LOW IMPACT DEVELOPMENT PLAN
(LID PLAN)

for

SIGNAL HILL BUSINESS PARK PROJECT

APN 7210-043- 002-004, 010-014, 016-026 & 7215-009-003 & 006

E. 21st Street and Walnut Avenue
Signal Hill, California 90755

Prepared for:

SIGNAL HILL XC, LLC
3010 Old Ranch Parkway, Suite 470
Seal Beach, CA 90740
(562) 795-0270

Prepared by:

CA Engineering, Inc.
13821 Newport Avenue, Suite 110
Tustin, CA 92780
(949) 724-9480

Date Prepared: April 23, 2019
Date Revised: August 20, 2019

Fred Cornwell, RCE #45591

REGISTERED PROFESSIONAL ENGINEER
FRED CORNWELL
NO. 45591
CIVIL
STATE OF CALIFORNIA

Project Owner's Certification

I certify under penalty of law that this document and all attachments were prepared under my jurisdiction or supervision in accordance with a system designed to assure that qualified personnel properly gather and evaluate 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, to the best of my knowledge and belief, the information submitted is true, accurate, and complete. I am aware that there are significant penalties for submitting false information, including the possibility of fine and imprisonment for knowing violations.

Owner's Name:	Signal Hill XC, LLC		
Name / Title of Owner's Authorized Signatory:	Gretchen Kendrick, Authorized Signatory		
Company:	Signal Hill XC, LLC		
Address:	3010 Old Ranch Parkway, Suite 470, Seal Beach, CA 90740		
Email:	gretchenk@xebecrealty.com		
Telephone No:	(562) 795-0270		
Signature:		Date:	

Preparer (Engineer) Certification

Engineer's Name:	Fred Cornwell, P.E.		
Engineer's Title:	Principal		
Company:	CA Engineering, Inc.		
Address:	13821 Newport Avenue, Suite 110, Tustin, CA 92780		
Email:	fcornwell@ca-eng.net		
Telephone No:	(949) 724-9480 (x2012)		
I hereby certify that this Low Impact Development Plan is in compliance with, and meets the requirements set forth in, Order No. R4-2012-0175, of the Los Angeles Regional Water Quality Control Board.			
Engineer's Signature		Date	8/20/2019
Place Stamp Here	REGISTERED PROFESSIONAL ENGINEER FRED CORNWELL NO. 45591 CIVIL STATE OF CALIFORNIA		

TABLE OF CONTENTS

PROJECT SITE INFORMATION

Name of Project: **Signal Hill Business Park Project**

Project Location: **E. 21st Street and Walnut Avenue, Signal Hill, California 90755**
APN 7210-043- 002-004, 010-014, 016-026 & 7215-009-003 & 006

Total Project Area: **378,514 square feet / 8.69 acres**

Type of Development: **Industrial Development (Industrial/Warehouse Buildings)**

SIC Codes: **5199 (Wholesale Trade—Wholesale Distribution of Non-Durable Goods, Not Elsewhere Classified (www.osha.gov/oshstats/sicser.html)**

Natural Slope More Than 20%? **No**

Amount of Soil Expected to be Disturbed by Grading, Clearing and Excavating: **378,514 square feet / 8.69 acres**

Total Pervious / Impervious Area Pre-Project: **96% Pervious (364,165 square feet / 8.36 acres) / 4% Impervious (14,349 square feet / 0.33 acres)**

Total Pervious / Impervious Area Post-Project: **22% Pervious (82,477 square feet / 1.89 acres) / 78% Impervious (296,037 square feet / 6.80 acres)**

Expected Date to Begin Grading: **January 15, 2020**

Expected Date of Project Completion: **March 1, 2021**

Proposed Project a Designated Project? **Yes**

Designated Project Category: **Industrial park consisting of 10,000 square feet or more of surface area**

The applicable Designated Project Category is identified below:

Check below	**Designated Project Categories**
	All development projects equal to one acre or greater of disturbed area and adding more than 10,000 square feet of impervious surface area.
X	Industrial parks with 10,000 square feet or more of surface area.
	Commercial malls with 10,000 square feet or more of surface area.
	Retail gasoline outlets with 5,000 square feet or more of surface area.
	Restaurants (Standard Industrial Classification [SIC] Code 5812) with 5,000 square feet or more of surface area.
	Parking lots with 5,000 square feet or more of impervious surface area, or with 25 or more parking spaces.
	Automotive service facilities (SIC Codes: 5013, 5014, 5511, 5541, 7532-7534, or 7536-7539) with 5,000 square feet or more of surface area.
	Projects located in or directly adjacent to, or discharging directly to a Significant Ecological Area (SEA), where the development will: • Discharge stormwater runoff that is likely to impact a sensitive biological species or habitat; and • Create 2,500 square feet or more of impervious surface area.
	Redevelopment projects, which are developments that result in creation or addition or replacement of either: (1) 5,000 square feet or more of impervious surface on a site that was previously developed as described in the above categories; or (2) 10,000 square feet or more of impervious surface area on a site that was previously developed as a single family home. • Where 50 percent or more of the impervious surface of a previously developed site is proposed to be altered and the previous development project was not subject to post-construction stormwater quality control measures, the entire development site (e.g., both the existing development and the proposed alteration) must meet the requirements of the LID Standards Manual. • Where less than 50 percent of the impervious surface of a previously developed site is proposed to be altered and the previous development project was not subject to post-construction stormwater quality control measures, only the proposed alteration must meet the requirements of the LID Standards Manual. • Redevelopment does not include routine maintenance activities that are conducted to maintain original line and grade, hydraulic capacity, original purpose of facility or emergency redevelopment activity required to protect public health and safety. Impervious surface replacement, such as the reconstruction of parking lots and roadways, which does not disturb additional area and maintains the original grade and alignment, is considered routine maintenance activity. Redevelopment does not include repaving of existing roads to maintain original line and grade.

Section 1
PROJECT, SITE AND DRAINAGE DESCRIPTIONS

1.1 Applicant and LID Plan Preparer Information

Applicant Information:

- Name of project owner: **Signal Hill XC, LLC**
- Address of project owner: **3010 Old Ranch Parkway, Suite 470**
  Seal Beach, California, 90740
- Telephone for project owner: **(562) 795-0270**
- Project contact person name, address, phone number and email**:**

Steven Christie
Signal Hill XC, LLC
3010 Old Ranch Parkway, Suite 470
Seal Beach, CA 90740
(562) 284-5005
StevenC@xebecrealty.com

LID Plan Preparer Information:

Fred Cornwell, P.E., RCE 45591
CA Engineering, Inc.
13821 Newport Avenue, Suite 110
Tustin, CA 92780
(949) 724-9480 (x2012)
fcornwell@ca-eng.net

1.2 Permits

- Permit number(s), condition number(s), and any acquired waste discharge identification numbers (WDIDs) pertaining to project.

None issued yet

1.3 Project Description

The Signal Hill Business Park Project site encompasses approximately 8.69 acres (378,514 square feet), and is located at E. 21st Street and Walnut Avenue in the City of Signal Hill, Los Angeles County, California. The site consists of three vacant dirt covered parcels of land and a portion of E. 21st Street. Existing streets separate the parcels. The northernmost parcel (Parcel 1) is bounded by an apartment complex to the north, Walnut Avenue to the east, Gundry Avenue to the west, and E. 21st Street to the south. The second parcel (Parcel 2) is located just south of Parcel 1 and is bounded by E. 21st Street to the north, Walnut Avenue to the east, and Jenni Rivera Memorial Park to the west and south. The easternmost parcel (Parcel 3) is bounded by the American University of Health Sciences to the north, Gaviota Avenue to the east, Walnut Avenue to the west, and E. 20th Street and Alamitos Avenue to the south.

The proposed project will involve construction of nine industrial buildings and associated parking areas, drive aisles, driveways, walkways, and necessary infrastructure such as water, sewer, storm drain, and dry utilities. A portion of the project area will be dedicated to public right of ways. The industrial buildings will have a total footprint area of approximately 138,695 square feet, the drive aisles, parking areas and remaining hardscape will occupy 143,952 square feet, and the right of way dedication will comprise 13,390 square feet, for a total impervious area of 296,037 square feet, or 78% of the project area. The proposed project will also include 82,477 square feet of landscaping, for a total pervious area of 22% of the project site.

There are seven proposed trash enclosures which will be located as identified on the Site Plan included in Section 6 of this LID Plan.

The planned development is proposing to use “conservation design” landscaping, and all landscape areas will be planted with native, drought tolerant species.

There are no known materials or wastes that are anticipated to be used or produced at the proposed development that would be classified as “hazardous.” Further, none of the materials to be used at the proposed development will be stored outside.

The project will not violate any water quality standards because the project will be required to meet the City’s NPDES permit discharge requirements.

1.4 Site and Drainage Descriptions

Existing and Proposed Drainage Conditions: The site currently drains from the north to the south with a slight gradient to the west. The site elevations range from 50 feet above mean sea level (msl) along the northern property boundary to approximately 21 feet above msl at the southern boundary. Storm water currently sheet flows to E. 21st Street, Walnut Avenue, and Alamitos Avenue where it is collected in existing catch basins and conveyed either to the storm drain systems in Walnut Avenue or Alamitos Avenue. The flows are conveyed by the storm drain to the Los Angeles River, which discharges to San Pedro Bay, which outlets to the Pacific Ocean.

The project area currently has no water quality or drainage mitigation devices installed on-site.

The drainage for the proposed project generally follows the existing flow characteristics. The site has been divided into three drainage areas which comprise, collectively, 352,021 square feet. The following portions of the proposed project area have been excluded from the drainage areas: 13,103 square feet of self-retaining landscaping located at certain borders of the project, and 13,390 square feet of project area that will be dedicated to public right of ways at Walnut Avenue, Gundry Avenue, and 20th Street. The drainage areas and excluded project areas are identified on the Site Plan included in Section 6 of this LID Plan.

The development is proposing to install a biofiltration planter in each drainage area as the stormwater quality control measure to mitigate the first flush flows as required by the City. For each area, the onsite flows will be captured by catch basins with proprietary filter inserts and then directed to 60” underground storage pipes via low-flow pipes. The 60” detention pipes will be sized to store 1.5 times the SWQDv for each drainage area. The detained storm water will then be pumped into the biofiltration planters which will be lined due to the contaminated soil at the site.

The biofiltration planters will be designed and sized in accordance with the requirements of Stormwater Quality Control Measure Fact Sheet—BIO-1: Biofiltration (2014 LID Standards Manual). The planters’ underdrains will convey the treated stormwater flows from Drainage Areas A1 and A2 to the existing storm drain system in Walnut Avenue, and will convey the treated stormwater flows from Drainage Area A3 to the existing storm drain system in Alamitos Avenue. During storm events when the hydraulic grade line exceeds the storage pipe capacity, the water will overflow into the existing storm drains via high-flow pipes. (See Section 3 of the Hydrology Report, attached hereto as Appendix F.)

Predominant Soil Type: Undocumented fill was encountered at depths from 1 to 5 feet below the existing site grades at the boring locations. The fill soils generally consisted of sandy silt with scattered gravels. Native alluvium was encountered beneath the artificial fill soils to the maximum depth explored of 51.5 feet below the existing grade. Generally, the alluvium consisted of silt and clayey silt in the upper 10 to 15 feet. Below this depth, the soils generally consisted of fine to medium grained sand with some clay and silt layers to the total depth explored of 51.5 feet below grade. (See page 5 of the Geotechnical Investigation Report, attached hereto as Appendix D.)

Depth to Groundwater: The geotechnical engineer for the project encountered subsurface water at a depth of approximately 25 to 29 feet below grade during the site exploration which extended to a maximum depth of 51.5 feet below existing ground surface. In addition, based on the geotechnical engineer’s review of available historical groundwater information (CDMG, 1998), regional groundwater has been mapped in the general site area at approximately 15 feet below site grade. (See page 5 of the Geotechnical Investigation Report, attached hereto as Appendix D.)

Infiltration Rate and Feasibility:
According to GeoTracker (http://geotracker.waterboards.ca.gov/), the project site is located on two open Leaking Underground Storage Tank (LUST) sites and, therefore, infiltration is prohibited. (See the GeoTracker Map attached hereto as Appendix C.)

Consequently, no infiltration tests were conducted at the site since infiltration is infeasible due to the presence of contaminated soil. (See page 12 of the Geotechnical Investigation Report, attached hereto as Appendix D.)

Stormwater Runoff Harvest and Use Feasibility: The proposed development will contain insufficient landscape area to effectively utilize stormwater runoff for irrigation. In addition, the landscape areas will be planted with native, drought tolerant plant species, further reducing the irrigation requirements.

Section 2
POLLUTANTS OF CONCERN AND HYDROMODIFICATION REQUIREMENTS

2.1 Pollutants of Concern

Pollutants of Concern from Land Use:
Pursuant to Table 7-3 of the Los Angeles County Department of Public Works "Low Impact Development Standards Manual," dated February 2014, the typical pollutants of concern from the proposed project (Industrial Land Use) are the following: **Suspended Solids; Total Phosphorus; Total Nitrogen; Total Kjeldahl Nitrogen; Cadmium; Chromium; Copper; Lead; and Zinc.**

Table 7-3. Typical Pollutants of Concern by Land Use (1)

Land Use	Pollutants of Concern (2)								
	Suspended Solids	Total Phosphorus	Total Nitrogen	Total Kjeldahl Nitrogen	Cadmium, Total	Chromium, Total	Copper, Total	Lead, Total	Zinc, Total
High Density Single Family Residential	X	X			(4)	(4)	X	X	X
Multi-Family Residential	X				(4)	(4)	X		X
Mixed Residential	X	X	X		(4)	(4)	X	X	X
Commercial	X	X	X	X	(4)	(4)	X	X	X
Industrial	X	X	X	X	(4)	(4)	X	X	X
Critical Facilities (3)	X	(4)	(4)	(4)	(4)	(4)	X	X	X
Transportation (streets, roads)	X	X	X	X	(4)	(4)	X	X	X
Institutional (educational facilities)	X				(4)	(4)	X		X

(1) Adapted from Table A-3 of the *Technical Manual for Stormwater Best Management Practices in the County of Los Angeles* (February 2004) and the Southern California Coastal Water Research Project Land Use Specific Storm Water Monitoring Data. X = exceedance of "standard" by observed median/average concentration; blank = no exceedance of "standard" by observed median/average concentration.

(2) Derived from Table 11 of the 2012 Los Angeles County MS4 Permit (page 104).

(3) Critical facilities include automobile dismantling (SIC 50xx), automobile repair (SIC 75xx), metal fabrication (SIC 34xx), motor freight (SIC 42xx), automobile dealerships (SIC 55xx), chemical manufacturing (SIC 28xx), and machinery manufacturing (SIC 35xx).

(4) No available data to determine if these pollutants of concern originate from this land use. Pollutant is assumed to be produced by this land use unless otherwise proven by the project applicant.

Pollutants of Concern from Receiving Water Impairment:

The receiving water for each project point of discharge and all downstream receiving waters are as follows:

Watershed: Los Angeles River Watershed

Receiving Waters:

Storm Drain

Los Angeles River Reach 1 (Estuary to Carson Street)

Los Angeles River Estuary (Queensway Bay)

San Pedro Bay Near/Off Shore Zones

Pacific Ocean

Downstream receiving waters identified above that are listed on the 2014/2016 (most recent) list of Clean Water Act Section 303(d) impaired water bodies, and all pollutants for which the receiving waters are impaired, are as follows:

Los Angeles River Reach 1—Ammonia, Cadmium, Copper (Dissolved), Cyanide, Indicator Bacteria, Lead, Nutrients (Algae), pH, Trash, and Zinc (Dissolved)

Los Angeles River Estuary —Chlordane, DDT (sediment), PCBs (sediment), Toxicity, and Trash

San Pedro Bay Near/Off Shore Zones—Chlordane, PCBs, Total DDT, and Toxicity

TMDLS for Receiving Waters:

Los Angeles River Reach 1—Ammonia, Cadmium, Copper (Dissolved), Indicator Bacteria, Lead, Nutrients (Algae), pH, Trash, and Zinc (Dissolved)

Los Angeles River Estuary —Chlordane, DDT (sediment), and Trash

San Pedro Bay Near/Off Shore Zones—Chlordane, PCBs, Total DDT, and Toxicity

Pollutants of Concern from the project land use and from receiving water impairment are as follows:

Pollutant of Concern Summary Table

Pollutant Type	From Project Land Use	Listed for Receiving Water
Suspended Solids	X	
Total Phosphorus	X	
Total Nitrogen	X	
Total Kjeldahl Nitrogen	X	
Cadmium, Total	X	X
Chromium, Total	X	
Copper, Total	X	X
Lead, Total	X	X
Zinc, Total	X	X

2.2 Hydromodification Requirements / Exemption(s) from Hydromodification Control Measure Implementation

Downstream conveyance facilities that currently receive runoff from this site are engineered, concrete storm drain facilities and channels. Therefore, there is no increased potential for downstream erosion due to post-development project runoff. **Accordingly, the project qualifies for the following exemptions from implementation of hydromodification control measures pursuant to Section 8.2 of the LID Standards Manual:**

“Projects that have any increased discharge directly or through a storm drain to a sump, lake, area under tidal influence, into a waterway that has an estimated hundred (100)-year peak flow of 25,000 cfs or more, or other receiving water that is not susceptible to hydromodification impacts”; and

“Projects that discharge directly or through a storm drain into concrete or otherwise engineered channel (i.e., channelized or armored with rip-rap, shotcrete), which, in turn, discharge into receiving water that is not susceptible to hydromodification impacts.”

Section 3
SOURCE CONTROL AND STORMWATER QUALITY CONTROL MEASURE SELECTION PROCESS

3.1 Site Design Principles

The site design principles to be incorporated in the project design are identified as follows:

Minimize Stormwater Runoff, Minimize Project's Impervious Footprint

Maximize the permeable area. This can be achieved in various ways, including but not limited to, increasing building density (number of stories above or below ground) and developing land use regulations seeking to limit impervious surfaces.		
Yes (X)		**The planned development will include "conservation design" landscaping to the maximum extent possible. In addition, three large biofiltration planters will be utilized to treat stormwater, which also will increase the permeable area of the site.**
Runoff from developed areas may be reduced by using alternative materials or surfaces with a lower Coefficient of Runoff, or "C-Factor".		
	No (X)	**Not applicable to this site**
Conserve natural areas. This can be achieved by concentrating or clustering development on the least environmentally sensitive portions of a site while leaving the remaining land in a natural, undisturbed condition.		
	No (X)	**There are no natural areas on site.**
Construct walkways, trails, patios, overflow parking lots, alleys, driveways, low-traffic streets, and other low-traffic areas with open-jointed paving materials or permeable surfaces, such as pervious concrete, porous asphalt, unit pavers, and granular materials.		
	No (X)	**None proposed**
Construct streets, sidewalks, and parking lot aisles to the minimum widths necessary, provided that public safety and a pedestrian friendly environment are not compromised. Incorporate landscaped buffer areas between sidewalks and streets.		
Yes (X)		**In compliance with City ordinances**
Reduce widths of street where off-street parking is available.		
	No (X)	**All surrounding streets are existing.**

Maximize canopy interception and water conservation by preserving existing native trees and shrubs, and planting additional native or drought tolerant trees and large shrubs.		
Yes (X)		**The site has been designed to include "conservation design" landscaping to the maximum extent possible.**
Other comparable site design options that are equally effective.		
	No (X)	**None proposed**
Minimize the use of impervious surfaces, such as decorative concrete, in the landscape design.		
Yes (X)		**No decorative concrete or other unnecessary impervious surfaces will be used at the proposed development.**
Use natural drainage systems.		
	No (X)	**None exist on the site**
Where soils conditions are suitable, use perforated pipe or gravel filtration pits for low flow infiltration.		
	No (X)	**None proposed. The project site is located on two open Leaking Underground Storage Tank (LUST) sites and, therefore, infiltration is prohibited. (See the GeoTracker Map attached hereto as Appendix C.)**
Construct onsite ponding areas, rain gardens, or retention facilities to increase opportunities for infiltration, while being cognizant of the need to prevent the development of vector breeding areas.		
	No (X)	**None proposed. The project site is located on two open Leaking Underground Storage Tank (LUST) sites and, therefore, infiltration is prohibited. (See the GeoTracker Map attached hereto as Appendix C.)**

Minimize Directly Connected Impervious Areas

<table>
<tr><td colspan="3">Where landscaping is proposed, drain rooftops into adjacent landscaping prior to discharging to the storm drain.</td></tr>
<tr><td>Yes (X)</td><td></td><td>Rooftops have been designed to drain into adjacent landscaping where possible.</td></tr>
<tr><td colspan="3">Where landscaping is proposed, drain impervious sidewalks, walkways, trails, and patios into adjacent landscaping.</td></tr>
<tr><td>Yes (X)</td><td></td><td>All hardscape areas drain runoff to landscape areas where possible.</td></tr>
<tr><td colspan="3">Increase the use of vegetated drainage swales in lieu of underground piping or imperviously lined swales.</td></tr>
<tr><td></td><td>No (X)</td><td>None proposed.</td></tr>
</table>

3.2 Source Control Measures

The following tables list the Non-Structural and Structural Source Control Measures that shall be implemented for the project. Where a required Source Control Measure is not applicable to the project due to project characteristics, justification and/or alternative practices for preventing pollutants is provided. In addition to completing the following table, detailed descriptions on the implementation of planned Source Control Measures is provided.

Non-Structural Source Control Measures				
Identifier	**Name**	**Check One**		**If not applicable, state brief reason**
		Included	**Not Applicable**	
N1	Education for Property Owners, Tenants and Occupants	X		
N2	Activity Restrictions	X		
N3	Common Area Landscape Management	X		
N4	Maintenance of Source Control and Stormwater Quality Control Measures	X		
N5	Title 22 CCR Compliance (How development will comply)		X	Not applicable. The project site will not require Title 22 CCR compliance since the operation of the project site will not generate hazardous wastes as part of its routine operation.
N6	Local Industrial Permit Compliance		X	Not applicable.
N7	Spill Contingency Plan	X		
N8	Underground Storage Tank Compliance		X	Not applicable. No underground storage tanks are proposed.
N9	Hazardous Materials Disclosure Compliance		X	Not applicable. The project site will not handle or dispose of hazardous materials as part of its routine operations.
N10	Uniform Fire Code Implementation	X		
N11	Common Area Litter Control	X		
N12	Employee Training	X		
N13	Housekeeping of Loading Docks		X	Not applicable. No loading docks are proposed.
N14	Common Area Catch Basin Inspection	X		
N15	Street Sweeping Private Streets and Parking Lots	X		
N16	Retail Gasoline Outlets		X	Not applicable. No retail gasoline outlets at site.

N1 Property Owner Education

The Owner will review the environmental awareness educational materials and Source Control Measure Fact Sheets included in Appendix I of this LID Plan prior to or during the commencement of operations. Among other things, these materials will inform the Owner of the impacts of dumping oil, paints, solvents or other potentially harmful chemicals into the storm drain; the proper use and management of fertilizers, pesticides and herbicides in landscaping practices; the impacts of littering and improper watering; and proper maintenance practices for the business.

N2 Activity Restrictions

The Owner shall identify surface water quality protection requirements to ensure that surface water quality activities shall be conducted in conformance with the Project LID Plan as it relates to the handling and disposal of contaminants and, through the use of employee training manuals or another equally effective method, shall develop corresponding use restrictions. The use restrictions shall include, but not be limited to, the following:

(a) The Owner shall periodically provide to his employees environmental awareness education materials made available by the local municipalities. These materials will describe the use of chemicals (including pesticides and fertilizers) that should be limited to the covered property with no discharge of specified wastes via hosing or other direct discharge to gutter, catch basins, settling basins and storm drains.

(b) The Owner shall require the use of fertilizers and pesticides to be in strict conformance with City and County guidelines.

(c) The Owner shall prohibit the discharge of leaf litter, grass clippings, trash, animal wastes, paint, or masonry wastes to streets or storm drain systems.

(d) The Owner shall prohibit hosing down any paved surface where the result would be the flow of non-storm water into the street or storm drains.

(e) The Owner shall prohibit oil changing or other auto repairs that could discharge pollutants.

N3 Common Area Landscape Management

Management programs will be designed and implemented by the Owner to maintain all of the landscaped areas within the project site. These programs will include how to mitigate the potential dangers of fertilizer and pesticide usage, require that fertilizer and pesticide usage shall be consistent with City and County guidelines, discuss utilization of water-efficient landscaping practices, require that maintenance be consistent with the County water conservation guidelines or the City equivalent, and detail the proper disposal of landscape wastes.

The Owner shall implement irrigation and landscaping which will utilize moisture sensors, smart timers, rain shut-off valves and the grouping of plants with similar water requirements in order to prevent excess irrigation and its corresponding runoff. The Owner shall also maintain erosion control devices on the property until adequate vegetation coverage has been achieved following establishment of the landscape plantings.

The Owner shall also perform periodic inspection and adjustment of the automatic irrigation system for valve and sprinkler operation and irrigation spray heads for damage as necessary to ensure adequate moisture delivery without allowing overspray or excessive watering that would lead to unnecessary runoff.

N4 Maintenance of Source Control and Stormwater Quality Control Measures

The Owner shall be responsible for implementation of each applicable non-structural source control measure as well as scheduling inspection and maintenance cleaning of all applicable structural source control and stormwater quality control measures. The Owner, through its landscape or other maintenance contractor, will be responsible for inspection and maintenance activities in landscape areas. Debris and other water pollutants will be controlled, contained and disposed of in a proper manner by the maintenance contractor.

N7 Spill Contingency Plan

The Owner shall prepare a Spill Contingency Plan which will describe how the employees are to respond to spills of hazardous and/or polluting materials. The plan will require cleanup materials to be stored on-site and the proper disposal of any utilized cleanup materials.

N10 Uniform Fire Code Implementation

The Owner shall comply with Article 80 of the Uniform Fire Code which is which is enforced by the fire protection agency.

N11 Common Area Litter Control

One outdoor trash enclosure will be provided at the project. The Owner will be responsible to provide or arrange for weekly sweeping and trash pick-up at the site. The Owner may contract with its landscape or other maintenance contractor to perform these duties, as well as to conduct weekly inspections of all trash receptacles to make sure lids are closed and pick-up of any excess trash on the ground has occurred, and to note and investigate any trash disposal violations.

As part of the litter control maintenance activities, the biofiltration planters will be routinely inspected and all trash and debris will be removed.

N12 Employee Training

The Owner shall establish an education program for its employees and/or contractors to inform and train personnel engaged in maintenance activities regarding the impact of dumping oil, paints, solvents or other potentially harmful chemicals into the storm drain; the proper use of fertilizers and pesticides in landscaping maintenance practices; and the impacts of littering and improper water disposal.

N14 Common Area Catch Basin Inspection

Twice a year, prior to and after the rainy season, and after major storm events, the catch basins shall be visually inspected for damage and have all debris removed.

N15 Private Street and Parking Lot Sweeping

The Owner, through its employees and/or landscaping or other maintenance contractor, shall sweep all private streets, parking areas and drive aisles within the project at least once a month, or more often if needed. Debris, sediment and trash picked up during sweeping operations will be deposited in the trash receptacles.

Structural Source Control Measures				
Identifier	**Name**	**Check One**		**If not applicable, state brief reason**
		Included	**Not Applicable**	
S1	Storm Drain Message and Signage	X		
S2	Outdoor Material Storage Area		X	Not applicable. No outdoor material storage areas are proposed.
S3	Outdoor Trash Storage / Waste Handling Area	X		
S4	Outdoor Loading / Unloading Dock Area		X	Not applicable. No outdoor loading/unloading dock areas are proposed.
S5	Outdoor Vehicle / Equipment Repair / Maintenance Area		X	Not applicable. No vehicle / equipment repair or maintenance areas are proposed.
S6	Outdoor Vehicle / Equipment / Accessory Wash Area		X	Not applicable. No vehicle / equipment / accessory wash areas are proposed.
S7	Fuel & Maintenance Area		X	Not applicable. No fuel or maintenance areas are proposed.
S8	Landscape Irrigation Practices	X		
S9	Building Materials Selection	X		
S10	Animal Care and Handling Facilities		X	Not applicable to project.
S11	Outdoor Horticulture Areas		X	Not applicable to project.

S1 Storm Drain Message and Signage (LID Standards Manual Fact Sheet S-1)

The Owner is responsible for labeling all of the project's storm drain inlets and catch basins with the phrase, “NO DUMPING! DRAINS TO OCEAN,” or an equally effective phrase, to alert the public to the destination of pollutants discharged into storm water. This signage is to be included on the project plans. The signage and stenciling shall be maintained for legibility by the Owner.

S3 Outdoor Trash Storage and Waste Handling Area (LID Standards Manual Fact Sheet S-3)

Seven outdoor trash enclosures are proposed for this site and their locations are depicted on the LID Site Plan included in Section 6. The proposed trash enclosure areas will be paved with Portland cement concrete or an equivalent impervious surface, and have been designed to not allow run-on from adjoining areas and to divert drainage from adjoining roofs and pavements around the trash enclosure areas. The trash enclosure areas shall also provide a solid roof to prevent direct precipitation, and the trash area drains will not connect to the municipal storm drain system.

In conjunction with maintenance activities, the Owner will be responsible for inspecting the trash enclosures on a weekly basis to ensure that no hazardous materials or other inappropriate materials are being disposed of, and to ensure that trash is not allowed to overflow the provided bins. The Owner shall schedule trash pick-up for disposal of dumpster(s) and free standing trash receptacles weekly of each year. The Owner shall also post signs on or near the dumpsters with the words “Do not dump hazardous materials here” or similar. The Owner shall also repair or replace leaky receptacles.

S8 Landscape Irrigation Practices (LID Standards Manual Fact Sheet S-8)

The Owner shall direct its landscaping architect to design the timing and application methods of irrigation water to minimize the runoff of excess irrigation water into the municipal storm drain system, and to choose plants that minimize the need for fertilizer and pesticides. The following methods to reduce excessive irrigation runoff shall be incorporated where determined applicable and feasible:

1. Employing rain shutoff devices to prevent irrigation after precipitation.

2. Designing irrigation systems to each landscape area’s specific water requirements.

3. Using flow reducers or shutoff valves triggered by a pressure drop to control water loss in the event of broken sprinkler heads or lines.

4. Implementing a landscape plan consistent with County water conservation guidelines or city equivalent which may include provision of water sensors, programmable irrigation times (for short cycles), etc.

5. The timing and application methods of irrigation water shall be designed to minimize the runoff of excess irrigation water into the municipal storm drain system.

6. Employing other comparable, equally effective, methods to reduce irrigation water runoff.

7. Group plants with similar water requirements in order to reduce excess irrigation runoff and promote surface filtration. Choose plants with low irrigation requirements (for example, native or drought tolerant species). Utilize other design features, such as:

(a) Use mulches (such as wood chips or shredded wood products) in planter areas without ground cover to minimize sediment in runoff.

(b) Install appropriate plant materials for the location, in accordance with amount of sunlight and climate, and use native plant material where possible and/or as recommended by the landscape architect.

(c) Leave a vegetative barrier along the property boundary and interior watercourses, to act as a pollutant filter, where appropriate and feasible.

The Owner shall be responsible for implementing and maintaining efficient irrigation systems for all landscaping including but not limited to provisions for water sensors, programmable irrigation cycles, and rain shutoff devices. The irrigation systems shall comply with local and statewide ordinances related to irrigation efficiency. The Owner shall also be responsible for the installation and maintenance of all landscape areas utilizing similar planting materials with similar water requirements to reduce excess irrigation runoff.

S9 Building Materials Selection (LID Standards Manual Fact Sheet S-9)

The Owner shall direct its architect to minimize the use of copper and galvanized (zinc-coated) metals on buildings and fencing to reduce leaching of these pollutants into stormwater runoff. Pressure-treated wood (which is typically treated using arsenate, copper, and chromium compounds) shall also be avoided as a building material.

3.3 Stormwater Quality Control Measure(s)

The selected stormwater quality control measures that will be implemented for the project to address the pollutants of concern identified in Section 2.1 of this LID Plan are identified below:

Stormwater Quality Control Measure Fact Sheet BIO-1: Biofiltration Planter

Stormwater Quality Control Measure Fact Sheet T-6: Proprietary Treatment Control Measures (Catch Basin Insert Filters—Pretreatment for Biofiltration Planter)

The following table lists the pollutants treated by the selected Biofiltration Planter (see page E-53 of the Stormwater Quality Control Measure Fact Sheet BIO-1:Biofiltration, a copy of which is included in Section 6 of this LID Plan):

Pollutant of Concern	Treated by Biofiltration?
Suspended solids	No
Total phosphorus	No
Total nitrogen	Yes
Total Kjeldahl nitrogen	Yes
Cadmium, total	No
Chromium, total	Yes
Copper, total	No
Lead, total	Yes
Zinc, total	No

The Kristar FloGard +Plus is a proprietary catch basin insert filter designed to remove sediment, gross solids, trash, and petroleum hydrocarbons from stormwater runoff. Based on field and laboratory tests, the filters remove up to 86% of total suspended solids and 80% of oils and grease. (See the Kristar FloGard +PLUS Catch Basin Insert Filter Specifications, a copy of which is included in Section 6 of this LID Plan.)

3.4 Stormwater Quality Control Measure Design Criteria

3.4.1 Calculation of the Stormwater Quality Design Volume (SWQDv) or Project Q_{PM}:

The Stormwater Quality Design Volumes (SWQDvs) for Drainage Areas A1-A3, set forth in the table below, were derived using the HydroCalc 1.0.2 calculator downloaded from the Department of Public Works web site. The SWQDv calculator results are included in Appendix E of this LID Plan.

The SWQDvs were determined using a design storm defined as the 0.75-inch, 24-hour rain event, since this value is greater than the 85th percentile, 24-hour rain event which is 0.59 inches. (See the Rainfall Hydrology Map for Los Angeles County attached hereto as Exhibit B.) **However, since none of the stormwater flows can be reliability retained on the project site due to the presence of contaminated soils, the volume of stormwater that is required to be treated by biofiltration is increased by 50%, as set forth below.**

DRAINAGE AREA	AREA (ACRES)	STORMWATER QUALITY DESIGN VOLUME (SWQDv)	VOLUME OF STORMWATER TO BE TREATED (SWQDv * 1.5)
A1	3.87	8,234 CF	12,351 CF
A2	1.88	3,634 CF	5,451 CF
A3	2.34	4,372 CF	6,558 CF

3.4.2 Sizing of Stormwater Quality Control Measure:

The sizing calculations for the biofiltration planters and sump pumps are set forth on the LID Site Plan included in Section 6 of this LID Plan. The sizing calculations for the detention pipes are set forth below.

Detention Pipe Sizing for Area A1:

60” HDPE pipe cross-sectional area = πr^2 = π(2.5)^2 = 19.63 cf/lf
Length of pipe required =pipe volume/pipe area = 12,287cf / 19.63 cf/lf = 626 lf
Length of pipe provided = 634 lf > 626 lf

Detention Pipe Sizing for Area A2:

60” HDPE pipe cross-sectional area = πr^2 = π(2.5)^2 = 19.63 cf/lf
Length of pipe required =pipe volume/pipe area = 5,336cf / 19.63 cf/lf = 272 lf
Length of pipe provided = 297 lf > 272 lf

Detention Pipe Sizing for Area A3:

60” HDPE pipe cross-sectional area = πr^2 = π(2.5)^2 = 19.63 cf/lf
Length of pipe required =pipe volume/pipe area = 6,380cf / 19.63 cf/lf = 325 lf
Length of pipe provided = 364 lf > 325 lf

Section 4
OPERATION AND MAINTENANCE

Signal Hill XC, LLC (the owner of the project) shall assume all inspection and maintenance responsibilities for the source control and stormwater quality control measures for the Signal Hill Business Park Project until the project is sold, at which time all such inspection and maintenance responsibilities shall be transferred to the new owner.

CONTACT NAME	**Steven Christie**
COMPANY	**Signal Hill XC, LLC**
ADDRESS	**3010 Old Ranch Parkway, Suite 470 Seal Beach, CA 90740**
PHONE /EMAIL	**(562) 284-5005 StevenC@xebecrealty.com**

A copy of the Operation and Maintenance (O&M) Plan is attached to the Project LID Plan as Appendix G.

A Master Covenant and Agreement (MCA) will be recorded in the County Recorder's Office with respect to the Project Property prior to approval of the LID Plan.

Should the maintenance responsibility be transferred at any time during the operational life of the Signal Hill Business Park Project, a formal notice of transfer shall be submitted to the City of Signal Hill at the time the maintenance responsibility of the property subject to this LID Plan is transferred. The transfer of responsibility shall be incorporated into this LID Plan as an amendment.

Section 5
FUNDING

The funding source for the installation, operation and maintenance of each source control and stormwater quality control measure identified in this LID Plan shall be as follows:

Installation of Structural Source Control and Stormwater Quality Control Measures:

**Signal Hill XC, LLC
3010 Old Ranch Parkway, Suite 470
Seal Beach, CA 90740
(562) 284-5005
Contact: Steven Christie
StevenC@xebecrealty.com**

Long-term Responsibilities for Non-Structural & Structural Source Control and Stormwater Quality Control Measures:

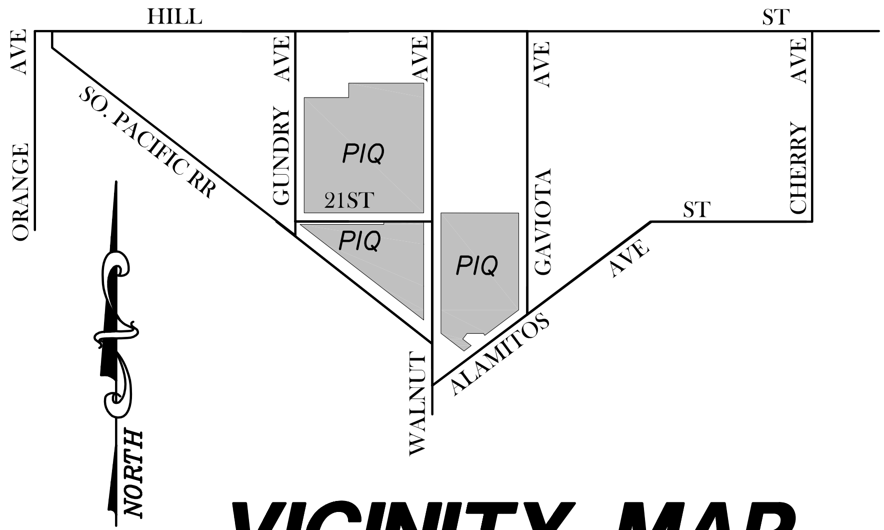
**Signal Hill XC, LLC
3010 Old Ranch Parkway, Suite 470
Seal Beach, CA 90740
(562) 284-5005
Contact: Steven Christie
StevenC@xebecrealty.com**

Section 6
VICINITY MAP, SITE PLAN & STORMWATER QUALITY CONTROL MEASURES DETAILS

<u>Attachments Included in Section 6:</u>

- **Vicinity Map**
- **LID Site Plan**
- **Stormwater Quality Control Measure Fact Sheet—T-6: Proprietary Treatment Control Measures (2014 LID Standards Manual)**
- **Kristar FloGard +PLUS Catch Basin Filter Insert Specifications**
- **Stormwater Quality Control Measure Fact Sheet—BIO-1: Biofiltration (2014 LID Standards Manual)**

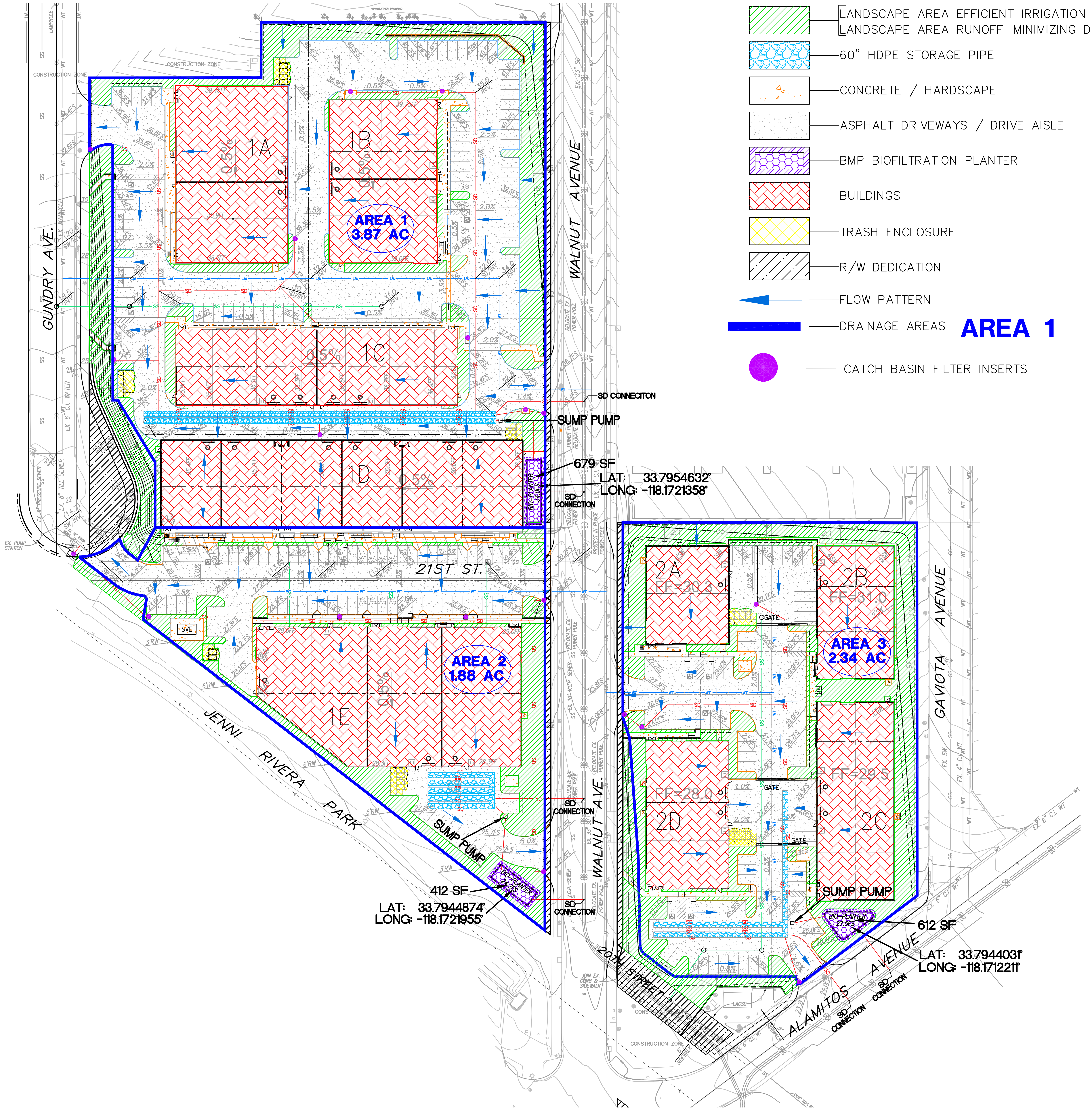
VICINITY MAP

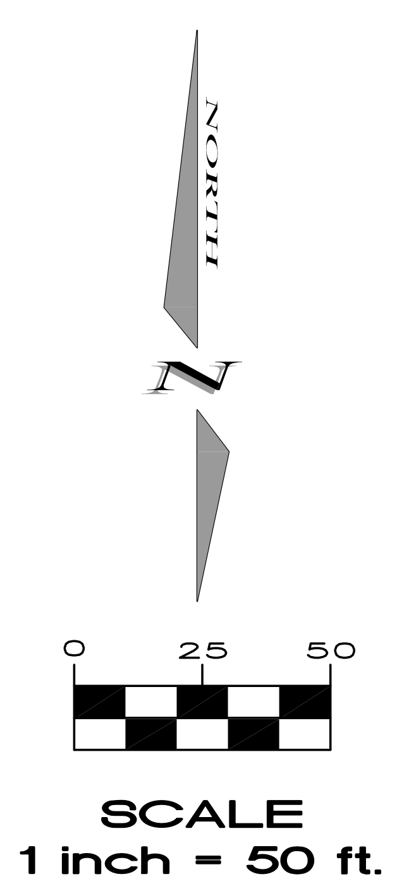


VICINITY MAP

N.T.S.

LID SITE PLAN





SCALE
1 inch = 50 ft.

LEGEND STRUCTURAL / TREATMENT BMPS

- 🟩 LANDSCAPE AREA EFFICIENT IRRIGATION
  LANDSCAPE AREA RUNOFF–MINIMIZING DESIGN
- ▨ 60" HDPE STORAGE PIPE
- ☐ CONCRETE / HARDSCAPE
- ☐ ASPHALT DRIVEWAYS / DRIVE AISLE
- ▨ BMP BIOFILTRATION PLANTER
- 🟥 BUILDINGS
- 🟨 TRASH ENCLOSURE
- ▨ R/W DEDICATION
- ← FLOW PATTERN
- ▬ DRAINAGE AREAS **AREA 1**
- ● CATCH BASIN FILTER INSERTS

PROJECT DATA:

TOTAL SITE AREA OF PROPOSED
DEVELOPMENT: 8.69 AC (378,514 SF)

R/W DEDICATION: 13,390 SF
BUILDING AREA: 138,695 SF
WALKWAYS/CONC. GUTTER AREAS: 10,085 SF
DRIVEWAYS / DRIVE AISLES: 133,867 SF

DRAINAGE AREA LANDSCAPE: 69,374 SF
SELF–RETAINING LANDSCAPE: 13,103 SF
LANDSCAPE PROVIDED: 82,477 SF
(22% PERVIOUS AREA)

CURRENT USE: VACANT
PROPOSED USE: INDUSTRIAL
WATERSHED: LOS ANGELES RIVER

AREA	TOTAL AREA	L.S. AREA	IMP. AREA	% IMPERVIOUS
A1	168,386 SF	23,863 SF	144,523 SF	86%
A2	81,870 SF	18,733 SF	63,137 SF	77%
A3	101,765 SF	26,778 SF	74,987 SF	74%

AREA 1
(SWQDv) – 8,234 CF
REQUIRED (SWQDv)*1.5 – 12,351 CF
STORAGE PIPE VOLUME – 12,450 CF ~ 634 LF

BIOTREATMENT AREA REQUIRED:
96HR DRAWDOWN PER LID
VOLUME (CF) / ((2.5"/HR)(1/12 FT/IN) * 96HR))
12,450 CF / (2.5"/HR)*(1/12 FT/IN) * 96HR) = 623 SF
BIOTREATMENT AREA PROVIDED: 679 SF > 623 SF

PUMP REQUIREMENTS
MINIMUM FLOW (DRAW DOWN IN 96 HRS)
12,450 CF /96HRS
(12,450 CF*7.48GAL/CF) / (96HR*60MIN/HR) = 16.17 GPM
MAXIMUM FLOW (MAX FLOW THRU BIO–PLANTER)
679 SF*(2.5"/HR*(1/12 FT/IN)*(1/60 HR/MIN)*(7.48 GAL/CF)=17.64 GPM
USE 17.0 GPM PUMP

AREA 2
(SWQDv) – 3,634 CF
REQUIRED (SWQDv)*1.5 – 5,451 CF
STORAGE PIPE VOLUME – 5,825 CF ~ 297 LF

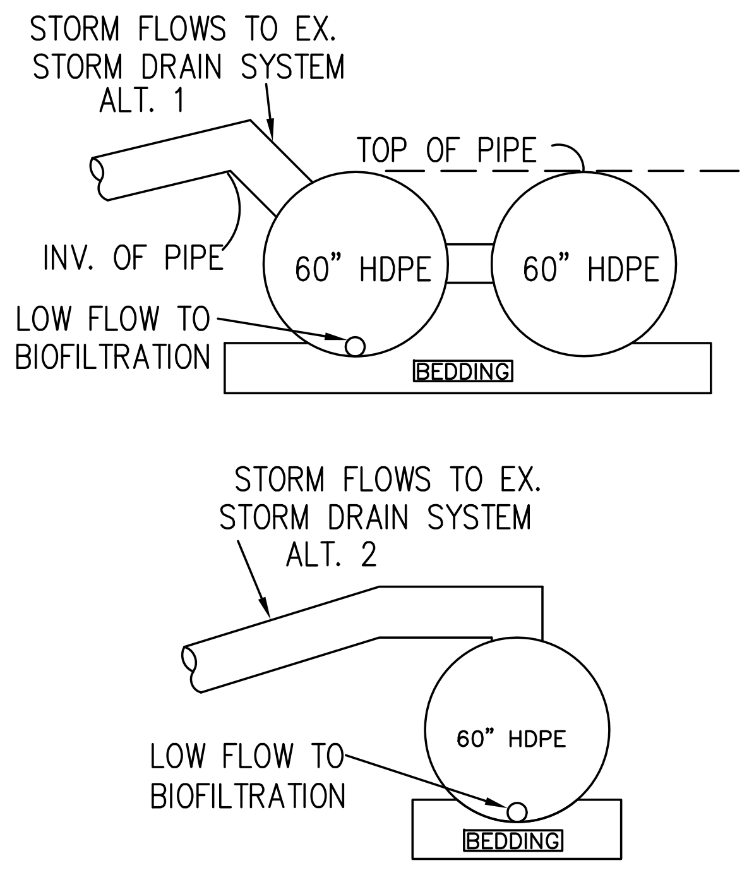
BIOTREATMENT AREA REQUIRED:
96HR DRAWDOWN PER LID
VOLUME (CF) / ((2.5"/HR)(1/12 FT/IN) * 96HR))
5,825 CF / (2.5"/HR)*(1/12 FT/IN) * 96HR) = 291 SF
BIOTREATMENT AREA PROVIDED: 412 SF > 291 SF

PUMP REQUIREMENTS
MINIMUM FLOW (DRAW DOWN IN 96 HRS)
5,825 CF /96HRS
(5,825 CF*7.48GAL/CF) / (96HR*60MIN/HR) = 7.56 GPM
MAXIMUM FLOW (MAX FLOW THRU BIO–PLANTER)
412 SF*(2.5"/HR*(1/12 FT/IN)*(1/60 HR/MIN)*(7.48 GAL/CF)=10.7 GPM
USE 8.0 GPM PUMP

AREA 3
(SWQDv) – 4,372 CF
REQUIRED (SWQDv)*1.5 – 6,558 CF
STORAGE PIPE VOLUME – 7,150 CF ~ 364 LF

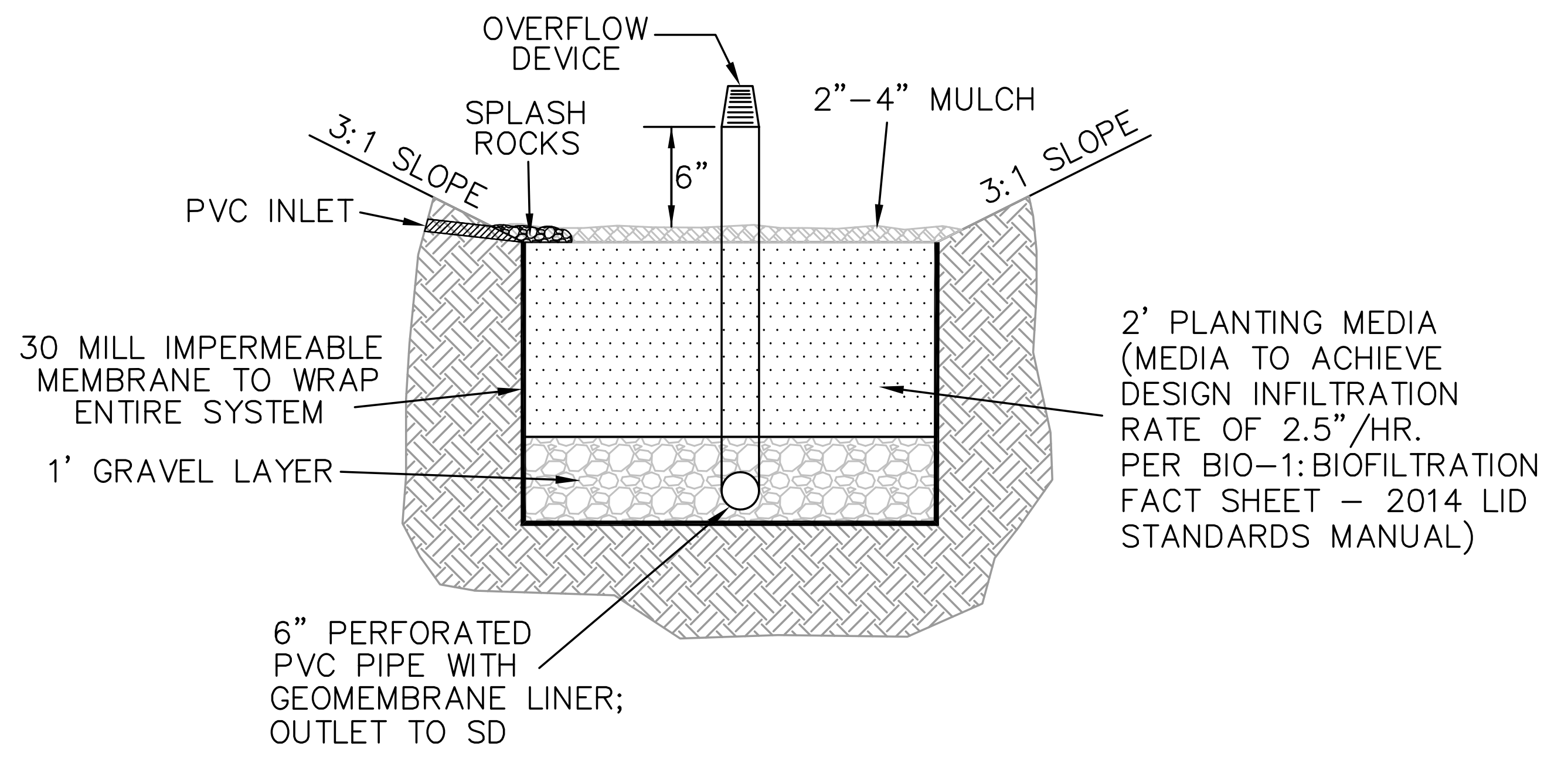
BIOTREATMENT AREA REQUIRED:
96HR DRAWDOWN PER LID
VOLUME (CF) / ((2.5"/HR)(1/12 FT/IN) * 96HR))
7,150 CF / (2.5"/HR)*(1/12 FT/IN) * 96HR) = 358 SF
BIOTREATMENT AREA PROVIDED: 612 SF > 358 SF

PUMP REQUIREMENTS
MINIMUM FLOW (DRAW DOWN IN 96 HRS)
7,150 CF /96HRS
(7,150 CF*7.48GAL/CF) / (96HR*60MIN/HR) = 9.29 GPM
MAXIMUM FLOW (MAX FLOW THRU BIO–PLANTER)
612 SF*(2.5"/HR*(1/12 FT/IN)*(1/60 HR/MIN)*(7.48 GAL/CF)=15.90 GPM
USE 10.0 GPM PUMP



DETENTION PIPES

N.T.S.



BIO-1: BIOFILTRATION PLANTER

N.T.S.

PREPARED BY:

CA ENGINEERING, INC.
Planning • Engineering • Surveying
13821 NEWPORT AVE., STE 110
TUSTIN, CA 92780
949-724-9480 949-724-9484 FAX

LID SITE PLAN
E. 21ST ST & WALNUT AVE.
SIGNAL HILL, CA

SHEET
1
OF
1

STORMWATER QUALITY
CONTROL MEASURE FACT SHEET

T-6: PROPRIETARY TREATMENT CONTROL MEASURES

(2014 LID STANDARDS MANUAL)

T-6: Proprietary Treatment Control Measures

Definition

The LID Standards Manual provided information for selecting and designing the more common treatment-based stormwater quality control measures for projects. The treatment-based stormwater quality control measures included in this appendix (T-1 to T-5) are non-proprietary (public domain) designs that have been reviewed and evaluated by LACDPW and determined generally acceptable.

Proprietary devices are commercial products that typically aim at providing stormwater treatment in space-limited applications, often using patented innovative technologies. The most commonly encountered classes of proprietary stormwater quality control measures include hydrodynamic separation, catch basin insert technologies, cartridge filter-type controls, and proprietary biotreatment devices.

Hydrodynamic separation devices (alternatively, swirl concentrators) are devices that remove trash, debris, and coarse sediment from incoming flows using screening, gravity settling, and centrifugal forces generated by forcing the influent into a circular motion. By having the water move in a circular fashion, rather than a straight line, it is possible to obtain significant removal of suspended sediments and attached pollutants with less space as compared to wet vaults and other settling devices. Hydrodynamic devices were originally developed for combined sewer overflows, where they were used primarily to remove coarse inorganic solids. Hydrodynamic separation has been adapted for stormwater treatment by several manufacturers and is currently used to remove trash, debris, and other coarse solids down to sand-sized particles. Several types of hydrodynamic separation devices are also designed to remove floating oils and grease using sorbent media.

Catch basin inserts are manufactured filters or fabric placed in a drop inlet to remove sediment and debris and may include sorbent media to remove floating oils and grease. There are a multitude of inserts of various shapes and configurations, typically falling into one of three groups: socks, boxes, and trays. The sock-type filters are typically constructed of a fabric, usually polypropylene. The fabric may be attached to a frame or the grate of the inlet may hold the sock. Socks are meant for vertical (drop) inlets. Boxes are constructed of plastic or wire mesh. Typically a polypropylene “bag” is placed in the wire mesh box and the bag takes the form of the box. Most box products are one box; that is, settling and filtration through media occur in the same box. Other products consist of one or more trays or mesh grates. The trays may hold different types of media. Filtration media vary by manufacturer. Types include polypropylene, porous polymer, treated cellulose, and activated carbon. Inserts are an easy and inexpensive retrofitting option because drain inlets are already a component of most standard drainage systems. Inserts are usually only suitable for mitigating relatively small tributary areas (less than one acre) because they are limited by treatment capacity and influent flow rate.

Cartridge filter-type controls typically consist of a series of vertical filters contained in a vault or catch basin that provide treatment through filtration and sedimentation. The vault may be divided into multiple chambers where the first chamber acts as a pre-settling basin for removal of coarse sediment while another chamber acts as the filter bay and houses the filter cartridges. The performance and capacity of a cartridge filter installation depends on the properties of the media contained in the cartridges. Cartridge filter manufacturers often provide an array of media types each with varying properties, targeting various pollutants and a range of particle sizes. Commonly used media include media that target solids, such as perlite, and media that target both dissolved and non-dissolved constituents, such as compost leaf media, zeolite, and iron-infused polymers. Manufacturers try to distinguish their products through innovative designs that aim at providing self cleaning and draining, uniformly loaded, and clog resistant cartridges that functional properly over a wide range of hydraulic loadings and pollutant concentrations.

Proprietary biotreatment devices are devices that are manufactured to mimic natural systems such as wetlands by incorporating plants, soil, and microbes engineered to provide treatment at higher flow rates or higher volumes and with smaller footprints than their natural counterparts. Incoming flows are typically filtered through natural media (mulch, compost, soil, plants, microbes, etc) and either infiltrated or collected by an underdrain and delivered to the storm system. Tributary areas for biotreatment devices tend to be limited to 0.5 to 1.0 acres.

The vendors of the various proprietary stormwater quality control measures provide detailed documentation for device selection, sizing, and maintenance requirements. Tributary area sizes are limited to the capacities of the largest available model. The latest manufacturer supplied documentation must be used for sizing and selection of all proprietary devices. Links to the websites of a number of vendors of proprietary devices are provided at www.BMPLA.org. All proprietary devices proposed for use by a project applicant must be approved by LACDPW.

General Design Specifications

Proprietary stormwater quality control measure vendors are constantly updating and expanding their product lines, so refer to the latest design guidance from the vendors. General guidelines on the performance, sizing, and operation and maintenance of proprietary devices are provided through LACDPW Watershed Division.

Expected Performance

For hydrodynamic devices, it has been stated with respect to combined sewer overflows that the practical lower limit of hydrodynamic separation is a particle with a settling velocity of 12 to 16.5 ft/hr (0.10 to 0.14 cm/s). As such, the focus for hydrodynamic separation in combined sewer overflows has been with settleable solids generally 200 μm and larger, given the presence of the lighter organic solids. For inorganic sediment, the above settling velocity range represents a particle diameter of 50 to 100 μm. Thus, hydrodynamic separation devices are effective for removal of course sediment, trash, and debris and useful for pretreatment in combination with other types of stormwater quality control measures that target smaller particle sizes.

Because there is a wide range of catch basin insert configurations, it is not possible to generalize the expected performance. Inserts should mainly be used for catching coarse sediments and floatable trash, and are effective for pretreatment in combination with other types of stormwater quality control measures. Trash and large objects can greatly reduce the effectiveness of catch basin inserts with respect to sediment and hydrocarbon capture. Frequent maintenance and the use of screens and grates to keep trash out may decrease the likelihood of clogging and prevent obstruction and bypass of incoming flows.

Cartridge filters have been proven to provide efficient removals for both dissolved and non-dissolved pollutants. However, cartridge filters are less adept at handling high flow rates when compared to catch basin inserts and hydrodynamic devices due to the enhanced treatment provided through the filtration mechanism.

Because proprietary biotreatment devices are relatively new compared to the other types of proprietary treatment devices included in the LID Standards Manual, there are fewer third party studies on proprietary biotreatment devices. The available performance information is mostly vendor-supplied. According to the vendors, like their natural counterparts, proprietary biotreatment devices are highly efficient at mitigating dissolved metals, nutrients, and suspended solids.

Sizing

Hydrodynamic devices, catch basin inserts, and cartridge filters are flow-based stormwater quality control measures, but can be sized to capture and treat the mitigation volume of the SWQDv with additional facilities to manage stormwater runoff flow. Proprietary biotreatment devices on the other hand include both volume-based and flow-based stormwater quality control measures. Volume-based proprietary devices should be sized to capture and treat the mitigation volume of the SWQDv if used as a standalone stormwater quality control measure.

Auxiliary components of proprietary devices such as sorbent media, screens, baffles, and sumps are selected based on site-specific conditions such as the expected loading and the desired frequency of maintenance. Sizing of proprietary devices is reduced to a simple process whereby a model can simply be selected from a table or a chart based on a few known quantities (tributary area, location, design flow rate, design volume, etc). Some manufacturers either size the devices for potential clients or offer calculators on their websites that simplify the design process even further and lessens the possibility of using obsolete design information. For the latest sizing guidelines, refer to the manufacturer's website.

Operation and Maintenance

Hydrodynamic Separation Devices

Hydrodynamic separators do not have moving parts and are not maintenance intensive. However, maintenance is important to ensure that the device operates as efficiently as possible. Proper maintenance involves frequent inspections throughout the first year of installation, especially after major storm events. The systems are considered full when the sediment level is within one foot from the top of the unit, at which point it must be cleaned out. Removal of sediment can be performed with a sump vacuum or vactor truck. Some hydrodynamic separator devices may contribute to mosquito breeding if they do not fully drain stormwater runoff between storm events. Refer to manufacturer's guidelines for inspection and maintenance activities.

Catch Basin Inserts

Catch basin inserts can be maintenance-intensive because of their susceptibility for accumulating trash and debris. Regular maintenance activities include the clean-up and removal of accumulated trash and sediment while major maintenance activities include replacing filter media (if used) and or repairing/replacing geomembrane fabrics. Refer to manufacturer's guidelines for inspection and maintenance activities.

Cartridge Filters

For cartridge filters, maintenance activities include periodically removing trash, debris, and sediment from the vault floor, typically twice per year depending on the accumulation rate, using a sump vacuum or vactor truck. The cartridges may need to be replaced when they become saturated, which will occur approximately every other year depending on the pollutant accumulation rate. The manufacturers of these devices typically provide contract operation and maintenance services.

All stormwater vaults that contain standing water can become a breeding area for vectors. Manufacturers have developed systems, such as a perforated pipe installed in the bottom of the vault that is encased in a filter sock to prevent clogging, to completely drain the vault.

Biotreatment Devices

Maintenance of biotreatment devices can be provided by the manufacturer and typically consists of routine inspection and hand removal of accumulated trash and debris. Vactor trucks or mechanical maintenance activities are not needed for biotreatment devices.

KRISTAR FLOGARD +PLUS CATCH BASIN FILTER INSERT SPECIFICATIONS

KRISTAR

FloGard®+PLUS
Catch Basin Insert Filter

FloGard®+PLUS Catch Basin Insert Filter

GENERAL FILTER CONFIGURATION

FloGard®+PLUS catch basin insert filter shall provide solids filtration through a filter screen or filter liner, and hydrocarbon capture shall be effected using a non-leaching absorbent material contained in a pouch or similar removable restraint. Hydrocarbon absorbent shall not be placed at an exposed location at the entry to the filter that would allow blinding by debris and sediment without provision for self-cleaning in operation.

Filter shall conform to the dimensions of the inlet in which it is applied, allow removal and replacement of all internal components, and allow complete inspection and cleaning in the field.

FLOW CAPACITY

Filter shall provide two internal high-flow bypass locations that in total exceed the inlet peak flow capacity. Filter shall provide filtered flow capacity in excess of the required "first flush" treatment flow. Unit shall not impede flow into or through the catch basin when properly sized and installed.

MATERIALS

Filter support frame shall be constructed of type 304 stainless steel. Filter screen, when used in place of filter liner, shall be type 304 or 316 stainless steel, with an apparent opening size of not less than 4 U.S. mesh. Filter liner, when used in place of filter screen, shall be woven polypropylene geotextile fabric liner with an apparent opening size (AOS) of not less than 40 U.S. mesh as determined by ASTM D 4751. Filter liner shall include a support basket of polypropylene geogrid with stainless steel cable reinforcement.

Filter frame shall be rated at a minimum 25-year service life. All other materials, with the exception of the hydrocarbon absorbent, shall have a rated service life in excess of 2 years.

FloGard®+PLUS TEST RESULTS SUMMARY

Testing Agency	% TSS Removal	% Oil and Grease Removal	% PAH Removal
UCLA	80	70 to 80	
U of Auckland Tonking & Taylor Ltd. (for city of Auckland)	78 to 95		
U of Hawaii (for city of Honolulu)	80		20 to 40

FEATURES

- Easy to install, inspect and maintain
- Can be retrofitted to existing drain catch basins – or used in new projects
- Economical and efficient
- Catches pollutants where they are easiest to catch (at the inlet)
- No standing water – minimizes vector, bacteria and odor problems
- Can be incorporated as part of a "Treatment Train"

BENEFITS

- Lower installation, inspection and maintenance costs
- Versatile installation applications
- Higher return on investment
- Allows for installation on small and confined sites
- Minimizes vector, bacteria and odor problems
- Allows user to target specific pollutants

Innovative stormwater management products

KRISTAR

FloGard® +PLUS

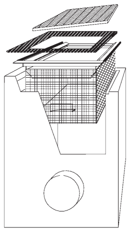
Catch Basin Insert Filter

INSTALLATION AND MAINTENANCE

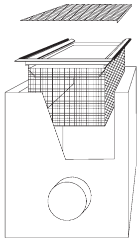
Filter shall be installed and maintained in accordance with manufacturer's general instructions and recommendations.

PERFORMANCE

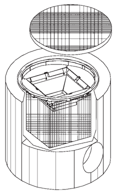
Filter shall provide 80% removal of total suspended solids (TSS) from treated flow with a particle size distribution consistent with typical urban street deposited sediments. Filter shall capture at least 70% of oil and grease and 40% of total phosphorus (TP) associated with organic debris from treated flow. Unit shall provide for isolation of trapped pollutants, including debris, sediments, and floatable trash and hydrocarbons, from bypass flow such that re-suspension and loss of pollutants is minimized during peak flow events.



FloGard+PLUS Combination Inlet



FloGard+PLUS Flat Grate



FloGard+PLUS Round Gated Inlet

FloGard®+PLUS COMPETITIVE FEATURE COMPARISON

Evaluation of FloGard+PLUS Units (Based on flow-comparable units) (Scale 1-10, 10 being best)	**FloGard+PLUS**	**Other Insert Filter Types****
Flow Rate	10	7
Removal Efficiency*	80%	45%
Capacity – Sludge and Oil	7	7
Service Life	10	3
Installation – Ease of Handling / Installation	8	6
Ease of Inspections & Maintenance	7	7
Value	**10**	**2**

*approximate, based on field sediment removal testing in urban street application **average

Long-Term Cost Comparison (Scale 1-10, 10 being lowest cost, higher number being best)	**FloGard+PLUS**	**Other Insert Filter Types**
Unit cost — initial ($/cfs treated)	10	4
Installation cost ($/cfs treated)	9	6
Adsorbent replacement (annual avg $/cfs treated)	10	2
Unit materials replacement (annual avg $/cfs treated)	10	10
Maintenance cost (annual avg $/cfs treated)	9	6
Total first yr ($/cfs treated)	10	5
Total Annual Avg ($/cfs treated, avg over 20 yrs)*	**10**	**5**

*assumes 3% annual inflation

Captured debris from
FloGard+PLUS,
Dana Point, CA

KriStar Enterprises, Inc.
P.O. Box 6419
Santa Rosa, CA 95406-1419

PH: 800-579-8819
FAX: 707-524-8186
www.kristar.com

FGP-T 11.19.18.04.2M

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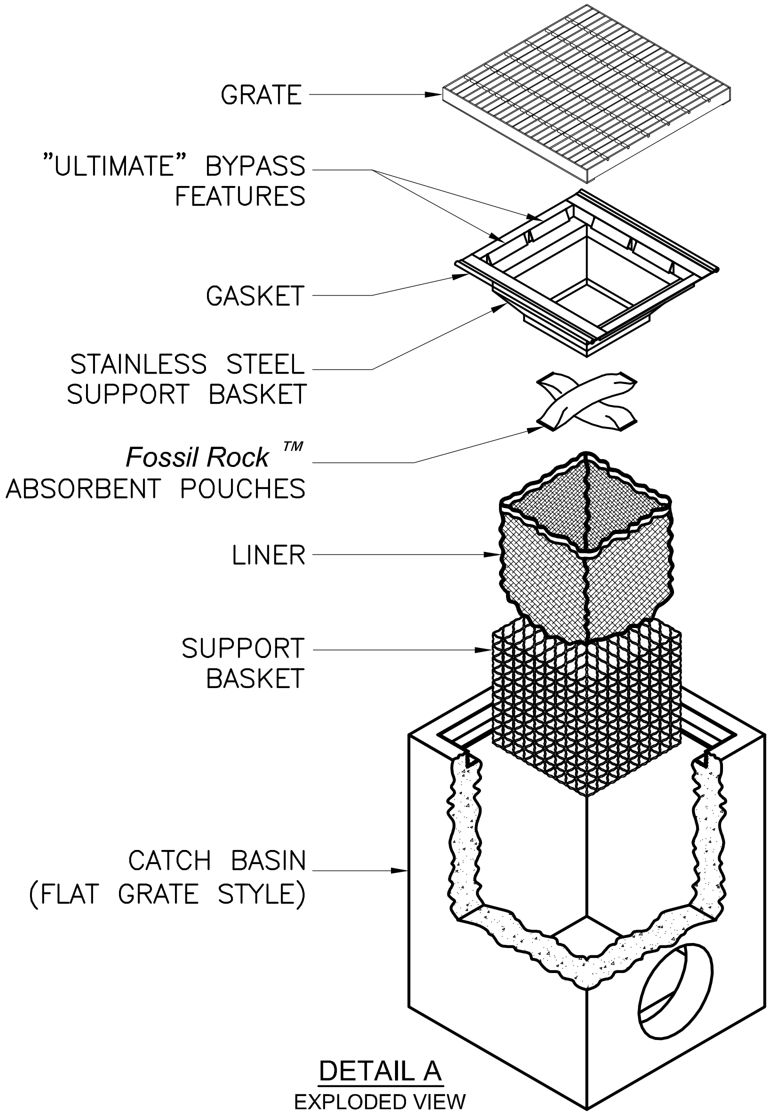
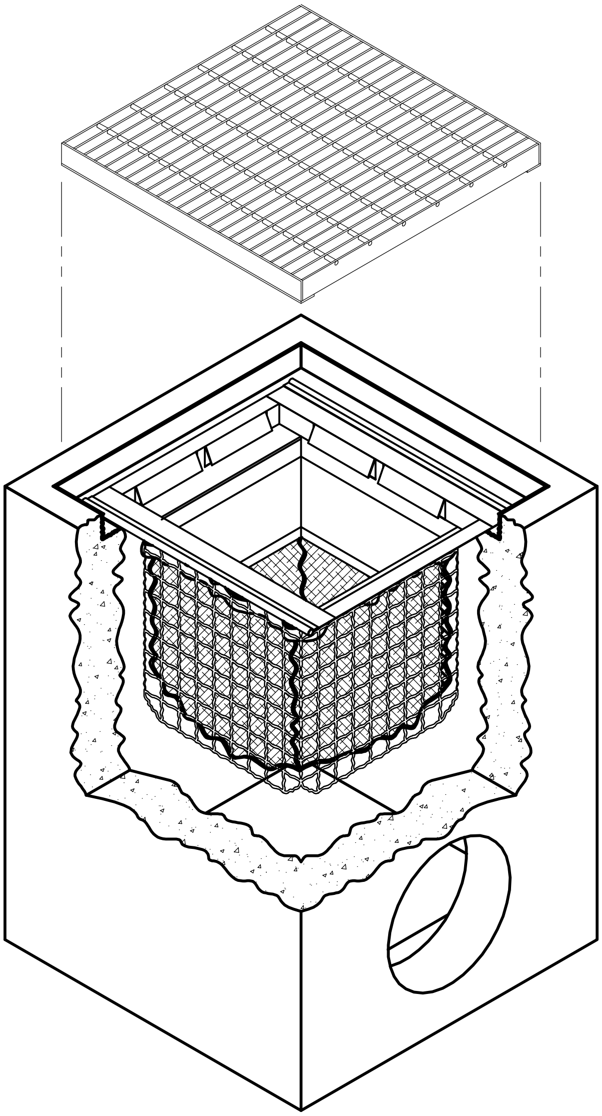


DETAIL A
EXPLODED VIEW



FLOGARD+PLUS® FILTER
-INSTALLED INTO CATCH BASIN-

NOTES:

1. FloGard®+Plus (frame mount) high capacity catch basin inserts are available in most sizes and styles (see specifier chart, sheet 2 of 2). Refer to the FloGard®+Plus (wall mount) insert for devices to fit non-standard, or combination style catch basins.

2. Filter insert shall have both an "initial" filtering bypass and "ultimate" high flow bypass feature.

3. Filter support frame shall be constructed from stainless steel Type 304.

4. Allow a minimum of 2.0 feet, of clearance between the bottom of the grate and top of outlet pipe(s), or refer to the FloGard® insert for "shallow" installations.

5. Filter medium shall be *Fossil Rock* ™, installed and maintained in accordance with manufacturer specifications.

6. Storage capacity reflects 80% of maximum solids collection prior to impeding filtering bypass.

7. Filtered flow r\rate includes a safety factor of two.

U.S. PATENT # 6,00,023 & 6,877,029

TITLE

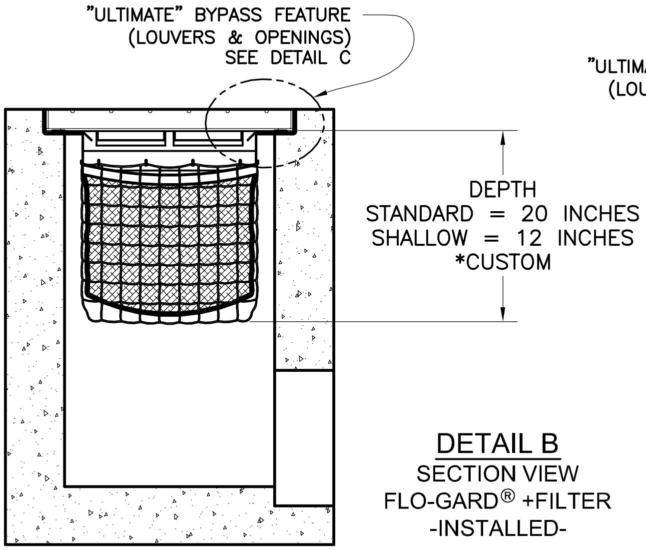
FloGard® +PLUS
CATCH BASIN FILTER INSERT
(Frame Mount)
FLAT GRATED INLET

KriStar Enterprises, Inc.
P.O. Box 6419, Santa Rosa, CA 95406
Ph: 800.579.8819, Fax: 707.524.8186, www.kristar.com

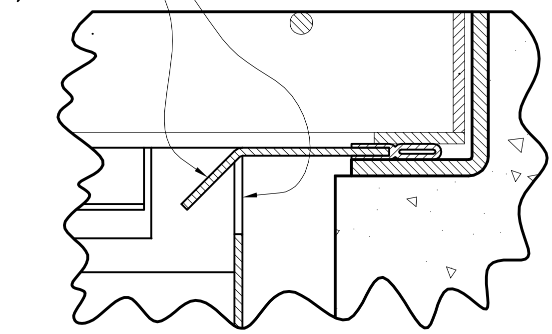
DRAWING NO.	REV	ECO	DATE	
FGP-0001	A	0001	JPR 09/01/06	SHEET 1 OF 2

FGP-0001

U.S. PATENT # 6,00,023 & 6,877,029



DETAIL B
SECTION VIEW
FLO-GARD® +FILTER
-INSTALLED-



DETAIL C
"ULTIMATE"
BYPASS FEATURES

* MANY OTHER STANDARD & CUSTOM SIZES & DEPTHS AVAILABLE UPON REQUEST.

SPECIFIER CHART

MODEL NO. STANDARD DEPTH	STANDARD & SHALLOW DEPTH (Data in these columes is the same for both STANDARD & SHALLOW versions)			STANDARD DEPTH -20 Inches-		MODEL NO. SHALLOW DEPTH	SHALLOW DEPTH -12 Inches-	
	INLET ID Inside Dimension (inch x inch)	GRATE OD Outside Dimension (inch x inch)	TOTAL BYPASS CAPACITY (cu. ft.)	SOLIDS STORAGE CAPACITY (cu. ft.)	FILTERED FLOW (cu. ft. / sec.)		SOLIDS STORAGE CAPACITY (cu. ft.)	FILTERED FLOW (cu. ft. / sec.)
FGP-12F	12 X 12	12 X 14	2.8	0.3	0.4	FGP-12F8	.15	.25
FGP-1530F	15 X 30	15 X 35	6.9	2.3	1.6	FGP-1530F8	1.3	.9
FGP-16F	16 X 16	16 X 19	4.7	0.8	0.7	FGP-16F8	.45	.4
FGP-1624F	16 X 24	16 X 26	5.0	1.5	1.2	FGP-1624F8	.85	.7
FGP-18F	18 X 18	18 X 20	4.7	0.8	0.7	FGP-18F8	.45	.4
FGP-1820F	16 X 19	18 X 21	5.9	2.1	1.4	FGP-1820F8	1.2	.8
FGP-1824F	16 X 22	18 X 24	5.0	1.5	1.2	FGP-1824F8	.85	.7
FGP-1836F	18 X 36	18 X 40	6.9	2.3	1.6	FGP-1836F8	1.3	.9
FGP-2024F	18 X 22	20 X 24	5.9	1.2	1.0	FGP-2024F8	.7	.55
FGP-21F	22 X 22	22 X 24	6.1	2.2	1.5	FGP-21F8	1.25	.85
FGP-2142F	21 X 40	24 X 40	9.1	4.3	2.4	FGP-2142F8	2.45	1.35
FGP-2148F	19 X 46	22 X 48	9.8	4.7	2.6	FGP-2148F8	2.7	1.5
FGP-24F	24 X 24	24 X 27	6.1	2.2	1.5	FGP-24F8	1.25	.85
FGP-2430F	24 X 30	26 X 30	7.0	2.8	1.8	FGP-2430F8	1.6	1.05
FGP-2436F	24 X 36	24 X 40	8.0	3.4	2.0	FGP-2436F8	1.95	1.15
FGP-2448F	24 X 48	26 X 48	9.3	4.4	2.4	FGP-2448F8	2.5	1.35
FGP-28F	28 X 28	32 X 32	6.3	2.2	1.5	FGP-28F8	1.25	.85
FGP-2440F	24 X 36	28 X 40	8.3	4.2	2.3	FGP-2440F8	2.4	1.3
FGP-30F	30 X 30	30 X 34	8.1	3.6	2.0	FGP-30F8	2.05	1.15
FGP-36F	36 X 36	36 X 40	9.1	4.6	2.4	FGP-36F8	2.65	1.35
FGP-3648F	36 X 48	40 X 48	11.5	6.8	3.2	FGP-3648F8	3.9	1.85
FGP-48F	48 X 48	48 X 54	13.2	9.5	3.9	FGP-48F8	5.45	2.25
FGP-SD24F	24 X 24	28 X 28	6.1	2.2	1.5	FGP-SD24F8	1.25	.85
FGP-1836FGO	18 X 36	20 X 40	6.9	2.3	1.6	FGP-1836F8GO	1.3	.9
FGP-2436FGO	20 X 36	24 X 40	8.0	3.4	2.0	FGP-2436F8GO	1.95	1.15
FGP-48FGO	18 X 48	20 X 54	6.3	2.2	1.5	FGP-48F8GO	1.25	.85

TITLE

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DRAWING NO.	REV	ECO	DATE	
FGP-0001	A	0001	JPR 09/01/06	SHEET 2 OF 2

GENERAL SPECIFICATIONS FOR MAINTENANCE OF *FLO-GARD+PLUS®* CATCH BASIN INSERT FILTERS

SCOPE:

Federal, State and Local Clean Water Act regulations and those of insurance carriers require that stormwater filtration systems be maintained and serviced on a recurring basis. The intent of the regulations is to ensure that the systems, on a continuing basis, efficiently remove pollutants from stormwater runoff thereby preventing pollution of the nation's water resources. These specifications apply to the FloGard+Plus® Catch Basin Insert Filter.

RECOMMENDED FREQUENCY OF SERVICE:

Drainage Protection Systems (DPS) recommends that installed Flo-Gard+Plus® Catch Basin Insert Filters be serviced on a recurring basis. Ultimately, the frequency depends on the amount of runoff, pollutant loading and interference from debris (leaves, vegetation, cans, paper, etc.); however, it is recommended that each installation be serviced a minimum of three times per year, with a change of filter medium once per year. DPS technicians are available to do an on-site evaluation, upon request.

RECOMMENDED TIMING OF SERVICE:

DPS guidelines for the timing of service are as follows:

1. For areas with a definite rainy season: Prior to, during and following the rainy season.
2. For areas subject to year-round rainfall: On a recurring basis (at least three times per year).
3. For areas with winter snow and summer rain: Prior to and just after the snow season and during the summer rain season.
4. For installed devices not subject to the elements (washracks, parking garages, etc.): On a recurring basis (no less than three times per years).

SERVICE PROCEDURES:

1. The catch basin grate shall be removed and set to one side. The catch basin shall be visually inspected for defects and possible illegal dumping. If illegal dumping has occurred, the proper authorities and property owner representative shall be notified as soon as practicable.
2. Using an industrial vacuum, the collected materials shall be removed from the liner. (Note: DPS uses a truck-mounted vacuum for servicing Flo-Gard+Plus® catch basin inserts.)
3. When all of the collected materials have been removed, the filter medium pouches shall be removed by unsnapping the tether from the D-ring and set to one side. The filter liner, gaskets, stainless steel frame and mounting brackets, etc. shall be inspected for continued serviceability. Minor damage or defects found shall be corrected on-the-spot and a notation made on the Maintenance Record. More extensive deficiencies that affect the efficiency of the filter (torn liner, etc.), if approved by the customer representative, will be corrected and an invoice submitted to the representative along with the Maintenance Record.
4. The filter medium pouches shall be inspected for defects and continued serviceability and replaced as necessary and the pouch tethers re-attached to the liner's D-ring. See below.
5. The grate shall be replaced.

REPLACEMENT AND DISPOSAL OF EXPOSED FILTER MEDIUM AND COLLECTED DEBRIS

The frequency of filter medium pouch exchange will be in accordance with the existing DPS-Customer Maintenance Contract. DPS recommends that the medium be changed at least once per year. During the appropriate service, or if so determined by the service technician during a non-scheduled service, the filter medium pouches will be replaced with new pouches. Once the exposed pouches and debris have been removed, DPS has possession and must dispose of it in accordance with local, state and federal agency requirements.

DPS also has the capability of servicing all manner of catch basin inserts and catch basins without inserts, underground oil/water separators, stormwater interceptors and other such devices. All DPS personnel are highly qualified technicians and are confined space trained and certified. Call us at (888) 950-8826 for further information and assistance.

STORMWATER QUALITY CONTROL MEASURE FACT SHEET

BIO-1: BIOFILTRATION

(2014 LID STANDARDS MANUAL)

BIO-1: Biofiltration

Definition

A biofiltration area is a vegetated shallow depression that is designed to receive and treat stormwater runoff from downspouts, piped inlets, or sheet flow from adjoining paved areas. A shallow ponding zone is provided above the vegetated surface for temporary storage of stormwater runoff. During storm events, stormwater runoff accumulates in the ponding zone and gradually infiltrates the surface and filters through the biofiltration soil media before being collected by an underdrain system.

Stormwater runoff treatment occurs through a variety of natural mechanisms as stormwater runoff filters through the vegetation root zone. In biofiltration areas, microbes and organic material in the biofiltration soil media help promote the adsorption of pollutants (e.g., dissolved metals and petroleum hydrocarbons) into the soil matrix. Plants utilize soil moisture and promote the drying of the soil through transpiration. Biofiltration areas are typically planted with native, drought-tolerant plant species that do not require fertilization and can withstand wet soils for at least 96 hours.

A schematic of a typical biofiltration area is presented in Figure E-7.

LID Ordinance Requirements

Biofiltration can be used as an alternative compliance measure.

Pollutant of Concern	Treated by Biofiltration?
Suspended solids	No
Total phosphorus	No
Total nitrogen	Yes
Total Kjeldahl nitrogen	Yes
Cadmium, total	No
Chromium, total	Yes
Copper, total	No
Lead, total	Yes
Zinc, total	No

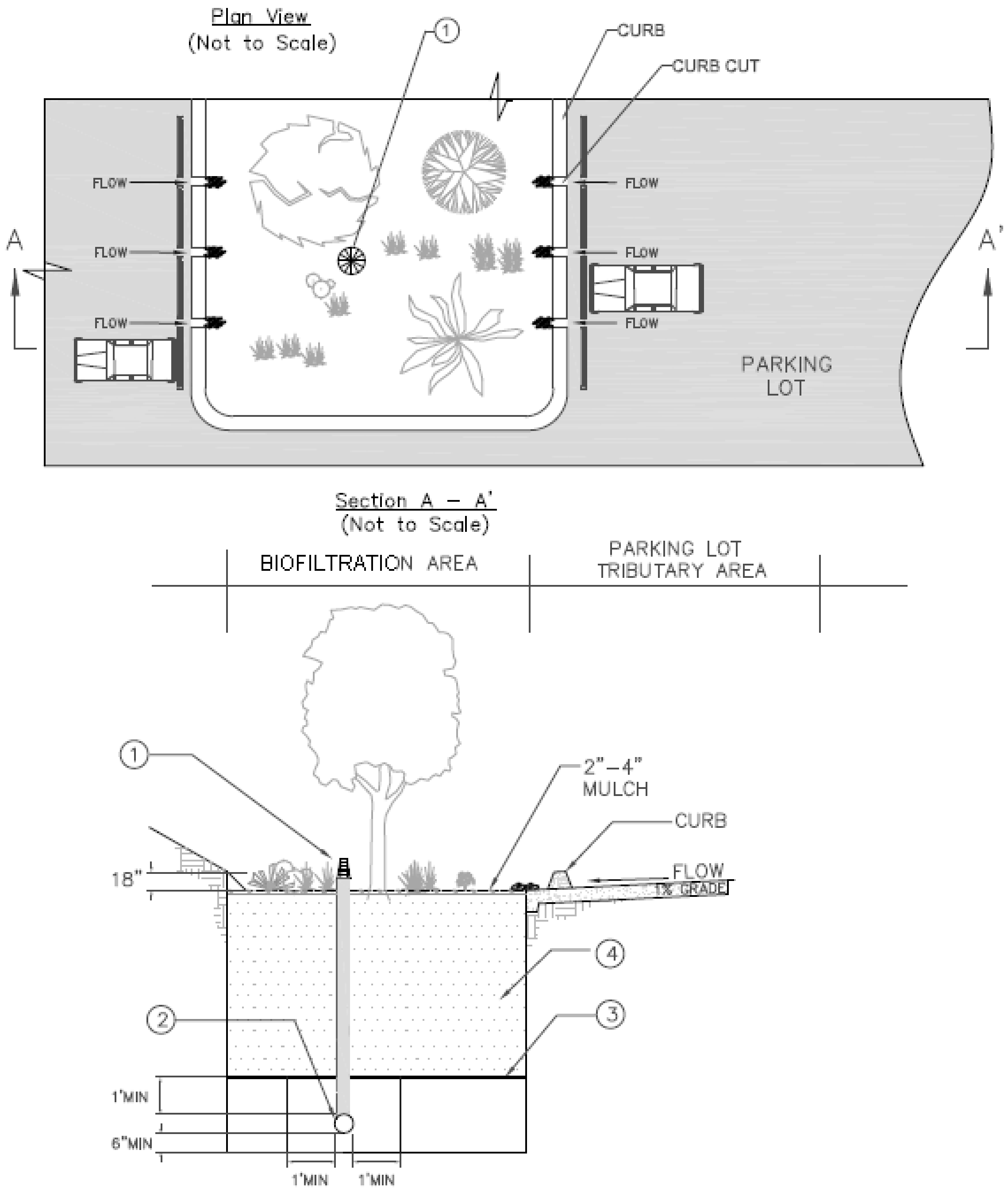
Source: Treatment Best Management Practices Performance, Los Angeles Regional Water Quality Control Board, December 9, 2013.

Advantages

- Has a low cost for installation
- Enhances site aesthetics
- Requires little maintenance

Disadvantages

- May require individual owner/tenants to perform maintenance



NOTES
① OVERFLOW DEVICE: VERTICAL RISER OR EQUIVALENT.
② PERFORATED 6" MIN PVC PIPE UNDERDRAIN SYSTEM. WHERE SOIL CONDITIONS ALLOW, OMIT THE UNDERDRAIN AND INSTALL AN APPROPRIATELY SIZED GRAVEL DRAINAGE LAYER (TYPICALLY A WASHED 57 STONE) BENEATH THE PLANTING MEDIA FOR ENHANCED INFILTRATION.
③ OPTIONAL CHOKING GRAVEL LAYER.
④ 2' MIN PLANTING MIX; 3' PREFERRED.

Figure E-7. Biofiltration Area Schematic

General Constraints and Implementation Considerations

- Biofiltration areas can be applied in various settings including, but not limited to:
    - Individual lots for rooftop, driveway, and other on-site impervious surface
    - Shared facilities located in common areas for individual lots
    - Areas within loop roads or cul-de-sacs
    - Landscaped parking lot islands
    - Within right-of-ways along roads
    - Common landscaped areas in apartment complexes or other multi-family housing designs
    - Parks and along open space perimeter
- If tire curbs are provided and parking stalls are shortened, cars are allowed to overhang the biofiltration area.
- Biofiltration areas must be located sufficiently far from structure foundations to avoid damage to structures (as determined by a certified structural or geotechnical engineer).
- Any parking areas bordering the biofiltration area must be monolithically poured concrete or deepended curb concrete to provide structural stability to the adjacent parking section.
- Geomembrane liners must be used in areas subject to spills or pollutant hot spots.
- During construction activities should avoid compaction of native soils below planting media layer or gravel zone.
- Stormwater runoff must be diverted around the biofiltration area during the period of vegetation establishment. If diversion is not feasible, the graded and seeded areas must be protected with suitable sediment controls (i.e., silt fences).All damaged areas should be repaired, seeded, or re-planted immediately.
- The general landscape irrigation system should incorporate the biofiltration area, as applicable.

Design Specifications

The following sections describe the design specifications for biofiltration areas.

Geotechnical

Due to the potential to contaminate groundwater, cause slope instability, impact surrounding structures, and potential for insufficient infiltration capacity, an extensive geotechnical site investigation must be conducted during the site planning process to verify site suitability for biofiltration. All geotechnical investigations must be performed according to the most recent GMED Policy GS 200.1. Soil infiltration rates and the groundwater table depth must be evaluated to ensure that conditions are satisfactory for proper operation of a biofiltration area. The project applicant must demonstrate through infiltration testing, soil logs, and the written opinion of a licensed civil engineer that sufficiently permeable soils exist on-site to allow the construction of a properly functioning biofiltration system.

Biofiltration areas are appropriate for soils with a minimum corrected in-situ infiltration rate of 0.3 in/hr. The geotechnical report must determine if the proposed project site is suitable for a biofiltration area and must recommend a design infiltration rate (see “Design Infiltration Rate” under the “Sizing” section). The geotechnical investigation should be such that a good understanding is gained as to how the stormwater runoff will move through the soil (horizontally or vertically) and if there are any geological conditions that could inhibit the movement of water.

Pretreatment

Pretreatment refers to design features that provide settling of large particles before stormwater runoff enters a stormwater quality control measure in order to reduce the long-term maintenance burden. Pretreatment should be provided to reduce the sediment load entering a biofiltration area in order to maintain the infiltration rate of the biofiltration area. To ensure that biofiltration areas are effective, the project applicant must incorporate pretreatment devices that provide sediment removal (e.g., vegetated swales, vegetated filter strips, sedimentation manholes, and proprietary devices). The use of at least two pretreatment devices is highly recommended for biofiltration areas.

Geometry

- Biofiltration areas must be sized to capture and treat 1.5 times the SWQDv that is not reliably retained on the project site with an 18-inch maximum ponding depth.
- The planting soil depth must be a minimum of two feet, although three feet is preferred. The planting soil depth should provide a beneficial root zone for the chosen vegetation and adequate water storage for the stormwater runoff. A deeper planting soil depth will also provide a smaller surface area footprint.
- A gravel storage layer below the biofiltration area soil media is required to provide adequate temporary storage to retain 1.5 times the SWQDv that is not reliably retained on the project site and to promote infiltration.

Sizing

Biofiltration areas are sized using a simple sizing method where 1.5 times the SWQDv that is not reliably retained on the project site must be completely filtered within 96 hours. If the incoming stormwater runoff flow rate is lower than the long term filtration rate, above ground storage does not need to be provided. If the incoming stormwater runoff flow rate is higher than the long term filtration rate, above ground storage shall be provided (see steps below).

Step 1: Calculate the design volume

Biofiltration areas should be sized to capture and treat 1.5 times the portion of the SWQDv (see Section 6 for SWQDv calculation procedures) that is not reliability retained on the project site, as calculated by the equation below:

$$V_B = 1.5 \times (SWQDv - V_R)$$

Where:

V_B = Biofiltration volume [ft^3];
SWQDv = Stormwater quality design volume [ft^3]; and
V_R = Volume of stormwater runoff reliably retained on-site [ft^3].

Step 2: Calculate the design infiltration rate

Determine the corrected in-situ infiltration rate (f_{design}) of the native soil using the procedures described in the most recent GMED Policy GS 200.1.

Step 3: Calculate the surface area

Select a surface ponding depth (d) that satisfies the geometric criteria and meets the site constraints. Selecting a deeper ponding depth (up to 1.5 ft) generally yields a smaller footprint, however, it will require greater consideration for public safety, energy dissipation, and plant selection.

Calculate the time for the selected ponding depth to filter through the planting media using the following equation:

$$\mathrm{d} = t_p \times \frac{\mathrm{f_{design}}}{12}$$

Where:

d = Ponding depth (max 1.5 ft) [ft];
t_p = Required detention time for surface ponding (max 96 hr) [hr]; and
f_{design} = Design infiltration rate [in/hr].

If t_p exceeds 96 hours, reduce surface ponding depth (d). In nearly all cases, t_p should not approach 96 hours unless f_{design} is low.

Calculate the required infiltrating surface (filter bottom area) using the following equation:

$$A = \frac{V_B}{d}$$

Where:

A = Bottom surface area of biofiltration area [ft^2];
V_B = Biofiltration design volume [ft^3]; and
d = Ponding depth (max 1.5 ft) [ft].

Flow Entrance and Energy Dissipation

Maintain a minimum slope of 1 percent for pervious surfaces and 0.5 percent for impervious surfaces to the biofiltration area inlet. The following types of flow entrance can be used for biofiltration cells:

- Level spreaders (i.e., slotted curbs) can be used to facilitate sheet flow.
- Dispersed, low velocity flow across a landscape area. Dispersed flow may not be possible given space limitations or if the biofiltration area is controlling roadway or parking lot flows where curbs are mandatory.
- Dispersed flow across pavement or gravel and past wheel stops for parking areas.
- Flow spreading trench around perimeter of biofiltration area. May be filled with pea gravel or vegetated with 3:1 side slopes similar to a swale. A vertical-walled open trench may also be used at the discretion of LACDPW.
- Curb cuts for roadside or parking lot areas, if approved by LACDPW: curb cuts should include rock or other erosion controls in the channel entrance to dissipate energy. Flow entrance should drop two to three inches from curb line and provide an area for settling and periodic removal of sediment and coarse material before flow dissipates to the remainder of the biofiltration area.
- Piped entrances, such as roof downspouts, should include rock, splash blocks, or other erosion controls at the entrance to dissipate energy and disperse flows.
- Woody plants (trees, shrubs, etc.) can restrict or concentrate flows and can be damaged by erosion around the root ball and must not be placed directly in the entrance flow path.

Drainage

Biofiltration areas must be designed to drain below the planting soil in less than 96 hours. Soils must be allowed to dry out periodically in order to restore hydraulic capacity to receive stormwater runoff from subsequent storm events, maintain infiltration rates, maintain adequate soil oxygen levels for healthy soil biota and vegetation, and provide proper soil conditions for biodegradation and retention of pollutants.

Underdrain

Biofiltration areas require an underdrain to collect and discharge stormwater runoff that has been filtered through the soil media, but not infiltrated, to another stormwater quality control measure, storm drain system, or receiving water. The underdrain must have a mainline diameter of eight inches using slotted PVC SDR 26 or PVC C9000. Slotted PVC allows for pressure water cleaning and root cutting, if necessary. The slotted pipe should have two to four rows of slots cut perpendicular to the axis of the pipe or at right angles to the pitch of corrugations. Slots should be 0.04 to 0.1 inches wide with a length of 1 to 1.25 inches. Slots should be longitudinally-spaced such that the pipe has a minimum of one square inch opening per lineal foot and should face down.

The underdrain should be placed in a gravel envelope (Class 2 Permeable Material per Caltrans Spec. 68-1.025) that measures three feet wide and six inches deep. The underdrain is elevated from the bottom of the biofiltration area by six inches within the gravel envelope to create a fluctuating anaerobic/aerobic zone below the underdrain to facilitate denitrification within the anaerobic/anoxic zone and reduce nutrient concentrations. The top and sides of the underdrain pipe should be covered with gravel to a minimum depth of 12 inches. The underdrain and gravel envelope should be covered with a geomembrane liner to prevent clogging. The following aggregate should be used for the gravel envelope:

Particle Size (ASTM D422)	% Passing by Weight
¾ inch	100%
¼ inch	30-60%
#8	20-50%
#50	3-12%
#200	0-1%

Underdrains should be sloped at a minimum of 0.5 percent and must drain freely to an approved discharge point.

Rigid non-perforated observation pipes with a diameter equal to the underdrain diameter should be connected to the underdrain to provide a clean-out port as well as an observation well to monitor drainage rates. The wells/clean-outs should be connected to the perforated underdrain with the appropriate manufactured connections. The wells/clean-outs should extend six inches above the top elevation of the biofiltration area mulch, and should be capped with a lockable screw cap. The ends of underdrain pipes not terminating in an observation well/clean-out should also be capped.

Hydraulic Restriction Layer

Lateral infiltration pathways may need to be restricted due to the close proximity of roads, foundations, or other infrastructure. A geomembrane liner, or other equivalent waterproofing, may be placed along the vertical walls to reduce lateral flows. This geomembrane liner must have a minimum thickness of 30 mils and meet the requirements of Table E-12. Generally, waterproof barriers should not be placed on the bottom of the biofiltration unit, as this would prevent incidental infiltration which is important to meeting the required pollutant load reduction.

Table E-12. Geomembrane Liner Specifications for Biofiltration Areas

Parameter	Test Method	Specifications
Material		Nonwoven geomembrane liner
Unit weight		8 oz/yd^3 (minimum)
Filtration rate		0.08 in/sec (minimum)
Puncture strength	ASTM D-751 (Modified)	125 lbs (minimum)
Mullen burst strength	ASTM D-751	400 lb/in^2 (minimum)
Tensile strength	AST D-1682	300 lbs (minimum)
Equiv. opening size	US Standard Sieve	No. 80 (minimum)

Planting/Storage Media

- The planting media placed in the biofiltration area should achieve a long-term, in-place infiltration rate of at least 5 in/hr. Higher infiltration rates of up to 12 in/hr are permissible. The biofiltration soil media must retain sufficient moisture to support vigorous plant growth.
- The planting media mix must consist of 60 to 80 percent sand and 20 to 40 percent compost.
- Sand should be free of wood, waste, coatings such as clay, stone dust, carbonate, or any other deleterious material. All aggregate passing the No. 200 sieve size should be non-plastic. Sand for biofiltration should be analyzed by an accredited laboratory using #200, #100, #40, #30, #16, #8, #4, and 3/8 sieves (ASTM D422 or as approved by the local permitting authority) and meet the following gradations (Note: all sand complying with ASTM C33 for fine aggregate comply with the gradation requirements listed below):

Particle Size (ASTM D422)	% Passing by Weight
3/8 inch	100%
#4	90-100%
#8	70-100%
#16	40-95%
#30	15-70%
#40	5-55%
#110	0-15%
#200	0-5%

Note: The gradation of the sand component of the biofiltration soil media is believed to be a major factor in the infiltration rate of the media mix. If the desired hydraulic conductivity of the biofiltration soil media cannot be achieved within the specified proportions of sand and compost (#2), then it may be necessary to utilize sand at the coarser end of the range specified minimum percent passing.

- Compost should be a well-decomposed, stable, weed-free organic matter source derived from waste materials including yard debris, wood wastes, or other organic material not including manure or biosolids meeting standards developed by the USCC. The product shall be certified through the USCC STA Program (a compost testing and information disclosure program). Compost quality shall be verified via a laboratory analysis to be:
    - Feedstock materials must be specified and include one or more of the following: landscape/yard trimmings, grass clippings, food scraps, and agricultural crop residues.
    - pH between 6.5 and 8.0 (may vary with plant palette)
    - Organic Matter: 35 to 75 percent dry weight basis
    - Carbon and Nitrogen Ratio: 15:1 < C:N < 25:1
    - Maturity/Stability: Compost must have a dark brown color and a soil-like odor. Compost exhibiting a sour or putrid smell, containing recognizable grass or leaves, or is hot (120°F) upon delivery or rewetting is not acceptable.
    - Toxicity: any one of the following measures is sufficient to indicate non-toxicity:
        - NH_4:NH_3 < 3
        - Ammonium < 500 ppm, dry weight basis
        - Seed germination > 80 percent of control
        - Plant trials > 80 percent of control
        - Solvita® > 5 index value
    - Nutrient content:
        - Total Nitrogen content ≥ 0.9 percent preferred
        - Total Boron should be < 80 ppm; soluble boron < 2.5 ppm
    - Salinity: < 6.0 mmhos/cm
    - Compost for biofiltration area should be analyzed by an accredited laboratory using #200, ¼-inch, ½-inch, and 1-inch sieves (ASTM D422) and meet the gradation requirements in the table below:

Particle Size (ASTM D422)	% Passing by Weight
1 inch	99-100
½ inch	90-100
¼ inch	40-90
#200	2-10

Tests should be sufficiently recent to represent the actual material that is anticipated to be delivered to the site. If processes or sources used by the supplier have changed significantly since the most recent testing, new tests should be requested.

The gradation of compost used in biofiltration soil media is believed to play an important role in the saturated infiltration rate of the media. To achieve a higher saturated infiltration rate, it may be necessary to utilize compost at the coarser end of the range (minimum percent passing). The percent passing the #200 sieve (fines) is believed to be the most important factor in hydraulic conductivity.

In addition, coarser compost mix provides more heterogeneity of the biofiltration soil media, which is believed to be advantageous for more rapid development of soil structure needed to support healthy biological processes. This may be an advantage for plant establishment with lower nutrient and water input.

- Biofiltration soil media not meeting the above criteria should be evaluated on a case-by-case basis. Alternative biofiltration soil media must meet the following specifications:

  "Soils for biofiltration facilities must be sufficiently permeable to infiltrate stormwater runoff at a minimum of rate of 5 in/hr during the life of the facility, and provide sufficient retention of moisture and nutrients to support healthy vegetation." The following steps shall be followed by LACDPW to verify that alternative biofiltration soil media mixes meet the specification:

  - Submittals – The applicant must submit to LACDPW for approval:
    - A sample of mixed biofiltration soil media.
    - Certification from the soil supplier or an accredited laboratory that the biofiltration soil media meets the requirements of this specification.
    - Certification from an accredited geotechnical testing laboratory that the biofiltration soil media has an infiltration rate between 5 and 12 in/hr.
    - Organic content test results of the biofiltration soil media. Organic content test shall be performed in accordance with the Testing Methods for the Examination of Compost and Composting (TMECC) 05.07A, "Loss-On-Ignition Organic Matter Method".
    - Organic grain size analysis results of mixed biofiltration soil media performed in accordance with ASTM D422, Standard Test Method for Particle Size Analysis of Soils.
    - A description of the equipment and methods used to mix the sand and compost to produce the biofiltration soil media.
  - The name of the testing laboratory(ies) and the following information:

    - Contact person(s)
    - Address(es)
    - Phone contact(s)
    - E-mail address(es)
    - Qualifications of laboratory(ies) and personnel including date of current certification by STA, ASTM, or approved equal.
  - Biofiltration soils shall be analyzed by an accredited laboratory using #200 and ½-inch sieves (ASTM D422 or as approved by LACDPW), and meet the gradation described in the table below:

Particle Size (ASTM D422)	% Passing by Weight
½ inch	97-100
#200	2-5

- Biofiltration soil media shall be analyzed by an accredited geotechnical laboratory for the following tests:
  - Moisture – density relationships (compaction tests) must be conducted on biofiltration soil media. Biofiltration soil media for the permeability test shall be compacted to 85 to 90 percent of the maximum dry density (ASTM D1557).
  - Constant head permeability testing in accordance with ASTM D2434 shall be conducted on a minimum of two samples with a 6-inch mold and vacuum saturation.
- Mulch is recommended for the purpose of retaining moisture, preventing erosion, and minimizing weed growth. Projects subject to the California Model Water Efficiency Landscaping Ordinance (or comparable local ordinance) will be required to provide at least 2 inches of mulch. Aged mulch, also called compost mulch, reduces the ability of weeds to establish, keeps soil moist, and replenishes soil nutrients. Biofiltration areas must be covered with two to four inches (average three inches) of mulch at the start and an annual placement (preferably in June after weeding) of one to two inches of mulch beneath plants.
- The planting media design height must be marked appropriately, such as a collar on the overflow device or with a stake inserted two feet into the planting media and notched, to show biofiltration surface level and ponding level.

Vegetation

Prior to installation, a licensed landscape architect must certify that all plants, unless otherwise specifically permitted, conform to the standards of the current edition of American Standard for Nursery Stock as approved by the American Standards Institute, Inc. All plant grades shall be those established in the current edition of American Standards for Nursery Stock.

- Shade trees must have a single main trunk. Trunks must be free of branches below the following heights:

CALIPER (in)	Height (ft)
1½-2½	5
3	6

- Plants must be tolerant of summer drought, ponding fluctuations, and saturated soil conditions for 96 hours.
- It is recommended that a minimum of three types of tree, shrubs, and/or herbaceous groundcover species be incorporated to protect against facility failure due to disease and insect infestations of a single species.
- Native plant species and/or hardy cultivars that are not invasive and do not require chemical inputs must be used to the maximum extent practicable.

The biofiltration area should be vegetated to resemble a terrestrial forest community ecosystem, which is dominated by understory trees, a shrub layer, and herbaceous ground cover. Select vegetation that:

- Is suited to well-drained soil;
- Will be dense and strong enough to stay upright, even in flowing water;
- Has minimum need for fertilizers;
- Is not prone to pests and is consistent with Integrated Pest Management practices; and
- Is consistent with local water conservation ordinance requirements.

Irrigation System

Provide an irrigation system to maintain viability of vegetation, if applicable. The irrigation system must be designed to local code or ordinance specifications.

Restricted Construction Materials

The use of pressure-treated wood or galvanized metal at or around a biofiltration area is prohibited.

Overflow Device

An overflow device is required at the 18-inch ponding depth. The following, or equivalent, should be provided:

- A vertical PVC pipe (SDR 26) to act as an overflow riser.
- The overflow riser(s) should be eight inches or greater in diameter, so it can be cleaned without damage to the pipe.

- The inlet to the riser should be at the ponding depth (18 inches for fenced biofiltration areas and 6 inches for areas that are not fenced), and be capped with a spider cap to exclude floating mulch and debris. Spider caps should be screwed in or glued (e.g., not removable). The overflow device should convey stormwater runoff in excess of 1.5 times the SWQDv that is not reliably retained on the project site to an approved discharge location (another stormwater quality control measure, storm drain system, or receiving water).

