0.10	0.0000	0.0000	0.19	0.00	1.804	1450	7980	0.00009	0.82592	4491	0.01116	0.005	0.004	0.00	0.05	1.0	41	N/A
14.90	35.9	0.019	-0.500	0.000	0.10	0.0000	0.0000	0.19	0.00	1.811	1457	7005	0.00010	0.82860	4481	0.01320	0.007	0.006	0.00	0.05	0.9	36	N/A
15.00	33.1	0.029	-0.304	0.000	0.10	0.0000	0.0000	0.18	0.00	1.818	1464	6465	0.00011	0.83128	4471	0.01471	0.008	0.007	0.00	0.05	0.9	33	N/A
15.10	33.3	0.029	-0.316	0.000	0.10	0.0000	0.0000	0.17	0.00	1.825	1470	6512	0.00011	0.83396	4461	0.01465	0.008	0.007	0.00	0.05	0.9	33	N/A
15.20	34.1	0.025	-0.371	0.000	0.10	0.0000	0.0000	0.17	0.00	1.832	1477	6682	0.00011	0.83664	4451	0.01425	0.008	0.006	0.00	0.05	0.9	34	N/A
15.30	34.4	0.024	-0.396	0.000	0.10	0.0000	0.0000	0.16	0.00	1.839	1484	6766	0.00011	0.83931	4441	0.01410	0.008	0.006	0.00	0.05	0.9	34	N/A
15.40	34.5	0.024	-0.401	0.000	0.10	0.0000	0.0000	0.16	0.00	1.846	1490	6903	0.00011	0.84199	4431	0.01382	0.007	0.006	0.00	0.05	0.7	35	N/A
15.50	37.4	0.015	-0.607	0.000	0.10	0.0000	0.0000	0.15	0.00	1.853	1497	7491	0.00010	0.84467	4421	0.01253	0.006	0.005	0.00	0.05	0.7	38	N/A
15.60	37.3	0.015	-0.607	0.000	0.10	0.0000	0.0000	0.15	0.00	1.860	1503	7504	0.00010	0.84735	4411	0.01257	0.006	0.005	0.00	0.05	0.7	38	N/A
15.70	31.2	0.039	-0.171	0.000	0.10	0.0000	0.0000	0.14	0.00	1.866	1509	5847	0.00013	0.85003	4401	0.01744	0.011	0.009	0.00	0.05	1.2	30	N/A
15.80	21.1	0.141	0.461	0.141	0.10	0.0141	0.0221	0.14	0.01	1.873	1516	3196	0.00024	0.85270	4392	0.04372	0.059	0.049	0.00	0.05	2.6	18	0.16
15.90	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.13	0.00	1.880	1522	1817	0.00042	0.85538	4382	0.14355	0.379	0.317	0.00	0.04	N/A	N/A	N/A
16.00	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.13	0.00	1.887	1528	1447	0.00053	0.85806	4372	0.27370	0.952	0.796	0.00	0.04	N/A	N/A	N/A
16.10	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.12	0.00	1.894	1534	1250	0.00061	0.86074	4363	0.44598	1.854	1.550	0.00	0.04	N/A	N/A	N/A
16.20	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.11	0.00	1.901	1540	1090	0.00071	0.86342	4353	0.74646	3.664	3.063	0.00	0.04	N/A	N/A	N/A
16.30	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.11	0.00	1.908	1546	1198	0.00065	0.86609	4344	0.52850	2.321	1.941	0.00	0.04	N/A	N/A	N/A
16.40	12.8	0.348	0.835	0.348	0.10	0.0348	0.0320	0.10	0.01	1.915	1552	1536	0.00051	0.86877	4334	0.23672	0.773	0.646	0.00	0.04	2.6	10	0.09
16.50	14.2	0.301	0.788	0.301	0.10	0.0301	0.0299	0.10	0.01	1.921	1558	1843	0.00042	0.87145	4325	0.14504	0.382	0.319	0.00	0.02	2.4	11	0.10
16.60	14.0	0.306	0.793	0.306	0.10	0.0306	0.0302	0.09	0.01	1.928	1564	1785	0.00044	0.87413	4316	0.15871	0.435	0.364	0.00	0.01	2.6	11	0.10
16.70	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.09	0.00	1.935	1569	1658	0.00047	0.87681	4307	0.19493	0.585	0.489	0.00	0.00	N/A	N/A	N/A
16.80	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.08	0.00	1.942	1575	1580	0.00050	0.87949	4297	0.22500	0.716	0.599	0.00	0.00	N/A	N/A	N/A
16.90	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.08	0.00	1.949	1581	1448	0.00055	0.88216	4288	0.29494	1.045	0.874	0.00	0.00	N/A	N/A	N/A
17.00	N.A.	0.000	0.000	0.000	0.05	0.0000	0.0000	0.07	0.00	1.956	1586	1463	0.00054	0.88484	4279	0.28760	1.009	0.843	0.00	0.00	N/A	N/A	N/A

CONE PENETRATION TEST-BASED LIQUEFACTION ANALYSIS BASED ON IDRISS & BOULANGER (2008)

References:

1 - Idriss, I.M. and Boulanger, R.W. (2008). *Soil Liquefaction During Earthquakes* , Earthquake Engineering Research Institute, EERI Publication MNO-12.

2 - Ishihara, K. and Yoshimine, M. (1992). "Evaluation of Settlements in Sand Deposits Following Liquefaction During Earthquakes," *Soils and Foundations* , Vol. 32, No. 1, pp. 173-188, March 1992.

3 - Tokimatsu, K. and Seed H.B. (1987). "Evaluation of Settlements in Sands Due to Earthquake Shaking," Journal of Geotechnical Engineering, Vol. 113, No. 8, August.

4 - Pradel, D. (1998). "Procedure to Evaluate Earthquake-Induced Settlements in Sand," Journal of Geotechnical and Geoenvironmental Engineering, Vol. 124, No. 4, April.

5 - Cetin, K.O., Bilge, H.T., Wu, J., Kammerer, A.M., and Seed R.B. (2009). "Procedure to Evaluate Earthquake-Induced Settlements in Sand," Journal of Geotechnical and Geoenvironmental Engineering, Vol. 135, No. 3, March.

6 - Boulanger, R.W. and Idriss, I.M. (2014). "CPT and SPT Based Liquefaction Triggering Procedures," Report No. UCD/CGM-14/01, University of California at Davis

Project	**Chevron Guadalupe Tank Battery 9 Site**
Test Boring No	**TSMACPT-14**

Test Boring Information:

Approx. depth to ground water table		59.7 ft	18.20 m
Moist unit weight of soil	γ_m	115 pcf	18.08 kN/m^3
Saturated unit weight of soil	γ_{sat}	125 pcf	19.65 kN/m^3

Earthquake Information:

Earthquake magnitude	M_w	6.9
Peak horizontal ground surface acceleratio	a_{max}	0.490 g
Number of equivalent cycle	N	10.1

Atmospheric pressure	P_a	101.3 kPa

N/L = Non-liquefiable clay-like soil

N.A. = Not Applicable

Sum
0.00

Sum	Total
0.08	**0.08**

Factor of Safety Agaist Liquefaction (Idriss & Boulanger, 2008 and Boulanger & Idriss, 2014)

Depth, Z (m)	Depth, Z (ft)	q_c (kPa)	f_s (kPa)	σ_{vc} (kPa)	σ'_{vc} (kPa)	Q	F	I_c	Soil Type	Fines (%)	Interpreted q_c	C_N	q_{c1N}	q_{c1N-cs}	Stress Reduction Factor (r_d)	CSR	K_σ for sand	$CRR_{M=7.5}$ at σ'_{vc}=1	MSF_{max}	MSF	CRR	$(FS)_L$
1.60	5.25	23977	84	28.9	28.9	442	0.35	1.1	Unsaturated	4	23977	1.39	330.2	330.2	0.99	0.315	1.1	2.000	2.20	1.257	2.000	**N/L**
1.70	5.58	23440	82	30.7	30.7	420	0.35	1.1	Unsaturated	4	23440	1.37	317.7	317.7	0.99	0.315	1.1	2.000	2.20	1.257	2.000	**N/L**
1.80	5.90	20708	80	32.5	32.5	360	0.39	1.2	Unsaturated	4	20708	1.35	276.4	276.4	0.99	0.315	1.1	2.000	2.20	1.257	2.000	**N/L**
1.90	6.23	15781	71	34.3	34.3	267	0.45	1.4	Unsaturated	7	15781	1.33	207.7	209.4	0.99	0.314	1.1	3.346	2.20	1.257	2.000	**N/L**
2.00	6.56	11264	54	36.2	36.2	186	0.48	1.5	Unsaturated	8	11264	1.31	146.2	151.7	0.99	0.314	1.1	0.300	1.69	1.148	0.379	**N/L**
2.10	6.89	8851	39	38.0	38.0	142	0.45	1.6	Unsaturated	10	8851	1.29	113.4	125.0	0.98	0.314	1.1	0.183	1.43	1.091	0.220	**N/L**
2.20	7.22	7697	32	39.8	39.8	121	0.41	1.6	Unsaturated	10	7697	1.28	97.5	108.1	0.98	0.313	1.1	0.149	1.31	1.066	0.175	**N/L**
2.30	7.54	8399	31	41.6	41.6	129	0.37	1.6	Unsaturated	10	8399	1.26	105.1	116.2	0.98	0.313	1.1	0.163	1.36	1.077	0.193	**N/L**
2.40	7.87	12518	34	43.4	43.4	188	0.27	1.4	Unsaturated	7	12518	1.25	154.9	156.3	0.98	0.312	1.1	0.336	1.74	1.160	0.429	**N/L**
2.50	8.20	13837	41	45.2	45.2	204	0.30	1.4	Unsaturated	7	13837	1.24	169.4	170.9	0.98	0.312	1.1	0.518	1.95	1.203	0.686	**N/L**
2.60	8.53	15268	48	47.0	47.0	221	0.31	1.3	Unsaturated	6	15268	1.22	185.0	185.1	0.98	0.312	1.1	0.900	2.18	1.253	1.240	**N/L**
2.70	8.86	15684	50	48.8	48.8	222	0.32	1.3	Unsaturated	6	15684	1.21	188.1	188.3	0.98	0.311	1.1	1.038	2.20	1.257	1.435	**N/L**
2.80	9.18	16828	56	50.6	50.6	234	0.34	1.3	Unsaturated	6	16828	1.20	199.9	200.1	0.98	0.311	1.1	1.900	2.20	1.257	2.000	**N/L**
2.90	9.51	17787	65	52.4	52.4	243	0.37	1.3	Unsaturated	6	17787	1.19	209.4	209.6	0.97	0.310	1.1	3.382	2.20	1.257	2.000	**N/L**
3.00	9.84	18944	74	54.2	54.2	255	0.39	1.3	Unsaturated	6	18944	1.18	221.0	221.2	0.97	0.310	1.1	2.000	2.20	1.257	2.000	**N/L**
3.10	10.17	20139	82	56.0	56.0	267	0.41	1.3	Unsaturated	6	20139	1.17	232.9	233.1	0.97	0.309	1.1	2.000	2.20	1.257	2.000	**N/L**
3.20	10.50	21631	89	57.8	57.8	282	0.41	1.3	Unsaturated	6	21631	1.16	248.1	248.3	0.97	0.309	1.1	2.000	2.20	1.257	2.000	**N/L**
3.30	10.82	24906	90	59.7	59.7	320	0.36	1.2	Unsaturated	4	24906	1.15	283.3	283.3	0.97	0.309	1.1	2.000	2.20	1.257	2.000	**N/L**
3.40	11.15	27865	106	61.5	61.5	352	0.38	1.2	Unsaturated	4	27865	1.14	314.5	314.5	0.97	0.308	1.1	2.000	2.20	1.257	2.000	**N/L**
3.50	11.48	30423	126	63.3	63.3	379	0.42	1.2	Unsaturated	4	30423	1.13	340.8	340.8	0.97	0.308	1.1	2.000	2.20	1.257	2.000	**N/L**
3.60	11.81	31116	139	65.1	65.1	382	0.45	1.2	Unsaturated	4	31116	1.12	346.0	346.0	0.96	0.307	1.1	2.000	2.20	1.257	2.000	**N/L**
3.70	12.14	32300	150	66.9	66.9	392	0.46	1.2	Unsaturated	4	32300	1.11	356.5	356.5	0.96	0.307	1.1	2.000	2.20	1.257	2.000	**N/L**
3.80	12.46	32044	149	68.7	68.7	383	0.47	1.3	Unsaturated	6	32044	1.11	351.2	351.5	0.96	0.306	1.1	2.000	2.20	1.257	2.000	**N/L**
3.90	12.79	31122	158	70.5	70.5	367	0.51	1.3	Unsaturated	6	31122	1.10	338.8	339.1	0.96	0.306	1.1	2.000	2.20	1.257	2.000	**N/L**
4.00	13.12	31447	157	72.3	72.3	367	0.50	1.3	Unsaturated	6	31447	1.09	340.0	340.3	0.96	0.305	1.1	2.000	2.20	1.257	2.000	**N/L**
4.10	13.45	32013	165	74.1	74.1	369	0.52	1.3	Unsaturated	6	32013	1.09	343.9	344.2	0.96	0.305	1.1	2.000	2.20	1.257	2.000	**N/L**
4.20	13.78	32462	170	75.9	75.9	369	0.52	1.3	Unsaturated	6	32462	1.08	346.5	346.8	0.96	0.304	1.1	2.000	2.20	1.257	2.000	**N/L**
4.30	14.10	32881	171	77.7	77.7	370	0.52	1.3	Unsaturated	6	32881	1.07	348.8	349.1	0.95	0.304	1.1	2.000	2.20	1.257	2.000	**N/L**
4.40	14.43	32394	177	79.5	79.5	360	0.55	1.3	Unsaturated	6	32394	1.07	341.6	341.9	0.95	0.303	1.1	2.000	2.20	1.257	2.000	**N/L**
4.50	14.76	31656	176	81.4	81.4	348	0.56	1.3	Unsaturated	6	31656	1.06	331.8	332.1	0.95	0.303	1.1	2.000	2.20	1.257	2.000	**N/L**
4.60	15.09	30928	175	83.2	83.2	336	0.57	1.4	Unsaturated	7	30928	1.05	322.3	324.7	0.95	0.303	1.1	2.000	2.20	1.257	2.000	**N/L**
4.70	15.42	29532	176	85.0	85.0	317	0.60	1.4	Unsaturated	7	29532	1.05	306.0	308.3	0.95	0.302	1.1	2.000	2.20	1.257	2.000	**N/L**
4.80	15.74	29997	168	86.8	86.8	319	0.56	1.4	Unsaturated	7	29997	1.04	309.1	311.4	0.95	0.302	1.0	2.000	2.20	1.257	2.000	**N/L**
4.90	16.07	31438	163	88.6	88.6	331	0.52	1.3	Unsaturated	6	31438	1.04	322.2	322.5	0.95	0.301	1.0	2.000	2.20	1.257	2.000	**N/L**
5.00	16.40	31081	146	90.4	90.4	324	0.47	1.3	Unsaturated	6	31081	1.03	316.9	317.1	0.94	0.301	1.0	2.000	2.20	1.257	2.000	**N/L**
5.10	16.73	30582	132	92.2	92.2	315	0.43	1.3	Unsaturated	6	30582	1.02	310.2	310.4	0.94	0.300	1.0	2.000	2.20	1.257	2.000	**N/L**
5.20	17.06	30382	115	94.0	94.0	310	0.38	1.3	Unsaturated	6	30382	1.02	306.6	306.8	0.94	0.300	1.0	2.000	2.20	1.257	2.000	**N/L**
5.30	17.38	30193	97	95.8	95.8	305	0.32	1.2	Unsaturated	4	30193	1.01	303.1	303.1	0.94	0.299	1.0	2.000	2.20	1.257	2.000	**N/L**
5.40	17.71	30264	97	97.6	97.6	303	0.32	1.2	Unsaturated	4	30264	1.01	302.3	302.3	0.94	0.299	1.0	2.000	2.20	1.257	2.000	**N/L**
5.50	18.04	31904	100	99.4	99.4	317	0.31	1.2	Unsaturated	4	31904	1.00	317.2	317.2	0.94	0.298	1.0	2.000	2.20	1.257	2.000	**N/L**
5.60	18.37	34471	110	101.2	101.2	339	0.32	1.2	Unsaturated	4	34471	1.00	341.1	341.1	0.93	0.297	1.0	2.000	2.20	1.257	2.000	**N/L**
5.70	18.70	36126	122	103.0	103.0	353	0.34	1.2	Unsaturated	4	36126	0.99	355.8	355.8	0.93	0.297	1.0	2.000	2.20	1.257	2.000	**N/L**
5.80	19.02	37041	138	104.9	104.9	358	0.37	1.2	Unsaturated	4	37041	0.99	363.1	363.1	0.93	0.296	1.0	2.000	2.20	1.257	2.000	**N/L**
5.90	19.35	36825	140	106.7	106.7	353	0.38	1.2	Unsaturated	4	36825	0.99	359.4	359.4	0.93	0.296	1.0	2.000	2.20	1.257	2.000	**N/L**
6.00	19.68	36990	149	108.5	108.5	352	0.40	1.2	Unsaturated	4	36990	0.98	359.4	359.4	0.93	0.295	1.0	2.000	2.20	1.257	2.000	**N/L**
6.10	20.01	37713	161	110.3	110.3	356	0.43	1.3	Unsaturated	6	37713	0.98	364.8	365.1	0.93	0.295	1.0	2.000	2.20	1.257	2.000	**N/L**
6.20	20.34	37622	161	112.1	112.1	352	0.43	1.3	Unsaturated	6	37622	0.97	362.4	362.7	0.92	0.294	1.0	2.000	2.20	1.257	2.000	**N/L**
6.30	20.66	37749	187	113.9	113.9	350	0.50	1.3	Unsaturated	6	37749	0.97	362.1	362.4	0.92	0.294	1.0	2.000	2.20	1.257	2.000	**N/L**
6.40	20.99	37350	185	115.7	115.7	344	0.50	1.3	Unsaturated	6	37350	0.96	356.8	357.1	0.92	0.293	1.0	2.000	2.20	1.257	2.000	**N/L**
6.50	21.32	37297	171	117.5	117.5	341	0.46	1.3	Unsaturated	6	37297	0.96	354.8	355.1	0.92	0.293	1.0	2.000	2.20	1.257	2.000	**N/L**
6.60	21.65	37707	189	119.3	119.3	342	0.50	1.3	Unsaturated	6	37707	0.96	357.3	357.6	0.92	0.292	0.9	2.000	2.20	1.257	2.000	**N/L**
6.70	21.98	37592	206	121.1	121.1	338	0.55	1.3	Unsaturated	6	37592	0.95	354.8	355.1	0.92	0.292	0.9	2.000	2.20	1.257	2.000	**N/L**
6.80	22.30	36940	203	122.9	122.9	330	0.55	1.4	Unsaturated	7	36940	0.95	347.3	349.8	0.91	0.291	0.9	2.000	2.20	1.257	2.000	**N/L**
6.90	22.63	36672	203	124.7	124.7	325	0.56	1.4	Unsaturated	7	36672	0.95	343.4	345.9	0.91	0.291	0.9	2.000	2.20	1.257	2.000	**N/L**
7.00	22.96	36889	203	126.5	126.5	325	0.55	1.4	Unsaturated	7	36889	0.94	344.1	346.6	0.91	0.290	0.9	2.000	2.20	1.257	2.000	**N/L**
7.10	23.29	37315	213	128.4	128.4	326	0.57	1.4	Unsaturated	7	37315	0.94	346.8	349.3	0.91	0.289	0.9	2.000	2.20	1.257	2.000	**N/L**
7.20	23.62	35819	216	130.2	130.2	311	0.60	1.4	Unsaturated	7	35819	0.94	331.7	334.1	0.91	0.289	0.9	2.000	2.20	1.257	2.000	**N/L**
7.30	23.94	30240	226	132.0	132.0	260	0.75	1.5	Unsaturated	8	30240	0.93	279.0	287.6	0.91	0.288	0.9	2.000	2.20	1.257	2.000	**N/L**
7.40	24.27	19044	171	133.8	133.8	162	0.91	1.7	Unsaturated	11	19044	0.93	175.1	202.4	0.90	0.288	0.9	2.167	2.20	1.257	2.000	**N/L**
7.50	24.60	13288	113	135.6	135.6	112	0.86	1.8	Unsaturated	13	13288	0.93	121.7	153.8	0.90	0.287	1.0	0.316	1.71	1.153	0.347	**N/L**
7.60	24.93	12435	84	137.4	137.4	104	0.68	1.8	Unsaturated	13	12435	0.92	113.5	144.4	0.90	0.287	1.0	0.255	1.61	1.130	0.275	**N/L**
7.70	25.26	11931	77	139.2	139.2	99	0.65	1.8	Unsaturated	13	11931	0.92	108.5	138.6	0.90	0.286	1.0	0.228	1.55	1.117	0.243	**N/L**
7.80	25.58	11651	77	141.0	141.0	96	0.66	1.8	Unsaturated	13	11651	0.92	105.6	135.3	0.90	0.286	1.0	0.215	1.51	1.110	0.228	**N/L**
7.90	25.91	11506	69	142.8	142.8	94	0.61	1.8	Unsaturated	13	11506	0.91	104.0	133.3	0.89	0.285	1.0	0.208	1.50	1.106	0.219	**N/L**
8.00	26.24	11099	65	144.6	144.6	91	0.59	1.8	Unsaturated	13	11099	0.91	100.0	128.7	0.89	0.284	1.0	0.194	1.46	1.098	0.202	**N/L**
8.10	26.57	11024	63	146.4	146.4	89	0.58	1.8	Unsaturated	13	11024	0.91	99.0	127.6	0.89	0.284	1.0	0.190	1.45	1.096	0.198	**N/L**
8.20	26.90	11140	59	148.2	148.2	90	0.54	1.8	Unsaturated	13	11140	0.90	99.7	128.4	0.89	0.283	0.9	0.193	1.45	1.097	0.200	**N/L**
8.30	27.22	11196	59	150.0	150.0	90	0.54	1.8	Unsaturated	13	11196	0.90	99.9	128.6	0.89	0.283	0.9	0.193	1.45	1.097	0.201	**N/L**
8.40	27.55	11577	61	151.9	151.9	92	0.53	1.8	Unsaturated	13	11577	0.90	102.9	132.1	0.89	0.282	0.9	0.204	1.49	1.104	0.213	**N/L**
8.50	27.88	12013	62	153.7	153.7	95	0.53	1.8	Unsaturated	13	12013	0.90	106.5	136.2	0.88	0.281	0.9	0.219	1.52	1.112	0.229	**N/L**
8.60	28.21	12831	64	155.5	155.5	101	0.50	1.7	Unsaturated	11	12831	0.89	113.4	134.2	0.88	0.281	0.9	0.211	1.50	1.108	0.220	**N/L**
8.70	28.54	13497	66	157.3	157.3	106	0.50	1.7	Unsaturated	11	13497	0.89	118.9	140.3	0.88	0.280	0.9	0.236	1.56	1.121	0.247	**N/L**
8.80	28.86	14383	60	159.1	159.1	112	0.42	1.7	Unsaturated	11	14383	0.89	126.3	148.5	0.88	0.280	0.9	0.279	1.65	1.140	0.295	**N/L**

Settelemnt of Liquefiable Soil (Idriss and Boulnager, 2008)

Depth, Z (m)	q_t (kPa)	N_{60}	$N_{1,60}$	$\Delta(N_1)_{60}$	$N_{1,60-CS}$	Limiting Shear Strain γ_{lim}	Parameter F_α	Max. Shear Strain γ_{max}	ΔHi (m)	ΔLDI_i (m)	Vert. Recon. Strain ε_v	DF_i	ΔSi (inch)
1.60	23908	36.5	50.8	0.0	N.A.	0.000	0.000	0.000	0.05	0.0000	0.0000	0.91	0.00
1.70	23260	35.5	48.6	0.0	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.91	0.00
1.80	20394	32.0	43.2	0.0	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.90	0.00
1.90	15898	26.5	35.3	0.1	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.90	0.00
2.00	11509	19.8	26.0	0.4	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.89	0.00
2.10	8848	15.8	20.4	0.9	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.89	0.00
2.20	7973	14.2	18.2	0.9	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.88	0.00
2.30	8982	16.0	20.2	0.9	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.87	0.00
2.40	12064	20.1	25.2	0.1	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.87	0.00
2.50	13913	23.2	28.7	0.1	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.86	0.00
2.60	15109	24.5	29.9	0.0	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.86	0.00
2.70	15786	25.6	31.0	0.0	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.85	0.00
2.80	16830	27.2	32.7	0.0	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.85	0.00
2.90	17834	28.9	34.3	0.0	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.84	0.00
3.00	19010	30.8	36.3	0.0	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.84	0.00
3.10	20199	32.7	38.2	0.0	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.83	0.00
3.20	21762	35.2	40.8	0.0	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.83	0.00
3.30	24412	38.4	44.1	0.0	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.82	0.00
3.40	27592	43.4	49.4	0.0	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.81	0.00
3.50	30272	47.6	53.8	0.0	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.81	0.00
3.60	31169	49.0	55.0	0.0	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.80	0.00
3.70	32042	50.3	56.1	0.0	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.80	0.00
3.80	32043	51.9	57.4	0.0	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.79	0.00
3.90	31320	50.7	55.7	0.0	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.79	0.00
4.00	31446	50.9	55.6	0.0	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.78	0.00
4.10	31940	51.7	56.1	0.0	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.78	0.00
4.20	32456	52.5	56.7	0.0	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.77	0.00
4.30	32854	53.2	57.0	0.0	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.76	0.00
4.40	32405	52.5	55.9	0.0	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.76	0.00
4.50	31605	51.2	54.2	0.0	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.75	0.00
4.60	31018	51.8	54.5	0.1	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.75	0.00
4.70	30062	50.2	52.5	0.1	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.74	0.00
4.80	29996	50.1	52.1	0.1	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.74	0.00
4.90	31069	50.3	52.1	0.0	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.73	0.00
5.00	31120	50.4	51.9	0.0	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.73	0.00
5.10	30762	49.8	51.0	0.0	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.72	0.00
5.20	30162	48.8	49.8	0.0	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.72	0.00
5.30	29884	47.0	47.6	0.0	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.71	0.00
5.40	30280	47.6	48.0	0.0	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.70	0.00
5.50	31832	50.0	50.2	0.0	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.70	0.00
5.60	34377	54.0	54.0	0.0	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.69	0.00
5.70	35930	56.5	56.2	0.0	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.69	0.00
5.80	36786	57.8	57.2	0.0	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.68	0.00
5.90	36933	58.0	57.2	0.0	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.68	0.00
6.00	37062	58.2	57.1	0.0	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.67	0.00
6.10	37492	60.7	59.3	0.0	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.67	0.00
6.20	37647	60.9	59.3	0.0	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.66	0.00
6.30	37717	61.1	59.2	0.0	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.66	0.00
6.40	37350	60.5	58.3	0.0	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.65	0.00
6.50	37297	60.4	58.0	0.0	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.64	0.00
6.60	37651	61.0	58.3	0.0	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.64	0.00
6.70	37520	60.7	57.9	0.0	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.63	0.00
6.80	37042	61.8	58.7	0.1	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.63	0.00
6.90	36773	61.4	58.1	0.1	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.62	0.00
7.00	36890	61.6	58.0	0.1	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.62	0.00
7.10	37129	62.0	58.2	0.1	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.61	0.00
7.20	35460	59.2	55.4	0.1	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.61	0.00
7.30	29482	50.8	47.3	0.4	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.60	0.00
7.40	19794	36.5	33.9	1.7	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.60	0.00
7.50	14025	26.8	24.8	2.5	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.59	0.00
7.60	12493	23.8	22.0	2.5	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.58	0.00
7.70	11878	22.7	20.8	2.5	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.58	0.00
7.80	11659	22.2	20.4	2.5	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.57	0.00
7.90	11444	21.8	19.9	2.5	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.57	0.00
8.00	11095	21.2	19.3	2.5	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.56	0.00
8.10	11024	21.0	19.1	2.5	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.56	0.00
8.20	11094	21.2	19.1	2.5	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.55	0.00
8.30	11247	21.5	19.3	2.5	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.55	0.00
8.40	11570	22.1	19.8	2.5	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.54	0.00
8.50	12019	22.9	20.5	2.5	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.54	0.00
8.60	12812	23.6	21.1	1.7	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.53	0.00
8.70	13513	24.9	22.1	1.7	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.52	0.00
8.80	14239	26.2	23.3	1.7	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.52	0.00

Settlement of Unsaturated Sand (Tokimatsu & Seed, 1987, and Pradel, 1998) / Cumulative / S_r (Idriss & Boulanger, 2008)

Depth, Z (m)	$p = \sigma_m$ (tsf)	τ_{ave} (psf)	G_{max} (tsf)	τ_{ave}/G_{max}	a	b	γ_{eff} (%)	ε_{15} (%)	ε_{Nc} (%)	Settlement (inch)	Cumulative Settlement (inch)	$\Delta(N_1)_{60-Sr}$	$(N_1)_{60-Sr}$	S_r/σ_{v0}'
1.60	0.202	192	3399	0.00003	0.20272	16691	0.00311	0.001	0.001	0.00	0.08	N/A	N/A	N/A
1.70	0.215	204	3354	0.00003	0.20764	16095	0.00337	0.001	0.001	0.00	0.08	N/A	N/A	N/A
1.80	0.228	216	3069	0.00004	0.21256	15552	0.00396	0.002	0.001	0.00	0.08	N/A	N/A	N/A
1.90	0.240	228	2574	0.00004	0.21749	15056	0.00517	0.003	0.002	0.00	0.08	N/A	N/A	N/A
2.00	0.253	239	1947	0.00006	0.22241	14600	0.00778	0.006	0.005	0.00	0.08	N/A	N/A	N/A
2.10	0.266	251	1565	0.00008	0.22733	14178	0.01119	0.011	0.009	0.00	0.08	N/A	N/A	N/A
2.20	0.278	263	1426	0.00009	0.23225	13788	0.01370	0.015	0.013	0.00	0.08	N/A	N/A	N/A
2.30	0.291	275	1623	0.00008	0.23717	13425	0.01191	0.012	0.010	0.00	0.08	N/A	N/A	N/A
2.40	0.304	287	2064	0.00007	0.24209	13087	0.00895	0.007	0.006	0.00	0.08	N/A	N/A	N/A
2.50	0.316	299	2404	0.00006	0.24701	12770	0.00770	0.005	0.004	0.00	0.08	N/A	N/A	N/A
2.60	0.329	310	2555	0.00006	0.25193	12473	0.00746	0.005	0.004	0.00	0.08	N/A	N/A	N/A
2.70	0.342	322	2693	0.00006	0.25685	12194	0.00729	0.004	0.004	0.00	0.08	N/A	N/A	N/A
2.80	0.354	334	2896	0.00006	0.26177	11931	0.00695	0.004	0.003	0.00	0.08	N/A	N/A	N/A
2.90	0.367	346	3094	0.00006	0.26669	11682	0.00667	0.003	0.003	0.00	0.08	N/A	N/A	N/A
3.00	0.379	357	3325	0.00005	0.27161	11447	0.00635	0.003	0.003	0.00	0.08	N/A	N/A	N/A
3.10	0.392	369	3560	0.00005	0.27653	11224	0.00607	0.003	0.002	0.00	0.08	N/A	N/A	N/A
3.20	0.405	381	3865	0.00005	0.28145	11012	0.00570	0.002	0.002	0.00	0.08	N/A	N/A	N/A
3.30	0.417	392	4238	0.00005	0.28637	10811	0.00530	0.002	0.002	0.00	0.08	N/A	N/A	N/A
3.40	0.430	404	4825	0.00004	0.29129	10619	0.00471	0.002	0.001	0.00	0.08	N/A	N/A	N/A
3.50	0.443	415	5329	0.00004	0.29621	10436	0.00434	0.001	0.001	0.00	0.08	N/A	N/A	N/A
3.60	0.455	427	5524	0.00004	0.30113	10261	0.00430	0.001	0.001	0.00	0.08	N/A	N/A	N/A
3.70	0.468	438	5716	0.00004	0.30605	10093	0.00426	0.001	0.001	0.00	0.08	N/A	N/A	N/A
3.80	0.481	450	5926	0.00004	0.31097	9933	0.00421	0.001	0.001	0.00	0.08	N/A	N/A	N/A
3.90	0.493	461	5828	0.00004	0.31589	9780	0.00441	0.001	0.001	0.00	0.08	N/A	N/A	N/A
4.00	0.506	473	5887	0.00004	0.32081	9632	0.00448	0.001	0.001	0.00	0.08	N/A	N/A	N/A
4.10	0.519	484	6014	0.00004	0.32573	9490	0.00449	0.001	0.001	0.00	0.08	N/A	N/A	N/A
4.20	0.531	496	6146	0.00004	0.33065	9354	0.00449	0.001	0.001	0.00	0.08	N/A	N/A	N/A
4.30	0.544	507	6256	0.00004	0.33557	9223	0.00451	0.001	0.001	0.00	0.08	N/A	N/A	N/A
4.40	0.557	518	6204	0.00004	0.34049	9097	0.00467	0.001	0.001	0.00	0.08	N/A	N/A	N/A
4.50	0.569	530	6083	0.00004	0.34541	8975	0.00489	0.001	0.001	0.00	0.08	N/A	N/A	N/A
4.60	0.582	541	6189	0.00004	0.35033	8857	0.00491	0.001	0.001	0.00	0.08	N/A	N/A	N/A
4.70	0.594	552	6029	0.00005	0.35525	8744	0.00517	0.002	0.001	0.00	0.08	N/A	N/A	N/A
4.80	0.607	563	6045	0.00005	0.36017	8634	0.00527	0.002	0.001	0.00	0.07	N/A	N/A	N/A
4.90	0.620	574	6102	0.00005	0.36509	8528	0.00533	0.002	0.001	0.00	0.07	N/A	N/A	N/A
5.00	0.632	586	6141	0.00005	0.37001	8425	0.00540	0.002	0.001	0.00	0.07	N/A	N/A	N/A
5.10	0.645	597	6099	0.00005	0.37493	8326	0.00556	0.002	0.002	0.00	0.07	N/A	N/A	N/A
5.20	0.658	608	6007	0.00005	0.37985	8229	0.00578	0.002	0.002	0.00	0.07	N/A	N/A	N/A
5.30	0.670	619	5803	0.00005	0.38477	8136	0.00613	0.002	0.002	0.00	0.07	N/A	N/A	N/A
5.40	0.683	630	5906	0.00005	0.38969	8045	0.00613	0.002	0.002	0.00	0.07	N/A	N/A	N/A
5.50	0.696	641	6235	0.00005	0.39461	7957	0.00587	0.002	0.002	0.00	0.07	N/A	N/A	N/A
5.60	0.708	651	6763	0.00005	0.39953	7871	0.00545	0.002	0.001	0.00	0.07	N/A	N/A	N/A
5.70	0.721	662	7098	0.00005	0.40446	7788	0.00525	0.002	0.001	0.00	0.07	N/A	N/A	N/A
5.80	0.734	673	7297	0.00005	0.40938	7707	0.00518	0.001	0.001	0.00	0.07	N/A	N/A	N/A
5.90	0.746	684	7356	0.00005	0.41430	7629	0.00523	0.001	0.001	0.00	0.07	N/A	N/A	N/A
6.00	0.759	695	7411	0.00005	0.41922	7552	0.00527	0.001	0.001	0.00	0.07	N/A	N/A	N/A
6.10	0.772	705	7754	0.00005	0.42414	7478	0.00510	0.001	0.001	0.00	0.07	N/A	N/A	N/A
6.20	0.784	716	7816	0.00005	0.42906	7405	0.00514	0.001	0.001	0.00	0.07	N/A	N/A	N/A
6.30	0.797	727	7860	0.00005	0.43398	7334	0.00519	0.001	0.001	0.00	0.07	N/A	N/A	N/A
6.40	0.810	737	7813	0.00005	0.43890	7265	0.00531	0.001	0.001	0.00	0.07	N/A	N/A	N/A
6.50	0.822	748	7830	0.00005	0.44382	7198	0.00538	0.001	0.001	0.00	0.07	N/A	N/A	N/A
6.60	0.835	758	7933	0.00005	0.44874	7132	0.00538	0.001	0.001	0.00	0.07	N/A	N/A	N/A
6.70	0.847	769	7933	0.00005	0.45366	7068	0.00546	0.002	0.001	0.00	0.07	N/A	N/A	N/A
6.80	0.860	779	8106	0.00005	0.45858	7006	0.00541	0.001	0.001	0.00	0.07	N/A	N/A	N/A
6.90	0.873	789	8074	0.00005	0.46350	6945	0.00551	0.002	0.001	0.00	0.07	N/A	N/A	N/A
7.00	0.885	800	8128	0.00005	0.46842	6885	0.00555	0.002	0.001	0.00	0.07	N/A	N/A	N/A
7.10	0.898	810	8208	0.00005	0.47334	6827	0.00557	0.002	0.001	0.00	0.07	N/A	N/A	N/A
7.20	0.911	820	7865	0.00005	0.47826	6770	0.00593	0.002	0.001	0.00	0.07	N/A	N/A	N/A
7.30	0.923	830	6772	0.00006	0.48318	6714	0.00715	0.003	0.002	0.00	0.07	N/A	N/A	N/A
7.40	0.936	840	4876	0.00009	0.48810	6659	0.01081	0.006	0.005	0.00	0.07	N/A	N/A	N/A
7.50	0.949	850	3590	0.00012	0.49302	6606	0.01649	0.013	0.011	0.00	0.07	N/A	N/A	N/A
7.60	0.961	860	3207	0.00013	0.49794	6553	0.01969	0.018	0.015	0.00	0.07	N/A	N/A	N/A
7.70	0.974	870	3059	0.00014	0.50286	6502	0.02147	0.020	0.017	0.00	0.07	N/A	N/A	N/A
7.80	0.987	880	3012	0.00015	0.50778	6452	0.02233	0.022	0.018	0.00	0.07	N/A	N/A	N/A
7.90	0.999	890	2965	0.00015	0.51270	6403	0.02323	0.023	0.020	0.00	0.07	N/A	N/A	N/A
8.00	1.012	900	2883	0.00016	0.51762	6355	0.02464	0.026	0.022	0.00	0.07	N/A	N/A	N/A
8.10	1.025	910	2873	0.00016	0.52254	6308	0.02515	0.027	0.022	0.00	0.06	N/A	N/A	N/A
8.20	1.037	920	2900	0.00016	0.52746	6261	0.02515	0.027	0.022	0.00	0.06	N/A	N/A	N/A
8.30	1.050	929	2948	0.00016	0.53238	6216	0.02487	0.026	0.022	0.00	0.06	N/A	N/A	N/A
8.40	1.062	939	3041	0.00015	0.53730	6171	0.02402	0.024	0.020	0.00	0.06	N/A	N/A	N/A
8.50	1.075	948	3168	0.00015	0.54222	6128	0.02287	0.022	0.019	0.00	0.06	N/A	N/A	N/A
8.60	1.088	958	3270	0.00015	0.54714	6085	0.02210	0.021	0.017	0.00	0.06	N/A	N/A	N/A
8.70	1.100	967	3458	0.00014	0.55206	6043	0.02060	0.018	0.015	0.00	0.05	N/A	N/A	N/A
8.80	1.113	977	3654	0.00013	0.55698	6002	0.01925	0.016	0.013	0.00	0.05	N/A	N/A	N/A

Depth, Z (m)	Depth, Z (ft)	q_c (kPa)	f_s (kPa)	σ_{vc} (kPa)	σ'_{vc} (kPa)	Q	F	I_c	Soil Type	Fines (%)	Interpreted q_c	C_N	q_{c1N}	$q_{c1N\text{-}cs}$	Stress Reduction Factor (r_d)	CSR	K_σ for sand	$CRR_{M=7.5}$ at σ'_{vc}=1	MSF_{max}	MSF	CRR	$(FS)_L$	q_t (kPa)	N_{60}	$N_{1,60}$	$\Delta(N_1)_{60}$	$N_{1,60\text{-}CS}$	Limiting Shear Strain γ_{lim}	Parameter F_α	Max. Shear Strain γ_{max}	ΔHi (m)	ΔLDI_i (m)	Vert. Recon. Strain ε_v	DF_i	ΔSi (inch)	$p = \sigma_m$ (tsf)	τ_{ave} (psf)	G_{max} (tsf)	τ_{ave}/G_{max}	a	b	γ_{eff} (%)	ε_{15} (%)	ε_{Nc} (%)	Settlement (inch)	Settlement (inch)	$\Delta(N_1)_{60\text{-}Sr}$	$(N_1)_{60\text{-}Sr}$	S_r/σ_{v0}'
8.90	29.19	14710	63	160.9	160.9	114	0.43	1.7	Unsaturated	11	14710	0.88	128.8	151.3	0.88	0.279	0.9	0.297	1.68	1.147	0.315	N/L	14734	27.1	24.0	1.7	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.51	0.00	1.126	986	3791	0.00013	0.56190	5961	0.01849	0.015	0.012	0.00	0.05	N/A	N/A	N/A
9.00	29.52	15209	69	162.7	162.7	117	0.46	1.7	Unsaturated	11	15209	0.88	132.8	155.7	0.87	0.279	0.9	0.331	1.74	1.158	0.352	N/L	15145	27.9	24.6	1.7	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.51	0.00	1.138	996	3907	0.00013	0.56682	5921	0.01793	0.014	0.012	0.00	0.05	N/A	N/A	N/A
9.10	29.85	15247	72	164.5	164.5	117	0.48	1.7	Unsaturated	11	15247	0.88	132.7	155.6	0.87	0.278	0.9	0.330	1.74	1.158	0.351	N/L	18135	33.4	29.4	1.7	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.50	0.00	1.151	1005	4691	0.00011	0.57174	5882	0.01413	0.009	0.007	0.00	0.05	N/A	N/A	N/A
9.20	30.18	15654	71	166.3	166.3	119	0.46	1.6	Unsaturated	10	15654	0.88	135.9	148.8	0.87	0.277	0.9	0.281	1.65	1.140	0.295	N/L	18503	33.0	28.9	0.9	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.50	0.00	1.164	1014	4638	0.00011	0.57666	5844	0.01450	0.009	0.008	0.00	0.05	N/A	N/A	N/A
9.30	30.50	17619	75	168.1	168.1	134	0.43	1.6	Unsaturated	10	17619	0.87	152.5	166.4	0.87	0.277	0.9	0.448	1.88	1.189	0.482	N/L	17775	31.7	27.7	0.9	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.49	0.00	1.176	1023	4467	0.00011	0.58158	5806	0.01543	0.010	0.009	0.00	0.05	N/A	N/A	N/A
9.40	30.83	16999	82	169.9	169.9	128	0.49	1.6	Unsaturated	10	16999	0.87	146.7	160.3	0.87	0.276	0.9	0.374	1.80	1.171	0.398	N/L	16994	30.3	26.4	0.9	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.49	0.00	1.189	1032	4282	0.00012	0.58650	5769	0.01653	0.012	0.010	0.00	0.05	N/A	N/A	N/A
9.50	31.16	12763	65	171.7	171.7	95	0.51	1.8	Unsaturated	13	12763	0.87	109.8	140.1	0.87	0.276	0.9	0.235	1.56	1.120	0.243	N/L	13009	24.8	21.6	2.5	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.48	0.00	1.202	1041	3521	0.00015	0.59143	5732	0.02212	0.020	0.017	0.00	0.05	N/A	N/A	N/A
9.60	31.49	11235	56	173.5	173.5	83	0.51	1.8	Unsaturated	13	11235	0.87	96.4	124.6	0.86	0.275	0.9	0.182	1.42	1.090	0.185	N/L	11344	21.6	18.8	2.5	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.48	0.00	1.214	1050	3078	0.00017	0.59635	5696	0.02754	0.030	0.025	0.00	0.05	N/A	N/A	N/A
9.70	31.82	10500	40	175.4	175.4	77	0.39	1.8	Unsaturated	13	10500	0.86	89.9	117.1	0.86	0.274	0.9	0.165	1.37	1.078	0.166	N/L	10496	20.0	17.3	2.5	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.47	0.00	1.227	1059	2855	0.00019	0.60127	5661	0.03150	0.037	0.031	0.00	0.04	N/A	N/A	N/A
9.80	32.14	10083	37	177.2	177.2	74	0.38	1.8	Unsaturated	13	10083	0.86	86.1	112.7	0.86	0.274	0.9	0.157	1.34	1.072	0.157	N/L	10161	19.4	16.7	2.5	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.46	0.00	1.240	1068	2770	0.00019	0.60619	5626	0.03353	0.042	0.035	0.00	0.04	N/A	N/A	N/A
9.90	32.47	10320	41	179.0	179.0	75	0.41	1.8	Unsaturated	13	10320	0.86	87.9	114.8	0.86	0.273	0.9	0.160	1.35	1.075	0.161	N/L	10500	20.0	17.2	2.5	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.46	0.00	1.252	1077	2869	0.00019	0.61111	5592	0.03198	0.038	0.032	0.00	0.04	N/A	N/A	N/A
10.00	32.80	12589	50	180.8	180.8	92	0.40	1.7	Unsaturated	11	12589	0.86	106.9	127.1	0.86	0.273	0.9	0.189	1.44	1.095	0.191	N/L	12944	23.8	20.5	1.7	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.45	0.00	1.265	1086	3424	0.00016	0.61603	5558	0.02441	0.024	0.020	0.00	0.04	N/A	N/A	N/A
10.10	33.13	18979	71	182.6	182.6	138	0.38	1.6	Unsaturated	10	18979	0.86	160.7	175.1	0.85	0.272	0.9	0.601	2.01	1.217	0.644	N/L	19779	35.2	30.1	0.9	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.45	0.00	1.277	1094	5069	0.00011	0.62095	5525	0.01417	0.009	0.007	0.00	0.03	N/A	N/A	N/A
10.20	33.46	27998	112	184.4	184.4	204	0.40	1.4	Unsaturated	7	27998	0.85	236.5	238.4	0.85	0.271	0.8	2.000	2.20	1.257	2.000	N/L	26576	44.4	37.9	0.1	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.44	0.00	1.290	1103	6400	0.00009	0.62587	5493	0.01063	0.005	0.004	0.00	0.03	N/A	N/A	N/A
10.30	33.78	22676	134	186.2	186.2	164	0.59	1.6	Unsaturated	10	22676	0.85	191.1	207.2	0.85	0.271	0.8	2.898	2.20	1.257	2.000	N/L	22769	40.5	34.5	0.9	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.44	0.00	1.303	1112	5862	0.00009	0.63079	5461	0.01197	0.006	0.005	0.00	0.03	N/A	N/A	N/A
10.40	34.11	18514	97	188.0	188.0	133	0.53	1.6	Unsaturated	10	18514	0.85	155.6	169.6	0.85	0.270	0.9	0.497	1.93	1.199	0.525	N/L	19246	34.3	29.1	0.9	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.43	0.00	1.315	1120	4966	0.00011	0.63571	5429	0.01498	0.010	0.008	0.00	0.03	N/A	N/A	N/A
10.50	34.44	21947	87	189.8	189.8	157	0.40	1.5	Unsaturated	8	21947	0.85	184.0	190.4	0.85	0.270	0.9	1.144	2.20	1.257	1.225	N/L	23035	39.7	33.6	0.4	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.43	0.00	1.328	1129	5766	0.00010	0.64063	5398	0.01245	0.007	0.006	0.00	0.03	N/A	N/A	N/A
10.60	34.77	30644	115	191.6	191.6	219	0.38	1.4	Unsaturated	7	30644	0.84	256.2	258.2	0.84	0.269	0.8	2.000	2.20	1.257	2.000	N/L	29954	50.0	42.2	0.1	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.42	0.00	1.341	1137	7279	0.00008	0.64555	5368	0.00941	0.004	0.003	0.00	0.03	N/A	N/A	N/A
10.70	35.10	29671	158	193.4	193.4	211	0.54	1.5	Unsaturated	8	29671	0.84	247.5	255.4	0.84	0.268	0.8	2.000	2.20	1.257	2.000	N/L	29126	50.2	42.3	0.4	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.42	0.00	1.353	1146	7322	0.00008	0.65047	5337	0.00942	0.004	0.003	0.00	0.03	N/A	N/A	N/A
10.80	35.42	25611	123	195.2	195.2	181	0.49	1.5	Unsaturated	8	25611	0.84	213.1	220.2	0.84	0.268	0.8	2.000	2.20	1.257	2.000	N/L	25611	44.1	37.1	0.4	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.41	0.00	1.366	1154	6453	0.00009	0.65539	5308	0.01109	0.005	0.004	0.00	0.03	N/A	N/A	N/A
10.90	35.75	32111	128	197.1	197.1	226	0.40	1.4	Unsaturated	7	32111	0.84	266.5	268.6	0.84	0.267	0.8	2.000	2.20	1.257	2.000	N/L	32509	54.3	45.5	0.1	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.40	0.00	1.379	1162	7952	0.00007	0.66031	5278	0.00868	0.003	0.003	0.00	0.03	N/A	N/A	N/A
11.00	36.08	44003	171	198.9	198.9	309	0.39	1.3	Unsaturated	6	44003	0.84	364.4	364.6	0.84	0.267	0.8	2.000	2.20	1.257	2.000	N/L	42395	68.6	57.4	0.0	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.40	0.00	1.391	1170	10078	0.00006	0.66523	5250	0.00663	0.002	0.002	0.00	0.03	N/A	N/A	N/A
11.10	36.41	42180	245	200.7	200.7	294	0.58	1.4	Unsaturated	7	42180	0.83	348.4	351.0	0.84	0.266	0.8	2.000	2.20	1.257	1.996	N/L	40844	68.2	56.9	0.1	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.39	0.00	1.404	1179	10034	0.00006	0.67015	5221	0.00672	0.002	0.002	0.00	0.03	N/A	N/A	N/A
11.20	36.74	33955	217	202.5	202.5	236	0.64	1.5	Unsaturated	8	33955	0.83	279.8	288.5	0.83	0.265	0.8	2.000	2.20	1.257	1.989	N/L	34441	59.4	49.4	0.4	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.39	0.00	1.417	1187	8753	0.00007	0.67507	5193	0.00793	0.003	0.002	0.00	0.03	N/A	N/A	N/A
11.30	37.06	31692	166	204.3	204.3	219	0.53	1.5	Unsaturated	8	31692	0.83	260.6	268.8	0.83	0.265	0.8	2.000	2.20	1.257	1.982	N/L	31828	54.9	45.5	0.4	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.38	0.00	1.429	1195	8106	0.00007	0.67999	5165	0.00875	0.003	0.003	0.00	0.03	N/A	N/A	N/A
11.40	37.39	31203	152	206.1	206.1	215	0.49	1.5	Unsaturated	8	31203	0.83	256.0	264.0	0.83	0.264	0.8	2.000	2.20	1.257	1.976	N/L	31203	53.8	44.6	0.4	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.38	0.00	1.442	1203	7963	0.00008	0.68491	5138	0.00901	0.003	0.003	0.00	0.03	N/A	N/A	N/A
11.50	37.72	31202	141	207.9	207.9	214	0.45	1.4	Unsaturated	7	31202	0.83	255.4	257.3	0.83	0.264	0.8	2.000	2.20	1.257	1.969	N/L	31121	52.0	42.9	0.1	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.37	0.00	1.455	1211	7710	0.00008	0.68983	5111	0.00943	0.004	0.003	0.00	0.03	N/A	N/A	N/A
11.60	38.05	30830	143	209.7	209.7	210	0.47	1.5	Unsaturated	8	30830	0.82	251.7	259.7	0.83	0.263	0.8	2.000	2.20	1.257	1.963	N/L	30830	53.1	43.8	0.4	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.37	0.00	1.467	1219	7900	0.00008	0.69475	5085	0.00923	0.004	0.003	0.00	0.03	N/A	N/A	N/A
11.70	38.38	30816	150	211.5	211.5	209	0.49	1.5	Unsaturated	8	30816	0.82	251.0	259.0	0.82	0.262	0.8	2.000	2.20	1.257	1.956	N/L	30815	53.1	43.7	0.4	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.36	0.00	1.480	1226	7912	0.00008	0.69967	5059	0.00928	0.004	0.003	0.00	0.03	N/A	N/A	N/A
11.80	38.70	31441	171	213.3	213.3	212	0.55	1.5	Unsaturated	8	31441	0.82	255.6	263.7	0.82	0.262	0.8	2.000	2.20	1.257	1.950	N/L	31277	53.9	44.3	0.4	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.35	0.00	1.493	1234	8047	0.00008	0.70459	5033	0.00916	0.004	0.003	0.00	0.03	N/A	N/A	N/A
11.90	39.03	31066	187	215.1	215.1	209	0.61	1.5	Unsaturated	8	31066	0.82	252.0	260.0	0.82	0.261	0.8	2.000	2.20	1.257	1.943	N/L	31165	53.7	44.0	0.4	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.35	0.00	1.505	1242	8034	0.00008	0.70951	5008	0.00924	0.004	0.003	0.00	0.03	N/A	N/A	N/A
12.00	39.36	30919	157	216.9	216.9	207	0.51	1.5	Unsaturated	8	30919	0.82	250.2	258.2	0.82	0.261	0.8	2.000	2.20	1.257	1.937	N/L	31004	53.4	43.7	0.4	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.34	0.00	1.518	1249	8009	0.00008	0.71443	4983	0.00934	0.004	0.003	0.00	0.03	N/A	N/A	N/A
12.10	39.69	31335	160	218.7	218.7	209	0.51	1.5	Unsaturated	8	31335	0.82	253.0	261.0	0.82	0.260	0.8	2.000	2.20	1.257	1.931	N/L	31334	54.0	44.0	0.4	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.34	0.00	1.530	1257	8110	0.00008	0.71935	4958	0.00927	0.004	0.003	0.00	0.03	N/A	N/A	N/A
12.20	40.02	31913	170	220.6	220.6	212	0.54	1.5	Unsaturated	8	31913	0.81	257.1	265.3	0.81	0.259	0.8	2.000	2.20	1.257	1.925	N/L	31827	54.8	44.6	0.4	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.33	0.00	1.543	1265	8253	0.00008	0.72427	4933	0.00914	0.003	0.003	0.00	0.03	N/A	N/A	N/A
12.30	40.34	31423	182	222.4	222.4	208	0.58	1.5	Unsaturated	8	31423	0.81	252.6	260.7	0.81	0.259	0.8	2.000	2.20	1.257	1.918	N/L	31609	54.5	44.2	0.4	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.33	0.00	1.556	1272	8213	0.00008	0.72919	4909	0.00926	0.004	0.003	0.00	0.03	N/A	N/A	N/A
12.40	40.67	31462	178	224.2	224.2	207	0.57	1.5	Unsaturated	8	31462	0.81	252.4	260.4	0.81	0.258	0.8	2.000	2.20	1.257	1.912	N/L	31462	54.2	43.9	0.4	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.32	0.00	1.568	1279	8190	0.00008	0.73411	4885	0.00935	0.004	0.003	0.00	0.03	N/A	N/A	N/A
12.50	41.00	31680	178	226.0	226.0	208	0.57	1.5	Unsaturated	8	31680	0.81	253.6	261.7	0.81	0.258	0.8	2.000	2.20	1.257	1.906	N/L	31743	54.7	44.2	0.4	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.32	0.00	1.581	1287	8279	0.00008	0.73903	4862	0.00929	0.004	0.003	0.00	0.03	N/A	N/A	N/A
12.60	41.33	32258	176	227.8	227.8	211	0.55	1.5	Unsaturated	8	32258	0.81	257.7	265.8	0.81	0.257	0.8	2.000	2.20	1.257	1.900	N/L	32324	55.7	44.9	0.4	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.31	0.00	1.594	1294	8446	0.00008	0.74395	4839	0.00913	0.003	0.003	0.00	0.03	N/A	N/A	N/A
12.70	41.66	32966	176	229.6	229.6	215	0.54	1.5	Unsaturated	8	32966	0.81	262.8	271.1	0.80	0.256	0.8	2.000	2.20	1.257	1.894	N/L	32686	56.3	45.4	0.4	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.31	0.00	1.606	1301	8557	0.00008	0.74887	4816	0.00904	0.003	0.003	0.00	0.03	N/A	N/A	N/A
12.80	41.98	31904	159	231.4	231.4	207	0.50	1.5	Unsaturated	8	31904	0.80	253.8	261.9	0.80	0.256	0.8	2.000	2.20	1.257	1.888	N/L	31982	55.1	44.3	0.4	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.30	0.00	1.619	1309	8388	0.00008	0.75379	4793	0.00932	0.004	0.003	0.00	0.03	N/A	N/A	N/A
12.90	42.31	31845	156	233.2	233.2	206	0.49	1.5	Unsaturated	8	31845	0.80	252.8	260.9	0.80	0.255	0.7	2.000	2.20	1.257	1.882	N/L	31705	54.6	43.8	0.4	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.29	0.00	1.632	1316	8331	0.00008	0.75871	4771	0.00946	0.004	0.003	0.00	0.03	N/A	N/A	N/A
13.00	42.64	31572	154	235.0	235.0	203	0.49	1.5	Unsaturated	8	31572	0.80	250.2	258.1	0.80	0.255	0.7	2.000	2.20	1.257	1.877	N/L	31633	54.5	43.6	0.4	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.29	0.00	1.644	1323	8327	0.00008	0.76363	4749	0.00952	0.004	0.003	0.00	0.03	N/A	N/A	N/A
13.10	42.97	31845	152	236.8	236.8	204	0.48	1.5	Unsaturated	8	31845	0.80	251.8	259.8	0.80	0.254	0.7	2.000	2.20	1.257	1.871	N/L	31908	55.0	43.9	0.4	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.28	0.00	1.657	1330	8415	0.00008	0.76855	4727	0.00946	0.004	0.003	0.00	0.03	N/A	N/A	N/A
13.20	43.30	32595	157	238.6	238.6	208	0.49	1.5	Unsaturated	8	32595	0.80	257.2	265.3	0.80	0.253	0.7	2.000	2.20	1.257	1.865	N/L	32635	56.2	44.8	0.4	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.28	0.00	1.670	1337	8622	0.00008	0.77347	4706	0.00924	0.004	0.003	0.00	0.03	N/A	N/A	N/A
13.30	43.62	32851	185	240.4	240.4	209	0.57	1.5	Unsaturated	8	32851	0.80	258.7	266.9	0.79	0.253	0.7	2.000	2.20	1.257	1.859	N/L	32974	56.8	45.2	0.4	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.27	0.00	1.682	1344	8727	0.00008	0.77840	4684	0.00916	0.003	0.003	0.00	0.03	N/A	N/A	N/A
13.40	43.95	32624	176	242.2	242.2	207	0.55	1.5	Unsaturated	8	32624	0.79	256.4	264.5	0.79	0.252	0.7	2.000	2.20	1.257	1.854	N/L	32815	56.6	44.9	0.4	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.27	0.00	1.695	1350	8700	0.00008	0.78332	4663	0.00925	0.004	0.003	0.00	0.03	N/A	N/A	N/A
13.50	44.28	33149	155	244.1	244.1	209	0.47	1.5	Unsaturated	8	33149	0.79	260.1	268.2	0.79	0.252	0.7	2.000	2.20	1.257	1.848	N/L	33249	57.3	45.4	0.4	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.26	0.00	1.708	1357	8831	0.00008	0.78824	4643	0.00914	0.003	0.003	0.00	0.03	N/A	N/A	N/A
13.60	44.61	34952	176	245.9	245.9	220	0.51	1.5	Unsaturated	8	34952	0.79	273.7	282.2	0.79	0.251	0.7	2.000	2.20	1.257	1.842	N/L	34961	60.3	47.6	0.4	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.26	0.00	1.720	1364	9302	0.00007	0.79316	4622	0.00864	0.003	0.003	0.00	0.03	N/A	N/A	N/A
13.70	44.94	36577	208	247.7	247.7	229	0.57	1.5	Unsaturated	8	36577	0.79	285.8	294.6	0.79	0.250	0.7	2.000	2.20	1.257	1.837	N/L	36406	62.7	49.5	0.4	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.25	0.00	1.733	1371	9703	0.00007	0.79808	4602	0.00827	0.003	0.002	0.00	0.03	N/A	N/A	N/A
13.80	45.26	35300	214	249.5	249.5	220	0.61	1.5	Unsaturated	8	35300	0.79	275.3	283.9	0.78	0.250	0.7	2.000	2.20	1.257	1.831	N/L	35102	60.5	47.7	0.4	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.25	0.00	1.745	1377	9371	0.00007	0.80300	4582	0.00866	0.003	0.003	0.00	0.03	N/A	N/A	N/A
13.90	45.59	32320	175	251.3	251.3	201	0.55	1.5	Unsaturated	8	32320	0.79	251.6	259.6	0.78	0.249	0.7	2.000	2.20	1.257	1.826	N/L	32421	55.9	43.9	0.4	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.24	0.00	1.758	1384	8671	0.00008	0.80792	4562	0.00955	0.004	0.003	0.00	0.02	N/A	N/A	N/A
14.00	45.92	30069	164	253.1	253.1	186	0.55	1.5	Unsaturated	8	30069	0.78	233.6	241.2	0.78	0.249	0.7	2.000	2.20	1.257	1.821	N/L	29930	51.6	40.5	0.4	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.23	0.00	1.771	1390	8018	0.00009	0.81284	4542	0.01055	0.005	0.004	0.00	0.02	N/A	N/A	N/A
14.10	46.25	26732	144	254.9	254.9	165	0.54	1.6	Unsaturated	10	26732	0.78	207.3	224.4	0.78	0.248	0.7	2.000	2.20	1.257	1.815	N/L	26759	47.7	37.3	0.9	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.23	0.00	1.783	1397	7420	0.00009	0.81776	4523	0.01166	0.006	0.005	0.00	0.02	N/A	N/A	N/A
14.20	46.58	25782	143	256.7	256.7	158	0.56	1.6	Unsaturated	10	25782	0.78	199.6	216.2	0.78	0.247	0.7	2.000	2.20	1.257	1.810	N/L	25782	45.9	35.9	0.9	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.22	0.00	1.796	1403	7161	0.00010	0.82268	4504	0.01225	0.006	0.005	0.00	0.02	N/A	N/A	N/A
14.30	46.90	28308	157	258.5	258.5	173	0.56	1.6	Unsaturated	10	28308	0.78	218.7	236.4	0.77	0.247	0.7	2.000	2.20	1.257	1.805	N/L	28138	50.1	39.1	0.9	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.22	0.00	1.809	1410	7828	0.00009	0.82760	4485	0.01103	0.005	0.004	0.00	0.02	N/A	N/A	N/A
14.40	47.23	31990	178	260.3	260.3	195	0.56	1.5	Unsaturated	8	31990	0.78	246.7	254.6	0.77	0.246	0.7	2.000	2.20	1.257	1.799	N/L	32139	55.4	43.1	0.4	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.21	0.00	1.821	1416	8667	0.00008	0.83252	4466	0.00980	0.004	0.003	0.00	0.02	N/A	N/A	N/A
14.50	47.56	36846	199	262.1	262.1	225	0.54	1.5	Unsaturated	8	36846	0.78	283.7	292.4	0.77	0.246	0.7	2.000	2.20	1.257	1.794	N/L	36729	63.3	49.2	0.4	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.21	0.00	1.834	1422	9921	0.00007	0.83744	4448	0.00839	0.003	0.002	0.00	0.02	N/A	N/A	N/A
14.60	47.89	39607	218	263.9	263.9	241	0.55	1.5	Unsaturated	8	39607	0.78	304.4	313.6	0.77	0.245	0.7	2.000	2.20	1.257	1.789	N/L	39536	68.1	52.9	0.4	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.20	0.00	1.847	1428	10697	0.00007	0.84236	4429	0.00773	0.002	0.002	0.00	0.02	N/A	N/A	N/A
14.70	48.22	40835	223	265.7	265.7	247	0.55	1.4	Unsaturated	7	40835	0.77	313.2	315.5	0.77	0.244	0.7	2.000	2.20	1.257	1.784	N/L	40670	67.9	52.6	0.1	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.20	0.00	1.859	1434	10677	0.00007	0.84728	4411	0.00778	0.002	0.002	0.00	0.02	N/A	N/A	N/A
14.80	48.54	39244	250	267.6	267.6	237	0.64	1.5	Unsaturated	8	39244	0.77	300.5	309.6	0.77	0.244	0.7	2.000	2.20	1.257	1.779	N/L	39067	67.3	52.1	0.4	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.19	0.00	1.872	1440	10604	0.00007	0.85220	4393	0.00788	0.002	0.002	0.00	0.02	N/A	N/A	N/A
14.90	48.87	34739	225	269.4	269.4	209	0.65	1.5	Unsaturated	8	34739	0.77	265.5	273.8	0.76	0.243	0.7	2.000	2.20	1.257	1.774	N/L	34866	60.1	46.4	0.4	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.19	0.00	1.885	1446	9479	0.00008	0.85712	4376	0.00902	0.003	0.003	0.00	0.02	N/A	N/A	N/A
15.00	49.20	30878	163	271.2	271.2	185	0.53	1.5	Unsaturated	8	30878	0.77	235.6	243.2	0.76	0.243	0.7	2.000	2.20	1.257	1.768	N/L	30857	53.2	41.0	0.4	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.18	0.00	1.897	1452	8402	0.00009	0.86204	4358	0.01047	0.004	0.004	0.00	0.02	N/A	N/A	N/A
15.10	49.53	26726	147	273.0	273.0	159	0.56	1.6	Unsaturated	10	26726	0.77	203.6	220.4	0.76	0.242	0.7	2.000	2.20	1.257	1.763	N/L	26786	47.7	36.7	0.9	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.17	0.00	1.910	1458	7548	0.00010	0.86696	4341	0.01199	0.006	0.005	0.00	0.02	N/A	N/A	N/A
15.20	49.86	23366	147	274.8	274.8	138	0.64	1.7	Unsaturated	11	23366	0.77	177.7	205.2	0.76	0.241	0.7	2.571	2.20	1.257	2.000	N/L	23607	43.5	33.4	1.7	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.17	0.00	1.923	1464	6893	0.00011	0.87188	4324	0.01350	0.007	0.006	0.00	0.02	N/A	N/A	N/A
15.30	50.18	22398	127	276.6	276.6	132	0.58	1.7	Unsaturated	11	22398	0.77	170.0	196.8	0.76	0.241	0.7	1.584	2.20	1.257	1.483	N/L	22301	41.1	31.5	1.7	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.16	0.00	1.935	1470	6521	0.00011	0.87680	4307	0.01456	0.008	0.007	0.00	0.02	N/A	N/A	N/A
15.40	50.51	21003	119	278.4	278.4	123	0.57	1.7	Unsaturated	11	21003	0.77	159.1	184.8	0.75	0.240	0.8	0.887	2.17	1.251	0.859	N/L	20902	38.5	29.5	1.7	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.16	0.00	1.948	1475	6122	0.00012	0.88172	4290	0.01587	0.010	0.008	0.00	0.02	N/A	N/A	N/A
15.50	50.84	18495	79	280.2	280.2	108	0.44	1.7	Unsaturated	11	18495	0.76	139.9	163.5	0.75	0.240	0.8	0.411	1.84	1.180	0.395	N/L	18648	34.4	26.2	1.7	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.15	0.00	1.961	1481	5470	0.00014	0.88664	4273	0.01852	0.013	0.011	0.00	0.02	N/A	N/A	N/A
15.60	51.17	16448	51	282.0	282.0	96	0.32	1.7	Unsaturated	11	16448	0.76	124.2	146.2	0.75	0.239	0.8	0.265	1.63	1.134	0.253	N/L	16698	30.8	23.5	1.7	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.15	0.00	1.973	1487	4905	0.00015	0.89156	4257	0.02163	0.018	0.015	0.00	0.02	N/A	N/A	N/A
15.70	51.50	16135	51	283.8	283.8	93	0.32	1.7	Unsaturated	11	16135	0.76	121.6	143.4	0.75	0.238	0.8	0.250	1.60	1.128	0.238	N/L	16169	29.8	22.7	1.7	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.14	0.00	1.986	1492	4757	0.00016	0.89648	4240	0.02269	0.020	0.016	0.00	0.02	N/A	N/A	N/A
15.80	51.82	16215	55	285.6	285.6	94	0.35	1.7	Unsaturated	11	16215	0.76	122.0	143.8	0.75	0.238	0.8	0.252	1.60	1.129	0.240	N/L	16215	29.9	22.7	1.7	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.14	0.00	1.998	1498	4778	0.00016	0.90140	4224	0.02265	0.019	0.016	0.00	0.02	N/A	N/A	N/A
15.90	52.15	16442	59	287.4	287.4	95	0.37	1.7	Unsaturated	11	16442	0.76	123.5	145.5	0.75	0.237	0.8	0.261	1.62	1.132	0.248	N/L	16479	30.4	23.0	1.7	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.13	0.00	2.011	1503	4863	0.00015	0.90632	4208	0.02219	0.019	0.016	0.00	0.02	N/A	N/A	N/A
16.00	52.48	17135	59	289.2	289.2	98	0.35	1.7	Unsaturated	11	17135	0.76	128.5	151.0	0.74	0.237	0.8	0.295	1.68	1.146	0.281	N/L	17258	31.8	24.1	1.7	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.13	0.00	2.024	1509	5100	0.00015	0.91124	4193	0.02084	0.017	0.014	0.00	0.01	N/A	N/A	N/A
16.10	52.81	18460	56	291.1	291.1	106	0.31	1.6	Unsaturated	10	18460	0.76	138.2	151.3	0.74	0.236	0.8	0.297	1.68	1.147	0.282	N/L	18261	32.5	24.6	0.9	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.12	0.00	2.036	1514	5224	0.00014	0.91616	4177	0.02025	0.016	0.013	0.00	0.01	N/A	N/A	N/A
16.20	53.14	17339	55	292.9	292.9	99	0.32	1.6	Unsaturated	10	17339	0.76	129.6	142.2	0.74	0.236	0.8	0.244	1.58	1.125	0.231	N/L	17672	31.5	23.8	0.9	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.11	0.00	2.049	1519	5064	0.00015	0.92108	4161	0.02124	0.017	0.014	0.00	0.01	N/A	N/A	N/A
16.30	53.46	16690	56	294.7	294.7	95	0.34	1.7	Unsaturated	11	16690	0.75	124.6	146.6	0.74	0.235	0.8	0.268	1.63	1.135	0.253	N/L	16883	31.1	23.4	1.7	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.11	0.00	2.062	1524	5011	0.00015	0.92600	4146	0.02164	0.018	0.015	0.00	0.01	N/A	N/A	N/A
16.40	53.79	16713	55	296.5	296.5	95	0.34	1.7	Unsaturated	11	16713	0.75	124.6	146.6	0.74	0.234	0.8	0.268	1.63	1.135	0.253	N/L	17357	32.0	24.1	1.7	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.10	0.00	2.074	1530	5160	0.00015	0.93092	4131	0.02086	0.017	0.014	0.00	0.01	N/A	N/A	N/A
16.50	54.12	20386	65	298.3	298.3	116	0.32	1.6	Unsaturated	10	20386	0.75	151.7	165.5	0.73	0.234	0.8	0.436	1.87	1.186	0.414	N/L	20064	35.7	26.9	0.9	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.10	0.00	2.087	1535	5774	0.00013	0.93584	4116	0.01797	0.013	0.011	0.00	0.01	N/A	N/A	N/A
16.60	54.45	20882	80	300.1	300.1	118	0.39	1.6	Unsaturated	10	20882	0.75	155.1	169.1	0.73	0.233	0.8	0.489	1.92	1.197	0.464	N/L	20983	37.4	28.0	0.9	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.09	0.00	2.100	1540	6047	0.00013	0.94076	4101	0.01696	0.011	0.009	0.00	0.01	N/A	N/A	N/A
16.70	54.78	21735	76	301.9	301.9	123	0.36	1.6	Unsaturated	10	21735	0.75	161.2	175.6	0.73	0.233	0.8	0.612	2.02	1.218	0.581	N/L	21716	38.7	29.0	0.9	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.09	0.00	2.112	1545	6267	0.00012	0.94568	4086	0.01625	0.010	0.009	0.00	0.01	N/A	N/A	N/A
16.80	55.10	22912	88	303.7	303.7	129	0.39	1.6	Unsaturated	10	22912	0.75	169.7	184.5	0.73	0.232	0.8	0.877	2.17	1.250	0.829	N/L	22701	40.4	30.2	0.9	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.08	0.00	2.125	1550	6560	0.00012	0.95060	4072	0.01537	0.009	0.008	0.00	0.01	N/A	N/A	N/A
16.90	55.43	22646	108	305.5	305.5	127	0.48	1.6	Unsaturated	10	22646	0.75	167.4	182.2	0.73	0.232	0.8	0.793	2.13	1.242	0.749	N/L	22665	40.4	30.1	0.9	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.08	0.00	2.138	1555	6559	0.00012	0.95552	4057	0.01542	0.009	0.008	0.00	0.01	N/A	N/A	N/A
17.00	55.76	22670	105	307.3	307.3	127	0.47	1.6	Unsaturated	10	22670	0.75	167.4	182.1	0.73	0.231	0.8	0.790	2.13	1.241	0.745	N/L	23050	41.0	30.6	0.9	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.07	0.00	2.150	1559	6680	0.00012	0.96044	4043	0.01512	0.009	0.008	0.00	0.00	N/A	N/A	N/A
17.10	56.09	25532	105	309.1	309.1	143	0.42	1.6	Unsaturated	10	25532	0.74	188.2	204.1	0.72	0.230	0.7	2.403	2.20	1.257	2.000	N/L	25531	45.5	33.8	0.9	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.07	0.00	2.163	1564	7409	0.00011	0.96537	4029	0.01330	0.007	0.006	0.00	0.00	N/A	N/A	N/A
17.20	56.42	29665	110	310.9	310.9	165	0.37	1.5	Unsaturated	8	29665	0.74	218.3	225.5	0.72	0.230	0.7	2.000	2.20	1.257	1.665	N/L	29290	50.5	37.5	0.4	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.06	0.00	2.176	1569	8237	0.00010	0.97029	4015	0.01171	0.006	0.005	0.00	0.00	N/A	N/A	N/A
17.30	56.74	31975	117	312.7	312.7	178	0.37	1.5	Unsaturated	8	31975	0.74	235.0	242.5	0.72	0.229	0.7	2.000	2.20	1.257	1.661	N/L	31881	54.9	40.8	0.4	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.05	0.00	2.188	1574	8978	0.00009	0.97521	4001	0.01058	0.005	0.004	0.00	0.00	N/A	N/A	N/A
17.40	57.07	32648	91	314.6	314.6	181	0.28	1.4	Unsaturated	7	32648	0.74	239.5	241.4	0.72	0.229	0.7	2.000	2.20	1.257	1.656	N/L	32638	54.5	40.4	0.1	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.05	0.00	2.201	1578	8916	0.00009	0.98013	3987	0.01070	0.005	0.004	0.00	0.00	N/A	N/A	N/A
17.50	57.40	31692	70	316.4	316.4	175	0.22	1.4	Unsaturated	7	31692	0.74	232.2	234.0	0.72	0.228	0.7	2.000	2.20	1.257	1.652	N/L	31820	53.1	39.3	0.1	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.04	0.00	2.213	1583	8704	0.00009	0.98505	3973	0.01106	0.005	0.004	0.00	0.00	N/A	N/A	N/A
17.60	57.73	30237	64	318.2	318.2	167	0.21	1.4	Unsaturated	7	30237	0.74	221.2	223.0	0.71	0.228	0.7	2.000	2.20	1.257	1.648	N/L	30470	50.9	37.6	0.1	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.04	0.00	2.226	1587	8347	0.00010	0.98997	3960	0.01167	0.005	0.005	0.00	0.00	N/A	N/A	N/A
17.70	58.06	30020	61	320.0	320.0	165	0.20	1.4	Unsaturated	7	30020	0.74	219.3	221.0	0.71	0.227	0.7	2.000	2.20	1.257	1.643	N/L	30019	50.1	37.0	0.1	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.03	0.00	2.239	1592	8234	0.00010	0.99489	3946	0.01191	0.006	0.005	0.00	0.00	N/A	N/A	N/A
17.80	58.38	30689	60	321.8	321.8	168	0.20	1.3	Unsaturated	6	30689	0.74	223.8	224.0	0.71	0.227	0.7	2.000	2.20	1.257	1.639	N/L	30657	49.6	36.6	0.0	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.03	0.00	2.251	1596	8165	0.00010	0.99981	3933	0.01207	0.006	0.005	0.00	0.00	N/A	N/A	N/A
17.90	58.71	31010	53	323.6	323.6	169	0.17	1.3	Unsaturated	6	31010	0.74	225.8	226.0	0.71	0.226	0.7	2.000	2.20	1.257	1.635	N/L	31171	50.5	37.1	0.0	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.02	0.00	2.264	1601	8313	0.00010	1.00473	3920	0.01184	0.006	0.005	0.00	0.00	N/A	N/A	N/A
18.00	59.04	31279	54	325.4	325.4	170	0.17	1.3	Unsaturated	6	31279	0.73	227.4	227.6	0.71	0.225	0.6	2.000	2.20	1.257	1.631	N/L	31278	50.6	37.2	0.0	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.02	0.00	2.277	1605	8352	0.00010	1.00965	3907	0.01181	0.006	0.005	0.00	0.00	N/A	N/A	N/A

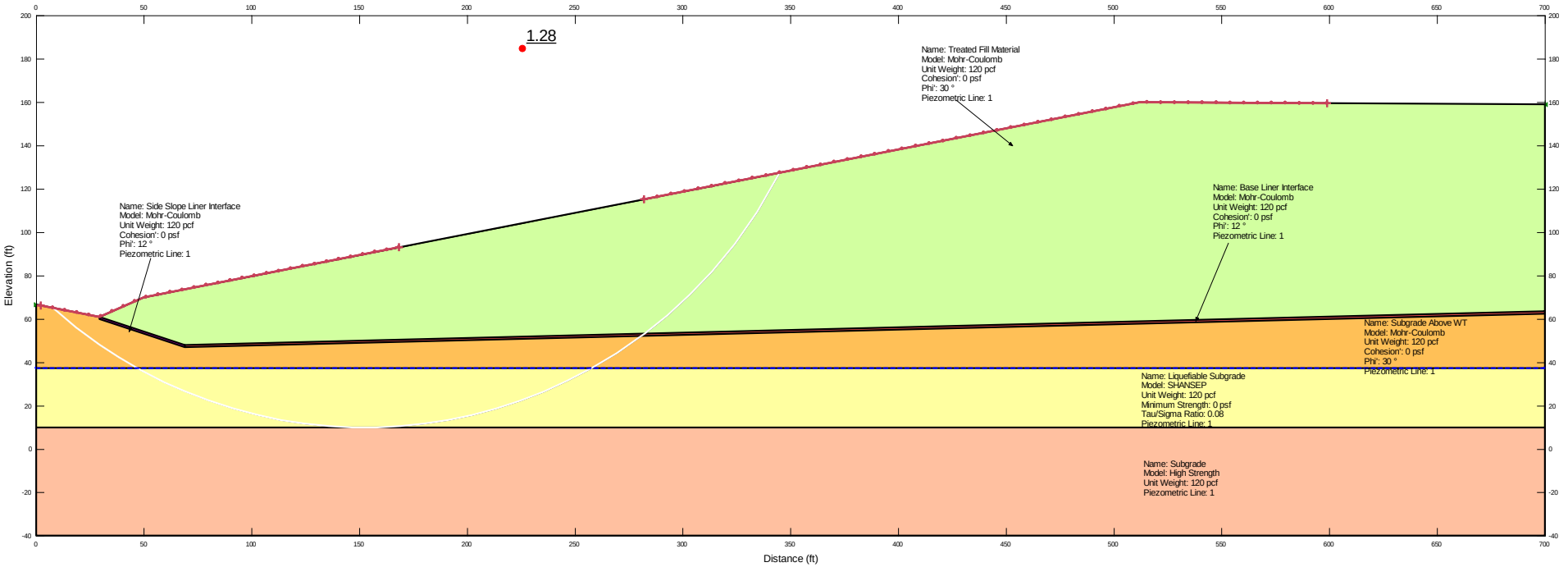
Depth, Z (m)	Depth, Z (ft)	q_c (kPa)	f_s (kPa)	σ_{vc} (kPa)	σ'_{vc} (kPa)	Q	F	I_c	Soil Type	Fines (%)	Interpreted q_c	C_N	q_{c1N}	q_{c1N-cs}	Stress Reduction Factor (r_d)	CSR	K_σ for sand	$CRR_{M=7.5}$ at $\sigma'_{vc}=1$	MSF_{max}	MSF	CRR	$(FS)_L$
18.10	59.37	31078	62	327.2	327.2	169	0.20	1.3	Unsaturated	6	31078	0.73	225.7	225.8	0.71	0.225	0.6	2.000	2.20	1.257	1.627	**N/L**
18.20	59.70	28998	41	329.0	329.0	157	0.14	1.3	Unsaturated	6	28998	0.73	210.2	210.4	0.70	0.224	0.6	3.585	2.20	1.257	2.000	**N/L**