Maintenance Requirements

Maintenance and regular inspections are important for proper function of biofiltration areas. Biofiltration areas require annual plant, soil, and mulch layer maintenance to ensure optimal infiltration, storage, and pollutant removal capabilities. In general, biofiltration maintenance requirements are typical landscape care procedures and include:

- Irrigate plants as needed during prolonged dry periods. In general, plants should be selected to be drought-tolerant and not require irrigation after establishment (two to three years).
- Inspect flow entrances, ponding area, and surface overflow areas periodically, and replace soil, plant material, and/or mulch layer in areas if erosion has occurred. Properly-designed facilities with appropriate flow velocities should not cause erosion except potentially during in extreme events. If erosion occurs, the flow velocities and gradients within the biofiltration area and flow dissipation and erosion protection strategies in the pretreatment area and flow entrance should be reassessed. If sediment is deposited in the biofiltration area, identify the source of the sediment within the tributary area, stabilize the source, and remove excess surface deposits.
- Prune and remove dead plant material as needed. Replace all dead plants, and if specific plants have a high mortality rate, assess the cause and, if necessary, replace with more appropriate species.
- Remove weeds as needed until plants are established. Weed removal should become less frequent if the appropriate plant species are used and planting density is attained.
- Select the proper soil mix and plants for optimal fertility, plant establishment, and growth to preclude the use of nutrient and pesticide supplements. By design, biofiltration facilities are located in areas where phosphorous and nitrogen levels are often elevated such that these should not be limiting nutrients. Addition of nutrients and pesticides may contribute pollutant loads to receiving waters.
- In areas where heavy metals deposition is likely (i.e., tributary areas to industrial, vehicle dealerships/repair, parking lots, roads), replace mulch annually. In areas where metals deposition is less likely (i.e., residential lots), replace or add mulch as needed to maintain a two to three inch depth at least once every two years.

- Analyze soil for fertility and pollutant levels if necessary. Biofiltration soil media are designed to maintain long-term fertility and pollutant processing capability.
- Eliminate standing water to prevent vector breeding.
- Inspect overflow devices for obstructions or debris, which should be removed immediately. Repair or replace damaged pipes upon discovery.
- Inspect, and clean if necessary, the underdrain.

A summary of potential problems that need to be addressed by maintenance activities is presented in Table E-13.

The County requires execution of a maintenance agreement to be recorded by the property owner for the on-going maintenance of any privately-maintained stormwater quality control measures. The property owner is responsible for compliance with the maintenance agreement. A sample maintenance agreement is presented in Appendix H.

Table E-13. Biofiltration Troubleshooting Summary

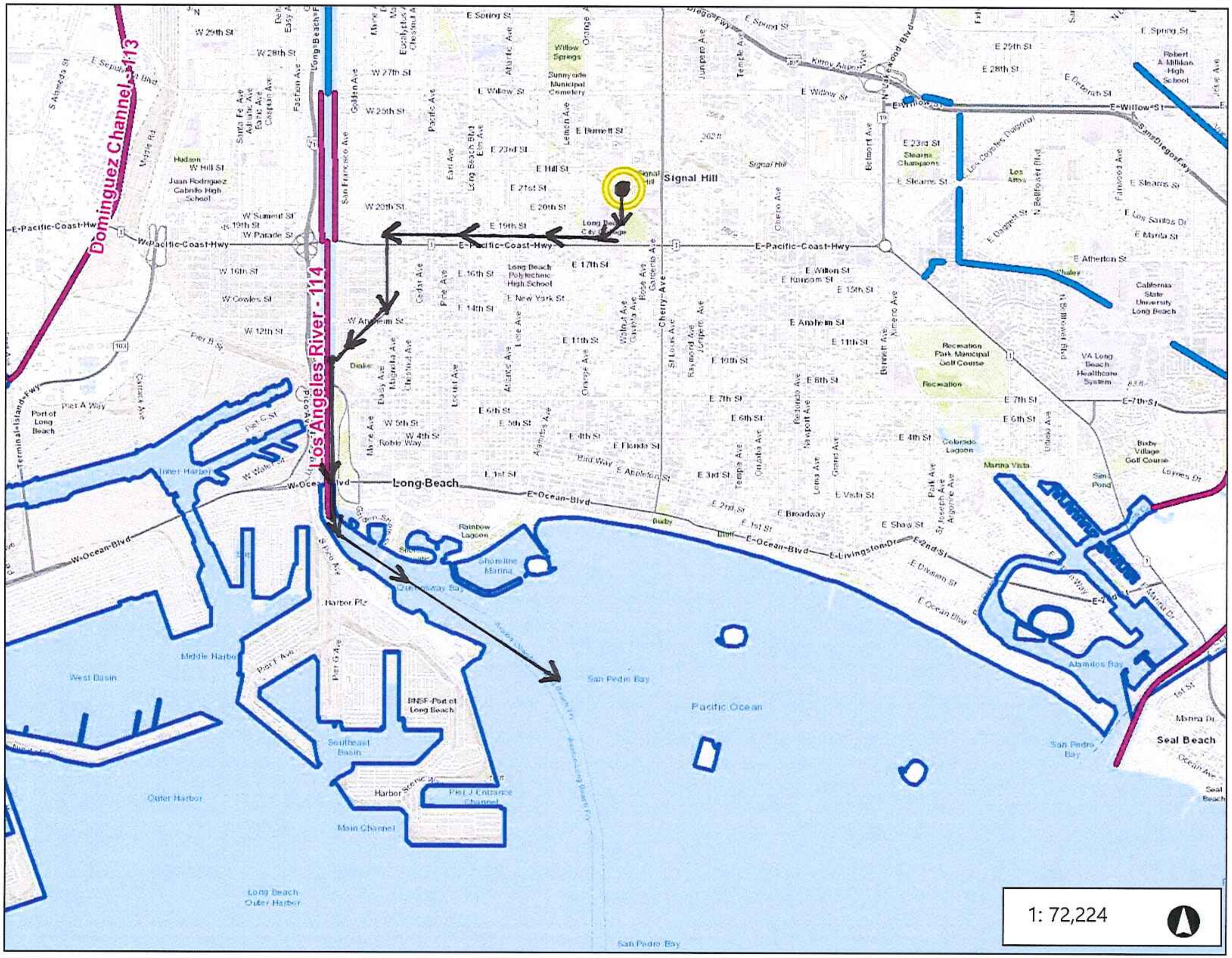
Problem	Conditions When Maintenance Is Needed	Maintenance Required
Vegetation	Overgrown vegetation	Mow and prune vegetation as appropriate.
	Presence of invasive, poisonous, nuisance, or noxious vegetation or weeds	Remove this vegetation and plant native species as needed.
Trash and Debris	Trash, plant litter, and dead leaves present	Remove and properly dispose of trash and debris.
Irrigation (if applicable)	Not functioning correctly	Check irrigation system for clogs or broken lines and repair as needed.
Inlet/Overflow	Inlet/overflow areas clogged with sediment and/or debris	Remove material.
	Overflow pipe blocked or broken	Repair as needed.
Erosion/Sediment Accumulation	Splash pads or spreader incorrectly placed Presence of erosion or sediment accumulation	Check inlet structure to ensure proper function. Repair, or replace if necessary, the inlet device. Repair eroded areas with gravel as needed. Re-grade the biofiltration area as needed.
Contaminants and Pollution	Any evidence of oil, gasoline, contaminants, or other pollutants	Remove any evidence of visual contamination from floatables such as oil and grease.
Standing water	Standing water observed more than 96 hours after storm event	Inspect, and clean as needed, the underdrain to ensure proper function. Clear clogs as needed. Remove and replace planter media (sand, gravel, topsoil, mulch) and vegetation.

APPENDIX A

RECEIVING WATERS MAP

County of Los Angeles
Department of Public Works

LA County Flood Control System



2.3 0 1.14 2.3 Miles

WGS_1984_Web_Mercator_Auxiliary_Sphere

Legend

- ● Debris Basins
- ▬ Soft Bottom Channels
- ▬ Concrete Lined Channels
- Citations

Notes

Receiving Waters Map
Project Location: E. 21st Street and Walnut Ave., Signal Hill, CA

→ Drainage flow from project site to Pacific Ocean

Department of Public Works
dpw.lacounty.gov

search our site..

Los Angeles County Storm Drain System

File Geodatabase Download

MS4 Outfalls Download

Search | Layers | Info

Enter Address, Cross Street, or Parcel No.:
(ex: 900 S. Fremont Ave., Fremont@Valley, 5342005904)

2025 Walnut, Signal Hill, CA

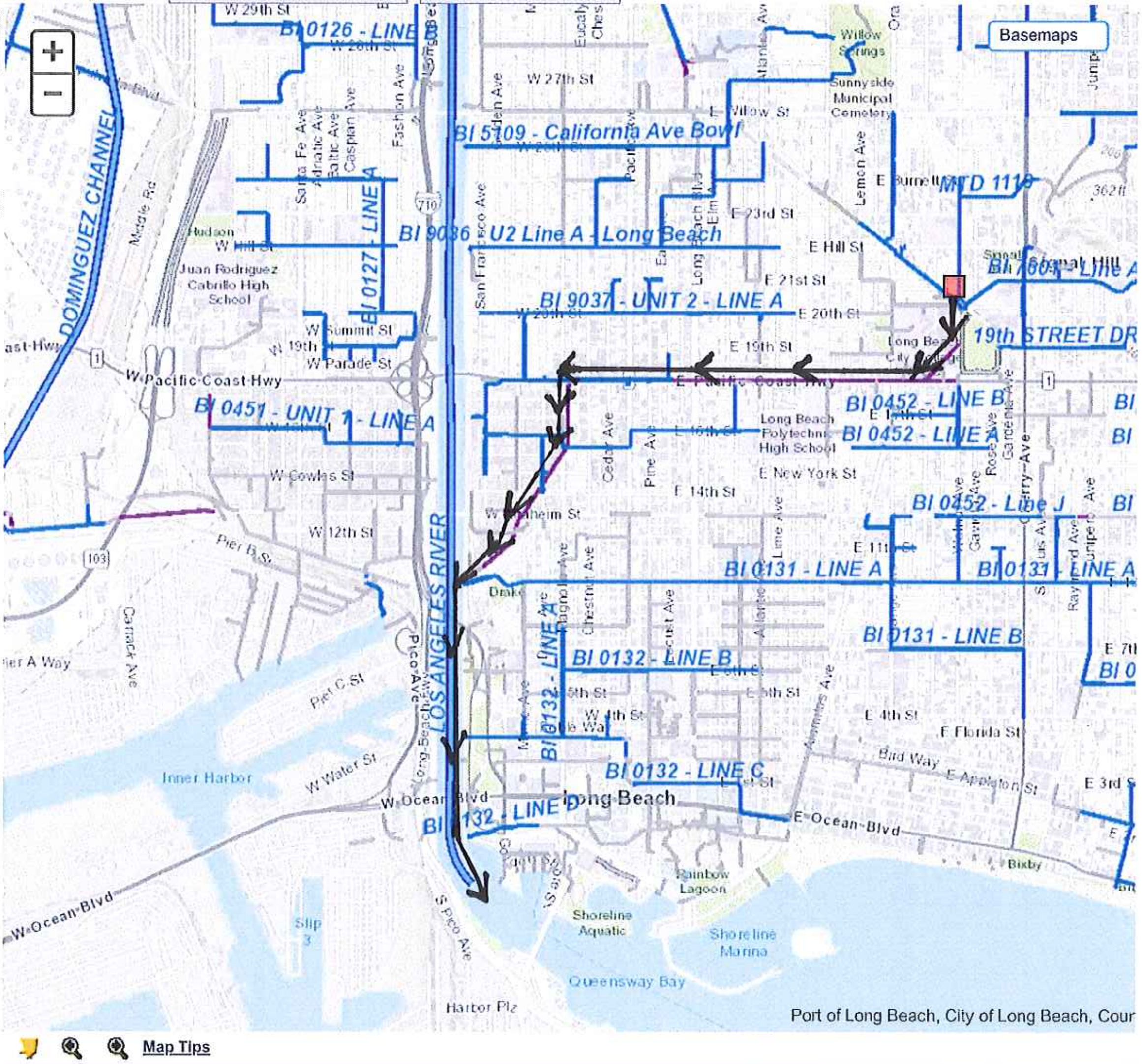
Search

Search Results:

2025 Walnut Signal Hill CA

Enter Channel, Drain, or Old Drawing No.:
(ex. Coyote Creek, MTD 359, 275-416-D2, CC 2650)

Search



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APPENDIX B

RAINFALL HYDROLOGY MAP FOR LOS ANGELES COUNTY

Department of Public Works
dpw.lacounty.gov

search our site..

Hydrology Map

A GIS viewer application to view the data for the hydrology manual.

LAYERS

- ☑ 🟥 50yr Two Tenths (Rainfall)
- ☐ 🟦 DPA Zones
- ☑ 🟩 Soils 2004
- ☑ — Final 85th Percentile, 24-hr Rainfall
- ☐ — Final 95th Percentile, 24-hr Rainfall
- ☐ — 1-year, 1-hour Rainfall Intensity

SEARCH

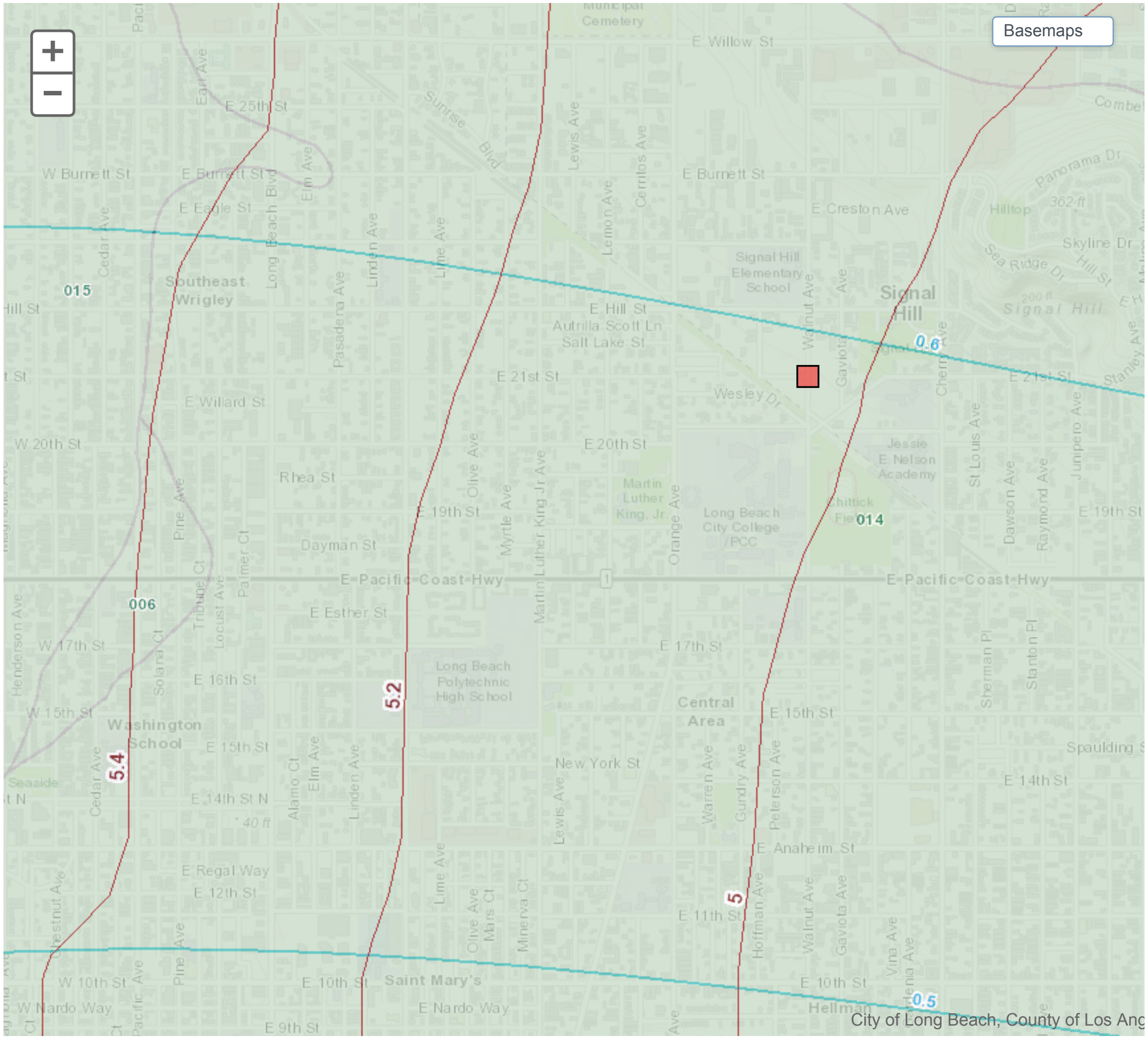
Enter Address, Cross Street, or Parcel No.:
(ex: 900 S. Fremont Ave., Fremont@Valley, 5342005904)

WALNUT AVE & 21ST ST, SIGNAL HILL

Search

Address Search Results:

WALNUT AVE AND 21ST ST SIGNAL HILL



Map Tips

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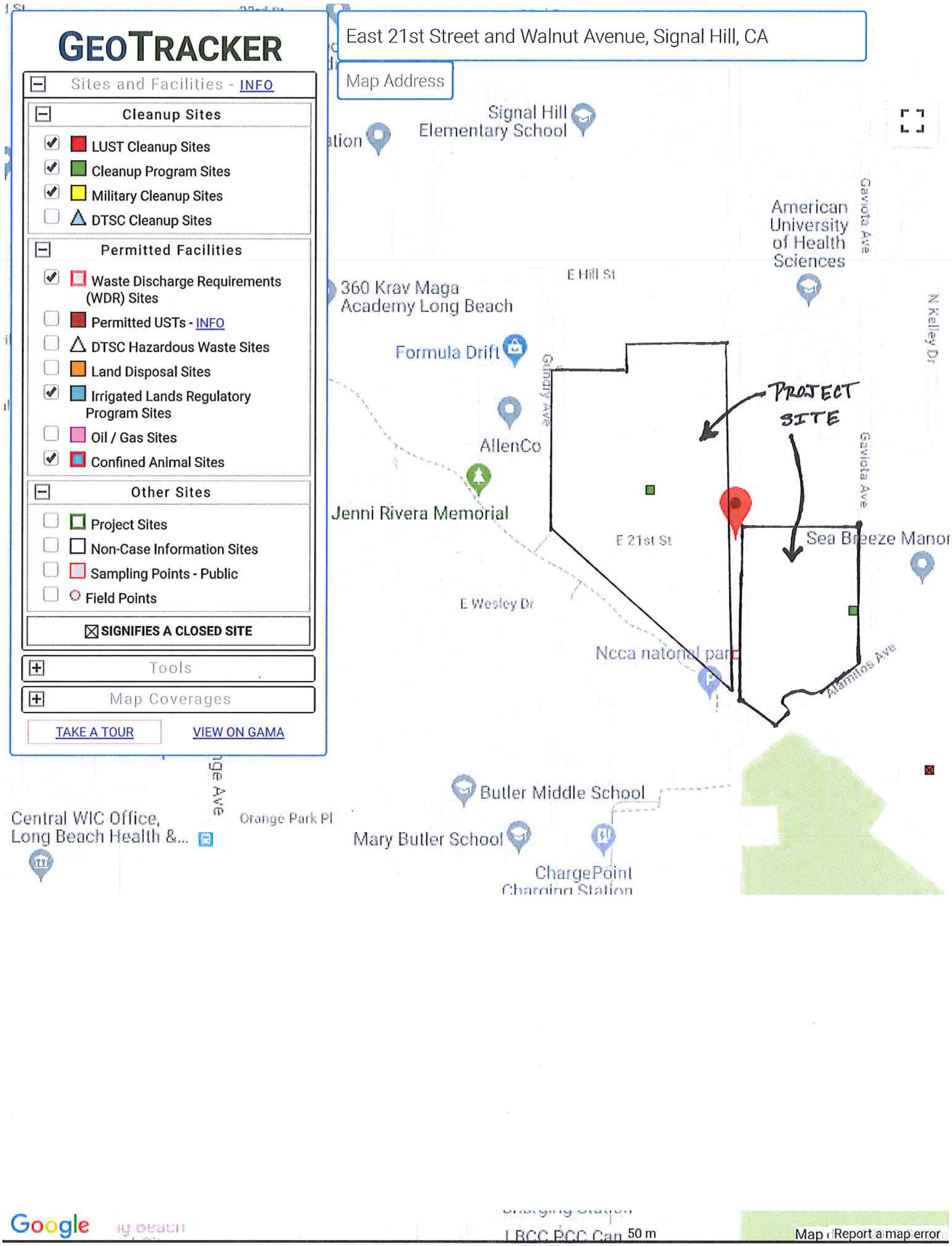
APPENDIX C

GEOTRACKER MAP OF OPEN LEAKING UNDERGROUND STORAGE TANK (LUST) SITES



GEOTRACKER

⊟ Sites and Facilities - INFO

⊟ Cleanup Sites

- ☑ 🟥 LUST Cleanup Sites
- ☑ 🟩 Cleanup Program Sites
- ☑ 🟨 Military Cleanup Sites
- ☐ △ DTSC Cleanup Sites

⊟ Permitted Facilities

- ☑ 🟥 Waste Discharge Requirements (WDR) Sites
- ☐ 🟥 Permitted USTs - INFO
- ☐ △ DTSC Hazardous Waste Sites
- ☐ 🟧 Land Disposal Sites
- ☑ 🟦 Irrigated Lands Regulatory Program Sites
- ☐ 🟪 Oil / Gas Sites
- ☑ 🟦 Confined Animal Sites

⊟ Other Sites

- ☐ 🟩 Project Sites
- ☐ ☐ Non-Case Information Sites
- ☐ 🟥 Sampling Points - Public
- ☐ ○ Field Points

☒ SIGNIFIES A CLOSED SITE

⊞ Tools

⊞ Map Coverages

TAKE A TOUR VIEW ON GAMA

East 21st Street and Walnut Avenue, Signal Hill, CA

Map Address

PROJECT SITE

⊞ SITES CURRENTLY VISIBLE ON MAP

APPENDIX D

TGR GEOTECHNICAL, INC.’S PRELIMINARY GEOTECHNICAL INVESTIGATION REPORT, SIGNAL HILL BUSINESS PARK, 20TH STREET AND WALNUT AVENUE, SIGNAL HILL, CALIFORNIA, DATED MAY 16, 2017 (DRAFT VERSION)

Geotechnical
Environmental
Hydrogeology
Material Testing
Construction Inspection

May 16, 2017 Project No. 16-6239

Xebec Realty Partners, LLC
3010 Old Ranch Parkway, Suite 470
Seal Beach, CA 92660

Attention: Jake Spring, Senior Acquisitions Analyst

Subject: Preliminary Geotechnical Investigation Report, Signal Hill Business Park, 20th Street and Walnut Avenue, Signal Hill, California

Jake,

In accordance with your request and authorization, TGR Geotechnical, Inc. (TGR) has performed a preliminary geotechnical investigation for the proposed development at the subject site in the City of Signal Hill, California. This report presents the findings of our geotechnical investigation, including site seismicity and liquefaction analysis and provides geotechnical design recommendations for the proposed improvements. The work was performed in general accordance with our proposal dated March 24, 2017.

Based on our investigation the proposed development is feasible from a geotechnical viewpoint provided the recommendations presented in this report are implemented during design and construction.

If you have any questions regarding this report, please do not hesitate to contact this office. We appreciate this opportunity to be of service.

Respectfully submitted,

TGR GEOTECHNICAL, INC.

Sanjay Govil, PhD, PE, GE 2382
Principal Geotechnical Engineer

Edward L. Burrows, M.S, PG, CEG 1750
Principal Engineering Geologist

Distribution: (4) Addressee

Attachments:

Figure 1 - Site Location Map
Figure 2 - Regional Geology Map
Figure 3 - Historically High Groundwater Map
Figure 4 - Regional Fault Map
Figure 5 - Seismic Hazard Zone Map
Figure 6 - Retaining Wall Detail

Plate 1 - Geotechnical Map

Appendix A – References
Appendix B – Log of Borings and CPTs by TGR and APEX
Appendix C – Laboratory Testing Procedures and Results
Appendix D – Liquefaction

INTRODUCTION

Site Descriptions and Proposed Project Development

The subject site consists of two vacant undeveloped dirt covered parcels of land consisting of a total of 8.38 acres. The westernmost parcel is bounded by Walnut Avenue on the east, Gundry Avenue on the west, an apartment complex currently under construction on the north and a landscaped area running parallel with E. Wesley Avenue to the south. This parcel is currently bisected by East 21st Street. The easternmost parcel is bounded by Walnut Avenue on the west, Gaviota Avenue on the east, Alamitos Avenue on the south and American University of Health Services on the north. Both the east and west parcels have a southerly gradient with elevations ranging from 45 feet above mean seal level (msl) along the northern property boundary to approximately 22 feet above msl at the southeast corner of the site. The elevations on the eastern parcel range from 42 feet above msl along the northern property boundary to 23 feet above msl at the southern boundary of the site. A limited review of available historic aerial photos shows that from at least 2002 to 2013 there were soil stockpiles at various locations across both sites. In 1994, there were numerous large diameter storage tanks located on both parcels along with other structures that appear to be oil field related.

Based on our review of the conceptual site plan (GAA Architects, 2017), we understand that the proposed development of the site will consist of nine buildings ranging in size from 6,900 sq. ft. to 26,400 sq. ft. with associated parking, drive aisles, and trash enclosures.

Previous Studies

Prior to the preparation of our report, TGR was provided with boring and CPT logs completed by APEX. The borings and CPTs were completed as part of environmental studies for the subject site. The logs of borings and CPTs by APEX are presented in Appendix B and the locations of the borings and CPTs are shown on Plate 1. Findings these boring and CPT logs are as follows:

The borings, for the most part, were in the northern portion of the westernmost parcel (above 21st Street). The CPTs were in both the northern and southern portions of the westernmost parcel as well as the eastern parcel. The borings consisted of seven (7) 2.5-inch-diameter geoprobes advanced to depths of 32 to 40 feet below ground surface (bgs) and one (1) 8-inch diameter hollow stem auger boring advanced to a depth of 35 feet bgs. Twenty-one (21) CPTs were advanced to depths ranging from approximately 28 to 51 feet bgs.

The subsurface conditions encountered in the APEX borings generally consisted of a blanket of artificial fill ranging from one (1) to five (5) feet in depth which was encountered throughout the project site. Immediately underlying the artificial fill to depths ranging from 8 ½ to 14 feet silt and clayey silt was encountered. Below this and generally extending to the maximum depths explored, sand was encountered. Groundwater was encountered within the APEX borings at depths ranging from 24 to 40 feet bgs.

Scope of Work

The scope of work for this geotechnical investigation included the following:

- Site reconnaissance.

- Review of readily available aerial photographs and previous work done for the site.
- Excavation of five (5) hollow stem auger borings to the approximate depths of 16.5 feet to 51.5 feet below the existing grade.
- Laboratory testing of selected samples for in-situ moisture density, maximum dry density and optimum moisture content, shear, consolidation, expansion potential, sulfates, corrosion, R-value, and sieve analysis.
- Analyses of data, including site seismicity, liquefaction study, seismic settlement, and foundation design for proposed improvements, and soils engineering/earthwork with respect to the suitability of the proposed development.
- Preparing this report summarizing current subsurface soil conditions, findings, and presenting our recommendations for the proposed development.

Field Investigation

Field exploration was performed on April 6, 2017 by a member from our firm who logged the borings and obtained representative samples, which were subsequently transported to the laboratory for further review and testing. The approximate locations of the borings are indicated on the enclosed Boring Location Map (Plate 1).

The subsurface conditions were explored by drilling, sampling, and logging five borings with a truck mounted hollow stem drill rig. Borings B-1 and B-5 were advanced to an approximate depth of 16.5 feet below existing grade, boring B-2 was advanced to an approximate depth of 26.5 feet below existing grade, and borings B-3 and B-4 were advanced to a depth of 51.5 feet below existing grade. Subsequent to drilling, all borings were backfilled with bentonite and the cuttings drummed for disposal by others. The logs of borings presenting soil conditions and descriptions are given in Appendix B.

The drill rig was equipped with a sampling apparatus to allow for recovery of driven modified California Ring Sampler (CRS), 3-inch outside diameter, and 2.42-inch inside diameter and SPT samples. Driven samples and bulk samples of the earth materials encountered at selected intervals were recovered from the borings.

The samples were driven using an automatic 140-pound hammer falling freely from a height of 30 inches. The blow counts for CRS were converted to equivalent SPT blow count. Soil descriptions were entered on the logs in general accordance with the Unified Soil Classification System (USCS). The locations and depths of the soil samples recovered are indicated on the logs in Appendix B.

Laboratory Testing

Laboratory tests were performed on representative samples to verify the field classification of the recovered samples and to evaluate the geotechnical properties of the subsurface soils. The following tests were performed:

- In-situ moisture content (ASTM D2216) and dry density (ASTM D7263);
- Maximum Dry Density and Optimum Moisture Content (ASTM D1557);
- Corrosion series:
  1. Soluble Sulfate (CAL.417A);
  2. Soluble Chlorides (CAL.422);

    3. Minimum Resistivity (CAL.643); and
    4. pH.
- Consolidation (ASTM D2435);
- Direct Shear Strength (ASTM D3080);
- Expansion Potential (ASTM D4829);
- R-Value (CAL 301); and
- Sieve Analysis (ASTM D6913).

Laboratory tests for geotechnical characteristics were performed in general accordance with the ASTM procedures. The results of the in-situ moisture content and density tests are shown on the borings logs (Appendix B). The results of the laboratory tests are presented in Appendix C.

GEOTECHNICAL FINDINGS

Geology

Regional Geologic Setting

The project site is located in the southwest portion of the Long Beach 7.5-minute Quadrangle, Los Angeles County, California. Per the Geologic Map of the Long Beach 30'x60' Quadrangle, Los Angeles County, California (CGS, 2010), the subject site is underlain by Quaternary alluvial deposits comprised of layers of gravel, sand and silt. Figure 2 presents the Regional Geology Map.

Earth Units

Based on our subsurface investigation and a review of the borings by APEX, the subject area is underlain by a thin mantle of fill overlying Quaternary age alluvial deposits. The undocumented fill, which varies in thickness from 1 to 5 feet, consisted of sandy silt with scattered gravels. The undocumented fill is not considered suitable for support of the proposed structures. Based on verbal conversations with APEX, some oversize material (cobble to boulder size) was encountered during their field exploration in the southern portion of the western parcel. Based on a photo provided to us, the oversize material appears to be concrete. Given the history of the site and the observation of previous stockpiled material at the site as part of our limited aerial photo review, oversize material may be encountered during grading. While the amount of oversize material at the site is anticipated to be minor, its presence should be noted and accounted for. The underlying alluvium was present to the maximum depth explored of 51.5 feet below the existing grade. Generally, the alluvium consisted of silt and clayey silt in the upper 10 to 15 feet. Below this depth, the soils generally consisted of fine to medium grained sand with some clay and silt layers to the total depth explored of 51.5 feet below grade. Detailed descriptions of the earth units encountered in our borings are presented in the log of the borings.

Groundwater

Subsurface water was encountered during the exploration at 25 to 29 feet below existing ground surface. Based on our review of available historical groundwater information (CDMG, 1998) regional groundwater has been mapped in the general site area at approximately 15 feet below site grade (Figure 3). Seasonal and long-term fluctuations in the groundwater may occur as a result of variations in subsurface conditions, rainfall, run-off conditions and other factors.

Therefore, variations from our observations may occur. Static groundwater is not anticipated to impact the proposed development.

Seismic Review

Faulting and Seismicity

The subject site, like the rest of Southern California, is located within a seismically active region as a result of being located near the active margin between the North American and Pacific tectonic plates. The principal source of seismic activity is movement along the northwest-trending regional faults such as the San Andreas, San Jacinto and Elsinore fault zones. These fault systems produce approximately 5 to 35 millimeters per year of slip between the plates.

By definition of the State Mining and Geology Board, an active fault is one which has had surface displacement within the Holocene Epoch (roughly the last 11,000 years). The State Mining and Geology Board has defined a potentially active fault as any fault which has been active during the Quaternary Period (approximately the last 1,600,000 years). These definitions are used in delineating Earthquake Fault Zones as mandated by the Alquist-Priolo Geologic Hazard Zones Act of 1972 and as subsequently revised in 1994 (Hart, 1997) as the Alquist-Priolo Geologic Hazard Zoning Act and Earthquake Fault Zones.

These active and potentially active faults are capable of producing potentially damaging seismic shaking at the site. It is anticipated that the subject site will periodically experience ground acceleration as the result of small to moderate magnitude earthquakes. Other active faults without surface expression (blind faults) or other potentially active seismic sources that are not currently zoned and may be capable of generating an earthquake are known to be present under the region.

Based on our review of the referenced geologic maps, as well as our field reconnaissance, the subject site is not included within any Earthquake Fault Zones as created by the Alquist-Priolo Earthquake Fault Zoning Act (Hart, 1997). Our review of geologic literature pertaining to the site area indicates that there are no known active or potentially active faults located within or immediately adjacent to the subject property. The nearest fault to the subject site is the Newport Inglewood Fault, mapped approximately 0.25 miles northeast of the subject site. Other faults nearby include the Los Alamitos Fault mapped 3.6 miles northeast, the THUMS-Huntington Beach Fault mapped approximately 4.9 miles southwest, and the Palos Verdes Fault Zone mapped approximately 6.6 miles southwest of the site. Regional Fault Map (Figure 4) presents the location of the site with respect to the regional faults.

Secondary Seismic Hazards

Surface Fault Rupture and Ground Shaking

Since no known faults are located within the site, surface fault rupture is not anticipated. However, due to the proximity of known active and potentially active faults, severe ground shaking should be expected during the life of the proposed structures.

Liquefaction

Liquefaction is a seismic phenomenon in which loose, saturated, fine-grained granular soils behave similarly to a fluid when subjected to high-intensity ground shaking. Liquefaction occurs when these ground conditions exist: 1) Shallow groundwater; 2) Low density, fine, clean sandy soils; and 3) High-intensity ground motion. Effects of liquefaction can include sand boils, settlement, and bearing capacity failures below foundations.

A review of the Seismic Hazard Zone Map, Long Beach Quadrangle indicates that a portion of the project site is located in an area identified as having a potential for soil liquefaction (see Figure 5). Published historic high groundwater at this site is approximately 15 feet (Seismic Hazard Zone Report 028, 1998). Groundwater was encountered in borings B-3 and B-4 at depths of 25 and 29 feet, respectively. Liquefaction analysis was performed on the subsurface profile represented by borings B-3 and B-4. The analysis utilized a peak ground acceleration of 0.629g (peak ground acceleration for 2% probability of exceedance in 50 years) and a moment magnitude of 7.1. A historic high groundwater of 15 feet below existing grade was utilized in the calculations. The subsurface soils generally have a negligible potential for liquefaction. The total seismic settlement is estimated to be 0.0 to 0.2 inches. Details of calculations are presented in Appendix D.

Seismically Induced Settlement

Ground accelerations generated from a seismic event can produce settlements in sands or in granular earth materials both above and below the groundwater table. This phenomenon is often referred to as seismic settlement and is most common in relatively clean sands, although it can also occur in other soil materials. The total seismic settlement for the above subject site is anticipated to range from 0.0 inches to 0.20 inches. The differential seismic settlement is estimated to be negligible.

Lateral Spreading

Seismically induced lateral spreading involves primarily movement of earth materials due to earth shaking. Lateral spreading is demonstrated by near-vertical cracks with predominantly horizontal movement of the soil mass involved. The topography in the vicinity of the subject site is relatively flat. Therefore, the potential for lateral spreading at the subject site is considered very low.

DISCUSSIONS AND CONCLUSIONS

General

Based on our field exploration, laboratory testing and engineering analysis, it is our opinion that the proposed structures will be safe against hazard from landslide, settlement, or slippage and the proposed construction will have no adverse effect on the geologic stability of the adjacent properties provided our recommendations presented in this report are followed.

Conclusions

Based on our findings and analyses, the subject site is likely to be subjected to moderate to severe ground shaking due to the proximity of known active and potentially active faults. This may reasonably be expected during the life of the structures and should be designed accordingly.

The engineering evaluation performed concerning site preparation and the recommendations presented are based on information provided to us and obtained by us during our office and fieldwork. This report is prepared for the development of the nine industrial buildings between 6,900 and 24,600 square feet and associated parking lots, drive aisles, and trash enclosures at the subject property. In the event that any significant changes are made to the proposed development, the conclusions and recommendations contained in this report shall not be considered valid unless the changes are reviewed and the recommendations of this report are verified or modified in writing by TGR.

RECOMMENDATIONS

Seismic Design Parameters

When reviewing the 2016 California Building Code the following data should be incorporated into the design.

Latitude (degree)	33.7956
Longitude (degree)	-118.1727
Site Class	D
Site Coefficient, F_a	1.0
Site Coefficient, F_v	1.5
Mapped Spectral Acceleration at 0.2-sec Period, S_s	1.631 g
Mapped Spectral Acceleration at 1.0-sec Period, S_1	0.611 g
Spectral Acceleration at 0.2-sec Period Adjusted for Site Class, S_{MS}	1.631 g
Spectral Acceleration at 1.0-sec Period Adjusted for Site Class, S_{M1}	0.916 g
Design Spectral Acceleration at 0.2-sec Period, S_{DS}	1.087 g
Design Spectral Acceleration at 1.0-sec Period, S_{D1}	0.611 g

The structural consultant should review the above parameters and the 2016 California Building Code to evaluate the seismic design.

Conformance to the criteria presented in the above table for seismic design does not constitute any type of guarantee or assurance that significant structural damage or ground failure will not occur during a large earthquake event. The intent of the code is “life safety” and not to completely prevent damage of the structure, since such design may be economically prohibitive.

Foundation Design Recommendations

The proposed buildings may be supported on continuous and/or spread footings. Bearing capacity recommendations for shallow foundations are presented below. These recommendations assume that the footings will be supported on a minimum of three (3) feet or half the width of the footing (whichever is greater) of engineered fill. Existing undocumented fill is considered unsuitable for the support of structures and shall be removed prior to the placement of engineered fill.

For foundations supported on three (3) feet or half the width of the footing (whichever is greater) of engineered fill with minimum ninety (90) percent relative compaction, an allowable bearing pressure of 2000 pounds per square foot may be used in design.

All shallow foundations should extend a minimum of twenty-four (24) inches below the lowest adjacent grade. The minimum recommended footing width is fifteen (15) inches for continuous footing and twenty-four (24) inches for pad footing. A minimum reinforcement of two (2) No. 4 steel bar top and bottom is required for continuous footings from a geotechnical viewpoint.

A one-third (1/3) increase on the aforementioned bearing pressure may be used in design for short-term wind or seismic loads.

Total settlement is estimated to not exceed 1.0 inches and the differential settlement is estimated as 0.50 inches over 30 feet or less.

Resistance to lateral loads including wind and seismic forces may be provided by frictional resistance between the bottom of concrete and the underlying fill soils and by passive pressure against the sides of the foundations. A coefficient of friction of 0.35 may be used between concrete foundation and underlying soil. The recommended passive pressure of the engineered fill may be taken as an equivalent fluid pressure of 250 pounds per cubic foot (2,500 psf max).

Retaining Walls

The following soil parameters may be used for the design of retaining walls with level backfill and a maximum height of ten (10) feet. Retaining walls may be supported on continuous footings with a minimum width of 18 inches and minimum embedment of 24 inches below lowest adjacent grade.

Conditions	Equivalent Fluid Pressure (psf/ft)
Active (level)	45
Active (2:1)	66
Passive	250 (maximum 2500 psf)

- The retaining wall may be designed for a seismic uniform lateral load of $18H^2$ pounds. The seismic load shall be applied at a distance of 0.6H above the base of the wall.
- A coefficient of friction of 0.35 may be used between concrete foundation and underlying soil.
- All footings should meet the setback requirements presented in 2016 CBC.
- The retaining wall should be provided with a drainage system (Miradrain or equivalent) to prevent buildup of hydrostatic pressure behind the walls. We do not recommend omitting the drains behind walls.

In addition to the above lateral forces due to retained earth, surcharge due to improvements, such as an adjacent structure, should be considered in the design of retaining walls. Loads applied within a 1:1 projection from the surcharging structure on the stem of the wall shall be considered as lateral surcharge. For lateral surcharge conditions, we recommend utilizing a horizontal load equal to 50 percent of the vertical load, as a minimum. This horizontal load should be applied below the 1:1 projection plane. To minimize the surcharge load from an adjacent footing, deepened footings may be considered.

Cement Type and Corrosion

Concrete used should be designed in accordance with the provisions of ACI 318-11, Chapter 4 for Exposure Class S0.

Corrosion tests indicate strong corrosion potential for ferrous metals exposed to site soils.

TGR does not practice corrosion engineering. If needed, a qualified specialist should review the site conditions and evaluate the corrosion potential of the site soil to the proposed improvements and to provide the appropriate corrosion mitigations for the project.

Expansive Soil

Expansion index testing performed indicates that the materials underlying the site are considered to have a “very low” expansion potential (EI=10).

Shrinkage/Subsidence

Removal and recompaction of the near surface soils is estimated to result in shrinkage ranging from 10 to 15 percent. Minor ground subsidence is expected to occur in the soils below the zone of removal, due to settlement and machinery working. The subsidence is estimated to be between one and two tenths of a foot.

Slab-On-Grade

Slab-on-grade should be a minimum of 5-inches thick and reinforced with a minimum of No. 4 reinforcing bar on 18-inch centers in two horizontally perpendicular directions. Reinforcing should be properly supported to ensure placement near the vertical midpoint of the slab. "Hooking" of the reinforcement is not considered an acceptable method of positioning the steel. The slab should not be structurally connected to the buildings. The subgrade material should be compacted to a minimum of 90 percent of the maximum laboratory dry density (ASTM 1557) to a minimum depth of three (3) feet. Prior to placement of concrete, the subgrade soils should be well moistened to at least optimum moisture content and verified by our field representative. The actual thickness and reinforcement of the slab shall be designed by the structural engineer and should include the anticipated loading condition (fork lift, etc.) and the anticipated use of the building. Areas requiring moisture sensitive flooring shall be underlain by a minimum 10-mil visqueen overlain and underlain by 2-inches clean moist sand.

Flatwork

Flatwork should be a minimum of 4-inches thick should be reinforced with a minimum of No. 3 reinforcing bar on 24-inch centers in two horizontally perpendicular directions. Reinforcing should be properly supported to ensure placement near the vertical midpoint of the slab. "Hooking" of the reinforcement is not considered an acceptable method of positioning the steel. The subgrade material should be compacted to a minimum of 90 percent of the maximum laboratory dry density (ASTM 1557) to a minimum depth of two (2) feet. Prior to placement of concrete, the subgrade soils should be well moistened to at least optimum moisture content and verified by our field representative. The actual thickness and reinforcement of the slab shall be designed by the structural engineer and should include the anticipated loading condition. Due to the presence of near surface compressible soils, some movement of the flatwork is anticipated.

Site Development Recommendations

General

During earthwork construction, all site preparation and the general procedures of the contractor should be observed, and the fill selectively tested by a representative of TGR. If unusual or unexpected conditions are exposed in the field, they should be reviewed by this office and if warranted, modified and/or additional recommendations will be offered. During site work, voids created from removal of buried elements (footings, pipelines, etc) shall be backfilled with engineered fill (min 90% relative compaction per ASTM D1557) under the observation of TGR.

Grading

All grading should conform to the guidelines presented in the California Building Code (2016 edition), except where specifically superseded in the text of this report. Prior to grading, TGR's representative should be present at the pre-construction meeting to provide grading guidelines, if needed, and review any earthwork. All uncertified fill within the building footprint and 5 feet outside laterally should be removed and replaced with engineered fill. Based on our review of information provided by APEX, it is our understanding that a portion of the onsite soils have environmental contamination that would require export and proper disposal of excavated soils. Due to the required removal of soil, export should be expected, and import of approved soil may be required to achieve design grades.

To support the foundation a minimum three (3) feet or half the width of the footing (whichever is greater) of approved engineered fill should be placed under the footings. A minimum of three (3) feet of engineered fill is recommended under slab-on-grade, and a minimum of two (2) feet of engineered fill is recommended under flatwork and pavement. Site soils could be reused as engineered fill provided there are no environmental concerns with the soil and the recommendations presented in this report are implemented. Exposed bottoms should be scarified a minimum of 6-inches, moisture conditioned and compacted to a minimum 90 percent relative compaction. Subsequently, site fill soils should be re-compacted to a minimum of ninety (90) percent relative compaction at a minimum of optimum moisture content. The lateral extent of removals beyond the building/structure/footing limits should be equal to at least the depth of fill or 5 feet, whichever is greater.

The depth of over-excavation should be reviewed by the Geotechnical Consultant during the actual construction. Any subsurface obstruction buried structural elements, and unsuitable material encountered during grading, should be immediately brought to the attention of the Geotechnical Consultant for proper exposure, removal and processing, as recommended.

Fill Placement

Prior to any fill placement, TGR should observe the exposed surface soils. The site soils may be re-used as engineered fill provided they comply with environmental regulations and are free of organic content and particle size greater than 4-inches. Fill shall be moisture-conditioned to a minimum of optimum moisture content and compacted to a minimum relative compaction of 90 percent in accordance with ASTM D1557. Any import soils shall be non-expansive and approved by TGR Geotechnical Inc.

Compaction

Prior to fill placement, the exposed surface should be scarified to a minimum depth of six (6) inches, fill placed in six (6) inch thick loose lifts if cohesionless and eight (8) inch thick loose lifts if cohesive fill, moisture conditioned to near optimum for cohesionless soils or a minimum of two (2) percent over optimum moisture for cohesive soils, and compacted to a minimum relative compaction of ninety (90) percent in accordance with ASTM D 1557.

Trenching

All excavations should conform to CAL-OSHA and local safety codes.

Drainage

Positive site drainage should be maintained at all times. Water should be directed away from foundations and not allowed to pond and/or seep into the ground. Pad drainage should be directed towards street/parking or other approved area.

Utility Trench Backfill

All utility trench backfill in structural areas and beneath hardscape features should be brought to near-optimum moisture content and compacted to a minimum relative compaction of 90 percent of the laboratory standard. Flooding/jetting is not recommended.

Sand backfill, (unless trench excavation material), should not be allowed in parallel exterior trenches adjacent to and within an area extending below a 1:1 plane projected from the outside bottom edge of the footing. All trench excavations should minimally conform to CAL-OSHA and local safety codes. Soils generated from utility trench excavations may be used provided it is moisture conditioned and compacted to 90 percent minimum relative compaction.

Percolation Testing

The upper 10 to 15 feet of the onsite soils consisted of silts and clayey silts where explored. The historic high groundwater for the general site area is approximately 15 feet below ground surface. Furthermore, the onsite soils had a moderate to strong hydrocarbon odor. Based on the above, percolation testing was not performed at the subject site.

Preliminary Pavement Design

The Caltrans method of design was utilized to develop the following asphalt pavement section. The section was developed based on a tested “R-Value” for site subgrade soils.

Traffic indices of 4.5, 5, 6, and 7 were assumed for use in the evaluation of automobile parking stalls and driveways, and medium and heavy truck driveways, respectively. The traffic indices are subject to approval by controlling authorities and shall be approved by the project civil engineer.

ASPHALT PAVEMENT SECTION					PCC PAVEMENT SECTION		
Pavement Utilization	Traffic Index	Asphalt (Inch)	Aggregate Base (Inch)	Total (Inch)	PCC	Aggregate Base (Inch)	Total (Inch)
Parking Stalls	4.5	3.0	4.0	7.0	--	--	--
Auto Driveways	5.0	3.0	6.0	9.0	--	--	--
Truck Aisles/ Driveways	6.0	4.0	6.0	10.0	**7	-	7
Loading Dock	7.0	4.0	8.0	12.0	**7	-	7

**Minimum concrete compressive strength of 4,000 psi.

Aggregate base material should consist of CAB/CMB complying with the specifications in Section 200.2.2 of the current "Standard Specifications for Public Works Construction" and should be compacted to at least ninety-five (95) percent of the maximum dry density (ASTM D1557). The surface of the aggregate base should exhibit a firm and unyielding condition just prior to the placement of asphalt concrete paving.

The pavement subgrade should be constructed in accordance with the recommendations presented in the grading section of this report.

The PCC pavement should be minimally reinforced with #4 bars at 24-inches on center in two perpendicular directions or a minimum 7 pounds per cubic yard of Fibermesh 650 (or equivalent). The maximum joint spacing shall be 10 feet on center.

The R-value and the associated pavement section should be confirmed at the completion of site grading.

Geotechnical Review of Plans

All grading and foundation plans should be reviewed and accepted by the geotechnical consultant prior to construction. If significant time elapses since preparation of this report, the geotechnical consultant should verify the current site conditions, and provide any additional recommendations (if necessary) prior to construction.

Geotechnical Observation/Testing During Construction

The geotechnical consultant should perform observation and/or testing at the following stages:

- During any grading and fill placement;
- After foundation excavation and prior to placing concrete;
- During placement of aggregate base and asphalt concrete;

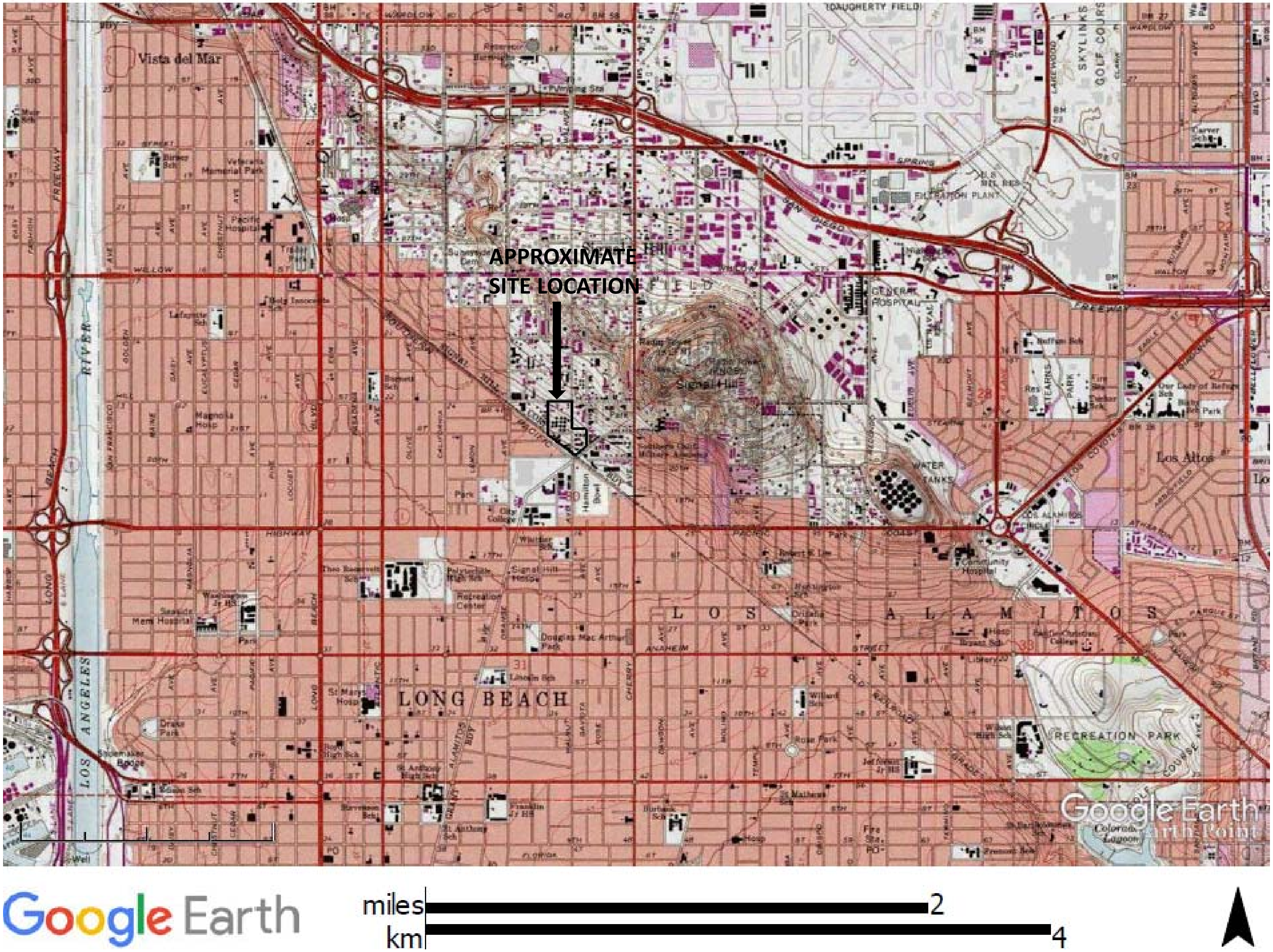
- When any unusual soil conditions are encountered during any construction operation subsequent to issuance of this report.

Limitations

This report was prepared for a specific client and a specific project, based on the client's needs, directions and requirements at the time.

This report was necessarily based upon data obtained from a limited number of observances, site visits, soil and/or other samples, tests, analyses, histories of occurrences, spaced subsurface exploration and limited information on historical events and observations. Such information is necessarily incomplete. Variations can be experienced within small distances and under various climatic conditions. Changes in subsurface conditions can and do occur over time.

This report is not authorized for use by, and is not to be relied upon by any party except the client with whom TGR contracted for the work. Use or reliance on this report by any other party is that party's sole risk. Unauthorized use of or reliance on this report constitutes and agreement to defend and indemnify TGR from and against any liability which may arise as a result of such use or reliance, regardless of any fault, negligence, or strict liability of TGR.



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Hydrogeology
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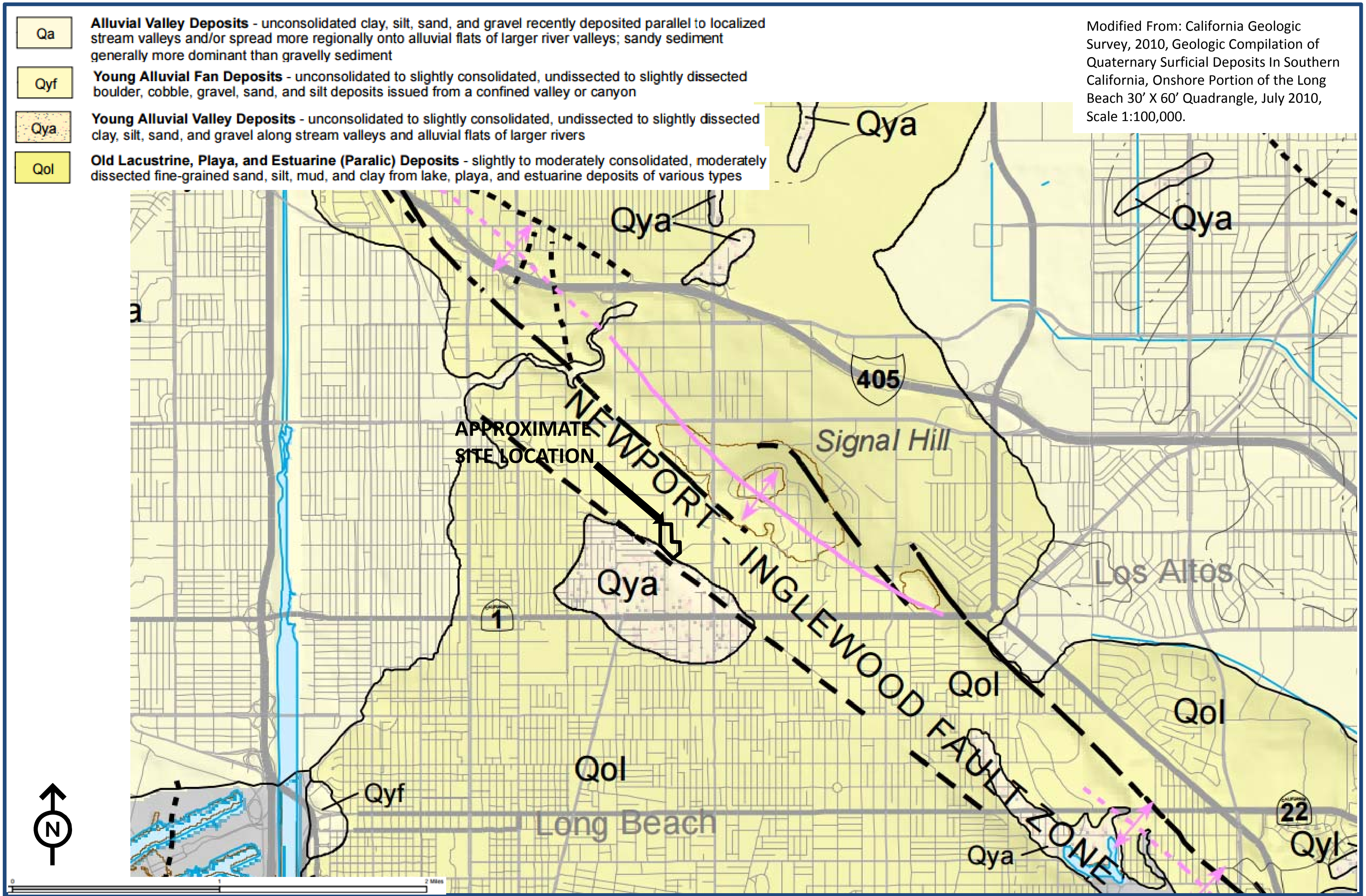
SITE LOCATION MAP
SIGNAL HILL BUSINESS PARK,
2020 WALNUT AVENUE, SIGNAL HILL, CALIFORNIA

PROJECT NO. 16-6239

FIGURE 1



Qa	**Alluvial Valley Deposits** - unconsolidated clay, silt, sand, and gravel recently deposited parallel to localized stream valleys and/or spread more regionally onto alluvial flats of larger river valleys; sandy sediment generally more dominant than gravelly sediment
Qyf	**Young Alluvial Fan Deposits** - unconsolidated to slightly consolidated, undissected to slightly dissected boulder, cobble, gravel, sand, and silt deposits issued from a confined valley or canyon
Qya	**Young Alluvial Valley Deposits** - unconsolidated to slightly consolidated, undissected to slightly dissected clay, silt, sand, and gravel along stream valleys and alluvial flats of larger rivers
Qol	**Old Lacustrine, Playa, and Estuarine (Paralic) Deposits** - slightly to moderately consolidated, moderately dissected fine-grained sand, silt, mud, and clay from lake, playa, and estuarine deposits of various types

Modified From: California Geologic Survey, 2010, Geologic Compilation of Quaternary Surficial Deposits In Southern California, Onshore Portion of the Long Beach 30' X 60' Quadrangle, July 2010, Scale 1:100,000.

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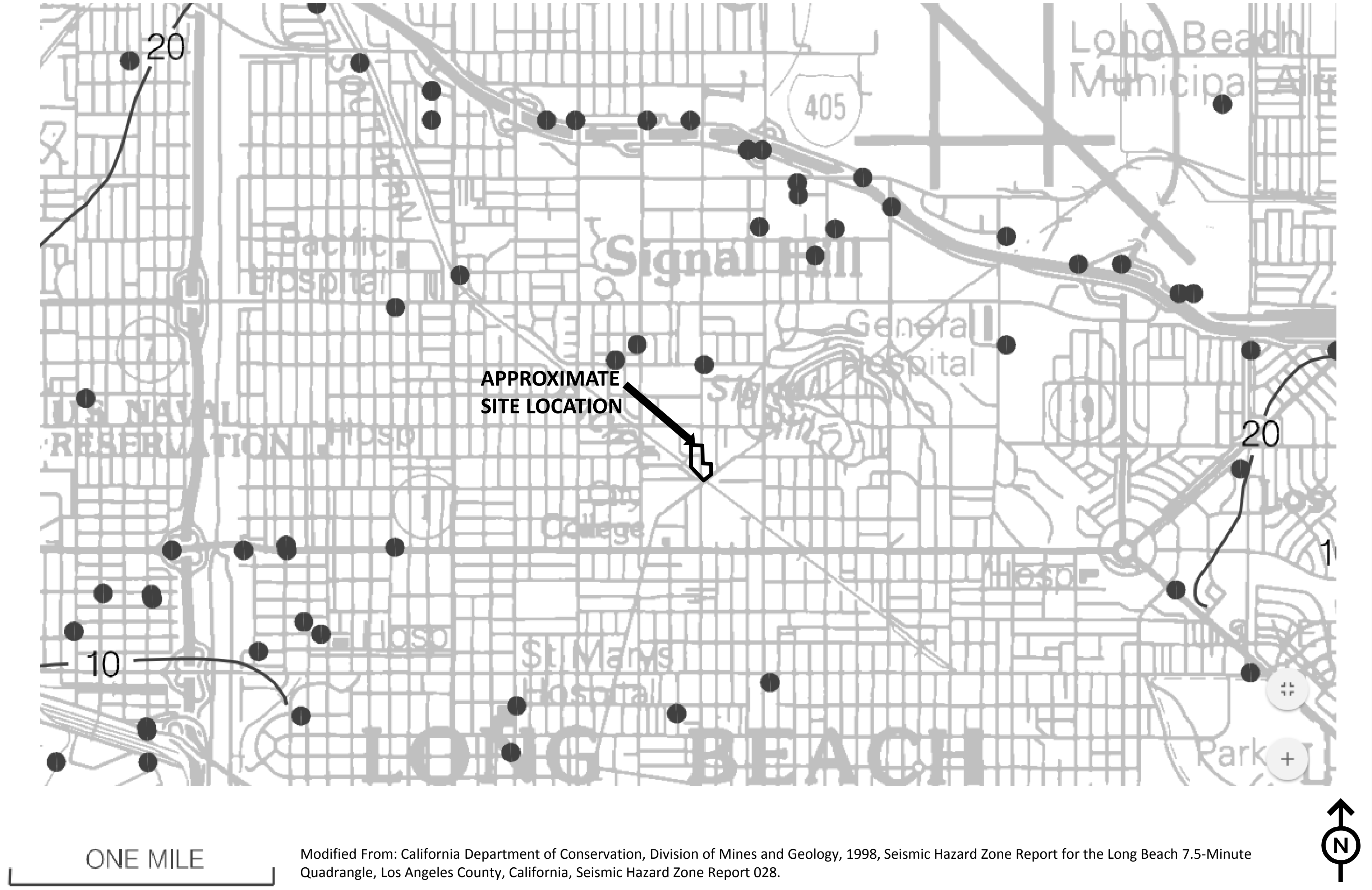
REGIONAL GEOLOGY MAP
SIGNAL HILL BUSINESS PARK,
2020 WALNUT AVENUE, SIGNAL HILL, CALIFORNIA

PROJECT NO. 16-6239

FIGURE 2



Modified From: California Department of Conservation, Division of Mines and Geology, 1998, Seismic Hazard Zone Report for the Long Beach 7.5-Minute Quadrangle, Los Angeles County, California, Seismic Hazard Zone Report 028.

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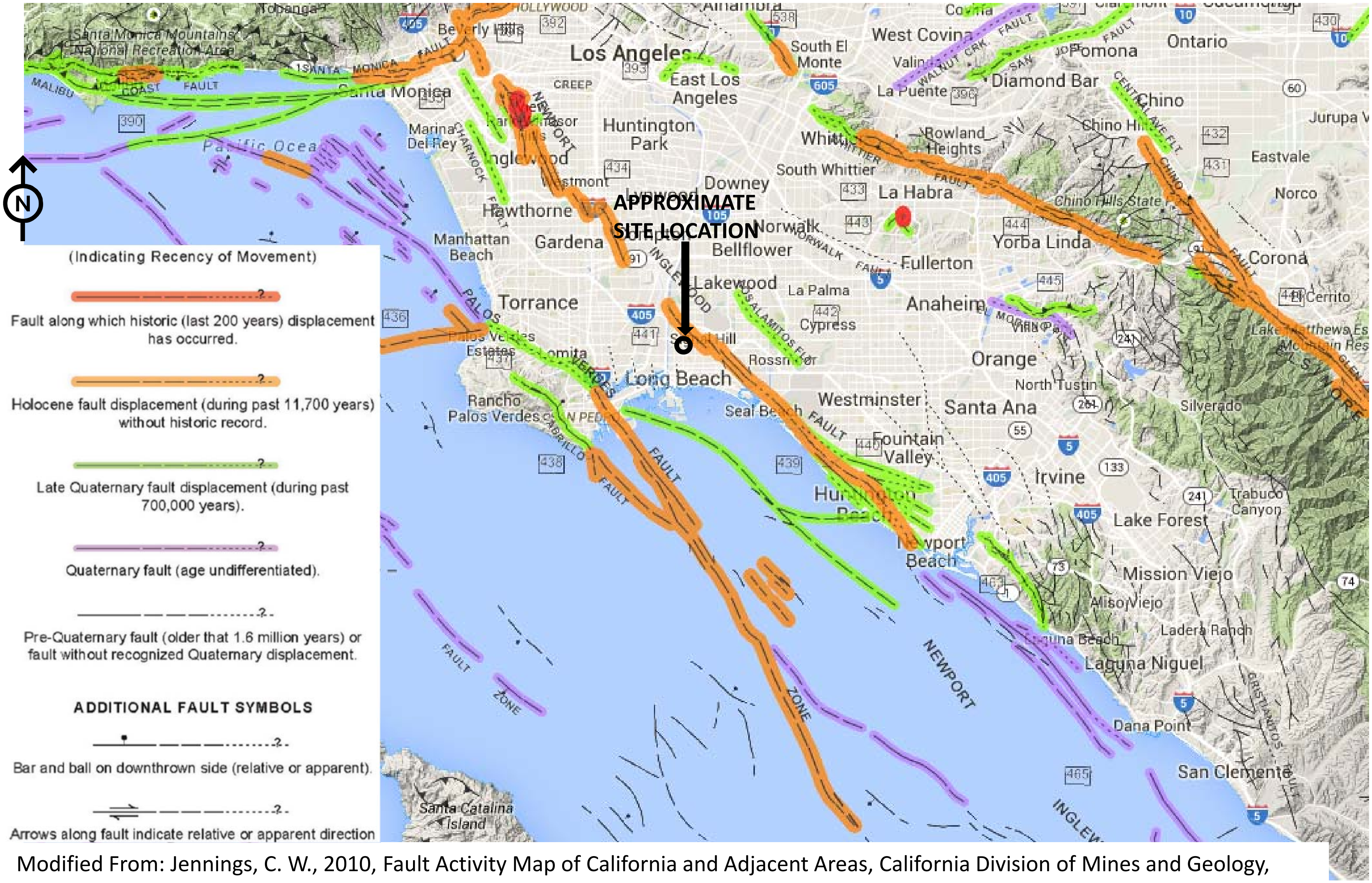
HISTORIC HIGH GROUNDWATER MAP
SIGNAL HILL BUSINESS PARK,
2020 WALNUT AVENUE, SIGNAL HILL, CALIFORNIA

PROJECT NO. 16-6239

FIGURE 3



Modified From: Jennings, C. W., 2010, Fault Activity Map of California and Adjacent Areas, California Division of Mines and Geology, Geologic Data Map Series, No. 6, Scale 1:750,000.

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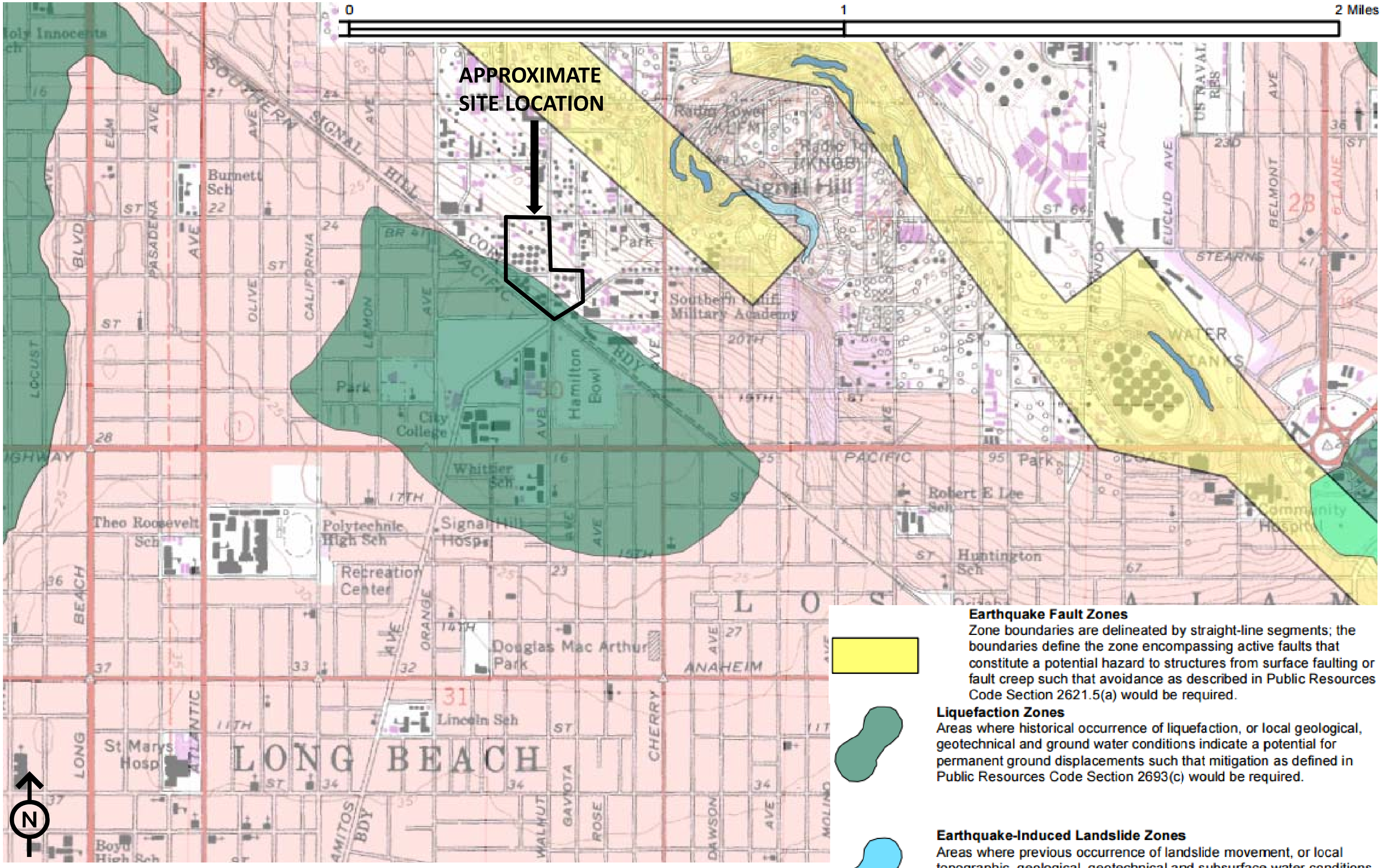
REGIONAL FAULT MAP
SIGNAL HILL BUSINESS PARK,
2020 WALNUT AVENUE, SIGNAL HILL, CALIFORNIA

PROJECT NO. 16-6239

FIGURE 4



🟨 **Earthquake Fault Zones**
Zone boundaries are delineated by straight-line segments; the boundaries define the zone encompassing active faults that constitute a potential hazard to structures from surface faulting or fault creep such that avoidance as described in Public Resources Code Section 2621.5(a) would be required.

🟩 **Liquefaction Zones**
Areas where historical occurrence of liquefaction, or local geological, geotechnical and ground water conditions indicate a potential for permanent ground displacements such that mitigation as defined in Public Resources Code Section 2693(c) would be required.

🟦 **Earthquake-Induced Landslide Zones**
Areas where previous occurrence of landslide movement, or local topographic, geological, geotechnical and subsurface water conditions indicate a potential for permanent ground displacements such that mitigation as defined in Public Resources Code Section 2693(c) would be required.

Modified From: California Geologic Survey, 1998, Earthquake Zones of Required Investigation, Long Beach Quadrangle, Earthquake Fault Zones Revised Official Map Released July 1, 1986, Seismic Hazard Zones official map Released March 25, 1999

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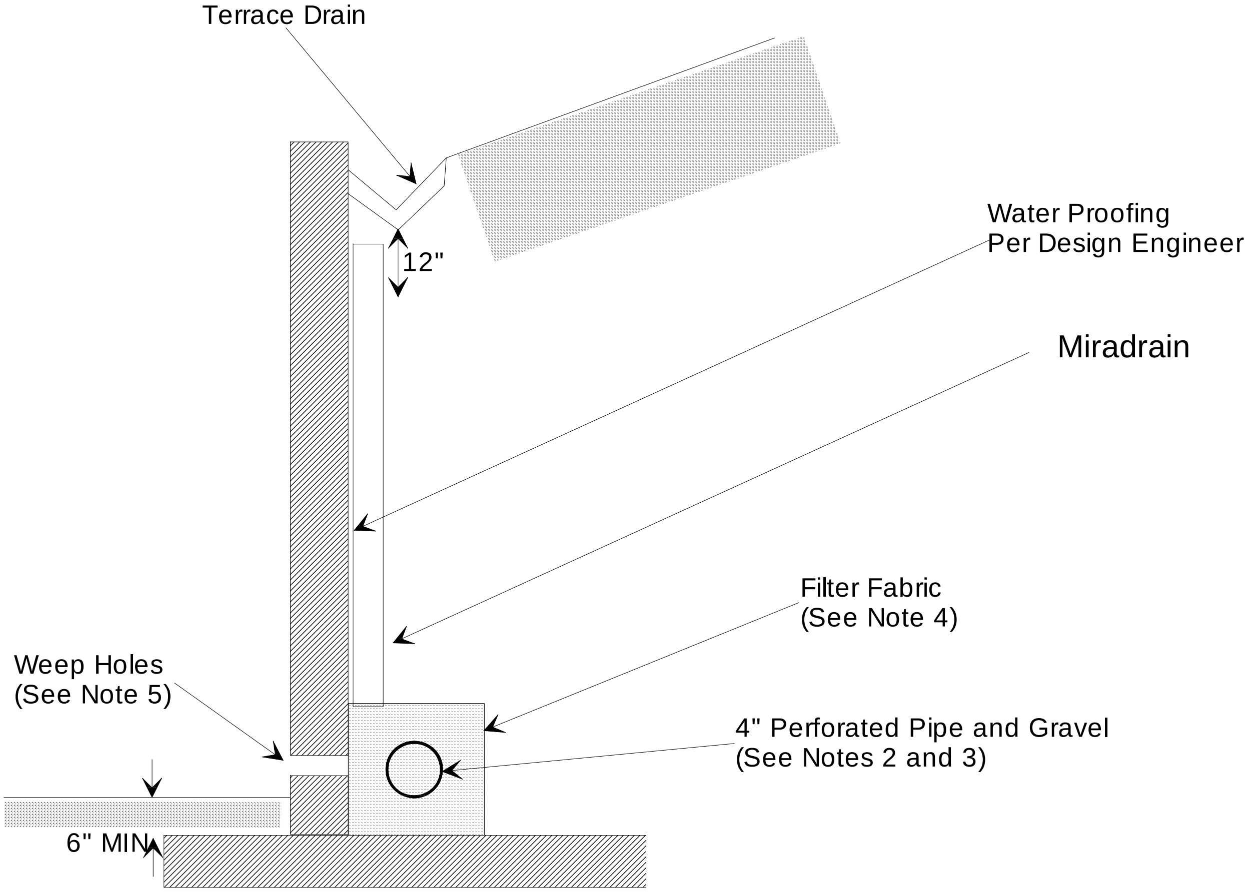
SEISMIC HAZARD ZONE MAP
SIGNAL HILL BUSINESS PARK,
2020 WALNUT AVENUE, SIGNAL HILL, CALIFORNIA

PROJECT NO. 16-6239

FIGURE 5



GENERAL NOTES

- Waterproofing should be provided where moisture through the wall is undesirable.
- Waterproofing of the wall is not under the purview of the geotechnical engineer.
- All drains should have a minimum 1% gradient.
- The subdrain should have a 4-inch diameter solid pipe outlet discharging to a suitable disposal area and shall be designed by the project engineer. The subdrain pipe shall be accessible for cleaning.
- Other subdrain backfill options are subject to review by the geotechnical engineer and may involve modification of the design parameters.

NOTES

1. The granular backfill shall have a sand equivalent of 30 or greater and shall be non expansive. or greater and shall be well graded & non expansive.
2. One (1) cubic foot per foot of 1/4 to 1-1/2 inch gravel wrapped in filter fabric.
3. Pipe shall be ABS SDR35 or PVC Schedule 40 or equivalent with 3/8 inch perforations. Pipe shall be installed with performations down.
4. The filter fabric shall be Mirafi 140NC or equivalent.
5. Weepholes shall be a minimum 3-inch in diameter and spaced no more than 10 foot on center. The weepholes shall drain appropriately so as not to adversely impact any foundations. This shall be designed by the project engineer.
6. Final retaining wall plans should be reviewed and approved by the geotechnical engineer.

NOT TO SCALE

TGR

TYPICAL RETAINING WALL
BACKFILL AND SUBDRAIN DETAIL
FOR WALLS UP TO 10 FEET HIGH

Project No.: 16-6239

FIGURE 6

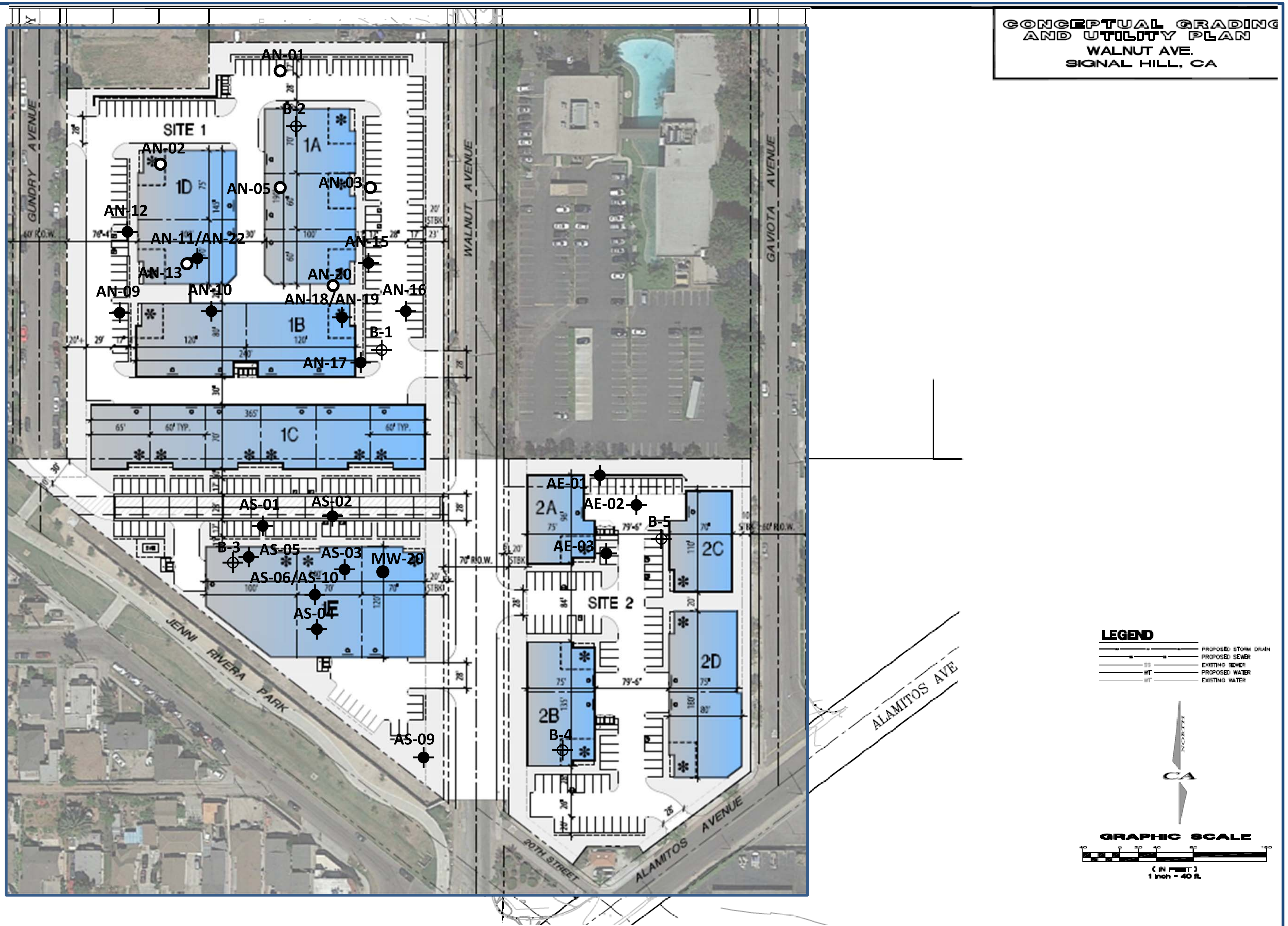
LEGEND

B-5 ⌖ Approximate Location of Boring by TGR

MW-20 ● Approximate Location of Groundwater Monitoring Well (APEX, 2017)

AE-01 ✛ Approximate Location of Boring by UVOST (2016)

AN-20 ○ Approximate Location of Soil and Groundwater Grab Sample (Apex, 2017)



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GEOTECHNICAL MAP
SIGNAL HILL BUSINESS PARK
2020 WALNUT AVENUE, SIGNAL HILL, CALIFORNIA

Project No.:16-6239

PLATE 1

APPENDIX A
REFERENCES

APPENDIX A

References

California, State of, Department of Conservation, Division of Mines and Geology, 2008, Guidelines for Evaluating and Mitigating Seismic Hazards in California, CDMG Special Publication 117A.

___________________, 1998, Maps of Known Active Fault Near – Source Zones in California and Adjacent Portions of Nevada.

___________________, 1998, Seismic Hazard Zone Report for the Long Beach 7.5-Minute Quadrangle, Los Angeles County, California, Seismic Hazard Zone Report 028.

___________________, 1999, State of California Seismic Hazard Zones Map, Long Beach Quadrangle, Official Map Released March 25, 1999, Scale 1:24,000.

___________________, 2010, Geologic Map of California; California Geologic Data Map Series Map No. 2.

GAA Architects, 2017, Conceptual Site Plan Scheme A7.8, Signal Hill Business Park, Project No. XRP018.01, dated 5-9-17

Hart, E. W., 1997, Fault-Rupture Hazard Zones in California, Alquist-Priolo Earthquake Fault Zoning with Index to Special Study Zones Maps: Department of Conservation, Division of Mines and Geology, Special Publication 42.

International Code Council (ICC), California Building Code, 2016 Edition

Jennings, C. W., 2010, Fault Activity Map of California and Adjacent Areas, California Division of Mines and Geology, Geologic Data Map Series, No. 6, Scale 1:750,000.

APPENDIX B
LOG OF BORINGS

THE FOLLOWING DESCRIBES THE TERMS AND SYMBOLS USED ON THE LOG OF BORINGS TO SUMMARIZE THE RESULTS OBTAINED IN THE FIELD INVESTIGATION AND SUBSEQUENT LABORATORY TESTING.

DENSITY AND CONSISTENCY

The consistency of fine grained soils and the density of coarse grained soils are described on the basis of the Standard Penetration Test as follows:

COARSE GRAINED SOILS		**Estimated Unconfined Compressive Strength (Tsf)**	**FINE GRAINED SOILS**	
Very Loose	< 4	< 0.25	Very soft	< 2
Loose	4 – 10	0.35 – 0.50	Soft	2 – 4
Medium	10 – 30	0.50 – 1.0	Firm (medium)	4 – 8
Dense	30 – 50	1.0 – 2.0	Stiff	8 – 15
Very dense	> 50	2.0 – 4.0	Very stiff	15 – 30
		> 4.0	Hard	> 30

PARTICULE SIZE DEFINITION (As per ASTM D2487 And D422)

Boulder	⇒ Larger than 12 inches	Coarse Sands	⇒ No. 10 to No. 4 sieve
Cobbles	⇒ 3 to 12 inches	Medium Sands	⇒ No. 40 to No. 10 sieve
Coarse Gravel	⇒ 3/4 to 3 inches	Fine Sands	⇒ No. 200 to 40 sieve
Fine Gravel	⇒ No. 4 to 3/4 inches	Silt	⇒ 5µm to No. 200 sieve
		Clay	⇒ Smaller than 5µm

SOIL CLASSIFICATION

Soils and bedrock are classified and described based on their engineering properties and characteristics and using ASTM D2487 and D2488.

Percentage description of minor components

Trace	1-10 %	Some	20-35 %
Little	10-20 %	And or y	35-50 %

Stratified soils description

Parting	0 to 1/16 inch thick	Layer	½ to 12 inches thick
Seam	1/16 to ½ inch thick	Stratum	> 12 inches thick

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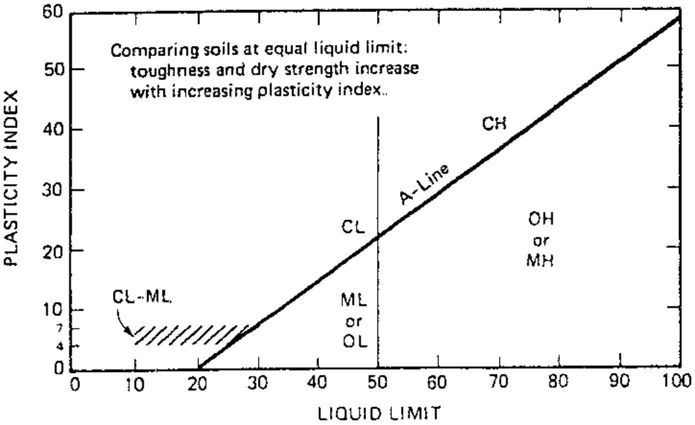
LOG OF BORING EXPLANATION

Page 1 of 2

PLATE 1

SOIL CLASSIFICATION CHART

MAJOR DIVISIONS			SYMBOLS		TYPICAL DESCRIPTIONS	CLASSIFICATION CRITERIA
			GRAPH	LETTER		
COARSE GRAINED SOILS MORE THAN 50% OF MATERIAL IS LARGER THAN NO. 200 SIEVE SIZE	GRAVEL AND GRAVELLY SOILS MORE THAN 50% OF COARSE FRACTION RETAINED ON NO. 4 SIEVE	CLEAN GRAVELS (LITTLE OR NO FINES)	●	GW	WELL-GRADED GRAVELS, GRAVEL - SAND MIXTURES, LITTLE OR NO FINES	$C_u = \frac{D_{60}}{D_{10}} > 4$ $C_c = \frac{(D_{30})^2}{D_{10} \times D_{60}} = 1$ to 3
			○	GP	POORLY-GRADED GRAVELS, GRAVEL - SAND MIXTURES, LITTLE OR NO FINES	Not meeting all above requirements
		GRAVELS WITH FINES (APPRECIABLE AMOUNT OF FINES)	○	GM	SILTY GRAVELS, GRAVEL - SAND - SILT MIXTURES	Atterberg limits below "A" line or $I_p<4$
			▩	GC	CLAYEY GRAVELS, GRAVEL - SAND - CLAY MIXTURES	Atterberg limits above "A" line or $I_p>7$
	SAND AND SANDY SOILS MORE THAN 50% OF COARSE FRACTION PASSING ON NO. 4 SIEVE	CLEAN SANDS (LITTLE OR NO FINES)	░	SW	WELL-GRADED SANDS, GRAVELLY SANDS, LITTLE OR NO FINES	$C_u = \frac{D_{60}}{D_{10}} > 6$ $C_c = \frac{(D_{30})^2}{D_{10} \times D_{60}} = 1$ to 3
			░	SP	POORLY-GRADED SANDS, GRAVELLY SAND, LITTLE OR NO FINES	Not meeting all above requirements
		SANDS WITH FINES (APPRECIABLE AMOUNT OF FINES)	▥	SM	SILTY SANDS, SAND - SILT MIXTURES	Atterberg limits below "A" line or $I_p<4$
			▨	SC	CLAYEY SANDS, SAND - CLAY MIXTURES	Atterberg limits above "A" line or $I_p>7$
FINE GRAINED SOILS MORE THAN 50% OF MATERIAL IS SMALLER THAN NO. 200 SIEVE SIZE	SILTS AND CLAYS	LIQUID LIMIT LESS THAN 50	▥	ML	INORGANIC SILTS AND VERY FINE SANDS, ROCK FLOUR, SILTY OR CLAYEY FINE SANDS OR CLAYEY SILTS WITH SLIGHT PLASTICITY	$W_L < 50$
			▩	CL	INORGANIC CLAYS OF LOW TO MEDIUM PLASTICITY, GRAVELLY CLAYS, SANDY CLAYS, SILTY CLAYS, LEAN CLAYS	$W_L < 30$
			☰	OL	ORGANIC SILTS AND ORGANIC SILTY CLAYS OF LOW PLASTICITY	$W_L < 50$
	SILTS AND CLAYS	LIQUID LIMIT GREATER THAN 50	▥	MH	INORGANIC SILTS, MICACEOUS OR DIATOMACEOUS FINE SAND OR SILTY SOILS	$W_L > 50$
			▨	CH	INORGANIC CLAYS OF HIGH PLASTICITY	$W_L > 50$
			▤	OH	ORGANIC CLAYS OF MEDIUM TO HIGH PLASTICITY, ORGANIC SILTS	$W_L > 50$
HIGHLY ORGANIC SOILS			⁂	PT	PEAT, HUMUS, SWAMP SOILS WITH HIGH ORGANIC CONTENTS	Strong color or odor and often fibrous texture



LABORATORY TEST DESIGNATIONS

BR	Bearing Ration	PP	Pocket Penetrometer
C	Consolidation	R	R-Value
COR	Corrosion Test	S	Direct Shear
Chl	Water Soluble Chlorides	SA	Sieve Analysis
EI	Expansive Index	SE	Sand Equivalent
ER	Electrical Resistivity	Sg	Specific Gravity
K	Permeability	SO_4	Water Soluble Sulfates
MC	Moisture Content	SV	Shear Vane
OC	Organic Content	TC	Triaxial Compression
PH	PH Test	UC	Unconfined Compression

ADDITIONAL SOIL CLASSIFICATION

▩	⁘	✕	▨
Fill	Ss Sandstone	Ms Siltstone	Bdr Bedrock

PARTICLE SIZE LIMITS

SILT OR CLAY	SAND			GRAVEL		COBBLES	BOULDERS
	FINE	MEDIUM	COARSE	FINE	COARSE		

NO. 200 NO. 40 NO. 10 NO 4 ¾ in. 3 in. (12 in.)

U. S. STANDARD SIEVE SIZE

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LOG OF BORING EXPLANATION

Page 2 of 2

PLATE 1

LOG OF EXPLORATORY BORING B-1

Sheet **1** of **1**

Project Number: **16-6239**
Project Name: **Xebec Signal Hill**
Date Drilled: **4/6/17 - 4/6/17**
Ground Elev:

Logged By: **ELB**
Project Engineer: **SG**
Drill Type: **Hollow Stem**
Drive Wt & Drop: **140lbs / 30in**

■ Shelby Tube
☒ Standard Split Spoon
◉ No recovery
⧓ Modified California
▼ Water Table ATD

Depth (ft)	Graphic Log	FIELD RESULTS: Bulk Sample	Drive Sample	SPT blows/ft (or equivalent N)	Pocket Pen (tsf)	USCS	SUMMARY OF SUBSURFACE CONDITIONS	LAB RESULTS: Moisture Content (%)	Dry Density, (pcf)	Other Tests
							Surface covered with imported gravel.			
							Silt- brown, slightly moist, stiff.			
			⧓	16		ML		10	116	
5			⧓	34		ML		13	121	
							Silt- grey, slightly moist, slight hydrocarbon odor.			
10			⧓	7		SP	Sand- grey, slightly moist, fine grained, hydrocarbon odor.	17	99	Consol
15			⧓	22		SP	Sand- light grey, slightly moist, fine to medium grained, slight hydrocarbon odor.	3	100	
							Total Depth: 16.5 feet below existing grade. No groundwater encountered during drilling. No caving observed. Boring backfilled with bentonite upon completion, cuttings placed in 55-gallon drums for removal by others.			
20										

PLATE 2

TGR GEOTECHNICAL, INC.

LOG OF EXPLORATORY BORING B-2

Sheet **1** of **1**

Project Number:	**16-6239**	Logged By:	**ELB**
Project Name:	**Xebec Signal Hill**	Project Engineer:	**SG**
Date Drilled:	**4/6/17 - 4/6/17**	Drill Type:	**Hollow Stem**
Ground Elev:		Drive Wt & Drop:	**140lbs / 30in**

■ Shelby Tube
☒ Standard Split Spoon
◉ No recovery
⧓ Modified California
▼ Water Table ATD

Depth (ft)	Graphic Log	FIELD RESULTS Bulk Sample	Drive Sample	SPT blows/ft (or equivalent N)	Pocket Pen (tsf)	USCS	SUMMARY OF SUBSURFACE CONDITIONS	LAB RESULTS Moisture Content (%)	Dry Density, (pcf)	Other Tests
		▤					Silt- brown, dry, loose.			
		▤					Sandy Silt- dark grey, slightly moist, hydrocarbon odor.			
		▤	⧓	6		ML		14	104	Cor., Max, Shear
5			⧓	16		ML		15	118	Consol
10							Silt- grey, slightly moist, hydrocarbon odor, trace of fine grained sand.			
			⧓	11		ML		14	106	
15							Sand- light grey, slightly moist, fine to medium grained, strong hydrocarbon odor.			
			⧓	21		SP		9	95	
20			⧓	42		SP		7	103	
25			☒	44		SP		4		
							Total Depth: 26.5 feet below existing grade. No groundwater encountered during drilling. No caving observed. Boring backfilled with bentonite upon completion, cuttings placed in 55-gallon drums for removal by others.			

This Boring Log should be evaluated in conjunction with the complete geotechnical report. This Boring Log represents conditions observed at the specific location and date indicated, it is not warranted to be representative of subsurface conditions at other locations and times.

PLATE 3

TGR GEOTECHNICAL, INC.

LOG OF EXPLORATORY BORING B-3

Sheet **1** of **2**

Project Number: **16-6239**
Project Name: **Xebec Signal Hill**
Date Drilled: **4/6/17 - 4/6/17**
Ground Elev:

Logged By: **ELB**
Project Engineer: **SG**
Drill Type: **Hollow Stem**
Drive Wt & Drop: **140lbs / 30in**

■ Shelby Tube
☒ Standard Split Spoon
◉ No recovery
⧗ Modified California
▼ Water Table ATD

Depth (ft)	Graphic Log	FIELD RESULTS					SUMMARY OF SUBSURFACE CONDITIONS	LAB RESULTS		
		Bulk Sample	Drive Sample	SPT blows/ft (or equivalent N)	Pocket Pen (tsf)	USCS		Moisture Content (%)	Dry Density (pcf)	Other Tests
							Siltt Sand to Sandy Silt- some clay, dark grey, moist, hydrocarbon odor.			
		■	⧗	20		ML		11	124	EI, Cor., R-value
5			⧗	28		ML	Silt- dark grey, slightly moist, hydrocarbon odor.	13	124	
10			⧗	32		SP	Sand- grey, slightly moist, fine grained, hydrocarbon odor.	10	123	
15			⧗	15		SP	Sand- grey, slightly moist, fine to medium grained, hydrocarbon odor.	14	110	
20			☒	26		SP		19		-200= 3.5%
25			☒	35		SP	▼ ...becomes wet.	18		

LOG OF BORING 16-6239 XEBEC SIGNAL HILL.GPJ TGR GEOTECH.GDT 4/24/17

TGR GEOTECHNICAL, INC.

LOG OF EXPLORATORY BORING B-3

Sheet **2** of **2**

Project Number: **16-6239**
Project Name: **Xebec Signal Hill**
Date Drilled: **4/6/17 - 4/6/17**
Ground Elev:

Logged By: **ELB**
Project Engineer: **SG**
Drill Type: **Hollow Stem**
Drive Wt & Drop: **140lbs / 30in**

■ Shelby Tube
☒ Standard Split Spoon
◉ No recovery
⧓ Modified California
▼ Water Table ATD

Depth (ft)	Graphic Log	FIELD RESULTS Bulk Sample	Drive Sample	SPT blows/ft (or equivalent N)	Pocket Pen (tsf)	USCS	SUMMARY OF SUBSURFACE CONDITIONS	LAB RESULTS Moisture Content (%)	Dry Density, (pcf)	Other Tests
			☒	46		SP	Sand- grey, slightly moist, fine to medium grained, 2-inch thick layer of silt, hydrocarbon odor.	18		
35			☒	26		ML	Clayey Silt- light grey, orange oxidation, slightly moist.	19		
40			☒	42		ML	Clay, Silt, and Sand layers- grey and light grey, slightly moist to moist, fine to medium sand.	30		-200= 74.1%
45			☒	35		SP	Sand- grey, wet, fine grained, hydrocarbon odor.	26		
50			☒			SP		29		-200= 11%
55							Total Depth: 51.5 feet below existing grade. Groundwater encountered at 25 feet below grade during drilling. No caving observed. Boring backfilled with bentonite upon completion, cuttings placed in 55-gallon drums for removal by others.			

This Boring Log should be evaluated in conjunction with the complete geotechnical report. This Boring Log represents conditions observed at the specific location and date indicated, it is not warranted to be representative of subsurface conditions at other locations and times.

TGR GEOTECHNICAL, INC.

LOG OF EXPLORATORY BORING B-4

Sheet **1** of **2**

Project Number: **16-6239**
Project Name: **Xebec Signal Hill**
Date Drilled: **4/6/17 - 4/6/17**
Ground Elev:

Logged By: **ELB**
Project Engineer: **SG**
Drill Type: **Hollow Stem**
Drive Wt & Drop: **140lbs / 30in**

■ Shelby Tube
☒ Standard Split Spoon
◉ No recovery
⧗ Modified California
▼ Water Table ATD

Depth (ft)	Graphic Log	FIELD RESULTS					SUMMARY OF SUBSURFACE CONDITIONS	LAB RESULTS		
		Bulk Sample	Drive Sample	SPT blows/ft (or equivalent N)	Pocket Pen (tsf)	USCS		Moisture Content (%)	Dry Density, (pcf)	Other Tests
0							Sandy Silt- light brown to reddish brown, dry to slightly moist, no hydrocarbon odor.			
			⧗	12		ML		5	106	
5							Silt- reddish brown, dry to slightly moist, no hydrocarbon odor.			
			⧗	>50		ML		6	126	
10							Sand- light brown to reddish brown, slightly moist, fine grained, slight hydrocarbon odor.			
			⧗	41		SP		12	125	Consol
15							Sand- fine to medium grained, light brown, slightly moist, slight hydrocarbon odor.			
			⧗	30		SP		4		
20			☒	56		SP		4		-200= 3.8%
25			☒	49		SP		21		
							▼ ...becomes wet.			

TGR GEOTECHNICAL, INC.

LOG OF EXPLORATORY BORING B-4

Sheet **2** of **2**

Project Number:	**16-6239**	Logged By:	**ELB**
Project Name:	**Xebec Signal Hill**	Project Engineer:	**SG**
Date Drilled:	**4/6/17 - 4/6/17**	Drill Type:	**Hollow Stem**
Ground Elev:		Drive Wt & Drop:	**140lbs / 30in**

■ Shelby Tube
☒ Standard Split Spoon
◉ No recovery
⧗ Modified California
▼ Water Table ATD

Depth (ft)	Graphic Log	FIELD RESULTS Bulk Sample	Drive Sample	SPT blows/ft (or equivalent N)	Pocket Pen (tsf)	USCS	SUMMARY OF SUBSURFACE CONDITIONS	LAB RESULTS Moisture Content (%)	Dry Density, (pcf)	Other Tests
	▨		☒	60		SP	Sand- fine to medium grained, light brown, wet, slight hydrocarbon odor.	21		
35	▨		☒	28		SP	...no hydrocarbon odor.	20		
40	▨		☒	30		SP		28		-200= 44.9%
45	▨		☒	32		SP	Sand- fine to medium grained, light brown, wet, layered with light brown silt.	29		
50	▨		☒	26		SP		25		
							Total Depth: 51.5 feet below existing grade. Groundwater encountered at 29 feet below grade during drilling. No caving observed. Boring backfilled with bentonite upon completion, cuttings placed in 55-gallon drums for removal by others.			
55										

LOG OF EXPLORATORY BORING B-5

Sheet **1** of **1**

Project Number: **16-6239**
Project Name: **Xebec Signal Hill**
Date Drilled: **4/6/17 - 4/6/17**
Ground Elev:

Logged By: **ELB**
Project Engineer: **SG**
Drill Type: **Hollow Stem**
Drive Wt & Drop: **140lbs / 30in**

■ Shelby Tube
☒ Standard Split Spoon
◉ No recovery
⧓ Modified California
▼ Water Table ATD

Depth (ft)	Graphic Log	FIELD RESULTS Bulk Sample	Drive Sample	SPT blows/ft (or equivalent N)	Pocket Pen (tsf)	USCS	SUMMARY OF SUBSURFACE CONDITIONS	LAB RESULTS Moisture Content (%)	Dry Density, (pcf)	Other Tests
		▤	⧓	31		SM	Silty Sand- light brown, dry to slightly moist, no hydrocarbon odor.	5	111	EI, Cor., R-value
5			⧓	49		ML	Silt- reddish brown, slightly moist, no hydrocarbon odor.	9	129	Consol
10			⧓	29		SP	Sand- fine grained, brown, slightly moist, no hydrocarbon odor.	13	122	
15			⧓	21		SP	Sand- medium grained, light brown, slightly moist, no hydrocarbon odor.	5	132	
							Total Depth: 16.5 feet below existing grade. No groundwater encountered during drilling. No caving observed. Boring backfilled with bentonite upon completion, cuttings placed in 55-gallon drums for removal by others.			
20										

PLATE 8

TGR GEOTECHNICAL, INC.

BOREHOLE LOG

BORING / WELL ID: **AN-01**

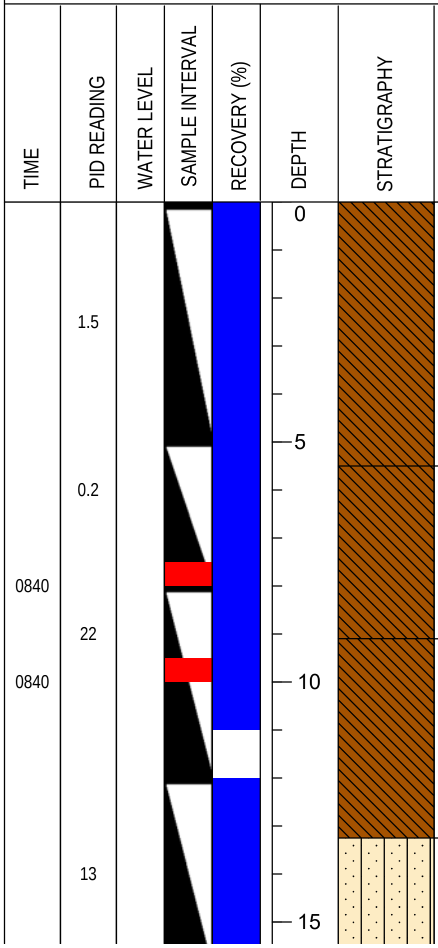
TOTAL DEPTH: **40'**

PROJECT NAME AND SITE ADDRESS: **Former ChemOil Facility, Signal Hill, California**

BORING LOCATION / DESCRIPTION: **North parcel, north side.**

PROJECT INFORMATION		DRILLING INFORMATION	
PROJECT NO.:	**093-CHEMOIL-001**	SUBCONTRACTOR:	**Kehoe Testing & Engineering**
PERMIT NO.:		EQUIPMENT:	**GeoProbe 7800**
LOGGED BY:	**R. Robitaille**	SAMPLING METHOD:	**Continuous 1.75" x 48"**
REVIEWED BY:	**P. Fuller**	MONITORING DEVICE:	**PID 100 ppm Hexane**
SURFACE ELEVATION:	**42.5 feet amsl**	BORING DIAMETER (IN):	**2.5 inches**
CASING TOP ELEVATION:	**NA**	ANNULUS MATERIAL:	**NA**
START DATE (TIME):	**01/04/17 (0750)**	BORING ANGLE: **Vertical**	CASING DIAMETER: **NA**
FINISH DATE (TIME):	**01/04/17 (1000)**	SCREEN INTERVAL:	**NA**

▽ First Water Encountered ▼ Stabilized Water Level 🟥 Sample Packaged for Analysis



LITHOLOGIC DESCRIPTION
(classification, color, moisture, density, grain size / plasticity, other)
ALL PERCENTAGES ARE APPROXIMATE
UNLESS OTHERWISE STATED.

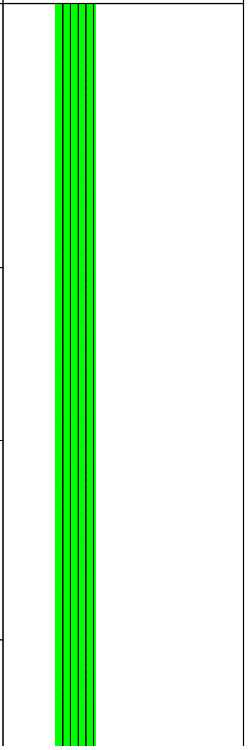
Boring cleared to five feet bgs with hand auger.
ML: Sandy silt with gravel, very dark brown (10YR 3/2), moderately hard, dry, trace concrete debris, fill.

ML: Clayey silt, dark yellowish brown (10YR 4/6), moderately soft, dry, trace fine grained sand.

ML: Dark greenish gray (GLEY 4/1), moderately soft, dry, trace fine grained sand.

SM: Silty sand, gray (5Y 5/1), loose, dry, well sorted fine to very fine grained sand, micaceous.

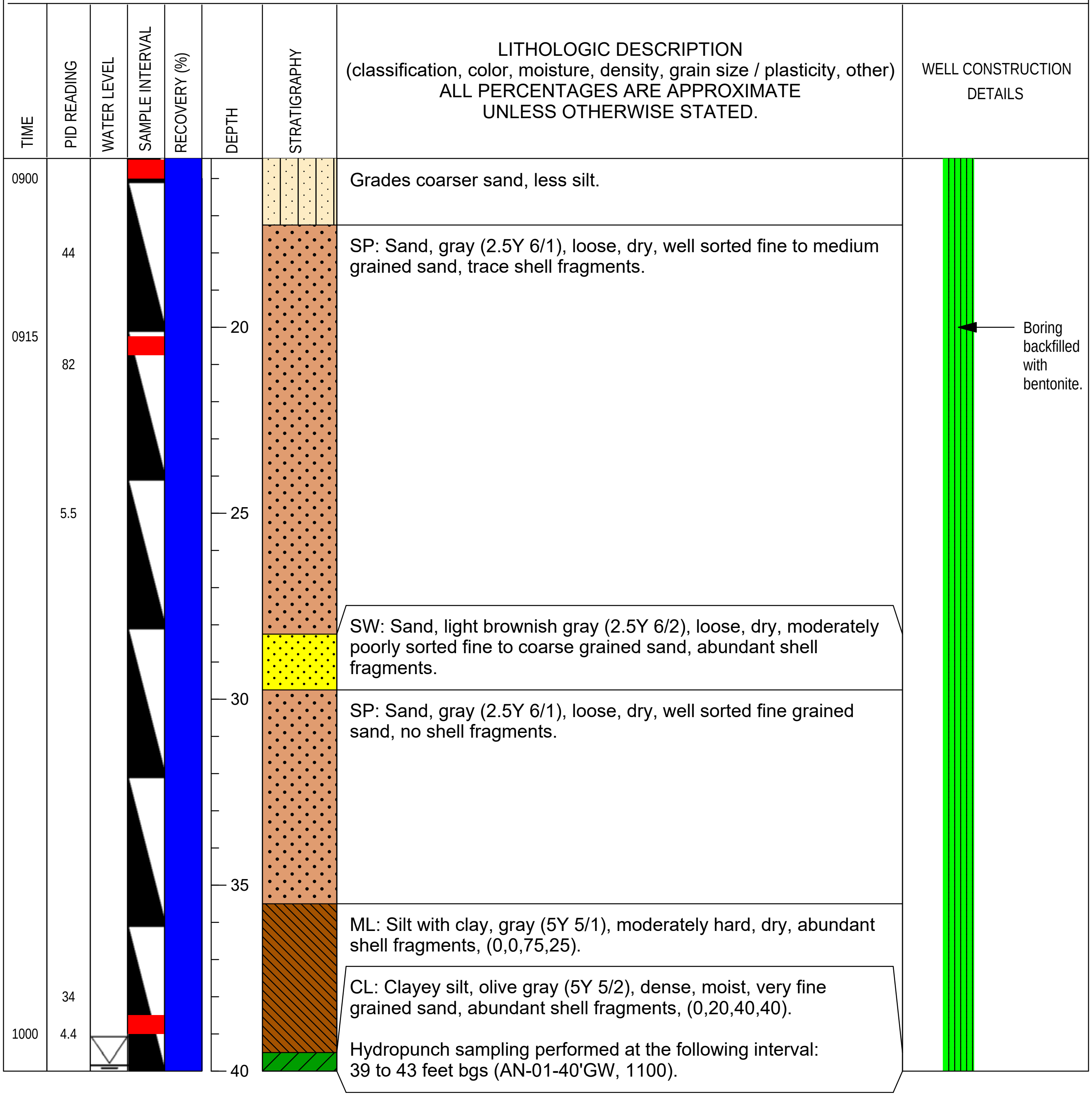
WELL CONSTRUCTION DETAILS



BOREHOLE LOG

BORING / WELL ID: **AN-01**
TOTAL DEPTH: **40'**

PROJECT NAME AND SITE ADDRESS: **Former ChemOil Facility, Signal Hill, California**
BORING LOCATION / DESCRIPTION: **North parcel, north side.**



LITHOLOGIC DESCRIPTION
(classification, color, moisture, density, grain size / plasticity, other)
ALL PERCENTAGES ARE APPROXIMATE
UNLESS OTHERWISE STATED.

Grades coarser sand, less silt.

SP: Sand, gray (2.5Y 6/1), loose, dry, well sorted fine to medium grained sand, trace shell fragments.

SW: Sand, light brownish gray (2.5Y 6/2), loose, dry, moderately poorly sorted fine to coarse grained sand, abundant shell fragments.

SP: Sand, gray (2.5Y 6/1), loose, dry, well sorted fine grained sand, no shell fragments.

ML: Silt with clay, gray (5Y 5/1), moderately hard, dry, abundant shell fragments, (0,0,75,25).

CL: Clayey silt, olive gray (5Y 5/2), dense, moist, very fine grained sand, abundant shell fragments, (0,20,40,40).

Hydropunch sampling performed at the following interval:
39 to 43 feet bgs (AN-01-40'GW, 1100).

BOREHOLE LOG

BORING / WELL ID: **AN-02**
TOTAL DEPTH: **38'**

PROJECT NAME AND SITE ADDRESS: **Former ChemOil Facility, Signal Hill, California**
BORING LOCATION / DESCRIPTION: **North parcel**

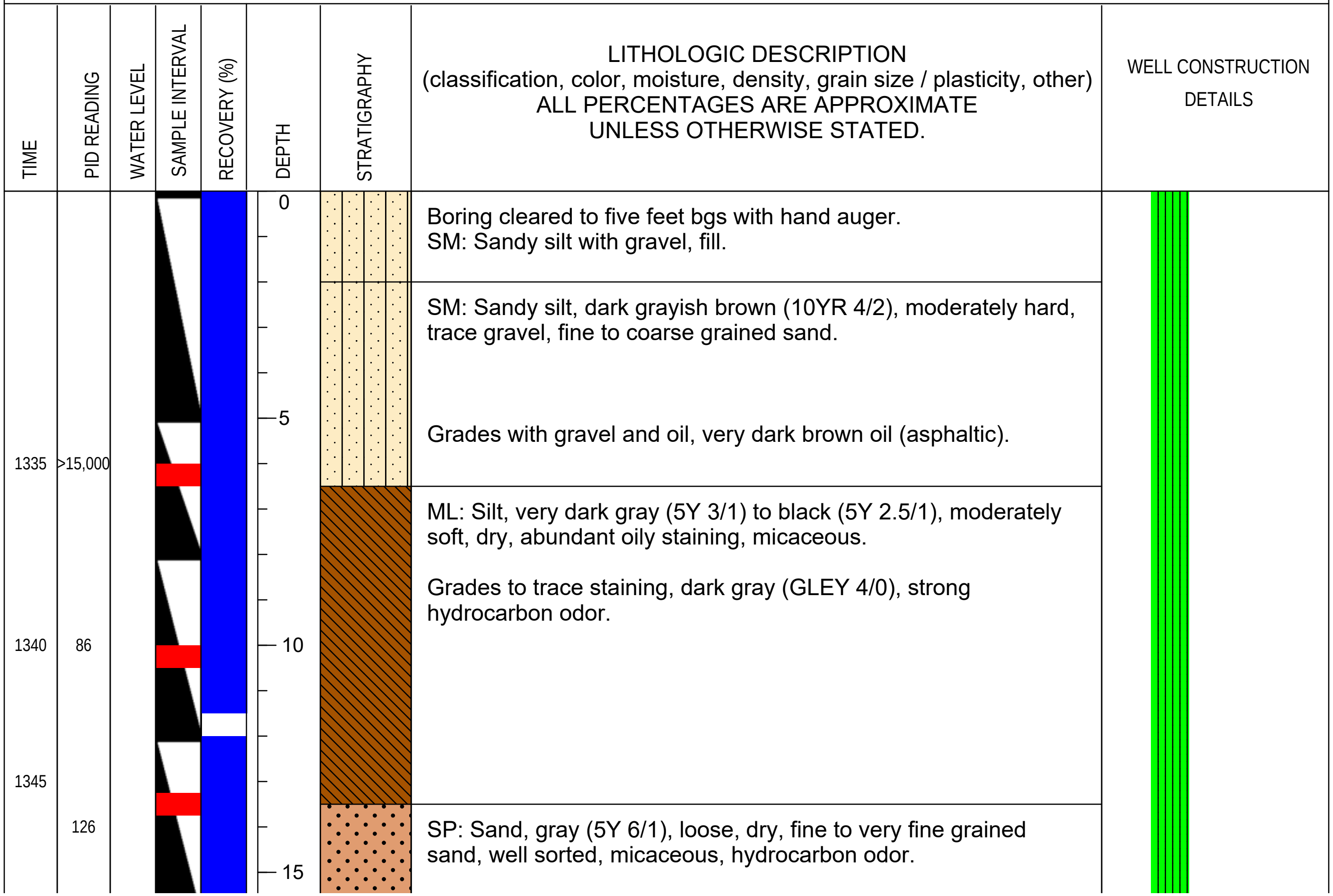
PROJECT INFORMATION

PROJECT NO.: **093-CHEMOIL-001**
PERMIT NO.:
LOGGED BY: **R. Robitaille**
REVIEWED BY: **P. Fuller**
SURFACE ELEVATION: **35.4 feet amsl**
CASING TOP ELEVATION: **NA**
START DATE (TIME): **01/04/17 (1320)**
FINISH DATE (TIME): **01/04/17 (1440)**

DRILLING INFORMATION

SUBCONTRACTOR: **Kehoe Testing & Engineering**
EQUIPMENT: **GeoProbe 7800**
SAMPLING METHOD: **Continuous 1.75' x 48"**
MONITORING DEVICE: **PID 100ppm Hexane**
BORING DIAMETER (IN): **2.5 inches**
ANNULUS MATERIAL: **NA**
BORING ANGLE: **Vertical** CASING DIAMETER: **NA**
SCREEN INTERVAL: **NA**

▽ First Water Encountered ▼ Stabilized Water Level 🟥 Sample Packaged for Analysis



TIME	PID READING
1335	>15,000
1340	86
1345	
	126

LITHOLOGIC DESCRIPTION
(classification, color, moisture, density, grain size / plasticity, other)
ALL PERCENTAGES ARE APPROXIMATE
UNLESS OTHERWISE STATED.

Boring cleared to five feet bgs with hand auger.
SM: Sandy silt with gravel, fill.

SM: Sandy silt, dark grayish brown (10YR 4/2), moderately hard, trace gravel, fine to coarse grained sand.

Grades with gravel and oil, very dark brown oil (asphaltic).

ML: Silt, very dark gray (5Y 3/1) to black (5Y 2.5/1), moderately soft, dry, abundant oily staining, micaceous.

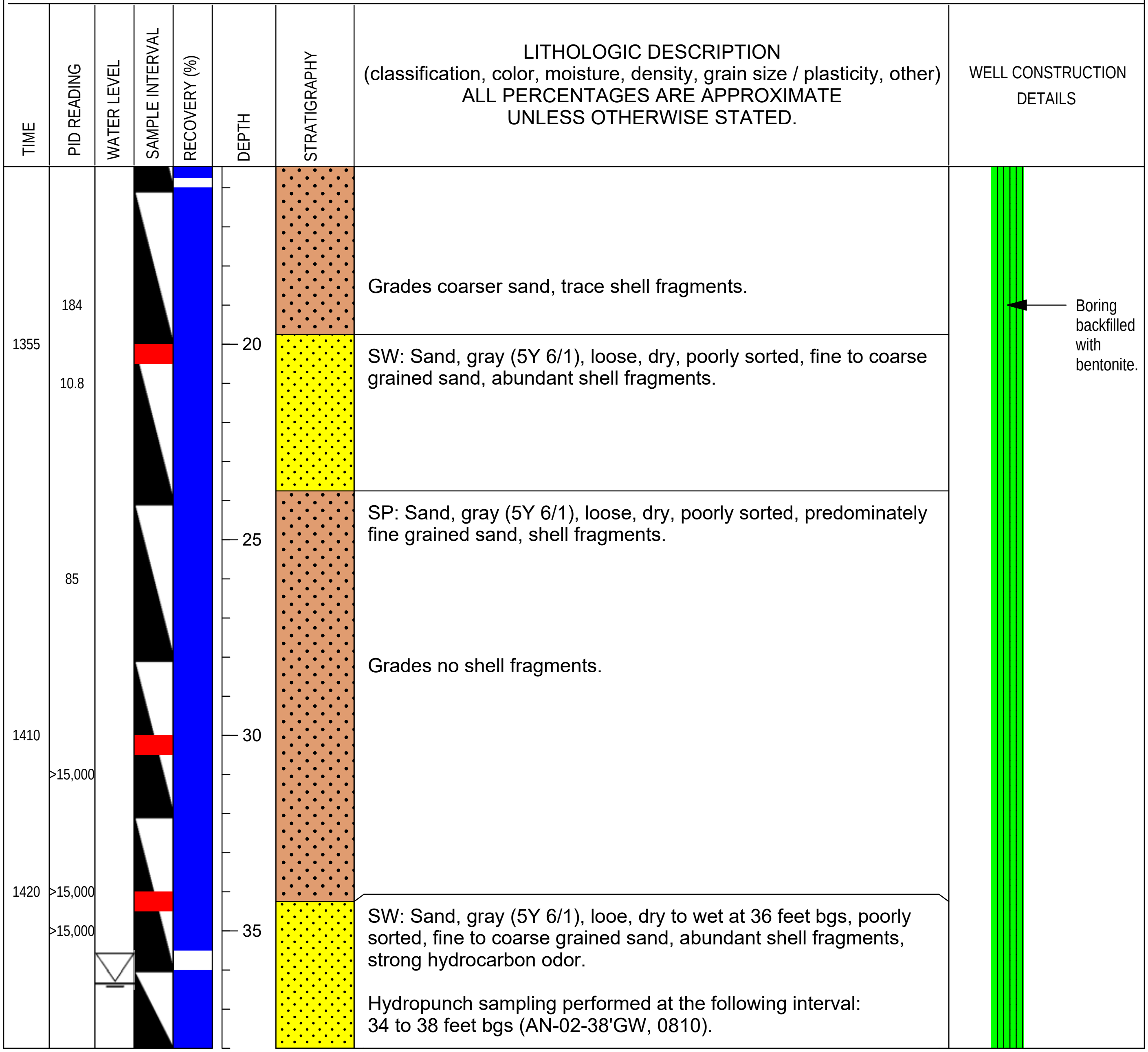
Grades to trace staining, dark gray (GLEY 4/0), strong hydrocarbon odor.

SP: Sand, gray (5Y 6/1), loose, dry, fine to very fine grained sand, well sorted, micaceous, hydrocarbon odor.

BOREHOLE LOG

BORING / WELL ID: **AN-02**
TOTAL DEPTH: **38'**

PROJECT NAME AND SITE ADDRESS: **Former ChemOil Facility, Signal Hill, California**
BORING LOCATION / DESCRIPTION: **North parcel**



TIME	PID READING	DEPTH	LITHOLOGIC DESCRIPTION (classification, color, moisture, density, grain size / plasticity, other) ALL PERCENTAGES ARE APPROXIMATE UNLESS OTHERWISE STATED.	WELL CONSTRUCTION DETAILS
			Grades coarser sand, trace shell fragments.	
	184			Boring backfilled with bentonite.
1355		20	SW: Sand, gray (5Y 6/1), loose, dry, poorly sorted, fine to coarse grained sand, abundant shell fragments.	
	10.8			
			SP: Sand, gray (5Y 6/1), loose, dry, poorly sorted, predominately fine grained sand, shell fragments.	
		25		
	85			
			Grades no shell fragments.	
1410		30		
	>15,000			
1420	>15,000		SW: Sand, gray (5Y 6/1), looe, dry to wet at 36 feet bgs, poorly sorted, fine to coarse grained sand, abundant shell fragments, strong hydrocarbon odor. Hydropunch sampling performed at the following interval: 34 to 38 feet bgs (AN-02-38'GW, 0810).	
	>15,000	35		

BOREHOLE LOG

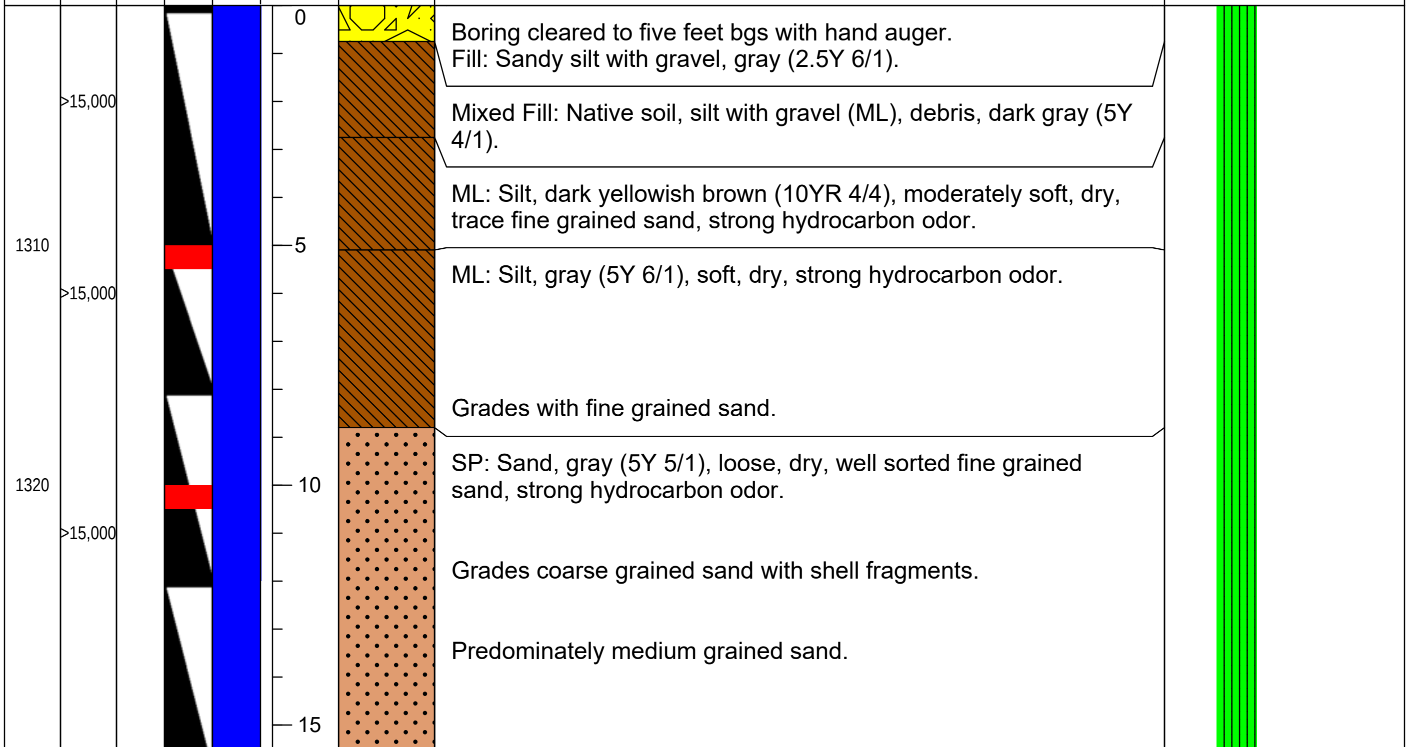
BORING / WELL ID: **AN-03**
TOTAL DEPTH: **36'**

PROJECT NAME AND SITE ADDRESS: **Former ChemOil Facility, Signal Hill, California**
BORING LOCATION / DESCRIPTION: **East side of north parcel**

PROJECT INFORMATION		DRILLING INFORMATION	
PROJECT NO.:	**093-CHEMOIL-001**	SUBCONTRACTOR:	**Kehoe Testing & Engineering**
PERMIT NO.:		EQUIPMENT:	**GeoProbe 7800**
LOGGED BY:	**R. Robitaille**	SAMPLING METHOD:	**Continuous 1.75" x 48"**
REVIEWED BY:	**P. Fuller**	MONITORING DEVICE:	**PID 100 ppm Hexane**
SURFACE ELEVATION:	**35.8 feet amsl**	BORING DIAMETER (IN):	**2.5 inches**
CASING TOP ELEVATION:	**NA**	ANNULUS MATERIAL:	**NA**
START DATE (TIME):	**01/05/17 (1245)**	BORING ANGLE: **Vertical** CASING DIAMETER:	**NA**
FINISH DATE (TIME):	**01/05/17 (1345)**	SCREEN INTERVAL:	**NA**

▽ First Water Encountered ▼ Stabilized Water Level 🟥 Sample Packaged for Analysis

TIME	PID READING	WATER LEVEL	SAMPLE INTERVAL	RECOVERY (%)	DEPTH	STRATIGRAPHY	LITHOLOGIC DESCRIPTION (classification, color, moisture, density, grain size / plasticity, other) ALL PERCENTAGES ARE APPROXIMATE UNLESS OTHERWISE STATED.	WELL CONSTRUCTION DETAILS



Boring cleared to five feet bgs with hand auger.
Fill: Sandy silt with gravel, gray (2.5Y 6/1).

Mixed Fill: Native soil, silt with gravel (ML), debris, dark gray (5Y 4/1).

ML: Silt, dark yellowish brown (10YR 4/4), moderately soft, dry, trace fine grained sand, strong hydrocarbon odor.

ML: Silt, gray (5Y 6/1), soft, dry, strong hydrocarbon odor.

Grades with fine grained sand.

SP: Sand, gray (5Y 5/1), loose, dry, well sorted fine grained sand, strong hydrocarbon odor.

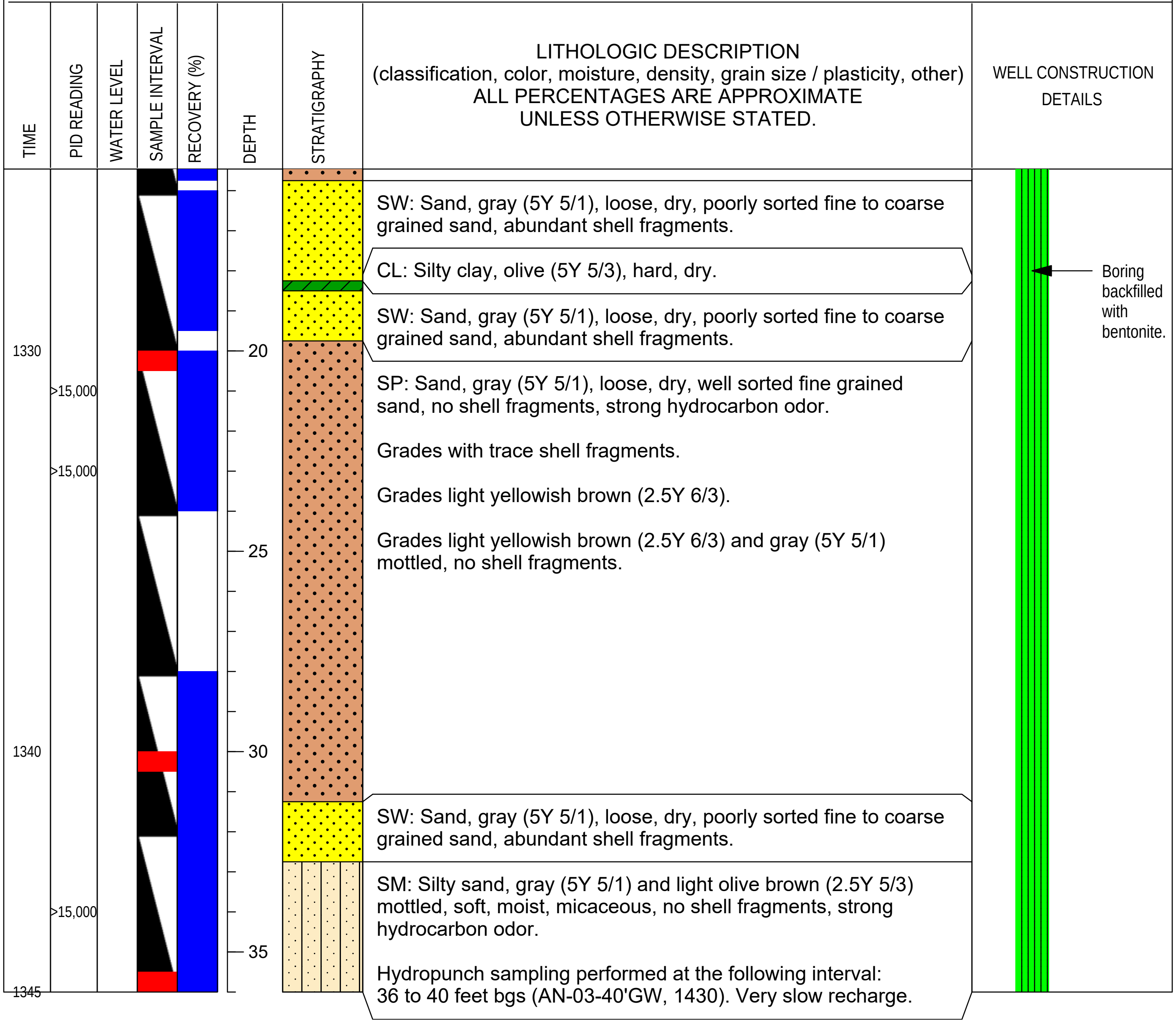
Grades coarse grained sand with shell fragments.

Predominately medium grained sand.

BOREHOLE LOG

BORING / WELL ID: **AN-03**
TOTAL DEPTH: **36'**

PROJECT NAME AND SITE ADDRESS: **Former ChemOil Facility, Signal Hill, California**
BORING LOCATION / DESCRIPTION: **East side of north parcel**



LITHOLOGIC DESCRIPTION
(classification, color, moisture, density, grain size / plasticity, other)
ALL PERCENTAGES ARE APPROXIMATE
UNLESS OTHERWISE STATED.

SW: Sand, gray (5Y 5/1), loose, dry, poorly sorted fine to coarse grained sand, abundant shell fragments.

CL: Silty clay, olive (5Y 5/3), hard, dry.

SW: Sand, gray (5Y 5/1), loose, dry, poorly sorted fine to coarse grained sand, abundant shell fragments.

SP: Sand, gray (5Y 5/1), loose, dry, well sorted fine grained sand, no shell fragments, strong hydrocarbon odor.

Grades with trace shell fragments.

Grades light yellowish brown (2.5Y 6/3).

Grades light yellowish brown (2.5Y 6/3) and gray (5Y 5/1) mottled, no shell fragments.

SW: Sand, gray (5Y 5/1), loose, dry, poorly sorted fine to coarse grained sand, abundant shell fragments.

SM: Silty sand, gray (5Y 5/1) and light olive brown (2.5Y 5/3) mottled, soft, moist, micaceous, no shell fragments, strong hydrocarbon odor.

Hydropunch sampling performed at the following interval:
36 to 40 feet bgs (AN-03-40'GW, 1430). Very slow recharge.

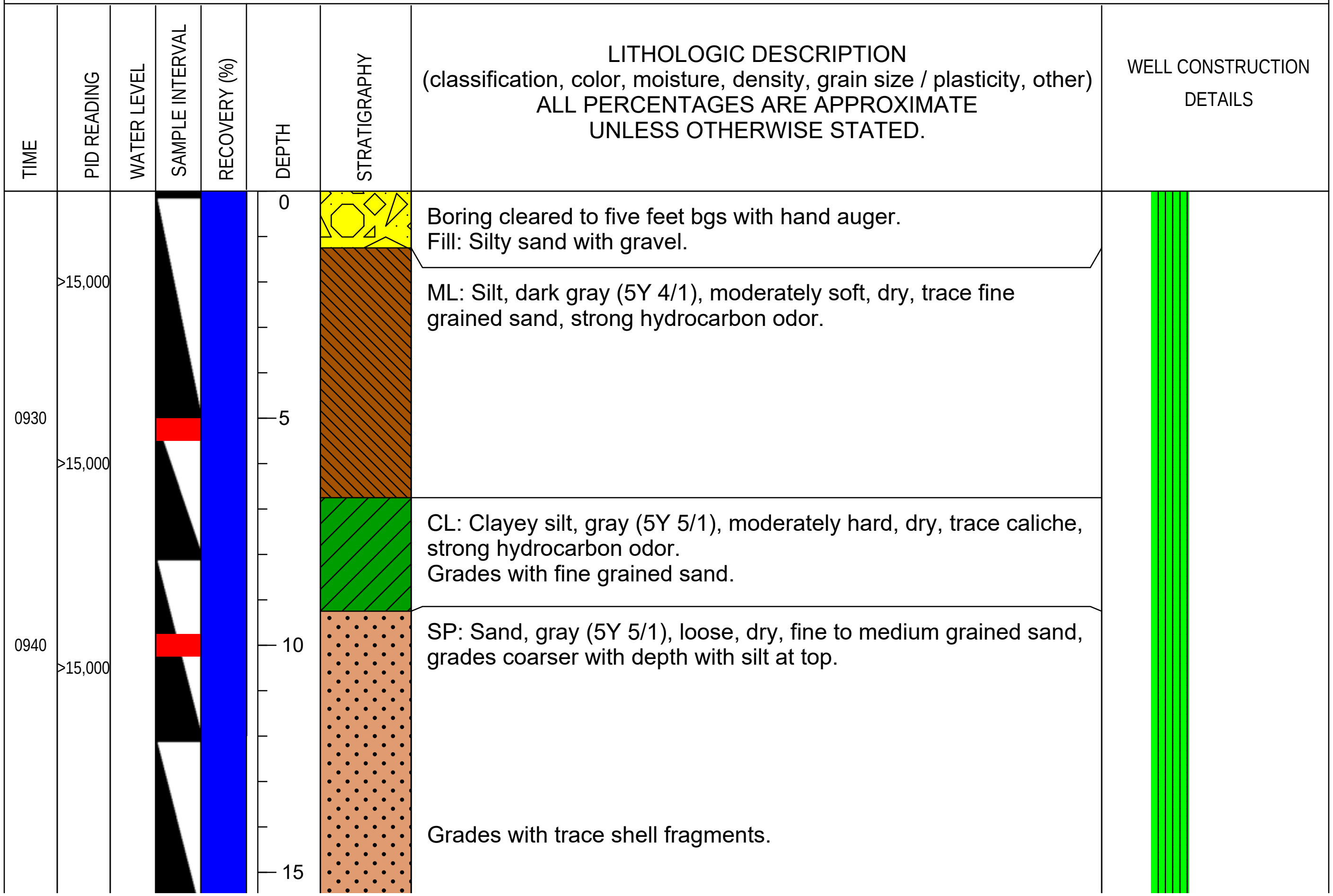
BOREHOLE LOG

BORING / WELL ID: **AN-05**
TOTAL DEPTH: **36'**

PROJECT NAME AND SITE ADDRESS: **Former ChemOil Facility, Signal Hill, California**
BORING LOCATION / DESCRIPTION: **North parcel, central area**

PROJECT INFORMATION		DRILLING INFORMATION	
PROJECT NO.:	**093-CHEMOIL-001**	SUBCONTRACTOR:	**Kehoe Testing & Engineering**
PERMIT NO.:		EQUIPMENT:	**GeoProbe 7800**
LOGGED BY:	**R. Robitaille**	SAMPLING METHOD:	**Continuous 1.75" x 48"**
REVIEWED BY:	**P. Fuller**	MONITORING DEVICE:	**PID 100ppm Hexane**
SURFACE ELEVATION:	**33.9 feet amsl**	BORING DIAMETER (IN):	**2.5 inches**
CASING TOP ELEVATION:	**NA**	ANNULUS MATERIAL:	**NA**
START DATE (TIME):	**01/05/17 (0845)**	BORING ANGLE: **Vertical**	CASING DIAMETER: **NA**
FINISH DATE (TIME):	**01/05/17 (1010)**	SCREEN INTERVAL:	**NA**

▽ First Water Encountered ▼ Stabilized Water Level 🟥 Sample Packaged for Analysis



LITHOLOGIC DESCRIPTION
(classification, color, moisture, density, grain size / plasticity, other)
ALL PERCENTAGES ARE APPROXIMATE
UNLESS OTHERWISE STATED.

Boring cleared to five feet bgs with hand auger.
Fill: Silty sand with gravel.

ML: Silt, dark gray (5Y 4/1), moderately soft, dry, trace fine grained sand, strong hydrocarbon odor.

CL: Clayey silt, gray (5Y 5/1), moderately hard, dry, trace caliche, strong hydrocarbon odor.
Grades with fine grained sand.

SP: Sand, gray (5Y 5/1), loose, dry, fine to medium grained sand, grades coarser with depth with silt at top.

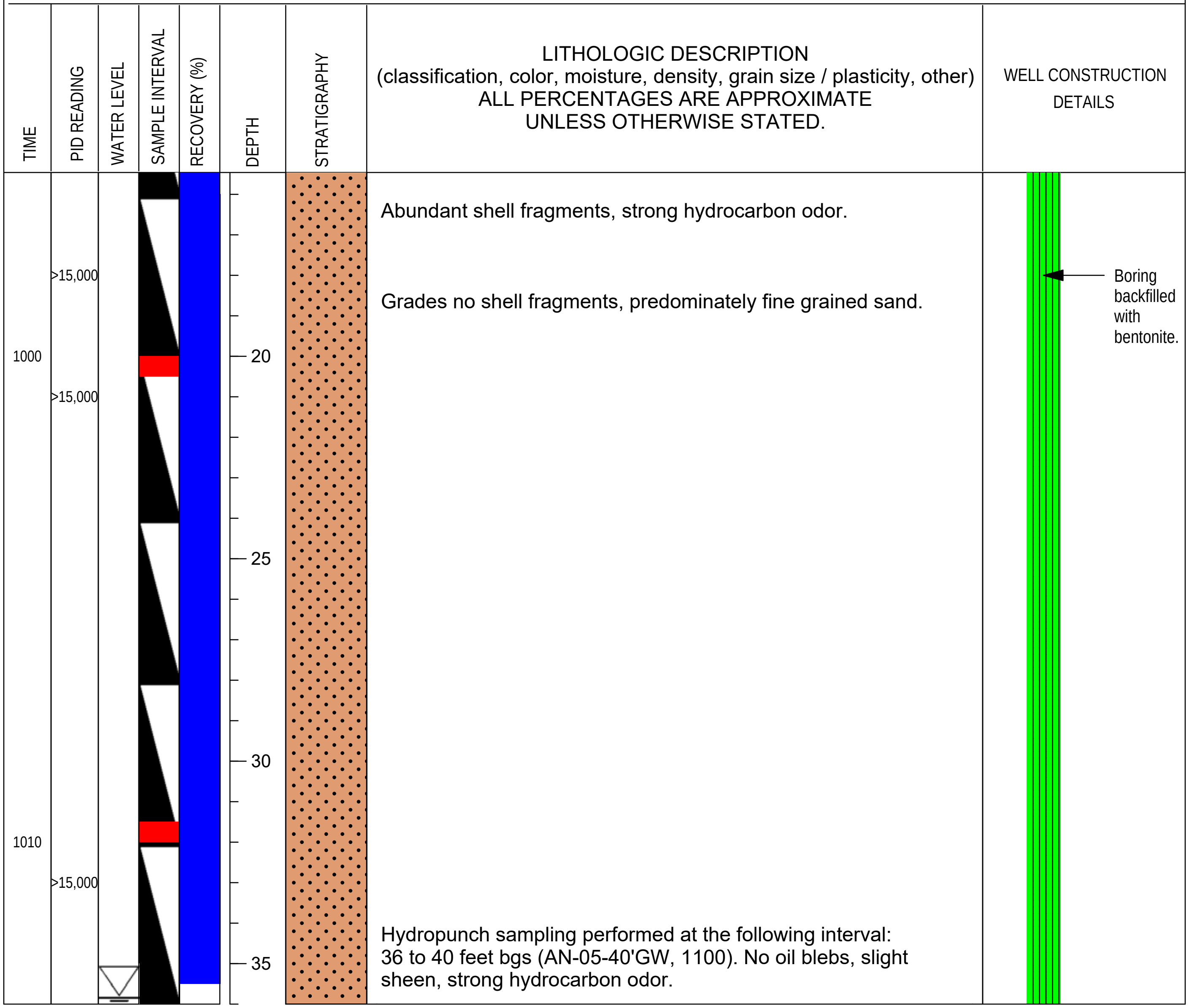
Grades with trace shell fragments.

APEX

BOREHOLE LOG

BORING / WELL ID: **AN-05**
TOTAL DEPTH: **36'**

PROJECT NAME AND SITE ADDRESS: **Former ChemOil Facility, Signal Hill, California**
BORING LOCATION / DESCRIPTION: **North parcel, central area**



LITHOLOGIC DESCRIPTION
(classification, color, moisture, density, grain size / plasticity, other)
ALL PERCENTAGES ARE APPROXIMATE
UNLESS OTHERWISE STATED.

Abundant shell fragments, strong hydrocarbon odor.

Grades no shell fragments, predominately fine grained sand.

Hydropunch sampling performed at the following interval: 36 to 40 feet bgs (AN-05-40'GW, 1100). No oil blebs, slight sheen, strong hydrocarbon odor.

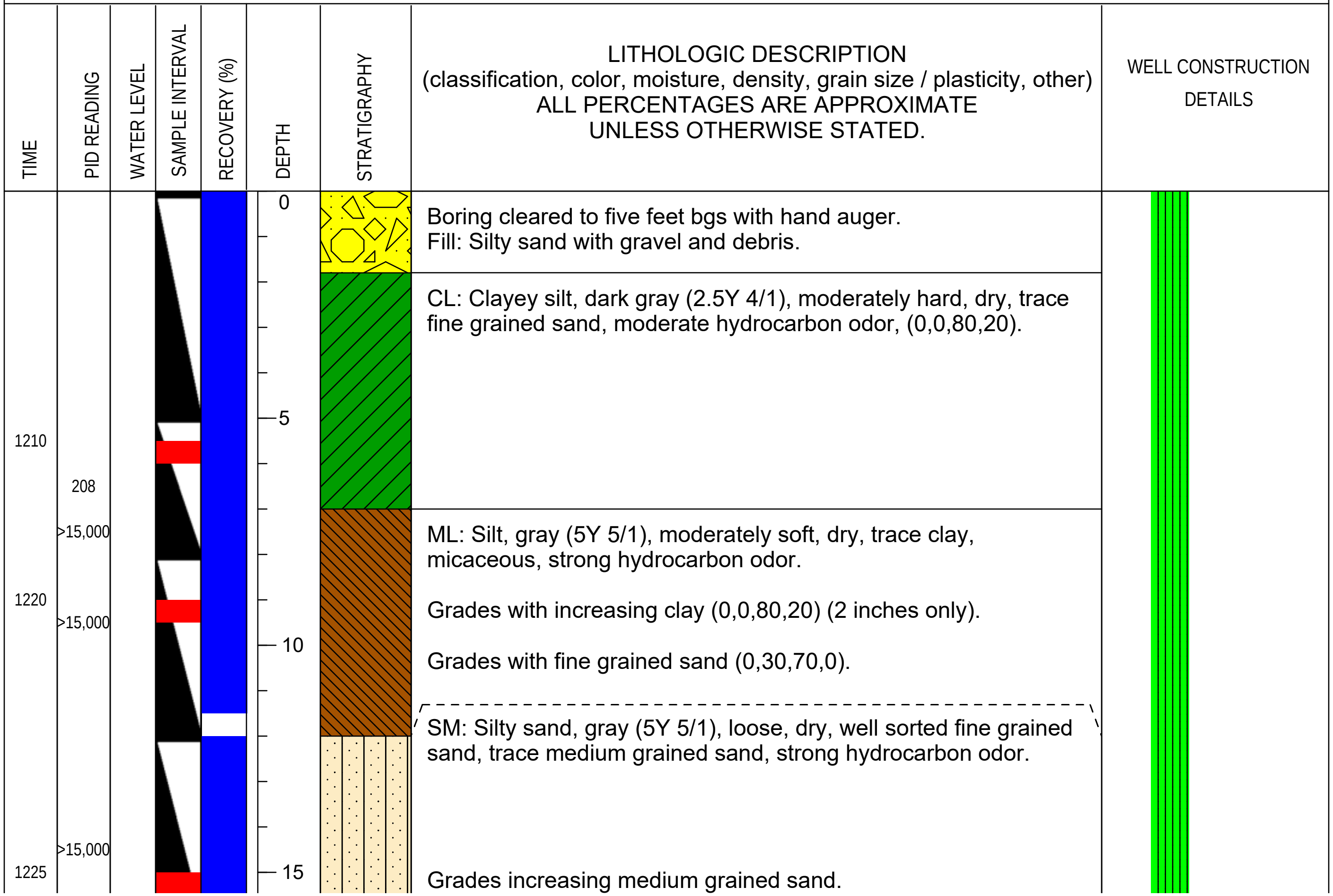
BOREHOLE LOG

BORING / WELL ID: **AN-13**
TOTAL DEPTH: **32'**

PROJECT NAME AND SITE ADDRESS: **Former ChemOil Facility, Signal Hill, California**
BORING LOCATION / DESCRIPTION: **Center of north parcel**

PROJECT INFORMATION		DRILLING INFORMATION	
PROJECT NO.:	**093-CHEMOIL-001**	SUBCONTRACTOR:	**Kehoe Testing & Engineering**
PERMIT NO.:		EQUIPMENT:	**GeoProbe 7800**
LOGGED BY:	**R. Robitaille**	SAMPLING METHOD:	**Continuous 1.75" x 48"**
REVIEWED BY:	**P. Fuller**	MONITORING DEVICE:	**PID 100 ppm Hexane**
SURFACE ELEVATION:	**29.9 feet amsl**	BORING DIAMETER (IN):	**2.5 inches**
CASING TOP ELEVATION:	**NA**	ANNULUS MATERIAL:	**NA**
START DATE (TIME):	**01/09/17 (1200)**	BORING ANGLE: **Vertical**	CASING DIAMETER: **NA**
FINISH DATE (TIME):	**01/09/17 (1620)**	SCREEN INTERVAL:	**NA**

▽ First Water Encountered ▼ Stabilized Water Level 🟥 Sample Packaged for Analysis



LITHOLOGIC DESCRIPTION
(classification, color, moisture, density, grain size / plasticity, other)
ALL PERCENTAGES ARE APPROXIMATE
UNLESS OTHERWISE STATED.

Boring cleared to five feet bgs with hand auger.
Fill: Silty sand with gravel and debris.

CL: Clayey silt, dark gray (2.5Y 4/1), moderately hard, dry, trace fine grained sand, moderate hydrocarbon odor, (0,0,80,20).

ML: Silt, gray (5Y 5/1), moderately soft, dry, trace clay, micaceous, strong hydrocarbon odor.

Grades with increasing clay (0,0,80,20) (2 inches only).

Grades with fine grained sand (0,30,70,0).

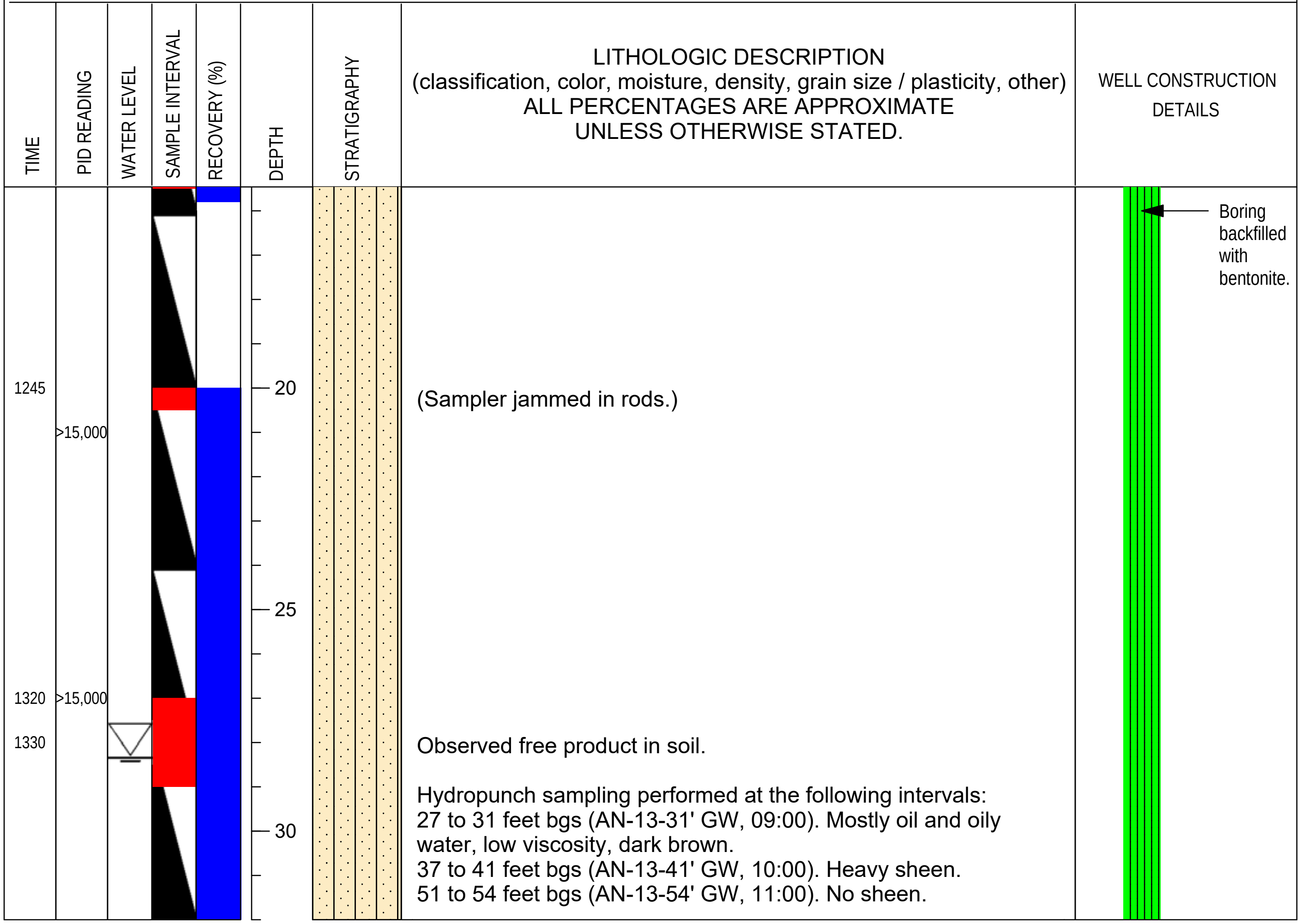
SM: Silty sand, gray (5Y 5/1), loose, dry, well sorted fine grained sand, trace medium grained sand, strong hydrocarbon odor.

Grades increasing medium grained sand.

BOREHOLE LOG

BORING / WELL ID: **AN-13**
TOTAL DEPTH: **32'**

PROJECT NAME AND SITE ADDRESS: **Former ChemOil Facility, Signal Hill, California**
BORING LOCATION / DESCRIPTION: **Center of north parcel**



(Sampler jammed in rods.)

Observed free product in soil.

Hydropunch sampling performed at the following intervals:
27 to 31 feet bgs (AN-13-31' GW, 09:00). Mostly oil and oily water, low viscosity, dark brown.
37 to 41 feet bgs (AN-13-41' GW, 10:00). Heavy sheen.
51 to 54 feet bgs (AN-13-54' GW, 11:00). No sheen.

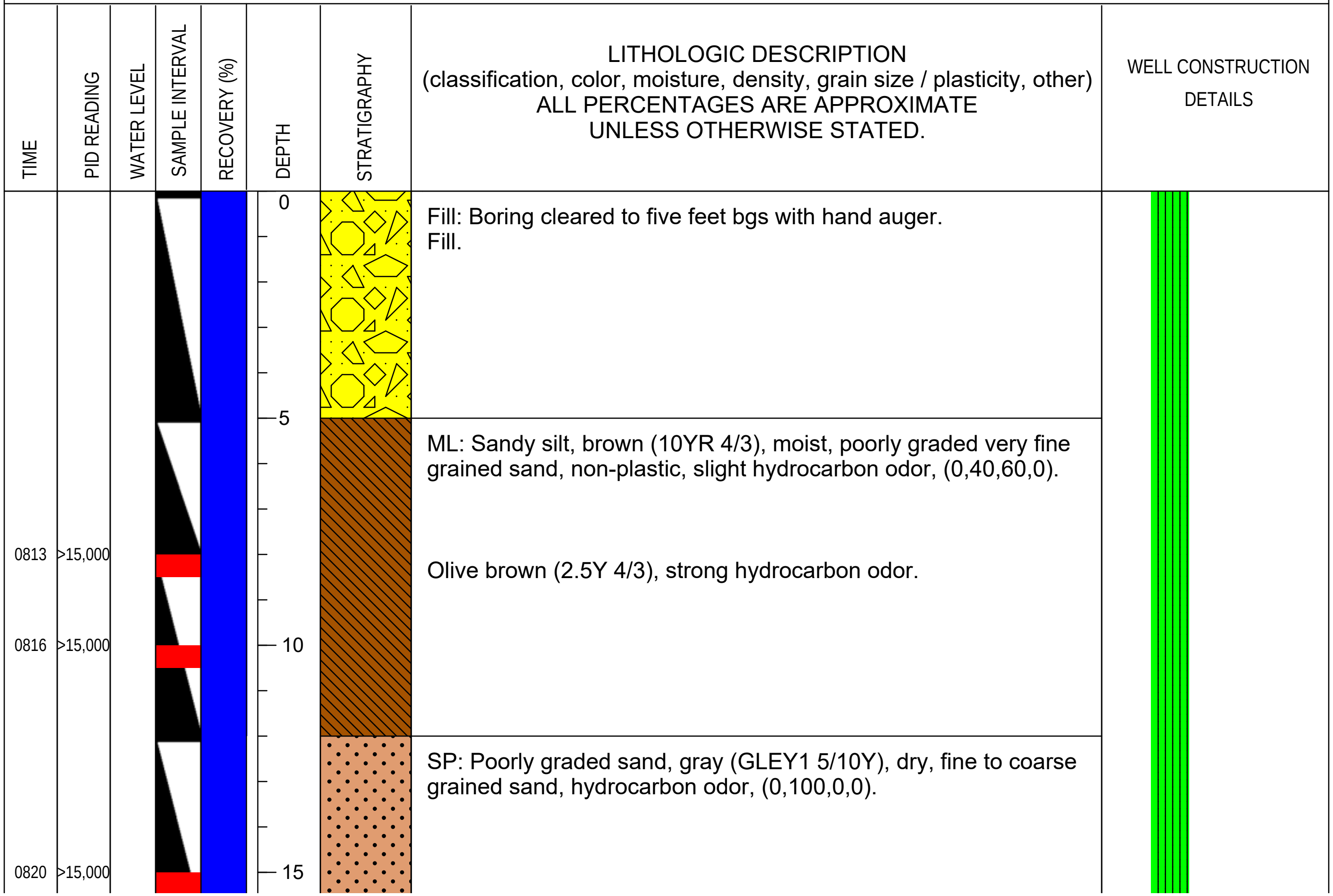
BOREHOLE LOG

BORING / WELL ID: **AN-20**
TOTAL DEPTH: **36'**

PROJECT NAME AND SITE ADDRESS: **Former ChemOil Facility, Signal Hill, California**
BORING LOCATION / DESCRIPTION: **Southwest of MW-11, northwest parcel**

PROJECT INFORMATION		DRILLING INFORMATION	
PROJECT NO.:	**093-CHEMOIL-001**	SUBCONTRACTOR:	**Kehoe Testing & Engineering**
PERMIT NO.:		EQUIPMENT:	**GeoProbe 6610DT**
LOGGED BY:	**A. Czuba**	SAMPLING METHOD:	**Continuous 1.75" x 48"**
REVIEWED BY:	**P. Fuller**	MONITORING DEVICE:	**PID 100ppm Hexane**
SURFACE ELEVATION:	**30.7 feet amsl**	BORING DIAMETER (IN):	**2.5 inches**
CASING TOP ELEVATION:	**NA**	ANNULUS MATERIAL:	**NA**
START DATE (TIME):	**01/18/17 (0805)**	BORING ANGLE: **Vertical**	CASING DIAMETER: **NA**
FINISH DATE (TIME):	**01/18/17 (0850)**	SCREEN INTERVAL:	**NA**

▽ First Water Encountered ▼ Stabilized Water Level 🟥 Sample Packaged for Analysis



LITHOLOGIC DESCRIPTION
(classification, color, moisture, density, grain size / plasticity, other)
ALL PERCENTAGES ARE APPROXIMATE
UNLESS OTHERWISE STATED.

Fill: Boring cleared to five feet bgs with hand auger.
Fill.

ML: Sandy silt, brown (10YR 4/3), moist, poorly graded very fine grained sand, non-plastic, slight hydrocarbon odor, (0,40,60,0).

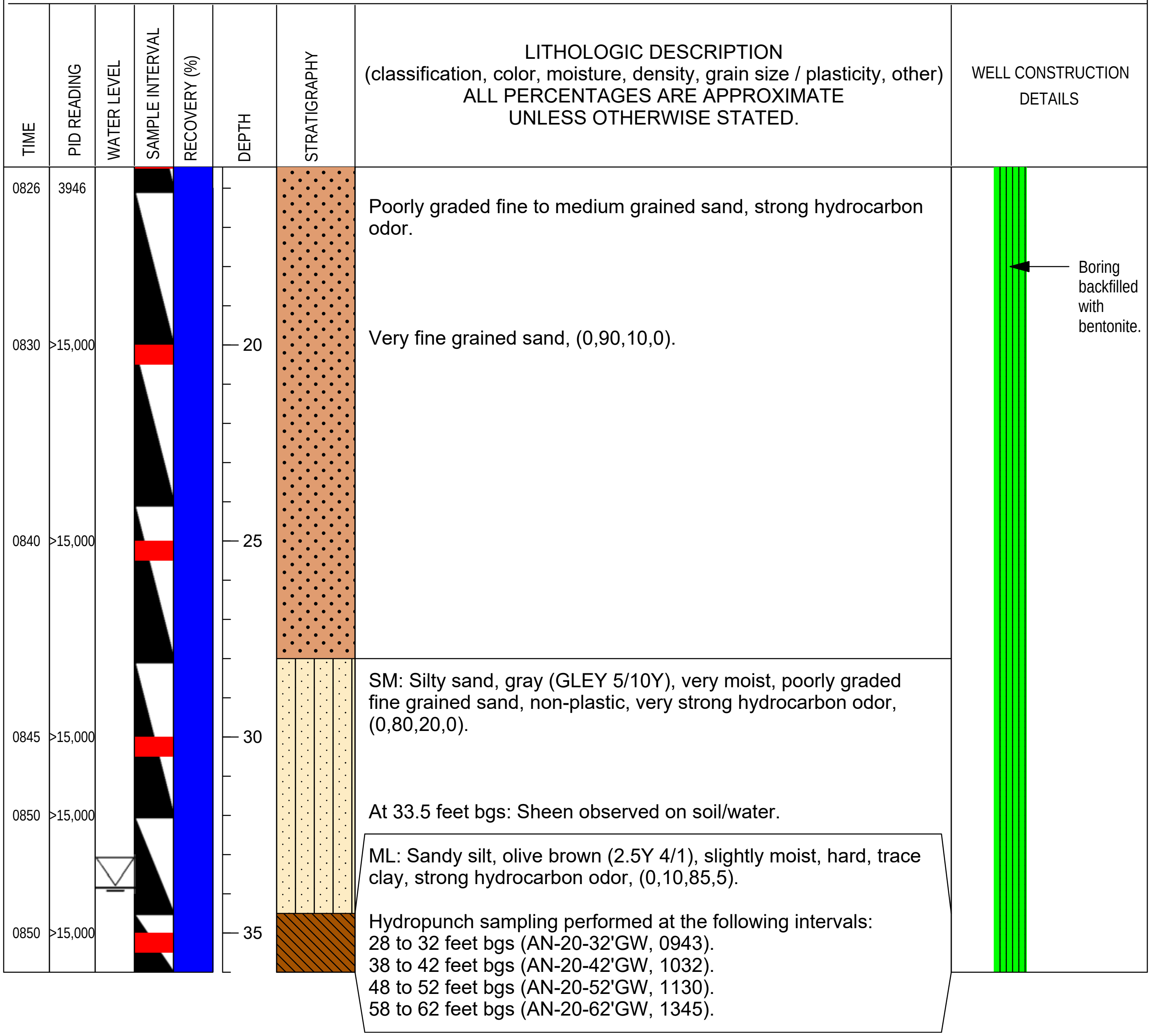
Olive brown (2.5Y 4/3), strong hydrocarbon odor.

SP: Poorly graded sand, gray (GLEY1 5/10Y), dry, fine to coarse grained sand, hydrocarbon odor, (0,100,0,0).

BOREHOLE LOG

BORING / WELL ID: **AN-20**
TOTAL DEPTH: **36'**

PROJECT NAME AND SITE ADDRESS: **Former ChemOil Facility, Signal Hill, California**
BORING LOCATION / DESCRIPTION: **Southwest of MW-11, northwest parcel**



TIME	PID READING	DEPTH
0826	3946	
0830	>15,000	20
0840	>15,000	25
0845	>15,000	30
0850	>15,000	
0850	>15,000	35

LITHOLOGIC DESCRIPTION
(classification, color, moisture, density, grain size / plasticity, other)
ALL PERCENTAGES ARE APPROXIMATE
UNLESS OTHERWISE STATED.

Poorly graded fine to medium grained sand, strong hydrocarbon odor.

Very fine grained sand, (0,90,10,0).

SM: Silty sand, gray (GLEY 5/10Y), very moist, poorly graded fine grained sand, non-plastic, very strong hydrocarbon odor, (0,80,20,0).

At 33.5 feet bgs: Sheen observed on soil/water.

ML: Sandy silt, olive brown (2.5Y 4/1), slightly moist, hard, trace clay, strong hydrocarbon odor, (0,10,85,5).

Hydropunch sampling performed at the following intervals:
28 to 32 feet bgs (AN-20-32'GW, 0943).
38 to 42 feet bgs (AN-20-42'GW, 1032).
48 to 52 feet bgs (AN-20-52'GW, 1130).
58 to 62 feet bgs (AN-20-62'GW, 1345).

BOREHOLE LOG

BORING / WELL ID: **AO-01**
TOTAL DEPTH: **32'**

PROJECT NAME AND SITE ADDRESS: **Former ChemOil Facility, Signal Hill, California**
BORING LOCATION / DESCRIPTION: **In the street in fron tof 2109 Gundry Avenue**

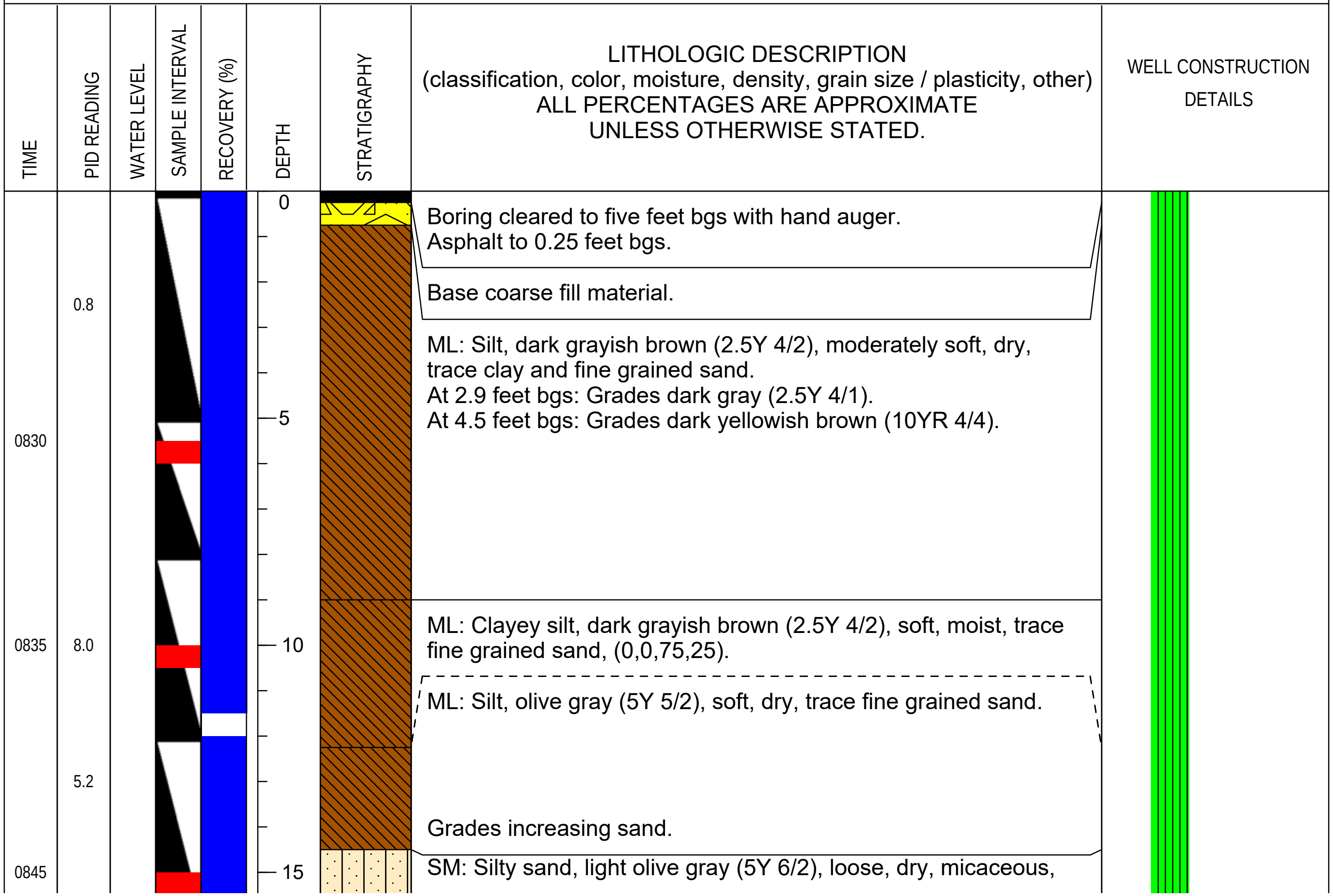
PROJECT INFORMATION

PROJECT NO.: **093-CHEMOIL-001**
PERMIT NO.:
LOGGED BY: **R. Robitaille**
REVIEWED BY: **P. Fuller**
SURFACE ELEVATION: **27.0 feet amsl**
CASING TOP ELEVATION: **NA**
START DATE (TIME): **01/10/17 (0700)**
FINISH DATE (TIME): **01/10/17 (0930)**

DRILLING INFORMATION

SUBCONTRACTOR: **Kehoe Testing & Engineering**
EQUIPMENT: **GeoProbe 7800**
SAMPLING METHOD: **Continuous 1.75" x 48"**
MONITORING DEVICE: **PID 100ppm Hexane**
BORING DIAMETER (IN): **2.5 inches**
ANNULUS MATERIAL: **NA**
BORING ANGLE: **Vertical** CASING DIAMETER: **NA**
SCREEN INTERVAL: **NA**

▽ First Water Encountered ▼ Stabilized Water Level 🟥 Sample Packaged for Analysis



LITHOLOGIC DESCRIPTION
(classification, color, moisture, density, grain size / plasticity, other)
ALL PERCENTAGES ARE APPROXIMATE
UNLESS OTHERWISE STATED.

Boring cleared to five feet bgs with hand auger.
Asphalt to 0.25 feet bgs.

Base coarse fill material.

ML: Silt, dark grayish brown (2.5Y 4/2), moderately soft, dry, trace clay and fine grained sand.
At 2.9 feet bgs: Grades dark gray (2.5Y 4/1).
At 4.5 feet bgs: Grades dark yellowish brown (10YR 4/4).

ML: Clayey silt, dark grayish brown (2.5Y 4/2), soft, moist, trace fine grained sand, (0,0,75,25).

ML: Silt, olive gray (5Y 5/2), soft, dry, trace fine grained sand.

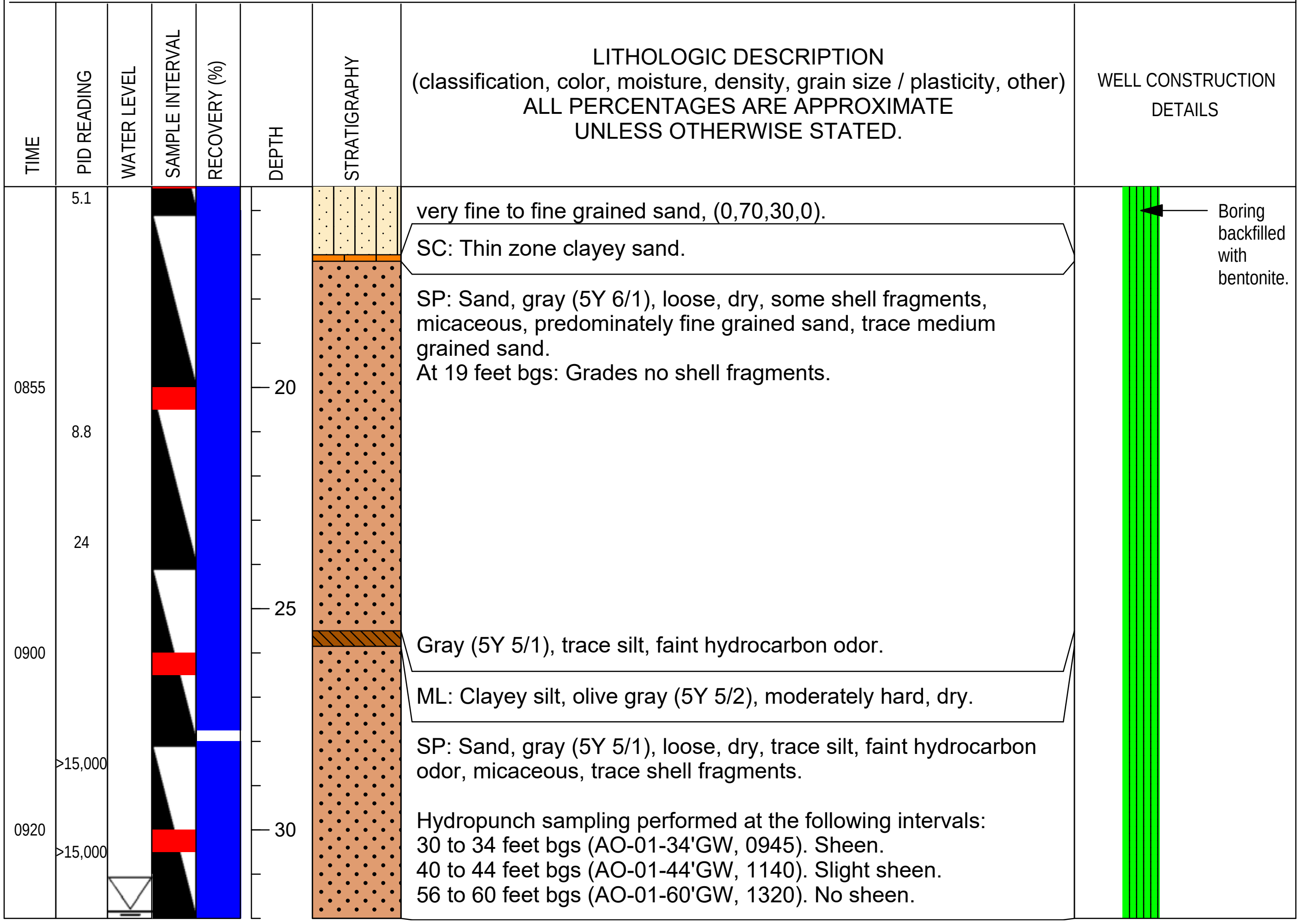
Grades increasing sand.

SM: Silty sand, light olive gray (5Y 6/2), loose, dry, micaceous,

BOREHOLE LOG

BORING / WELL ID: **AO-01**
TOTAL DEPTH: **32'**

PROJECT NAME AND SITE ADDRESS: **Former ChemOil Facility, Signal Hill, California**
BORING LOCATION / DESCRIPTION: **In the street in fron tof 2109 Gundry Avenue**



LITHOLOGIC DESCRIPTION
(classification, color, moisture, density, grain size / plasticity, other)
ALL PERCENTAGES ARE APPROXIMATE
UNLESS OTHERWISE STATED.

very fine to fine grained sand, (0,70,30,0).

SC: Thin zone clayey sand.

SP: Sand, gray (5Y 6/1), loose, dry, some shell fragments, micaceous, predominately fine grained sand, trace medium grained sand.
At 19 feet bgs: Grades no shell fragments.

Gray (5Y 5/1), trace silt, faint hydrocarbon odor.

ML: Clayey silt, olive gray (5Y 5/2), moderately hard, dry.

SP: Sand, gray (5Y 5/1), loose, dry, trace silt, faint hydrocarbon odor, micaceous, trace shell fragments.

Hydropunch sampling performed at the following intervals:
30 to 34 feet bgs (AO-01-34'GW, 0945). Sheen.
40 to 44 feet bgs (AO-01-44'GW, 1140). Slight sheen.
56 to 60 feet bgs (AO-01-60'GW, 1320). No sheen.

BOREHOLE LOG

BORING / WELL ID: **MW-20**
TOTAL DEPTH: **35'**

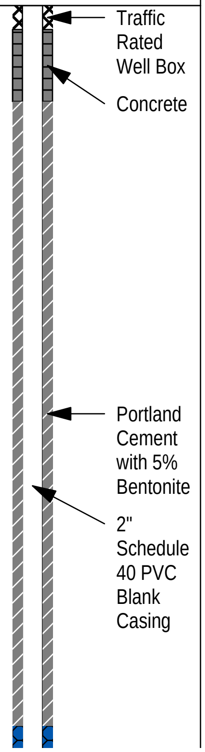
PROJECT NAME AND SITE ADDRESS: **Former ChemOil Facility, Signal Hill, California**
BORING LOCATION / DESCRIPTION: **Southwest parcel near AS-03.**

PROJECT INFORMATION		DRILLING INFORMATION	
PROJECT NO.:	**093-CHEMOIL-001**	SUBCONTRACTOR:	**Gregg Drilling**
PERMIT NO.:	**SR0092630**	EQUIPMENT:	**Truck-mounted HSA**
LOGGED BY:	**A. Czuba**	SAMPLING METHOD:	**Split Spoon**
REVIEWED BY:	**P. Fuller**	MONITORING DEVICE:	**PID**
SURFACE ELEVATION:	**25.4 feet amsl**	BORING DIAMETER (IN):	**8 inches**
CASING TOP ELEVATION:	**24.79 feet amsl**	ANNULUS MATERIAL:	**#2/12 Monterey Sand**
START DATE (TIME):	**01/10/17**	BORING ANGLE: **Vertical**	CASING DIAMETER: **2 inches**
FINISH DATE (TIME):	**01/10/17**	SCREEN INTERVAL:	**20 to 35 feet bgs**

▽ First Water Encountered ▼ Stabilized Water Level 🟥 Sample Packaged for Analysis

TIME	PID READING	WATER LEVEL	SAMPLE INTERVAL	RECOVERY (%)	DEPTH	STRATIGRAPHY	LITHOLOGIC DESCRIPTION (classification, color, moisture, density, grain size / plasticity, other) ALL PERCENTAGES ARE APPROXIMATE UNLESS OTHERWISE STATED.
0920	0				0		Boring cleared to five feet bgs with hand auger. SM: Silty sand, brown, slightly moist, poorly graded fine to coarse grained sand, low plasticity, no odor, (0,80,20,0).
							SM: Silty sand, olive gray, dry, moderately soft, poorly graded, trace clay, slight hydrocarbon odor.
0943	40				5		
0943	40						
0949	34.2						Grades brown.
			🟥				Grades olive gray, poorly graded very fine grained sand.
0955	>15,000						ML: Clayey silt, dark olive gray, dry, hard, poorly graded, low plasticity, no odor.
1000	>15,000				10		SM: Silty sand, olive gray, dry, very fine grained sand, slight hydrocarbon odor, (0,70,30,0).
1006	>15,000		🟥				
							Grades increasing silt, (0,60,40,0).
1015	>15,000						SP: Poorly graded sand, dark gray, dry, fine to medium grained sand, trace silt, slight hydrocarbon odor, (0,100,0,0).
1015	>15,000						SM: Silty sand, gray, dry, poorly graded fine to medium grained
1020	81				15		

WELL CONSTRUCTION DETAILS



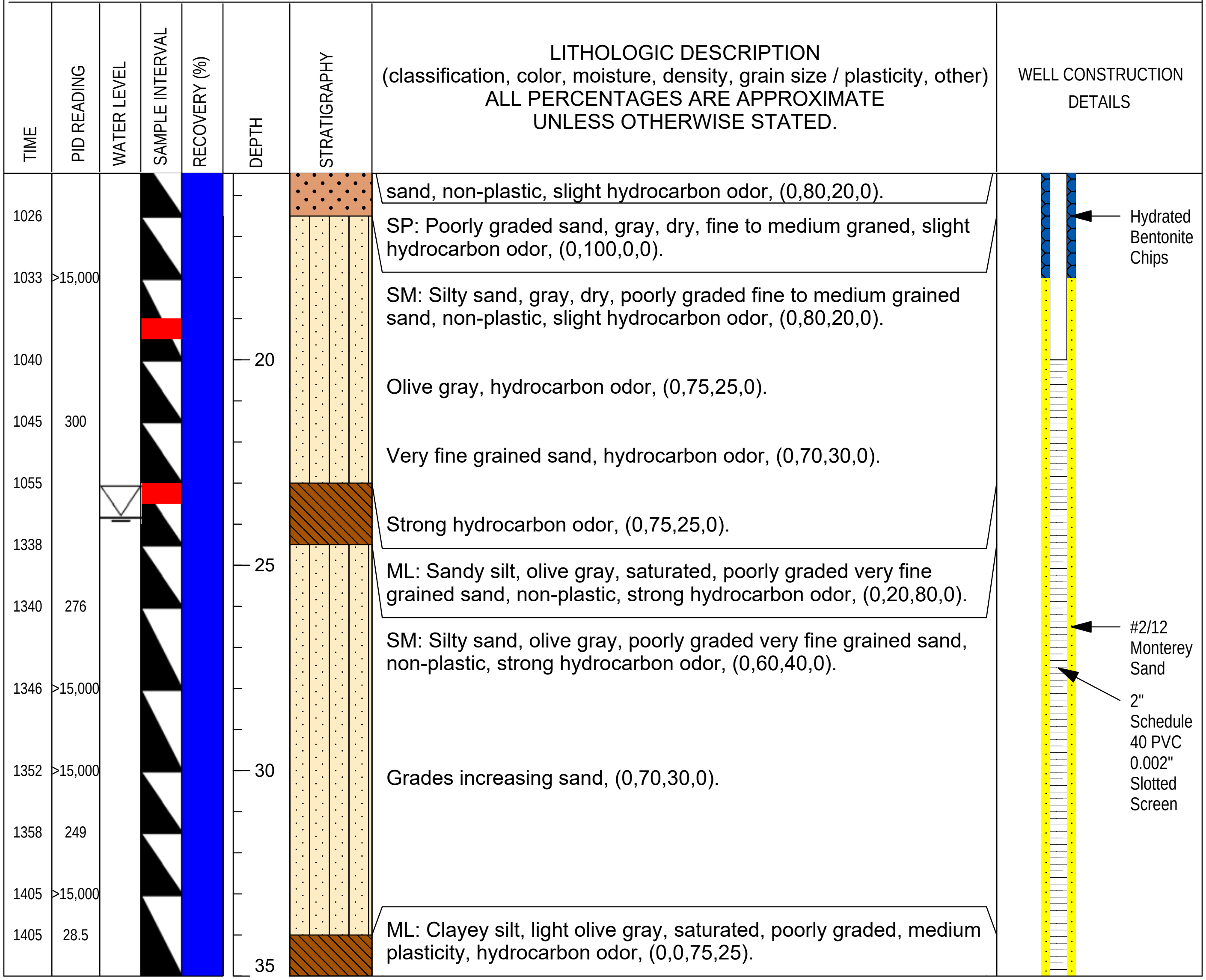
BOREHOLE LOG

BORING / WELL ID: **MW-20**

TOTAL DEPTH: **35'**

PROJECT NAME AND SITE ADDRESS: **Former ChemOil Facility, Signal Hill, California**

BORING LOCATION / DESCRIPTION: **Southwest parcel near AS-03.**



LITHOLOGIC DESCRIPTION
(classification, color, moisture, density, grain size / plasticity, other)
ALL PERCENTAGES ARE APPROXIMATE
UNLESS OTHERWISE STATED.

sand, non-plastic, slight hydrocarbon odor, (0,80,20,0).

SP: Poorly graded sand, gray, dry, fine to medium graned, slight hydrocarbon odor, (0,100,0,0).

SM: Silty sand, gray, dry, poorly graded fine to medium grained sand, non-plastic, slight hydrocarbon odor, (0,80,20,0).

Olive gray, hydrocarbon odor, (0,75,25,0).

Very fine grained sand, hydrocarbon odor, (0,70,30,0).

Strong hydrocarbon odor, (0,75,25,0).

ML: Sandy silt, olive gray, saturated, poorly graded very fine grained sand, non-plastic, strong hydrocarbon odor, (0,20,80,0).

SM: Silty sand, olive gray, poorly graded very fine grained sand, non-plastic, strong hydrocarbon odor, (0,60,40,0).

Grades increasing sand, (0,70,30,0).

ML: Clayey silt, light olive gray, saturated, poorly graded, medium plasticity, hydrocarbon odor, (0,0,75,25).

TIME	PID READING
1026	
1033	>15,000
1040	
1045	300
1055	
1338	
1340	276
1346	>15,000
1352	>15,000
1358	249
1405	>15,000
1405	28.5

FUGRO USA LAND, INC.
469 Roland Way
Oakland, CA 9621
T +1 510-430-8851

Date: February 20, 2017
Report Number 04.0916-0020

Apex Companies, LLC
3478 Buskirk Avenue, Suite 100
Pleasant Hill, CA 94523

Attn.: Kirsten L. Duey

REPORT FOR PIEZOCONE PENETRATION TESTING ULTRA-VIOLET OPTICAL SCREENING TOOL PCPT/UVOST™) TESTING AND RELATED SERVICES SIGNAL HILL, CALIFORNIA

Dear Ms. Duey:

Fugro USA Land, Inc. (Fugro) is pleased to present this data report for Piezocone Penetration (PCPT) and Ultra-Violet Optical Screening Tool (UVOST™) testing at the above-referenced site to The Source Group, a division of Apex Companies. PCPT/UVOST™ provided continuous characterization of stratigraphy and petroleum hydrocarbon distribution at the testing location. A description of the PCPT and UVOST™ technologies and a discussion of general UVOST™ data interpretation follow. PCPT and UVOST™ logs are included as attachments.

Scope of Services

We performed eighteen (18) PCPT/ UVOST™ soundings as directed by client representative. Fugro is pleased to present data report for Piezocone Penetration Testing (PCPT) services and Ultra-Violet Optical Screening Tool (UVOST™) screening performed at the above-referenced site in accordance with Fugro Proposal PLC16-042 dated November 16, 2016 to The Source Group.

PCPT Testing

The PCPT soundings were conducted in general accordance with ASTM D5778-12, Electronic Friction Cone and Piezocone Penetration Testing of Soils using a 30-ton truck mounted PCPT unit. The in-situ soil data was obtained by hydraulically advancing a cylindrical steel rod, with an instrumented probe at the base, vertically into the subsurface materials at a constant rate of 2 centimeters per second. The instrumented probe consists of a cone-shaped tip element, with an apex angle of 60 degrees with a base area of 15 square centimeters (cm2), a cylindrical-shaped side friction with a surface area of 200 cm2 Measurements of penetration resistance at the cone tip (qc), frictional resistance along the friction sleeve (fs), and pore water pressure (u2), were recorded with depth during penetration. PCPT sounding measurements collected for this project are presented on the logs attached at the end of this report.

PCPT methods test the soil in situ and soil samples are not obtained. There are several methods to identify the soil type using the PCPT data collected. For your reference, we have presented soil stratigraphy using the attached Campanella and Robertson's Simplified Soil Behavior Chart (12-zone, 1986). Please note that because of the empirical nature of the soil behavior chart, the soil identification should be verified locally from soil borings and laboratory testing. Some soils, such as cemented or calcareous soils, or glacial tills are outside the limits of the soil behavior chart.

UVOST™ Testing

Fugro USA Land's UVOST™ Laser-Induced Fluorescence system was used for this investigation to screen soils for petroleum hydrocarbon materials containing aromatic hydrocarbon constituents. The system consists of a laser mounted in the CPT unit that is connected to a down-hole sensor. The down-hole sensor consists of a sapphire window mounted flush with the side of the cone penetrometer probe.

The laser and associated equipment transmit pulsed of light to the sensor through a fiber optic cable. The wavelength of the pulsed excitation light is set to an excitation wavelength of 308 nm.

The laser light passes through the sapphire window and is absorbed by aromatic hydrocarbon molecules in contact with the window, as the probe is advanced. This addition of energy (photons) to the aromatic hydrocarbons causes them to fluoresce. A portion of the fluorescence emitted from any encountered aromatic constituents is returned through the sapphire window and conveyed by a second fiber optic cable to a detection system within the CPT unit. The emission data resulting from the pulsed laser light is averaged into one reading per one-second interval (approximately one reading per 2 cm vertical interval) and is recorded continuously.

Several characteristics of the emitted fluorescence are measured and recorded simultaneously at four (4) specific wavelengths (340, 390, 440, and 490 nm). These four wavelengths represent the spectrum of fluorescence typically produced by aromatic hydrocarbons ranging from light fuels through heavy contaminants such as coal tar and creosote. The recorded data is then presented as a color graph of fluorescence intensity (the combined fluorescence of all four monitored wavelengths) versus depth (FVD).

On the FVD graph, each of the four monitored wavelengths is assigned a color. These colors are combined based on the proportional fluorescence intensity of each of the individual wavelengths. The combined color is then used on the FVD graph. Changes in color on the FVD graph typically represent changes in product type. Similarly, like colors on the FVD graph typically represent the same product, regardless of the total fluorescence intensity. Changes in the total fluorescence intensity typically indicate changes in contaminant concentration, with higher fluorescence intensities representing proportionally higher concentrations when compared to lower fluorescence intensities.

In addition to the FVD graph, randomly selected depth specific waveforms are presented at up to five (5) depths throughout the sounding. These waveform graphs are presented to the left of the FVD graph on each plot. On each waveform graph, shorter waves are shown on the left and increase from left to right. For general interpretation purposes, lighter aromatic hydrocarbon molecules will emit fluorescence at the shorter wavelengths, and heavier, longer chained hydrocarbons will emit fluorescence at the longer wavelengths. The presented waveforms can be compared to waveforms typical of common hydrocarbon products to determine the likely product type that has been encountered. Please note that the waveforms are available at every two-centimeter interval throughout the entire sounding. Additional waveforms can be generated at any time during or after testing is complete.

REFERENCE SOLUTION: The fluorescence intensity of a reference solution placed on the sapphire window was measured immediately prior to conducting each test. This reference solution measurement serves two purposes. First, as a quality control check, the solution is used to ensure that the performance of the system is within specifications. Second, it allows for normalization of the data from different test locations for variation in laser power, operating conditions, and monitored emission wavelength. The reference solution used for this project was the standard M1 reference, which is a proprietary PHC containing solution. M1 provides consistent fluorescence response across the portion of the spectrum analyzed by UVOST™ and therefore, allows the fluorescence data collected to be consistently normalized to intensities recorded as a percentage of M1.

LIMITATIONS OF ENVIRONMENTAL SUBSURFACE WORK

Fugro's report is based upon our observations made during fieldwork, the information provided to Fugro and the results of the UVOST™/PCPT survey. Given the inherent limitation of environmental subsurface work, Fugro cannot guarantee that the site is free of hazardous or potentially hazardous materials or conditions or that latent or undiscovered conditions will not become evident in the future. Fugro's report was prepared in accordance with our proposal and the General Conditions agreed to between Fugro and Client and no warranties, representations, or certifications are made.

Closing

Fugro appreciates the opportunity to be of service to THE SOURCE GROUP. If you have any questions, please feel free to contact me at 510-430-8851.

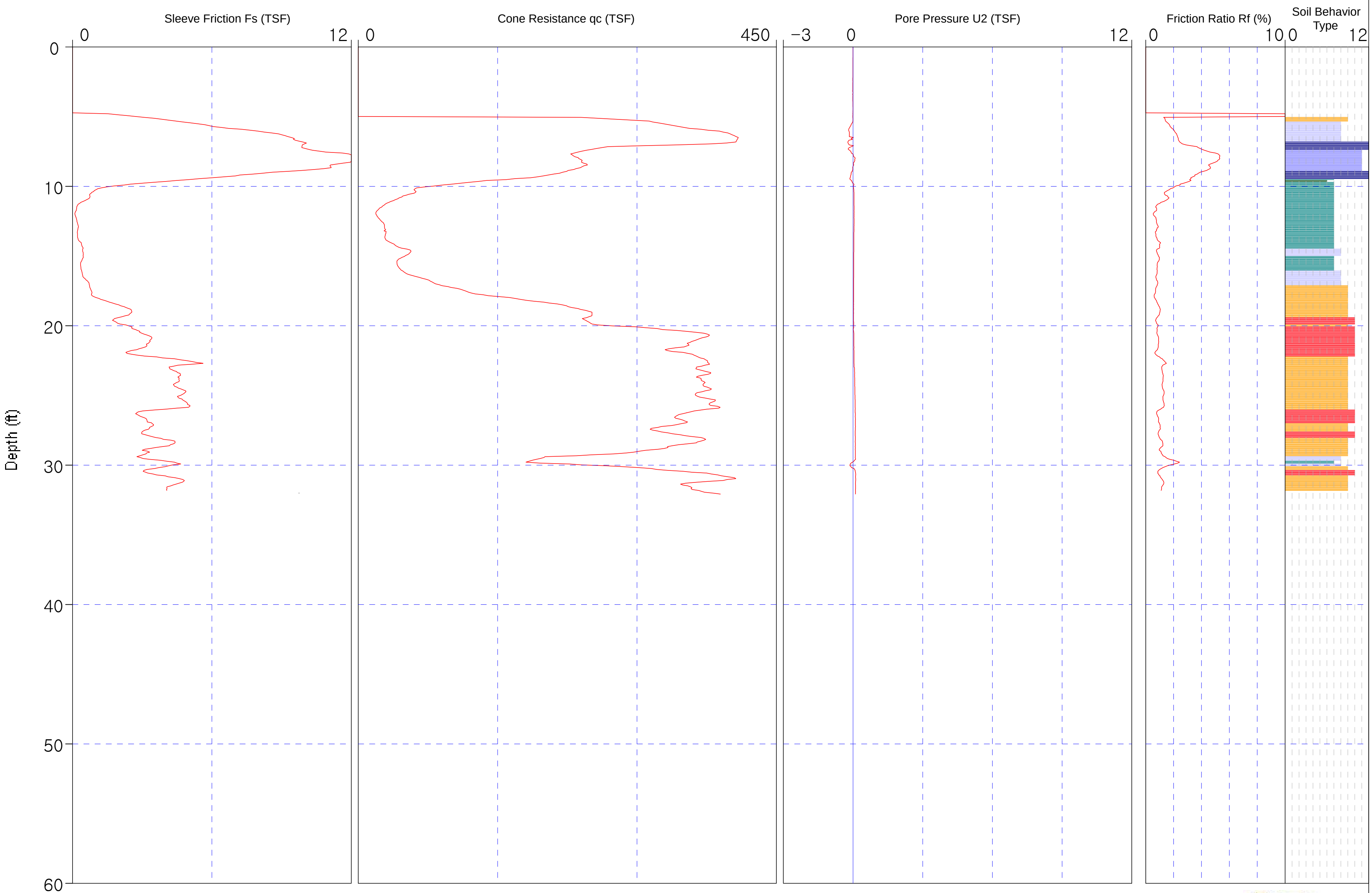
Best Regards,
FUGRO USA LAND, INC.
Virgil A. Baker
Virgil A. Baker
CPT Manager

Attachments: PCPT Sounding Logs (18 pages)
UVOST™ Sounding Logs (18 pages)
Additional PCPT Sounding Logs Generated During PCPT/MIP Testing (3 pages)
Campanella and Robertson's Simplified Soil Behavior Chart (1 page)
"Interpreting LIF Waveforms", Dakota Technologies (6 pages)

Job Number: 04.0916-0020
Operator: Danny Garza
Location: Signal Hill, CA

CPT Number: AE-01
Date: 13-Dec-2016
Elevation: 0.00

Coordinates:
Cone Number: CP15-CF25PB7SN2-P1E1 1519



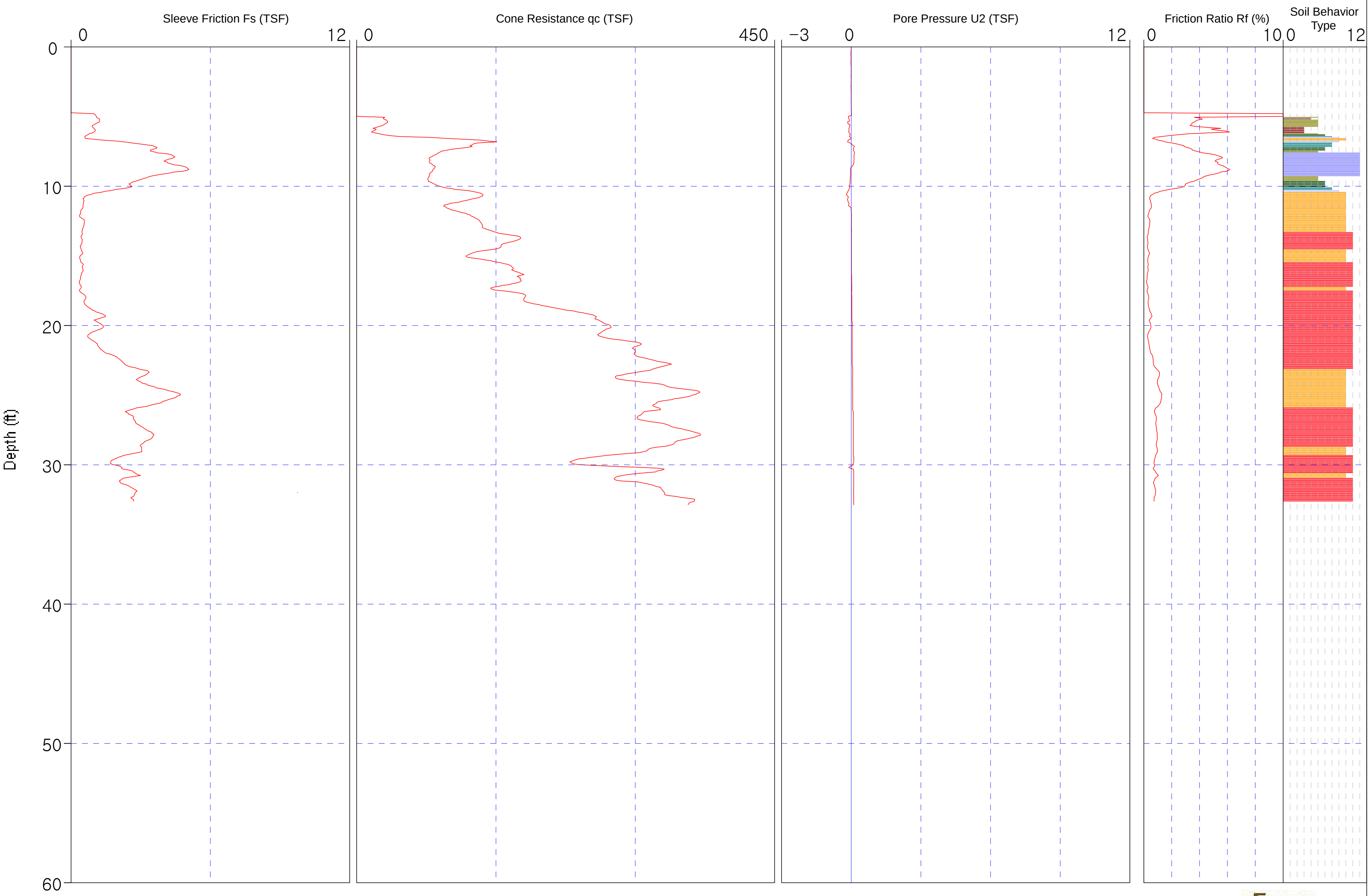
⬜ (1) sensitive fine grained (OL-CH)
⬛ (2) organic material (OL-OH)
🟥 (3) clay (CH)
🟫 (4) silty clay to clay (CL-CH)
🟩 (5) clayey silt to silty clay (MH-CL)
🟩 (6) sandy silt to clayey silt (ML-MH)
🟩 (7) silty sand to sandy silt (SM-ML)
🟪 (8) sand to silty sand (SM-SP)
🟧 (9) sand (SW-SP)
🟥 (10) gravel to gravelly sand (SW-GW)
🟦 (11) very stiff fine grained* (CH-CL)
🟦 (12) sand to clayey sand* (SC-SM)

Robertson et al. 1986 *Overconsolidated or Cemented

Job Number: 04.0916-0020
Operator: Danny Garza
Location: Signal Hill, CA

CPT Number: AE-02
Date: 13-Dec-2016
Elevation: 0.00

Coordinates:
Cone Number: CP15-CF25PB7SN2-P1E1 1519



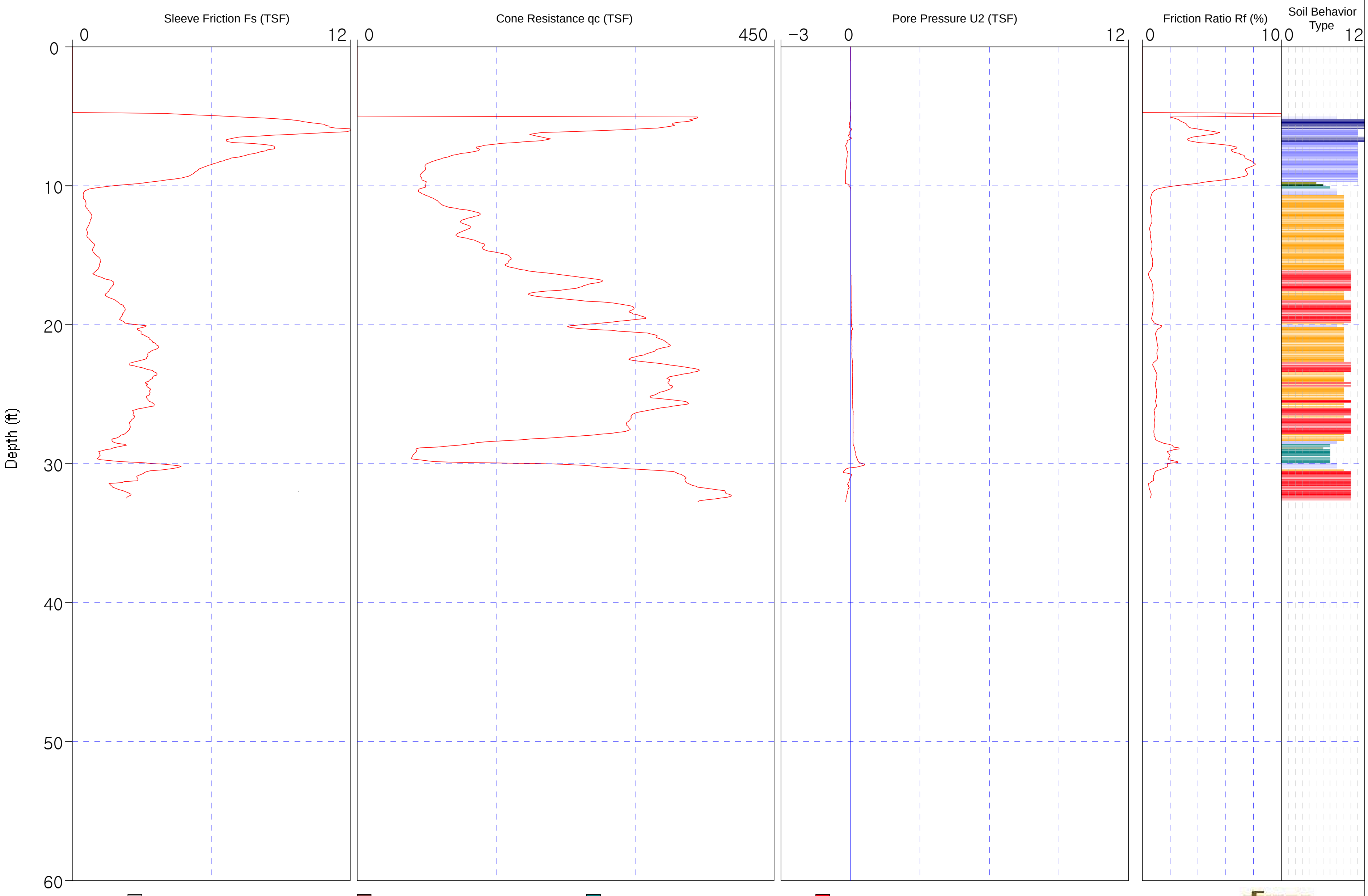
- ▨ (1) sensitive fine grained (OL-CH)
- ▨ (2) organic material (OL-OH)
- ▨ (3) clay (CH)
- ▨ (4) silty clay to clay (CL-CH)
- ▨ (5) clayey silt to silty clay (MH-CL)
- ▨ (6) sandy silt to clayey silt (ML-MH)
- ▨ (7) silty sand to sandy silt (SM-ML)
- ▨ (8) sand to silty sand (SM-SP)
- 🟧 (9) sand (SW-SP)
- 🟥 (10) gravel to gravelly sand (SW-GW)
- ▨ (11) very stiff fine grained* (CH-CL)
- ▨ (12) sand to clayey sand* (SC-SM)

Robertson et al. 1986 *Overconsolidated or Cemented

Job Number: 04.0916-0020
Operator: Danny Garza
Location: Signal Hill, CA

CPT Number: AE-03
Date: 13-Dec-2016
Elevation: 0.00

Coordinates:
Cone Number: CP15-CF25PB7SN2-P1E1 1519



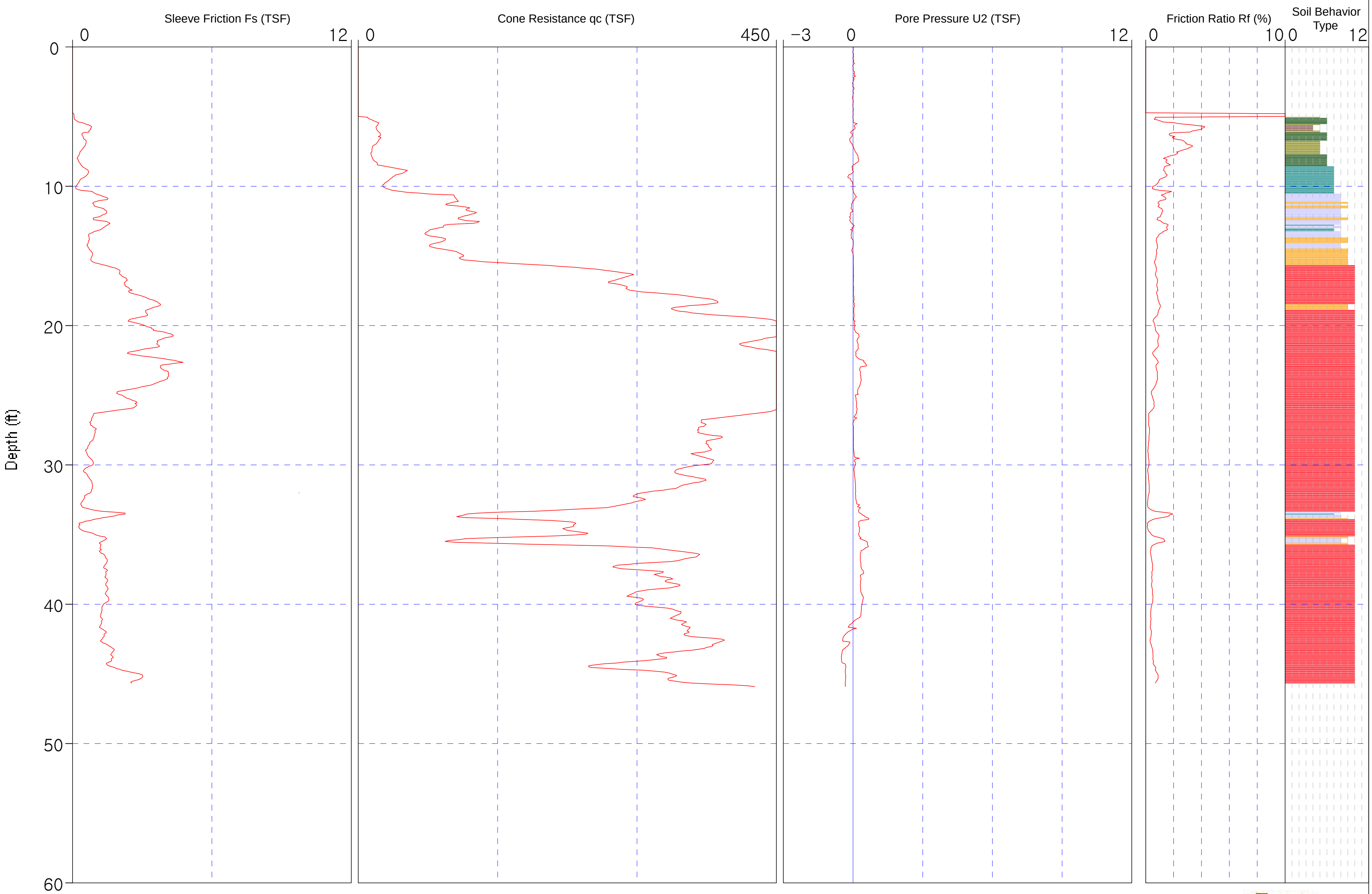
■ (1) sensitive fine grained (OL-CH)
■ (2) organic material (OL-OH)
■ (3) clay (CH)
■ (4) silty clay to clay (CL-CH)
■ (5) clayey silt to silty clay (MH-CL)
■ (6) sandy silt to clayey silt (ML-MH)
■ (7) silty sand to sandy silt (SM-ML)
■ (8) sand to silty sand (SM-SP)
■ (9) sand (SW-SP)
■ (10) gravel to gravelly sand (SW-GW)
■ (11) very stiff fine grained* (CH-CL)
■ (12) sand to clayey sand* (SC-SM)

Robertson et al. 1986 *Overconsolidated or Cemented

Job Number: 04.0916-0020
Operator: Danny Garza
Location: Signal Hill, CA

CPT Number: AN-09
Date: 14-Dec-2016
Elevation: 0.00

Coordinates:
Cone Number: CP15-CF25PB7SN2-P1E1 1519



■ (1) sensitive fine grained (OL-CH)
■ (2) organic material (OL-OH)
■ (3) clay (CH)

■ (4) silty clay to clay (CL-CH)
■ (5) clayey silt to silty clay (MH-CL)
■ (6) sandy silt to clayey silt (ML-MH)

■ (7) silty sand to sandy silt (SM-ML)
■ (8) sand to silty sand (SM-SP)
■ (9) sand (SW-SP)

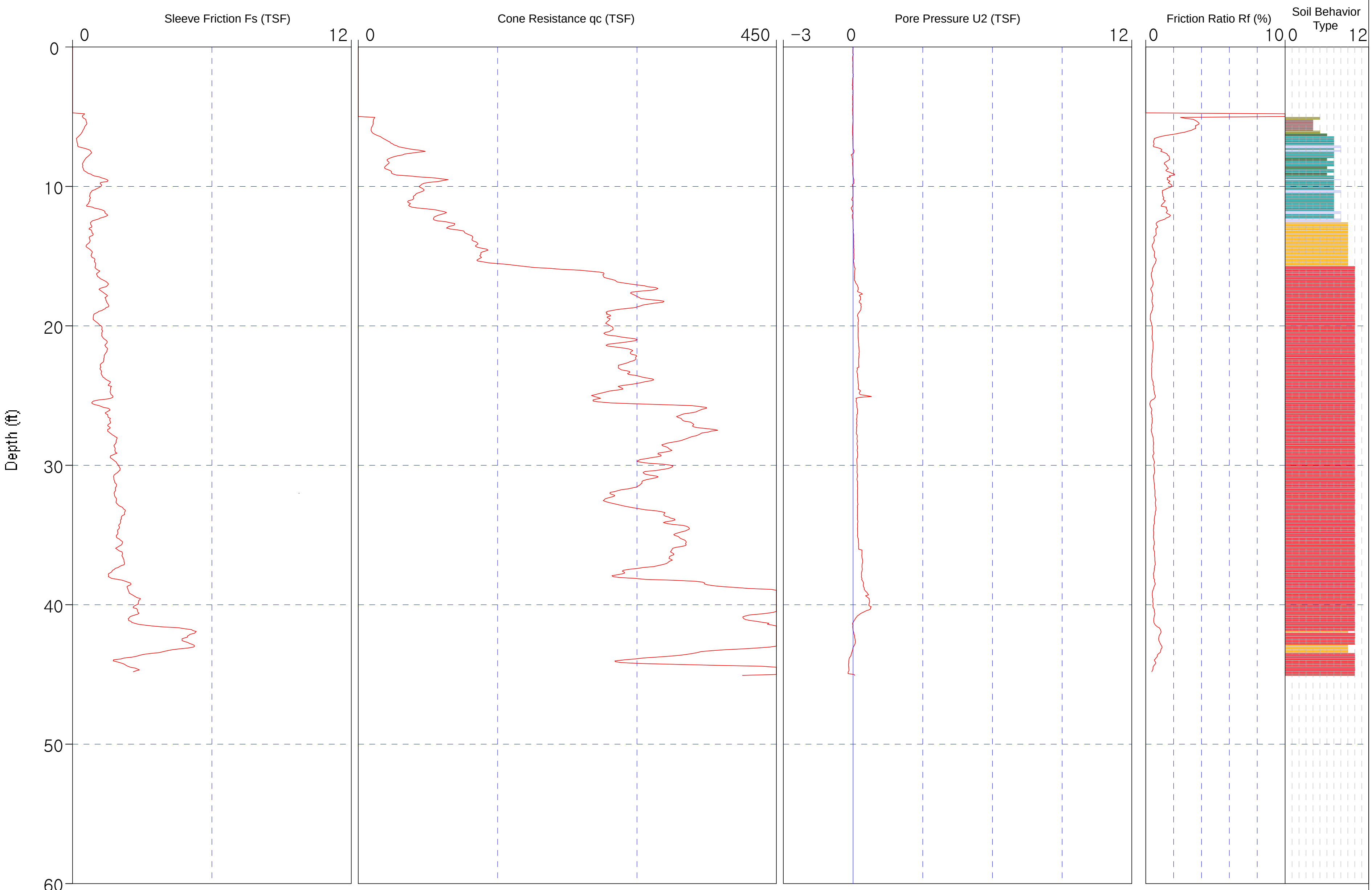
■ (10) gravel to gravelly sand (SW-GW)
■ (11) very stiff fine grained* (CH-CL)
■ (12) sand to clayey sand* (SC-SM)

Robertson et al. 1986 *Overconsolidated or Cemented

Job Number: 04.0916-0020
Operator: Danny Garza
Location: Signal Hill, CA

CPT Number: AN-10
Date: 14-Dec-2016
Elevation: 0.00

Coordinates:
Cone Number: CP15-CF25PB7SN2-P1E1 1519



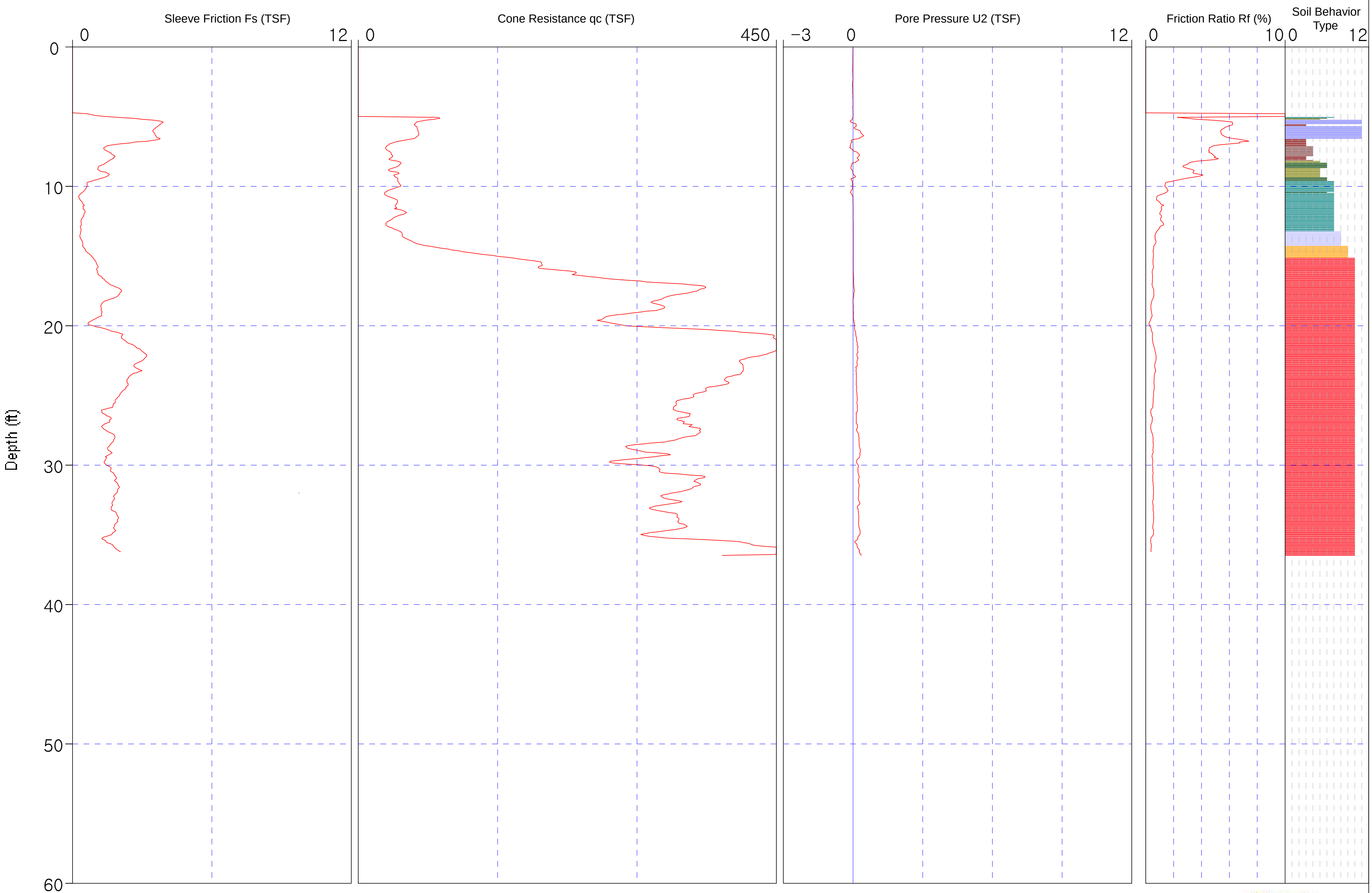
🟫 (1) sensitive fine grained (OL-CH)
🟫 (2) organic material (OL-OH)
🟥 (3) clay (CH)
🟫 (4) silty clay to clay (CL-CH)
🟫 (5) clayey silt to silty clay (MH-CL)
🟩 (6) sandy silt to clayey silt (ML-MH)
🟦 (7) silty sand to sandy silt (SM-ML)
🟪 (8) sand to silty sand (SM-SP)
🟧 (9) sand (SW-SP)
🟥 (10) gravel to gravelly sand (SW-GW)
🟦 (11) very stiff fine grained* (CH-CL)
🟦 (12) sand to clayey sand* (SC-SM)