Depth, Z (m)	q_t (kPa)	N_{60}	$N_{1,60}$	$\Delta(N_1)_{60}$	$N_{1,60-CS}$	Limiting Shear Strain γ_{lim}	Parameter F_α	Max. Shear Strain γ_{max}	ΔHi (m)	ΔLDI_i (m)	Vert. Recon. Strain ε_v	DF_i	ΔSi (inch)
18.10	30933	50.1	36.7	0.0	N.A.	0.000	0.000	0.000	0.10	0.0000	0.0000	0.01	0.00
18.20	29483	47.7	35.0	0.0	N.A.	0.000	0.000	0.000	0.05	0.0000	0.0000	0.01	0.00

Depth, Z (m)	$p = \sigma_m$ (tsf)	τ_{ave} (psf)	G_{max} (tsf)	τ_{ave}/G_{max}	a	b	γ_{eff} (%)	ε_{15} (%)	ε_{Nc} (%)	Settlement (inch)	Settlement (inch)	$\Delta(N_1)_{60-Sr}$	$(N_1)_{60-Sr}$	S_r/σ_{v0}'
18.10	2.289	1609	8271	0.00010	1.01457	3894	0.01199	0.006	0.005	0.00	0.00	N/A	N/A	N/A
18.20	2.302	1614	7894	0.00010	1.01949	3881	0.01273	0.007	0.005	0.00	0.00	N/A	N/A	N/A

APPENDIX H

Post-Liquefaction Slope Stability Analysis Results


1.28
Name: Treated Fill Material
Model: Mohr-Coulomb
Unit Weight: 120 pcf
Cohesion': 0 psf
Phi': 30 °
Piezometric Line: 1
Name: Side Slope Liner Interface
Model: Mohr-Coulomb
Unit Weight: 120 pcf
Cohesion': 0 psf
Phi': 12 °
Piezometric Line: 1
Name: Base Liner Interface
Model: Mohr-Coulomb
Unit Weight: 120 pcf
Cohesion': 0 psf
Phi': 12 °
Piezometric Line: 1
Name: Subgrade Above WT
Model: Mohr-Coulomb
Unit Weight: 120 pcf
Cohesion': 0 psf
Phi': 30 °
Piezometric Line: 1
Name: Liquefiable Subgrade
Model: SHANSEP
Unit Weight: 120 pcf
Minimum Strength: 0 psf
Tau/Sigma Ratio: 0.08
Piezometric Line: 1
Name: Subgrade
Model: High Strength
Unit Weight: 120 pcf
Piezometric Line: 1
Elevation (ft)
Distance (ft)

B-B', Post-Liquefaction Slope Stability

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File Information

File Version: 9.01
Date: 06/10/2019
Time: 04:17:18 PM
Tool Version: 9.1.0.16306
File Name: B-B'_Post-Liquef.gsz
Last Solved Date: 06/10/2019
Last Solved Time: 04:17:30 PM

Project Settings

Unit System: U.S. Customary Units

Analysis Settings

B-B', Post-Liquefaction Slope Stability

Description: Chevron, Guadalupe Restoration Project, Slope Stability, Cross Section
Kind: SLOPE/W
Method: Morgenstern-Price
Settings
- Side Function
  - Interslice force function option: Half-Sine
- PWP Conditions from: Piezometric Line
  - Apply Phreatic Correction: No
  - Use Staged Rapid Drawdown: No
- Unit Weight of Water: 62.430189 pcf

Slip Surface

Direction of movement: Right to Left
Use Passive Mode: No
Slip Surface Option: Entry and Exit
Critical slip surfaces saved: 1
Optimize Critical Slip Surface Location: No
Tension Crack Option: (none)

Distribution

F of S Calculation Option: Constant

Advanced

Geometry Settings

Minimum Slip Surface Depth: 0.1 ft
Number of Slices: 30

Factor of Safety Convergence Settings

Maximum Number of Iterations: 100
Tolerable difference in F of S: 0.001

Solution Settings

Search Method: Root Finder
Tolerable difference between starting and converged F of S: 3
Maximum iterations to calculate converged lambda: 20
Max Absolute Lambda: 2

Materials

Treated Fill Material

Model: Mohr-Coulomb
Unit Weight: 120 pcf
Cohesion': 0 psf
Phi': 30 °
Phi-B: 0 °

Pore Water Pressure

Piezometric Line: 1

Base Liner Interface

Model: Mohr-Coulomb
Unit Weight: 120 pcf
Cohesion': 0 psf
Phi': 12 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

Subgrade

Model: High Strength
Unit Weight: 120 pcf
Pore Water Pressure
Piezometric Line: 1

Side Slope Liner Interface

Model: Mohr-Coulomb
Unit Weight: 120 pcf
Cohesion': 0 psf
Phi': 12 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

Liquefiable Subgrade

Model: SHANSEP
Unit Weight: 120 pcf
Minimum Strength: 0 psf
Tau/Sigma Ratio: 0.08
Pore Water Pressure
Piezometric Line: 1

Subgrade Above WT

Model: Mohr-Coulomb

Unit Weight: 120 pcf
Cohesion': 0 psf
Phi': 30 °
Phi-B: 0 °
Pore Water Pressure
Piezometric Line: 1

Slip Surface Entry and Exit

Left Type: Range
Left-Zone Left Coordinate: (2.22774, 66.26956) ft
Left-Zone Right Coordinate: (168.44769, 93.07423) ft
Left-Zone Increment: 30
Right Type: Range
Right-Zone Left Coordinate: (282.02313, 115.19931) ft
Right-Zone Right Coordinate: (599.00068, 159.53723) ft
Right-Zone Increment: 50
Radius Increments: 10

Slip Surface Limits

Left Coordinate: (0, 66.7) ft
Right Coordinate: (700, 159) ft

Piezometric Lines

Piezometric Line 1

Coordinates

	X	Y
Coordinate 1	0 ft	37.3 ft

Coordinate 2	700 ft	37.3 ft

Points

	X	Y
Point 1	0 ft	66.7 ft
Point 2	29.5 ft	61 ft
Point 3	50 ft	70 ft
Point 4	512 ft	160 ft
Point 5	700 ft	159 ft
Point 6	69 ft	48 ft
Point 7	700 ft	63.5 ft
Point 8	29.5 ft	60 ft
Point 9	69 ft	47 ft
Point 10	700 ft	62.5 ft
Point 11	0 ft	37.3 ft
Point 12	700 ft	37.3 ft
Point 13	0 ft	10 ft
Point 14	700 ft	10 ft
Point 15	0 ft	-40 ft
Point 16	700 ft	-40 ft

Regions

	Material	Points	Area
Region 1	Treated Fill Material	2,3,4,5,7,6	47,128 ft²

Region 2	Side Slope Liner Interface	2,6,9,8	39.5 ft²
Region 3	Base Liner Interface	6,7,10,9	631 ft²
Region 4	Subgrade Above WT	1,2,8,9,10,12,11	12,434 ft²
Region 5	Liquefiable Subgrade	13,11,12,14	19,110 ft²
Region 6	Subgrade	13,14,16,15	35,000 ft²

Slip Results

Slip Surfaces Analysed: 11833 of 17391 converged

Current Slip Surface

Slip Surface: 678
Factor of Safety: 1.28
Volume: 19,482.523 ft³
Weight: 2,337,902.8 lbf
Resisting Moment: 97,633,770 lbf·ft
Activating Moment: 76,252,154 lbf·ft
Resisting Force: 371,955.88 lbf
Activating Force: 290,417.48 lbf
Slip Rank: 1 of 17,391 slip surfaces
Exit: (7.8189755, 65.189215) ft
Entry: (345.09783, 127.48659) ft
Radius: 216.73576 ft
Center: (152.38604, 226.66601) ft

Slip Slices

	X	Y	PWP	Base Normal Stress	Frictional Strength	Cohesive Strength	Suction Strength	Base Material
Slice 1	13.239232 ft	60.646312 ft	-1,457.5147 psf	688.92416 psf	397.75055 psf	0 psf	0 psf	Subgrade Above WT
Slice 2	24.079744 ft	52.119077 ft	-925.15776 psf	1,862.0572 psf	1,075.0592 psf	0 psf	0 psf	Subgrade Above WT
Slice 3	33.864696 ft	45.282719 ft	-498.36268 psf	3,182.8726 psf	1,837.6323 psf	0 psf	0 psf	Subgrade Above WT
Slice 4	42.594089 ft	39.865347 ft	-160.15511 psf	4,704.2698 psf	2,716.0114 psf	0 psf	0 psf	Subgrade Above WT
Slice 5	48.479393 ft	36.469275 ft	51.86232 psf	4,267.5412 psf	0 psf	311.33717 psf	0 psf	Liquefiable Subgrade
Slice 6	54.75 ft	33.240872 ft	253.41213 psf	4,879.9892 psf	0 psf	341.49778 psf	0 psf	Liquefiable Subgrade
Slice 7	64.25 ft	28.728155 ft	535.14188 psf	5,683.7959 psf	0 psf	380.04771 psf	0 psf	Liquefiable Subgrade
Slice 8	74.563405 ft	24.471815 ft	800.86603 psf	6,465.9809 psf	0 psf	418.93805 psf	0 psf	Liquefiable Subgrade
Slice 9	85.690216 ft	20.530455 ft	1,046.9259 psf	7,213.6831 psf	0 psf	457.8989 psf	0 psf	Liquefiable Subgrade
Slice 10	96.817027 ft	17.254106 ft	1,251.469 psf	7,860.8278 psf	0 psf	493.79699 psf	0 psf	Liquefiable Subgrade
Slice 11	107.94384 ft	14.611839 ft	1,416.4262 psf	8,410.5902 psf	0 psf	526.77475 psf	0 psf	Liquefiable Subgrade
Slice 12	119.07065 ft	12.580103 ft	1,543.2678 psf	8,866.4871 psf	0 psf	556.94067 psf	0 psf	Liquefiable Subgrade
Slice 13	130.19746 ft	11.141582 ft	1,633.075 psf	9,232.3544 psf	0 psf	584.37448 psf	0 psf	Liquefiable Subgrade
Slice 14	141.32427 ft	10.28441 ft	1,686.5884 psf	9,512.2609 psf	0 psf	609.13084 psf	0 psf	Liquefiable Subgrade
Slice 15	152.38604 ft	10 ft	1,704.3441 psf	9,709.6543 psf	0 psf	631.12766 psf	0 psf	Liquefiable Subgrade
Slice 16	163.43601 ft	10.283503 ft	1,686.645 psf	9,829.7888 psf	0 psf	650.48685 psf	0 psf	Liquefiable Subgrade
Slice 17	174.53922 ft	11.13763 ft	1,633.3217 psf	9,877.3094 psf	0 psf	667.31754 psf	0 psf	Liquefiable Subgrade
Slice 18	185.64243 ft	12.57061 ft	1,543.8605 psf	9,854.7046 psf	0 psf	681.48227 psf	0 psf	Liquefiable Subgrade
Slice 19	196.74564 ft	14.594209 ft	1,417.5268 psf	9,764.7594 psf	0 psf	692.92686 psf	0 psf	Liquefiable Subgrade
Slice 20	207.84885 ft	17.225596 ft	1,253.2488 psf	9,609.413 psf	0 psf	701.57222 psf	0 psf	Liquefiable Subgrade
Slice 21	218.95206 ft	20.488116 ft	1,049.5691 psf	9,389.5278 psf	0 psf	707.31085 psf	0 psf	Liquefiable Subgrade
Slice 22	230.05527 ft	24.412414 ft	804.57443 psf	9,104.6289 psf	0 psf	710.00161 psf	0 psf	Liquefiable Subgrade
Slice 23	241.15848 ft	29.03806 ft	515.79449 psf	8,752.5924 psf	0 psf	709.46225 psf	0 psf	Liquefiable Subgrade

Slice 24	252.26169 ft	34.415892 ft	180.05542 psf	8,329.2462 psf	0 psf	705.45863 psf	0 psf	Liquefiable Subgrade
Slice 25	263.60706 ft	40.766325 ft	-216.40332 psf	6,571.8611 psf	3,794.2658 psf	0 psf	0 psf	Subgrade Above WT
Slice 26	275.1946 ft	48.219986 ft	-681.73676 psf	5,880.1659 psf	3,394.9154 psf	0 psf	0 psf	Subgrade Above WT
Slice 27	281.68399 ft	52.724409 ft	-962.94874 psf	6,408.634 psf	1,362.1972 psf	0 psf	0 psf	Base Liner Interface
Slice 28	287.60613 ft	57.417184 ft	-1,255.9196 psf	5,070.2478 psf	2,927.309 psf	0 psf	0 psf	Treated Fill Material
Slice 29	298.05917 ft	66.341768 ft	-1,813.0831 psf	4,319.2645 psf	2,493.7285 psf	0 psf	0 psf	Treated Fill Material
Slice 30	308.51221 ft	76.52555 ft	-2,448.8585 psf	3,500.7085 psf	2,021.135 psf	0 psf	0 psf	Treated Fill Material
Slice 31	318.96524 ft	88.250399 ft	-3,180.843 psf	2,605.1552 psf	1,504.0871 psf	0 psf	0 psf	Treated Fill Material
Slice 32	329.41828 ft	101.95991 ft	-4,036.7301 psf	1,621.277 psf	936.04468 psf	0 psf	0 psf	Treated Fill Material
Slice 33	339.87131 ft	118.43302 ft	-5,065.1497 psf	537.49623 psf	310.3236 psf	0 psf	0 psf	Treated Fill Material

APPENDIX I

Seismic Hazard Analysis

TECHNICAL MEMORANDUM

DATE October 4, 2019 **Reference No.** 1783552-1-TM-3

TO Danielle Wold
Chevron EMC

CC Richard Haughey, Nagesh Koragappa, Alan Hull

FROM Don Lowry **EMAIL DLowry@Golder.com**

REVISED DETERMINISTIC SEISMIC HAZARD ANALYSIS FOR THE GUADALUPE TANK BATTERY 9 SITE, GUADALUPE, SAN LUIS OBISPO COUNTY, CALIFORNIA

This revised technical memorandum presents the results of a deterministic seismic hazard analysis (DSHA) for the Guadalupe Tank Battery 9 (TB9) restoration project site (Site). The results incorporate readily available information on the location and activity of seismogenic faults within 62 mi (100 km) of the Site.

This technical memorandum revises Golder's technical memorandum of September 2018 by providing additional peak horizontal ground accelerations (PGA) for outcropping rock conditions (i.e. $V_{S,30}$ = 760 m/s) for the controlling maximum credible earthquake (MCE) at the site. The median acceleration response spectrum for the MCE is provided, along with three spectrally matched acceleration time histories in a separate technical memorandum.

1.0 PROJECT BACKGROUND

The proposed TB9 project is a Soil Management Area (SMA) encompassing approximately 750,000 to 800,000 cubic yards of available airspace, and with a leachate collection system. The unit will be permitted as a Class II landfill under California Code of Regulations Title 27 (Title 27 CCR). The Site is located about 3 miles west of Guadalupe, in San Luis Obispo County, California (Figure 1).

2.0 SCOPE OF WORK

Title 27 CCR requires that the maximum credible earthquake (MCE) ground motions are to be developed based on the recent, readily available, and relevant scientific information. Accordingly, Golder Associates Inc. (Golder) undertook the following scope of work to acquire and interpret the "the available science" to develop the PGA estimate for the Site:

- Compiled the record of historical earthquakes with epicenters located within about a 62 mi (100 km) radius of the Site.
- Compiled information on the location and activity of faults mapped within about 62 mi of the Site. Fault locations and characteristics developed for the third Uniform California Earthquake Rupture Forecast (UCERF3) model reported by Field et al. (2013) were used to identify and characterize the potential MCE sources for the DSHA.

Golder Associates Inc.
7245 W. Alaska Drive, Suite 200, Lakewood, Colorado 80226 USA T: +1 303 980-0540 F: +1 303 985-2080

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- Completed a DSHA revision to identify the controlling MCE and associated median horizontal PGA for both a weak rock ($V_{S,30}$ = 760 m/s) and stiff soil site condition ($V_{S,30}$ = 259 m/s).
- Compared the PGA value developed from the DSHA to those available for selected return periods from the US Geological Survey (USGS) 2014 national probabilistic seismic hazard maps.
- Undertook a deaggregation to identify the earthquake sources for both the 475- and 2,475-year return PGA.
- Prepared this technical memorandum that presents the results of Golder's analysis, including the MCE PGA for the Site.

3.0 TECTONIC AND GEOLOGIC SETTING

3.1 Regional Geomorphic Province

The Site is located in San Luis Obispo County, California, near its boundary with Santa Barbara County, and within about 1.4 miles of the Pacific coastline. The Site is located in the Coast Ranges geomorphic province (CGS 2002) dominated by northwest-trending, moderately elevated mountains and valleys that extend parallel to the central California coastline. The Coast Ranges province extends from Humboldt County in the northwest to the Transverse Ranges, north of Los Angeles, in the southeast, a distance of about 600 mi (965 km). The Coast Ranges province is bounded on the east by the Great Valley province.

The Site is situated within coastal sand dune deposits that mantle the western extent of the Santa Maria River valley (Figure 2). The valley is bounded:

- On the northeast by low coastal mountains that include Temettate Ridge (1,800 ft/550 m), Newsome Ridge (1,600 ft/485 m) and Loma Pelona (1,785 ft/545 m) (Figure 1)
- On the southwest by the Casmalia Hills, with a maximum elevation of 1,660 ft (505 m) at Mount Lospe (Figure 1)

The Casmalia Hills are the northern and westernmost onshore extent of the Transverse Ranges and the southwestern edge of Santa Maria River valley forms the boundary between the Coastal Ranges and Transverse Ranges geomorphic provinces.

3.2 Tectonic Setting

The present-day tectonics surrounding the Site are largely controlled by deformation associated with the northwest-striking, right-lateral (dextral) strike-slip (RLSS) faults associated with the San Andreas fault system (SAF). The SAF marks the boundary between the Pacific and the North America tectonic plates and has among the highest average slip rates and shortest surface rupture recurrence intervals in the region (Field et al. 2013). There are two key sections of the SAF located within 62 mi (100 km) of the site—the Parkfield and Cholame-Carrizo sections (USGS 2006). Both sections, along with the Creeping section to the north and the Mojave section to the south, ruptured during the moment magnitude (**M)**7.9 1857 Fort Tejon earthquake. Nearby faults within the SAF system include the San Juan, Rinconada and West Huasna faults in westward progression from the SAF.

The western Coast Ranges expose many reverse-oblique, en echelon arranged faults. These faults were mostly active in the late-Pleistocene (last ca 130,000 years), and act to transfer strain between dextral strike-slip faults

parallel to the coastline, including the Hosgri and San Simeon faults to the west and Oceanic and West Huasna faults to the east (USGS 2006).

The Site is located within the coastal sand dune deposits (Qs) at the Guadalupe Oil Field (Figure 2). The dunes extend along the coastal portion of the Santa Maria Valley from near Oceano in the north to south of the Santa Maria River, a distance of about 12 miles (mi) (19 kilometers [km]). The dunes extend westward into the Santa Maria Valley up to 3.5 miles (Dibblee 1989). The Santa Maria Valley is more than 14 miles (22 km) wide along the coastline but narrows to less than 2 miles (3.2 km) southeast of the City of Santa Maria.

3.3 Regional Geology

Based on the cross section from Dibblee (1994), the generalized depositional sequence underlying the Santa Maria Valley and the project Site are:

- **Coastal Dune Deposits (Qs)**: Wind-blown sands, deposited mainly along the coastline (Holocene)
- **Valley Floodplain Alluvium (Qa)**: A thin veneer of surficial alluvium deposited on the valley floor (Holocene)
- **Orcutt Formation (Qo)**: Non-marine weakly-consolidated wind-blown sand and gravel deposit (Pleistocene)
- **Paso Robles Formation (QTp)**: Non-marine weakly-consolidated alluvial gravels, sands, and clay (Pleistocene)
- **Careaga Sand (Tca)**: Marine, weakly-indurated fossiliferous sand (Pliocene-Pleistocene)
- **Foxen Claystone (Tf)**: Marine claystone (Pliocene)
- **Sisquoc Formation (Tsq)**: Marine diatomaceous claystone (Miocene-Pliocene)
- **Monterey Shale (Tm)**: Marine (biogenic) thin-bedded siliceous shale (late-Miocene)

The weakly consolidated Quaternary units (including the Careaga Sand deposits) have a maximum thickness of about 8,000 feet (ft) (2.4 km) in the Santa Maria Valley. Neogene and older sedimentary rocks make up an additional 18,000 ft (5.5.km) before reaching the Jurassic Franciscan Formation rocks that form the local bedrock (Woodring and Bramlette 1950).

Southwest of the Site, the Casmalia Hills rise above the coastline exposing basement rocks composed of the Point Sal Ophiolite, a metamorphosed assemblage of Jurassic-aged mafic igneous and deep marine sedimentary rocks. The basement rocks are overlain by Cretaceous-aged Espada Formation marine sedimentary deposits, including shale, sandstone, and conglomerate. This entire assemblage has been unconformably buried by the Oligocene-aged non-marine Lospe Formation (claystone and sandstone), early- to mid-Miocene aged Point Sal formation (shale, sandstone, and dolomite) and mid- to late Miocene aged marine sediments of the Monterey Shale formation. A younger sequence of marine, shallow-marine, and non-marine sedimentary units are in fault contact with older rocks along the northern flank of the Casmalia Hills (Dibblee 1989).

North and northeast of the Site, the hills rising from Santa Maria Valley expose a moderately folded sequence of rocks that range from Miocene (Obispo Formation volcanic rocks (Tot/Tov)) through Quaternary (Paso Robles Formation (QTp)). Several prominent sets of northwest-trending hills are present between the Santa Maria Valley to the southwest and the Huasna Valley to the northeast, including Temettate Ridge and Newsome Ridge. The West Huasna fault dissects these hills with a steep down-to-the-west geometry (Dibblee 2006).

3.4 Seismotectonic Setting

This section summarizes information on the historical earthquake record (seismic history) of the region surrounding the Site. The section also includes descriptions of the major known active faults in the region surrounding the Site.

3.4.1 Historical Earthquakes

Figure 1 shows historical earthquake epicenters in the region surrounding the Site. Instrumental and reported historical records from the early 19th century through December 2011 reveal that there at least 633 earthquake epicenters with moment magnitudes greater than 3.0 located within about 62 mi (100 km) of the Site (Figure 1). Earthquake epicenter locations and magnitudes are from the UCERF3 Catalog of Field et al. (2013). Of these recorded earthquakes, eight have exceeded **M**[1]6.0—the most recent in September 2004 (i.e., 2004 Parkfield Earthquake). The largest earthquake recorded with an epicenter located within 62 mi of the Site was an estimated **M**7.1 event that occurred in November 1927 offshore, and west of Lompoc, California. It was located about 30 mi (49 km) southwest of the Site (Figure 1).

The closest recorded earthquakes to the Site greater than or equal to **M**3.0 are an **M**3.2 earthquake in October 2000 and a **M**3.8 earthquake in March 2000. Both earthquakes have epicenters located about 6 mi (9 to 10 km) east of the Site. The largest recorded earthquake within a 25 mi (40 km) radius of the Site was an estimated **M**5.8 earthquake on July 28, 1902, located about 17 mi (28 km) southeast of the Site (Figure 1).

3.4.2 Significant Faults within 62 mi (100 km) of the Site

Key sources of information on the location and activity of potential seismogenic faults in California are the following:

- Quaternary Fault and Fold Database of the United States (USGS 2006)
- Probabilistic Seismic Hazard Analysis for the State of California (Petersen et al. 1996)
- Uniform California Earthquake Rupture Forecast, Version 2 (UCERF2) (Field et al. 2007)
- Uniform California Earthquake Rupture Forecast, Version 3 (UCERF3) – The Time-Independent Model (Field et al. 2013)

Golder's review of these sources indicates that there are 22 major faults or distinct fault sections within about 62 mi (100 km) of the Site (Figure 1). Of those, two faults show surface fault rupture within historic time (since mid-19th century) and seven faults have one or more surface ruptures within the last 15,000 years (generally Holocene). The remaining 14 faults only have inferred surface rupture during the last 130,000 years (late Pleistocene). The locations of faults within USG. (2006) older than 130,000 years are not considered in this study because of the uncertainty in their seismogenic potential.

[1] **M** =moment magnitude

Table 1: Major Faults Mapped within about 62 mi (100 km) of the Guadalupe TB9 Site, San Luis Obispo County, California

Fault Number[1]	Major Fault or Fault Zone[1]	Age of Most Recent Displacement[2]	Approximate Distance from Project Site (mi/km)[3]	Total Length (mi/km)[4]	Fault Type[5]	Dip Angle (°), Direction[6]	Upper and (Lower) Seismogenic Depth (km)[7]	Estimated Average Slip Rate (mm/yr)[8]	Surface Rupture Recurrence Interval (years)[8]
n/a	Shoreline fault zone Northern Segment Central Segment Southern Segment San Luis Bay Segment	Late Pleistocene (< 130 ka) [a]	1.0/1.6 23/37 17/28 13/21 1.0/1.6	30.2/48.7 5.8/9.4 6.0/9.7 4.4/7.1 14/22.5	RLSS	90	0 (12) [d]	0.2±0.1 [e]	20-40k [d]
84 [b] 295 [c]	Casmalia fault zone	Late Pleistocene (< 130 ka)	2.8/4.5	30/47.9	R	75° NE[a]	0 (12) [a]	0.25 [a]	Unk
692 [a] 82 [b] 288 [c]	San Luis Range fault system Oceano fault	Late Pleistocene (< 130 ka)	6.3/10.2	13/21	R	45° NE[a]	0 (12) [a]	0.0276 [a]	Unk
681 [a] 296 [c]	Lions Head fault zone	Late Pleistocene (< 130 ka)	6.7/10.7	40/65.2	R	75° [c] NE[a]	0 (12) [a]	0.02 [a]	Unk
691 [a] 82 [b] 304 [c]	SAN LUIS RANGE 2011 CFM (UCERF3) Santa Maria River fault + Foxen Canyon Fault	Late Pleistocene (< 130 ka)	9.4/15	49/78.9	R	52° NE[a]	0 (12) [a]	0.0276 [a]	Unk
74 [a] 79a-d [b] 285 [c]	Los Osos fault zone	Holocene (< 15 ka) and Late Pleistocene (< 130 ka)	13.2/21	36/57.9	R	45, W? [a]	0 (12) [a]	0.39 [a] < 0.2 [b]	Unk
709 [a] 352 b 371 [b] 289 [c]	Oceanic/West Huasna fault (Note: UCERF3 combines these two faults) [a,b]	Late Pleistocene (<130 ka)	14.3/23	76/121.9 [b]	R	58, W [b]	0 (7) [a]	0.39 [b]	Unk
30 [a] 81a [b]	Hosgri fault zone, San Luis-Pismo section	Holocene (< 15 ka)	17/27.5	15/24	RLSS	60-90 E 80° E [a]	0 (12.2) [a]	1-5 [b]	Unk
262 [b]	Cambria Fault [b]	Late Pleistocene (<130 ka)	20/33	19/30.4 [b]	R	45 E	0 (12) assumed	Unk	Unk

Fault Number[1]	Major Fault or Fault Zone[1]	Age of Most Recent Displacement[2]	Approximate Distance from Project Site (mi/km)[3]	Total Length (mi/km)[4]	Fault Type[5]	Dip Angle (°), Direction[6]	Upper and (Lower) Seismogenic Depth (km)[7]	Estimated Average Slip Rate (mm/yr)[8]	Surface Rupture Recurrence Interval (years)[8]
683 [a] 85 [b] 302 [c]	Los Alamos fault	Holocene (< 15 ka) and Late Pleistocene (< 130 ka)	22/36	16.7/26.9	R	30 SW	0 (12) [a]	0.39 [a]	Unk
781 [a] 253 [b] 299/300 [c]	Santa Ynez River fault zone	Late Pleistocene (<130 ka)	23/37	45/72.8	R	70 SW	0 (12) [a]	0.39 [a]	Unk
31[a] 77[b]	San Juan FZ [a, b]	Holocene (<15 ka) to Early Quaternary (< 2.4 Ma)	37/59	51/82.1 [a] 51/81 [b]	RLSS	90° Assumed	0 (13) [a]	0.01 [a]	Unk
77 [a] 87a, b[b] 320 [c]	Santa Ynez (west)	Late Pleistocene (<130 ka)	38/61	49/79.6	R	70° S	0 (9.2) [a]	2.0 [a]	Unk
80 [b] 255 [c]	San Simeon fault zone	Holocene (< 15 ka) and Late Pleistocene (< 130 ka)	40/64	49/79	RLSS	90° Assumed	0 (12) Assumed	1-5 [b]	Unk
650 [a] 63c [b]	Rinconada fault zone, Rinconada section [a, b]	Late Pleistocene (<130 ka)	45/72	76/122.8 [a] 54/87 [b]	RLSS	82 [a], NE and SW 90 [b]	0 (8.5) [a]	0.39 [a]	1,883 [c]
285 & 300 [a] 1g [b]	San Andreas fault zone Cholame-Carrizo section	Recent (<150 years) (1857) and Holocene (< 15 ka)	47/76	75/121.7	RLSS	90° [a]	0 (12-15.1) [a]	34.0 [a]	100-450 [b]
79 [a] 87d [b] 321 [c]	Santa Ynez (east)	Late Pleistocene (<130 ka)	51/82	42/68.4	R	70° N	0 (13.3) [a]	2.0 [a]	Unk
432 [b]	San Pedro fault	Late Pleistocene (<130 ka)	53/85	6.2/10	R, LLSS	60° W Assumed	0 (12) Assumed	unk	Unk
263 [b]	San Jose fault	Late Pleistocene (<130 ka)	53/86	8/13	R, LLSS	60° W Assumed	0 (12) Assumed	unk	Unk

Fault Number[1]	Major Fault or Fault Zone[1]	Age of Most Recent Displacement[2]	Approximate Distance from Project Site (mi/km)[3]	Total Length (mi/km)[4]	Fault Type[5]	Dip Angle (°), Direction[6]	Upper and (Lower) Seismogenic Depth (km)[7]	Estimated Average Slip Rate (mm/yr)[8]	Surface Rupture Recurrence Interval (years)[8]
78 [a] 88a-c [b]	Mission Ridge fault system	Holocene (< 15 ka) and Late Pleistocene (< 130 ka)	55/89.5	31/50	R, LLSS	60° E[b]	0 (7.6) [a]	0.9 [a]	Unk
32[a] 1f [b]	San Andreas Fault, Parkfield section [a, b]	Recent (<150 years), including years 1857, 1881, 1901, 1922, 1934, 1966, 2004	56/90	26/36.5 [a] 20/32 [b]	RLSS	90° [a]	0 (10.2) [a]	35.0 [a] 26.3 ±3.9 [b]	25 ±15 [a]
118 [a] 90 [b]	Red Mountain fault zone	Late Pleistocene (<130 ka)	57/92	62/100.6	R	56° N[a, e] 60° N[b, e]	0 (14.1) [a]	2.0 [a]	Unk

Notes: ka = thousand years; Ma = million years; N = Normal Fault; RLSS = Right Lateral Strike Slip; LLSS = Left Lateral Strike Slip; unk = unknown; n/a = not applicable/appropriate; MCE = maximum credible earthquake

1. The names of faults, fault zones, and fault numbers were taken from:
   a. Field, et al. (2013)
   b. USGS (2006)
   c. Jennings (2010)
2. Age of most recent pre-historic surface displacement taken from the Quaternary Fault and Fold Database of the United States (USGS 2006), where available. Other sources include:
   a. Nishenko et al. (2018)
3. The fault-to-site distances are the closest approach of the mapped fault traces to the Site. Distances were measured from the fault traces as plotted on Google Earth™ (from USGS 2006) and using a Site location of 34.973°N, 120.624°W.
4. Length is based on:
   a. Field, et al. (2013); and
   b. The total lengths of the faults and fault segments as indicated in the Quaternary Fault and Fold Database of the United States (USGS 2006)
5. Fault type (R = reverse; RLSS = right-lateral strike-slip)
6. Fault dip and direction determined from Field, et al. (2013) and USG.S 2006. Dip assumed to be 90° for strike slip faults, 75º for normal faults and 60° for reverse faults where no other information is available.
7. Seismogenic Depth and Average fault slip rates taken from:
   a. Field, et al. (2013)
   b. USGS (2006).
   c. For USGS (2006) generalized value intervals (i.e., 0.2 to 1.0 mm/yr), mid-range values assumed used for MCE calculation.
   d. Nishenko et al. (2018)
8. Slip rate and recurrence interval as defined within studies noted below:
   a. Field, et al. (2013)
   b. USGS (2006)
   c. Wesnouski (1986)
   d. Nishenko et al. (2018)
   e. PG&E (2015)

3.4.3 Studies Relating to the Diablo Canyon Power Plant (DCPP) – Shoreline Fault Zone

Studies undertaken by Pacific Gas & Electric (PG&E), USGS, geoscience practitioners, and local universities have – over the last decade – increased understanding the earthquake shaking and fault rupture hazards in the region surrounding the Diablo Canyon Power Plant (DCPP), located about 21 mi (34 km) northwest of the Site. PG&E (2015) is a comprehensive characterization of seismic sources in the region. Of significance to the TP-9 Site is the Shoreline fault zone (SFZ) and its tectonic characterization by PG&E (2011, 2015) and Nishenko et al. (2018). The SFZ is not recognized as a fault source in the UCERF3 or the National Probabilistic Seismic Hazard Model (USGS 2014b).

The SFZ as mapped by both PG&E (2015) and Nishenko et al. (2018) is considered in this study. The SFZ is mapped to within 1 mi (1.6 km) of the Site, closer than any of the faults contained described above.

Golder's review of Nishenko et al. (2018) indicates that the SFZ is a dextral strike-slip fault made up of a northern, central, and southern segments. The southern segment is well-defined by PG&E (2015) north of its intersection with the Oceano (thrust) fault (OF; offshore south of Avila Beach), with earthquake hypocenters associated with the SFZ. South of the OF intersection, the SFZ is mapped through San Luis Obispo Bay and possibly onshore south of the TP-9 site, near the mouth of the Santa Maria River. Mapping by PG&E (2015) shows this SFZ extension as uncertain south of the OF. Marine sediments of Holocene age (i.e., less than about 11,700 years) bury the SFZ extension through San Luis Bay. Due to the lack of evidence for Holocene surface rupture and microseismicity along the SFZ south of the intersection with the OF, Holocene activity of this section of the SFZ is unlikely (PG&E 2015; Nishenko et al. 2018). Nishenko et al. (2018) estimated an **M**6.7 for the maximum credible earthquake (MCE), with a recurrence interval for the San Luis Bay section of the SFZ at 20 to 40,000 years.

3.4.4 Casmalia Fault Zone

The Casmalia fault zone is considered by Hanson et al. (2004) to be the source of a May 1980 earthquake (**M**5.1) and associated aftershocks; and several other earthquakes recorded between October 1987 and January 1997 (Hanson et al. 2004). Earthquake focal mechanisms constructed from p-wave data indicate that the fault motion was almost pure reverse associated with a relatively steep-dipping Casmalia fault plane (55° to 80° SW).

The Casmalia fault forms the boundary between structural blocks associated with the offshore Hosgri fault zone, including the Santa Maria Valley and Casmalia structural blocks (Willingham et al. (1995). The Casmalia structural block is bounded by the Casmalia fault zone on the northeast and the Lions Head fault on the southeast. The Casmalia Hills represent a horst developed between the two faults.

3.4.5 Oceanic – West Huasna Fault Zone

Rupture on the Oceanic fault produced the 2003 **M**6.6 San Simeon earthquake, although surface rupture is not known to have accompanied the 2003 earthquake. The fault links and transfers slip from the Hosgri fault system in the west to the West Huasna fault in the east (Graymer et al. 2014) (Figure 1). Its orientation relative to the Hosgri and West Huasna Faults results in a significant component of reverse (up to the northeast) slip. The Oceanic and West Huasna faults are combined within the current UCERF3 fault model (Field et al. 2013).

4.0 EVALUATION OF SEISMIC HAZARDS

This section presents the results of both a site-specific DSHA and comparison to probabilistic seismic hazard analyses (PSHA) results for the Site. Golder estimated fault lengths and fault trace-to-site based on mapped traces from USGS (2006), and as shown on Google Earth™ and/or ArcGIS Earth™. The probabilistic results are those based on the USGS national seismic hazard maps and related hazard mapping tools.

4.1 Seismic Source Parameters For Significant Faults

The development and estimation of the MCE magnitude for the 22 faults was based on the empirical fault rupture/earthquake magnitude relationships developed by Wells and Coppersmith (1994), and Hanks and Bakun (2002). Individual fault, geologic, and geometric data are taken from either Field et al. (2013) or CGS (2006).

4.1.1 Maximum Credible Earthquake Magnitude

California Code of Regulations Title 27 defines the MCE as "…the maximum earthquake that appears capable of occurring under the presently known geologic framework….little regard is given to its probability of occurrence except that its likelihood of occurring is great enough to be of concern." Estimation of the ground motions associated with the MCE requires that the magnitude of the MCE is established, as described below.

Table 2 presents two values for the MCE magnitude. The first column labeled "Calculated M" shows the value obtained using Wells and Coppersmith (1994) for reverse faults and Hanks and Bakun (2002) for strike-slip faults and the fault geometry data listed in Table 1. For the reverse faults, we used an average of values obtained using both surface rupture length (SRL) and rupture area (RA) equations.

The second column is labeled "MCE," which represents the median MCE (shown in first column as "Calculated M") after being reduced by the aseismicity factor (reducing the area of the fault by the provided factor) for each structure as provided in Field et al. (2013). In most cases, application of the aseismic factor reduced the area about 10%, but the San Andreas fault – Parkfield segment, which has an aseismic factor of 0.7, had a significant reduction in RA. Golder notes that in the absence of fault specific data all UCERF3 faults have an aseismicity factor of 0.10 (10%). As a result, the recalculated M results in a drop of up to 0.1 magnitude units for most faults within revised Table 2, with the SAF (Parkfield segment) being the lone variation with a drop of 0.6 magnitude units.

Title 27 defines the MCE as "the maximum earthquake that appears capable of occurring under the presently known geologic framework." However, Title 27 does not specify how the MCE should be determined. Based on recent landfill projects, the median earthquake magnitude calculated from the empirical relations representative of a reasonable MCE estimate has been used and accepted by the RWQCB.

4.2 Site Soil Condition

The site is situated on dune sand (Qs) deposited over valley floodplain alluvium (Qa). Review of Dibblee (1989) indicates that the site is about 80-foot above mean sea level (amsl), while exposures of alluvium about 4 mi (0.7 km) north of the site are shown at be at about 40-foot amsl. Golder assumed for the purposes of this evaluation that the Qa unit is unconsolidated and that the Qs (dune sand) deposits are poorly graded and unconsolidated. This analysis was used to assume a $V_{S,30}$ (average shear velocity in the upper 100 ft [30 m]) of 850 feet per second (ft/s) (259 meters per second [m/s]), which represents the mid-point of soil Site Class D as defined within ASCE 7-10 (ASCE 2010). This $V_{S,30}$ value is about 10% to 20% higher than the 200 to 250 m/s $V_{S,30}$ reported from similar site soil conditions (sand and alluvium) at 15 sites near Oceano, about 10 miles north of the TB9 site.

These $V_{S,30}$ measurements are from profiles generally less than 100 ft reported by the USGS (https://earthquake.usgs.gov/data/vs30/us/).

4.3 Deterministic Seismic Hazard Analysis

DSHA uses available historical and instrumental earthquake records and geologic data to generate discrete, single-valued estimates of earthquake ground motions at a site. These single-valued estimates are commonly the basis for seismic analysis and design of major structures such as landfills, dams, and mine infrastructure. Median (50th-percentile) PGA values are sometimes used for analysis and design of moderate to low failure consequence structures, while median + 1σ (84th-percentile) values are sometime used for high consequence failure structures such as major dams and impoundments. This study reports only median PGA values in accordance with the standard of practice for landfill design in California.

In DSHA, one or more MCEs are specified by magnitude and location with respect to the site of interest. In areas like central California, major earthquakes are assumed to be generated by movement along mapped faults, and on that part of the fault closest to the Site. Estimates of Site earthquake ground motions are based on displacement along a known fault, with a specified MCE magnitude, a source-to-site distance, and for the site soil conditions.

Site PGA (5%-damped) values were calculated for two site soil conditions.

- A $V_{S,30}$ of 259 m/s as the arithmetic mean PGA of four equally weights NGA-West2 ground motion models (GMM) developed by Abrahamson and Silva (2013), Boore et al. (2013), Campbell and Bozorgnia (2013) and Chiou and Youngs (2013)
- A $V_{S,30}$ of 760 m/s using the GMMs of Abrahamson and Silva (2013), Boore et al. (2013), Campbell and Bozorgnia (2013) and Chiou and Youngs (2013) weighted at 0.22 each and Idriss (2013) weighted at 0.12. This weighting corresponds to that used by the U.S. Geological Survey for the National Seismic Hazard Model (USGS 2014b).

Table 2 lists the distances for each fault as applied in the NGA-West2 NGA GMMs to calculate the MCE PGA. Table 2 also lists the median horizontal PGA (5%-damped) expected at the Site from individual and some combined fault sources.

Table 2: Fault Parameters used and Median PGA Values for Two Site Soil Conditions at the Guadalupe TB9 Site, San Luis Obispo County, California

Fault or Fault Zone[1]	Rrup	Rjb	Rx	Ry0	Calculated M[2]	MCE[3]	Median PGA[5] ($V_{S,30}$=259 m/s) (g)	Median PGA[4] ($V_{S,30}$=760 m/s) (g)
Casmalia fault zone	4.35	1.28	4.50	0.00	6.9	6.9	0.49	0.48
Lions Head fault zone	10.84	8.17	7.20	7.13	7.1	7.0	0.33	0.28
Los Osos fault zone	14.85	9.00	21.00	0.00	7.1	7.0	0.32	0.27
Oceano Fault	10.20	10.20	10.20	0.00	6.6	6.6	0.28	0.24
San Luis Range 2011 CFM (Santa Maria F. + Foxen Canyon F.)	14.91	14.91	14.91	0.00	7.2	7.2	0.27	0.22
Oceanic/West Huasna faults	19.90	18.63	23.00	0.00	7.1	7.1	0.22	0.17
Santa Ynez River fault zone	37.00	37.00	37.00	0.00	7.1	7.1	0.14	0.10
Cambria Fault	32.50	32.50	27.16	17.85	6.8	6.7	0.12	0.09
Hosgri fault zone, San Luis-Pismo section	27.40	27.40	7.30	26.40	6.4	6.4	0.12	0.08
Los Alamos fault	44.63	44.63	9.00	43.71	6.8	6.8	0.10	0.06
Santa Ynez (west)	58.20	58.20	55.72	16.80	7.1	7.1	0.09	0.06
San Juan fault zone	59.00	59.00	59.00	0.00	7.1	7.0	0.08	0.06
San Simeon fault zone	64.36	64.36	6.78	64.41	7.0	7.0	0.08	0.05
San Andreas fault zone – Cholame to Carrizo section	76.00	76.00	76.00	0.00	7.4	7.4	0.08	0.05
Santa Ynez (east) fault	79.20	78.08	51.76	62.41	7.1	7.1	0.07	0.04
Red Mountain fault zone	88.72	87.59	48.00	78.00	7.3	7.3	0.07	0.04

Fault or Fault Zone[1]	Rrup	Rjb	Rx	Ry0	Calculated M[2]	MCE[3]	Median PGA[5] ($V_{S,30}$=259 m/s) (g)	Median PGA[4] ($V_{S,30}$=760 m/s) (g)
Rinconada fault zone	70.13	70.13	44.93	53.85	7.1	7.0	0.07	0.04
Mission Ridge fault system	90.63	90.63	70.00	57.56	6.9	6.8	0.04	0.03
San Pedro fault	85.00	85.00	1.63	85.00	6.2	6.2	0.03	0.02
San Jose fault	86.12	86.12	4.50	86.00	6.3	6.3	0.03	0.02
San Andreas fault zone – Parkfield section	87.80	87.80	77.50	41.23	6.6	6.0	0.02	0.01

Notes: Rrup = Closest distance to coseismic rupture (km); Rjb = Closest distance to surface projection of coseismic rupture (km); Rx = Horizontal distance from top of rupture measured perpendicular to fault strike (km); Ry0 = Horizontal distance off the end of the rupture measured parallel to strike (km); MCE = maximum credible earthquake

1) Fault names as defined in Table 1.
2) Values calculated using applicable empirical length-magnitude scaling relations of Wells and Coppersmith (1994) and Hanks and Bakun (2002). For reverse faults, we used the median value of Wells and Coppersmith (1994) relations using surface rupture length (SRL) and rupture area (RA). For strike-slip faults, we applied Hanks and Bakun (2002).
3) MCE values obtained by reducing the calculated M value by the aseismicity factor for each structure as provided in Field et al. (2013). An aseismicity factor of 10% (0.10) was applied throughout UCERF3 where no data was available. Due to uncertainties built into the various equations (i.e. W&C SRL = standard deviation of 0.28, RA = 0.24 and H&B RA = 0.04), MCE values for reverse faults were increased by 0.3 after aseismicity factors were applied to account for the upper bound of uncertainty.
4) Median PGA calculated assuming $V_{S,30}$ = 259 m/s, and using the following NGA-West2 GMMs weighted equally: Abrahamson and Silva (2013), Boore et a. (2013), Campbell and Bozorgnia (2013), Chiou and Youngs (2013).
5) Median PGA calculated assuming $V_{S,30}$ = 760 m/s, and using the following NGA-West2 GMMs with relative weighting in brackets: Abrahamson and Silva (2013) [0.22], Boore et al. (2013) [0.22], Campbell and Bozorgnia (2013) [0.22], Chiou and Youngs (2013) [0.22], Idriss (2013) [0.12]

4.3.1 Hazard Deaggregation Analysis

Figure 2a shows the results of a deaggregation analysis for the Site for the 475-year return period PGA. The results shown in Figure 2a indicate that the primary contributors to the 475-year return period PGA hazard are **M**5.0 to **M**7.6 earthquakes with epicenters located within about 5 km (3.1 mi), **M**6.0 to **M**7.7 earthquakes with epicenters located about 25 km (15.5 mi) from the site and **M**7.3 to **M**8.3 earthquakes with epicenters located about 75 km (47 mi) from the Site. These sources generally equate to the Casmalia fault at a distance of 4.5 km (2.8 mi), the Oceanic/West Huasna fault system at 23 km (14.4.mi) and the San Andreas fault at a distance of 72 km. Hazard sources located beyond the San Andreas fault zone ore than about 75 km (42 mi) from the site.

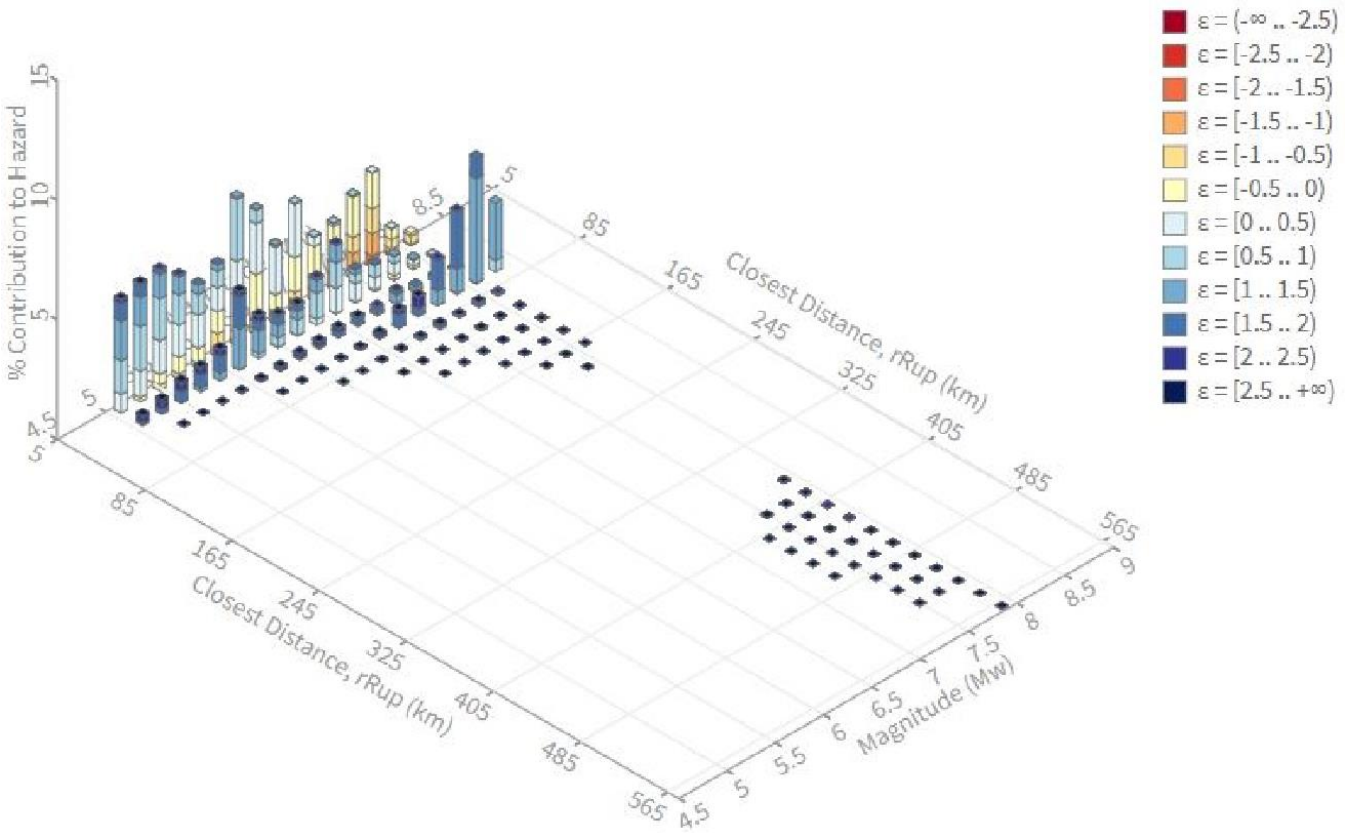

Figure 2a: Magnitude-Distance Deaggregation for the 475-year return period PGA for a site soil condition of VS,30 of 760 m/s.

Figure 2b shows the results of deaggregation analysis for the Site for a 2,475-year return period PGA. The results shown in Figure 2b indicate that the primary contributors to the 2,475-year return period PGA hazard are **M**5.0 to **M**7.9 earthquakes with epicenters located within about 5 km (3.1 mi) of the Site, with significantly smaller contributions from sources at 25 km (15.5.mi) and 75 km (42 mi) distances.

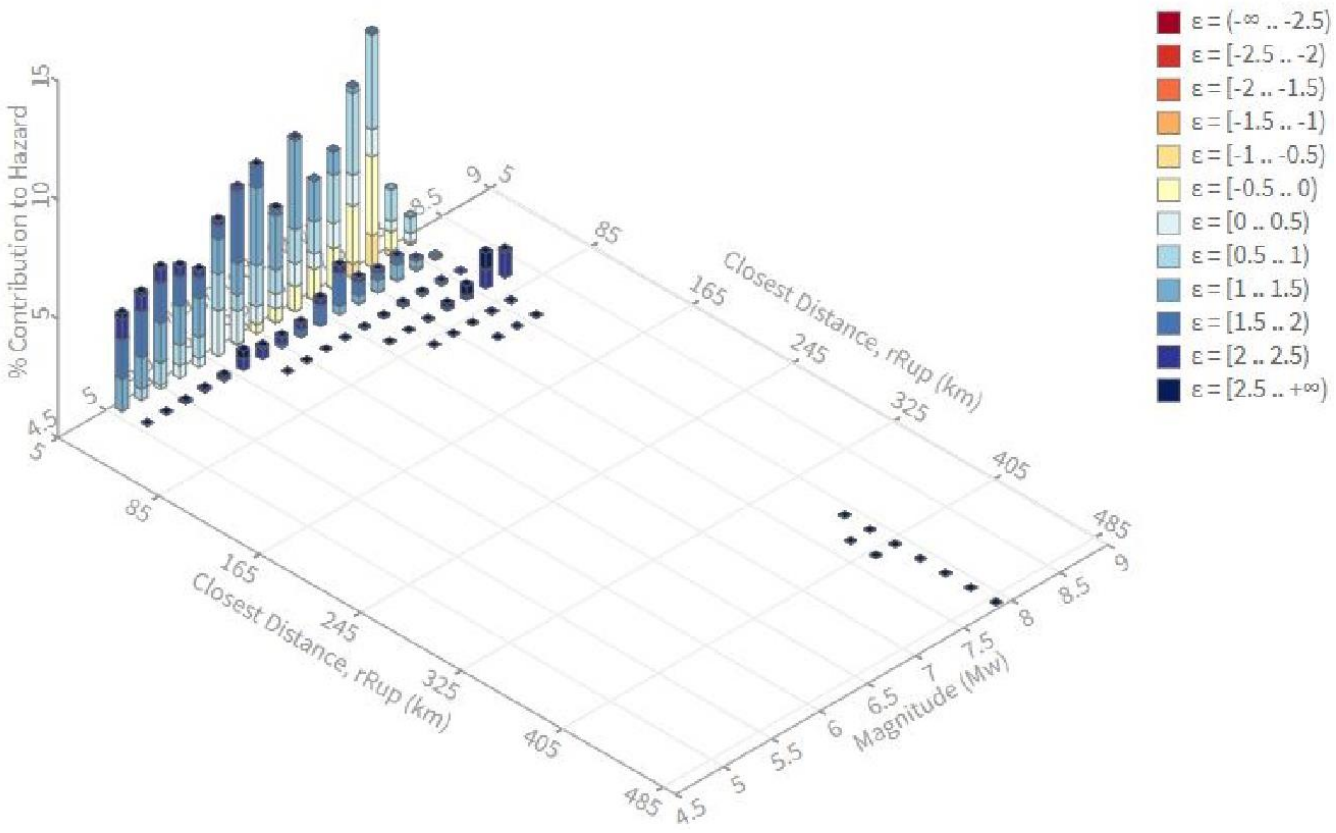

Figure 2b: Magnitude-Distance Deaggregation for the 2,475-year return period PGA for a site soil condition of VS,30 760 m/s.

4.3.2 Conclusion from Deterministic Seismic Hazard Analysis at the Guadalupe TB9 SMA

Table 2 lists estimated median (5%-damped) PGAs at the Site for a site soil condition of $V_{S,30}$ = 259 m/s that range from 0.02 to 0.49 g. Table 2 also lists estimated median (5%-damped) PGAs at the Site for a site soil condition of $V_{S,30}$ = 760 m/s that range from 0.01 to 0.48 g. The largest estimated median PGA of 0.48 g arises from an **M**6.9 earthquake occurring on the Casmalia Fault about 2.8 mi (4.5 km) southwest of the Site (Figure 1).

4.4 Probabilistic Seismic Hazard Analysis

PSHA is used to estimate earthquake ground motions for regions and for sites (e.g., McGuire 2004). PSHA provides a probabilistic estimate (annual exceedance probability [AEP]) for a specified earthquake ground motion. The earthquake ground motions can be PGA estimates, as is usually required for landfills in California, or spectral accelerations (accelerations at a specified frequency), as commonly used in most modern building codes.

The USGS developed national probabilistic seismic hazard models in 1996, 2002, 2008, and 2014. Each update of the national probabilistic model and associated hazard maps has incorporated the latest information on fault locations, fault characteristics, historical earthquakes, and the number and weighting of ground motion models (GMM) developed from earthquake records in the US and around the world. The national hazard models are used to estimate PGA and spectral accelerations for sites in the conterminous United States based on the Unified Hazard Tool (USGS 2014b).

Table 3a lists PGA and selected spectral accelerations for three return periods and three spectral periods from the Conterminous US probabilistic seismic hazard model. PGA values listed in Table 3a were calculated assuming an ASCE 7-10 soil Site Class D soil condition of stiff soil with a $V_{S,30}$ of 259 m/s.

Table 3a: Outcropping Stiff Soil PGA and Spectral Accelerations (5%-damped) for Selected Return Periods at the Guadalupe TB9 SMA, San Luis Obispo County, California

Probability of Exceedance (return period in years)[1]	Mean PGA (g)	Mean 0.2 Second (g)	Mean 1.0 Second (g)
10% in 50 years (475)	0.30	0.72	0.37
5% in 50 years (975)	0.40	0.96	0.51
2% in 50 years (2,475)	0.57	1.35	0.74

Notes: PGA = peak ground acceleration
1. Values from the 2014 USGS national seismic hazard model for a site with $V_{S,30}$ of 259 m/s at location 34.973°N, 120.624°W.

Table 3b lists PGA and selected spectral accelerations for three return periods and three spectral periods from the Conterminous US probabilistic seismic hazard model. PGA values listed in Table 3b were calculated assuming an ASCE 7-10 soil Site Class B/C boundary soil condition of rock with a $V_{S,30}$ of 760 m/s.

Table 3b: Outcropping Weak Rock PGA and Spectral Accelerations (5%-damped) for Selected Return Periods at the Guadalupe TB9 SMA, San Luis Obispo County, California

Probability of Exceedance (return period in years)[2]	Mean PGA (g)	Mean 0.2 Second (g)	Mean 1.0 Second (g)
10% in 50 years (475)	0.20	0.44	0.13
5% in 50 years (975)	0.28	0.62	0.19
2% in 50 years (2,475)	0.40	0.92	0.29

Notes: PGA = peak ground acceleration
2. Values from the 2014 USGS national seismic hazard model for a site with $V_{S,30}$ of 760 m/s at location 34.973°N, 120.624°W.

4.4.1 Conclusion from Probabilistic Seismic Hazard Analysis Results for the Site

The 2014 USGS national probabilistic hazard model indicates a mean 475-year return period PGA (5%-damped) of about 0.30 g for a stiff soil site condition (Table 3a) and 0.20 g for a rock site (Table 3b). The 0.20 g value for the 475-year mean PGA (rock soil condition) indicates a moderate level of seismic hazard at the Site.

Comparison between mean probabilistic and median deterministic PGA ground motions indicates that the estimated median deterministic PGA value of 0.48 g has a mean return period of about 4,000 years.

5.0 SUMMARY OF CONCLUSIONS

The Guadalupe TB9 SMA site is located in a region of moderate historical earthquake activity west of the SAF within the North America-Pacific plate boundary zone. More than 600 earthquakes greater than **M**3.0 have epicenters within about 62 mi (100 km) of the Site since the early 19th century. There are 22 significant faults mapped within 62 mi (100 km) of the Site, and of those, two fault sections (San Andreas fault: Cholame-Carrizo and Parkfield sections) have had surface fault rupture within historical time (i.e., since mid-19th century). Seven faults are considered to have had surface rupture within the last 15,000 years. The remaining 14 faults have inferred surface rupture less than 130,000 years ago (late Pleistocene). Faults older than late Pleistocene were not included in this study.

DSHA indicates that the Casmalia fault develops the highest MCE median PGA at the Site. The PGA arises from an **M**6.9 earthquake located about 2.8 mi (4.5 km) from the Site. Using the geometric mean of five NGA-West2 GMPEs with variable weightings, the strongest median PGA value for an assumed rock site (i.e., $V_{S,30}$ = 760 m/s) is 0.48 g. This PGA value has a return period estimated from the 2014 USGS national seismic hazard model at about 4,000 years.

6.0 CLOSING

This office-based analysis of fault activity and seismic hazard is for use by Chevron Environmental Management Company. The results of the assessment indicate a relatively moderate level of seismic hazard based on probabilistic analysis, and a higher deterministic median PGA value because of the Site's close proximity to the Casmalia fault. If you have any questions or concerns, then please contact us.

Donald Lowry, PG, CEG
Senior Engineering Geologist

Alan Hull, PG, CEG
Principal, Global Seismic Hazard Practice Leader

DL/AH/af

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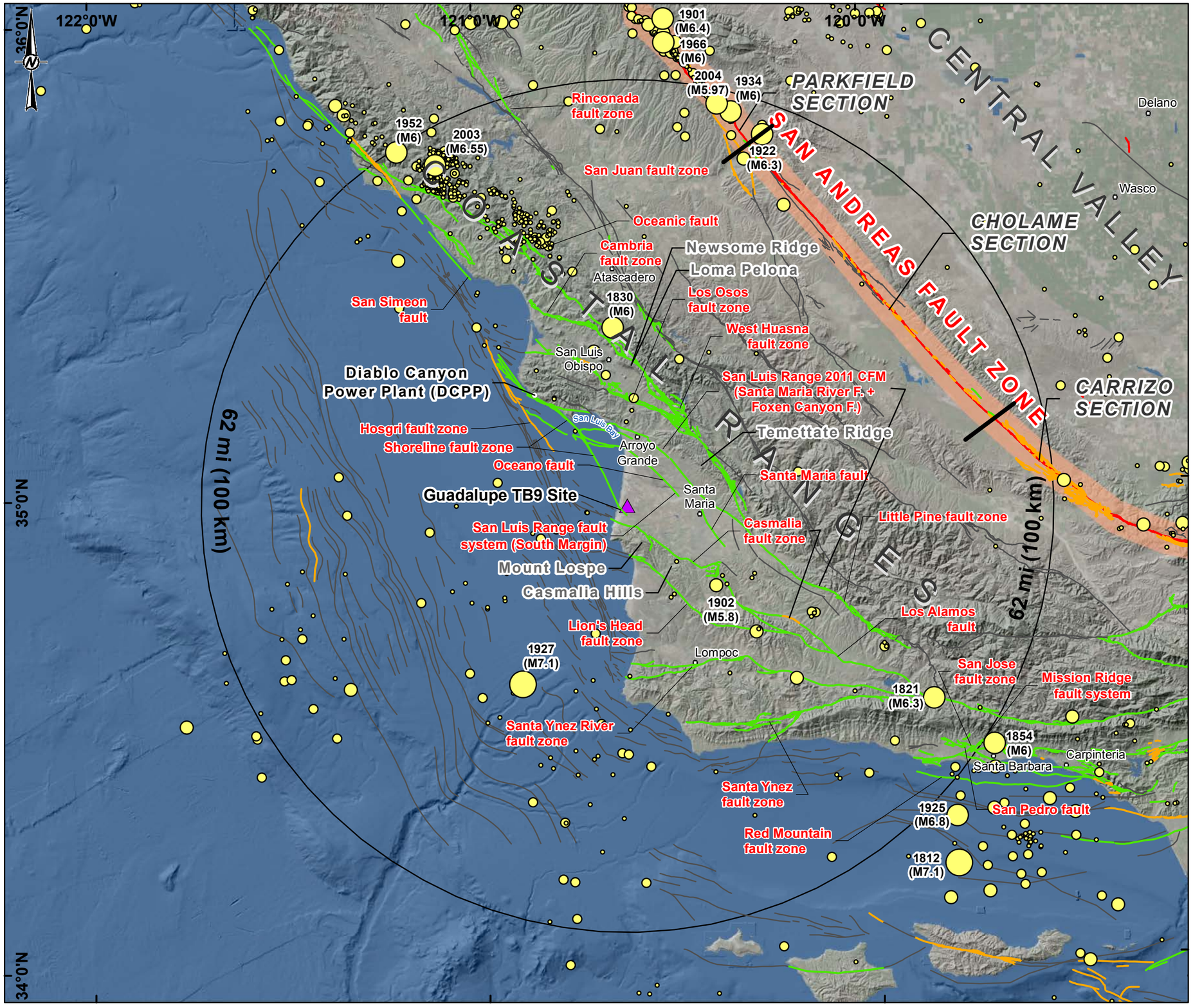
Figures



LEGEND

- Guadalupe TB9 Site

Historical Earthquake Epicenters

Magnitude

- 3.0 - 3.9
- 4.0 - 4.9
- 5.0 - 5.9
- 6.0 - 6.9
- 7.0 - 7.9

(Year and magnitude of significant events labeled)

Faults

Age of Most Recent Activity

- Historic (<150 years)
- Holocene (<15,000 years)
- Late Quaternary (<130,000 years)
- Undifferentiated Quaternary
- 1857 San Andreas Fault Rupture

0 5 10 20
MILES

0 12.5 25 50
KILOMETERS

REFERENCE(S)

1. EARTHQUAKE EPICENTERS (FIELD ET AL. 2013)
2. FAULT LOCATIONS: USGS (2018), NISHENKO ET AL. (2018), PG&E (2015)
3. COORDINATE SYSTEM: NAD 1983 UTM ZONE 10N
4. SERVICE LAYER CREDITS:
AIRBUS,USGS,NGA,NASA,CGIAR,GEBCO,NCEAS,NLS,OS,NMA,GEODATASTYRELSEN,GSA,GSI AND THE GIS USER COMMUNITY
SOURCE: ESRI, DIGITALGLOBE, GEOEYE, EARTHSTAR GEOGRAPHICS, CNES/AIRBUS DS, USDA, USGS, AEROGRID, IGN, AND THE GIS USER COMMUNITY

CLIENT
CHEVRON ENVIRONMENTAL MANAGEMENT COMPANY

PROJECT
SEISMIC HAZARD ASSESSMENT
GUADALUPE TANK BATTERY 9 SITE
SAN LUIS OBISPO COUNTY, CALIFORNIA

TITLE
HISTORICAL EARTHQUAKE EPICENTERS AND MAPPED FAULTS WITHIN ABOUT 62 MI (100 KM) OF THE GUADALUPE TANK BATTERY 9 SITE

CONSULTANT
GOLDER

YYYY-MM-DD	2018-09-07
PREPARED	HJ
REVIEWED	DL
APPROVED	AH

PROJECT NO.	PHASE	REV.	FIGURE
1783552	-	A	1

IF THIS MEASUREMENT DOES NOT MATCH WHAT IS SHOWN, THE SHEET SIZE HAS BEEN MODIFIED FROM: ANSI B

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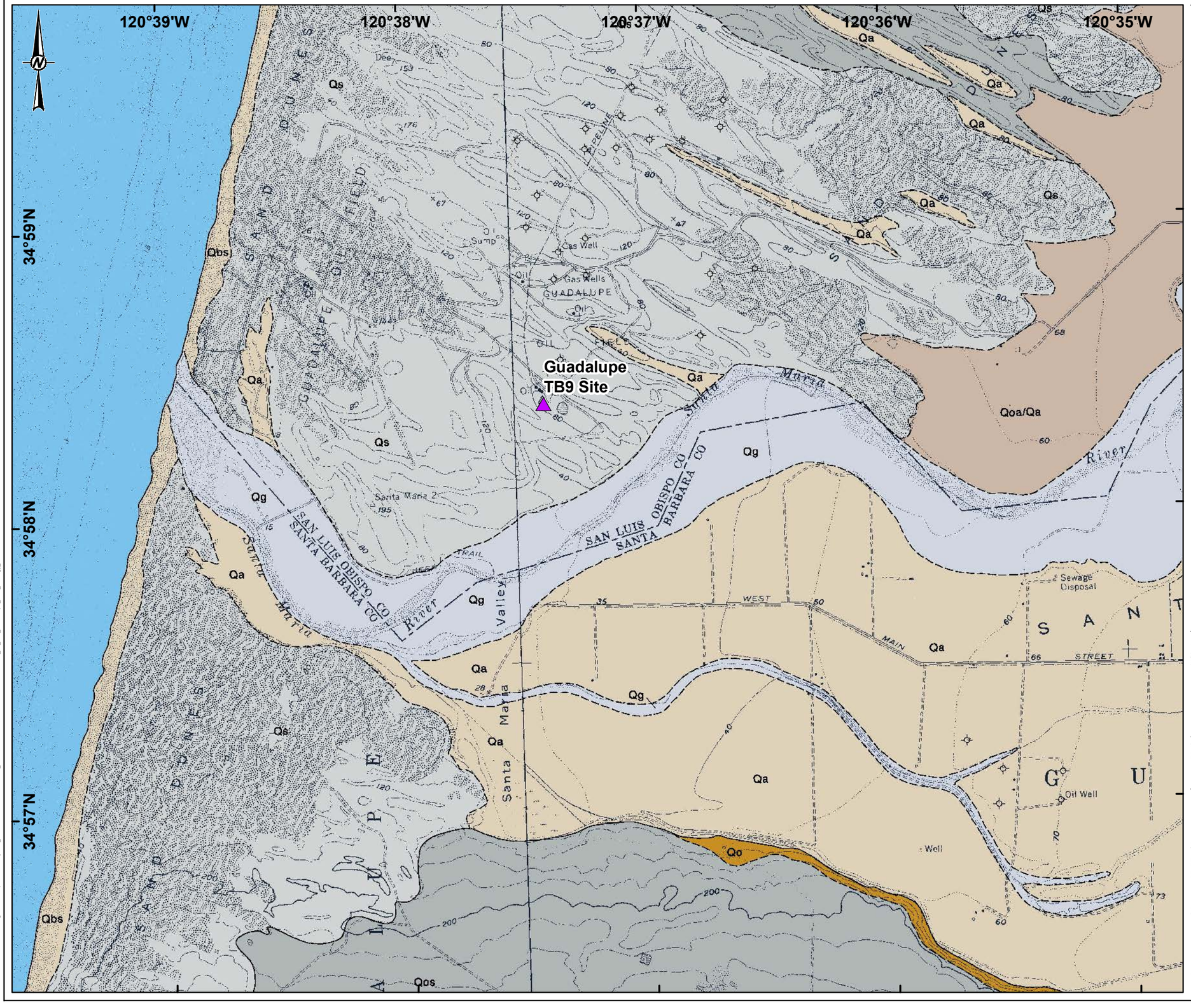

LEGEND

- Guadalupe TB9 Site

Surficial Geology

- Qa - Valley and floodplain alluvium
- Qbs - Beach sand deposits
- Qg - Stream channel deposits of sand and silt
- Qoa/Qa - Older dissected surficial sediments
- Qs - Dune sand deposits
- Qos - Older Dune sand deposits
- Qo - Orcutt sand

0 0.2 0.4 0.8
MILES

0 0.325 0.65 1.3
KILOMETERS

REFERENCE(S)

1. DIBBLEE (2009) - GEOLOGY
2. COORDINATE SYSTEM: NAD 1983 UTM ZONE 10N
3. SERVICE LAYER CREDITS:

CLIENT
CHEVRON ENVIRONMENTAL MANAGEMENT COMPANY

PROJECT
SEISMIC HAZARD ASSESSMENT
GUADALUPE TANK BATTERY 9 SITE
SAN LUIS OBISPO COUNTY, CALIFORNIA

TITLE
SURFICIAL GEOLOGY OF AREA SURROUNDING THE GUADALUPE TANK BATTERY 9 SITE

CONSULTANT
GOLDER

YYYY-MM-DD	2018-07-12
PREPARED	HJ
REVIEWED	DL
APPROVED	AH

PROJECT NO.	PHASE	REV.	FIGURE
1783552	-	A	2

IF THIS MEASUREMENT DOES NOT MATCH WHAT IS SHOWN, THE SHEET SIZE HAS BEEN MODIFIED FROM: ANSI B

25mm

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APPENDIX J

Construction Specifications

CONSTRUCTION SPECIFICATIONS

GUADALUPE RESTORATION PROJECT
SOIL MANAGEMENT AREA
TANK BATTERY 9 AREA

Chevron Environmental Manage Company
Guadalupe, California

Prepared for:

Chevron Environmental Manage Company
2184 West Thronberry Road
Guadalupe, California 93434

Prepared by:

Golder Associates Inc.
425 Lakeside Dr
Sunnyvale, California 94085
(408) 220-9223

1783552

August 2019

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DIVISION 2 - SITE WORK

Section	Description
02110	Site Clearing, Grubbing, and Stripping
02221	Earthwork
02222	Low-Permeability Soil Layer
02223	Gravel
02225	Operations Layer
02725	HDPE Pipe and Fittings
02751	HDPE Geomembrane
02752	Geotextiles
02755	Geocomposites
02756	Geosynthetic Clay Liner

DIVISION 11 – EQUIPMENT

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DIVISION 2

SITE WORK

SECTION 02110

SITE CLEARING, GRUBBING, AND STRIPPING

PART 1: GENERAL

1.01 DESCRIPTION

A. This section describes the general material and construction requirements for clearing, grubbing and stripping of vegetation and topsoil associated with the construction of the liner system for the Guadalupe Restoration Project Soil Management Area.

1.02 RELATED SECTIONS

A. Section 02221 - Earthwork

1.03 REFERENCES

A. Construction Quality Assurance (CQA) Plan

1.04 SUBMITTALS

A. Submit written notice of intent to perform clearing, grubbing, or stripping to CQA Engineer at least 7 days in advance of performing these activities.

PART 2: PRODUCTS

Not Applicable

PART 3: EXECUTION

3.01 PROTECTION

A. Protect plant growth and features remaining outside of the project boundaries.

B. Protect bench marks and existing work from damage or displacement.

C. Maintain designated site access for vehicle traffic.

D. Locate and protect existing utilities and monitoring wells. Damage caused to existing utilities or wells shall be repaired by the Contractor at no added cost to the Owner.

3.02 GENERAL CLEARING, GRUBBING AND STRIPPING REQUIREMENTS

A. Clearing shall consist of cutting, removing, and disposing of all vegetation including any trees, snags, stumps, shrubs, limbs, and other vegetative growth. Clearing shall also include the removal and disposal of rubbish and any debris that is designated by Owner.

B. Grubbing shall consist of the removal and disposal of wood or root matter below the ground surface remaining after clearing and shall include stumps, trunks, roots, or root systems to a minimum depth of 6 inches below the ground surface.

C. Stripping shall include the removal and disposal of all organic sod, topsoil, plant growth and associated roots. Stripping shall extend to the bottom of the root zone.

D. Contractor shall coordinate handling of clearing and grubbing debris with the Owner. No burning of debris will be permitted.

E. Topsoil from the strippings will be stockpiled in areas designated by the Owner. All stockpiles shall be track-walked and graded to drain upon completion.

F. All cut and fill areas will be cleared, grubbed, and stripped prior to filling or grading to design elevations.

G. Conduct operations and maintain the project site to minimize dust creation and dispersion.

3.03 ADDITIONAL CLEARING AND STRIPPING REQUIREMENTS

A. Borrow Area: Where vegetation is established, Contractor shall clear and strip to a minimum depth of 18-inches. The stripping depth requirement is a site permit condition and must be achieved. Stripped topsoil and vegetation soil shall be placed in berm as shown in the plans. Berm location shall be surveyed and constructed in the location shown in the plans.

B. General Earthfill: Contractor shall clear and strip any vegetation to a depth of at least 4-inches or greater as required to remove vegetation, roots and organic topsoil. Strippings shall be stockpiled at a location designated by the Owner.

END OF SECTION

SECTION 02221

EARTHWORK

PART 4: GENERAL

4.01 DESCRIPTION

A. This section describes the requirements for general earthworks including general fill placement, excavation, and subgrade preparation associated with the construction of the liner system for the Guadalupe Restoration Project Soil Management Area.

4.02 RELATED SECTIONS

A. Section 02110 - Site Clearing and Grubbing

B. Section 02222 - Foundation Soil and Low-Permeability Soil Layer

C. Section 02223 - Gravel

D. Section 02225 – Operations Layer

E. Section 02751 - HDPE Geomembranes

4.03 REFERENCES

A. Latest version of American Society for Testing and Materials (ASTM) standards:

1. ASTM D422 - Standard Test Method for Particle Size Analysis of Soils

2. ASTM D1140 - Standard Test Method for Amount of Material in Soils Finer than No. 200 Sieve

3. ASTM D1556 - Standard Test Method for Density and Unit Weight of Soil In Place by Sand-Cone Method

4. ASTM D1557 - Standard Test Methods for Laboratory Compaction Characteristics of Soils using Modified Effort

5. ASTM D2216 - Standard Test Methods for Laboratory Determination of Water (Moisture) Content of Soil and Rock by Mass

6. ASTM D2487 - Standard Practice for Classification of Soils for Engineering Purposes

7. ASTM D2937 - Standard Test Method for Density of Soil in Place by the Drive-Cylinder Method

8. ASTM D4220 - Standard Practices for Preserving and Transporting Soil Samples

9. ASTM D4318 - Standard Test Methods for Liquid Limit, Plastic Limit, and Plasticity Index of Soils

10. ASTM D4643 - Standard Test Method for Determination of Water (Moisture) Content of Soil by the Microwave Oven Method

11. ASTM D6938 - Standard Test Methods for In-Place Density and Water Content of Soil and Soil-Aggregate by Nuclear Methods

B. Construction Quality Assurance Plan

4.04 SUBMITTALS

A. Contractor shall notify CQA Engineer in writing a minimum of 7 days prior to starting work under this Section.

B. Contractor shall submit controlled low-strength material mix design with passing 28-day compressive strength per this Section a minimum of 7 days prior to material placement.

C. Contractor shall submit copies of any permits that may be required to Owner prior to start of work.

D. Submit a Health and Safety Plan to Owner.

4.05 QUALITY ASSURANCE

A. Contractor shall comply with the CQA Plan.

B. Observation, sampling and testing will be performed by the CQA Engineer to confirm that the materials and construction are in compliance with the requirements of these Construction Specifications. Contractor shall make allowances for sampling and testing by the CQA Engineer in both production and scheduling.

4.06 SAFETY

A. Contractor is solely responsible for performing work in a safe manner and complying with all applicable local, state and federal codes, ordinances, laws, and regulations.

PART 5: PRODUCTS

5.01 GENERAL EARTHFILL

A. General earthfill shall consist of soil free from significant amounts of organic materials, loam, wood, trash, or other deleterious materials. General fill shall not contain particles larger than 6 inches in the largest dimension.

B. Controlled low-strength material must be a fluid workable mixture of aggregate, cement, and water. Cement must be one of the following:

1. Cement complying with ASTM C150

2. Blended hydraulic cement complying with either of the following:

a. ASTM C595

b. Physical requirements in ASTM C1157

When tested under ASTM D4832, the controlled low-strength material must have a 28-day compressive strength:

1. A minimum of 75 psi for pipe backfill shown on the Construction Drawings

Water must be free of oil, salts, and other impurities that adversely affect the backfill.

Aggregate must be one of the following:

1. Commercial-quality concrete sand

2. Excavated or imported material in any combination, free of organic material and other deleterious substances and complying with the gradation requirements shown in the following table:

Sieve Size	Percentage Passing
1-1/2”	100
1”	80-100
3/4”	60-100
3/8”	50-100
No. 4	40-80
No.100	10-40

Mix materials thoroughly by machine. A pugmill rotary drum or other authorized mixer must be used. Mix until cement and water are thoroughly dispersed.

5.02 OTHER SOIL MATERIALS

A. Low-permeability soil shall conform to the requirements of Section 02222.

B. Foundation soil shall conform to the requirements of Section 02222.

C. Gravel material shall conform to the requirements of Section 02223.

D. Operations layer material shall conform to the requirements of Section 02225.

PART 6: EXECUTION

6.01 EXCAVATION

A. Take the necessary precautions to maintain the site in a condition that is relatively dry and free of standing water. Contractor shall be responsible for removing water that accumulates within the footprint of the disposal modules and the designated borrow area due to precipitation or surface water run-on.