Robertson et al. 1986 *Overconsolidated or Cemented

Job Number: 04.0916-0020
Operator: Danny Garza
Location: Signal Hill, CA

CPT Number: AN-11
Date: 15-Dec-2016
Elevation: 0.00

Coordinates:
Cone Number: CP15-CF25PB7SN2-P1E1 1519



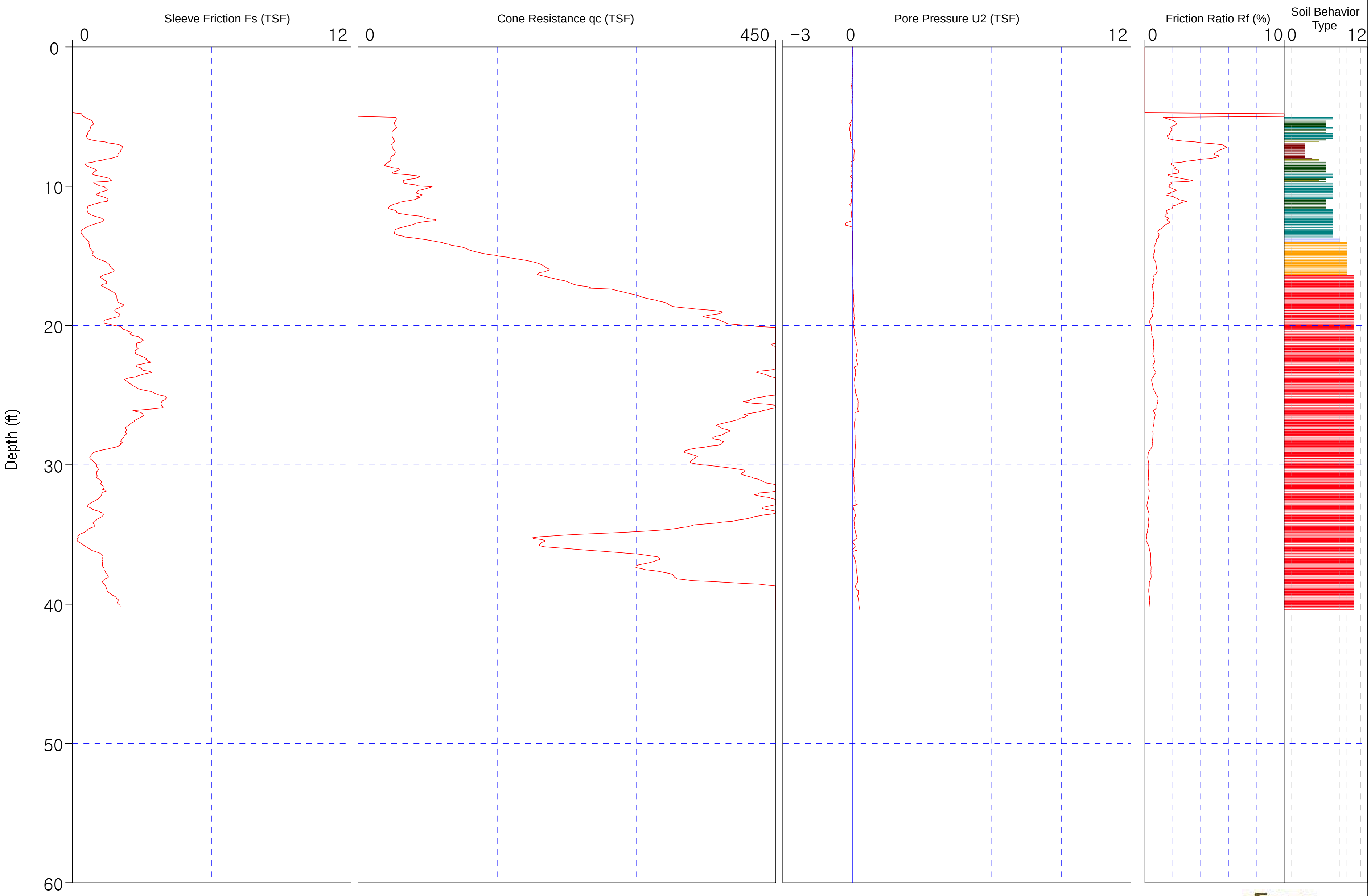
- ■ (1) sensitive fine grained (OL-CH)
- ■ (2) organic material (OL-OH)
- ■ (3) clay (CH)
- ■ (4) silty clay to clay (CL-CH)
- ■ (5) clayey silt to silty clay (MH-CL)
- ■ (6) sandy silt to clayey silt (ML-MH)
- ■ (7) silty sand to sandy silt (SM-ML)
- ■ (8) sand to silty sand (SM-SP)
- 🟧 (9) sand (SW-SP)
- 🟥 (10) gravel to gravelly sand (SW-GW)
- 🟦 (11) very stiff fine grained* (CH-CL)
- ■ (12) sand to clayey sand* (SC-SM)

Robertson et al. 1986 *Overconsolidated or Cemented

Job Number: 04.0916-0020
Operator: Danny Garza
Location: Signal Hill, CA

CPT Number: AN-12
Date: 15-Dec-2016
Elevation: 0.00

Coordinates:
Cone Number: CP15-CF25PB7SN2-P1E1 1519



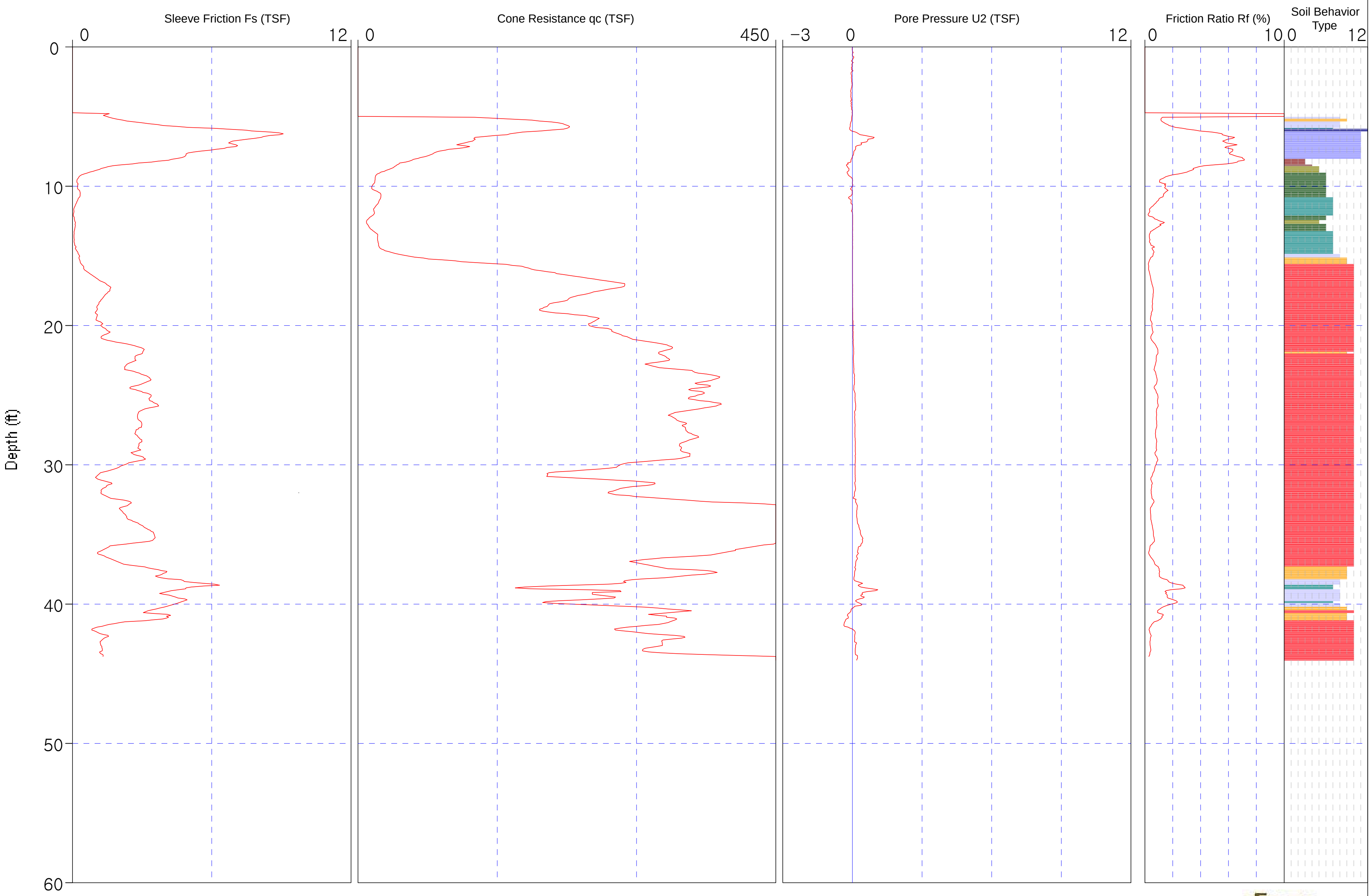
🟫 (1) sensitive fine grained (OL-CH)
🟫 (2) organic material (OL-OH)
🟥 (3) clay (CH)
🟫 (4) silty clay to clay (CL-CH)
🟫 (5) clayey silt to silty clay (MH-CL)
🟩 (6) sandy silt to clayey silt (ML-MH)
🟦 (7) silty sand to sandy silt (SM-ML)
🟪 (8) sand to silty sand (SM-SP)
🟧 (9) sand (SW-SP)
🟥 (10) gravel to gravelly sand (SW-GW)
🟦 (11) very stiff fine grained* (CH-CL)
🟦 (12) sand to clayey sand* (SC-SM)

Robertson et al. 1986 *Overconsolidated or Cemented

Job Number: 04.0916-0020
Operator: Danny Garza
Location: Signal Hill, CA

CPT Number: AN-15
Date: 14-Dec-2016
Elevation: 0.00

Coordinates:
Cone Number: CP15-CF25PB7SN2-P1E1 1519



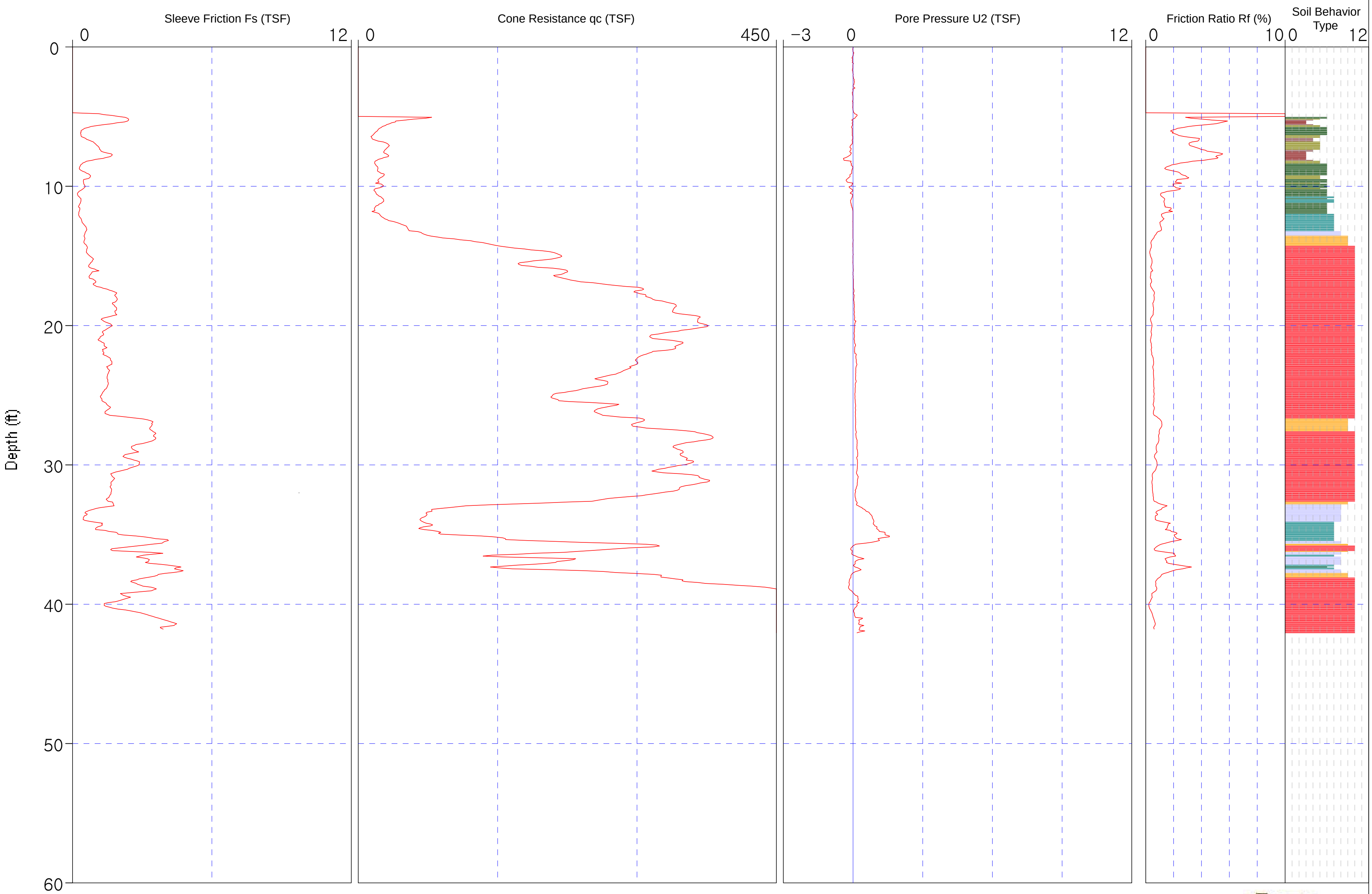
🟫 (1) sensitive fine grained (OL-CH)
🟫 (2) organic material (OL-OH)
🟥 (3) clay (CH)
🟫 (4) silty clay to clay (CL-CH)
🟫 (5) clayey silt to silty clay (MH-CL)
🟩 (6) sandy silt to clayey silt (ML-MH)
🟦 (7) silty sand to sandy silt (SM-ML)
🟪 (8) sand to silty sand (SM-SP)
🟧 (9) sand (SW-SP)
🟥 (10) gravel to gravelly sand (SW-GW)
🟦 (11) very stiff fine grained* (CH-CL)
🟦 (12) sand to clayey sand* (SC-SM)

Robertson et al. 1986 *Overconsolidated or Cemented

Job Number: 0409160020
Operator: D. Garza
Location: Signal Hill, CA

CPT Number: AN-16
Date: 14-Dec-2016
Elevation: 0.00

Coordinates:
Cone Number: CP15-CF25PB7SN2-P1E1 1519



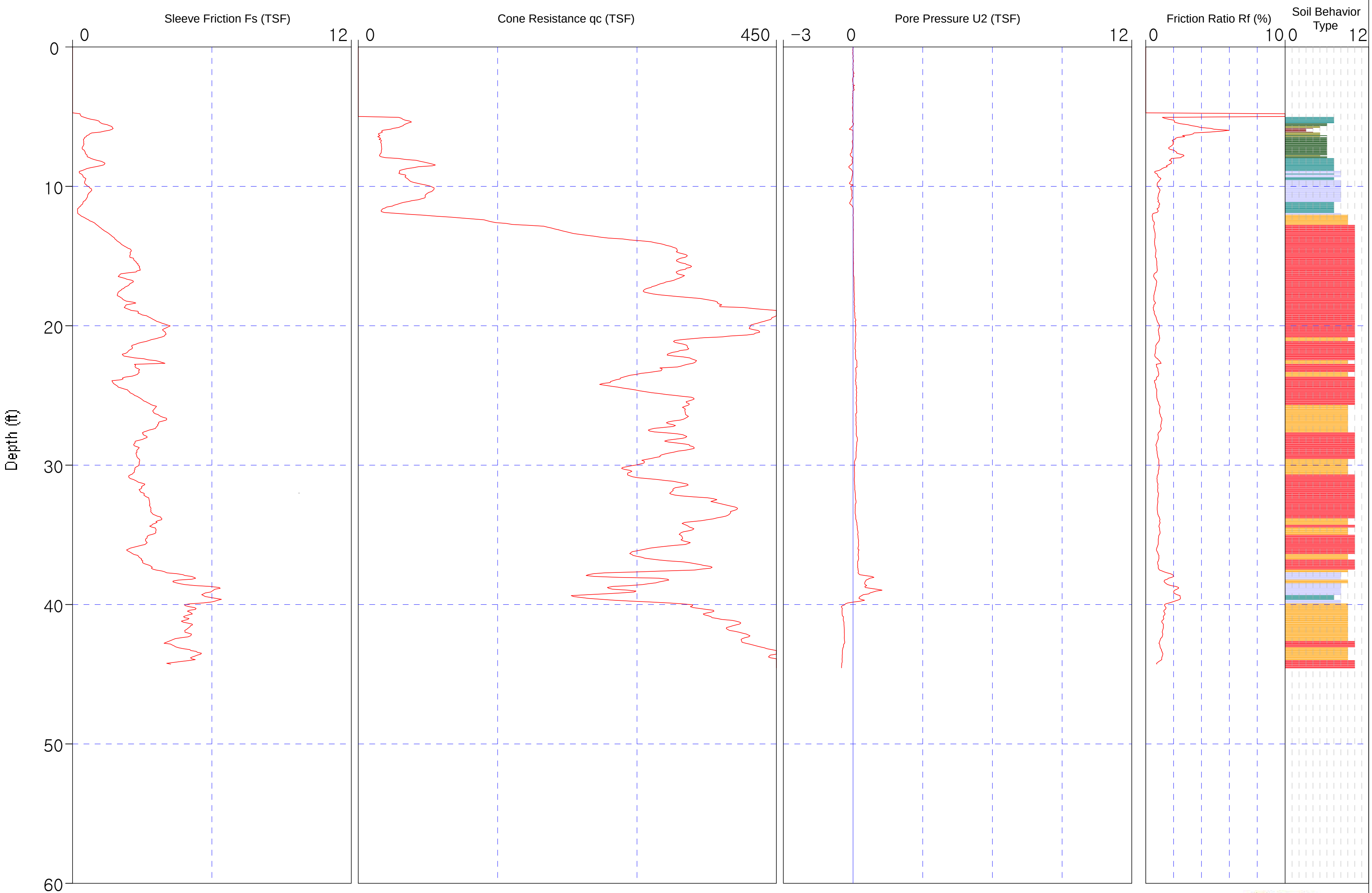
■ (1) sensitive fine grained (OL-CH)
■ (2) organic material (OL-OH)
■ (3) clay (CH)
■ (4) silty clay to clay (CL-CH)
■ (5) clayey silt to silty clay (MH-CL)
■ (6) sandy silt to clayey silt (ML-MH)
■ (7) silty sand to sandy silt (SM-ML)
■ (8) sand to silty sand (SM-SP)
■ (9) sand (SW-SP)
■ (10) gravel to gravelly sand (SW-GW)
■ (11) very stiff fine grained* (CH-CL)
■ (12) sand to clayey sand* (SC-SM)

Robertson et al. 1986 *Overconsolidated or Cemented

Job Number: 04.0916-0020
Operator: Danny Garza
Location: Signal Hill, CA

CPT Number: AN-17
Date: 15-Dec-2016
Elevation: 0.00

Coordinates:
Cone Number: CP15-CF25PB7SN2-P1E1 1519



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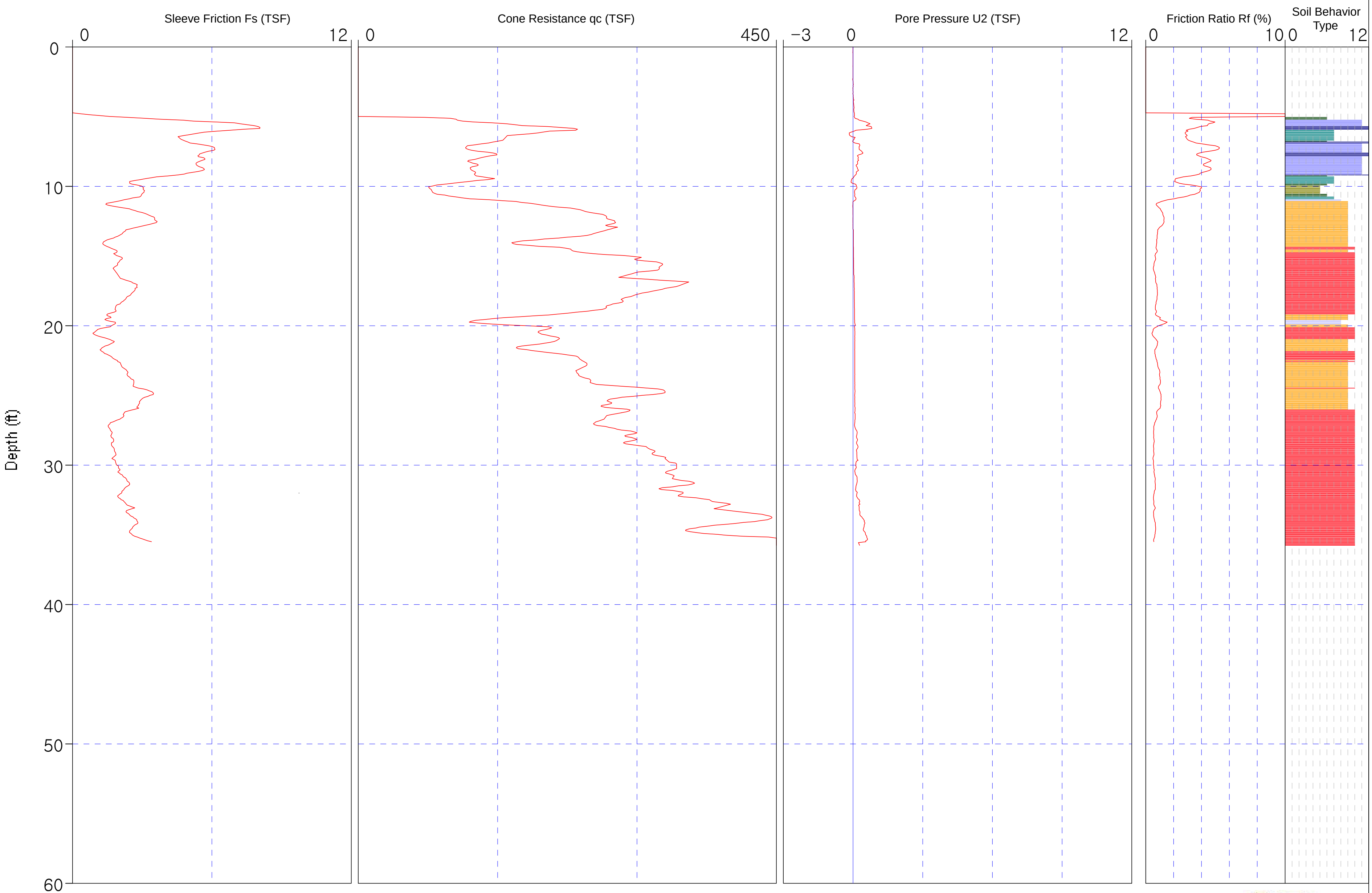
■ (2) organic material (OL-OH)
■ (3) clay (CH)
■ (4) silty clay to clay (CL-CH)
■ (5) clayey silt to silty clay (MH-CL)
■ (6) sandy silt to clayey silt (ML-MH)
■ (7) silty sand to sandy silt (SM-ML)
■ (8) sand to silty sand (SM-SP)
■ (9) sand (SW-SP)
■ (10) gravel to gravelly sand (SW-GW)
■ (11) very stiff fine grained* (CH-CL)
■ (12) sand to clayey sand* (SC-SM)

Robertson et al. 1986 *Overconsolidated or Cemented

Job Number: 04.0916-0020
Operator: Danny Garza
Location: Signal Hill, CA

CPT Number: AN-18
Date: 15-Dec-2016
Elevation: 0.00

Coordinates:
Cone Number: CP15-CF25PB7SN2-P1E1 1519



⬜ (1) sensitive fine grained (OL-CH)
⬛ (2) organic material (OL-OH)
🟥 (3) clay (CH)

🟫 (4) silty clay to clay (CL-CH)
🟫 (5) clayey silt to silty clay (MH-CL)
🟩 (6) sandy silt to clayey silt (ML-MH)

🟦 (7) silty sand to sandy silt (SM-ML)
🟪 (8) sand to silty sand (SM-SP)
🟧 (9) sand (SW-SP)

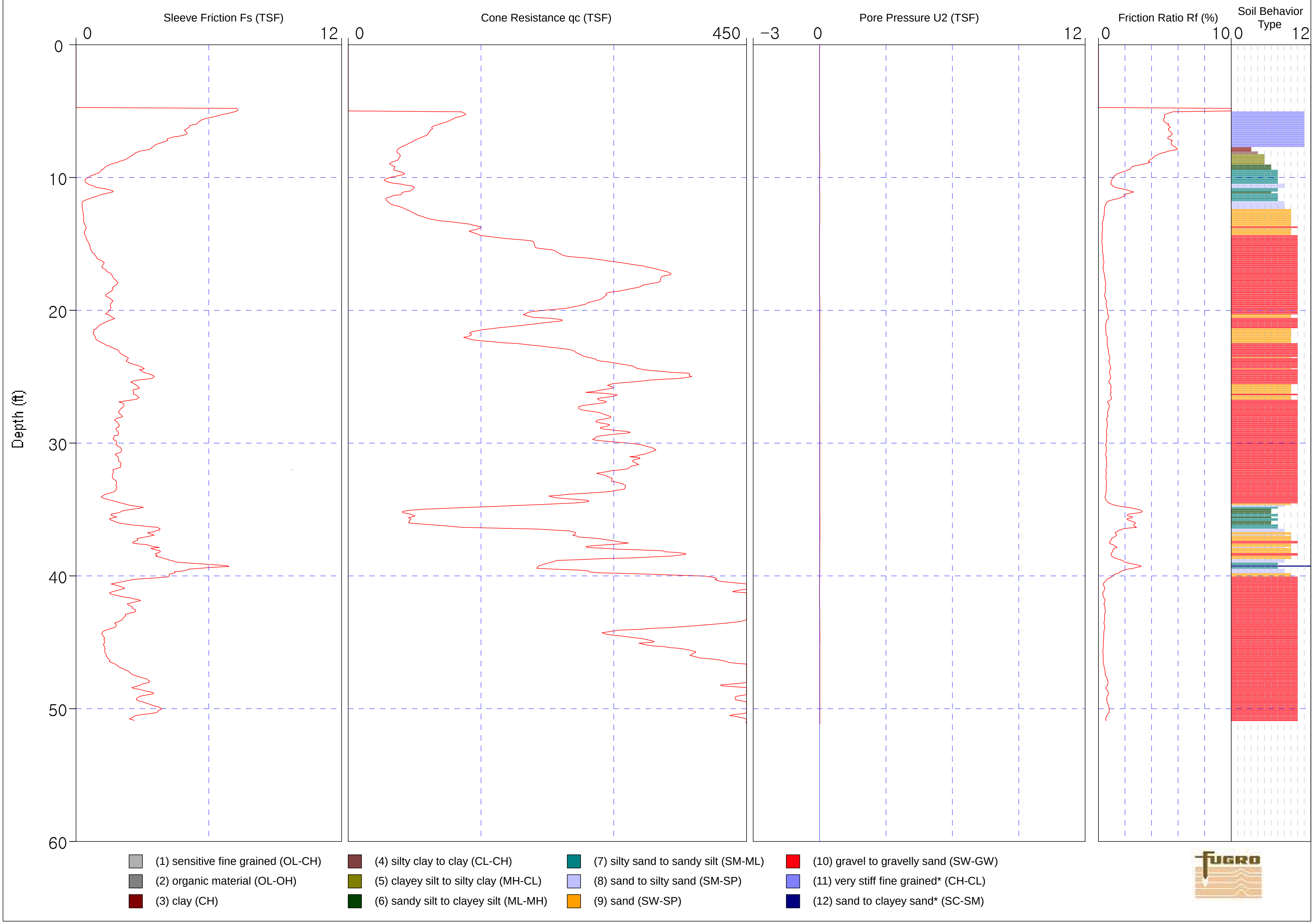
🟥 (10) gravel to gravelly sand (SW-GW)
🟦 (11) very stiff fine grained* (CH-CL)
🟦 (12) sand to clayey sand* (SC-SM)

Robertson et al. 1986 *Overconsolidated or Cemented

Job Number: 04.0916-0020
Operator: Danny Garza
Location: Signal Hill, CA

CPT Number: AN-19
Date: 19-Dec-2016
Elevation: 0.00

Coordinates:
Cone Number: CP15-CF25PB7SN2-P1E1 2095

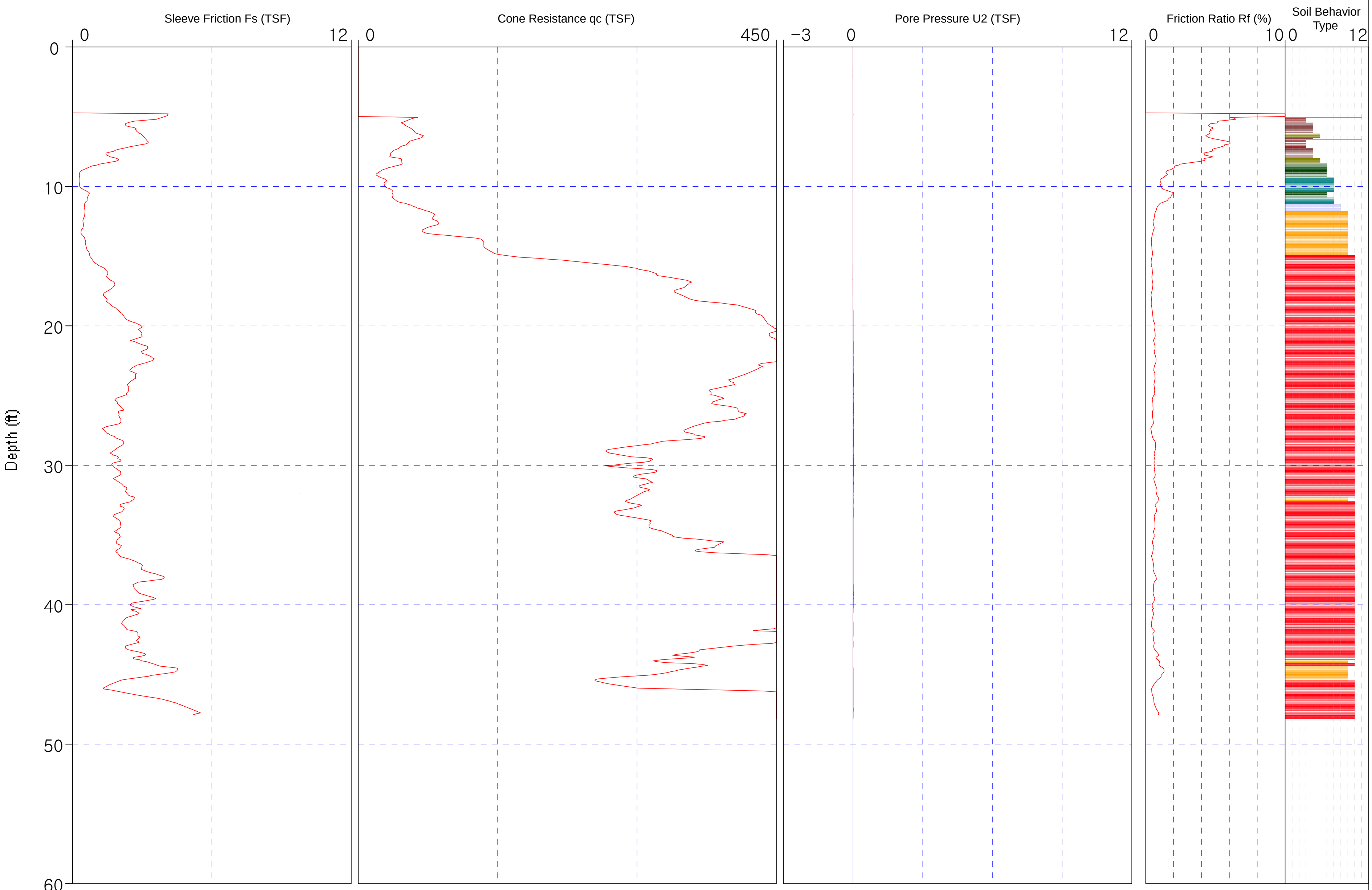


Robertson et al. 1986 *Overconsolidated or Cemented

Job Number: 04.0916-0020
Operator: Danny Garza
Location: Signal Hill, CA

CPT Number: AN-21
Date: 19-Dec-2016
Elevation: 0.00

Coordinates:
Cone Number: CP15-CF25PB7SN2-P1E1 2095

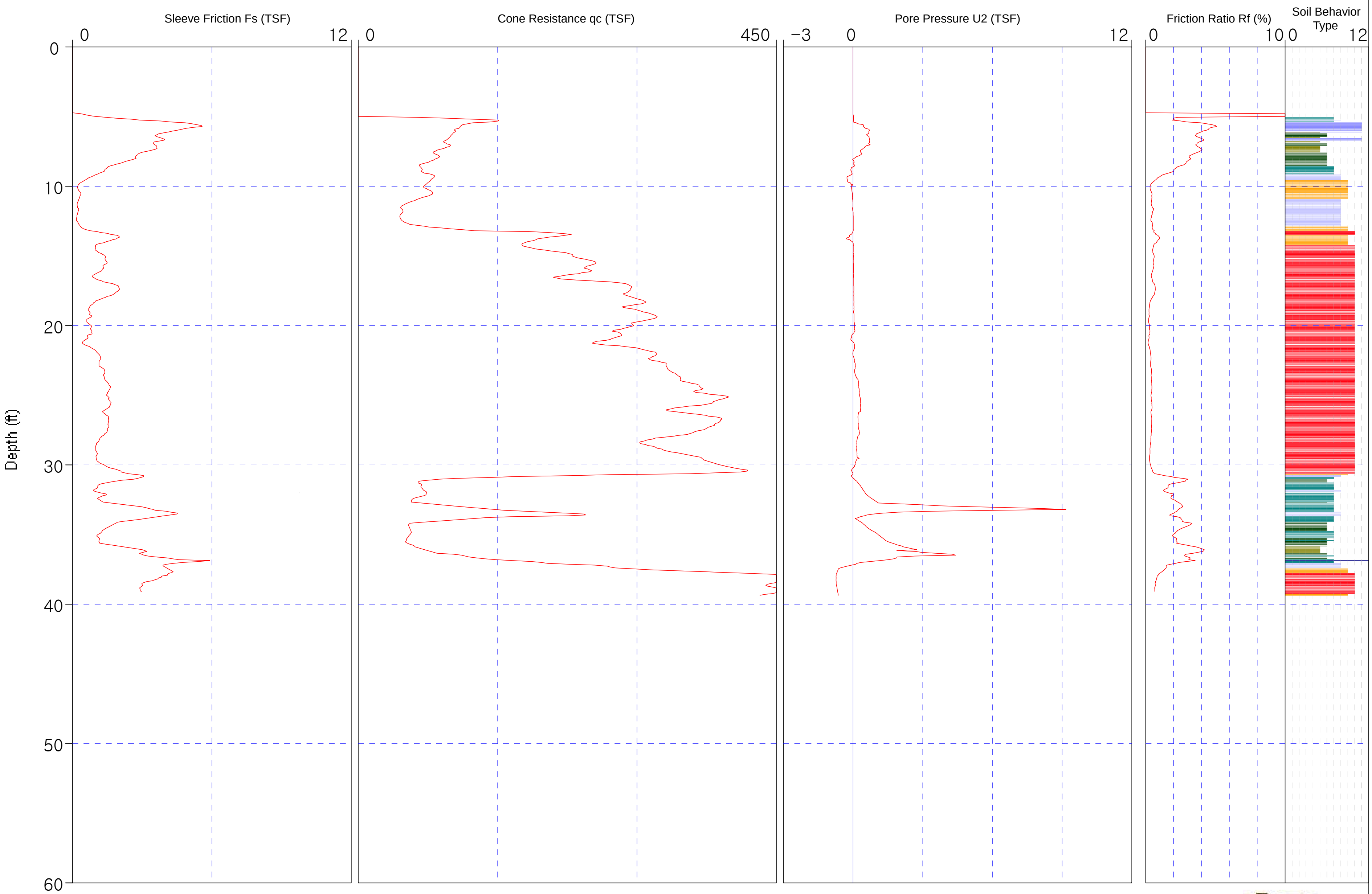


▨ (1) sensitive fine grained (OL-CH)
▨ (2) organic material (OL-OH)
▨ (3) clay (CH)
▨ (4) silty clay to clay (CL-CH)
▨ (5) clayey silt to silty clay (MH-CL)
▨ (6) sandy silt to clayey silt (ML-MH)
▨ (7) silty sand to sandy silt (SM-ML)
▨ (8) sand to silty sand (SM-SP)
▨ (9) sand (SW-SP)
🟥 (10) gravel to gravelly sand (SW-GW)
▨ (11) very stiff fine grained* (CH-CL)
▨ (12) sand to clayey sand* (SC-SM)

FUGRO

Robertson et al. 1986 *Overconsolidated or Cemented

Job Number:	04.0916-0020	**CPT Number:**	AS-01	**Coordinates:**	
Operator:	Danny Garza	**Date:**	14-Dec-2016	**Cone Number:**	CP15-CF25PB7SN2-P1E1 1519
Location:	Signal Hill, CA	**Elevation:**	0.00		



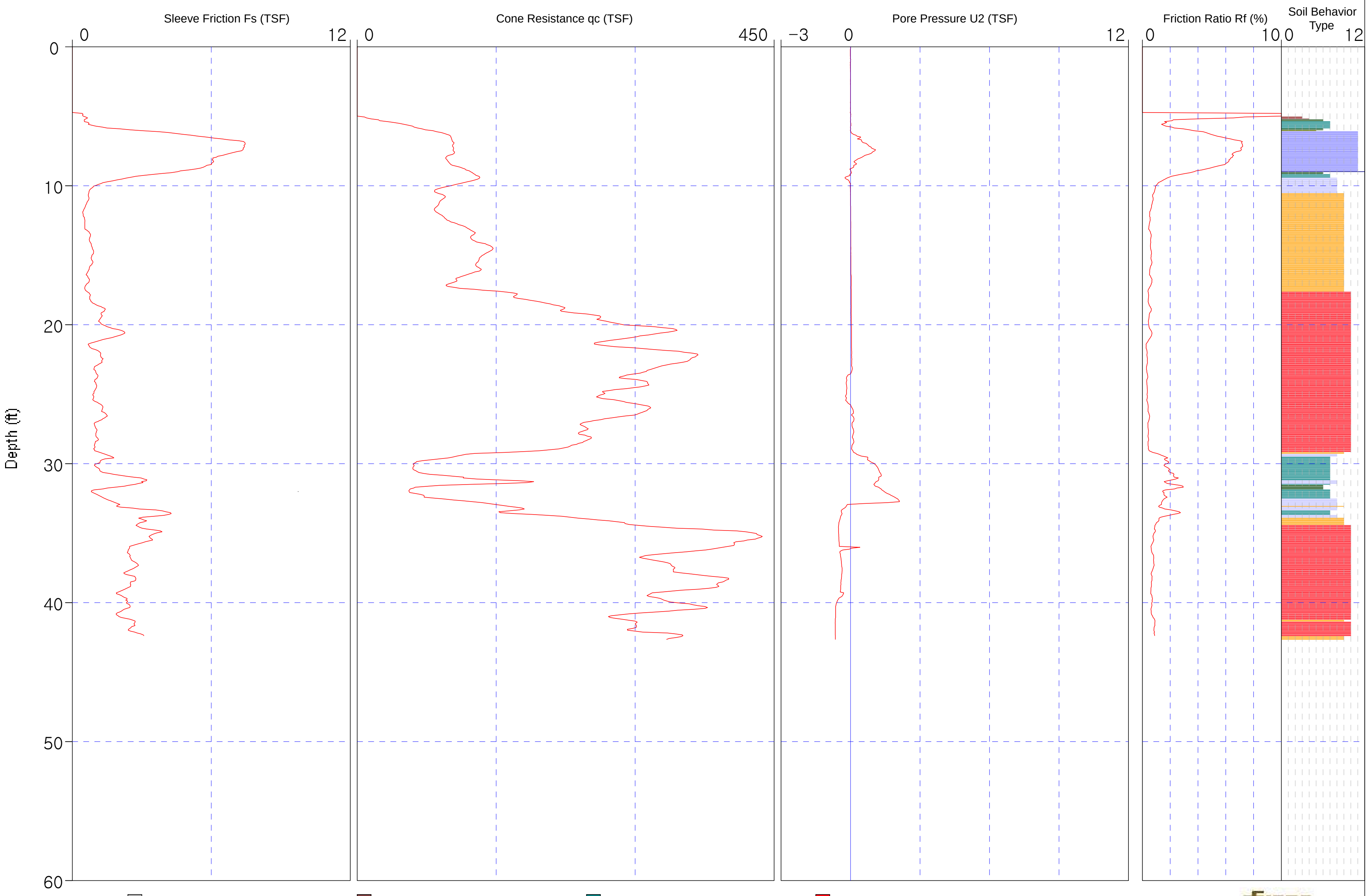
⬜ (1) sensitive fine grained (OL-CH)	🟫 (4) silty clay to clay (CL-CH)	🟦 (7) silty sand to sandy silt (SM-ML)	🟥 (10) gravel to gravelly sand (SW-GW)
⬛ (2) organic material (OL-OH)	🟫 (5) clayey silt to silty clay (MH-CL)	⬜ (8) sand to silty sand (SM-SP)	🟪 (11) very stiff fine grained* (CH-CL)
🟥 (3) clay (CH)	🟩 (6) sandy silt to clayey silt (ML-MH)	🟧 (9) sand (SW-SP)	🟦 (12) sand to clayey sand* (SC-SM)

Robertson et al. 1986 *Overconsolidated or Cemented

Job Number: 04.0916-0020
Operator: Danny Garza
Location: Signal Hill, CA

CPT Number: AS-02
Date: 13-Dec-2016
Elevation: 0.00

Coordinates:
Cone Number: CP15-CF25PB7SN2-P1E1 1519



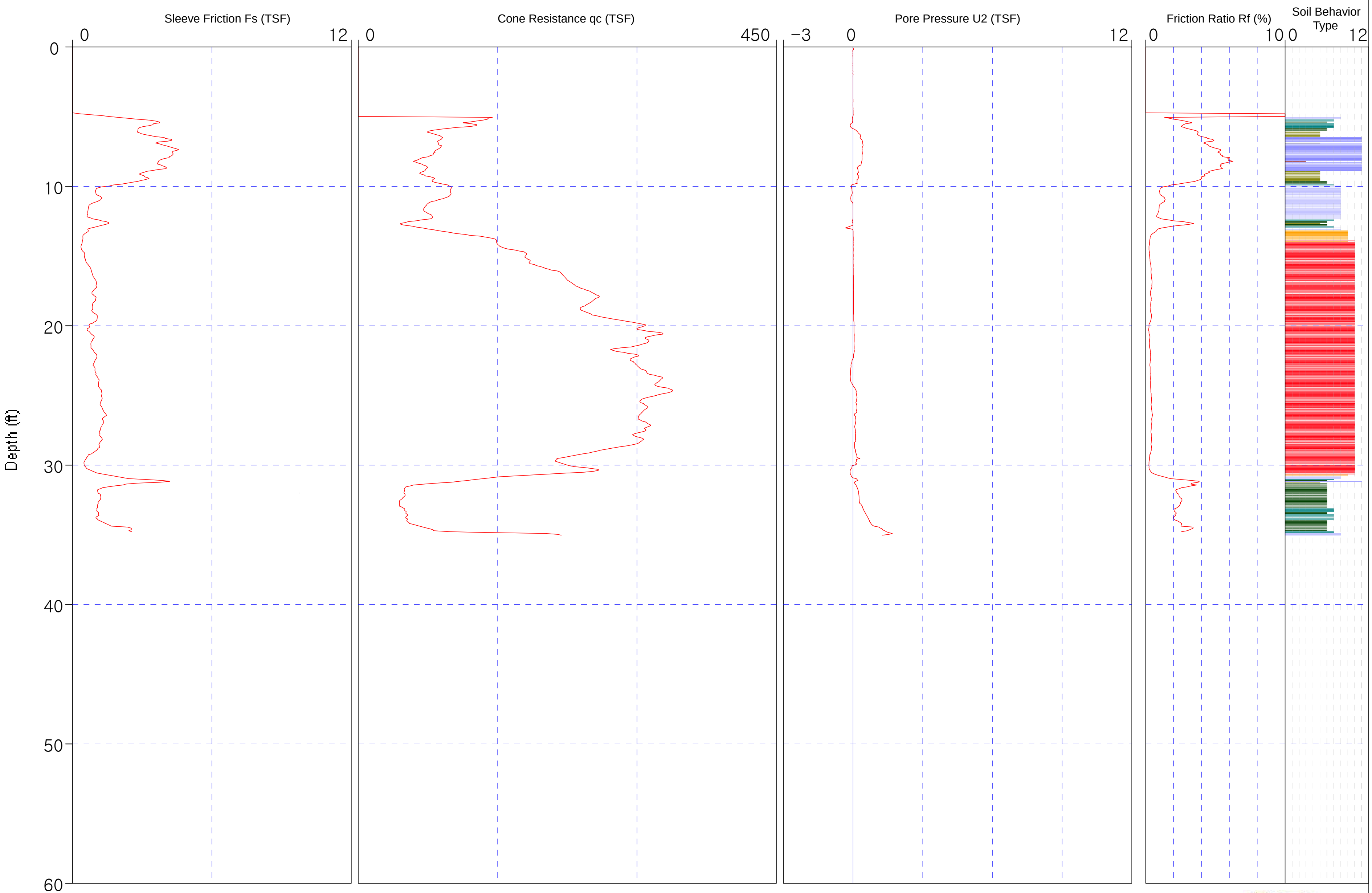
⬜ (1) sensitive fine grained (OL-CH)	🟫 (4) silty clay to clay (CL-CH)	🟦 (7) silty sand to sandy silt (SM-ML)	🟥 (10) gravel to gravelly sand (SW-GW)
⬛ (2) organic material (OL-OH)	🟫 (5) clayey silt to silty clay (MH-CL)	🟪 (8) sand to silty sand (SW-SP)	🟦 (11) very stiff fine grained* (CH-CL)
🟥 (3) clay (CH)	🟩 (6) sandy silt to clayey silt (ML-MH)	🟧 (9) sand (SW-SP)	⬛ (12) sand to clayey sand* (SC-SM)

Robertson et al. 1986 *Overconsolidated or Cemented

Job Number: 04.0916-0020
Operator: Danny Garza
Location: Signal Hill, CA

CPT Number: AS-03
Date: 14-Dec-2016
Elevation: 0.00

Coordinates:
Cone Number: CP15-CF25PB7SN2-P1E1 1519



- ■ (1) sensitive fine grained (OL-CH)
- ■ (2) organic material (OL-OH)
- ■ (3) clay (CH)
- ■ (4) silty clay to clay (CL-CH)
- ■ (5) clayey silt to silty clay (MH-CL)
- ■ (6) sandy silt to clayey silt (ML-MH)
- ■ (7) silty sand to sandy silt (SM-ML)
- ■ (8) sand to silty sand (SM-SP)
- ■ (9) sand (SW-SP)
- 🟥 (10) gravel to gravelly sand (SW-GW)
- ■ (11) very stiff fine grained* (CH-CL)
- ■ (12) sand to clayey sand* (SC-SM)

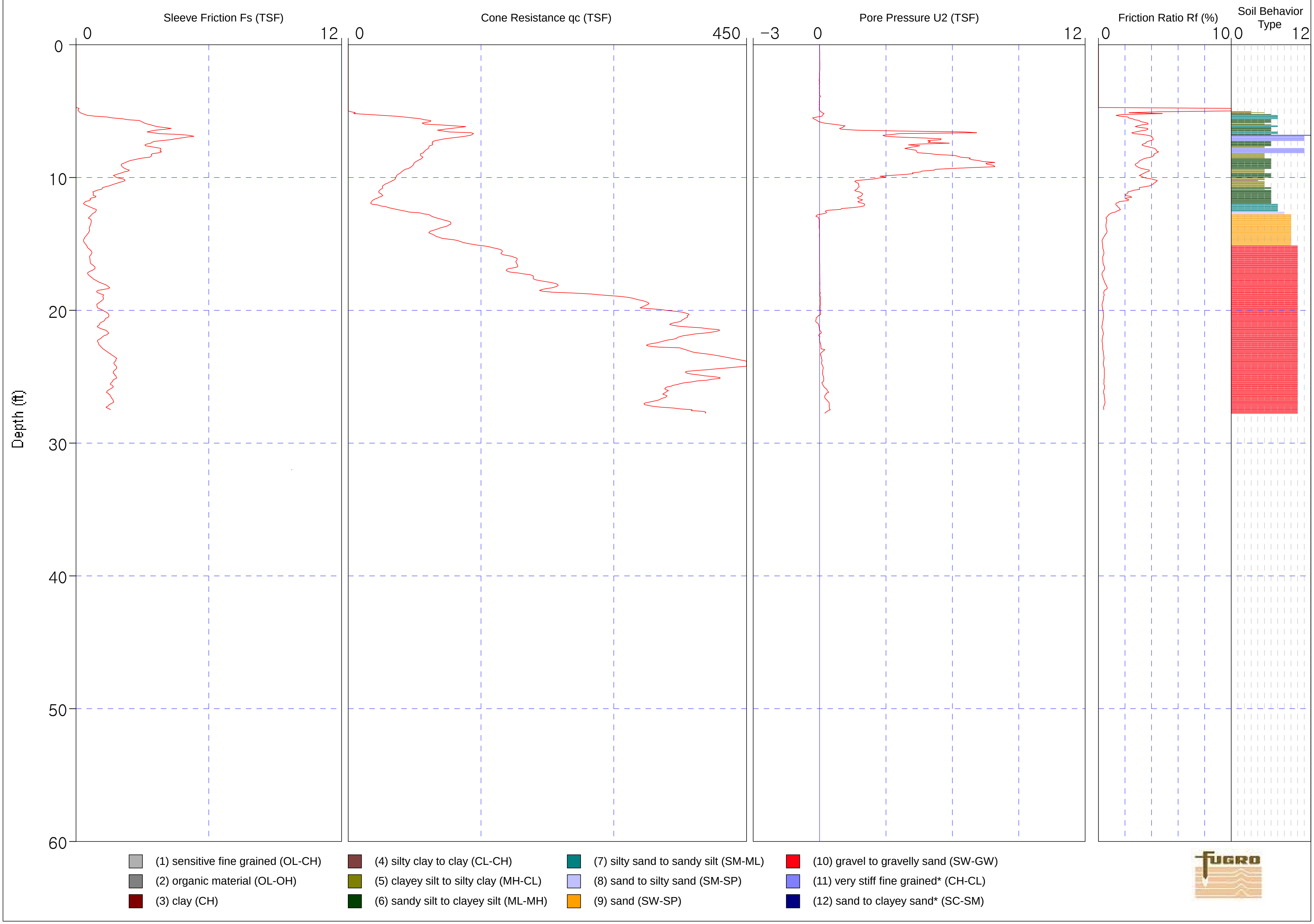
FUGRO

Robertson et al. 1986 *Overconsolidated or Cemented

Job Number: 04.0916-0020
Operator: Danny Garza
Location: Signal Hill, CA

CPT Number: AS-04
Date: 14-Dec-2016
Elevation: 0.00

Coordinates:
Cone Number: CP15-CF25PB7SN2-P1E1 1519

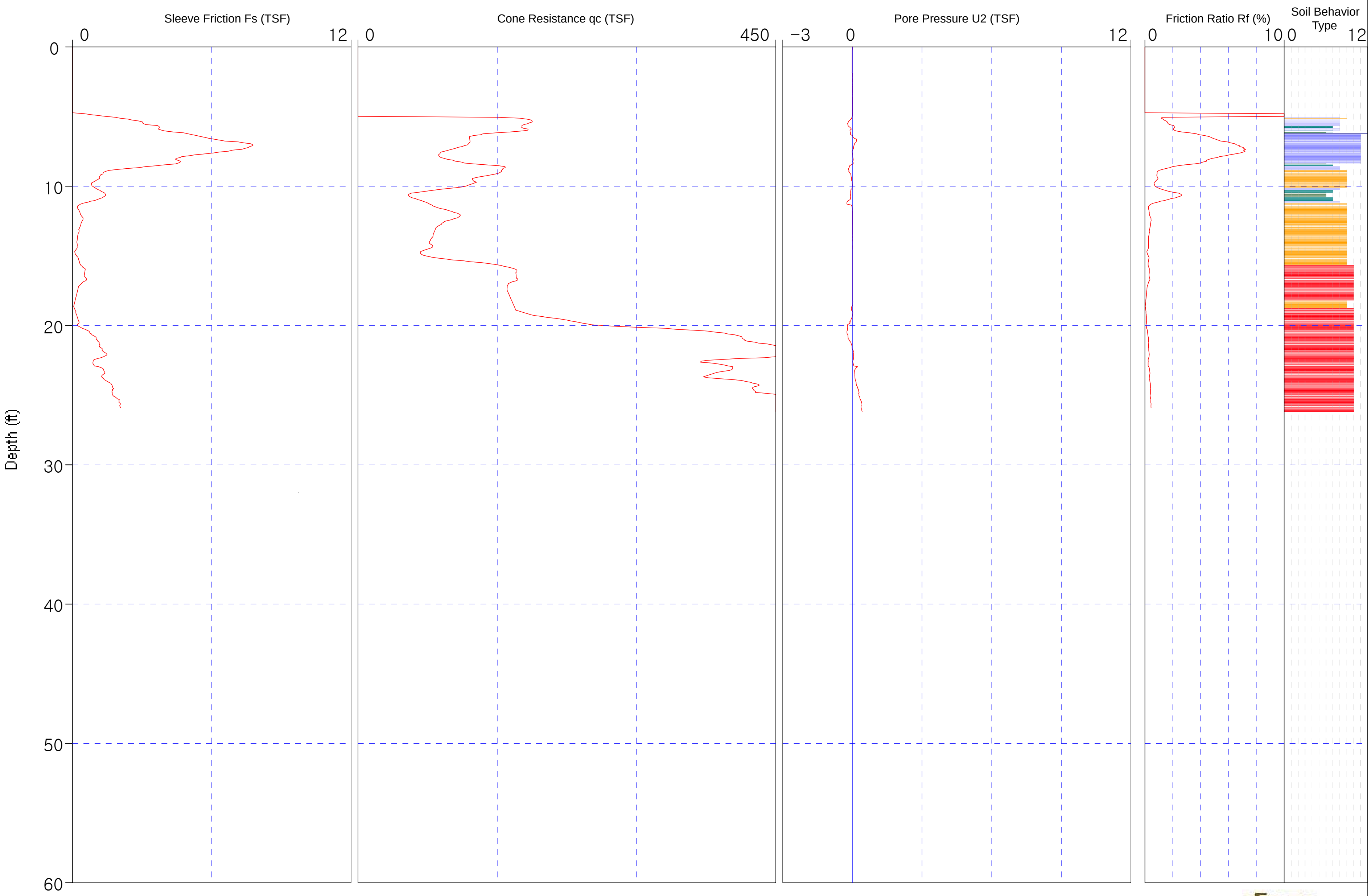


Robertson et al. 1986 *Overconsolidated or Cemented

Job Number: 04.0916-0020
Operator: Danny Garza
Location: Signal Hill, CA

CPT Number: AS-05
Date: 14-Dec-2016
Elevation: 0.00

Coordinates:
Cone Number: CP15-CF25PB7SN2-P1E1 1519



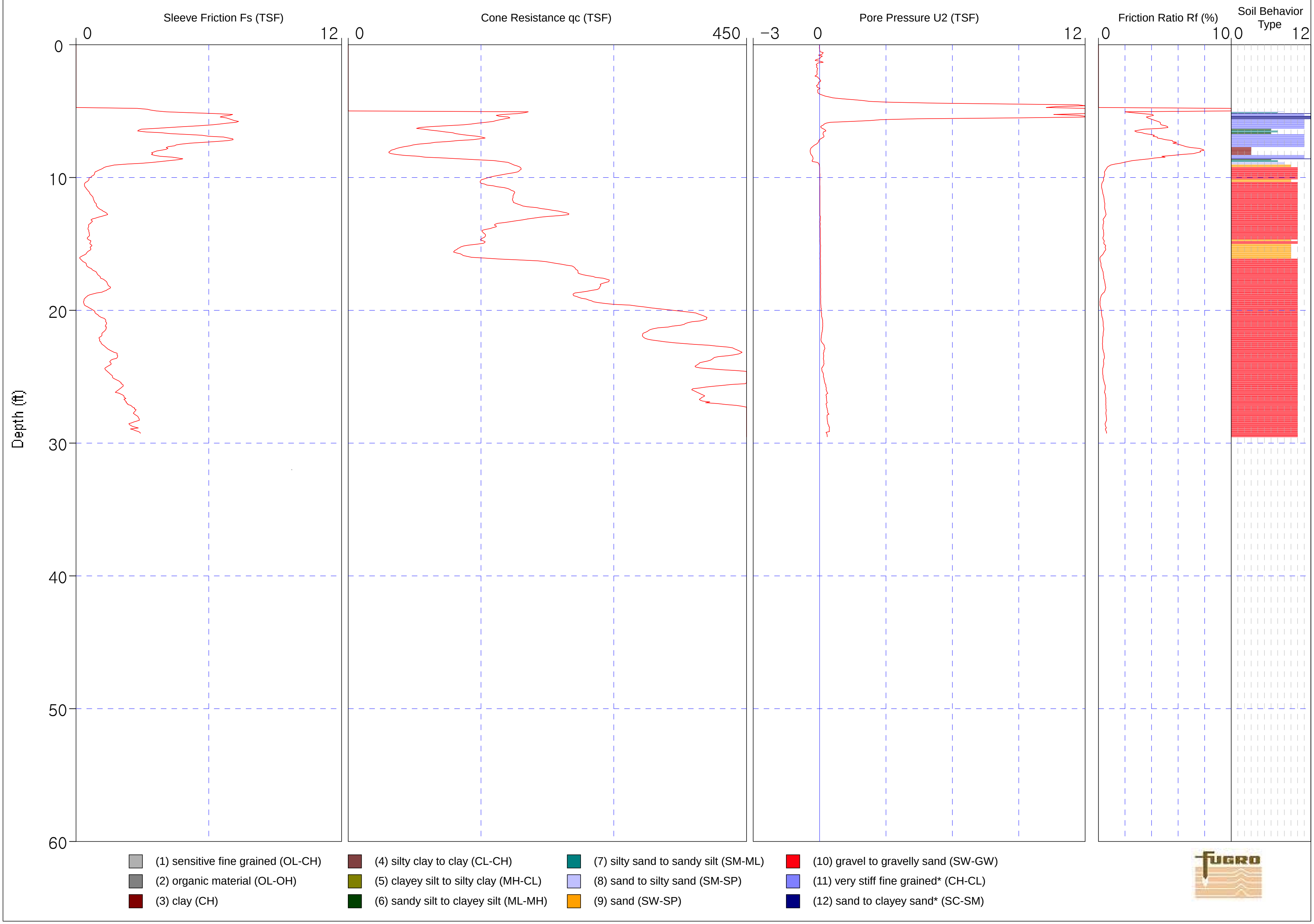
- 🟫 (1) sensitive fine grained (OL-CH)
- 🟫 (2) organic material (OL-OH)
- 🟫 (3) clay (CH)
- 🟫 (4) silty clay to clay (CL-CH)
- 🟫 (5) clayey silt to silty clay (MH-CL)
- 🟩 (6) sandy silt to clayey silt (ML-MH)
- 🟩 (7) silty sand to sandy silt (SM-ML)
- 🟦 (8) sand to silty sand (SM-SP)
- 🟧 (9) sand (SW-SP)
- 🟥 (10) gravel to gravelly sand (SW-GW)
- 🟦 (11) very stiff fine grained* (CH-CL)
- 🟦 (12) sand to clayey sand* (SC-SM)

Robertson et al. 1986 *Overconsolidated or Cemented

Job Number: 0409160020
Operator: D. Garza
Location: Signal Hill, CA

CPT Number: AS-06
Date: 15-Dec-2016
Elevation: 0.00

Coordinates:
Cone Number: CP15-CF25PB7SN2-P1E1 1519

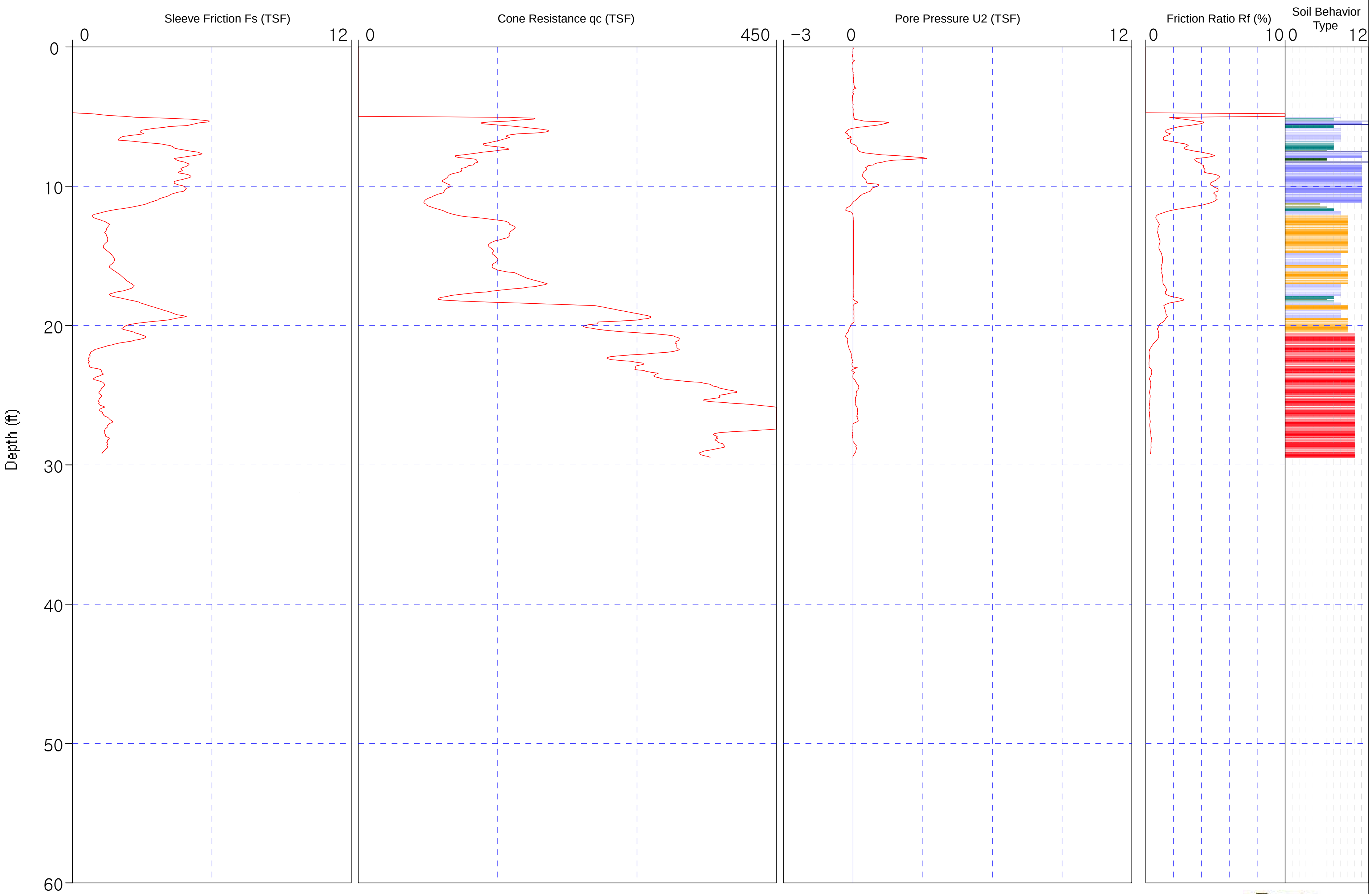


Robertson et al. 1986 *Overconsolidated or Cemented

Job Number: 04.0916-0020
Operator: Danny Garza
Location: Signal Hill, CA

CPT Number: AS-09
Date: 14-Dec-2016
Elevation: 0.00

Coordinates:
Cone Number: CP15-CF25PB7SN2-P1E1 1519



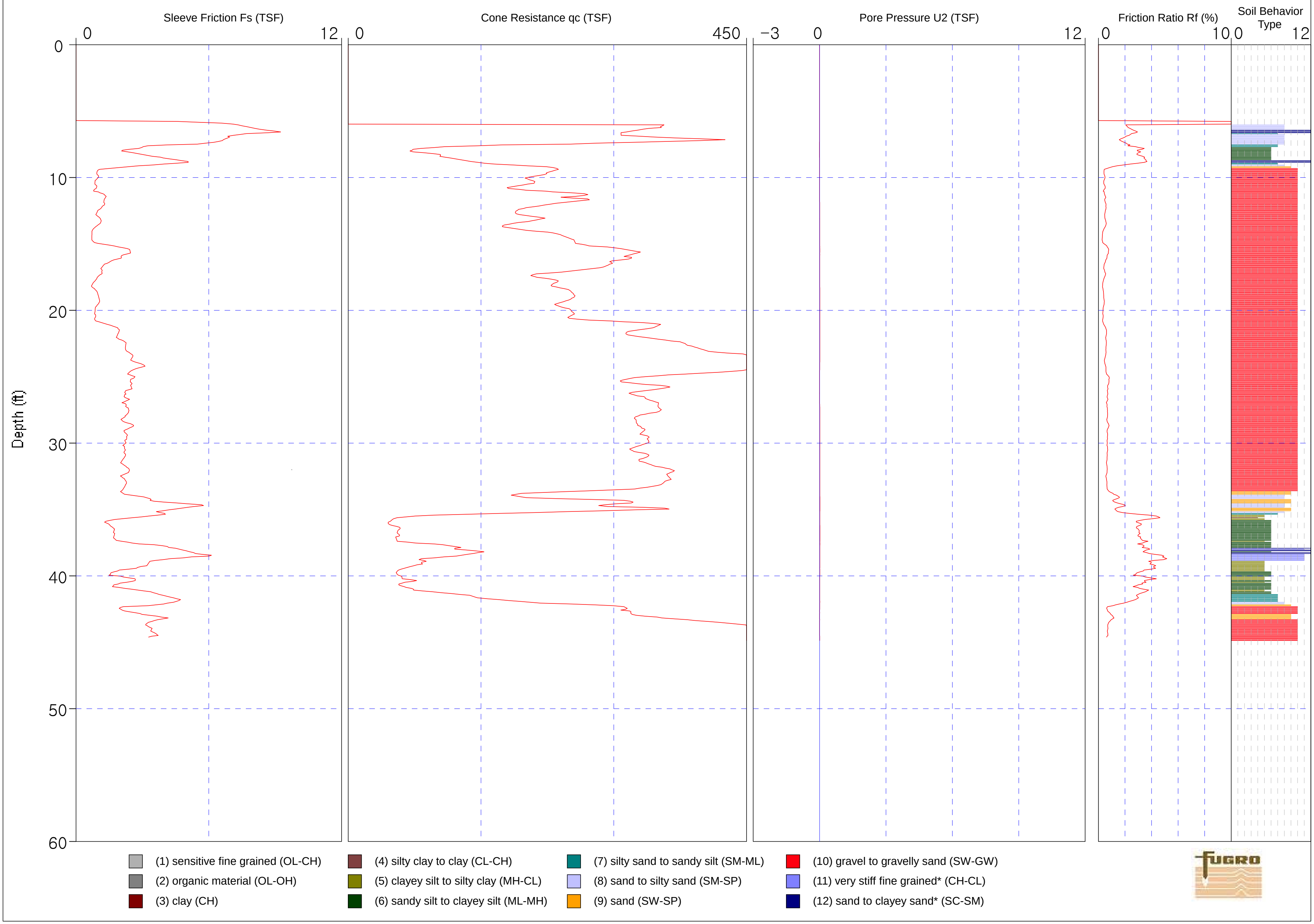
■ (1) sensitive fine grained (OL-CH)
■ (2) organic material (OL-OH)
■ (3) clay (CH)
■ (4) silty clay to clay (CL-CH)
■ (5) clayey silt to silty clay (MH-CL)
■ (6) sandy silt to clayey silt (ML-MH)
■ (7) silty sand to sandy silt (SM-ML)
■ (8) sand to silty sand (SM-SP)
■ (9) sand (SW-SP)
■ (10) gravel to gravelly sand (SW-GW)
■ (11) very stiff fine grained* (CH-CL)
■ (12) sand to clayey sand* (SC-SM)

Robertson et al. 1986 *Overconsolidated or Cemented

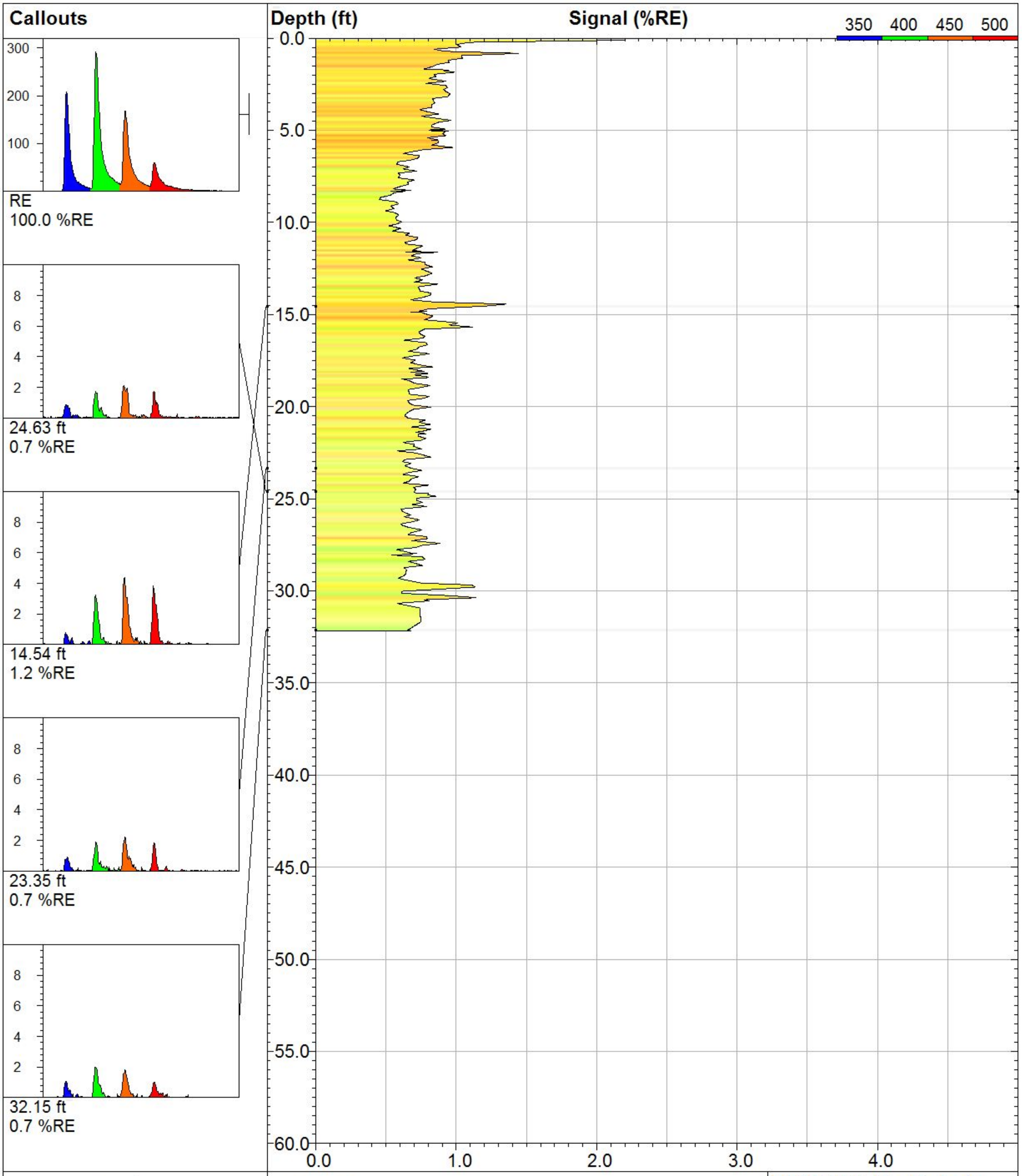
Job Number: 04.0916-0020
Operator: Danny Garza
Location: Signal Hill, CA

CPT Number: AS-10
Date: 19-Dec-2016
Elevation: 0.00

Coordinates:
Cone Number: CP15-CF25PB7SN2-P1E1 2095



Robertson et al. 1986 *Overconsolidated or Cemented



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WWW.DAKOTATECHNOLOGIES.COM

AE-01

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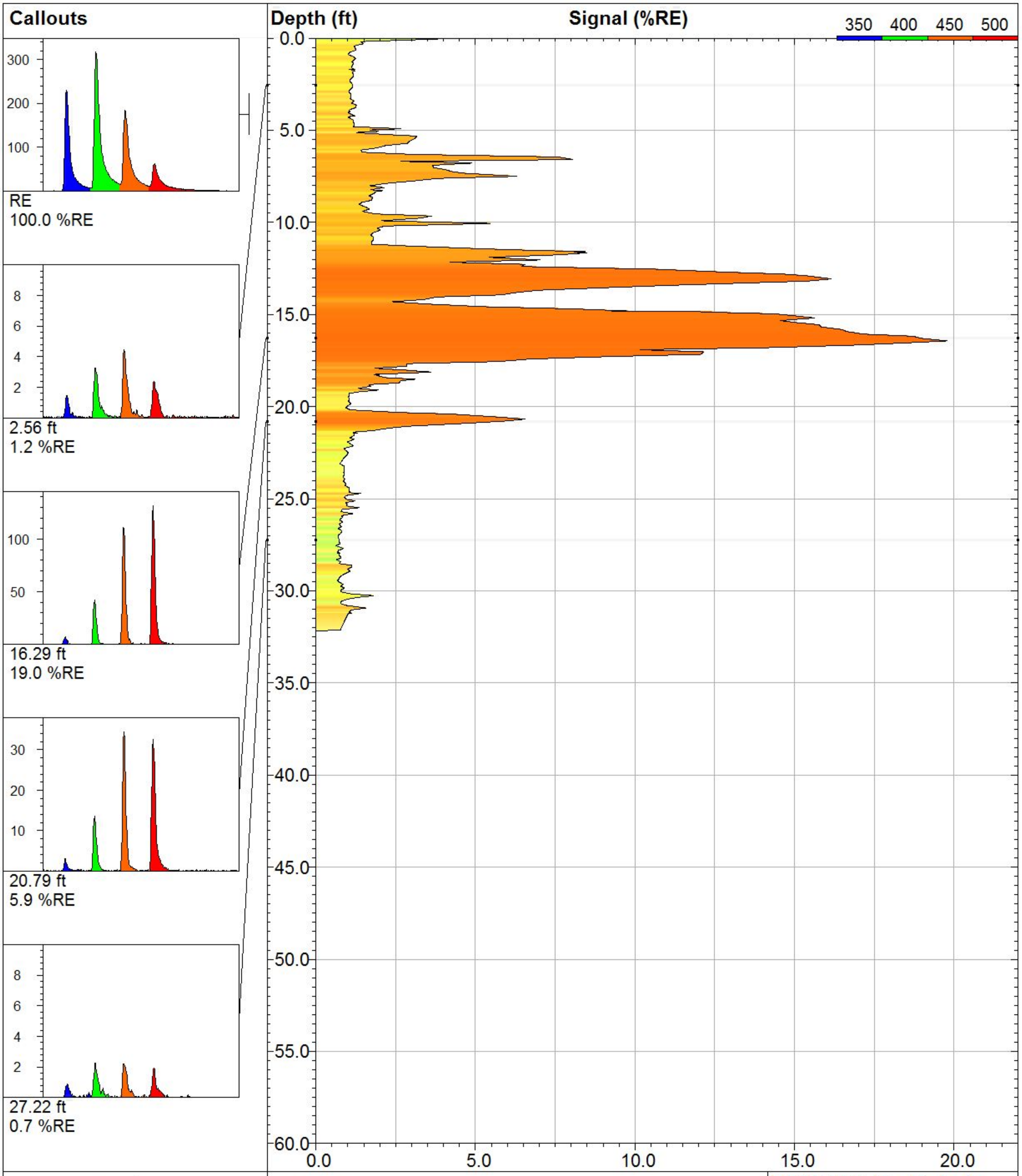
Site: **2040 Walnut, Signal Hill ca**	*Y Coord.(Lat-N) / System:* **Unavailable / NA**	*Final depth:* **32.16 ft**
Client / Job: **The Source Group / 04.09**	*X Coord.(Lng-E) / Fix:* **Unavailable / NA**	*Max signal:* **2.2 %RE @ 0.11 ft**
Operator / Unit: **D. Garza / UVOST1012**	*Elevation:* **Unavailable**	*Date & Time:* **2016-12-13 14:28 PST**



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AE-02

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Site: **2040 Walnut, Signal Hill ca**

Y Coord.(Lat-N) / System: **Unavailable / NA**

Final depth: **32.15 ft**

Client / Job: **The Source Group / 04.09**

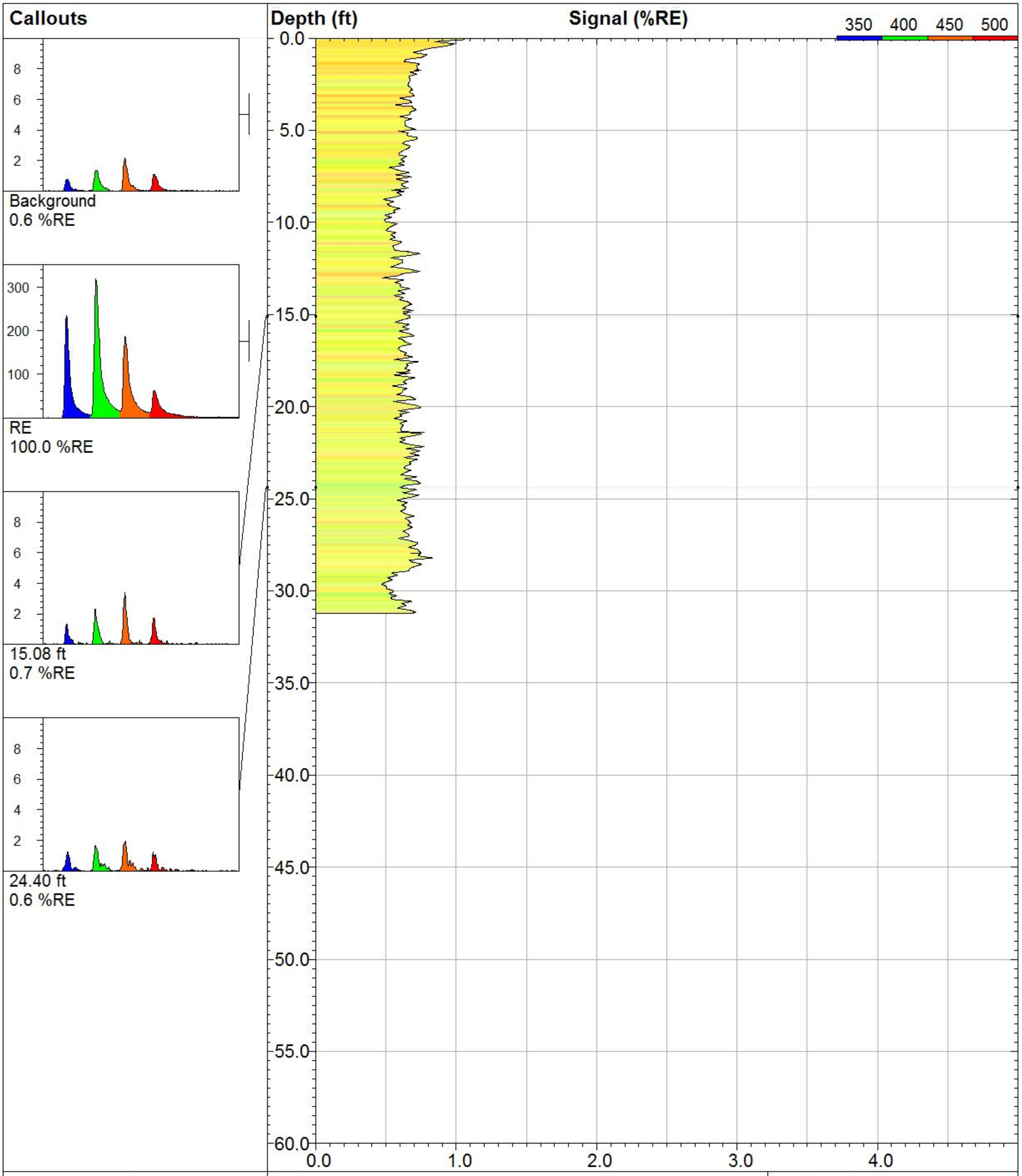
X Coord.(Lng-E) / Fix: **Unavailable / NA**

Max signal: **19.8 %RE @ 16.43 ft**

Operator / Unit: **D. Garza / UVOST1012**

Elevation: **Unavailable**

Date & Time: **2016-12-13 12:31 PST**



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AE-03

UVOST® By Dakota
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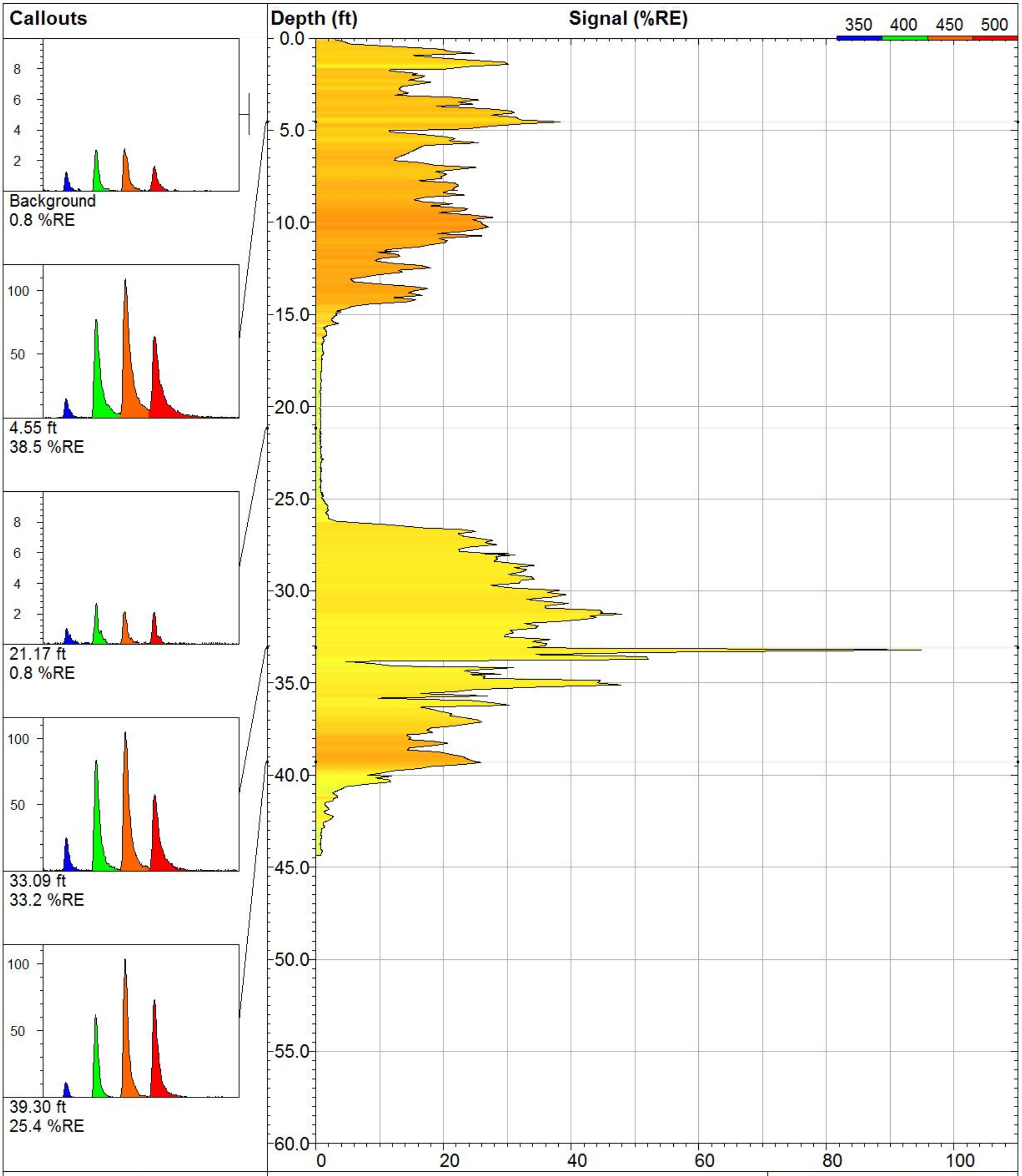
Site: **2040 Walnut, Signal Hill ca**	*Y Coord.(Lat-N) / System:* **Unavailable / NA**	*Final depth:* **31.24 ft**
Client / Job: **The Source Group / 04.09**	*X Coord.(Lng-E) / Fix:* **Unavailable / NA**	*Max signal:* **1.1 %RE @ 0.08 ft**
Operator / Unit: **D. Garza / UVOST1012**	*Elevation:* **Unavailable**	*Date & Time:* **2016-12-13 15:12 PST**



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AN-09

UVOST® By Dakota
www.DakotaTechnologies.com

Site:
2040 Walnut, Signal Hill ca

Y Coord.(Lat-N) / System:
Unavailable / NA

Final depth:
44.36 ft

Client / Job:
The Source Group / 04.09

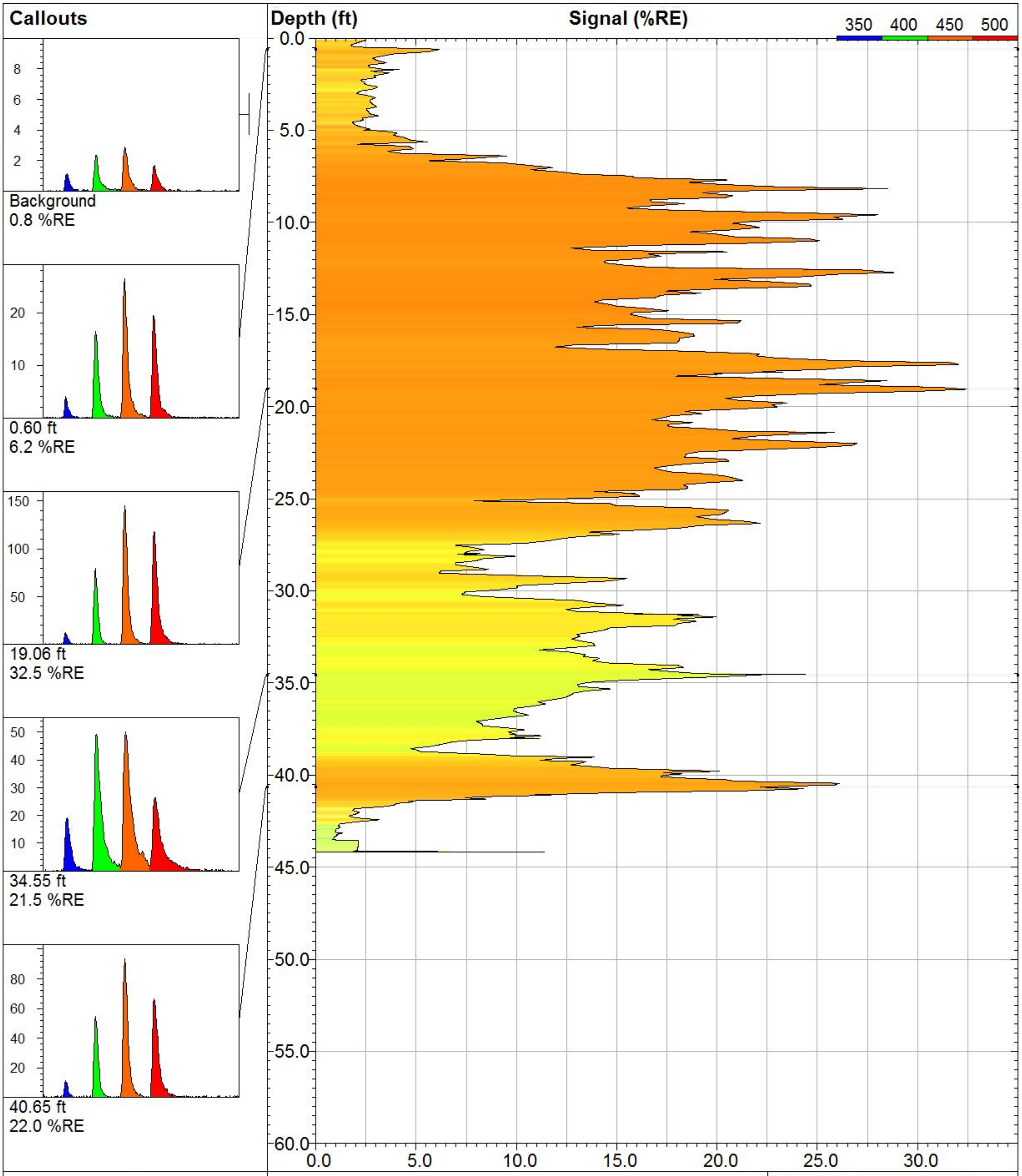
X Coord.(Lng-E) / Fix:
Unavailable / NA

Max signal:
95.2 %RE @ 33.20 ft

Operator / Unit:
D. Garza / UVOST1012

Elevation:
Unavailable

Date & Time:
2016-12-14 13:34 PST



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AN-10

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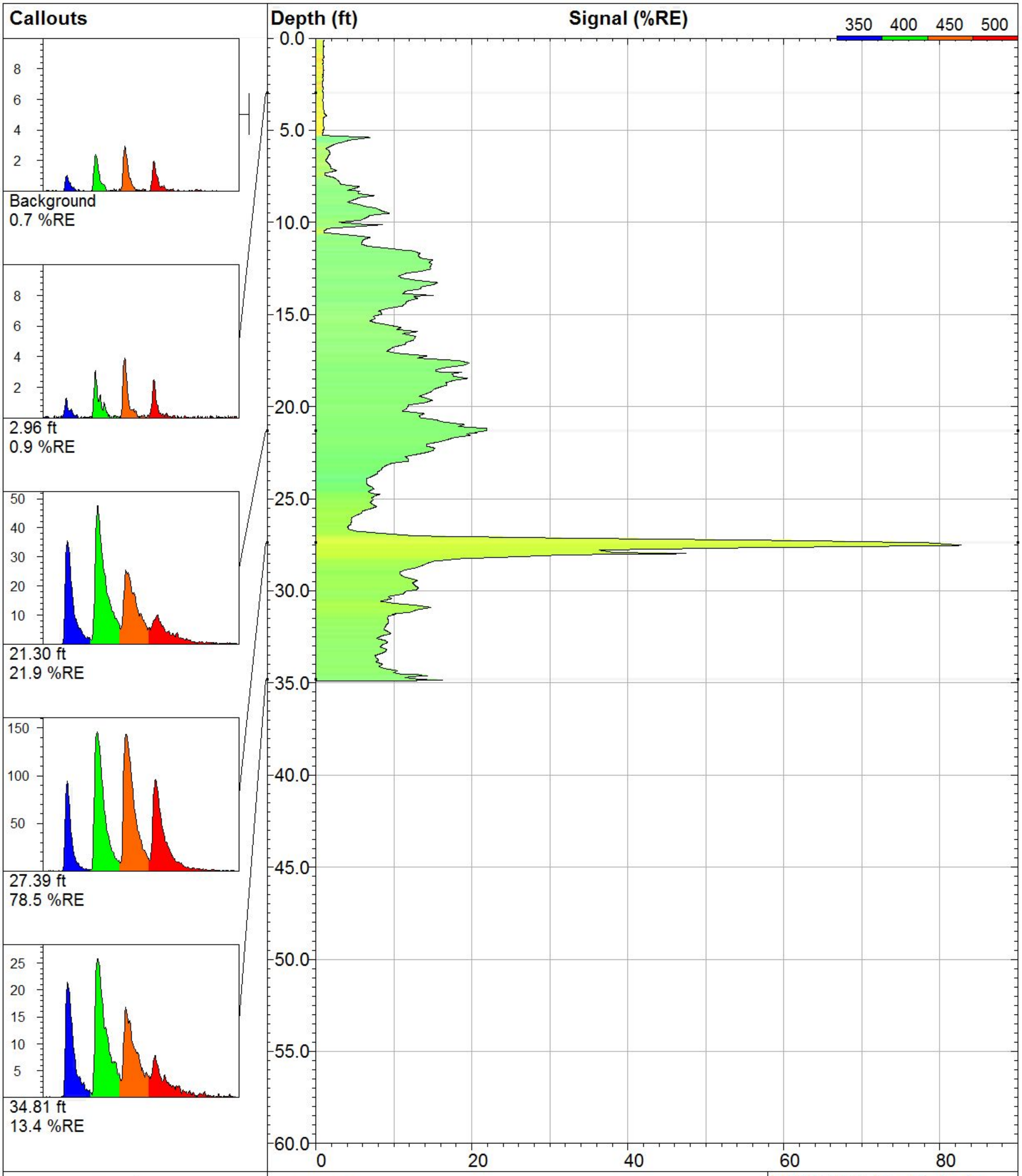
Site: **2040 Walnut, Signal Hill ca**	*Y Coord.(Lat-N) / System:* **Unavailable / NA**	*Final depth:* **44.19 ft**
Client / Job: **The Source Group / 04.09**	*X Coord.(Lng-E) / Fix:* **Unavailable / NA**	*Max signal:* **32.5 %RE @ 19.06 ft**
Operator / Unit: **D. Garza / UVOST1012**	*Elevation:* **Unavailable**	*Date & Time:* **2016-12-14 14:32 PST**



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AN-11

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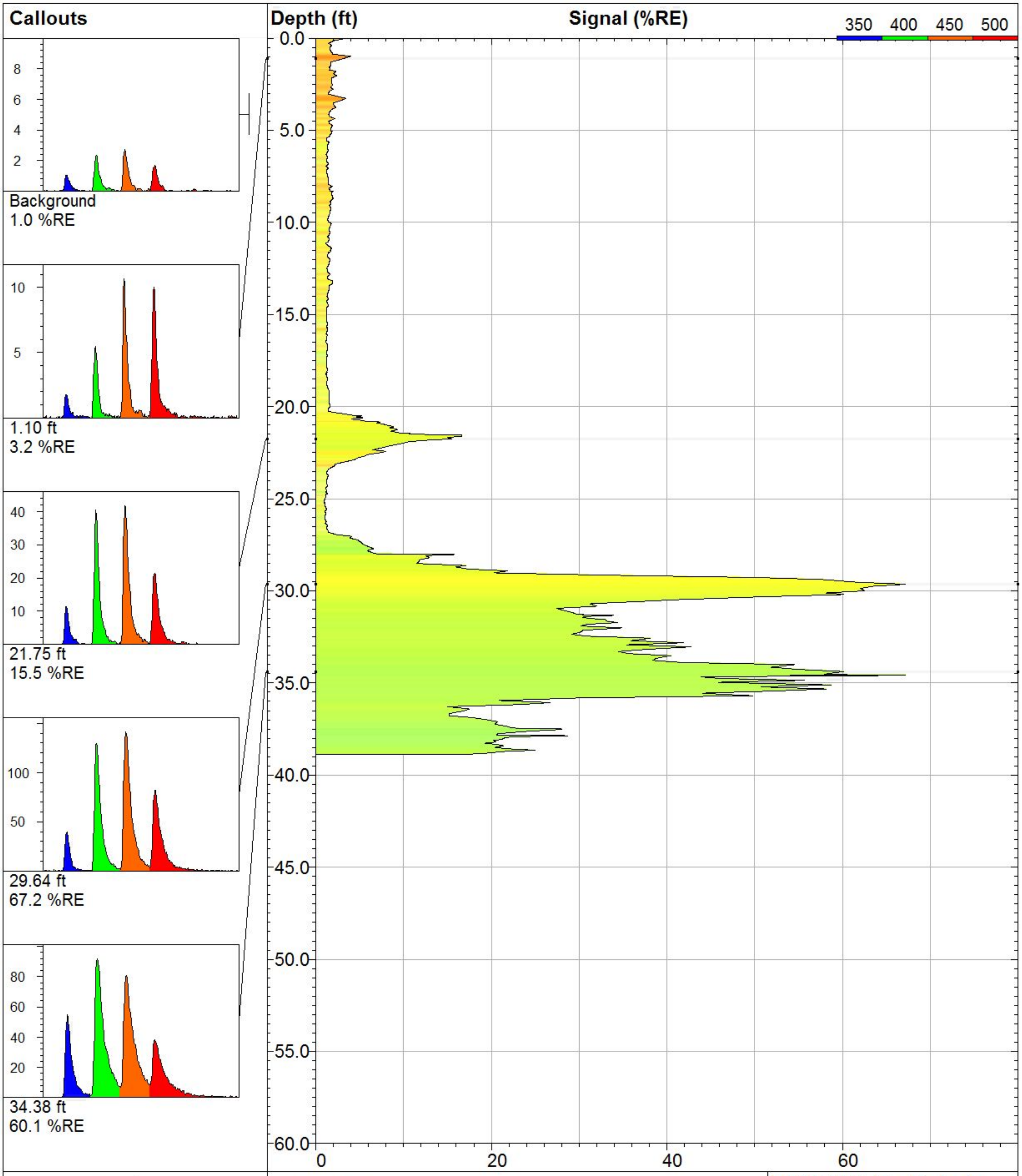
Site: **2040 Walnut, Signal Hill ca**	*Y Coord.(Lat-N) / System:* **Unavailable / NA**	*Final depth:* **34.88 ft**
Client / Job: **The Source Group / 04.09**	*X Coord.(Lng-E) / Fix:* **Unavailable / NA**	*Max signal:* **82.9 %RE @ 27.53 ft**
Operator / Unit: **D. Garza / UVOST1012**	*Elevation:* **Unavailable**	*Date & Time:* **2016-12-15 09:40 PST**



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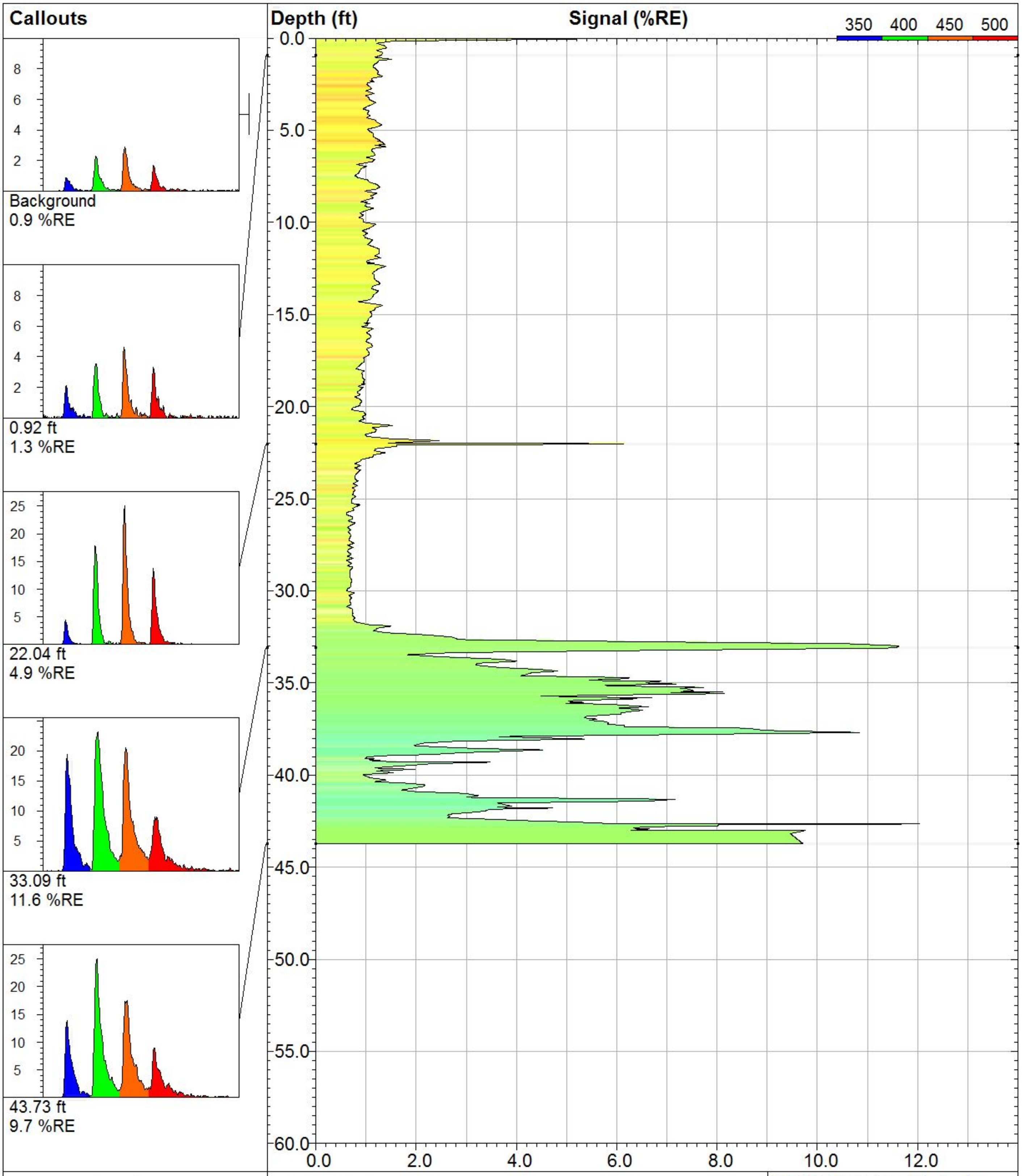
AN-12		**UVOST® By Dakota** www.DakotaTechnologies.com
Site: **2040 Walnut, Signal Hill ca**	*Y Coord.(Lat-N) / System:* **Unavailable / NA**	*Final depth:* **38.89 ft**
Client / Job: **The Source Group / 04.09**	*X Coord.(Lng-E) / Fix:* **Unavailable / NA**	*Max signal:* **72.9 %RE @ 34.56 ft**
Operator / Unit: **D. Garza / UVOST1012**	*Elevation:* **Unavailable**	*Date & Time:* **2016-12-15 10:27 PST**



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AN-15

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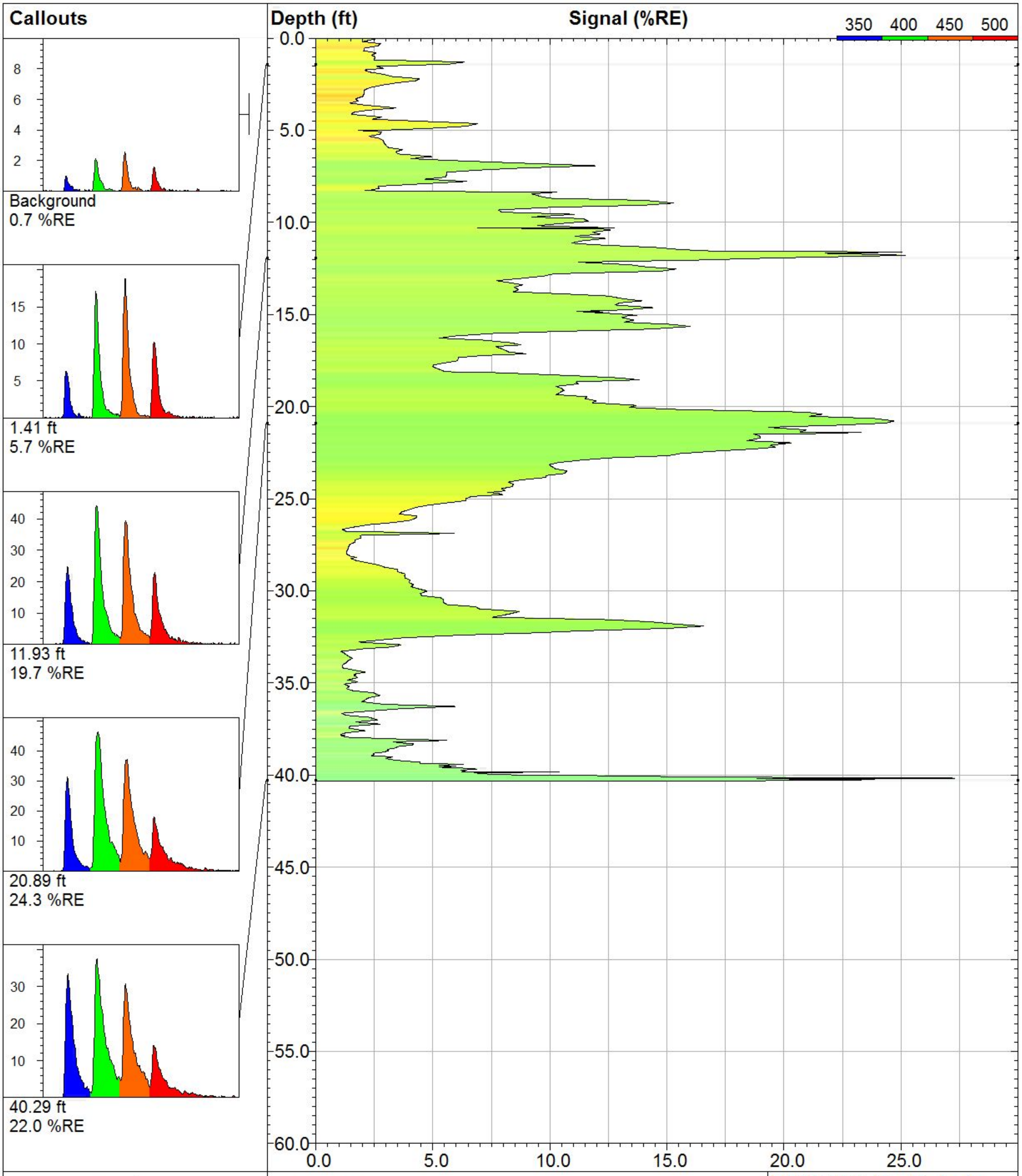
Site: **2040 Walnut, Signal Hill ca**	*Y Coord.(Lat-N) / System:* **Unavailable / NA**	*Final depth:* **43.73 ft**
Client / Job: **The Source Group / 04.09**	*X Coord.(Lng-E) / Fix:* **Unavailable / NA**	*Max signal:* **12.6 %RE @ 42.65 ft**
Operator / Unit: **D. Garza / UVOST1012**	*Elevation:* **Unavailable**	*Date & Time:* **2016-12-14 15:22 PST**



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Site: **2040 Walnut, Signal Hill ca**

Y Coord.(Lat-N) / System: **Unavailable / NA**

Final depth: **40.32 ft**

Client / Job: **The Source Group / 04.09**

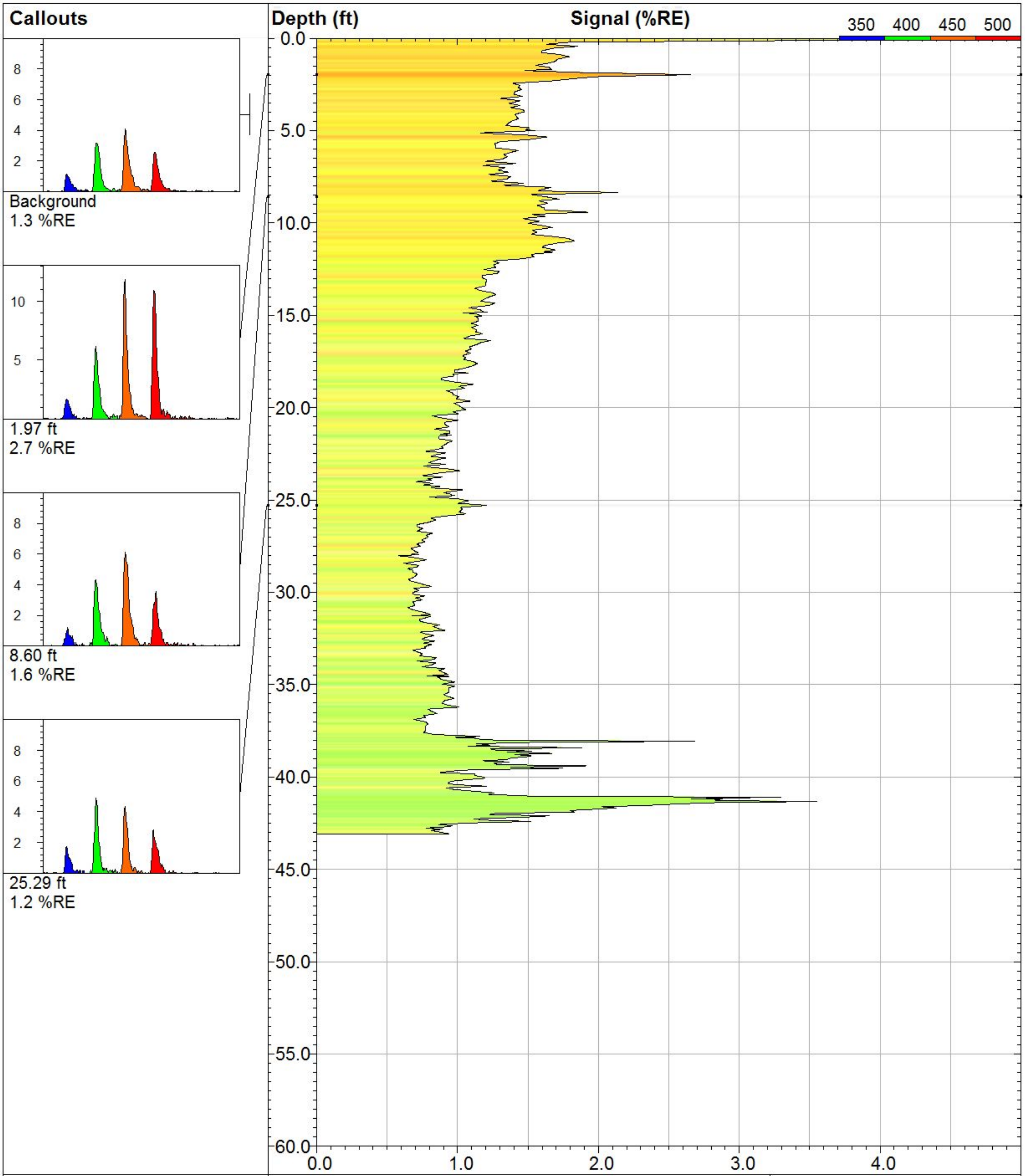
X Coord.(Lng-E) / Fix: **Unavailable / NA**

Max signal: **28.1 %RE @ 40.17 ft**

Operator / Unit: **D. Garza / UVOST1012**

Elevation: **Unavailable**

Date & Time: **2016-12-14 16:11 PST**



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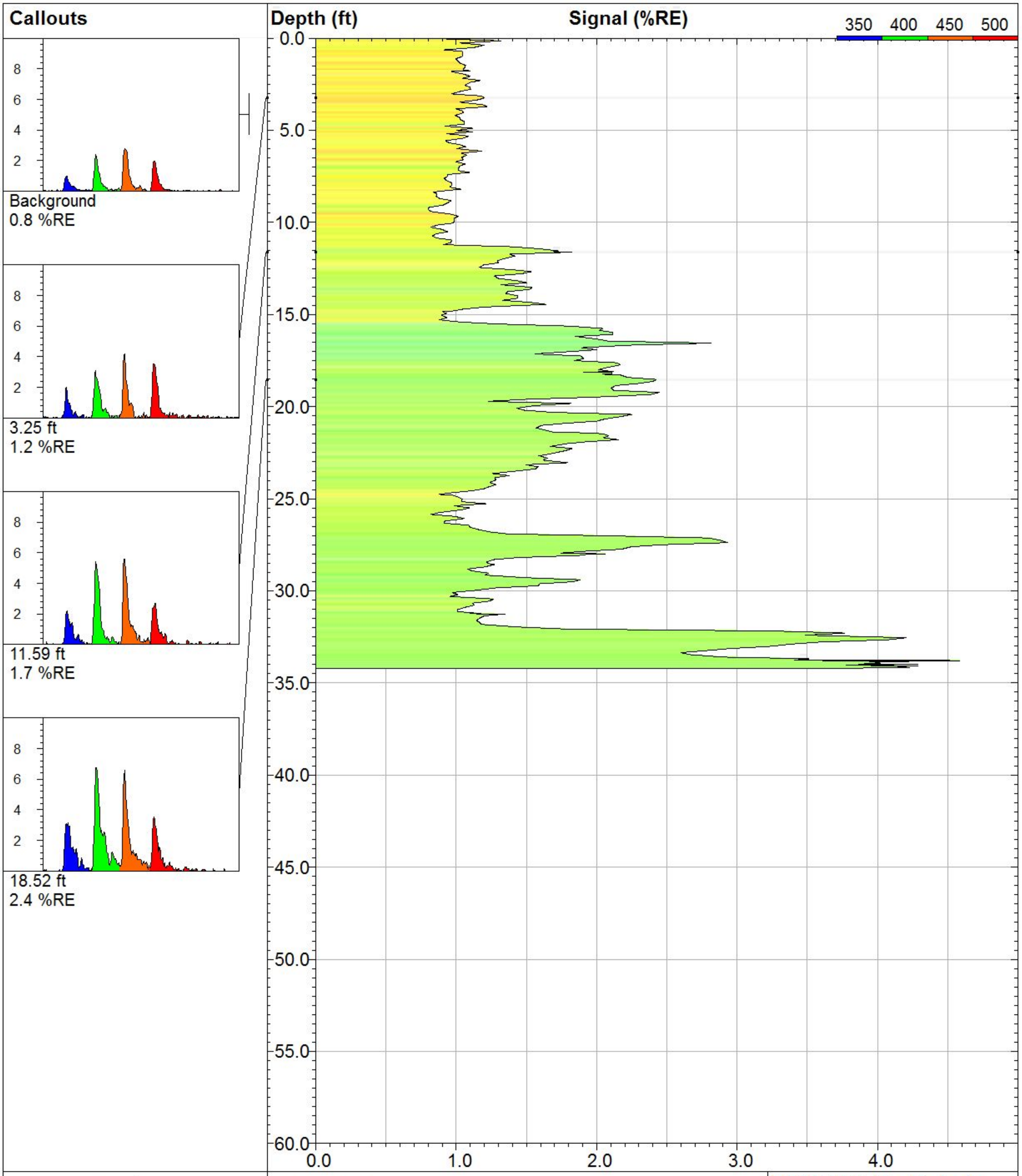
Site: **2040 Walnut, Signal Hill ca**	*Y Coord.(Lat-N) / System:* **Unavailable / NA**	*Final depth:* **43.08 ft**
Client / Job: **The Source Group / 04.09**	*X Coord.(Lng-E) / Fix:* **Unavailable / NA**	*Max signal:* **4.1 %RE @ 0.08 ft**
Operator / Unit: **D. Garza / UVOST1012**	*Elevation:* **Unavailable**	*Date & Time:* **2016-12-15 07:54 PST**



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AN-18

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Site:
2040 Walnut, Signal Hill ca

Y Coord.(Lat-N) / System:
Unavailable / NA

Final depth:
34.21 ft

Client / Job:
The Source Group / 04.09

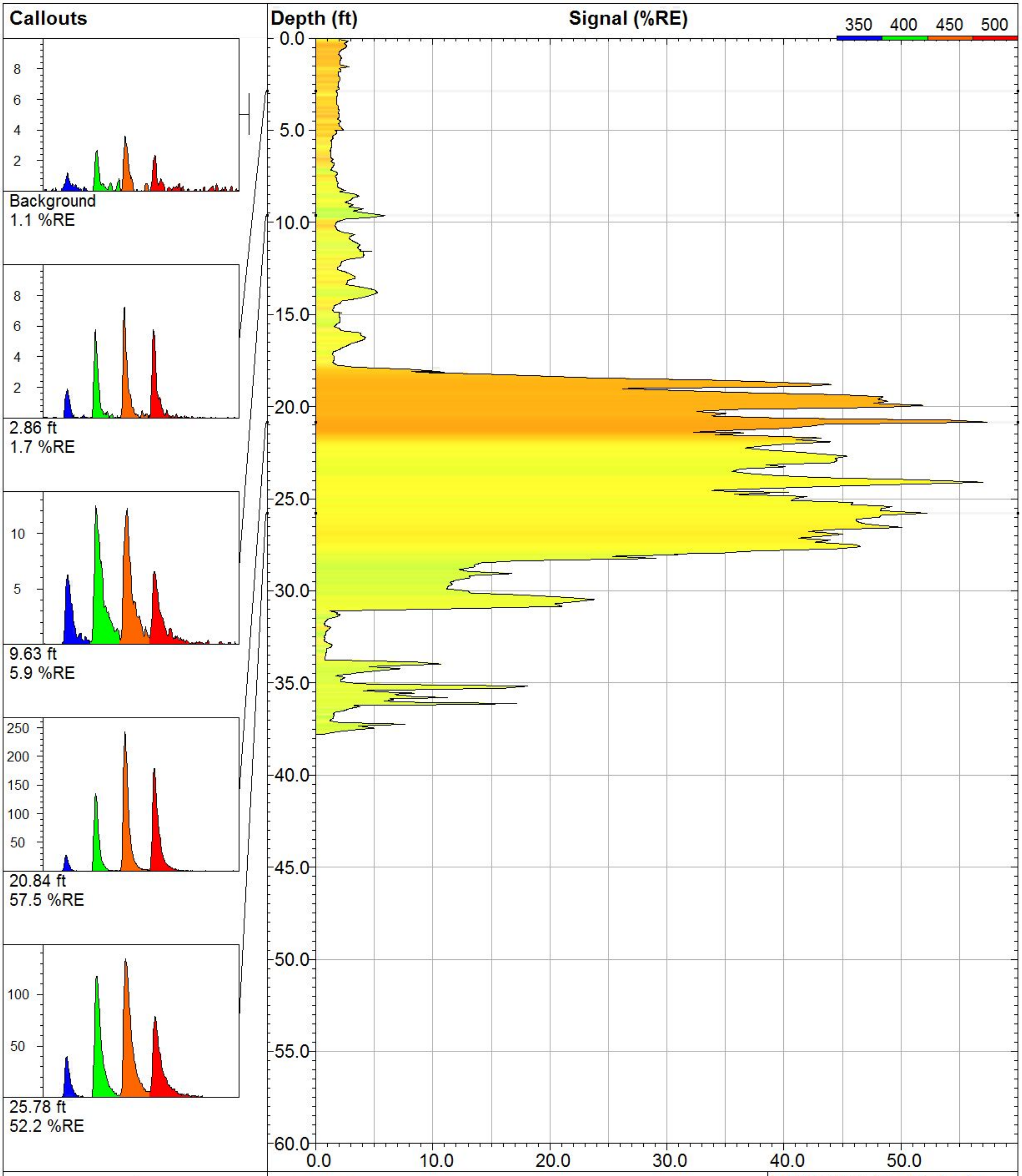
X Coord.(Lng-E) / Fix:
Unavailable / NA

Max signal:
4.6 %RE @ 33.78 ft

Operator / Unit:
D. Garza / UVOST1012

Elevation:
Unavailable

Date & Time:
2016-12-15 08:47 PST



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AS-01

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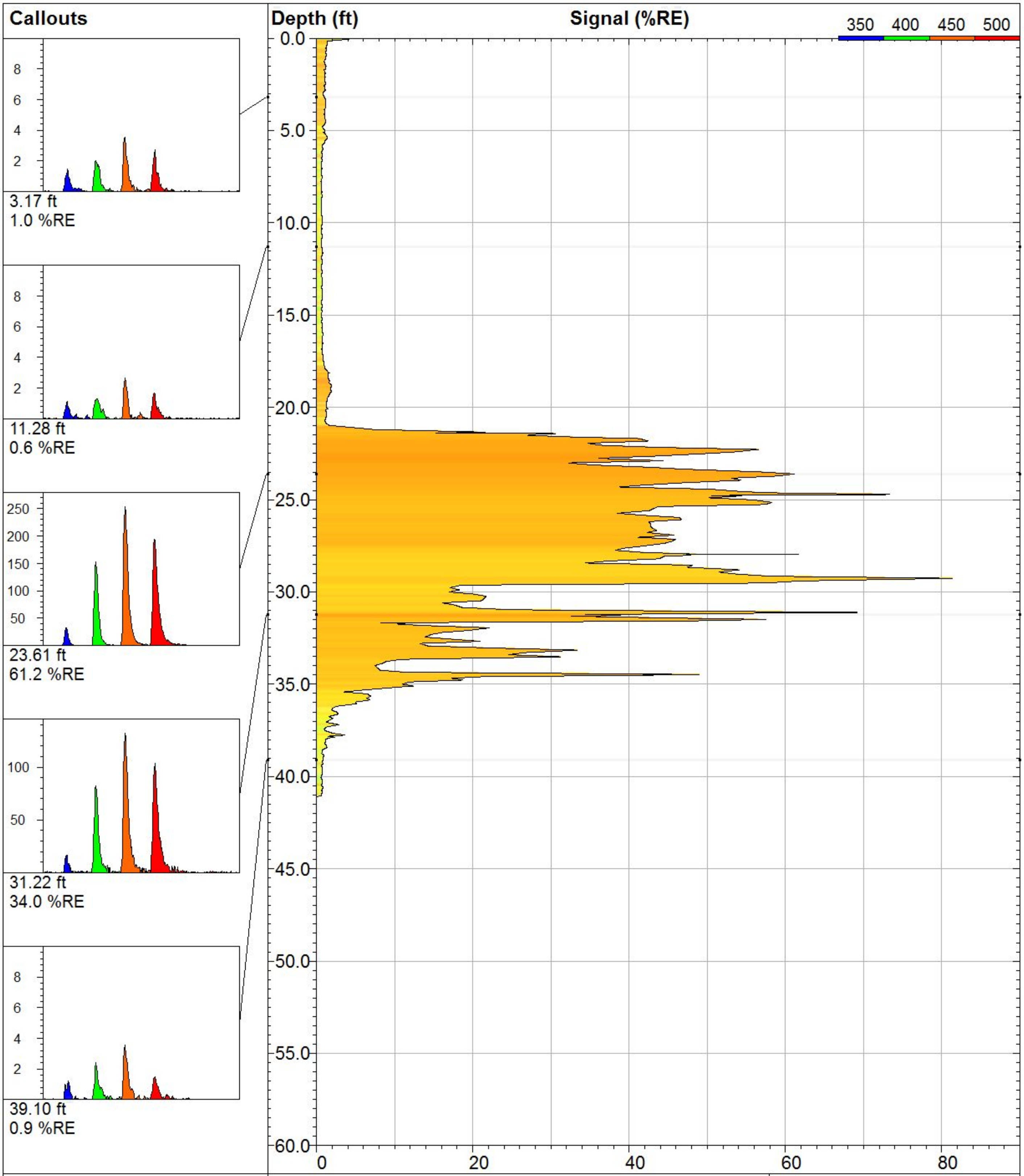
Site: **2040 Walnut st. Signal Hill ca**	*Y Coord.(Lat-N) / System:* **Unavailable / NA**	*Final depth:* **37.80 ft**
Client / Job: **The Source Group / 04.09**	*X Coord.(Lng-E) / Fix:* **Unavailable / NA**	*Max signal:* **57.5 %RE @ 20.84 ft**
Operator / Unit: **D. Garza / UVOST1012**	*Elevation:* **Unavailable**	*Date & Time:* **2016-12-14 08:22 PST**



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AS-02

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Site:
2040 Walnut, Signal Hill ca

Y Coord.(Lat-N) / System:
Unavailable / NA

Final depth:
41.08 ft

Client / Job:
The Source Group / 04.09

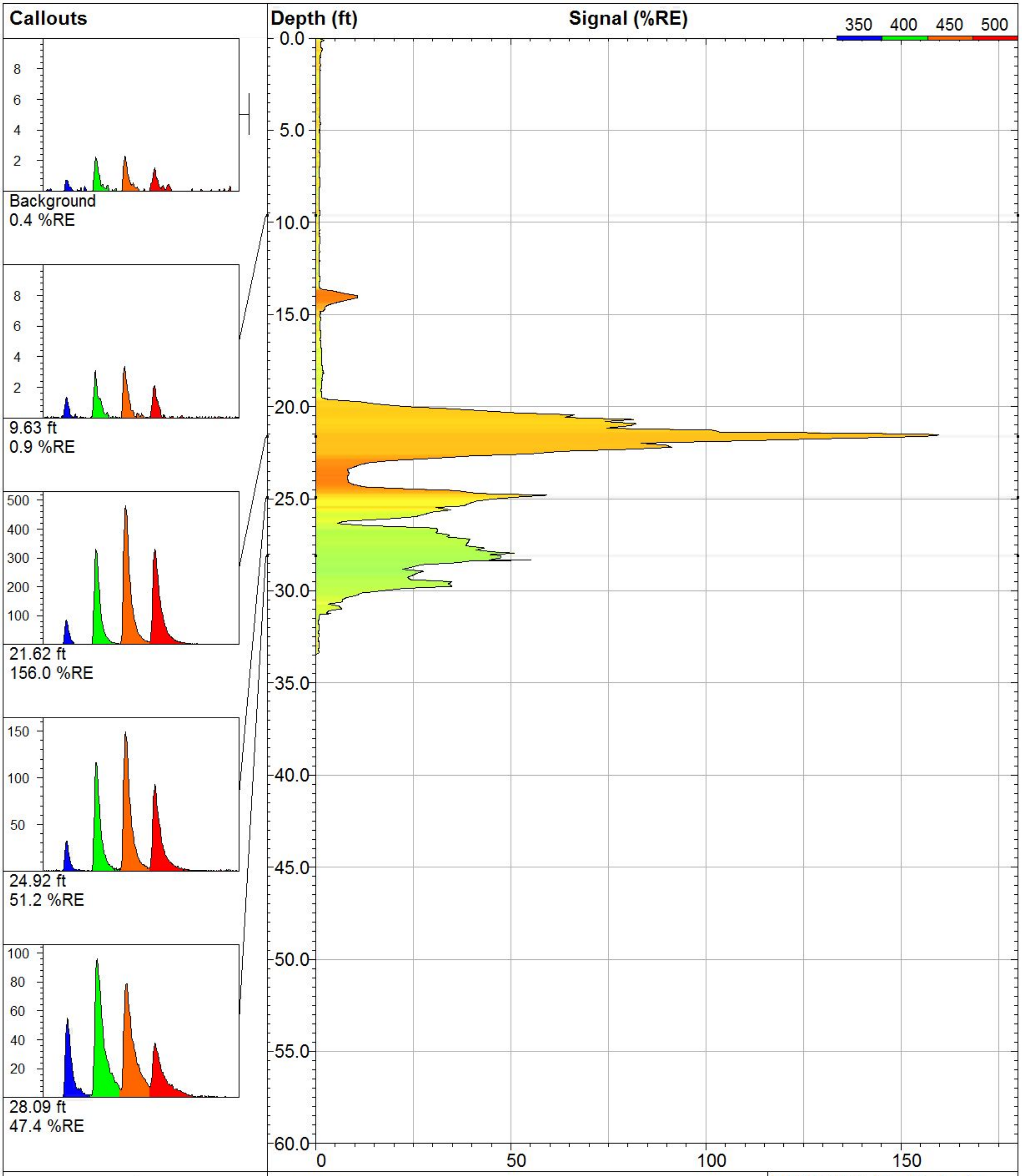
X Coord.(Lng-E) / Fix:
Unavailable / NA

Max signal:
81.6 %RE @ 29.26 ft

Operator / Unit:
D. Garza / UVOST1012

Elevation:
Unavailable

Date & Time:
2016-12-13 16:31 PST



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AS-03

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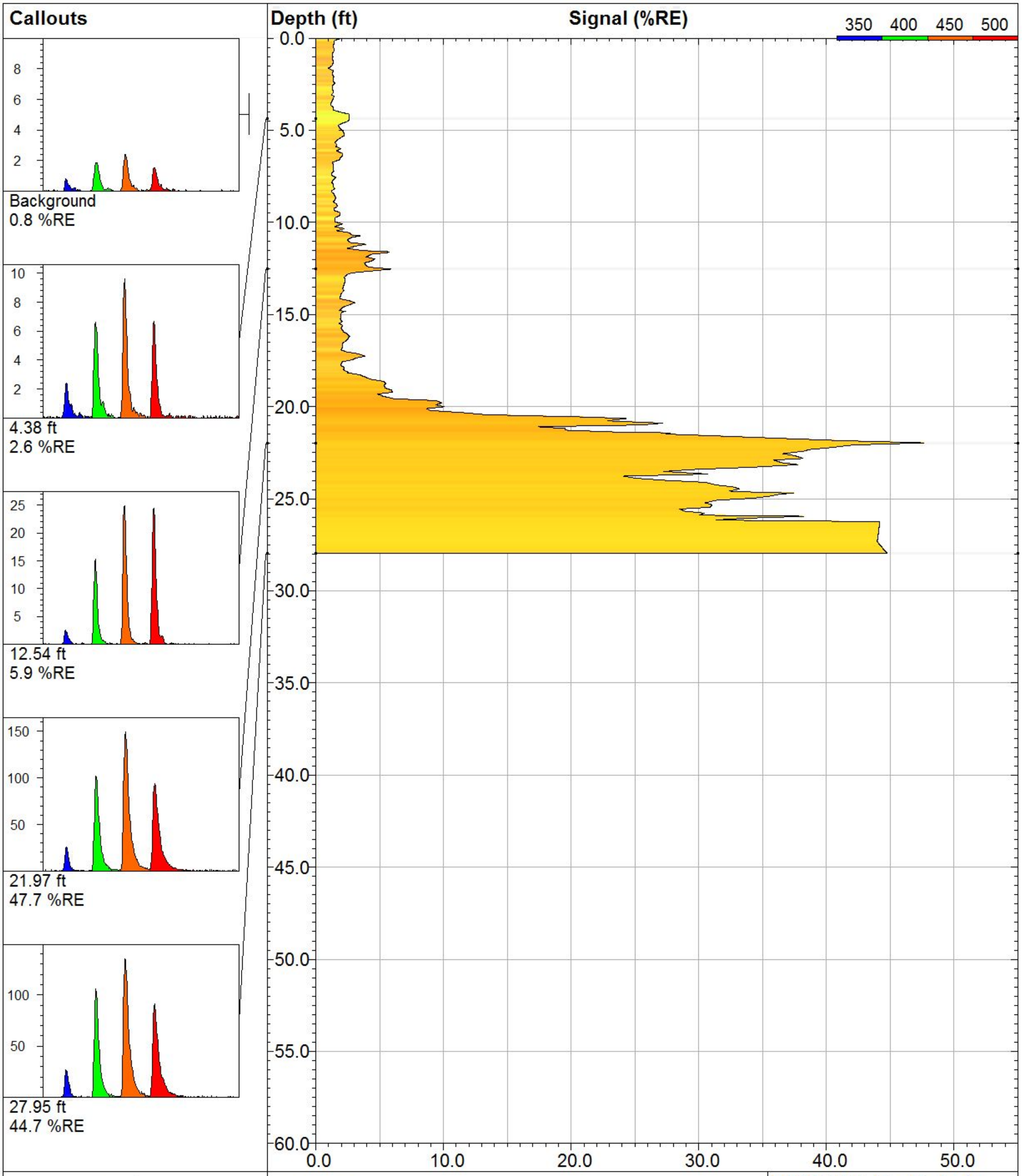
Site: **2040 Walnut st. Signal Hill ca**	*Y Coord.(Lat-N) / System:* **Unavailable / NA**	*Final depth:* **33.41 ft**
Client / Job: **The Source Group / 04.09**	*X Coord.(Lng-E) / Fix:* **Unavailable / NA**	*Max signal:* **159.8 %RE @ 21.52 ft**
Operator / Unit: **D. Garza / UVOST1012**	*Elevation:* **Unavailable**	*Date & Time:* **2016-12-14 09:12 PST**



AS-04

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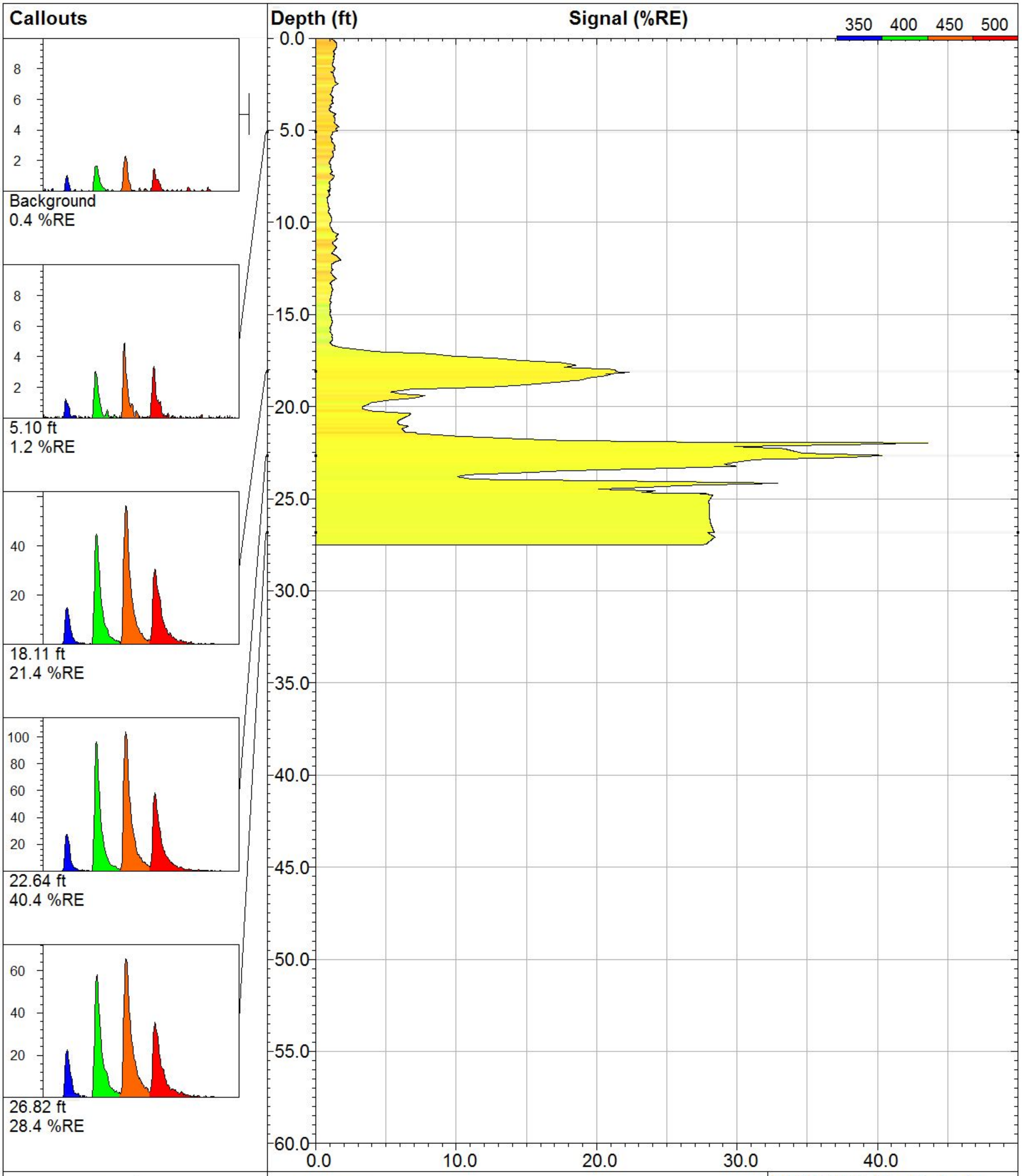
Site: **2040 Walnut, Signal Hill ca**	*Y Coord.(Lat-N) / System:* **Unavailable / NA**	*Final depth:* **27.96 ft**
Client / Job: **The Source Group / 04.09**	*X Coord.(Lng-E) / Fix:* **Unavailable / NA**	*Max signal:* **47.7 %RE @ 21.96 ft**
Operator / Unit: **D. Garza / UVOST1012**	*Elevation:* **Unavailable**	*Date & Time:* **2016-12-14 10:42 PST**



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AS-05

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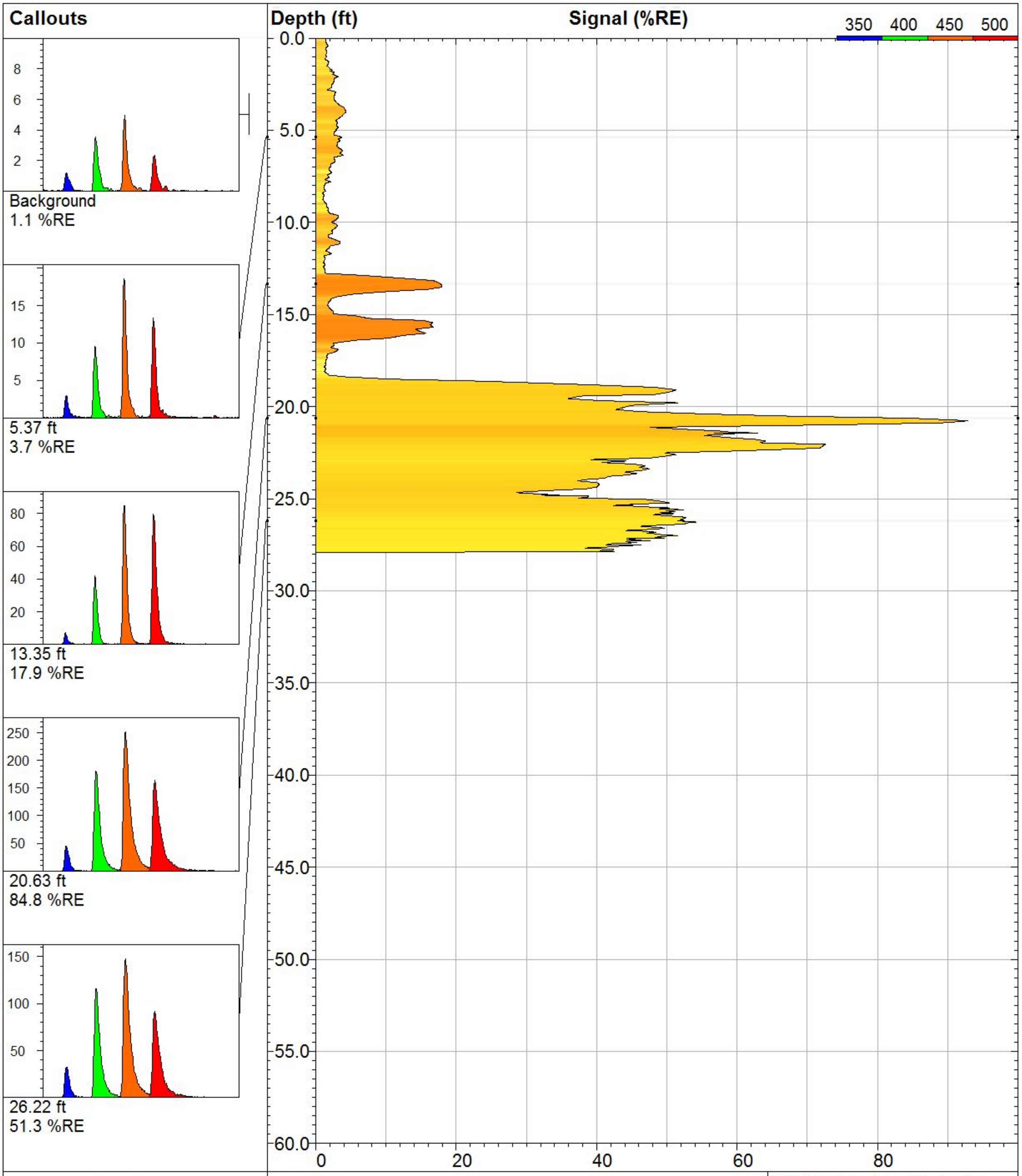
Site: **2040 Walnut, Signal Hill ca**	*Y Coord.(Lat-N) / System:* **Unavailable / NA**	*Final depth:* **27.49 ft**
Client / Job: **The Source Group / 04.09**	*X Coord.(Lng-E) / Fix:* **Unavailable / NA**	*Max signal:* **43.6 %RE @ 21.96 ft**
Operator / Unit: **D. Garza / UVOST1012**	*Elevation:* **Unavailable**	*Date & Time:* **2016-12-14 09:54 PST**



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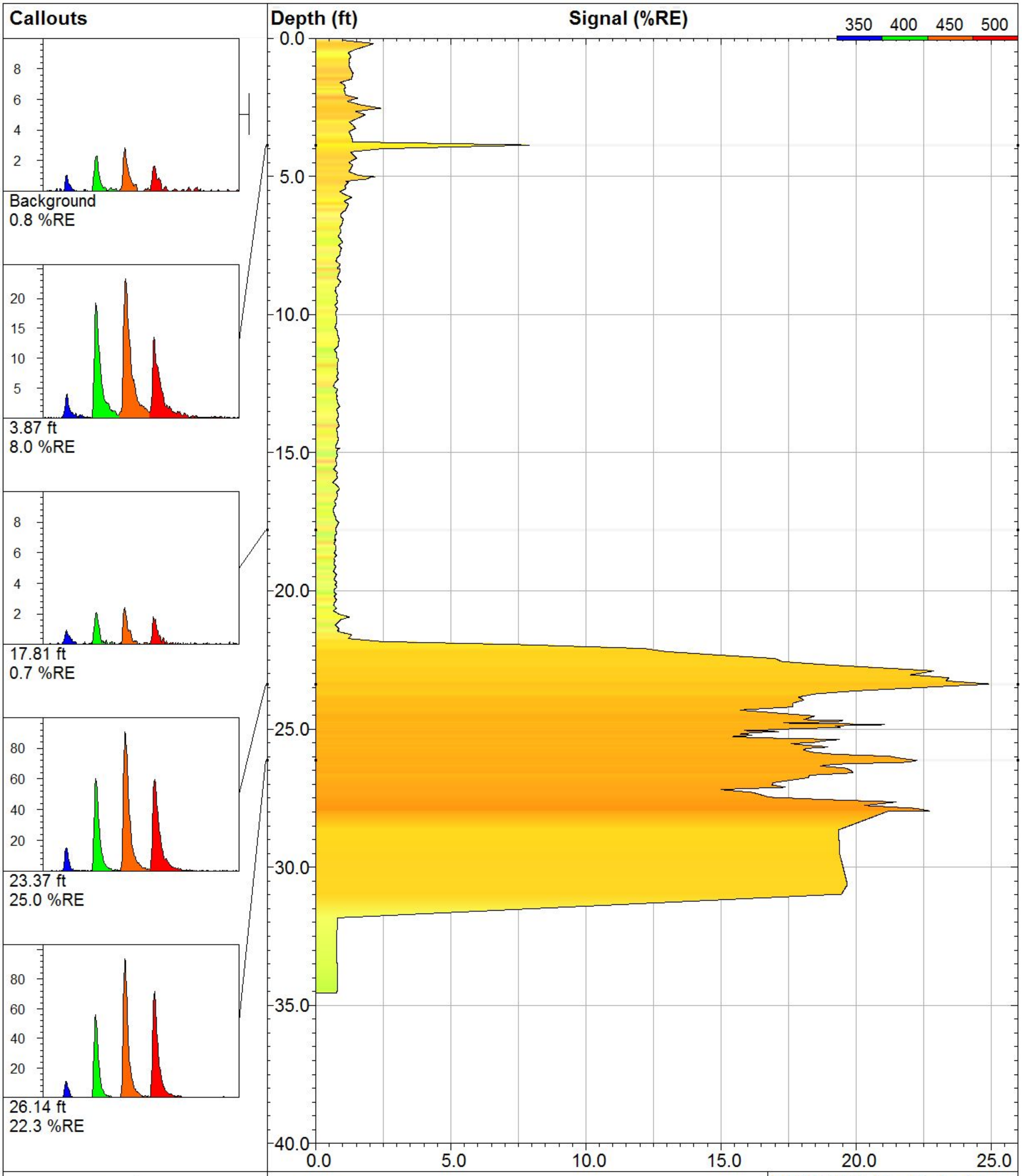
Site: **2040 Walnut, Signal Hill ca**	*Y Coord.(Lat-N) / System:* **Unavailable / NA**	*Final depth:* **27.89 ft**
Client / Job: **The Source Group / 04.09**	*X Coord.(Lng-E) / Fix:* **Unavailable / NA**	*Max signal:* **93.0 %RE @ 20.76 ft**
Operator / Unit: **D. Garza / UVOST1012**	*Elevation:* **Unavailable**	*Date & Time:* **2016-12-15 14:02 PST**



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AS-09

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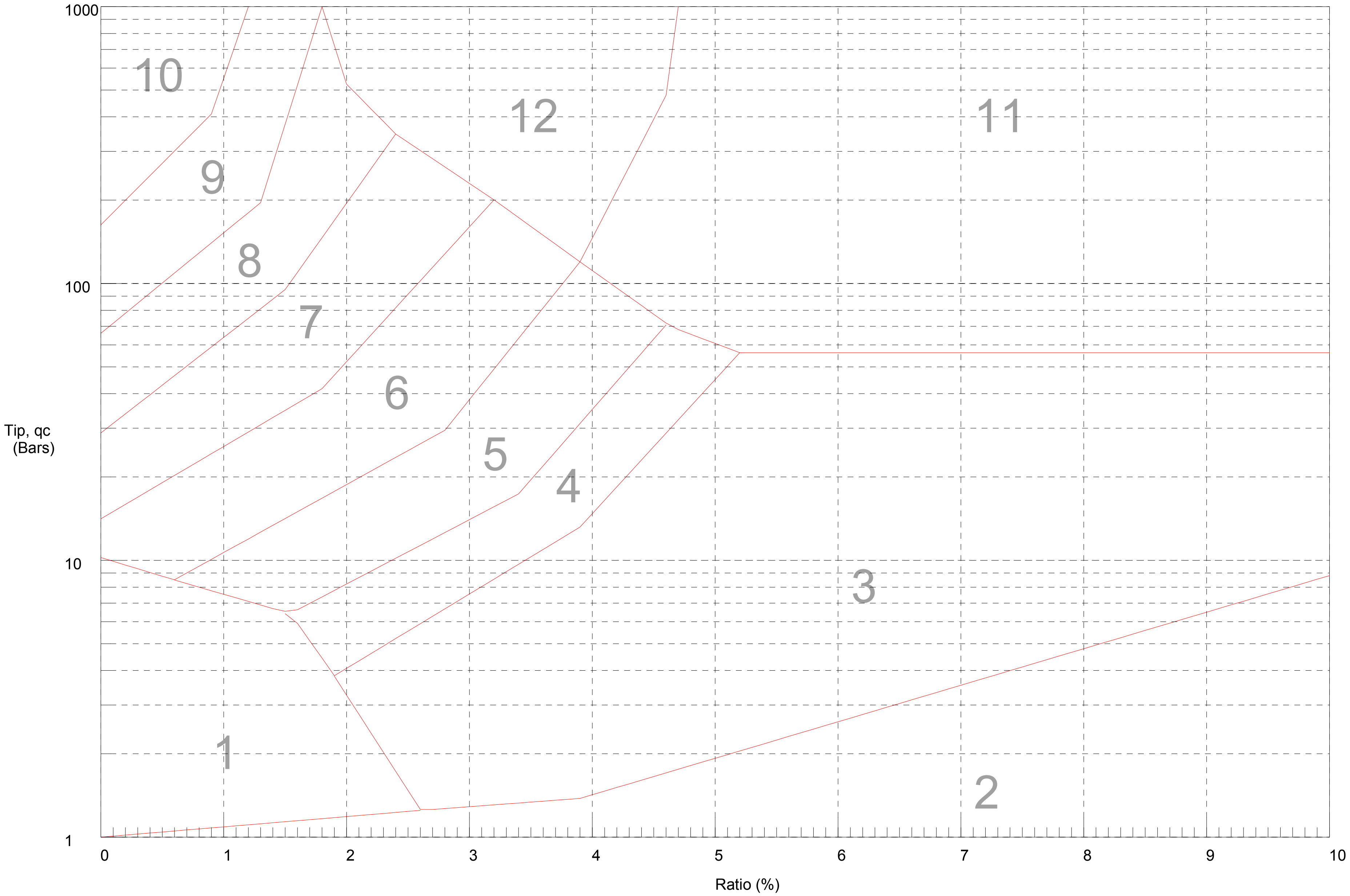
Site: **2040 Walnut, Signal Hill ca**	*Y Coord.(Lat-N) / System:* **Unavailable / NA**	*Final depth:* **34.55 ft**
Client / Job: **The Source Group / 04.09**	*X Coord.(Lng-E) / Fix:* **Unavailable / NA**	*Max signal:* **25.0 %RE @ 23.37 ft**
Operator / Unit: **D. Garza / UVOST1012**	*Elevation:* **Unavailable**	*Date & Time:* **2016-12-14 11:28 PST**

12 Zone Soil Behavior Chart

Classification Data:
Robertson and Campanella UBC-1986



1 sensitive fine grained
2 organic material
3 clay
4 silty clay to clay
5 clayey silt to silty clay
6 sandy silt to clayey silt
7 silty sand to sandy silt
8 sand to silty sand
9 sand
10 gravelly sand to sand
11 very stiff fine grained (*)
12 sand to clayey sand (*)

* Overconsolidated or cemented

< Back To Newsletters

Interpreting LIF Waveforms

Laser-Induced Fluorescence Primer II: Interpreting Waveforms

Randy St. Germain, President

Ultraviolet (UV) laser-induced fluorescence (LIF) screening tools cause fluorescence in light non-aqueous phase liquids (LNAPLs). Total fluorescence readings estimate the quantity of LNAPL present, but LIF can also capture fluorescence "waveforms" to qualitatively evaluate LNAPL type.

[This article focuses on UV LIF's application to petroleum fuels and oils, but NOT creosotes and coal tar. These require the Tar-specific Green Optical Screening Tool or TarGOST. TarGOST and the problem inherent with the fluorescence of heavier hydrocarbons will be discussed in a forthcoming LIF Line]

BACKGROUND:

Optical screening tools (OSTs) "flash" a sample with intense light for a few nanoseconds, then analyze the fluorescence that continues to be emitted long after the flash has stopped. This fluorescence "lifetime" varies, from well under a nanosecond to tens or even hundreds of nanoseconds.

OSTs have this time-resolved LIF capability built in so that they can simultaneously record the "color" (spectral nature) and lifetime (temporal nature) of the fluorescence. OST LIF systems can tentatively identify the type of petroleum, discern false positives, and detect weathering of certain LNAPLs with lifetimes playing a major role.

MULTI-WAVELENGTH WAVEFORMS:

The left side of Figure A illustrates the combined spectral/temporal nature of the fluorescence emitted by the polycyclic aromatic hydrocarbons (PAHs) in diesel, and the right side shows the 2D "shorthand" style waveform characteristic of OST data.

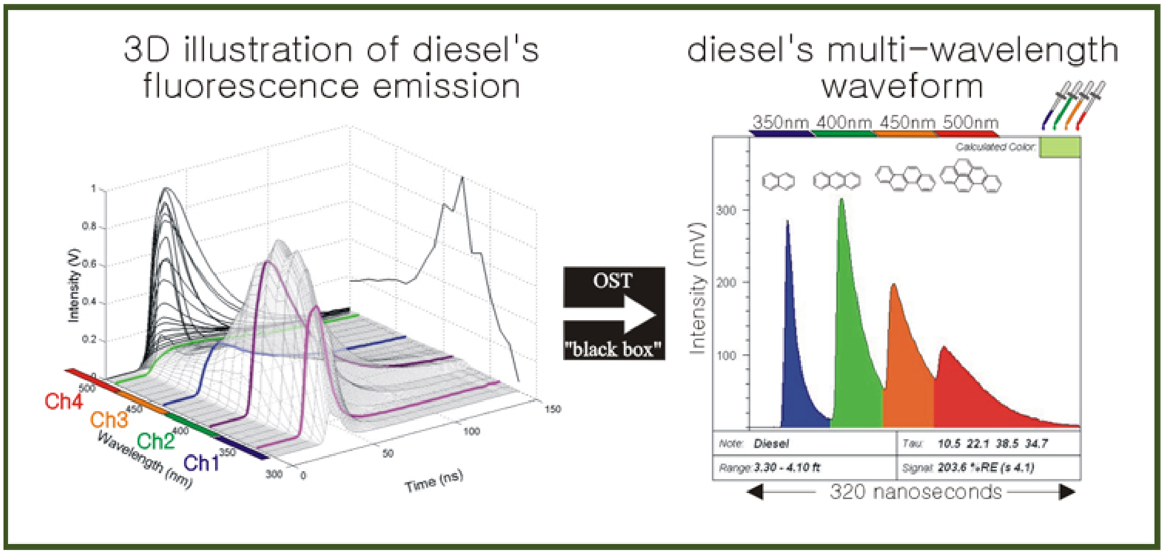


Figure A: The fluorescence emitted by the PAHs in diesel.

Key characteristics of waveforms include:

Intensity (Amount of Fluorescence)

The y-axis represents the intensity or “brightness” of the fluorescence. It is a voltage.

- Intensity generally increases with increasing fuel/oil pore saturation.

- The relative fluorescence intensity is dependent on the composition of the fuel.
  - Some fuels (diesel and crude) fluoresce more intensely than others (gasoline).
  - Low viscosity, high solvent content fuels/oils dominated by smaller 2-3 ring PAHs usually fluoresce better (higher voltages) than large PAHs containing fuels, oils, greases or sludge.

The Four Fluorescence Channels (“Peaks”)

The x-axis of Figure A represents 320 nanoseconds of time during which the four wavelength ranges of fluorescence arrive at the detector at sequentially delayed times.

- The four peaks or channels represent 350 nm (blue), 400 nm (green), 450 nm (orange), and 500 nm (red). Each peak is 40 nm wide.

- It is important to note that the blue, green, orange, and red aren’t the true colors of those wavelengths – just colors chosen to represent the four peaks.

- The relative intensities between the four channels is used to fill the LIF log with blended color to visualize fluorescence trends “at a glance”. [note the fill-color boxes in upper right corner of the example waveforms to follow]

- OST systems are “calibrated” by applying the Reference Emitter (RE) fluid to the window and recording RE’s response. The RE is a standard fluorescing NAPL supplied by Dakota to all OST service providers for the last 15 years. The purpose of the RE is to:
  1. Normalize the data for push-to-push fluctuations in optical throughput.
  2. System check to make sure all optics are intact and operating normally.

- All downhole data is normalized to the RE (as percentage) so that data is consistent across all OSTs across the globe, regardless of who is operating them.

- The factory RE is displayed on the oscilloscope along with the latest RE, assisting the operator in assuring that the OST data they generate “matches” all other OSTs.

- The area under the curve of all four channels is summed and divided by the RE waveforms’ areas to generate the normalized total fluorescence “Signal” of an LIF log.

- One PAH will usually occupy more than one channel since PAHs fluoresce broadly (naphthalene is a notable exception, fluorescing almost exclusively in the blue channel).

- In general, the shorter wavelength channels (blue/green) are occupied by 2- and 3-ring PAHs, the middle (green/orange) by 3- and 4-ring PAHs, and the rightmost (orange/red) by 4-ring and larger PAHs [Figure A].

- The voltage or height of the waveform generally scales with NAPL saturation for any single NAPL on a single soil type.

Lifetimes (Decaying Fluorescence)

The x-axis of waveforms represents the extremely short time period necessary to capture the pulse of PAH fluorescence. The lifetime is the average time the laser-induced PAH population stays in the excited state prior to fluorescing.

- PAHs fluoresce from a few to hundreds of nanoseconds after excitation.

- In the characteristic diesel example, the blue channel has a shorter lifetime than the green channel (see how the intensity falls back toward baseline more quickly on the right side of the 350 nm peak).

- The lifetimes of some channels “bleed” into subsequent channels (green into orange, for instance) and influence the log’s fill colors.

- Short lifetimes often indicate an energy transfer from smaller excited-state PAHs to surrounding, larger PAHs or the matrix. This leads to quenching (reduction) of fluorescence and red-shifting of the emission toward the right (longer wavelength).

- Long lifetimes often indicate oxygen starvation and/or a solvent-rich fluorescent friendly environment. Natural gas condensates can have unusually long lifetimes.

EXAMPLE WAVEFORMS:

PAHs:

PAH waveforms show the general trend of emission with size/complexity of PAHs (Figure B).

- The upper-left is Naphthalene, fluorescing almost entirely in the blue channel.

- The upper-right is Anthracene, the simple addition of one more benzene ring onto a naphthalene shifted the fluorescence by about 75-100 nm (about 1.5-2 “channels”).

- The lower-left is Pyrene, which is one ring larger but more “compact” so the red-shifting is moderate comparatively.

- The lower-right is Benzo (a) pyrene, emitting almost entirely in the red channel.

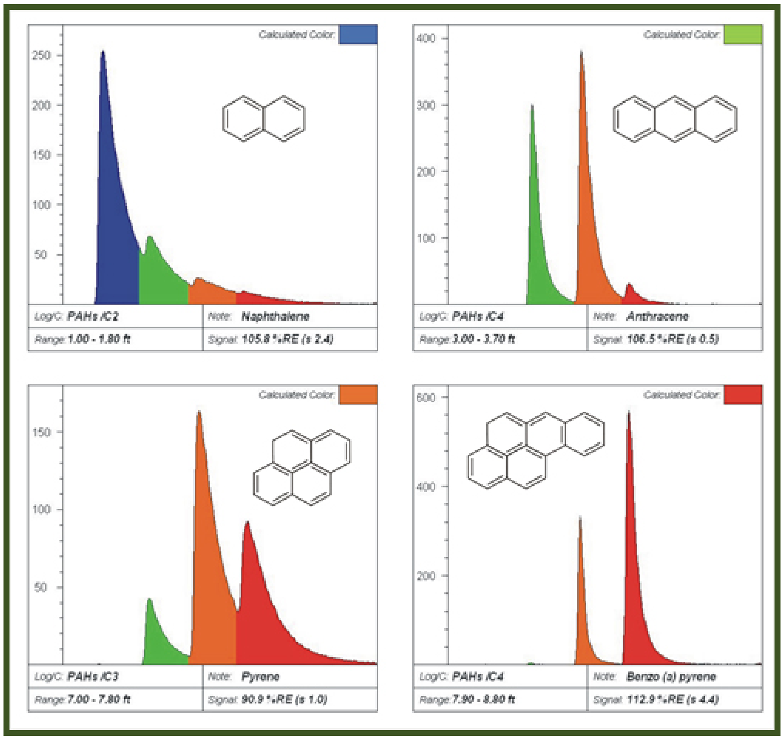


Figure B: The trend of PAH fluorescence "red-shifting" with increasing size and complexity of the PAH.

Fuels/Oils:

Fuels/oils contain complex chemical composition, which results in broad waveforms. The “EPA 16” PAHs only account for approximately 1 percent of the PAHs in crude oil, so there are usually a wide variety of PAHs fluorescing. From “blue to red” some common fuel/oil waveforms, shown in Figure C, include the following:

- Jet/Kerosene [Row 1]:
  - Naphthalene and Jet/Kerosene waveforms are similar because those fuels’ PAH content are dominated by the naphthalenes.

- Gasoline [Row 2]:
  - Intact (unweathered) gasoline has the typical shape shown and will fluoresce well enough to be delineated with LIF, even though gasoline contains low concentrations of 2- to 3-ring PAHs relative to the benzene, toluene, ethylebenzene and xylenes (BTEX) and aliphatics.

- Diesel [Row 3]:
  - Diesel has a short lifetime blue (2-ring PAH) peak that is about the same height as the longer lifetime green peak. Evidence of weathering in diesels is rare.

- Oils [Row 4]:
  - Oils such as crude, lubricating, and cutting types fluoresce well and are usually found slightly right of center (red-shifted) and have medium to long lifetimes.

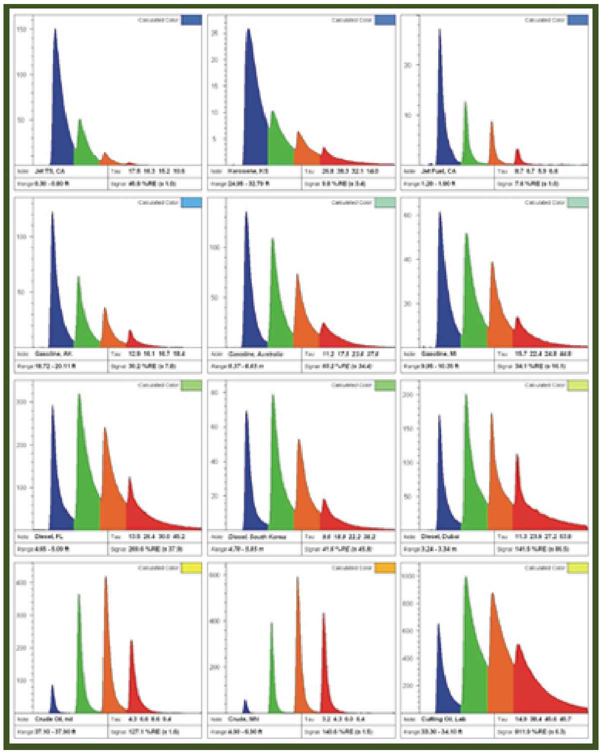


Figure C: Common fuel/oil waveforms.

Weathering:

Weathering typically removes the most soluble, volatile, and readily metabolized PAHs first. Large PAHs remain behind, which causes a red-shift in the fluorescence waveform. Simultaneously there is a loss of solvent aliphatics, which often shortens the lifetime so a weathered light fuel will start to look like oil or even tar. Figure D demonstrates weathering of gasoline in a lab experiment, resulting in red-shifting that can make weathered gasoline display an "oil" waveform. When jet/kerosene weather, they simply "disappear" (become non-fluorescent) because there are too few larger PAHs to fluoresce once the naphthalenes are gone. It is important to appreciate that NAPL (especially gasolines) can vary in their appearance even prior to spilling. The degree of red-shifting is relative to the starting product and site conditions. For instance, one site's intact (unweathered) gasoline waveform might very well be identical to different site's moderately weathered gasoline.

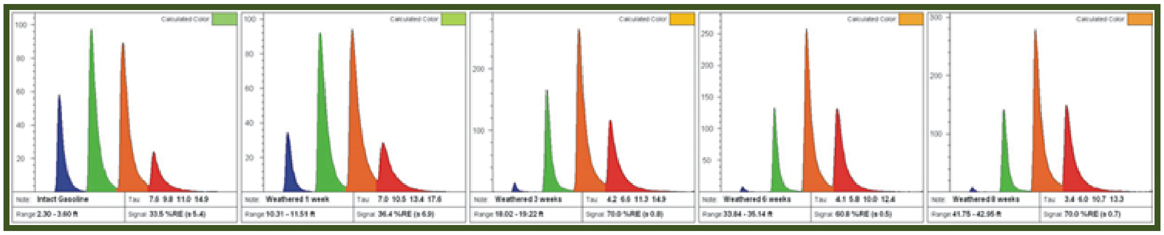


Figure D: Weathering causes red-shifting of gasoline's fluorescence.

False Positives and Oddities:

Areas with little to no contamination may fluoresce, which generates "false positives." Figure E contains a variety of noise, false-positives, or highly unusual waveforms. Be prepared to obtain samples in order to figure out what materials are causing any odd fluorescence waveforms.

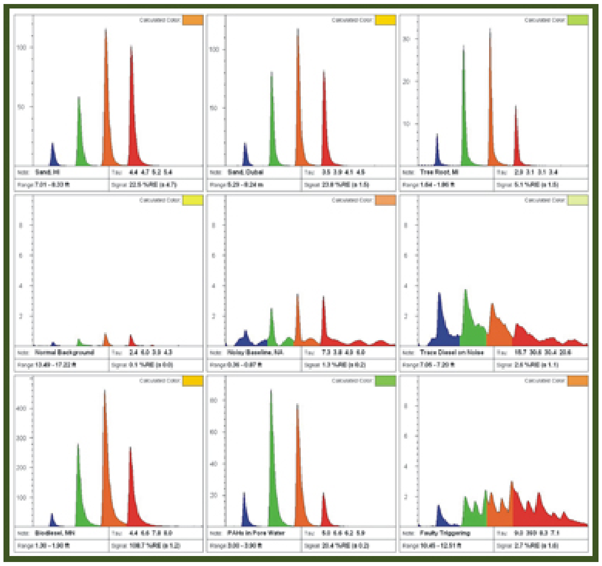


Figure E: Examples of noise, false positives and unusual waveforms.

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APPENDIX C
LABORATORY TEST RESULTS

APPENDIX C

Laboratory Testing Procedures and Results

Moisture and Density Determination Tests: Moisture content and dry density determinations were performed on relatively undisturbed samples obtained from the test borings. The results of these tests are presented in the boring logs. Where applicable, only moisture content was determined from "undisturbed" or disturbed samples.

Maximum Density Tests: The maximum dry density and optimum moisture content of typical materials were determined in accordance with ASTM Test Method D1557. The results of these tests are presented in the test data and in the table below:

Sample Location	Sample Description	Maximum Dry Density (Pcf)	Optimum Moisture Content (%)
B-2 @ 0-5 feet	Sandy Silt	127.0	11

Direct Shear Tests: Direct shear test was performed on selected remolded and/or undisturbed sample, which was soaked for a minimum of 24 hours under a surcharge equal to the applied normal force during testing. After transfer of the sample to the shear box, and reloading the sample, pore pressures set up in the sample due to the transfer were allowed to dissipate for a period of approximately 1-hour prior to application of shearing force. The sample was tested under various normal loads, a motor-driven, strain-controlled, direct-shear testing apparatus at a strain rate of less than 0.001 to 0.5 inches per minute (depending upon the soil type). The test result is presented in the test data.

Sample Location	Sample Description	Friction Angle (degrees)	Apparent Cohesion (psf)
B-2 @ 0-5 feet	Sandy Silt (Remolded)	28	0
B-2@ 5 feet	Sandy Silt	38	168

Consolidation Tests (ASTM D2435): Consolidation test were performed on selected, relatively undisturbed ring samples. Samples were placed in a consolidometer and loads were applied in geometric progression. The percent consolidation for each load cycle was recorded as the ratio of the amount of vertical compression to the original 1-inch height. The consolidation pressure curves are presented in the test data.

Soluble Sulfates: The soluble sulfate contents of selected samples were determined by standard geochemical methods. The test results are presented in the table below:

Sample Location	Sample Description	Water Soluble Sulfate in Soil, (% by Weight)	Sulfate Content (ppm)	Exposure Class*
B-2 @ 0-5 ft	Silty Sand	0.0274	274	S0
B-3 @ 0-5 ft	Dark Brown Silty Sand	0.0200	200	S0
B-5 @ 0-5 ft	Silty Sand	0.0225	225	S0

* Based on the current version of ACI 318-11 Building Code, Table No. 4.2.1; Exposure Categories and Classes.

Corrosivity Test: Electrical conductivity, pH, and soluble chloride tests were conducted on representative samples and the results are provided below and in the test data:

Sample Location	Sample Description	Soluble Chloride (CAL.422) ppm	Electrical Resistivity (CAL.643) (ohm-cm)	PH (CAL.747)	Potential Degree of Attack on Steel
B-2 @ 0-5 feet	Silty Sand	145	1,500	7.0	Strong
B-3 @ 0-5 feet	Dark Brown Silty Sand	112	2,000	7.0	Strong
B-5 @ 0-5 feet	Silty Sand	107	2,000	6.9	Strong

Expansion Index Tests: The expansion potential of selected materials was evaluated by the Expansion Index Test, ASTM D4829. Specimens are molded under a given compactive energy to approximately the optimum moisture content and approximately 50 percent saturation or approximately 90 percent relative compaction. The prepared 1-inch thick by 4-inch diameter specimens are loaded to an equivalent 144 psf surcharge and are inundated with tap water until volumetric equilibrium is reached. The results of these tests are presented in the table below:

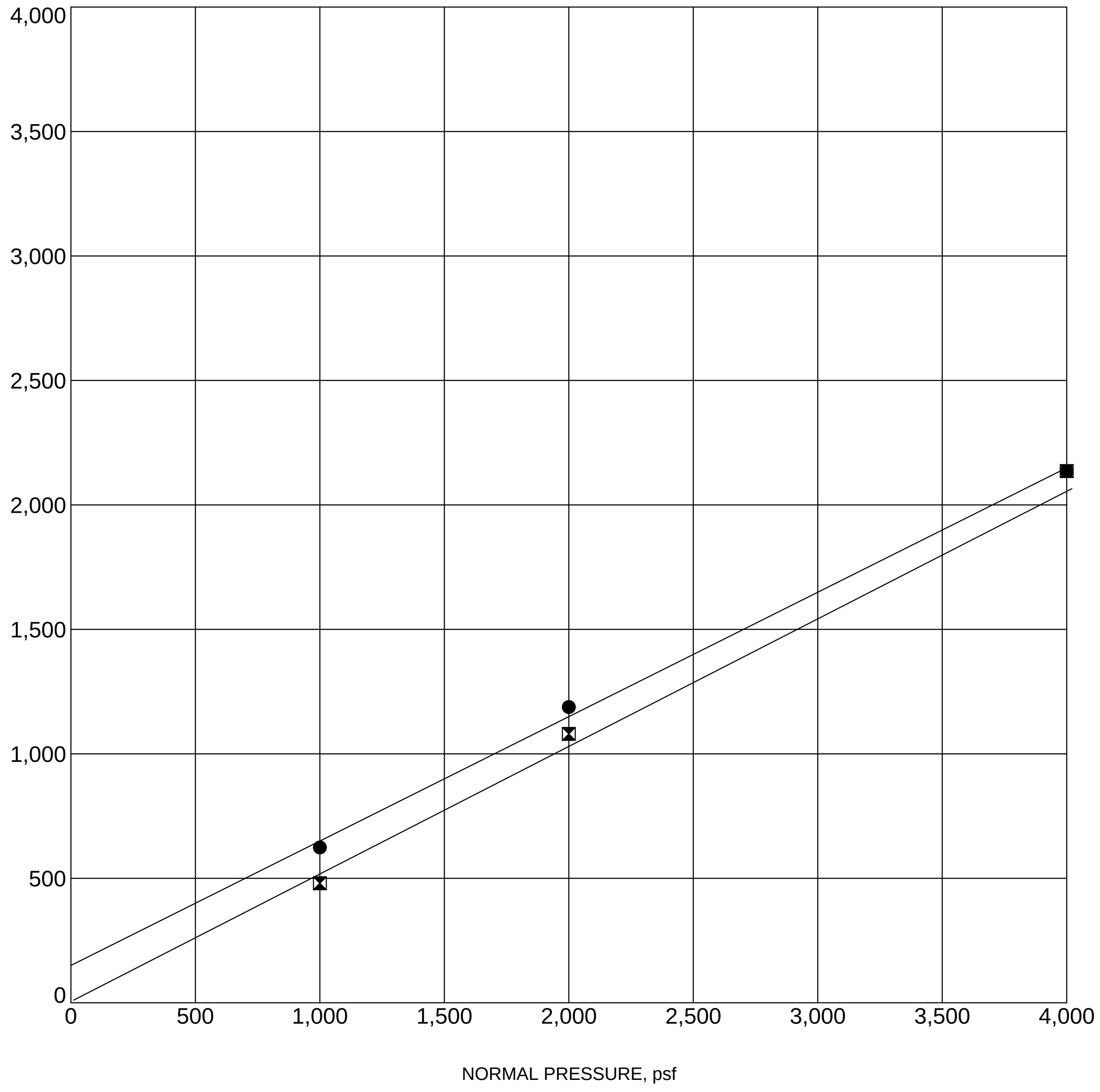
Sample Location	Sample Description	Expansion Index	Expansion Potential
B-3 @ 0-5 feet	Fine Silty Sand	10	Very Low
B-5 @ 0-5 feet	Silty Sand	4	Very Low

Wash Sieve Test: Typical materials were washed over No. 200 sieve (ASTM Test Method D1140). The test results are presented below:

Sample Location	% Passing No. 200 Sieve
B-3 @ 20 feet	3.5%
B-3 @ 40 feet	74.1%
B-3 @ 50 feet	11.0%
B-4 @ 20 feet	3.8%
B-4 @ 40 feet	44.9%

R-Value: The resistance "R"-Value was determined by the California Materials Method No. 301 for subgrade soils. One sample was prepared and exudation pressure and "R"-Value determined. The graphically determined "R"-Value at exudation pressure of 300 psi is summarized in the table below:

Sample Location	Sample Description	R-Value
B-3 @ 0-5 ft	Fine Sandy Silt	48
B-5 @ 0-5ft	Silty Sand	61



	Specimen Identification		Classification	γ_d	MC%	c	ϕ
●	**B-2**	**0-5 feet**	**Sandy Silt, Remolded, Peak Stress**	**114**	**11**	**150**	**27**
☒	**B-2**	**0-5 feet**	**Sandy Silt, Remolded, Ultimate Stress**	**114**	**11**	**0**	**28**

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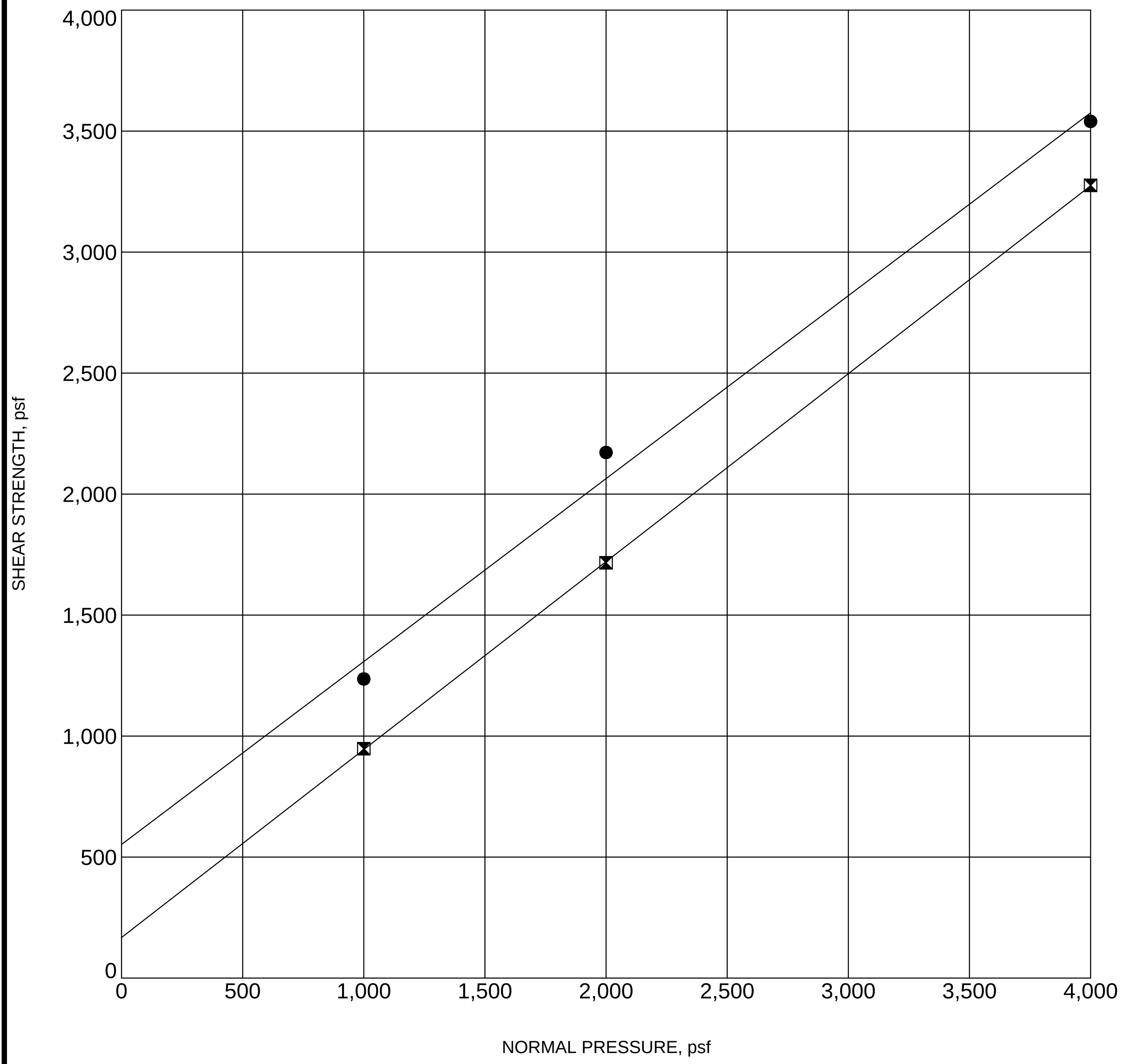
DIRECT SHEAR TEST

Project Number: 16-6239

Project Name: Xebec Signal Hill



Specimen Identification			Classification	γ_d	MC%	c	ϕ
●	**B-2**	**5 ft**	**Silt, Peak Stress**	**118**	**15**	**552**	**37**
☒	**B-2**	**5 ft**	**Silt, Ultimate Stress**	**118**	**15**	**168**	**38**

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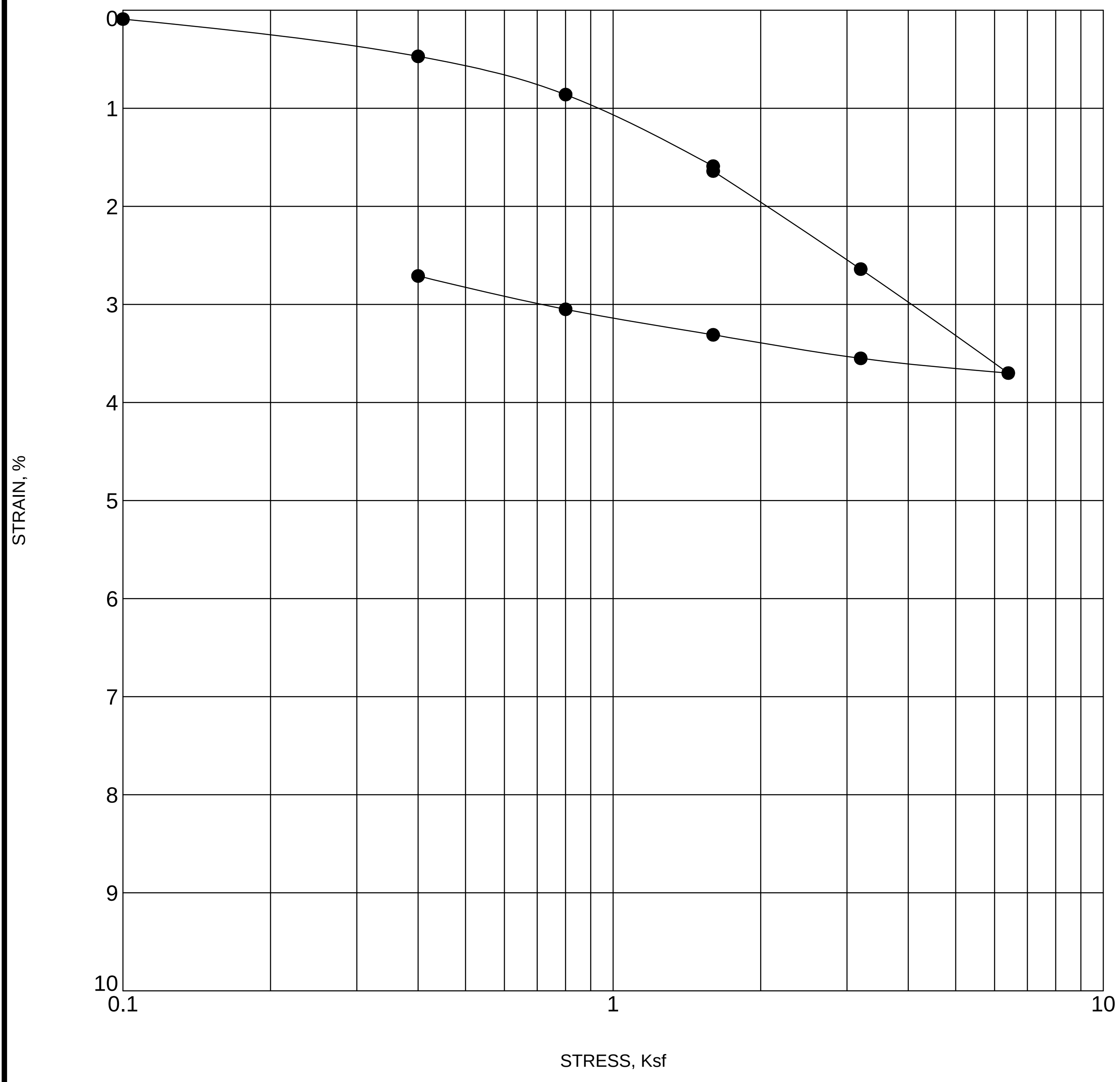
DIRECT SHEAR TEST

Project Number: 16-6239

Project Name: Xebec Signal Hill



	Specimen Identification		Classification	γ_d	MC%
●	**B-1**	**10.0**	**Sand**	**99**	**17**

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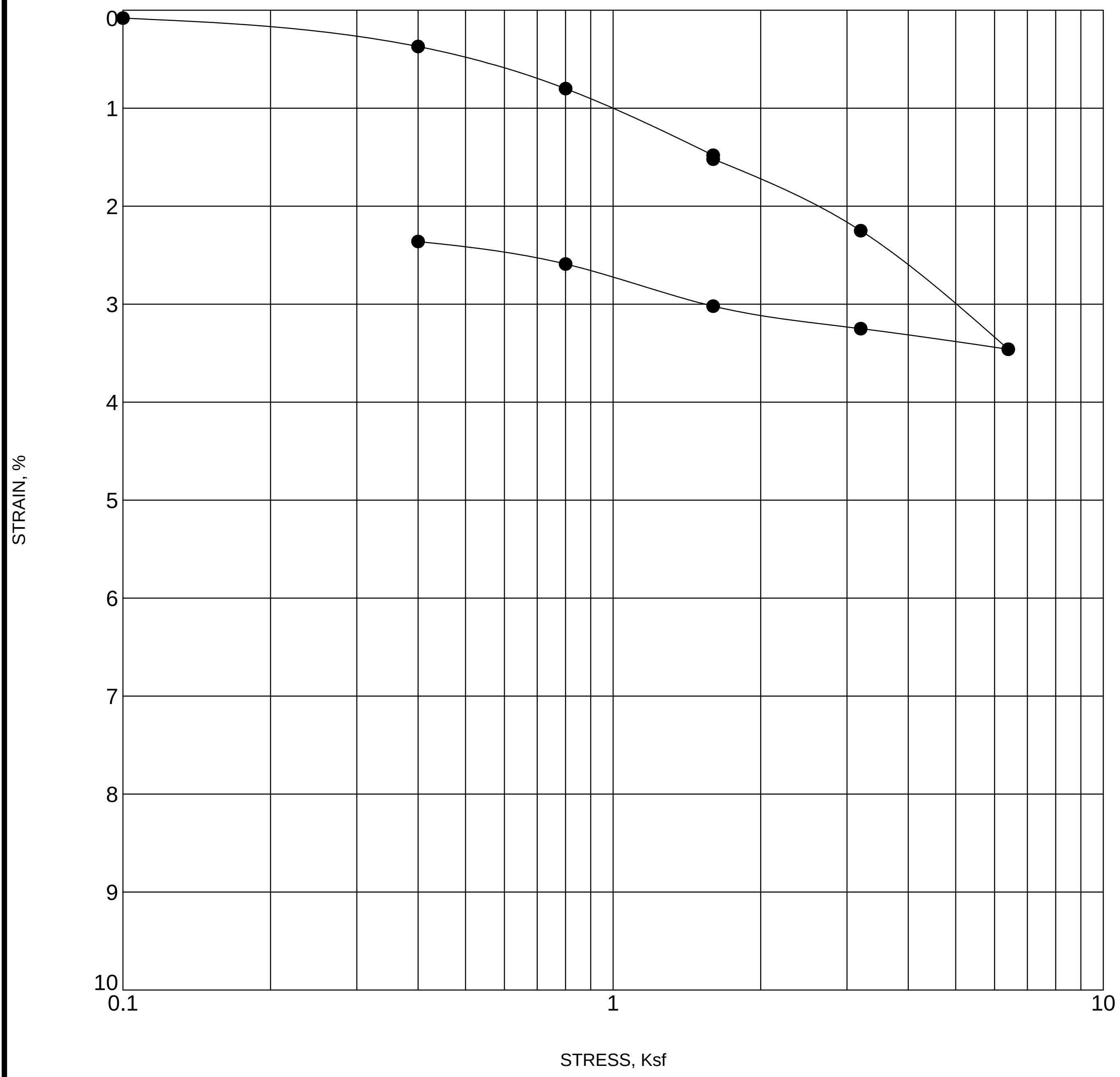
Santa Ana, CA
Telephone:
Fax:

CONSOLIDATION TEST

Project Number: 16-6239

Project Name: Xebec Signal Hill



	Specimen Identification		Classification	γ_d	MC%
●	**B-2**	**5.0**	**Silt**	**118**	**15**

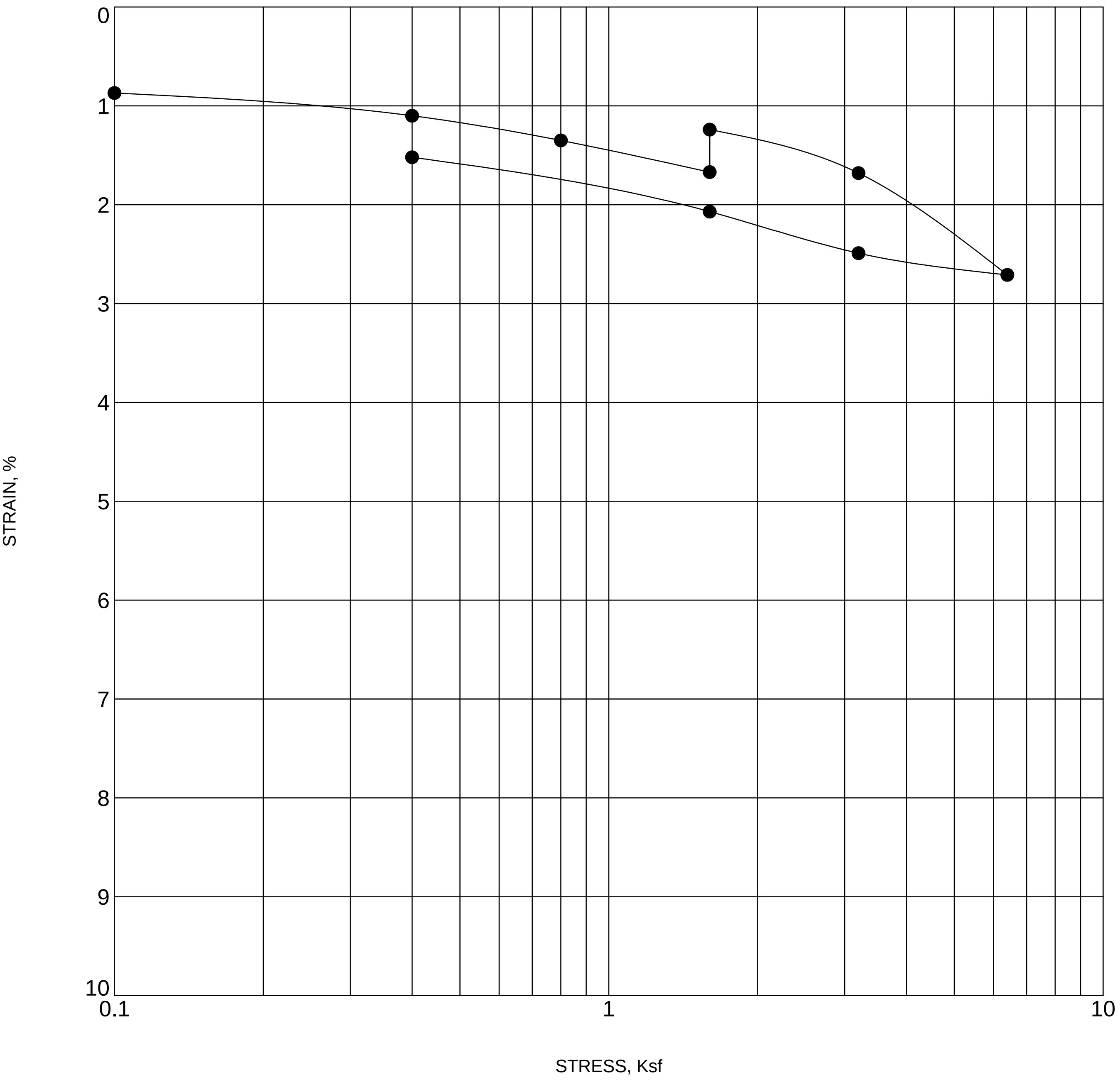
TGR GEOTECHNICAL, INC.

3037 S. Harbor Blvd.
Santa Ana, CA
Telephone:
Fax:

CONSOLIDATION TEST

Project Number: 16-6239

Project Name: Xebec Signal Hill



	Specimen Identification		Classification	γ_d	MC%
●	**B-4**	**10.0**	**Sand**	**125**	**12**

TGR GEOTECHNICAL, INC.

3037 S. Harbor Blvd.
Santa Ana, CA
Telephone:
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CONSOLIDATION TEST

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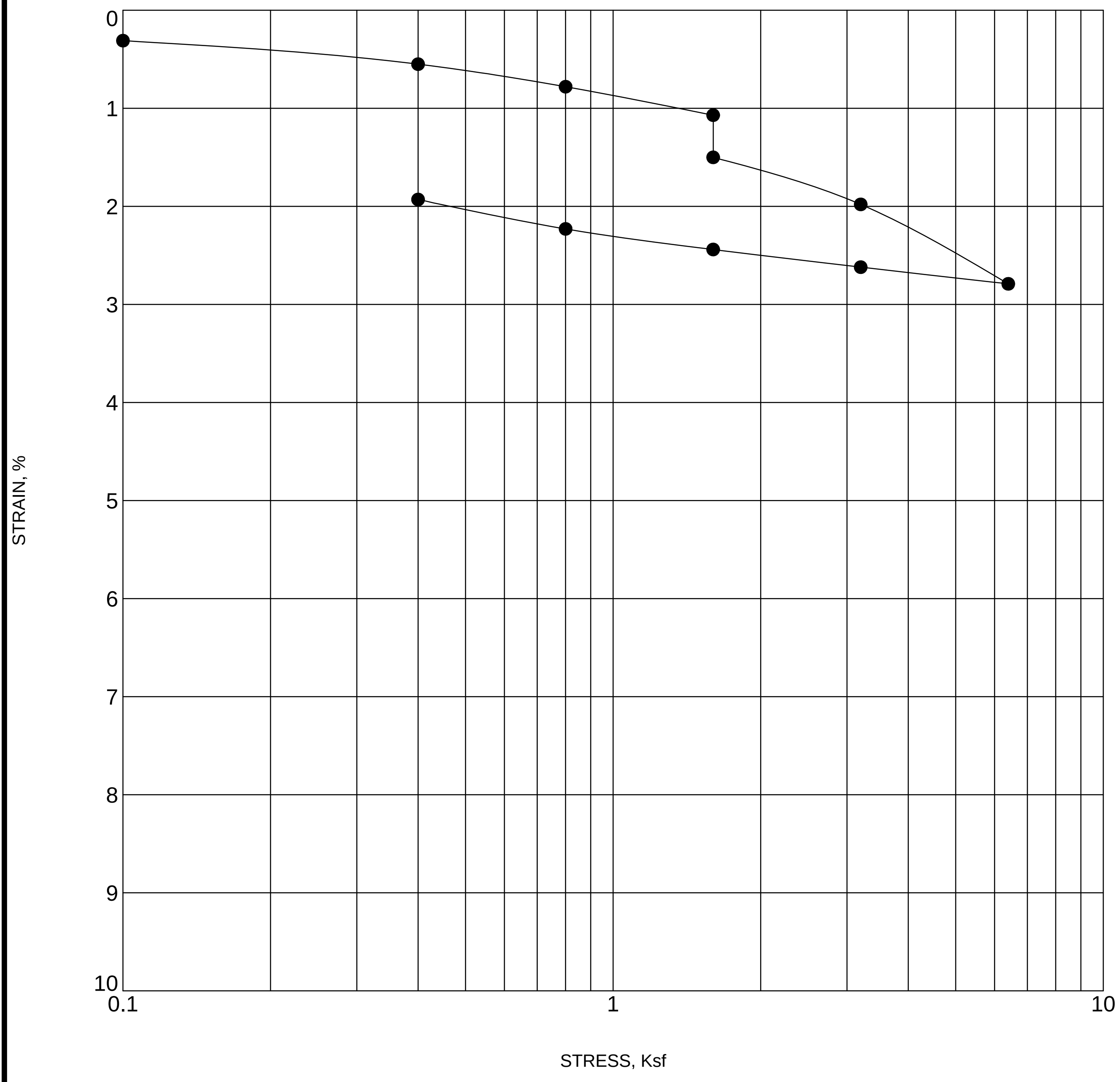
Project Name: Xebec Signal Hill



	Specimen Identification		Classification	γ_d	MC%
●	**B-5**	**5.0**	**Silt**	**129**	**9**

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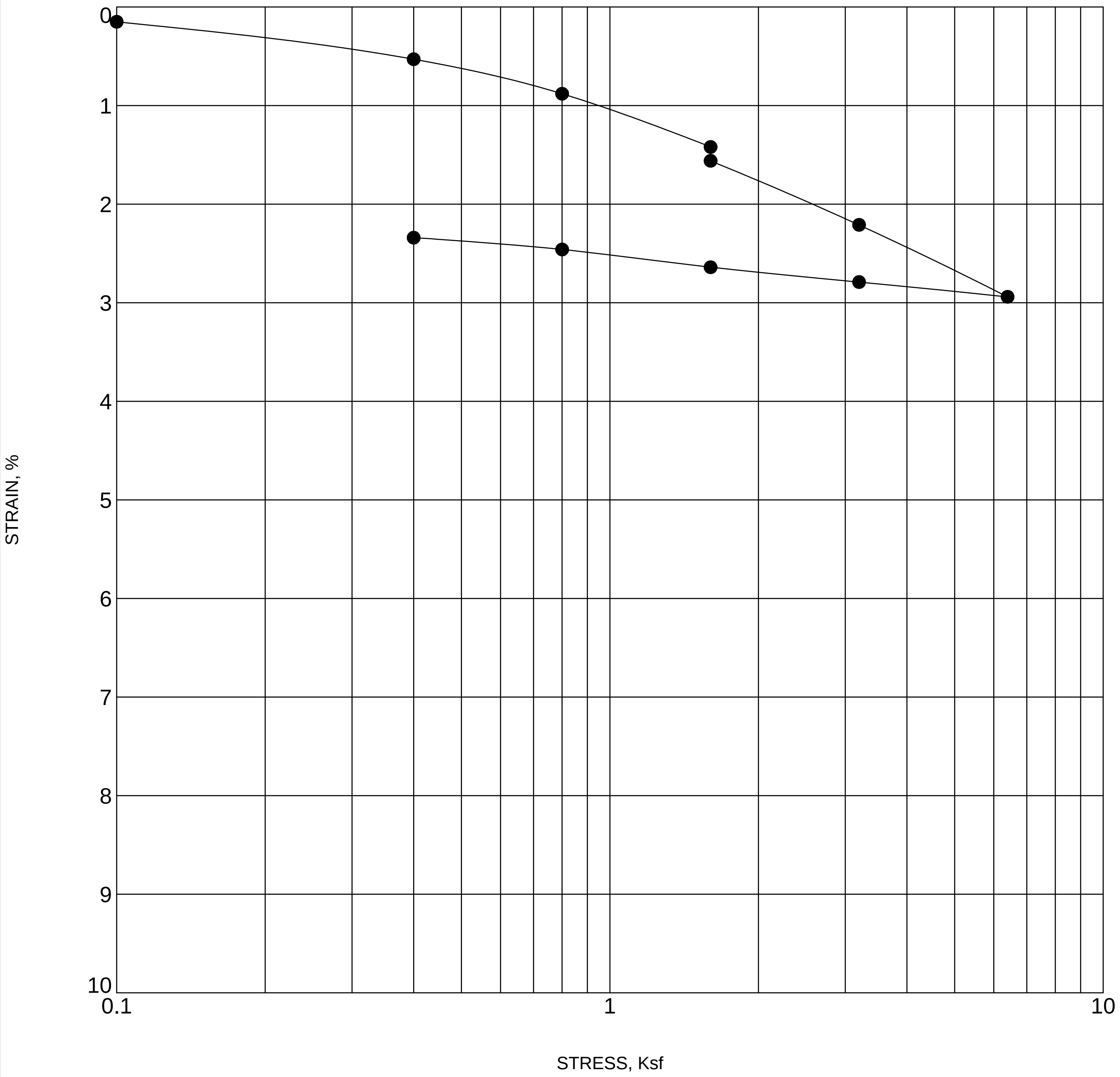
3037 S. Harbor Blvd.
Santa Ana, CA
Telephone:
Fax:

CONSOLIDATION TEST

Project Number: 16-6239

Project Name: Xebec Signal Hill



Specimen Identification			Classification	γ_d	MC%
●	**B-2**	**15.0**	**Sand**	**95**	**9**

TGR GEOTECHNICAL, INC.

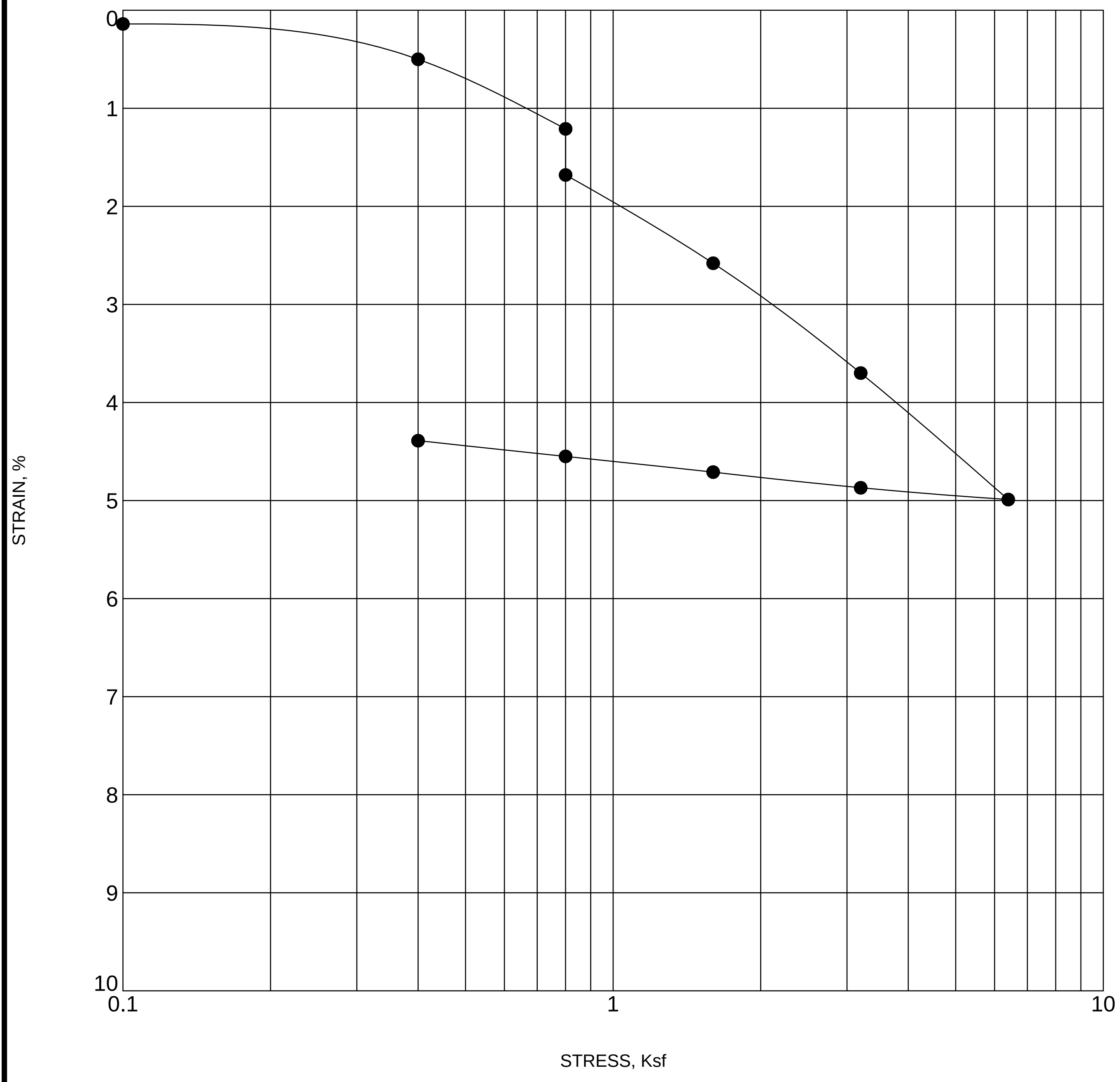
3037 S. Harbor Blvd.
Santa Ana, CA
Telephone:
Fax:

CONSOLIDATION TEST

Project Number: 16-6239

Project Name: Xebec Signal Hill

US CONSOL STRAIN 16-6239 XEBEC SIGNAL HILL.GPJ TGR GEOTECH.GDT 5/9/17



	Specimen Identification		Classification	γ_d	MC%
●	**B-5**	**15.0**	**Sand**	**132**	**5**

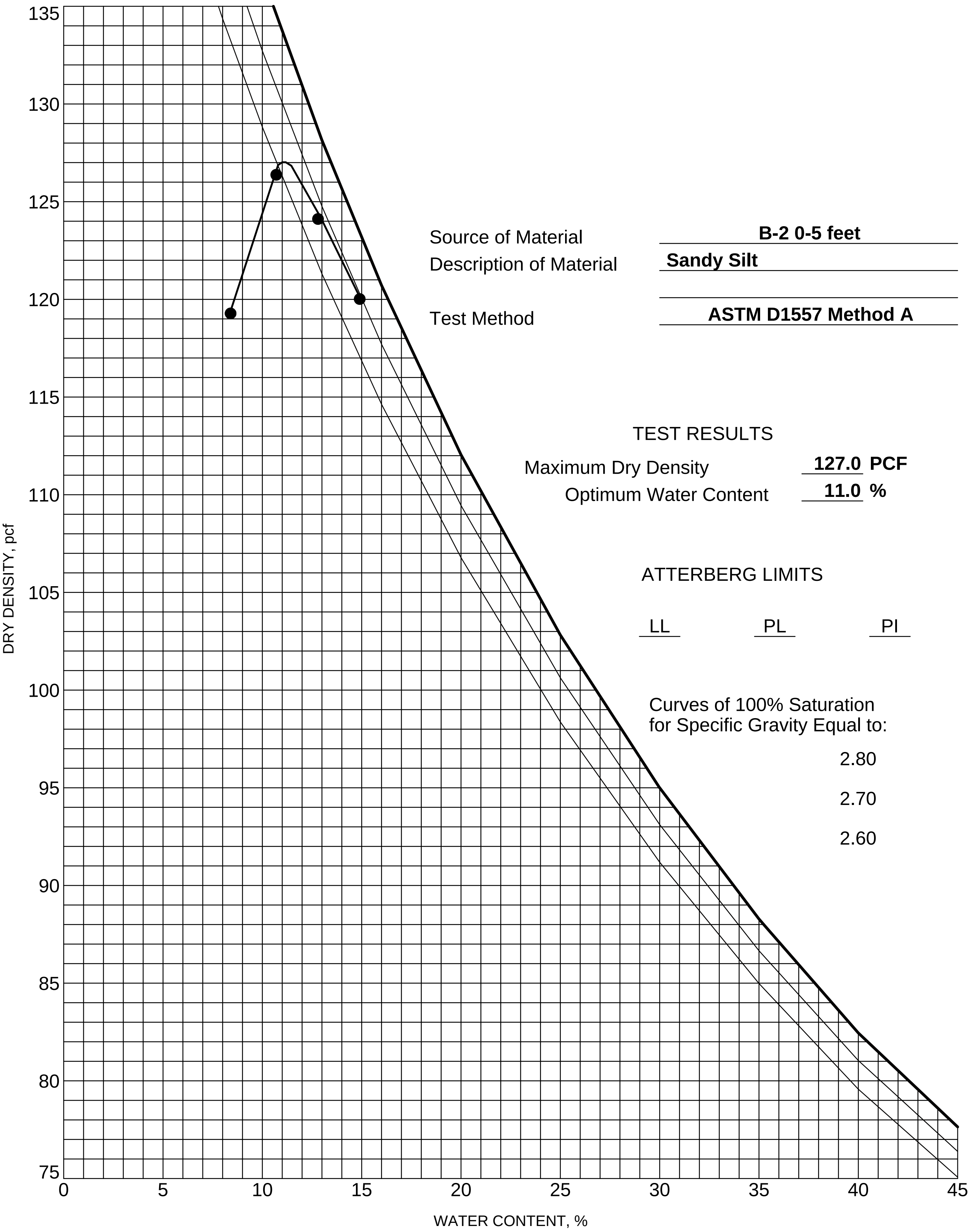
TGR GEOTECHNICAL, INC.

3037 S. Harbor Blvd.
Santa Ana, CA
Telephone:
Fax:

CONSOLIDATION TEST

Project Number: 16-6239

Project Name: Xebec Signal Hill



Source of Material **B-2 0-5 feet**

Description of Material **Sandy Silt**

Test Method **ASTM D1557 Method A**

TEST RESULTS

Maximum Dry Density **127.0 PCF**

Optimum Water Content **11.0 %**

ATTERBERG LIMITS

LL	PL	PI

TGR GEOTECHNICAL, INC.

3037 S. Harbor Blvd.
Santa Ana, CA
Telephone:
Fax:

MOISTURE-DENSITY RELATIONSHIP

Project Number: 16-6239

Project Name: Xebec Signal Hill

ANAHEIM TEST LAB, INC

3008 ORANGE AVENUE
SANTA ANA, CALIFORNIA 92707
PHONE (714) 549-7267

TO:

TGR GEOTECHNICAL
3037 S. HARBOR BLVD.
SANTA ANA, CA 92704

DATE: 04/11/17

P.O. NO: VERBAL

LAB NO: C-0421 1-2

SPECIFICATION: CA-417/422/643

MATERIAL: Soil

PROJECT NO: 16-6239

Xebec-Signal Hill

ANALYTICAL REPORT

CORROSION SERIES

SUMMARY OF DATA

	PH	SOLUBLE SULFATES per CA. 417 ppm	SOLUBLE CHLORIDES per CA. 422 ppm	MIN. RESISTIVITY per CA. 643 ohm-cm
1) B-3 @ 0-5’ Dark Brown, Silty Sand	7.0	200	112	2,000
2) B-5 @ 0-5’ Silty Sand	6.9	225	107	2,000

RESPECTFULLY SUBMITTED

WES BRIDGER CHEMIST

ANAHEIM TEST LAB, INC
3008 ORANGE AVENUE
SANTA ANA, CALIFORNIA 92707
PHONE (714) 549-7267

TO:

TGR GEOTECHNICAL
3037 S. HARBOR BLVD.
SANTA ANA, CA 92704

DATE: 04/12/17

P.O. NO: VERBAL

LAB NO: C-0425

SPECIFICATION: CA-417/422/643

MATERIAL: Silty Sand

PROJECT NO: 16-6239

Xebec-Signal Hill

ANALYTICAL REPORT

CORROSION SERIES

SUMMARY OF DATA

	PH	SOLUBLE SULFATES per CA. 417 ppm	SOLUBLE CHLORIDES per CA. 422 ppm	MIN. RESISTIVITY per CA. 643 ohm-cm
B-2 @ 0-5'	7.0	274	145	1,500

RESPECTFULLY SUBMITTED

WES BRIDGER CHEMIST

ANAHEIM TEST LAB, INC
3008 ORANGE AVENUE
SANTA ANA, CALIFORNIA 92707
PHONE (714) 549-7267

TO:

TGR GEOTECHNICAL
3037 S. HARBOR BLVD.
SANTA ANA, CA. 92704

DATE: 04/13/17

P.O. NO.: VERBAL

LAB NO.: C-0421 1-2

SPECIFICATION: CA 301

MATERIAL: Soil

PROJECT#: 16-6239
Xebec-Signal Hill

ANALYTICAL REPORT

"R" VALUE

	BY EXUDATION	BY EXPANSION
1) B-3 @ 0-5' Brown, F. Sandy Silt w. trace Gravel	48	56
2) B-5 @ 0-5' Brown, F.M. Silty Sand w. Gravel	61	N/A

RESPECTFULLY SUBMITTED

WES BRIDGER CHEMIST

"R" VALUE CA 301

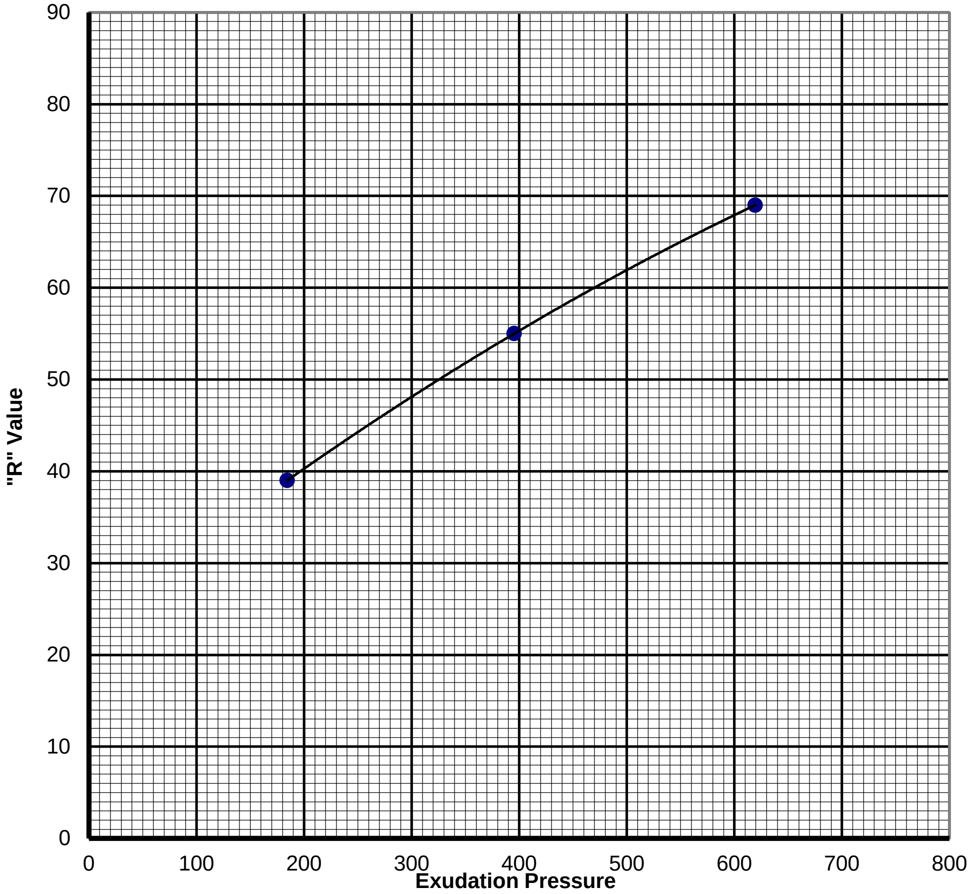
Client: TGR **ATL No.:** C 0421-1 **Date:** 4/12/2017

Client Reference No.: 16-6239

Sample: B-3 @ 0 - 5' **Soil Type:** Brown, F. Sandy Silt w. trace Gravel

TEST SPECIMEN		A	B	C	D
Compactor Air Pressure	psi	100	200	300	
Initial Moisture Content	%	8.4	8.4	8.4	
Moisture at Compaction	%	10.2	9.3	8.4	
Briquette Height	in.	2.52	2.50	2.52	
Dry Density	pcf	118.2	121.3	122.8	
EXUDATION PRESSURE	psi	184	395	619	
EXPANSION dial	(x .0001)	0	15	31	
Ph at 1000 pounds	psi	40	28	19	
Ph at 2000 pounds	psi	80	57	39	
Displacement	turns	3.99	3.65	3.41	
"R" Value		39	55	69	
CORRECTED "R" VALUE		39	55	69	

Final "R" Value	
BY EXUDATION: @ 300 psi	**48**
BY EXPANSION: TI = 5.0	**56**

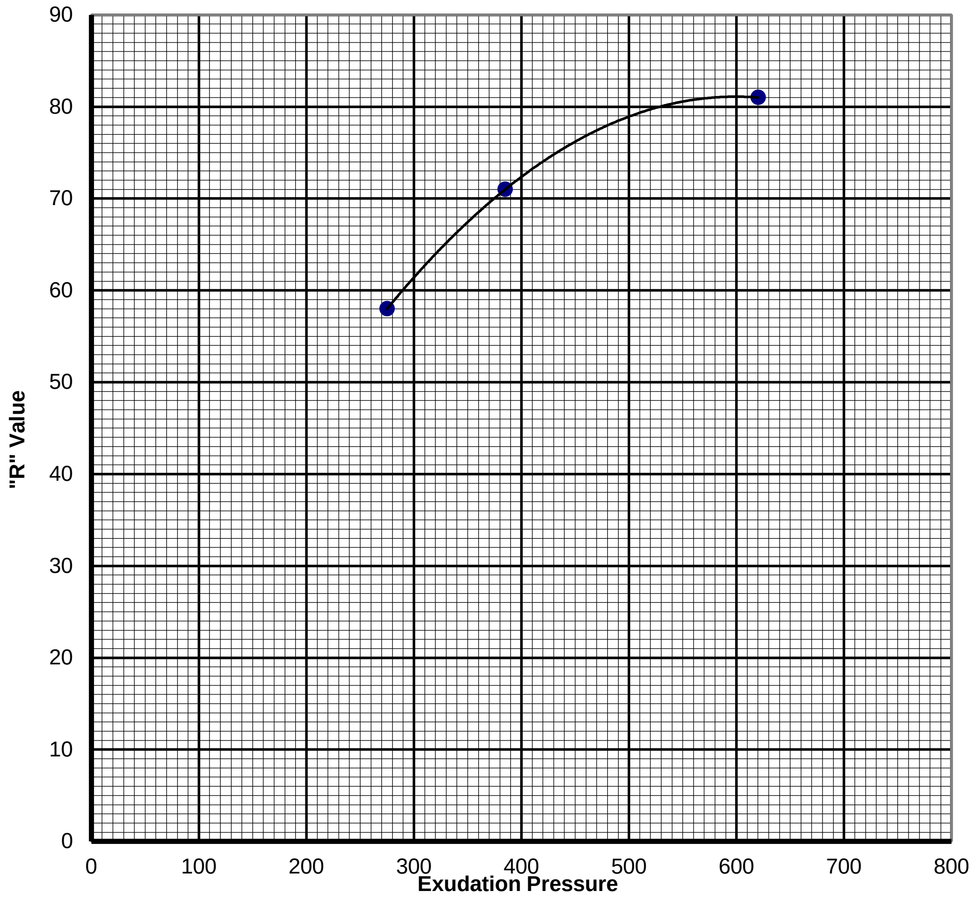


"R" VALUE CA 301

Client: TGR **ATL No.:** C 0421-2 **Date:** 4/12/2017
Client Reference No.: 16-6239
Sample: B-5 @ 0 - 5' **Soil Type:** Brown, F.M. Silty Sand w. Gravel

TEST SPECIMEN		A	B	C	D
Compactor Air Pressure	psi	300	350	350	
Initial Moisture Content	%	4.0	4.0	4.0	
Moisture at Compaction	%	10.1	9.6	9.2	
Briquette Height	in.	2.54	2.42	2.46	
Dry Density	pcf	118.8	120.2	122.1	
EXUDATION PRESSURE	psi	275	385	620	
EXPANSION dial	(x .0001)	0	0	0	
Ph at 1000 pounds	psi	28	20	16	
Ph at 2000 pounds	psi	51	35	24	
Displacement	turns	3.8	3.6	3.32	
"R" Value		58	71	81	
CORRECTED "R" VALUE		58	71	81	

Final "R" Value	
BY EXUDATION: @ 300 psi	**61**
BY EXPANSION: TI = 5.0	**N/A**



APPENDIX D
LIQUEFACTION ANALYSIS

LIQUEFACTION ANALYSIS

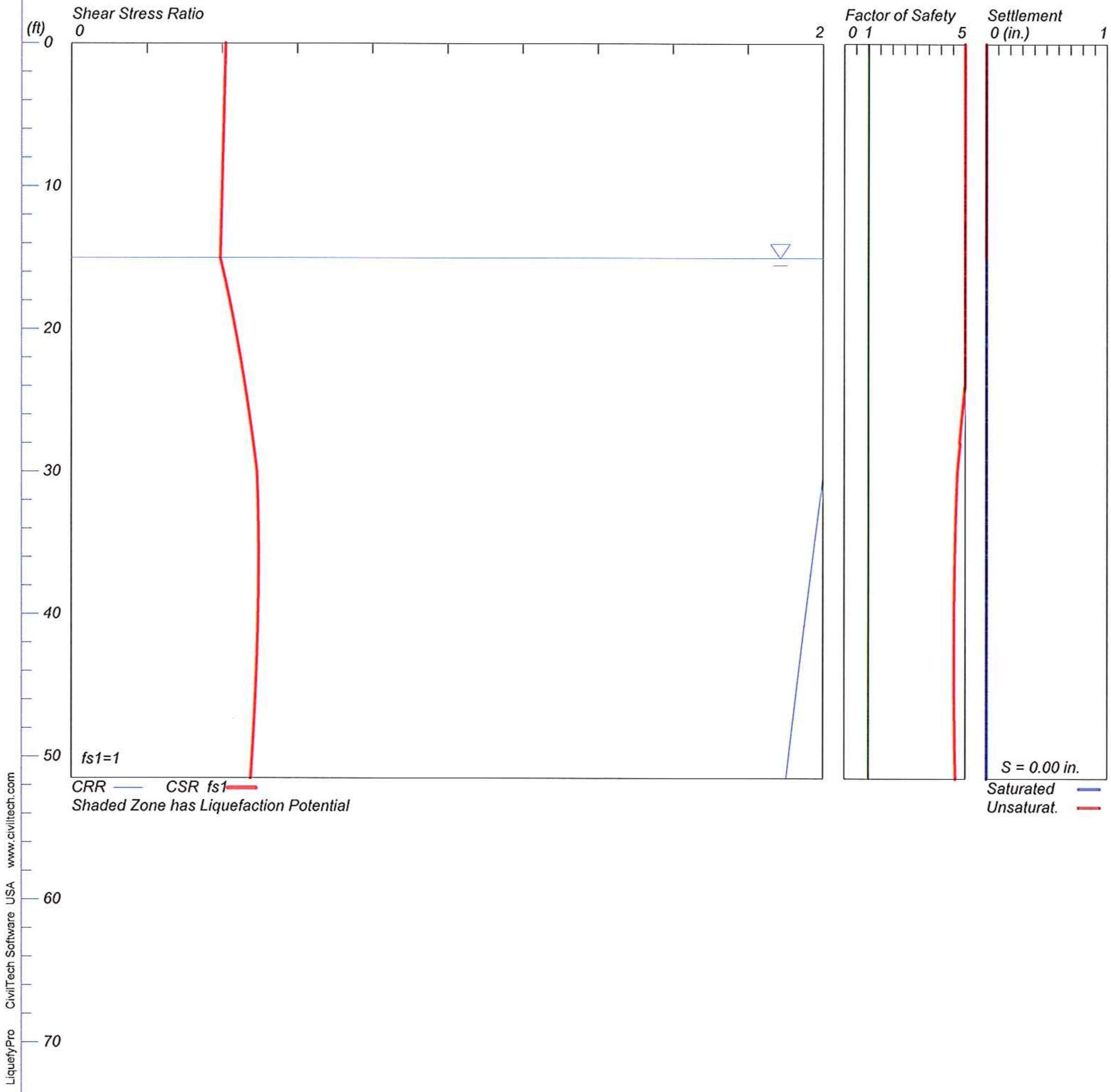
Xebec Signal Hill

Hole No.=B-3   Water Depth=15 ft

Ground Improvement of Fill=5 ft

Magnitude=7.1

Acceleration=0.629g



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************************************************************************************
*******************
                                    LIQUEFACTION ANALYSIS CALCULATION SHEET

                                          Copyright by CivilTech Software
                                                www.civiltech.com
                                         (425) 453-6488  Fax (425) 453-5848

************************************************************************************
*******************
        Licensed to ,   5/1/2017        9:42:13 AM

        Input File Name: D:\Liquefy5\16-6239-Xebec Signal Hill-B3.liq
        Title:  Xebec Signal Hill
        Subtitle:  16-6239

        Surface Elev.=
        Hole No.=B-3
        Depth of Hole= 51.5 ft
        Water Table during Earthquake= 15.0 ft
        Water Table during In-Situ Testing= 25.0 ft
        Max. Acceleration= 0.63 g
        Earthquake Magnitude= 7.1

 Input Data:
        Surface Elev.=
        Hole No.=B-3
        Depth of Hole=51.5 ft
        Water Table during Earthquake= 15.0 ft
        Water Table during In-Situ Testing= 25.0 ft
        Max. Acceleration=0.63 g
        Earthquake Magnitude=7.1

        1. SPT or BPT Calculation.
        2. Settlement Analysis Method: Ishihara / Yoshimine*
        3. Fines Correction for Liquefaction: Stark/Olson et al.*
        4. Fine Correction for Settlement: During Liquefaction*
        5. Settlement Calculation in: All zones*
        6. Hammer Energy Ratio,                                   Ce = 1.25
        7. Borehole Diameter,                                         Cb= 1.15
        8. Sampling Method,                                          Cs= 1.2
        9. User request factor of safety (apply to CSR) ,   User= 1
           Plot one CSR curve (fs1=1)
        10. Use Curve Smoothing: Yes*
        * Recommended Options

        Fill on Top= 5 ft                       Fill Unit Weight= 125 pcf
        Depth of this report is based on original ground surface, not based on fill
        In-Situ Test Data:
        Depth   SPT     gamma   Fines
        ft              pcf     %
        ____________________________________
        0.0     20.0    124.0   NoLiq
        6.0     28.0    124.0   NoLiq
        11.0    32.0    123.0   NoLiq
        16.0    15.0    110.0   3.5
        21.0    26.0    110.0   3.5
        26.0    35.0    110.0   3.5
        31.0    46.0    110.0   3.5
        36.0    26.0    110.0   3.5
        41.0    42.0    110.0   74.0
```

```
        46.0    35.0    110.0   74.0
        51.0    36.0    110.0   11.0
        ____________________________________

Output Results:
        Settlement of Saturated Sands=0.00 in.
        Settlement of Unsaturated Sands=0.00 in.
        Total Settlement of Saturated and Unsaturated Sands=0.00 in.
        Differential Settlement=0.000 to 0.000 in.