B. Excavation shall be accomplished by methods which preserve the undisturbed state of the soils below the limits of the excavation. Soils which become soft, loose, or otherwise unsatisfactory for support of structures as a result of inadequate excavation, dewatering, or other construction methods shall be removed and replaced with suitable fill at no additional cost to the Owner.

C. Temporary and final excavation slopes in the borrow area shall not be steeper than 3 horizontal to 1 vertical.

D. If the bottom of any excavation within the Soil Management Area is taken below the limits shown on the Drawings, it shall be refilled by the Contractor and compacted in accordance with the requirements for general fill in this Section.

E. Excavated materials shall be placed in stockpile(s) designated by the Owner. The Contractor may use this material as general fill if it meets the material requirements of this Section for general fill.

6.02 PREPARATION FOR FILL PLACEMENT

A. Before placing fill materials, prepare the area by clearing existing obstructions, vegetation, and debris in accordance with Section 02110 – Site Clearing, Grubbing, and Stripping.

B. Maintain and operate proper and adequate surface drainage to the satisfaction of the CQA Engineer in order to keep the site dry and in such conditions that

placement and compaction of fill may proceed unhindered by saturation of the area.

C. If surface soil in fill placement areas is poorly compacted or excessively soft to a depth of greater than 6-inches, remove affected soil to competent material and replace in accordance with general fill placement methods.

6.03 GENERAL FILL PLACEMENT

A. Obtain fill materials from the required excavation or borrow areas.

B. The fill shall be placed to the lines, grades and elevations shown on the Drawings or as directed in the field by the CQA Engineer.

C. Prior to general fill placement, the subgrade shall be lightly scarified and moisture conditioned to the specified moisture content as determined by ASTM D 1557 and compacted to provide a firm and non-yielding surface. Soft or excessively wet areas shall be over-excavated a minimum of two feet to firm material and shall be backfilled and compacted with general fill.

D. The fill material shall be placed and compacted in loose lifts that result in a nominal compacted thickness of 6 inches. The first lift of anchor trench backfill may be placed with a maximum loose lift thickness of 12 inches.

E. Each lift of general fill shall be compacted to at least 90 percent of the maximum dry density and at the specified moisture content as determined by ASTM D1557. The first lift of anchor trench backfill shall be compacted to at least 85 percent of the maximum dry density according to ASTM D1557 at the specified moisture content.

F. The Contractor is responsible for moisture conditioning the borrow soils to the required moisture range. This may include drying for overly wet soils or may include addition of moisture for drier soils.

G. If new general fill is placed next to existing general fill, each lift of new general fill shall be keyed into the existing general fill.

H. In the event of a failing test, supplemental testing will be performed to define the area that has been inadequately compacted. Material not meeting specified compaction criteria shall be reworked or replaced, at no additional cost to the Owner, and then retested prior to subsequent lift placement over the area.

I. Grade and restore areas inadvertently disturbed during construction to their original grade and profile.

J. Water used for moisture conditioning shall be obtained from sources approved by the Owner.

K. The entire area shall be left in a manner to promote run-off at the end of each day.

L. Final grading shall be completed to the lines and grades shown on the Drawings and within the specified tolerances.

M. General fill placed for perimeter berm slopes shall be over-built and trimmed back to finish grades to ensure the general fill at the slope surface meets compaction requirements. The final surface shall be smooth, firm, non-yielding, and free from debris or other deleterious material.

N. Where finish grades require seeding, final grades shall be track-walked.

6.04 LINER SUBGRADE PREPARATION

A. The final surface of the subgrade shall not contain particles larger than 1/2-inch in the largest dimension. Contractor shall use hand-labor as necessary to remove rocks larger than 1/2-inch from the subgrade surface. Prior to acceptance of the liner subgrade, the CQA Monitor shall inspect the surface and identify areas not meeting this requirement.

B. Where the liner subgrade has been constructed during a previous summer, or if the subgrade has been exposed to wet weather, Contractor shall scarify, moisture condition and recompact the upper six inches of the subgrade surface to ensure that underlying soils meet the compaction and moisture content requirements set forth in this Section. Additionally, Contractor shall re-grade the surface to meet the grading tolerances identified in this Section.

6.05 TOLERANCES

A. All material limits shall be constructed within a tolerance of ±1.0 ft for horizontal state plan coordinates, ± 0.1 ft vertical for reference to mean sea level (MSL), and ±0.1 ft where dimensions are shown or specified as a minimum. All grading shall be performed to maintain slopes and drainage as shown on the Drawings. All flow paths leading to sumps shall be constructed to the minimum grades shown on the Drawings.

B. A Surveyor licensed in the State of California shall prepare as-built survey record drawing to confirm that the tolerances are as required. The as-built documentation shall be reviewed by the CQA Engineer for approval prior to placement of subsequent layers. As-built documentation is required for finished subgrade.

6.06 DUST CONTROL

A. The Contractor is required to implement dust control measures as necessary to minimize dust generation during all construction activities.

END OF SECTION

SECTION 02222

LOW-PERMEABILITY SOIL LAYER

PART 1: GENERAL

1.01 DESCRIPTION

A. This section describes the requirements for the production, placement, and trimming of the foundation and low-permeability soil layer materials associated with the construction of the liner system for the Guadalupe Restoration Project Soil Management Area.

1.02 RELATED SECTIONS

A. Section 02221 - Earthwork

B. Section 02751 - HDPE Geomembranes

C. Section 02756 – Geosynthetic Clay Liner

1.03 REFERENCES

A. Latest Version of American Society for Testing and Materials (ASTM) standards:

1. ASTM D422 – Standard Test Method for the Particle-Size Analysis of Soils

2. ASTM D854 - Standard Test Methods for Specific Gravity of Soil Solids by Water Pycnometer

3. ASTM D1140 - Standard Test Methods for Amount of Material in Soils Finer than No. 200 Sieve

4. ASTM D1556 – Standard Test Method for Density and Unit Weight of Soil in Place by the Sand Cone Method

5. ASTM D1557 – Standard Test Methods for Laboratory Compaction Characteristics of Soils Using Modified Effort

6. ASTM D1587 - Standard Practice for Thin-Walled Tube Sampling of Soils for Geotechnical Purposes

7. ASTM D2216 – Standard Test Methods for Laboratory Determination of Water (Moisture) Content of Soil and Rock by Mass

8. ASTM D2937 – Standard Test Method for Density of Soil in Place by the Drive-Cylinder Method

9. ASTM D4220 - Standard Practices for Preserving and Transporting Soil Samples

10. ASTM D4318 – Standard Test Methods for Liquid Limit, Plastic Limit, and Plasticity Index of Soils

11. ASTM D4643 – Standard Test Method for Determination of Water (Moisture) Content of Soil by the Microwave Oven Method

12. ASTM D5084 - Standard Test Methods for Measurement of Hydraulic Conductivity of Saturated Porous Materials Using a Flexible Wall Permeameter

13. ASTM D6391 - Standard Test Method for Field Measurement of Hydraulic Conductivity Limits of Porous Materials Using Two Stages of Infiltration from a Borehole.

14. ASTM D6938 – Standard Tests Method for In-Place Density and Water Content of Soil and Soil-Aggregate by Nuclear-Methods (Shallow Depth)

B. Construction Quality Assurance (CQA) Plan

1.04 SUBMITTALS

A. The Contractor shall submit a detailed plan for the preparation of the low-permeability soil material, including a description of the equipment and procedures to be used and methods for monitoring gradation and moisture conditioning. This plan shall be approved by the Owner prior to the start of low-permeability soil production.

B. Notify CQA Engineer in writing at least 7 days in advance of performing work under this section.

1.05 QUALITY ASSURANCE

A. The CQA Engineer shall test the low-permeability soil material during production and following placement in accordance with the CQA Plan. The Contractor shall make allowances for sampling and testing by the CQA Engineer in both production operations and schedule.

PART 2: PRODUCTS

2.01 LOW-PERMEABILITY SOIL MATERIALS

A. The low-permeability soil materials shall consist of a relatively homogeneous fine-grained soil. The-low permeability soil shall be classified as an SC, CL, or CH material by the CQA Engineer unless otherwise directed by the Owner. Material used for low-permeability soil material shall meet the following minimum requirements:

Percent Passing No. 200 Sieve	≥30
Plasticity Index	>10
Maximum Particle Size	1 inch

B. The compacted low-permeability soil shall have an in-situ hydraulic conductivity equal to or less than $1x10^{-7}$ cm/sec as measured by ASTM D5084. To achieve this permeability requirement, the material properties may need to be more stringent than indicated in Article 2.1.A of this Section.

C. The low-permeability soil materials shall be prepared by the Contractor and tested by the CQA Engineer in compliance with the CQA Plan. Testing will be done to determine fines content, Atterberg limits, and permeability. The Contractor shall make the low-permeability borrow source available to the Engineer at all times for sampling, testing, or visual observation.

D. The low-permeability soil materials shall be free of organics, foreign debris, rocks greater than 1-inch in diameter, and other deleterious material.

PART 3: EXECUTION

3.01 LOW-PERMEABILITY SOIL PREPARATION

A. The low-permeability soil material shall be mixed to achieve a homogenous material. The Contractor shall break up, crush, or use any other process approved by the Owner that will produce the required properties.

B. The Contractor shall segregate and obtain low-permeability soil material from Owner designated borrow areas.

3.02 MOISTURE CONDITIONING

A. The prepared low-permeability soil materials shall be moisture conditioned to the specified minimum moisture content. This moisture content may be modified by the CQA Engineer during the pre-construction testing and test pad construction (if required).

B. The moisture content of the material shall be uniform. If wet zones are encountered within the low-permeability or foundation soil materials, they shall be allowed to dry or mixed with surrounding material. Conversely, if dry zones are encountered within the low-permeability soil materials, they shall be moisture conditioned and mixed with the surrounding material.

3.03 SUBGRADE PREPARATION

A. The surface of the soil liner subgrade shall be graded to lines, grades, and tolerances shown on the Drawings.

3.04 PLACEMENT AND COMPACTION

A. The preliminary compaction window for the low-permeability soil is shown in Figure 02222-1 is defined by the following:

1. The minimum moisture content shall be as specified. Meeting compaction at a higher moisture content in the range of the compaction window may be more difficult to achieve than at a lower moisture content.

2. A minimum relative compaction of 90 percent as determined by ASTM D1557.

3. A density greater than that represented by a line between a degree of saturation of 85 percent at 90 percent relative compaction and a degree of saturation of 83 percent at 92 percent relative compaction.

B. Prior to production, the CQA Engineer shall confirm and/or modify the above preliminary compaction window based on the pre-construction testing and the results of the test pad (if required).

C. The low-permeability soil materials shall be placed and compacted in lifts not exceeding 8 inches loose or 6 inches compacted.

D. The compacted low-permeability soil materials distribution and gradation throughout the liner shall be free from lenses, pockets, streaks, layers, or material differing substantially in texture or gradation from surrounding material.

E. The moisture content of the low-permeability soil materials shall be uniform throughout each lift prior to and during compaction of the material. The Contractor shall be responsible for meeting moisture content, compaction, and material classification specifications. If the low-permeability soil material cannot be conditioned to meet the placement specifications, the material shall be removed and replaced with new low-permeability soil material.

F. The Contractor shall place lifts of low-permeability soil materials to form a continuous monolithic material. If a lift of compacted low-permeability soil dries out during placement operations, the Contractor shall moisture condition the dry soil and recompact the lift prior to placement of additional lifts. If a lift of compacted low-permeability soil becomes overly wet due to precipitation or over watering, the Contractor shall allow the wet soil to dry or remove the material before placement of additional lifts. Each new lift shall be kneaded into the previously placed lift.

G. All low-permeability soil materials shall be compacted with a self-propelled kneading, sheepsfoot or padfoot, compactor. Hauling and spreading equipment will not be considered as compaction equipment. The use of rubber-tired and/or smooth drum compaction equipment is not allowed.

3.05 GRADING

A. The surface of the low-permeability soil layer shall be graded to the lines and grades shown on the Drawings. The surface of the low-permeability soil layer shall be rolled with a smooth drum roller or other suitable device to remove all ridges and surface irregularities. The CQA Engineer shall determine if the surface preparation is sufficient to place the HDPE geomembrane.

B. All wheel ruts on the surface of the low-permeability soil layer shall be repaired by the earthworks Contractor prior to placement of the HDPE geomembrane. Methods for repair of the low-permeability soil layer are specified in Part 3.06 of this Section. Alternate methods for repair of the low-permeability soil layer will be allowed if submitted by the Contractor and approved by the Engineer.

C. The Contractor shall maintain the low-permeability soil layer surface in a condition suitable for geomembrane installation until the surface is covered. Contractor shall apply water to the surface to prevent desiccation cracking. Desiccation cracks larger than 0.1 feet deep or 0.25 inches wide shall be excavated to the full depth of the crack and repaired.

D. The maximum particle size that may be exposed on the low-permeability soil layer surface shall be 1/2-inch. Larger particles shall be removed by the Contractor and the low-permeability soil layer surface repaired in accordance with Article 3.06.

E. Contractor shall repair all ruts, erosion rills or other damage that may occur prior to the placement of the geomembrane.

3.06 REPAIR OF THE LOW-PERMEABILITY SOIL LAYER

A. The Contractor shall repair the surface of any areas identified by the CQA Engineer to be out of tolerance as follows:

1. Scarify surface and spray with water

2. Place additional approved low-permeability soil materials

3. Compact low-permeability soil materials with self-propelled sheepsfoot type compactor

4. Trim surface to design grades and tolerances

5. Roll surface to remove irregularities

3.07 TOLERANCES

A. The low-permeability soil layer shall be constructed to tolerance of –0.0 ft to +0.2 feet of the design elevation. The contractor shall also ensure that the foundation soil and low-permeability soil liner shall have a minimum thickness of 5.0 feet and that positive drainage grades are retained throughout the liner. The contractor

shall also ensure that the low-permeability layer has the minimum thickness as shown on the Drawings.

B. A surveyor licensed in the State of California shall prepare an as-built survey record drawing to confirm that the tolerances are as required. The as-built record drawing shall be reviewed by the CQA Engineer for approval prior to placement of subsequent materials.

END OF SECTION

SECTION 02223

GRAVEL

PART 1: GENERAL

1.01 DESCRIPTION

A. This section describes the requirements for placement of the LCRS gravel associated with construction of the liner system for the Guadalupe Restoration Project Soil Management Area.

1.02 RELATED SECTIONS

A. Section 02221 - Earthwork

B. Section 02751 - HDPE Geomembranes

C. Section 02752 – Geotextiles

D. Section 02755 – Geocomposites

1.03 REFERENCES

A. Latest Version of American Society for Testing and Materials (ASTM) standards:

1. ASTM C136 - Standard Test Method for Particle-Size Analysis of Fine and Coarse Aggregate

2. ASTM D2434 - Standard Test Method for Permeability of Granular Soils (Constant Head)

3. ASTM D5821 - Standard Test Method for Determining the Percentage of Fractured Particles in Coarse Aggregate

B. Construction Quality Assurance (CQA) Plan.

1.04 SUBMITTALS

A. Submit gravel samples at least 7 days prior to full-scale production for testing by CQA Engineer.

B. Prior to commencement of LCRS gravel placement, the Contractor will provide a resume for the grading equipment operator that demonstrates a minimum of 200 hours of experience spreading gravel with tolerances similar to those required in this Section.

1.05 QUALITY ASSURANCE

A. Perform in accordance with the CQA Plan.

PART 2: PRODUCTS

2.01 LCRS GRAVEL

A. LCRS gravel shall be comprised of durable, sub-rounded gravel with no more than 25 percent of particles 3/8-inch or larger with more than one fractured face, as determined by ASTM D5821 and shall meet the following gradation requirements.

US Sieve Size	Percent Passing
1/2"	100
3/8"	85-100
No. 4	0-30
No. 200	0-2

B. LCRS Gravel shall exhibit a permeability of 1 cm/sec or greater.

PART 3: EXECUTION

3.01 PLACEMENT OF LCRS GRAVEL

A. Place gravel over the floor as shown in the Drawings.

B. Equipment operating and material placement requirements:

1. Grading equipment shall operate on a minimum thickness of 0.5 feet.

2. Grading equipment for spreading the gravel shall be a low ground pressure dozer with a maximum track pressure of 5.5 psi with a maximum operating weight of 44,000 lbs.

3. Grading equipment operator shall possess a minimum of 200-hours of experience spreading drainage gravel with tolerances similar to those required in this section.

4. When operating over the geosynthetic liner, hauling equipment shall comply as follows:

   a. Hauling equipment shall operate on the completed operations layer surface constructed to the minimum thickness requirements.

   b. If operating on gravel, hauling equipment shall operate on temporary “roads” that are a minimum of three feet thick and 15 feet wide. These roads will be graded out by grading equipment that meets the above requirements.

5. Sharp turns by equipment shall not be permitted. If any hauling, placing, or grading equipment turns sharply or operates on less than required minimum thickness of gravel, the area below the equipment shall be carefully excavated to expose the underlying geomembrane. Damaged areas shall be repaired by Contractor in accordance with procedures described in Section 02751- HDPE Geomembranes at no cost to Owner.

6. Sequence liner construction to minimize gravel push distances. Gravel shall be pushed a distance of more than 100 feet only if the total thickness of the gravel is greater than one foot at the time the gravel is pushed.

7. Take precautions to prevent damage to underlying layers.

8. Prevent excessive wrinkle development in the geosynthetic layers. Excessive wrinkles shall be cut out and repaired in accordance with procedures described in Section 02751- HDPE Geomembranes at no cost to Owner. To prevent wrinkles, the Contractor may place material in the early morning hours when the geosynthetic materials are cool and by monitoring and walking out wrinkles in the geosynthetic materials that appear at the face of the placement operations.

9. Grading equipment shall be equipped with laser or global positioning satellite surveying technology that provides the operator real-time measurement of the dozer blade relative to the top of the liner.

C. Protect HDPE pipe from mechanical damage.

D. The Contractor shall maintain the final surface of the gravel layer free of ruts, and depressions until the overlying materials are placed.

E. During placement of the gravel, the Contractor shall apply clean water to the gravel surface to help maintain adequate moisture for the electrical leak location survey. Contractor shall apply water as directed by the CQA Engineer.

3.02 TOLERANCES

A. The final grade of the finished gravel for the LCRS layer shall be within 0.0 to +0.2 ft of the design thickness, and shall be within 0.0 to + 0.2 ft of the design elevations.

B. As-built LCRS gravel record drawings:

1. A surveyor licensed in the State of California shall prepare an as-built, survey record drawing to confirm that the specified tolerances are met. The as-built record drawing shall be reviewed by the CQA Engineer for approval prior to placement of subsequent materials.

2. As an alternative to surveying, thickness measurements may be taken, compiled and presented as an as-built LCRS gravel record drawing. Measurements shall be taken on a minimum 50-foot grid, including

gradebreaks, control point locations, and gravel limits. Thickness measurements shall be obtained from top-of-gravel and top-of-soil liner information at the same location. An acceptable method shall be to take a height reading relative to a laser setup on top of the gravel, then excavate a hole and take a reading below the gravel, where the difference between the measurements is the gravel thickness. Alternative thickness measurement methods may be used upon acceptance by the CQA Engineer.

END OF SECTION

SECTION 02225

OPERATIONS LAYER

PART 1: GENERAL

1.01 DESCRIPTION

A. This section describes the requirements for placement of operations layer associated with the construction of the liner system for the Guadalupe Restoration Project Soil Management Area.

1.02 RELATED SECTIONS

A. Section 02221 – Earthwork

B. Section 02223 – Gravel

C. Section 02752 – Geotextiles

D. Section 02755 – Geocomposites

1.03 REFERENCES

A. Latest version of American Society for Testing and Materials (ASTM) standards

B. Construction Quality Assurance (CQA) Plan

1.04 SUBMITTALS

A. Provide written notice to CQA Engineer at least 7 days in advance of performing work under this Section.

PART 2: PRODUCTS

2.01 OPERATIONS LAYER MATERIAL

A. Soil Operations Layer: The operations layer material shall consist of soil free of metal and construction debris, stumps, and other deleterious material. The maximum allowable particle size (largest dimension) is 3 inches for material placed on the floor and 1-inch for material placed on the side slopes.

B. Onsite soil impacted with petroleum hydrocarbons may be used of the operations layer.

C. Material shall form a firm, stable base when placed.

PART 3: EXECUTION

3.01 PLACEMENT

A. The soil operations layer shall be placed over the areas indicated on the Drawings.

B. Prior to the placement of the operations layer material, final inspection of the geotextile and LCRS geocomposite drainage layer by the CQA Engineer will be made to verify integrity.

C. Hauling and grading equipment shall operate on a minimum of 12 inches of operations layer material over the floor area. Hauling equipment shall have a maximum operating weight of 63 tons and a maximum ground pressure of 25 psi. Operations layer shall be pushed and spread using tracked grading equipment. Grading equipment shall have a maximum operating weight of 30 tons and a maximum ground pressure of 11 psi.

D. Operations layer material placed on the side slopes shall be pushed from the bottom up the slope. In no case shall material be placed down the slope.

E. Contractor shall apply water to the operations layer surface as required to maintain adequate moisture for the electrical leak location survey. Contractor shall apply water as directed by the CQA Engineer.

F. Operations layer placement for the Guadalupe Restoration Project Soil Management Area liner system shall be performed by the Contractor.

3.02 TOLERANCES

A. The final grade of the finished operations layer shall be within $\pm$0.1 ft of the design thickness and shall provide positive drainage. At the discretion of the Owner, the thickness may exceed the plus tolerance provided that positive drainage is maintained.

END OF SECTION

SECTION 02725

HDPE PIPE AND FITTINGS

PART 1: GENERAL

1.01 DESCRIPTION

A. This section describes the material and construction requirements for the HDPE pipe associated with the construction of the liner system for Disposal the Guadalupe Restoration Project Soil Management Area.

1.02 RELATED SECTIONS

A. Section 02221 - Earthwork

B. Section 02223 - Gravel

C. Section 02751 - HDPE Geomembranes

D. Section 02752 - Geotextiles

E. Section 02755 - Geocomposites

1.03 REFERENCES

A. Latest version of American Society for Testing and Materials (ASTM) standards:

1. ASTM D1505 - Standard Test Method for Density of Plastics by the Density-Gradient Technique

2. ASTM D1603 - Standard Test Method for Carbon Black Content in Olefin Plastics

3. ASTM D1693 - Standard Test Method for Environmental Stress-Cracking of Ethylene Plastics

4. ASTM F2620 – Standard Practice for Heat Fusion Joining of Polyethylene Pipe and Fittings

5. ASTM D2837 - Test Method for Obtaining Hydrostatic Design Basis for Thermoplastic Pipe Materials or Pressure Design Basis for Thermoplastic Pipe Materials

6. ASTM D3350 - Standard Specification for Polyethylene Plastics Pipe and Fittings Material

7. ASTM F714 - Standard Specification for Polyethylene (PE) Plastics Pipe (SDR-PR) Based on Outside Diameter

B. Construction Quality Assurance (CQA) Plan

1.04 SUBMITTALS

A. Submit to Owner written warranties obtained from Pipe Manufacturer and the Pipe Installer against defects in material and workmanship. Warranty conditions proposed by the Pipe Manufacturer or Pipe Installer concerning limits of liability will be evaluated and must be acceptable to the Owner.

B. Submit detailed shop drawings of all HDPE pipe and fittings, a list of materials to be furnished, and the names of the suppliers. Submittals shall be made at least 7 days before the start of work.

C. Submit manufacturer's quality control certificate for the HDPE pipe product showing the following:

1. Certificate stating the specific resin, its source and properties.

2. Certification that reclaimed material added to the resin does not exceed 10 percent by weight.

3. Certification that the pipe meets the minimum physical property requirements.

PART 2: PRODUCTS

2.01 HDPE MATERIALS

A. Specific gravity, as determined by ASTM D1505 shall be at least 0.94.

B. Carbon black content, as determined by ASTM D1603 shall be at least 2.0 percent.

2.02 HDPE PIPE AND PIPE FITTINGS

A. All HDPE pipe and fittings shall comply with ASTM F714 and ASTM D3350.

B. All HDPE pipe and fittings shall be polyethylene Type III piping manufactured from resin with a cell classification of 345464 C/E per ASTM D3350. The pipe shall have a minimum hydrostatic design basis rating of 1,600 psi (ASTM D2837).

C. All HDPE pipe and fittings shall have a maximum Standard Dimension Ratio (SDR) as specified on the Drawings.

D. HDPE pipe shall be furnished non-perforated or perforated as specified on the Drawings.

E. HDPE pipes and fittings shall be homogeneous throughout and free of visible cracks, holes, (except as noted on the Drawings), blisters, bubbles, undispersed raw materials, or any foreign inclusions or other deleterious effects.

F. Fittings at the ends of pipes shall consist of HDPE end caps unless indicated otherwise on the Drawings.

G. Pipe elbows shall be manufactured to the angle specified on the plans. Contractor shall allow for sufficient lead time during procurement of custom pipe fittings.

PART 3: EXECUTION

3.01 INSTALLATION

A. HDPE PIPE

1. All HDPE pipe and fittings shall be installed in accordance with the manufacturer's recommendations.

2. Foreign material shall be removed from the interior of all pipe and fittings prior to welding.

3. All joining or coupling of pipe sections shall be accomplished by thermal butt fusion in accordance with ASTM F2620. No solvent or adhesive welding will be allowed. Field-cutting of pipes, where required, shall be made with a machine specifically designed for cutting pipe. Cuts shall be carefully made, without damage to pipe or lining, so as to leave a smooth end at right angles to the axis of the pipe.

4. All pipe and fittings shall be laid or placed to the lines, grades, and elevations, as shown on the Drawings.

5. No pipe shall be placed until the Engineer has approved the bedding conditions.

6. Blocking under piping shall not be permitted unless specifically accepted by the Engineer for special conditions.

7. Place 60-mil HDPE geomembrane rub sheet beneath pipe joints including, all flange fittings. Rub sheet shall measure at least 2-foot by 2-foot in area.

8. Pipe boots to be secured to pipe by extrusion welding.

3.02 TOLERANCES

A. The Contractor shall be responsible for installing all HDPE piping within the following tolerances:

1. Horizontal tolerance: 0.5 ft maximum

2. Vertical tolerance: 0.1 ft maximum

3. Maintain positive grades - no reverse slopes allowed at any location.

B. A Surveyor licensed in the State of California shall prepare as-built survey record drawing to confirm that the tolerances are as required.

END OF SECTION

SECTION 02751

HDPE GEOMEMBRANE

PART 1: GENERAL

1.01 DESCRIPTION

A. This section describes the requirements for the manufacture, supply, installation, and quality control (QC) of High Density Polyethylene (HDPE) geomembrane associated with the construction of the liner system for the Guadalupe Restoration Project Soil Management Area.

1.02 RELATED SECTIONS

A. Section 02221 - Earthwork

B. Section 02222 – Foundation Soil and Low-Permeability Soil Layer

C. Section 02223 - Gravel

D. Section 02225 - Operations Layer

E. Section 02725 - HDPE Pipe

F. Section 02752 - Geotextiles

G. Section 02755 - Geocomposites

1.03 REFERENCES

A. Latest Version of American Society for Testing and Materials (ASTM) standards:

1. ASTM D638 - Test Method for Tensile Properties of Plastics

2. ASTM D746 – Test Method for Determination of Low Temperature Brittleness Properties

3. ASTM D1004 – Test Method for Initial Tear Resistance of Plastic File and Sheeting

4. ASTM D1204 – Test Method for Linear Dimensional Changes of Non-rigid Thermoplastic Sheeting or Film at Elevated Temperature

5. ASTM D1238 - Standard Test Method for Flow Rates of Thermoplastics by Extrusion Plastometer

6. ASTM D1505 - Standard Test Method for Density of Plastics by Density-Gradient Technique

7. ASTM D1603 – Test Method for Carbon Black in Olefin Plastics

8. ASTM D1693 – Test Method for Environmental Stress Crack Resistance

9. ASTM D3895 – Standard Test Method for Oxidative Induction Time of Polyolefins by Differential Scanning Calorimetry

10. ASTM D4833 – Test Method for Puncture Resistance for Geotextiles, Geomembranes, and Related Products

11. ASTM D5199 – Standard Test Method for Measuring the Nominal Thickness of Geomembranes

12. ASTM D5321 - Test Method for Determining the Coefficient of Soil and Geosynthetic or Geosynthetic and Geosynthetic Friction by the Direct Shear Method

13. ASTM D5397 – Standard Test Method for Evaluation of Stress Crack Resistance of Polyolefin Geomembranes Using Notched Constant Tensile Load Test

14. ASTM D5596 - Standard Test Method for Microscopic Evaluation of the Dispersion of Carbon Black in Polyolefin Geosynthetics

15. ASTM D5885 – Standard Test Method for Oxidative Induction Time of Polyolefin Geosynthetics by High-Pressure Differential Scanning Calorimetry

16. ASTM D5994 - Standard Test Method for Measuring Core Thickness of Textured Geomembrane

17. ASTM D6392 - Standard Test Method for Determining the Integrity of Nonreinforced Geomembrane Seams Produced Using Thermo-Fusion Methods

18. ASTM D7007 – Standard Practices for Electrical Methods for Locating Leaks in Geomembranes Covered with Water or Earth Materials

B. Latest version of Geosynthetics Research Institute (GRI) testing methods:

1. GRI-GM13 - Test Properties, Testing Frequency and Recommended Warranty for High Density Polyethylene (HDPE) Smooth and Textured Geomembranes

2. GRI-GM19 - Seam Strength and Related Properties of Thermally Bonded Polyolefin Geomembranes

C. Construction Quality Assurance (CQA) Plan

1.04 SUBMITTALS

A. Production Data: Furnish the following in writing to the CQA Engineer a minimum of seven calendar days prior to geomembrane shipment to the site:

1. Resin:

a. Statement of production dates and origin of resin used to manufacture the geomembrane for the project.

b. Certification stating all resin is from the same manufacturer and that reclaimed polymer added to the resin during the manufacturing of the geomembrane does not exceed 10 percent by weight.

c. Copies of the quality control certificates issued by the manufacturer and resin supplier indicating that the resin used to manufacture the geomembrane meets these specifications.

2. Quality Control: A copy of the manufacturer's quality control program shall be submitted to the CQA Engineer a minimum of seven calendar days prior to geomembrane shipment to the site. Quality control testing shall be performed by the manufacturer in accordance with the test procedures, and frequency listed in the Quality Control Program and as approved by the CQA Engineer. Prior to delivery the following shall be submitted to the CQA Engineer for Review:

a. Certificates for each shift's production of geomembrane, statements of production dates.

b. Certification stating all geomembrane rolls are furnished by one manufacturer, and all rolls are manufactured from one resin type obtained from one resin supplier.

c. Copies of quality control certificates issued by the Manufacturer. The quality control certificates shall include:

i. Roll numbers and identification

ii. Sampling procedures

iii. Results of quality control tests, including descriptions of the test methods used

d. The results of the manufacturing quality control tests shall meet or exceed the property values listed in Table 02751-1.

e. Geomembrane delivery, storage, handling and installation instructions.

3. Extrudate Beads and/or Rod:

    a. Statement of production dates.

    b. Certification stating all extrudate is from one manufacturer, is the same resin type, and was obtained from the same resin supplier as the resin used to manufacture the geomembrane rolls.

    c. Copies of quality control certificates issued by the Manufacturer.

B. Prior to mobilization of the Installer to the site, the Contractor shall submit the following information from Geosynthetic Installer:

1. Shop drawings indicating panel layout and field seams 14 calendar days prior to installation of geomembrane.

2. Installation schedule.

3. Copy of Installer's letter of approval or license by the Geomembrane Manufacturer.

4. Installation capabilities, including:

    a. Information on equipment proposed for this project;

    b. Average daily production anticipated for this project; and

    c. Quality control procedures.

5. Copies of the quality control/quality assurance program for the manufacturer of the geomembrane liner.

6. Resume of the superintendent to be assigned to this project, including dates and duration of employment.

7. Resumes of all personnel who will perform seaming operations on this project, including dates and duration of employment.

8. The installation crew shall have the following experience.

    a. The superintendent shall have supervised the installation of a minimum of 2,000,000 sf of polyethylene geomembrane and 500,000 sf of geotextile.

    b. The master seamer shall have experience seaming a minimum of 1,000,000 sf of polyethylene geomembrane using the same type of seaming apparatus to be used at this site.

    c. All other seaming personnel shall have seamed at least 100,000 sf of polyethylene geomembrane using the same type of seaming apparatus to be used at this site. Personnel who have seamed less

than 100,000 sf of polyethylene geomembrane shall be allowed to seam only under the direct supervision of the master seamer or Superintendent.

C. During the installation, the Installer shall be responsible for the timely submission to the CQA Engineer of subgrade acceptance certificates, signed by the Installer, for each area to be covered by geomembrane.

D. The Contractor shall furnish the Owner upon completion of the project:

1. A 20-year written warranty provided by the manufacturer against defects in material. Warranty conditions concerning limits of liability will be evaluated and must be acceptable to the Owner.

2. A 1-year warranty provided by the Geosynthetics Installer against defects in workmanship. Warranty conditions concerning limits of liability will be evaluated and must be acceptable to the Owner.

3. As-built Geomembrane Panel Drawings. As-built shall include panel locations, panel identification numbers, geomembrane roll numbers for each panel, seam caps, destructive sample locations, and large repairs.

1.05 QUALITY ASSURANCE

A. Perform work in accordance with the Installer's Quality Control Program and the Construction Quality Assurance Plan.

B. Attend a pre-installation conference one week prior to commencing work of this section. Require attendance of parties directly affecting the work of this Section.

PART 2: PRODUCTS

2.01 DELIVERY, STORAGE AND HANDLING

A. Conform to the manufacturer's requirements to prevent damage to geomembrane.

B. Delivery:

1. Deliver materials to the site only after the CQA Engineer and the Owner approve required submittals.

2. All rolls of geomembrane delivered to the site shall be identified at the factory with the following:

a. Manufacturer's name

b. Product identification

c. Lot number

d. Roll number

e. Roll dimensions

3. Separate damaged rolls from undamaged rolls and store at locations designated by the Owner until proper disposition of material is determined by the Owner and the CQA Engineer.

4. The Owner will be the final authority regarding damage.

5. Separate rolls without proper documentation and store until the CQA Engineer approval is received.

6. The contractor shall be responsible for offloading all of the geosynthetics.

C. On-Site Storage:

1. Store in space allocated by the Owner.

2. Protect from puncture, dirt, grease, water, moisture, mud, mechanical abrasions, excessive heat or other damage.

3. Store on level prepared surface (not on wooden pallets).

4. Stack per Manufacturer's recommendation but no more than three rolls high.

D. On-Site Handling:

1. Use appropriate handling equipment to load, move or deploy geomembrane rolls. Appropriate handling equipment includes cloth chokers and spreader bar for loading, spreader and roll bars for deployment. Dragging panels on ground surface will not be permitted.

2. Do not fold geomembrane material; folded material shall be rejected.

3. The installer is responsible for storage, and transporting material from storage area to liner facility.

E. Damaged Geomembrane:

1. Geomembrane damage will be documented by the CQA Engineer.

2. Damaged geomembrane shall be repaired, if possible, in accordance with these specifications or shall be replaced at no additional cost to the Owner.

2.02 MATERIALS

A. The geomembrane shall be comprised of high density polyethylene (HDPE) material as indicated on the Drawings, manufactured of new, first-quality

products designed and manufactured specifically for the purpose of liquid containment in hydraulic structures.

B. The geomembrane shall be produced free of holes, blisters, undispersed raw materials, or any sign of contamination by foreign matter. Any such defect shall be repaired in accordance with the repair procedures in Article 3.06.

C. The geomembrane shall be manufactured with a minimum of 15.0 feet seamless width. There shall be no factory seams.

D. The geomembrane liner shall be HDPE 60-mil and textured as indicated on the Drawings.

E. The geomembrane shall be supplied in rolls; folds will not be permitted. Identify each roll with labels indicating lot number, roll number, thickness, length, width, manufacturer, and plant location.

F. Specifications for HDPE geomembrane properties are presented in Table 02751-1 included at the end of this section. Supplied material shall conform to these properties based upon the manufacturer's QC testing and CQA conformance testing.

G. Resin:

1. Shall be HDPE, new, first quality, compounded and manufactured specifically for producing HDPE geomembrane.

2. Do not intermix resin types.

H. Extrudate Rod or Bead:

1. Shall be made from same resin as the geomembrane.

2. Additives shall be thoroughly dispersed.

3. Shall be free of contamination by moisture or foreign matter.

I. The textured geomembrane shall exhibit minimum shear strength characteristics along the textured geomembrane/low-permeability soil liner interface and textured geomembrane/geosynthetic clay liner interface. These characteristics shall be demonstrated with direct shear testing (ASTM D5321) by an independent CQA laboratory.

1. The minimum residual shear strength shall correspond to an internal friction angle of 12 degrees with no cohesion as determined by the following test conditions:

a. Perform direct shear test (ASTM D5321) at normal stresses of 2,000, 4,000, 6,000 and 10,000 psf.

b. For the low-permeability soil liner interface, compact soil to 90 percent relative compaction at the specified moisture content.

c. For the low-permeability soil liner interface, allow compacted soil to consolidate under each load.

d. Use a shearing rate of 0.04 in./min for the geomembrane/low-permeability soil liner interface and 0.2 in./min. for the geomembrane/geosynthetic clay liner interface.

2. The texturing shall remain intact under the above test conditions (no peeling or shearing of the texturing).

2.03 EQUIPMENT

A. Welding equipment and accessories shall meet the following requirements:

1. Equipped with gauges showing temperatures both in apparatus and at nozzle (extrusion welder) or at wedge (fusion welder).

2. Maintain adequate number of welding apparatus to avoid delaying work.

3. Use power source capable of providing constant voltage under combined-line load.

4. Provide secondary containment to catch spilled fuel under electric generator, if located on geomembrane.

B. Provide calibrated tensiometer capable of quantitatively measuring geomembrane strength:

1. Equipped with gauge accurate to +2 lbs per inch of geomembrane width and capable of pulling at 2 inches per minute and 20 inches per minute.

2. Provide one inch die for cutting sample specimens.

3. Provide certificate of tensiometer calibration within the past 12 months.

2.04 CONFORMANCE TESTING

A. Material that arrives at the site will be sampled and conformance tested by the CQA Engineer at a minimum frequency of one per 150,000 square feet of material supplied to the project, with a minimum of one sample per production lot. Contractor shall pay for shipping the conformance samples to the geosynthetic CQA laboratory specified by the CQA engineer. Materials may be sampled at the plant at the discretion of the owner. Materials may be sampled at the plant at the option of the owner as follows:

1. Geoemembrane manufacturer shall sample the geomembrane as directed by the CQA Engineer.

2. Contractor or Geoemembrane manufacturer shall be responsible for all costs to sample and ship the samples to the CQA Engineer's CQA laboratory for testing.

B. As a minimum, the following tests will be performed by a geosynthetics CQA laboratory and shall meet the requirements outlined in Table 02751-1.

1. Thickness (ASTM D5994)

2. Specific Gravity (ASTM D1505)

3. Carbon Black Content (ASTM D1603)

4. Carbon Black Dispersion (ASTM D5596)

5. Tensile Properties (ASTM D638)

6. Puncture Resistance (ASTM D4833)

C. If a test result is in non-conformance with the specifications, all material from that production lot represented by the failed test shall be rejected. Rejected material may be minimized by bounding the nonconformance material with additional passing tests conducted by the geosynthetics CQA laboratory. Additional tests shall be conducted at no additional cost to the Owner. The Contractor or Manufacturer shall pay for all additional tests.

D. Rejected material shall be replaced at no additional cost to Owner. The Contractor or Manufacturer shall pay for all replaced material.

E. A minimum of one large-scale direct shear test shall be performed (ASTM D5321) to verify the material requirements in Paragraph 2.02.I for each interface identified. Additional tests shall be performed at the discretion of the CQA Engineer and/or if the geomembrane texturing appears to vary.

PART 3: EXECUTION

3.01 EXAMINATION

A. Verify in writing that the surface on which the geomembrane will be installed is acceptable. In so doing the Installer shall assume full liability for the accepted surface.

B. The beginning of installation means acceptance of existing conditions. The Installer shall be responsible for maintenance of the geomembrane covered subgrade once installation of geomembrane begins.

3.02 PREPARATION

A. Maintain the surface suitability and integrity until the lining installation is completed and accepted.

B. Repair rough areas and any damage to the subgrade caused by installation of the liner.

C. To avoid sharp bends in the geomembrane, bevel the leading edges of the anchor trench.

D. Subgrade shall be smooth, uniform, firm and free from rocks or other debris. For deployment over soil subgrade, no rocks or protrusions greater than 1/2-inch in diameter shall be exposed at the subgrade surface.

3.03 DEPLOYMENT

A. Geomembrane shall not be deployed:

1. During precipitation;

2. In the presence of excessive moisture;

3. In areas of ponded water;

4. In the presence of excessive winds; or

5. In excessive heat or cold.

B. Each panel shall be marked with an "identification code" (number or letter) consistent with the layout plan. The identification code shall be simple and logical. The number of panels deployed in one day shall be limited by the number of panels which can be seamed on the same day. All deployed panels shall be seamed to adjacent panels by the end of each day.

C. The following is the acceptable method of deployment:

1. Use equipment which will not damage geomembrane by handling, trafficking, leakage of hydrocarbons or other means.

2. Do not allow personnel working on geomembrane to wear damaging shoes, or engage in activities that could damage geomembrane.

3. Smoking on the liner is prohibited.

4. Round sharp corners of clamps and other metal tools used in the work area.

5. Do not allow clamps and other metal tools to be tossed or thrown.

6. Unroll panels with a method that protects geomembrane from scratches and crimps and protects soil surface and underlying geotextile from damage.

7. Use a method to minimize wrinkles, especially differential wrinkles between adjacent panels.

8. Place adequate hold-downs to prevent uplift by wind.

9. Use hold-downs that will not damage geomembrane such as sandbags.

10. Use continuous hold-downs along leading edges to minimize risk of wind flow under panels.

11. Panels shall be deployed perpendicular to slope elevation contours and the generation of seams shall be minimized.

12. Protect geomembrane in heavy traffic areas by geotextile, extra geomembrane or other suitable materials.

13. Do not allow vehicular traffic on geomembrane surface.

14. Panels deployed on grades steeper than 12% shall extend a minimum of 5 feet beyond the crest or toe of that grade.

D. Visually inspect sheet surface during unrolling of geomembrane and mark faulty or suspect areas for repair or test. Replace faulty (requires more than one patch per 200 square feet) geomembrane stock at no additional cost to the Owner.

E. Deploy geomembrane in ambient temperatures less than 104° F (40° C) and greater than 32° F (0° C), measured 6 inches above geomembrane surface. In prevailing warm or cold weather conditions deployment may be acceptable if the provisions for sampling in such conditions is satisfied (see Section 3.05 below). The geomembrane shall not be deployed during precipitation, in the presence of excessive moisture, in area of ponded water, or in the presence of excessive winds.

3.04 FIELD SEAMING

A. Orient seams perpendicular to slope elevation contours, i.e., orient down (not across) slope and use seam numbering system compatible with panel number system.

B. Minimize the number of field seams in corners, odd-shaped geometric locations and outside corners.

C. Overlap panels by a minimum of 3 inches for extrusion welding and 4 inches for fusion welding. Use procedures to temporarily bond adjacent panels together that do not damage the geomembrane and that are not detrimental to seam weld material for extrusion welding.

D. Do not use solvent or adhesive unless product is approved in writing by the Owner.

E. No horizontal seams shall be allowed on grades steeper than 12% or within 5 feet of the crest or toe of slopes. A horizontal seam is defined as more than half of the panel width.

F. Clean surface of grease, moisture, dust, dirt, debris or other foreign material.

G. Prior to any extrusion welding, the geomembrane seam or repair shall be prepared as follows:

1. Clean surface of oxidation by disc grinder or equivalent not more than one hour before seaming; use number 80 grit sandpaper for the disc grinder. Bevel edges of geomembrane before bonding and provide continuous tacking in repair areas.

2. Repair area where excessive grinding substantially reduces sheet thickness by more than 4 mils beyond extents of weld.

3. Clean grinding dust around weld area after grinding.

4. The following procedure shall be followed for wrinkles and fishmouths.

a. Cut along the ridge of the wrinkle or fishmouth.

b. Overlap a minimum of 3 inches and seam.

c. Any portion where the overlap is less than 3 inches shall be patched with an oval or round patch of geomembrane that extends a minimum of 6 inches beyond the cut in all directions.

5. If required, a firm, dry substrate (piece of geomembrane or other material) may be placed directly under the seam overlap to achieve proper support.

6. Keep water from intercepting the weld during and immediately after welding the seam.

7. For existing welds, or welds that are over 3 minutes old, grind the existing weld two inches back from point of termination and restart welding on ground weld.

H. At least one spare operable seaming apparatus shall be maintained for every three seaming teams. Place protective fabric or piece of geomembrane beneath hot welding apparatus when resting on geomembrane lining and use an electric generator capable of providing constant voltage under combined line load. The electric generator shall generally be located outside of liner. Provide protective lining and secondary containment large enough to catch spilled fuel under electric generators when located on the liner. The welding apparatus shall be equipped with gauges giving temperatures in apparatus and at nozzle.

I. For extrusion welding, purge welding apparatus of heat-degraded extrudate before welding if extruder is stopped for longer than five minutes. All purged extrudate shall be disposed of off the geomembrane. Each extruder shoe shall be inspected daily for wear to assure that its offset is the same as the geomembrane thickness. Repair or replace worn shoes, damaged or misaligned armature brushes, nozzle contamination, or other worn or damaged parts. Avoid stop-start welding.

Remove extrudate rod from welder when not using welder for long period (over two hours). No welding may commence on the liner until the field trial seam sample, made by that equipment and seamer, passes destructive testing.

J. Test and set "hot air system" using scrap material at least each day prior to commencing seaming and adjust hot air velocity to preclude wind effects. Adjust contact pressure rollers to prevent surface ripples in sheet. No equipment shall be used for welding the geomembrane until a field trial seam sample made by that equipment has passed destructive testing.

K. In performing hot wedge welding, the welding apparatus shall be automated vehicular mounted devices equipped with gauges giving applicable temperatures and pressures. The edge of cross seams shall be ground to smooth incline (top and bottom) prior to welding. A smooth insulating plate or fabric shall be placed beneath the hot welding apparatus after usage. Protect against moisture buildup between sheets. If welding across cross seams, conduct field test seams at least every two hours, otherwise once prior to start of work and once at mid-day. No equipment is allowed to commence welding on geomembrane until the field trial seam sample made by that equipment has passed destructive testing.

L. Field trial seams shall be conducted, per seaming apparatus and per seamer, on pieces of geomembrane liner to verify adequate seaming conditions at the following frequency:

1. At beginning of each seaming period.

2. At least once every five hours.

3. At the discretion of the CQA Engineer.

M. Make the trial seams at area of seaming and in contact with subgrade (same condition as the liner to be seamed). The seam sample shall be at least 42 inches long and 12 inches wide with the seam centered lengthwise. A one foot length of each trial seam sample shall be submitted to the CQA Engineer for archive. Cut three 1-inch wide specimens and test two for peel adhesion, and one for bonded seam strength (shear). Each double wedge fusion seam specimens shall be tested for peel on both sides of the weld. A specimen passes when:

1. The locus-of-break is not one of the following failing modes as defined by ASTM D6392:

   a. An adhesion failure (code AD, AD1 or AD2),

   b. Greater than 25% adhesion failure on an adhesion-break (code AD-BRK), or

   c. An adhesion-weld break through an extrusion weld which exhibits a strength less than required by Table 02751-2

2. The break is ductile.

3. The strength of breaks for the trial seam testing shall conform to the values listed in Table 02751-2, included at the end of this section.

N. A trial seam sample passes when 5 out of 5 specimens have passing results in peel and shear tests. If a specimen fails (one of the specimens fails in either peel or shear mode), the trial seam procedure shall be repeated in its entirety. If the repeated trial seam fails, the seaming apparatus or operator may not weld until the deficiencies or conditions are corrected and two consecutive passing field trial seams are achieved.

O. The following procedures shall be followed during cold weather conditions.

1. Geomembrane surface temperatures shall be determined by the CQA Engineer at intervals of at least once per 100 feet of seam length to determine if preheating is required. For extrusion welding, preheating is required if the surface temperature of the geomembrane is below 32°F (0°C).

2. For fusion welding, preheating may be waived by the Owner based upon a recommendation by the CQA Engineer, if the installer demonstrates to the CQA Engineer's satisfaction that welds of equivalent quality may be obtained without preheating at the expected temperature of installation.

3. If preheating is required, the CQA Engineer will observe all areas of geomembrane that have been preheated by a hot air device prior to seaming, to ensure that they have not been overheated.

4. Care shall be taken to confirm that the surface temperatures are not lowered below the minimum surface temperatures specified for welding due to winds or other adverse conditions. It may be necessary to provide wind protection for the seam area.

5. All preheating devices shall receive approval by the CQA Engineer prior to use.

6. Additional destructive tests will be taken at an interval between 250 and 500 feet of seam length, at the discretion of the CQA Engineer.

7. Sheet grinding may be performed before preheating, if applicable.

8. Trial seaming shall be conducted under the same ambient temperature and preheating conditions as the production seams. Under cold weather conditions, new trial seams shall be conducted if the ambient temperature drops by more than 10°F from the initial trial seam test conditions. Such new trial seams shall be conducted upon completion of seams in progress during the temperature drop.

P. The following procedures shall be followed during warm weather conditions.

1. At ambient temperatures above 104°F (40°C), no seaming of the geomembrane shall be permitted unless the Installer can demonstrate to the satisfaction of the CQA Engineer that the geomembrane seam quality is not compromised. Trial seaming shall be conducted under the same ambient temperature conditions as the production seams. At the option of the CQA Engineer, additional destructive testing may be required for any suspected areas.

3.05 FIELD QUALITY CONTROL

A. The Installer shall designate a full-time quality control (QC) technician who shall be responsible for supervising and/or conducting the field quality control program. The QC technician may not be replaced without written authorization by the Owner.

B. Non-Destructive Seam Testing

1. The Installer shall non-destructively test field welds for continuity over their full length using vacuum test units. The non-destructive testing shall be performed concurrently with seaming work progress, not at the completion of all seaming. Any defects located in the seam shall be repaired in accordance with Section 3.06. The following non-destructive testing procedures shall be used to test the field seams for continuity.

   a. Vacuum box testing for extrusion welds.

   b. Air pressure testing for double fusion seams.

2. Vacuum Box Testing

   a. The vacuum box testing equipment shall comprise the following.

      i. Rigid housing; transparent viewing window; a soft rubber gasket attached to bottom of housing; porthole or valve assembly; and a vacuum gauge.

      ii. A vacuum pump capable of applying 5 psi gage pressure of vacuum to the box.

      iii. A bucket of soapy solution and applicator.

   b. The procedure for vacuum testing is as follows:

      i. Clean window, gasket surfaces, and check for leaks.

      ii. Energize vacuum pump and reduce tank pressure to approximately 5 psi.

      iii. Wet a strip of geomembrane approximately 12 inches by 30 inches (or length of box) with soapy solution.

iv. Place box over wetted area and compress.

v. Close bleed valve and open vacuum valve.

vi. Ensure that a leak tight seal is created.

vii. Examine length of weld through viewing window for presence of soap bubbles for a period of not less than 10 seconds.

viii. If no bubbles appear after 10 seconds, close vacuum valve and open bleed valve, move box over next adjoining area with minimum three inches overlap and repeat process.

ix. Areas where soap bubbles appear will be marked by the CQA Engineer with a defect code. The Installer shall then repair the area in accordance with Section 3.06 and retest the repaired area.

3. Air Pressure Testing (Double Fusion Seams Only)

a. The air pressure testing equipment shall comprise the following.

i. An air pump, equipped with pressure gauge having an accuracy of 1 psi, capable of generating and sustaining a pressure between 25 to 30 psi and mounted on a cushion to protect geomembrane.

ii. Rubber hose with fittings and connections.

iii. Sharp hollow needle or other pressure feed device approved by the Owner.

b. To perform the test:

i. Seal both ends of the seam to be tested.

ii. Insert a needle or other approved pressure feed device into tunnel created by double hot wedge seaming and insert a protective cushion between air pump and geomembrane.

iii. Energize air pump to 25 to 30 psi, close valve, and sustain pressure for a minimum of five minutes.

iv. If loss of pressure exceeds 2 psi or does not stabilize, locate faulty area and repair in accordance with Section 3.06.

v. Release pressure at opposite end of seam from gauge to verify that the seam is not blocked.

vi. Remove approved pressure feed device and seal penetration holes by extrusion welding.

4. Spark Testing

a. Welds that cannot be tested by vacuum box or air pressure test (i.e. pipe boot) shall be spark tested.

b. The spark testing equipment shall comprise the following.

i. 24 gauge copper wire.

ii. ii. Low-amperage electric detector, 20,000 to 30,000 volt, with brush-type electrode capable of causing visible arc up to ¾ inch from copper wire.

c. To perform the test:

i. Place copper wire within 1/4 inch of the edge of extrusion seam or clamp seal.

ii. Pass electrode over seam or clamp area and observe for spark. If a spark is detected perform a repair.

C. Destructive Seam Testing

1. For destructive seam testing, the CQA Engineer shall be provided with a minimum of one sample per 500 feet of seam length by each welding apparatus. The location will be selected by the CQA Engineer and the installer will not be informed of the sample location in advance. The installer shall visually observe, mark and repair suspect welds before release of a section to the CQA Engineer for destructive sample marking. Cut destructive samples as seaming and nondestructive testing progresses, prior to completion of liner installation. The CQA Engineer will mark destructive samples with consecutive numbering, location, apparatus I.D., technician I.D., Engineer I.D., and apparatus settings and date. Record, in written form, weld and test date, time, location, seam number, ambient temperatures, machine settings, technician I.D., apparatus I.D., and pass or fail description. The installer shall immediately repair holes in geomembrane resulting from obtaining destructive samples and vacuum test patches. The size of destructive samples shall be 12 inches wide by 48 inches long with seam centered lengthwise.

2. Two 1-inch wide specimens shall be taken from each side of the sample and tested by the Installer for peel and shear in the field prior to CQA destructive testing. If any of these specimens fail, the Installer shall track the failure immediately. The remaining sample shall be cut into three 14-inch long pieces and distributed as follows:

a. To the CQA Engineer for destructive testing.

b. To the CQA Engineer for archive.

c. To the Installer for its use.

3. Ten 1-inch wide specimens shall be taken from one piece. Five specimens shall be tested for peel and five for shear strengths in accordance with the CQA Plan, with test results meeting the requirements of Table 02751-2, included at the end of this section. In the event of failure, the procedures for failed seam tracking are:

   a. Retrace welding path a minimum of 10 feet in both directions from the failed test location and remove (at these locations) a one inch wide specimen for testing. Repeat tracking procedures until the Installer is confident of seam quality.

   b. Obtain destructive samples from each side of the welding path and give samples to the CQA Engineer for destructive testing.

   c. Repeat process if additional tests fail.

   d. Reconstruct seam between passing test locations to satisfaction of the CQA Engineer.

   e. Reconstruction may be one of the following:

      i. Cut out old seam, reposition panel and re-seam.

      ii. Add cap strip.

   f. Cut additional destructive samples from reconstruction at discretion of CQA Engineer.

   g. If additional destructive sample results are not acceptable, repeat process until reconstructed seam is judged satisfactory by the CQA Engineer.

D. For final seaming inspection, check the seams and surface of geomembrane for defects, holes, blisters, undispersed raw materials, or signs of contamination by foreign matter. Brush, blow, or wash geomembrane surface if dirt inhibits inspection. The CQA Engineer shall decide if cleaning of geomembrane surface and welds is needed to facilitate inspection. Distinctively mark repair areas and indicate required type of repair.

3.06 REPAIR PROCEDURES

A. The geomembrane will be inspected before and after seaming for evidence of defects, holes, blisters, undispersed raw materials, and any sign of contamination by foreign matter. The surface of the geomembrane shall be clean at the time of inspection. The geomembrane surface shall be swept or washed by the Installer if surface contamination inhibits inspection. The Installer shall ensure that an inspection of the geomembrane precedes any seaming of that section.

B. Remove damaged geomembrane and replace with acceptable geomembrane materials if damage cannot be satisfactorily repaired.

C. Repair, removal and replacement shall be at the Subcontractor's expense if the damage results from the installer's, or the Subcontractor's sub-subcontractor activities.

D. Repair any portion of the geomembrane exhibiting a flaw, or failing a destructive or non-destructive test. The Installer shall be responsible for repair of damaged or defective areas. Agreement upon the appropriate repair method shall be decided between the CQA Engineer and the Installer. Procedures available include:

1. Patching: Used to repair holes (over 1/4-inch diameter), tears (over 1/4 inch long), undispersed raw materials, and contamination by foreign matter.

2. Grinding and welding: Used to repair pinholes, blemishes and over-grinding.

3. Capping: Used to repair large lengths of failed seams.

4. Removing the seam and replacing with a strip of new material.

E. In addition, the following procedures shall be observed.

1. Geomembrane surfaces to be repaired shall be abraded (extrusion welds only) no more than 1/2 hour prior to the repair.

2. All geomembrane surfaces shall be clean and dry at the time of repair.

3. The repair procedures, materials, and techniques shall be approved in advance of the specific repair by the CQA Engineer.

4. Extend patches or caps at least 6 inches beyond the edge of the defect, i.e., be a minimum of 12 inches in diameter, and round all corners of material to be patched.

5. Bevel the edge of the patch and do not cut patch with repair sheet in contact with geomembrane. Temporarily bond the patch to the geomembrane with an approved method, extrusion weld the patch and then vacuum test the repair.

F. Repair Verification:

1. Number and log each patch repair (performed by the CQA Engineer).

2. Non-destructively test each repair using methods specified in this Section.

3. Provide daily documentation of non-destructive and destructive testing to the CQA Engineer. The documentation shall identify seams that initially failed the test and include the evidence that these seams were repaired and retested successfully.

3.07 PREPARATION FOR ELECTRICAL LEAK LOCATION SURVEY

A. Preparation for the Electrical Leak Location Survey (ELLS) consists of all work necessary to prepare the liner system for an ELLS. An ELLS will be performed on the bare lower HDPE geomembrane, bare upper HDPE geomembrane, and operations layer. Preparations for the ELLS shall be completed as follows:

1. The Contractor shall provide a water truck and driver to add water to the gravel and the operations soil during construction and prior to the ELLS to maintain moisture in these layers. This water application shall be at the direction of the Project Manager or CQA Consultant.

2. The ELLS shall be completed on the floor area after the operations layer has been placed. It is anticipated that the Contractor will leave a small strip of operations layer uncompleted at the edges and tie-in areas to provide electrical isolation of the liner system. Completion of the operations layer soil placement will follow successful completion of the ELLS.

3. The ELLS firm shall furnish and the Installer shall install permanent electrodes within the low-permeability soil layer prior to the installation of the primary geomembrane. The end(s) of the wires leading to the electrodes shall be made accessible to the ELLS Surveyor at the time of the ELLS.

4. The Contractor shall prepare the liner for the ELLS by ensuring that a minimum of 6 inches and maximum of 3 feet of the 60-mil HDPE geomembrane is continuously exposed around the floor including removal of a portion of any access ramps to the operations layer.

5. The Contractor shall supply an AC power source for the ELLS (110V, 5A).

6. The Contractor shall supply two supervised laborers with equipment to assist with laying out the survey string lines and wetting the survey area if the surface of the operations layer is dry.

7. The ELLS is expected to take up to 3 working days to complete. The Contractor shall allow for time necessary to complete the survey.

B. If the ELLS identifies potential damages and/or leaks in the liner, the Contractor is responsible for all work and costs necessary to expose the liner, repair the damages or leaks in the liner, and reconstruct the necessary layers of the liner system.

C. Construction of the remaining portion of the liner system can commence after successful completion of the ELLS and once the repair of all damaged liner and/or leaks are completed to the satisfaction of the CQA Engineer.

3.08 ACCEPTANCE

A. The Subcontractor shall retain ownership and responsibility for the geomembrane until acceptance by the Owner.

B. Acceptance Criteria: The following shall be completed:

1. Verification of adequacy of field seams, repairs and testing by the CQA Engineer.

2. Electrical Leak Location Survey (ELLS) in accordance with Section 3.07 and the CQA Plan.

3. All submittals.

4. "As-built" drawings, approved and final drawings submitted.

5. Construction area cleaned.

6. Final field inspection

7. Warranty signed over to the Owner.

C. Field Inspections: Inspect the completed work with the Owner; defects, wrinkles, suspicious looking welds shall be noted and marked; document, correct and arrange further field inspections until no corrective action is necessary.

TABLE 02751-1

HDPE GEOMEMBRANE PROPERTIES

Property	Qualifier	Units	Specification	Test Method
Thickness	min. average	mils	60	ASTM D5994[(1)]
	minimum	mils	54	
Density	min. avg.	g/cc	0.940	ASTM D792/D1505
Carbon Black Content	range	%	2 - 3	ASTM D1603
Carbon Black Dispersion	rating	-	Category 1,2,&3	ASTM D5596[(2)]
Tensile Properties				ASTM D6693 [(3)]
1. Yield Strength	min. avg.	lb/in	126	
2. Break Strength	min. avg.	lb/in	90	
3. Elongation at Yield	min. avg.	%	12	
4. Elongation at Break	min. avg.	%	100	
Tear Resistance	min. avg.	lb	42	ASTM D1004[(4)]
Puncture Resistance	min. avg.	lb	90	ASTM D4833
Oxidation Induction Time				
1. Standard, or	min. avg.	minutes	100	ASTM D3895
2. High Pressure	min. avg.	minutes	400	ASTM D5885
Stress Crack Resistance	min. avg.	hours	300	ASTM D5397 [(5)]

1. 10 measurements across the width of the roll (perpendicular to the machine direction) and report average and lowest individual readings.
2. At least 9 specimens will be Category 1 or 2. No more than one specimen shall be Category 3. No specimen shall be Category 4 or 5.
3. Type IV die. ASTM D638 test specimen shall be used.
   a) The grip separation shall be 2.5 inches. This test does not require the use of extensometers. The rate of grip separation will be 2 inches per minute.
   b) Machine Direction (MD) and Transverse Direction (TD) average values should be on the basis of 5 test specimens in each direction.
   c) Yield elongation is based on a gauge length of 1.3 inches. Break elongation is based on a gauge length of 2.0 inches.
4. Die C
5. a) P-NCTL test is not appropriate for testing geomembranes with textured or irregular rough surfaces. Test should be conducted on smooth edges of textured rolls or on smooth sheets made from the same formulation as being used for the textured sheet materials.
   b) The yield stress used to calculate the applied load for the SP-NCTL test should be the manufacturer's mean value via MQC testing.

TABLE 02751-2

HDPE GEOMEMBRANE SEAM PROPERTIES

PROPERTY	QUALIFIER	UNITS	SPECIFICATION	METHOD
Shear Seam Strength [1, 2]	minimum	lb/in.	120	ASTM D6392(1)
Shear Seam Elongation [3]	minimum	%	50	ASTM D6392(2)
Peel Adhesion [1, 2]				
Fusion Strength	minimum	lb/in.	91	ASTM D6392(1)
Extrusion Strength	minimum	lb/in.	78	ASTM D6392(1)
Peel Separation	maximum	%	25	ASTM D6392(1)

1. For shear tests, the sheet shall yield before failure of the seam. For either test, testing shall be discontinued when the sample has visually yielded. Sample break shall conform to a passing locus-of-break as described in paragraph 3.04.M.1 of this Section.
2. Elongation measurements shall be omitted for field testing.

END OF SECTION

SECTION 02752

GEOTEXTILES

PART 1: GENERAL

1.01 DESCRIPTION

A. This section describes the general requirements for the manufacture, supply, installation, and quality control (QC) of geotextiles associated with the construction of the liner system for the Guadalupe Restoration Project Soil Management Area.

1.02 RELATED SECTIONS

A. Section 02223 - Gravel

B. Section 02225 - Operations Layer

C. Section 02751 - HDPE Geomembranes

D. Section 02755 - Geocomposites

1.03 REFERENCES

A. Latest version of the American Society for Testing and Materials (ASTM) standards:

1. ASTM D3786 - Standard Test Method for Bursting Strength of Textile Fabrics-Diaphragm Bursting Strength Tester Method

2. ASTM D4491 - Standard Test Methods for Water Permeability of Geotextiles by Permittivity

3. ASTM D4533 - Standard Test Method for Trapezoid Tearing Strength of Geotextiles

4. ASTM D4632 - Standard Test Method for Grab Breaking Load and Elongation of Geotextiles

5. ASTM D4751 - Standard Test Method for Determining Apparent Opening Size of a Geotextile

6. ASTM D5199 - Standard Test Method for Measuring the Nominal Thickness of Geosynthetics

7. ASTM D5261 - Standard Test Method for Measuring Mass Per Unit Area of Geotextiles

8. ASTM D6241 – Standard Test Method for Static Puncture Strength of Geotextiles and Geotextile-Related Products Using a 50-mm Probe

1.04 SUBMITTALS

A. Quality Control Submittals:

1. A copy of the Manufacturer's quality control (QC) plan.

2. Manufacturing QC certificates for each production run. The certificates shall identify the origin and the manufacturer of the resin. The certificates shall be signed by responsible parties employed by the manufacturer (such as the production manager). Tests shall be performed at the frequency indicated in the Manufacturer's QC Plan.

3. The QC certificates shall include roll numbers and identification, sampling procedures, and results of quality control tests verifying that each of the properties listed in Table 02752-1 are met. The Manufacturer quality control tests to be performed include the tests specified in Article 2.1 of this section.

4. Manufacturer's certification that the geotextile products meet or exceed specified requirements and are 100% free of needles.

B. The Installer shall submit the following.

1. Installation plan

2. Proposed seam stitching methods

1.05 QUALITY ASSURANCE

A. Perform work in accordance with the Construction Quality Assurance (CQA) plan.

1.06 QUALIFICATIONS

A. Geotextile shall be supplied by a Geotextile Manufacturer meeting the following qualification requirements:

1. The Geotextile Manufacturer shall be responsible for the production and delivery of geotextile rolls and shall be a well-established firm with more than two years' experience in the manufacture of geotextiles. The Geotextile Manufacturer shall submit a statement to the CQA Engineer listing:

a. Certified minimum average roll property values of the proposed geotextiles and the test methods used to determine those properties.

b. Projected delivery date of the material for this project.

PART 2: PRODUCTS

2.01 MATERIALS

A. Geotextile Filter: Geotextiles shall have the following minimum properties:

Table 02752-1

Fabric Property	ASTM Test Method	Qualifier	Units	Minimum Values
Mass Per Unit Area	D5261	Min. Avg.	oz/sy	8
Trapezoidal Tear Strength	D4533	Min. Avg.	lbs	75
Grab Strength	D4632	Min. Avg.	lbs	200
CBR Puncture Strength	D6241	Min. Avg.	lbs	535
Permittivity	D4491	Min. Avg.	s^{-1}	0.60
AOS (maximum value)	D4751	Max.	mm	0.21
AOS (average value)	D4751	Avg.	mm	0.18

B. All geotextiles shall be a non-woven, triple-punched, needle-punched polyester or polypropylene fabric free from needles or other foreign material.

2.02 CONFORMANCE TESTING

A. Material that arrives at the site will be sampled and conformance tested by the CQA Engineer at a minimum frequency of one per 150,000 square feet of material supplied to the project with a minimum of one sample per production lot. The Contractor shall pay for shipping the conformance samples to the geosynthetic CQA laboratory specified by the CQA engineer. Materials may be sampled at the plant at the discretion of the owner.

B. If a test result is in nonconformance with the specifications, all material from that production lot represented by the failed test will be rejected. Rejected material may be minimized by bounding the nonconformance material with additional passing tests conducted by the geosynthetic CQA laboratory. Additional tests shall be conducted at no additional cost to the Owner. The Contractor or Manufacture shall pay for additional testing.

C. Rejected material shall be replaced at no cost to Owner. The Contractor or Manufacture shall pay for replaced material.

2.03 DELIVERY, STORAGE, AND HANDLING

A. Handling, storage, and care of the geotextiles following transportation to the site shall be the responsibility of the Installer. The Installer shall be liable for all damage to the materials incurred prior to final acceptance of the liner system by the CQA Engineer.

B. The Installer shall be responsible for storage of the geotextile at the site after the material is delivered. The geotextile shall be stored off the ground and out of direct sunlight, and shall be protected from mud, dirt, dust, and any additional storage procedures required by the Geotextile Manufacturer.

C. All rolls of geotextile shall be identified at the factory with the following:

1. Manufacturer's name

2. Product identification

3. Lot Number

4. Roll number

5. Roll dimensions

D. Geotextiles shall be handled in such a manner as to ensure they are not damaged in any way.

E. Precautions shall be taken to prevent damage to underlying materials during placement of the geotextile.

F. After unwrapping the geotextile from its cover, the geotextile shall not be left exposed for a period in excess of 30 days.

PART 3: EXECUTION

3.01 INSTALLATION

A. Filter geotextile seams shall be continuously sewn. Geotextile seams shall be overlapped a minimum of 6 inches prior to sewing. No horizontal seams shall be allowed on slopes steeper than 5 horizontal to 1 vertical.

B. Polymeric thread, with chemical resistance properties equal to or exceeding those of the geotextile, shall be used for all sewing. The seams shall be sewn using Stitch Type 401. The seam type shall be Federal Standard Type SSa-1.

C. The Contractor and Geosynthetics Installer shall examine the entire geotextile surface after installation to ensure that no potentially harmful foreign objects are present. Such foreign objects shall be removed and damaged geotextile shall be repaired or replaced at no cost to Owner.

D. Use care not to damage underlying materials during installation.

E. Prevent the geotextile from accumulating excessive dust.

F. The Geosynthetic Installer shall be responsible for field handling, storing, deploying, seaming or connecting, temporary restraining (against wind), anchoring, and other aspects of geotextile installation.

G. The Contractor shall accept and retain full responsibility for all materials and installation and shall be held responsible for any defects in the completed system.

H. No equipment shall operate directly on the geotextile.

3.02 REPAIRS

A. Any holes or tears in the geotextile shall be repaired using a geotextile patch consisting of the same geotextile material.

1. On slopes inclined steeper than 10 horizontal to 1 vertical, patches shall be sewn into place with a minimum 6-inch overlap.

2. On slopes inclined at 10 horizontal to 1 vertical or less, patches may be heat-bonded with a 6-inch overlap in all directions.

END OF SECTION

SECTION 02755

GEOCOMPOSITES

PART 1: GENERAL

1.01 DESCRIPTION

A. Requirements for the manufacture, supply, installation, and quality control (QC) of geocomposites associated with the construction of the liner system for the Guadalupe Restoration Project Soil Management Area.

1.02 RELATED SECTIONS

A. Section 02221 - Earthwork

B. Section 02223 - Gravel

C. Section 02225 - Operations Layer

D. Section 02751 - HDPE Geomembranes

E. Section 02752 - Geotextiles

1.03 REFERENCES

A. Latest version of the American Society of Testing and Materials (ASTM) standards:

1. ASTM D792 - Standard Test Methods for Density and Specific Gravity (Relative Density) of Plastics by Displacement

2. ASTM D1238 - Standard Test Method for Melt Flow Rates of Thermoplastics by Extrusion Plastometer

3. ASTM D1505 - Standard Test Method for Density of Plastics by Density - Gradient Technique

4. ASTM D1603 - Standard Test Method for Carbon Black Content in Olefin Plastics

5. ASTM D3786 - Standard Test Method for Bursting Strength of Textile Fabrics-Diaphragm Bursting Strength Tester Method

6. ASTM D4355 – Standard Test Method for Deterioration of Geotextiles by Exposure to Light, Moisture, and Heat in a Xenon Arc Type Apparatus

7. ASTM D4491 - Standard Test Methods for Water Permeability of Geotextiles by Permittivity

8. ASTM D4533 - Standard Test Method for Trapezoid Tearing Strength of Geotextiles

9. ASTM D4632 - Standard Test Method for Grab Breaking Load and Elongation of Geotextiles

10. ASTM D4716 - Test Method for Determining the (In-plane) Flow Rate per Unit Width and Hydraulic Transmissivity of a Geosynthetic Using a Constant Head

11. ASTM D4751 - Standard Test Method for Determining Apparent Opening Size of a Geotextile

12. ASTM D4833 - Standard Test Method for Index Puncture Resistance of Geotextiles, Geomembranes, and Related Products

13. ASTM D5199 – Standard Test Method for Measuring the Nominal Thickness of Geosynthetics

14. ASTM D5261 - Standard Test Method for Measuring Mass Per Unit Area of Geotextiles

15. ASTM D7005 - Standard Test Method for Determining the Bond Strength (Ply Adhesion) of Geocomposites

B. Construction Quality Assurance Plan

1.04 SUBMITTALS

A. Geocomposite Manufacturer shall submit to the CQA Engineer the following documentation on the raw materials used to manufacture the geocomposite:

1. Quality control certificates issued by the raw material supplier including the production dates of the raw material used to manufacture geocomposite for the project.

2. Results of tests conducted by the Geocomposite Manufacturer to verify the quality of the resin used to manufacture the geocomposite rolls assigned to the project and the origin of the resin and quality control certificates issued by the resin supplier.

B. A copy of the Geocomposite Manufacturer’s Quality Control Program.

C. Quality control certificates for test results at the sampling frequency indicated by the Manufacturer’s QC Plan shall be submitted.

1. Manufacturing quality control certificates for each shift’s production shall be signed by responsible parties employed by the Manufacturer (such as the production manager).

2. The quality control certificates shall include:

a. Roll numbers and identification

b. Sampling procedures

c. Results of the quality control tests verifying each of the properties listed in Table 02755-1

d. Transmissivity tests do not need to be completed as routine QC tests. However, manufacturer shall include a written statement that the product has been tested and meets or exceeds the transmissivity requirements. Tests results for the product shall be included.

D. Manufacturer's certification that the geotextile products meet or exceed specified requirements and are 100% free of needles.

1.05 QUALITY ASSURANCE

A. Perform work in accordance with Manufacturer's instructions and the CQA Plan.

1.06 QUALIFICATIONS

A. Geocomposite Manufacturer shall be a well-established firm with more than two years of experience in the manufacture of geocomposites.

B. Geocomposite Installer shall meet the requirements of the CQA Plan.

PART 2: PRODUCTS

2.01 MATERIALS

A. The geocomposite to be used on the project shall comprise HDPE geonet drainage material with non-woven, needle-punched geotextiles bonded on the upper and lower surfaces. The geotextile component shall be triple-punched, needle-punched non-woven 8 oz/sy geotextile meeting the requirements of Geotextile Filters in Section 02752. The geotextile will be thermally bonded to the geonet component of the geocomposite. Chemical bonding is not allowed.

B. Geocomposite shall meet the minimum properties listed in Table 02755-1.

2.02 CONFORMANCE TESTING

A. Material arriving at the site will be sampled and conformance tested by the CQA Engineer at a minimum frequency of one per 250,000 square feet of material supplied to the project with a minimum of one sample per production lot (geocomposite production lot). Contractor shall pay for shipping the conformance samples to the geosynthetic CQA laboratory specified by the CQA engineer. Materials may be sampled at the plant at the discretion of the owner. Materials may be sampled at the plant at the discretion of the Owner. If so, the

geonet and geotextile samples should be sampled prior to bonding. As a minimum, conformance tests shall include:

1. Geonet:

    a. Density - ASTM D 1505

    b. Thickness - ASTM D 5199

2. Geotextile:

    a. Mass Per Unit Area - ASTM D 5261

    b. Permittivity - ASTM D 4491

3. Geocomposite

    a. Peel Strength – ASTM D 7005

B. If a test result is in nonconformance with the specifications, all material from that production lot presented by the failed test shall be rejected. Rejected material may be minimized by bounding the nonconformance material with additional passing tests conducted by the geosynthetic CQA laboratory. Additional tests will be conducted at no additional cost to the Owner. The Contractor or Manufacturer shall pay for additional testing.

C. Rejected material shall be replaced at no cost to Owner. The Contractor or Manufacture shall pay for replaced material.

2.03 DELIVERY, STORAGE, AND HANDLING

A. The Contractor shall be responsible for handling, storage, and care of the geocomposites following transportation to the site. The Contractor shall be liable for all damage to the materials incurred prior to final acceptance of the liner system by the CQA Consultant.

B. The geocomposite shall be stored off the ground and out of direct sunlight, and shall be protected from mud, dirt, dust, and any additional storage procedures required by the Geocomposite Manufacturer.

C. All rolls of geocomposite shall be identified at the factory with the following:

1. Manufacturer’s name

2. Product identification

3. Lot Number

4. Roll number

5. Roll dimensions

D. The geocomposites shall be handled in such a manner as to ensure they are not damaged in any way.

E. Precautions shall be taken to prevent damage to underlying layers during placement of the geocomposite.

F. After unwrapping the geocomposite from its cover, the geocomposite shall not be left exposed for a period in excess of 45 days.

PART 3: EXECUTION

3.01 EXAMINATION

A. Verify that other work is complete over the areas where the geocomposite is to be deployed.

3.02 PREPARATION

A. Protect elements surrounding the work of this section from damage.

3.03 INSTALLATION

A. The geocomposite shall be installed in accordance with the Manufacturer's recommended procedures and the CQA Plan.

B. The CQA Engineer shall verify that all geocomposite rolls and underlying layers are free from deleterious material or debris prior to the geocomposite deployment. Dirt entrapped in the geocomposite following deployment shall be cleaned or affected geocomposite removed and replaced prior to placement of successive layers.

C. On side-slopes, the geocomposite shall be secured in the anchor trench and shall be deployed parallel to the dip of the slope. The geocomposite panels shall be positioned to minimize wrinkles.

D. The Installer is responsible for anchoring exposed geocomposite to protect against wind damage until subsequent layers are placed.

E. The geocomposite shall not be welded to the geomembrane unless specified otherwise.

F. The geocomposite shall only be cut utilizing methods and tools (i.e., a hooked utility blade) which will not damage the geocomposite.

G. The geonet component of the geocomposite shall be overlapped a minimum of 4 inches between adjacent panels and shall be fastened by nylon ties. Ties shall be yellow or white for easy inspection. No metallic materials are allowed. Ties shall be placed every 5 feet along the lengths of adjacent panels, every 1 ft across butt-seams, and every 6 in. in any anchor trench.

H. Butt-seams will only be allowed on grades less than 15%.

I. The bottom geotextile component of the geocomposite shall be overlapped. The top geotextile component shall overlapped a minimum of 6 in. and shall be continuously sewn.

J. Polymeric thread, with chemical resistance properties equal to or exceeding those of the geotextile, shall be used for all sewing. The seams shall be sewn using Stitch Type 401. The seam type shall be Federal Standard Type SSa-1.

K. The Geosynthetic Installer shall be responsible for field handling, storing, deploying, seaming or joining, temporary restraining (against wind), anchoring, and other aspects of geocomposite installation.

L. The Installer shall accept and retain full responsibility for all materials and installation and shall be held responsible for any defects in the completed systems.

3.04 REPAIRS

A. Any defects observed in the geocomposite shall be brought to the attention of the CQA Engineer.

B. Holes or tears in the geocomposite shall be repaired with geocomposite patches extending 2 feet beyond the edges of the hole or tear. The patch shall be secured in place by using approved ties spaced at 6 inches. The ties shall extend though the geonet component of the patch and through the geotextile and geonet components of the geocomposite requiring repair. The upper geotextile component of the patch shall be heat bonded to the geotextile component of the geocomposite requiring repair.

3.05 FIELD QUALITY CONTROL

A. Field inspection and testing shall be performed in accordance with the CQA Plan.

3.06 PROTECTION

A. Do not permit traffic over any of the Products related to this Section.

B. The Contractor or Geosynthetics Installer shall place all soil materials in such a manner as to ensure that:

1. The geocomposite and underlying materials are not damaged

2. Minimal slippage occurs between the geocomposite and the underlying geosynthetic layers

3. Excess tensile stresses are not developed in the geocomposite

TABLE 02755-1

GEOCOMPOSITE PROPERTY VALUES

PROPERTIES	QUALIFIER	UNITS	SPECIFIED VALUES	TEST METHOD
Geonet Component:				
Polymer Composition	minimum	%	95% polyethylene by weight	
Polymer Density	min. avg.	g/cc	0.935	ASTM D1505
Carbon Black Content	range	%	2-3	ASTM D1603
Foaming Agents	maximum	%	0.0	N/A
Nominal Thickness	min. avg.	mils	200	ASTM D5199
Geotextile Component:				
Polymer Composition	minimum	%	95% polyester or polypropylene	
Mass per Unit Area	min. avg.	oz/yd^2	8	ASTM D5261
Filter Requirements				
Apparent Opening Size	maximum	mm	0.21	ASTM D4751
Permittivity	min. avg.	s^{-1}	0.60	ASTM D4491
Mechanical Requirements				
Grab Strength	min. avg.	lb	200	ASTM D4632
Tear Strength	min. avg.	lb	75	ASTM D4533
Puncture Strength	min. avg.	lb	100	ASTM D4833
UV Stability, 500 hrs	min. avg.	% retained	50	ASTM D4355
Geocomposites:				
Transmissivity[1]	minimum	m^2/s	$1x10^{-5}$	ASTM D4716
Peel Strength[2]	min. avg.	lb/in.	1.0 lb/in avg (0.5 lb/in min.)	ASTM D7005

Notes:

(1) The design transmissivity is the hydraulic transmissivity of the geocomposite using water at 68°F ± 3°F with a hydraulic gradient of not less than 0.1, nor more than 0.5, under a compressive stress of not less than 8,000 psf. For the test, the geocomposite shall be sandwiched between HDPE geomembrane and a layer of sand. The minimum test duration will be 24 hours and the report for the test results shall include measurements at intervals over the entire test duration.

(2) The average peel strength of all specimens tested shall be 1.0 lb/in or greater and no single specimen shall have peel strength less than 0.5 lb/in.

END OF SECTION

SECTION 02756

GEOSYNTHETIC CLAY LINER

PART 1: GENERAL

1.01 DESCRIPTION

A. This section describes the requirements for the manufacture, supply, installation, and quality control of the geosynthetic clay liner (GCL) associated with the construction of the liner system for the Guadalupe Restoration Project Soil Management Area.

1.02 RELATED SECTIONS

A. Section 02221 - Earthwork

B. Section 02222 – Foundation Soil and Low-Permeability Soil Layer

C. Section 02751 - HDPE Geomembranes

D. Section 02752 - Geotextiles

1.03 REFERENCES

A. Latest version of the American Society of Testing and Materials (ASTM) standards:

1. ASTM D4632 – Test Method for Measuring Nominal Thickness of Geotextiles and Geomembranes

2. ASTM D5084 – Measurement of Hydraulic Conductivity of Saturated porous Materials using a Flexible Wall Permeameter

3. ASTM D5887 - Standard Test Method for Measurement of the Index Flux through Saturated Geosynthetic Clay Liner Specimens Using a Flexible Wall Permeameter

4. ASTM D5888 - Standard Guide for Storage and Handling of Geosynthetic Clay Liners

5. ASTM D5889 - Standard Practice for Quality Control of Geosynthetic Clay Liners

6. ASTM D5890 - Standard Test Method for Swell Index Measurement of Clay Mineral Component of Geosynthetic Clay Liners

7. ASTM D5891 - Standard Test Method for Measurement of Fluid Loss of Clay Component of Geosynthetic Clay Liners

8. ASTM D5993 - Standard Test Method for Measuring the Mass per Unit Area of Geosynthetic Clay Liners

9. ASTM D6141 - Standard Guide for Screening the Clay Portion of a Geosynthetic Clay Liner (GCL) for Chemical Compatibility to Liquids

10. ASTM D6243 - Standard Test Method for Determining the Internal and Interface Shear Resistance of Geosynthetic Clay Liner by the Direct Shear Method

11. ASTM D6496 - Standard Test Method for Determining Average Bonding Peel Strength Between the Top and Bottom Layers of Needle-Punched Geosynthetic Clay Liners

B. Latest version of Geosynthetics Research Institute (GRI) testing methods:

1. GRI-GCL3 – Test Methods, Required Properties, and Testing Frequencies for Geosynthetic Clay Liners (GCLs)

1.04 SUBMITTALS

A. Quality Control Submittals:

1. A copy of the manufacturer's quality control plan.

2. Quality control (QC) certificates containing the manufacturer's QC testing results. At a minimum, QC certifications shall include the requirements listed in Part 2.02.A of this section. QC certificates shall be submitted at a the frequency indicated in the Manufacturer's QC Plan for GCL continuously produced and supplied to the project and at least one per lot.

3. Manufacturer's certificate that products meet or exceed specified requirements.

1.05 QUALITY ASSURANCE

A. Perform work in accordance to the Construction Quality Assurance Plan.

1.06 QUALIFICATIONS

A. The Contractor shall be experienced in this installation of geosynthetic clay liners. Experience is based on verifiable project references for a minimum cumulative of 1,000,000 sf installed. In the event the Contractor is not experienced, a Representative of the geosynthetic clay liner Manufacturer shall be on site to train the Contractor, at no additional cost to the Owner.

PART 2: PRODUCTS

2.01 ACCEPTABLE MANUFACTURERS

A. The GCL shall consist of Bentomat DN or equivalent. The following product is prequalified for the work specified herein:

Bentomat DN GCL - manufactured by:

CETCO Minerals Technologies
Hoffman Estates, Illinois

1. The GCL product shall consist of sodium bentonite adhered to geotextile backing on both sides. The GCL shall include internal stitching through the material that joins the backing fabrics.

B. The above product is prequalified based on information provided by the GCL Manufacturer. The Contractor is responsible for confirming with the Manufacturer that the product will meet the requirements of Part 2.02 of this Section. Products are approved for use based on conformance testing conducted by the Owner.

2.02 CONFORMANCE TESTING

A. Material that arrives at the site shall be sampled and conformance tested by the CQA Engineer at a minimum frequency of one per 150,000 sf of GCL supplied to the project with a minimum of one sample per lot. Contractor shall pay for shipping the conformance samples to the geosynthetic CQA laboratory specified by the CQA engineer. Materials may be sampled at the plant at the discretion of the owner. The CQA Engineer shall determine that the following specifications are met:

1. Maximum moisture content of 25% at the time of manufacture per ASTM D2216.

2. Bentonite mass per unit area of 0.75 lbs/ft^2 at 0% moisture (0.95 lbs/ft2 at 20% moisture) per ASTM 5993.

3. Minimum average free swell of 24 ml per ASTM D5890.

4. Maximum fluid loss of 18 ml per ASTM D5891.

5. Maximum hydraulic conductivity of 5 x 10^{-9} cm/sec per ASTM D5084.

B. If a test result is in non-conformance with the specifications, all material from that production lot represented by the failed test shall be rejected. Rejected material may be minimized by bounding the non-conformance material with additional passing tests conducted by the geosynthetic CQA laboratory. Additional tests and replaced material will be provided at no additional cost to the Owner. The

Contractor or Manufacturer shall pay for the additional testing and replaced materials.

2.03 DELIVERY, STORAGE, AND HANDLING

A. Handling, storage, and care of the geosynthetic clay liner, prior to and following installation, are the responsibility of the Contractor, until Final Acceptance of the liner system by the Owner.

B. Store and protect the geosynthetic clay liner. GCL shall be protected from ultraviolet light exposure, moisture, puncture, cutting, or other damaging or deleterious conditions. Any additional storage procedures required by the Manufacturer shall be the Contractor's responsibility.

C. In order to prevent damage to the geosynthetic clay liner prior to installation, the following procedures shall be followed:

1. Store the material in a covered work area protected from rain and moisture at all times.

2. Store the material off of the ground, on pallets or other equivalent device to keep the material from contacting the ground.

D. All rolls of GCL shall be identified at the factory with the following:

1. Manufacturer's name

2. Product identification

3. Lot number

4. Roll number

5. Roll dimensions

E. GCL rolls shall be shipped and stored in relatively opaque and water tight wrappings.

PART 3: EXECUTION

3.01 INSTALLATION

A. Subgrade shall be smooth, uniform, firm and free from rocks or other debris. For deployment over soil subgrade, no rocks or protrusions greater than 3/8-inch in diameter shall be exposed at the subgrade surface.

B. Repair rough areas and any damage to the subgrade caused by installation of the lining and fill any ruts caused by equipment prior to GCL deployment.

C. Install the GCL so that panel seams are parallel to the dip of the slope.

D. Pull GCL panels from roll suspended at the crest of the slope. Do not install the GCL over wet subgrade, in standing water, or during precipitation events. Geomembrane shall not be placed on a GCL which is hydrated.

E. The GCL shall be overlapped as follows:

1. On slopes of 3H:1V or steeper, overlap GCL at least 18 inches along the length of the GCL panel. The overlap may be reduced to 9-inches on slopes less than 3H:1V.

2. Overlap seams at least 24 inches along the ends of the GCL panel (only where end-to-end seams are allowed).

F. Place only as much GCL each day as can be covered with HDPE liner. The GCL shall be covered by HDPE liner at the end of each working day.

G. Use single panels of bentonite mat from the anchor trench over the crest of slope down to the lower limit of mat or an intermediate bench.

H. End-to-end seams are only allowed on slopes of 10 percent or less and at least 5 feet from breaks in grades over 10 percent (i.e. slope hinge or slope toe).

I. Do not drag textured geomembranes across previously installed bentonite mat. Use a smooth rub sheet between mat and geomembrane, or other methods, to prevent damage. Remove rub sheet when geomembrane is in position.

J. All hydrated GCL shall be removed and replaced by the Contractor at no additional cost to the Owner.

3.02 GCL SEAMING

A. Pull GCL tight to smooth out creases or irregularities in the panels.

B. Remove all dirt and debris from the overlap area.

C. Installation practices:

1. Place 0.50 lbs/ft^2 of bentonite between overlapped panels. This bentonite enhancement may be eliminated where Bentomat Supergroove seams are present.

2. Heat bond overlapped panels together along all seams.

D. In the case of the prequalified material, seams shall consist of overlap only. In the case of the non-prequalified material, seams shall consist of heat bonded overlap and bentonite only. In either case, do not staple or otherwise join mechanically.

3.03 REPAIR

A. Repair cuts, tears, or holes in the GCL by covering with a geosynthetic clay liner patch. On slopes greater than 5 percent, the patch shall overlap the edges of the hole or tear by a minimum of 2 ft in all directions. On slopes 5 percent or flatter, the patch shall overlap the edges of the hole by a minimum of 1 ft in all directions.

B. Attach patch to panel using either non-hazardous, non-toxic adhesive as recommended by GCL manufacturer or by spot welding with hot air apparatus ("Leistering"). Attachment method shall be approved by Construction Manager (based on recommendations of the CQA Engineer) prior to use.

C. All repairs shall be made at no additional cost to the Owner.

END OF SECTION

TABLE 02756-1

BENTONITE PROPERTIES

Property	Qualifier	Units	Specification	Test Method
Moisture Content (at the time of manufacturing)	max.	% by Wt.	25	ASTM D2216
Bentonite Mass per Unit Area[1]	min. avg.	lbs/sf	0.75	ASTM D5993
Free Swell	min. avg.	ml	24	ASTM D5890
Fluid Loss	max.	ml	18	ASTM D5891
Hydraulic Conductivity[2]	max.	cm/s	5×10^{-9}	ASTM D5084

1. Bentonite mass per unit area reported at 0% moisture content.
2. Hydraulic conductivity performed at a confining pressure of 5 psi.

DIVISION 11

EQUIPMENT

SECTION 11210

LEACHATE EXTRACTION SYSTEM

PART 1: GENERAL

1.01 DESCRIPTION

A. This section describes the material construction requirements for the leachate extraction system associated with construction of the liner system for Guadalupe Restoration Project Soil Management Area.

1.02 RELATED SECTIONS

A. Section 02725 - HDPE Pipe

1.03 SUBMITTALS

A. Submit product information on pumps, controls, piping and fittings, and sensors.

B. Submit shop drawings on shed construction for approval prior to construction.

PART 2: PRODUCTS

2.01 GENERAL

A. The Contractor shall be responsible for supplying and installing an operational automated leachate extraction system. The Contractor shall provide pumps, control panels, generator, battery bank, solar panels, lifting cables, discharge and conveyance piping, shelter, leachate storage tank, float level sensors, wiring, and other materials necessary to extract leachate from Disposal Module (DM) 9.1.

2.02 PUMPS

A. Provide two (2) pumps – one each for the LCRS riser pipe and the LDS riser pipe. Both pumps shall be Grundfos submersible pump model number 25-SQF-3 or equivalent.

2.03 CONTROL PANELS AND LIQUID LEVEL CONTROLS

A. Provide a control panel to automate pump activation. Control panel shall monitor high and low leachate sump levels and high (shut-off) leachate storage tank level. Control panel shall have an on/off switch to allow for manual pump operation.

B. Provide a control panel to automate power generation. Control panel shall monitor battery voltage and control battery charging through solar panels or generator. A multi-power point tracking (MPPT) charge controller shall be provided. An on/off switch shall also be included to allow manual operation of the pump(s).

C. Liquid level controls shall consist of pressure transducers or level floats.

1. Liquid level controls have an accuracy of determining liquid levels to within +/- 0.1 feet.

2. Wetted parts shall be type 316 stainless steel or other chemically resistant material that is compatible with leachate.

3. Liquid level controls shall be attached to the sump pumps. Sump liquid level sensors shall have a minimum range of 0 to 15 feet.

4. A liquid level control shall be mounted in the leachate tank. The control shall include communication wiring between the leachate tank and the pump control panel.

2.04 GENERATOR

A. Provide one generator. Generator shall be gas-powered, 5 kilowatt rating minimum. Output voltages shall include 120-volts AC and 12-volt DC. Generator shall be Honda Model EM 5000SX or equivalent. Procurement of the generator shall include an automatic start module.

2.05 BATTERIES

A. Provide eight (8) batteries. Batteries shall be L-16 or equivalent. Procurement of batteries shall include interconnects and cabling.

2.06 SOLAR PANELS

A. Provide sixteen (18) solar panels. Solar panels shall be API 120 watt, 24 vDC or equivalent. Procurement of solar panels shall include a mounting kit to mount panels on shed roof.

2.07 SHED

A. Provide one shed to house battery bank and generator. Floor dimensions of shed shall be 10-ft x 12-ft minimum. A division wall shall be constructed between the generator and battery operation areas to provide two 10-ft x 6-ft areas based on division wall centerline. Doors to each section shall be installed on outer wall adjacent to access road. Roof dimensions shall be 13-ft by 16-ft minimum and shall be inclined at 30 to 35 degrees from horizontal to face southward. Roof shall be structurally capable of supporting mounted solar panels.

B. Shed shall be ventilated. Ventilation for both sections shall include minimum 4-in high by 12-in wide vent at both base and highest location relative to inclined roof. An additional vent shall be provided in the generator section with a 12-in minimum diameter fan mounted to direct air-flow outward. Operation of this fan shall be powered and controlled to operate when generator is running.

C. Shed shall be founded upon reinforced concrete slab and anchored to the slab. Slab shall be designed by Contractor.

D. Contractor shall submit shop drawings of shed and shed foundation for approval by Engineer prior to procurement and/or construction.

2.08 RISER PIPE FLANGES

A. Provide custom-manufactured riser pipe flanges. Riser pipe flanges shall conform to the Drawings and Specifications. Flanges shall be manufactured by:

1. Real Environmental Products, 19550 Berry Street, Building B, Unit A, Pine Grove, CA 95665, Tel: (209) 296-7900.

B. Provide one custom-manufactured riser pipe flange for the 18-in diameter LCRS riser pipe. The LCRS riser pipe flange shall include the following ports:

1. LDS pump return port outfitted with a 1-in diameter cam-lock fitting.

2. LCRS extraction pump installation/removal port outfitted with a 1-in diameter cam-lock fitting for the leachate conveyance pipe.

3. A sounding port.

4. A transducer port (transducer not installed under this contract).

C. Provide one custom-manufactured riser pipe flange for the 12-in diameter LDS riser pipe. The LDS riser pipe flange shall include the following ports:

1. LDS extraction pump installation/removal port outfitted with a 1-in diameter cam-lock fitting for the return hose to the LCRS riser pipe flange.

2. A sounding port.

3. A transducer port (transducer not installed under this contract).

D. Provide one custom-manufactured riser pipe flange for the 12-in diameter LDS riser pipe. The LDS riser pipe flange shall include the following ports:

1. LDS extraction pump (not installed under this contract) installation/removal port outfitted with a 1-in diameter cam-lock fitting for the return hose to the L riser pipe flange.

2. A sounding port.

3. A transducer port (transducer not installed under this contract).

2.09 PIPES AND HOSES

A. Provide 2-in diameter, SDR 21 HDPE leachate conveyance piping between LCRS riser pipe pump discharge port and leachate tank. Joints shall be butt-fusion welded. Pipe shall include a cam-lock fitting at the LCRS riser pipe end. Pipe

shall be temporarily terminated at the leachate tank end. Owner will be responsible for connecting leachate conveyance pipe to the leachate tank.

B. One hose shall be provided between the LDS riser pipe flange and the LCRS riser pipe flange. The LDS hose shall be with cam-lock fittings at both ends.

C. A 2-in diameter, SDR 21 HDPE saddle tee shall be mounted to the side of the LCRS riser pipe. Tee shall extend a minimum of 6 inches from riser pipe to provide a stub-out for future use. Terminate end of tee with weld-on cap.

PART 3: EXECUTION

3.01 INSTALLATION

A. The leachate extraction system installer shall be subcontracted to the Contractor. Installation of the Leachate Extraction System shall be performed by:

1. Advance: Solar, Hydro, Wind Power, Inc., (Advance Power) 6331 North State Street, Redwood Valley, CA 95470, Tel: (707) 485-0588.

B. The pumps shall be operated from a control panel mounted on the shed. The pumps shall be installed into the lower (horizontal) sections of the LCRS and LDS riser pipes. Discharge piping shall extend from the pumps to the riser pipe flanges. Removal cables shall be fastened between the pumps and attached to the riser pipe flanges. Liquid level sensors shall be installed and positioned to control the pump operation. All materials shall be chemically resistant to typical leachate constituents. Install pump in accordance with the manufacturer's recommendations and as shown on the Drawings.

C. Install custom-manufactured pipe flanges on the LDS, and LCRS riser pipes. Attached pump discharge piping and removal cables to flanges.

D. Install return hoses between the LDS riser pipe and the LCRS riser pipe flanges using cam-lock couplings.

E. Install the leachate conveyance line from the LCRS riser pipe pump port to the leachate storage tank location.

F. Construct shed per the approved shop drawings. Mount shed on a concrete foundation slab.

G. Install the battery bank in one section of shed. Connect batteries in series.

H. Install generator in other section of shed. Mount the generator to the slab. Install an exhaust extension on the generator muffler and route exhaust out through an exhaust port in the wall. Use an approved insulating wall port.

I. Mount control systems on shed and wire to pumps, batteries, solar panels, generator, and leachate tank shut-off sensor.

J. Install the LFG collection pipe stub-out to the LCRS riser pipe wall. The LCRS riser pipe shall be perforated at this mounting point to provide a horizontal connection. The mounting shall be sealed using welding techniques to eliminate any inflow of ambient air into the LFG collection system at this point.

END OF SECTION

APPENDIX K

Construction Quality Assurance Plan

CONSTRUCTION QUALITY ASSURANCE PLAN

Soil Management Area

Submitted to:

Chevron Environmental Management Company
2184 West Thornberry Road
Guadalupe, CA 93434

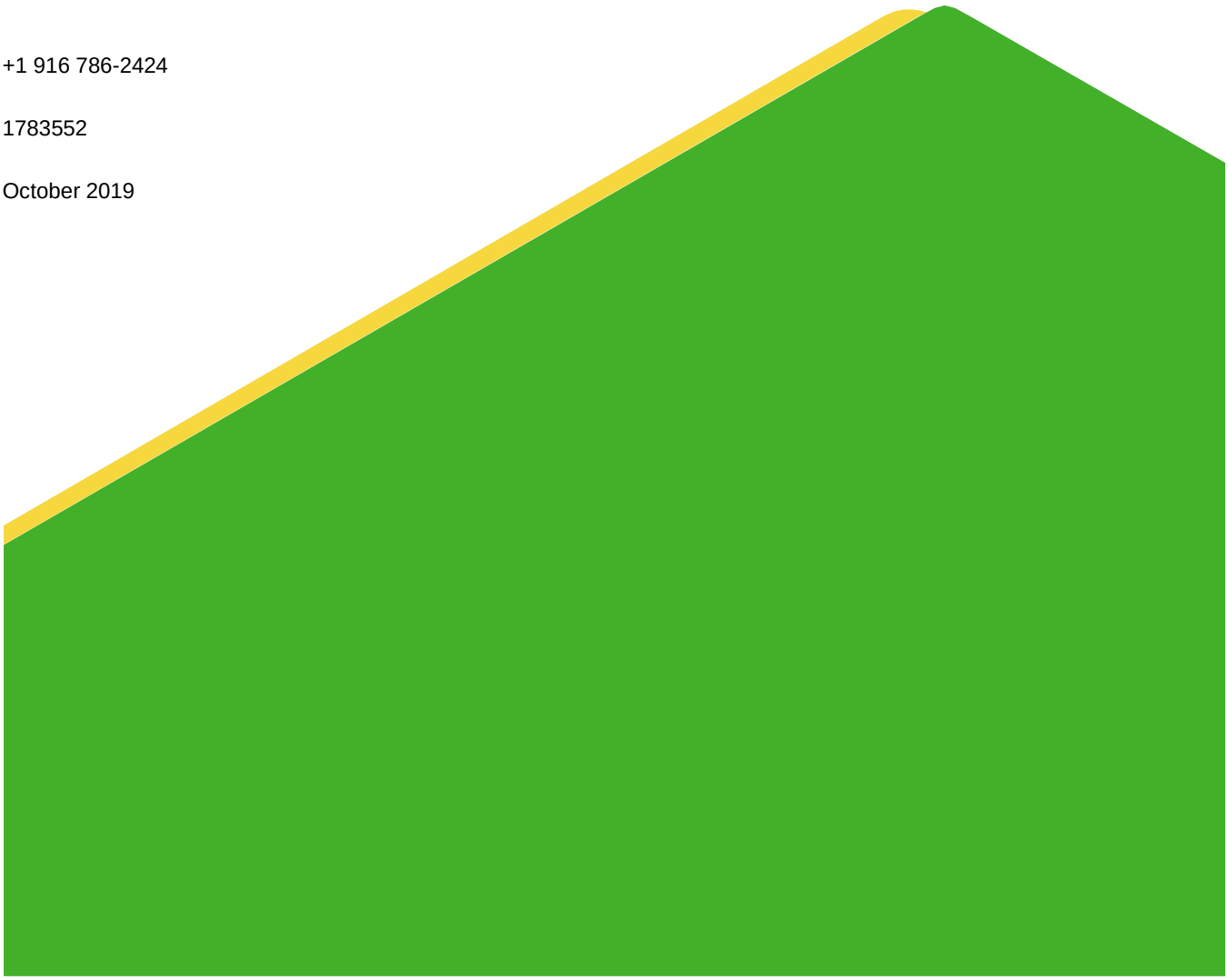
Submitted by:

Golder Associates Inc.
1000 Enterprise Way, Suite 190
Roseville, California, USA 95678

+1 916 786-2424

1783552

October 2019



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1.0 INTRODUCTION

This plan addresses the Construction Quality Assurance (CQA) procedures required during the construction of the liner system for the Soil Management Area (SMA) at the Tank Battery 9 Area, which is part of the Guadalupe Restoration Project, located in Guadalupe California. This CQA Plan establishes procedures to verify that construction is in accordance with the approved engineering standards and specifications, meets the appropriate regulatory requirements, and develops the necessary documentation for submittal to the regulatory agencies. The objective of this plan is to establish the following:

- Duties of parties responsible for the CQA program
- Qualification requirements of the CQA Engineer(s)
- Inspection activities
- Sampling strategies
- Document control measures
- Procedures for approving the materials purchased for construction
- Methods for assuring compliance to design standards and technical specifications (Project Specifications) during construction
- Procedures for resolving issues that may occur concerning the design and construction
- Documentation of construction and testing for submittal to the regulatory agency for their review

The intent of the CQA Plan is to provide independent third party verification and testing to demonstrate that the Contractors and Installers have met their obligations in the supply and installation of components and materials according to the design documents, Project Specifications, and regulatory requirements. Quality control is provided by the Manufacturers, Installers, and Contractors and refers only to their actions taken to verify that materials and workmanship meet the requirements of the project construction drawings (Drawings) and Project Specifications.

2.0 PARTIES INVOLVED WITH CONSTRUCTION QUALITY ASSURANCE

The following section provides descriptions of the parties referred to in this CQA Plan including their responsibilities and qualifications.

2.1 Owner/Operator

Chevron Environmental Management Company is the Owner and Operator of this facility. For the purposes of this CQA Plan and the Project Specifications, all references to the Owner or Operator shall mean Chevron Environmental Management Company.

2.2 Project Manager

The Project Manager is the official representative of the Owner and is responsible for construction activities at the facility, including oversight and construction management. The Project Manager is responsible for coordinating construction and quality assurance activities for the project. The Project Manager shall be responsible for the resolution of all quality assurance issues that arise during the liner system construction and must be involved in any decisions that may affect future operations at the SMA.

2.3 Design Engineer

The Design Engineer, also referred to as the "Designer" or “Engineer”, is the individual or firm responsible for the design and preparation of the Drawings and the Project Specifications. The Designer is responsible for approving all design and Project Specification changes, modifications, or clarifications encountered during construction. The Design Engineer for the Guadalupe Restoration Project liner system is Golder Associates Inc., of Roseville, California. During the course of the project, the Design Engineer shall remain in communication with the Project Manager.

2.4 CQA Engineer and CQA Monitor(s)

The CQA Engineer and CQA Monitors(s) will be responsible for understanding this CQA Plan and shall conduct CQA testing, monitoring, documentation and reporting, as required by this CQA Plan. The CQA Engineer will be the engineer-of-record and will stamp the final report. The implementation and reporting of this CQA Plan shall be conducted under the direct supervision of a State of California registered civil engineer or certified engineering geologist experienced in the construction of base liner systems. The CQA Engineer will communicate directly with the Project Manager.

2.5 Geosynthetics Manufacturer

The geosynthetics manufacturer(s), also referred to as the "Manufacturer," is responsible for production of the geosynthetic components outlined in this plan. The Manufacturer may be affiliated with the Geosynthetics Installer. Each Manufacturer must pre-qualify that they are able to produce material that meets the requirements of the Project Specifications. The Geosynthetics Manufacturer will submit materials and documentation to the Project Manager or Geosynthetics Installer.

2.6 Geosynthetics Installer

The Geosynthetics Installer (also referred to as the "Geosynthetics Installation Contractor" or the "Installer") is responsible for proper installation of the geosynthetic components in accordance with the Drawings and Project Specifications. The Installer shall also be responsible for procurement of the geosynthetic materials in conformance with the Project Specifications unless otherwise arranged by the Owner. The Installer may be affiliated with the Manufacturer. The Installer will work as a subcontractor to the Earthworks Contractor.

The Installer must meet the experience requirements outlined in the Project Specifications. The Installer shall provide a qualified Superintendent who will provide full-time technical guidance to the field crew. The Superintendent will represent the Installer at all site meetings and will act as the spokesperson for the Installer on the project.

Welding technicians will be evaluated based on performance. The CQA Engineer, through the Project Manager, reserves the right to reject any welding technician whose performance is unsatisfactory.

2.7 Earthworks Contractor

The Earthworks Contractor, also referred to as the "Contractor," is responsible for completion of the site work as defined by contract with the Owner and in accordance with the Drawings and Project Specifications except for materials provided by the Owner. The Earthworks Contractor will be responsible for retaining a surveyor to set lines and grades required for excavation and construction. The Earthworks Contractor will be contracted with the Owner and will communicate directly with the Project Manager.

2.8 CQA Surveyor

The CQA Surveyor is the firm or individual responsible for performing the quality assurance surveying tasks outlined in this plan including the preparation of stamped as-built survey record drawings (also referred to as “As-Built Drawings” or “Record Drawings”) to be included in the CQA Certification Report. CQA surveying shall be performed under the direction of a California State Licensed Land Surveyor. The CQA Surveyor may be contracted with the Earthworks Contractor or the Owner. The CQA Surveyor will communicate directly with the Earthworks Contractor or Owner.

2.9 Independent CQA Laboratory

The Independent CQA Laboratory (CQA Lab) is the third party responsible for performing the quality assurance soils and/or geosynthetics laboratory testing tasks listed in this CQA Plan in accordance with the specified methodology. Standards for testing include, but are not limited to American Society for Testing and Materials (ASTM), California Department of Transportation (Caltrans), California Test Methods (CTM), or Geosynthetic Institute (GSI) methods. The CQA Lab is directed by the CQA Engineer and may be affiliated with the CQA Consultant firm or company. The geosynthetics-testing laboratory shall be accredited by the Geosynthetics Accreditation Institute Laboratory Accreditation Program (GAI-LAP). The CQA Lab shall not be affiliated with the Earthworks Contractor or Geosynthetics Installer. The CQA Lab will communicate directly with the CQA Engineer.

2.10 ELLS Surveyor

The ELLS Surveyor is the third party responsible for performing the quality assurance electrical leak location survey (ELLS) task listed in this plan. The ELLS Surveyor is directed by the CQA Engineer and may be affiliated with the CQA Consultant firm or company. The ELLS Surveyor shall not be affiliated with the Earthworks Contractor or Geosynthetics Installer. The ELLS Surveyor will communicate directly with the CQA Engineer.

3.0 MEETINGS

Meetings shall be held during the life of the project to enhance coordination among the various parties involved. Meetings will include a pre-construction meeting, progress meetings and resolution meetings, if necessary.

3.1 Pre-Construction Meeting

A pre-construction meeting will be held at the site prior to the start of construction. The Design Engineer, Project Manager, CQA Monitor, CQA Engineer, Geosynthetics Installer, Earthworks Contractor, and others designated by the Owner shall attend this meeting. The purpose of this meeting will at a minimum:

- Define lines of communication, responsibility, and authority
- Conduct a site inspection to discuss work areas, work plans, stockpiling, lay-down areas, access roads, haul roads, and related items
- Review the project schedule
- Review the Drawings, CQA Plan, and Project Specifications
- Review work area security and safety protocol

The CQA Engineer or his designee will document this meeting and copies of the meeting minutes will be distributed to all parties.

3.2 Progress Meetings

Weekly progress meetings will be held. At a minimum, the CQA Engineer, the Project Manager and the Contractor(s) will attend these meetings. The CQA Monitor is responsible for organizing and conducting the progress meetings. The purpose of these meetings will be to:

- Review the previous week's accomplishments and activities
- Review upcoming scheduled work and project milestones
- Discuss any problems or potential construction problems
- Review the results and status of CQA field and laboratory testing

The CQA Engineer will document these meetings and the minutes shall be transmitted to all in attendance.

3.3 Resolution Meetings

Special meetings will be held, as needed, to discuss and resolve potential problems or deficiencies. At a minimum, these meetings will be attended by the Project Manager, CQA Engineer, CQA Monitor, and the Installer and/or Contractor. If the problem relates to a design issue, the Design Engineer shall also be present. The CQA Monitor will document the meeting.

When deficiencies (items that do not meet project requirements) are discovered, the CQA Monitor or CQA Engineer shall immediately determine the nature and extent of the problem and notify the Installer or Contractor. If unsatisfactory test results identify a deficiency, additional tests will be performed to define the extent of the deficient material or work area.

The Installer or Contractor shall correct the deficiency to the satisfaction of the CQA Engineer. If unable to correct the problem, the CQA Engineer will notify the CQA Monitor who will assist during problem resolution. If the solution involves a design revision, the Project Manager shall also be contacted. Design revisions can only be made by the Design Engineer.

The corrected deficiency shall be re-tested and/or approved before any additional related work is performed by the Installer or Contractor. Retest results shall be recorded by the CQA Monitor and included in the final report documentation.

4.0 EARTHWORK CONSTRUCTION QUALITY ASSURANCE

Construction of the SMA or specified earthwork must be in accordance with the approved Construction Drawings and Project Specifications. This CQA Plan establishes the construction quality assurance monitoring and testing program designed to verify construction compliance. The earthwork quality assurance testing program consists of testing of soil and rock materials used in the SMA construction. Quality assurance testing and observation is required during construction of the liner system components.

4.1 Construction Monitoring and Testing

All components of the construction shall be observed and tested as required by the CQA Monitor to verify that the construction is in accordance with the Project Specifications. The CQA Engineer shall review the work performed by the CQA Monitor and identify inadequate construction methodologies or materials that may adversely impact the performance of the facility being constructed and/or existing structures. Visual observations and verification of the

independent survey required for specific layers throughout the construction process shall be made to evaluate whether the materials are placed to the lines and grades as shown on the Drawings.

The CQA Monitor or CQA Engineer will give the Project Manager sufficient notice of anticipated completion of the construction components so that related CQA documentation may be reviewed and accepted without delay to the contractor. Specific CQA observations and/or testing are required for the following:

- General fill
- Subgrade preparation
- Low-Permeability Soil Placement
- Geosynthetic Clay Liner
- Geomembrane liner including seams
- Geotextile filter layer
- Geocomposite layers
- High density polyethylene (HDPE) piping (leachate collection and removal system (LCRS), and leak detection)
- Leak detection, and LCRS gravel
- Operations layer

4.1.1 Subgrade Preparation

The CQA Monitor shall observe and document the subgrade preparation including:

- Monitoring the stripping of vegetated soil and growth media to be stockpiled in an area designated by the Project Manager
- Monitoring that appropriate dust control measures are implemented
- Visually inspecting the excavation for moisture seeps, soft or excessively wet areas, and unstable slopes
- Monitoring subgrade preparation and confirming that the surface of the subgrade is free of soft, organic, and otherwise deleterious materials, and that the surface is firm and unyielding
- Verify that the CQA Survey has been completed and that the Record Drawings furnished by the surveyor indicates compliance with the lines, grade, elevations, and tolerances as indicated by the Drawings and Project Specifications

4.1.2 General Earthworks Construction Testing

The general earthworks components of the liner system include the general fill, and operations layer materials. Borrow materials will be obtained from excavation or areas designated by the Owner. CQA observation and/or testing is required during construction to verify that the materials and construction are in accordance with the Project Specifications. The tests to be performed, including testing frequency, for each material type are presented in Table 1. The testing frequencies specified in Table 1 may be increased when construction conditions warrant additional tests. Additional tests shall be recommended by the CQA Monitor and approved by the CQA Engineer.

Table 1: EARTHWORK CONSTRUCTION TESTING FREQUENCY

Test Designation	ASTM Designation	General Fill	Operations Soil Layer
Moisture-Density	D1557	1 Per 10,000 CY or Each Material Type	---
Nuclear Moisture-Density[1]	D6938	1 Per 500 CY	---
Sand Cone Test, or Drive Cylinder Test[2]	D1556 D2937	1 Per 20 Nuclear Density Tests	---
Moisture Content	D2216/D4643	As Necessary to Check Gauge	1 Per 5,000 CY
Particle Size	D422/D1140	---	1 Per 5,000 CY
Soil Classification	D2487/2488	Each Material Type	Each Material Type

Notes:

1) Tests shall be performed on an even grid to provide adequate testing coverage. For large fills in small areas, the testing frequency shall be increased as necessary to verify testing for each lift of soil placed.

2) Drive Cylinder test may be performed on fine-grained clay or silt materials only.

4.1.3 General Fill and Subgrade Preparation

General Fill and Subgrade Preparation: Construction observation and monitoring during general fill and subgrade preparation includes:

- Monitoring fill placement to verify that the Contractor obtains borrow materials from the approved excavation or stockpile location
- Observe construction staking to verify that the general fill soils are placed to the lines, grades, and elevations shown on the Drawings
- Verify that fill is placed in loose lifts that result in a nominal compacted thickness of 6 inches
- Verify that the Contractor adequately moisture conditions the borrow soils
- Perform field and laboratory testing in accordance with Table 1 to verify that the fill materials are placed to the moisture and density requirements indicated in the Project Specifications
- Verify that the subgrade preparation materials are suitable for supporting geosynthetic materials
- Promptly notify the Contractor of test results that affect the work. Notify the Project Manager of construction progress and of the results of all testing. In the event of failing tests, verify that the Contractor adequately reworks the areas which do not meet the Project Specifications

- Verify that the CQA Survey has been completed and that the Record Drawing furnished by the surveyor indicates compliance with the lines, grades, elevations, and tolerances as indicated by the Drawings and Project Specifications

Operations Layer Placement: Construction observation and monitoring required during operations layer placement includes:

- Observation and monitoring of hauling and spreading equipment to verify that the minimum thickness is maintained between equipment and the HDPE geomembrane
- Verify the integrity of the geotextile layer by final inspection of all seams and geotextile panels
- Verify that the operations layer fill materials meet the Project Specifications
- Observe that operations layer fill materials are pushed upslope on side slope areas
- Verify that the thickness of operations layer required by the Drawings is achieved

4.1.4 Low-Permeability Soil Placement

CQA observation and/or testing is required during construction to verify that the low-permeability materials and construction are in accordance with the Project Specifications. The tests to be performed, including testing frequency, are presented in Table 2. The testing frequencies specified in Table 2 may be increased when construction conditions warrant additional tests. Additional tests shall be recommended by the CQA Monitor and approved by the CQA Engineer.

Table 2: LOW-PERMEABILITY SOIL LAYER CONSTRUCTION TESTING FREQUENCY

Test Designation	ASTM Designation	Low-Permeability Soil
Moisture-Density	D1557	1 Per 5,000 or change in material
Nuclear Moisture-Density[2]	D6938	1 Per 250 CY
Moisture Content	D2216/D4643	1 Per 1,500 CY
Sand Cone, or Drive Cylinder	D1556, D2937	1 Per 20 Nuclear Density Tests
Particle Size[2]	D422/D1140	1 Per 1,500 CY
Atterberg Limits[2]	D4318	1 Per 1,500 CY
Soil Classification[2]	D2487/D2488	1 Per 1,500 CY
Laboratory Hydraulic Conductivity on Field Collected Sample[2,3,4]	D5084 (15 psi)	1 Per 1,500 CY

Notes:

1) Specified frequency or one per material type and source, whichever is greater. Moisture, density, particle-size, and Atterberg Limits testing frequencies shall also apply to the Foundation Soil Layer.

2) Tests shall be performed on an approximately even grid to provide adequate testing coverage.

3) Samples will be collected and transported to the laboratory using the same procedures selected by the CQA Engineer for the test pad (i.e., Shelby tubes or block samples).

4) Laboratory samples will be tested at confining pressures of 15 psi.

Construction observation and monitoring during the low-permeability soil placement includes:

- Verify that the Contractor obtains low-permeability soil material from the approved excavation or borrow location
- Observe construction staking and/or grade control methods to verify that the low-permeability layer soils are placed to the lines, grades, and elevations shown on the Drawings
- Verify that fill is placed in loose lifts no more than 8-inches thick that result in a nominal compacted thickness of 6-inches or less
- Verify that the Contractor adequately moisture conditions the borrow soils
- Perform field testing in accordance with Table 2 to verify that the fill materials are placed to the moisture and density requirements indicated in the Project Specifications

- Perform laboratory testing in accordance with Table 2 to verify that the low-permeability soil exhibits the required material properties
- Promptly notify the Contractor of test results that affect the work. Notify the Project Manager of construction progress and of the results of all testing. In the event of failing tests, verify that the Contractor adequately reworks the areas which do not meet the Project Specifications
- Observe that the Contractor takes adequate protective measures to maintain the surface of the compacted low-permeability soil layer and prevent desiccation cracking
- Verify that the CQA Survey has been completed and that the Record Drawing furnished by the surveyor indicates compliance with the lines, grades, elevations, and tolerances as indicated by the Project Drawings and Specifications

4.1.5 LCRS Gravel Layer Placement

Gravel components utilized for the liner system consist of a subrounded, well-sorted gravel material as indicated by the Project Specifications. Both pre-construction and construction testing are required for the gravel materials. Pre-construction testing consists of testing proposed materials from samples obtained at the aggregate source. Construction testing consists of testing performed from samples obtained during delivery of materials during the module construction. The tests to be performed, including testing frequency, for each material type are presented in Table 3. The testing frequencies specified in Table 3 may be increased when construction conditions warrant additional tests. Additional testing may be performed on suspect materials as recommended by the CQA Engineer.

Table 3: GRAVEL TESTING FREQUENCY

Test Designation	ASTM Designation	Gravel
Sieve Analysis	D422/C136	1 Per Source[1] 1 Test Per 1,500 CY
Visual Classification	D2488	Continuous
Hydraulic Conductivity	D2434	1 Per Source[1] 1 Test Per 1,500 CY
Fractured Faces (Gravel Fraction Only)	D5821	1 Per Source[1] 1 Test Per 1,500 CY

Notes:

1) One test required for each source as a pre-construction test requirement. Additional testing is required at the specified frequency during construction.

The CQA Monitor shall observe that care is taken when placing the gravel on the HDPE geomembrane and that the geomembrane is not punctured or damaged during placement operations. The CQA Monitor shall observe and document that appropriate light ground pressure equipment is used and that such equipment avoids sharp turns. If

the equipment or gravel placement procedures do not comply with the Project Specifications, the geomembrane shall be exposed and inspected for potential damage.

Construction observation and monitoring required during LCRS gravel layer placement includes:

- Verification that all pre-construction testing has been performed and that laboratory test results indicate compliance with the Project Specifications. The CQA Monitor shall assure that the Project Engineer and the Contractor receive prompt notification of material conformance
- Verify that the material upon which the gravel will be placed (HDPE geomembrane) has been installed in accordance with the Drawings and Project Specifications, and that all required testing, and as-built documentation have been completed
- Observation and monitoring of hauling equipment and spreading equipment to verify that (in the case of the LCRS gravel placement) the minimum thickness is maintained for spreading and hauling equipment above the HDPE geomembrane
- Collect and transmit to the laboratory the required number of gravel samples for testing. Communicate with the laboratory to verify that the materials tested comply with the Project Specifications
- Visually observe the gravel materials as delivered to the site to inspect for any variability in the aggregate, taking care to observe for variation in gradation, excess fines, excess angular material, or any deleterious material present in the aggregate
- Verify that the CQA Survey has been completed and that the Record Drawings furnished by the surveyor indicates compliance with the lines, grades, elevations, and tolerances as indicated by the Drawings and Project Specifications

4.2 CQA Surveying

CQA surveying shall be conducted such that all applicable standards are followed. The CQA Surveyor shall furnish Record Drawings for review by the CQA Engineer. The CQA Surveyor shall provide confirmation that surveyed materials are constructed to the lines and grades identified in the Drawings and Project Specifications. The CQA Monitor shall review and approve the Record Drawings prior to placement of a new system component over the work. Required Record Drawings shall be as specified in the Project Specifications. All CQA surveying shall be performed under the direction of a surveyor licensed to perform such work in the State of California. All Record Drawings shall be signed and sealed by the licensed surveyor who directed the CQA survey work. Record Drawings shall be at a scale not smaller than 1 inch = 50 feet. The accuracy of the surveying shall be sufficient to determine if the measurements are within the tolerances specified in the Project Specifications and Design Drawings.

The required surveying of liner system elevations shall be carried out on a 50-foot square grid at the locations designated on the Drawings. The grid points for each successive earthworks layer shall have the same horizontal locations for comparison of layer thickness. Additional survey locations shall be recorded to define the following features in the liner system: toe of slope, hinge of slope, grade breaks, sumps, anchor trench, drainage system piping, and perimeter drainage ditch. The thicknesses of the geosynthetic liner system components on the Drawings shall be interpreted as negligible.

5.0 GEOSYNTHETICS CONSTRUCTION QUALITY ASSURANCE

Construction of the specified geosynthetics must be in accordance with the approved Drawings and Project Specifications. This Quality Assurance program consists of reviewing Geosynthetics Manufacturer's and Installer's Quality Control submittals, material conformance testing, construction monitoring and testing.

The types of geosynthetic materials used in the liner system construction include geomembrane, geotextile, geocomposite, geosynthetic clay liner and HDPE pipe and fittings. These geosynthetic materials are defined in the Project Specifications. Prior to and during construction, these geosynthetic materials shall be sampled and tested to determine if they conform to Project Specifications. All geosynthetic conformance testing shall be the responsibility of the CQA Engineer.

5.1 Review Quality Control Submittals

Prior to geosynthetic materials installation, the CQA Engineer shall review the Geosynthetic Installation Contractor's Quality Control submittals to confirm that materials meet Project Specifications. The CQA Engineer shall review the following submittals for each geosynthetic material specified for the Project:

- Geosynthetic material samples, name of Manufacturer, and minimum material certifications which shall include the Manufacturer's minimum physical properties of the material, test methods (ASTM and GSI Standards) used, and factory and site seaming methods
- Manufacturer's Quality Control Manual followed during the manufacturing process
- The origin (supplier's name and production plant), identification (brand name and lot number) and material properties of the resin used to manufacture the product
- Geosynthetics Installation Contractor's Quality Control Manual, for the installation and testing of the geosynthetics
- Resumes of the Installation Superintendent, Master Seamer, and Seamers to be assigned to this project (geomembrane only)
- Certification that both the Installation Superintendent and the Master Seamer have reviewed this Construction Quality Assurance Plan, Project Specifications, and Drawings
- A copy of the Quality Control Certificates on each lot of resin issued by the resin Supplier for the specific material for this project. Geomembrane submittals shall include certification of the resin for extrusion welding rod
- The result of quality control testing conducted on the resin used in manufacturing the specific material for this project
- A listing which correlates the resin to the individual geosynthetic rolls and extruded materials
- A copy of the geosynthetic roll Quality Control Certificates which shall be supplied at a minimum frequency of one (1) per every fifty thousand (50,000) square feet of geosynthetic material continuously produced and supplied to the project unless otherwise presented in the Project Specifications
- A panel layout drawing for geomembrane showing the proposed installation layout identifying field seams as well as any variance or additional details which deviate from the Design Drawings

- A detailed installation schedule for the project
- Certification that the extrusion welding rod to be used is comprised of the same resin type as the geomembrane to be used (geomembrane only)

5.2 Conformance Testing

Prior to geosynthetic installation, the CQA Engineer shall obtain samples of the geosynthetics for conformance testing to evaluate or confirm that these materials meet Project Specifications. Unless stated otherwise in the Project Specifications, the conformance testing frequency shall be performed at a rate of 1 sample per 150,000 square feet, or one sample per lot, whichever results in the greater number of conformance tests. The geocomposite shall be sampled at a minimum frequency of 1 sample per 250,000 square feet. Samples shall be taken across the entire width of the roll and shall not include the first 3 feet. The samples shall be a minimum of 3-feet wide by the roll width. The CQA Engineer shall mark the machine direction, roll number, and the date obtained on the sample and then forward the sample to the geosynthetic laboratory.

All conformance tests shall be performed in accordance with the Project Specifications. The CQA Engineer shall review the test results and shall report any nonconformance to the Project Manager and the Geosynthetics Installation Contractor.

5.3 Geosynthetics Construction Monitoring and Testing

All geosynthetic components of the construction shall be monitored and tested to verify that the construction is in accordance with the Project Specifications. The CQA Engineer shall identify inadequate construction methodologies or materials that may adversely impact the performance of the facility being constructed and existing structures. Visual observations throughout the construction process shall be made to evaluate whether materials are placed to the lines and grades as shown on the Drawings.

The CQA Monitor shall review the following submittals provided by the Geosynthetics Installer during the project:

- Quality control documentation recorded during installation
- Daily reports detailing arrival and departure times, the personnel present on-site, the progress of the work, the arrival of materials, and any problems encountered
- Subgrade surface acceptance certificates for each area to be covered by the liner system, signed by the Geosynthetics Installer's Superintendent

The CQA Monitor shall observe and document the geosynthetic installation including:

- Delivery and unloading of geosynthetic materials to the site to verify that the materials are not damaged and are properly labeled
- Obtaining geosynthetic packaging identification slips for verification and generation of an on-site materials inventory
- Subgrade conditions prior to liner installation and verify that any deficiencies (e.g. surface irregularities, protrusions, excessively soft areas, stones, desiccation cracks) noted are corrected
- Verification that the CQA surveyor has verified all lines and grades
- Handling of geosynthetic materials from storage to the work area

- Temporary and permanent anchoring of geosynthetics to verify that design and Project Specifications are met
- Verification that required overlap distances are met

5.3.1 Geomembrane

During geomembrane installation, the CQA Monitor(s) shall observe and document deployment, trial seams, field seaming, non-destructive and destructive seam testing, and repairs to determine whether the installation is in accordance with the Project Specifications.

Storage and Handling - Geomembranes shall be stored at a site selected by the Project Manager. Rolls shall be off loaded using the appropriate equipment and straps. Rolls shall not be placed directly on the ground and shall be stacked no higher than three rolls. Only soft-sole shoes will be allowed on the deployed geomembrane and rub sheets shall be placed under equipment.

Deployment - The CQA Monitor shall verify that only approved materials are used, that each panel is given a unique panel number, that no geomembrane is placed during inclement or unsuitable weather conditions, that the geomembrane is not damaged during installation, that excessive wrinkles are not present, and that anchoring is performed in accordance with the Drawings and Project Specifications. The CQA Monitor shall record the deployment on a deployment log form.

Trial Seams - The CQA Monitor shall verify that seaming conditions are adequate, tests are performed at required intervals, specified test procedures are followed, and that re-testing is performed in accordance with the Project Specifications. The Geosynthetic Installer shall perform pre-weld testing at the beginning of each crew shift and immediately following any work stoppage (e.g., for lunch, weather, etc.) of 30 minutes or more. Seaming operation shall not commence until the CQA Monitor has determined that the seaming process meets the Project Specifications. Testing shall include visual observation of a trial seam a minimum of 42-inches long on the geomembrane material. The Installer shall mark the trial seam with date, ambient temperature, welding machine number, welding technician's initials, machine temperature, and speed. For extrusion welding, the Installer shall record the nozzle and extrusion settings and for fusion welding, the wedge temperature and machine speed shall be recorded. A 1-foot portion of each trial seam sample shall be archived by the CQA Monitor at the site. The CQA Monitor shall record the trial seam test results on a trial seam log form.

Field Seaming - The CQA Monitor shall verify that only approved equipment and personnel perform welding, all welding is performed under suitable conditions as specified in the Project Specifications, specified overlaps are achieved, seams are oriented in accordance with project requirements, and that grinding techniques and extrudate meet project requirements for extrusion welding. The CQA Monitor shall record all field seaming on the field seaming log forms.

Seaming shall not proceed at an ambient temperature below 32°F or above 104°F unless the Installer demonstrates he is capable of achieving acceptable results through the utilization of special seaming techniques. Such cold or hot weather seaming shall be proven by an approved program presented in the Project Specifications or presented otherwise by the Design Engineer. If seaming operations are conducted at night, lighting equipment shall be sufficient to allow the Installer and CQA Monitor to adequately and safely perform their duties.

Non-Destructive Seam Continuity Testing - The CQA Monitor shall verify that all seams are non-destructively tested in accordance with the Project Specifications. If the seam cannot be tested, the CQA Monitor shall observe cap strip operations and verify that test equipment and gauges are functioning properly and that test procedures are in accordance with the project requirements. The CQA Monitor shall verify that all failing tests are repaired and

re-tested until passing results are achieved. The CQA Monitor shall record all non-destructive test locations on the vacuum test and pressure test log forms.

Destructive Seam Testing - The Geosynthetic Installer shall obtain samples, at locations selected and marked by the CQA Monitor, of the field seamed geomembrane. The samples shall be taken centered over the seam and prioritized as follows:

- All areas identified as suspect during non-destructive testing/monitoring
- Seams that appear suspect to the CQA Monitor
- A minimum of one sample per day
- A minimum of one sample for each geomembrane seaming apparatus
- A minimum of one sample for each representative working conditions (e.g. weather conditions)
- A minimum of one sample every 500 feet of seaming for each apparatus

Two types of samples shall be obtained at each location. The first sample shall consist of two specimens, each cut approximately 1-inch wide by 8-inches long, taken 48-inches apart. These specimens shall be tested for peel and shear strength in the field by the Installer using a calibrated field tensiometer capable of quantitatively measuring peel and shear strengths. The CQA Monitor shall observe all field tests and record the test results.

If one or both of the specimens fail, the Installer shall take additional test samples 10 feet from the point of the failed test in each direction and repeat the field test procedure. If these additional tests fail, then the procedure shall be repeated until the length of the poor quality seam is established. If the initial field tests pass, the second type of sample shall be taken between the passing specimens. The second sample type shall be approximately 42-inches along and 12-inches across. The sample shall be divided into three equal sections and distributed and tested as follows:

- One sample - Manufacturer/Installer for their use
- One sample - CQA Monitor for destructive testing
- One sample - CQA Monitor for site archives

Each sample shall be subject to the following destructive tests at an independent CQA Geosynthetics Laboratory or at the CQA Site Office and tested per ASTM D6392 with appropriate calibrated equipment:

- Seam shear strength (five tests)
- Seam peel strength (five tests)

For fusion seams, one peel strength test refers to testing of both sides of the seam.

Failed destructive tests shall be subject to additional testing until the failing test is bound. The Installer shall take another test sample 10 feet from the point of the failed test in each direction and repeat the field test procedure. If subsequent tests fail, then the procedure is repeated until the length of the poor quality seam is established. Once the field tests have passed, a second sample shall be taken between the passing specimens and tested by the Independent CQA Laboratory or by the CQA Engineer. Failed seams shall be tracked according to the welding

apparatus and the machine operator. All failed seams shall be bounded by locations from which passing Independent CQA Laboratory tests have been taken.

The Installer shall be responsible for patching all areas cut for test samples in accordance with the Project Specifications and the Manufacturer's recommended procedures, and for non-destructive testing (e.g. vacuum box, etc.) of the patch seams. The CQA Monitor shall record all test locations, results, actions taken in conjunction with destructive test failures, and repairs.

Repairs - The CQA Monitor shall observe and document that all repair materials, techniques, and procedures used for repairs are approved in advance and meet the requirements of the Project Specifications. The CQA Monitor shall verify that all repairs are marked, recorded, repaired, tested, and that wrinkles are addressed, prior to being covered by other materials; and that repairs are performed as specified, including specified type of repair according to type of damage and proper patch size or dimension. The CQA Monitor shall record defects and repairs on log forms.

Acceptance - The CQA Engineer shall accept areas of the geomembrane prior to coverage of the geomembrane by other materials. Acceptance of areas shall follow these procedures:

- As-built panel layout survey
- Full documentation of all seams
- Full documentation of nondestructive testing on all seams and repairs
- Full documentation of repairs on all defects
- Full documentation of passing destructive tests
- A final “walk-over” of the area to observe any subsequent damages or non-addressed items

5.3.2 Geotextile

During geotextile installation, the CQA Monitor shall observe and document deployment, adequate overlap, seaming, and repairs to evaluate whether the installation is in accordance with the Project Specifications.

Deployment - The CQA Monitor shall verify that the underlying layers are clean and free of deleterious materials prior to deployment, and anchoring is achieved as specified. The CQA Monitor shall make observations to inspect for the presence of damaged material or the presence of broken needles used in the manufacturing process.

Seams - The CQA Monitor shall verify sufficient overlap and that the specified seam procedures were followed as required in the Project Specifications.

Repairs - The CQA Monitor shall verify that all repairs are performed in accordance with Project Specifications.

Protection – The CQA Monitor shall verify that deployment methods and equipment do not damage underlying materials. The CQA Monitor shall observe and document that all geotextile materials are covered with the approved material and that traffic or hauling equipment does not damage the geotextile or the overlying materials during installation. In the presence of wind, the geotextile shall be securely anchored with sandbags or equivalent.

5.3.3 Geocomposite

During geocomposite installation, the CQA Monitor shall observe and document deployment, adequate overlap, seaming, and repairs to evaluate whether the installation is in accordance with the Project Specifications.

Deployment - The CQA Monitor shall verify that the underlying layers are clean and free of deleterious materials prior to deployment, and that anchoring is achieved as specified.

Seams and Repairs - The CQA Monitor shall verify sufficient overlap and that the specified seam procedures were followed as required in the Project Specifications. The CQA Monitor shall verify that all repairs are performed in accordance with Project Specifications.

Protection – The CQA Monitor shall verify that deployment methods and equipment do not damage underlying materials. The CQA Monitor shall observe and document that all geocomposite materials are covered with the approved material and that traffic or hauling equipment does not damage the geocomposite during installation or the overlying materials. In the presence of wind, the geocomposite shall be securely anchored with sandbags or equivalent.

5.3.4 Geosynthetic Clay Liner

During geosynthetic clay liner (GCL) installation, the CQA Monitor shall observe and document deployment, adequate overlap, and repairs to evaluate whether the installation is in accordance with the Project Specifications.

Deployment - The CQA Monitor shall verify that the underlying layers are clean and free of deleterious materials prior to deployment, anchoring is achieved as specified, specified methods are used to minimize wrinkles, panels are oriented properly, and stacking procedures are performed according to the Project Specifications.

Seams and Repairs - The CQA Monitor shall verify sufficient overlap and that the specified seam procedures were followed as required in the Project Specifications. The CQA Monitor shall verify that all repairs are performed in accordance with Project Specifications.

Protection – The CQA Monitor shall observe and document that all GCL materials are promptly covered with the overlying HDPE geomembrane the same day in which the GCL is deployed.

5.3.5 HDPE Pipe and Fittings

During polyethylene pipe installation, the CQA Monitor shall observe and document that the installation is in accordance with the Project Specifications. Monitoring shall include:

Placement - Observation that the handling procedures used do not damage the pipe or underlying materials, backfill is placed in accordance with the requirements of the Project Specifications so as not to damage the pipe, any foreign material is removed from the interior of the pipe, and indentations on the pipe are within the allowable limits.

Joints and Connections - Monitoring of the jointing and connection operations to verify that the Contractor or Installer follows the Project Specifications and the Pipe Manufacturer's recommendations, verification that the pipes are clean when installed, and that perforated sections of pipe are aligned properly prior to connection.

Non-destructive Testing - Observe any required testing of the pipe to verify accordance with the Project Specifications.

5.3.6 Electrical Leak Location Survey

An ELLS shall be completed following the placement of the soil operations layer on the floor and prior to the placement of the operations layer on the slope. The CQA Engineer/Monitor shall verify that the liner is properly prepared for the ELLS and shall verify that adequate moisture is added to the gravel and operations layer prior to conducting the test. All edges of the liner must be “electrically isolated” prior to completing the test. Therefore, the LCRS gravel and operations layer will be temporarily terminated approximately 3 feet from the edges of the new liner system. The ELLS shall conform to the applicable requirements of ASTM D7007.

In the event the ELLS identifies anomalies that are potentially indicative of a defect in the liner system, the CQA Monitor shall document the location of the suspect area, and then observe and document the exposure of the liner system and any subsequent repairs that may be necessary. The CQA Monitor will photograph the area after it is exposed, and after any repairs are completed.

The ELLS Surveyor shall submit a report detailing the procedures used and the results of their survey.

6.0 DOCUMENTATION

An effective Quality Assurance program depends on thorough monitoring and documentation of all construction activities during all phases of construction. Documentation shall consist of daily record keeping, construction problem resolutions, design and specification changes, photographic records, weekly progress reports, chain of custody forms for test sample tracking, and a certification and summary report. During construction, all documentation shall be kept on site and will be available for review by the Project Manager, CQA Engineer, or CQA Monitors.

No section of the liner system may be covered up until the CQA Monitor or CQA Engineer observes, approves and documents the completed section of the liner system and assures that all requirements have been met by the Contractor or Installer.

6.1 Daily Record Keeping

Daily records shall consist of field notes, observation and testing data sheets, summary of the daily meetings with the Installer and Contractor, and reporting of construction problems and resolutions. This information shall be submitted weekly along with a weekly CQA Summary Report to the CQA Engineer. Copies of all CQA documentation shall be maintained at the site and be made available for review by the Project Manager.

6.2 Soils Observation and Testing Data Sheets

Soils observation and testing data sheets generally include the following information:

- Date, project name, location, and weather data
- A reduced-scale site plan, or full-scale plots, showing work areas and test locations
- Descriptions of ongoing construction
- Summary of test results and samples taken, with locations and elevations
- Off-site materials received including quarry certificates
- Test equipment calibrations, if necessary

- Signature or initials of the CQA Monitor

6.3 Geosynthetic Observation and Testing Forms

Geosynthetic observation and testing forms generally include the following information:

- Date, project name, location, and weather data
- Identification of panel or seam number
- Numbering system identifying test or sample number
- Location and identification of repairs and date of repair
- Length and/or thickness measurements for geosynthetic panels or seams
- Welding machine temperatures and settings
- Welding machine and technician identifications
- Location of tests and test results
- Identification of testing technicians and time of tests
- Signature or initials of the CQA Monitor

6.4 Construction Problem and Resolution Documentation

Any construction problem which cannot be resolved between the Installer, Contractor, and CQA Monitor may require a special meeting in order to resolve the problem. The problem should be discussed with the Project Manager, CQA Engineer, and Design Engineer if a design issue is involved. Specific written documentation of that problem should be prepared, if warranted, and will generally include the following information:

- Detailed description of the problem
- Location and cause of the problem
- How and when the situation or deficiency was identified
- How the problem was resolved
- Any measures taken to prevent similar problems in the future
- Signature of the CQA Engineer and CQA Monitor

Copies of all Construction Problem and Resolution Sheets requiring a Resolution Meeting will be submitted to the Project Manager.

6.5 Photo Documentation

All phases of construction shall be sufficiently photographed by the CQA Monitor. Photographs shall be identified by separate photographic log by location, time, date, and name of the person taking the photograph. A camera that records the time and date shall be used. Representative photographs will be included in the certification report.

6.6 Design and Specification Changes

If it is necessary to address design and specification changes, modifications, or clarifications during construction, the CQA Monitor or CQA Engineer will inform the Project Manager who will notify the Design Engineer. Design and specification changes shall only be made with written agreement from the Project Manager and Design Engineer.

6.7 Certification Report

At the completion of construction, a certification report shall be prepared and signed by the CQA Engineer to certify that the work has been performed in compliance with the Drawings and Project Specifications and will contain the following general information:

- Summary of construction activities
- Observation and test data summary sheets
- Sampling, testing locations, and test results
- A description of significant construction problems and the resolution of these problems
- Changes to the Drawings or Project Specifications and the justification for these changes
- Record Drawings
- A certification statement signed and sealed by a civil engineer (PE) or engineering geologist (CEG) registered in the State of California, by whom the CQA activities were supervised and work performed in responsible charge

The Record Drawings shall be prepared by the CQA Surveyor and shall accurately locate all construction items including the lines, grades, and thickness of all soil components for the liner system.

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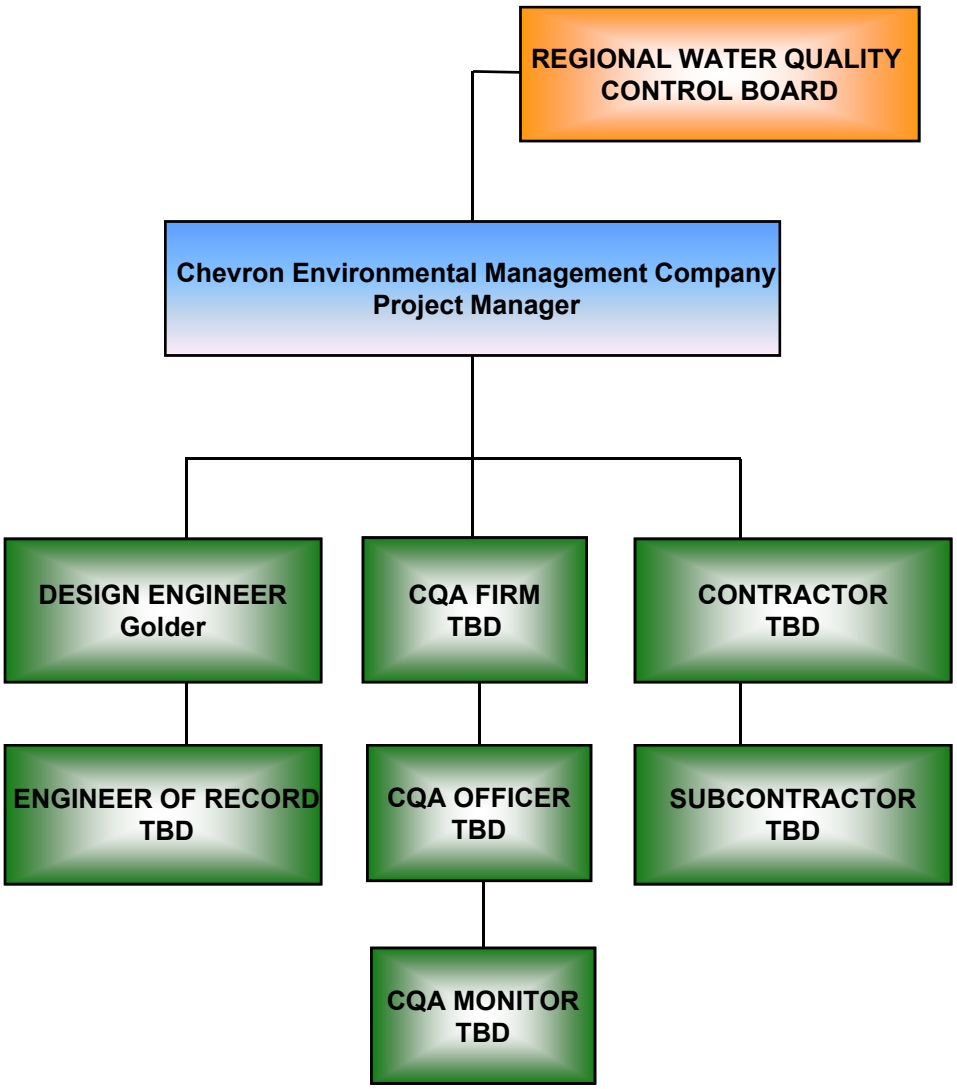
Figure

FIGURE 1
GUADALUPE RESTORATION PROJECT
ORGANIZATION AND COMMUNICATION CHART
GUADALUPE, CALIFORNIA



ATTACHMENT A

Daily Report

DAILY SUMMARY REPORT

PROJECT NUMBER: _____ **PROJECT TITLE** Gudalupe Restoration Project
OWNER: Chevron Environmental Management Company **CONTRACTOR** _____
LOCATION: Guadalupe, CA

DATE _____ **S M T W T F S**

WEATHER: **TEMPERATURE** **LOW** _____ **@** _____ **HIGH** _____ **@** _____
CLOUD COVER _____ **PRECIPITATION** _____ **WIND** _____

GOLDER PERSONNEL ON SITE: _____

SUMMARY OF CONSTRUCTION PROGRESS: _____

GOLDER ACTIVITIES AND TEST RESULTS: _____

Submitted By

_____
CQA Monitor

ATTACHMENT B

Soil Field Forms

FIELD MOISTURE / DENSITY TEST RECORD
NUCLEAR GAUGE METHOD
ASTM D6938

PROJECT NUMBER: _____ **PROJECT TITLE:** Guadalupe Restoration Project
OWNER: Chevron Environmental Management **CONTRACTOR:** _____
LOCATION: Guadalupe, CA **DATE TESTED:** _____

TEST NUMBER							
TEST LOCATION							
ELEVATION							
DEPTH							
DENSITY COUNT							
MOISTURE COUNT							
WET DENSITY, PCF							
MOISTURE, %							
DRY DENSITY, PCF							
MATERIAL DESCRIPTION							
MAX DRY DENSITY, PCF							
OPTIMUM MOISTURE, %							
% COMPACTION							
DIFF FROM O.M.C.							
PASS/FAIL (DENSITY)							
PASS/FAIL (MOISTURE)							

SPECIFICATIONS:
_____ **% MODIFIED Proctor**
_____ **% OF O.M.C.**

DAILY STANDARD COUNTS:
MOISTURE _____
DENSITY _____

TESTED BY: _____ **CHECKED BY:** _____ **DATE:** _____

GCS FORM: S17

FIELD DENSITY TEST RECORD
DRIVE CYLINDER METHOD
ASTM D2937

PROJECT NUMBER: _____ **PROJECT TITLE:** Guadalupe Restoration Project

OWNER: Chevron Environmental Management Company **CONTRACTOR:** _____

SITE LOCATION: Guadalupe, CA

TEST NUMBER: _____ **DATE TESTED:** _____

LOCATION: _____ **ELEVATION:** _____

IN SITU DENSITY DETERMINATION		
CYLINDER NUMBER		
WT. CYLINDER+SOIL, lb		
CYLINDER WT., lb		
WT. OF SOIL, lb		
CYLINDER VOLUME, cu ft		
WET DENSITY, pcf		
MOISTURE CONTENT DETERMINATION	OVEN DRY QUICK FRY MICROWAVE OTHER	OVEN DRY QUICK FRY MICROWAVE OTHER
CONTAINER NUMBER		
WT. WET SOIL+CONTAINER, g		
WT. DRY SOIL+CONTAINER, g		
WT. CONTAINER, g		
WT. WATER, g		
WT. DRY SOIL, g		
MOISTURE CONTENT, %		
DRY DENSITY, pcf		

TEST RESULTS

PROCTOR CURVE NO. _____

☐ CHECK POINT ☐ VISUALLY

☐ RAPID 3-POINT ☐ OTHER

MAX. DRY DENSITY, pcf _____

OPT. MOISTURE CONTENT, % _____

PERCENT COMPACTION _____

DIFFERENCE FROM O.M.C. _____

SPECIFICATIONS:

_____ **% STANDARD/MODIFIED**

_____ **% OF O.M.C.**

RESULTS:

	PASS	FAIL
DENSITY		
MOISTURE		

MATERIAL DESCRIPTION:

REMARKS:

☐ SEE ATTACHED SHEET FOR PROCTOR CURVE SELECTION INFORMATION

TESTED BY: _____ **CHECKED BY:** _____ **DATE:** _____

WATER CONTENT DETERMINATION
(ASTM D4643/D2216)

PROJECT NUMBER: _____ **PROJECT TITLE:** Guadalupe Restoration Project
PROJECT NAME: Chevron Environmental Management Co **CONTRACTOR:** _____
LOCATION: Guadalupe, CA

Microwave/Oven	M/O	M/O	M/O	M/O	M/O	M/O
SAMPLE NUMBER						
TARE NUMBER						
WEIGHT OF WET SOIL + TARE (gm)						
WEIGHT OF DRY SOIL + TARE (gm)						
WEIGHT OF TARE (gm)						
WEIGHT OF WATER (gm)						
WEIGHT OF DRY SOIL (gm)						
WATER CONTENT (%)						
Microwave/Oven	M/O	M/O	M/O	M/O	M/O	M/O
SAMPLE NUMBER						
TARE NUMBER						
WEIGHT OF WET SOIL + TARE (gm)						
WEIGHT OF DRY SOIL + TARE (gm)						
WEIGHT OF TARE (gm)						
WEIGHT OF WATER (gm)						
WEIGHT OF DRY SOIL (gm)						
WATER CONTENT (%)						
Microwave/Oven	M/O	M/O	M/O	M/O	M/O	M/O
SAMPLE NUMBER						
TARE NUMBER						
WEIGHT OF WET SOIL + TARE (gm)						
WEIGHT OF DRY SOIL + TARE (gm)						
WEIGHT OF TARE (gm)						
WEIGHT OF WATER (gm)						
WEIGHT OF DRY SOIL (gm)						
WATER CONTENT (%)						

$$\text{WATER CONTENT (\%)} = \frac{\text{WEIGHT OF WATER}}{\text{WEIGHT OF DRY SOIL}} \times 100$$

TESTED BY: _____ **DATE OF TESTING:** _____
CALCULATED BY: _____ **REMARKS:** _____
CHECKED BY: _____

WCDETERM -APRIL 1999

ATTACHMENT C

Geosynthetic Field Forms

GEOSYNTHETIC INVENTORY CONTROL LOG

PROJECT NO: _____ **PROJECT TITLE:** Guadalupe Restoration Project

OWNER: Chevron Environmental Management Company **CONTRACTOR:** _____

LOCATION: Guadalupe, CA

SHEET NUMBER

MATERIAL TYPE: GEOMEMBRANE GEONET GEOTEXTILE OTHER _____

DATE OF ARRIVAL: _____ **DATE OF INVENTORY** _____

MATERIAL MANUFACTURER: _____ **INVENTORY MONITOR** _____

PRODUCT IDENTIFICATION: _____ **CONDITION IN TRUCK** _____

TRUCK TYPE: _____ **UNLOADING METHOD** _____

	ROLL NUMBER	BATCH OR LOT NO.	MATERIAL DIMENSIONS			QC CERT Y / N	CONF SAMP. Y / N	OTHER _____	REMARKS
			LENGTH	WIDTH	THICKNESS OR WEIGHT				
1									
2									
3									
4									
5									
6									
7									
8									
9									
10									
11									
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17									
18									
19									
20									
21									
22									
23									
24									
25									

GAI FORM: G2

REVIEWED BY: _____ **DATE** _____

(JUNE 2003)

GOLDER ASSOCIATES INC.

CERTIFICATE OF ACCEPTANCE
OF SOIL SURFACE

GEOSYNTHETIC INSTALLER

COMPANY _____

ADDRESS _____

_____

_____

PROJECT

LOCATION: Guadalupe, CA

PROJECT: Guadalupe Restoration Project

OWNER: Chevron Environmental Management Co

I, the Undersigned, the duly authorized representative of _____

_____

do hereby accept the area of soil surface bounded by _____

_____

_____

_____

_____

and shall be responsible for maintaining its integrity and suitability in accordance with the project specifications from this date to the completion of the installation.

NAME	SIGNATURE	TITLE	DATE

CERTIFICATE OF ACCEPTANCE RECEIVED BY QA / QC MANAGER

NAME	SIGNATURE	TITLE	DATE

GCS FORM: G4

(JUNE 1992)

GOLDER ASSOCIATES INC.

GEOMEMBRANE PANEL DEPLOYMENT LOG

PROJECT NUMBER: _____ **PROJECT TITLE:** Guadalupe Restoration Project
OWNER: Chevron Environmental Management Company **CONTRACTOR:** _____
LOCATION: Guadalupe, CA

GEOMEMBRANE : SECONDARY PRIMARY CLOSURE OTHER _____
SUBGRADE CONDITION (SURFACE COMPACTION, PROTRUSIONS, DESICCATION, EXCESSIVE MOISTURE):
REMARKS : _____

DATE: _____

TRANSPORT EQUIPMENT _____ **SHEET NUMBER:** _____

DESCRIPTION	PANEL NUMBER	PANEL NUMBER	PANEL NUMBER
ROLL NUMBER			
PANEL DIMENSIONS			
AMBIENT AIR TEMP.			
VISUAL OBSERVATION			
OBSERVED OVERLAP			
MONITOR			
REMARKS			

DESCRIPTION	PANEL NUMBER	PANEL NUMBER	PANEL NUMBER
ROLL NUMBER			
PANEL DIMENSIONS			
AMBIENT AIR TEMP.			
VISUAL OBSERVATION			
OBSERVED OVERLAP			
MONITOR			
REMARKS			

DESCRIPTION	PANEL NUMBER	PANEL NUMBER	PANEL NUMBER
ROLL NUMBER			
PANEL DIMENSIONS			
AMBIENT AIR TEMP.			
VISUAL OBSERVATION			
OBSERVED OVERLAP			
MONITOR			
REMARKS			

DESCRIPTION	PANEL NUMBER	PANEL NUMBER	PANEL NUMBER
ROLL NUMBER			
PANEL DIMENSIONS			
AMBIENT AIR TEMP.			
VISUAL OBSERVATION			
OBSERVED OVERLAP			
MONITOR			
REMARKS			

GAI FORM: G11
(FEBRUARY 2016)

REVIEWED BY: _____ **DATE:** _____

GOLDER ASSOCIATES INC.

GEOMEMBRANE TRIAL SEAM LOG

PROJECT NUMBER: _____ **PROJECT TITLE:** Guadalupe Restoration Project

OWNER: Chevron Environmental Management Company **CONTRACTOR:** _____

LOCATION: Guadalupe, CA

_____ **TF - # = FUSION** **DATE:** _____

_____ **TX - # = EXTRUSION** **SHEET NUMBER:** _____

SAMPLE NUMBER	APPROX. TIME	WELDING MACHINE NUMBER	WELD TECH.	TEMPERATURES				TEST RESULTS			PASS OR FAIL	MON.	REMARKS
				AMBIENT AIR TEMP.	PREHEAT OR MACHINE SPEED	EXTRUDER	NOZZLE OR WEDGE	INSIDE PEEL MODE STRENGTH	OUTSIDE PEEL MODE STRENGTH	SHEAR MODE STRENGTH			
								/ /	/ /	/			
								/ /	/ /	/			
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GAI FORM: G12 REVIEWED BY: _____ DATE: _____

(JUNE 2003)

GOLDER ASSOCIATES INC.

GEOMEMBRANE SEAM LOG

PROJECT: _____ PROJECT TITLE: Guadalupe Restoration Project

OWNER: Chevron Environmental Management Company CONTRACTOR: _____

LOCATION: Guadalupe, CA

PASSING TRIAL SEAMS

	NO.	TIME	TECH ID
☐ FUSION			
☐ EXTRUSION			

DATE: _____

MACHINE # _____

DESTRUCTIVE LENGTH CARRY-OVER FROM PREVIOUS LOG _____

SHEET NUMBER: _____

	SEAM NUMBER	SEAM SECTION START POINT	SEAM SECTION FINISH POINT	APPROX. START TIME	AMB. AIR TEMP	WELD TECH	PREHEAT OR MACH. SPEED	MACHINE TEMPERATURES DIGITAL SET WEDGE OR BARREL NOZZLE	MACHINE TEMPERATURES INDICATOR WEDGE OR BARREL NOZZLE	APPROX. LENGTH WELDED	LENGTH FROM PREVIOUS DESTR.	DESTR. NUMBER	MON.	REMARKS	** NON-DESTRUCTIVE TEST DATE	** NON-DESTRUCTIVE MON.
1	/	-						-	-							
2	/	-						-	-							
3	/	-						-	-							
4	/	-						-	-							
5	/	-						-	-							
6	/	-						-	-							
7	/	-						-	-							
8	/	-						-	-							
9	/	-						-	-							
10	/	-						-	-							
11	/	-						-	-							
12	/	-						-	-							
13	/	-						-	-							
14	/	-						-	-							
15	/	-						-	-							
16	/	-						-	-							
17	/	-						-	-							

* REFERENCE SEAM ENDPOINTS FROM AN END OF SEAM (EOS), A REPAIR NUMBER, OR A POINT LOCATION ON THE SEAM.

DAILY TOTAL DESTRUCTIVE LENGTH CARRY-OVER

** COLUMNS TO BE USED BY THE DATA REVIEWER ONLY

REVIEWED BY: _____ DATE: _____

GAI FORM : G13
(JUNE 2003)

GOLDER ASSOCIATES

GEOMEMBRANE SEAM PRESSURE TEST LOG

PROJECT: _____ **PROJECT TITLE:** Guadalupe Restoration Project

OWNER: Chevron Environmental Management Company **CONTRACTOR:** _____

LOCATION: Guadalupe, CA

DATE: _____

SHEET NUMBER: _____

	SEAM NUMBER	SEAM SECTION* FROM	TO	PRESS. GAUGE NUMBER	TECH ID	TIME START	FINISH	PRESSURE INITIAL	FINISH	OBS. TEST	RESULTS PASS / FAIL	SEAM COMPLETE NO	YES	MON.	REMARKS
1	/	-				:		:							
2	/	-				:		:							
3	/	-				:		:							
4	/	-				:		:							
5	/	-				:		:							
6	/	-				:		:							
7	/	-				:		:							
8	/	-				:		:							
9	/	-				:		:							
10	/	-				:		:							
11	/	-				:		:							
12	/	-				:		:							
13	/	-				:		:							
14	/	-				:		:							
15	/	-				:		:							
16	/	-				:		:							
17	/	-				:		:							
18	/	-				:		:							
19	/	-				:		:							
20	/	-				:		:							

* REFERENCE SEAM ENDPOINTS FROM AN END OF SEAM (EOS), A REPAIR NUMBER, OR A POINT LOCATION ON THE SEAM (i e, REFERENCE POINT, DISTANCE, DIRECTION FROM REF. PT.)