        Depth   CRRv    CSRm    F.S.    S_sat.  S_dry   S_all
        ft                              in.     in.     in.
        _______________________________________________________
        0.00    2.00    0.41    5.00    0.00    0.00    0.00
        0.05    2.00    0.41    5.00    0.00    0.00    0.00
        0.10    2.00    0.41    5.00    0.00    0.00    0.00
        0.15    2.00    0.41    5.00    0.00    0.00    0.00
        0.20    2.00    0.41    5.00    0.00    0.00    0.00
        0.25    2.00    0.41    5.00    0.00    0.00    0.00
        0.30    2.00    0.41    5.00    0.00    0.00    0.00
        0.35    2.00    0.41    5.00    0.00    0.00    0.00
        0.40    2.00    0.41    5.00    0.00    0.00    0.00
        0.45    2.00    0.41    5.00    0.00    0.00    0.00
        0.50    2.00    0.41    5.00    0.00    0.00    0.00
        0.55    2.00    0.41    5.00    0.00    0.00    0.00
        0.60    2.00    0.41    5.00    0.00    0.00    0.00
        0.65    2.00    0.41    5.00    0.00    0.00    0.00
        0.70    2.00    0.41    5.00    0.00    0.00    0.00
        0.75    2.00    0.41    5.00    0.00    0.00    0.00
        0.80    2.00    0.41    5.00    0.00    0.00    0.00
        0.85    2.00    0.41    5.00    0.00    0.00    0.00
        0.90    2.00    0.41    5.00    0.00    0.00    0.00
        0.95    2.00    0.41    5.00    0.00    0.00    0.00
        1.00    2.00    0.41    5.00    0.00    0.00    0.00
        1.05    2.00    0.41    5.00    0.00    0.00    0.00
        1.10    2.00    0.41    5.00    0.00    0.00    0.00
        1.15    2.00    0.41    5.00    0.00    0.00    0.00
        1.20    2.00    0.41    5.00    0.00    0.00    0.00
        1.25    2.00    0.41    5.00    0.00    0.00    0.00
        1.30    2.00    0.41    5.00    0.00    0.00    0.00
        1.35    2.00    0.41    5.00    0.00    0.00    0.00
        1.40    2.00    0.41    5.00    0.00    0.00    0.00
        1.45    2.00    0.41    5.00    0.00    0.00    0.00
        1.50    2.00    0.41    5.00    0.00    0.00    0.00
        1.55    2.00    0.41    5.00    0.00    0.00    0.00
        1.60    2.00    0.41    5.00    0.00    0.00    0.00
        1.65    2.00    0.41    5.00    0.00    0.00    0.00
        1.70    2.00    0.41    5.00    0.00    0.00    0.00
        1.75    2.00    0.41    5.00    0.00    0.00    0.00
        1.80    2.00    0.41    5.00    0.00    0.00    0.00
        1.85    2.00    0.41    5.00    0.00    0.00    0.00
        1.90    2.00    0.41    5.00    0.00    0.00    0.00
        1.95    2.00    0.41    5.00    0.00    0.00    0.00
        2.00    2.00    0.41    5.00    0.00    0.00    0.00
        2.05    2.00    0.41    5.00    0.00    0.00    0.00
        2.10    2.00    0.41    5.00    0.00    0.00    0.00
        2.15    2.00    0.41    5.00    0.00    0.00    0.00
        2.20    2.00    0.41    5.00    0.00    0.00    0.00
        2.25    2.00    0.41    5.00    0.00    0.00    0.00
        2.30    2.00    0.41    5.00    0.00    0.00    0.00
        2.35    2.00    0.41    5.00    0.00    0.00    0.00
        2.40    2.00    0.41    5.00    0.00    0.00    0.00
        2.45    2.00    0.41    5.00    0.00    0.00    0.00
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2.65    2.00    0.41    5.00    0.00    0.00    0.00
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2.75    2.00    0.41    5.00    0.00    0.00    0.00
2.80    2.00    0.41    5.00    0.00    0.00    0.00
2.85    2.00    0.41    5.00    0.00    0.00    0.00
2.90    2.00    0.41    5.00    0.00    0.00    0.00
2.95    2.00    0.41    5.00    0.00    0.00    0.00
3.00    2.00    0.41    5.00    0.00    0.00    0.00
3.05    2.00    0.41    5.00    0.00    0.00    0.00
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3.15    2.00    0.41    5.00    0.00    0.00    0.00
3.20    2.00    0.41    5.00    0.00    0.00    0.00
3.25    2.00    0.41    5.00    0.00    0.00    0.00
3.30    2.00    0.41    5.00    0.00    0.00    0.00
3.35    2.00    0.41    5.00    0.00    0.00    0.00
3.40    2.00    0.41    5.00    0.00    0.00    0.00
3.45    2.00    0.41    5.00    0.00    0.00    0.00
3.50    2.00    0.41    5.00    0.00    0.00    0.00
3.55    2.00    0.41    5.00    0.00    0.00    0.00
3.60    2.00    0.41    5.00    0.00    0.00    0.00
3.65    2.00    0.41    5.00    0.00    0.00    0.00
3.70    2.00    0.41    5.00    0.00    0.00    0.00
3.75    2.00    0.41    5.00    0.00    0.00    0.00
3.80    2.00    0.41    5.00    0.00    0.00    0.00
3.85    2.00    0.41    5.00    0.00    0.00    0.00
3.90    2.00    0.41    5.00    0.00    0.00    0.00
3.95    2.00    0.41    5.00    0.00    0.00    0.00
4.00    2.00    0.41    5.00    0.00    0.00    0.00
4.05    2.00    0.40    5.00    0.00    0.00    0.00
4.10    2.00    0.40    5.00    0.00    0.00    0.00
4.15    2.00    0.40    5.00    0.00    0.00    0.00
4.20    2.00    0.40    5.00    0.00    0.00    0.00
4.25    2.00    0.40    5.00    0.00    0.00    0.00
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4.45    2.00    0.40    5.00    0.00    0.00    0.00
4.50    2.00    0.40    5.00    0.00    0.00    0.00
4.55    2.00    0.40    5.00    0.00    0.00    0.00
4.60    2.00    0.40    5.00    0.00    0.00    0.00
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4.75    2.00    0.40    5.00    0.00    0.00    0.00
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4.90    2.00    0.40    5.00    0.00    0.00    0.00
4.95    2.00    0.40    5.00    0.00    0.00    0.00
5.00    2.00    0.40    5.00    0.00    0.00    0.00
5.05    2.00    0.40    5.00    0.00    0.00    0.00
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5.25    2.00    0.40    5.00    0.00    0.00    0.00
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5.40    2.00    0.40    5.00    0.00    0.00    0.00
5.45    2.00    0.40    5.00    0.00    0.00    0.00
5.50    2.00    0.40    5.00    0.00    0.00    0.00
5.55    2.00    0.40    5.00    0.00    0.00    0.00
5.60    2.00    0.40    5.00    0.00    0.00    0.00
```

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5.65    2.00    0.40    5.00    0.00    0.00    0.00
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5.75    2.00    0.40    5.00    0.00    0.00    0.00
5.80    2.00    0.40    5.00    0.00    0.00    0.00
5.85    2.00    0.40    5.00    0.00    0.00    0.00
5.90    2.00    0.40    5.00    0.00    0.00    0.00
5.95    2.00    0.40    5.00    0.00    0.00    0.00
6.00    2.00    0.40    5.00    0.00    0.00    0.00
6.05    2.00    0.40    5.00    0.00    0.00    0.00
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6.15    2.00    0.40    5.00    0.00    0.00    0.00
6.20    2.00    0.40    5.00    0.00    0.00    0.00
6.25    2.00    0.40    5.00    0.00    0.00    0.00
6.30    2.00    0.40    5.00    0.00    0.00    0.00
6.35    2.00    0.40    5.00    0.00    0.00    0.00
6.40    2.00    0.40    5.00    0.00    0.00    0.00
6.45    2.00    0.40    5.00    0.00    0.00    0.00
6.50    2.00    0.40    5.00    0.00    0.00    0.00
6.55    2.00    0.40    5.00    0.00    0.00    0.00
6.60    2.00    0.40    5.00    0.00    0.00    0.00
6.65    2.00    0.40    5.00    0.00    0.00    0.00
6.70    2.00    0.40    5.00    0.00    0.00    0.00
6.75    2.00    0.40    5.00    0.00    0.00    0.00
6.80    2.00    0.40    5.00    0.00    0.00    0.00
6.85    2.00    0.40    5.00    0.00    0.00    0.00
6.90    2.00    0.40    5.00    0.00    0.00    0.00
6.95    2.00    0.40    5.00    0.00    0.00    0.00
7.00    2.00    0.40    5.00    0.00    0.00    0.00
7.05    2.00    0.40    5.00    0.00    0.00    0.00
7.10    2.00    0.40    5.00    0.00    0.00    0.00
7.15    2.00    0.40    5.00    0.00    0.00    0.00
7.20    2.00    0.40    5.00    0.00    0.00    0.00
7.25    2.00    0.40    5.00    0.00    0.00    0.00
7.30    2.00    0.40    5.00    0.00    0.00    0.00
7.35    2.00    0.40    5.00    0.00    0.00    0.00
7.40    2.00    0.40    5.00    0.00    0.00    0.00
7.45    2.00    0.40    5.00    0.00    0.00    0.00
7.50    2.00    0.40    5.00    0.00    0.00    0.00
7.55    2.00    0.40    5.00    0.00    0.00    0.00
7.60    2.00    0.40    5.00    0.00    0.00    0.00
7.65    2.00    0.40    5.00    0.00    0.00    0.00
7.70    2.00    0.40    5.00    0.00    0.00    0.00
7.75    2.00    0.40    5.00    0.00    0.00    0.00
7.80    2.00    0.40    5.00    0.00    0.00    0.00
7.85    2.00    0.40    5.00    0.00    0.00    0.00
7.90    2.00    0.40    5.00    0.00    0.00    0.00
7.95    2.00    0.40    5.00    0.00    0.00    0.00
8.00    2.00    0.40    5.00    0.00    0.00    0.00
8.05    2.00    0.40    5.00    0.00    0.00    0.00
8.10    2.00    0.40    5.00    0.00    0.00    0.00
8.15    2.00    0.40    5.00    0.00    0.00    0.00
8.20    2.00    0.40    5.00    0.00    0.00    0.00
8.25    2.00    0.40    5.00    0.00    0.00    0.00
8.30    2.00    0.40    5.00    0.00    0.00    0.00
8.35    2.00    0.40    5.00    0.00    0.00    0.00
8.40    2.00    0.40    5.00    0.00    0.00    0.00
8.45    2.00    0.40    5.00    0.00    0.00    0.00
8.50    2.00    0.40    5.00    0.00    0.00    0.00
8.55    2.00    0.40    5.00    0.00    0.00    0.00
8.60    2.00    0.40    5.00    0.00    0.00    0.00
8.65    2.00    0.40    5.00    0.00    0.00    0.00
8.70    2.00    0.40    5.00    0.00    0.00    0.00
8.75    2.00    0.40    5.00    0.00    0.00    0.00
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8.80    2.00    0.40    5.00    0.00    0.00    0.00
8.85    2.00    0.40    5.00    0.00    0.00    0.00
8.90    2.00    0.40    5.00    0.00    0.00    0.00
8.95    2.00    0.40    5.00    0.00    0.00    0.00
9.00    2.00    0.40    5.00    0.00    0.00    0.00
9.05    2.00    0.40    5.00    0.00    0.00    0.00
9.10    2.00    0.40    5.00    0.00    0.00    0.00
9.15    2.00    0.40    5.00    0.00    0.00    0.00
9.20    2.00    0.40    5.00    0.00    0.00    0.00
9.25    2.00    0.40    5.00    0.00    0.00    0.00
9.30    2.00    0.40    5.00    0.00    0.00    0.00
9.35    2.00    0.40    5.00    0.00    0.00    0.00
9.40    2.00    0.40    5.00    0.00    0.00    0.00
9.45    2.00    0.40    5.00    0.00    0.00    0.00
9.50    2.00    0.40    5.00    0.00    0.00    0.00
9.55    2.00    0.40    5.00    0.00    0.00    0.00
9.60    2.00    0.40    5.00    0.00    0.00    0.00
9.65    2.00    0.40    5.00    0.00    0.00    0.00
9.70    2.00    0.40    5.00    0.00    0.00    0.00
9.75    2.00    0.40    5.00    0.00    0.00    0.00
9.80    2.00    0.40    5.00    0.00    0.00    0.00
9.85    2.00    0.40    5.00    0.00    0.00    0.00
9.90    2.00    0.40    5.00    0.00    0.00    0.00
9.95    2.00    0.40    5.00    0.00    0.00    0.00
10.00   2.00    0.40    5.00    0.00    0.00    0.00
10.05   2.00    0.40    5.00    0.00    0.00    0.00
10.10   2.00    0.40    5.00    0.00    0.00    0.00
10.15   2.00    0.40    5.00    0.00    0.00    0.00
10.20   2.00    0.40    5.00    0.00    0.00    0.00
10.25   2.00    0.40    5.00    0.00    0.00    0.00
10.30   2.00    0.40    5.00    0.00    0.00    0.00
10.35   2.00    0.40    5.00    0.00    0.00    0.00
10.40   2.00    0.40    5.00    0.00    0.00    0.00
10.45   2.00    0.40    5.00    0.00    0.00    0.00
10.50   2.00    0.40    5.00    0.00    0.00    0.00
10.55   2.00    0.40    5.00    0.00    0.00    0.00
10.60   2.00    0.40    5.00    0.00    0.00    0.00
10.65   2.00    0.40    5.00    0.00    0.00    0.00
10.70   2.00    0.40    5.00    0.00    0.00    0.00
10.75   2.00    0.40    5.00    0.00    0.00    0.00
10.80   2.00    0.40    5.00    0.00    0.00    0.00
10.85   2.00    0.40    5.00    0.00    0.00    0.00
10.90   2.00    0.40    5.00    0.00    0.00    0.00
10.95   2.00    0.40    5.00    0.00    0.00    0.00
11.00   2.00    0.40    5.00    0.00    0.00    0.00
11.05   2.00    0.40    5.00    0.00    0.00    0.00
11.10   2.00    0.40    5.00    0.00    0.00    0.00
11.15   2.00    0.40    5.00    0.00    0.00    0.00
11.20   2.00    0.40    5.00    0.00    0.00    0.00
11.25   2.00    0.40    5.00    0.00    0.00    0.00
11.30   2.00    0.40    5.00    0.00    0.00    0.00
11.35   2.00    0.40    5.00    0.00    0.00    0.00
11.40   2.00    0.40    5.00    0.00    0.00    0.00
11.45   2.00    0.40    5.00    0.00    0.00    0.00
11.50   2.00    0.40    5.00    0.00    0.00    0.00
11.55   2.00    0.40    5.00    0.00    0.00    0.00
11.60   2.00    0.40    5.00    0.00    0.00    0.00
11.65   2.00    0.40    5.00    0.00    0.00    0.00
11.70   2.00    0.40    5.00    0.00    0.00    0.00
11.75   2.00    0.40    5.00    0.00    0.00    0.00
11.80   2.00    0.40    5.00    0.00    0.00    0.00
11.85   2.00    0.40    5.00    0.00    0.00    0.00
11.90   2.00    0.40    5.00    0.00    0.00    0.00
```

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11.95   2.00    0.40    5.00    0.00    0.00    0.00
12.00   2.00    0.40    5.00    0.00    0.00    0.00
12.05   2.00    0.40    5.00    0.00    0.00    0.00
12.10   2.00    0.40    5.00    0.00    0.00    0.00
12.15   2.00    0.40    5.00    0.00    0.00    0.00
12.20   2.00    0.40    5.00    0.00    0.00    0.00
12.25   2.00    0.40    5.00    0.00    0.00    0.00
12.30   2.00    0.40    5.00    0.00    0.00    0.00
12.35   2.00    0.40    5.00    0.00    0.00    0.00
12.40   2.00    0.40    5.00    0.00    0.00    0.00
12.45   2.00    0.40    5.00    0.00    0.00    0.00
12.50   2.00    0.40    5.00    0.00    0.00    0.00
12.55   2.00    0.40    5.00    0.00    0.00    0.00
12.60   2.00    0.40    5.00    0.00    0.00    0.00
12.65   2.00    0.40    5.00    0.00    0.00    0.00
12.70   2.00    0.40    5.00    0.00    0.00    0.00
12.75   2.00    0.40    5.00    0.00    0.00    0.00
12.80   2.00    0.40    5.00    0.00    0.00    0.00
12.85   2.00    0.40    5.00    0.00    0.00    0.00
12.90   2.00    0.40    5.00    0.00    0.00    0.00
12.95   2.00    0.40    5.00    0.00    0.00    0.00
13.00   2.00    0.40    5.00    0.00    0.00    0.00
13.05   2.00    0.40    5.00    0.00    0.00    0.00
13.10   2.00    0.40    5.00    0.00    0.00    0.00
13.15   2.00    0.40    5.00    0.00    0.00    0.00
13.20   2.00    0.40    5.00    0.00    0.00    0.00
13.25   2.00    0.40    5.00    0.00    0.00    0.00
13.30   2.00    0.40    5.00    0.00    0.00    0.00
13.35   2.00    0.40    5.00    0.00    0.00    0.00
13.40   2.00    0.40    5.00    0.00    0.00    0.00
13.45   2.00    0.40    5.00    0.00    0.00    0.00
13.50   2.00    0.40    5.00    0.00    0.00    0.00
13.55   2.00    0.40    5.00    0.00    0.00    0.00
13.60   2.00    0.40    5.00    0.00    0.00    0.00
13.65   2.00    0.40    5.00    0.00    0.00    0.00
13.70   2.00    0.40    5.00    0.00    0.00    0.00
13.75   2.00    0.40    5.00    0.00    0.00    0.00
13.80   2.00    0.40    5.00    0.00    0.00    0.00
13.85   2.00    0.40    5.00    0.00    0.00    0.00
13.90   2.00    0.40    5.00    0.00    0.00    0.00
13.95   2.00    0.40    5.00    0.00    0.00    0.00
14.00   2.00    0.40    5.00    0.00    0.00    0.00
14.05   2.00    0.40    5.00    0.00    0.00    0.00
14.10   2.00    0.40    5.00    0.00    0.00    0.00
14.15   2.00    0.40    5.00    0.00    0.00    0.00
14.20   2.00    0.40    5.00    0.00    0.00    0.00
14.25   2.00    0.40    5.00    0.00    0.00    0.00
14.30   2.00    0.40    5.00    0.00    0.00    0.00
14.35   2.00    0.40    5.00    0.00    0.00    0.00
14.40   2.00    0.40    5.00    0.00    0.00    0.00
14.45   2.00    0.40    5.00    0.00    0.00    0.00
14.50   2.00    0.40    5.00    0.00    0.00    0.00
14.55   2.00    0.39    5.00    0.00    0.00    0.00
14.60   2.00    0.39    5.00    0.00    0.00    0.00
14.65   2.00    0.39    5.00    0.00    0.00    0.00
14.70   2.00    0.39    5.00    0.00    0.00    0.00
14.75   2.00    0.39    5.00    0.00    0.00    0.00
14.80   2.00    0.39    5.00    0.00    0.00    0.00
14.85   2.00    0.39    5.00    0.00    0.00    0.00
14.90   2.00    0.39    5.00    0.00    0.00    0.00
14.95   2.00    0.39    5.00    0.00    0.00    0.00
15.00   2.00    0.39    5.00    0.00    0.00    0.00
15.05   2.00    0.40    5.00    0.00    0.00    0.00
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15.10   2.00    0.40    5.00    0.00    0.00    0.00
15.15   2.00    0.40    5.00    0.00    0.00    0.00
15.20   2.00    0.40    5.00    0.00    0.00    0.00
15.25   2.00    0.40    5.00    0.00    0.00    0.00
15.30   2.00    0.40    5.00    0.00    0.00    0.00
15.35   2.00    0.40    5.00    0.00    0.00    0.00
15.40   2.00    0.40    5.00    0.00    0.00    0.00
15.45   2.00    0.40    5.00    0.00    0.00    0.00
15.50   2.00    0.40    5.00    0.00    0.00    0.00
15.55   2.00    0.40    5.00    0.00    0.00    0.00
15.60   2.00    0.40    5.00    0.00    0.00    0.00
15.65   2.00    0.40    5.00    0.00    0.00    0.00
15.70   2.00    0.40    5.00    0.00    0.00    0.00
15.75   2.00    0.40    5.00    0.00    0.00    0.00
15.80   2.00    0.40    5.00    0.00    0.00    0.00
15.85   2.00    0.40    5.00    0.00    0.00    0.00
15.90   2.00    0.40    5.00    0.00    0.00    0.00
15.95   2.00    0.40    5.00    0.00    0.00    0.00
16.00   2.00    0.40    5.00    0.00    0.00    0.00
16.05   2.00    0.40    5.00    0.00    0.00    0.00
16.10   2.00    0.40    5.00    0.00    0.00    0.00
16.15   2.00    0.40    5.00    0.00    0.00    0.00
16.20   2.00    0.41    5.00    0.00    0.00    0.00
16.25   2.00    0.41    5.00    0.00    0.00    0.00
16.30   2.00    0.41    5.00    0.00    0.00    0.00
16.35   2.00    0.41    5.00    0.00    0.00    0.00
16.40   2.00    0.41    5.00    0.00    0.00    0.00
16.45   2.00    0.41    5.00    0.00    0.00    0.00
16.50   2.00    0.41    5.00    0.00    0.00    0.00
16.55   2.00    0.41    5.00    0.00    0.00    0.00
16.60   2.00    0.41    5.00    0.00    0.00    0.00
16.65   2.00    0.41    5.00    0.00    0.00    0.00
16.70   2.00    0.41    5.00    0.00    0.00    0.00
16.75   2.00    0.41    5.00    0.00    0.00    0.00
16.80   2.00    0.41    5.00    0.00    0.00    0.00
16.85   2.00    0.41    5.00    0.00    0.00    0.00
16.90   2.00    0.41    5.00    0.00    0.00    0.00
16.95   2.00    0.41    5.00    0.00    0.00    0.00
17.00   2.00    0.41    5.00    0.00    0.00    0.00
17.05   2.00    0.41    5.00    0.00    0.00    0.00
17.10   2.00    0.41    5.00    0.00    0.00    0.00
17.15   2.00    0.41    5.00    0.00    0.00    0.00
17.20   2.00    0.41    5.00    0.00    0.00    0.00
17.25   2.00    0.41    5.00    0.00    0.00    0.00
17.30   2.00    0.41    5.00    0.00    0.00    0.00
17.35   2.00    0.41    5.00    0.00    0.00    0.00
17.40   2.00    0.42    5.00    0.00    0.00    0.00
17.45   2.00    0.42    5.00    0.00    0.00    0.00
17.50   2.00    0.42    5.00    0.00    0.00    0.00
17.55   2.00    0.42    5.00    0.00    0.00    0.00
17.60   2.00    0.42    5.00    0.00    0.00    0.00
17.65   2.00    0.42    5.00    0.00    0.00    0.00
17.70   2.00    0.42    5.00    0.00    0.00    0.00
17.75   2.00    0.42    5.00    0.00    0.00    0.00
17.80   2.00    0.42    5.00    0.00    0.00    0.00
17.85   2.00    0.42    5.00    0.00    0.00    0.00
17.90   2.00    0.42    5.00    0.00    0.00    0.00
17.95   2.00    0.42    5.00    0.00    0.00    0.00
18.00   2.00    0.42    5.00    0.00    0.00    0.00
18.05   2.00    0.42    5.00    0.00    0.00    0.00
18.10   2.00    0.42    5.00    0.00    0.00    0.00
18.15   2.00    0.42    5.00    0.00    0.00    0.00
18.20   2.00    0.42    5.00    0.00    0.00    0.00
```

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18.25   2.00    0.42    5.00    0.00    0.00    0.00
18.30   2.00    0.42    5.00    0.00    0.00    0.00
18.35   2.00    0.42    5.00    0.00    0.00    0.00
18.40   2.00    0.42    5.00    0.00    0.00    0.00
18.45   2.00    0.42    5.00    0.00    0.00    0.00
18.50   2.00    0.42    5.00    0.00    0.00    0.00
18.55   2.00    0.42    5.00    0.00    0.00    0.00
18.60   2.00    0.42    5.00    0.00    0.00    0.00
18.65   2.00    0.42    5.00    0.00    0.00    0.00
18.70   2.00    0.43    5.00    0.00    0.00    0.00
18.75   2.00    0.43    5.00    0.00    0.00    0.00
18.80   2.00    0.43    5.00    0.00    0.00    0.00
18.85   2.00    0.43    5.00    0.00    0.00    0.00
18.90   2.00    0.43    5.00    0.00    0.00    0.00
18.95   2.00    0.43    5.00    0.00    0.00    0.00
19.00   2.00    0.43    5.00    0.00    0.00    0.00
19.05   2.00    0.43    5.00    0.00    0.00    0.00
19.10   2.00    0.43    5.00    0.00    0.00    0.00
19.15   2.00    0.43    5.00    0.00    0.00    0.00
19.20   2.00    0.43    5.00    0.00    0.00    0.00
19.25   2.00    0.43    5.00    0.00    0.00    0.00
19.30   2.00    0.43    5.00    0.00    0.00    0.00
19.35   2.00    0.43    5.00    0.00    0.00    0.00
19.40   2.00    0.43    5.00    0.00    0.00    0.00
19.45   2.00    0.43    5.00    0.00    0.00    0.00
19.50   2.00    0.43    5.00    0.00    0.00    0.00
19.55   2.00    0.43    5.00    0.00    0.00    0.00
19.60   2.00    0.43    5.00    0.00    0.00    0.00
19.65   2.00    0.43    5.00    0.00    0.00    0.00
19.70   2.00    0.43    5.00    0.00    0.00    0.00
19.75   2.00    0.43    5.00    0.00    0.00    0.00
19.80   2.00    0.43    5.00    0.00    0.00    0.00
19.85   2.00    0.43    5.00    0.00    0.00    0.00
19.90   2.00    0.43    5.00    0.00    0.00    0.00
19.95   2.00    0.43    5.00    0.00    0.00    0.00
20.00   2.00    0.43    5.00    0.00    0.00    0.00
20.05   2.00    0.44    5.00    0.00    0.00    0.00
20.10   2.00    0.44    5.00    0.00    0.00    0.00
20.15   2.00    0.44    5.00    0.00    0.00    0.00
20.20   2.00    0.44    5.00    0.00    0.00    0.00
20.25   2.00    0.44    5.00    0.00    0.00    0.00
20.30   2.00    0.44    5.00    0.00    0.00    0.00
20.35   2.00    0.44    5.00    0.00    0.00    0.00
20.40   2.00    0.44    5.00    0.00    0.00    0.00
20.45   2.00    0.44    5.00    0.00    0.00    0.00
20.50   2.00    0.44    5.00    0.00    0.00    0.00
20.55   2.00    0.44    5.00    0.00    0.00    0.00
20.60   2.00    0.44    5.00    0.00    0.00    0.00
20.65   2.00    0.44    5.00    0.00    0.00    0.00
20.70   2.00    0.44    5.00    0.00    0.00    0.00
20.75   2.00    0.44    5.00    0.00    0.00    0.00
20.80   2.00    0.44    5.00    0.00    0.00    0.00
20.85   2.00    0.44    5.00    0.00    0.00    0.00
20.90   2.00    0.44    5.00    0.00    0.00    0.00
20.95   2.00    0.44    5.00    0.00    0.00    0.00
21.00   2.00    0.44    5.00    0.00    0.00    0.00
21.05   2.00    0.44    5.00    0.00    0.00    0.00
21.10   2.00    0.44    5.00    0.00    0.00    0.00
21.15   2.00    0.44    5.00    0.00    0.00    0.00
21.20   2.00    0.44    5.00    0.00    0.00    0.00
21.25   2.00    0.44    5.00    0.00    0.00    0.00
21.30   2.00    0.44    5.00    0.00    0.00    0.00
21.35   2.00    0.44    5.00    0.00    0.00    0.00
```

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21.40   2.00    0.44    5.00    0.00    0.00    0.00
21.45   2.00    0.44    5.00    0.00    0.00    0.00
21.50   2.00    0.45    5.00    0.00    0.00    0.00
21.55   2.00    0.45    5.00    0.00    0.00    0.00
21.60   2.00    0.45    5.00    0.00    0.00    0.00
21.65   2.00    0.45    5.00    0.00    0.00    0.00
21.70   2.00    0.45    5.00    0.00    0.00    0.00
21.75   2.00    0.45    5.00    0.00    0.00    0.00
21.80   2.00    0.45    5.00    0.00    0.00    0.00
21.85   2.00    0.45    5.00    0.00    0.00    0.00
21.90   2.00    0.45    5.00    0.00    0.00    0.00
21.95   2.00    0.45    5.00    0.00    0.00    0.00
22.00   2.00    0.45    5.00    0.00    0.00    0.00
22.05   2.00    0.45    5.00    0.00    0.00    0.00
22.10   2.00    0.45    5.00    0.00    0.00    0.00
22.15   2.00    0.45    5.00    0.00    0.00    0.00
22.20   2.00    0.45    5.00    0.00    0.00    0.00
22.25   2.00    0.45    5.00    0.00    0.00    0.00
22.30   2.00    0.45    5.00    0.00    0.00    0.00
22.35   2.00    0.45    5.00    0.00    0.00    0.00
22.40   2.00    0.45    5.00    0.00    0.00    0.00
22.45   2.00    0.45    5.00    0.00    0.00    0.00
22.50   2.00    0.45    5.00    0.00    0.00    0.00
22.55   2.00    0.45    5.00    0.00    0.00    0.00
22.60   2.00    0.45    5.00    0.00    0.00    0.00
22.65   2.00    0.45    5.00    0.00    0.00    0.00
22.70   2.00    0.45    5.00    0.00    0.00    0.00
22.75   2.00    0.45    5.00    0.00    0.00    0.00
22.80   2.00    0.45    5.00    0.00    0.00    0.00
22.85   2.00    0.45    5.00    0.00    0.00    0.00
22.90   2.00    0.45    5.00    0.00    0.00    0.00
22.95   2.00    0.45    5.00    0.00    0.00    0.00
23.00   2.00    0.45    5.00    0.00    0.00    0.00
23.05   2.00    0.46    5.00    0.00    0.00    0.00
23.10   2.00    0.46    5.00    0.00    0.00    0.00
23.15   2.00    0.46    5.00    0.00    0.00    0.00
23.20   2.00    0.46    5.00    0.00    0.00    0.00
23.25   2.00    0.46    5.00    0.00    0.00    0.00
23.30   2.00    0.46    5.00    0.00    0.00    0.00
23.35   2.00    0.46    5.00    0.00    0.00    0.00
23.40   2.00    0.46    5.00    0.00    0.00    0.00
23.45   2.00    0.46    5.00    0.00    0.00    0.00
23.50   2.00    0.46    5.00    0.00    0.00    0.00
23.55   2.00    0.46    5.00    0.00    0.00    0.00
23.60   2.00    0.46    5.00    0.00    0.00    0.00
23.65   2.00    0.46    5.00    0.00    0.00    0.00
23.70   2.00    0.46    5.00    0.00    0.00    0.00
23.75   2.00    0.46    5.00    0.00    0.00    0.00
23.80   2.00    0.46    5.00    0.00    0.00    0.00
23.85   2.00    0.46    5.00    0.00    0.00    0.00
23.90   2.00    0.46    5.00    0.00    0.00    0.00
23.95   2.00    0.46    4.99    0.00    0.00    0.00
24.00   2.00    0.46    4.99    0.00    0.00    0.00
24.05   2.00    0.46    4.99    0.00    0.00    0.00
24.10   2.00    0.46    4.98    0.00    0.00    0.00
24.15   2.00    0.46    4.98    0.00    0.00    0.00
24.20   2.00    0.46    4.98    0.00    0.00    0.00
24.25   2.00    0.46    4.97    0.00    0.00    0.00
24.30   2.00    0.46    4.97    0.00    0.00    0.00
24.35   2.00    0.46    4.97    0.00    0.00    0.00
24.40   2.00    0.46    4.96    0.00    0.00    0.00
24.45   2.00    0.46    4.96    0.00    0.00    0.00
24.50   2.00    0.46    4.96    0.00    0.00    0.00
```

```
24.55   2.00    0.46    4.95    0.00    0.00    0.00
24.60   2.00    0.46    4.95    0.00    0.00    0.00
24.65   2.00    0.46    4.95    0.00    0.00    0.00
24.70   2.00    0.47    4.95    0.00    0.00    0.00
24.75   2.00    0.47    4.94    0.00    0.00    0.00
24.80   2.00    0.47    4.94    0.00    0.00    0.00
24.85   2.00    0.47    4.94    0.00    0.00    0.00
24.90   2.00    0.47    4.93    0.00    0.00    0.00
24.95   2.00    0.47    4.93    0.00    0.00    0.00
25.00   2.00    0.47    4.93    0.00    0.00    0.00
25.05   2.00    0.47    4.92    0.00    0.00    0.00
25.10   2.00    0.47    4.92    0.00    0.00    0.00
25.15   2.00    0.47    4.92    0.00    0.00    0.00
25.20   2.00    0.47    4.92    0.00    0.00    0.00
25.25   2.00    0.47    4.91    0.00    0.00    0.00
25.30   2.00    0.47    4.91    0.00    0.00    0.00
25.35   2.00    0.47    4.91    0.00    0.00    0.00
25.40   2.00    0.47    4.90    0.00    0.00    0.00
25.45   2.00    0.47    4.90    0.00    0.00    0.00
25.50   2.00    0.47    4.90    0.00    0.00    0.00
25.55   2.00    0.47    4.89    0.00    0.00    0.00
25.60   2.00    0.47    4.89    0.00    0.00    0.00
25.65   2.00    0.47    4.89    0.00    0.00    0.00
25.70   2.00    0.47    4.89    0.00    0.00    0.00
25.75   2.00    0.47    4.88    0.00    0.00    0.00
25.80   2.00    0.47    4.88    0.00    0.00    0.00
25.85   2.00    0.47    4.88    0.00    0.00    0.00
25.90   2.00    0.47    4.87    0.00    0.00    0.00
25.95   2.00    0.47    4.87    0.00    0.00    0.00
26.00   2.00    0.47    4.87    0.00    0.00    0.00
26.05   2.00    0.47    4.87    0.00    0.00    0.00
26.10   2.00    0.47    4.86    0.00    0.00    0.00
26.15   2.00    0.47    4.86    0.00    0.00    0.00
26.20   2.00    0.47    4.86    0.00    0.00    0.00
26.25   2.00    0.47    4.86    0.00    0.00    0.00
26.30   2.00    0.47    4.85    0.00    0.00    0.00
26.35   2.00    0.47    4.85    0.00    0.00    0.00
26.40   2.00    0.47    4.85    0.00    0.00    0.00
26.45   2.00    0.47    4.84    0.00    0.00    0.00
26.50   2.00    0.48    4.84    0.00    0.00    0.00
26.55   2.00    0.48    4.84    0.00    0.00    0.00
26.60   2.00    0.48    4.84    0.00    0.00    0.00
26.65   2.00    0.48    4.83    0.00    0.00    0.00
26.70   2.00    0.48    4.83    0.00    0.00    0.00
26.75   2.00    0.48    4.83    0.00    0.00    0.00
26.80   2.00    0.48    4.83    0.00    0.00    0.00
26.85   2.00    0.48    4.82    0.00    0.00    0.00
26.90   2.00    0.48    4.82    0.00    0.00    0.00
26.95   2.00    0.48    4.82    0.00    0.00    0.00
27.00   2.00    0.48    4.81    0.00    0.00    0.00
27.05   2.00    0.48    4.81    0.00    0.00    0.00
27.10   2.00    0.48    4.81    0.00    0.00    0.00
27.15   2.00    0.48    4.81    0.00    0.00    0.00
27.20   2.00    0.48    4.80    0.00    0.00    0.00
27.25   2.00    0.48    4.80    0.00    0.00    0.00
27.30   2.00    0.48    4.80    0.00    0.00    0.00
27.35   2.00    0.48    4.80    0.00    0.00    0.00
27.40   2.00    0.48    4.79    0.00    0.00    0.00
27.45   2.00    0.48    4.79    0.00    0.00    0.00
27.50   2.00    0.48    4.79    0.00    0.00    0.00
27.55   2.00    0.48    4.79    0.00    0.00    0.00
27.60   2.00    0.48    4.78    0.00    0.00    0.00
27.65   2.00    0.48    4.78    0.00    0.00    0.00
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27.70   2.00    0.48    4.78    0.00    0.00    0.00
27.75   2.00    0.48    4.78    0.00    0.00    0.00
27.80   2.00    0.48    4.77    0.00    0.00    0.00
27.85   2.00    0.48    4.77    0.00    0.00    0.00
27.90   2.00    0.48    4.77    0.00    0.00    0.00
27.95   2.01    0.48    4.80    0.00    0.00    0.00
28.00   2.01    0.48    4.79    0.00    0.00    0.00
28.05   2.01    0.48    4.79    0.00    0.00    0.00
28.10   2.01    0.48    4.79    0.00    0.00    0.00
28.15   2.01    0.48    4.78    0.00    0.00    0.00
28.20   2.01    0.48    4.78    0.00    0.00    0.00
28.25   2.01    0.48    4.78    0.00    0.00    0.00
28.30   2.01    0.48    4.77    0.00    0.00    0.00
28.35   2.01    0.48    4.77    0.00    0.00    0.00
28.40   2.01    0.48    4.77    0.00    0.00    0.00
28.45   2.01    0.49    4.77    0.00    0.00    0.00
28.50   2.01    0.49    4.76    0.00    0.00    0.00
28.55   2.01    0.49    4.76    0.00    0.00    0.00
28.60   2.01    0.49    4.76    0.00    0.00    0.00
28.65   2.01    0.49    4.75    0.00    0.00    0.00
28.70   2.01    0.49    4.75    0.00    0.00    0.00
28.75   2.01    0.49    4.75    0.00    0.00    0.00
28.80   2.01    0.49    4.74    0.00    0.00    0.00
28.85   2.01    0.49    4.74    0.00    0.00    0.00
28.90   2.01    0.49    4.74    0.00    0.00    0.00
28.95   2.01    0.49    4.74    0.00    0.00    0.00
29.00   2.01    0.49    4.73    0.00    0.00    0.00
29.05   2.01    0.49    4.73    0.00    0.00    0.00
29.10   2.01    0.49    4.73    0.00    0.00    0.00
29.15   2.01    0.49    4.72    0.00    0.00    0.00
29.20   2.01    0.49    4.72    0.00    0.00    0.00
29.25   2.01    0.49    4.72    0.00    0.00    0.00
29.30   2.01    0.49    4.72    0.00    0.00    0.00
29.35   2.01    0.49    4.71    0.00    0.00    0.00
29.40   2.01    0.49    4.71    0.00    0.00    0.00
29.45   2.00    0.49    4.71    0.00    0.00    0.00
29.50   2.00    0.49    4.70    0.00    0.00    0.00
29.55   2.00    0.49    4.70    0.00    0.00    0.00
29.60   2.00    0.49    4.70    0.00    0.00    0.00
29.65   2.00    0.49    4.70    0.00    0.00    0.00
29.70   2.00    0.49    4.69    0.00    0.00    0.00
29.75   2.00    0.49    4.69    0.00    0.00    0.00
29.80   2.00    0.49    4.69    0.00    0.00    0.00
29.85   2.00    0.49    4.69    0.00    0.00    0.00
29.90   2.00    0.49    4.68    0.00    0.00    0.00
29.95   2.00    0.49    4.68    0.00    0.00    0.00
30.00   2.00    0.49    4.68    0.00    0.00    0.00
30.05   2.00    0.49    4.68    0.00    0.00    0.00
30.10   2.00    0.49    4.68    0.00    0.00    0.00
30.15   2.00    0.49    4.67    0.00    0.00    0.00
30.20   2.00    0.49    4.67    0.00    0.00    0.00
30.25   2.00    0.49    4.67    0.00    0.00    0.00
30.30   2.00    0.49    4.67    0.00    0.00    0.00
30.35   2.00    0.49    4.67    0.00    0.00    0.00
30.40   2.00    0.49    4.67    0.00    0.00    0.00
30.45   2.00    0.49    4.67    0.00    0.00    0.00
30.50   2.00    0.49    4.67    0.00    0.00    0.00
30.55   2.00    0.49    4.66    0.00    0.00    0.00
30.60   2.00    0.49    4.66    0.00    0.00    0.00
30.65   2.00    0.49    4.66    0.00    0.00    0.00
30.70   2.00    0.49    4.66    0.00    0.00    0.00
30.75   2.00    0.49    4.66    0.00    0.00    0.00
30.80   2.00    0.49    4.66    0.00    0.00    0.00
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30.85   2.00    0.49    4.66    0.00    0.00    0.00
30.90   2.00    0.49    4.66    0.00    0.00    0.00
30.95   2.00    0.49    4.65    0.00    0.00    0.00
31.00   2.00    0.49    4.65    0.00    0.00    0.00
31.05   2.00    0.49    4.65    0.00    0.00    0.00
31.10   2.00    0.49    4.65    0.00    0.00    0.00
31.15   2.00    0.49    4.65    0.00    0.00    0.00
31.20   2.00    0.49    4.65    0.00    0.00    0.00
31.25   2.00    0.49    4.65    0.00    0.00    0.00
31.30   2.00    0.49    4.65    0.00    0.00    0.00
31.35   2.00    0.49    4.65    0.00    0.00    0.00
31.40   2.00    0.49    4.64    0.00    0.00    0.00
31.45   2.00    0.49    4.64    0.00    0.00    0.00
31.50   1.99    0.49    4.64    0.00    0.00    0.00
31.55   1.99    0.49    4.64    0.00    0.00    0.00
31.60   1.99    0.49    4.64    0.00    0.00    0.00
31.65   1.99    0.49    4.64    0.00    0.00    0.00
31.70   1.99    0.49    4.64    0.00    0.00    0.00
31.75   1.99    0.49    4.64    0.00    0.00    0.00
31.80   1.99    0.49    4.64    0.00    0.00    0.00
31.85   1.99    0.49    4.64    0.00    0.00    0.00
31.90   1.99    0.49    4.63    0.00    0.00    0.00
31.95   1.99    0.49    4.63    0.00    0.00    0.00
32.00   1.99    0.49    4.63    0.00    0.00    0.00
32.05   1.99    0.49    4.63    0.00    0.00    0.00
32.10   1.99    0.49    4.63    0.00    0.00    0.00
32.15   1.99    0.49    4.63    0.00    0.00    0.00
32.20   1.99    0.49    4.63    0.00    0.00    0.00
32.25   1.99    0.49    4.63    0.00    0.00    0.00
32.30   1.99    0.50    4.63    0.00    0.00    0.00
32.35   1.99    0.50    4.63    0.00    0.00    0.00
32.40   1.99    0.50    4.62    0.00    0.00    0.00
32.45   1.99    0.50    4.62    0.00    0.00    0.00
32.50   1.99    0.50    4.62    0.00    0.00    0.00
32.55   1.99    0.50    4.62    0.00    0.00    0.00
32.60   1.99    0.50    4.62    0.00    0.00    0.00
32.65   1.99    0.50    4.62    0.00    0.00    0.00
32.70   1.99    0.50    4.62    0.00    0.00    0.00
32.75   1.99    0.50    4.62    0.00    0.00    0.00
32.80   1.99    0.50    4.62    0.00    0.00    0.00
32.85   1.99    0.50    4.62    0.00    0.00    0.00
32.90   1.99    0.50    4.61    0.00    0.00    0.00
32.95   1.99    0.50    4.61    0.00    0.00    0.00
33.00   1.99    0.50    4.61    0.00    0.00    0.00
33.05   1.99    0.50    4.61    0.00    0.00    0.00
33.10   1.99    0.50    4.61    0.00    0.00    0.00
33.15   1.99    0.50    4.61    0.00    0.00    0.00
33.20   1.99    0.50    4.61    0.00    0.00    0.00
33.25   1.99    0.50    4.61    0.00    0.00    0.00
33.30   1.99    0.50    4.61    0.00    0.00    0.00
33.35   1.99    0.50    4.61    0.00    0.00    0.00
33.40   1.99    0.50    4.61    0.00    0.00    0.00
33.45   1.99    0.50    4.61    0.00    0.00    0.00
33.50   1.99    0.50    4.60    0.00    0.00    0.00
33.55   1.98    0.50    4.60    0.00    0.00    0.00
33.60   1.98    0.50    4.60    0.00    0.00    0.00
33.65   1.98    0.50    4.60    0.00    0.00    0.00
33.70   1.98    0.50    4.60    0.00    0.00    0.00
33.75   1.98    0.50    4.60    0.00    0.00    0.00
33.80   1.98    0.50    4.60    0.00    0.00    0.00
33.85   1.98    0.50    4.60    0.00    0.00    0.00
33.90   1.98    0.50    4.60    0.00    0.00    0.00
33.95   1.98    0.50    4.60    0.00    0.00    0.00
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34.00   1.98    0.50    4.60    0.00    0.00    0.00
34.05   1.98    0.50    4.60    0.00    0.00    0.00
34.10   1.98    0.50    4.59    0.00    0.00    0.00
34.15   1.98    0.50    4.59    0.00    0.00    0.00
34.20   1.98    0.50    4.59    0.00    0.00    0.00
34.25   1.98    0.50    4.59    0.00    0.00    0.00
34.30   1.98    0.50    4.59    0.00    0.00    0.00
34.35   1.98    0.50    4.59    0.00    0.00    0.00
34.40   1.98    0.50    4.59    0.00    0.00    0.00
34.45   1.98    0.50    4.59    0.00    0.00    0.00
34.50   1.98    0.50    4.59    0.00    0.00    0.00
34.55   1.98    0.50    4.59    0.00    0.00    0.00
34.60   1.98    0.50    4.59    0.00    0.00    0.00
34.65   1.98    0.50    4.59    0.00    0.00    0.00
34.70   1.98    0.50    4.59    0.00    0.00    0.00
34.75   1.98    0.50    4.59    0.00    0.00    0.00
34.80   1.98    0.50    4.58    0.00    0.00    0.00
34.85   1.98    0.50    4.58    0.00    0.00    0.00
34.90   1.98    0.50    4.58    0.00    0.00    0.00
34.95   1.98    0.50    4.58    0.00    0.00    0.00
35.00   1.98    0.50    4.58    0.00    0.00    0.00
35.05   1.98    0.50    4.58    0.00    0.00    0.00
35.10   1.98    0.50    4.58    0.00    0.00    0.00
35.15   1.98    0.50    4.58    0.00    0.00    0.00
35.20   1.98    0.50    4.58    0.00    0.00    0.00
35.25   1.98    0.50    4.58    0.00    0.00    0.00
35.30   1.98    0.50    4.58    0.00    0.00    0.00
35.35   1.98    0.50    4.58    0.00    0.00    0.00
35.40   1.98    0.50    4.58    0.00    0.00    0.00
35.45   1.98    0.50    4.58    0.00    0.00    0.00
35.50   1.98    0.50    4.58    0.00    0.00    0.00
35.55   1.98    0.50    4.57    0.00    0.00    0.00
35.60   1.98    0.50    4.57    0.00    0.00    0.00
35.65   1.97    0.50    4.57    0.00    0.00    0.00
35.70   1.97    0.50    4.57    0.00    0.00    0.00
35.75   1.97    0.50    4.57    0.00    0.00    0.00
35.80   1.97    0.50    4.57    0.00    0.00    0.00
35.85   1.97    0.50    4.57    0.00    0.00    0.00
35.90   1.97    0.50    4.57    0.00    0.00    0.00
35.95   1.97    0.50    4.57    0.00    0.00    0.00
36.00   1.97    0.50    4.57    0.00    0.00    0.00
36.05   1.97    0.50    4.57    0.00    0.00    0.00
36.10   1.97    0.50    4.57    0.00    0.00    0.00
36.15   1.97    0.50    4.57    0.00    0.00    0.00
36.20   1.97    0.50    4.57    0.00    0.00    0.00
36.25   1.97    0.50    4.57    0.00    0.00    0.00
36.30   1.97    0.50    4.57    0.00    0.00    0.00
36.35   1.97    0.50    4.57    0.00    0.00    0.00
36.40   1.97    0.50    4.57    0.00    0.00    0.00
36.45   1.97    0.50    4.56    0.00    0.00    0.00
36.50   1.97    0.50    4.56    0.00    0.00    0.00
36.55   1.97    0.50    4.56    0.00    0.00    0.00
36.60   1.97    0.50    4.56    0.00    0.00    0.00
36.65   1.97    0.50    4.56    0.00    0.00    0.00
36.70   1.97    0.50    4.56    0.00    0.00    0.00
36.75   1.97    0.50    4.56    0.00    0.00    0.00
36.80   1.97    0.50    4.56    0.00    0.00    0.00
36.85   1.97    0.50    4.56    0.00    0.00    0.00
36.90   1.97    0.50    4.56    0.00    0.00    0.00
36.95   1.97    0.50    4.56    0.00    0.00    0.00
37.00   1.97    0.50    4.56    0.00    0.00    0.00
37.05   1.97    0.50    4.56    0.00    0.00    0.00
37.10   1.97    0.50    4.56    0.00    0.00    0.00
```

```
37.15   1.97    0.50    4.56    0.00    0.00    0.00
37.20   1.97    0.50    4.56    0.00    0.00    0.00
37.25   1.97    0.50    4.56    0.00    0.00    0.00
37.30   1.97    0.50    4.56    0.00    0.00    0.00
37.35   1.97    0.50    4.56    0.00    0.00    0.00
37.40   1.97    0.50    4.56    0.00    0.00    0.00
37.45   1.97    0.50    4.56    0.00    0.00    0.00
37.50   1.97    0.50    4.55    0.00    0.00    0.00
37.55   1.97    0.50    4.55    0.00    0.00    0.00
37.60   1.97    0.50    4.55    0.00    0.00    0.00
37.65   1.97    0.50    4.55    0.00    0.00    0.00
37.70   1.97    0.50    4.55    0.00    0.00    0.00
37.75   1.97    0.50    4.55    0.00    0.00    0.00
37.80   1.96    0.50    4.55    0.00    0.00    0.00
37.85   1.96    0.50    4.55    0.00    0.00    0.00
37.90   1.96    0.50    4.55    0.00    0.00    0.00
37.95   1.96    0.50    4.55    0.00    0.00    0.00
38.00   1.96    0.50    4.55    0.00    0.00    0.00
38.05   1.96    0.50    4.55    0.00    0.00    0.00
38.10   1.96    0.50    4.55    0.00    0.00    0.00
38.15   1.96    0.50    4.55    0.00    0.00    0.00
38.20   1.96    0.50    4.55    0.00    0.00    0.00
38.25   1.96    0.50    4.55    0.00    0.00    0.00
38.30   1.96    0.50    4.55    0.00    0.00    0.00
38.35   1.96    0.50    4.55    0.00    0.00    0.00
38.40   1.96    0.50    4.55    0.00    0.00    0.00
38.45   1.96    0.50    4.55    0.00    0.00    0.00
38.50   1.96    0.50    4.55    0.00    0.00    0.00
38.55   1.96    0.50    4.55    0.00    0.00    0.00
38.60   1.96    0.50    4.55    0.00    0.00    0.00
38.65   1.96    0.50    4.55    0.00    0.00    0.00
38.70   1.96    0.50    4.55    0.00    0.00    0.00
38.75   1.96    0.50    4.55    0.00    0.00    0.00
38.80   1.96    0.50    4.55    0.00    0.00    0.00
38.85   1.96    0.50    4.55    0.00    0.00    0.00
38.90   1.96    0.50    4.55    0.00    0.00    0.00
38.95   1.96    0.50    4.54    0.00    0.00    0.00
39.00   1.96    0.50    4.54    0.00    0.00    0.00
39.05   1.96    0.50    4.54    0.00    0.00    0.00
39.10   1.96    0.50    4.54    0.00    0.00    0.00
39.15   1.96    0.50    4.54    0.00    0.00    0.00
39.20   1.96    0.50    4.54    0.00    0.00    0.00
39.25   1.96    0.50    4.54    0.00    0.00    0.00
39.30   1.96    0.50    4.54    0.00    0.00    0.00
39.35   1.96    0.50    4.54    0.00    0.00    0.00
39.40   1.96    0.50    4.54    0.00    0.00    0.00
39.45   1.96    0.50    4.54    0.00    0.00    0.00
39.50   1.96    0.50    4.54    0.00    0.00    0.00
39.55   1.96    0.50    4.54    0.00    0.00    0.00
39.60   1.96    0.50    4.54    0.00    0.00    0.00
39.65   1.96    0.50    4.54    0.00    0.00    0.00
39.70   1.96    0.50    4.54    0.00    0.00    0.00
39.75   1.96    0.50    4.54    0.00    0.00    0.00
39.80   1.96    0.50    4.54    0.00    0.00    0.00
39.85   1.96    0.50    4.54    0.00    0.00    0.00
39.90   1.95    0.50    4.54    0.00    0.00    0.00
39.95   1.95    0.50    4.54    0.00    0.00    0.00
40.00   1.95    0.50    4.54    0.00    0.00    0.00
40.05   1.95    0.50    4.54    0.00    0.00    0.00
40.10   1.95    0.50    4.54    0.00    0.00    0.00
40.15   1.95    0.50    4.54    0.00    0.00    0.00
40.20   1.95    0.50    4.54    0.00    0.00    0.00
40.25   1.95    0.50    4.54    0.00    0.00    0.00
```

```
40.30   1.95    0.49    4.54    0.00    0.00    0.00
40.35   1.95    0.49    4.54    0.00    0.00    0.00
40.40   1.95    0.49    4.54    0.00    0.00    0.00
40.45   1.95    0.49    4.54    0.00    0.00    0.00
40.50   1.95    0.49    4.54    0.00    0.00    0.00
40.55   1.95    0.49    4.54    0.00    0.00    0.00
40.60   1.95    0.49    4.54    0.00    0.00    0.00
40.65   1.95    0.49    4.54    0.00    0.00    0.00
40.70   1.95    0.49    4.54    0.00    0.00    0.00
40.75   1.95    0.49    4.54    0.00    0.00    0.00
40.80   1.95    0.49    4.54    0.00    0.00    0.00
40.85   1.95    0.49    4.54    0.00    0.00    0.00
40.90   1.95    0.49    4.54    0.00    0.00    0.00
40.95   1.95    0.49    4.54    0.00    0.00    0.00
41.00   1.95    0.49    4.54    0.00    0.00    0.00
41.05   1.95    0.49    4.54    0.00    0.00    0.00
41.10   1.95    0.49    4.54    0.00    0.00    0.00
41.15   1.95    0.49    4.54    0.00    0.00    0.00
41.20   1.95    0.49    4.54    0.00    0.00    0.00
41.25   1.95    0.49    4.54    0.00    0.00    0.00
41.30   1.95    0.49    4.54    0.00    0.00    0.00
41.35   1.95    0.49    4.54    0.00    0.00    0.00
41.40   1.95    0.49    4.54    0.00    0.00    0.00
41.45   1.95    0.49    4.54    0.00    0.00    0.00
41.50   1.95    0.49    4.54    0.00    0.00    0.00
41.55   1.95    0.49    4.54    0.00    0.00    0.00
41.60   1.95    0.49    4.54    0.00    0.00    0.00
41.65   1.95    0.49    4.54    0.00    0.00    0.00
41.70   1.95    0.49    4.54    0.00    0.00    0.00
41.75   1.95    0.49    4.54    0.00    0.00    0.00
41.80   1.95    0.49    4.54    0.00    0.00    0.00
41.85   1.95    0.49    4.54    0.00    0.00    0.00
41.90   1.95    0.49    4.54    0.00    0.00    0.00
41.95   1.95    0.49    4.54    0.00    0.00    0.00
42.00   1.95    0.49    4.54    0.00    0.00    0.00
42.05   1.95    0.49    4.54    0.00    0.00    0.00
42.10   1.94    0.49    4.54    0.00    0.00    0.00
42.15   1.94    0.49    4.54    0.00    0.00    0.00
42.20   1.94    0.49    4.54    0.00    0.00    0.00
42.25   1.94    0.49    4.54    0.00    0.00    0.00
42.30   1.94    0.49    4.54    0.00    0.00    0.00
42.35   1.94    0.49    4.54    0.00    0.00    0.00
42.40   1.94    0.49    4.54    0.00    0.00    0.00
42.45   1.94    0.49    4.54    0.00    0.00    0.00
42.50   1.94    0.49    4.54    0.00    0.00    0.00
42.55   1.94    0.49    4.54    0.00    0.00    0.00
42.60   1.94    0.49    4.54    0.00    0.00    0.00
42.65   1.94    0.49    4.54    0.00    0.00    0.00
42.70   1.94    0.49    4.54    0.00    0.00    0.00
42.75   1.94    0.49    4.54    0.00    0.00    0.00
42.80   1.94    0.49    4.54    0.00    0.00    0.00
42.85   1.94    0.49    4.54    0.00    0.00    0.00
42.90   1.94    0.49    4.54    0.00    0.00    0.00
42.95   1.94    0.49    4.54    0.00    0.00    0.00
43.00   1.94    0.49    4.54    0.00    0.00    0.00
43.05   1.94    0.49    4.54    0.00    0.00    0.00
43.10   1.94    0.49    4.54    0.00    0.00    0.00
43.15   1.94    0.49    4.54    0.00    0.00    0.00
43.20   1.94    0.49    4.54    0.00    0.00    0.00
43.25   1.94    0.49    4.54    0.00    0.00    0.00
43.30   1.94    0.49    4.54    0.00    0.00    0.00
43.35   1.94    0.49    4.54    0.00    0.00    0.00
43.40   1.94    0.49    4.54    0.00    0.00    0.00
```

```
43.45   1.94    0.49    4.54    0.00    0.00    0.00
43.50   1.94    0.49    4.54    0.00    0.00    0.00
43.55   1.94    0.49    4.54    0.00    0.00    0.00
43.60   1.94    0.49    4.54    0.00    0.00    0.00
43.65   1.94    0.49    4.54    0.00    0.00    0.00
43.70   1.94    0.49    4.54    0.00    0.00    0.00
43.75   1.94    0.49    4.54    0.00    0.00    0.00
43.80   1.94    0.49    4.54    0.00    0.00    0.00
43.85   1.94    0.49    4.54    0.00    0.00    0.00
43.90   1.94    0.49    4.54    0.00    0.00    0.00
43.95   1.94    0.49    4.54    0.00    0.00    0.00
44.00   1.94    0.49    4.54    0.00    0.00    0.00
44.05   1.94    0.49    4.54    0.00    0.00    0.00
44.10   1.94    0.49    4.54    0.00    0.00    0.00
44.15   1.94    0.49    4.54    0.00    0.00    0.00
44.20   1.94    0.49    4.54    0.00    0.00    0.00
44.25   1.94    0.49    4.54    0.00    0.00    0.00
44.30   1.93    0.49    4.54    0.00    0.00    0.00
44.35   1.93    0.49    4.54    0.00    0.00    0.00
44.40   1.93    0.49    4.54    0.00    0.00    0.00
44.45   1.93    0.49    4.54    0.00    0.00    0.00
44.50   1.93    0.49    4.54    0.00    0.00    0.00
44.55   1.93    0.49    4.54    0.00    0.00    0.00
44.60   1.93    0.49    4.54    0.00    0.00    0.00
44.65   1.93    0.49    4.54    0.00    0.00    0.00
44.70   1.93    0.49    4.54    0.00    0.00    0.00
44.75   1.93    0.49    4.54    0.00    0.00    0.00
44.80   1.93    0.49    4.54    0.00    0.00    0.00
44.85   1.93    0.49    4.54    0.00    0.00    0.00
44.90   1.93    0.49    4.54    0.00    0.00    0.00
44.95   1.93    0.49    4.54    0.00    0.00    0.00
45.00   1.93    0.49    4.54    0.00    0.00    0.00
45.05   1.93    0.49    4.54    0.00    0.00    0.00
45.10   1.93    0.49    4.54    0.00    0.00    0.00
45.15   1.93    0.49    4.54    0.00    0.00    0.00
45.20   1.93    0.49    4.54    0.00    0.00    0.00
45.25   1.93    0.49    4.54    0.00    0.00    0.00
45.30   1.93    0.49    4.54    0.00    0.00    0.00
45.35   1.93    0.49    4.54    0.00    0.00    0.00
45.40   1.93    0.49    4.54    0.00    0.00    0.00
45.45   1.93    0.49    4.54    0.00    0.00    0.00
45.50   1.93    0.49    4.54    0.00    0.00    0.00
45.55   1.93    0.49    4.54    0.00    0.00    0.00
45.60   1.93    0.49    4.54    0.00    0.00    0.00
45.65   1.93    0.49    4.54    0.00    0.00    0.00
45.70   1.93    0.49    4.54    0.00    0.00    0.00
45.75   1.93    0.49    4.54    0.00    0.00    0.00
45.80   1.93    0.49    4.54    0.00    0.00    0.00
45.85   1.93    0.49    4.54    0.00    0.00    0.00
45.90   1.93    0.49    4.54    0.00    0.00    0.00
45.95   1.93    0.49    4.54    0.00    0.00    0.00
46.00   1.93    0.49    4.55    0.00    0.00    0.00
46.05   1.93    0.49    4.55    0.00    0.00    0.00
46.10   1.93    0.49    4.55    0.00    0.00    0.00
46.15   1.93    0.49    4.55    0.00    0.00    0.00
46.20   1.93    0.49    4.55    0.00    0.00    0.00
46.25   1.93    0.49    4.55    0.00    0.00    0.00
46.30   1.93    0.49    4.55    0.00    0.00    0.00
46.35   1.93    0.49    4.55    0.00    0.00    0.00
46.40   1.93    0.49    4.55    0.00    0.00    0.00
46.45   1.93    0.49    4.55    0.00    0.00    0.00
46.50   1.92    0.49    4.55    0.00    0.00    0.00
46.55   1.92    0.49    4.55    0.00    0.00    0.00
```

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46.60   1.92    0.49    4.55    0.00    0.00    0.00
46.65   1.92    0.49    4.55    0.00    0.00    0.00
46.70   1.92    0.49    4.55    0.00    0.00    0.00
46.75   1.92    0.49    4.55    0.00    0.00    0.00
46.80   1.92    0.49    4.55    0.00    0.00    0.00
46.85   1.92    0.49    4.55    0.00    0.00    0.00
46.90   1.92    0.49    4.55    0.00    0.00    0.00
46.95   1.92    0.49    4.55    0.00    0.00    0.00
47.00   1.92    0.49    4.55    0.00    0.00    0.00
47.05   1.92    0.49    4.55    0.00    0.00    0.00
47.10   1.92    0.49    4.55    0.00    0.00    0.00
47.15   1.92    0.49    4.55    0.00    0.00    0.00
47.20   1.92    0.49    4.55    0.00    0.00    0.00
47.25   1.92    0.49    4.55    0.00    0.00    0.00
47.30   1.92    0.49    4.55    0.00    0.00    0.00
47.35   1.92    0.49    4.55    0.00    0.00    0.00
47.40   1.92    0.49    4.55    0.00    0.00    0.00
47.45   1.92    0.49    4.55    0.00    0.00    0.00
47.50   1.92    0.48    4.56    0.00    0.00    0.00
47.55   1.92    0.48    4.56    0.00    0.00    0.00
47.60   1.92    0.48    4.56    0.00    0.00    0.00
47.65   1.92    0.48    4.56    0.00    0.00    0.00
47.70   1.92    0.48    4.56    0.00    0.00    0.00
47.75   1.92    0.48    4.56    0.00    0.00    0.00
47.80   1.92    0.48    4.56    0.00    0.00    0.00
47.85   1.92    0.48    4.56    0.00    0.00    0.00
47.90   1.92    0.48    4.56    0.00    0.00    0.00
47.95   1.92    0.48    4.56    0.00    0.00    0.00
48.00   1.92    0.48    4.56    0.00    0.00    0.00
48.05   1.92    0.48    4.56    0.00    0.00    0.00
48.10   1.92    0.48    4.56    0.00    0.00    0.00
48.15   1.92    0.48    4.56    0.00    0.00    0.00
48.20   1.92    0.48    4.56    0.00    0.00    0.00
48.25   1.92    0.48    4.56    0.00    0.00    0.00
48.30   1.92    0.48    4.56    0.00    0.00    0.00
48.35   1.92    0.48    4.56    0.00    0.00    0.00
48.40   1.92    0.48    4.56    0.00    0.00    0.00
48.45   1.92    0.48    4.56    0.00    0.00    0.00
48.50   1.92    0.48    4.56    0.00    0.00    0.00
48.55   1.92    0.48    4.56    0.00    0.00    0.00
48.60   1.92    0.48    4.56    0.00    0.00    0.00
48.65   1.92    0.48    4.56    0.00    0.00    0.00
48.70   1.92    0.48    4.57    0.00    0.00    0.00
48.75   1.91    0.48    4.57    0.00    0.00    0.00
48.80   1.91    0.48    4.57    0.00    0.00    0.00
48.85   1.91    0.48    4.57    0.00    0.00    0.00
48.90   1.91    0.48    4.57    0.00    0.00    0.00
48.95   1.91    0.48    4.57    0.00    0.00    0.00
49.00   1.91    0.48    4.57    0.00    0.00    0.00
49.05   1.91    0.48    4.57    0.00    0.00    0.00
49.10   1.91    0.48    4.57    0.00    0.00    0.00
49.15   1.91    0.48    4.57    0.00    0.00    0.00
49.20   1.91    0.48    4.57    0.00    0.00    0.00
49.25   1.91    0.48    4.57    0.00    0.00    0.00
49.30   1.91    0.48    4.57    0.00    0.00    0.00
49.35   1.91    0.48    4.57    0.00    0.00    0.00
49.40   1.91    0.48    4.57    0.00    0.00    0.00
49.45   1.91    0.48    4.57    0.00    0.00    0.00
49.50   1.91    0.48    4.57    0.00    0.00    0.00
49.55   1.91    0.48    4.57    0.00    0.00    0.00
49.60   1.91    0.48    4.57    0.00    0.00    0.00
49.65   1.91    0.48    4.57    0.00    0.00    0.00
49.70   1.91    0.48    4.58    0.00    0.00    0.00
```

```
        49.75   1.91    0.48    4.58    0.00    0.00    0.00
        49.80   1.91    0.48    4.58    0.00    0.00    0.00
        49.85   1.91    0.48    4.58    0.00    0.00    0.00
        49.90   1.91    0.48    4.58    0.00    0.00    0.00
        49.95   1.91    0.48    4.58    0.00    0.00    0.00
        50.00   1.91    0.48    4.58    0.00    0.00    0.00
        50.05   1.91    0.48    4.58    0.00    0.00    0.00
        50.10   1.91    0.48    4.58    0.00    0.00    0.00
        50.15   1.91    0.48    4.58    0.00    0.00    0.00
        50.20   1.91    0.48    4.58    0.00    0.00    0.00
        50.25   1.91    0.48    4.58    0.00    0.00    0.00
        50.30   1.91    0.48    4.58    0.00    0.00    0.00
        50.35   1.91    0.48    4.58    0.00    0.00    0.00
        50.40   1.91    0.48    4.58    0.00    0.00    0.00
        50.45   1.91    0.48    4.58    0.00    0.00    0.00
        50.50   1.91    0.48    4.58    0.00    0.00    0.00
        50.55   1.91    0.48    4.58    0.00    0.00    0.00
        50.60   1.91    0.48    4.59    0.00    0.00    0.00
        50.65   1.91    0.48    4.59    0.00    0.00    0.00
        50.70   1.91    0.48    4.59    0.00    0.00    0.00
        50.75   1.91    0.48    4.59    0.00    0.00    0.00
        50.80   1.91    0.48    4.59    0.00    0.00    0.00
        50.85   1.91    0.48    4.59    0.00    0.00    0.00
        50.90   1.91    0.48    4.59    0.00    0.00    0.00
        50.95   1.91    0.48    4.59    0.00    0.00    0.00
        51.00   1.90    0.48    4.59    0.00    0.00    0.00
        51.05   1.90    0.48    4.59    0.00    0.00    0.00
        51.10   1.90    0.48    4.59    0.00    0.00    0.00
        51.15   1.90    0.48    4.59    0.00    0.00    0.00
        51.20   1.90    0.48    4.59    0.00    0.00    0.00
        51.25   1.90    0.48    4.59    0.00    0.00    0.00
        51.30   1.90    0.48    4.59    0.00    0.00    0.00
        51.35   1.90    0.48    4.59    0.00    0.00    0.00
        51.40   1.90    0.48    4.60    0.00    0.00    0.00
        51.45   1.90    0.48    4.60    0.00    0.00    0.00
        51.50   1.90    0.48    4.60    0.00    0.00    0.00
        _______________________________________________________
        * F.S.<1, Liquefaction Potential Zone
        (F.S. is limited to 5,  CRR is limited to 2,    CSR is limited to 2)

        Units           Depth = ft, Stress or Pressure = tsf (atm), Unit Weight =
pcf, Settlement = in.

____________________________________________________________________________________
        CRRv            Cyclic resistance ratio from soils
        CSRm            Cyclic stress ratio induced by a given earthquake (with user
request factor of safety)
        F.S.            Factor of Safety against liquefaction, F.S.=CRRv/CSRm
        S_sat           Settlement from saturated sands
        S_dry           Settlement from Unsaturated Sands
        S_all           Total Settlement from Saturated and Unsaturated Sands
        NoLiq           No-Liquefy Soils
```

LIQUEFACTION ANALYSIS

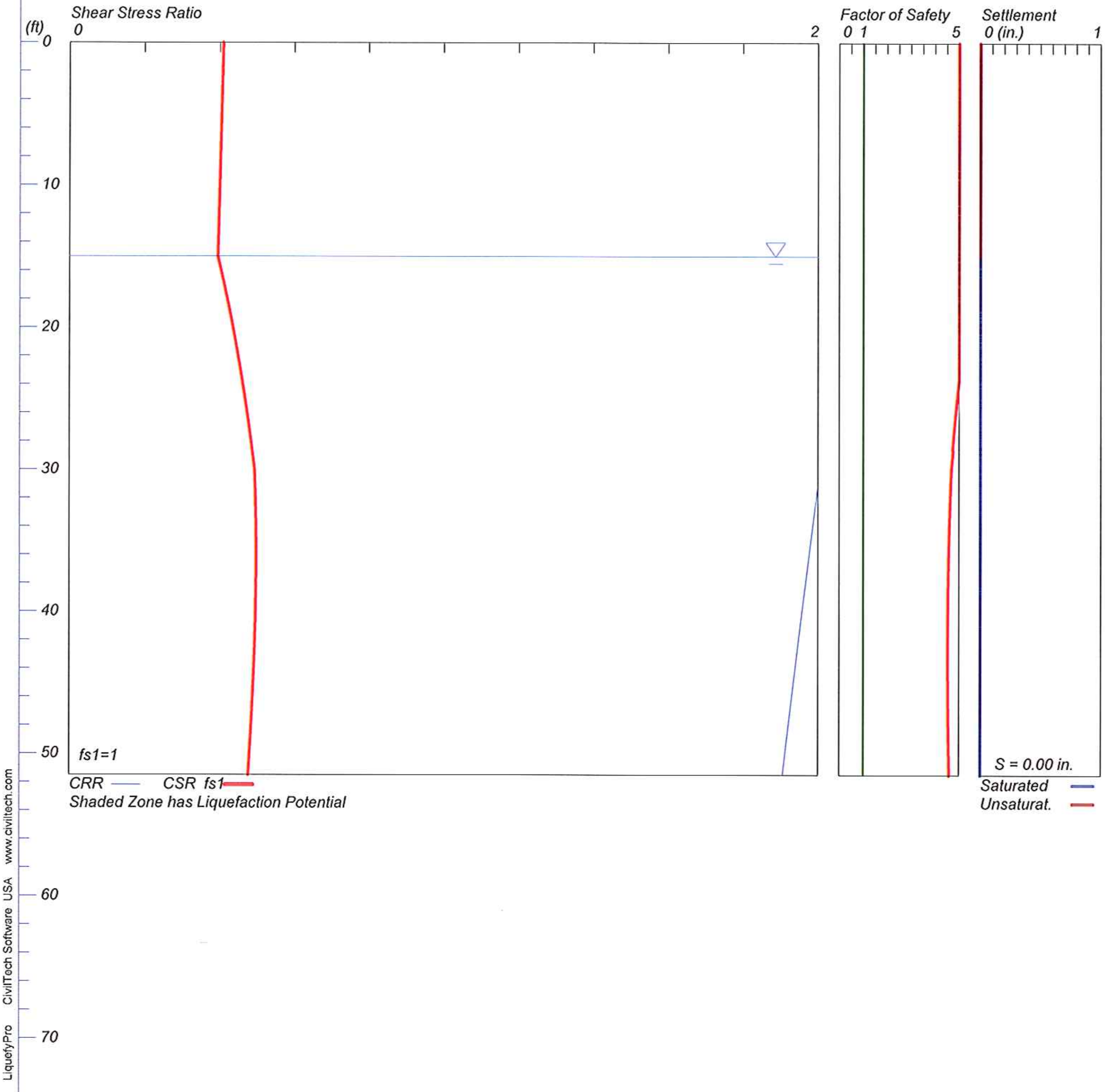
Xebec Signal Hill

Hole No.=B-4 Water Depth=15 ft

Ground Improvement of Fill=5 ft

Magnitude=7.1

Acceleration=0.629g



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************************************************************************************
*******************
                                    LIQUEFACTION ANALYSIS CALCULATION SHEET

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                                                www.civiltech.com
                                         (425) 453-6488  Fax (425) 453-5848


************************************************************************************
*******************
        Licensed to ,   5/1/2017        9:46:05 AM

        Input File Name: D:\Liquefy5\16-6239-Xebec Signal Hill-B4.liq
        Title:  Xebec Signal Hill
        Subtitle:  16-6239

        Surface Elev.=
        Hole No.=B-4
        Depth of Hole= 51.5 ft
        Water Table during Earthquake= 15.0 ft
        Water Table during In-Situ Testing= 25.0 ft
        Max. Acceleration= 0.63 g
        Earthquake Magnitude= 7.1

 Input Data:
        Surface Elev.=
        Hole No.=B-4
        Depth of Hole=51.5 ft
        Water Table during Earthquake= 15.0 ft
        Water Table during In-Situ Testing= 25.0 ft
        Max. Acceleration=0.63 g
        Earthquake Magnitude=7.1

        1. SPT or BPT Calculation.
        2. Settlement Analysis Method: Ishihara / Yoshimine*
        3. Fines Correction for Liquefaction: Stark/Olson et al.*
        4. Fine Correction for Settlement: During Liquefaction*
        5. Settlement Calculation in: All zones*
        6. Hammer Energy Ratio,                                   Ce = 1.25
        7. Borehole Diameter,                                         Cb= 1.15
        8. Sampling Method,                                          Cs= 1.2
        9. User request factor of safety (apply to CSR) ,   User= 1
           Plot one CSR curve (fs1=1)
        10. Use Curve Smoothing: Yes*
        * Recommended Options

        Fill on Top= 5 ft                       Fill Unit Weight= 125 pcf
        Depth of this report is based on original ground surface, not based on fill
        In-Situ Test Data:
        Depth   SPT     gamma   Fines
        ft              pcf     %
        ____________________________________
        0.0     12.0    106.0   NoLiq
        6.0     50.0    126.0   NoLiq
        11.0    41.0    125.0   NoLiq
        16.0    30.0    110.0   3.8
        21.0    56.0    110.0   3.8
        26.0    49.0    110.0   3.8
        31.0    60.0    110.0   3.8
        36.0    28.0    110.0   3.8
        41.0    30.0    110.0   45.0
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        46.0    32.0    110.0   45.0
        51.0    26.0    110.0   45.0
        ____________________________________

Output Results:
        Settlement of Saturated Sands=0.00 in.
        Settlement of Unsaturated Sands=0.00 in.
        Total Settlement of Saturated and Unsaturated Sands=0.00 in.
        Differential Settlement=0.000 to 0.000 in.

        Depth   CRRv    CSRm    F.S.    S_sat.  S_dry   S_all
        ft                              in.     in.     in.
        _______________________________________________________
        0.00    2.00    0.41    5.00    0.00    0.00    0.00
        0.05    2.00    0.41    5.00    0.00    0.00    0.00
        0.10    2.00    0.41    5.00    0.00    0.00    0.00
        0.15    2.00    0.41    5.00    0.00    0.00    0.00
        0.20    2.00    0.41    5.00    0.00    0.00    0.00
        0.25    2.00    0.41    5.00    0.00    0.00    0.00
        0.30    2.00    0.41    5.00    0.00    0.00    0.00
        0.35    2.00    0.41    5.00    0.00    0.00    0.00
        0.40    2.00    0.41    5.00    0.00    0.00    0.00
        0.45    2.00    0.41    5.00    0.00    0.00    0.00
        0.50    2.00    0.41    5.00    0.00    0.00    0.00
        0.55    2.00    0.41    5.00    0.00    0.00    0.00
        0.60    2.00    0.41    5.00    0.00    0.00    0.00
        0.65    2.00    0.41    5.00    0.00    0.00    0.00
        0.70    2.00    0.41    5.00    0.00    0.00    0.00
        0.75    2.00    0.41    5.00    0.00    0.00    0.00
        0.80    2.00    0.41    5.00    0.00    0.00    0.00
        0.85    2.00    0.41    5.00    0.00    0.00    0.00
        0.90    2.00    0.41    5.00    0.00    0.00    0.00
        0.95    2.00    0.41    5.00    0.00    0.00    0.00
        1.00    2.00    0.41    5.00    0.00    0.00    0.00
        1.05    2.00    0.41    5.00    0.00    0.00    0.00
        1.10    2.00    0.41    5.00    0.00    0.00    0.00
        1.15    2.00    0.41    5.00    0.00    0.00    0.00
        1.20    2.00    0.41    5.00    0.00    0.00    0.00
        1.25    2.00    0.41    5.00    0.00    0.00    0.00
        1.30    2.00    0.41    5.00    0.00    0.00    0.00
        1.35    2.00    0.41    5.00    0.00    0.00    0.00
        1.40    2.00    0.41    5.00    0.00    0.00    0.00
        1.45    2.00    0.41    5.00    0.00    0.00    0.00
        1.50    2.00    0.41    5.00    0.00    0.00    0.00
        1.55    2.00    0.41    5.00    0.00    0.00    0.00
        1.60    2.00    0.41    5.00    0.00    0.00    0.00
        1.65    2.00    0.41    5.00    0.00    0.00    0.00
        1.70    2.00    0.41    5.00    0.00    0.00    0.00
        1.75    2.00    0.41    5.00    0.00    0.00    0.00
        1.80    2.00    0.41    5.00    0.00    0.00    0.00
        1.85    2.00    0.41    5.00    0.00    0.00    0.00
        1.90    2.00    0.41    5.00    0.00    0.00    0.00
        1.95    2.00    0.41    5.00    0.00    0.00    0.00
        2.00    2.00    0.41    5.00    0.00    0.00    0.00
        2.05    2.00    0.41    5.00    0.00    0.00    0.00
        2.10    2.00    0.41    5.00    0.00    0.00    0.00
        2.15    2.00    0.41    5.00    0.00    0.00    0.00
        2.20    2.00    0.41    5.00    0.00    0.00    0.00
        2.25    2.00    0.41    5.00    0.00    0.00    0.00
        2.30    2.00    0.41    5.00    0.00    0.00    0.00
        2.35    2.00    0.41    5.00    0.00    0.00    0.00
        2.40    2.00    0.41    5.00    0.00    0.00    0.00
        2.45    2.00    0.41    5.00    0.00    0.00    0.00
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2.50    2.00    0.41    5.00    0.00    0.00    0.00
2.55    2.00    0.41    5.00    0.00    0.00    0.00
2.60    2.00    0.41    5.00    0.00    0.00    0.00
2.65    2.00    0.41    5.00    0.00    0.00    0.00
2.70    2.00    0.41    5.00    0.00    0.00    0.00
2.75    2.00    0.41    5.00    0.00    0.00    0.00
2.80    2.00    0.41    5.00    0.00    0.00    0.00
2.85    2.00    0.41    5.00    0.00    0.00    0.00
2.90    2.00    0.41    5.00    0.00    0.00    0.00
2.95    2.00    0.41    5.00    0.00    0.00    0.00
3.00    2.00    0.41    5.00    0.00    0.00    0.00
3.05    2.00    0.41    5.00    0.00    0.00    0.00
3.10    2.00    0.41    5.00    0.00    0.00    0.00
3.15    2.00    0.41    5.00    0.00    0.00    0.00
3.20    2.00    0.41    5.00    0.00    0.00    0.00
3.25    2.00    0.41    5.00    0.00    0.00    0.00
3.30    2.00    0.41    5.00    0.00    0.00    0.00
3.35    2.00    0.41    5.00    0.00    0.00    0.00
3.40    2.00    0.41    5.00    0.00    0.00    0.00
3.45    2.00    0.41    5.00    0.00    0.00    0.00
3.50    2.00    0.41    5.00    0.00    0.00    0.00
3.55    2.00    0.41    5.00    0.00    0.00    0.00
3.60    2.00    0.41    5.00    0.00    0.00    0.00
3.65    2.00    0.41    5.00    0.00    0.00    0.00
3.70    2.00    0.41    5.00    0.00    0.00    0.00
3.75    2.00    0.41    5.00    0.00    0.00    0.00
3.80    2.00    0.41    5.00    0.00    0.00    0.00
3.85    2.00    0.41    5.00    0.00    0.00    0.00
3.90    2.00    0.41    5.00    0.00    0.00    0.00
3.95    2.00    0.41    5.00    0.00    0.00    0.00
4.00    2.00    0.41    5.00    0.00    0.00    0.00
4.05    2.00    0.40    5.00    0.00    0.00    0.00
4.10    2.00    0.40    5.00    0.00    0.00    0.00
4.15    2.00    0.40    5.00    0.00    0.00    0.00
4.20    2.00    0.40    5.00    0.00    0.00    0.00
4.25    2.00    0.40    5.00    0.00    0.00    0.00
4.30    2.00    0.40    5.00    0.00    0.00    0.00
4.35    2.00    0.40    5.00    0.00    0.00    0.00
4.40    2.00    0.40    5.00    0.00    0.00    0.00
4.45    2.00    0.40    5.00    0.00    0.00    0.00
4.50    2.00    0.40    5.00    0.00    0.00    0.00
4.55    2.00    0.40    5.00    0.00    0.00    0.00
4.60    2.00    0.40    5.00    0.00    0.00    0.00
4.65    2.00    0.40    5.00    0.00    0.00    0.00
4.70    2.00    0.40    5.00    0.00    0.00    0.00
4.75    2.00    0.40    5.00    0.00    0.00    0.00
4.80    2.00    0.40    5.00    0.00    0.00    0.00
4.85    2.00    0.40    5.00    0.00    0.00    0.00
4.90    2.00    0.40    5.00    0.00    0.00    0.00
4.95    2.00    0.40    5.00    0.00    0.00    0.00
5.00    2.00    0.40    5.00    0.00    0.00    0.00
5.05    2.00    0.40    5.00    0.00    0.00    0.00
5.10    2.00    0.40    5.00    0.00    0.00    0.00
5.15    2.00    0.40    5.00    0.00    0.00    0.00
5.20    2.00    0.40    5.00    0.00    0.00    0.00
5.25    2.00    0.40    5.00    0.00    0.00    0.00
5.30    2.00    0.40    5.00    0.00    0.00    0.00
5.35    2.00    0.40    5.00    0.00    0.00    0.00
5.40    2.00    0.40    5.00    0.00    0.00    0.00
5.45    2.00    0.40    5.00    0.00    0.00    0.00
5.50    2.00    0.40    5.00    0.00    0.00    0.00
5.55    2.00    0.40    5.00    0.00    0.00    0.00
5.60    2.00    0.40    5.00    0.00    0.00    0.00
```