GAI FORM: G16
JUNE 2003)

REVIEWED BY: _____ **DATE:** _____

GEOMEMBRANE DEFECT LOG

PROJECT NUMBER: _____ **PROJECT TITLE:** Guadalupe Restoration Project
OWNER: Chevron Environmental Management **CONTRACTOR:** _____
LOCATION: Guadalupe, CA

SHEET NUMBER _____

DEFECT CODE	DEFECT LOCATION: SEAM, PANEL OR REPAIR NO.	DEFECT LOCATION: DEFECT LOCATION DESCRIPTION	DEFECT TYPE	LOG DATE	MON.	REMARKS	** REPAIR DATE	** TEST DATE
A								
B								
C								
D								
E								
F								
G								
H								
I								
J								
K								
M								
N								
P								
Q								
R								
S								
T								
W								
X								

AD - ANIMAL RELATED DAMAGE
B - UNDISPERSED RESIN BEAD
BO - FUSION WELDER BURN
BS - BOOT/SKIRT FOR FML PENETRATION
CO - CHANGE OF OVERLAP
CR - CREASE
D - INSTALLATION DAMAGE
DS-# - DESTRUCTIVE TEST NUMBER
EE - EARTHWORK EQUIPMENT DAMAGE
EXT - EXTENSION
FM - FISHMOUTH
FS - FAILED SEAM LENGTH
FTS - FIELD TEST STRIP
HT - HEAT TACK BURN
IO - INSUFFICIENT OVERLAP (UNDER SPEC.)
MD - MANUFACTURER / DELIVERY DAMAGE
PT - PRESSURE TEST CUT
SI - SOIL SURFACE IRREGULARITY
SL - SLAG ON TEXTURED SHEET
T - THREE PANEL INTERSECTION
VL - VACUUM TEST LEAK
WR - WRINKLE
WS - WELDER RESTART
OTHER _____

** COLUMNS TO BE USED BY THE DATA REVIEWER ONLY.

GAI FORM: G18
(JUNE 2003)

REVIEWED BY: _____ **DATE:** _____

GOLDER ASSOCIATES INC.

GEOMEMBRANE REPAIR LOG

PROJECT NUMBER: _____ **PROJECT TITLE:** Guadalupe Restoration Proje
OWNER: Chevron Environmental Management Company **CONTRACTOR:** _____
LOCATION: Guadalupe, CA

PASSING TRIAL SEAMS

NO.	TIME	TECH. ID

MACHINE NUMBER _____

DATE _____

SHEET NUMBER _____

	DEFECT CODE	REPAIR DATE	APPROX. TIME	REPAIR TYPE	APPROX. DIMENSION	WELD TECH.	MON.	REMARKS
1								
2								
3								
4								
5								
6								
7								
8								
9								
10								
11								
12								
13								
14								
15								
16								
17								
18								
19								
20								
21								
22								
23								
24								
25								

REPAIR TYPE: P - PATCH, C - CAP, RS - RECONSTRUCTED SEAM, G&W - GRIND WELD

DATE: _____ **REVIEWED BY:** _____

GEOMEMBRANE SEAM VACUUM TEST LOG

PROJECT NO: _____ **PROJECT TITLE:** Guadalupe Restoration Project

OWNER: Chevron Environmental Management Company **CONTRACTOR:** _____

LOCATION: Guadalupe, CA

VACUUM BOX NUMBER _____ **SHEET NUMBER** _____

SEAMS

	SEAM NUMBER	SEAM SECTION * FROM	TO	TEST DATE	TECH ID	DEFECTS * *	SEAM COMPLETE NO	YES	OBS. TEST	MON.	REMARKS
1	/	-					|				
2	/	-					|				
3	/	-					|				
4	/	-					|				
5	/	-					|				
6	/	-					|				
7	/	-					|				
8	/	-					|				
9	/	-					|				
10	/	-					|				
11	/	-					|				
12	/	-					|				
13	/	-					|				
14	/	-					|				
15	/	-					|				
16	/	-					|				
17	/	-					|				
18	/	-					|				
19	/	-					|				
20	/	-					|				

REPAIRS

	DEFECT CODE	TEST DATE	TECH ID	DEFECTS * *	OBS. TEST	MON.	REMARKS
21							
22							
23							
24							
25							
26							
27							
28							
29							
30							
31							
32							
33							
34							
35							
36							
37							
38							
39							
40							

* REFERENCE SEAM ENDPOINTS FROM AN END OF SEAM (EOS), A REPAIR NUMBER, OR A POINT LOCATION ON THE SEAM (i e, REFERENCE POINT, DISTANCE, DIRECTION FROM REF. PT.)

* * RECORD QUANTITY OF LEAKS DETECTED AND REFERENCE NEW DEFECT CODE IN REMARKS.

GAI FORM: G17
(JUNE 2003)

REVIEWED BY: _____ **DATE:** _____

GOLDER ASSOCIATES INC

GEOMEMBRANE SEAM DESTRUCTIVE SAMPLE LOG

PROJECT NO: _____ **PROJECT TITLE:** Guadalupe Restoration Project

OWNER: Chevron Environmental Management Company **CONTRACTOR:** _____

LOCATION: Guadalupe, CA

SHEET NUMBER: _____

	DESTRUCTIVE SAMPLE NUMBER	SEAM NUMBER	MACHINE NUMBER	DATE REMOVED	FIELD TEST RESULTS PEEL SHEAR (PASS/FAIL)	MON.	DATE SHIPPED	LAB TEST STATUS (PASS/FAIL)	DATE OF NOTIFICATION	REMARKS
1		/		/ /	:		/ /		/ /	
2		/		/ /	:		/ /		/ /	
3		/		/ /	:		/ /		/ /	
4		/		/ /	:		/ /		/ /	
5		/		/ /	:		/ /		/ /	
6		/		/ /	:		/ /		/ /	
7		/		/ /	:		/ /		/ /	
8		/		/ /	:		/ /		/ /	
9		/		/ /	:		/ /		/ /	
10		/		/ /	:		/ /		/ /	
11		/		/ /	:		/ /		/ /	
12		/		/ /	:		/ /		/ /	
13		/		/ /	:		/ /		/ /	
14		/		/ /	:		/ /		/ /	
15		/		/ /	:		/ /		/ /	
16		/		/ /	:		/ /		/ /	
17		/		/ /	:		/ /		/ /	
18		/		/ /	:		/ /		/ /	
19		/		/ /	:		/ /		/ /	
20		/		/ /	:		/ /		/ /	

GAI FORM: G20

(JUNE 2003)

REVIEWED BY: _____ **DATE:** _____

golder.com

APPENDIX L

LCRS Calculations/HELP Model

CALCULATIONS

DATE:	April 15, 2020	**MADE BY:**	HSG
PROJECT NO.:	1783552	**CHECKED BY:**	LMA
SUBJECT:	Soil Management Area HELP Model	**REVIEWED BY:**	RGH
PROJECT SHORT TITLE:	Guadalupe Restoration Project- Tank Battery 9 Area		

1.0 Purpose

To evaluate the hydrologic performance, prior to final cover, of the soil management area for the Guadalupe Restoration Project and verify that the proposed LCRS design can accommodate the average annual precipitation in Guadalupe, California.

2.0 Method

Values such as peak daily flow in the LCRS and the maximum head on the liner system are estimated using the Hydrologic Evaluation of Landfill Performance (HELP) model. The HELP model uses climatologic data, material and vegetative cover characteristics, and design data, including liner installation quality information to perform the water balance.

3.0 Assumptions

National Oceanic and Atmospheric Administration (NOAA) reports the average annual precipitation at the Santa Maria Airport, which is located approximately 11 miles East of the Guadalupe Restoration Project site, to be 12.76 inches for the period of record from 1948-2018. The HELP model generated synthetic precipitation data using the weather pattern from San Diego, California. This synthetically generated data resulted in an average annual precipitation of 13.34 over the five-year model period. Table 1 provides the synthetic monthly precipitation values for San Diego along with the scaled values for each month.

Table 1: Average Monthly Precipitation

	Synthetic San Diego Precipitation (in)	Scaled to 12.76 (in)
January	4.65	2.49
February	3.23	2.24
March	2.64	1.95
April	1.53	1.39
May	0.32	0.38

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1000 Enterprise Way, Suite 190, Roseville, California, USA 95678
T: +1 916 786-2424 F: +1 916 786-2434

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	Synthetic San Diego Precipitation (in)	Scaled to 12.76 (in)
June	0.11	0.10
July	0.03	0.01
August	0.05	0.02
September	0.19	0.19
October	1.06	0.52
November	2.35	1.50
December	3.55	1.97
Total	19.71	12.76

The synthetic weather generator routine in the HELP model was used to generate 5 years of weather data. The average annual precipitation for the synthetically generated 5-year period equaled 13.34 inches which is greater than the average annual precipitation of 12.76 inches for the site.

Along the floor, the following layers were modeled (from top to bottom):

- Daily Cover (Thickness: 12 inches)
- Treated Soil (Thickness: 120 inches)
- Operations Layer (Thickness: 12 inches)
- Geotextile (8oz/sy) (Thickness: 0.2 inches)
- LCRS Gravel (Thickness: 12 inches)
- Geotextile (8oz/sy) (Thickness: 0.2 inches)
- HDPE Geomembrane (Thickness: 60 mil) with Geotextile (8oz/sy)
- Geosynthetic Clay Liner (GCL) (Thickness: 0.25 inches)
- Double Sided Geocomposite (Thickness: 0.2 inches)
- HDPE Geomembrane (Thickness: 60 mil)
- Compacted Clay Layer (Thickness: 12 inches)

For the LCRS layer, the drainage length and slope were 344 feet and 3.6%, respectively. The placement quality of the geomembrane was assumed to be “Geotextile separating geomembrane liner and drainage limiting soil” for the primary geomembrane and “Good” for the second geomembrane with up to one defect per acre.

Each layer was assigned a hydraulic conductivity value as listed in Table 2. To simulate a worst-case condition, it was assumed that a single, 10-foot thick layer of treated waste was in place with any intermediate cover.

Table 2: Layer Material Properties

Layer	Hydraulic Conductivity/Transmissivity
Daily Cover	2.10×10^{-3} (cm/sec)
Treated Soil	1.00×10^{-3} (cm/sec)
Operations Layer	2.10×10^{-4} (cm/sec)
Geotextile (default)	10.00 (cm^2/sec)
LCRS Gravel	1.0 (cm/sec)
Geomembrane with geotextile (default)	2.00×10^{-13} (cm/sec)
GCL (default)	3.00×10^{-9} (cm/sec)
Geocomposite (default)	10.00 (cm^2/sec)
Geomembrane (default)	2.0×10^{-13} (cm/sec)
Clay Layer	1.00×10^{-7} (cm/sec)

4.0 Conclusions

Golder modeled the liner system for the proposed soil management area. A summary of the results of the HELP model analysis is shown in Table 3. The reported values include peak daily values for flow in the LCRS and maximum head above the geomembrane liner. The HELP model analysis is included as Attachment A.

Table 3: Results of the HELP Analysis

Description	Average Annual Precipitation (in)	Peak Annual Precipitation (in)	Peak Daily Head Above Geomembrane Liner (in)	Peak Daily Leachate Volume (cf/ac/day)	Peak Daily Leachate Volume (gal/ac/day)
Soil Management Area Floor	13.34	18.63	2.218	755	5,648

The peak daily leachate volume from the LCRS is approximately 755 cubic feet per acre per day. This results in a peak daily head above the geomembrane liner of 2.218 inches, which is less than the 12 inches allowed by EPA Subtitle D.

ATTACHMENT A

HELP ANALYSIS

```
**********************************************************************
**********************************************************************
**                                                                  **
**                                                                  **
**              HYDROLOGIC EVALUATION OF LANDFILL PERFORMANCE        **
**                HELP MODEL VERSION 3.07  (1 NOVEMBER 1997)        **
**                  DEVELOPED BY ENVIRONMENTAL LABORATORY           **
**                    USAE WATERWAYS EXPERIMENT STATION             **
**             FOR USEPA RISK REDUCTION ENGINEERING LABORATORY       **
**                                                                  **
**                                                                  **
**********************************************************************
**********************************************************************


PRECIPITATION DATA FILE:    C:\CHEVGUAD\GUAD4-1.D4
TEMPERATURE DATA FILE:      C:\CHEVGUAD\GUAD7.D7
SOLAR RADIATION DATA FILE:  C:\CHEVGUAD\GUAD13.D13
EVAPOTRANSPIRATION DATA:    C:\CHEVGUAD\GUAD11.D11
SOIL AND DESIGN DATA FILE:  C:\CHEVGUAD\GUAD10.D10
OUTPUT DATA FILE:           C:\CHEVGUAD\GUADOUT1.OUT


TIME:  11:34     DATE:   4/15/2020


**********************************************************************

     TITLE:  1ft cover on 10ft soil with high permeability, Chevron Guada

**********************************************************************


     NOTE:  INITIAL MOISTURE CONTENT OF THE LAYERS AND SNOW WATER WERE
               COMPUTED AS NEARLY STEADY-STATE VALUES BY THE PROGRAM.


                                LAYER  1
                                --------

                    TYPE 1 - VERTICAL PERCOLATION LAYER
                        MATERIAL TEXTURE NUMBER   0
          THICKNESS                     =     12.00   INCHES
```

```
POROSITY                    =      0.6710 VOL/VOL
FIELD CAPACITY              =      0.2920 VOL/VOL
WILTING POINT               =      0.0770 VOL/VOL
INITIAL SOIL WATER CONTENT  =      0.1856 VOL/VOL
EFFECTIVE SAT. HYD. COND.   =  0.209999993000E-02 CM/SEC
```

LAYER 2

```
          TYPE 1 - VERTICAL PERCOLATION LAYER
              MATERIAL TEXTURE NUMBER   0
THICKNESS                   =    120.00   INCHES
POROSITY                    =      0.5010 VOL/VOL
FIELD CAPACITY              =      0.2840 VOL/VOL
WILTING POINT               =      0.1350 VOL/VOL
INITIAL SOIL WATER CONTENT  =      0.2691 VOL/VOL
EFFECTIVE SAT. HYD. COND.   =  0.100000005000E-02 CM/SEC
```

LAYER 3

```
          TYPE 1 - VERTICAL PERCOLATION LAYER
              MATERIAL TEXTURE NUMBER   0
THICKNESS                   =     12.00   INCHES
POROSITY                    =      0.5010 VOL/VOL
FIELD CAPACITY              =      0.2840 VOL/VOL
WILTING POINT               =      0.1350 VOL/VOL
INITIAL SOIL WATER CONTENT  =      0.2840 VOL/VOL
EFFECTIVE SAT. HYD. COND.   =  0.209999993000E-02 CM/SEC
```

LAYER 4

```
          TYPE 1 - VERTICAL PERCOLATION LAYER
              MATERIAL TEXTURE NUMBER  20
THICKNESS                   =      0.20   INCHES
POROSITY                    =      0.8500 VOL/VOL
FIELD CAPACITY              =      0.0100 VOL/VOL
WILTING POINT               =      0.0050 VOL/VOL
INITIAL SOIL WATER CONTENT  =      0.0334 VOL/VOL
EFFECTIVE SAT. HYD. COND.   =   10.0000000000     CM/SEC
```

LAYER 5

TYPE 2 - LATERAL DRAINAGE LAYER
MATERIAL TEXTURE NUMBER 0

THICKNESS	=	12.00	INCHES
POROSITY	=	0.3970	VOL/VOL
FIELD CAPACITY	=	0.0320	VOL/VOL
WILTING POINT	=	0.0130	VOL/VOL
INITIAL SOIL WATER CONTENT	=	0.0320	VOL/VOL
EFFECTIVE SAT. HYD. COND.	=	0.300000012000	CM/SEC
SLOPE	=	3.60	PERCENT
DRAINAGE LENGTH	=	344.0	FEET

LAYER 6

TYPE 4 - FLEXIBLE MEMBRANE LINER
MATERIAL TEXTURE NUMBER 35

THICKNESS	=	0.06	INCHES
POROSITY	=	0.0000	VOL/VOL
FIELD CAPACITY	=	0.0000	VOL/VOL
WILTING POINT	=	0.0000	VOL/VOL
INITIAL SOIL WATER CONTENT	=	0.0000	VOL/VOL
EFFECTIVE SAT. HYD. COND.	=	0.199999996000E-12	CM/SEC
FML PINHOLE DENSITY	=	1.00	HOLES/ACRE
FML INSTALLATION DEFECTS	=	1.00	HOLES/ACRE
FML PLACEMENT QUALITY	=	6 - W/ GEOTEXTILE	
GEOTEXTILE TRANSMISSIVITY	=	0.000010	CM*CM/SEC

LAYER 7

TYPE 3 - BARRIER SOIL LINER
MATERIAL TEXTURE NUMBER 16

THICKNESS	=	12.00	INCHES
POROSITY	=	0.4270	VOL/VOL
FIELD CAPACITY	=	0.4180	VOL/VOL
WILTING POINT	=	0.3670	VOL/VOL
INITIAL SOIL WATER CONTENT	=	0.4270	VOL/VOL

EFFECTIVE SAT. HYD. COND. = 0.100000001000E-06 CM/SEC

GENERAL DESIGN AND EVAPORATIVE ZONE DATA

NOTE: SCS RUNOFF CURVE NUMBER WAS COMPUTED FROM DEFAULT SOIL DATA BASE USING SOIL TEXTURE # 9 WITH BARE GROUND CONDITIONS, A SURFACE SLOPE OF 1.% AND A SLOPE LENGTH OF 1800. FEET.

SCS RUNOFF CURVE NUMBER	=	90.80	
FRACTION OF AREA ALLOWING RUNOFF	=	100.0	PERCENT
AREA PROJECTED ON HORIZONTAL PLANE	=	1.000	ACRES
EVAPORATIVE ZONE DEPTH	=	24.0	INCHES
INITIAL WATER IN EVAPORATIVE ZONE	=	3.849	INCHES
UPPER LIMIT OF EVAPORATIVE STORAGE	=	14.064	INCHES
LOWER LIMIT OF EVAPORATIVE STORAGE	=	2.544	INCHES
INITIAL SNOW WATER	=	0.000	INCHES
INITIAL WATER IN LAYER MATERIALS	=	43.443	INCHES
TOTAL INITIAL WATER	=	43.443	INCHES
TOTAL SUBSURFACE INFLOW	=	0.00	INCHES/YEAR

EVAPOTRANSPIRATION AND WEATHER DATA

NOTE: EVAPOTRANSPIRATION DATA WAS OBTAINED FROM Guadalupe CALIFORNIA

STATION LATITUDE	=	38.40	DEGREES
MAXIMUM LEAF AREA INDEX	=	1.00	
START OF GROWING SEASON (JULIAN DATE)	=	73	
END OF GROWING SEASON (JULIAN DATE)	=	319	
EVAPORATIVE ZONE DEPTH	=	24.0	INCHES
AVERAGE ANNUAL WIND SPEED	=	8.10	MPH
AVERAGE 1ST QUARTER RELATIVE HUMIDITY	=	77.00	%
AVERAGE 2ND QUARTER RELATIVE HUMIDITY	=	60.00	%
AVERAGE 3RD QUARTER RELATIVE HUMIDITY	=	55.00	%
AVERAGE 4TH QUARTER RELATIVE HUMIDITY	=	73.00	%

NOTE: PRECIPITATION DATA WAS SYNTHETICALLY GENERATED USING COEFFICIENTS FOR SAN DIEGO CALIFORNIA

NORMAL MEAN MONTHLY PRECIPITATION (INCHES)

JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
2.49	2.24	1.95	1.39	0.38	0.10
0.01	0.02	0.19	0.52	1.50	1.97

NOTE: TEMPERATURE DATA WAS SYNTHETICALLY GENERATED USING
COEFFICIENTS FOR SANTA MARIA CALIFORNIA

NORMAL MEAN MONTHLY TEMPERATURE (DEGREES FAHRENHEIT)

JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
50.80	52.30	52.40	54.20	56.80	59.80
62.30	63.10	63.00	60.50	55.50	51.40

NOTE: SOLAR RADIATION DATA WAS SYNTHETICALLY GENERATED USING
COEFFICIENTS FOR SANTA MARIA CALIFORNIA
AND STATION LATITUDE = 38.40 DEGREES

****

MONTHLY TOTALS (IN INCHES) FOR YEAR 1

	JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
PRECIPITATION	0.91	0.26	2.70	2.06	0.01	0.09
	0.00	0.00	0.00	0.39	0.95	1.13
RUNOFF	0.000	0.000	0.115	0.192	0.000	0.000
	0.000	0.000	0.000	0.000	0.000	0.001
EVAPOTRANSPIRATION	0.881	0.447	1.554	2.420	1.607	0.088
	0.031	0.000	0.000	0.114	0.864	0.614
LATERAL DRAINAGE COLLECTED	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001
FROM LAYER 5	0.0001	0.0001	0.0000	0.0000	0.0000	0.0000

PERCOLATION/LEAKAGE THROUGH	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
LAYER 7	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000

MONTHLY SUMMARIES FOR DAILY HEADS (INCHES)

AVERAGE DAILY HEAD ON	0.000	0.000	0.000	0.000	0.000	0.000
TOP OF LAYER 6	0.000	0.000	0.000	0.000	0.000	0.000
STD. DEVIATION OF DAILY	0.000	0.000	0.000	0.000	0.000	0.000
HEAD ON TOP OF LAYER 6	0.000	0.000	0.000	0.000	0.000	0.000

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ANNUAL TOTALS FOR YEAR 1

	INCHES	CU. FEET	PERCENT
PRECIPITATION	8.50	30855.004	100.00
RUNOFF	0.308	1118.374	3.62
EVAPOTRANSPIRATION	8.621	31292.555	101.42
DRAINAGE COLLECTED FROM LAYER 5	0.0008	2.839	0.01
PERC./LEAKAGE THROUGH LAYER 7	0.000003	0.009	0.00
AVG. HEAD ON TOP OF LAYER 6	0.0000		
CHANGE IN WATER STORAGE	-0.429	-1558.796	-5.05
SOIL WATER AT START OF YEAR	43.443	157699.156	
SOIL WATER AT END OF YEAR	43.014	156140.359	
SNOW WATER AT START OF YEAR	0.000	0.000	0.00
SNOW WATER AT END OF YEAR	0.000	0.000	0.00
ANNUAL WATER BUDGET BALANCE	0.0000	0.022	0.00

****

****

MONTHLY TOTALS (IN INCHES) FOR YEAR 2

	JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
PRECIPITATION	2.97	0.76	3.06	0.00	0.52	0.00
	0.00	0.00	0.00	1.30	1.76	1.61
RUNOFF	0.133	0.000	0.037	0.000	0.000	0.000
	0.000	0.000	0.000	0.151	0.064	0.000
EVAPOTRANSPIRATION	1.131	1.708	2.650	1.203	0.908	0.407
	0.000	0.000	0.000	0.282	0.908	1.309
LATERAL DRAINAGE COLLECTED	0.0000	0.0000	0.0000	0.0000	0.0000	0.0058
FROM LAYER 5	0.0011	0.0005	0.0003	0.0002	0.0002	0.0002
PERCOLATION/LEAKAGE THROUGH	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
LAYER 7	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000

MONTHLY SUMMARIES FOR DAILY HEADS (INCHES)

AVERAGE DAILY HEAD ON	0.000	0.000	0.000	0.000	0.000	0.001
TOP OF LAYER 6	0.000	0.000	0.000	0.000	0.000	0.000
STD. DEVIATION OF DAILY	0.000	0.000	0.000	0.000	0.000	0.001
HEAD ON TOP OF LAYER 6	0.000	0.000	0.000	0.000	0.000	0.000

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ANNUAL TOTALS FOR YEAR 2

	INCHES	CU. FEET	PERCENT
PRECIPITATION	11.98	43487.391	100.00
RUNOFF	0.384	1395.735	3.21
EVAPOTRANSPIRATION	10.506	38136.809	87.70
DRAINAGE COLLECTED FROM LAYER 5	0.0085	30.960	0.07
PERC./LEAKAGE THROUGH LAYER 7	0.000003	0.009	0.00
AVG. HEAD ON TOP OF LAYER 6	0.0001		
CHANGE IN WATER STORAGE	1.081	3923.896	9.02
SOIL WATER AT START OF YEAR	43.014	156140.359	
SOIL WATER AT END OF YEAR	44.095	160064.266	
SNOW WATER AT START OF YEAR	0.000	0.000	0.00
SNOW WATER AT END OF YEAR	0.000	0.000	0.00
ANNUAL WATER BUDGET BALANCE	0.0000	-0.018	0.00

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MONTHLY TOTALS (IN INCHES) FOR YEAR 3

	JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
PRECIPITATION	3.63	6.82	1.43	1.13	0.63	0.02
	0.00	0.00	0.00	2.76	1.15	1.06
RUNOFF	0.159	2.245	0.004	0.031	0.000	0.000
	0.000	0.000	0.000	0.302	0.000	0.000
EVAPOTRANSPIRATION	1.381	1.915	1.619	1.018	1.849	1.243
	0.005	0.000	0.000	2.225	1.027	0.824

LATERAL DRAINAGE COLLECTED	0.0060	2.2252	1.7763	0.0721	0.0652	0.0013
FROM LAYER 5	0.0006	0.0003	0.0002	0.0002	0.0001	0.0001
PERCOLATION/LEAKAGE THROUGH	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
LAYER 7	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000

MONTHLY SUMMARIES FOR DAILY HEADS (INCHES)

AVERAGE DAILY HEAD ON	0.001	0.447	0.322	0.014	0.012	0.000
TOP OF LAYER 6	0.000	0.000	0.000	0.000	0.000	0.000
STD. DEVIATION OF DAILY	0.005	0.454	0.290	0.026	0.017	0.000
HEAD ON TOP OF LAYER 6	0.000	0.000	0.000	0.000	0.000	0.000

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ANNUAL TOTALS FOR YEAR 3

	INCHES	CU. FEET	PERCENT
PRECIPITATION	18.63	67626.914	100.00
RUNOFF	2.741	9948.184	14.71
EVAPOTRANSPIRATION	13.105	47571.625	70.34
DRAINAGE COLLECTED FROM LAYER 5	4.1479	15056.876	22.26
PERC./LEAKAGE THROUGH LAYER 7	0.000007	0.025	0.00
AVG. HEAD ON TOP OF LAYER 6	0.0664		
CHANGE IN WATER STORAGE	-1.364	-4949.819	-7.32
SOIL WATER AT START OF YEAR	44.095	160064.266	
SOIL WATER AT END OF YEAR	42.731	155114.437	
SNOW WATER AT START OF YEAR	0.000	0.000	0.00
SNOW WATER AT END OF YEAR	0.000	0.000	0.00

ANNUAL WATER BUDGET BALANCE	0.0000	0.026	0.00

****

****

MONTHLY TOTALS (IN INCHES) FOR YEAR 4

	JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
PRECIPITATION	3.16	3.27	1.72	1.41	0.00	0.00
	0.00	0.00	0.56	0.93	2.73	1.27
RUNOFF	0.333	0.290	0.079	0.012	0.000	0.000
	0.000	0.000	0.000	0.000	0.028	0.044
EVAPOTRANSPIRATION	0.860	1.772	2.732	1.646	1.211	0.980
	0.000	0.000	0.299	0.362	1.213	1.291
LATERAL DRAINAGE COLLECTED	0.0001	0.0001	0.2259	0.0093	0.0008	0.0004
FROM LAYER 5	0.0003	0.0002	0.0002	0.0001	0.0001	0.0001
PERCOLATION/LEAKAGE THROUGH	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
LAYER 7	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000

MONTHLY SUMMARIES FOR DAILY HEADS (INCHES)

AVERAGE DAILY HEAD ON	0.000	0.000	0.041	0.002	0.000	0.000
TOP OF LAYER 6	0.000	0.000	0.000	0.000	0.000	0.000
STD. DEVIATION OF DAILY	0.000	0.000	0.038	0.003	0.000	0.000
HEAD ON TOP OF LAYER 6	0.000	0.000	0.000	0.000	0.000	0.000

****

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ANNUAL TOTALS FOR YEAR 4

	INCHES	CU. FEET	PERCENT
PRECIPITATION	15.05	54631.512	100.00
RUNOFF	0.786	2851.636	5.22
EVAPOTRANSPIRATION	12.365	44885.160	82.16
DRAINAGE COLLECTED FROM LAYER 5	0.2377	862.714	1.58
PERC./LEAKAGE THROUGH LAYER 7	0.000003	0.010	0.00
AVG. HEAD ON TOP OF LAYER 6	0.0036		
CHANGE IN WATER STORAGE	1.662	6032.003	11.04
SOIL WATER AT START OF YEAR	42.731	155114.437	
SOIL WATER AT END OF YEAR	44.393	161146.437	
SNOW WATER AT START OF YEAR	0.000	0.000	0.00
SNOW WATER AT END OF YEAR	0.000	0.000	0.00
ANNUAL WATER BUDGET BALANCE	0.0000	-0.013	0.00

****

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MONTHLY TOTALS (IN INCHES) FOR YEAR 5

	JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
PRECIPITATION	3.57	1.83	3.26	0.39	0.35	0.00
	0.00	0.00	0.00	1.29	1.33	0.54
RUNOFF	0.503	0.078	0.170	0.000	0.000	0.000
	0.000	0.000	0.000	0.029	0.122	0.000
EVAPOTRANSPIRATION	1.383	1.805	2.491	1.962	0.756	1.395

	0.230	0.000	0.000	0.465	0.721	1.267
LATERAL DRAINAGE COLLECTED	0.3456	0.1259	0.2016	0.2027	0.0023	0.0006
FROM LAYER 5	0.0004	0.0003	0.0002	0.0002	0.0001	0.0001
PERCOLATION/LEAKAGE THROUGH	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
LAYER 7	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000

MONTHLY SUMMARIES FOR DAILY HEADS (INCHES)

AVERAGE DAILY HEAD ON	0.063	0.025	0.037	0.038	0.000	0.000
TOP OF LAYER 6	0.000	0.000	0.000	0.000	0.000	0.000
STD. DEVIATION OF DAILY	0.112	0.031	0.026	0.032	0.000	0.000
HEAD ON TOP OF LAYER 6	0.000	0.000	0.000	0.000	0.000	0.000

****

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ANNUAL TOTALS FOR YEAR 5

	INCHES	CU. FEET	PERCENT
PRECIPITATION	12.56	45592.805	100.00
RUNOFF	0.902	3274.212	7.18
EVAPOTRANSPIRATION	12.476	45286.090	99.33
DRAINAGE COLLECTED FROM LAYER 5	0.8801	3194.620	7.01
PERC./LEAKAGE THROUGH LAYER 7	0.000003	0.012	0.00
AVG. HEAD ON TOP OF LAYER 6	0.0136		
CHANGE IN WATER STORAGE	-1.698	-6162.141	-13.52
SOIL WATER AT START OF YEAR	44.393	161146.437	
SOIL WATER AT END OF YEAR	42.695	154984.297	
SNOW WATER AT START OF YEAR	0.000	0.000	0.00

SNOW WATER AT END OF YEAR	0.000	0.000	0.00
ANNUAL WATER BUDGET BALANCE	0.0000	0.011	0.00

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AVERAGE MONTHLY VALUES IN INCHES FOR YEARS 1 THROUGH 5

	JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
PRECIPITATION						
TOTALS	2.85	2.59	2.43	1.00	0.30	0.02
	0.00	0.00	0.11	1.33	1.58	1.12
STD. DEVIATIONS	1.12	2.63	0.82	0.82	0.29	0.04
	0.00	0.00	0.25	0.88	0.71	0.39
RUNOFF						
TOTALS	0.226	0.523	0.081	0.047	0.000	0.000
	0.000	0.000	0.000	0.096	0.043	0.009
STD. DEVIATIONS	0.195	0.970	0.065	0.082	0.000	0.000
	0.000	0.000	0.000	0.131	0.051	0.019
EVAPOTRANSPIRATION						
TOTALS	1.127	1.529	2.209	1.650	1.266	0.823
	0.053	0.000	0.060	0.689	0.947	1.061
STD. DEVIATIONS	0.256	0.610	0.575	0.568	0.460	0.557
	0.100	0.000	0.134	0.868	0.185	0.321
LATERAL DRAINAGE COLLECTED FROM LAYER 5						
TOTALS	0.0704	0.4703	0.4408	0.0569	0.0137	0.0016
	0.0005	0.0003	0.0002	0.0002	0.0001	0.0001
STD. DEVIATIONS	0.1539	0.9826	0.7542	0.0869	0.0288	0.0024
	0.0004	0.0002	0.0001	0.0001	0.0001	0.0000

PERCOLATION/LEAKAGE THROUGH LAYER 7

TOTALS	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
STD. DEVIATIONS	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000

AVERAGES OF MONTHLY AVERAGED DAILY HEADS (INCHES)

DAILY AVERAGE HEAD ON TOP OF LAYER 6

AVERAGES	0.0128	0.0945	0.0800	0.0107	0.0025	0.0003
	0.0001	0.0001	0.0000	0.0000	0.0000	0.0000
STD. DEVIATIONS	0.0279	0.1974	0.1369	0.0163	0.0052	0.0004
	0.0001	0.0000	0.0000	0.0000	0.0000	0.0000

AVERAGE ANNUAL TOTALS & (STD. DEVIATIONS) FOR YEARS 1 THROUGH 5

	INCHES		CU. FEET	PERCENT
PRECIPITATION	13.34	(3.768)	48438.7	100.00
RUNOFF	1.024	(0.9924)	3717.63	7.675
EVAPOTRANSPIRATION	11.414	(1.8384)	41434.45	85.540
LATERAL DRAINAGE COLLECTED FROM LAYER 5	1.05499	(1.76573)	3829.602	7.90607
PERCOLATION/LEAKAGE THROUGH LAYER 7	0.00000	(0.00000)	0.013	0.00003
AVERAGE HEAD ON TOP OF LAYER 6	0.017	(0.028)		
CHANGE IN WATER STORAGE	-0.150	(1.4785)	-542.97	-1.121

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PEAK DAILY VALUES FOR YEARS 1 THROUGH 5

	(INCHES)	(CU. FT.)
PRECIPITATION	2.42	8784.601
RUNOFF	1.018	3693.6809
DRAINAGE COLLECTED FROM LAYER 5	0.20767	753.84296
PERCOLATION/LEAKAGE THROUGH LAYER 7	0.000000	0.00081
AVERAGE HEAD ON TOP OF LAYER 6	1.168	
MAXIMUM HEAD ON TOP OF LAYER 6	2.218	
LOCATION OF MAXIMUM HEAD IN LAYER 5 (DISTANCE FROM DRAIN)	17.0 FEET	
SNOW WATER	0.00	0.0000

MAXIMUM VEG. SOIL WATER (VOL/VOL) 0.3446

MINIMUM VEG. SOIL WATER (VOL/VOL) 0.1060

*** Maximum heads are computed using McEnroe's equations. ***

Reference: Maximum Saturated Depth over Landfill Liner
by Bruce M. McEnroe, University of Kansas
ASCE Journal of Environmental Engineering
Vol. 119, No. 2, March 1993, pp. 262-270.

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FINAL WATER STORAGE AT END OF YEAR 5

LAYER	(INCHES)	(VOL/VOL)
1	1.4732	0.1228
2	32.2995	0.2692
3	3.4080	0.2840
4	0.0066	0.0330
5	0.3840	0.0320
6	0.0000	0.0000
7	5.1240	0.4270
SNOW WATER	0.000	

****
****

ATTACHMENT B

LCRS CALCULATIONS

GOLDER

CALCULATIONS

Date:	1-Jun-20	**Made by:**	C. Z. Grubbs
Project No.:	1783552	**Checked by:**	E. Domek
Subject:	LCRS Capacity Calculations	**Reviewed by:**	R. Haughey
Project Short Title:	Guadalupe Restoration Project- Tank Battery 9 Area		

1.0 LCRS Drainage Layer Capacity

Darcy's Law was used to calculate the head on the liner. The horizontal lengths and slopes heights were obtained from measuring the proposed Base Grade Plan in AutoCAD Civil 3D 2019. The impingement rate was calculated using the HELP Model . A minimum factor of safety of 2 is required.

Soil Management Area

Input			**8-inch SDR17**	
qi		cf/acre/day	753	HELP Model
Liquid Impingement rate	q_i	in/day	0.207	
Liquid Impingement rate	q_i	ft/sec	2.0E-07	
Liquid Impingement rate	Q_i	cfs	6.9E-05	$Q_i = q_i * L * w$
Slope Height	H	ft	12	From AutoCAD Civil 3D
Horizontal length	L	ft	344	From AutoCAD Civil 3D Longest flow path
Hydraulic Gradient	i	ft/ft	0.036	$i = \frac{H}{L}$
Thickness of Drainage Gravel Layer	t	ft	1.00	From Design Drawings
Permeability per Measure	K_{spec}	cm/s	1.00	Minimum per spec
Permeability per Measure	K_{spec}	ft/sec	0.03	
Head on liner, h	h	ft	0.0583	$h = \frac{Q_i}{i * K_{spec} * w}$
Factor of Safety			17.2	
MAXIMUM HEAD CHECK			**PASS**	

GOLDER

CALCULATIONS

Date:	1-Jun-20	**Made by:**	C. Z. Grubbs
Project No.:	1783552	**Checked by:**	E. Domek
Subject:	LCRS Capacity Calculations	**Reviewed by:**	R. Haughey
Project Short Title:	Guadalupe Restoration Project- Tank Battery 9 Area		

2.0 LCRS Pipe Capacity

The methodology used for these calculations was using manning's equation to calculate full flow capacity for the cell. The horizontal length and slope height were obtained from measuring the Base Grade Plans in AutoCAD Civil 3D 2019. The impingement rate was calculated using the HELP model. This leachate production rate was used to determine the volume of leachate in the LCRS system and compared to the full flow capacity of the pipe. A minimum factor of safety of 2 is required for the flow capacity.

Input		Unit	8-inch SDR17	Notes:
Cell Area		acres	17.7	From AutoCAD Civil 3D
Liquid Impingement rate	q_i	cf/day/acre	599.65	HELP Model
Liquid Impingement rate	q_i	cf/day	10,592.127	
Liquid Impingement rate	q_i	cfs	0.123	
Pipe length	L	ft	1327	From AutoCAD Civil 3D
Slope	S	ft/ft	0.02	From AutoCAD Civil 3D
Pipe Outer Diameter	D_o	in	8.625	
Dimension Ratio	DR		17.0	
Wall Thickness	t	in	0.507	$t = \frac{D_o}{DR}$
Pipe Inner Diameter	D_i	in	7.610	$D_i = D_o - t$
Area of Pipe	A	ft^2	0.316	
Hydraulic Radius	R	ft	0.159	Assumed full flow pipe R= D/4
Full Flow Capacity	Q	cfs	1.625	$Q = \left(\frac{1.49}{n}\right) AR^{2/3}\sqrt{S}$ Assume n = 0.012 for HDPE.
Factor of Safety			13	
F.O.S. CHECK			**Pass**	

APPENDIX M

Conceptual Stormwater Management Plans

NOTE(S)

1. CONTOURS SHOW ON THIS MAP WERE PREPARED USING PHOTOGRAMMETRIC METHODS BY CENTRAL COAST AERIAL MAPPING, INC. DATE OF TOPOGRAPHY: JANUARY 2020.
2. AERIAL IMAGERY PROVIDED BY BING, DATE: UNKNOWN.

CLIENT
CHEVRON ENVIRONMENTAL MANAGEMENT COMPANY
2184 WEST THORNBERRY ROAD
GUADALUPE, CA 93434

CONSULTANT
GOLDER

YYYY-MM-DD	2020-06-05
DESIGNED	MAG
PREPARED	MAG
REVIEWED	LMA
APPROVED	RVH

PROJECT
GUADALUPE RESTORATION PROJECT
SOIL MANAGEMENT AREA
TANK BATTERY 9 AREA

TITLE
MATERIAL LAYDOWN AREAS

PROJECT NO.	REV.	FIGURE
1783552	0	1

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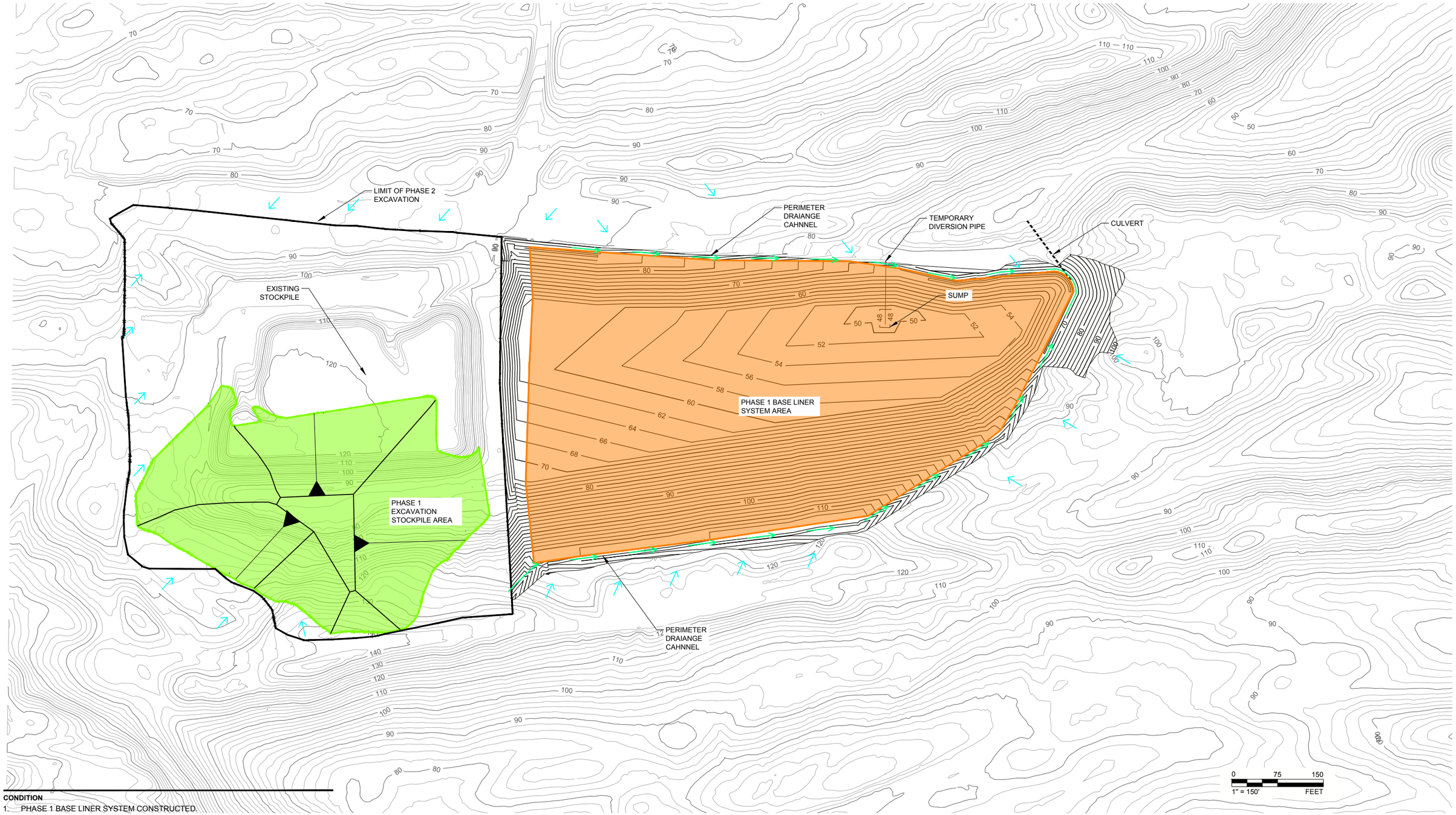

CONDITION

1. PHASE 1 BASE LINER SYSTEM CONSTRUCTED.
2. NO IMPACTED SOILS PLACED IN PHASE 1 AREA.

STORMWATER MANAGEMENT

1. STORMWATER MANAGEMENT SYSTEM IN-PLACE.
2. UNTIL IMPACTED SOIL IS PLACED IN PHASE 1 RUN-OFF IS CLEAN AND DIVERTED TO NATURAL DRAINAGE.
3. RUN-OFF FROM IMPACTED SOILS IN THE PHASE 2 AREA MANAGED PER CURRENT OPERATING PROCEDURES.

NOTE(S)

1. THIS MAP WAS PREPARED USING PHOTOGRAMMETRIC METHODS BY CENTRAL COAST AERIAL MAPPING, INC. DATE OF TOPOGRAPHY: JANUARY 2020.

LEGEND

- BASE LINER SYSTEM AREA
- PERIMETER DRAINAGE CHANNEL
- CULVERT
- SURFACE WATER DRAINAGE DIRECTION

CLIENT
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2184 WEST THORNBERRY ROAD
GUADALUPE, CA 93434

CONSULTANT
GOLDER

YYYY-MM-DD	2020-06-08
DESIGNED	MAG
PREPARED	MAG
REVIEWED	LMA
APPROVED	RVH

PROJECT
GUADALUPE RESTORATION PROJECT
SOIL MANAGEMENT AREA
TANK BATTERY 9 AREA

TITLE
PHASE 1 BASE LINER CONSTRUCTION COMPLETED IMPACTED SOILS STOCKPILED

PROJECT NO.	REV.	FIGURE
1783552	0	2

IF THIS MEASUREMENT DOES NOT MATCH WHAT IS SHOWN, THE SHEET SIZE HAS BEEN MODIFIED FROM: ANSI B

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TO TEMPORARY STORAGE

TEMPORARY HDPE COLLECTION PIPES

GRAVEL PAD FOR PUMP & GENERATOR

DIESEL POWERED GENERATOR AND 500 GPM PUMP

PERIMETER DRAIANGE CAHNNEL

CULVERT

VISQUEEN LINED RUN-OFF COLLECTION POINT

PHASE 2 EXCAVATION AREA

PERIMETER DRAIANGE CAHNNEL

0 75 150
1" = 150' FEET

CONDITION

1. PHASE 1 BASE LINER SYSTEM CONSTRUCTED AND IMPACTED SOILS FROM PHASE 2 AREA HAVE BEEN EXCAVATED AND PLACED IN THE LINED PHASE 1 AREA.

STORMWATER MANAGEMENT

1. RUN-OFF FROM THE PHASE 1 AREA IS DIRECTED TO THE COLLECTION POINT.
2. WATER ACCUMULATED AT THE COLLECTION POINT IS IMMEDIATELY PUMPED TO THE TEMPORARY STORAGEAND THEN TRANSFERED TO THE AWTS.

NOTE(S)

1. THIS MAP WAS PREPARED USING PHOTOGRAMMETRIC METHODS BY CENTRAL COAST AERIAL MAPPING, INC. DATE OF TOPOGRAPHY: JANUARY 2020.

LEGEND

- BASE LINER SYSTEM AREA
- FILL AREA BELOW SURROUNDING GRADE
- RUNOFF COLLECTION BASIN AREA
- PERIMETER DRAINAGE CHANNEL
- CULVERT
- SURFACE WATER DRAINAGE DIRECTION

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2184 WEST THORNBERRY ROAD
GUADALUPE, CA 93434

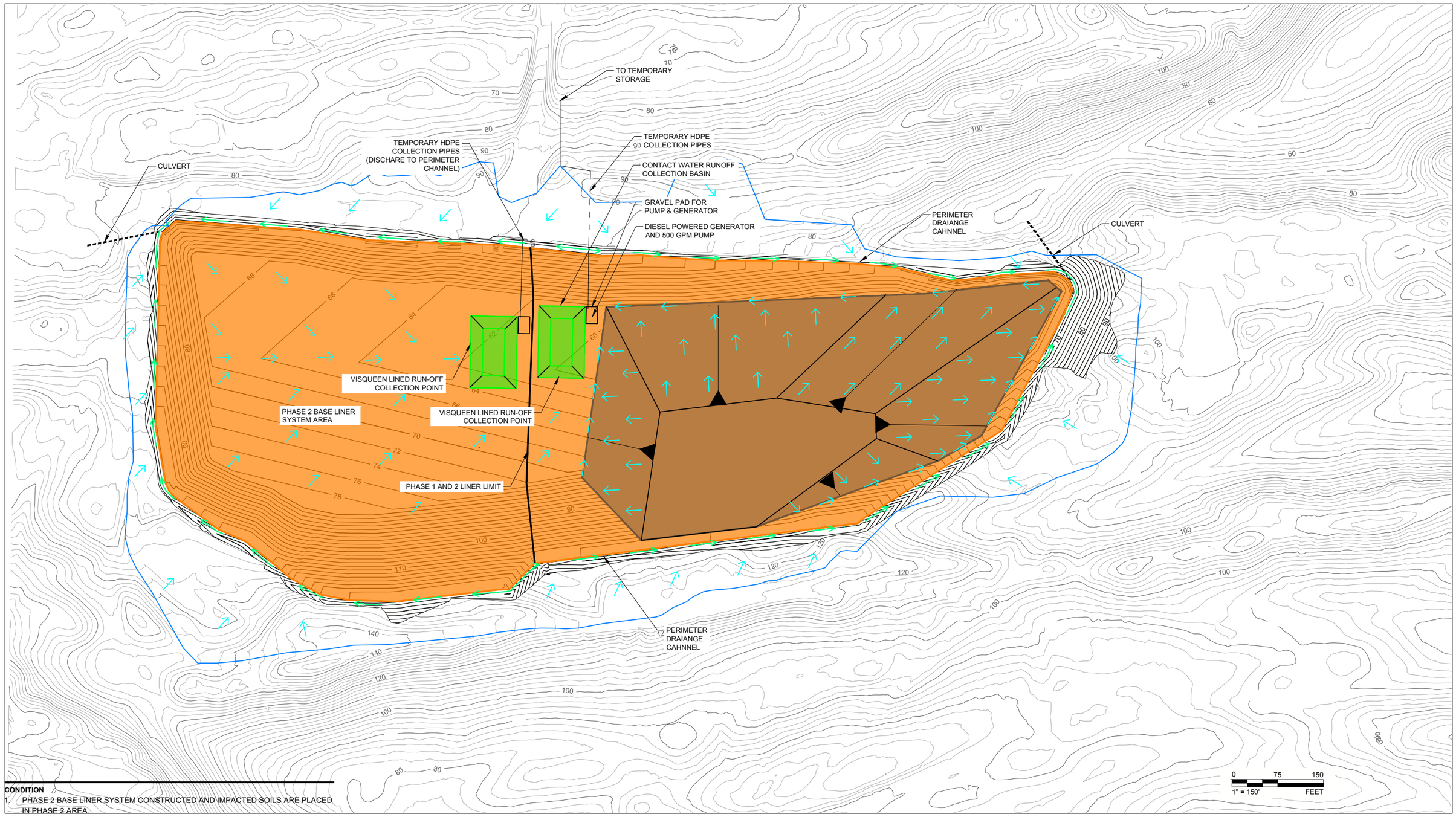
GOLDER

2020-06-08	
MAG	
MAG	
LMA	
RVH	

GUADALUPE RESTORATION PROJECT
SOIL MANAGEMENT AREA
TANK BATTERY 9 AREA

SMA PHASE 1 CONSTRUCTION COMPLETE
EXCAVATION OF PHASE 2 AREA COMPLETE

1783552 0 FIGURE 3



CONDITION

1. PHASE 2 BASE LINER SYSTEM CONSTRUCTED AND IMPACTED SOILS ARE PLACED IN PHASE 2 AREA.
2. RUN-OFF FORM PHASE 2 IS NON-CONTACT WATER.
3. FUTURE IMPACTED SOIL PLACEMENT: ALIGNMENTS STABILITY BERM, BUT FOCUSES ON FILLIN IN THE PHASE 1 AREA.

STORMWATER MANAGEMENT

1. SECOND COLLECTION PINT SET IN PHASE 2 AREA TO DIVERT CLEAN RUN-OFF.
2. RUN-OFF FROM PHASE 1 AND THE STABILITY BERM IS CONSIDERED CONTACT WATER REQUIRING TREATMENT.

NOTE(S)

1. THIS MAP WAS PREPARED USING PHOTOGRAMMETRIC METHODS BY CENTRAL COAST AERIAL MAPPING, INC. DATE OF TOPOGRAPHY: JANUARY 2020.

LEGEND

- BASE LINER SYSTEM AREA
- FILL AREA BELOW SURROUNDING GRADE
- RUNOFF COLLECTION BASIN AREA
- PERIMETER DRAINAGE CHANNEL
- CULVERT
- SURFACE WATER DRAINAGE DIRECTION

CLIENT
CHEVRON ENVIRONMENTAL MANAGEMENT COMPANY
2184 WEST THORNBERRY ROAD
GUADALUPE, CA 93434

CONSULTANT
GOLDER

YYYY-MM-DD	2020-06-09
DESIGNED	MAG
PREPARED	MAG
REVIEWED	LMA
APPROVED	RVH

PROJECT
GUADALUPE RESTORATION PROJECT
SOIL MANAGEMENT AREA
TANK BATTERY 9 AREA

TITLE
SMA PHASE 2 CONSTRUCTED NO WASTE IN PHASE 2

PROJECT NO.	REV.	FIGURE
1783552	0	4

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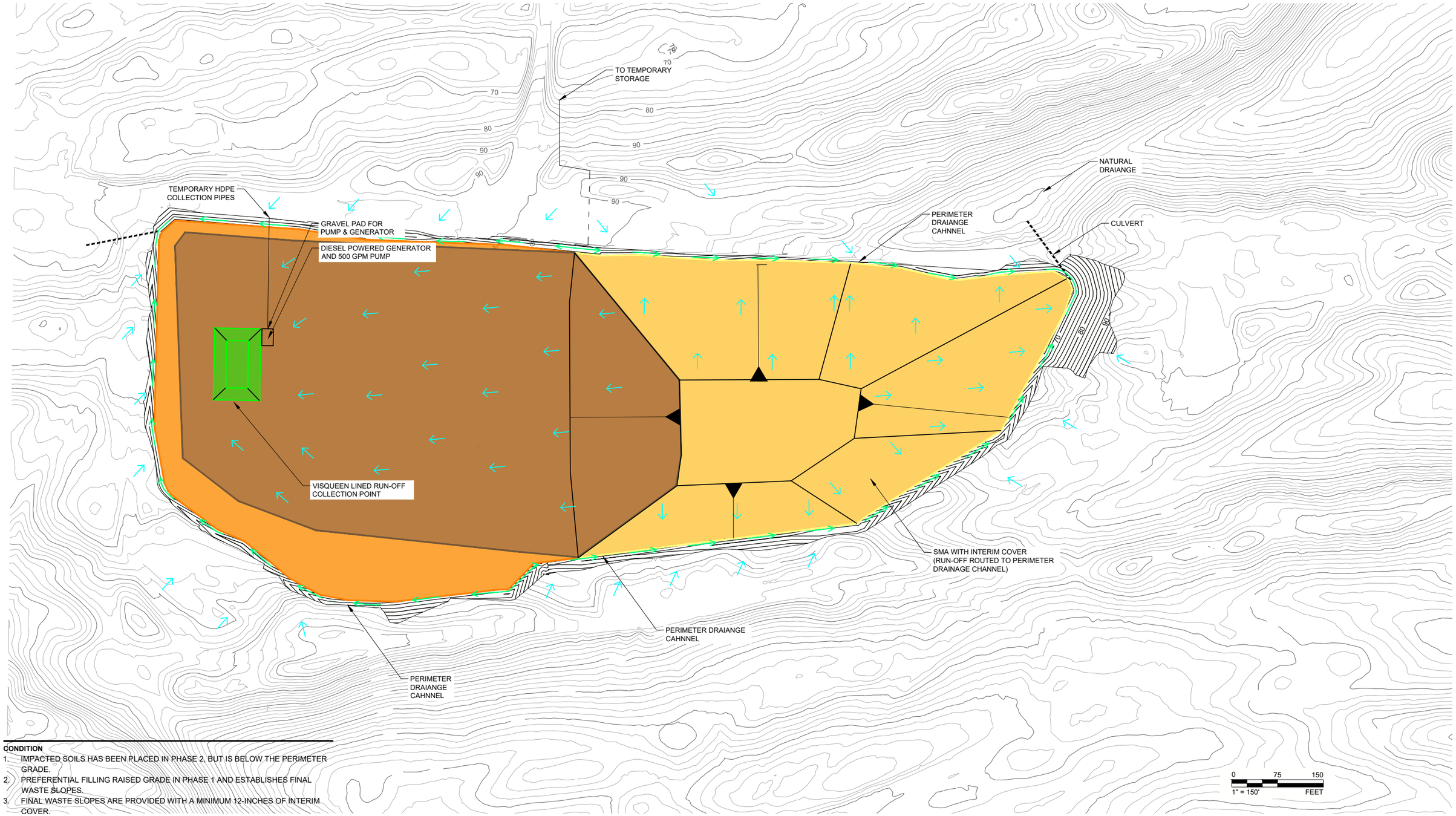

CONDITION

1. IMPACTED SOILS HAS BEEN PLACED IN PHASE 2, BUT IS BELOW THE PERIMETER GRADE.
2. PREFERENTIAL FILLING RAISED GRADE IN PHASE 1 AND ESTABLISHES FINAL WASTE SLOPES.
3. FINAL WASTE SLOPES ARE PROVIDED WITH A MINIMUM 12-INCHES OF INTERIM COVER.

STORMWATER MANAGEMENT

1. RUN-OFF FROM SLOPES WITH INTERIM COVER IS TO BE CONSIDERED NON-CONTACT AND IS ROUTER TO NATURAL DRAINAGE.
2. SECOND COLLECTION POINT FOR NON-CONTACT RUN-OFF IS NO LONGER NEEDED AND REMOVED.
3. RUN-OFF FORM UNCOVERED IMPACTED SOIL IS CONSIDERED CONTACT WATER AND IS ROUTED TO THE AWTS FRO TREATMENT.

NOTE(S)

1. THIS MAP WAS PREPARED USING PHOTOGRAMMETRIC METHODS BY CENTRAL COAST AERIAL MAPPING, INC. DATE OF TOPOGRAPHY: JANUARY 2020.

LEGEND

- BASE LINER SYSTEM AREA
- FILL AREA BELOW SURROUNDING GRADE
- FILL AREA AT FINAL GRADE
- RUNOFF COLLECTION BASIN AREA
- PERIMETER DRAINAGE CHANNEL
- CULVERT
- SURFACE WATER DRAINAGE DIRECTION

CLIENT
CHEVRON ENVIRONMENTAL MANAGEMENT COMPANY
2184 WEST THORNBERRY ROAD
GUADALUPE, CA 93434

CONSULTANT
GOLDER

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DESIGNED	MAG
PREPARED	MAG
REVIEWED	LMA
APPROVED	RVH

PROJECT
GUADALUPE RESTORATION PROJECT
SOIL MANAGEMENT AREA
TANK BATTERY 9 AREA

TITLE
OPERATION OF COMPLETED SMA
PHASE 2 BELOW PERIMETER GRADE

PROJECT NO. 1783552 | REV. 0 | FIGURE 5

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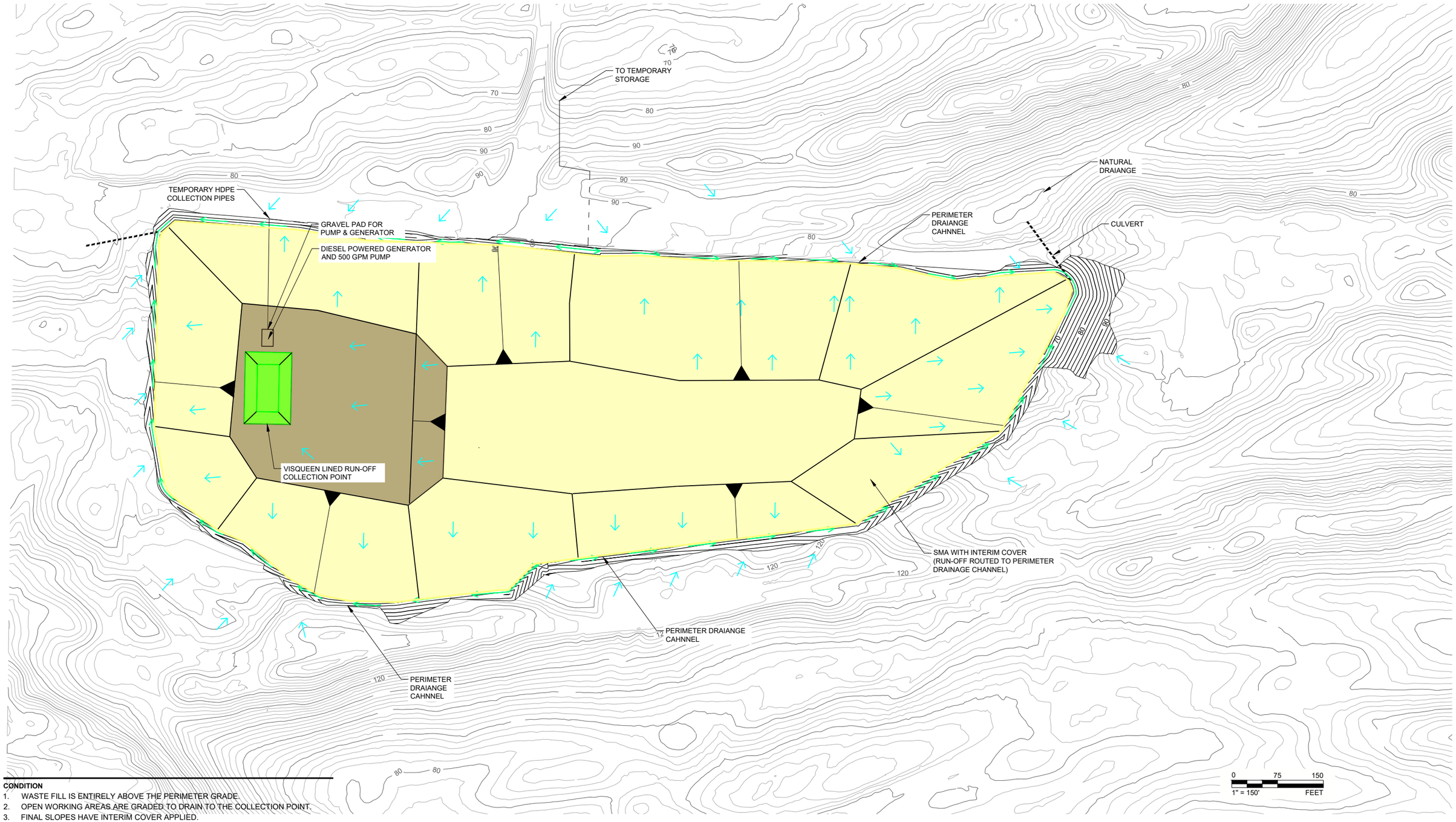

CONDITION

1. WASTE FILL IS ENTIRELY ABOVE THE PERIMETER GRADE.
2. OPEN WORKING AREAS ARE GRADED TO DRAIN TO THE COLLECTION POINT.
3. FINAL SLOPES HAVE INTERIM COVER APPLIED.

STORMWATER MANAGEMENT

1. RUN-OFF FROM THE OPEN WORKING AREAS IS COLLECTED.
2. WATER ACCUMULATED AT THE COLLECTION POINT IS IMMMEDIATELY PUMPED TO THE TEMPORARY STORAGE AND THEN TRANSFERED TO THE AWTS.
3. RUN-OFF FROM AREAS WITH INTERIM COVER ISINTERCEPTED BY THE PERIMETER CHANNEL AND ROUTED TO A NATURAL DRAINAGE.

NOTE(S)

1. THIS MAP WAS PREPARED USING PHOTOGRAMMETRIC METHODS BY CENTRAL COAST AERIAL MAPPING, INC. DATE OF TOPOGRAPHY: JANUARY 2020.

LEGEND

- BASE LINER SYSTEM AREA
- FILL AREA BELOW SURROUNDING GRADE
- FILL AREA AT FINAL GRADE
- RUNOFF COLLECTION BASIN AREA
- PERIMETER DRAINAGE CHANNEL
- CULVERT
- SURFACE WATER DRAINAGE DIRECTION

CLIENT
CHEVRON ENVIRONMENTAL MANAGEMENT COMPANY
2184 WEST THORNBERRY ROAD
GUADALUPE, CA 93434

CONSULTANT
GOLDER

YYYY-MM-DD	2020-06-08
DESIGNED	MAG
PREPARED	MAG
REVIEWED	LMA
APPROVED	RVH

PROJECT
GUADALUPE RESTORATION PROJECT
SOIL MANAGEMENT AREA
TANK BATTERY 9 AREA

TITLE
OPERATION OF COMPLETED SMA PHASE 2 ABOVE PERIMETER GRAD

PROJECT NO.	REV.	FIGURE
1783552	0	6

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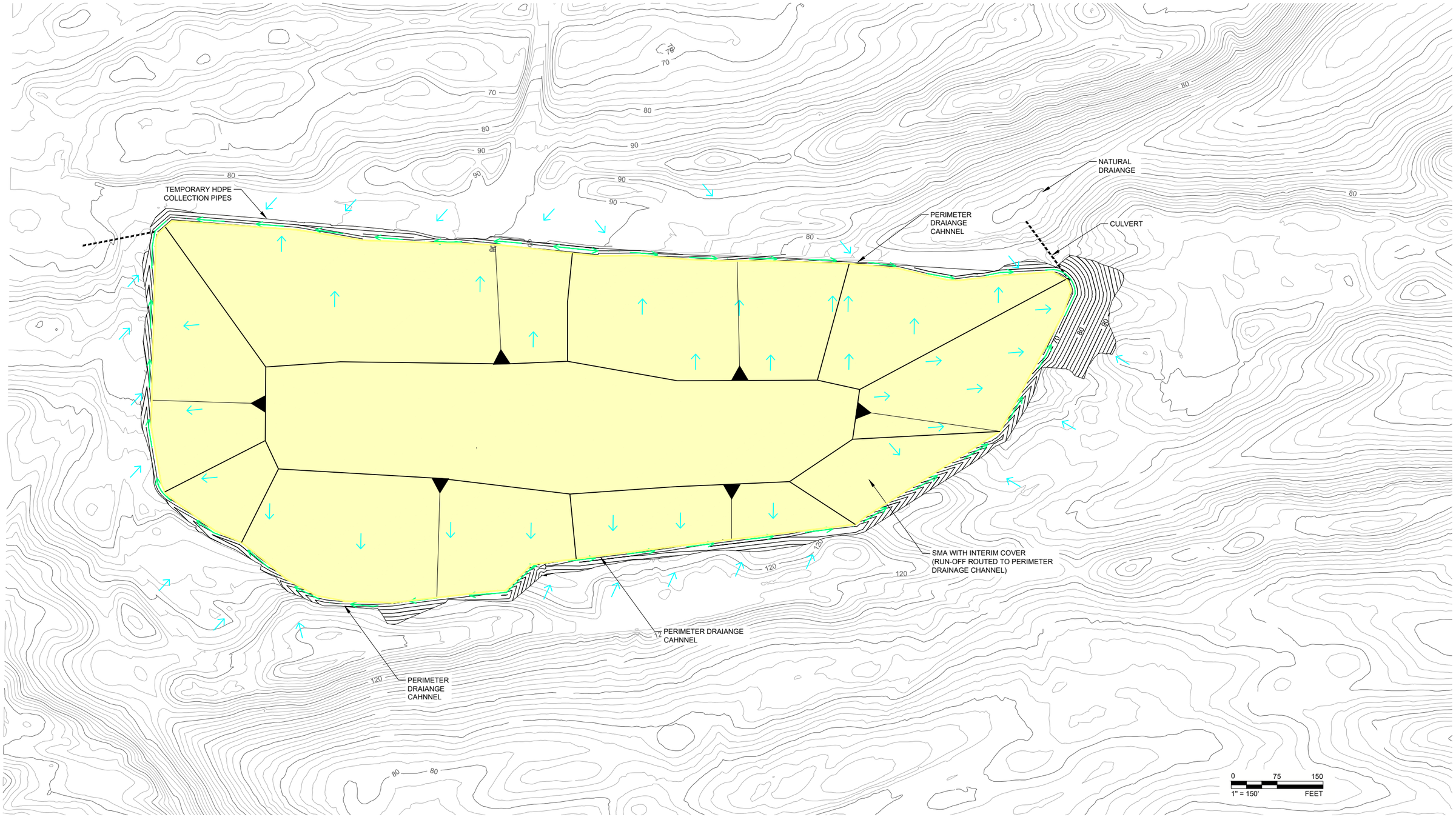

NOTE(S)

1. THIS MAP WAS PREPARED USING PHOTOGRAMMETRIC METHODS BY CENTRAL COAST AERIAL MAPPING, INC. DATE OF TOPOGRAPHY: JANUARY 2020.

LEGEND

- FILL AREA AT FINAL GRADE
- PERIMETER DRAINAGE CHANNEL
- CULVERT
- SURFACE WATER DRAINAGE DIRECTION

CLIENT
CHEVRON ENVIRONMENTAL MANAGEMENT COMPANY
2184 WEST THORNBERRY ROAD
GUADALUPE, CA 93434

CONSULTANT
GOLDER

YYYY-MM-DD	2020-06-09
DESIGNED	MAG
PREPARED	MAG
REVIEWED	LMA
APPROVED	RVH

PROJECT
GUADALUPE RESTORATION PROJECT
SOIL MANAGEMENT AREA
TANK BATTERY 9 AREA

TITLE
POST-CLOSURE CONDITION

PROJECT NO.	REV.	FIGURE
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APPENDIX N

Drainage Analyses

GOLDER

CALCULATIONS

DATE June 10, 2020 **Made by:** MAG

PROJECT NO. 1783552 **Checked by:** LMA

SITE NAME Chevron Guadalupe Restoration Project **Reviewed by:** RVH

SUBJECT **SMA STORMWATER MANAGEMENT DURING AND AFTER CONSTRUCTION**

1.0 OBJECTIVE

Calculate the stormwater run-off and associated hydraulic requirements during construction, operation, and after closure of the Soil Management Area (SMA) at the Guadalupe Restoration Project site. Since run-off from the SMA during operation will be considered contact water, and therefore contaminated, a necessary element of stormwater management will be ensuring that the Advanced Water Treatment System (AWTS) has sufficient capacity. Consequently, the analysis includes:

- Assessment of the conditions during operation and closure that will generate run-off,
- Estimate of the monthly water balance during the wettest month to determine whether sufficient treatment capacity is available at the AWTS,
- Calculation of the run-off volume resulting from the 1,000-year 24-hour storm and the largest estimated active area of the SMA during operation to determine necessary storage capacity,
- Run-off peak flows resulting from the 1,000-year storm following closure and capping of the SMA, and
- Sizing of channels, conduits, and desilting structures.

2.0 DESIGN CRITERIA

As described in California Code of Regulations (CCR) Title 27 §20365(c)(1) and Table 4.1 of that section the 1,000-year frequency, 24-hour duration (1,000-yr, 24-hr) design storm has been used to size drainage structures for the operating and post-closure conditions. The 1,000-yr, 24-hr point precipitation estimate was obtained from the National Oceanic and Atmospheric Administration (NOAA), Atlas 14, Volume 6, Version 2 for the SMA located at latitude 34.9785°N, longitude 120.6198° W. A rainfall depth of 5.40 inches was determined for the 1,000-yr, 24-hr storm event. Point precipitation frequency estimates are presented in Attachment 1.

The TR-55 SCS Runoff curve number method to calculate peak stormwater flows for the proposed interim fill conditions. For the final grading plan, the Rational Method was used to calculate peak stormwater flows that were used to size the permanent drainage structures.

3.0 STORMWATER MANAGEMENT DURING OPERATION

The SMA will be constructed in phases, which will create distinct stormwater management conditions, and are illustrated in Appendix M of the ROWD. For each of these conditions stormwater controls must be appropriately sized to capture and convey contact water to the on-site AWTS. There will be three stages of stormwater management during construction as discussed below. The fourth and final phase is after closure and is discussed in the next section for the permanent drainage controls associated with the proposed final grading plan.

Golder Associates Inc.
1000 Enterprise Way, Suite 190, Roseville, California, USA 95678 T: +1 916 786-2424 F: +1 916 786-2434

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- Stage 1 stormwater management, Run-on towards the SMA will be diverted into the surrounding natural drainages. Run-off that has been in contact with the impacted soils will be routed to a collection point within the lined portion of the landfill. The collection point will be underlain with a temporary flexible membrane liner and provided with a pump to immediately remove run-off. A set of temporary HDPE pipes will route water to one or more temporary water storage locations. Bladder tanks or temporary rigid wall tanks will hold the water until it can be processed through the AWTS. The water will be transferred from the temporary tanks to the AWTS via a pump and temporary HDPE pipelines.
- Stage 2 stormwater management, in Stage 2 the entire SMA liner system will have been completed, but the fill will be below the surrounding grade. Stormwater management will be essentially the same as described for Stage 1, but the collection point will be moved, as needed, to accommodate fill operations. It is expected that fill operations will preferentially use the Phase 1 area, using only enough of the Phase 2 area to buttress the fill in order to minimize the surface area of impacted soil that can generate contact water. A second collection point will be provided in the Phase 2 area to handle non-contact (i.e., clean) water and remove it from the cell. The non-contact water will be discharged to the natural drainages. It is also understood that given the high hydraulic conductivity of the dune sands, a significant portion of any precipitation will infiltrate and be collected by the LCRS and managed as leachate, which will also be treated at the AWTS.
- Stage 3 stormwater management, as portions of the fill prism rise above the surrounding grade, those permanent slopes will be provided with at least 1 foot of clean soil consistent with the material that will be used for the final cover. Run-off from these areas will be directed to an adjacent natural drainage. Exposed working areas within the SMA will be managed as described for Stages 1 and 2, directing run-off to an internal collection point, routing the water to temporary storage, and processing through the AWTS.

4.0 HYDROLOGY CALCULATIONS

Runoff calculation volumes were calculating using the TR-55 SCS Runoff curve number method. A SCS Curve Number of 68 determined from the USDA, “Urban Hydrology for Small Watersheds, TR-55”. Table 2-2c was used for the SMA interim fill area. The proposed interim fill area classifies as hydraulic soil group A since it will be covered in sandy onsite soils. The estimated peak run-off volumes calculated for the 1,000-year, 24-hour storm event for each stage of the construction as shown in Table 1. The peak run-off volumes were calculated by using the rainfall runoff calculated in Equation 1 and calculating the peak run-off volume for the fill area with Equation 2.The critical stage will be during stage 2 where the anticipated peak run-off for a 1,000-year, 24-hour storm event is approximately 487,000 gallons. An additional storage volume of 500,000 gallons will be constructed to manage this volume.

Equation 1: Rainfall Run-off (SCS Runoff Curve Number Method)

$$q = \frac{(P-0.2S)^2}{(P+0.8S)}$$

Where: q = Rainfall Runoff, in

P = Rainfall, in

S = Potential Maximum Runoff Retention, in

S = 1000/(CN-10)

Equation 2: Run-off Volume

$Q = qA/12$

Where: Q = Runoff Volume, cf

q = Rainfall Run-off, in

A = Area, sf

5.0 POST-CLOSURE STORMWATER MANAGEMENT

The permanent drainage conditions once the site has been closed in accordance with the proposed final grading plan were calculated using the Rational Method The drainage subbasins for the proposed final cover grading plan are shown in Figure 1. Subbasin areas were determined utilizing Autodesk's AutoCAD Civil 3D 2019 (AutoCAD) software. Details of the calculation and assumptions are described below.

5.1 Runoff Coefficient

Runoff coefficients for each subbasin were assumed to be 0.8 for the final grading plan cover areas. The subbasins have been assumed to have minimal surface stormwater storage and therefore have relatively large runoff coefficients. Golder utilized the runoff coefficients to calculate overland time of concentration (Tc).

5.2 Time of Concentration

The Tc is defined as the time required for a particle of water to travel from the most hydraulically distant point to the point of collection within a subbasin.

Information used to calculate the Tc includes the surface condition (roughness coefficient), the flow length, upstream and downstream elevations (slope) along with any drainage structure geometry, as appropriate. The flow lengths were delineated and measured within AutoCAD's Civil 3D software program utilizing the existing ground topography and the proposed final grading plan.

Flow lengths within each subbasin are classified as sheet flow, shallow concentrated flow, and natural/constructed channel or pipe flow segments. Maximum overland flow length has been assumed to be 300 feet and shallow concentrated flow occurs after 300 feet of overland flow up until the point where natural channel flow, constructed channel flow or pipe flow begins. Proposed channels are assumed to be constructed of earthen-lined channels or erosion control mat-lined channels and have a Manning's hydraulic coefficient of 0.03. Proposed downdrains are assumed to be corrugated HDPE pipe with a Manning's hydraulic coefficient of 0.024. The average flow path slope for each flow condition was calculated using Equation 3. Overland sheet flow travel time was calculated using Equation 4. Shallow concentrated flow travel time was calculated using Equation 5. Channel flow travel time was calculated using Equation 6 with the velocity calculated using Equation7. All equations are provided below. Calculations and results are presented in Table 2.

Equation 3: Average Flow Path Slopes

$S = \frac{E_1 - E_2}{L}$

Where: S = Average land slope, ft/ft

E_1 = Upstream elevation, ft

E_2 = Downstream elevation, ft

L = Flow length, ft

Equation 4: Overland Sheet Flow Travel Time (FAA Method)

$$T_0 = \frac{1.8 * (1.1 - C) * L^{\frac{1}{2}}}{S_{avg}^{1/3}}$$

Where: T_0 = Travel time, min

L = Overland flow distance, ft

S = Slope, %

C = run-off coefficient

Equation 5: Shallow Concentrated Flow Travel Time

$$T_s = \frac{L}{60 * 16.13 * S^{\frac{1}{2}}}$$

Where: T_s = Travel time, min

L = Flow length, ft

S = Slope, ft/ft

Equation 6: Conveyance Flow Travel Time

$$T_c = \frac{L}{60 * V}$$

Where: Tc = Travel time, min

L = Flow length, ft

V = Average velocity, ft/sec

Equation 7: Average Velocity for Conveyance Flow (Manning's Equation)

$$V = \frac{1.486}{n} R^{2/3} S^{1/2}$$

Where: V = Average velocity, ft/sec

n = Manning's roughness coefficient

R = Hydraulic Radius, ft

A = Flow cross sectional area, ft^2

S = Slope, ft/ft

5.3 Conveyance System Capacities

The peak discharge flow rate for each subbasin was calculated using the Rational Method. The normal depth for each conveyance structure was calculated by inserting the peak discharge into Manning's Equations and iteratively solving for the normal depth, which is a function of the flow rate and hydraulic radius. Calculations for the channel is summarized in Table 4.

Equation 6: Manning's Equation

$$Q = \frac{1.486}{n} A R^{2/3} S^{1/2}$$

Where: Q = Discharge, ft^3/sec

n = manning's roughness coefficient

A = Flow area, ft^2

R = Hydraulic radius, ft

S = Slope, ft/ft

5.4 Conclusion

Results of the analysis are provided in Table 1, Table 4 and Table 5. Table 1 shows the runoff volume for each stage of interim fill. Table 4 provides results for channel depths and dimensions. Table 5 provides results for downdrain sizes.

6.0 AWTS CAPACITY CALCULATION-PEAK MONTHLY WATER BALANCE

Completion and operation of the SMA will introduce two new fluid inputs to the AWTS. One will be leachate collected from the LCRS, and the other will be precipitation run-off from the open working face. Golder evaluated the capacity of the AWTS to handle the additional anticipated flows from the operation of the SMA. Historical AWTS flow data collected by Entact from 2014 to 2019 was used to determine a maximum anticipated flow from the existing site activities. The monitoring data collected by TriHydro is also provided. Based on this information, the maximum anticipated average flow is estimated to be 18 gallons per minute (gpm) for existing onsite activities. From the HELP model (Appendix L of the ROWD), the peak leachate generation is estimated to be 78 gpm.

Once the entire footprint has been construction but before the SMA is closed, stormwater run-off that comes into contact with uncapped slopes will be captured and conveyed to the AWTS. Based on historical climate data, the peak stormwater run-off would occur during the month of January which has the highest volume of monthly precipitation of 2.49 inches. Using this value, the maximum anticipated inflows from stormwater would be approximately 24 gpm. Summing these rates together gives a total anticipated inflow volume to the AWTS of 121 gpm, this is less than the AWTS maximum allowable flow rate of 160 gpm. Therefore, the AWTS is has adequate capacity to handle the additional flows from the construction of the SMA. The AWTS capacity calculation is included as Attachment 2.

Attachments

Tables

Table 1 Hydrology Stage Volume Calculation

Table 2 Landfill Drainage Area Measurements

Table 3 Landfill Time of Concentration

Table 4 Channel Geometry Summary

Table 5 Pipe Geometry Summary

Figures

Figure 1 Drainage Basin Delineation

Attachment

Attachment 1 Point Precipitation Estimates

Attachment 2 AWTS Capacity Calculation

References

Atlas, N. O. A. A. "Precipitation-Frequency Atlas of the United States." (14). Volume 6, Version 2.

United States Department of Agriculture (USDA), “Urban Hydrology for Small Watersheds, TR-55”, Natural Resources Conservation Service, Conservation Engineering Division, Technical Report 55, June 1986.

Tables

TABLE 1
HYDROLOGY STAGE VOLUME CALCULATION
HYDROLOGY AND HYDRAULICS ANALYSIS
CHEVRON GUADLAUPE SMA

Design Area	Area (sf)	Curve Number (CN)	Maximum Retention, S (in)	Runoff q (in)	Runoff Volume Q (cf)	Runoff Volume Q (gal)
Stage 1						
Constructed Base Liner Area	345,239					
Contact Water Area	229,141	68	4.71	2.17	41,423	309,846
Stage 2						
Constructed Base Liner Area	681,756					
Contact Water Area	359,341	68	4.71	2.17	64,960	485,903
Stage 3						
Constructed Base Liner Area	681,756					
Contact Water Area	94,488	68	4.71	2.17	17,081	127,767

Notes:

1. Calculated using TR-55 SCS Runoff curve number method for 1,000 year, 24-hour Storm Event
2. Results from SCS runoff curve number Method: $Q = (P-0.2S)^2 / (P+0.8S)$

   where: Q = Rainfall Runoff (in)
   P = Rainfall (in), 5.4
   S = Potential maximum runoff retention after runoff begins (in)

   where: S = 1000/CN-10
   CN = Curve Number

3. Runoff Volume Calculation: $Q = qA/12$

   where: Q = Total Runoff Flow (cf)
   q = Runoff (in)
   A = Catchment Area (sf)

TABLE 2
LANDFILL DRAINAGE AREA MEASUREMENTS
DRAINAGE CONVEYANCE DESIGN
CHEVRON GUADALUPE SMA

Design Area	Area (sf)	Area (ac)	Runoff Coefficient, C	Total Plan Length	Overland Sheet Flow						Shallow Concentrated Flow						Channel or Culvert Flow						
				Plan Length (ft)	Plan Length (ft)	Overland Start El.	Overland End el.	Slope (%)	Slope Factor	Surface Length (ft)	Plan Length (ft)	Overland Start El.	Overland End El.	Slope (%)	Slope Factor	Surface Length (ft)	Channel or Culvert Description	Plan Length (ft)	Ditch/Pipe/Channel Start el.	Ditch/Pipe/ Channel End el.	Slope (%)	Slope Factor	Surface Length (ft)
A-1	29,072	0.67	0.80	42	42	140	128	33	1.054	44							C-1	158	128	117	7.0	1.002	158
																	P-1	123	117	116	0.8	1.000	123
A-2	133,238	3.06	0.80	186	186	160	154	3	1.000	186							C-2	406	117	116	0.2	1.000	406
				91	91	154	124	33	1.053	96							P-2	47	124	114	21.4	1.023	48
				18	18	124	122	12	1.007	18	44	122	117	12	1.007	45							
A-3	29,593	0.68	0.80	45	45	140	138	4.5	1.001	45							C-3	319	116	80	11.3	1.006	321
				56	56	138	119	33	1.054	59													
A-4	133,940	3.07	0.80	125	125	157	140	14	1.009	126							C-4	228	80	60	8.8	1.004	229
				40	40	140	138	4.5	1.001	41													
				130	130	138	112	20	1.020	133	180	112	80	20	1.020	184							
A-5	68,749	1.58	0.80	282	282	160	152	3	1.000	282							C-5	255	152	130	8.5	1.004	255
A-6	21,555	0.49	0.80	191	191	160	154	3	1.000	191							C-6	53	131	127	6.7	1.002	53
				72	72	154	131	33	1.053	76							C-18	140	127	124	2.1	1.000	140
A-7	17,882	0.41	0.80	42	42	140	128	33	1.053	44							C-7	171	128	126	1.2	1.000	171
A-8	31,719	0.73	0.80	300	300	160	151	3	1.000	300	3	151	150	3	1.000	3	C-8	140	126	118	5.7	1.002	140
											77	150	125	33	1.053	81							
A-9	38,251	0.88	0.80	267	267	160	152	3	1.000	267							C-9	128	117	111	4.3	1.001	128
				31	31	152	142	33	1.054	33	76	142	117	33	1.053	80							
A-10	44,418	1.02	0.80	187	187	160	154	3	1.000	187							C-10	102	112	109	3.1	1.000	102
				107	107	154	119	33	1.054	113	20	119	112	33	1.053	21							
A-11	29,642	0.68	0.80	172	172	160	154	3	1.000	172							C-11	48	110	106	8.8	1.004	49
				121	121	154	114	33	1.054	128	10	114	110	33	1.053	11							
A-12	12,767	0.29	0.80	7	7	156	156	3	1.000	7							C-12	110	106	105	0.9	1.000	110
				153	153	156	105	33	1.054	162													
A-13	60,408	1.39	0.80	8	8	156	156	3	1.000	8							C-13	95	105	86	20.1	1.020	97
				161	161	156	102	33	1.054	170													
A-14	132,364	3.04	0.80	212	212	160	90	33	1.053	223							C-14	425	90	80	2.4	1.000	425
A-15	81,528	1.87	0.80	239	239	160	81	33	1.053	252							C-15	474	81	60	4.4	1.001	475
																	P-3	80	68	66	2.5	1.000	80
A-16	31,865	0.73	0.80	216	216	160	89	33	1.053	228							C-16	92	89	86	2.9	1.000	92
A-17	115,988	2.66	0.80	226	226	160	85	33	1.053	238							C-17	470	86	85	0.2	1.000	470
																	P-4	77	84	80	5.2	1.001	77

TABLE 3
PEAK FLOW CALCULATIONS
DRAINAGE CONVEYANCE DESIGN
CHEVRON GUADLAUPE SMA

Drainage Area			Runoff Coeff. C (1)	Overland		Shallow Concentrated		Channel/Swale/Culvert/Downdrain						Travel Time						
Design Point	I.D. #	Area (acres)		Length L (ft)	Slope s (%)	Length L (ft)	Slope s (ft/ft)	I.D. #	Length L (ft)	Slope s (%)	Manning n (3)	Hydraulic Radius (ft)	Velocity V (ft/sec) (2)	Overland t_o (min.)	Shallow Concentrated t_s (min.)	Channel/Swale t_c (min.)	Time of Concentration T_t (min.) (4)	Design Time of Concentration T_t (min.) (5)	Intensity I (in./hr)	Peak Discharge Q_p (cfs) (5)
	A-1	0.67	0.80	44	33			C-1	158	7.0	0.030	0.2	5.1	1.1	0.00	0.5	1.6	5.0	5.6	3.0
	P-1							P-1	123	0.8	0.016	0.3	4.0			0.5				
DP-1	A-1	0.67	0.80											1.1	0.00	1.0	2.1	5.0	5.6	3.0
	A-5	1.58	0.80	282	3			C-5	255	8.5	0.030	0.3	6.5	6.3		0.7	6.9	6.9	4.7	5.9
DP-2	A-5	1.58	0.80											6.3	0.00	0.7	6.9	6.9	4.7	5.9
	A-6	0.49	0.80	191	3			C-6	53	6.7	0.030	0.3	6.3	5.2		0.1	6.8	6.8	4.8	1.9
				76	33									1.5						
DP-2	A-5	1.58	0.80											6.3	0.00	0.7				
DP-3	A-5, A-6	2.07	0.80											6.6	0.00	0.8	7.4	7.4	4.5	7.5
DP-1	A-1	0.67	0.80											1.1	0.000	1.0	2.1			
	A-2	3.06	0.80	186	3									5.1						
				96	33			C-2	406	0.2	0.030	0.9	2.1	1.6		3.3	11.0	11.0	3.7	9.1
				18	12	45	12							1.0	0.01					
	P-2							P-2	48	21.4	0.016	0.2	16.8			0.0				
	C-18							C-18	140	2.1	0.030	0.4	4.1			0.6	8.0	8.0	4.4	7.7
DP-3	A-5, A-6	2.07	0.80											6.6	0.00	0.8				
DP-4	A-1, A-5, A-6, A-2	5.80	0.80											7.8	0.01	4.7	12.5	12.5	3.5	16.2
	A-3	0.68	0.80	45	5			C-3	321	11.3	0.030	0.4	9.5	2.2		0.6	4.0	5.0	5.6	3.0
				59	33									1.3						
DP-4	A-1, A-5, A-6, A-2	5.80	0.80											7.8	0.01	4.7				
DP-5	A-1, A-5, A-6, A-2, A-3	6.48	0.80											7.8	0.01	5.2	13.0	13.0	3.4	17.7
	A-4	3.07	0.80	186	3			C-4	406	6.7	0.030	0.5	8.2	5.1	--	0.8	7.6	7.6	4.5	11.0
				96	33	45	12							1.6	0.01					
DP-5	A-1, A-5, A-6, A-2, A-3	6.48	0.80											7.8	0.01	5.2				
DP-6	A-1, A-5, A-6, A-2, A-3, A-4	9.55	0.80											7.8	0.01	6.1	13.8	13.8	3.3	25.2
	A-7	0.41	0.80	44	33			C-7	171	1.2	0.030	0.3	2.3	1.1		1.2	2.4	5.0	5.6	1.8
DP-7	A-7	0.41	0.80											1.1	0.00	1.2	2.4	5.0	5.6	1.8
	A-8	0.73	0.80	300	3	3	3	C-8	140	5.7	0.030	0.3	5.0	6.5	0.00	0.5	7.0	7.0	4.7	2.7
						81	33								0.01					
DP-7	A-7	0.41	0.80											1.1	0.00	1.2				
DP-8	A-7, A-8	1.14	0.80											6.5	0.02	1.7	8.2	8.2	4.3	3.9
	A-9	0.88	0.80	267	3			C-9	128	4.3	0.030	0.4	5.2	6.1		0.4	7.5	7.5	4.5	3.2
				33	33	80	33							1.0	0.01					
DP-8	A-7, A-8	1.14	0.80											6.5	0.02	1.2				
DP-9	A-7, A-8, A-9	2.02	0.80											7.1	0.01	1.6	8.7	8.7	4.2	6.7
	A-10	1.02	0.80	187	3			C-10	102	3.1	0.030	0.4	5.1	5.1		0.3	7.2	7.2	4.6	3.7
				113	33	21	33							1.8	0.00					
DP-9	A-7, A-8, A-9	2.02	0.80											7.1	0.01	1.6				
DP-10	A-7, A-8, A-9, A-10	3.04	0.80											7.1	0.01	2.0	9.1	9.1	4.1	9.9
	A-11	0.68	0.80	172	3			C-11	49	8.8	0.030	0.4	7.9	4.9		0.1	6.9	6.9	4.7	2.6
				128	33	11	33							1.9	0.00					
DP-10	A-7, A-8, A-9, A-10	3.04	0.80											7.1	0.01	2.0				
DP-11	A-7, A-8, A-9, A-10, A-11	3.72	0.80											7.1	0.01	2.1	9.2	9.2	4.1	12.1

TABLE 3
PEAK FLOW CALCULATIONS
DRAINAGE CONVEYANCE DESIGN
CHEVRON GUADLAUPE SMA

Drainage Area			Runoff Coeff. C (1)	Overland		Shallow Concentrated		Channel/Swale/Culvert/Downdrain						Travel Time						
Design Point	I.D. #	Area (acres)		Length L (ft)	Slope s (%)	Length L (ft)	Slope s (ft/ft)	I.D. #	Length L (ft)	Slope s (%)	Manning n (3)	Hydraulic Radius (ft)	Velocity V (ft/sec) (2)	Overland t_o (min.)	Shallow Concentrated t_s (min.)	Channel/Swale t_c (min.)	Time of Concentration T_t (min.) (4)	Design Time of Concentration T_t (min.) (5)	Intensity I (in./hr)	Peak Discharge Q_p (cfs) (5)
	A-12	0.29	0.80	7 162	3 33			C-12	110	0.9	0.030	0.6	3.4	1.0 2.1		0.5	3.6	5.0	5.6	1.3
DP-11	A-7, A-8, A-9, A-10, A-11	3.72	0.80											7.1	0.01	2.1				
DP-12	A-7, A-8, A-9, A-10, A-11, A-12	4.01	0.80											7.1	0.01	2.6	9.7	9.7	4.0	12.7
	A-13	1.39	0.80	8 170	3 33			C-13	97	20.1	0.030	0.4	11.7	1.1 2.2		0.1	3.4	5.0	5.6	6.2
DP-12	A-7, A-8, A-9, A-10, A-11, A-12	4.01	0.80											7.1	0.01	2.6				
DP-13	A-7, A-8, A-9, A-10, A-11, A-12, A-13	5.40	0.80											7.1	0.01	2.8	9.9	9.9	3.9	16.9
	A-14	3.04	0.80	223	33			C-14	425	2.4	0.030	0.5	5.0	2.5		1.4	3.9	5.0	5.6	13.5
DP-14	A-14	3.04	0.80											2.5	0.00	1.4	3.9	5.0	5.6	13.5
	A-15	1.87	0.80	252	33			C-15	229	8.8	0.030	0.6	9.9	2.7		0.4	3.1	5.0	5.6	8.3
DP-14	A-14	3.04	0.80											2.5	0.00	1.4				
DP-15	A-14, A-15	4.91	0.80											2.7	0.00	1.8	4.5	5.0	5.6	21.8
	A-16	0.73	0.80	228	33			C-16	92	2.9	0.030	0.3	3.7	2.5		0.4	3.0	5.0	5.6	3.2
DP-16	A-16	0.73	0.80											2.5	0.00	0.4	3.0	5.0	5.6	3.2
	A-17	2.66	0.80	238	33			C-17	470	0.2	0.030	0.8	2.0	2.6		4.0				
DP-16	A-16	0.73	0.80											2.5	0.00	0.4				
DP-17	A-16, A-17	3.39	0.80											2.6	0.00	4.4	7.0	7.0	4.7	12.7
DP-6	A-1, A-5, A-6, A-2, A-3, A-4	9.55	0.80											7.8	0.0	6.1	13.8			
DP-15	A-14, A-15	4.91	0.80											2.7	0.0	1.8	4.5			
	P-3							P-3	80	2.5	0.024	0.830	8.6			0.2				
	A-1 to A-5, A-14, A-15	14.46	0.80											7.8		6.2	14.0	14.0	3.3	38.0
DP-13	A-7, A-8, A-9, A-10, A-11, A-12, A-13	5.40	0.80											7.1	0.0	2.8	9.9			
DP-17	A-16, A-17	3.39	0.80											2.6	0.0	4.4	7.0			
	P-4							P-4	77	5.2	0.024	0.609	10.1			0.1				
	A-7 to A-13, A-16, A-17	8.79	0.80											7.1		2.9	10.0	10.0	3.9	27.4

Notes:

1. Calculated using San Luis Obispo County Drainage Manual.
2. Results from Chezy-Manning Formula:

$$V = (1.486 \times R^{(2/3)} \times S^{(1/2)})/n$$

where: V = Velocity (ft/s), S = Slope (ft/ft), R = Hydraulic Radius (ft), n = Manning's n (dimensionless)

3. Mannings n = 0.03 for V-ditches, n =0.024 for Corrugated HDPEPipe
4. Time of Concentration (FAA Manual):

$$t_o = 1.8 \times (1.1-C)L^{1/2}/S^{1/3} \qquad t_s = L/(60 \times 16.13 \times s^{0.5}) \qquad t_c = (1/60) \times (L/V_{ave})$$

$$T_t = t_o + t_s + t_c$$

5. Minimum design Time of Concentration 5 min.
6. Discharge is based on the Rational Method: Q=CiA

where: Q = Flow (cfs)
C = Runoff Coefficient
i = Rainfall Intensity (in/hr)
A = Catchment Area (ac)

TABLE 4
CHANNEL GEOMETRY
DRAINAGE CONVEYANCE DESIGN
CHEVRON GUADALUPE

Ditch/ Outlet ID	Tributary Area ID	Design Flow (cfs)	Channel Characteristics							Design Flow Characteristics					
			Type	Length (ft)	Depth (ft)	Base (ft)	Side Slopes (__H:1V)	Minimum Grade (ft/ft)	Manning's Roughness (n)[2]	Depth (ft)	Area (sf)	Design Velocity (fps)	Hydraulic Perimeter (ft)	Flow Velocity V[1] (fps)	Flow Time (min.)
C-1	A-1	2.96	Erosion Control Lined	158	2	0	2	0.070	0.030	0.54	0.58	5.08	2.4	5.1	0.5
C-2	A-1, A-5, A-6, A-2	16.16	Earthen V-Ditch	406	2	0	2	0.002	0.030	1.93	7.45	2.17	8.6	2.1	3.3
C-3	A-1, A-5, A-6, A-2, A-3	17.65	Erosion Control Lined	321	2	0	2	0.113	0.030	0.97	1.86	9.48	4.3	9.5	0.6
C-4	A-1, A-5, A-6, A-2, A-3, A-4	25.23	Erosion Control Lined	229	2	0	2	0.088	0.030	1.16	2.67	9.46	5.2	9.4	0.4
C-5	A-5	5.93	Erosion Control Lined	255	1.5	0	2	0.085	0.030	0.68	0.91	6.49	3.0	6.5	0.7
C-6	A-5, A-6	7.52	Erosion Control Lined	53	1.5	0	2	0.067	0.030	0.77	1.19	6.30	3.5	6.3	0.1
C-7	A-7	1.82	Earthen V-Ditch	171	2	0	2	0.012	0.030	0.63	0.79	2.30	2.8	2.3	1.2
C-8	A-7, A-8	3.93	Erosion Control Lined	140	2	0	2	0.057	0.030	0.62	0.78	5.05	2.8	5.0	0.5
C-9	A-7, A-8, A-9	6.73	Erosion Control Lined	128	2	0	2	0.043	0.030	0.80	1.29	5.21	3.6	5.2	0.4
C-10	A-7, A-8, A-9, A-10	9.95	Erosion Control Lined	102	2	0	2	0.031	0.030	0.99	1.96	5.07	4.4	5.1	0.3
C-11	A-7, A-8, A-9, A-10, A-11	12.11	Erosion Control Lined	49	2	0	2	0.088	0.030	0.88	1.54	7.86	3.9	7.9	0.1
C-12	A-7, A-8, A-9, A-10, A-11, A-12	12.68	Earthen V-Ditch	110	2	0	2	0.009	0.030	1.37	3.73	3.40	6.1	3.4	0.5
C-13	A-7, A-8, A-9, A-10, A-11, A12, A-13	16.95	Erosion Control Lined	97	2	0	2	0.201	0.030	0.85	1.45	11.66	3.8	11.7	0.1
C-14	A-14	13.50	Earthen V-Ditch	425	1.5	0	2	0.024	0.030	1.17	2.72	4.96	5.2	5.0	1.4
C-15	A-14, A-15	21.81	Erosion Control Lined	475	1.5	0	2	0.044	0.030	1.24	3.09	7.05	5.6	7.0	1.1
C-16	A-16	3.25	Earthen V-Ditch	92	2	0	2	0.029	0.030	0.66	0.87	3.73	3.0	3.7	0.4
C-17	A-16, A-17	12.72	Earthen V-Ditch	470	2	0	2	0.002	0.030	1.79	6.44	1.97	8.0	2.0	4.0
C-18	A-5, A-6, C-18	7.71	Earthen V-Ditch	140	1.5	0	2	0.021	0.030	0.96	1.86	4.14	4.3	4.1	0.6

Notes:

[1]Chezy-Manning Formula:

$V = (1.486/n) \times R_H^{2/3} \times S_o^{1/2}$

$R_H = A / P$

$P = B + 2 \times D \times (z^2+1)^{1/2}$

$A = (B + z \times D) \times D$

V = Velocity (ft/s)
n = Manning's n
R_H = Hydraulic Radius (ft)
S_o= Channel Slope (ft/ft)
z = Horizontal Component of the Side Slope, _H:1V.

and: A = Flow Area (sf)
P = Hydraulic Perimeter (ft)
B = Channel Base Width (ft)
D = Channel Flow Depth (ft)

[2]Manning's n = 0.030 for Earthen V-Ditch, Erosion Control Lined V-Ditch

TABLE 5
PIPE GEOMETRY
DRAINAGE CONVEYANCE DESIGN
CHEVRON GUADALUPE

Pipe Location/Section	Tributary Area ID[3]	Design Flow (cfs)	Pipe Characteristics						Design Flow Characteristics				
			Type	Length (ft)	Diameter (ft)	Central Angle (rad)	Minimum Grade (ft/ft)	Manning's Roughness (n)[2]	Depth (ft)	Area (sf)	Hydraulic Perimeter (ft)	Flow Velocity V[1] (fps)	Flow Time (min.)
P-1	A-1	3.0	Corrugated HDPE	123	2	2.26	0.008	0.016	0.57	0.74	2.3	4.0	0.5
P-2	A-5, A-6, C-18	7.7	Corrugated HDPE	48	2	1.87	0.214	0.016	0.41	0.46	1.9	16.8	0.0
P-3	A-1 to A-5, A-14, A-15	38.0	Corrugated HDPE	80	3	2.76	0.025	0.024	1.79	4.39	5.3	8.6	0.2
P-4	A-7 to A-13, A-16, A-17	27.4	Corrugated HDPE	77	2	1.84	0.052	0.024	1.61	2.71	4.4	10.1	0.1

Notes:

[1]Chezy-Manning Formula:

$V = (1.486/n) \times R_H^{2/3} \times S_o^{1/2}$

$R_H = A / P$

$\theta = 2 \times \arccos((r - h)/r)$

$P = r \times \theta$ or $P = 2\pi r - r \times \theta$

$A = r2 \times (\theta - \sin\theta)/2$ or

$A = \pi r^2 - r^2 \times (\theta - \sin\theta)/2$

$h = y$ or $h = 2r - y$

V = Velocity (ft/s)

n = Manning's n

S_o= Channel Slope (ft/ft)

y = Depth of flow

θ = Central Angle

and: A = Flow Area (sf)

P = Hydraulic Perimeter (ft)

B = Channel Base Width (ft)

D = Channel Flow Depth (ft)

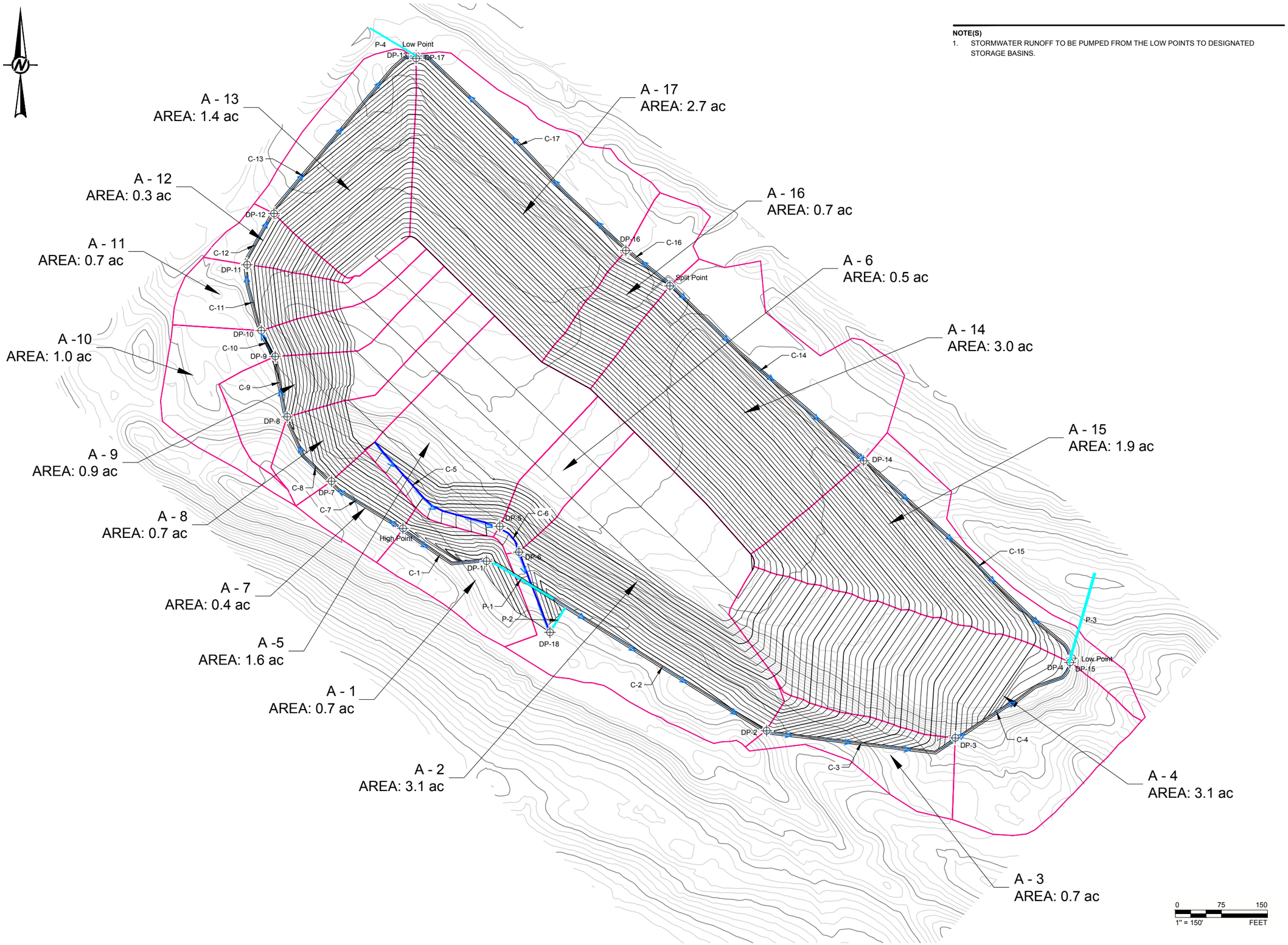
r = Channel Radius (ft)

h = Circle Segment height (ft)

[2]Manning's n = 0.024 for Corrugated HDPE Pipe

[3]See C-18 calculations in grey text on Table 2 for P-2 analysis.

Figure



NOTE(S)

1. STORMWATER RUNOFF TO BE PUMPED FROM THE LOW POINTS TO DESIGNATED STORAGE BASINS.

CLIENT
CHEVRON ENVIRONMENTAL MANAGEMENT COMPANY
2184 WEST THORNBERRY ROAD
GUADALUPE, CA 93434

CONSULTANT
GOLDER

YYYY-MM-DD	2019-08-27
DESIGNED	CMM
PREPARED	CMM
REVIEWED	LMA
APPROVED	RGH

PROJECT
GUADALUPE RESTORATION PROJECT
SOIL MANAGEMENT AREA
TANK BATTERY 9 AREA

TITLE
DRAINAGE BASIN DELINEATION

PROJECT NO.
1783552

REV.
0

FIGURE
1

IF THIS MEASUREMENT DOES NOT MATCH WHAT IS SHOWN, THE SHEET SIZE HAS BEEN MODIFIED FROM: ANSI B

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ATTACHMENTS

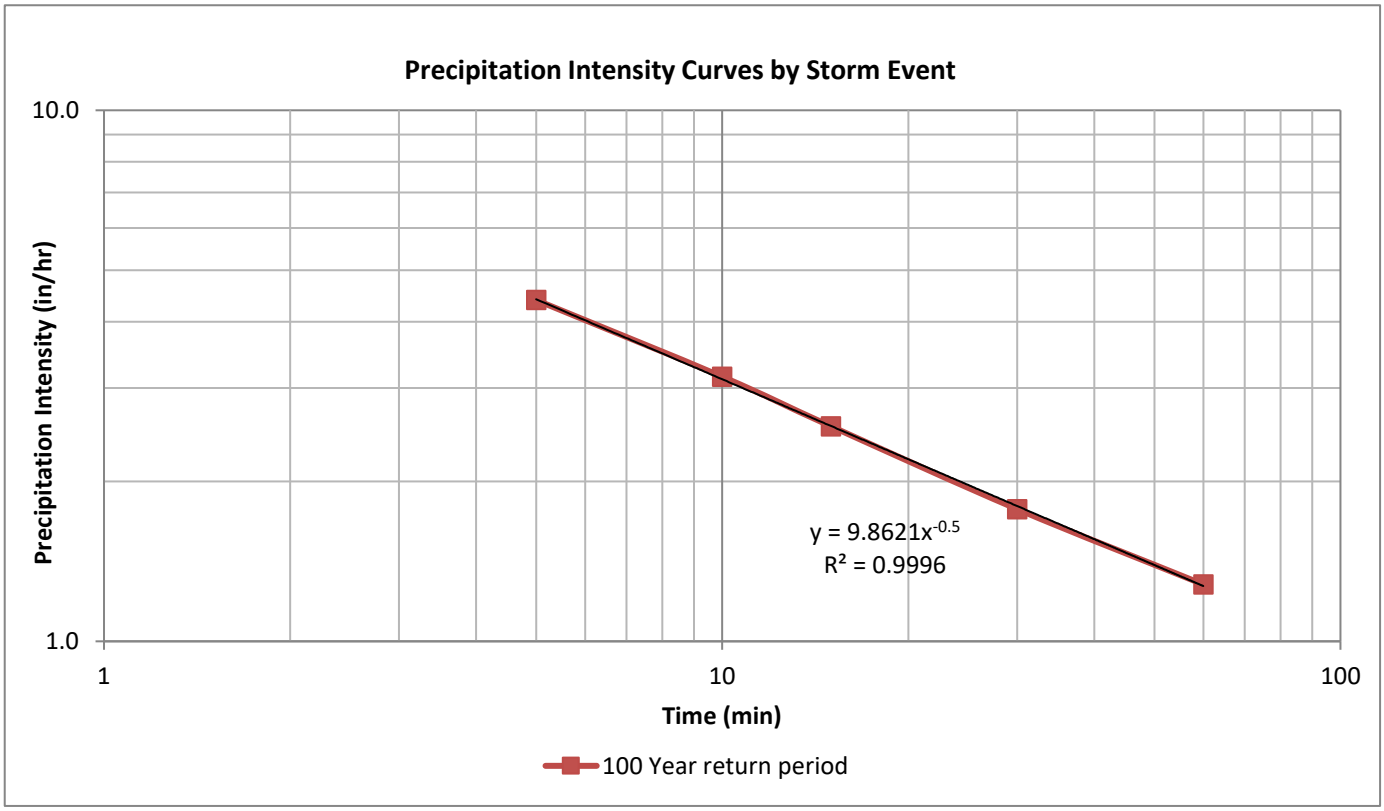
ATTACHMENT 1

Point Precipitation Estimates

INTENSITY CURVE SUMMARY
1000-YEAR STORM
CHEVRON GUADALUPE

	1,000 Year Storm	
Time (min)	**Chart Values (in)**	**Precipitation Depth (in/hr)**
5	0.37	4.39
10	0.53	3.15
15	0.64	2.54
30	0.89	1.77
60	1.28	1.28

Chart Values based on NOAA 14 Point Precipitation Frequency Estimates: CA



NOAA Atlas 14, Volume 6, Version 2
Location name: Nipomo, California, USA*
Latitude: 34.9785°, Longitude: -120.6198°
Elevation: 132.58 ft**
* source: ESRI Maps
** source: USGS

POINT PRECIPITATION FREQUENCY ESTIMATES

Sanja Perica, Sarah Dietz, Sarah Heim, Lillian Hiner, Kazungu Maitaria, Deborah Martin, Sandra Pavlovic, Ishani Roy, Carl Trypaluk, Dale Unruh, Fenglin Yan, Michael Yekta, Tan Zhao, Geoffrey Bonnin, Daniel Brewer, Li-Chuan Chen, Tye Parzybok, John Yarchoan

NOAA, National Weather Service, Silver Spring, Maryland

PF_tabular | PF_graphical | Maps_&_aerials

PF tabular

PDS-based point precipitation frequency estimates with 90% confidence intervals (in inches)[1]

Duration	Average recurrence interval (years)									
	1	2	5	10	25	50	100	200	500	1000
5-min	**0.119** (0.106-0.134)	**0.147** (0.131-0.166)	**0.182** (0.162-0.206)	**0.209** (0.184-0.239)	**0.243** (0.205-0.291)	**0.268** (0.220-0.329)	**0.291** (0.232-0.369)	**0.315** (0.242-0.413)	**0.344** (0.252-0.476)	**0.366** (0.257-0.527)
10-min	**0.170** (0.152-0.192)	**0.211** (0.188-0.238)	**0.261** (0.232-0.296)	**0.299** (0.263-0.343)	**0.348** (0.294-0.417)	**0.384** (0.315-0.471)	**0.418** (0.333-0.529)	**0.451** (0.347-0.592)	**0.494** (0.361-0.682)	**0.525** (0.368-0.756)
15-min	**0.205** (0.184-0.232)	**0.255** (0.227-0.288)	**0.315** (0.280-0.358)	**0.362** (0.318-0.415)	**0.421** (0.355-0.504)	**0.464** (0.381-0.570)	**0.505** (0.403-0.640)	**0.546** (0.420-0.716)	**0.597** (0.437-0.824)	**0.635** (0.445-0.914)
30-min	**0.287** (0.257-0.325)	**0.356** (0.318-0.403)	**0.441** (0.392-0.500)	**0.506** (0.445-0.580)	**0.589** (0.497-0.705)	**0.649** (0.533-0.797)	**0.707** (0.563-0.895)	**0.763** (0.587-1.00)	**0.835** (0.611-1.15)	**0.887** (0.622-1.28)
60-min	**0.414** (0.370-0.467)	**0.513** (0.457-0.580)	**0.634** (0.564-0.720)	**0.728** (0.641-0.835)	**0.847** (0.715-1.01)	**0.934** (0.767-1.15)	**1.02** (0.811-1.29)	**1.10** (0.846-1.44)	**1.20** (0.879-1.66)	**1.28** (0.896-1.84)
2-hr	**0.608** (0.543-0.687)	**0.753** (0.672-0.853)	**0.932** (0.828-1.06)	**1.07** (0.940-1.23)	**1.24** (1.05-1.49)	**1.37** (1.12-1.68)	**1.49** (1.19-1.89)	**1.61** (1.24-2.11)	**1.76** (1.28-2.42)	**1.86** (1.31-2.68)
3-hr	**0.759** (0.678-0.858)	**0.941** (0.839-1.07)	**1.16** (1.03-1.32)	**1.34** (1.18-1.53)	**1.55** (1.31-1.86)	**1.71** (1.40-2.10)	**1.86** (1.48-2.36)	**2.01** (1.55-2.63)	**2.19** (1.60-3.03)	**2.33** (1.63-3.35)
6-hr	**1.05** (0.936-1.18)	**1.30** (1.16-1.47)	**1.61** (1.43-1.83)	**1.85** (1.62-2.12)	**2.15** (1.81-2.57)	**2.37** (1.94-2.91)	**2.57** (2.05-3.26)	**2.78** (2.14-3.64)	**3.04** (2.22-4.19)	**3.23** (2.26-4.64)
12-hr	**1.33** (1.19-1.50)	**1.65** (1.47-1.87)	**2.05** (1.82-2.32)	**2.35** (2.07-2.70)	**2.74** (2.31-3.28)	**3.02** (2.48-3.71)	**3.29** (2.63-4.17)	**3.56** (2.74-4.67)	**3.90** (2.85-5.38)	**4.14** (2.91-5.97)
24-hr	**1.69** (1.52-1.91)	**2.10** (1.90-2.38)	**2.62** (2.35-2.97)	**3.01** (2.69-3.45)	**3.52** (3.04-4.17)	**3.89** (3.29-4.70)	**4.25** (3.50-5.27)	**4.61** (3.69-5.87)	**5.06** (3.89-6.73)	**5.40** (4.00-7.42)
2-day	**2.03** (1.84-2.30)	**2.55** (2.30-2.89)	**3.21** (2.89-3.64)	**3.73** (3.33-4.26)	**4.41** (3.81-5.22)	**4.92** (4.15-5.94)	**5.42** (4.46-6.71)	**5.92** (4.74-7.54)	**6.57** (5.05-8.73)	**7.07** (5.24-9.72)
3-day	**2.24** (2.02-2.52)	**2.82** (2.55-3.19)	**3.60** (3.24-4.08)	**4.23** (3.78-4.84)	**5.09** (4.39-6.02)	**5.76** (4.86-6.96)	**6.44** (5.30-7.97)	**7.14** (5.72-9.09)	**8.09** (6.21-10.7)	**8.83** (6.55-12.2)
4-day	**2.45** (2.21-2.77)	**3.10** (2.80-3.51)	**3.98** (3.59-4.52)	**4.72** (4.21-5.39)	**5.74** (4.95-6.79)	**6.54** (5.53-7.90)	**7.38** (6.08-9.13)	**8.25** (6.61-10.5)	**9.47** (7.27-12.6)	**10.4** (7.74-14.4)
7-day	**2.88** (2.60-3.25)	**3.67** (3.31-4.15)	**4.73** (4.25-5.36)	**5.61** (5.01-6.42)	**6.85** (5.91-8.10)	**7.83** (6.61-9.46)	**8.84** (7.28-10.9)	**9.91** (7.94-12.6)	**11.4** (8.75-15.1)	**12.6** (9.33-17.3)
10-day	**3.11** (2.81-3.51)	**3.98** (3.59-4.50)	**5.15** (4.63-5.84)	**6.13** (5.47-7.01)	**7.50** (6.47-8.87)	**8.58** (7.25-10.4)	**9.71** (8.00-12.0)	**10.9** (8.73-13.9)	**12.6** (9.65-16.7)	**13.9** (10.3-19.1)
20-day	**3.73** (3.37-4.21)	**4.81** (4.34-5.44)	**6.28** (5.65-7.12)	**7.52** (6.71-8.60)	**9.27** (8.00-11.0)	**10.7** (9.01-12.9)	**12.1** (9.99-15.0)	**13.7** (11.0-17.4)	**15.9** (12.2-21.1)	**17.6** (13.1-24.3)
30-day	**4.38** (3.96-4.95)	**5.68** (5.12-6.42)	**7.45** (6.71-8.45)	**8.96** (7.99-10.2)	**11.1** (9.57-13.1)	**12.8** (10.8-15.5)	**14.6** (12.0-18.1)	**16.5** (13.3-21.1)	**19.3** (14.8-25.6)	**21.5** (15.9-29.6)
45-day	**5.44** (4.92-6.15)	**7.07** (6.38-7.99)	**9.31** (8.38-10.6)	**11.2** (10.0-12.8)	**13.9** (12.0-16.5)	**16.1** (13.6-19.5)	**18.5** (15.2-22.9)	**21.0** (16.8-26.7)	**24.5** (18.8-32.6)	**27.4** (20.3-37.7)
60-day	**6.18** (5.59-6.98)	**8.03** (7.24-9.08)	**10.6** (9.51-12.0)	**12.7** (11.4-14.6)	**15.8** (13.7-18.7)	**18.4** (15.5-22.2)	**21.0** (17.3-26.0)	**23.9** (19.1-30.4)	**28.0** (21.5-37.2)	**31.3** (23.2-43.1)

[1] Precipitation frequency (PF) estimates in this table are based on frequency analysis of partial duration series (PDS).

Numbers in parenthesis are PF estimates at lower and upper bounds of the 90% confidence interval. The probability that precipitation frequency estimates (for a given duration and average recurrence interval) will be greater than the upper bound (or less than the lower bound) is 5%. Estimates at upper bounds are not checked against probable maximum precipitation (PMP) estimates and may be higher than currently valid PMP values.

Please refer to NOAA Atlas 14 document for more information.

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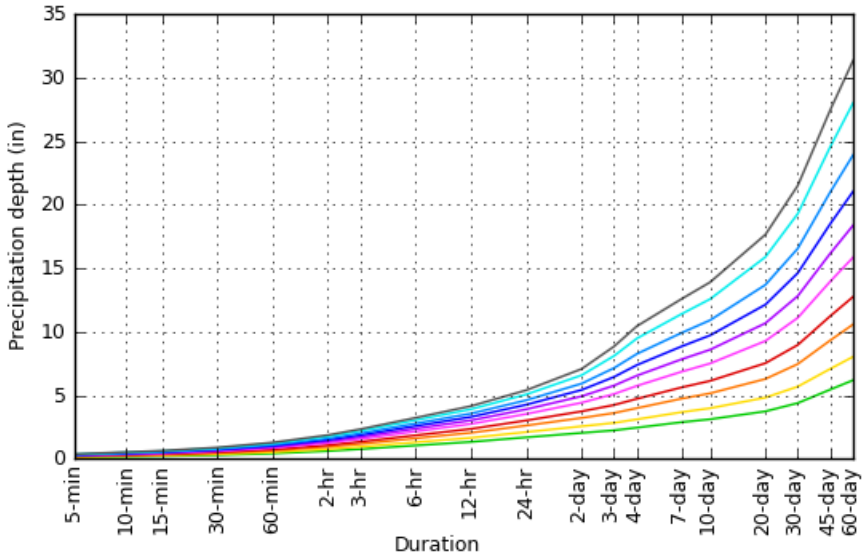
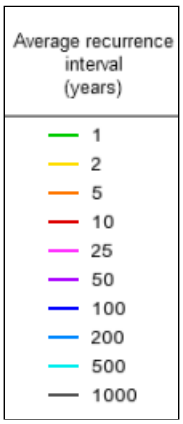
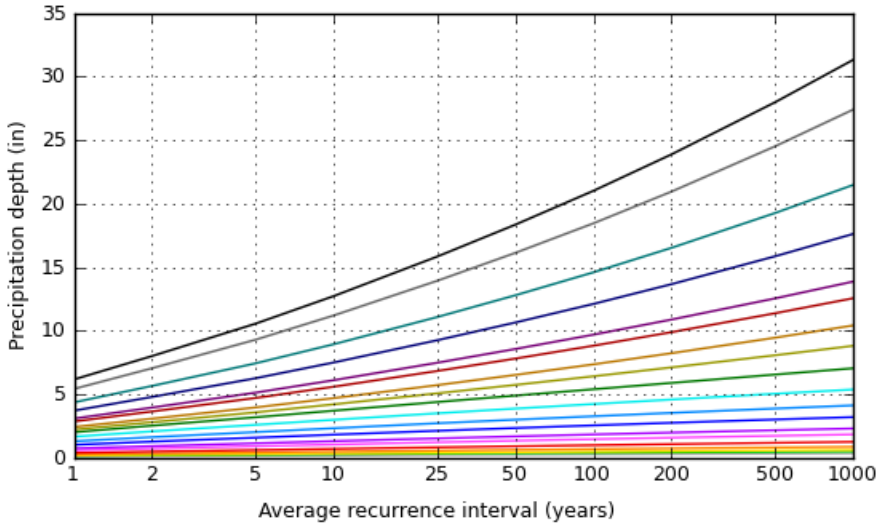
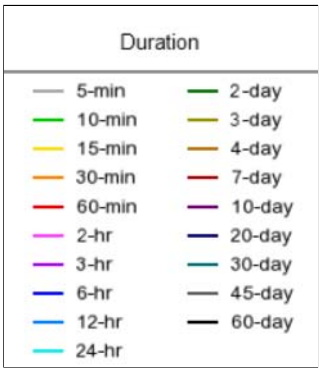
PF graphical

PDS-based depth-duration-frequency (DDF) curves
Latitude: 34.9785°, Longitude: -120.6198°









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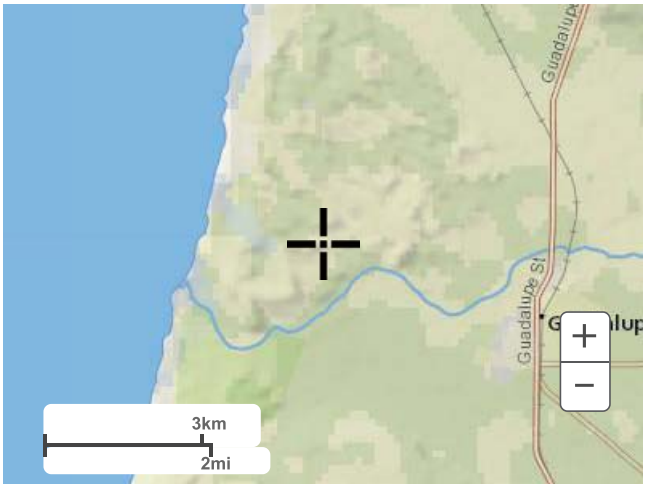
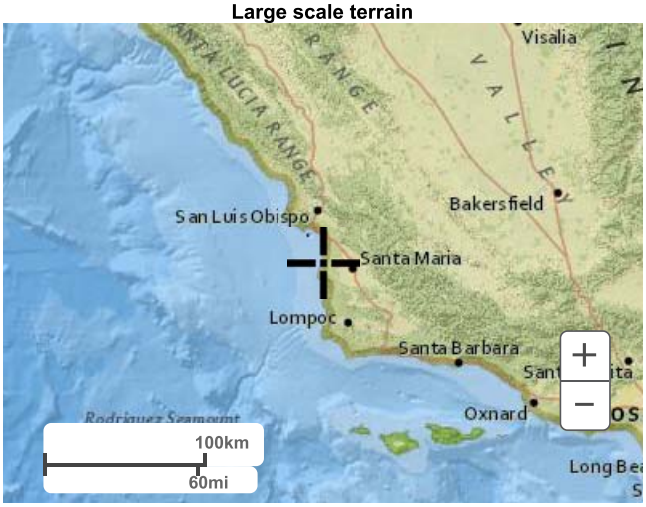
Maps & aerials

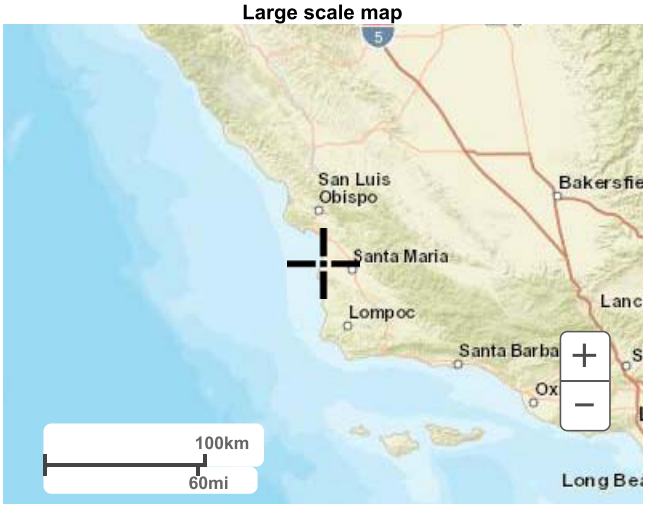
Small scale terrain



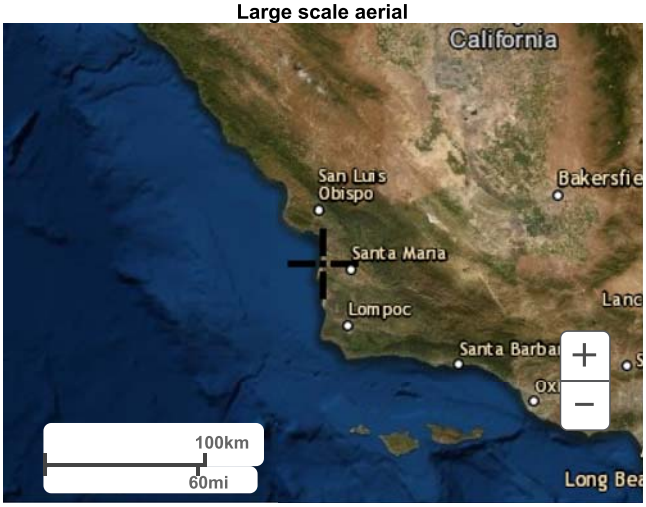
Large scale terrain



Large scale map



Large scale aerial



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US Department of Commerce
National Oceanic and Atmospheric Administration
National Weather Service
National Water Center
1325 East West Highway
Silver Spring, MD 20910
Questions?: HDSC.Questions@noaa.gov

Disclaimer

ATTACMENT 2

AWTS Capacity Calculation

GOLDER

CALCULATIONS

Date:	1-Jun-20	**Made by:**	HSG
Project No.:	1783552	**Checked by:**	LMA
Subject:	Discharge to Onsite Treatment Plant	**Reviewed by:**	RGH
Project Short Title:	Chevron Guadalupe Restoration Project		

Purpose

To determine if the existing Advanced Water Treatment System (AWTS) onsite is capable of handling the total inflow from the site following the construction of the proposed Soil Management Area (SMA).

Volume Calculations

Inflows to the AWTS include fluids from remediation wells and storm run-off from various remediation areas. Following the construction of the SMA, leachate flows and surface runoff from SMA will also be treated by the AWTS. Discharge rates from each of the contributing areas are provided in the tables below.

Table 1: Flows From Remediation Wells

Baseline Flow During Dry Months	3-6	gpm
Baseline Flow During Wet Months	5-10	gpm
Max Flow During Wet Months	**18**	gpm

Flow rate from remediation wells is based on nominal raw data from 2014-2019. The data is provided in Attachment 1 and 2.

Table 2: Leachate From Proposed SMA:

Peak Daily LCRS Flow Rate	753.84	cf/acre
LCRS Area	20	acres
Estimated Max LCRS Flow	**78**	gpm

The value of peak daily LCRS flow rate is from HELP analysis performed by Golder in 2020 (Appendix L of Report of Waste Discharge).

Table 3: Stormwater Runoff

January Mean Precipitation	2.49	inches
Area	20	acres
Run-off Coefficient	0.8	-
Monthly Run-off	1,081,752	gallons
Days	31	Days
Effective Flow Rate	**24**	gpm

Historically, the month of January experiences the greatest average monthly precipitation depths. Therefore, the maximum value is used in the calculation.

TOTAL INFLOW TO AWTS	**121**	**gpm**

Conclusions

The AWTS has an effective maximum flow rate of 160 gpm. Sum of the discharge rates of fluids generated onsite including from the proposed SMA are below the effective flow rate of the AWTS. The AWTS is capable of handing additional flow generated by the proposed SMA.

Attachment 1: AWTS Monthly Discharge Volume Raw Data From ENTACT
Attachment 2: AWTS Quarterly Discharge Volume Raw Data From Trihydro Corporation

Attachment 1

AWTS Monthly Discharge Volumes Raw Data From ENTACT

ATTACHMENT 1 - AWTS MONTHLY DISCHARGE VOLUME RAW DATA FROM ENTACT
SOIL MANAGEMENT AREA, TANK BATTERY 9 AREA
GUADALUPE RESTORATION PROJECT

Table 1: Raw Data in US Barrels

All Units in US Barrels (bbls)	2014	2015	2016	2017	2018	2019	Maximum Monthly Value	Average Monthly Value
Jan	562	6,436	13,368	14,588	14,997	11,330	14,997	10,214
Feb	4,473	6,254	7,512	3,318	3,050	11,921	11,921	6,088
Mar	8,228	6,905	10,311	13,751	7,822	8,172	13,751	9,198
Apr	4,094	9,180	5,304	2,747	2,642	3,321	9,180	4,548
May	3,938	9,093	6,128	1,515	1,693	3,136	9,093	4,251
Jun	9,773	4,192	3,008	323	1,151	364	9,773	3,135
Jul	3,515	10,701	4,047	4,612	3,615	1,559	10,701	4,675
Aug	6,241	2,195	3,671	8,096	4,761	719	8,096	4,281
Sep	3,269	5,153	2,291	10,121	4,482	1,913	10,121	4,538
Oct	6,477	3,249	12,846	7,320	2,666	-	12,846	6,512
Nov	9,209	7,410	11,969	5,672	6,561	-	11,969	8,164
Dec	18,862	9,455	11,826	5,306	7,341	-	18,862	10,558
Annual Total:	78,641	80,223	92,281	77,369	60,781	42,435		

Table 2: Raw Data in US Gallons

All Units In US Gallons*	2014	2015	2016	2017	2018	2019	Maximum Monthly Value	Average Monthly Value
Jan	23,604	270,312	561,456	612,696	629,874	475,860	629,874	428,967
Feb	187,866	262,668	315,504	139,356	128,100	500,682	500,682	255,696
Mar	345,576	290,010	433,062	577,542	328,524	343,224	577,542	386,323
Apr	171,948	385,560	222,768	115,374	110,964	139,482	385,560	191,016
May	165,396	381,906	257,376	63,630	71,106	131,712	381,906	178,521
Jun	410,466	176,064	126,336	13,566	48,342	15,288	410,466	131,677
Jul	147,630	449,442	169,974	193,704	151,830	65,478	449,442	196,343
Aug	262,122	92,190	154,182	340,032	199,962	30,198	340,032	179,781
Sep	137,298	216,426	96,222	425,082	188,244	80,346	425,082	190,603
Oct	272,034	136,458	539,532	307,440	111,972	-	539,532	273,487
Nov	386,778	311,220	502,698	238,224	275,562	-	502,698	342,896
Dec	792,204	397,110	496,692	222,852	308,322	-	792,204	443,436
Annual Total:	3,302,922	3,369,366	3,875,802	3,249,498	2,552,802	1,782,270		

* One (1) US Barrel (bbl) equals forty-two (42) US gallons.

ATTACHMENT 1 - AWTS MONTHLY DISCHARGE VOLUME RAW DATA FROM ENTACT
SOIL MANAGEMENT AREA, TANK BATTERY 9 AREA
GUADALUPE RESTORATION PROJECT

Table 3: Nominal Raw Data

All Units In US Gallons	Days	Maximum Monthly Value	Average Monthly Value	Nominal Maximum Flow Rate (gpm)	Nominal Average Flow Rate (gpm)	Nominal Average Flow Per Well (gpd)**
Jan	31	629,874	428,967	14	10	692
Feb	28	500,682	255,696	12	6	457
Mar	31	577,542	386,323	13	9	623
Apr	30	385,560	191,016	9	4	318
May	31	381,906	178,521	9	4	288
Jun	30	410,466	131,677	10	3	219
Jul	31	449,442	196,343	10	4	317
Aug	31	340,032	179,781	8	4	290
Sep	30	425,082	190,603	10	4	318
Oct	31	539,532	273,487	12	6	441
Nov	30	502,698	342,896	12	8	571
Dec	31	792,204	443,436	**18**	10	715

** Nominal Average Flow per Well based on a total of twenty (20) wells contributing inflow to the Advanced Water Treatment System.

Attachment 2

AWTS Quarterly Discharge Volume Raw Data From Trihydro Corporation

ATTACHMENT 2 - AWTS QUATERLY DISCHARGE VOLUME RAW DATA FROM TRIHYDRO CORPORATION
SOIL MANAGEMENT AREA, TANK BATTERY 9 AREA
GUADALUPE RESTORATION PROJECT

Year	Reporting Quarter	Operation (days)	Treated (gallons)	Treatment Flowrate (gpm)	Discharge Volume (gallons)	Discharged to	Discharge Flowrate (gpm)	Discharge Volume (gpd)
2016	1Q, 2Q	61	606,530	40	126,060	E4A	120	240 to 32,440
					480,470	E4A	120	240 to 32,440
	3Q, 4Q	70	1,552,280	42	1,552,280	E4A	120	1,680 to 115,300
2017	1Q, 2Q	76	1,420,660	40	1,420,660	E4A	120	60 to 86,070
	3Q, 4Q	145	1,908,960	40	1,845,590	E4A	120	1,130 to 45,350
					63,370	Recirculated	120	
2018	1Q, 2Q	105	1,663,070	40	1,264,180	E4A	120	50 to 140,380
					52,830	E5A	120	50 to 140,380
					346,060	Recirculated	120	50 to 140,380
	3Q, 4Q	119	1,266,380	40	917,980	E4A	120	10 to 80,310
				40	237,650	E5A	120	10 to 80,310
				40	110,750	TB8	120	10 to 80,310
					97,230	Recirculated		
2019	1Q, 2Q	112	1,693,460	40	1,693,460	E4A	120	490 to 62,120
	3Q, 4Q	63	968,410	40	-	E4A	120	650 to 104,170
	TOTAL:	**751**	**11,079,750**	-	**9,701,910**	-	-	-
AVERAGE (GALLONS/DAY):		-	**14,753**	-	**12,919**	-	-	-

APPENDIX O

Emergency Response Plan

human energy®

Guadalupe Remediation Project
Emergency Response Plan

Chevron Environmental Management Company (CEMC)
Downstream Business Unit
January 2020

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1 Emergency Response Preamble

The provisions of this Emergency Response Plan (ERP) are provided by Chevron EMC Guadalupe Project in an organized effort to protect site personnel from injury and minimize property damage in the event of an emergency situation at the Chevron EMC Guadalupe Project located at 2184 West Thornberry Road within San Luis Obispo County, California.

This ERP is a working document designed to address the most probable emergency scenarios at the site. Resources will be made available to respond to an emergency event by using trained employees and additional response agencies. All employees and business partners shall be aware of this emergency response procedure.

Business Partners, retained by Chevron EMC Guadalupe, conducting the work, are responsible for understanding and complying with this ERP. Additionally, all Business Partners are directly responsible for the safety and health protection of their employees.

All site personnel, to include Chevron EMC employees and Business Partners, will be trained on this plan to ensure that all of the proper procedures are followed in a safe and responsible manner. A master copy of the ERP will be kept in the Chevron EMC Guadalupe main office and will be available to all site personnel.

Statement of Policy
Facility and personnel safety will always take precedence over maintaining operations. Personnel will not attempt to continue working on or remain at a location if the facility is in an unsafe condition. All personnel are authorized to stop work if an unsafe condition posing an immediate hazard occurs. All emergency response actions, processes, and procedures will follow and be conducted in accordance with the Chevron Way and Chevron Tenets of Operation. No reprimands will be given if the situation later proves less serious than thought. Hazards of a less serious nature should be brought to the attention of the supervisor who will assess the situation and initiate appropriate action.

Under emergency response conditions or drills, employees are expected to act only in accordance with their training, the Chevron Way, and the Chevron Tenets of Operation. At no time will any employee place themselves, or allow themselves to be placed, into a life-threatening situation.

The following priorities will govern our response to any emergency situation:

1. The safety of employees takes precedence over all other considerations.
2. We will minimize impact on the environment once the safety of all personnel has been secured.
3. We will endeavor to minimize damage to or loss of property and equipment, keeping safety and environmental concerns at the top of our priority list.

1.1 Approach

The general approach for responding to emergencies is:

- Immediate first response by site personnel who are trained and experienced in first response
- Stabilization of site conditions, including shut down of work activities
- Mobilize Emergency Response Trailer to incident scene (when applicable) along with First Aid kit and AED (when relevant)
- Notification of site management, emergency responders and other authorities as listed in Appendix A.
- When necessary, facilitate transport of injured individuals to medical facilities

The Business Partner's Project Manager, or designee, is responsible for ensuring availability of first response equipment and trained personnel for first response actions at the site. First response equipment on the site is shared by all Business Partners (BP).

The locations of emergency response medical facilities and points of contact for emergency notification will be posted on site and in accordance with this Emergency Response Plan and the Business Partner's Site-Specific Health and Safety Plan. Emergency access and evacuation routes will also be posted on site and available to personnel. As part of the development of each Business Partner's Site-specific Health and Safety Plan, and prior to commencement of remediation activities, the Business Partner's Project Manager, or designee, will ensure that qualified personnel have inspected the site to ensure adequate access and that first response equipment is available onsite, including first aid equipment, fire extinguishers and liquid hydrocarbon spill recovery equipment. The following types of emergencies are discussed specifically below: Site Worker Injuries, Facility Fire, Wild Fire, Liquid Hydrocarbon Spill, Earthquake, Extreme Weather.

1.2 Emergency Response Philosophy

When you respond to an emergency, whether you are the first to arrive or in a support role, you have three concerns which should be part of any action you might take.

- Safety for yourself and those around you. We will put safety first when dealing with any incident. What can be done to guarantee the safety of yourself and those involved in the incident?
- Environmental Impact - We will minimize impact on the environment once we have established a safe area in which to proceed.
- Outcome on all Chevron and non-Chevron property - We will attempt to minimize damage to or loss of property and equipment, keeping safety and environmental concerns at the top of our priority list.

1.3 Developing an Action Plan

When developing an action plan, consider the following:

- What can be done to ensure the safety of those involved in this incident?
- What is the objective of the initial response? What is the objective of support response?
- How much support will it require to effectively deal with the situation?

2 Emergency Response Preparation

This plan identifies the most probable risks for emergencies at the Guadalupe site. The plan outlines mitigation steps, including emergency response (ER) actions to ensure the safety of personnel, and the public, as well as, to protect the environment and assets.

The scope and application of the ERP covers Guadalupe main offices and field operations.

This plan is intended to comply with 29 CFR 1910.38, 119, and Chevron Operational Excellence (OE) Elements 1 (1.1, 1.3) and 11 (11.2 and 11.3).

2.1 Site-Specific Safety Orientation

For Guadalupe Field Operations and Office personnel, a Guadalupe site orientation and safety training is required. A Guadalupe site specific safety orientation will be given to all new employees, contractors, and visitors. This orientation may be tailored to the needs of the visitor, but will include information on relevant alarm systems, safety, operations, personal protective equipment (PPE) requirements, and emergency procedures for the Guadalupe site. Any Chevron employee or designee assigned to the site can give the orientation. Currently, the contractor crew includes several personnel that are qualified to give the orientation. Completion of the orientation is documented and kept at the Guadalupe main office by the Chevron Administrative Technician. Newly assigned employees and contractors that meet the Short Service Employee (SSE) criteria are entered into the SSE program. This program physically identifies these employees with orange hardhats. Please reference the CEMC CHESM Process Document for more information on the SSE program.

2.2 Alarm Systems

Guadalupe Main Offices

Notification of an emergency situation may be given at the Guadalupe Main Offices using either of the following methods:

- Audible fire/smoke alarms
- Verbally (radio, cell phone, in person)

Guadalupe Field Operations

Verbal commands (radio, cell phone, in person) as identified and outlined on the JSA.

Guadalupe Supervisory Control and Data Acquisition (SCADA)

- Activated fire alarm at the operational systems sent as pages to the on-call operator

2.3 Muster Points

Emergency muster points will be discussed during pre-job meetings and noted in the Job Safety Analysis (JSA).

Primary Muster Points

There are three pre-designated emergency mustering points at the Guadalupe site:

- The main office parking lot
- TB9/LTU (S)
- E3A/E4A Stockpile Area (W)

Alternate and temporary mustering points may be established by site management based on operational need. These will be discussed with field crews and documented on the JSA when applicable. The map in Appendix C notates the location of the muster points and includes emergency access/evacuation routes.

3 Evacuation Procedures

Guadalupe Field Locations

All personnel present on site are noted by crew leaders and supervisors. In the event of an emergency requiring evacuation personnel will mobilize to the designated muster point where a headcount will be conducted prior to mobilizing offsite. If evacuation is required, personnel will follow the exit route as indicated in Appendix C.

Guadalupe Main Offices

Duties of individuals, trained to carry out the safe and orderly emergency evacuation of the Guadalupe Main Offices are noted below:

Position	Duty
All CEMC and BP Employees	Evacuate and assist others in leaving building and reporting to the muster point.
BP Project Manager (PM) (or designee)	Notify all personnel of evacuation
	Assign floor warden to sweep building
	Take roll call at the muster point
	Oversee evacuation of their personnel
CEMC Team Lead or designated person in charge	Direct additional response as appropriate
	Post personnel at the gate to direct emergency services
	Determine when all-clear may be given

All employees will immediately evacuate the location and report to the main office muster point where they will await instructions from their supervisor or the Chevron designated person in charge.

All personnel, including visitors, are required to be documented on a logbook upon entering the Guadalupe site. The time of their arrival and departure from the facility is noted in the logbook. In the event of an emergency, the BP PM will designate a person to obtain a copy of the logbook from the front gate. Chevron personnel or designee will use the logbook, and verbal communication(s) at the muster point to account for all personnel. If necessary, available personnel may initiate a search for any missing person(s), as long as it is safe to do so.

All-Clear Signal: When employees have been evacuated from the building, re-entry will only be permitted after it has been determined safe to do so by CEMC Team Lead or designated person in charge. This may be done in consultation with local emergency responders.

4 Accident / Incident - Emergency Action Plan

For the purposes of this emergency response plan, an accident or incident occurring on or off Chevron property can be defined as:

- Motor vehicle accident, with or without injury
- Work-related accident, with or without injury
- Personal injury, to include non-work-related activity or pre-existing health condition.

Position	**Actions**
First Responder	• Assess the situation for hazards present. Only approach injured person (IP) when it is safe. • Notify your supervisor and request support personnel: · Describe the incident and include: § Location of incident § Nature of injury § # of IP's and their condition § Equipment involved § Environmental factors § Other hazards that may exist · Describe resources needed. Examples: § First Aid Kit, AED, etc. § Additional support personnel § Ambulance, Fire Truck, Police • Move IP to safe location only if necessary and is safe to do so • Administer CPR/First Aid as appropriate • Remain with IP until support/relief arrives

Supervisor	• Receive initial incident notification from first responder • Obtain incident information • Obtain information on resources needed • Contact Injury Care Management Consultation Service (Axiom) for initial treatment recommendations. • Call 911 (if applicable) · Describe the incident and include: § Location of incident § Nature of injury(s) § # of IPs and their condition § Equipment involved § Environmental factors § Other hazards that may exist • Dispatch support to incident • Notify Chevron person in charge and BP PM • Dispatch ER escort to front gate • Notify traffic control to stop all non-essential vehicle traffic • Provide update to first responder
CEMC Team Lead or designated person in charge	• Receive incident notification/briefing · Incident description · Resources deployed · Resources requested • Make determination on who will be the IC and any IC supporting roles, as necessary • Initiate CEMC internal notifications • Coordinate response with ER agencies • Command the response

5 Fire – Emergency Action Plan

There are multiple facilities at the Guadalupe site which contain combustible material and some containing flammable material. Appendix B contains a site facilities map

which notes key facilities where a fire may occur; however, the potential for a fire is not strictly limited to those facilities.

Propane Tank Fire. In the event of a propane tank fire, site personnel will not attempt to contain or combat the fire and will evacuate the immediate area and put as much distance between themselves and the source as they possibly can. Then follow the notification procedures as previously outlined.

Wild Fires. Considering the vegetation on site, the agricultural fields that border the site to the east, the ocean to the west, the dunes to north, the western prevailing wind direction, and the abundance of fire breaks throughout the site in the form of access road, it has been determined that threat of a wildfire is minimal.

Certain personnel onsite have fire extinguisher training. Fire extinguisher are located throughout the site and within every contractor truck and heavy equipment. Records of those personnel and their training can be obtained from the Padre and ENTACT HES personnel.

Position	**Actions**
First Responder	• Assess the situation for hazards present. • Notify all personnel in the immediate vicinity • Make an initial response effort to suppress and contain the fire only if you are trained and it is safe to do so. • Notify your supervisor and request support personnel: · Describe the incident and include: § Location of fire § Source of fire (electrical, liquid hydrocarbon, etc.) § Equipment/facility involved § Environmental factors § Other hazards that may exist · Describe resources needed. Examples include additional support personnel or external ER agencies • If there are injured parties, do not attempt to remove them to a safe area until: · Your backup arrives · You have proper equipment · It is safe to do so • Examine the source of the fire and adjacent facilities. *You may decide it is best to establish a safe*

	perimeter, evacuate adjacent facilities, and wait for qualified help.
Supervisor and/or Designee	• Receive initial incident notification from first responder • Obtain incident information • Obtain information on resources needed • Call 911 (if applicable) · Describe the incident and include: § Location of fire § Source of fire (electrical, liquid, hydrocarbon, etc.) § # of IPs and their condition § Equipment involved § Environmental factors § Other hazards that may exist • Dispatch support to incident • Notify Chevron person in charge and BP PM • Notify Traffic Control to stop all non-essential vehicle traffic • Dispatch operational support to assess critical site infrastructure and roadways for additional threats • Dispatch ER escort to front gate • Provide update to first responder
CEMC Team Lead or designated person in charge	• Receive incident notification/briefing • Make determination on who will be the IC and any IC supporting roles, as necessary • Initiate CEMC internal notification • Coordinate response with ER agencies • Command the response
Traffic Control	• Initiate stand down and clear all traffic from road • Support transportation of responding personnel

6 Earthquake/Tsunami - Emergency Action Plan

According to OSHA, the primary dangers to workers during an earthquake result from being struck by structural components or furnishings, inadequately secured stored materials, burns resulting from building fires resulting from gas leaks or electrical shorts, or exposure to chemicals released from stored or process chemicals.

Be on the lookout for fires. Fire is the most common earthquake-related hazard, due to broken gas lines, damaged electrical lines or appliances, and previously contained

fires or sparks being released. Stay away from powerlines, downed powerlines, and objects that may be touching a downed powerline such as fences, guardrails, etc. In the event of an earth quake take the following the measures.

Position	**Actions**
Persons located within a facility	• Seek "safe places", and drop, cover, and hold on. *A safe place could be under a sturdy table or desk or against an interior wall away from windows, bookcases or tall furniture that could fall on you.* • Wait in your safe place until the shaking stops Be prepared for aftershocks • Check the safety of those around you, and assist those in need • Evacuate the facility when clearance is provided by the EMC Team Lead or designee and it is safe to do so. Mobilize to the nearest muster point • Wait at the muster point until a head count has been taken and approval to resume work has occurred
Persons located outside of a facility	• Stay outside • Move away buildings, trees, streetlights, overhead power lines, heavy equipment and anything that has the potential to collapse or fall • Crouch down and cover your head • Wait in your safe place until the shaking stops *Be prepared for aftershocks* • Check the safety of those around you, and assist those in need • Mobilize to the nearest muster point ** Not E3A • Wait at the muster point until a head count has been taken and approval to resume work has occurred • If driving, and it is safe to do so, stop the vehicle and follow the guidelines above

Tsunamis

The Guadalupe site is bordered on its western perimeter by the Pacific Ocean. This places the western and southwestern most portions of the site within the tsunami inundation zone. Because the site is located within the sand dunes, threats of liquefaction is also a concern in the coastal zone where wave run-up is likely.

Unlike normal waves, tsunamis approach land in a manner similar to a surge or flash flood. They are triggered by earthquakes and/or underwater landslides. Tsunamis can originate in the middle of the ocean and travel several miles before making landfall. If a person is working in proximity to the coast, especially if they are within the tsunami inundation zone, and feel a large earthquake it is important to follow the steps outlined in the table above, and as soon as the shaking has stopped, move inland and go to high ground. When it is safe to do so, report to the nearest mustering area.

** *Do not utilize the E3A mustering point in the event of an earthquake or Tsunami*. Its proximity to the tsunami inundation zone, coupled with the threat of liquefaction, makes this location unsuitable for post-earthquake mustering.

For additional information on the tsunami inundation areas, please visit the websites listed below:

County of Santa Barbra Tsunami Preparedness
San Luis Obispo County Tsunami Preparedness

Post-Earthquake Response (O&M)

Work shall not resume until the threat of aftershocks has passed. Upon reviewing the severity of the earthquake, the Chevron Team Lead or designee shall determine what facility inspections are required. The best management practice after any major earthquake or tsunami includes inspection of critical facilities under the supervision/direction of the O&M Supervisor. The critical facilities have been identified on the map provided in Appendix B and are listed below. When inspecting facilities where hydrocarbons are present, **use a PID or TLV monitor** to check for potential hydrocarbon vapors.

Position	Actions
BP O&M Crew	• Open (air gap) the Re-closure at the main office, which will de-energize the entire lease. • **Below is a list of the facilities that must be inspected prior to re-energizing** · Advanced Water Treatment System · All overhead powerlines · All ground Transformers · All recovery well production lines · All active recovery wells · Water plant building – P3A pad · All office locations · Liquid or gaseous phase hydrocarbons storage areas • Report findings to supervisor
BP O&M Supervisor	• Oversee inspections by O&M crew • Provide updates to BP PM at agreed upon intervals
CEMC Team Lead or designated person in charge	• Obtain a copy of logbook from front gate security guard • Designate a person responsible for headcount at each of the muster locations • Meet with O&M supervisor and align on facility priority inspections and agree to touchpoint intervals • Obtain results of headcount • Coordinate search for any missing persons • Review any notifications issued by the U.S. Tsunami Warning System • Issue “All Clear” when it is safe to resume work • Initiate CEMC internal notification

7 Gas Leak - Emergency Action Plan

There is no known liquid natural gas (LNG) lines running through the Guadalupe Restoration Project lease; however, compressed propane gas is stored at three locations onsite:

M3 Area

K-13A (TB 9 Area/LTU Area)

E2 (Compressor Plant Area).

The facilities map in Appendix B notes these locations. In the event a leak is detected or suspected the table below details specific actions to be taken.

Position	Actions
First Responder	• Assess the situation for hazards present. Do not approach if you are uncertain it is safe to do so. • Avoid low-lying areas • Notify all personnel in the immediate vicinity • Shut off all vehicles and possible sources of ignition • If safe to do so, close the tank valve • If it is not safe to approach the leak source, evacuate to a safe area upwind of the source (follow DOT guidebook • Notify your supervisor · Describe the incident and include: § Location and source of leak (if known) § Actions already taken § Environmental conditions/factors § Other hazards that may exist • If there are injured parties, do not attempt to remove them to a safe area until: § Your backup arrives, § You have proper equipment, and § It is safe to do so. • Establish a safe perimeter
Supervisor	• Receive initial incident notification from first responder • Obtain incident information • Obtain information on resources needed • Call propane servicing provider

	· Describe the incident and include: § Site location § Equipment involved § Environmental factors § Other hazards that may exist • Dispatch support to incident (if qualified personnel are available) • Notify Chevron person in charge and BP PM • Establish a safe perimeter • Dispatch ER escort to front gate • Notify traffic control to stop all non-essential vehicle traffic
CEMC Team Lead or designated person in charge	• Receive incident notification/briefing • Make determination on who will be the IC and any IC supporting roles, as necessary • Initiate CEMC internal notification (if applicable) • Coordinate response with ER agencies • Command the response

8 Liquid Hydrocarbon Spill

Detailed spill response procedures are addressed in section 8 of the approved Spill Prevention Control and Countermeasure Plan. The Guadalupe site stores minimal quantities of Liquid Hydrocarbons. Materials stored are under secondary containment to prevent possible impacts to the environment. If any personnel identify a spill they are to notify their supervisor and secure the area.

appendix a: Emergency Contact Information

CALL (9) 911 FOR ALL EMERGENCIES

Guadalupe Restoration Project Address:
2184 West Thornberry
Guadalupe, CA 93434

Radio Jimmy Gotz or call (9) 805-343-7703 (Front Gate) for Emergency Assistance

The Padre room phone can be used in case of a power outage.
All numbers without an area code are area code 805.
For on-site phones, dial 9 first, then phone number.

EMERGENCY

First Call (9) 911

		Office	Cell
Chevron Area Manager	Owen Ranta	546-6912	815-530-6939
Chevron Proj. Manager	Danielle Wold	858-3028	832-581-5426
Trihydro PM	Ercan Candan	858-3032	805-264-0765
Trihydro HES	Charles Froome		316-619-8690
ENTACT PM	Kaley Kozlowski	858-3066	815-343-3637
ENTACT HES	Lance Bruce	858-3051	630-669-3940
GANDA PM	Tom Olson	858-3029	717-1938
All Seasons PM	Greg Nowell	858-3057	235-3857
Marian Medical Center Emergency Medicine		739-3200	

NON-EMERGENCY

Marian Medical Center	805-739-3000
Arroyo Grande Community Hospital	805-489-4261
IMG Industrial Medical Center	805-922-8282
Guadalupe Fire Station	805-343-1444- Press 4
Santa Maria Fire Station	805-925-0951- Press 3
Mesa Fire Station- Station 22	805-473-7171
U.S. Coast Guard (Base Alameda, District 11)	510-437-3701
San Luis Obispo Sheriff	805-781-4550

appendix b: Facilities Map

M:\CHEVRON\GUADALUPE\GIS\MAPPING\GENERAL\SITEMAPS\H-S\EMERGENCYACTIONPLAN\APPB_GUAD_FACILITIESMAP.MXD

EXPLANATION

- LIQUID HYDROCARBON STORAGE
- PROPANE TANK
- TRANSFORMER
- POWER POLE
- IN-SERVICE WATERLINE
- OVERHEAD POWER LINES
- COUNTY LINE
- PROPERTY BOUNDARY
- SANTA MARIA RIVER STATE WETLAND DELINEATION
- EXISTING ROADWAY OR WELL PAD FEATURE
- FORMER ROADWAY OR WELL PAD FEATURE

NOTES:
DECON = DECONTAMINATION
GW = GROUNDWATER

N

0 1,300'

Trihydro CORPORATION
1252 Commerce Drive
Laramie, WY 82070
www.trihydro.com
(P) 307/745.7474 (F) 307/745.7729

APPENDIX B

FACILITIES MAP

CHEVRON ENVIRONMENTAL MANAGEMENT COMPANY GUADALUPE RESTORATION PROJECT

Drawn By: PH	Checked By: EC	Scale: 1 " = 1,300 '	Date: 2/13/20	File: AppB_Guad_FacilitiesMap.mxd

appendix c: Evacuation and Emergency Response Map

M:\CHEVRON\GUADALUPE\GIS\MAPPING\GENERAL\SITEMAPS\PH-SI\EMERGENCYACTIONPLAN\APPC_GUAD_EVACUATIONMAP.MXD

EXPLANATION

- AED
- DECON PAD
- DIESEL TANK
- EYE WASH STATION
- FIRE EXTINGUISHER
- FIRST AID KIT
- GUARD STATION
- LAND LINE
- PROPANE TANK
- ACTIVE RECOVERY SYSTEM
- COUNTY LINE
- PROPERTY BOUNDARY
- BORROW/STOCKPILE AREA
- BUILDING AREA
- EMERGENCY RESPONSE TRAILER
- TANK BATTERY AREA
- EXISTING ROADWAY OR WELL PAD FEATURE
- FORMER ROADWAY OR WELL PAD FEATURE

NOTES:
DECON = DECONTAMINATION
TB = TANK BATTERY

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APPENDIX C

EVACUATION AND EMERGENCY RESPONSE MAP

CHEVRON ENVIRONMENTAL MANAGEMENT COMPANY GUADALUPE RESTORATION PROJECT

Drawn By: PH	Checked By: EC	Scale: 1 " = 1,300 '	Date: 2/13/20	File: AppC_Guad_EvacuationMap.mxd

APPENDIX P

Erosion Calculation using RUSLE

GOLDER

CALCULATIONS

Date: July 8, 2019 **Made by:** H. Gill

Project No.: 1783552 **Checked by:**

Subject: Erosion Calculations using RUSLE **Reviewed by:**

Project Short Title: Chevron Guadalupe Closure

Based on methodology presented in Predicting Soil Erosion by Water: A Guide to conservation Planning With the Revised Universal Soil Loss Equation (RUSLE). Some values obtained from tables compiled by the Five Counties Salmonid Conservation Program.