```
5.65    2.00    0.40    5.00    0.00    0.00    0.00
5.70    2.00    0.40    5.00    0.00    0.00    0.00
5.75    2.00    0.40    5.00    0.00    0.00    0.00
5.80    2.00    0.40    5.00    0.00    0.00    0.00
5.85    2.00    0.40    5.00    0.00    0.00    0.00
5.90    2.00    0.40    5.00    0.00    0.00    0.00
5.95    2.00    0.40    5.00    0.00    0.00    0.00
6.00    2.00    0.40    5.00    0.00    0.00    0.00
6.05    2.00    0.40    5.00    0.00    0.00    0.00
6.10    2.00    0.40    5.00    0.00    0.00    0.00
6.15    2.00    0.40    5.00    0.00    0.00    0.00
6.20    2.00    0.40    5.00    0.00    0.00    0.00
6.25    2.00    0.40    5.00    0.00    0.00    0.00
6.30    2.00    0.40    5.00    0.00    0.00    0.00
6.35    2.00    0.40    5.00    0.00    0.00    0.00
6.40    2.00    0.40    5.00    0.00    0.00    0.00
6.45    2.00    0.40    5.00    0.00    0.00    0.00
6.50    2.00    0.40    5.00    0.00    0.00    0.00
6.55    2.00    0.40    5.00    0.00    0.00    0.00
6.60    2.00    0.40    5.00    0.00    0.00    0.00
6.65    2.00    0.40    5.00    0.00    0.00    0.00
6.70    2.00    0.40    5.00    0.00    0.00    0.00
6.75    2.00    0.40    5.00    0.00    0.00    0.00
6.80    2.00    0.40    5.00    0.00    0.00    0.00
6.85    2.00    0.40    5.00    0.00    0.00    0.00
6.90    2.00    0.40    5.00    0.00    0.00    0.00
6.95    2.00    0.40    5.00    0.00    0.00    0.00
7.00    2.00    0.40    5.00    0.00    0.00    0.00
7.05    2.00    0.40    5.00    0.00    0.00    0.00
7.10    2.00    0.40    5.00    0.00    0.00    0.00
7.15    2.00    0.40    5.00    0.00    0.00    0.00
7.20    2.00    0.40    5.00    0.00    0.00    0.00
7.25    2.00    0.40    5.00    0.00    0.00    0.00
7.30    2.00    0.40    5.00    0.00    0.00    0.00
7.35    2.00    0.40    5.00    0.00    0.00    0.00
7.40    2.00    0.40    5.00    0.00    0.00    0.00
7.45    2.00    0.40    5.00    0.00    0.00    0.00
7.50    2.00    0.40    5.00    0.00    0.00    0.00
7.55    2.00    0.40    5.00    0.00    0.00    0.00
7.60    2.00    0.40    5.00    0.00    0.00    0.00
7.65    2.00    0.40    5.00    0.00    0.00    0.00
7.70    2.00    0.40    5.00    0.00    0.00    0.00
7.75    2.00    0.40    5.00    0.00    0.00    0.00
7.80    2.00    0.40    5.00    0.00    0.00    0.00
7.85    2.00    0.40    5.00    0.00    0.00    0.00
7.90    2.00    0.40    5.00    0.00    0.00    0.00
7.95    2.00    0.40    5.00    0.00    0.00    0.00
8.00    2.00    0.40    5.00    0.00    0.00    0.00
8.05    2.00    0.40    5.00    0.00    0.00    0.00
8.10    2.00    0.40    5.00    0.00    0.00    0.00
8.15    2.00    0.40    5.00    0.00    0.00    0.00
8.20    2.00    0.40    5.00    0.00    0.00    0.00
8.25    2.00    0.40    5.00    0.00    0.00    0.00
8.30    2.00    0.40    5.00    0.00    0.00    0.00
8.35    2.00    0.40    5.00    0.00    0.00    0.00
8.40    2.00    0.40    5.00    0.00    0.00    0.00
8.45    2.00    0.40    5.00    0.00    0.00    0.00
8.50    2.00    0.40    5.00    0.00    0.00    0.00
8.55    2.00    0.40    5.00    0.00    0.00    0.00
8.60    2.00    0.40    5.00    0.00    0.00    0.00
8.65    2.00    0.40    5.00    0.00    0.00    0.00
8.70    2.00    0.40    5.00    0.00    0.00    0.00
8.75    2.00    0.40    5.00    0.00    0.00    0.00
```

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8.80    2.00    0.40    5.00    0.00    0.00    0.00
8.85    2.00    0.40    5.00    0.00    0.00    0.00
8.90    2.00    0.40    5.00    0.00    0.00    0.00
8.95    2.00    0.40    5.00    0.00    0.00    0.00
9.00    2.00    0.40    5.00    0.00    0.00    0.00
9.05    2.00    0.40    5.00    0.00    0.00    0.00
9.10    2.00    0.40    5.00    0.00    0.00    0.00
9.15    2.00    0.40    5.00    0.00    0.00    0.00
9.20    2.00    0.40    5.00    0.00    0.00    0.00
9.25    2.00    0.40    5.00    0.00    0.00    0.00
9.30    2.00    0.40    5.00    0.00    0.00    0.00
9.35    2.00    0.40    5.00    0.00    0.00    0.00
9.40    2.00    0.40    5.00    0.00    0.00    0.00
9.45    2.00    0.40    5.00    0.00    0.00    0.00
9.50    2.00    0.40    5.00    0.00    0.00    0.00
9.55    2.00    0.40    5.00    0.00    0.00    0.00
9.60    2.00    0.40    5.00    0.00    0.00    0.00
9.65    2.00    0.40    5.00    0.00    0.00    0.00
9.70    2.00    0.40    5.00    0.00    0.00    0.00
9.75    2.00    0.40    5.00    0.00    0.00    0.00
9.80    2.00    0.40    5.00    0.00    0.00    0.00
9.85    2.00    0.40    5.00    0.00    0.00    0.00
9.90    2.00    0.40    5.00    0.00    0.00    0.00
9.95    2.00    0.40    5.00    0.00    0.00    0.00
10.00   2.00    0.40    5.00    0.00    0.00    0.00
10.05   2.00    0.40    5.00    0.00    0.00    0.00
10.10   2.00    0.40    5.00    0.00    0.00    0.00
10.15   2.00    0.40    5.00    0.00    0.00    0.00
10.20   2.00    0.40    5.00    0.00    0.00    0.00
10.25   2.00    0.40    5.00    0.00    0.00    0.00
10.30   2.00    0.40    5.00    0.00    0.00    0.00
10.35   2.00    0.40    5.00    0.00    0.00    0.00
10.40   2.00    0.40    5.00    0.00    0.00    0.00
10.45   2.00    0.40    5.00    0.00    0.00    0.00
10.50   2.00    0.40    5.00    0.00    0.00    0.00
10.55   2.00    0.40    5.00    0.00    0.00    0.00
10.60   2.00    0.40    5.00    0.00    0.00    0.00
10.65   2.00    0.40    5.00    0.00    0.00    0.00
10.70   2.00    0.40    5.00    0.00    0.00    0.00
10.75   2.00    0.40    5.00    0.00    0.00    0.00
10.80   2.00    0.40    5.00    0.00    0.00    0.00
10.85   2.00    0.40    5.00    0.00    0.00    0.00
10.90   2.00    0.40    5.00    0.00    0.00    0.00
10.95   2.00    0.40    5.00    0.00    0.00    0.00
11.00   2.00    0.40    5.00    0.00    0.00    0.00
11.05   2.00    0.40    5.00    0.00    0.00    0.00
11.10   2.00    0.40    5.00    0.00    0.00    0.00
11.15   2.00    0.40    5.00    0.00    0.00    0.00
11.20   2.00    0.40    5.00    0.00    0.00    0.00
11.25   2.00    0.40    5.00    0.00    0.00    0.00
11.30   2.00    0.40    5.00    0.00    0.00    0.00
11.35   2.00    0.40    5.00    0.00    0.00    0.00
11.40   2.00    0.40    5.00    0.00    0.00    0.00
11.45   2.00    0.40    5.00    0.00    0.00    0.00
11.50   2.00    0.40    5.00    0.00    0.00    0.00
11.55   2.00    0.40    5.00    0.00    0.00    0.00
11.60   2.00    0.40    5.00    0.00    0.00    0.00
11.65   2.00    0.40    5.00    0.00    0.00    0.00
11.70   2.00    0.40    5.00    0.00    0.00    0.00
11.75   2.00    0.40    5.00    0.00    0.00    0.00
11.80   2.00    0.40    5.00    0.00    0.00    0.00
11.85   2.00    0.40    5.00    0.00    0.00    0.00
11.90   2.00    0.40    5.00    0.00    0.00    0.00
```

```
11.95   2.00    0.40    5.00    0.00    0.00    0.00
12.00   2.00    0.40    5.00    0.00    0.00    0.00
12.05   2.00    0.40    5.00    0.00    0.00    0.00
12.10   2.00    0.40    5.00    0.00    0.00    0.00
12.15   2.00    0.40    5.00    0.00    0.00    0.00
12.20   2.00    0.40    5.00    0.00    0.00    0.00
12.25   2.00    0.40    5.00    0.00    0.00    0.00
12.30   2.00    0.40    5.00    0.00    0.00    0.00
12.35   2.00    0.40    5.00    0.00    0.00    0.00
12.40   2.00    0.40    5.00    0.00    0.00    0.00
12.45   2.00    0.40    5.00    0.00    0.00    0.00
12.50   2.00    0.40    5.00    0.00    0.00    0.00
12.55   2.00    0.40    5.00    0.00    0.00    0.00
12.60   2.00    0.40    5.00    0.00    0.00    0.00
12.65   2.00    0.40    5.00    0.00    0.00    0.00
12.70   2.00    0.40    5.00    0.00    0.00    0.00
12.75   2.00    0.40    5.00    0.00    0.00    0.00
12.80   2.00    0.40    5.00    0.00    0.00    0.00
12.85   2.00    0.40    5.00    0.00    0.00    0.00
12.90   2.00    0.40    5.00    0.00    0.00    0.00
12.95   2.00    0.40    5.00    0.00    0.00    0.00
13.00   2.00    0.40    5.00    0.00    0.00    0.00
13.05   2.00    0.40    5.00    0.00    0.00    0.00
13.10   2.00    0.40    5.00    0.00    0.00    0.00
13.15   2.00    0.40    5.00    0.00    0.00    0.00
13.20   2.00    0.40    5.00    0.00    0.00    0.00
13.25   2.00    0.40    5.00    0.00    0.00    0.00
13.30   2.00    0.40    5.00    0.00    0.00    0.00
13.35   2.00    0.40    5.00    0.00    0.00    0.00
13.40   2.00    0.40    5.00    0.00    0.00    0.00
13.45   2.00    0.40    5.00    0.00    0.00    0.00
13.50   2.00    0.40    5.00    0.00    0.00    0.00
13.55   2.00    0.40    5.00    0.00    0.00    0.00
13.60   2.00    0.40    5.00    0.00    0.00    0.00
13.65   2.00    0.40    5.00    0.00    0.00    0.00
13.70   2.00    0.40    5.00    0.00    0.00    0.00
13.75   2.00    0.40    5.00    0.00    0.00    0.00
13.80   2.00    0.40    5.00    0.00    0.00    0.00
13.85   2.00    0.40    5.00    0.00    0.00    0.00
13.90   2.00    0.40    5.00    0.00    0.00    0.00
13.95   2.00    0.40    5.00    0.00    0.00    0.00
14.00   2.00    0.40    5.00    0.00    0.00    0.00
14.05   2.00    0.40    5.00    0.00    0.00    0.00
14.10   2.00    0.40    5.00    0.00    0.00    0.00
14.15   2.00    0.40    5.00    0.00    0.00    0.00
14.20   2.00    0.40    5.00    0.00    0.00    0.00
14.25   2.00    0.40    5.00    0.00    0.00    0.00
14.30   2.00    0.40    5.00    0.00    0.00    0.00
14.35   2.00    0.40    5.00    0.00    0.00    0.00
14.40   2.00    0.40    5.00    0.00    0.00    0.00
14.45   2.00    0.40    5.00    0.00    0.00    0.00
14.50   2.00    0.40    5.00    0.00    0.00    0.00
14.55   2.00    0.39    5.00    0.00    0.00    0.00
14.60   2.00    0.39    5.00    0.00    0.00    0.00
14.65   2.00    0.39    5.00    0.00    0.00    0.00
14.70   2.00    0.39    5.00    0.00    0.00    0.00
14.75   2.00    0.39    5.00    0.00    0.00    0.00
14.80   2.00    0.39    5.00    0.00    0.00    0.00
14.85   2.00    0.39    5.00    0.00    0.00    0.00
14.90   2.00    0.39    5.00    0.00    0.00    0.00
14.95   2.00    0.39    5.00    0.00    0.00    0.00
15.00   2.00    0.39    5.00    0.00    0.00    0.00
15.05   2.00    0.40    5.00    0.00    0.00    0.00
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```
15.10   2.00    0.40    5.00    0.00    0.00    0.00
15.15   2.00    0.40    5.00    0.00    0.00    0.00
15.20   2.00    0.40    5.00    0.00    0.00    0.00
15.25   2.00    0.40    5.00    0.00    0.00    0.00
15.30   2.00    0.40    5.00    0.00    0.00    0.00
15.35   2.00    0.40    5.00    0.00    0.00    0.00
15.40   2.00    0.40    5.00    0.00    0.00    0.00
15.45   2.00    0.40    5.00    0.00    0.00    0.00
15.50   2.00    0.40    5.00    0.00    0.00    0.00
15.55   2.00    0.40    5.00    0.00    0.00    0.00
15.60   2.00    0.40    5.00    0.00    0.00    0.00
15.65   2.00    0.40    5.00    0.00    0.00    0.00
15.70   2.00    0.40    5.00    0.00    0.00    0.00
15.75   2.00    0.40    5.00    0.00    0.00    0.00
15.80   2.00    0.40    5.00    0.00    0.00    0.00
15.85   2.00    0.40    5.00    0.00    0.00    0.00
15.90   2.00    0.40    5.00    0.00    0.00    0.00
15.95   2.00    0.40    5.00    0.00    0.00    0.00
16.00   2.00    0.40    5.00    0.00    0.00    0.00
16.05   2.00    0.40    5.00    0.00    0.00    0.00
16.10   2.00    0.40    5.00    0.00    0.00    0.00
16.15   2.00    0.40    5.00    0.00    0.00    0.00
16.20   2.00    0.41    5.00    0.00    0.00    0.00
16.25   2.00    0.41    5.00    0.00    0.00    0.00
16.30   2.00    0.41    5.00    0.00    0.00    0.00
16.35   2.00    0.41    5.00    0.00    0.00    0.00
16.40   2.00    0.41    5.00    0.00    0.00    0.00
16.45   2.00    0.41    5.00    0.00    0.00    0.00
16.50   2.00    0.41    5.00    0.00    0.00    0.00
16.55   2.00    0.41    5.00    0.00    0.00    0.00
16.60   2.00    0.41    5.00    0.00    0.00    0.00
16.65   2.00    0.41    5.00    0.00    0.00    0.00
16.70   2.00    0.41    5.00    0.00    0.00    0.00
16.75   2.00    0.41    5.00    0.00    0.00    0.00
16.80   2.00    0.41    5.00    0.00    0.00    0.00
16.85   2.00    0.41    5.00    0.00    0.00    0.00
16.90   2.00    0.41    5.00    0.00    0.00    0.00
16.95   2.00    0.41    5.00    0.00    0.00    0.00
17.00   2.00    0.41    5.00    0.00    0.00    0.00
17.05   2.00    0.41    5.00    0.00    0.00    0.00
17.10   2.00    0.41    5.00    0.00    0.00    0.00
17.15   2.00    0.41    5.00    0.00    0.00    0.00
17.20   2.00    0.41    5.00    0.00    0.00    0.00
17.25   2.00    0.41    5.00    0.00    0.00    0.00
17.30   2.00    0.41    5.00    0.00    0.00    0.00
17.35   2.00    0.41    5.00    0.00    0.00    0.00
17.40   2.00    0.42    5.00    0.00    0.00    0.00
17.45   2.00    0.42    5.00    0.00    0.00    0.00
17.50   2.00    0.42    5.00    0.00    0.00    0.00
17.55   2.00    0.42    5.00    0.00    0.00    0.00
17.60   2.00    0.42    5.00    0.00    0.00    0.00
17.65   2.00    0.42    5.00    0.00    0.00    0.00
17.70   2.00    0.42    5.00    0.00    0.00    0.00
17.75   2.00    0.42    5.00    0.00    0.00    0.00
17.80   2.00    0.42    5.00    0.00    0.00    0.00
17.85   2.00    0.42    5.00    0.00    0.00    0.00
17.90   2.00    0.42    5.00    0.00    0.00    0.00
17.95   2.00    0.42    5.00    0.00    0.00    0.00
18.00   2.00    0.42    5.00    0.00    0.00    0.00
18.05   2.00    0.42    5.00    0.00    0.00    0.00
18.10   2.00    0.42    5.00    0.00    0.00    0.00
18.15   2.00    0.42    5.00    0.00    0.00    0.00
18.20   2.00    0.42    5.00    0.00    0.00    0.00
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18.25   2.00    0.42    5.00    0.00    0.00    0.00
18.30   2.00    0.42    5.00    0.00    0.00    0.00
18.35   2.00    0.42    5.00    0.00    0.00    0.00
18.40   2.00    0.42    5.00    0.00    0.00    0.00
18.45   2.00    0.42    5.00    0.00    0.00    0.00
18.50   2.00    0.42    5.00    0.00    0.00    0.00
18.55   2.00    0.42    5.00    0.00    0.00    0.00
18.60   2.00    0.42    5.00    0.00    0.00    0.00
18.65   2.00    0.43    5.00    0.00    0.00    0.00
18.70   2.00    0.43    5.00    0.00    0.00    0.00
18.75   2.00    0.43    5.00    0.00    0.00    0.00
18.80   2.00    0.43    5.00    0.00    0.00    0.00
18.85   2.00    0.43    5.00    0.00    0.00    0.00
18.90   2.00    0.43    5.00    0.00    0.00    0.00
18.95   2.00    0.43    5.00    0.00    0.00    0.00
19.00   2.00    0.43    5.00    0.00    0.00    0.00
19.05   2.00    0.43    5.00    0.00    0.00    0.00
19.10   2.00    0.43    5.00    0.00    0.00    0.00
19.15   2.00    0.43    5.00    0.00    0.00    0.00
19.20   2.00    0.43    5.00    0.00    0.00    0.00
19.25   2.00    0.43    5.00    0.00    0.00    0.00
19.30   2.00    0.43    5.00    0.00    0.00    0.00
19.35   2.00    0.43    5.00    0.00    0.00    0.00
19.40   2.00    0.43    5.00    0.00    0.00    0.00
19.45   2.00    0.43    5.00    0.00    0.00    0.00
19.50   2.00    0.43    5.00    0.00    0.00    0.00
19.55   2.00    0.43    5.00    0.00    0.00    0.00
19.60   2.00    0.43    5.00    0.00    0.00    0.00
19.65   2.00    0.43    5.00    0.00    0.00    0.00
19.70   2.00    0.43    5.00    0.00    0.00    0.00
19.75   2.00    0.43    5.00    0.00    0.00    0.00
19.80   2.00    0.43    5.00    0.00    0.00    0.00
19.85   2.00    0.43    5.00    0.00    0.00    0.00
19.90   2.00    0.43    5.00    0.00    0.00    0.00
19.95   2.00    0.44    5.00    0.00    0.00    0.00
20.00   2.00    0.44    5.00    0.00    0.00    0.00
20.05   2.00    0.44    5.00    0.00    0.00    0.00
20.10   2.00    0.44    5.00    0.00    0.00    0.00
20.15   2.00    0.44    5.00    0.00    0.00    0.00
20.20   2.00    0.44    5.00    0.00    0.00    0.00
20.25   2.00    0.44    5.00    0.00    0.00    0.00
20.30   2.00    0.44    5.00    0.00    0.00    0.00
20.35   2.00    0.44    5.00    0.00    0.00    0.00
20.40   2.00    0.44    5.00    0.00    0.00    0.00
20.45   2.00    0.44    5.00    0.00    0.00    0.00
20.50   2.00    0.44    5.00    0.00    0.00    0.00
20.55   2.00    0.44    5.00    0.00    0.00    0.00
20.60   2.00    0.44    5.00    0.00    0.00    0.00
20.65   2.00    0.44    5.00    0.00    0.00    0.00
20.70   2.00    0.44    5.00    0.00    0.00    0.00
20.75   2.00    0.44    5.00    0.00    0.00    0.00
20.80   2.00    0.44    5.00    0.00    0.00    0.00
20.85   2.00    0.44    5.00    0.00    0.00    0.00
20.90   2.00    0.44    5.00    0.00    0.00    0.00
20.95   2.00    0.44    5.00    0.00    0.00    0.00
21.00   2.00    0.44    5.00    0.00    0.00    0.00
21.05   2.00    0.44    5.00    0.00    0.00    0.00
21.10   2.00    0.44    5.00    0.00    0.00    0.00
21.15   2.00    0.44    5.00    0.00    0.00    0.00
21.20   2.00    0.44    5.00    0.00    0.00    0.00
21.25   2.00    0.44    5.00    0.00    0.00    0.00
21.30   2.00    0.44    5.00    0.00    0.00    0.00
21.35   2.00    0.44    5.00    0.00    0.00    0.00
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21.40   2.00    0.45    5.00    0.00    0.00    0.00
21.45   2.00    0.45    5.00    0.00    0.00    0.00
21.50   2.00    0.45    5.00    0.00    0.00    0.00
21.55   2.00    0.45    5.00    0.00    0.00    0.00
21.60   2.00    0.45    5.00    0.00    0.00    0.00
21.65   2.00    0.45    5.00    0.00    0.00    0.00
21.70   2.00    0.45    5.00    0.00    0.00    0.00
21.75   2.00    0.45    5.00    0.00    0.00    0.00
21.80   2.00    0.45    5.00    0.00    0.00    0.00
21.85   2.00    0.45    5.00    0.00    0.00    0.00
21.90   2.00    0.45    5.00    0.00    0.00    0.00
21.95   2.00    0.45    5.00    0.00    0.00    0.00
22.00   2.00    0.45    5.00    0.00    0.00    0.00
22.05   2.00    0.45    5.00    0.00    0.00    0.00
22.10   2.00    0.45    5.00    0.00    0.00    0.00
22.15   2.00    0.45    5.00    0.00    0.00    0.00
22.20   2.00    0.45    5.00    0.00    0.00    0.00
22.25   2.00    0.45    5.00    0.00    0.00    0.00
22.30   2.00    0.45    5.00    0.00    0.00    0.00
22.35   2.00    0.45    5.00    0.00    0.00    0.00
22.40   2.00    0.45    5.00    0.00    0.00    0.00
22.45   2.00    0.45    5.00    0.00    0.00    0.00
22.50   2.00    0.45    5.00    0.00    0.00    0.00
22.55   2.00    0.45    5.00    0.00    0.00    0.00
22.60   2.00    0.45    5.00    0.00    0.00    0.00
22.65   2.00    0.45    5.00    0.00    0.00    0.00
22.70   2.00    0.45    5.00    0.00    0.00    0.00
22.75   2.00    0.45    5.00    0.00    0.00    0.00
22.80   2.00    0.45    5.00    0.00    0.00    0.00
22.85   2.00    0.45    5.00    0.00    0.00    0.00
22.90   2.00    0.46    5.00    0.00    0.00    0.00
22.95   2.00    0.46    5.00    0.00    0.00    0.00
23.00   2.00    0.46    5.00    0.00    0.00    0.00
23.05   2.00    0.46    5.00    0.00    0.00    0.00
23.10   2.00    0.46    5.00    0.00    0.00    0.00
23.15   2.00    0.46    5.00    0.00    0.00    0.00
23.20   2.00    0.46    5.00    0.00    0.00    0.00
23.25   2.00    0.46    5.00    0.00    0.00    0.00
23.30   2.00    0.46    5.00    0.00    0.00    0.00
23.35   2.00    0.46    5.00    0.00    0.00    0.00
23.40   2.00    0.46    5.00    0.00    0.00    0.00
23.45   2.00    0.46    5.00    0.00    0.00    0.00
23.50   2.00    0.46    5.00    0.00    0.00    0.00
23.55   2.00    0.46    5.00    0.00    0.00    0.00
23.60   2.00    0.46    5.00    0.00    0.00    0.00
23.65   2.00    0.46    5.00    0.00    0.00    0.00
23.70   2.00    0.46    5.00    0.00    0.00    0.00
23.75   2.00    0.46    5.00    0.00    0.00    0.00
23.80   2.00    0.46    4.99    0.00    0.00    0.00
23.85   2.00    0.46    4.99    0.00    0.00    0.00
23.90   2.00    0.46    4.99    0.00    0.00    0.00
23.95   2.00    0.46    4.98    0.00    0.00    0.00
24.00   2.00    0.46    4.98    0.00    0.00    0.00
24.05   2.00    0.46    4.98    0.00    0.00    0.00
24.10   2.00    0.46    4.97    0.00    0.00    0.00
24.15   2.00    0.46    4.97    0.00    0.00    0.00
24.20   2.00    0.46    4.97    0.00    0.00    0.00
24.25   2.00    0.46    4.96    0.00    0.00    0.00
24.30   2.00    0.46    4.96    0.00    0.00    0.00
24.35   2.00    0.46    4.96    0.00    0.00    0.00
24.40   2.00    0.46    4.95    0.00    0.00    0.00
24.45   2.00    0.46    4.95    0.00    0.00    0.00
24.50   2.00    0.46    4.95    0.00    0.00    0.00
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24.55   2.00    0.47    4.95    0.00    0.00    0.00
24.60   2.00    0.47    4.94    0.00    0.00    0.00
24.65   2.00    0.47    4.94    0.00    0.00    0.00
24.70   2.00    0.47    4.94    0.00    0.00    0.00
24.75   2.00    0.47    4.93    0.00    0.00    0.00
24.80   2.00    0.47    4.93    0.00    0.00    0.00
24.85   2.00    0.47    4.93    0.00    0.00    0.00
24.90   2.00    0.47    4.92    0.00    0.00    0.00
24.95   2.00    0.47    4.92    0.00    0.00    0.00
25.00   2.00    0.47    4.92    0.00    0.00    0.00
25.05   2.00    0.47    4.91    0.00    0.00    0.00
25.10   2.00    0.47    4.91    0.00    0.00    0.00
25.15   2.00    0.47    4.91    0.00    0.00    0.00
25.20   2.00    0.47    4.91    0.00    0.00    0.00
25.25   2.00    0.47    4.90    0.00    0.00    0.00
25.30   2.00    0.47    4.90    0.00    0.00    0.00
25.35   2.00    0.47    4.90    0.00    0.00    0.00
25.40   2.00    0.47    4.89    0.00    0.00    0.00
25.45   2.00    0.47    4.89    0.00    0.00    0.00
25.50   2.00    0.47    4.89    0.00    0.00    0.00
25.55   2.00    0.47    4.88    0.00    0.00    0.00
25.60   2.00    0.47    4.88    0.00    0.00    0.00
25.65   2.00    0.47    4.88    0.00    0.00    0.00
25.70   2.00    0.47    4.88    0.00    0.00    0.00
25.75   2.00    0.47    4.87    0.00    0.00    0.00
25.80   2.00    0.47    4.87    0.00    0.00    0.00
25.85   2.00    0.47    4.87    0.00    0.00    0.00
25.90   2.00    0.47    4.86    0.00    0.00    0.00
25.95   2.00    0.47    4.86    0.00    0.00    0.00
26.00   2.00    0.47    4.86    0.00    0.00    0.00
26.05   2.00    0.47    4.86    0.00    0.00    0.00
26.10   2.00    0.47    4.85    0.00    0.00    0.00
26.15   2.00    0.47    4.85    0.00    0.00    0.00
26.20   2.00    0.47    4.85    0.00    0.00    0.00
26.25   2.00    0.47    4.84    0.00    0.00    0.00
26.30   2.00    0.48    4.84    0.00    0.00    0.00
26.35   2.00    0.48    4.84    0.00    0.00    0.00
26.40   2.00    0.48    4.84    0.00    0.00    0.00
26.45   2.00    0.48    4.83    0.00    0.00    0.00
26.50   2.00    0.48    4.83    0.00    0.00    0.00
26.55   2.00    0.48    4.83    0.00    0.00    0.00
26.60   2.00    0.48    4.83    0.00    0.00    0.00
26.65   2.00    0.48    4.82    0.00    0.00    0.00
26.70   2.00    0.48    4.82    0.00    0.00    0.00
26.75   2.00    0.48    4.82    0.00    0.00    0.00
26.80   2.00    0.48    4.81    0.00    0.00    0.00
26.85   2.00    0.48    4.81    0.00    0.00    0.00
26.90   2.00    0.48    4.81    0.00    0.00    0.00
26.95   2.00    0.48    4.81    0.00    0.00    0.00
27.00   2.00    0.48    4.80    0.00    0.00    0.00
27.05   2.00    0.48    4.80    0.00    0.00    0.00
27.10   2.00    0.48    4.80    0.00    0.00    0.00
27.15   2.00    0.48    4.80    0.00    0.00    0.00
27.20   2.00    0.48    4.79    0.00    0.00    0.00
27.25   2.00    0.48    4.79    0.00    0.00    0.00
27.30   2.00    0.48    4.79    0.00    0.00    0.00
27.35   2.00    0.48    4.79    0.00    0.00    0.00
27.40   2.00    0.48    4.78    0.00    0.00    0.00
27.45   2.00    0.48    4.78    0.00    0.00    0.00
27.50   2.00    0.48    4.78    0.00    0.00    0.00
27.55   2.00    0.48    4.78    0.00    0.00    0.00
27.60   2.00    0.48    4.77    0.00    0.00    0.00
27.65   2.00    0.48    4.77    0.00    0.00    0.00
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27.70   2.00    0.48    4.77    0.00    0.00    0.00
27.75   2.00    0.48    4.77    0.00    0.00    0.00
27.80   2.00    0.48    4.76    0.00    0.00    0.00
27.85   2.00    0.48    4.76    0.00    0.00    0.00
27.90   2.00    0.48    4.76    0.00    0.00    0.00
27.95   2.00    0.48    4.76    0.00    0.00    0.00
28.00   2.00    0.48    4.75    0.00    0.00    0.00
28.05   2.00    0.48    4.75    0.00    0.00    0.00
28.10   2.00    0.48    4.75    0.00    0.00    0.00
28.15   2.00    0.48    4.75    0.00    0.00    0.00
28.20   2.00    0.48    4.74    0.00    0.00    0.00
28.25   2.00    0.49    4.74    0.00    0.00    0.00
28.30   2.00    0.49    4.74    0.00    0.00    0.00
28.35   2.00    0.49    4.74    0.00    0.00    0.00
28.40   2.00    0.49    4.73    0.00    0.00    0.00
28.45   2.00    0.49    4.73    0.00    0.00    0.00
28.50   2.00    0.49    4.73    0.00    0.00    0.00
28.55   2.00    0.49    4.73    0.00    0.00    0.00
28.60   2.00    0.49    4.72    0.00    0.00    0.00
28.65   2.01    0.49    4.75    0.00    0.00    0.00
28.70   2.01    0.49    4.75    0.00    0.00    0.00
28.75   2.01    0.49    4.74    0.00    0.00    0.00
28.80   2.01    0.49    4.74    0.00    0.00    0.00
28.85   2.01    0.49    4.74    0.00    0.00    0.00
28.90   2.01    0.49    4.74    0.00    0.00    0.00
28.95   2.01    0.49    4.73    0.00    0.00    0.00
29.00   2.01    0.49    4.73    0.00    0.00    0.00
29.05   2.01    0.49    4.73    0.00    0.00    0.00
29.10   2.01    0.49    4.72    0.00    0.00    0.00
29.15   2.01    0.49    4.72    0.00    0.00    0.00
29.20   2.01    0.49    4.72    0.00    0.00    0.00
29.25   2.01    0.49    4.72    0.00    0.00    0.00
29.30   2.01    0.49    4.71    0.00    0.00    0.00
29.35   2.01    0.49    4.71    0.00    0.00    0.00
29.40   2.01    0.49    4.71    0.00    0.00    0.00
29.45   2.01    0.49    4.70    0.00    0.00    0.00
29.50   2.01    0.49    4.70    0.00    0.00    0.00
29.55   2.01    0.49    4.70    0.00    0.00    0.00
29.60   2.01    0.49    4.70    0.00    0.00    0.00
29.65   2.01    0.49    4.69    0.00    0.00    0.00
29.70   2.01    0.49    4.69    0.00    0.00    0.00
29.75   2.01    0.49    4.69    0.00    0.00    0.00
29.80   2.01    0.49    4.68    0.00    0.00    0.00
29.85   2.01    0.49    4.68    0.00    0.00    0.00
29.90   2.01    0.49    4.68    0.00    0.00    0.00
29.95   2.01    0.49    4.68    0.00    0.00    0.00
30.00   2.01    0.49    4.67    0.00    0.00    0.00
30.05   2.01    0.49    4.67    0.00    0.00    0.00
30.10   2.01    0.49    4.67    0.00    0.00    0.00
30.15   2.00    0.49    4.67    0.00    0.00    0.00
30.20   2.00    0.49    4.67    0.00    0.00    0.00
30.25   2.00    0.49    4.67    0.00    0.00    0.00
30.30   2.00    0.49    4.67    0.00    0.00    0.00
30.35   2.00    0.49    4.67    0.00    0.00    0.00
30.40   2.00    0.49    4.66    0.00    0.00    0.00
30.45   2.00    0.49    4.66    0.00    0.00    0.00
30.50   2.00    0.49    4.66    0.00    0.00    0.00
30.55   2.00    0.49    4.66    0.00    0.00    0.00
30.60   2.00    0.49    4.66    0.00    0.00    0.00
30.65   2.00    0.49    4.66    0.00    0.00    0.00
30.70   2.00    0.49    4.66    0.00    0.00    0.00
30.75   2.00    0.49    4.66    0.00    0.00    0.00
30.80   2.00    0.49    4.65    0.00    0.00    0.00
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30.85   2.00    0.49    4.65    0.00    0.00    0.00
30.90   2.00    0.49    4.65    0.00    0.00    0.00
30.95   2.00    0.49    4.65    0.00    0.00    0.00
31.00   2.00    0.49    4.65    0.00    0.00    0.00
31.05   2.00    0.49    4.65    0.00    0.00    0.00
31.10   2.00    0.50    4.65    0.00    0.00    0.00
31.15   2.00    0.50    4.65    0.00    0.00    0.00
31.20   2.00    0.50    4.65    0.00    0.00    0.00
31.25   2.00    0.50    4.64    0.00    0.00    0.00
31.30   2.00    0.50    4.64    0.00    0.00    0.00
31.35   2.00    0.50    4.64    0.00    0.00    0.00
31.40   2.00    0.50    4.64    0.00    0.00    0.00
31.45   2.00    0.50    4.64    0.00    0.00    0.00
31.50   2.00    0.50    4.64    0.00    0.00    0.00
31.55   2.00    0.50    4.64    0.00    0.00    0.00
31.60   2.00    0.50    4.64    0.00    0.00    0.00
31.65   2.00    0.50    4.64    0.00    0.00    0.00
31.70   2.00    0.50    4.63    0.00    0.00    0.00
31.75   2.00    0.50    4.63    0.00    0.00    0.00
31.80   2.00    0.50    4.63    0.00    0.00    0.00
31.85   2.00    0.50    4.63    0.00    0.00    0.00
31.90   2.00    0.50    4.63    0.00    0.00    0.00
31.95   2.00    0.50    4.63    0.00    0.00    0.00
32.00   2.00    0.50    4.63    0.00    0.00    0.00
32.05   2.00    0.50    4.63    0.00    0.00    0.00
32.10   2.00    0.50    4.63    0.00    0.00    0.00
32.15   2.00    0.50    4.63    0.00    0.00    0.00
32.20   1.99    0.50    4.62    0.00    0.00    0.00
32.25   1.99    0.50    4.62    0.00    0.00    0.00
32.30   1.99    0.50    4.62    0.00    0.00    0.00
32.35   1.99    0.50    4.62    0.00    0.00    0.00
32.40   1.99    0.50    4.62    0.00    0.00    0.00
32.45   1.99    0.50    4.62    0.00    0.00    0.00
32.50   1.99    0.50    4.62    0.00    0.00    0.00
32.55   1.99    0.50    4.62    0.00    0.00    0.00
32.60   1.99    0.50    4.62    0.00    0.00    0.00
32.65   1.99    0.50    4.62    0.00    0.00    0.00
32.70   1.99    0.50    4.61    0.00    0.00    0.00
32.75   1.99    0.50    4.61    0.00    0.00    0.00
32.80   1.99    0.50    4.61    0.00    0.00    0.00
32.85   1.99    0.50    4.61    0.00    0.00    0.00
32.90   1.99    0.50    4.61    0.00    0.00    0.00
32.95   1.99    0.50    4.61    0.00    0.00    0.00
33.00   1.99    0.50    4.61    0.00    0.00    0.00
33.05   1.99    0.50    4.61    0.00    0.00    0.00
33.10   1.99    0.50    4.61    0.00    0.00    0.00
33.15   1.99    0.50    4.61    0.00    0.00    0.00
33.20   1.99    0.50    4.61    0.00    0.00    0.00
33.25   1.99    0.50    4.60    0.00    0.00    0.00
33.30   1.99    0.50    4.60    0.00    0.00    0.00
33.35   1.99    0.50    4.60    0.00    0.00    0.00
33.40   1.99    0.50    4.60    0.00    0.00    0.00
33.45   1.99    0.50    4.60    0.00    0.00    0.00
33.50   1.99    0.50    4.60    0.00    0.00    0.00
33.55   1.99    0.50    4.60    0.00    0.00    0.00
33.60   1.99    0.50    4.60    0.00    0.00    0.00
33.65   1.99    0.50    4.60    0.00    0.00    0.00
33.70   1.99    0.50    4.60    0.00    0.00    0.00
33.75   1.99    0.50    4.60    0.00    0.00    0.00
33.80   1.99    0.50    4.60    0.00    0.00    0.00
33.85   1.99    0.50    4.59    0.00    0.00    0.00
33.90   1.99    0.50    4.59    0.00    0.00    0.00
33.95   1.99    0.50    4.59    0.00    0.00    0.00
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34.00    1.99     0.50     4.59     0.00     0.00     0.00
34.05    1.99     0.50     4.59     0.00     0.00     0.00
34.10    1.99     0.50     4.59     0.00     0.00     0.00
34.15    1.99     0.50     4.59     0.00     0.00     0.00
34.20    1.99     0.50     4.59     0.00     0.00     0.00
34.25    1.99     0.50     4.59     0.00     0.00     0.00
34.30    1.98     0.50     4.59     0.00     0.00     0.00
34.35    1.98     0.50     4.59     0.00     0.00     0.00
34.40    1.98     0.50     4.59     0.00     0.00     0.00
34.45    1.98     0.50     4.59     0.00     0.00     0.00
34.50    1.98     0.50     4.58     0.00     0.00     0.00
34.55    1.98     0.50     4.58     0.00     0.00     0.00
34.60    1.98     0.50     4.58     0.00     0.00     0.00
34.65    1.98     0.50     4.58     0.00     0.00     0.00
34.70    1.98     0.50     4.58     0.00     0.00     0.00
34.75    1.98     0.50     4.58     0.00     0.00     0.00
34.80    1.98     0.50     4.58     0.00     0.00     0.00
34.85    1.98     0.50     4.58     0.00     0.00     0.00
34.90    1.98     0.50     4.58     0.00     0.00     0.00
34.95    1.98     0.50     4.58     0.00     0.00     0.00
35.00    1.98     0.50     4.58     0.00     0.00     0.00
35.05    1.98     0.50     4.58     0.00     0.00     0.00
35.10    1.98     0.50     4.58     0.00     0.00     0.00
35.15    1.98     0.50     4.58     0.00     0.00     0.00
35.20    1.98     0.50     4.57     0.00     0.00     0.00
35.25    1.98     0.50     4.57     0.00     0.00     0.00
35.30    1.98     0.50     4.57     0.00     0.00     0.00
35.35    1.98     0.50     4.57     0.00     0.00     0.00
35.40    1.98     0.50     4.57     0.00     0.00     0.00
35.45    1.98     0.50     4.57     0.00     0.00     0.00
35.50    1.98     0.50     4.57     0.00     0.00     0.00
35.55    1.98     0.50     4.57     0.00     0.00     0.00
35.60    1.98     0.50     4.57     0.00     0.00     0.00
35.65    1.98     0.50     4.57     0.00     0.00     0.00
35.70    1.98     0.50     4.57     0.00     0.00     0.00
35.75    1.98     0.50     4.57     0.00     0.00     0.00
35.80    1.98     0.50     4.57     0.00     0.00     0.00
35.85    1.98     0.50     4.57     0.00     0.00     0.00
35.90    1.98     0.50     4.57     0.00     0.00     0.00
35.95    1.98     0.50     4.57     0.00     0.00     0.00
36.00    1.98     0.50     4.57     0.00     0.00     0.00
36.05    1.98     0.50     4.56     0.00     0.00     0.00
36.10    1.98     0.50     4.56     0.00     0.00     0.00
36.15    1.98     0.50     4.56     0.00     0.00     0.00
36.20    1.98     0.50     4.56     0.00     0.00     0.00
36.25    1.98     0.50     4.56     0.00     0.00     0.00
36.30    1.98     0.50     4.56     0.00     0.00     0.00
36.35    1.97     0.50     4.56     0.00     0.00     0.00
36.40    1.97     0.50     4.56     0.00     0.00     0.00
36.45    1.97     0.50     4.56     0.00     0.00     0.00
36.50    1.97     0.50     4.56     0.00     0.00     0.00
36.55    1.97     0.50     4.56     0.00     0.00     0.00
36.60    1.97     0.50     4.56     0.00     0.00     0.00
36.65    1.97     0.50     4.56     0.00     0.00     0.00
36.70    1.97     0.50     4.56     0.00     0.00     0.00
36.75    1.97     0.50     4.56     0.00     0.00     0.00
36.80    1.97     0.50     4.56     0.00     0.00     0.00
36.85    1.97     0.50     4.56     0.00     0.00     0.00
36.90    1.97     0.50     4.56     0.00     0.00     0.00
36.95    1.97     0.50     4.56     0.00     0.00     0.00
37.00    1.97     0.50     4.55     0.00     0.00     0.00
37.05    1.97     0.50     4.55     0.00     0.00     0.00
37.10    1.97     0.50     4.55     0.00     0.00     0.00
```

```
37.15   1.97    0.50    4.55    0.00    0.00    0.00
37.20   1.97    0.50    4.55    0.00    0.00    0.00
37.25   1.97    0.50    4.55    0.00    0.00    0.00
37.30   1.97    0.50    4.55    0.00    0.00    0.00
37.35   1.97    0.50    4.55    0.00    0.00    0.00
37.40   1.97    0.50    4.55    0.00    0.00    0.00
37.45   1.97    0.50    4.55    0.00    0.00    0.00
37.50   1.97    0.50    4.55    0.00    0.00    0.00
37.55   1.97    0.50    4.55    0.00    0.00    0.00
37.60   1.97    0.50    4.55    0.00    0.00    0.00
37.65   1.97    0.50    4.55    0.00    0.00    0.00
37.70   1.97    0.50    4.55    0.00    0.00    0.00
37.75   1.97    0.50    4.55    0.00    0.00    0.00
37.80   1.97    0.50    4.55    0.00    0.00    0.00
37.85   1.97    0.50    4.55    0.00    0.00    0.00
37.90   1.97    0.50    4.55    0.00    0.00    0.00
37.95   1.97    0.50    4.55    0.00    0.00    0.00
38.00   1.97    0.50    4.55    0.00    0.00    0.00
38.05   1.97    0.50    4.55    0.00    0.00    0.00
38.10   1.97    0.50    4.55    0.00    0.00    0.00
38.15   1.97    0.50    4.55    0.00    0.00    0.00
38.20   1.97    0.50    4.54    0.00    0.00    0.00
38.25   1.97    0.50    4.54    0.00    0.00    0.00
38.30   1.97    0.50    4.54    0.00    0.00    0.00
38.35   1.97    0.50    4.54    0.00    0.00    0.00
38.40   1.97    0.50    4.54    0.00    0.00    0.00
38.45   1.97    0.50    4.54    0.00    0.00    0.00
38.50   1.96    0.50    4.54    0.00    0.00    0.00
38.55   1.96    0.50    4.54    0.00    0.00    0.00
38.60   1.96    0.50    4.54    0.00    0.00    0.00
38.65   1.96    0.50    4.54    0.00    0.00    0.00
38.70   1.96    0.50    4.54    0.00    0.00    0.00
38.75   1.96    0.50    4.54    0.00    0.00    0.00
38.80   1.96    0.50    4.54    0.00    0.00    0.00
38.85   1.96    0.50    4.54    0.00    0.00    0.00
38.90   1.96    0.50    4.54    0.00    0.00    0.00
38.95   1.96    0.50    4.54    0.00    0.00    0.00
39.00   1.96    0.50    4.54    0.00    0.00    0.00
39.05   1.96    0.50    4.54    0.00    0.00    0.00
39.10   1.96    0.50    4.54    0.00    0.00    0.00
39.15   1.96    0.50    4.54    0.00    0.00    0.00
39.20   1.96    0.50    4.54    0.00    0.00    0.00
39.25   1.96    0.50    4.54    0.00    0.00    0.00
39.30   1.96    0.50    4.54    0.00    0.00    0.00
39.35   1.96    0.50    4.54    0.00    0.00    0.00
39.40   1.96    0.50    4.54    0.00    0.00    0.00
39.45   1.96    0.50    4.54    0.00    0.00    0.00
39.50   1.96    0.50    4.54    0.00    0.00    0.00
39.55   1.96    0.50    4.54    0.00    0.00    0.00
39.60   1.96    0.50    4.54    0.00    0.00    0.00
39.65   1.96    0.50    4.54    0.00    0.00    0.00
39.70   1.96    0.50    4.54    0.00    0.00    0.00
39.75   1.96    0.50    4.54    0.00    0.00    0.00
39.80   1.96    0.50    4.54    0.00    0.00    0.00
39.85   1.96    0.50    4.54    0.00    0.00    0.00
39.90   1.96    0.50    4.54    0.00    0.00    0.00
39.95   1.96    0.50    4.53    0.00    0.00    0.00
40.00   1.96    0.50    4.53    0.00    0.00    0.00
40.05   1.96    0.50    4.53    0.00    0.00    0.00
40.10   1.96    0.50    4.53    0.00    0.00    0.00
40.15   1.96    0.50    4.53    0.00    0.00    0.00
40.20   1.96    0.50    4.53    0.00    0.00    0.00
40.25   1.96    0.50    4.53    0.00    0.00    0.00
```

```
40.30   1.96    0.50    4.53    0.00    0.00    0.00
40.35   1.96    0.50    4.53    0.00    0.00    0.00
40.40   1.96    0.50    4.53    0.00    0.00    0.00
40.45   1.96    0.50    4.53    0.00    0.00    0.00
40.50   1.96    0.50    4.53    0.00    0.00    0.00
40.55   1.96    0.50    4.53    0.00    0.00    0.00
40.60   1.95    0.50    4.53    0.00    0.00    0.00
40.65   1.95    0.50    4.53    0.00    0.00    0.00
40.70   1.95    0.50    4.53    0.00    0.00    0.00
40.75   1.95    0.50    4.53    0.00    0.00    0.00
40.80   1.95    0.50    4.53    0.00    0.00    0.00
40.85   1.95    0.50    4.53    0.00    0.00    0.00
40.90   1.95    0.50    4.53    0.00    0.00    0.00
40.95   1.95    0.50    4.53    0.00    0.00    0.00
41.00   1.95    0.50    4.53    0.00    0.00    0.00
41.05   1.95    0.50    4.53    0.00    0.00    0.00
41.10   1.95    0.50    4.53    0.00    0.00    0.00
41.15   1.95    0.50    4.53    0.00    0.00    0.00
41.20   1.95    0.50    4.53    0.00    0.00    0.00
41.25   1.95    0.50    4.53    0.00    0.00    0.00
41.30   1.95    0.50    4.53    0.00    0.00    0.00
41.35   1.95    0.50    4.53    0.00    0.00    0.00
41.40   1.95    0.50    4.53    0.00    0.00    0.00
41.45   1.95    0.50    4.53    0.00    0.00    0.00
41.50   1.95    0.50    4.53    0.00    0.00    0.00
41.55   1.95    0.50    4.53    0.00    0.00    0.00
41.60   1.95    0.50    4.53    0.00    0.00    0.00
41.65   1.95    0.50    4.53    0.00    0.00    0.00
41.70   1.95    0.50    4.53    0.00    0.00    0.00
41.75   1.95    0.49    4.53    0.00    0.00    0.00
41.80   1.95    0.49    4.53    0.00    0.00    0.00
41.85   1.95    0.49    4.53    0.00    0.00    0.00
41.90   1.95    0.49    4.53    0.00    0.00    0.00
41.95   1.95    0.49    4.53    0.00    0.00    0.00
42.00   1.95    0.49    4.53    0.00    0.00    0.00
42.05   1.95    0.49    4.53    0.00    0.00    0.00
42.10   1.95    0.49    4.53    0.00    0.00    0.00
42.15   1.95    0.49    4.53    0.00    0.00    0.00
42.20   1.95    0.49    4.53    0.00    0.00    0.00
42.25   1.95    0.49    4.53    0.00    0.00    0.00
42.30   1.95    0.49    4.53    0.00    0.00    0.00
42.35   1.95    0.49    4.53    0.00    0.00    0.00
42.40   1.95    0.49    4.53    0.00    0.00    0.00
42.45   1.95    0.49    4.53    0.00    0.00    0.00
42.50   1.95    0.49    4.53    0.00    0.00    0.00
42.55   1.95    0.49    4.53    0.00    0.00    0.00
42.60   1.95    0.49    4.53    0.00    0.00    0.00
42.65   1.95    0.49    4.53    0.00    0.00    0.00
42.70   1.95    0.49    4.53    0.00    0.00    0.00
42.75   1.95    0.49    4.53    0.00    0.00    0.00
42.80   1.94    0.49    4.53    0.00    0.00    0.00
42.85   1.94    0.49    4.53    0.00    0.00    0.00
42.90   1.94    0.49    4.53    0.00    0.00    0.00
42.95   1.94    0.49    4.53    0.00    0.00    0.00
43.00   1.94    0.49    4.53    0.00    0.00    0.00
43.05   1.94    0.49    4.53    0.00    0.00    0.00
43.10   1.94    0.49    4.53    0.00    0.00    0.00
43.15   1.94    0.49    4.53    0.00    0.00    0.00
43.20   1.94    0.49    4.53    0.00    0.00    0.00
43.25   1.94    0.49    4.53    0.00    0.00    0.00
43.30   1.94    0.49    4.53    0.00    0.00    0.00
43.35   1.94    0.49    4.53    0.00    0.00    0.00
43.40   1.94    0.49    4.53    0.00    0.00    0.00
```

```
43.45   1.94    0.49    4.53    0.00    0.00    0.00
43.50   1.94    0.49    4.53    0.00    0.00    0.00
43.55   1.94    0.49    4.53    0.00    0.00    0.00
43.60   1.94    0.49    4.53    0.00    0.00    0.00
43.65   1.94    0.49    4.53    0.00    0.00    0.00
43.70   1.94    0.49    4.53    0.00    0.00    0.00
43.75   1.94    0.49    4.53    0.00    0.00    0.00
43.80   1.94    0.49    4.53    0.00    0.00    0.00
43.85   1.94    0.49    4.53    0.00    0.00    0.00
43.90   1.94    0.49    4.53    0.00    0.00    0.00
43.95   1.94    0.49    4.53    0.00    0.00    0.00
44.00   1.94    0.49    4.53    0.00    0.00    0.00
44.05   1.94    0.49    4.53    0.00    0.00    0.00
44.10   1.94    0.49    4.53    0.00    0.00    0.00
44.15   1.94    0.49    4.53    0.00    0.00    0.00
44.20   1.94    0.49    4.53    0.00    0.00    0.00
44.25   1.94    0.49    4.53    0.00    0.00    0.00
44.30   1.94    0.49    4.53    0.00    0.00    0.00
44.35   1.94    0.49    4.53    0.00    0.00    0.00
44.40   1.94    0.49    4.53    0.00    0.00    0.00
44.45   1.94    0.49    4.53    0.00    0.00    0.00
44.50   1.94    0.49    4.53    0.00    0.00    0.00
44.55   1.94    0.49    4.53    0.00    0.00    0.00
44.60   1.94    0.49    4.53    0.00    0.00    0.00
44.65   1.94    0.49    4.53    0.00    0.00    0.00
44.70   1.94    0.49    4.53    0.00    0.00    0.00
44.75   1.94    0.49    4.53    0.00    0.00    0.00
44.80   1.94    0.49    4.53    0.00    0.00    0.00
44.85   1.94    0.49    4.53    0.00    0.00    0.00
44.90   1.94    0.49    4.53    0.00    0.00    0.00
44.95   1.94    0.49    4.53    0.00    0.00    0.00
45.00   1.93    0.49    4.54    0.00    0.00    0.00
45.05   1.93    0.49    4.54    0.00    0.00    0.00
45.10   1.93    0.49    4.54    0.00    0.00    0.00
45.15   1.93    0.49    4.54    0.00    0.00    0.00
45.20   1.93    0.49    4.54    0.00    0.00    0.00
45.25   1.93    0.49    4.54    0.00    0.00    0.00
45.30   1.93    0.49    4.54    0.00    0.00    0.00
45.35   1.93    0.49    4.54    0.00    0.00    0.00
45.40   1.93    0.49    4.54    0.00    0.00    0.00
45.45   1.93    0.49    4.54    0.00    0.00    0.00
45.50   1.93    0.49    4.54    0.00    0.00    0.00
45.55   1.93    0.49    4.54    0.00    0.00    0.00
45.60   1.93    0.49    4.54    0.00    0.00    0.00
45.65   1.93    0.49    4.54    0.00    0.00    0.00
45.70   1.93    0.49    4.54    0.00    0.00    0.00
45.75   1.93    0.49    4.54    0.00    0.00    0.00
45.80   1.93    0.49    4.54    0.00    0.00    0.00
45.85   1.93    0.49    4.54    0.00    0.00    0.00
45.90   1.93    0.49    4.54    0.00    0.00    0.00
45.95   1.93    0.49    4.54    0.00    0.00    0.00
46.00   1.93    0.49    4.54    0.00    0.00    0.00
46.05   1.93    0.49    4.54    0.00    0.00    0.00
46.10   1.93    0.49    4.54    0.00    0.00    0.00
46.15   1.93    0.49    4.54    0.00    0.00    0.00
46.20   1.93    0.49    4.54    0.00    0.00    0.00
46.25   1.93    0.49    4.54    0.00    0.00    0.00
46.30   1.93    0.49    4.54    0.00    0.00    0.00
46.35   1.93    0.49    4.54    0.00    0.00    0.00
46.40   1.93    0.49    4.54    0.00    0.00    0.00
46.45   1.93    0.49    4.54    0.00    0.00    0.00
46.50   1.93    0.49    4.54    0.00    0.00    0.00
46.55   1.93    0.49    4.54    0.00    0.00    0.00
```

```
46.60   1.93    0.49    4.54    0.00    0.00    0.00
46.65   1.93    0.49    4.54    0.00    0.00    0.00
46.70   1.93    0.49    4.54    0.00    0.00    0.00
46.75   1.93    0.49    4.54    0.00    0.00    0.00
46.80   1.93    0.49    4.54    0.00    0.00    0.00
46.85   1.93    0.49    4.54    0.00    0.00    0.00
46.90   1.93    0.49    4.55    0.00    0.00    0.00
46.95   1.93    0.49    4.55    0.00    0.00    0.00
47.00   1.93    0.49    4.55    0.00    0.00    0.00
47.05   1.93    0.49    4.55    0.00    0.00    0.00
47.10   1.93    0.49    4.55    0.00    0.00    0.00
47.15   1.93    0.49    4.55    0.00    0.00    0.00
47.20   1.92    0.49    4.55    0.00    0.00    0.00
47.25   1.92    0.49    4.55    0.00    0.00    0.00
47.30   1.92    0.49    4.55    0.00    0.00    0.00
47.35   1.92    0.49    4.55    0.00    0.00    0.00
47.40   1.92    0.49    4.55    0.00    0.00    0.00
47.45   1.92    0.49    4.55    0.00    0.00    0.00
47.50   1.92    0.49    4.55    0.00    0.00    0.00
47.55   1.92    0.49    4.55    0.00    0.00    0.00
47.60   1.92    0.49    4.55    0.00    0.00    0.00
47.65   1.92    0.49    4.55    0.00    0.00    0.00
47.70   1.92    0.49    4.55    0.00    0.00    0.00
47.75   1.92    0.49    4.55    0.00    0.00    0.00
47.80   1.92    0.49    4.55    0.00    0.00    0.00
47.85   1.92    0.49    4.55    0.00    0.00    0.00
47.90   1.92    0.49    4.55    0.00    0.00    0.00
47.95   1.92    0.49    4.55    0.00    0.00    0.00
48.00   1.92    0.49    4.55    0.00    0.00    0.00
48.05   1.92    0.49    4.55    0.00    0.00    0.00
48.10   1.92    0.49    4.55    0.00    0.00    0.00
48.15   1.92    0.49    4.55    0.00    0.00    0.00
48.20   1.92    0.48    4.56    0.00    0.00    0.00
48.25   1.92    0.48    4.56    0.00    0.00    0.00
48.30   1.92    0.48    4.56    0.00    0.00    0.00
48.35   1.92    0.48    4.56    0.00    0.00    0.00
48.40   1.92    0.48    4.56    0.00    0.00    0.00
48.45   1.92    0.48    4.56    0.00    0.00    0.00
48.50   1.92    0.48    4.56    0.00    0.00    0.00
48.55   1.92    0.48    4.56    0.00    0.00    0.00
48.60   1.92    0.48    4.56    0.00    0.00    0.00
48.65   1.92    0.48    4.56    0.00    0.00    0.00
48.70   1.92    0.48    4.56    0.00    0.00    0.00
48.75   1.92    0.48    4.56    0.00    0.00    0.00
48.80   1.92    0.48    4.56    0.00    0.00    0.00
48.85   1.92    0.48    4.56    0.00    0.00    0.00
48.90   1.92    0.48    4.56    0.00    0.00    0.00
48.95   1.92    0.48    4.56    0.00    0.00    0.00
49.00   1.92    0.48    4.56    0.00    0.00    0.00
49.05   1.92    0.48    4.56    0.00    0.00    0.00
49.10   1.92    0.48    4.56    0.00    0.00    0.00
49.15   1.92    0.48    4.56    0.00    0.00    0.00
49.20   1.92    0.48    4.56    0.00    0.00    0.00
49.25   1.92    0.48    4.56    0.00    0.00    0.00
49.30   1.92    0.48    4.57    0.00    0.00    0.00
49.35   1.92    0.48    4.57    0.00    0.00    0.00
49.40   1.92    0.48    4.57    0.00    0.00    0.00
49.45   1.91    0.48    4.57    0.00    0.00    0.00
49.50   1.91    0.48    4.57    0.00    0.00    0.00
49.55   1.91    0.48    4.57    0.00    0.00    0.00
49.60   1.91    0.48    4.57    0.00    0.00    0.00
49.65   1.91    0.48    4.57    0.00    0.00    0.00
49.70   1.91    0.48    4.57    0.00    0.00    0.00
```

```
        49.75   1.91    0.48    4.57    0.00    0.00    0.00
        49.80   1.91    0.48    4.57    0.00    0.00    0.00
        49.85   1.91    0.48    4.57    0.00    0.00    0.00
        49.90   1.91    0.48    4.57    0.00    0.00    0.00
        49.95   1.91    0.48    4.57    0.00    0.00    0.00
        50.00   1.91    0.48    4.57    0.00    0.00    0.00
        50.05   1.91    0.48    4.57    0.00    0.00    0.00
        50.10   1.91    0.48    4.57    0.00    0.00    0.00
        50.15   1.91    0.48    4.57    0.00    0.00    0.00
        50.20   1.91    0.48    4.58    0.00    0.00    0.00
        50.25   1.91    0.48    4.58    0.00    0.00    0.00
        50.30   1.91    0.48    4.58    0.00    0.00    0.00
        50.35   1.91    0.48    4.58    0.00    0.00    0.00
        50.40   1.91    0.48    4.58    0.00    0.00    0.00
        50.45   1.91    0.48    4.58    0.00    0.00    0.00
        50.50   1.91    0.48    4.58    0.00    0.00    0.00
        50.55   1.91    0.48    4.58    0.00    0.00    0.00
        50.60   1.91    0.48    4.58    0.00    0.00    0.00
        50.65   1.91    0.48    4.58    0.00    0.00    0.00
        50.70   1.91    0.48    4.58    0.00    0.00    0.00
        50.75   1.91    0.48    4.58    0.00    0.00    0.00
        50.80   1.91    0.48    4.58    0.00    0.00    0.00
        50.85   1.91    0.48    4.58    0.00    0.00    0.00
        50.90   1.91    0.48    4.58    0.00    0.00    0.00
        50.95   1.91    0.48    4.58    0.00    0.00    0.00
        51.00   1.91    0.48    4.58    0.00    0.00    0.00
        51.05   1.91    0.48    4.59    0.00    0.00    0.00
        51.10   1.91    0.48    4.59    0.00    0.00    0.00
        51.15   1.91    0.48    4.59    0.00    0.00    0.00
        51.20   1.91    0.48    4.59    0.00    0.00    0.00
        51.25   1.91    0.48    4.59    0.00    0.00    0.00
        51.30   1.91    0.48    4.59    0.00    0.00    0.00
        51.35   1.91    0.48    4.59    0.00    0.00    0.00
        51.40   1.91    0.48    4.59    0.00    0.00    0.00
        51.45   1.91    0.48    4.59    0.00    0.00    0.00
        51.50   1.91    0.48    4.59    0.00    0.00    0.00
        _______________________________________________________
        * F.S.<1, Liquefaction Potential Zone
        (F.S. is limited to 5,  CRR is limited to 2,    CSR is limited to 2)

        Units           Depth = ft, Stress or Pressure = tsf (atm), Unit Weight =
pcf, Settlement = in.

____________________________________________________________________________________
        CRRv            Cyclic resistance ratio from soils
        CSRm            Cyclic stress ratio induced by a given earthquake (with user
request factor of safety)
        F.S.            Factor of Safety against liquefaction, F.S.=CRRv/CSRm
        S_sat           Settlement from saturated sands
        S_dry           Settlement from Unsaturated Sands
        S_all           Total Settlement from Saturated and Unsaturated Sands
        NoLiq           No-Liquefy Soils
```

APPENDIX E

STORMWATER QUALITY DESIGN VOLUME (SWQDV) CALCULATIONS

Peak Flow Hydrologic Analysis

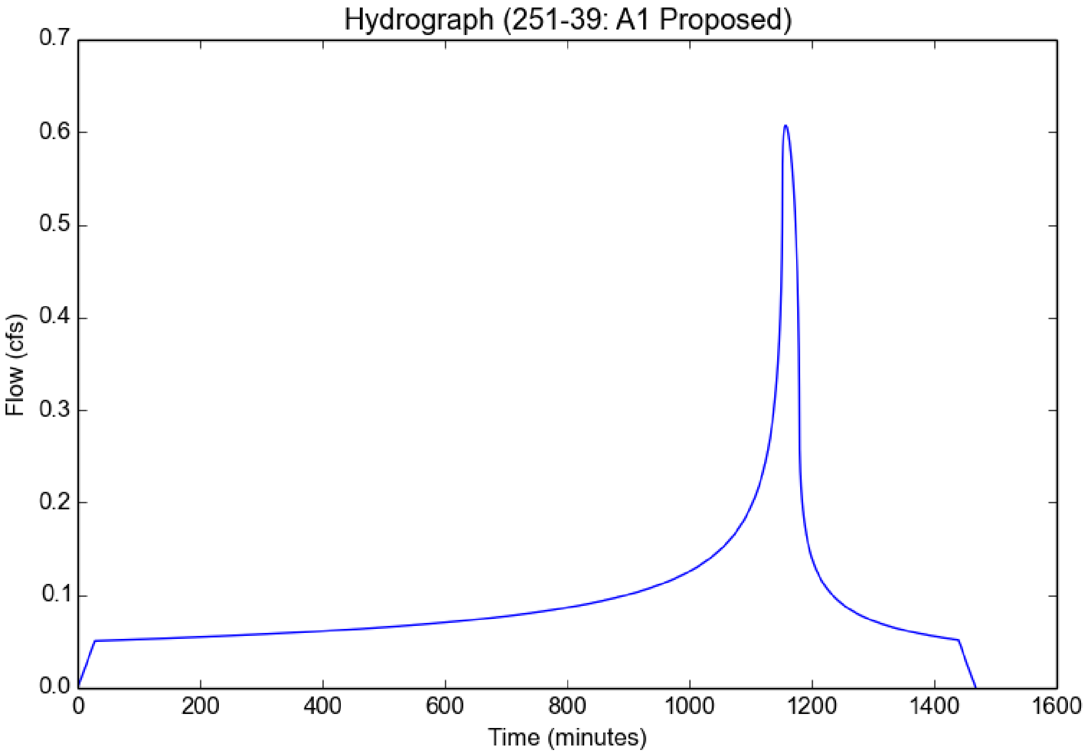
File location: S:/251-39 SIGNAL HILL/HYDROLOGY/NEW OUTPUT 8-20-19/Proposed-A1-85th.pdf
Version: HydroCalc 1.0.2

Input Parameters

Project Name	251-39
Subarea ID	A1 Proposed
Area (ac)	3.87
Flow Path Length (ft)	583.0
Flow Path Slope (vft/hft)	0.0335
85th Percentile Rainfall Depth (in)	0.75
Percent Impervious	0.86
Soil Type	14
Design Storm Frequency	85th percentile storm
Fire Factor	0
LID	True

Output Results

Modeled (85th percentile storm) Rainfall Depth (in)	0.75
Peak Intensity (in/hr)	0.1991
Undeveloped Runoff Coefficient (Cu)	0.1
Developed Runoff Coefficient (Cd)	0.788
Time of Concentration (min)	28.0
Clear Peak Flow Rate (cfs)	0.6072
Burned Peak Flow Rate (cfs)	0.6072
24-Hr Clear Runoff Volume (ac-ft)	0.189
24-Hr Clear Runoff Volume (cu-ft)	8233.8942



Peak Flow Hydrologic Analysis

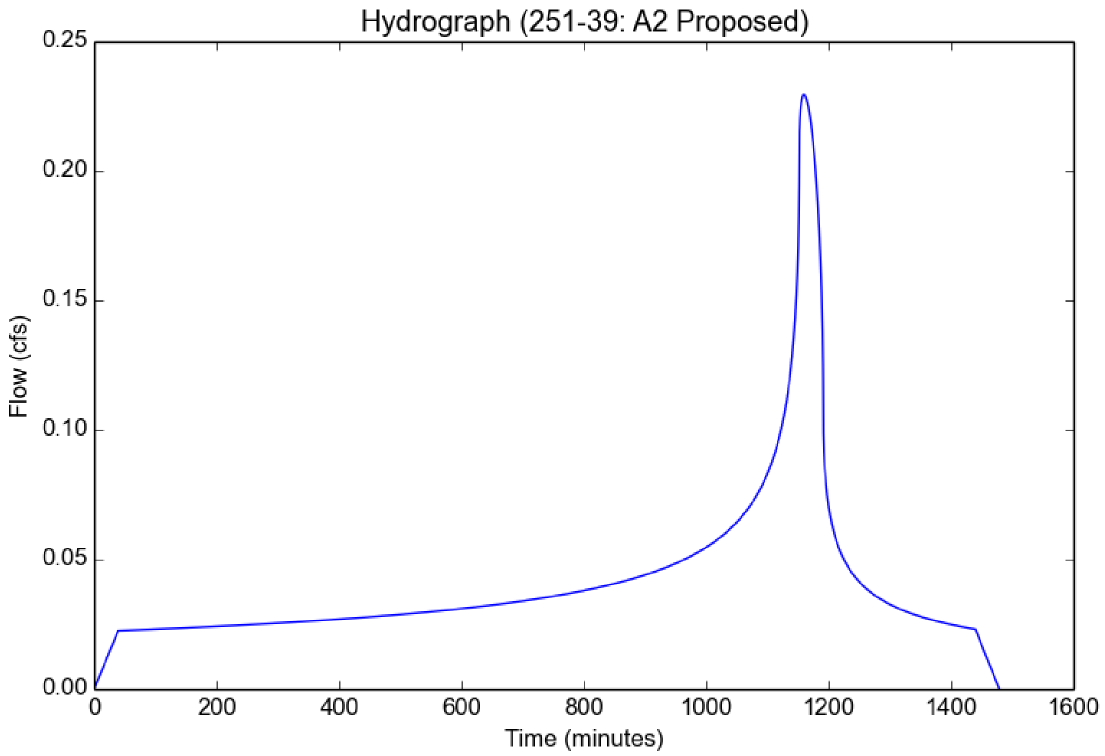
File location: S:/251-39 SIGNAL HILL/HYDROLOGY/NEW OUTPUT 8-20-19/Proposed-A2-85th.pdf
Version: HydroCalc 1.0.2

Input Parameters

Project Name	251-39
Subarea ID	A2 Proposed
Area (ac)	1.88
Flow Path Length (ft)	631.0
Flow Path Slope (vft/hft)	0.009
85th Percentile Rainfall Depth (in)	0.75
Percent Impervious	0.77
Soil Type	14
Design Storm Frequency	85th percentile storm
Fire Factor	0
LID	True

Output Results

Modeled (85th percentile storm) Rainfall Depth (in)	0.75
Peak Intensity (in/hr)	0.1704
Undeveloped Runoff Coefficient (Cu)	0.1
Developed Runoff Coefficient (Cd)	0.716
Time of Concentration (min)	39.0
Clear Peak Flow Rate (cfs)	0.2294
Burned Peak Flow Rate (cfs)	0.2294
24-Hr Clear Runoff Volume (ac-ft)	0.0834
24-Hr Clear Runoff Volume (cu-ft)	3634.4869



Peak Flow Hydrologic Analysis

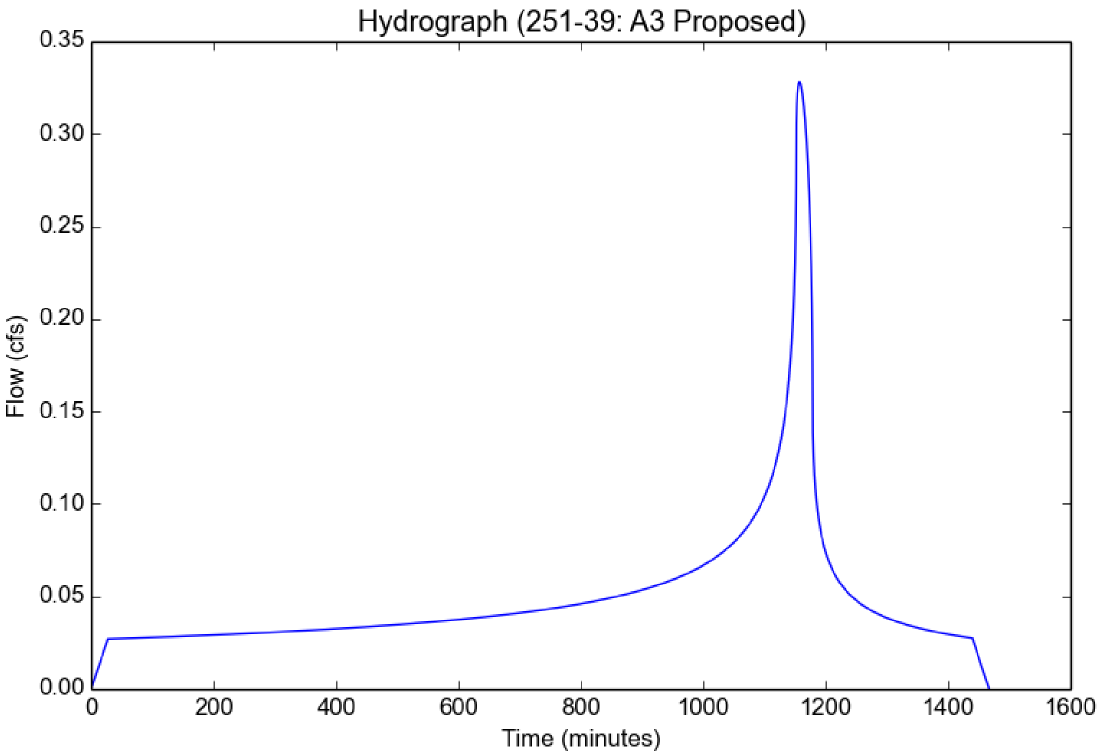
File location: S:/251-39 SIGNAL HILL/HYDROLOGY/NEW OUTPUT 8-20-19/Proposed-A3-85th.pdf
Version: HydroCalc 1.0.2

Input Parameters

Project Name	251-39
Subarea ID	A3 Proposed
Area (ac)	2.34
Flow Path Length (ft)	474.0
Flow Path Slope (vft/hft)	0.0338
85th Percentile Rainfall Depth (in)	0.75
Percent Impervious	0.74
Soil Type	14
Design Storm Frequency	85th percentile storm
Fire Factor	0
LID	True

Output Results

Modeled (85th percentile storm) Rainfall Depth (in)	0.75
Peak Intensity (in/hr)	0.2026
Undeveloped Runoff Coefficient (Cu)	0.1
Developed Runoff Coefficient (Cd)	0.692
Time of Concentration (min)	27.0
Clear Peak Flow Rate (cfs)	0.328
Burned Peak Flow Rate (cfs)	0.328
24-Hr Clear Runoff Volume (ac-ft)	0.1004
24-Hr Clear Runoff Volume (cu-ft)	4372.0966



APPENDIX F

HYDROLOGY REPORT (FOR CONCEPTUAL GRADING PLAN) FOR WALNUT AVE. INDUSTRIAL PROJECT, TENTATIVE TRACT MAP 80302, CITY OF SIGNAL HILL, DATED AUGUST 20, 2019

CA ENGINEERING, INC.

Planning • Engineering • Surveying

HYDROLOGY REPORT

(FOR CONCEPTUAL GRADING PLAN)

FOR

WALNUT AVE. INDUSTRIAL PROJECT

TRACT MAP No. 80302

City of Signal Hill

Date: April 22th, 2019
Revised: June 20th, 2019
Revised: August 20th, 2019

PLANS PREPARED UNDER THE SUPERVISION OF:

8/20/2019

Fred Cornwell, P.E. - R.C.E 45591 Date

FRED CORNWELL
NO. 45591
CIVIL

Table of Contents

1.0 INTRODUCTION

The purpose of this report is to present the hydrology analysis and drainage calculations prepared for Tentative Parcel Map 79278, located in the City of Signal Hill, California. This project proposes to construct nine industrial buildings totaling approximately 138,695 square feet on approximately 8.69 acres. This project would be considered an “Industrial/Commercial Development”. This report will focus on the runoff volume and water quality conditions relative to the conceptual grading of the project. The on-site drainage systems will be sized pursuant to the Precise Grading plan and associated sub-areas.

2.0 EXISTING DRAINAGE CONDITIONS

The site is currently vacant and consists of three separate dirt areas which are separated by existing streets. The first northern most area is surrounded by Gundry Ave to the west, 21st street to the south, Walnut Ave. to the east, and an existing construction site to the north. There are commercial businesses to the west of Gundry Ave., while to the east of Walnut Ave. lies the American University of Health Sciences. The second area is south of 21st street and west of Walnut Avenue. The southwest border of the second area is surrounded by Jenni Rivera Memorial Park. The third area is surrounded by the American University of Health to the north, Walnut Ave. to the west, Gaviota Ave. to the east, and a intersection of 20th St. and Alamitos Ave. to the south.

The on-site drainage drains from the north to the south with a slight gradient to the west. The site is relatively flat with a gradual drop in elevation from the north-east corner to the south-west. There are existing catch basins located on 21st street and Walnut Ave. that connect to the existing storm drain system that runs along Walnut Ave. The existing drainage is directed into the existing catch basins via surface flows and street gutters.

3.0 PROPOSED DRAINAGE CONDITIONS

The proposed drainage pattern will perpetuate the existing patterns of the site being drained from the north to the south. For each area the onsite flows will be captured by catch basins and area drains which will be directed into 60” storage pipes via low-flow pipes. The water will then be pumped into Bio-planters for treatment and then released into the existing storm drain system via the bioplanter underdrains. During storm events when the hydraulic grade line exceeds the storage pipe, the water will overflow into the existing storm drains via high-flow pipes.

Per the LA County LID Manual requirements, each drainage area will contain 60” detention pipes that will be sized to completely store 1.5 times the 85th percentile storm runoff volume. Each area will also contain a biofiltration planter sized to treat the volume contained in the detention pipes. Both treated flows from the Bio-Planters and overflows during larger storm events will be directed to the existing storm drain system that runs along Walnut Ave.

The on-site storm drain system will be sized to accommodate the 10 year storm event via 24” conduits which will outlet to the existing storm drain system. 10 year storm rainfall values are calculated using Table 5.3.1 of the LA County Hydrology Manual. During a 50 year storm event, the on-site storage and high flow conduits may overflow and sheet flow into the existing storm drain system; the site may experience slight ponding during this larger storm event.

4.0 HYDROLOGICAL AND SOIL DATA

References used in this report were the following:

- Los Angeles County Flood Control District, Hydrology Manual.

The following data is from the on-line Department of Public Works Hydrology map for the project site:

- 50 year Rainfall Isohyet – 5.10 inches
- 10 year Rainfall Isohyet – 3.64 inches (via Table 5.3.1)
- Final 85th Percentile, 24-hr Rainfall – 0.59 inches
- Soils Group Classification – 014

5.0 HYDROLOGY METHODOLOGY AND RESULTS

We have utilized the HydroCalc 1.0.2 calculator downloaded from the Department of Public Works web site to determine the proposed and existing hydrological conditions of the project. The 50 year, 10 year, and 85th percentile storms were input to determine the proposed and existing storm hydrographs. See "Appendix A" and "Appendix B" for HydroCalc output results. The tables below summarize the peak flows and runoff volume results for each drainage area.

		85th Percentile Storm Event		10 Year Storm Event		50 Year Storm Event	
	Area	Peak Flow (cfs)	Runoff Volume (cf)	Peak Flow (cfs)	Runoff Volume (cf)	Peak Flow (cfs)	Runoff Volume (cf)
Existing	1	0.09	2,042	2.31	10,887	7.32	17,149
Existing	2	0.02	479	1.70	2,867	3.48	4,430
Existing	3	0.04	814	2.17	4,806	4.79	7,521
Existing	**Total**	**0.15**	**3,335**	**6.18**	**18,560**	**15.59**	**29,100**
Proposed	1	0.61	8,234	5.42	40,163	8.77	56,412
Proposed	2	0.23	3,634	2.17	17,778	3.68	25,047
Proposed	3	0.33	4,372	3.31	21,442	5.58	30,204
Proposed	**Total**	**1.17**	**16,240**	**10.90**	**79,383**	**18.03**	**111,663**
	Net	**1.02**	**12,905**	**4.72**	**60,823**	**2.44**	**82,563**

In the hydrographs it is shown that the peak flows are increased from the existing condition to the proposed condition. This is due to the increase of impervious area when compared to existing conditions. However, we have created more storage due to water quality requirements which will help mitigate the increase in volume for the storm events. Per the LID Map shown in Exhibit D, the proposed storage for water quality is a combined volume of 25,425 CF. This storage volume is greater than the net volume increase of 16,240 CF.

6.0 WATER QUALITY

Sample water quality calculations for drainage area 1 will be described below. Calculations for drainage areas 2 and 3 are shown on the LID Plan and are summarized in the table below.

As shown in the project's Low Impact Development (LID) plan (Exhibit D), a 60" detention pipe will store all runoff volume before it is pumped into and treated with biofiltration planters. The treated water will outlet into the existing storm drain system along Walnut Avenue. Per the LA County LID Manual requirements, the planters must have a maximum drawdown time of 96 hours.

For area 1, the Stormwater Quality Design Volume (SWQDv) is equal to the proposed 85th percentile runoff volume of 8,234 CF (see section 5.0). However, since the water is not being infiltrated there is a 50% penalty that results in a SWQDv of 12,351 CF. To help mitigate the 50 year storm event, the 60" detention pipe is sized to hold the SWQDv. The length of pipe required is shown below:

5' pipe cross-sectional area = πr^2 = π(2.5)^2 =19.63 cf/lf
Length of pipe required =pipe volume/pipe area = 12,351 cf / 19.63 cf/lf = 629 lf
Length of pipe provided = 634 lf > 629 lf

The biofiltration planter sizing is based on a 96 hour drawdown time, the calculations are shown below:

$$\textbf{Biofiltration Area Required (sf)} = \frac{\text{Storage Volume (cf)}}{\text{Infiltration Rate (in/hr) * Drawdown Time (hr)}}$$

$$= \frac{\text{634 lf * 19.63 cf/lf}}{\text{2.5 in/hr*(1/12 ft/in) * 96 hr}}$$

$$= 623 \text{ sf}$$

Area Provided (sf) = 679 sf > 623 sf

Min. Pump Rate (gal/min) = Volume To Be Treated (cf) / maximum drawdown time
= 12,450 cf / (96 hr * 60min/hr)
= 2.16cf/min * (7.48gal/min)
= 16.17 gal/min*

*A pump rate of 17 gallons/minute will be used.

$$\textbf{Drawdown Time (maximum 96 hours)} = \frac{\text{SWQDv/Volume To Be Treated (cf)}}{\text{Biofiltration Area (sf) * Biofiltration Rate (in/hr)}}$$

$$= \frac{\text{12,450 cf}}{\text{679 sf * (2.5in/hr) * (1ft/12in)}}$$

$$= \text{88.05 hours} < \text{96 hours}$$

Area	SWQDv (cf)	Storage Volume Required (cf) ~1.5*SWQDv	Length of 60" Pipe Required (lf)	Length of 60" Pipe Provided (lf)	Storage Pipe Volume Provided (cf)	Biotreatment Area Required (sf)	Biotreatment Area Provided (sf)	Minimum Pump Flow to Achieve 96 Hr Drawdown (gpm)	Pump Provided (gpm)
1	8,234	12,351	629	634	12,450	623	679	16.17	17.0
2	3,634	5,451	278	297	5,825	291	412	7.56	8.0
3	4,372	6,558	334	364	7,150	358	612	9.29	10.0

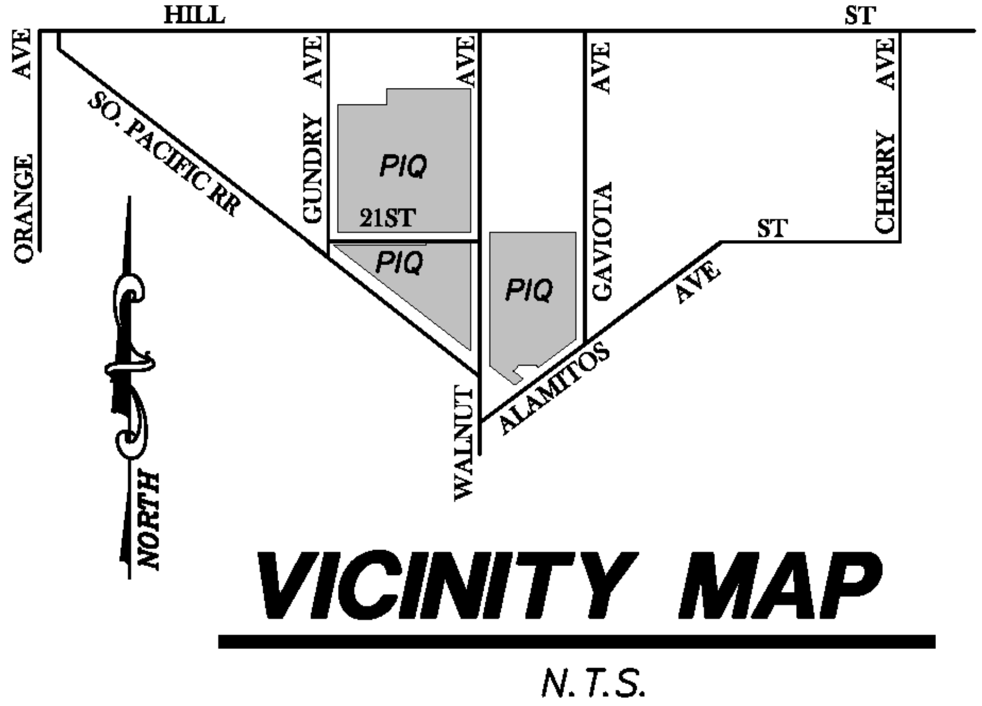
7.0 FLOOD PLAIN DESIGNATION

The site falls within a Zone "X" designation under the FEMA Map 06037C1970F, dated September 26, 2008. The site is an area of minimal flood hazard, and slightly overlaps an area with reduced flood risk due to levee.

8.0 CONCLUSION

Based upon the results of this report, it is concluded that the proposed facilities will adequately provide drainage conveyance in accordance with an 85th percentile storm event. The proposed facilities, with adequate maintenance, will convey flows safely through the site in accordance with the City of Signal Hill requirements. The flows will be detained in the storage pipes and then pumped into the biofiltration basins. The storage pipe will detain the 85th percentile storm while the basins will achieve a drawdown time of less than 96 hours. The onsite drainage system will also be sized to convey the 10-year storm to the existing storm drain system. In the event of a 50-year storm, the overflow runoff will be directed to existing storm drain system via sheet and gutter flows as well as the onsite storm drain system.

9.0 VICINITY MAP



APPENDICES

APPENDIX A: EXISTING PEAK FLOW HYDROLOGIC ANALYSIS (85th PERCENTILE, 10 YEAR, AND 50 YEAR STORMS)

Peak Flow Hydrologic Analysis

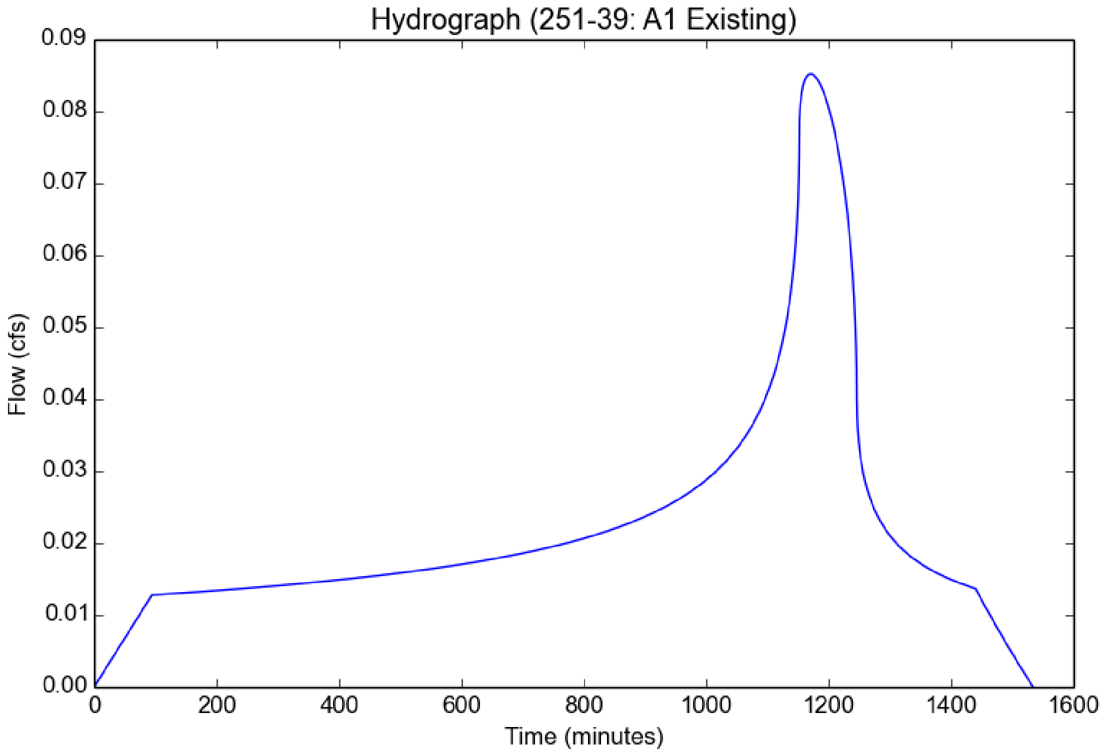
File location: S:/251-39 SIGNAL HILL/HYDROLOGY/NEW OUTPUT 8-20-19/Existing-A1-85th.pdf
Version: HydroCalc 1.0.2

Input Parameters

Project Name	251-39
Subarea ID	A1 Existing
Area (ac)	4.61
Flow Path Length (ft)	755.0
Flow Path Slope (vft/hft)	0.0383
85th Percentile Rainfall Depth (in)	0.75
Percent Impervious	0.08
Soil Type	14
Design Storm Frequency	85th percentile storm
Fire Factor	0
LID	True

Output Results

Modeled (85th percentile storm) Rainfall Depth (in)	0.75
Peak Intensity (in/hr)	0.1127
Undeveloped Runoff Coefficient (Cu)	0.1
Developed Runoff Coefficient (Cd)	0.164
Time of Concentration (min)	94.0
Clear Peak Flow Rate (cfs)	0.0852
Burned Peak Flow Rate (cfs)	0.0852
24-Hr Clear Runoff Volume (ac-ft)	0.0469
24-Hr Clear Runoff Volume (cu-ft)	2041.5481



Peak Flow Hydrologic Analysis

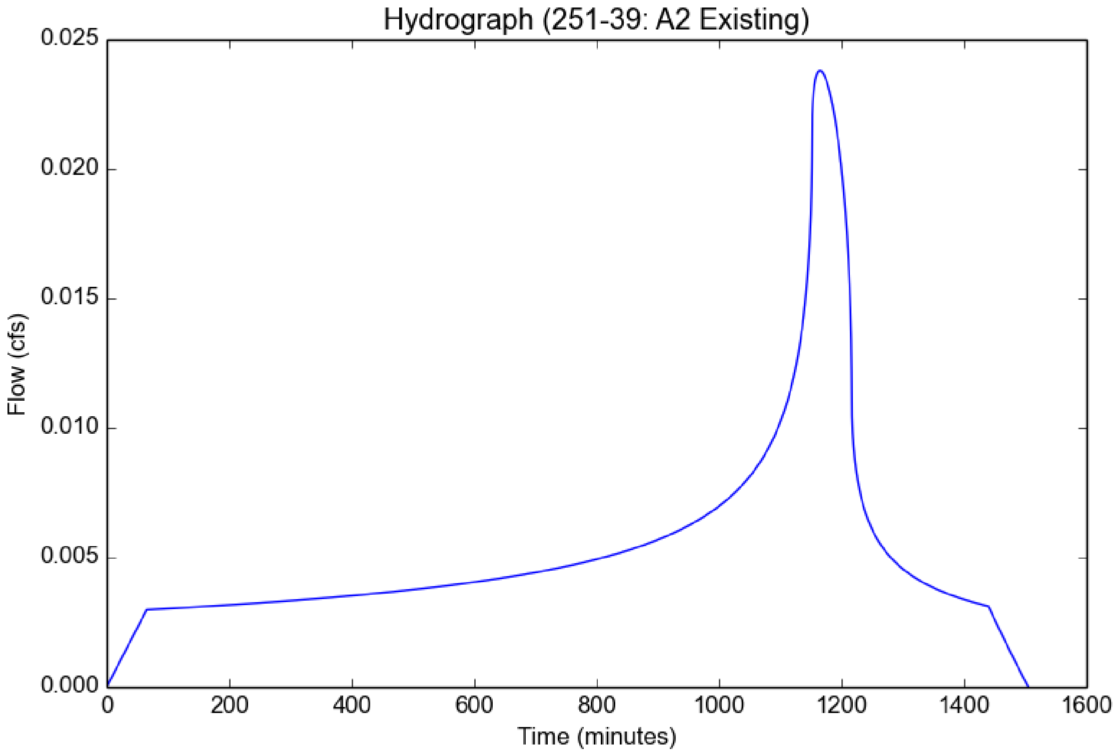
File location: S:/251-39 SIGNAL HILL/HYDROLOGY/NEW OUTPUT 8-20-19/Existing-A2-85th.pdf
Version: HydroCalc 1.0.2

Input Parameters

Project Name	251-39
Subarea ID	A2 Existing
Area (ac)	1.53
Flow Path Length (ft)	270.0
Flow Path Slope (vft/hft)	0.0285
85th Percentile Rainfall Depth (in)	0.75
Percent Impervious	0.02
Soil Type	14
Design Storm Frequency	85th percentile storm
Fire Factor	0
LID	True

Output Results

Modeled (85th percentile storm) Rainfall Depth (in)	0.75
Peak Intensity (in/hr)	0.134
Undeveloped Runoff Coefficient (Cu)	0.1
Developed Runoff Coefficient (Cd)	0.116
Time of Concentration (min)	65.0
Clear Peak Flow Rate (cfs)	0.0238
Burned Peak Flow Rate (cfs)	0.0238
24-Hr Clear Runoff Volume (ac-ft)	0.011
24-Hr Clear Runoff Volume (cu-ft)	479.2224



Peak Flow Hydrologic Analysis

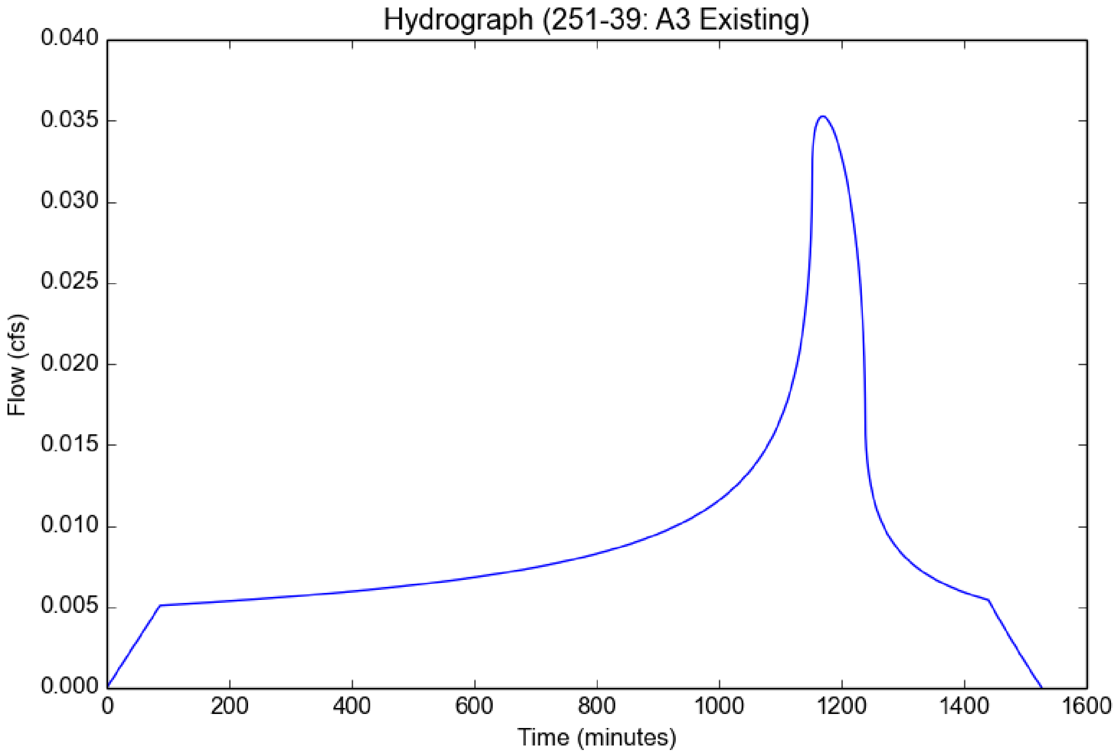
File location: S:/251-39 SIGNAL HILL/HYDROLOGY/NEW OUTPUT 8-20-19/Existing-A3-85th.pdf
Version: HydroCalc 1.0.2

Input Parameters

Project Name	251-39
Subarea ID	A3 Existing
Area (ac)	2.6
Flow Path Length (ft)	490.0
Flow Path Slope (vft/hft)	0.0467
85th Percentile Rainfall Depth (in)	0.75
Percent Impervious	0.02
Soil Type	14
Design Storm Frequency	85th percentile storm
Fire Factor	0
LID	True

Output Results

Modeled (85th percentile storm) Rainfall Depth (in)	0.75
Peak Intensity (in/hr)	0.1169
Undeveloped Runoff Coefficient (Cu)	0.1
Developed Runoff Coefficient (Cd)	0.116
Time of Concentration (min)	87.0
Clear Peak Flow Rate (cfs)	0.0352
Burned Peak Flow Rate (cfs)	0.0352
24-Hr Clear Runoff Volume (ac-ft)	0.0187
24-Hr Clear Runoff Volume (cu-ft)	814.4017



Peak Flow Hydrologic Analysis

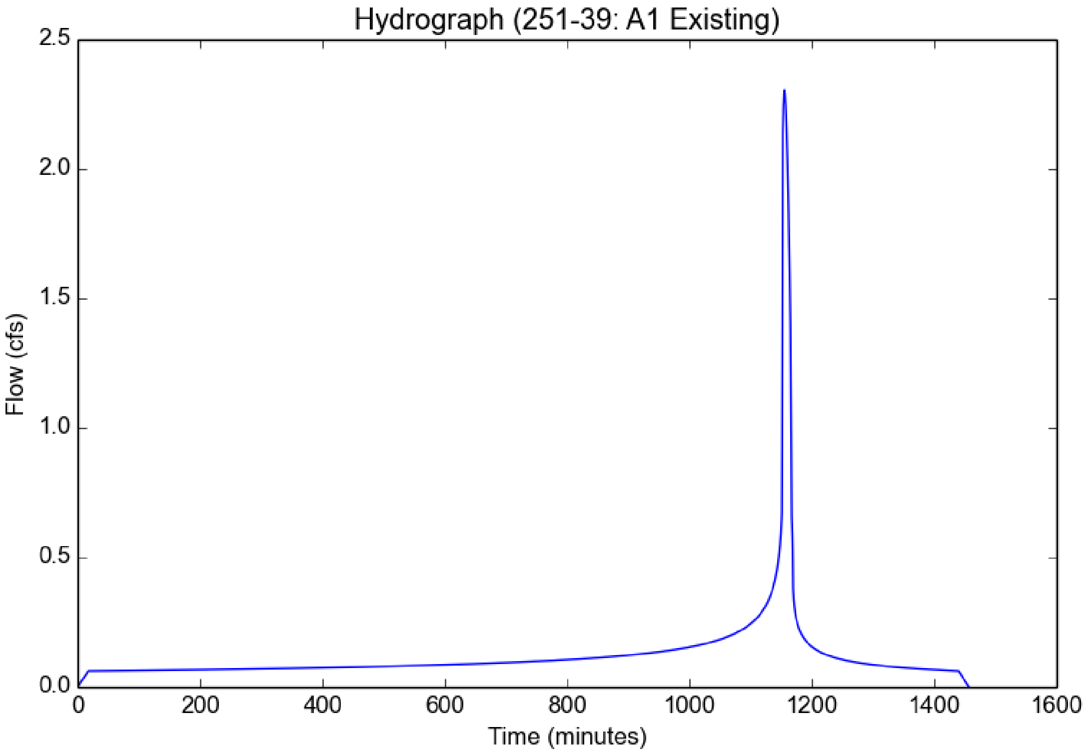
File location: S:/251-39 SIGNAL HILL/HYDROLOGY/NEW OUTPUT 8-20-19/Existing-A1-10yr.pdf
Version: HydroCalc 1.0.2

Input Parameters

Project Name	251-39
Subarea ID	A1 Existing
Area (ac)	4.61
Flow Path Length (ft)	755.0
Flow Path Slope (vft/hft)	0.0383
50-yr Rainfall Depth (in)	5.1
Percent Impervious	0.08
Soil Type	14
Design Storm Frequency	10-yr
Fire Factor	0
LID	False

Output Results

Modeled (10-yr) Rainfall Depth (in)	3.6414
Peak Intensity (in/hr)	1.2223
Undeveloped Runoff Coefficient (Cu)	0.3664
Developed Runoff Coefficient (Cd)	0.4091
Time of Concentration (min)	17.0
Clear Peak Flow Rate (cfs)	2.3053
Burned Peak Flow Rate (cfs)	2.3053
24-Hr Clear Runoff Volume (ac-ft)	0.2499
24-Hr Clear Runoff Volume (cu-ft)	10887.0197



Peak Flow Hydrologic Analysis

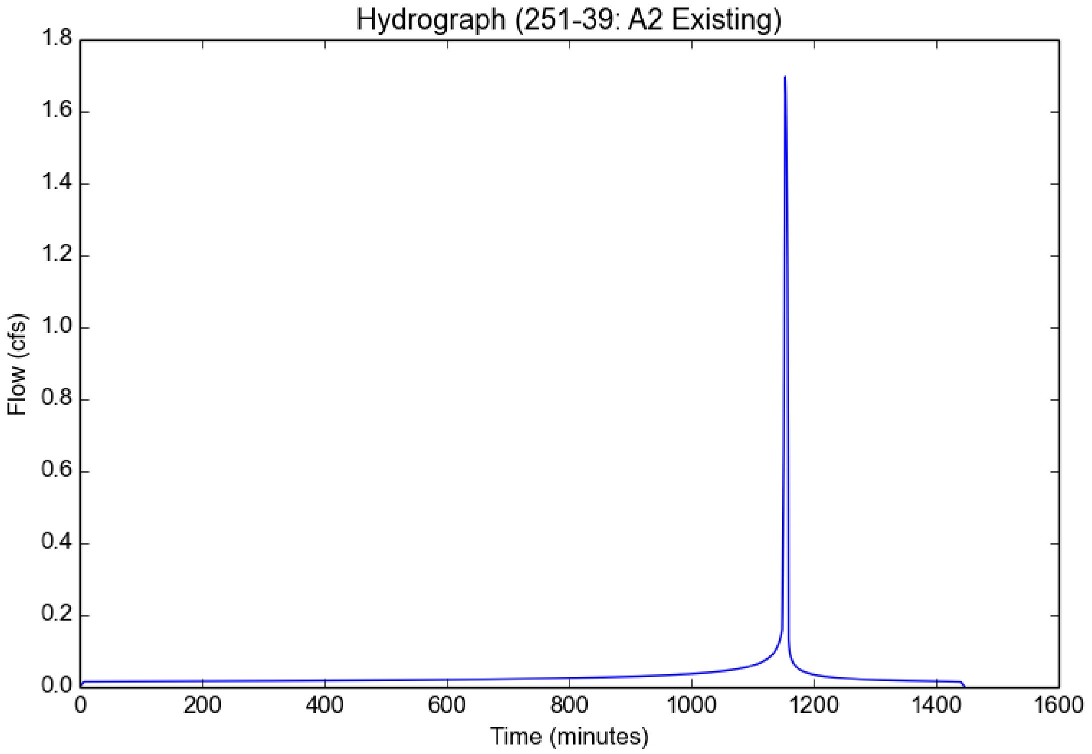
File location: S:/251-39 SIGNAL HILL/HYDROLOGY/NEW OUTPUT 8-20-19/Existing-A2-10yr.pdf
Version: HydroCalc 1.0.2

Input Parameters

Project Name	251-39
Subarea ID	A2 Existing
Area (ac)	1.53
Flow Path Length (ft)	270.0
Flow Path Slope (vft/hft)	0.0285
50-yr Rainfall Depth (in)	5.1
Percent Impervious	0.02
Soil Type	14
Design Storm Frequency	10-yr
Fire Factor	0
LID	False

Output Results

Modeled (10-yr) Rainfall Depth (in)	3.6414
Peak Intensity (in/hr)	1.8548
Undeveloped Runoff Coefficient (Cu)	0.5917
Developed Runoff Coefficient (Cd)	0.5979
Time of Concentration (min)	7.0
Clear Peak Flow Rate (cfs)	1.6968
Burned Peak Flow Rate (cfs)	1.6968
24-Hr Clear Runoff Volume (ac-ft)	0.0658
24-Hr Clear Runoff Volume (cu-ft)	2866.629



Peak Flow Hydrologic Analysis

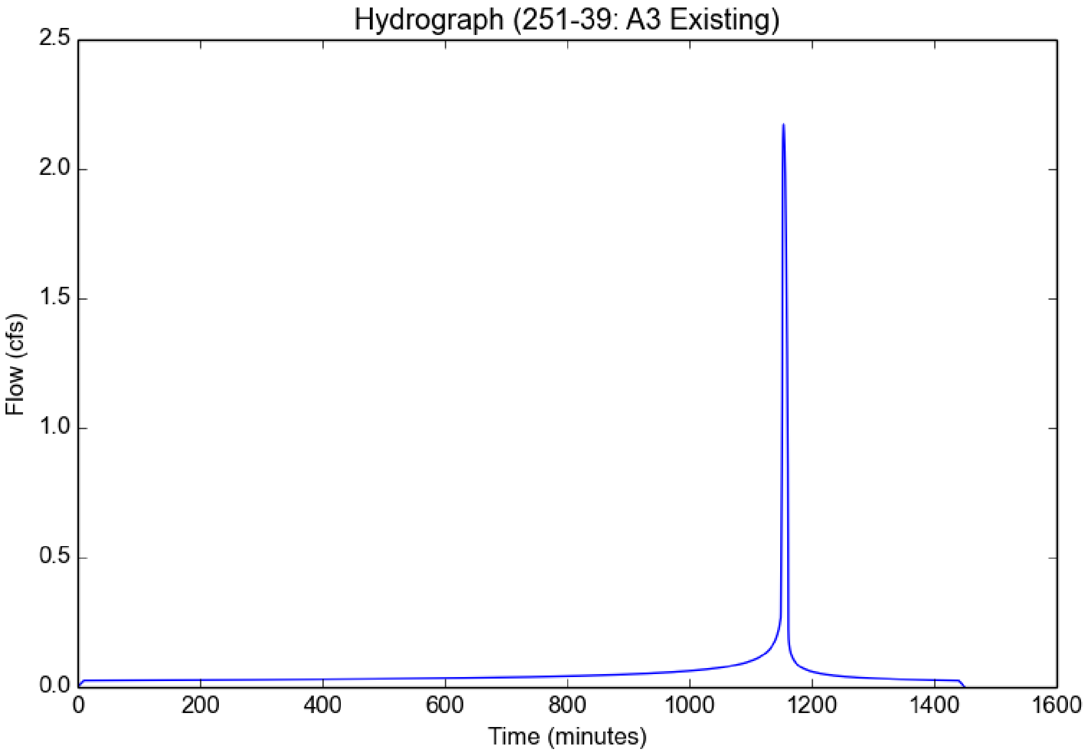
File location: S:/251-39 SIGNAL HILL/HYDROLOGY/NEW OUTPUT 8-20-19/Existing-A3-10yr.pdf
Version: HydroCalc 1.0.2

Input Parameters

Project Name	251-39
Subarea ID	A3 Existing
Area (ac)	2.6
Flow Path Length (ft)	490.0
Flow Path Slope (vft/hft)	0.0467
50-yr Rainfall Depth (in)	5.1
Percent Impervious	0.02
Soil Type	14
Design Storm Frequency	10-yr
Fire Factor	0
LID	False

Output Results

Modeled (10-yr) Rainfall Depth (in)	3.6414
Peak Intensity (in/hr)	1.5685
Undeveloped Runoff Coefficient (Cu)	0.5253
Developed Runoff Coefficient (Cd)	0.5328
Time of Concentration (min)	10.0
Clear Peak Flow Rate (cfs)	2.1728
Burned Peak Flow Rate (cfs)	2.1728
24-Hr Clear Runoff Volume (ac-ft)	0.1103
24-Hr Clear Runoff Volume (cu-ft)	4806.1865



Peak Flow Hydrologic Analysis

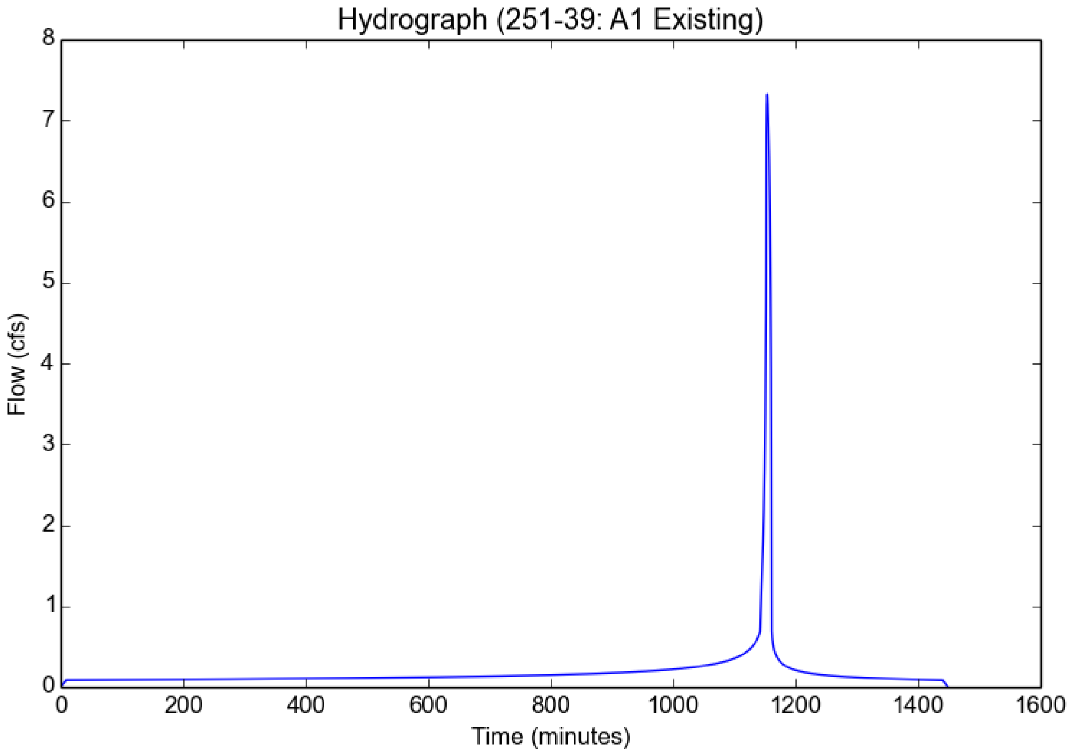
File location: S:/251-39 SIGNAL HILL/HYDROLOGY/NEW OUTPUT 8-20-19/Existing-A1-50yr.pdf
Version: HydroCalc 1.0.2

Input Parameters

Project Name	251-39
Subarea ID	A1 Existing
Area (ac)	4.61
Flow Path Length (ft)	755.0
Flow Path Slope (vft/hft)	0.0383
50-yr Rainfall Depth (in)	5.1
Percent Impervious	0.08
Soil Type	14
Design Storm Frequency	50-yr
Fire Factor	0
LID	False

Output Results

Modeled (50-yr) Rainfall Depth (in)	5.1
Peak Intensity (in/hr)	2.3083
Undeveloped Runoff Coefficient (Cu)	0.6696
Developed Runoff Coefficient (Cd)	0.688
Time of Concentration (min)	9.0
Clear Peak Flow Rate (cfs)	7.3214
Burned Peak Flow Rate (cfs)	7.3214
24-Hr Clear Runoff Volume (ac-ft)	0.3937
24-Hr Clear Runoff Volume (cu-ft)	17148.7237



Peak Flow Hydrologic Analysis

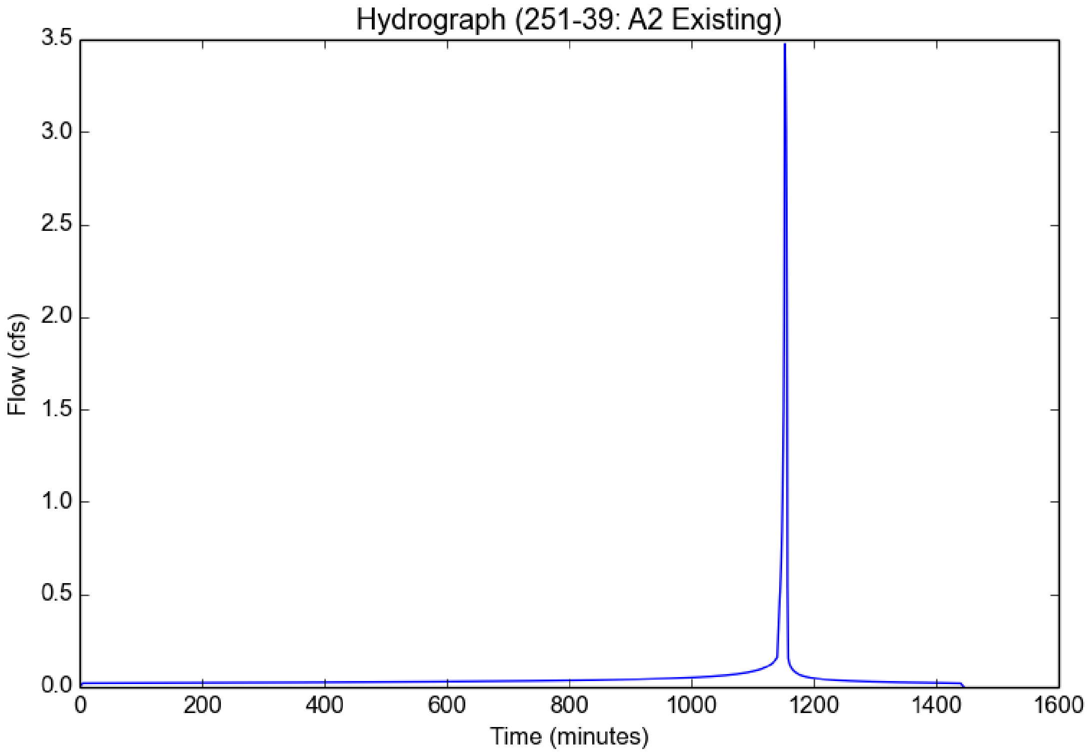
File location: S:/251-39 SIGNAL HILL/HYDROLOGY/NEW OUTPUT 8-20-19/Existing-A2-50yr.pdf
Version: HydroCalc 1.0.2

Input Parameters

Project Name	251-39
Subarea ID	A2 Existing
Area (ac)	1.53
Flow Path Length (ft)	270.0
Flow Path Slope (vft/hft)	0.0285
50-yr Rainfall Depth (in)	5.1
Percent Impervious	0.02
Soil Type	14
Design Storm Frequency	50-yr
Fire Factor	0
LID	False

Output Results

Modeled (50-yr) Rainfall Depth (in)	5.1
Peak Intensity (in/hr)	3.0428
Undeveloped Runoff Coefficient (Cu)	0.7435
Developed Runoff Coefficient (Cd)	0.7467
Time of Concentration (min)	5.0
Clear Peak Flow Rate (cfs)	3.4761
Burned Peak Flow Rate (cfs)	3.4761
24-Hr Clear Runoff Volume (ac-ft)	0.1017
24-Hr Clear Runoff Volume (cu-ft)	4429.8358



Peak Flow Hydrologic Analysis

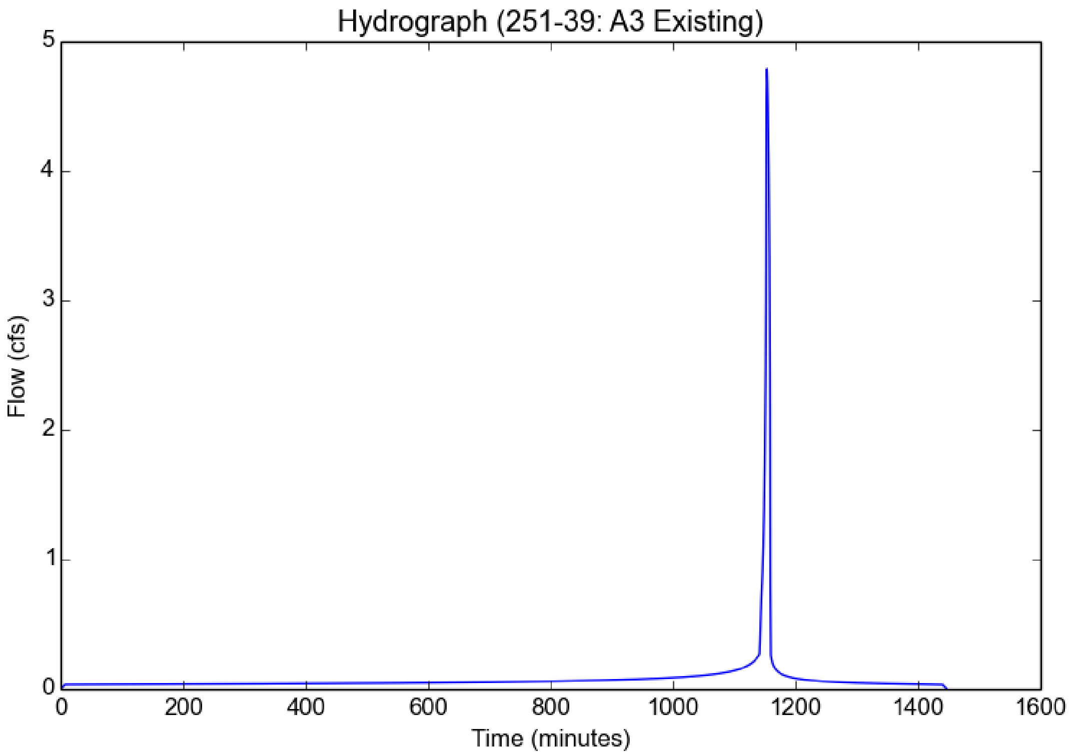
File location: S:/251-39 SIGNAL HILL/HYDROLOGY/NEW OUTPUT 8-20-19/Existing-A3-50yr.pdf
Version: HydroCalc 1.0.2

Input Parameters

Project Name	251-39
Subarea ID	A3 Existing
Area (ac)	2.6
Flow Path Length (ft)	490.0
Flow Path Slope (vft/hft)	0.0467
50-yr Rainfall Depth (in)	5.1
Percent Impervious	0.02
Soil Type	14
Design Storm Frequency	50-yr
Fire Factor	0
LID	False

Output Results

Modeled (50-yr) Rainfall Depth (in)	5.1
Peak Intensity (in/hr)	2.5977
Undeveloped Runoff Coefficient (Cu)	0.7054
Developed Runoff Coefficient (Cd)	0.7093
Time of Concentration (min)	7.0
Clear Peak Flow Rate (cfs)	4.7905
Burned Peak Flow Rate (cfs)	4.7905
24-Hr Clear Runoff Volume (ac-ft)	0.1727
24-Hr Clear Runoff Volume (cu-ft)	7521.0432



APPENDIX B: PROPOSED PEAK FLOW HYDROLOGIC ANALYSIS (85th PERCENTILE, 10 YEAR, AND 50 YEAR STORMS)

Peak Flow Hydrologic Analysis

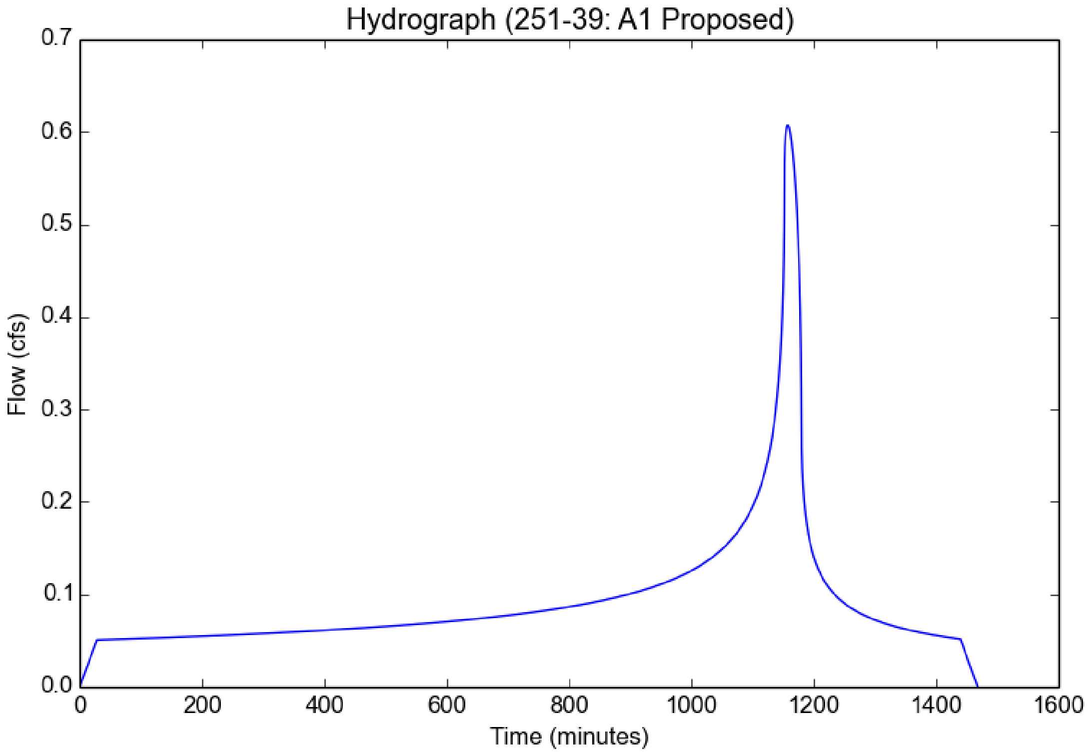
File location: S:/251-39 SIGNAL HILL/HYDROLOGY/NEW OUTPUT 8-20-19/Proposed-A1-85th.pdf
Version: HydroCalc 1.0.2

Input Parameters

Project Name	251-39
Subarea ID	A1 Proposed
Area (ac)	3.87
Flow Path Length (ft)	583.0
Flow Path Slope (vft/hft)	0.0335
85th Percentile Rainfall Depth (in)	0.75
Percent Impervious	0.86
Soil Type	14
Design Storm Frequency	85th percentile storm
Fire Factor	0
LID	True

Output Results

Modeled (85th percentile storm) Rainfall Depth (in)	0.75
Peak Intensity (in/hr)	0.1991
Undeveloped Runoff Coefficient (Cu)	0.1
Developed Runoff Coefficient (Cd)	0.788
Time of Concentration (min)	28.0
Clear Peak Flow Rate (cfs)	0.6072
Burned Peak Flow Rate (cfs)	0.6072
24-Hr Clear Runoff Volume (ac-ft)	0.189
24-Hr Clear Runoff Volume (cu-ft)	8233.8942



Peak Flow Hydrologic Analysis

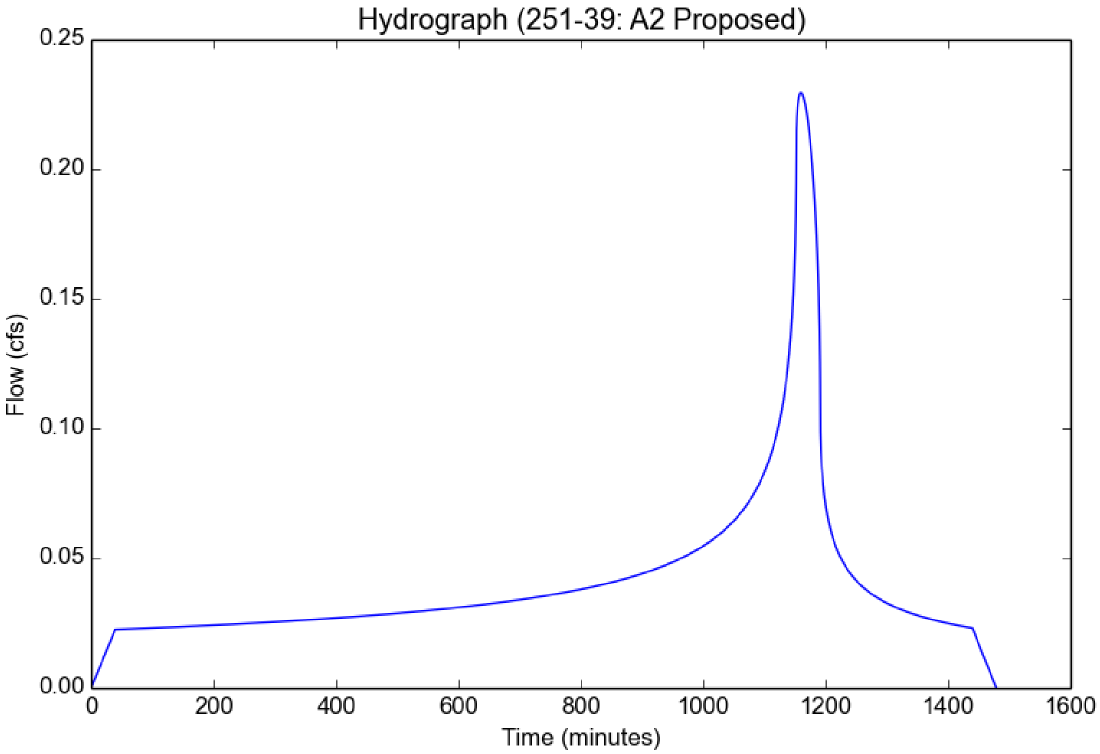
File location: S:/251-39 SIGNAL HILL/HYDROLOGY/NEW OUTPUT 8-20-19/Proposed-A2-85th.pdf
Version: HydroCalc 1.0.2

Input Parameters

Project Name	251-39
Subarea ID	A2 Proposed
Area (ac)	1.88
Flow Path Length (ft)	631.0
Flow Path Slope (vft/hft)	0.009
85th Percentile Rainfall Depth (in)	0.75
Percent Impervious	0.77
Soil Type	14
Design Storm Frequency	85th percentile storm
Fire Factor	0
LID	True

Output Results

Modeled (85th percentile storm) Rainfall Depth (in)	0.75
Peak Intensity (in/hr)	0.1704
Undeveloped Runoff Coefficient (Cu)	0.1
Developed Runoff Coefficient (Cd)	0.716
Time of Concentration (min)	39.0
Clear Peak Flow Rate (cfs)	0.2294
Burned Peak Flow Rate (cfs)	0.2294
24-Hr Clear Runoff Volume (ac-ft)	0.0834
24-Hr Clear Runoff Volume (cu-ft)	3634.4869



Peak Flow Hydrologic Analysis

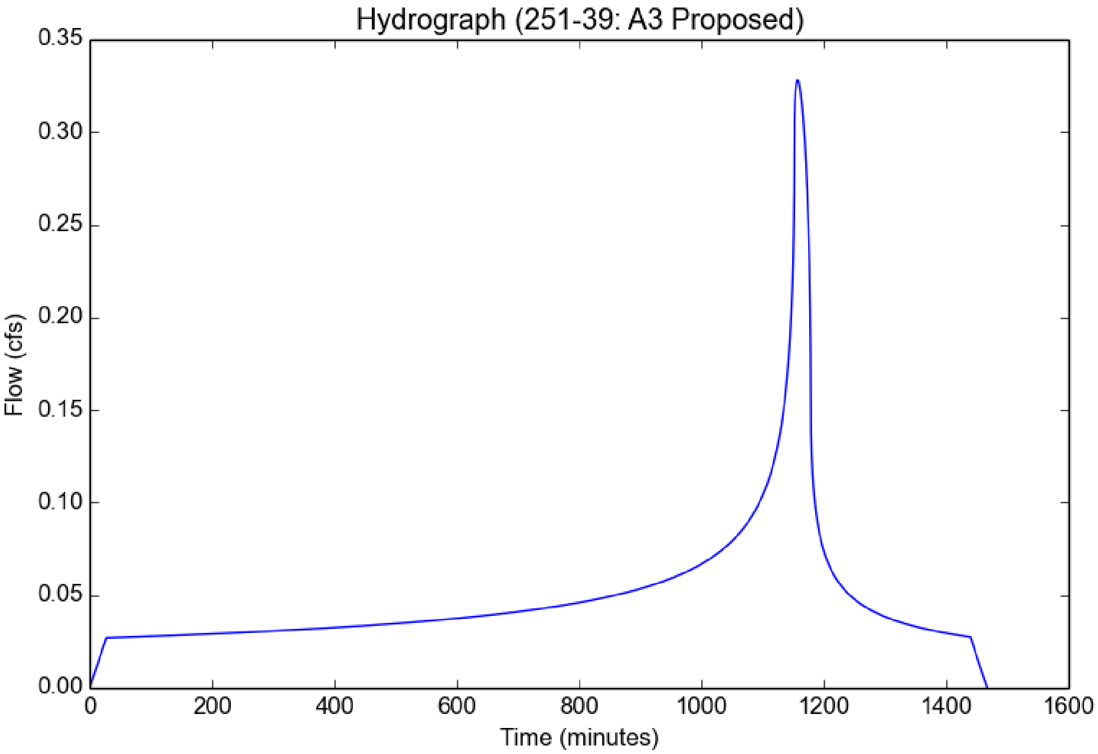
File location: S:/251-39 SIGNAL HILL/HYDROLOGY/NEW OUTPUT 8-20-19/Proposed-A3-85th.pdf
Version: HydroCalc 1.0.2

Input Parameters

Project Name	251-39
Subarea ID	A3 Proposed
Area (ac)	2.34
Flow Path Length (ft)	474.0
Flow Path Slope (vft/hft)	0.0338
85th Percentile Rainfall Depth (in)	0.75
Percent Impervious	0.74
Soil Type	14
Design Storm Frequency	85th percentile storm
Fire Factor	0
LID	True

Output Results

Modeled (85th percentile storm) Rainfall Depth (in)	0.75
Peak Intensity (in/hr)	0.2026
Undeveloped Runoff Coefficient (Cu)	0.1
Developed Runoff Coefficient (Cd)	0.692
Time of Concentration (min)	27.0
Clear Peak Flow Rate (cfs)	0.328
Burned Peak Flow Rate (cfs)	0.328
24-Hr Clear Runoff Volume (ac-ft)	0.1004
24-Hr Clear Runoff Volume (cu-ft)	4372.0966



Peak Flow Hydrologic Analysis

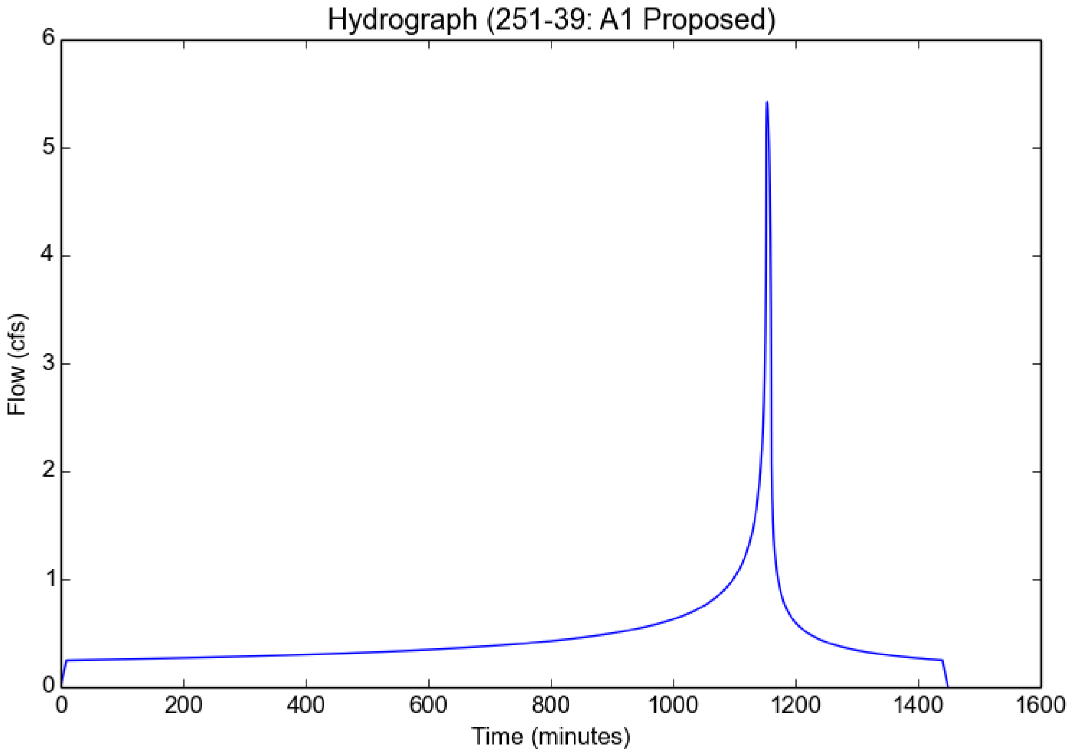
File location: S:/251-39 SIGNAL HILL/HYDROLOGY/NEW OUTPUT 8-20-19/Proposed-A1-10yr.pdf
Version: HydroCalc 1.0.2