Revised Universal Soil Loss Equation (RUSLE)

A = R x K x LS x C x P

Variable	Description	Value Used	Notes:
A	Soil loss in tons/yr/acre	-	Calucated using RUSLE for each slope below
R	Rainfall-Runoff erosivity factor	38.29	From EPA Rainfall Erosivity Factor Calculator
K	Soil Erodibility factor	0.325	Average value from K factor table for medium textured silt loam soils
LS	Slope Length/Steepness factor	varies	Interrpolated value from Table 4-2 based on slope (%) and slope length
C	Cover management factor	0.01	From Cover Management table for native vegetation
P	Support Practice Factor	1	No support practices used

Erosion Prediction Using RUSLE

Slope	Slope Length (ft)	LS Factor	**Soil Loss (tons/yr/acre)**
50:1	260	0.33	**0.04**
3:1	300	12.45	**1.55**
5:1	540	9.55	**1.19**

APPENDIX Q

Settlement Calculations

Date:	October 4, 2019	**Made by:**	CZG
Project No.:	1783552	**Checked by:**	LMA
Subject:	TB-9 Base Grade and Soil Settlement Calculations	**Reviewed by:**	KGH
Project Short Title:	Chevron Guadalupe Soil Management Area		

1.0 Purpose

To evaluate the settlement of the base grades and soil for the Chevron Guadalupe Soil Management Area, Tank Battery 9.

2.0 Method

Post-settlement grades were evaluated by calculating the differential settlement along the respective slopes using the consolidation settlement methods presented in Conduto, 1998.

3.0 References

Conduto, D.P. (1998). "Geotechnical Engineering: Principles and Practices," Upper Saddle River, New Jersey, Prentice-Hall, Inc.

Padre Associates, Inc. (2018). "Geotechnical Assessment Services Data Report, Tank Battery 9 (TB9), Guadalupe Restoration Project 2184 West Thornberry Road Guadalupe, San Luis Obispo County, California."

Trihydro Corporation. (2019). "Guadalupe Restoration Project Water Monitoring and Site Remediation Acitivities Semi-Annual Report July-December 2018, San Luis Obispo County, California."

4.0 Assumptions

4.1 Base Grade Settlement Assumptions

The base grade settlement was calculated along the Leachate Collection and Removal System (LCRS) pipe (Section A-A'). A plan and profile view of Section A-A' is provided in Attachment 1.

The average groundwater elevation was estimated to be at 32 feet based on findings in the Trihydro Corporation report.

The unit weight of the soil was estimated to be 120 pounds per cubic foot (pcf).

The final cover has a unit weight of 120 pcf and is 6-feet thick.

The existing soil stratigraphy was estimated using soil data from the Padre Associates report and the base grading plan from Golder Associates. The soil layers are made up of a combination of sands, silty sands, sandy silts, and engineered fill. The soil unit weights were estimated using the Padre Associates report while the primary and secondary compression ratios were determined using Conduto (1998).

4.2 Soil Settlement Assumptions

The soil settlement was calculated along Sections B-B', C-C', and D-D'. A plan and profile view of the sections are provided in Attachment 2.

The unit weight of the soil was estimated to be 120 pcf. The primary and secondary compression ratios were estimated based on soil type using Conduto (1998). The primary compression ratio was assumed to be 0.012 for the sand/silty sand layers and 0.0014 for sandy silt/silty sand layers. The secondary compression ratio was assumed to be 0.002 sand/silty sand layers and 0.003 sandy silt/silty sand layers. Sand layers were assumed to be non-compressible. The average age of the soil at closure is 5 years and the post-closure period is 30 years.

The final cover has a unit weight of 120 pcf and is 4-feet thick.

5.0 Settlement Calculations

The following equations (Conduto, 1998) were used to determine primary and secondary settlement for both the base grades and the soil.

Primary Consolidation:
$\delta_c = C_{C\varepsilon} * H * \text{Log}((\sigma'_{v0} + \Delta\sigma'_{v0}) / (\sigma'_{v0}))$

Secondary Consolidation:
$\delta_s = C_{\alpha\varepsilon} * H * \text{Log}(t2/t1)$

Where:
δc = Primary consolidation
$C_{C\varepsilon}$ = Primary consolidation ratio in terms of strain (0.012 or 0.014)
H = Thickness of soil layer
σ'_{v0} = Initial vertical effective stress
$\Delta\sigma'_{v0}$ = Change in vertical effective stress
δ_s = Secondary consolidation
$C_{\alpha\varepsilon}$ = Secondary consolidation ratio in terms of strain (0.0002 or 0.0003)
t1 = Time after application of load
t2 = Time required to complete consolidation settlement

6.0 Summary

Tables 1 and 2 summarize the differential settlement between points for the base grades and the soil, respectively. Detailed calculations are provided in Attachments 3 and 4.

Table 1: Base Grade Settlement Summary

Point Numbers	Differential Settlement (ft)	Pre-Settlement Grade (%)	Post-Settlement Grade (%)
Cross Section A-A'			
1 to 2	0.02	29.6	29.5
2 to 3	0	2.1	2.1
3 to 4	0.06	1.9	1.9
4 to 5	0.04	1.9	1.9

Table 2: Soil Settlement Summary

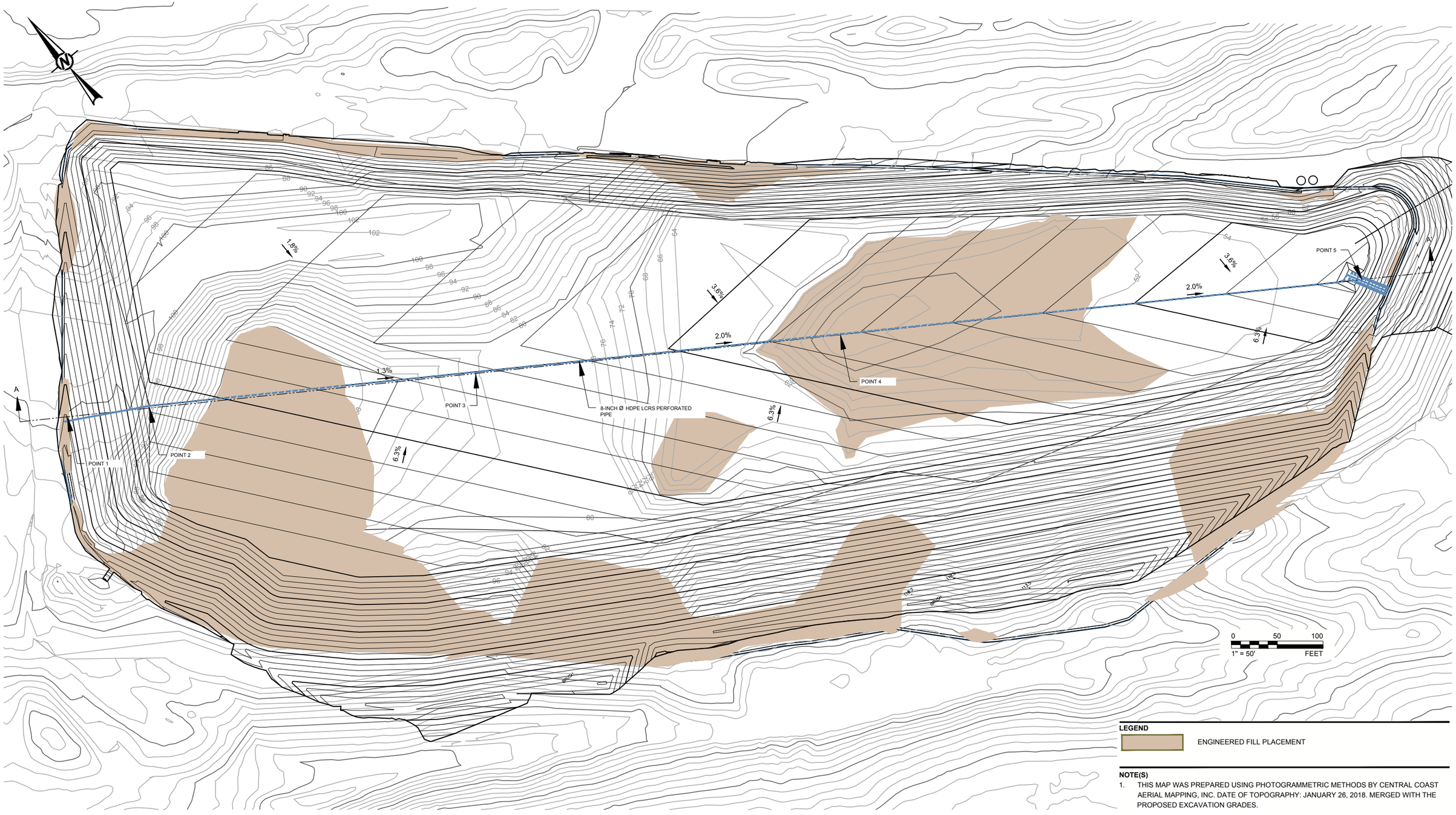
Point Numbers	Differential Settlement (ft)	Pre-Settlement Grade (%)	Post-Settlement Grade (%)
Cross Section B-B'			
1 to 2	0.12	32.6	32.6
2 to 3	0.0	0.1	0.1
3 to 4	0.0	0.0	0.0
4 to 5	0.12	17.9	17.9
Cross Section C-C'			
6 to 7	0.1	27.2	27.1
7 to 8	0.03	34.5	34.5
8 to 9	0.04	3.4	3.4
9 to 10	0.09	31.6	31.6
Cross Section D-D'			
11 to 12	0.13	33.1	33.1
12 to 13	0.01	3.2	3.2
13 to 14	0.12	32.9	32.8

7.0 Conclusions

Golder's settlement analysis has determined that the Chevron Guadalupe Soil Management Area (TB9) will maintain positive drainage along the base grade slopes and the final cover.

Attachment 1: Base Grade Settlement Plan and Profile
Attachment 2: Soil Settlement Plan and Profile
Attachment 3: Base Grade Settlement Calculations
Attachment 4: Soil Settlement Calculations

Attachment 1



LEGEND

ENGINEERED FILL PLACEMENT

NOTE(S)

1. THIS MAP WAS PREPARED USING PHOTOGRAMMETRIC METHODS BY CENTRAL COAST AERIAL MAPPING, INC. DATE OF TOPOGRAPHY: JANUARY 26, 2018. MERGED WITH THE PROPOSED EXCAVATION GRADES.

REV.	YYYY-MM-DD	DESCRIPTION	DESIGNED	PREPARED	REVIEWED	APPROVED
0	2019-07-08		MAG	CZG	LMA	RH

SEAL

CLIENT

CHEVRON ENVIRONMENTAL MANAGEMENT COMPANY
2184 WEST THORNBERRY ROAD
GUADALUPE, CA 93434

CONSULTANT

GOLDER

SACRAMENTO OFFICE
1000 ENTERPRISE WAY, SUITE 190
ROSEVILLE, CA 95678
USA
(916) 786-2424
www.golder.com

PROJECT

GUADALUPE RESTORATION PROJECT
SOIL MANAGEMENT AREA TANK
BATTERY 9 AREA

TITLE

BASE GRADE SETTLEMENT ANALYSIS

PROJECT NO.	REV.		DRAWING
1783552	0	1 of 2	1

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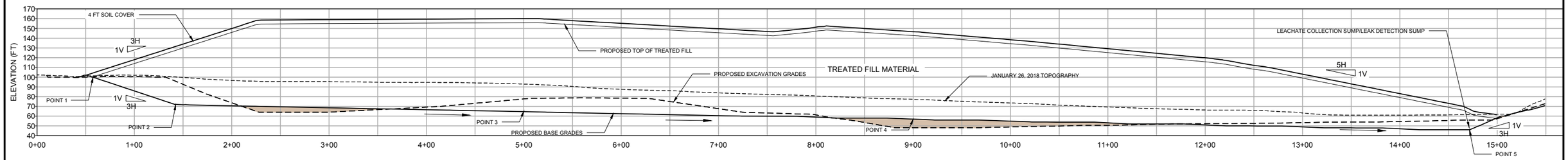

CROSS-SECTION A-A'

0 50 100

1" = 50' FEET

LEGEND

ENGINEERED FILL PLACEMENT

REV.	YYYY-MM-DD	DESCRIPTION	DESIGNED	PREPARED	REVIEWED	APPROVED
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CHEVRON ENVIRONMENTAL MANAGMENT COMPANY
2184 WEST THORNBERRY ROAD
GUADALUPE, CA 93434

CONSULTANT
GOLDER
SACRAMENTO OFFICE
1000 ENTERPRISE WAY, SUITE 190
ROSEVILLE, CA 95678
USA
(916) 786-2424
www.golder.com

PROJECT
GUADALUPE RESTORATION PROJECT
SOIL MANAGEMENT AREA TANK
BATTERY 9 AREA

TITLE
BASE GRADE SETTLEMENT ANALYSIS: SECTION PROFILE

PROJECT NO. 1783552 | REV. 0 | 2 of 2 | DRAWING 2

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Attachment 2

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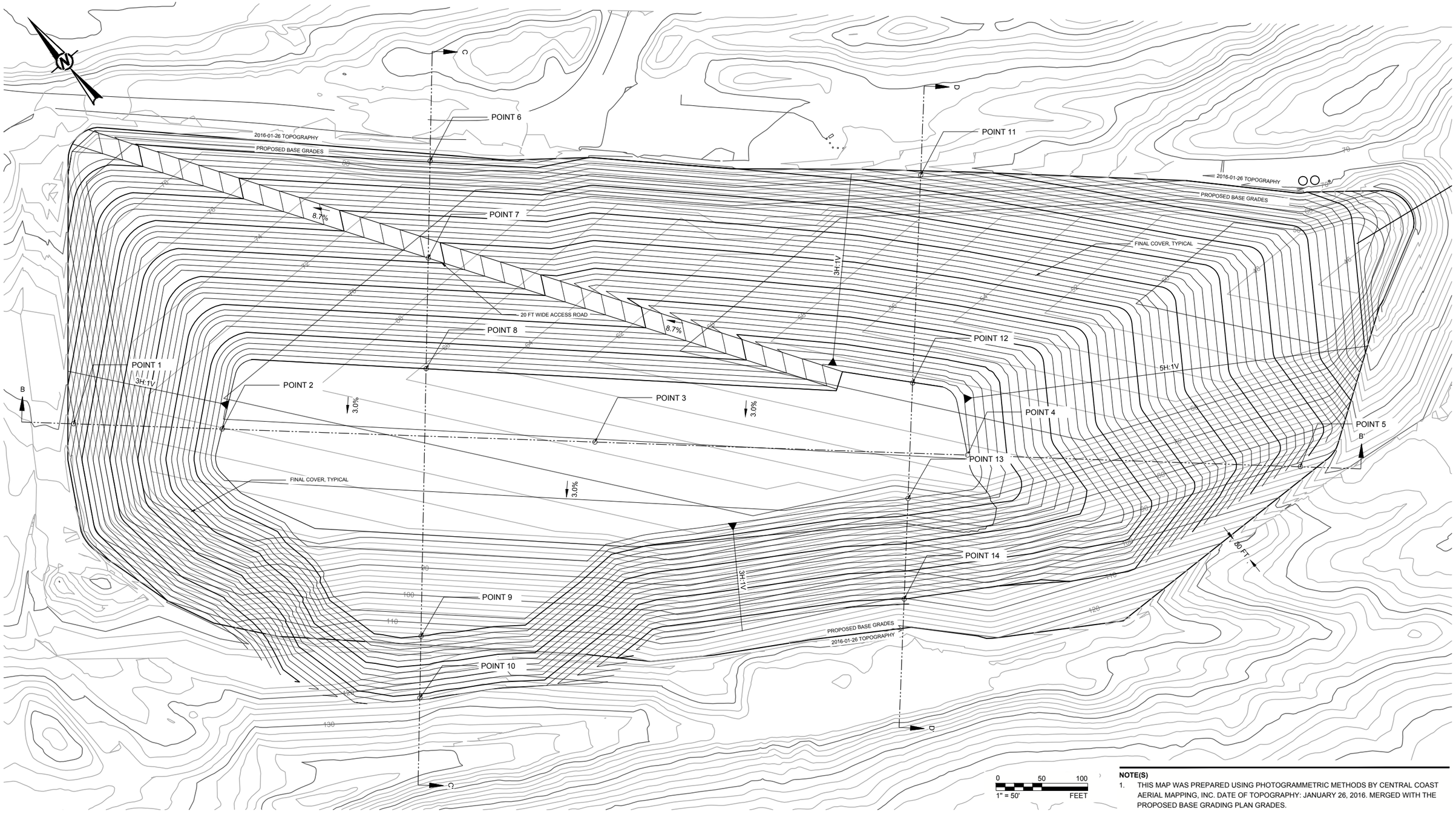

NOTE(S)

1. THIS MAP WAS PREPARED USING PHOTOGRAMMETRIC METHODS BY CENTRAL COAST AERIAL MAPPING, INC. DATE OF TOPOGRAPHY: JANUARY 26, 2016. MERGED WITH THE PROPOSED BASE GRADING PLAN GRADES.

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2184 WEST THORNBERRY ROAD
GUADALUPE, CA 93434

CONSULTANT
GOLDER
SACRAMENTO OFFICE
1000 ENTERPRISE WAY, SUITE 190
ROSEVILLE, CA 95678
USA
(916) 786-2424
www.golder.com

PROJECT
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SOIL MANAGEMENT AREA TANK
BATTERY 9 AREA

TITLE
SOIL SETTLEMENT ANALYSIS

PROJECT NO. 1783552 | REV. 1 of 2 | DRAWING 1

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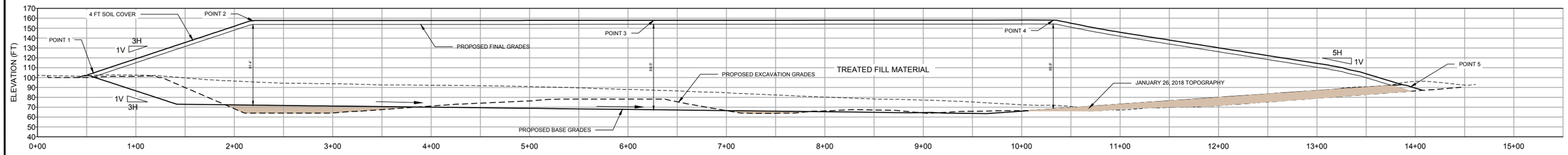
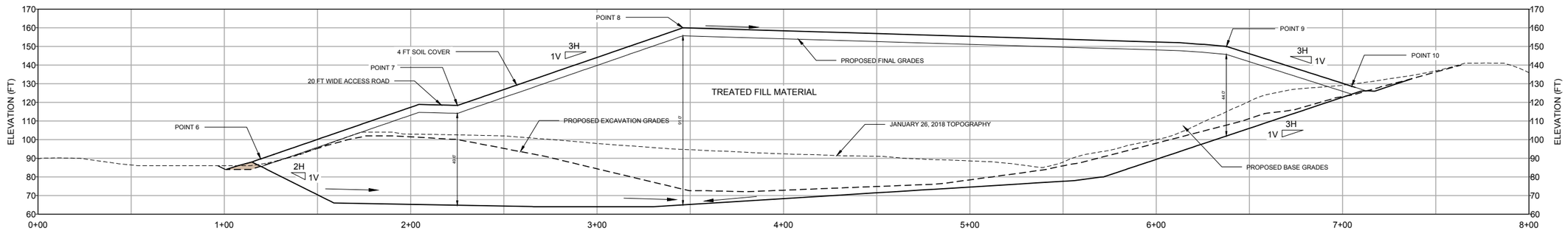


CROSS-SECTION B-B'

0 50 100
1" = 50' FEET



CROSS-SECTION C-C'

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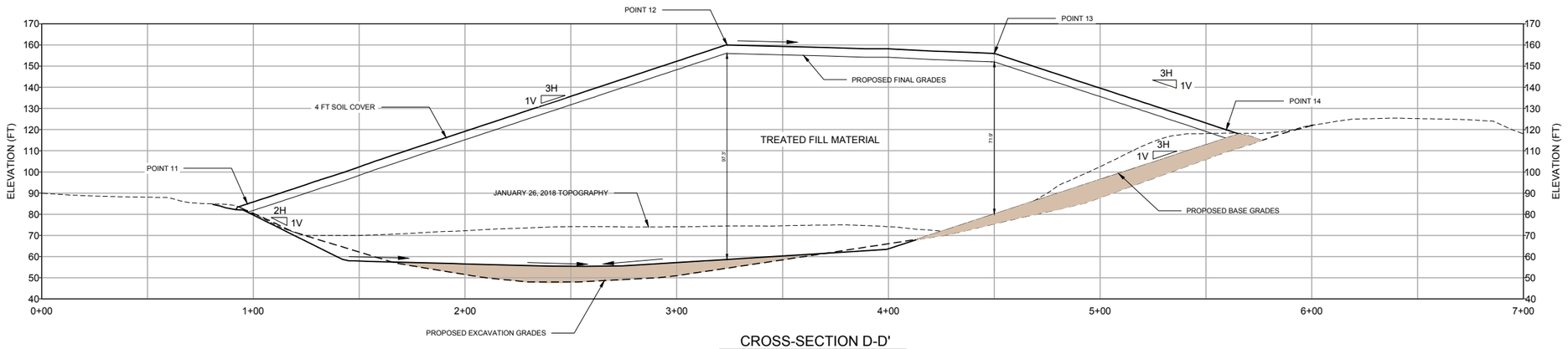
1" = 50' FEET



CROSS-SECTION D-D'

0 50 100
1" = 50' FEET

LEGEND

GENERAL FILL PLACEMENT

REV.	YYYY-MM-DD	DESCRIPTION	DESIGNED	PREPARED	REVIEWED	APPROVED
0	2019-07-08		MAG	CZG	LMA	RH

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2184 WEST THORNBERRY ROAD
GUADALUPE, CA 93434

CONSULTANT
GOLDER
SACRAMENTO OFFICE
1000 ENTERPRISE WAY, SUITE 190
ROSEVILLE, CA 95678
USA
(916) 786-2424
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PROJECT
GUADALUPE RESTORATION PROJECT
SOIL MANAGEMENT AREA TANK
BATTERY 9 AREA

TITLE
SOIL SETTLEMENT ANALYSIS: PROFILES

PROJECT NO. 1783552 | REV. 2 of 2 | DRAWING 2

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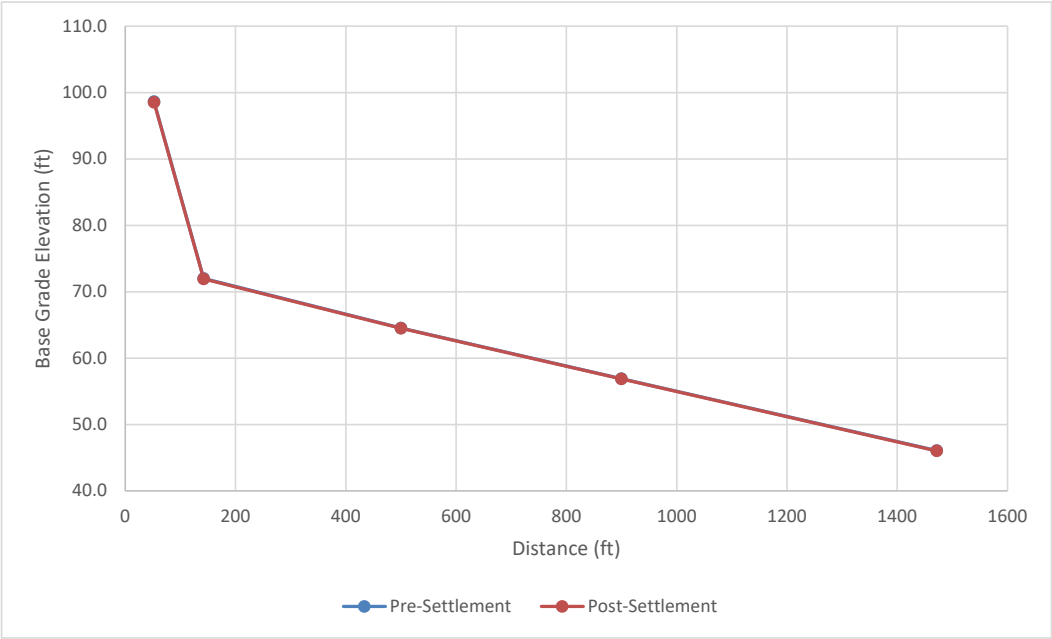
Attachment 3

GOLDER

Calculations

Date:	8-Jul-19	**Made by:**	CZG
Project No.:	1783552	**Checked by:**	LMA
Subject:	TB-9 Base Grade Settlement Calculations for Cross Section A-A'	**Reviewed by:**	KGH
Project Short Title:	Chevron Guadalupe Soil Management Area		

Point	Distance	Base Grade Elevation	Settlement	Post-Settlement Elev.	Design Slope	Post-Settlement Slope	Change in Slope
	(ft)	(ft)	(ft)	(ft)	(%)	(%)	(%)
1	52	98.6	0.10	98.5			
2	142	72.0	0.08	71.9	-29.6	**-29.5**	0.0
3	500	64.5	0.08	64.5	-2.1	**-2.1**	0.0
4	900	56.9	0.02	56.9	-1.9	**-1.9**	0.0
5	1472	46.1	0.06	46.0	-1.9	**-1.9**	0.0



Base Grade Settlement Calculations for Cross Section A-A'
Guadalupe Soil Management Area

Settlement Cross Section	**A-A'**

Average Groundwater Elevation	**32**	ft

Treated Soil Parameters:

Unit weight	120	pcf
Age of treated soil at closure	5	years
Post-closure period	30	years

Final Cover Parameters

Thickness	4	ft
Unit weight	120	pcf
Weight	480	psf

x and y Coordinates of Settlement Points:

Point	Distance	Top of Treated Soil	Base Grade Elevation	Treated Soil Thickness
	(ft)	(ft)	(ft)	(ft)
1	52	98.6	98.6	0.0
2	142	127.5	72.0	55.5
3	500	155.9	64.5	91.4
4	900	142.7	56.9	85.8
5	1472	63.0	46.1	16.9

Point Number	1

Soil thickness	0
Added weight from soil	0
Added weight from final cover	480
Total added weight, $\Delta\sigma'_{vo}$	480

Ground Water Table Depth BGS (ft)	67

Depth below base grade (ft)	60
Assumed number of sub layers	30
Layer thickness	2

Sub Layer Number	Sub Layer Thickness	Mid-Depth BGS	Material Type	Unit Weight, γ	Primary Compression Ratio, Ccε	σ_{vo}	$\Delta\sigma'_{vo}$	Primary Settlement	Secondary Compression Ratio, $C_{C\alpha}$	Secondary Settlement			Total Settlement
										t1	t2	Settlement	
	(ft)	(ft)		(pcf)		(psf)	(psf)	(inches)		(years)	(years)	(inches)	(inches)
1	2	1	Sand/Silty Sand	86.8	0.012	87	87	0.2	0.0002	0.2	30.2	0.001	0.236
2	2	3		86.8	0.012	260	260	0.1	0.0002	0.3	30.3	0.001	0.132
3	2	5	Silty Sand/Sandy Silt	86.8	0.014	434	434	0.1	0.0003	0.5	30.5	0.001	0.110
4	2	7	Sand/Silty Sand	86.8	0.012	608	608	0.1	0.0002	0.7	30.7	0.001	0.074
5	2	9		86.8	0.012	781	781	0.1	0.0002	0.8	30.8	0.001	0.061
6	2	11		86.8	0.012	955	955	0.1	0.0002	1.0	31.0	0.001	0.052
7	2	13		86.8	0.012	1128	1128	0.0	0.0002	1.2	31.2	0.001	0.045
8	2	15		86.8	0.012	1302	1302	0.0	0.0002	1.3	31.3	0.001	0.040
9	2	17		86.8	0.012	1476	1476	0.0	0.0002	1.5	31.5	0.001	0.036
10	2	19		86.8	0.012	1649	1649	0.0	0.0002	1.7	31.7	0.001	0.033
11	2	21		86.8	0.012	1823	1823	0.0	0.0002	1.8	31.8	0.001	0.030
12	2	23		86.8	0.012	1996	1996	0.0	0.0002	2.0	32.0	0.001	0.028
13	2	25		86.8	0.012	2170	2170	0.0	0.0002	2.2	32.2	0.001	0.026
14	2	27		86.8	0.012	2344	2344	0.0	0.0002	2.3	32.3	0.001	0.024
15	2	29		86.8	0.012	2517	2517	0.0	0.0002	2.5	32.5	0.001	0.022
16	2	31		86.8	0.012	2691	2691	0.0	0.0002	2.7	32.7	0.001	0.021
17	2	33		86.8	0.012	2864	2864	0.0	0.0002	2.8	32.8	0.001	0.020
18	2	35		86.8	0.012	3038	3038	0.0	0.0002	3.0	33.0	0.000	0.019
19	2	37		86.8	0.012	3212	3212	0.0	0.0002	3.2	33.2	0.000	0.018
20	2	39		86.8	0.012	3385	3385	0.0	0.0002	3.3	33.3	0.000	0.017
21	2	41		86.8	0.012	3559	3559	0.0	0.0002	3.5	33.5	0.000	0.016
22	2	43		86.8	0.012	3732	3732	0.0	0.0002	3.7	33.7	0.000	0.016
23	2	45		86.8	0.012	3906	3906	0.0	0.0002	3.8	33.8	0.000	0.015
24	2	47		86.8	0.012	4080	4080	0.0	0.0002	4.0	34.0	0.000	0.014
25	2	49		86.8	0.012	4253	4253	0.0	0.0002	4.2	34.2	0.000	0.014
26	2	51		86.8	0.012	4427	4427	0.0	0.0002	4.3	34.3	0.000	0.013
27	2	53		86.8	0.012	4600	4600	0.0	0.0002	4.5	34.5	0.000	0.013
28	2	55		86.8	0.012	4774	4774	0.0	0.0002	4.7	34.7	0.000	0.012
29	2	57		86.8	0.012	4948	4948	0.0	0.0002	4.8	34.8	0.000	0.012
30	2	59		86.8	0.012	5121	5121	0.0	0.0002	5.0	35.0	0.000	0.012
	40							1.2					1.177
													0.098 ft

σ_{vo} = Total vertical stress at the middle of the sublayer

Primary/Secondary Compression Ratio from Conduto, 1998

Unit weight estimated from Padre Associates, 2018

t_1 = Age of treated soil at landfill closure

t_2 = Age of treated soil 30 years after landfill closure

Point Number	2

Soil thickness	56
Added weight from soil	6665
Added weight from final cover (psf)	480
Total added weight, $\Delta\sigma'_{vo}$, (psf)	7145

Ground Water Table Depth BGS (ft)	40

Depth below base grade (ft)	32
Assumed number of sub layers	16
Layer thickness	2

Sub Layer Number	Sub Layer Thickness	Mid-Depth BGS	Material Type	Unit Weight, γ	Primary Compression Ratio, Ccε	σ_{vo}	$\Delta\sigma'_{vo}$	Primary Settlement	Secondary Compression Ratio, $C_{C\alpha}$	Secondary Settlement			Total Settlement
										t1	t2	Settlement	
	(ft)	(ft)		(pcf)		(psf)	(psf)	(inches)		(years)	(years)	(inches)	(inches)
1	2	1	Sand/Silty Sand	86.8	0.012	87	87	0.2	0.0002	0.3	30.3	0.001	0.236
2	2	3		86.8	0.012	260	260	0.1	0.0002	0.6	30.6	0.001	0.132
3	2	5		86.8	0.012	434	434	0.1	0.0002	0.9	30.9	0.001	0.094
4	2	7		86.8	0.012	608	608	0.1	0.0002	1.3	31.3	0.001	0.073
5	2	9		86.8	0.012	781	781	0.1	0.0002	1.6	31.6	0.001	0.061
6	2	11		86.8	0.012	955	955	0.1	0.0002	1.9	31.9	0.001	0.052
7	2	13		86.8	0.012	1128	1128	0.0	0.0002	2.2	32.2	0.001	0.045
8	2	15		86.8	0.012	1302	1302	0.0	0.0002	2.5	32.5	0.001	0.040
9	2	17		86.8	0.012	1476	1476	0.0	0.0002	2.8	32.8	0.001	0.036
10	2	19		86.8	0.012	1649	1649	0.0	0.0002	3.1	33.1	0.000	0.032
11	2	21		86.8	0.012	1823	1823	0.0	0.0002	3.4	33.4	0.000	0.030
12	2	23		86.8	0.012	1996	1996	0.0	0.0002	3.8	33.8	0.000	0.027
13	2	25		86.8	0.012	2170	2170	0.0	0.0002	4.1	34.1	0.000	0.025
14	2	27		86.8	0.012	2344	2344	0.0	0.0002	4.4	34.4	0.000	0.024
15	2	29		86.8	0.012	2517	2517	0.0	0.0002	4.7	34.7	0.000	0.022
16	2	31		86.8	0.012	2691	2691	0.0	0.0002	5.0	35.0	0.000	0.021
	32							0.9					0.949
								0.08					0.079 ft

σ_{vo} = Total vertical stress at the middle of the sublayer

Primary/Secondary Compression Ratio from Conduto, 1998

Unit weight estimated from Padre Associates, 2018

t_1 = Age of treated soil at landfill closure

t_2 = Age of treated soil 30 years after landfill closure

Point Number	**3**

Soil thickness	91
Added weight from soil	10966
Added weight from final cover (psf)	480
Total added weight, $\Delta\sigma'_{vo}$, (psf)	11446

Ground Water Table Depth BGS (ft)	33

Depth below base grade (ft)	32
Assumed number of sub layers	16
Layer thickness	2

Sub Layer Number	Sub Layer Thickness	Mid-Depth BGS	Material Type	Unit Weight, γ	Primary Compression Ratio, Ccε	σ_{vo}	$\Delta\sigma'_{vo}$	Primary Settlement	Secondary Compression Ratio, $C_{c\alpha}$	Secondary Settlement			Total Settlement
										t1	t2	Settlement	
	(ft)	(ft)		(pcf)		(psf)	(psf)	(inches)		(years)	(years)	(inches)	(inches)
1	2	1	Sand/Silty Sand	86.8	0.012	87	87	0.2	0.0002	0.3	30.3	0.001	0.236
2	2	3		86.8	0.012	260	260	0.1	0.0002	0.6	30.6	0.001	0.132
3	2	5		86.8	0.012	434	434	0.1	0.0002	0.9	30.9	0.001	0.094
4	2	7		86.8	0.012	608	608	0.1	0.0002	1.3	31.3	0.001	0.073
5	2	9		86.8	0.012	781	781	0.1	0.0002	1.6	31.6	0.001	0.061
6	2	11		86.8	0.012	955	955	0.1	0.0002	1.9	31.9	0.001	0.052
7	2	13		86.8	0.012	1128	1128	0.0	0.0002	2.2	32.2	0.001	0.045
8	2	15		86.8	0.012	1302	1302	0.0	0.0002	2.5	32.5	0.001	0.040
9	2	17		86.8	0.012	1476	1476	0.0	0.0002	2.8	32.8	0.001	0.036
10	2	19		86.8	0.012	1649	1649	0.0	0.0002	3.1	33.1	0.000	0.032
11	2	21		86.8	0.012	1823	1823	0.0	0.0002	3.4	33.4	0.000	0.030
12	2	23		86.8	0.012	1996	1996	0.0	0.0002	3.8	33.8	0.000	0.027
13	2	25		86.8	0.012	2170	2170	0.0	0.0002	4.1	34.1	0.000	0.025
14	2	27		86.8	0.012	2344	2344	0.0	0.0002	4.4	34.4	0.000	0.024
15	2	29	Sand	95.1	0	2526	2526	0.0	0.0000	4.7	34.7	0.000	0.000
16	2	31		95.1	0	2716	2716	0.0	0.0000	5.0	35.0	0.000	0.000
	32							0.9					0.906
								0.07					0.075 ft

σ_{vo} = Total vertical stress at the middle of the sublayer

Primary/Secondary Compression Ratio from Conduto, 1998

Unit weight estimated from Padre Associates, 2018

t_1 = Age of treated soil at landfill closure

t_2 = Age of treated soil 30 years after landfill closure

Point Number	4

Soil thickness	86
Added weight from soil	10295
Added weight from final cover (psf)	480
Total added weight, $\Delta\sigma'_{vo}$, (psf)	10775

Ground Water Table Depth BGS (ft)	25

Depth below base grade (ft)	36
Assumed number of sub layers	18
Layer thickness	2

Sub Layer Number	Sub Layer Thickness	Mid-Depth BGS	Material Type	Unit Weight, γ	Primary Compression Ratio, Ccε	σ_{vo}	$\Delta\sigma'_{vo}$	Primary Settlement	Secondary Compression Ratio, $C_{C\alpha}$	Secondary Settlement			Total Settlement
										t1	t2	Settlement	
	(ft)	(ft)		(pcf)		(psf)	(psf)	(inches)		(years)	(years)	(inches)	(inches)
1	2	1	Engineered Fill	120	0	120	120	0.0	0.0000	0.3	30.3	0.000	0.000
2	2	3		120	0	360	360	0.0	0.0000	0.6	30.6	0.000	0.000
3	2	5		120	0	600	600	0.0	0.0000	0.8	30.8	0.000	0.000
4	2	7		120	0	840	840	0.0	0.0000	1.1	31.1	0.000	0.000
5	2	9		120	0	1080	1080	0.0	0.0000	1.4	31.4	0.000	0.000
6	2	11	Sand/Silty Sand	86.8	0.012	1287	1287	0.0	0.0002	1.7	31.7	0.001	0.040
7	2	13		86.8	0.012	1460	1460	0.0	0.0002	1.9	31.9	0.001	0.036
8	2	15	Sand	95.1	0	1642	1642	0.0	0.0000	2.2	32.2	0.000	0.000
9	2	17		95.1	0	1833	1833	0.0	0.0000	2.5	32.5	0.000	0.000
10	2	19		95.1	0	2023	2023	0.0	0.0000	2.8	32.8	0.000	0.000
11	2	21	Sand/Silty Sand	86.8	0.012	2205	2205	0.0	0.0002	3.1	33.1	0.000	0.025
12	2	23		86.8	0.012	2378	2378	0.0	0.0002	3.3	33.3	0.000	0.023
13	2	25		86.8	0.012	2552	4080	0.0	0.0002	3.6	33.6	0.000	0.022
14	2	27		86.8	0.012	2725	4252	0.0	0.0002	3.9	33.9	0.000	0.021
15	2	29		86.8	0.012	2899	4423	0.0	0.0002	4.2	34.2	0.000	0.020
16	2	31		86.8	0.012	3073	4595	0.0	0.0002	4.4	34.4	0.000	0.019
17	2	33	Silty Sand/Sandy Silt	86.8	0.014	3246	4766	0.0	0.0003	4.7	34.7	0.000	0.021
18	2	35		86.8	0.014	3420	4938	0.0	0.0003	5.0	35.0	0.000	0.020
	36							0.2					0.246
								0.02					0.021 ft

σ_{vo} = Total vertical stress at the middle of the sublayer

Primary/Secondary Compression Ratio from Conduto, 1998

Unit weight estimated from Padre Associates, 2018

t_1 = Age of treated soil at landfill closure

t_2 = Age of treated soil 30 years after landfill closure

Point Number	5

Soil thickness	16.901
Added weight from soil	2028.12
Added weight from final cover (psf)	480
Total added weight, $\Delta\sigma'_{vo}$, (psf)	2508.12

Ground Water Table Depth BGS (ft)	14

Depth below base grade (ft)	22
Assumed number of sub layers	11
Layer thickness	2

Sub Layer Number	Sub Layer Thickness	Mid-Depth BGS	Material Type	Unit Weight, γ	Primary Compression Ratio, Cc	σ_{vo}	$\Delta\sigma'_{vo}$	Primary Settlement	Secondary Compression Ratio, $C_{c\alpha}$	Secondary Settlement			Total Settlement
										t1	t2	Settlement	
	(ft)	(ft)		(pcf)		(psf)	(psf)	(inches)		(years)	(years)	(inches)	(inches)
1	2	1	Sand/Silty Sand	86.8	0.012	87	87	0.2	0.0002	0.5	30.5	0.001	0.236
2	2	3		86.8	0.012	260	260	0.1	0.0002	0.9	30.9	0.001	0.131
3	2	5		86.8	0.012	434	434	0.1	0.0002	1.4	31.4	0.001	0.094
4	2	7		86.8	0.012	608	608	0.1	0.0002	1.8	31.8	0.001	0.073
5	2	9	Sand	95.1	0	790	790	0.0	0.0000	2.3	32.3	0.000	0.000
6	2	11		95.1	0	980	980	0.0	0.0000	2.7	32.7	0.000	0.000
7	2	13		95.1	0	1170	1170	0.0	0.0000	3.2	33.2	0.000	0.000
8	2	15	Silty Sand/Sandy Silt	86.8	0.014	1352	2215	0.0	0.0003	3.6	33.6	0.001	0.045
9	2	17		86.8	0.014	1525	2387	0.0	0.0003	4.1	34.1	0.001	0.040
10	2	19		86.8	0.014	1699	2558	0.0	0.0003	4.5	34.5	0.000	0.037
11	2	21		86.8	0.014	1873	2730	0.0	0.0003	5.0	35.0	0.000	0.034
	22							0.7					0.690
													0.058 ft

σ_{vo} = Total vertical stress at the middle of the sublayer

Primary/Secondary Compression Ratio from Conduto, 1998

Unit weight estimated from Padre Associates, 2018

t_1 = Age of treated soil at landfill closure

t_2 = Age of treated soil 30 years after landfill closure

Attachment 4

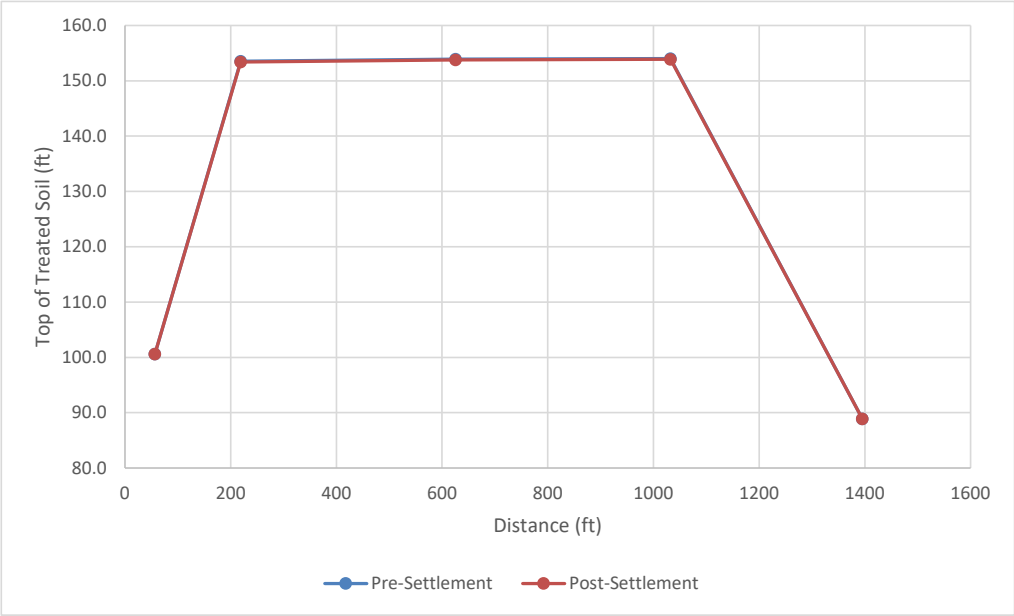
GOLDER

Calculations

Date:	8-Jul-19	**Made by:**	CZG
Project No.:	1783552	**Checked by:**	LMA
Subject:	TB-9 Soil Settlement Calculations for Cross Section B-B'	**Reviewed by:**	KGH
Project Short Title:	Chevron Guadalupe Soil Management Area		

Soil Settlement Summary Sheet

Point	Distance	Top of Soil	Settlement	Post-Settlement Elev.	Design Slope	Post-Settlement Slope	Change in Slope
	(ft)	(ft)	(ft)	(ft)	(%)	(%)	(%)
1	57	100.6	0.00	100.6			
2	219	153.5	0.12	153.4	32.6	**32.6**	-0.1
3	626	153.9	0.12	153.8	0.1	**0.1**	0.0
4	1032	154.0	0.12	153.9	0.0	**0.0**	0.0
5	1395	88.9	0.00	88.9	-17.9	**-17.9**	0.0



Soil Settlement Calculations for Cross Section B-B′
Guadalupe Soil Management Area

Settlement Cross Section	**B-B'**

Soil Parameters:

Unit weight	120	pcf	
Primary compression ratio ($C_{c\varepsilon}$)	0.014		Conduto (1998)
Secondary compression ratio ($C_{\alpha\varepsilon}$)	0.0003		Conduto (1998)
Age of soil at closure	5	years	
Post-closure period	30	years	

Final Cover Parameters

Thickness	4	ft
Unit weight	120	pcf
Weight	480	psf

x and y Coordinates of Settlement Points:

Point	Distance	Top of Treated Soil	Treated Soil Thickness
	(ft)	(ft)	(ft)
1	57	100.6	0.0
2	219	153.5	81.4
3	626	153.9	86.5
4	1032	154.0	85.8
5	1395	88.9	0.0

Point Number	**1**

Soil thickness	0
Added weight from final cover, $\Delta\sigma'_{vo}$	480

Assumed number of sub layers	1
Layer thickness	0

Sub Layer Number	Sub Layer Thickness	Mid-Depth	σ_{v0}	Primary Settlement	Secondary Settlement			Total Settlement
					t1	t2	Settlement	
	(ft)	(ft)	(psf)	(inches)	(years)	(years)	(inches)	(inches)
1	0	0	0	0.0	5.0	35.0	0.0	0.0
	0			0.0			0.0	0.0
								0.0 ft.

σ_{v0} = Total vertical stress at the middle of the sublayer

t_1 = Age of soil at landfill closure

t_2 = Age of soil 30 years after landfill closure

Point Number	2

Soil thickness	81.437
Added weight from final cover, $\Delta\sigma'_{vo}$	480

Assumed number of sub layers	41
Layer thickness	2

Sub Layer Number	Sub Layer Thickness	Mid-Depth	σ_{v0}	Primary Settlement	Secondary Settlement			Total Settlement
					t1	t2	Settlement	
	(ft)	(ft)	(psf)	(inches)	(years)	(years)	(inches)	(inches)
1	2	1	120	0.23	0.1	30.1	0.02	0.25
2	2	3	360	0.12	0.2	30.2	0.01	0.14
3	2	5	600	0.09	0.4	30.4	0.01	0.10
4	2	7	840	0.07	0.5	30.5	0.01	0.08
5	2	9	1080	0.05	0.6	30.6	0.01	0.07
6	2	11	1320	0.05	0.7	30.7	0.01	0.06
7	2	13	1560	0.04	0.9	30.9	0.01	0.05
8	2	15	1800	0.03	1.0	31.0	0.01	0.04
9	2	17	2040	0.03	1.1	31.1	0.01	0.04
10	2	19	2280	0.03	1.2	31.2	0.01	0.04
11	2	21	2520	0.03	1.4	31.4	0.01	0.03
12	2	23	2760	0.02	1.5	31.5	0.01	0.03
13	2	25	3000	0.02	1.6	31.6	0.01	0.03
14	2	27	3240	0.02	1.7	31.7	0.01	0.03
15	2	29	3480	0.02	1.8	31.8	0.01	0.03
16	2	31	3720	0.02	2.0	32.0	0.01	0.03
17	2	33	3960	0.02	2.1	32.1	0.01	0.02
18	2	35	4200	0.02	2.2	32.2	0.01	0.02
19	2	37	4440	0.01	2.3	32.3	0.01	0.02
20	2	39	4680	0.01	2.5	32.5	0.01	0.02
21	2	41	4920	0.01	2.6	32.6	0.01	0.02
22	2	43	5160	0.01	2.7	32.7	0.01	0.02
23	2	45	5400	0.01	2.8	32.8	0.01	0.02
24	2	47	5640	0.01	2.9	32.9	0.01	0.02
25	2	49	5880	0.01	3.1	33.1	0.01	0.02
26	2	51	6120	0.01	3.2	33.2	0.01	0.02
27	2	53	6360	0.01	3.3	33.3	0.01	0.02
28	2	55	6600	0.01	3.4	33.4	0.01	0.02
29	2	57	6840	0.01	3.6	33.6	0.01	0.02
30	2	59	7080	0.01	3.7	33.7	0.01	0.02
31	2	61	7320	0.01	3.8	33.8	0.01	0.02
32	2	63	7560	0.01	3.9	33.9	0.01	0.02
33	2	65	7800	0.01	4.1	34.1	0.01	0.01
34	2	67	8040	0.01	4.2	34.2	0.01	0.01
35	2	69	8280	0.01	4.3	34.3	0.01	0.01
36	2	71	8520	0.01	4.4	34.4	0.01	0.01
37	2	73	8760	0.01	4.5	34.5	0.01	0.01
38	2	75	9000	0.01	4.7	34.7	0.01	0.01
39	2	77	9240	0.01	4.8	34.8	0.01	0.01
40	2	79	9480	0.01	4.9	34.9	0.01	0.01
41	2	81	9720	0.01	5.0	35.0	0.01	0.01
	82			0.93			0.20	1.47
								0.12 ft.

σ_{v0} = Total vertical stress at the middle of the sublayer

t_1 = Age of treated soil at landfill closure

t_2 = Age of treated soil 30 years after landfill closure

Point Number	3

Soil thickness	86.502
Added weight from final cover, $\Delta\sigma'_{vo}$	480

Assumed number of sub layers	43
Layer thickness	2

Sub Layer Number	Sub Layer Thickness	Mid-Depth	σ_{v0}	Primary Settlement	Secondary Settlement			Total Settlement
					t1	t2	Settlement	
	(ft)	(ft)	(psf)	(inches)	(years)	(years)	(inches)	(inches)
1	2	1	120	0.23	0.1	30.1	0.02	0.25
2	2	3	360	0.12	0.2	30.2	0.01	0.14
3	2	5	600	0.09	0.3	30.3	0.01	0.10
4	2	7	840	0.07	0.5	30.5	0.01	0.08
5	2	9	1080	0.05	0.6	30.6	0.01	0.07
6	2	11	1320	0.05	0.7	30.7	0.01	0.06
7	2	13	1560	0.04	0.8	30.8	0.01	0.05
8	2	15	1800	0.03	0.9	30.9	0.01	0.04
9	2	17	2040	0.03	1.0	31.0	0.01	0.04
10	2	19	2280	0.03	1.2	31.2	0.01	0.04
11	2	21	2520	0.03	1.3	31.3	0.01	0.03
12	2	23	2760	0.02	1.4	31.4	0.01	0.03
13	2	25	3000	0.02	1.5	31.5	0.01	0.03
14	2	27	3240	0.02	1.6	31.6	0.01	0.03
15	2	29	3480	0.02	1.7	31.7	0.01	0.03
16	2	31	3720	0.02	1.8	31.8	0.01	0.03
17	2	33	3960	0.02	2.0	32.0	0.01	0.02
18	2	35	4200	0.02	2.1	32.1	0.01	0.02
19	2	37	4440	0.01	2.2	32.2	0.01	0.02
20	2	39	4680	0.01	2.3	32.3	0.01	0.02
21	2	41	4920	0.01	2.4	32.4	0.01	0.02
22	2	43	5160	0.01	2.5	32.5	0.01	0.02
23	2	45	5400	0.01	2.7	32.7	0.01	0.02
24	2	47	5640	0.01	2.8	32.8	0.01	0.02
25	2	49	5880	0.01	2.9	32.9	0.01	0.02
26	2	51	6120	0.01	3.0	33.0	0.01	0.02
27	2	53	6360	0.01	3.1	33.1	0.01	0.02
28	2	55	6600	0.01	3.2	33.2	0.01	0.02
29	2	57	6840	0.01	3.4	33.4	0.01	0.02
30	2	59	7080	0.01	3.5	33.5	0.01	0.02
31	2	61	7320	0.01	3.6	33.6	0.01	0.02
32	2	63	7560	0.01	3.7	33.7	0.01	0.02
33	2	65	7800	0.01	3.8	33.8	0.01	0.02
34	2	67	8040	0.01	3.9	33.9	0.01	0.01
35	2	69	8280	0.01	4.0	34.0	0.01	0.01
36	2	71	8520	0.01	4.2	34.2	0.01	0.01
37	2	73	8760	0.01	4.3	34.3	0.01	0.01
38	2	75	9000	0.01	4.4	34.4	0.01	0.01
39	2	77	9240	0.01	4.5	34.5	0.01	0.01
40	2	79	9480	0.01	4.6	34.6	0.01	0.01
41	2	81	9720	0.01	4.7	34.7	0.01	0.01
42	2	83	9960	0.01	4.9	34.9	0.01	0.01
43	2	85	10200	0.01	5.0	35.0	0.01	0.01
	86			1.15			0.20	1.50
								0.12 ft.

σ_{v0} = Total vertical stress at the middle of the sublayer

t_1 = Age of treated soil at landfill closure

t_2 = Age of treated soil 30 years after landfill closure

Point Number	4

Soil thickness	85.826
Added weight from final cover, $\Delta\sigma'_{vo}$	480

Assumed number of sub layers	43
Layer thickness	2

Sub Layer Number	Sub Layer Thickness	Mid-Depth	σ_{v0}	Primary Settlement	Secondary Settlement			Total Settlement
					t1	t2	Settlement	
	(ft)	(ft)	(psf)	(inches)	(years)	(years)	(inches)	(inches)
1	2	1	120	0.23	0.1	30.1	0.02	0.25
2	2	3	360	0.12	0.2	30.2	0.01	0.14
3	2	5	600	0.09	0.3	30.3	0.01	0.10
4	2	7	840	0.07	0.5	30.5	0.01	0.08
5	2	9	1080	0.05	0.6	30.6	0.01	0.07
6	2	11	1320	0.05	0.7	30.7	0.01	0.06
7	2	13	1560	0.04	0.8	30.8	0.01	0.05
8	2	15	1800	0.03	0.9	30.9	0.01	0.04
9	2	17	2040	0.03	1.0	31.0	0.01	0.04
10	2	19	2280	0.03	1.2	31.2	0.01	0.04
11	2	21	2520	0.03	1.3	31.3	0.01	0.03
12	2	23	2760	0.02	1.4	31.4	0.01	0.03
13	2	25	3000	0.02	1.5	31.5	0.01	0.03
14	2	27	3240	0.02	1.6	31.6	0.01	0.03
15	2	29	3480	0.02	1.7	31.7	0.01	0.03
16	2	31	3720	0.02	1.9	31.9	0.01	0.03
17	2	33	3960	0.02	2.0	32.0	0.01	0.02
18	2	35	4200	0.02	2.1	32.1	0.01	0.02
19	2	37	4440	0.01	2.2	32.2	0.01	0.02
20	2	39	4680	0.01	2.3	32.3	0.01	0.02
21	2	41	4920	0.01	2.4	32.4	0.01	0.02
22	2	43	5160	0.01	2.5	32.5	0.01	0.02
23	2	45	5400	0.01	2.7	32.7	0.01	0.02
24	2	47	5640	0.01	2.8	32.8	0.01	0.02
25	2	49	5880	0.01	2.9	32.9	0.01	0.02
26	2	51	6120	0.01	3.0	33.0	0.01	0.02
27	2	53	6360	0.01	3.1	33.1	0.01	0.02
28	2	55	6600	0.01	3.2	33.2	0.01	0.02
29	2	57	6840	0.01	3.4	33.4	0.01	0.02
30	2	59	7080	0.01	3.5	33.5	0.01	0.02
31	2	61	7320	0.01	3.6	33.6	0.01	0.02
32	2	63	7560	0.01	3.7	33.7	0.01	0.02
33	2	65	7800	0.01	3.8	33.8	0.01	0.02
34	2	67	8040	0.01	3.9	33.9	0.01	0.01
35	2	69	8280	0.01	4.0	34.0	0.01	0.01
36	2	71	8520	0.01	4.2	34.2	0.01	0.01
37	2	73	8760	0.01	4.3	34.3	0.01	0.01
38	2	75	9000	0.01	4.4	34.4	0.01	0.01
39	2	77	9240	0.01	4.5	34.5	0.01	0.01
40	2	79	9480	0.01	4.6	34.6	0.01	0.01
41	2	81	9720	0.01	4.7	34.7	0.01	0.01
42	2	83	9960	0.01	4.9	34.9	0.01	0.01
43	2	85	10200	0.01	5.0	35.0	0.01	0.01
	86			1.15			0.20	1.50
								0.12 ft.

σ_{v0} = Total vertical stress at the middle of the sublayer

t_1 = Age of treated soil at landfill closure

t_2 = Age of treated soil 30 years after landfill closure

Point Number	**5**

Soil thickness	0
Added weight from final cover, $\Delta\sigma'_{vo}$	480

Assumed number of sub layers	1
Layer thickness	0

Sub Layer Number	Sub Layer Thickness	Mid-Depth	σ_{v0}	Primary Settlement	Secondary Settlement			Total Settlement
					t1	t2	Settlement	
	(ft)	(ft)	(psf)	(inches)	(years)	(years)	(inches)	(inches)
1	0	0	0	0.0	5.0	35.0	0.0	0.0
	0			0.0			0.0	0.0
								0.0 ft.

σ_{v0} = Total vertical stress at the middle of the sublayer

t_1 = Age of soil at landfill closure

t_2 = Age of soil 30 years after landfill closure

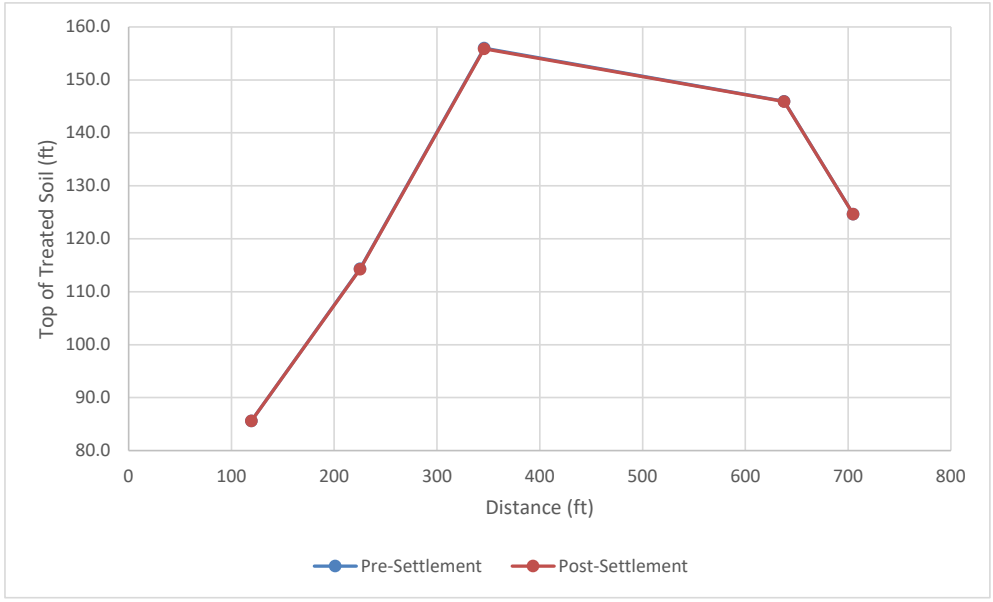
GOLDER

Calculations

Date:	8-Jul-19	**Made by:**	CZG
Project No.:	1783552	**Checked by:**	LMA
Subject:	TB-9 Soil Settlement Calculations for Cross Section C-C'	**Reviewed by:**	KGH
Project Short Title:	Chevron Guadalupe Soil Management Area		

Treated Soil Settlement Summary Sheet

Point	Distance	Top of Soil	Settlement	Post-Settlement Elev.	Design Slope	Post-Settlement Slope	Change in Slope
	(ft)	(ft)	(ft)	(ft)	(%)	(%)	(%)
6	119	85.6	0.00	85.6			
7	225	114.4	0.10	114.3	27.2	**27.1**	-0.1
8	346	156.0	0.13	155.9	34.5	**34.5**	0.0
9	638	146.0	0.09	145.9	-3.4	**-3.4**	0.0
10	705	124.6	0.00	124.6	-31.7	**-31.6**	0.1



Soil Settlement Calculations for Cross Section B-B′
Guadalupe Soil Management Area

Settlement Cross Section	**C-C'**

Treated Soil Parameters:

Unit weight	120	pcf	
Primary compression ratio ($C_{c\varepsilon}$)	0.014		Conduto (1998)
Secondary compression ratio ($C_{\alpha\varepsilon}$)	0.0003		Conduto (1998)
Age of soil at closure	5	years	
Post-closure period	30	years	

Final Cover Parameters

Thickness	4	ft
Unit weight	120	pcf
Weight	480	psf

x and y Coordinates of Settlement Points:

Point	Distance	Top of Soil	Soil Thickness
	(ft)	(ft)	(ft)
6	119	85.6	0.0
7	225	114.4	49.6
8	346	156.0	91.0
9	638	146.0	44.0
10	705	124.6	0.0

Point Number	**6**

Soil thickness	0
Added weight from final cover, $\Delta\sigma'_{vo}$	480

Assumed number of sub layers	1
Layer thickness	0

Sub Layer Number	Sub Layer Thickness	Mid-Depth	σ_{v0}	Primary Settlement	Secondary Settlement			Total Settlement
					t1	t2	Settlement	
	(ft)	(ft)	(psf)	(inches)	(years)	(years)	(inches)	(inches)
1	0	0	0	0.0	5.0	35.0	0.0	0.0
	0			0.0			0.0	0.0
								0.0 ft.

σ_{v0} = Total vertical stress at the middle of the sublayer

t_1 = Age of soil at landfill closure

t2 = Age of soil 30 years after landfill closure

Point Number	**7**

Soil thickness	49.606
Added weight from final cover, $\Delta\sigma'_{vo}$	480

Assumed number of sub layers	25
Layer thickness	2

Sub Layer Number	Sub Layer Thickness	Mid-Depth	σ_{v0}	Primary Settlement	Secondary Settlement			Total Settlement
					t1	t2	Settlement	
	(ft)	(ft)	(psf)	(inches)	(years)	(years)	(inches)	(inches)
1	2	1	120	0.23	0.2	30.2	0.01	0.25
2	2	3	360	0.12	0.4	30.4	0.01	0.14
3	2	5	600	0.09	0.6	30.6	0.01	0.10
4	2	7	840	0.07	0.8	30.8	0.01	0.08
5	2	9	1080	0.05	1.0	31.0	0.01	0.06
6	2	11	1320	0.05	1.2	31.2	0.01	0.05
7	2	13	1560	0.04	1.4	31.4	0.01	0.05
8	2	15	1800	0.03	1.6	31.6	0.01	0.04
9	2	17	2040	0.03	1.8	31.8	0.01	0.04
10	2	19	2280	0.03	2.0	32.0	0.01	0.04
11	2	21	2520	0.03	2.2	32.2	0.01	0.03
12	2	23	2760	0.02	2.4	32.4	0.01	0.03
13	2	25	3000	0.02	2.6	32.6	0.01	0.03
14	2	27	3240	0.02	2.8	32.8	0.01	0.03
15	2	29	3480	0.02	3.0	33.0	0.01	0.03
16	2	31	3720	0.02	3.2	33.2	0.01	0.02
17	2	33	3960	0.02	3.4	33.4	0.01	0.02
18	2	35	4200	0.02	3.6	33.6	0.01	0.02
19	2	37	4440	0.01	3.8	33.8	0.01	0.02
20	2	39	4680	0.01	4.0	34.0	0.01	0.02
21	2	41	4920	0.01	4.2	34.2	0.01	0.02
22	2	43	5160	0.01	4.4	34.4	0.01	0.02
23	2	45	5400	0.01	4.6	34.6	0.01	0.02
24	2	47	5640	0.01	4.8	34.8	0.01	0.02
25	2	49	5880	0.01	5.0	35.0	0.01	0.02
	50			0.99			0.20	1.19
								0.10 ft.

σ_{v0} = Total vertical stress at the middle of the sublayer

t_1 = Age of soil at landfill closure

t2 = Age of soil 30 years after landfill closure

Point Number	8

Soil thickness	91.017
Added weight from final cover, $\Delta\sigma'_{vo}$	480

Assumed number of sub layers	46
Layer thickness	2

Sub Layer Number	Sub Layer Thickness	Mid-Depth	σ_{v0}	Primary Settlement	Secondary Settlement			Total Settlement
					t1	t2	Settlement	
	(ft)	(ft)	(psf)	(inches)	(years)	(years)	(inches)	(inches)
1	2	1	120	0.23	0.1	30.1	0.02	0.25
2	2	3	360	0.12	0.2	30.2	0.01	0.14
3	2	5	600	0.09	0.3	30.3	0.01	0.10
4	2	7	840	0.07	0.4	30.4	0.01	0.08
5	2	9	1080	0.05	0.5	30.5	0.01	0.07
6	2	11	1320	0.05	0.7	30.7	0.01	0.06
7	2	13	1560	0.04	0.8	30.8	0.01	0.05
8	2	15	1800	0.03	0.9	30.9	0.01	0.04
9	2	17	2040	0.03	1.0	31.0	0.01	0.04
10	2	19	2280	0.03	1.1	31.1	0.01	0.04
11	2	21	2520	0.03	1.2	31.2	0.01	0.03
12	2	23	2760	0.02	1.3	31.3	0.01	0.03
13	2	25	3000	0.02	1.4	31.4	0.01	0.03
14	2	27	3240	0.02	1.5	31.5	0.01	0.03
15	2	29	3480	0.02	1.6	31.6	0.01	0.03
16	2	31	3720	0.02	1.8	31.8	0.01	0.03
17	2	33	3960	0.02	1.9	31.9	0.01	0.02
18	2	35	4200	0.02	2.0	32.0	0.01	0.02
19	2	37	4440	0.01	2.1	32.1	0.01	0.02
20	2	39	4680	0.01	2.2	32.2	0.01	0.02
21	2	41	4920	0.01	2.3	32.3	0.01	0.02
22	2	43	5160	0.01	2.4	32.4	0.01	0.02
23	2	45	5400	0.01	2.5	32.5	0.01	0.02
24	2	47	5640	0.01	2.6	32.6	0.01	0.02
25	2	49	5880	0.01	2.7	32.7	0.01	0.02
26	2	51	6120	0.01	2.9	32.9	0.01	0.02
27	2	53	6360	0.01	3.0	33.0	0.01	0.02
28	2	55	6600	0.01	3.1	33.1	0.01	0.02
29	2	57	6840	0.01	3.2	33.2	0.01	0.02
30	2	59	7080	0.01	3.3	33.3	0.01	0.02
31	2	61	7320	0.01	3.4	33.4	0.01	0.02
32	2	63	7560	0.01	3.5	33.5	0.01	0.02
33	2	65	7800	0.01	3.6	33.6	0.01	0.02
34	2	67	8040	0.01	3.7	33.7	0.01	0.01
35	2	69	8280	0.01	3.8	33.8	0.01	0.01
36	2	71	8520	0.01	4.0	34.0	0.01	0.01
37	2	73	8760	0.01	4.1	34.1	0.01	0.01
38	2	75	9000	0.01	4.2	34.2	0.01	0.01
39	2	77	9240	0.01	4.3	34.3	0.01	0.01
40	2	79	9480	0.01	4.4	34.4	0.01	0.01
41	2	81	9720	0.01	4.5	34.5	0.01	0.01
42	2	83	9960	0.01	4.6	34.6	0.01	0.01
43	2	85	10200	0.01	4.7	34.7	0.01	0.01
44	2	87	10440	0.01	4.8	34.8	0.01	0.01
45	2	89	10680	0.01	4.9	34.9	0.01	0.01
46	2	91	10920	0.01	5.1	35.1	0.01	0.01
	92			1.17			0.38	1.54
								0.13 ft.

σ_{v0} = Total vertical stress at the middle of the sublayer

t_1 = Age of soil at landfill closure

t2 = Age of soil 30 years after landfill closure

Point Number	**9**

Soil thickness	44.028
Added weight from final cover, $\Delta\sigma'_{vo}$	480

Assumed number of sub layers	22
Layer thickness	2

Sub Layer Number	Sub Layer Thickness	Mid-Depth	σ_{v0}	Primary Settlement	Secondary Settlement			Total Settlement
					t1	t2	Settlement	
	(ft)	(ft)	(psf)	(inches)	(years)	(years)	(inches)	(inches)
1	2	1	120	0.23	0.2	30.2	0.01	0.25
2	2	3	360	0.12	0.5	30.5	0.01	0.14
3	2	5	600	0.09	0.7	30.7	0.01	0.10
4	2	7	840	0.07	0.9	30.9	0.01	0.08
5	2	9	1080	0.05	1.1	31.1	0.01	0.06
6	2	11	1320	0.05	1.4	31.4	0.01	0.05
7	2	13	1560	0.04	1.6	31.6	0.01	0.05
8	2	15	1800	0.03	1.8	31.8	0.01	0.04
9	2	17	2040	0.03	2.0	32.0	0.01	0.04
10	2	19	2280	0.03	2.3	32.3	0.01	0.04
11	2	21	2520	0.03	2.5	32.5	0.01	0.03
12	2	23	2760	0.02	2.7	32.7	0.01	0.03
13	2	25	3000	0.02	3.0	33.0	0.01	0.03
14	2	27	3240	0.02	3.2	33.2	0.01	0.03
15	2	29	3480	0.02	3.4	33.4	0.01	0.03
16	2	31	3720	0.02	3.6	33.6	0.01	0.02
17	2	33	3960	0.02	3.9	33.9	0.01	0.02
18	2	35	4200	0.02	4.1	34.1	0.01	0.02
19	2	37	4440	0.01	4.3	34.3	0.01	0.02
20	2	39	4680	0.01	4.5	34.5	0.01	0.02
21	2	41	4920	0.01	4.8	34.8	0.01	0.02
22	2	43	5160	0.01	5.0	35.0	0.01	0.02
	44			0.96			0.18	1.13
								0.09 ft.

σ_{v0} = Total vertical stress at the middle of the sublayer

t_1 = Age of soil at landfill closure

t2 = Age of soil 30 years after landfill closure

Point Number	**10**

Soil thickness	0
Added weight from final cover, $\Delta\sigma'_{vo}$	480

Assumed number of sub layers	1
Layer thickness	0

Sub Layer Number	Sub Layer Thickness	Mid-Depth	σ_{v0}	Primary Settlement	Secondary Settlement			Total Settlement
					t1	t2	Settlement	
	(ft)	(ft)	(psf)	(inches)	(years)	(years)	(inches)	(inches)
1	0	0	0	0.0	5.0	35.0	0.0	0.0
	0			0.0			0.0	0.0
								0.0 ft.

σ_{v0} = Total vertical stress at the middle of the sublayer

t_1 = Age of soil at landfill closure

t2 = Age of soil 30 years after landfill closure

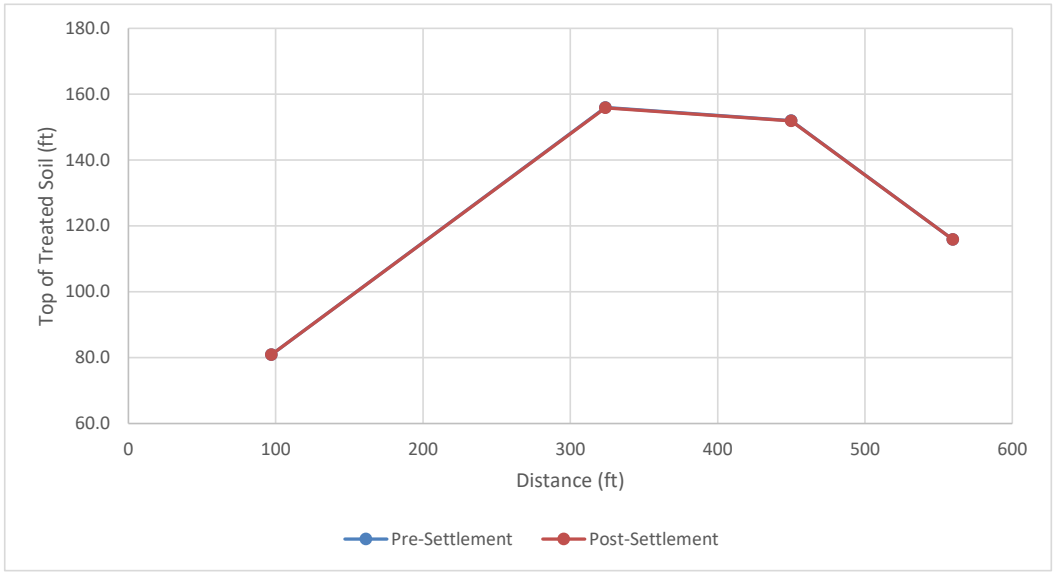
GOLDER

Calculations

Date:	8-Jul-19	**Made by:**	CZG
Project No.:	1783552	**Checked by:**	LMA
Subject:	TB-9 Soil Settlement Calculations for Cross Section D-D'	**Reviewed by:**	KGH
Project Short Title:	Chevron Guadalupe Soil Management Area		

Soil Settlement Summary Sheet

Point	Distance	Top of Soil	Settlement	Post-Settlement Elev.	Design Slope	Post-Settlement Slope	Change in Slope
	(ft)	(ft)	(ft)	(ft)	(%)	(%)	(%)
11	97	80.9	0.00	80.9			
12	324	156.0	0.13	155.9	33.1	**33.1**	-0.1
13	450	152.0	0.12	151.9	-3.2	**-3.2**	0.0
14	560	115.9	0.00	115.9	-32.9	**-32.8**	0.1



Soil Settlement Calculations for Cross Section C-C′
Guadalupe Soil Management Area

Settlement Cross Section	**D-D'**

Soil Parameters:

Unit weight	120	pcf	
Primary compression ratio ($C_{c\varepsilon}$)	0.014		Conduto (1982)
Secondary compression ratio ($C_{\alpha\varepsilon}$)	0.0003		Conduto (1982)
Age of soil at closure	5	years	
Post-closure period	30	years	

Final Cover Parameters

Thickness	4	ft
Unit weight	120	pcf
Weight	480	psf

x and y Coordinates of Settlement Points:

Point	Distance	Top of Soil	Soil Thickness
	(ft)	(ft)	(ft)
11	97	80.9	0.0
12	324	156.0	97.3
13	450	152.0	71.9
14	560	115.9	0.0

Point Number	**11**

Soil thickness	0
Added weight from final cover, $\Delta\sigma'_{vo}$	480

Assumed number of sub layers	1
Layer thickness	0

Sub Layer Number	Sub Layer Thickness	Mid-Depth	σ_{v0}	Primary Settlement	Secondary Settlement			Total Settlement
					t1	t2	Settlement	
	(ft)	(ft)	(psf)	(inches)	(years)	(years)	(inches)	(inches)
1	0	0	0	0.0	5.0	35.0	0.0	0.0
	0			0.0			0.0	0.0
								0.0 ft.

σ_{v0} = Total vertical stress at the middle of the sublayer

t_1 = Age of soil at landfill closure

t2 = Age of soil 30 years after landfill closure

Point Number	12

Soil thickness	97.316
Added weight from final cover, $\Delta\sigma'_{vo}$	480

Assumed number of sub layers	49
Layer thickness	2

Sub Layer Number	Sub Layer Thickness	Mid-Depth	σ_{v0}	Primary Settlement	Secondary Settlement			Total Settlement
					t1	t2	Settlement	
	(ft)	(ft)	(psf)	(inches)	(years)	(years)	(inches)	(inches)
1	2	1	120	0.23	0.1	30.1	0.02	0.25
2	2	3	360	0.12	0.2	30.2	0.01	0.14
3	2	5	600	0.09	0.3	30.3	0.01	0.10
4	2	7	840	0.07	0.4	30.4	0.01	0.08
5	2	9	1080	0.05	0.5	30.5	0.01	0.07
6	2	11	1320	0.05	0.6	30.6	0.01	0.06
7	2	13	1560	0.04	0.7	30.7	0.01	0.05
8	2	15	1800	0.03	0.8	30.8	0.01	0.05
9	2	17	2040	0.03	0.9	30.9	0.01	0.04
10	2	19	2280	0.03	1.0	31.0	0.01	0.04
11	2	21	2520	0.03	1.1	31.1	0.01	0.04
12	2	23	2760	0.02	1.2	31.2	0.01	0.03
13	2	25	3000	0.02	1.3	31.3	0.01	0.03
14	2	27	3240	0.02	1.4	31.4	0.01	0.03
15	2	29	3480	0.02	1.5	31.5	0.01	0.03
16	2	31	3720	0.02	1.6	31.6	0.01	0.03
17	2	33	3960	0.02	1.7	31.7	0.01	0.03
18	2	35	4200	0.02	1.8	31.8	0.01	0.02
19	2	37	4440	0.01	2.0	32.0	0.01	0.02
20	2	39	4680	0.01	2.1	32.1	0.01	0.02
21	2	41	4920	0.01	2.2	32.2	0.01	0.02
22	2	43	5160	0.01	2.3	32.3	0.01	0.02
23	2	45	5400	0.01	2.4	32.4	0.01	0.02
24	2	47	5640	0.01	2.5	32.5	0.01	0.02
25	2	49	5880	0.01	2.6	32.6	0.01	0.02
26	2	51	6120	0.01	2.7	32.7	0.01	0.02
27	2	53	6360	0.01	2.8	32.8	0.01	0.02
28	2	55	6600	0.01	2.9	32.9	0.01	0.02
29	2	57	6840	0.01	3.0	33.0	0.01	0.02
30	2	59	7080	0.01	3.1	33.1	0.01	0.02
31	2	61	7320	0.01	3.2	33.2	0.01	0.02
32	2	63	7560	0.01	3.3	33.3	0.01	0.02
33	2	65	7800	0.01	3.4	33.4	0.01	0.02
34	2	67	8040	0.01	3.5	33.5	0.01	0.02
35	2	69	8280	0.01	3.6	33.6	0.01	0.01
36	2	71	8520	0.01	3.7	33.7	0.01	0.01
37	2	73	8760	0.01	3.8	33.8	0.01	0.01
38	2	75	9000	0.01	3.9	33.9	0.01	0.01
39	2	77	9240	0.01	4.0	34.0	0.01	0.01
40	2	79	9480	0.01	4.1	34.1	0.01	0.01
41	2	81	9720	0.01	4.2	34.2	0.01	0.01
42	2	83	9960	0.01	4.3	34.3	0.01	0.01
43	2	85	10200	0.01	4.4	34.4	0.01	0.01
44	2	87	10440	0.01	4.5	34.5	0.01	0.01
45	2	89	10680	0.01	4.6	34.6	0.01	0.01
46	2	91	10920	0.01	4.7	34.7	0.01	0.01
47	2	93	11160	0.01	4.8	34.8	0.01	0.01
48	2	95	11400	0.01	4.9	34.9	0.01	0.01
49	2	97	11640	0.01	5.0	35.0	0.01	0.01
	98			1.18			0.40	1.59
								0.13 ft.

σ_{v0} = Total vertical stress at the middle of the sublayer

t_1 = Age of soil at landfill closure

t2 = Age of soil 30 years after landfill closure

Point Number	13

Soil thickness	71.936
Added weight from final cover, $\Delta\sigma'_{vo}$	480

Assumed number of sub layers	36
Layer thickness	2

Sub Layer Number	Sub Layer Thickness	Mid-Depth	σ_{v0}	Primary Settlement	Secondary Settlement			Total Settlement
					t1	t2	Settlement	
	(ft)	(ft)	(psf)	(inches)	(years)	(years)	(inches)	(inches)
1	2	1	120	0.23	0.1	30.1	0.02	0.25
2	2	3	360	0.12	0.3	30.3	0.01	0.14
3	2	5	600	0.09	0.4	30.4	0.01	0.10
4	2	7	840	0.07	0.6	30.6	0.01	0.08
5	2	9	1080	0.05	0.7	30.7	0.01	0.06
6	2	11	1320	0.05	0.8	30.8	0.01	0.06
7	2	13	1560	0.04	1.0	31.0	0.01	0.05
8	2	15	1800	0.03	1.1	31.1	0.01	0.04
9	2	17	2040	0.03	1.3	31.3	0.01	0.04
10	2	19	2280	0.03	1.4	31.4	0.01	0.04
11	2	21	2520	0.03	1.5	31.5	0.01	0.03
12	2	23	2760	0.02	1.7	31.7	0.01	0.03
13	2	25	3000	0.02	1.8	31.8	0.01	0.03
14	2	27	3240	0.02	1.9	31.9	0.01	0.03
15	2	29	3480	0.02	2.1	32.1	0.01	0.03
16	2	31	3720	0.02	2.2	32.2	0.01	0.03
17	2	33	3960	0.02	2.4	32.4	0.01	0.02
18	2	35	4200	0.02	2.5	32.5	0.01	0.02
19	2	37	4440	0.01	2.6	32.6	0.01	0.02
20	2	39	4680	0.01	2.8	32.8	0.01	0.02
21	2	41	4920	0.01	2.9	32.9	0.01	0.02
22	2	43	5160	0.01	3.1	33.1	0.01	0.02
23	2	45	5400	0.01	3.2	33.2	0.01	0.02
24	2	47	5640	0.01	3.3	33.3	0.01	0.02
25	2	49	5880	0.01	3.5	33.5	0.01	0.02
26	2	51	6120	0.01	3.6	33.6	0.01	0.02
27	2	53	6360	0.01	3.8	33.8	0.01	0.02
28	2	55	6600	0.01	3.9	33.9	0.01	0.02
29	2	57	6840	0.01	4.0	34.0	0.01	0.02
30	2	59	7080	0.01	4.2	34.2	0.01	0.02
31	2	61	7320	0.01	4.3	34.3	0.01	0.02
32	2	63	7560	0.01	4.4	34.4	0.01	0.01
33	2	65	7800	0.01	4.6	34.6	0.01	0.01
34	2	67	8040	0.01	4.7	34.7	0.01	0.01
35	2	69	8280	0.01	4.9	34.9	0.01	0.01
36	2	71	8520	0.01	5.0	35.0	0.01	0.01
	72			1.10			0.29	1.39
								0.12 ft.

σ_{v0} = Total vertical stress at the middle of the sublayer

t_1 = Age of soil at landfill closure

t2 = Age of soil 30 years after landfill closure

Point Number	**14**

Soil thickness	0
Added weight from final cover, $\Delta\sigma'_{vo}$	480

Assumed number of sub layers	1
Layer thickness	0

Sub Layer Number	Sub Layer Thickness	Mid-Depth	σ_{v0}	Primary Settlement	Secondary Settlement			Total Settlement
					t1	t2	Settlement	
	(ft)	(ft)	(psf)	(inches)	(years)	(years)	(inches)	(inches)
1	0	0	0	0.0	5.0	35.0	0.0	0.0
	0			0.0			0.0	0.0
								0.0 ft.

σ_{v0} = Total vertical stress at the middle of the sublayer

t_1 = Age of soil at landfill closure

t2 = Age of soil 30 years after landfill closure

APPENDIX R

Closure Cost Estimate Back-up Calculations

Table 6
Closure Cost Summary
Soil Management Area
Chevron Guadalupe

Item	Unit	Unit Cost	Quantity	Total Cost
1. Soil Layers				
a. Foundation Layer[1]	cy	$ 5.90	59,804	$ 352,844
b. Evapotranspiration Layer	cy	$ 5.40	105,700	$ 570,780
c. Excavation[2]	cy	$ 0.80	426,800	$ 341,440
d. LCRS Gravel Layer	cy	$ 8.70	14,981	$ 130,335
2. Geosynthics				
a. Geomembrane	sf	$ 0.21	1,511,133	$ 317,338
b. GCL	sf	$ 0.75	755,567	$ 566,675
c. Geotextile	sf	$ 0.37	781,500	$ 289,155
d. Geocomposite	sf	$ 0.71	1,120,333	$ 795,436
3. Design/Construction Quality Assurance				
a. Design, Plans, Specifications	ls	$ 99,341	1	$ 99,341
b. Post-Closure Maintenance Plan	ls	$ 31,600	1	$ 31,600
c. CQA	acre	$ 7,900	17	$ 134,300
4. Revegetation	acre	$ 1,275	17	$ 21,675
5. Landfill Gas Monitoring[3]	lump sum	--	--	$ -
6. Gas Control System[3]	lump sum	--	--	$ -
7. Groundwater Monitoring System[4]	lump sum	$ 43,412	1	$ 43,412
8. Drainage Structures				
a. CMP Downdrains	lf	$ 30.00	9,500	$ 285,000
b. V-ditches	lf	$ 11.30	3,100	$ 35,030
9. Security Measures[5]	lump sum	$ 6,075	1	$ 6,075
10. Closure Survey, Settlement Monuments	lump sum	$ 7,810	1	$ 7,810
			Subtotal:	$ 4,028,245
			Contingency (20%):	$ 805,649
			Total:	$ 4,833,895

Notes:

1. Includes subgrade fill, low permeability clay, and operations layer.
2. Includes clean material excavation and sump material excavation.
3. Landfill Gas Monitoring and Control System not required.
4. Assumes four additional groundwater wells will be installed to complete the groundwater monitoring system.
5. Perimeter fence is already in place. Costs for security include upgrading the site entrance gate at closure

1a. SOIL LAYERS PLACEMENT COST
CLOSURE COST ESTIMATE
CHEVRON GUADALUPE

Crew Costs:

Position	Personnel	Wage Rate	Units	Qnty	Subtotal
Laborer	1	$ 82.40	/hr	90	$ 7,416
Spreading Dozer Operator	1	$ 109.08	/hr	45	$ 4,909
Push Dozer Operator	1	$ 109.08	/hr	90	$ 9,818
Scraper Operator	5	$ 109.08	/hr	90	$ 49,088
Compactor	1	$ 109.08	/hr	90	$ 9,818
Grader Operator	1	$ 109.08	/hr	90	$ 9,818
Water Truck Operator	1	$ 87.19	/hr	90	$ 7,847
Maintenance Truck Operator	1	$ 82.40	/hr	90	$ 7,416
Gradesetter	1	$ 109.08	/hr	45	$ 4,909
Foreman	1	$ 94.25	/hr	90	$ 8,483
Supervisor	1	$ 130.50	/hr	45	$ 5,872.50
				Crew Total:	**$ 117,976**

Equipment Costs:

Item	No. of Equip.	Rate per Unit	Unit	Qnty	Subtotal
Mob/Demob	1	$ 45,000	ls	1	$ 45,000
Job Trailer	1	$ 17.63	/hr	90	$ 1,586
Generator	1	$ 17.31	/hr	90	$ 1,558
Pickup Truck	1	$ 30.07	/hr	90	$ 2,707
Spreading Dozer - CAT D6N	1	$ 98.16	/hr	45	$ 4,417
Push Dozer - CAT D8N	1	$ 190.24	/hr	90	$ 17,122
Scraper 1 - CAT 637	5	$ 297.22	/hr	90	$ 133,748
Compactor - CAT 815	1	$ 102.66	/hr	90	$ 9,239
Grader - CAT 140G	1	$ 95.15	/hr	45	$ 4,282
Water Truck - 4000 Gal	1	$ 78.34	/hr	90	$ 7,050
Maintenance Truck	1	$ 30.07	/hr	90	$ 2,707
				Equipment Total:	**$ 229,416**

FOUNDATION LAYER TOTAL: $ 347,392
Foundation Layer Unit Cost: $ 5.81 /cy
Rounded Foundation Unit Cost: $ 5.90 /cy

Schedule:

Work Item	Qnty[2]	Units	Production Rate[1]		Days
Soil Layers	59,804	cy	7,000	cy/day	9
				Project Duration:	**9**

Notes:

1. Foundation Layer production rate based on 5 scrapers, 7 loads/hr/scraper, 10 hrs/day, and 20 cy/load.
2. Quantities:

Area Description	Plan Volume (cy)	Correction Factor	Corrected Area (cy)
Subgrade Fill Volume	5,100	1.000	5,100
Low Permeability Clay Volume	27,352	1.000	27,352
Operations Layer Volume	27,352	1.000	27,352
		Total Area (cy)=	59,804

GOLDER

1b. EVAPOTRANSPIRATIVE FINAL COVER LAYER PLACEMENT COST
CLOSURE COST ESTIMATE
CHEVRON GUADALUPE

Crew Costs:

Position	Personnel	Wage Rate	Units	Qnty	Subtotal
Laborer	1	$ 82.40	/hr	160	$ 13,185
Spreading Dozer Operator	1	$ 109.08	/hr	160	$ 17,453
Push Dozer Operator	1	$ 109.08	/hr	80	$ 8,727
Scraper Operator	5	$ 109.08	/hr	160	$ 87,267
Grader Operator	1	$ 109.08	/hr	160	$ 17,453
Water Truck Operator	1	$ 87.19	/hr	160	$ 13,950
Maintenance Truck Operator	1	$ 82.40	/hr	160	$ 13,185
Gradesetter	1	$ 109.08	/hr	160	$ 17,453
Foreman	1	$ 94.25	/hr	160	$ 15,080
Supervisor	1	$ 130.50	/hr	160	$ 20,880
				Crew Total:	**$ 224,633**

Equipment Costs:

Item	No. of Equip.	Rate per Unit	Unit	Qnty	Subtotal
Mob/Demob	1	$ 30,000	ls	1	$ 30,000
Job Trailer	1	$ 17.63	/hr	160	$ 2,820
Pickup Truck	1	$ 30.07	/hr	160	$ 4,812
Spreading Dozer - CAT D6N	1	$ 98.16	/hr	160	$ 15,706
Push Dozer - CAT D8N	1	$ 190.24	/hr	80	$ 15,220
Scraper 1 - CAT 637	5	$ 297.22	/hr	160	$ 237,774
Grader - CAT 140G	1	$ 95.15	/hr	160	$ 15,224
Water Truck - 4000 Gal	1	$ 78.34	/hr	160	$ 12,534
Maintenance Truck	1	$ 30.07	/hr	160	$ 4,812
				Equipment Total:	**$ 338,901**

EVAPOTRANSPIRATION SOIL LAYER TOTAL: $ 563,534
Evapotransirative Soil Layer Unit Cost: $ 5.33 /cy
Rounded Evapotransirative Soil Layer Unit Cost: $ 5.40 /cy

Schedule:

Work Item	Qnty[2]	Units	Production Rate[1]		Days
Evapotranspirative Cover Layer	105,700	cy	7,000	cy/day	16
				Project Duration:	**16**

Notes:

1. Evapotranspirative Cover production rate based on 5 scrapers, 7 loads/hr/scraper, 10 hrs/day, and 20 cy/load.
2. Assumes 1 ft of vegetative soil required for final cover.

Area Description	Plan Volume (cy)	Correction Factor	Corrected Area (cy)
Evapotranspirative Cover Volume	105,700	1.000	105,700
		Total Area (cy)=	105,700

1c. EXCAVATION
CLOSURE COST ESTIMATE
CHEVRON GUADALUPE

Crew Costs:

Position	Personnel	Wage Rate	Units	Qnty	Subtotal
Dump Truck Operator	4	$ 88.68	/hr	160	$ 56,756
Excavator Operator	1	$ 74.79	/hr	80	$ 5,983
Foreman	1	$ 94.25	/hr	160	$ 15,080
Supervisor	1	$ 130.50	/hr	160	$ 20,880
				Crew Total:	**$ 98,700**

Equipment Costs:

Item	No. of Equip.	Rate per Unit	Unit	Qnty	Subtotal
Mob/Demob	1	$ 30,000	ls	1	$ 30,000
Job Trailer	1	$ 17.63	/hr	160	$ 2,820
Dump Truck	4	$ 100.38	/hr	160	$ 64,245
Excavator	1	$ 78.35	/hr	1430	$ 112,041
				Equipment Total:	**$ 209,106**

EXCAVATION TOTAL: $ 307,806
Excavation Unit Cost: $ 0.72 /cy
Rounded Excavation Unit Cost: $ 0.80 /cy

Schedule:

Work Item	Qnty[2]	Units	Production Rate[1]		Days
Excavation	426,800	cy	3,000	cy/day	143
				Project Duration:	**143**

Notes:
1. Excavation production rate based on 1 excavator, 4 dump trucks, and 10 hrs/day.
2. Includes clean material excavation and sump material excavatoin.

Area Description	Plan Volume (cy)	Correction Factor	Corrected Area (cy)
Clean Material	220,800	1.000	220,800
Sump Material	206,000	1.000	206,000
		Total Area (cy)=	426,800

GOLDER

1d. LCRS GRAVEL PLACEMENT
CLOSURE COST ESTIMATE
CHEVRON GUADALUPE

Crew Costs:

Position	Personnel	Wage Rate	Units	Qnty	Subtotal
Laborer	1	$ 82.40	/hr	30	$ 2,472
Spreading Dozer Operator	1	$ 109.08	/hr	30	$ 3,273
Push Dozer Operator	1	$ 109.08	/hr	15	$ 1,636
Scraper Operator	5	$ 109.08	/hr	30	$ 16,363
Grader Operator	1	$ 109.08	/hr	30	$ 3,273
Water Truck Operator	1	$ 87.19	/hr	30	$ 2,616
Maintenance Truck Operator	1	$ 82.40	/hr	30	$ 2,472
Gradesetter	1	$ 109.08	/hr	30	$ 3,273
Foreman	1	$ 94.25	/hr	30	$ 2,828
Supervisor	1	$ 130.50	/hr	30	$ 3,915
				Crew Total:	**$ 42,119**

Equipment Costs:

Item	No. of Equip.	Rate per Unit	Unit	Qnty	Subtotal
Mob/Demob	1	$ 30,000	ls	1	$ 30,000
Job Trailer	1	$ 17.63	/hr	30	$ 529
Pickup Truck	1	$ 30.07	/hr	30	$ 902
Spreading Dozer - CAT D6N	1	$ 98.16	/hr	30	$ 2,945
Push Dozer - CAT D8N	1	$ 190.24	/hr	15	$ 2,854
Scraper 1 - CAT 637	5	$ 297.22	/hr	30	$ 44,583
Grader - CAT 140G	1	$ 95.15	/hr	30	$ 2,855
Water Truck - 4000 Gal	1	$ 78.34	/hr	30	$ 2,350
Maintenance Truck	1	$ 30.07	/hr	30	$ 902
				Equipment Total:	**$ 87,919**

LCRS GRAVEL LAYER TOTAL: $ 130,038
LCRS Gravel Layer Unit Cost: $ 8.68 /cy
Rounded LCRS Gravel Layer Unit Cost: $ 8.70 /cy

Schedule:

Work Item	Qnty[2]	Units	Production Rate[1]		Days
LCRS Gravel	14,981	cy	7,000	cy/day	3
				Project Duration:	**3**

Notes:

1. Gravel placement production rate based on 5 scrapers, 7 loads/hr/scraper, 10 hrs/day, and 20 cy/load.
2. Quantities:

Area Description	Plan Volume (cy)	Correction Factor	Corrected Area (cy)
LCRS Gravel	14,981	1.000	14,981
		Total Area (cy)=	14,981

2a. GEOMEMBRANE
CLOSURE COST ESTIMATE
RECOLOGY HAY ROAD LANDFILL

Crew Costs:

Position	Personnel	Wage Rate	Unit	Qnty	Subtotal
Laborer	28	$ 82.40	/hr	110	$ 253,803
Forklift Operator	1	$ 87.59	/hr	110	$ 9,635
Foreman	1	$ 94.25	/hr	110	$ 10,368
Supervisor	1	$ 130.50	/hr	55	$ 7,178
				Crew Total:	**$ 280,983**

Materials:

Item	Number	Rate per Unit	Unit	Qnty	Subtotal
Geomembrane	--	$ 0.38	sf	27,352	$ 10,394
				Materials Subtotal:	**$ 10,394**
				15% Material Mark Up:	**$ 1,559**
				Material Total:	**$ 11,953**

Equipment Costs:

Item	No. of Equip.	Rate per Unit	Unit	Qnty	Subtotal
Mob/Demob	-	$ 750	ls	1	$ 750
Job Trailer	1	$ 17.63	/hr	110	$ 1,939
Pickup Truck	2	$ 30.07	/hr	110	$ 6,616
Forklift	1	$ 67.40	/hr	110	$ 7,414
				Equipment Total:	**$ 16,719**

GEOMEMBRANCE TOTAL: $ 309,655
Geomembrane Unit Cost: $ 0.205 /sf
Rounded Geomembrane Unit Cost: $ 0.21 /sf

Schedule:

Work Item	Qnty	Units	Production Rate[1]		Days
Geomembrane	1,511,133	sf	150,000	sf/day	11
				Project Duration:	**11**

Notes:

1. Production rate based on 2 crews, 14 workers and one forklift that produce 150,000 sf/day.

2b. GCL
CLOSURE COST ESTIMATE
RECOLOGY HAY ROAD LANDFILL

Crew Costs:

Position	Personnel	Wage Rate	Unit	Qnty	Subtotal
Laborer	28	$ 82.40	/hr	50	$ 115,365
Forklift Operator	1	$ 87.59	/hr	50	$ 4,380
Foreman	1	$ 94.25	/hr	50	$ 4,713
Supervisor	1	$ 130.50	/hr	50	$ 6,525
				Crew Total:	**$ 130,982**

Materials:

Item	Number	Rate per Unit	Unit	Qnty	Subtotal
GCL	--	$ 0.49	sf	755,567	$ 370,228
50-lb bags of Bentonite	--	$ 20	bag	75	$ 1,500
				Materials Subtotal:	**$ 371,728**
				15% Material Mark Up:	**$ 55,759**
				Material Total:	**$ 427,487**

Equipment Costs:

Item	No. of Equip.	Rate per Unit	Unit	Qnty	Subtotal
Mob/Demob	-	$ 1,500	ls	1	$ 1,500
Job Trailer	1	$ 17.63	/hr	50	$ 881
Pickup Truck	1	$ 30.07	/hr	50	$ 1,504
Forklift	1	$ 67.40	/hr	50	$ 3,370
				Equipment Total:	**$ 7,255**

GCL TOTAL:	**$**	**565,724**
GCL Unit Cost:	**$**	**0.749 /sf**
Rounded GCL Unit Cost:	**$**	**0.75 /sf**

Schedule:

Work Item	Qnty	Units	Production Rate[1]		Days
GCL	755,567	sf	160,000	sf/day	5
				Project Duration:	**5**

Notes:
1. Production rate based on 2 crews, 14 workers and one forklift that produce 160,000 sf/day.

2c. GEOTEXTILE
CLOSURE COST ESTIMATE
RECOLOGY HAY ROAD LANDFILL

Crew Costs:

Position	Personnel	Prevailing Wage Rate	Unit	Qnty	Subtotal
Laborer	14	$ 82.40	/hr	50	$ 57,682
Forklift Operator	2	$ 87.59	/hr	50	$ 8,759
Foreman	1	$ 94.25	/hr	50	$ 4,713
Supervisor	1	$ 130.50	/hr	50	$ 6,525
				Crew Total:	**$ 77,679**

Materials:

Item	Number	Rate per Unit	Unit	Qnty	Subtotal
Geotextile (10 oz/yd)	--	$ 0.22	sf	781,500	$ 171,930
				Materials Subtotal:	**$ 171,930**
				15% Material Mark Up:	**$ 25,790**
				Material Total:	**$ 197,720**

Equipment Costs:

Item	No. of Equip.	Rate per Unit	Unit	Qnty	Subtotal
Mob/Demob	-	$ 1,500	ls	1	$ 1,500
Job Trailer	1	$ 17.63	/hr	50	$ 881
Pickup Truck	1	$ 30.07	/hr	50	$ 1,504
Forklift	1	$ 67.40	/hr	50	$ 3,370
				Equipment Total:	**$ 7,255**

GEOTEXTILE TOTAL: $ 282,654
Geotextile Unit Cost: $ 0.362 /sf
Rounded Geotextile Unit Cost: $ 0.37 /sf

Schedule:

Work Item	Qnty	Units	Production Rate[1]		Days
Geotextile (10 oz/yd)	781,500	sf	160,000	sf/day	5
				Project Duration:	**5**

Notes:
1. Production rate based on 1 crew, 14 workers and one forklift that produce 160,000 sf/day.

2d. GEOCOMPOSITE
CLOSURE COST ESTIMATE
RECOLOGY HAY ROAD LANDFILL

Crew Costs:

Position	Personnel	Prevailing Wage Rate	Unit	Qnty	Subtotal
Laborer	28	$ 82.40	/hr	80	$ 184,584
Forklift Operator	1	$ 87.59	/hr	80	$ 7,008
Foreman	1	$ 94.25	/hr	80	$ 7,540
Supervisor	1	$ 130.50	/hr	80	$ 10,440
				Crew Total:	**$ 209,571**

Materials:

Item	Number	Rate per Unit	Unit	Qnty	Subtotal
Geocomposite	--	$ 0.44	sf	1,120,333	$ 492,947
				Materials Subtotal:	**$ 492,947**
				15% Material Mark Up:	**$ 73,942**
				Material Total:	**$ 566,888**

Equipment Costs:

Item	No. of Equip.	Rate per Unit	Unit	Qnty	Subtotal
Mob/Demob	-	$ 1,500	ls	1	$ 1,500
Job Trailer	1	$ 17.63	/hr	80	$ 1,410
Pickup Truck	1	$ 30.07	/hr	80	$ 2,406
Forklift	1	$ 67.40	/hr	80	$ 5,392
				Equipment Total:	**$ 10,708**

GEOCOMPOSITE TOTAL:	**$**	**787,168**	
Geocomposite Unit Cost:	**$**	**0.703**	**/sf**
Rounded Geocomposite Unit Cost:	**$**	**0.71**	**/sf**

Schedule:

Work Item	Qnty	Units	Production Rate[1]		Days
Geocomposite	1,120,333	sf	160,000	sf/day	8
				Project Duration:	**8**

Notes:
1. Production rate based on 2 crews, 14 workers and one forklift that produce 160,000 sf/day.

3. DESIGN/CONSTRUCTION QUALITY ASSURANCE (CQA) SERVICES
CLOSURE COST ESTIMATE
CHEVRON GUADALUPE

a. Design, Plans, & Specifications

Position	Personnel	Wage Rate	Unit	Qnty	Subtotal
Principal	1	$ 225	/hr	20	$ 4,500.00
Sr. Project Manager	1	$ 186	/hr	150	$ 27,900.00
Staff Engineer	1	$ 112	/hr	300	$ 33,600.00
Administrative	1	$ 73	/hr	20	$ 1,460.00
Drafter	1	$ 89	/hr	300	$ 26,700.00
Reproduction costs (3 copies of each report)	--	$ 150	lump	3	$ 450.00
Communication Fee	--	5.0%	Labor fees	$ 94,610	$ 4,730.50
				Design TOTAL:	**$ 99,341**

b. Post-Closure Maintenance Plan

Position	Personnel	Wage Rate	Unit	Qnty	Subtotal
Principal	1	$ 225	/hr	16	$ 3,600
Sr. Project Manager	1	$ 186	/hr	40	$ 7,440
Staff Engineer	1	$ 112	/hr	100	$ 11,200
Administrative	1	$ 73	/hr	10	$ 730
Drafter	1	$ 89	/hr	75	$ 6,675
Reproduction costs (3 copies of each report)	--	$ 150	lump	3	$ 450
Communication Fee	--	5.0%	Labor fees	$ 30,095	$ 1,505
				CPCMP TOTAL:	**$ 31,600**

c. Construction Quality Assurance (CQA)

Labor

Position	Personnel	Wage Rate	Unit	Qnty	Subtotal
CQA Officer (8 hrs/wk @ 4 wks)	1	$ 186	/hr	32	$ 5,952
CQA Technician (50 hrs/wk @ 4 wks)	1	$ 106	/hr	200	$ 21,200
Second CQA Technician (25 hrs/wk @ 4 wks)	1	$ 106	/hr	100	$ 10,600
Admin/Clerical (4 hrs/wk @ 4 wks)	1	$ 73	/hr	16	$ 1,168
Communication Fee - 5% on Labor	--	5.0%	Labor fees	$ 38,920	$ 1,946
				Labor Total:	***$ 40,866***

3. DESIGN/CONSTRUCTION QUALITY ASSURANCE (CQA) SERVICES
CLOSURE COST ESTIMATE
CHEVRON GUADALUPE

Field Equipment Expenses

Position	No. of Equipment	Unit Rate	Unit	Qnty	Subtotal
Field Office/Testing Equipment (PC/Printer, Scales, Ovens, Tools, etc)	--	$ 3,000	lump sum	1	$ 3,000
Nuclear Gauge	1	$ 450	/week	4	$ 1,800
Field Vehicle	1.5	$ 1,500	/month	1	$ 2,250
Per Diem	1.5	$ 875	/week	4	$ 5,250
Vehicle - CQA Officer	1	$ 150	/trip	1	$ 150
Cell Phone	2	$ 50	/month	1	$ 100
				Field Expenses Total:	***$ 12,550***

Soils Testing Expenses

Foundation Layer (51,100 cy)	Number	Unit Rate	Units	Qnty	Cost
Moisture - Density (ASTM D1557) - 1/10,000 cy	6	$ 134	/test	6	$ 804
Particle Size Analysis (ASTM D422/D1140) - 1/5,000 cy	11	$ 107	/test	11	$ 1,177
Soil Classification (ASTM D2487) - 1/5,000 cy	11	$ 11	/test	11	$ 121
Shipping Charges - Est.	20	$ 150	/package	20	$ 3,000

Low-Permeability Soil (27352 cy)	Number	Unit Rate	Units	Qnty	Cost
Moisture - Density (ASTM D1557) - 1/5,000 cy	6	$ 220	/test	6	$ 1,320
Particle Size Analysis (ASTM D6913/D1140) - 1/1,500 cy	19	$ 120	/test	19	$ 2,280
Atterberg Limits (ASTM D4318) - 1/1,500 cy	19	$ 130	/test	19	$ 2,470
Permeability (ASTM D5084) - 1/1,500 cy	19	$ 300	/test	19	$ 5,700
Moisture Content (ASTM D2216/D4643)	Onsite (No Charge)				$ -
Nuclear Moisture Density (ASTM D6938) - 1/250 cy	Onsite (No Charge)				$ -
Sand Cone / Drive Cylinder Density (ASTM D1556/D2937)	Onsite (No Charge)				$ -
Shipping Charges - Est.	6	$ 75	/package	6	$ 450

Evapotranspirative Final Cover Layer (105,700 cy)	Number	Unit Rate	Units	Qnty	Cost
Moisture - Density (ASTM D1557) - 1/10,000 cy	11	$ 134	/test	11	$ 1,474
Particle Size Analysis (ASTM D422/D1140) - 1/10,000 cy	11	$ 104	/test	11	$ 1,144
Soil Classification (ASTM D2487) - 1/10,000 cy	11	$ 11	/test	11	$ 121
Shipping Charges - Est.	6	$ 75	/package	6	$ 450

LCRS Gravel Layer (14,981 cy)	Number	Unit Rate	Units	Qnty	Cost
Soil Classification (ASTM D2488) - Ongoing	Onsite (No Charge)				$ -
Particle Size Analysis (ASTM D1140) - Source + 1/1,500 cy	5	$ 120	/test	5	$ 600
Fractured Faces (ASTM D5821) - Source + 1/1,500 cy	5	$ 120	/test	5	$ 600
Hydraulic Conductivity (ASTM D2434) - Source + 1/3,000 cy	3	$ 275	/test	3	$ 825
Shipping Charges - Est.	3	$ 75	/package	3	$ 225

Operations Layer (27,352 cy)	Number	Unit Rate	Units	Qnty	Cost
Moisture Content (ASTM D2216/D4643) - 1/1,500 cy	Onsite (No Charge)				$ -
Particle Size Analysis (ASTM D6913/D1140) - 1/3,000 cy	10	$ 120	/test	10	$ 1,200
Soil Classification (ASTM D2487) - Each Material	Onsite (No Charge)				$ -
Shipping Charges - Est.	3	$ 75	/package	3	$ 225
				Soils Testing Expense Total:	***$ 24,186***

Geosynthetics Testing Expenses

Geotextile (781,500 sf)	Number	Unit Rate	Units	Qnty	Cost
Mass/Unit Area (ASTM D5261) - 1 per 100,000 sf	8	$ 26	/test	8	$ 208
Grab Tensile Strength/Elongation (ASTM D4632) - 1 per 100,000 sf	8	$ 53	/test	8	$ 424
Trapezoidal Tear (ASTM D4533) - 1 per 100,000 sf	8	$ 53	/test	8	$ 424
Mullen Burst (ASTM D3786) - 1 per 100,000 sf	8	$ 53	/test	8	$ 424
Puncture Strength (ASTM D4833) - 1 per 100,000 sf	8	$ 53	/test	8	$ 424
Apparent Opening Size (ASTM D4751) - 1 per 100,000 sf	8	$ 120	/test	8	$ 960
Permittivity/Permeability (ASTM D4491) - 1 per 100,000 sf	8	$ 110	/test	8	$ 880
Shipping Costs for Samples - Fed Ex	8	$ 75	/package	8	$ 600

3. DESIGN/CONSTRUCTION QUALITY ASSURANCE (CQA) SERVICES
CLOSURE COST ESTIMATE
CHEVRON GUADALUPE

GCL (755,567 sf)	Number	Unit Rate	Units	Qnty	Cost
Geonet Density (ASTM D1505) - 1/100,000 sf	8	$ 39	/test	8	$ 312
Geonet Thickness (ASTM D5199) - 1/100,000 sf	8	$ 25	/test	8	$ 200
Geotextile Mass (ASTM D5261) - 1/100,000 sf	8	$ 26	/test	8	$ 208
Geotextile Permittivity (ASTM D4491) - 1/100,000 sf	8	$ 110	/test	8	$ 880
Transmissivity (ASTM D4716) - 1 per 100,000 sf	8	$ 330	/test	8	$ 2,640
Geocomposite Peel Strength (ASTM D7005) - 1 per 100,000 sf	8	$ 67	/test	8	$ 536
Shipping Costs for Samples - Fed Ex	8	$ 75	/package	8	$ 600

Geocomposite (1,120,333 sf)	Number	Unit Rate	Units	Qnty	Cost
Geonet Density (ASTM D1505) - 1/100,000 sf	12	$ 39	/test	12	$ 468
Geonet Thickness (ASTM D5199) - 1/100,000 sf	12	$ 25	/test	12	$ 300
Geotextile Mass (ASTM D5261) - 1/100,000 sf	12	$ 26	/test	12	$ 312
Geotextile Permittivity (ASTM D4491) - 1/100,000 sf	12	$ 110	/test	12	$ 1,320
Transmissivity (ASTM D4716) - 1 per 100,000 sf	12	$ 330	/test	12	$ 3,960
Geocomposite Peel Strength (ASTM D7005) - 1 per 100,000 sf	12	$ 67	/test	12	$ 804
Shipping Costs for Samples - Fed Ex	12	$ 75	/package	12	$ 900

Geomembrane (1,511,133 sf)	Number	Unit Rate	Units	Qnty	Cost
Density (ASTM D1505) - 1 per 100,000 sf	16	$ 39	/test	16	$ 624
Tensile Properties (ASTM D638) - 1 per 50,000 sf	31	$ 67	/test	31	$ 2,077
Tear Resistance (ASTM D1004 Die C) - 1 per 50,000 sf	31	$ 53	/test	31	$ 1,643
Puncture Resistance (ASTM D4833) - 1 per 50,000 sf	31	$ 53	/test	31	$ 1,643
Carbon Black: Content (ASTM D1603) - 1 per 100,000 sf	16	$ 49	/test	16	$ 784
Carbon Black: Dispersion (ASTM D5596) - 1 per 100,000 sf	16	$ 49	/test	16	$ 784
Seam Destructive Testing (ASTM D6392) - 1/ 500 ft of seam	159	$ 37	/test	159	$ 5,883
Thickness (ASTM D5994) - 1 per 100,000 sf	16	$ 25	/test	16	$ 400
Shipping Costs for Samples - Fed Ex	80	$ 75	/package	80	$ 6,000

Geosynthetics Testing Expenses: $ 37,622

CQA Report and Certification

Position	Personnel	Wage Rate	Unit	Qnty	Subtotal
Principal	1	$ 225	/hr	4	$ 900
CQA Officer	1	$ 160	/hr	16	$ 2,560
Sr. Project Manager (Tech. Review)	1	$ 186	/hr	24	$ 4,464
Staff Engineer	1	$ 112	/hr	60	$ 6,720
Administrative	1	$ 73	/hr	16	$ 1,168
Drafter	1	$ 89	/hr	16	$ 1,424
Reproduction costs (3 copies of each report)	--	$ 100	lump	3	$ 300
Communication Fee	--	5%	/hr	$ 16,336	$ 817

CQA Report and Certification Total: $ 18,353

CQA TOTAL: $ 133,577
CQA Total Per Acre: $ 7,900

DESIGN, CPCMP, AND CQA TOTAL: $ 264,517
Total per Acre: $ 15,600

4. REVEGETATION
CLOSURE COST ESTIMATE
CHEVRON GUADALUPE

Crew Costs:

Position	Personnel	Wage Rate	Unit	Qnty	Subtotal
Seed Truck Operator	1	$ 108.92	/hr	32	$ 3,486
				Crew Total:	**$ 3,486**

Materials:

Item	Number	Rate per Unit	Unit	Qnty	Subtotal
Seed Mix	--	$ 1,000	acre	17	$ 17,000
				Materials Subtotal:	**$ 17,000**
				15% Material Mark Up:	**$ 2,550**
				Material Total:	**$ 19,550**

Equipment Costs:

Item	No. of Equip.	Rate per Unit	Unit	Qnty	Subtotal
Mob/Demob	--	$ 500	ls	1	$ 500
Seed Truck	1	$ 100.38	/hr	32	$ 3,212
				Equipment Total:	**$ 3,712**

REVEGETATION TOTAL: $ 26,748
Revegetation Unit Cost: $ 1,573 /ac
Rounded Revegetation Unit Cost: $ 1,275 /ac

Schedule:

Work Item	Qnty	Units	Production Rate		Days
Seed Mix	17	acres	5	ac/day	4
				Project Duration:	**4**

7. GROUNDWATER MONITORING
Closure Cost Summary
CHEVRON GUADALUPE

a. Reporting

Position	Personnel	Wage Rate	Unit	Qnty	Subtotal
Principal	1	$ 225	/hr	1	$ 225
Sr. Project Manager	1	$ 186	/hr	4	$ 744
Staff Engineer	1	$ 112	/hr	12	$ 1,344
Administrative	1	$ 73	/hr	2	$ 146
Drafter	1	$ 89	/hr	8	$ 712
				Reporting Total:	**$ 3,171**

b. Inspection & Surveying

Crew & Equipment Costs:

Position	Personnel	Rate	Units	Qnty[2]	Subtotal
Field Technician	$ 1	$ 112	/hr	20	$ 2,240
2-Man Survey Crew	$ 1	$ 145	/hr	20	$ 2,900
Truck	$ 1	$ 30	/hr	20	$ 601
				Inspection & Survey Total:	**$ 5,741**

Material Costs:

Item	Number	Rate[3]	Units	Qnty	Subtotal
Additional Well Installation	--	$ 7,500	each	4	$ 30,000
				Material Subtotal:	**$ 30,000**
				15% Material Mark Up:	**$ 4,500**
				Material Total:	**$ 34,500**

Groundwater Monitoring Total: $ 43,412

Notes:
1. Assumes four additional wells will need to be installed to complete the groundwater monitoring system.
2. Assumes two 10-hour days to complete inspections and survey.
3. Includes labor, drilling subcontractor and well construction materials.

8a. CMP DOWNDRAINS
CLOSURE COST ESTIMATE
CHEVRON GUADALUPE

Crew Costs:

Position	Personnel	Wage Rate	Unit	Qnty	Subtotal
Laborer	1	$ 82.40	/hr	180	$ 14,833
Trackhoe Operator	1	$ 109.26	/hr	180	$ 19,666
Foreman	1	$ 94.25	/hr	180	$ 16,965
				Crew Total:	**$ 51,464**

Materials:

Item	Number	Rate per Unit	Unit	Qnty	Subtotal
CMP Pipe and slope stakes	--	$ 20.00	lf	9,500	$ 190,000
				Materials Subtotal:	**$ 190,000**
				15% Material Mark Up:	**$ 28,500**
				Material Total:	**$ 218,500**

Equipment Costs:

Item	No. of Equip.	Rate per Unit	Unit	Qnty	Subtotal
Mob/Demob	-	$ 1,000	ls	1	$ 1,000
Job Trailer	1	$ 17.63	/hr	180	$ 3,173
Pickup Truck	1	$ 30.07	/hr	180	$ 5,413
Trackhoe	1	$ 45.85	/hr	180	$ 8,253
				Equipment Total:	**$ 17,839**

CMP DOWNDRAINS TOTAL: $ 287,803
Drainage Structure Unit Cost: $ 30.00 /lf

Schedule:

Work Item	Qnty	Units	Production Rate	Days
Downdrain	9,500	lf	550 lf/day	18
			Project Duration:	**18**

8b. V-DITCH
CLOSURE COST ESTIMATE
CHEVRON GUADALUPE

Crew Costs:

Position	Personnel	Wage Rate	Units	Qnty	Subtotal
Laborer	1	$ 82.40	/hr	60	$ 4,944
Grader Operator	1	$ 109.08	/hr	60	$ 6,545
Trackhoe Operator	1	$ 109.26	/hr	60	$ 6,555
Foreman	1	$ 94.25	/hr	60	$ 5,655
				Crew Total:	**$ 23,700**

Equipment Costs:

Item	No. of Equip.	Rate per Unit	Unit	Qnty	Subtotal
Mob/Demob	-	$ 1,000	ls	1	$ 1,000
Pickup Truck	1	$ 30	/hr	60	$ 1,804
Grader - CAT 140G	1	$ 95	/hr	60	$ 5,709
Trackhoe	1	$ 46	/hr	60	$ 2,751
				Equipment Total:	**$ 11,264**

V-DITCH TOTAL: $ 34,964
Unlined V-Ditch Unit Cost: $ 11.30 /lf

Schedule:

Work Item	Qnty	Units	Production Rate		Days
Unlined V-Ditches[1]	3,100	lf	550	lf/day	6
				Project Duration:	**6**

Notes:

1. Assumed unlined natural channels (based on manning's roughness coeff used in SW calcs).

9. SECURITY MEASURES
CLOSURE COST ESTIMATE
CHEVRON GUADALUPE

Crew Costs:

Position	Personnel	Wage Rate	Units	Qnty[1]	Subtotal
Laborer	1	$ 82.40	/hr	8	$ 659
				Crew Total:	**$ 659**

Equipment Costs:

Item	Number	Rate	Units	Qnty[1]	Subtotal
Pickup Truck	1	$ 30.07	/hr	8	$ 241
				Equipment Total:	**$ 241**

Material Costs:

Item	Number	Rate	Units	Qnty[1]	Subtotal
Install Fence	--	$ 4,500	ls	1	$ 4,500
				Material Subtotal:	**$ 4,500**
				15% Material Mark Up:	**$ 675**
				Material Total:	**$ 5,175**
				SECURITY TOTAL:	**$ 6,075**

Notes:
1. Perimeter fence already in place. Assumes one 8-hour days for installation

10. CLOSURE SURVEY/SETTLEMENT MONUMENTS
CLOSURE COST ESTIMATE
CHEVRON GUADALUPE

Crew Costs:

Position	Personnel	Wage Rate	Unit	Qnty	Subtotal
2-Man Survey Crew	1	$ 145	/hr	8	$ 1,160
Licensed Surveyor	1	$ 116	/hr	2.5	$ 290
				Crew Total:	**$ 1,450**

Materials:

Item	Number	Rate per Unit	Unit	Qnty	Subtotal
Survey Monuments	--	$ 50	each	2	$ 100
				Materials Subtotal:	**$ 100**
				15% Material Mark Up:	**$ 15**
				Material Total:	**$ 115**

Equipment Costs:

Item	No. of Equip.	Rate per unit	Unit	Qnty	Subtotal
Pickup Truck	1	$ 30	/hr	8	$ 241
				Equipment Total:	**$ 241**

Aerial Survey:

Item	Number	Rate	Unit	Qnty	Subtotal
Aerial Survey Contractor	--	$ 6,000	/hr	1	$ 6,000
				Ariel Survey Total:	**$ 6,000**

CLOSURE SURVEY/SETTLEMENT MONUMENTS TOTAL: $ 7,810

Schedule:

Work Item	Qnty	Units	Production Rate		Days
Monument Install[1]	2	each	2	monuments/day	1
				Project Duration:	**1**

Notes:

1. Assumed 2 monuments.

LABOR & EQUIPMENT COSTS
CLOSURE COST ESTIMATE
CHEVRON GUADALUPE

Crew Costs:

Position	Source[1]	Operator Group	Base Wage Rate	Unit	12 % Labor Surcharge	33% Overhead & Profit	Rate	Unit
2 Man Survey Crew			$ 100.00	/hr	$ 12.00	$ 33.00	$ 145.00	/hr
3 Man Drilling Crew			$ 230.00	/hr	$ 27.60	$ 75.90	$ 333.50	/hr
Licensed Surveyor			$ 80.00	/hr	$ 9.60	$ 26.40	$ 116.00	/hr
Laborer	Laborer	3	$ 56.83	/hr	$ 6.82	$ 18.75	$ 82.40	/hr
Backhoe Operator	Operator	10	$ 75.35	/hr	$ 9.04	$ 24.87	$ 109.26	/hr
Compactor Operator	Operator	8	$ 75.23	/hr	$ 9.03	$ 24.83	$ 109.08	/hr
Foreman		--	$ 65.00	/hr	$ 7.80	$ 21.45	$ 94.25	/hr
Forklift Operator	Teamster	7	$ 60.41	/hr	$ 7.25	$ 19.94	$ 87.59	/hr
Dump Truck Operator	Teamster	10	$ 61.16	/hr	$ 7.34	$ 20.18	$ 88.68	/hr
Excavator Operator	Operator	3	$ 74.79	/hr	$ 8.97	$ 24.68	$ 108.45	/hr
Grader Operator	Operator	8	$ 75.23	/hr	$ 9.03	$ 24.83	$ 109.08	/hr
Gradesetter Operator	Operator	8	$ 75.23	/hr	$ 9.03	$ 24.83	$ 109.08	/hr
Grading Dozer Operator	Operator	8	$ 75.23	/hr	$ 9.03	$ 24.83	$ 109.08	/hr
Maintenance Truck Operator	Teamster	1	$ 56.83	/hr	$ 6.82	$ 18.75	$ 82.40	/hr
Mixer Operator	Operator	8	$ 75.23	/hr	$ 9.03	$ 24.83	$ 109.08	/hr
Scraper Operator - Mixing	Operator	8	$ 75.23	/hr	$ 9.03	$ 24.83	$ 109.08	/hr
Scraper Operator - Placement	Operator	8	$ 75.23	/hr	$ 9.03	$ 24.83	$ 109.08	/hr
Seed Truck Operator	Operator	6	$ 75.12	/hr	$ 9.01	$ 24.79	$ 108.92	/hr
Skid Track Loader Operator	Operator	3	$ 73.41	/hr	$ 8.81	$ 24.23	$ 106.44	/hr
Spreading Dozer Operator	Operator	8	$ 75.23	/hr	$ 9.03	$ 24.83	$ 109.08	/hr
Supervisor		--	$ 90.00	/hr	$ 10.80	$ 29.70	$ 130.50	/hr
Water Truck Operator - Mixing	Teamster	5	$ 60.13	/hr	$ 7.22	$ 19.84	$ 87.19	/hr
Water Truck Operator - Placement	Teamster	5	$ 60.13	/hr	$ 7.22	$ 19.84	$ 87.19	/hr

Engineering Costs:

Item	Rate per Unit	Unit
Principal	$ 225.00	/hr
Sr. Project Manager (Tech. Review)	$ 186.00	/hr
Staff Engineer	$ 112.00	/hr
Administrative	$ 73.00	/hr
Sr. Technician	$ 106.00	/hr
CQA Officer	$ 160.00	/hr
Drafter	$ 89.00	/hr

Equipment, Maintenance and Fuel Costs:

Item	Code	Cal Trans[2] Base Rate	15% Overhead & Profit	Rate	Unit
Job Trailer	100	$ 15.75	$ 1.88	$ 17.63	/hr
Generator	GEN1	$ 15.05	$ 2.26	$ 17.31	/hr
Pickup Truck	00-06	$ 26.15	$ 3.92	$ 30.07	/hr
Spreading Dozer - CAT D6M-LPG	3745	$ 85.36	$ 12.80	$ 98.16	/hr
Push Dozer - CAT D8N	4864	$ 165.43	$ 24.81	$ 190.24	/hr
Dump Truck	5AXL	$ 87.29	$ 13.09	$ 100.38	/hr
Excavator	310	$ 78.35	$ 11.75	$ 90.10	/hr
Grading Dozer - CAT D6	3720	$ 76.35	$ 11.45	$ 87.80	/hr
Scraper 1 - CAT 637 - Placement	2375	$ 258.45	$ 38.77	$ 297.22	/hr
Scraper 1 - CAT 637 - Mixing	2375	$ 258.45	$ 38.77	$ 297.22	/hr
Compactor - CAT 815	2300	$ 89.27	$ 13.39	$ 102.66	/hr
Grader - CAT 140G	3260	$ 82.74	$ 12.41	$ 95.15	/hr
Water Truck - 4000 Gal - Placement	48-60	$ 68.12	$ 10.22	$ 78.34	/hr
Water Truck - 4000 Gal - Mixing	48-60	$ 68.12	$ 10.22	$ 78.34	/hr
Maintenance Truck	00-06	$ 26.15	$ 3.92	$ 30.07	/hr
Mixer	5014	$ 74.96	$ 11.24	$ 86.20	/hr
Skid Track Loader	1623	$ 82.90	$ 12.44	$ 95.34	/hr
Seed Truck	5AXL	$ 87.29	$ 13.09	$ 100.38	/hr
Drill Rig 4500LH	5054	$ 191.36	$ 28.70	$ 220.06	/hr
Backhoe - CAT 426	1862	$ 39.87	$ 5.98	$ 45.85	/hr
Forklift	080-120	$ 58.61	$ 8.79	$ 67.40	/hr

Notes:

1. From the General Prevailing Wage determination made by the Director of Industrial Relations pursuant to California Labor Code Part 7, Chapter 1, Article 2, Sections 1770, 1773 and 1773.1; Tables: Craft: TEAMSTER, Craft: OPERATING ENGINEER, Craft: #OPERATING ENGINEER (HEAVY AND HIGHWAY WORK), and Craft: #LABORER AND RELATED CLASSIFICATIONS.
2. From the 2019 CalTrans Labor Surcharge and Equipment Rental Rates effective April 1, 2019 through March 31, 2020.

APPENDIX S

Postclosure Cost Estimate Back-up Calculations

Table 7
Postclosure Maintenance Cost Summary
Soil Mangement Area
Chevron Guadalupe

Item	Unit	Unit Cost	Annual Quantity	Total
1. Vegetation Maintenance[1]	acre	$ 7,840	0.2	$ 1,568
2. Leachate Monitoring & Maintenance				
a. Sampling and Inspection[2]	annually	$ 4,640	1	$ 4,640
b. O&M	annually	$ 1,549	1	$ 1,549
3. Landfill Gas Monitoring/Maintenance[3]				
a. Monitoring and Inspection	annually			
a. Operations and Maintenance	annually			
4. Leak Detection Monitoring/Maintenance	annually	$ 18,098	1	$ 18,098
5. Vadose Zone Monitoring/Maintenance	annually			
6. Groundwater Monitoring/Maintenance	annually	$ 15,921	1	$ 15,921
7. Surface Water Monitoring	annually	$ 4,591	1	$ 4,591
8. Drainage/Cover Maintenance				
a. Drainage Maintenance	every ten yrs	$ 13,515	0.1	$ 1,352
b. Settlement Regrading Maintenance	every five yrs	$ 8,884	0.2	$ 1,777
9. Security Maintenance	annually	$ 1,475	1	$ 1,475
10. Inspections	semi-annually	$ 1,729	2	$ 3,457
11. Miscellaneous				
a. Aerial Survey, Settlement Report	every five yrs	$ 11,000	0.2	$ 2,200
b. DM-1 Groundwater Maintenance	annually	$ 11,000	1	$ 11,000
12. Permitting Fees[4]	annually	$ 11,650	1	$ 11,650
			Total Annual Cost:	$ 79,276
			Cost x 30 yrs:	$ 2,378,294

Notes:

1. Assumes 1% of total area (17 acres) per year will need hydroseeding.

2. Sampling and testing costs based on testing protocol outlined in the WDR's.

3. Landfill gas monitoring not required.

4. Fees include Waste Discharge Requirements (WDR's) annual fees, Stormwater Discharge Permit, and Air Board Permit to Operate.

GOLDER

1. REVEGETATION
POSTCLOSURE COST ESTIMATE
CHEVRON GUADALUPE

Crew Costs:

Position	Personnel	Wage Rate	Unit	Qnty	Subtotal
Seed Truck Operator	1	$ 108.92	/hr	4	$ 436
				Crew Total:	**$ 436**

Materials:

Item	Number	Rate per Unit	Unit	Qnty	Subtotal
Seed Mix	--	$ 1,000	acre	0.2	$ 200
				Materials Subtotal:	**$ 200**
				15% Material Mark Up:	**$ 30**
				Material Total:	**$ 230**

Equipment, Maintenance and Fuel Costs:

Item	No. of Equip.	Rate per Day	Unit	Qnty	Subtotal
Mob/Demob	-	$ 500	ls	1	$ 500
Seed Truck	1	$ 803.07	/day	0.5	$ 402
				Equipment Total:	**$ 902**

REVEGETATION TOTAL: $ 1,567
Revegetation Unit Cost: $ 7,836 /ac
Revegetation Unit Cost Rounded: $ 7,840 /ac

Schedule:

Work Item	Qnty	Units	Production Rate		Days
Seed Mix	0.20	acres	10	ac/day	0.5
				Project Duration:	**0.5**

GOLDER

Table 7
Postclosure Maintenance Cost Summary
CHEVRON GUADALUPE

a. Annual Sampling & Inspection

Field Sampling Costs:

Item	Personnel	Wage Rate	Units	Qnty	Subtotal
Sr. Technician	1	$ 106	/hr	4	$ 424
Sr. Project Manager	1	$ 186	/hr	2	$ 372
Equipment	1	$ 50	/sample	2	$ 100
Truck	1	$ 30.07	/hr	4	$ 120
				Sampling Cost Per Round:	**$ 1,016**
				Rounds per Year:	**$ 1**
				Annual Sampling Cost:	**$ 1,016**

Lab Testing Costs - Detection (Annually):

Monitoring Parameter[1]	No. of Equip.	Unit Cost	Units	Tests per Round[1]	Subtotal
Ferrous Iron Unfiltered	--	$ 40	/test	2	$ 80
Ferrous Iron Filtered	--	$ 40	/test	2	$ 80
Benzene	--	$ 8	/test	2	$ 16
Toluene	--	$ 8	/test	2	$ 16
Ethyl-benzene	--	$ 10	/test	2	$ 20
Xylenes	--	$ 9	/test	2	$ 18
TPH	--	$ 24	/test	2	$ 48
Lab EDF Fee	--	1%	/test	1	$ 3
Administrative Fee	--	10%	/test	1	$ 28
				Detection Testing Cost per Round:	**$ 309**
				Rounds per Year:	**1**
				Annual Detection Testing Cost:	**$ 309**

Reporting Cost Per Round:

Item	Personnel	Prevailing Wage Rate	Units	Qnty	Subtotal
Principal	1	$ 225	/hr	1	$ 225
Sr. Project Manager	1	$ 186	/hr	8	$ 1,488
Staff Engineer	1	$ 112	/hr	10	$ 1,120
Drafter	1	$ 89	/hr	2	$ 178
Administrative	1	$ 73	/hr	2	$ 146
Office Service Fee	--	5%	rate		$ 158
				Reporting Cost per Round:	**$ 3,315**
				Rounds per Year:	**1**
				Annual Reporting Cost:	**$ 3,315**

Sampling and Reporting Cost per Round:	**$ 4,640**
Total Annual Leachate Monitoring Cost:	**$ 4,640**

Notes:

1. Number of samples per round include 1 sumps and 1 QC sample.

GOLDER

2b. LEACHATE MONITORING & MAINTENANCE COSTS
POSTCLOSURE COST ESTIMATE
CHEVRON GUADALUPE

b. O&M and Off-site Disposal

Crew Costs:

Item	Personnel	Wage Rate	Units	Qnty[1]	Subtotal
Sr. Technician	1	$ 106	/hr	8	$ 848
				Crew Total:	**$ 848**

Equipment Costs:

Item	Personnel	Wage Rate	Units	Qnty[1]	Subtotal
Pickup Truck	1	$ 30.07	/hr	8	$ 241
				Equipment Total:	**$ 241**

Materials:

Item	Rate[2]	Units	Qnty[1]	Subtotal
Pump Replacement	$ 400	/year	1	$ 400
			Material Subtotal:	**$ 400**
			15% Material Mark Up:	**$ 60**
			Material Total:	**$ 460**
			O&M TOTAL:	**$ 1,549**

Notes:

1. Assumes one 4-hour day, twice a year, to complete landfill leachate operation & maintenance activities.
2. Assumes 1 pump, $4,000 per pump replaced, every ten years.

$$\frac{\text{1 pump x \$4000 each}}{\text{10 years}} = \$400$$

GOLDER

Table 7
Postclosure Maintenance Cost Summary
CHEVRON GUADALUPE

a. Sampling & Inspection

Field Sampling Costs:

Item	Personnel	Wage Rate	Units	Qnty	Subtotal
Sr. Technician	1	$ 106.00	/hr	1	$ 106
Sr. Project Manager	1	$ 186.00	/hr	1	$ 186
Equipment	1	$ 35.00	/samples	2	$ 70
Truck	1	$ 30.07	/hr	1	$ 30
				Sampling Cost Per Round:	**$ 392**
				Rounds per Year:	**12**
				Annual Sampling Cost:	**$ 4,705**

Lab Testing Costs - (Liquid) Detection:

Monitoring Parameter[1]	Number	Unit Cost	Units	Tests per Round	Subtotal
TDS	--	$ 10	/test	2	$ 20
Chloride	--	$ 9	/test	2	$ 18
Bicarbonate & Carbonate	--	$ 16	/test	2	$ 32
Nitrate as Nitrogen	--	$ 10	/test	2	$ 20
Sulfate	--	$ 9	/test	2	$ 18
Anions (Ca, Mg, K, Na, Mn, Fe, Cr, Pb)	--	$ 24	/test	2	$ 48
Arsenic	--	$ 6	/test	2	$ 12
Volatile Organic Compounds	--	$ 70	/test	2	$ 140
Lab EDF Fee	--	1%	/test	1	$ 3
Administrative Fee	--	10%	/test	1	$ 31
				Detection Testing Cost per Round:	**$ 342**
				Rounds per Year:	**12**
				Annual Detection Testing Cost:	**$ 4,106**

GOLDER

Table 7
Postclosure Maintenance Cost Summary
CHEVRON GUADALUPE

Lab Testing Costs (Liquid) - Constituents of Concern:

Monitoring Parameter[1]	Number	Unit Cost	Units	Tests per Round	Subtotal
Ammonia-Nitrogen	--	$ 27	/test	2	$ 54
Nitrite-Nitrogen	--	$ 10	/test	2	$ 20
Total Kjeldahl Nitrogen	--	$ 28	/test	2	$ 56
Phosphate	--	$ 10	/test	2	$ 20
Phosphorous	--	$ 10	/test	2	$ 20
Fecal Coliform	--	$ 30	/test	2	$ 60
Total Alkalinity	--	$ 8	/test	2	$ 16
Total Organic Carbon	--	$ 25	/test	2	$ 50
Chemical Oxygen Demand	--	$ 22	/test	2	$ 44
Fixed Dissolved Solids	--	$ 10	/test	2	$ 20
Inorganics (dissolved)	--	$ 120	/test	2	$ 240
SVOCs	--	$ 125	/test	2	$ 250
Chlorphenoxy Herbicides	--	$ 85	/test	2	$ 170
Organophosphorus Compounds	--	$ 85	/test	2	$ 170
Lab EDF Fee	--	1%	/test	1	$ 9
Administrative Fee	--	10%	/test	1	$ 95

5-Year COC Testing Cost: $ 1,295
Rounds per Year: 0.2
Annual COC Testing Cost: $ 259

Reporting Cost Per Round:

Item	Personnel	Wage Rate	Units	Qnty	Subtotal
Principal	1	$ 225	/hr	1	$ 225
Sr. Project Manager	1	$ 186	/hr	6	$ 1,116
Staff Engineer	1	$ 112	/hr	12	$ 1,344
Drafter	1	$ 89	/hr	2	$ 178
Administrative	1	$ 73	/hr	2	$ 146
Office Service Fee	--	5%	rate		$ 150

Reporting Cost per Round: $ 3,159
Rounds per Year: 2
Annual Reporting Cost: $ 6,319

Total Annual Leal Detection Monitoring Cost: $ 15,389

Notes:

1. Assumes liquid present in one sump each round plus one CQ sample.
2. Assumes 12 one hour days (One per month) to monitor sump and take required samples.

GOLDER

Table 7
Postclosure Maintenance Cost Summary
CHEVRON GUADALUPE

b. Operations & Maintenance

Crew Costs:

Position	Personnel	Wage Rate	Units	Qnty[1]	Subtotal
Laborer	2	$ 82.40	/hr	8	$ 1,318
				Crew Total:	**$ 1,318**

Equipment Costs:

Item	Personnel	Wage Rate	Units	Qnty[1]	Subtotal
Pickup Truck	1	$ 30.07	/hr	8	$ 241
				Equipment Total:	**$ 241**

Materials:

Item	Rate	Units	Qnty	Subtotal
Riser Pipe Replacement Parts	$ 500.00	/event	2	$ 1,000
			Material Subtotal:	**$ 1,000**
			15% Material Mark Up:	**$ 150**
			Material Total:	**$ 1,150**
			YEARLY O&M TOTAL:	**$ 2,709**

Notes:

1. Assumes one 4-hour day, two events per year to complete landfill leak detection operation & maintenance activities.

GOLDER

Table 7
Postclosure Maintenance Cost Summary
CHEVRON GUADALUPE

a. Monitoring & Inspection

Field Sampling Costs:

Item	Personnel	Wage Rate	Units	Qnty	Subtotal
Sr. Technician	1	$ 106	/hr	8	$ 848
Sr. Project	1	$ 186	/hr	8	$ 1,488
Equipment	1	$ 35	samples	5	$ 175
Truck	1	$ 30.07	/hr	8	$ 241
				Sampling Cost Per Round:	**$ 2,752**
				Rounds per Year:	**2**
				Annual Sampling Cost:	**$ 5,503**

Lab Testing Costs - Backgound & Detection (Semi-Annually):

Monitoring Parameter[1]	Number	Unit Cost	Units	Tests per Round[2]	Subtotal
TDS	--	$ 10	/test	5	$ 50
Chloride	--	$ 9	/test	5	$ 45
Bicarbonate	--	$ 8	/test	5	$ 40
Nitrate-Nitrogen	--	$ 10	/test	5	$ 50
Sulfate	--	$ 9	/test	5	$ 45
Volatile Organic Compounds	--	$ 70	/test	5	$ 350
Lab EDF Fee	--	1%	/test	1	$ 6
Administrative Fee	--	10%	/test	1	$ 59
				Detection Testing Cost per Round:	**$ 644**
				Rounds per Year:	**2**
				Annual Detection Testing Cost:	**$ 1,289**

Lab Testing Costs - Backgound & Detection (Annually):

Monitoring Parameter[1]	Number	Unit Cost	Units	Tests per Round[2]	Subtotal
Carbonate	--	$ 8	/test	5	$ 40
Arsenic	--	$ 6	/test	5	$ 30
Chromium	--	$ 6	/test	5	$ 30
Lead	--	$ 6	/test	5	$ 30
Ammonia-Nitrogen	--	$ 27	/test	5	$ 135
Total Kjedahl Nitrogen	--	$ 28	/test	5	$ 140
Anions (Ca, Mg, K, Na, Mn, Fe)	--	$ 24	/test	5	$ 60
Lab EDF Fee	--	1%	/test	1	$ 5
Administrative Fee	--	10%	/test	1	$ 47
				Detection Testing Cost per Round:	**$ 517**
				Rounds per Year:	**1**
				Annual Detection Testing Cost:	**$ 517**

GOLDER

Table 7
Postclosure Maintenance Cost Summary
CHEVRON GUADALUPE

Lab Testing Costs - Constituents of Concern:

Monitoring Parameter[1]	Number	Unit Cost	Units	Tests per Round	Subtotal
Phosphorous	--	$ 10	/test	5	$ 50
Phosphate	--	$ 10	/test	5	$ 50
Fecal Coliform	--	$ 30	/test	5	$ 150
Total Alkalinity	--	$ 8	/test	5	$ 40
Total Organic Carbon	--	$ 25	/test	5	$ 125
Inorganics (dissolved)	--	$ 120	/test	5	$ 600
Nitrite-Nitrogen	--	$ 10	/test	5	$ 50
Chemical Oxygen Demand	--	$ 22	/test	5	$ 110
SVOCs	--	$ 125	/test	5	$ 625
Chlorphenoxy Herbicides	--	$ 85	/test	5	$ 425
Organophosphorus Compounds	--	$ 85	/test	5	$ 425
Fixed Dissolved Solids	--	$ 10	/test	5	$ 50
Lab EDF Fee	--	1%	/test	1	$ 24
Administrative Fee	--	10%	/test	1	$ 243
				5-Year COC Testing Cost:	**$ 2,967**
				Rounds per Year:	**0.2**
				Annual COC Testing Cost:	**$ 593**

Reporting Cost Per Round:

Item	Personnel	Wage Rate	Units	Qnty	Subtotal
Principal	1	$ 225	/hr	1	$ 225
Sr. Project Manager	1	$ 186	/hr	6	$ 1,116
Staff Engineer	1	$ 112	/hr	12	$ 1,344
Drafter	1	$ 89	/hr	2	$ 178
Administrative	1	$ 73	/hr	2	$ 146
Office Service Fee	--	5%	rate		$ 143
				Reporting Cost per Round:	**$ 3,152**
				Rounds per Year:	**2**
				Annual Reporting Cost:	**$ 6,304**
				Annual Sampling and Reporting Cost:	**$ 14,206**

Notes:

1. Assumes 4 background & detection monitoring wells and one QC sample.

GOLDER

Table 7
Postclosure Maintenance Cost Summary
CHEVRON GUADALUPE

b. Operations & Maintenance

Crew Costs:

Position	Personnel	Rate	Units	Qnty[1]	Subtotal
Sr. Technician	1	$ 106	/hr	10	$ 1,060
Truck	--	$ 30.07	/hr	10	$ 301
				Crew Annual Total:	**$ 1,361**

Subcontractor Costs:

Position	Number	Rate	Units	Qnty[2]	Subtotal
C57 License Driller	1	$ 4,000	/event	1	$ 4,000
				Equipment Total:	**$ 4,000**

Materials:

Item	Number	Rate[2]	Units	Qnty	Subtotal
Well Replacement	--	$ 1,000	/yr	1	$ 1,000
				Material Subtotal:	**$ 1,000**
				15% Material Mark Up:	**$ 150**
				Material Total:	**$ 1,150**

Reporting Cost Per Round:

Item	Personnel	Rate	Units	Qnty	Subtotal
Principal	1	$ 225	/hr	1	$ 225
Sr. Project Manager	1	$ 186	/hr	4	$ 744
Staff Engineer	1	$ 112	/hr	6	$ 672
Drafter	1	$ 89	/hr	2	$ 178
Administrative	1	$ 73	/hr	2	$ 146
Office Service Fee	--	5%	rate		$ 98
				Reporting Cost per Round:	**$ 2,063**
				Total Cost of One well:	**$ 8,574**
				Total Cost of all 4 Wells:	**$ 34,296**
				Total Cost of Well Replacement per year:	**$ 1,715**

Annual Groundwater Monitoring Costs: $ 14,206
Total Annual Groundwater Monitoring and Maintenance Cost: $ 15,921

Notes:
1. Assumes one 10-hour day to complete groundwater monitoring well operation & maintenance activities.
2. Assumes 4 total wells, replaced every 20 years, $20 per linear foot, 50 feet deep.

1 well x $20/lf x 50 lf = $1,000

$\frac{\text{4 wells x \$8,574 each}}{\text{20 years}}$ = $1,714.80

GOLDER

Table 7
Postclosure Maintenance Cost Summary
CHEVRON GUADALUPE

Field Sampling Costs:

Item	Personnel	Wage Rate	Units	Qnty	Subtotal
Sr. Technician	1	$ 106	/hr	4	$ 424
Sr. Project	1	$ 186	/hr	1	$ 186
Equipment	1	$ 35	samples	3	$ 105
Truck	1	$ 30.07	/hr	4	$ 120
				Sampling Cost Per Round:	**$ 835**
				Rounds per Year:	**2**
				Annual Sampling Cost:	**$ 1,671**

Lab Testing Costs - Detection (Semi-Annually):

Monitoring Parameter[1]	Number	Unit Cost	Units	Tests per Round	Subtotal
Total Dissolved Solids	--	$ 10	/test	3	$ 30
Chloride	--	$ 9	/test	3	$ 27
Sulfate	--	$ 9	/test	3	$ 27
Nitrate as Nitrogen	--	$ 10	/test	3	$ 30
Arsenic	--	$ 6	/test	3	$ 18
Chromium	--	$ 6	/test	3	$ 18
Lead	--	$ 6	/test	3	$ 18
Iron	--	$ 6	/test	3	$ 18
Bicarbonate	--	$ 8	/test	3	$ 24
Volatile Organic Compounds	--	$ 125	/test	3	$ 375
Lab EDF Fee	--	1%	/test	1	$ 6
Administrative Fee	--	10%	/test	1	$ 59
				Detection Testing Cost per Round:	**$ 650**
				Rounds per Year:	**2**
				Annual Detection Testing Cost:	**$ 1,300**

Lab Testing Costs - Detection (Annually):

Monitoring Parameter[1]	Number	Unit Cost	Units	Tests per Round	Subtotal
Ammonia-Nitrate	--	$ 27	/test	3	$ 81
Total Kjeldahl Nitrogen	--	$ 28	/test	3	$ 84
Lab EDF Fee	--	1%	/test	1	$ 2
Administrative Fee	--	10%	/test	1	$ 17
				Detection Testing Cost per Round:	**$ 183**
				Rounds per Year:	**1**
				Annual Detection Testing Cost:	**$ 183**

GOLDER

Table 7
Postclosure Maintenance Cost Summary
CHEVRON GUADALUPE

Lab Testing Costs - Constituents of Concern:

Monitoring Parameter[1]	Number	Unit Cost	Units	Tests per Round	Subtotal
Carbonate	--	$ 8	/test	3	$ 24
Anions (Ca, Mg, K, Na)	--	$ 24	/test	3	$ 72
Phosphate	--	$ 10	/test	3	$ 30
Nitrite as Nitrogen	--	$ 10	/test	3	$ 30
Fecal Coliform	--	$ 30	/test	3	$ 90
Total Alkalinity	--	$ 8	/test	3	$ 24
Total Organic Carbon	--	$ 25	/test	3	$ 75
Phosphorus	--	$ 10	/test	3	$ 30
Inorganics (dissolved)	--	$ 120	/test	3	$ 360
Fixed Dissolved Solids	--	$ 10	/test	3	$ 30
SVOCs with TICs	--	$ 125	/test	3	$ 375
Chloriophenoxy Herbicides	--	$ 85	/test	3	$ 255
Organophosphorus Pesticides	--	$ 85	/test	3	$ 255
Chemical Oxygen Demand	--	$ 22	/test	3	$ 66
Lab EDF Fee	--	1%	/test	1	$ 13
Administrative Fee	--	10%	/test	1	$ 135
				5-Year COC Testing Cost:	**$ 1,864**
				Rounds per Year:	**0.2**
				Annual COC Testing Cost:	**$ 373**

Reporting Costs:

Item	Personnel	Wage Rate	Units	Qnty	Subtotal
Principal	1	$ 225	/hr	0.5	$ 113
Sr. Project Manager	1	$ 186	/hr	2	$ 372
Staff Engineer	1	$ 112	/hr	4	$ 448
Drafter	1	$ 89	/hr	0.5	$ 45
Administrative	1	$ 73	/hr	0.5	$ 37
Office Service Fee	--	5%	rate		$ 51
				Material Total:	**$ 1,064**
				Rounds per Year:	**1**
				Annual Reporting Cost:	**$ 1,064**

Total Annual Surface Water Monitoring Cost: $ 4,591

Notes:

1. Assumes two surface water sampling locations and 1 quality control sample.

GOLDER

8a. DRAINAGE MAINTENANCE **Table 7**

POSTCLOSURE COST ESTIMATE
CHEVRON GUADALUPE

Crew Costs:

Position	Personnel	Wage Rate	Units	Qnty[1]	Subtotal
Laborer	1	$ 82.40	/hr	16	$ 1,318
Backhoe Operator	1	$ 109.26	/hr	16	$ 1,748
Foreman	1	$ 94.25	/hr	16	$ 1,508
Spreader Dozer Operator	1	$ 109.08	/hr	16	$ 1,745.34
				Crew Total:	**$ 6,320**

Equipment Costs:

Item	No. of Equip.	Wage Rate	Units	Qnty[1]	Subtotal
Mob/Demob	1	$ 500	ls	1	$ 500
Pickup Truck	1	$ 30.07	/hr	16	$ 481
Rubber-tired Backhoe	1	$ 45.85	/hr	16	$ 734
Spreading Dozer - CAT D6M LGP	1	$ 98.16	/hr	16	$ 1,571
				Equipment Total:	**$ 3,285**

Materials:

Item	Number	Rate	Units	Qnty[2]	Subtotal
CMP Downdrains	1	$ 20.00	/lf	170	$ 3,400
				Material Subtotal:	**$ 3,400**
				15% Material Mark Up:	**$ 510**
				Material Total:	**$ 3,910**

DRAINAGE MAINTENANCE TOTAL: $ 13,515

Annual Drainage Maintenance Total: $ 1,352

Notes:

1. Assumes two 8-hour days to complete drainage maintenance activities.
2. Assumes P-1 and P-2 to be replaced every ten years.

GOLDER

8b. SETTLEMENT REGRADING MAINTENANCE[1]
POSTCLOSURE COST ESTIMATE
CHEVRON GUADALUPE

Crew Costs:

Position	Personnel	Wage Rate	Units	Qnty[2]	Subtotal
Laborer	1	$ 82.40	/hr	24	$ 1,978
Trackhoe Operator	1	$ 109.26	/hr	24	$ 2,622
Foreman	1	$ 94.25	/hr	24	$ 2,262
				Crew Total:	**$ 6,862**

Equipment Costs:

Item	No. of Equip.	Wage Rate	Units	Qnty[2]	Subtotal
Mob/Demob	1	$ 200	ls	1	$ 200
Pickup Truck	1	$ 30.07	/hr	24	$ 722
Trackhoe	1	$ 45.85	/hr	24	$ 1,100
				Equipment Total:	**$ 2,022**

SETTLEMENT REGRADING MAINTENANCE TOTAL: $ 8,884

Annual Settlement Regrading Maintenacne Total: $ 1,777

Notes:

1. Repair method is to regrade the soil to create a drainage path.
2. Assumes 2 days to regrade.

9. SECURITY MAINTENANCE **Table 7**

POSTCLOSURE COST ESTIMATE
CHEVRON GUADALUPE

Crew Costs:

Position	Personnel	Wage Rate	Units	Qnty[1]	Subtotal
Laborer	1	$ 82.40	/hr	8	$ 659
				Crew Total:	**$ 659**

Equipment Costs:

Item	No. of Equip.	Rate	Units	Qnty[1]	Subtotal
Pickup Truck	1	$ 30.07	/hr	8	$ 241
				Equipment Total:	**$ 241**

Materials:

Item	Number	Rate	Units	Qnty[1]	Subtotal
Security Replacement (Fence, Signs, & other misc. equipment)	--	$ 500	ls	1	$ 500
				Material Subtotal:	**$ 500**
				15% Material Mark Up:	**$ 75**
				Material Total:	**$ 575**

SECURITY MAINTENANCE TOTAL: $ 1,475

Notes:

1. Assumes 8 hours of repair annually.

GOLDER

10. INSPECTIONS **Table 7**

POSTCLOSURE COST ESTIMATE
CHEVRON GUADALUPE

Crew Costs:

Position	Personnel	Wage Rate	Units	Qnty[1]	Subtotal
Qualified Engineer	1	$ 186	/hr	8	$ 1,488
				Crew Total:	**$ 1,488**

Equipment Costs:

Item	No. of Equip.	Rate	Units	Qnty[1]	Subtotal
Pickup Truck	1	$ 30.07	/hr	8	$ 241
				Equipment Total:	**$ 241**

SEMI-ANNUAL TOTAL: $ 1,729
ANNUAL TOTAL: $ 3,457

Notes:
1. Assumes 8 hours of inspection semi annually.

GOLDER

11. MISCELLANEOUS
POSTCLOSURE COST ESTIMATE
CHEVRON GUADALUPE

Miscellaneous Costs:

Item	Rate	Units	Qnty[1]	Subtotal
Aerial Topographic Survey	$ 5,000	ls	1	$ 5,000
Settlement Report	$ 6,000	ls	1	$ 6,000

Total: $ 11,000
Annual Frequency: 0.2
YEARLY TOTAL: $ 2,200

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12. PERMITTING FEES
POSTCLOSURE COST ESTIMATE
CHEVRON GUADALUPE

Permit Costs:

Item	Rate	Units	Qnty[1]	Subtotal
SWRCB Waste Discharge Permit	$ 10,000	/yr	1	$ 10,000
SWRCB Stormwater Discharge Permit	$ 850	/yr	1	$ 850
SLOAQMD Permit to Oprate	$ 800	/yr	1	$ 800
			Permit Total:	**$ 11,650**

TOTAL: $ 11,650

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Table 7
Postclosure Maintenance Cost Summary

Revised 5/11/2018

Test	Method (EPA)	Use
Ammonia-Nitrogen	EPA 4500-NH3	$ 27
Anions (Ca, Mg, K, Na)	EPA 200/300	$ 24
Arsenic	EPA 7061	$ 6
Bicarbonate & Carbonate	EPA 2310B	$ 16
Bicarbonate Alkalinity	EPA 310	$ 8
Calcium, dissolved	EPA 6010	$ 6
Carbon Dioxide		$ 40
Carbonate Alkalinity	EPA 310	$ 8
Chemical Oxygen Demand	EPA 410.4	$ 22
Chloride	EPA 300.0	$ 9
Chlorophenoxy Herbicides	EPA 8151	$ 85
Chromium	EPA 6010	$ 6
Cyanide	EPA 9010	$ 28
Fecal Coliform	EPA 9221B	$ 30
Ferrous Iron Unfiltered	SM 3500	$ 40
Ferrous Iron Filtered	SM 3500	$ 40
Fixed Dissolved Solids	EPA 2540E	$ 10
Fluoride	EPA 300	$ 9
Inorganics		$ 120
Lead	EPA 7421	$ 6
Magnesium, dissolved	EPA 6010	$ 6
Methane	RSK 175M	$ 115
Mercury	EPA 7470	$ 176
Metals 6000 series (Al, Sb, Ba, Be, Cd, Co, Cu, Fe, Mn, Ag, Sn, V, Zn)		$ 78
Metals 7000 series (Ni, Se, Tl)		$ 18
Nitrate + Nitrite as Nitrogen	EPA 353.2	$ 10
Nitrite-Nitrogen	EPA 300	$ 10
Organophosphorus Pesticides	EPA 8141	$ 85
Oxygen		$ 15
PCBs	EPA 8082	$ 60
Phosphate	EPA 300	$ 10
Phosphorous	EPA 365.3	$ 10
Potassium, dissolved	EPA 6010	$ 6
Sodium, dissolved	EPA 6010	$ 6
Sulfate	EPA 375.4	$ 9
Sulfide	EPA 9030	$ 28
SVOCs with TICs	EPA 8270 App. II	$ 125
Total Alkalinity	EPA 2310B	$ 8
Total Dissolved Solids	EPA 160.1	$ 10
Total Kjeldahl Nitrogen	EPA 4500-N-org	$ 28
Total Organic Carbon	EPA 415.1	$ 25
Total Suspended Solids	EPA 160.2	$ 10
VOCs with TICs	EPA 8260 App. II	$ 125
Volatile Organic Compounds	EPA 8260, App. I	$ 70
Lab EDF Fee		1%
Administrative Fee		10%

(1) Laboratory EDF and Administrative Fees apply to base test rates.

GOLDER

LABOR & EQUIPMENT COSTS
POSTCLOSURE COST ESTIMATE
CHEVRON GUADALUPE

Crew Costs:

Position	Source[1]	Operator Group	Base Wage Rate	12% Labor Surcharge	33% Overhead & Profit	Wage Rate	Unit
Laborer	Laborer	3	$ 56.83	$ 6.82	$ 18.75	$ 82.40	/hr
Maintenance Truck Operator	Teamster	1	$ 56.83	$ 6.82	$ 18.75	$ 82.40	/hr
Spreader Dozer Operator	Operator	8	$ 75.23	$ 9.03	$ 24.83	$ 109.08	/hr
Backhoe Operator	Operator	10	$ 75.35	$ 9.04	$ 24.87	$ 109.26	/hr
Water Truck Operator	Teamster	5	$ 60.13	$ 7.22	$ 19.84	$ 87.19	/hr
Dump Truck Driver	Teamster	10	$ 61.16	$ 7.34	$ 20.18	$ 88.68	/hr
Seed Truck Operator	Operator	6	$ 75.12	$ 9.01	$ 24.79	$ 108.92	/hr
Forklift Operator	Teamster	7	$ 60.41	$ 7.25	$ 19.94	$ 87.59	/hr
Skid Track Loader Operator	Operator	3	$ 73.41	$ 8.81	$ 24.23	$ 106.44	/hr
Foreman		--	$ 65.00	$ 7.80	$ 21.45	$ 94.25	/hr
Supervisor		--	$ 90.00	$ 10.80	$ 29.70	$ 130.50	/hr

Equipment, Maintenance and Fuel Costs:

Item	Code	CalTrans[2] Rate per/hr	15% Overhead & Profit	Rate per Unit	Unit
Pickup Truck	00-06	$ 26.15	$ 3.92	$ 30.07	/hr
Maintenance Truck	00-06	$ 26.15	$ 3.92	$ 30.07	/hr
Spreading Dozer - CAT D6N XL	3755	$ 87.97	$ 13.20	$ 101.17	/hr
Spreading Dozer - CAT D6M LPG	3745	$ 85.36	$ 12.80	$ 98.16	/hr
Rubber-tire Backhoe	1862	$ 39.87	$ 5.98	$ 45.85	/hr
Water Truck - 4000 Gal	48-60	$ 68.12	$ 10.22	$ 78.34	/hr
Dump Truck	5AXL	$ 87.29	$ 13.09	$ 100.38	/hr
Seed Truck	5AXL	$ 87.29	$ 13.09	$ 100.38	/hr
Skid Track Loader	1623	$ 82.90	$ 12.44	$ 95.34	/hr
Forklift	080-120	$ 58.61	$ 8.79	$ 67.40	/hr

Engineering Costs:

Item	Rate per Unit	Unit
Principal	$ 225.00	/hr
Sr. Project Manager	$ 186.00	/hr
Staff Engineer	$ 112.00	/hr
Sr. Technician	$ 106.00	/hr
Admin	$ 73.00	/hr
Drafter	$ 89.00	/hr

Notes:

1. From the General Prevailing Wage determination made by the Director of Industrial Relations pursuant to California Labor Code Part 7, Chapter 1, Article 2, Sections 1770, 1773 and 1773.1; Tables: Craft: TEAMSTER, Craft: OPERATING ENGINEER, Craft: #OPERATING ENGINEER (HEAVY AND HIGHWAY WORK), and Craft: #LABORER AND RELATED CLASSIFICATIONS.

2. From the 2019 CalTrans Labor Surcharge and Equipment Rental Rates effecitve April 1, 2019 through March 31, 2020.

APPENDIX T

Financial Assurance Mechanism

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