Input Parameters

Project Name	251-39
Subarea ID	A1 Proposed
Area (ac)	3.87
Flow Path Length (ft)	583.0
Flow Path Slope (vft/hft)	0.0335
50-yr Rainfall Depth (in)	5.1
Percent Impervious	0.86
Soil Type	14
Design Storm Frequency	10-yr
Fire Factor	0
LID	False

Output Results

Modeled (10-yr) Rainfall Depth (in)	3.6414
Peak Intensity (in/hr)	1.6481
Undeveloped Runoff Coefficient (Cu)	0.5438
Developed Runoff Coefficient (Cd)	0.8501
Time of Concentration (min)	9.0
Clear Peak Flow Rate (cfs)	5.4224
Burned Peak Flow Rate (cfs)	5.4224
24-Hr Clear Runoff Volume (ac-ft)	0.922
24-Hr Clear Runoff Volume (cu-ft)	40163.442



Peak Flow Hydrologic Analysis

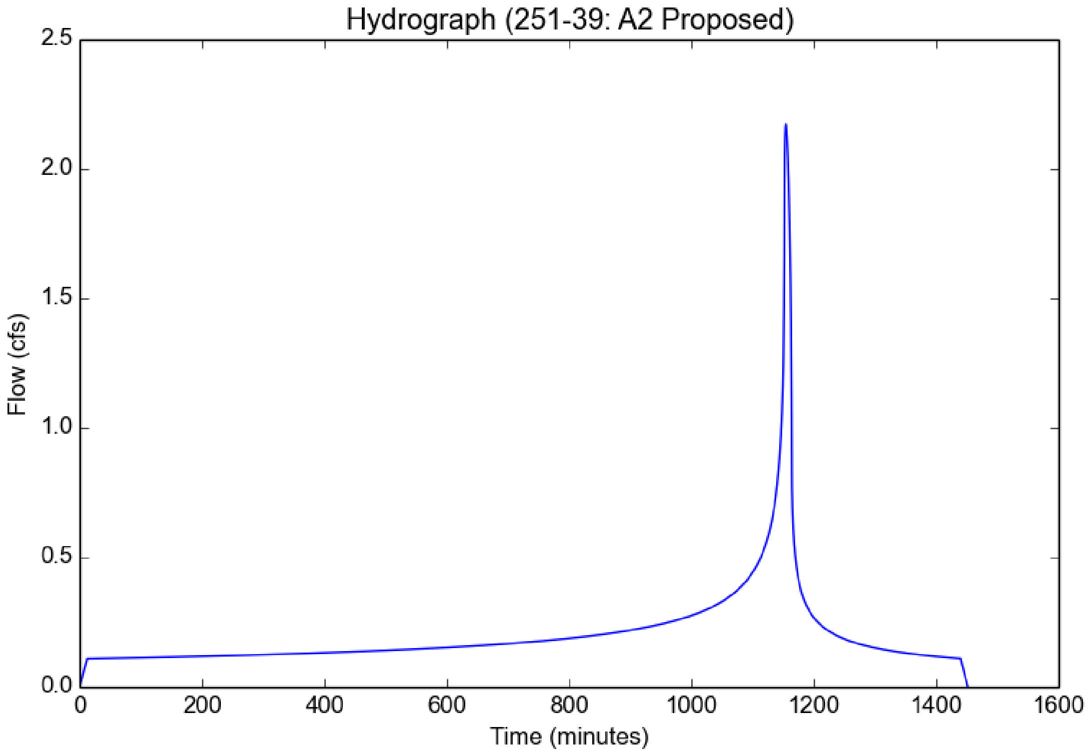
File location: S:/251-39 SIGNAL HILL/HYDROLOGY/NEW OUTPUT 8-20-19/Proposed-A2-10yr.pdf
Version: HydroCalc 1.0.2

Input Parameters

Project Name	251-39
Subarea ID	A2 Proposed
Area (ac)	1.88
Flow Path Length (ft)	631.0
Flow Path Slope (vft/hft)	0.009
50-yr Rainfall Depth (in)	5.1
Percent Impervious	0.77
Soil Type	14
Design Storm Frequency	10-yr
Fire Factor	0
LID	False

Output Results

Modeled (10-yr) Rainfall Depth (in)	3.6414
Peak Intensity (in/hr)	1.4397
Undeveloped Runoff Coefficient (Cu)	0.4783
Developed Runoff Coefficient (Cd)	0.803
Time of Concentration (min)	12.0
Clear Peak Flow Rate (cfs)	2.1735
Burned Peak Flow Rate (cfs)	2.1735
24-Hr Clear Runoff Volume (ac-ft)	0.4081
24-Hr Clear Runoff Volume (cu-ft)	17777.6519



Peak Flow Hydrologic Analysis

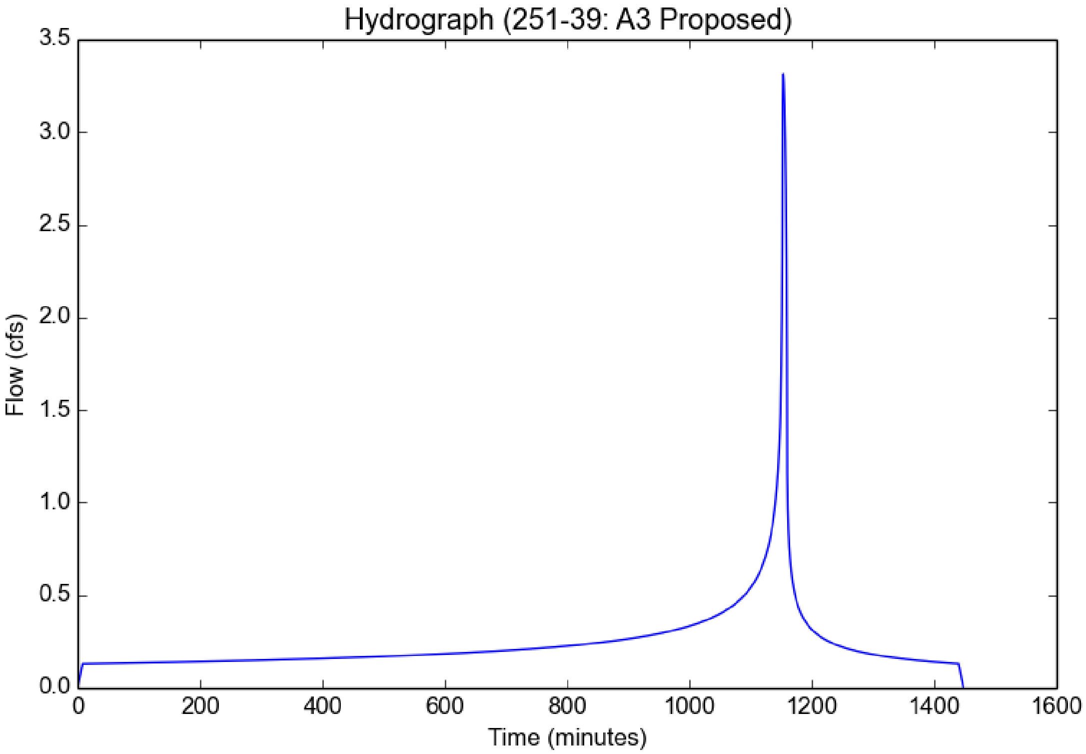
File location: S:/251-39 SIGNAL HILL/HYDROLOGY/NEW OUTPUT 8-20-19/Proposed-A3-10yr.pdf
Version: HydroCalc 1.0.2

Input Parameters

Project Name	251-39
Subarea ID	A3 Proposed
Area (ac)	2.34
Flow Path Length (ft)	474.0
Flow Path Slope (vft/hft)	0.0338
50-yr Rainfall Depth (in)	5.1
Percent Impervious	0.74
Soil Type	14
Design Storm Frequency	10-yr
Fire Factor	0
LID	False

Output Results

Modeled (10-yr) Rainfall Depth (in)	3.6414
Peak Intensity (in/hr)	1.7419
Undeveloped Runoff Coefficient (Cu)	0.5656
Developed Runoff Coefficient (Cd)	0.813
Time of Concentration (min)	8.0
Clear Peak Flow Rate (cfs)	3.3141
Burned Peak Flow Rate (cfs)	3.3141
24-Hr Clear Runoff Volume (ac-ft)	0.4922
24-Hr Clear Runoff Volume (cu-ft)	21441.7839



Peak Flow Hydrologic Analysis

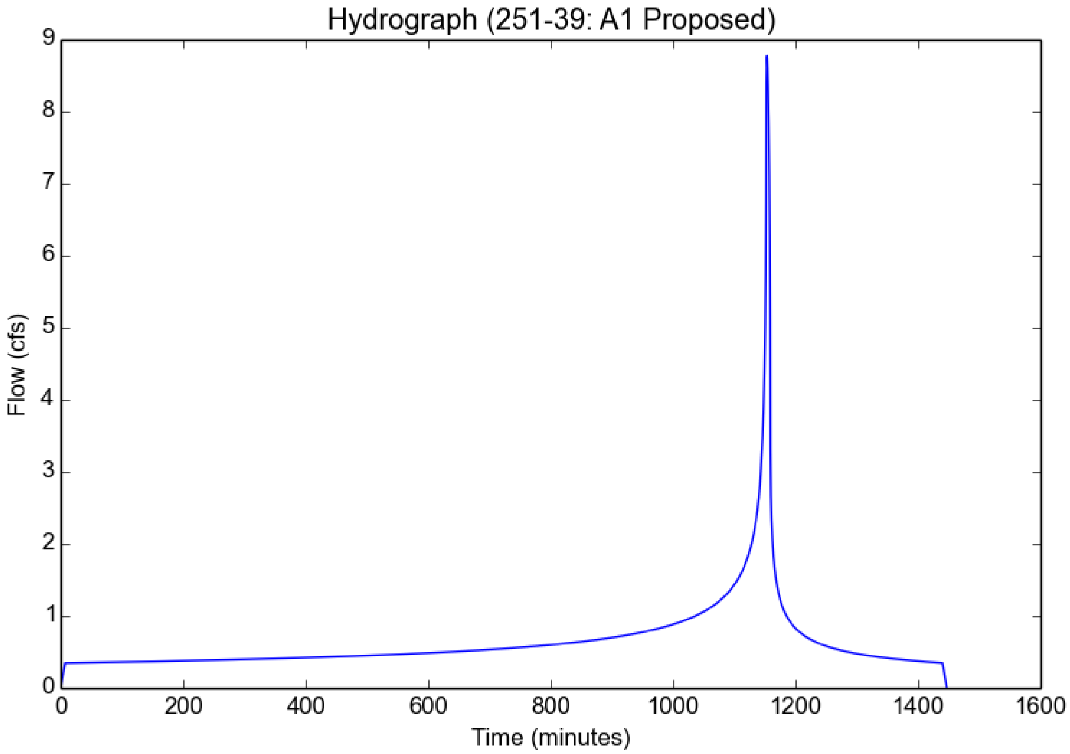
File location: S:/251-39 SIGNAL HILL/HYDROLOGY/NEW OUTPUT 8-20-19/Proposed-A1-50yr.pdf
Version: HydroCalc 1.0.2

Input Parameters

Project Name	251-39
Subarea ID	A1 Proposed
Area (ac)	3.87
Flow Path Length (ft)	583.0
Flow Path Slope (vft/hft)	0.0335
50-yr Rainfall Depth (in)	5.1
Percent Impervious	0.86
Soil Type	14
Design Storm Frequency	50-yr
Fire Factor	0
LID	False

Output Results

Modeled (50-yr) Rainfall Depth (in)	5.1
Peak Intensity (in/hr)	2.5977
Undeveloped Runoff Coefficient (Cu)	0.7054
Developed Runoff Coefficient (Cd)	0.8728
Time of Concentration (min)	7.0
Clear Peak Flow Rate (cfs)	8.774
Burned Peak Flow Rate (cfs)	8.774
24-Hr Clear Runoff Volume (ac-ft)	1.295
24-Hr Clear Runoff Volume (cu-ft)	56411.7571



Peak Flow Hydrologic Analysis

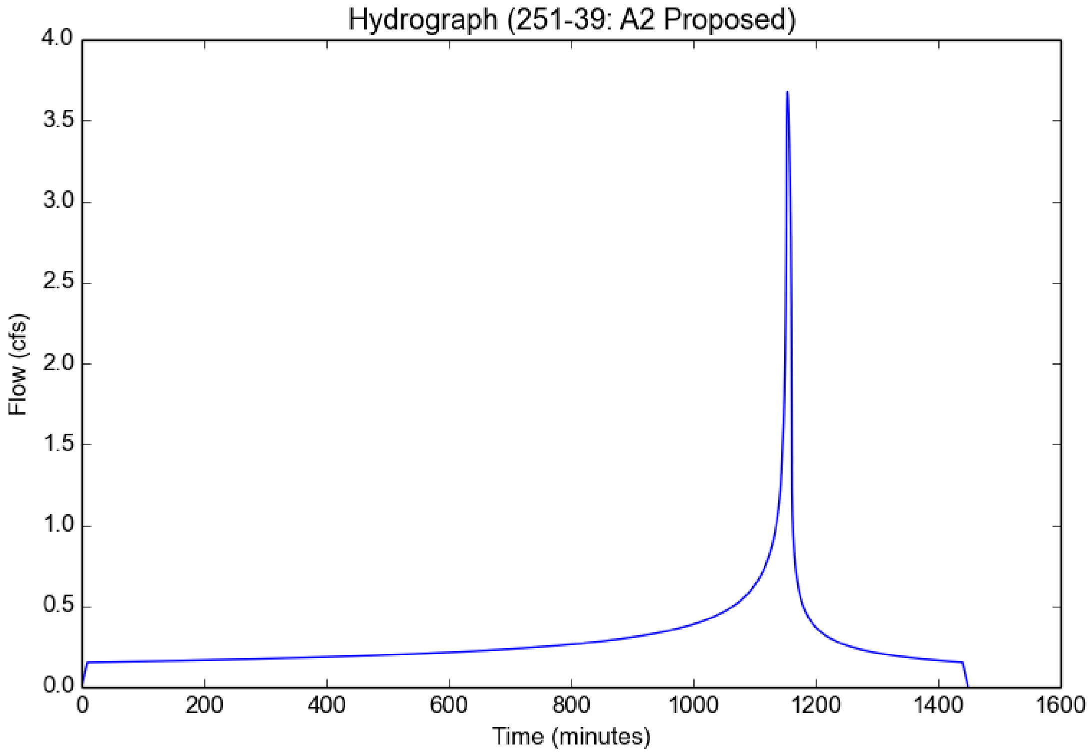
File location: S:/251-39 SIGNAL HILL/HYDROLOGY/NEW OUTPUT 8-20-19/Proposed-A2-50yr.pdf
Version: HydroCalc 1.0.2

Input Parameters

Project Name	251-39
Subarea ID	A2 Proposed
Area (ac)	1.88
Flow Path Length (ft)	631.0
Flow Path Slope (vft/hft)	0.009
50-yr Rainfall Depth (in)	5.1
Percent Impervious	0.77
Soil Type	14
Design Storm Frequency	50-yr
Fire Factor	0
LID	False

Output Results

Modeled (50-yr) Rainfall Depth (in)	5.1
Peak Intensity (in/hr)	2.3083
Undeveloped Runoff Coefficient (Cu)	0.6696
Developed Runoff Coefficient (Cd)	0.847
Time of Concentration (min)	9.0
Clear Peak Flow Rate (cfs)	3.6757
Burned Peak Flow Rate (cfs)	3.6757
24-Hr Clear Runoff Volume (ac-ft)	0.575
24-Hr Clear Runoff Volume (cu-ft)	25047.2152



Peak Flow Hydrologic Analysis

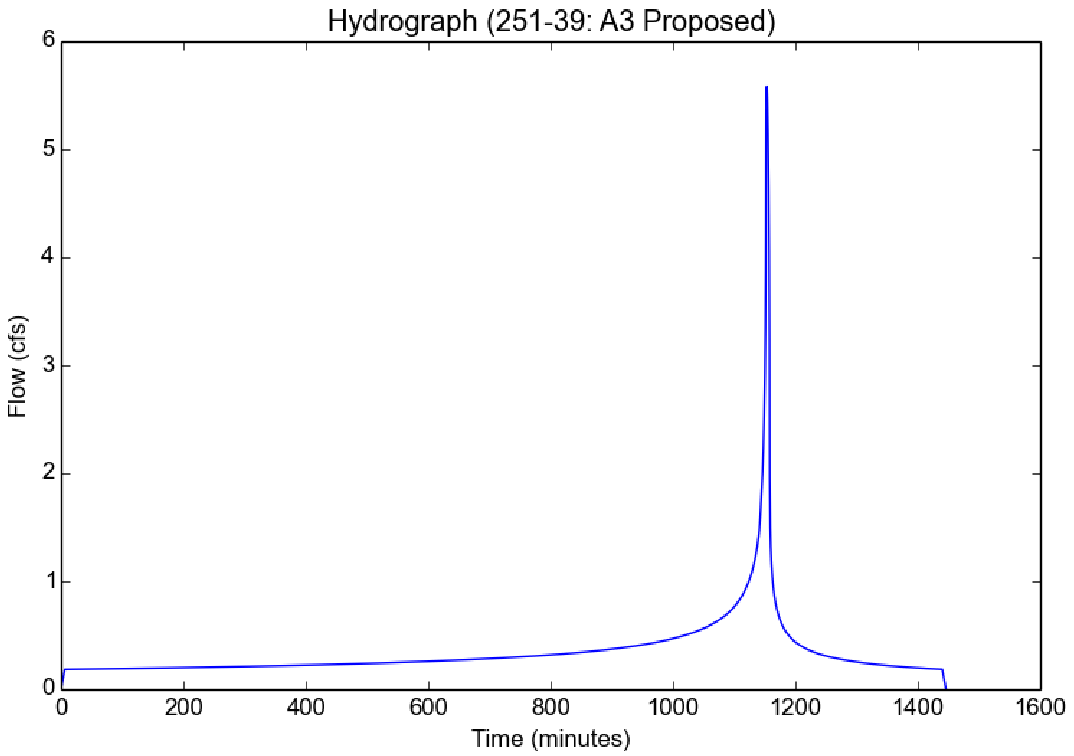
File location: S:/251-39 SIGNAL HILL/HYDROLOGY/NEW OUTPUT 8-20-19/Proposed-A3-50yr.pdf
Version: HydroCalc 1.0.2

Input Parameters

Project Name	251-39
Subarea ID	A3 Proposed
Area (ac)	2.34
Flow Path Length (ft)	474.0
Flow Path Slope (vft/hft)	0.0338
50-yr Rainfall Depth (in)	5.1
Percent Impervious	0.74
Soil Type	14
Design Storm Frequency	50-yr
Fire Factor	0
LID	False

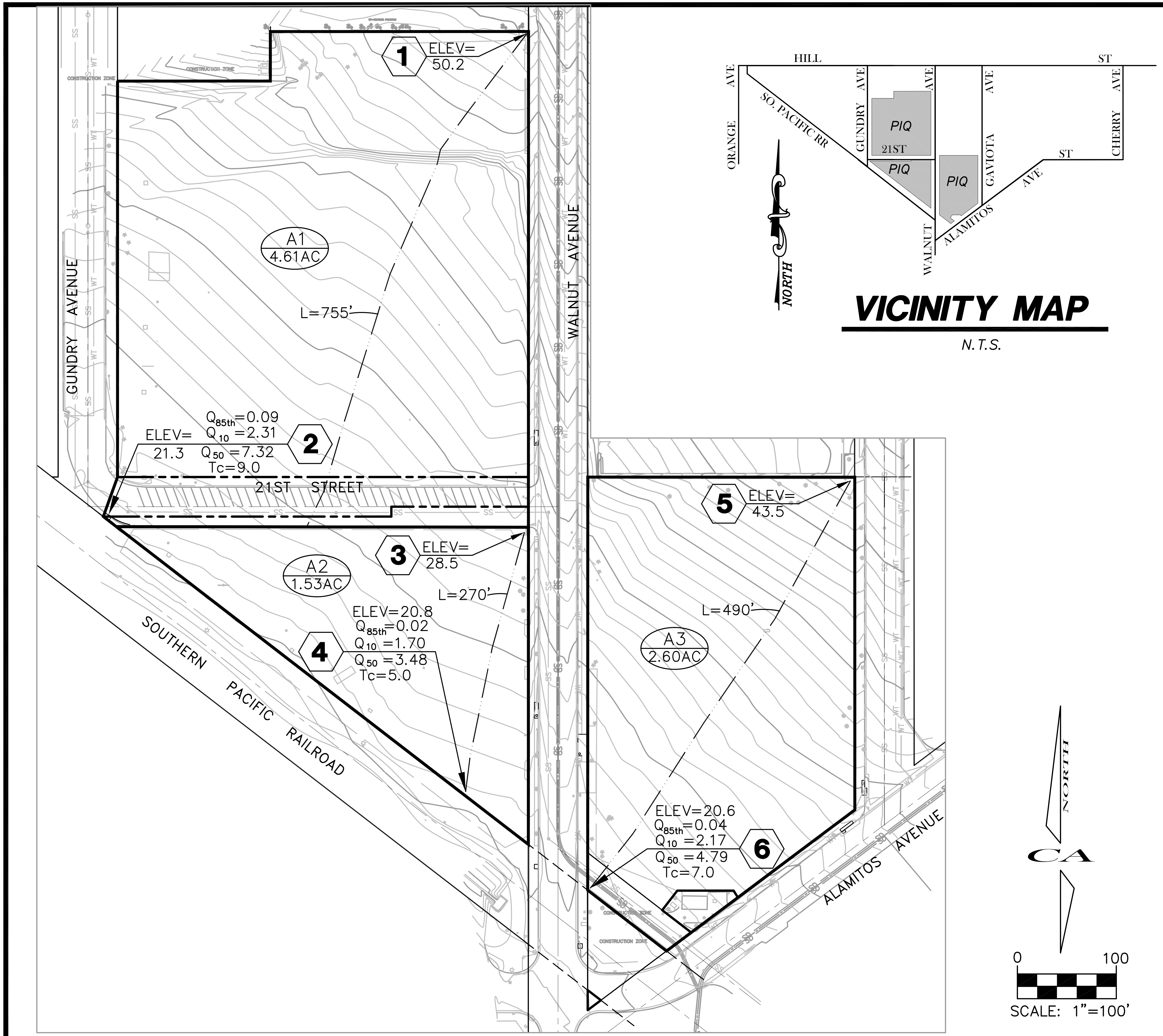
Output Results

Modeled (50-yr) Rainfall Depth (in)	5.1
Peak Intensity (in/hr)	2.7929
Undeveloped Runoff Coefficient (Cu)	0.7221
Developed Runoff Coefficient (Cd)	0.8538
Time of Concentration (min)	6.0
Clear Peak Flow Rate (cfs)	5.5796
Burned Peak Flow Rate (cfs)	5.5796
24-Hr Clear Runoff Volume (ac-ft)	0.6934
24-Hr Clear Runoff Volume (cu-ft)	30204.3716



EXHIBITS

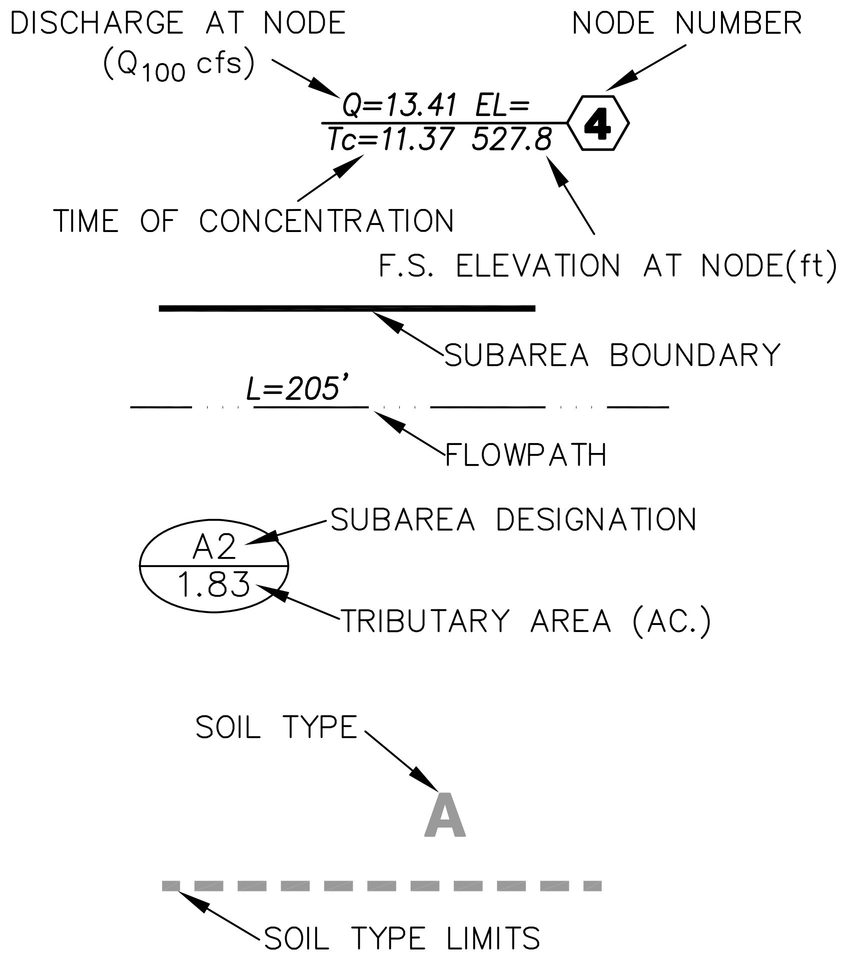
EXHIBIT A: EXISTING CONDITION HYDROLOGY MAP



VICINITY MAP

N.T.S.

LEGEND:



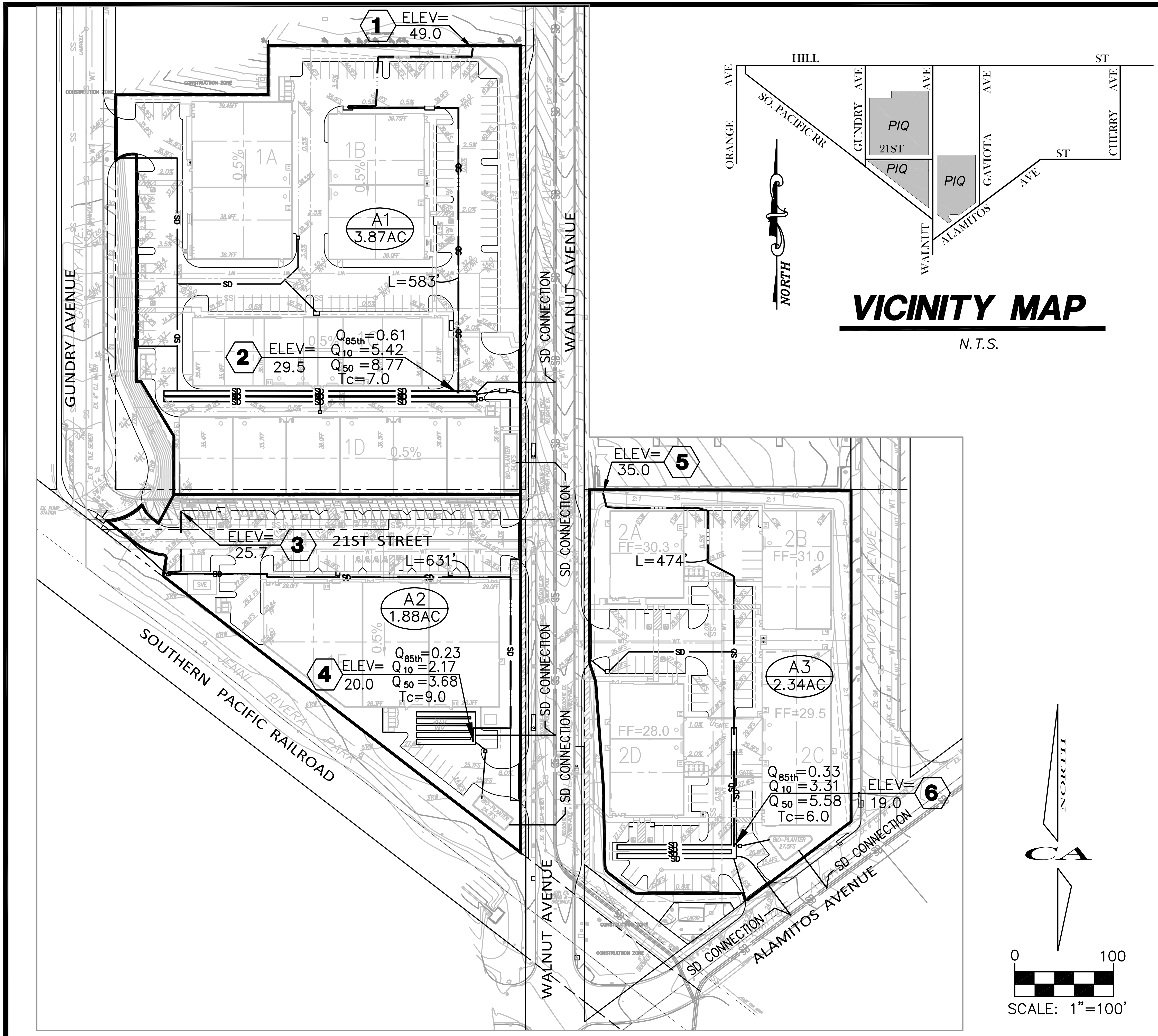
SCALE: 1"=100'

CITY OF SIGNAL HILL

HYDROLOGY MAP
(EXISTING CONDITION)

2025-2185 WALNUT AVE.

EXHIBIT B: PROPOSED CONDITION HYDROLOGY MAP



VICINITY MAP

N.T.S.

LEGEND:

DISCHARGE AT NODE (Q_{100} cfs)

NODE NUMBER

Q=13.41 EL=

Tc=11.37 527.8

4

TIME OF CONCENTRATION

F.S. ELEVATION AT NODE(ft)

SUBAREA BOUNDARY

L=205'

FLOWPATH

A2

1.83

SUBAREA DESIGNATION

TRIBUTARY AREA (AC.)

SOIL TYPE

A

SOIL TYPE LIMITS

SCALE: 1"=100'

CITY OF SIGNAL HILL

HYDROLOGY MAP
(PROPOSED CONDITION)

2025-2185 WALNUT AVE.

EXHIBIT C: RAINFALL INTENSITY & SOILS MAP FOR 85th PERCENTILE AND 50 YEAR STORMS)

Department of Public Works
dpw.lacounty.gov

search our site..

Hydrology Map

A GIS viewer application to view the data for the hydrology manual.

LAYERS

☑ ▬ 50yr Two Tenths (Rainfall)
☐ 🟦 DPA Zones
☑ 🟩 Soils 2004
☑ ▬ Final 85th Percentile, 24-hr Rainfall
☐ ▬ Final 95th Percentile, 24-hr Rainfall
☐ — 1-year, 1-hour Rainfall Intensity

SEARCH

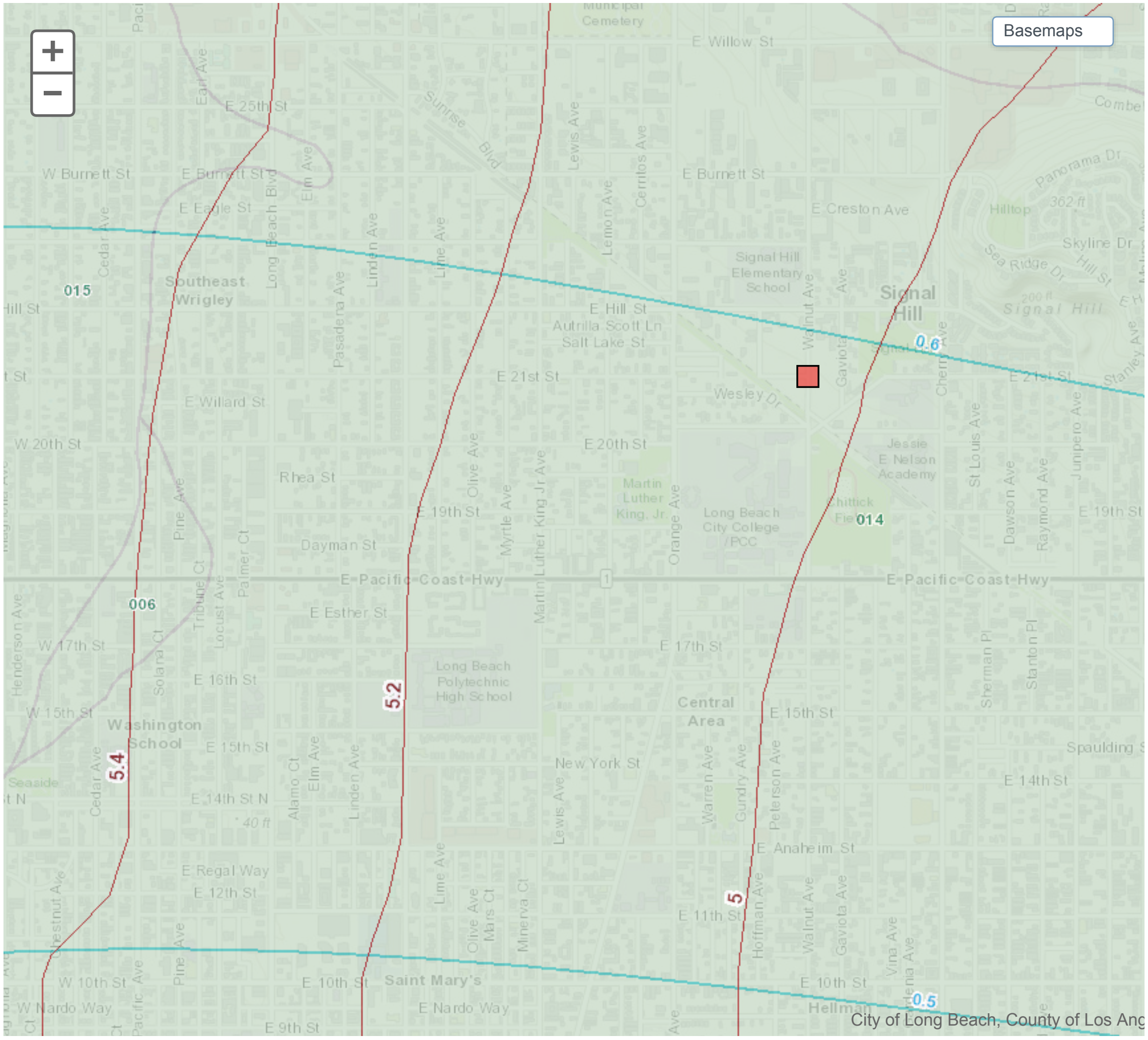
Enter Address, Cross Street, or Parcel No.:
(ex: 900 S. Fremont Ave., Fremont@Valley, 5342005904)

WALNUT AVE & 21ST ST, SIGNAL HILL

Search

Address Search Results:

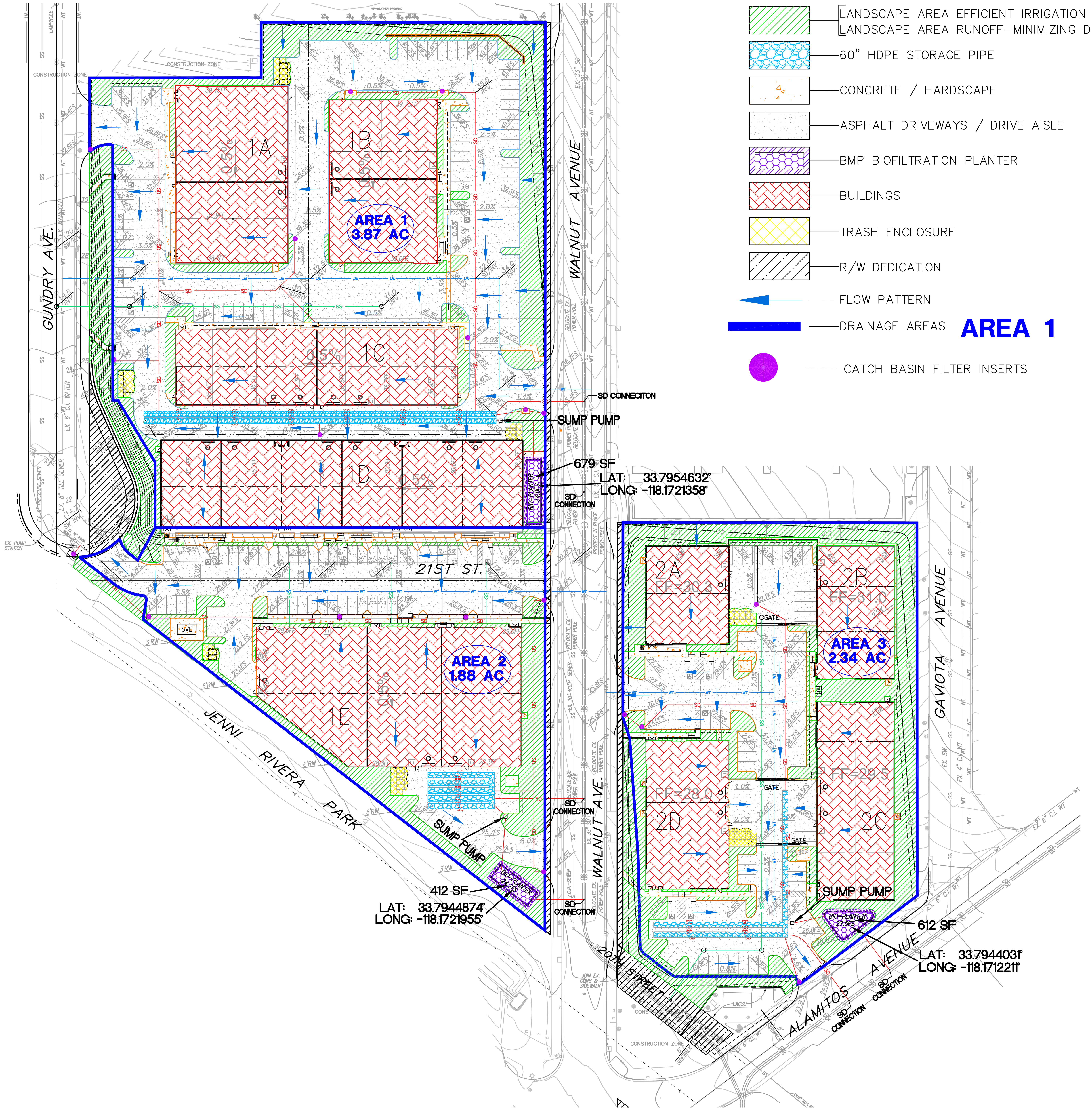
WALNUT AVE AND 21ST ST SIGNAL HILL



Map Tips

lacounty.gov | Public Works FAQ | Privacy / Terms of Use | Feedback |

EXHIBIT D: LID MAP



LEGEND STRUCTURAL / TREATMENT BMPS

▨	LANDSCAPE AREA EFFICIENT IRRIGATION LANDSCAPE AREA RUNOFF-MINIMIZING DESIGN
▨	60" HDPE STORAGE PIPE
▨	CONCRETE / HARDSCAPE
▨	ASPHALT DRIVEWAYS / DRIVE AISLE
▨	BMP BIOFILTRATION PLANTER
▨	BUILDINGS
▨	TRASH ENCLOSURE
▨	R/W DEDICATION
←	FLOW PATTERN
▬	DRAINAGE AREAS **AREA 1**
●	CATCH BASIN FILTER INSERTS

PROJECT DATA:

TOTAL SITE AREA OF PROPOSED DEVELOPMENT: 8.69 AC (378,514 SF)

R/W DEDICATION: 13,390 SF
BUILDING AREA: 138,695 SF
WALKWAYS/CONC. GUTTER AREAS: 10,085 SF
DRIVEWAYS / DRIVE AISLES: 133,867 SF

DRAINAGE AREA LANDSCAPE: 69,374 SF
SELF-RETAINING LANDSCAPE: 13,103 SF
LANDSCAPE PROVIDED: 82,477 SF
(22% PERVIOUS AREA)

CURRENT USE: VACANT
PROPOSED USE: INDUSTRIAL
WATERSHED: LOS ANGELES RIVER

AREA	TOTAL AREA	L.S. AREA	IMP. AREA	% IMPERVIOUS
A1	168,386 SF	23,863 SF	144,523 SF	86%
A2	81,870 SF	18,733 SF	63,137 SF	77%
A3	101,765 SF	26,778 SF	74,987 SF	74%

AREA 1
(SWQDv) – 8,234 CF
REQUIRED (SWQDv)*1.5 – 12,351 CF
STORAGE PIPE VOLUME – 12,450 CF ~ 634 LF

BIOTREATMENT AREA REQUIRED:
96HR DRAWDOWN PER LID
VOLUME (CF) / ((2.5"/HR)(1/12 FT/IN) * 96HR))
12,450 CF / (2.5"/HR)*(1/12 FT/IN) * 96HR) = 623 SF
BIOTREATMENT AREA PROVIDED: 679 SF > 623 SF

PUMP REQUIREMENTS
MINIMUM FLOW (DRAW DOWN IN 96 HRS)
12,450 CF /96HRS
(12,450 CF*7.48GAL/CF) / (96HR*60MIN/HR) = 16.17 GPM
MAXIMUM FLOW (MAX FLOW THRU BIO-PLANTER)
679 SF*(2.5"/HR*(1/12 FT/IN)*(1/60 HR/MIN)*(7.48 GAL/CF)=17.64 GPM
USE 17.0 GPM PUMP

AREA 2
(SWQDv) – 3,634 CF
REQUIRED (SWQDv)*1.5 – 5,451 CF
STORAGE PIPE VOLUME – 5,825 CF ~ 297 LF

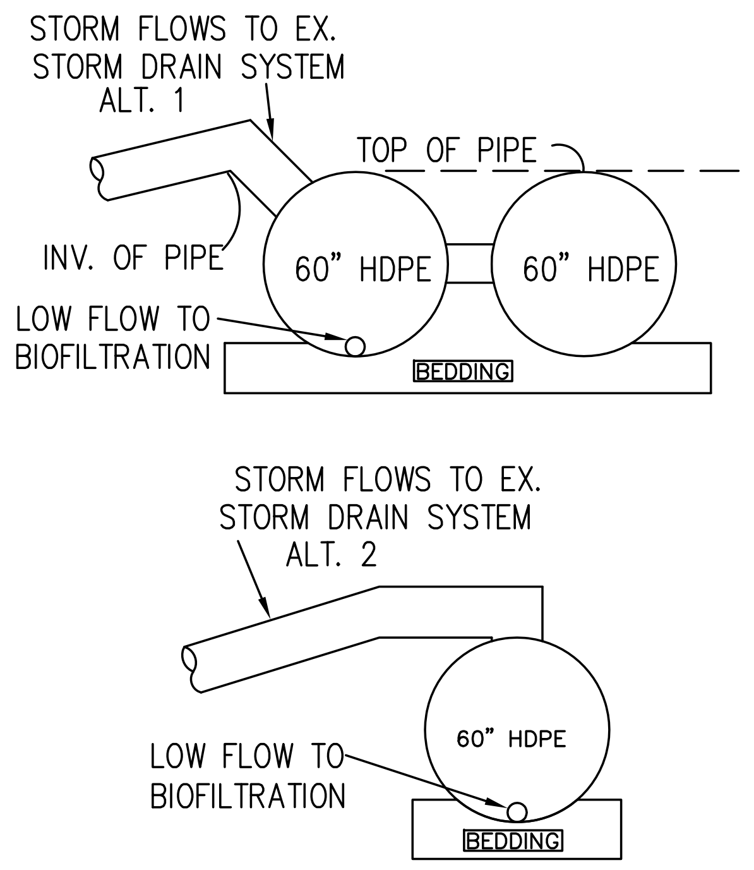
BIOTREATMENT AREA REQUIRED:
96HR DRAWDOWN PER LID
VOLUME (CF) / ((2.5"/HR)(1/12 FT/IN) * 96HR))
5,825 CF / (2.5"/HR)*(1/12 FT/IN) * 96HR) = 291 SF
BIOTREATMENT AREA PROVIDED: 412 SF > 291 SF

PUMP REQUIREMENTS
MINIMUM FLOW (DRAW DOWN IN 96 HRS)
5,825 CF /96HRS
(5,825 CF*7.48GAL/CF) / (96HR*60MIN/HR) = 7.56 GPM
MAXIMUM FLOW (MAX FLOW THRU BIO-PLANTER)
412 SF*(2.5"/HR*(1/12 FT/IN)*(1/60 HR/MIN)*(7.48 GAL/CF)=10.7 GPM
USE 8.0 GPM PUMP

AREA 3
(SWQDv) – 4,372 CF
REQUIRED (SWQDv)*1.5 – 6,558 CF
STORAGE PIPE VOLUME – 7,150 CF ~ 364 LF

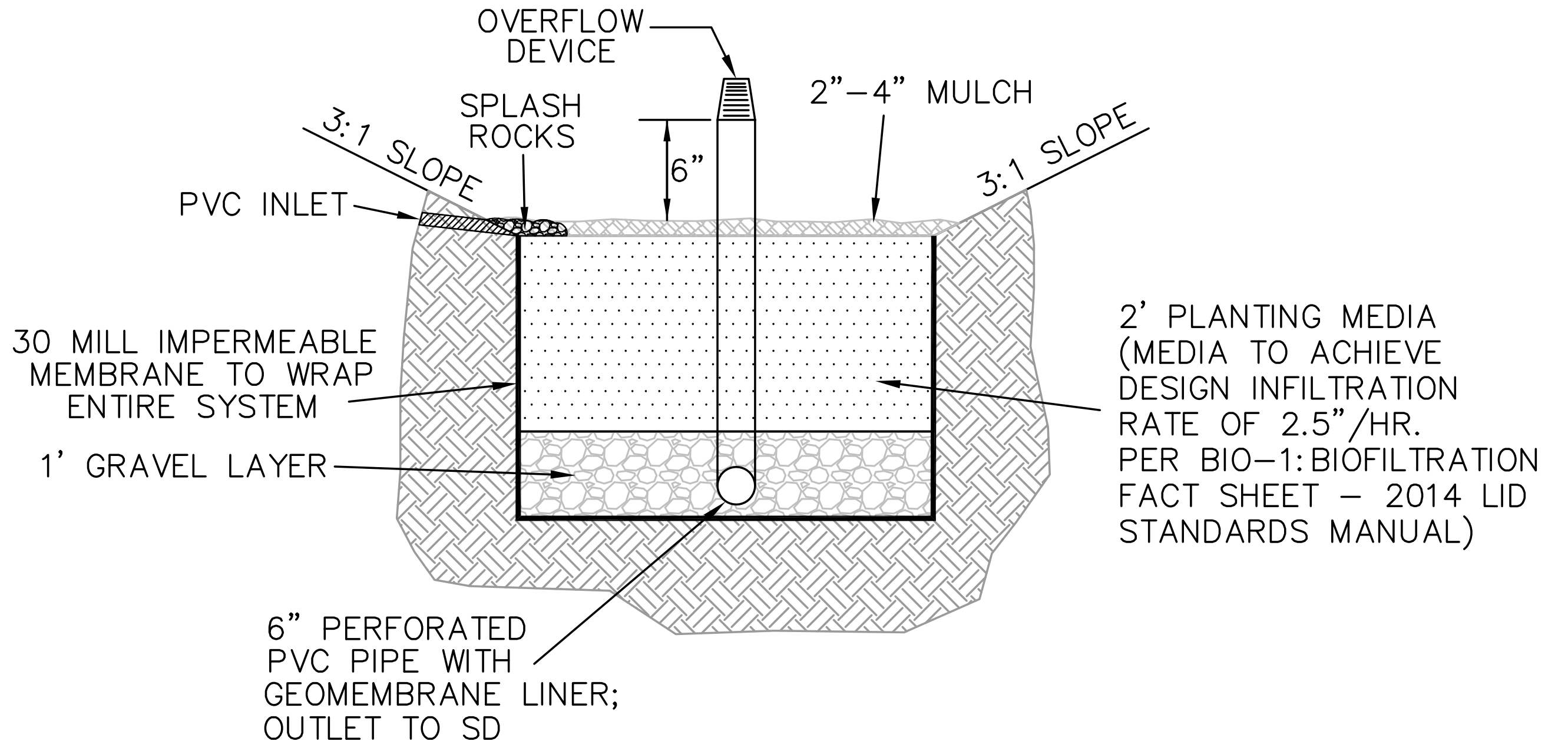
BIOTREATMENT AREA REQUIRED:
96HR DRAWDOWN PER LID
VOLUME (CF) / ((2.5"/HR)(1/12 FT/IN) * 96HR))
7,150 CF / (2.5"/HR)*(1/12 FT/IN) * 96HR) = 358 SF
BIOTREATMENT AREA PROVIDED: 612 SF > 358 SF

PUMP REQUIREMENTS
MINIMUM FLOW (DRAW DOWN IN 96 HRS)
7,150 CF /96HRS
(7,150 CF*7.48GAL/CF) / (96HR*60MIN/HR) = 9.29 GPM
MAXIMUM FLOW (MAX FLOW THRU BIO-PLANTER)
612 SF*(2.5"/HR*(1/12 FT/IN)*(1/60 HR/MIN)*(7.48 GAL/CF)=15.90 GPM
USE 10.0 GPM PUMP

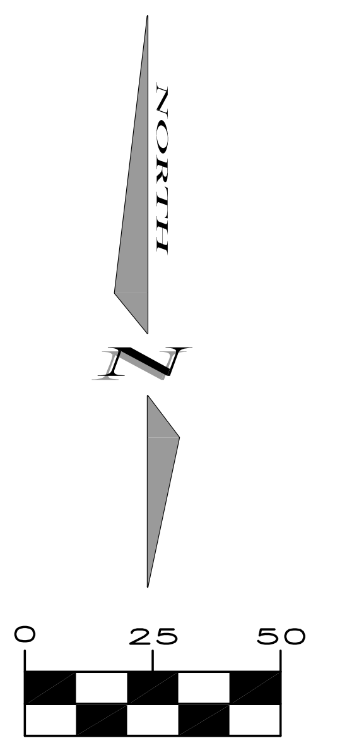


DETENTION PIPES

N.T.S.



BIO-1: BIOFILTRATION PLANTER



SCALE
1 inch = 50 ft.

N.T.S. **PREPARED BY:**

CA ENGINEERING, INC.
Planning • Engineering • Surveying
13821 NEWPORT AVE., STE 110
TUSTIN, CA 92780
949-724-9480 949-724-9484 FAX

LID SITE PLAN

E. 21ST ST & WALNUT AVE.
SIGNAL HILL, CA

SHEET 1 OF 1

EXHIBIT E: FIRM MAP

NOTES TO USERS

This map is for use in administering the National Flood Insurance Program. It does not necessarily identify all areas subject to flooding, particularly from local drainage sources of small size. The **community map repository** should be consulted for possible updated or additional flood hazard information.

To obtain more detailed information in areas where **Base Flood Elevations** (BFEs) and/or **floodways** have been determined, users are encouraged to consult the Flood Profiles and Floodway Data and/or Summary of Stillwater Elevations tables contained within the Flood Insurance Study (FIS) report that accompanies this FIRM. Users should be aware that BFEs shown on the FIRM represent rounded whole–foot elevations. These BFEs are intended for flood insurance rating purposes only and should not be used as the sole source of flood elevation information. Accordingly, flood elevation data presented in the FIS report should be utilized in conjunction with the FIRM for purposes of construction and/or floodplain management.

Coastal Base Flood Elevations shown on this map apply only landward of 0.0' North American Vertical Datum of 1988 (NAVD 88). Users of this FIRM should be aware that coastal flood elevations are also provided in the Summary of Stillwater Elevations table in the Flood Insurance Study report for this jurisdiction. Elevations shown in the Summary of Stillwater Elevations table should be used for construction and/or floodplain management purposes when they are higher than the elevations shown on this FIRM.

Boundaries of the **floodways** were computed at cross sections and interpolated between cross sections. The floodways were based on hydraulic considerations with regard to requirements of the National Flood Insurance Program. Floodway widths and other pertinent floodway data are provided in the Flood Insurance Study report for this jurisdiction.

Certain areas not in Special Flood Hazard Areas may be protected by **flood control structures.** Refer to Section 2.4 "Flood Protection Measures" of the Flood Insurance Study report for information on flood control structures for this jurisdiction.

The **projection** used in the preparation of this map was Universal Transverse Mercator (UTM) zone 11. The **horizontal datum** was NAD83, GRS1980 spheroid. Differences in datum, spheroid, projection or UTM zones used in the production of FIRMs for adjacent jurisdictions may result in slight positional differences in map features across jurisdiction boundaries. These differences do not affect the accuracy of this FIRM.

Flood elevations on this map are referenced to the North American Vertical Datum of 1988. These flood elevations must be compared to structure and ground elevations referenced to the same **vertical datum.** For information regarding conversion between the National Geodetic Vertical Datum of 1929 and the North American Vertical Datum of 1988, visit the National Geodetic Survey website at http://www.ngs.noaa.gov/ or contact the National Geodetic Survey at the following address:

NGS Information Services
NOAA, N/NGS12
National Geodetic Survey
SSMC–3, #9202
1315 East–West Highway
Silver Spring, MD 20910–3282

To obtain current elevation, description, and/or location information for **bench marks** shown on this map, please contact the Information Services Branch of the National Geodetic Survey at **(301) 713–3242,** or visit its website at http://www.ngs.noaa.gov/.

Base map information shown on this FIRM was derived from U.S. Geological Survey Digital Orthophoto Quadrangles produced at a scale of 1:12,000 from photography dated 1994 or later and from National Geospatial Intelligence Agency imagery produced at a scale of 1:4,000 from photography dated 2003 or later.

This map reflects more detailed and up–to–date **stream channel configurations** than those shown on the previous FIRM for this jurisdiction. The floodplains and floodways that were transferred from the previous FIRM may have been adjusted to conform to these new stream channel configurations. As a result, the Flood Profiles and Floodway Data tables *in the Flood Insurance Study report (which contains authoritative hydraulic data*) may reflect stream channel distances that differ from what is shown on this map.

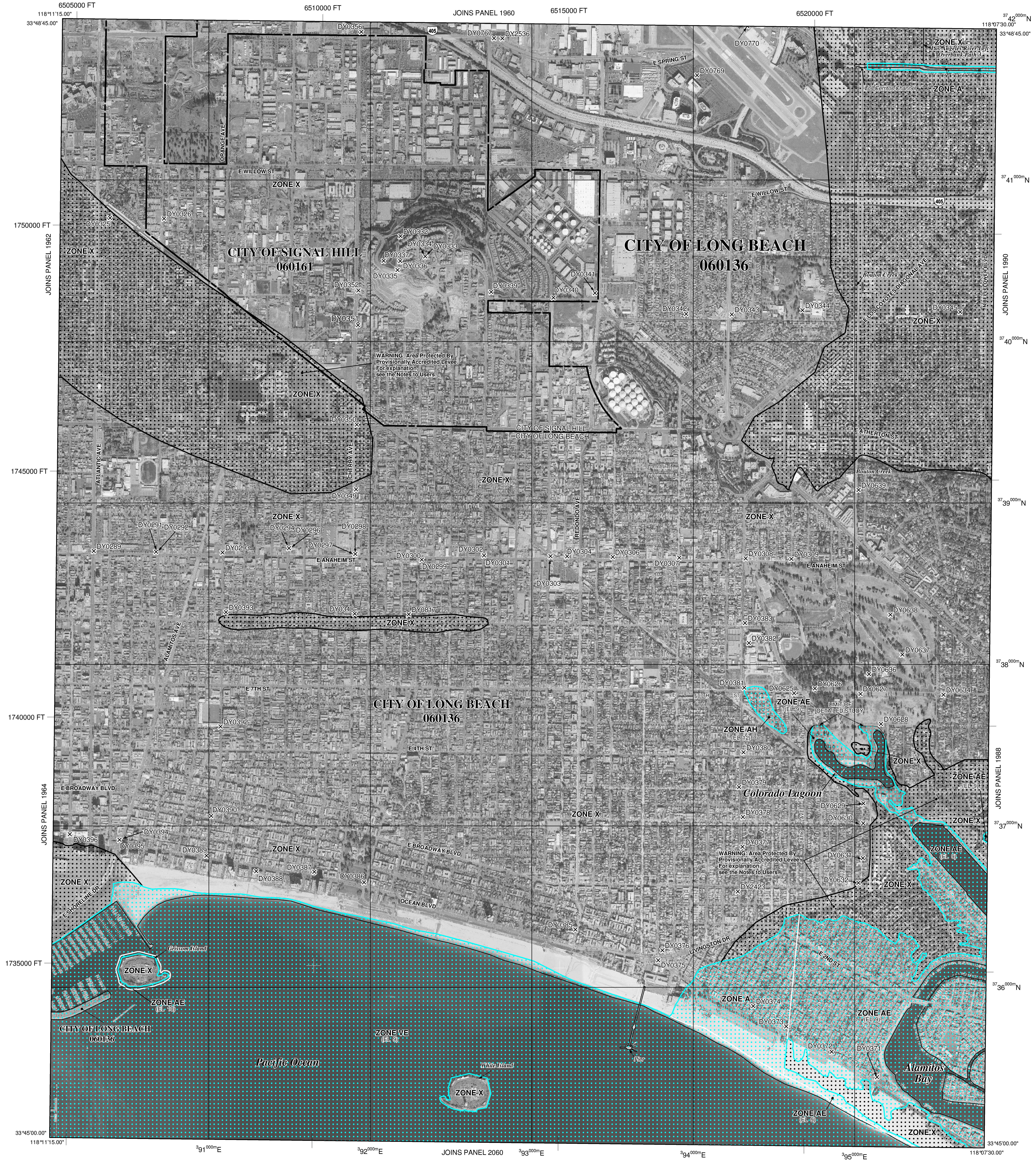
Corporate limits shown on this map are based on the best data available at the time of publication. Because changes due to annexations or de–annexations may have occurred after this map was published, map users should contact appropriate community officials to verify current corporate limit locations.

Please refer to the separately printed **Map Index** for an overview map of the county showing the layout of map panels; community map repository addresses; and a Listing of Communities table containing National Flood Insurance Program dates for each community as well as a listing of the panels on which each community is located.

Contact the **FEMA Map Service Center** at 1–800–358–9616 for information on available products associated with this FIRM. Available products may include previously issued Letters of Map Change, *a Flood Insurance Study report*, and/or digital versions of this map. The FEMA Map Service Center may also be reached by Fax at 1–800–358–9620 and its website at http://www.msc.fema.gov/.

If you have **questions about this map** or questions concerning the National Flood Insurance Program in general, please call **1–877–FEMA MAP** (1–877–336–2627) or visit the FEMA website at http://www.fema.gov/.

WARNING: This levee, dike, or other structure has been provisionally accredited and mapped as providing protection from the 1-percent-annual-chance flood. To maintain accreditation, the levee owner or community is required to submit documentation necessary to comply with 44 CFR Section 65.10 by October 16, 2009. Because of the risk of overtopping or failure of the structure, communities should take proper precautions to protect lives and minimize damages in these areas, such as issuing an evacuation plan and encouraging property owners to purchase flood insurance.



LEGEND

▨ SPECIAL FLOOD HAZARD AREAS (SFHAs) SUBJECT TO INUNDATION BY THE 1% ANNUAL CHANCE FLOOD

The 1% annual chance flood (100-year flood), also known as the base flood, is the flood that has a 1% chance of being equaled or exceeded in any given year. The Special Flood Hazard Area is the area subject to flooding by the 1% annual chance flood. Areas of Special Flood Hazard include Zones A, AE, AH, AO, AR, A99, V and VE. The Base Flood Elevation is the water-surface elevation of the 1% annual chance flood.

ZONE A	No Base Flood Elevations determined.
ZONE AE	Base Flood Elevations determined.
ZONE AH	Flood depths of 1 to 3 feet (usually areas of ponding); Base Flood Elevations determined.
ZONE AO	Flood depths of 1 to 3 feet (usually sheet flow on sloping terrain); average depths determined. For areas of alluvial fan flooding, velocities also determined.
ZONE AR	Special Flood Hazard Area formerly protected from the 1% annual chance flood by a flood control system that was subsequently decertified. Zone AR indicates that the former flood control system is being restored to provide protection from the 1% annual chance or greater flood.
ZONE A99	Area to be protected from 1% annual chance flood by a Federal flood protection system under construction; no Base Flood Elevations determined.
ZONE V	Coastal flood zone with velocity hazard (wave action); no Base Flood Elevations determined.
ZONE VE	Coastal flood zone with velocity hazard (wave action); Base Flood Elevations determined.

▨ FLOODWAY AREAS IN ZONE AE

The floodway is the channel of a stream plus any adjacent floodplain areas that must be kept free of encroachment so that the 1% annual chance flood can be carried without substantial increases in flood heights.

▨ OTHER FLOOD AREAS

ZONE X	Areas of 0.2% annual chance flood; areas of 1% annual chance flood with average depths of less than 1 foot or with drainage areas less than 1 square mile; and areas protected by levees from 1% annual chance flood.

☐ OTHER AREAS

ZONE X	Areas determined to be outside the 0.2% annual chance floodplain.
ZONE D	Areas in which flood hazards are undetermined, but possible.

▨ COASTAL BARRIER RESOURCES SYSTEM (CBRS) AREAS

▨ OTHERWISE PROTECTED AREAS (OPAs)

CBRS areas and OPAs are normally located within or adjacent to Special Flood Hazard Areas.

———	1% annual chance floodplain boundary
———	0.2% annual chance floodplain boundary
— — —	Floodway boundary
– ——— ——— –	Zone D boundary
●●●●●●●●●●●●●●●●	CBRS and OPA boundary
▨ ←	Boundary dividing Special Flood Hazard Areas of different Base Flood Elevations, flood depths or flood velocities.
~~ *513* ~~~~	Base Flood Elevation line and value; elevation in feet*
(EL 987)	Base Flood Elevation value where uniform within zone; elevation in feet*

* Referenced to the North American Vertical Datum of 1988 (NAVD 88)

Ⓐ———Ⓐ	Cross section line
㉓- - - - - - - -㉓	Transect line
97°07'30", 32°22'30"	Geographic coordinates referenced to the North American Datum of 1983 (NAD 83)
$^{42}75^{000m}$N	1000-meter Universal Transverse Mercator grid values, zone 11
6000000 FT	5000-foot grid ticks: California State Plane coordinate system, V zone (FIPSZONE 0405), Lambert Conformal Conic
DX5510 ×	Bench mark (see explanation in Notes to Users section of this FIRM panel)
● M1.5	River Mile

MAP REPOSITORIES
Refer to Map Repositories list on Map Index

EFFECTIVE DATE OF COUNTYWIDE
FLOOD INSURANCE RATE MAP
September 26, 2008
EFFECTIVE DATE(S) OF REVISION(S) TO THIS PANEL

For community map revision history prior to countywide mapping, refer to the Community Map History table located in the Flood Insurance Study report for this jurisdiction.

To determine if flood insurance is available in this community, contact your insurance agent or call the National Flood Insurance Program at 1–800–638–6620.

N

MAP SCALE 1" = 1000'

500 0 1000 2000 FEET

300 0 300 600 METERS

NFIP

NATIONAL FLOOD INSURANCE PROGRAM

PANEL 1970F

FIRM

FLOOD INSURANCE RATE MAP

LOS ANGELES COUNTY, CALIFORNIA

AND INCORPORATED AREAS

PANEL 1970 OF 2350
(SEE MAP INDEX FOR FIRM PANEL LAYOUT)

CONTAINS:

COMMUNITY	NUMBER	PANEL	SUFFIX
LONG BEACH, CITY OF	060136	1970	F
SIGNAL HILL, CITY OF	060161	1970	F

Notice to User: The **Map Number** shown below should be used when placing map orders; the **Community Number** shown above should be used on insurance applications for the subject community.

**MAP NUMBER
06037C1970F**

**EFFECTIVE DATE
SEPTEMBER 26, 2008**

Federal Emergency Management Agency

APPENDIX G

OPERATION AND MAINTENANCE (O&M) PLAN

Operation and Maintenance (O&M) Plan

Low Impact Development Plan (LID Plan)
for

SIGNAL HILL BUSINESS PARK PROJECT

E. 21st Street and Walnut Avenue
Signal Hill, CA 90755

Appendix G, Operation and Maintenance Plan
Note: OWNER = Signal Hill XC, LLC

Source / Quality Control Measure Applicable?	Source / Quality Control Name and Implementation, Maintenance and Inspection Procedures	Implementation, Maintenance, and Inspection Frequency and Schedule	Person or Entity with Operation & Maintenance Responsibility
Non-Structural Source Control Measures			
Y	N1. Education for Property Owners, Tenants and Occupants The Owner will review the environmental awareness educational materials and Source Control Measure Fact Sheets included in Appendix I of the Project LID Plan prior to or during the commencement of operations. Among other things, these materials will inform the Owner of the impacts of dumping oil, paints, solvents or other potentially harmful chemicals into the storm drain; the proper use and management of fertilizers, pesticides and herbicides in landscaping practices; the impacts of littering and improper watering; and proper maintenance practices for the business.	Frequency: Upon owner occupancy, and annually thereafter	Signal Hill XC, LLC (Owner) 3010 Old Ranch Parkway, Suite 470 Seal Beach, CA 90740 (562) 284-5005 Contact: Steven Christie StevenC@xebecrealty.com

Source / Quality Control Measure Applicable?	Source / Quality Control Name and Implementation, Maintenance and Inspection Procedures	Implementation, Maintenance, and Inspection Frequency and Schedule	Person or Entity with Operation & Maintenance Responsibility
Y	N2. Activity Restrictions The Owner shall identify surface water quality protection requirements to ensure that surface water quality activities shall be conducted in conformance with the Project LID Plan as it relates to the handling and disposal of contaminants and, through the use of lease terms, employee training manuals or another equally effective method, shall develop corresponding use restrictions. The use restrictions shall include, but not be limited to, the following: (a) The Owner shall periodically provide to his employees environmental awareness education materials made available by the local municipalities. These materials will describe the use of chemicals (including pesticides and fertilizers) that should be limited to the covered property with no discharge of specified wastes via hosing or other direct discharge to gutter, catch basins, settling basins and storm drains. (b) The Owner shall require the use of fertilizers and pesticides to be in strict conformance with City and County guidelines. (c) The Owner shall prohibit the discharge of leaf litter, grass clippings, trash, animal wastes, paint, or masonry wastes to streets or storm drain systems. (d) The Owner shall prohibit hosing down any paved surface where the result would be the flow of non-storm water into the street or storm drains. (e) The Owner shall prohibit oil changing or other auto repairs that could discharge pollutants.	Frequency: Continuous	Signal Hill XC, LLC (Owner) 3010 Old Ranch Parkway, Suite 470 Seal Beach, CA 90740 (562) 284-5005 Contact: Steven Christie StevenC@xebecrealty.com

Source / Quality Control Measure Applicable?	Source / Quality Control Name and Implementation, Maintenance and Inspection Procedures	Implementation, Maintenance, and Inspection Frequency and Schedule	Person or Entity with Operation & Maintenance Responsibility
Y	N3. Common Area Landscape Management Management programs will be designed and implemented by the Owner to maintain all of the landscaped areas within the project site. These programs will include how to mitigate the potential dangers of fertilizer and pesticide usage, require that fertilizer and pesticide usage shall be consistent with City and County guidelines, discuss utilization of water-efficient landscaping practices, require that maintenance be consistent with the County water conservation guidelines or the City equivalent, and detail the proper disposal of landscape wastes. The Owner shall implement irrigation and landscaping which will utilize moisture sensors, smart timers, rain shut-off valves and the grouping of plants with similar water requirements in order to prevent excess irrigation and its corresponding runoff. The Owner shall also maintain erosion control devices on the property until adequate vegetation coverage has been achieved following establishment of the landscape plantings. The Owner shall also perform periodic inspection and adjustment of the automatic irrigation system for valve and sprinkler operation and irrigation spray heads for damage as necessary to ensure adequate moisture delivery without allowing overspray or excessive watering that would lead to unnecessary runoff.	Frequency: Weekly	Signal Hill XC, LLC (Owner) 3010 Old Ranch Parkway, Suite 470 Seal Beach, CA 90740 (562) 284-5005 Contact: Steven Christie StevenC@xebecrealty.com

Source / Quality Control Measure Applicable?	Source / Quality Control Name and Implementation, Maintenance and Inspection Procedures	Implementation, Maintenance, and Inspection Frequency and Schedule	Person or Entity with Operation & Maintenance Responsibility
Y	N4. Maintenance of Source Control and Stormwater Quality Control Measures The Owner shall be responsible for implementation of each applicable non-structural source control measure as well as scheduling inspection and maintenance cleaning of all applicable structural source control and stormwater quality control measures. The Owner, through its landscape or other maintenance contractor, will be responsible for inspection and maintenance activities in landscape areas. Debris and other water pollutants will be controlled, contained and disposed of in a proper manner by the maintenance contractor.	Frequency: Continuous	Signal Hill XC, LLC (Owner) 3010 Old Ranch Parkway, Suite 470 Seal Beach, CA 90740 (562) 284-5005 Contact: Steven Christie StevenC@xebecrealty.com
N	N5. Title 22 CCR Compliance		
N	N6. Local Water Quality Permit Compliance		
Y	N7. Spill Contingency Plan The Owner shall prepare a Spill Contingency Plan which will describe how the employees are to respond to spills of hazardous and/or polluting materials. The plan will require cleanup materials to be stored on-site and the proper disposal of any utilized cleanup materials.	Frequency: Continuous	Signal Hill XC, LLC (Owner) 3010 Old Ranch Parkway, Suite 470 Seal Beach, CA 90740 (562) 284-5005 Contact: Steven Christie StevenC@xebecrealty.com

Source / Quality Control Measure Applicable?	Source / Quality Control Name and Implementation, Maintenance and Inspection Procedures	Implementation, Maintenance, and Inspection Frequency and Schedule	Person or Entity with Operation & Maintenance Responsibility
N	N8. Underground Storage Tank Compliance		
N	N9. Hazardous Materials Disclosure Compliance		
Y	N10. Uniform Fire Code Implementation The Owner shall comply with Article 80 of the Uniform Fire Code which is which is enforced by the fire protection agency.	Frequency: Continuous	Signal Hill XC, LLC (Owner) 3010 Old Ranch Parkway, Suite 470 Seal Beach, CA 90740 (562) 284-5005 Contact: Steven Christie StevenC@xebecrealty.com
Y	N11. Common Area Litter Control Seven outdoor trash enclosures will be provided at the project. The Owner will be responsible to provide or arrange for weekly sweeping and trash pick-up at the site. The Owner may contract with its landscape or other maintenance contractor to perform these duties, as well as to conduct weekly inspections of all trash receptacles to make sure lids are closed and pick-up of any excess trash on the ground has occurred, and to note and investigate any trash disposal violations. As part of the litter control maintenance activities, the biofiltration planters will be routinely inspected and all trash and debris will be removed to prevent blockage.	Frequency: Weekly	Signal Hill XC, LLC (Owner) 3010 Old Ranch Parkway, Suite 470 Seal Beach, CA 90740 (562) 284-5005 Contact: Steven Christie StevenC@xebecrealty.com

Source / Quality Control Measure Applicable?	Source / Quality Control Name and Implementation, Maintenance and Inspection Procedures	Implementation, Maintenance, and Inspection Frequency and Schedule	Person or Entity with Operation & Maintenance Responsibility
Y	N12. Employee Training The Owner shall establish an education program for its employees and/or contractors to inform and train personnel engaged in maintenance activities regarding the impact of dumping oil, paints, solvents or other potentially harmful chemicals into the storm drain; the proper use of fertilizers and pesticides in landscaping maintenance practices; and the impacts of littering and improper water disposal.	. Frequency: Annually	Signal Hill XC, LLC (Owner) 3010 Old Ranch Parkway, Suite 470 Seal Beach, CA 90740 (562) 284-5005 Contact: Steven Christie StevenC@xebecrealty.com
N	N13. Housekeeping of Loading Docks		
Y	N14. Common Area Catch Basin Inspection Catch basin inlets shall be inspected and, if necessary, cleaned prior to the storm season by October 1st each year and after all major storm events.	Frequency: Annually and Immediately After Major Storm Events	Signal Hill XC, LLC (Owner) 3010 Old Ranch Parkway, Suite 470 Seal Beach, CA 90740 (562) 284-5005 Contact: Steven Christie StevenC@xebecrealty.com

Source / Quality Control Measure Applicable?	Source / Quality Control Name and Implementation, Maintenance and Inspection Procedures	Implementation, Maintenance, and Inspection Frequency and Schedule	Person or Entity with Operation & Maintenance Responsibility
Y	N15. Street Sweeping Private Streets and Parking Lots The Owner, through its employees and/or landscaping or other maintenance contractor, shall sweep all private streets, parking areas and drive aisles within the project at least once a month, or more often if needed. Debris, sediment and trash picked up during sweeping operations will be deposited in the trash receptacles.	Frequency: Monthly or More Often if Needed	Signal Hill XC, LLC (Owner) 3010 Old Ranch Parkway, Suite 470 Seal Beach, CA 90740 (562) 284-5005 Contact: Steven Christie StevenC@xebecrealty.com

Source / Quality Control Measure Applicable?	Source / Quality Control Name and Implementation, Maintenance and Inspection Procedures	Implementation, Maintenance, and Inspection Frequency and Schedule	Person or Entity with Operation & Maintenance Responsibility
Structural Source Control BMPs			
Y	S1. Storm Drain Message and Signage The Owner is responsible for labeling all of the project's storm drain inlets and catch basins with the phrase, “NO DUMPING! DRAINS TO OCEAN,” or an equally effective phrase, to alert the public to the destination of pollutants discharged into storm water. This signage is to be included on the project plans. The signage and stenciling shall be maintained for legibility by the Owner.	Frequency: Continuous	Signal Hill XC, LLC (Owner) 3010 Old Ranch Parkway, Suite 470 Seal Beach, CA 90740 (562) 284-5005 Contact: Steven Christie StevenC@xebecrealty.com
N	S2. Outdoor Material Storage Area		

Source / Quality Control Measure Applicable?	Source / Quality Control Name and Implementation, Maintenance and Inspection Procedures	Implementation, Maintenance, and Inspection Frequency and Schedule	Person or Entity with Operation & Maintenance Responsibility
Y	S3. Outdoor Trash Storage / Waste Handling Area Seven outdoor trash enclosures are proposed for this site and their locations are depicted on the Site Plan included in Section 6 of the LID Plan. The proposed trash enclosure areas will be paved with Portland cement concrete or an equivalent impervious surface, and have been designed to not allow run-on from adjoining areas and to divert drainage from adjoining roofs and pavements around the trash enclosure areas. The trash enclosures shall also provide a solid roof to prevent direct precipitation, and the trash area drains will not connect to the municipal storm drain system. In conjunction with maintenance activities, the Owner will be responsible for inspecting the trash enclosures on a weekly basis to ensure that no hazardous materials or other inappropriate materials are being disposed of, and to ensure that trash is not allowed to overflow the provided bins. The Owner shall schedule trash pick-up for disposal of dumpster(s) and free standing trash receptacles weekly of each year. The Owner shall also post signs on or near the dumpsters with the words “Do not dump hazardous materials here” or similar. The Owner shall also repair or replace leaky receptacles.	Frequency: Weekly	Signal Hill XC, LLC (Owner) 3010 Old Ranch Parkway, Suite 470 Seal Beach, CA 90740 (562) 284-5005 Contact: Steven Christie StevenC@xebecrealty.com

Source / Quality Control Measure Applicable?	Source / Quality Control Name and Implementation, Maintenance and Inspection Procedures	Implementation, Maintenance, and Inspection Frequency and Schedule	Person or Entity with Operation & Maintenance Responsibility
N	S.4 Outdoor Loading / Unloading Dock Area		
N	S.5 Outdoor Vehicle / Equipment Repair / Maintenance Area		
N	S.6 Outdoor Vehicle / Equipment / Accessory Wash Area		
N	S.7 Fuel & Maintenance Area		

Source / Quality Control Measure Applicable?	Source / Quality Control Name and Implementation, Maintenance and Inspection Procedures	Implementation, Maintenance, and Inspection Frequency and Schedule	Person or Entity with Operation & Maintenance Responsibility
Y	S8. Landscape Irrigation Practices The Owner shall direct its landscaping architect to design the timing and application methods of irrigation water to minimize the runoff of excess irrigation water into the municipal storm drain system, and to choose plants that minimize the need for fertilizer and pesticides. The following methods to reduce excessive irrigation runoff shall be incorporated where determined applicable and feasible: 1. Employing rain shutoff devices to prevent irrigation after precipitation. 2. Designing irrigation systems to each landscape area's specific water requirements. 3. Using flow reducers or shutoff valves triggered by a pressure drop to control water loss in the event of broken sprinkler heads or lines.4. Implementing a landscape plan consistent with County water conservation guidelines or city equivalent, which may include provision of water sensors, programmable irrigation times (for short cycles), etc. 4. Implementing a landscape plan consistent with County water conservation guidelines or city equivalent, which may include provision of water sensors, programmable irrigation times (for short cycles), etc. 5. The timing and application methods of irrigation water shall be designed to minimize the runoff of excess irrigation water into the municipal storm drain system. 6. Employing other comparable, equally effective, methods to reduce irrigation water runoff.	Frequency: Monthly	Signal Hill XC, LLC (Owner) 3010 Old Ranch Parkway, Suite 470 Seal Beach, CA 90740 (562) 284-5005 Contact: Steven Christie StevenC@xebecrealty.com

Source / Quality Control Measure Applicable?	Source / Quality Control Name and Implementation, Maintenance and Inspection Procedures	Implementation, Maintenance, and Inspection Frequency and Schedule	Person or Entity with Operation & Maintenance Responsibility
Y	S8. Landscape Irrigation Practices (Continued) 7. Group plants with similar water requirements in order to reduce excess irrigation runoff and promote surface filtration. Choose plants with low irrigation requirements (for example, native or drought tolerant species). Utilize other design features, such as: (a) Use mulches (such as wood chips or shredded wood products) in planter areas without ground cover to minimize sediment in runoff. (b) Install appropriate plant materials for the location, in accordance with amount of sunlight and climate, and use native plant material where possible and/or as recommended by the landscape architect. (c) Leave a vegetative barrier along the property boundary and interior watercourses, to act as a pollutant filter, where appropriate and feasible. The Owner shall be responsible for implementing and maintaining efficient irrigation systems for all landscaping including but not limited to provisions for water sensors, programmable irrigation cycles, and rain shutoff devices. The irrigation systems shall comply with local and statewide ordinances related to irrigation efficiency. The Owner shall also be responsible for the installation and maintenance of all landscape areas utilizing similar planting materials with similar water requirements to reduce excess irrigation runoff.		

Source / Quality Control Measure Applicable?	Source / Quality Control Name and Implementation, Maintenance and Inspection Procedures	Implementation, Maintenance, and Inspection Frequency and Schedule	Person or Entity with Operation & Maintenance Responsibility
Y	S9. Building Materials Selection The Owner shall direct its architect to minimize the use of copper and galvanized (zinc-coated) metals on buildings and fencing to reduce leaching of these pollutants into stormwater runoff. Pressure-treated wood (which is typically treated using arsenate, copper, and chromium compounds) shall also be avoided as a building material.	Frequency: Continuous	Signal Hill XC, LLC (Owner) 3010 Old Ranch Parkway, Suite 470 Seal Beach, CA 90740 (562) 284-5005 Contact: Steven Christie StevenC@xebecrealty.com
N	S10. Animal Care and Handling Facilities .		
N	S11. Outdoor Horticulture Areas		

Stormwater Quality Control Measure Name and Implementation, Maintenance and Inspection Procedures	Implementation, Maintenance, and Inspection Frequency and Schedule	Person or Entity with Operation & Maintenance Responsibility
LID Stormwater Quality Control Measures		
Stormwater Quality Control Measure #1—Proprietary Treatment Control Measures (Proprietary Catch Basin Filter Inserts — Pretreatment for Biofiltration) (LID Standards Manual Fact Sheet T-6) (Kristar FloGard +Plus Catch Basin Filter Inserts or Approved Equivalent) Twice a year, prior to and after the rainy season, and after major storm events, the catch basin filter inserts shall be visually inspected for damage, have all sediment and debris removed, and the filter medium pouches shall be replaced if necessary. The owner may conduct this maintenance itself, or may enter into a service contract for the maintenance of the filter inserts as detailed in the Kristar FloGard +Plus Specifications /Maintenance Requirements brochure, a copy of which is attached hereto.	Frequency: Every Six Months (Approximately April 1st and October 1st) and Immediately After Major Storm Events	Signal Hill XC, LLC (Owner) 3010 Old Ranch Parkway, Suite 470 Seal Beach, CA 90740 (562) 284-5005 Contact: Steven Christie StevenC@xebecrealty.com
Stormwater Quality Control Measure #2—Biofiltration (LID Standards Manual Fact Sheet BIO-1) The biofiltration planters shall be visually inspected weekly and immediately after major storm events to remove collected sediment, litter and foreign debris, and to replace plants, mulch and/or planting media and prune vegetation if necessary. Overflow devices shall also be inspected weekly and any obstructions removed. The owner shall require the landscape contractor to perform routine maintenance of the vegetation and irrigation in the biofiltration planters. The biofiltration planters shall be planted with vegetation that will not require the application of fertilizers and pesticides. Annual inspections of the underdrains shall be conducted utilizing the designed inspection ports. The underdrains shall be cleaned when inspection reveals that accumulated sediment is clogging the system.	Frequency of Biofiltration Area Maintenance: Weekly And Immediately After Major Storm Events Frequency of Underdrain Maintenance: Annually, prior to October 15th	Signal Hill XC, LLC (Owner) 3010 Old Ranch Parkway, Suite 470 Seal Beach, CA 90740 (562) 284-5005 Contact: Steven Christie StevenC@xebecrealty.com

Stormwater Quality Control Measure Name and Implementation, Maintenance and Inspection Procedures	Implementation, Maintenance, and Inspection Frequency and Schedule	Person or Entity with Operation & Maintenance Responsibility
LID Stormwater Quality Control Measures		
Stormwater Quality Control Measure #3—Sump Pumps (HCP Pumps America Sump Pumps Installed in PSI Lift Stations, or Approved Equivalent) Twice a year, prior to and after the rainy season, the lift stations and sump pumps shall be visually inspected and maintained as set forth in the attached manufacturer's maintenance sheet.	Frequency: Every Six Months (Approximately April 1st and October 1st)	Signal Hill XC, LLC (Owner) 3010 Old Ranch Parkway, Suite 470 Seal Beach, CA 90740 (562) 284-5005 Contact: Steven Christie StevenC@xebecrealty.com

Required Permits

No permits are required for the implementation, operation, and maintenance of the Source Control or Stormwater Quality Control Measures described in this plan.

Recordkeeping

All records must be maintained for at least five (5) years and must be made available for review upon request.

APPENDIX H

RECORD OF IMPLEMENTATION, MAINTENANCE AND INSPECTION OF SOURCE CONTROL AND STORMWATER QUALITY CONTROL MEASURES

RECORD OF IMPLEMENTATION, MAINTENANCE AND INSPECTION OF SOURCE CONTROL AND STORMWATER QUALITY CONTROL MEASURES

Today's Date: ______________________________

Name of Person Performing Activity (Printed): ______________________________

Signature: ______________________________

Source / Quality Control Measure Name (As Shown in O&M Plan)	Brief Description of Implementation, Maintenance, and Inspection Activity Performed

APPENDIX I

MASTER COVENANT AND AGREEMENT (MCA)

Recording requested by and mail to:

Name:
City of Signal Hill
Department of Public Works
ATTN: Director of Public Works

Address:
2175 Cherry Avenue
Signal Hill, CA 90806

Space Above This Line For Recorder's Use

MASTER COVENANT AND AGREEMENT

REGARDING ON-SITE BMP MAINTENANCE

The undersigned hereby certifies I am (we are) the owner(s) of the hereinafter legally described real property located in the City of Signal Hill, County of Los Angeles, State of California (please give legal description: assessor's ID, tract no., lot no., etc.):

APN 7210-043- 002-004, 010-014, 016-026 & 7215-009-003 & 006

Site Address **E. 21st Street & Walnut Avenue, Signal Hill, CA 90755**

Owner(s) do hereby covenant and agree to and with the City of Signal Hill to maintain all on-site structural Best Management Practices (BMPs) in accordance with the Site Map and the Operations & Maintenance (O&M) Plan set forth in Attachment 1 hereto and incorporated herein by this reference. The specific structural BMPs are listed as follows:

> **Seven (7) Kristar FloGard Plus Catch Basin Filter Inserts; Biofiltration Planter with Underdrain (679 sf); Biofiltration Planter with Underdrain (412 sf); Biofiltration Planter with Underdrain (612 sf); 60" Underground HDPE Storage Pipe (634 lf); 60" Underground HDPE Storage Pipe (297 lf); 60" Underground HDPE Storage Pipe (364 lf); One (1) HCP Pumps America Sump Pump (17 gpm); One (1) HCP Pumps America Sump Pump (8 gpm); and One (1) HCP Pumps America Sump Pump (10 gpm)**

Owner(s) shall maintain the listed drainage devices above on the property indicated and as shown on plans permitted by the City of Santa Fe Springs in a good and functional condition to safeguard the property owners and adjoining properties from damage and pollution.

Owner(s) hereby consent to inspection of the Property by an inspector authorized by the City Manager, or his or her designee, for the purpose for verifying compliance with the provisions of this Agreement.

Owner(s) shall provide printed educational materials with any sale of the property which provide information on what stormwater management facilities are present, the type(s) and location(s) of maintenance signs that are required, and how the necessary maintenance can be performed.

Owner(s) shall provide actual notice of this Agreement and its terms to any respective successor(s) in interest to the Property prior to transfer of said interest to such successor(s) in interest. This covenant and agreement shall run with the land and shall be binding upon any future owners, encumbrances, their successors, heirs or assigns and shall continue in effect until the City of Santa Fe Springs approves its termination.

Signal Hill XC, LLC
(Print Name of Property Owner and Company)

____
(Print Name of Property Owner and Company)

____
(Signature of Property Owner)

By: Gretchen Kendrick, Authorized Signatory

____
(Signature of Property Owner)

Dated this__________day of__________20 _____

CALIFORNIA ALL-PURPOSE ACKNOWLEDGEMENT

****************************** Space Below This Line For Notary's Use ******************************

A notary public or other officer completing this certificate verifies only the identity of the individual who signed the document to which this certificate is attached, and not the truthfulness, accuracy, or validity of that document.

State of ______________________________}
}
County of______________________________}

On________________________before me, ______________________________________
(Insert Name of Notary Public and Title)

personally appeared ____, who proved to me on the basis of satisfactory evidence to be the person(s) whose name(s) is/are subscribed to the within instrument and acknowledged to me that he/she/they executed the same in his/her/their authorized capacity(ies), and that by his/her/their signature(s) on the instrument the person(s), or the entity upon behalf on which the person(s) acted, executed the instrument.

I certify under PENALTY OF PERJURY under the laws of the State of California that the foregoing paragraph is true and correct.

WITNESS my hand and official seal.

Signature__________________________(Seal)

Though the information below is not required by law, it may prove valuable to persons relying on the document and could prevent fraudulent removal and reattachment of this form to another document.

Description of attached document

Title or type of document: **LID Site Plan, Operations and Maintenance (O&M) Plan, and Project Owner's Certification**

____

Document Date: ____ Number of Pages:_______________

Signer(s) Other than Named Above: ____

APPENDIX J

EDUCATIONAL MATERIALS / SOURCE CONTROL MEASURE FACT SHEETS

- **S-1 Storm Drain Message and Signage (LID Standards Manual Fact Sheet)**
- **S-3 Outdoor Trash Storage and Waste Handling Area (LID Standards Manual Fact Sheet)**
- **S-8 Landscape Irrigation Practices (LID Standards Manual Fact Sheet)**
- **S-9 Building Materials Selection (LID Standards Manual Fact Sheet)**
- **SC-11 Spill Prevention, Control & Cleanup**
- **SC-34 Waste Handling & Disposal**
- **SC-35 Safer Alternative Products**
- **SC-41 Building & Grounds Maintenance**
- **SC-42 Building Repair and Construction**
- **SC-43 Parking / Storage Area Maintenance**
- **SC-44 Drainage System Maintenance**
- **SD-10 Site Design & Landscape Planning**

S-1: Storm Drain Message and Signage

Purpose

Waste material dumped into storm drain inlets can adversely impact surface and ground waters. In fact, any material discharged into the storm drain system has the potential to significantly impact downstream receiving waters. Storm drain messages have become a popular method of alerting and reminding the public about the effects of and the prohibitions against waste disposal into the storm drain system. The signs are typically stenciled or affixed near the storm drain inlet or catch basin. The message simply informs the public that dumping of wastes into storm drain inlets is prohibited and/or that the drain ultimately discharges into receiving waters.

General Guidance

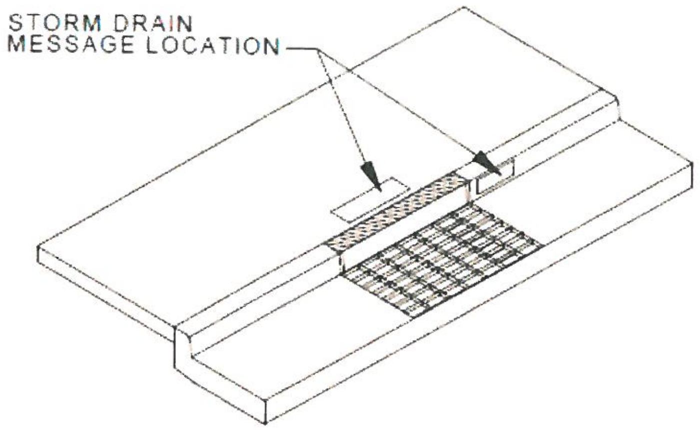
- The signs must be placed so they are easily visible to the public.
- Be aware that signs placed on sidewalk will be worn by foot traffic.

Design Specifications

- Signs with language and/or graphical icons that prohibit illegal dumping, must be posted at designated public access points along channels and streams within the project area. Consult with Los Angeles County Department of Public Works (LACDPW) staff to determine specific signage requirements for channels and streams.
- Storm drain message markers, placards, concrete stamps, or stenciled language/icons (e.g., "No Dumping – Drains to the Ocean") are required at all storm drain inlets and catch basins within the project area to discourage illegal or inadvertent dumping. Signs should be placed in clear sight facing anyone approaching the storm drain inlet or catch basin from either side (see Figure D-1 and Figure D-2). LACDPW staff should be contacted to determine specific requirements for types of signs and methods of application. A stencil can be purchased for a nominal fee from LACDPW Building and Safety Office by calling (626) 458-3171. All storm drain inlet and catch basin locations must be identified on the project site map.

Maintenance Requirements

Legibility and visibility of markers and signs should be maintained (e.g., signs should be repainted or replaced as necessary). If required by LACDPW, the owner/operator or homeowner's association shall enter into a maintenance agreement with the agency or record a deed restriction upon the property title to maintain the legibility of placards and signs.



NOTES:

1. STORM DRAIN MESSAGE SHALL BE APPLIED IN SUCH A WAY AS TO PROVIDE A CLEAR, LEGIBLE IMAGE.
2. STORM DRAIN MESSAGE SHALL BE PERMANENTLY APPLIED DURING THE CONSTRUCTION OF THE CURB AND GUTTER USING A METHOD APPROVED BY THE LOCAL AGENCY.

Figure D-1. Storm Drain Message Location – Curb Type Inlet

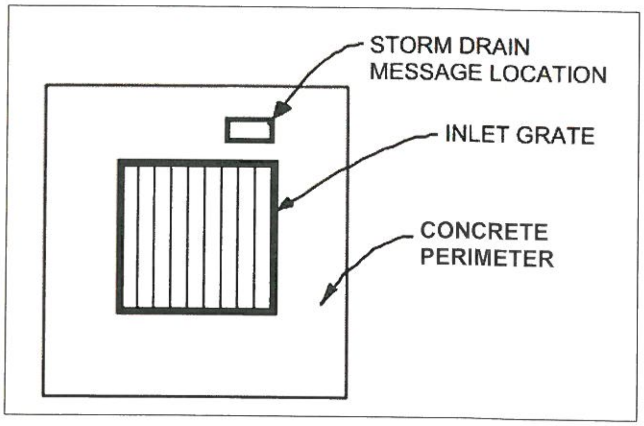


Figure D-2. Storm Drain Message Location – Catch Basin/Area Type Inlet

S-3: Outdoor Trash Storage and Waste Handling Area

Purpose

Stormwater runoff from areas where trash is stored or handled can be polluted. Loose trash and debris can be easily transported by water or wind into nearby storm drain inlets, channels, and/or receiving waters. Waste handling operations (i.e., dumpsters, litter control, waste piles) may be sources of stormwater pollution.

Design Specifications

Wastes from commercial and industrial sites are typically hauled away for disposal by either public or commercial carriers that may have design or access requirements for waste storage areas. Design specifications for waste handling areas are regulated by local building and fire codes and by current County ordinances and zoning requirements. The design specifications, listed below in Table D-3, are recommendations and are not intended to conflict with requirements established by the waste hauler. The design specifications are intended to enhance local codes and ordinances while addressing stormwater runoff concerns. The waste hauler should be contacted prior to the design of trash storage and collection areas to determine established and accepted guidelines for designing trash collection areas. All hazardous waste must be handled in accordance with the legal requirements established in Title 22 of the California Code of Regulations. Conflicts or issues should be discussed with LACDPW staff.

Table D-3. Design Specifications for Outdoor Trash Storage and Waste Handling Area

Design Feature	Design Specifications
Surfacing	• Construct/pave outdoor trash storage and waste handling area with Portland cement concrete or an equivalent impervious surface.
Screens/Covers	• Install a screen or wall around trash storage area to prevent off-site transport of loose trash. • Use lined bins or dumpsters to reduce leaking of liquid wastes. • Use waterproof lids on bins/dumpsters or provide a roof to cover storage area enclosure (LACDPW discretion) to prevent precipitation from entering containers.
Grading/Drainage	• Berm and/or grade waste handling area to prevent stormwater run-on. • Locate waste handling area at least 35 feet from storm drains. • Divert drainage from adjoining roofs and pavement away from adjacent trash storage areas.
Signs	• Post signs on all dumpsters and/or inside enclosures prohibiting disposal of liquids and hazardous materials in accordance with any waste disposal ordinance.

Accumulated Water

Stormwater runoff, non-stormwater runoff, and spills will accumulate in containment areas and sumps with impervious surfaces. Contaminated accumulated water must be disposed of in accordance with applicable laws and regulations, and cannot be discharged directly to the storm drain or sanitary sewer system without appropriate permitting. Contact LACDPW (1-888-CLEAN-LA) for information regarding discharge of contaminated accumulated water.

Maintenance Requirements

The integrity of structural elements that are subject to damage (e.g., screens, covers, signs) must be maintained by the owner/operator as required by local codes and ordinances. Outdoor trash storage and waste handling areas must be checked periodically to ensure containment of accumulated water and prevention of stormwater run-on. Maintenance agreements between LACDPW and the owner/operator may be required. Failure to properly maintain building and property may subject the property owner to citation.

S-8: Landscape Irrigation Practices

Purpose

Irrigation runoff provides a pathway for pollutants (i.e., nutrients, bacteria, organics, sediment) to enter the storm drain system. By effectively irrigating, less runoff is produced resulting in less potential for pollutants to enter the storm drain system.

General Guidance

- Do not allow irrigation runoff from the landscaped area to drain directly to storm drain system.
- Minimize use of fertilizer, pesticides, and herbicides on landscaped areas.
- Plan sites with sufficient landscaped area and dispersal capacity (e.g., ability to receive irrigation water without generating runoff).
- Consult a landscape professional regarding appropriate plants, fertilizer, mulching applications, and irrigation requirements (if any) to ensure healthy vegetation growth.

Design Specifications

- Choose plants that minimize the need for fertilizer and pesticides.
- Group plants with similar water requirements and water accordingly.
- Use mulch to minimize evaporation and erosion.
- Include a vegetative boundary around project site to act as a filter.
- Design the irrigation system to only water areas that need it.
- Install an approved subsurface drip, pop-up, or other irrigation system.[1] The irrigation system should employ effective energy dissipation and uniform flow spreading methods to prevent erosion and facilitate efficient dispersion.
- Install rain sensors to shut off the irrigation system during and after storm events.
- Include pressure sensors to shut off flow-through system in case of sudden pressure drop. A sudden pressure drop may indicate a broken irrigation head or water line.
- If the hydraulic conductivity in the soil is not sufficient for the necessary water application rate, implement soil amendments to avoid potential geotechnical hazards (i.e., liquefaction, landslide, collapsible soils, and expansive soils).

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[1] If alternative distribution systems (e.g., spray irrigation) are approved, the County will establish guidelines to implement these new systems.

- For sites located on or within 50 feet of a steep slope (15% or greater), do not irrigate landscape within three days of a storm event to avoid potential geotechnical instability.[2]
- Implement Integrated Pest Management practices.

For additional guidelines and requirements, refer to the Los Angeles County Department of Health Services.

Maintenance Requirements

Maintain irrigation areas to remove trash and debris and loose vegetation. Rehabilitate areas of bare soil. If a rain or pressure sensor is installed, it should be checked periodically to ensure proper function. Inspect and maintain irrigation equipment and components to ensure proper functionality. Clean equipment as necessary to prevent algae growth and vector breeding. Maintenance agreements between LACDPW and the owner/operator may be required. Failure to properly maintain building and property may subject the property owner to citation.

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[2] As determined by the City of Los Angeles, Building and Safety Division

S-9: Building Materials Selection

Purpose

Building materials can potentially contribute pollutants of concern to stormwater runoff through leaching. For example, metal buildings, roofing, and fencing materials may be significant sources of metals in stormwater runoff, especially due to acidic precipitation. The use of alternative building materials can reduce pollutant sources in stormwater runoff by eliminating compounds that can leach into stormwater runoff. Alternative building materials may also reduce the need to perform maintenance activities (i.e., painting) that involve pollutants of concern, and may reduce the volume of stormwater runoff. Alternative materials are available to replace lumber and paving.

Design Specifications

Lumber

Decks and other house components constructed using pressure-treated wood that is typically treated using arsenate, copper, and chromium compounds are hazardous to the environment. Pressure-treated wood may be replaced with cement-fiber or vinyl.

Roofs, Fencing, and Metals

Minimizing the use of copper and galvanized (zinc-coated) metals on buildings and fencing can reduce leaching of these pollutants into stormwater runoff. The following building materials are conventionally made of galvanized metals:

- Metal roofs;
- Chain-link fencing and siding; and
- Metal downspouts, vents, flashing, and trim on roofs.

Architectural use of copper for roofs and gutters should be avoided. As an alternative to copper and galvanized materials, coated metal products are available for both roofing and gutter application. Vinyl-coated fencing is an alternative to traditional galvanized chain-link fences. These products eliminate contact of bare metal with precipitation or stormwater runoff, and reduce the potential for stormwater runoff contamination. Roofing materials are also made of recycled rubber and plastic.

Green roofs may be an option. Green roofs use vegetation such as grasses and other plants as an exterior surface. The plants reduce the velocity of stormwater runoff and absorb water to reduce the volume of stormwater runoff. One potential problem with using green roofs in the Los Angeles County area is the long, hot and dry summers, which may kill the plants if they are not watered. See the Green Roof Fact Sheet (RET-7) in Appendix E.

Pesticides

The use of pesticides around foundations can be reduced through the use of alternative barriers. Sand barriers can be applied around foundations to deter termites, as they cannot tunnel through sand. Metal shields also block termites from tunneling. Additionally, diatomaceous earth can be used to repel or kill a wide variety of other pests.

Maintenance Requirements

The integrity of structural elements that are subject to damage (e.g., signs) must be maintained by the owner/operator as required by local codes and ordinances. Maintenance agreements between LACDPW and the owner/operator may be required. Failure to properly maintain building and property may subject the property owner to citation.

Spill Prevention, Control & Cleanup SC-11

Photo Credit: Geoff Brosseau

Objectives

- Cover
- Contain
- Educate
- Reduce/Minimize
- Product Substitution

Targeted Constituents

Sediment	
Nutrients	
Trash	
Metals	☑
Bacteria	
Oil and Grease	☑
Organics	☑

Description

Many activities that occur at an industrial or commercial site have the potential to cause accidental or illegal spills. Preparation for accidental or illegal spills, with proper training and reporting systems implemented, can minimize the discharge of pollutants to the environment.

Spills and leaks are one of the largest contributors of stormwater pollutants. Spill prevention and control plans are applicable to any site at which hazardous materials are stored or used. An effective plan should have spill prevention and response procedures that identify potential spill areas, specify material handling procedures, describe spill response procedures, and provide spill clean-up equipment. The plan should take steps to identify and characterize potential spills, eliminate and reduce spill potential, respond to spills when they occur in an effort to prevent pollutants from entering the stormwater drainage system, and train personnel to prevent and control future spills.

Approach

Pollution Prevention

- Develop procedures to prevent/mitigate spills to storm drain systems. Develop and standardize reporting procedures, containment, storage, and disposal activities, documentation, and follow-up procedures.

- Develop a Spill Prevention Control and Countermeasure (SPCC) Plan. The plan should include:

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  - Description of the facility, owner and address, activities and chemicals present
  - Facility map
  - Notification and evacuation procedures
  - Cleanup instructions
  - Identification of responsible departments
  - Identify key spill response personnel

- Recycle, reclaim, or reuse materials whenever possible. This will reduce the amount of process materials that are brought into the facility.

Suggested Protocols (including equipment needs)

Spill Prevention

- Develop procedures to prevent/mitigate spills to storm drain systems. Develop and standardize reporting procedures, containment, storage, and disposal activities, documentation, and follow-up procedures.
- If consistent illegal dumping is observed at the facility:
  - Post “No Dumping” signs with a phone number for reporting illegal dumping and disposal. Signs should also indicate fines and penalties applicable for illegal dumping.
  - Landscaping and beautification efforts may also discourage illegal dumping.
  - Bright lighting and/or entrance barriers may also be needed to discourage illegal dumping.
- Store and contain liquid materials in such a manner that if the tank is ruptured, the contents will not discharge, flow, or be washed into the storm drainage system, surface waters, or groundwater.
- If the liquid is oil, gas, or other material that separates from and floats on water, install a spill control device (such as a tee section) in the catch basins that collects runoff from the storage tank area.
- Routine maintenance:
  - Place drip pans or absorbent materials beneath all mounted taps, and at all potential drip and spill locations during filling and unloading of tanks. Any collected liquids or soiled absorbent materials must be reused/recycled or properly disposed.
  - Store and maintain appropriate spill cleanup materials in a location known to all near the tank storage area; and ensure that employees are familiar with the site’s spill control plan and/or proper spill cleanup procedures.
  - Sweep and clean the storage area monthly if it is paved, *do not hose down the area to a storm drain.*

  - Check tanks (and any containment sumps) daily for leaks and spills. Replace tanks that are leaking, corroded, or otherwise deteriorating with tanks in good condition. Collect all spilled liquids and properly dispose of them.

- Label all containers according to their contents (e.g., solvent, gasoline).

- Label hazardous substances regarding the potential hazard (corrosive, radioactive, flammable, explosive, poisonous).

- Prominently display required labels on transported hazardous and toxic materials (per US DOT regulations).

- Identify key spill response personnel.

Spill Control and Cleanup Activities

- Follow the Spill Prevention Control and Countermeasure Plan.

- Clean up leaks and spills immediately.

- Place a stockpile of spill cleanup materials where it will be readily accessible (e.g., near storage and maintenance areas).

- On paved surfaces, clean up spills with as little water as possible. Use a rag for small spills, a damp mop for general cleanup, and absorbent material for larger spills. If the spilled material is hazardous, then the used cleanup materials are also hazardous and must be sent to a certified laundry (rags) or disposed of as hazardous waste. Physical methods for the cleanup of dry chemicals include the use of brooms, shovels, sweepers, or plows.

- Never hose down or bury dry material spills. Sweep up the material and dispose of properly.

- Chemical cleanups of material can be achieved with the use of adsorbents, gels, and foams. Use adsorbent materials on small spills rather than hosing down the spill. Remove the adsorbent materials promptly and dispose of properly.

- For larger spills, a private spill cleanup company or Hazmat team may be necessary.

Reporting

- Report spills that pose an immediate threat to human health or the environment to the Regional Water Quality Control Board.

- Federal regulations require that any oil spill into a water body or onto an adjoining shoreline be reported to the National Response Center (NRC) at 800-424-8802 (24 hour).

- Report spills to local agencies, such as the fire department; they can assist in cleanup.

- Establish a system for tracking incidents. The system should be designed to identify the following:

  - Types and quantities (in some cases) of wastes

  - Patterns in time of occurrence (time of day/night, month, or year)

  - Mode of dumping (abandoned containers, “midnight dumping” from moving vehicles, direct dumping of materials, accidents/spills)

  - Responsible parties

Training

- Educate employees about spill prevention and cleanup.

- Well-trained employees can reduce human errors that lead to accidental releases or spills:

  - The employee should have the tools and knowledge to immediately begin cleaning up a spill should one occur.

  - Employees should be familiar with the Spill Prevention Control and Countermeasure Plan.

- Employees should be educated about aboveground storage tank requirements. Employees responsible for aboveground storage tanks and liquid transfers should be thoroughly familiar with the Spill Prevention Control and Countermeasure Plan and the plan should be readily available.

- Train employees to recognize and report illegal dumping incidents.

Other Considerations (Limitations and Regulations)

- A Spill Prevention Control and Countermeasure Plan (SPCC) is required for facilities that are subject to the oil pollution regulations specified in Part 112 of Title 40 of the Code of Federal Regulations or if they have a storage capacity of 10,000 gallons or more of petroleum. (Health and Safety Code 6.67)

- State regulations also exist for storage of hazardous materials (Health & Safety Code Chapter 6.95), including the preparation of area and business plans for emergency response to the releases or threatened releases.

- Consider requiring smaller secondary containment areas (less than 200 sq. ft.) to be connected to the sanitary sewer, prohibiting any hard connections to the storm drain.

Requirements

Costs (including capital and operation & maintenance)

- Will vary depending on the size of the facility and the necessary controls.

- Prevention of leaks and spills is inexpensive. Treatment and/or disposal of contaminated soil or water can be quite expensive.

Maintenance (including administrative and staffing)

- This BMP has no major administrative or staffing requirements. However, extra time is needed to properly handle and dispose of spills, which results in increased labor costs.

Supplemental Information

Further Detail of the BMP

Reporting

Record keeping and internal reporting represent good operating practices because they can increase the efficiency of the facility and the effectiveness of BMPs. A good record keeping system helps the facility minimize incident recurrence, correctly respond with appropriate cleanup activities, and comply with legal requirements. A record keeping and reporting system should be set up for documenting spills, leaks, and other discharges, including discharges of hazardous substances in reportable quantities. Incident records describe the quality and quantity of non-stormwater discharges to the storm sewer. These records should contain the following information:

- Date and time of the incident
- Weather conditions
- Duration of the spill/leak/discharge
- Cause of the spill/leak/discharge
- Response procedures implemented
- Persons notified
- Environmental problems associated with the spill/leak/discharge

Separate record keeping systems should be established to document housekeeping and preventive maintenance inspections, and training activities. All housekeeping and preventive maintenance inspections should be documented. Inspection documentation should contain the following information:

- The date and time the inspection was performed
- Name of the inspector
- Items inspected
- Problems noted
- Corrective action required
- Date corrective action was taken

Other means to document and record inspection results are field notes, timed and dated photographs, videotapes, and drawings and maps.

Aboveground Tank Leak and Spill Control

Accidental releases of materials from aboveground liquid storage tanks present the potential for contaminating stormwater with many different pollutants. Materials spilled, leaked, or lost from tanks may accumulate in soils or on impervious surfaces and be carried away by stormwater runoff.

The most common causes of unintentional releases are:

- Installation problems
- Failure of piping systems (pipes, pumps, flanges, couplings, hoses, and valves)
- External corrosion and structural failure
- Spills and overfills due to operator error
- Leaks during pumping of liquids or gases from truck or rail car to a storage tank or vice versa

Storage of reactive, ignitable, or flammable liquids should comply with the Uniform Fire Code and the National Electric Code. Practices listed below should be employed to enhance the code requirements:

- Tanks should be placed in a designated area.
- Tanks located in areas where firearms are discharged should be encapsulated in concrete or the equivalent.
- Designated areas should be impervious and paved with Portland cement concrete, free of cracks and gaps, in order to contain leaks and spills.
- Liquid materials should be stored in UL approved double walled tanks or surrounded by a curb or dike to provide the volume to contain 10 percent of the volume of all of the containers or 110 percent of the volume of the largest container, whichever is greater. The area inside the curb should slope to a drain.
- For used oil or dangerous waste, a dead-end sump should be installed in the drain.
- All other liquids should be drained to the sanitary sewer if available. The drain must have a positive control such as a lock, valve, or plug to prevent release of contaminated liquids.
- Accumulated stormwater in petroleum storage areas should be passed through an oil/water separator.

Maintenance is critical to preventing leaks and spills. Conduct routine inspections and:

- Check for external corrosion and structural failure.
- Check for spills and overfills due to operator error.
- Check for failure of piping system (pipes, pumps, flanger, coupling, hoses, and valves).
- Check for leaks or spills during pumping of liquids or gases from truck or rail car to a storage facility or vice versa.

- Visually inspect new tank or container installation for loose fittings, poor welding, and improper or poorly fitted gaskets.

- Inspect tank foundations, connections, coatings, and tank walls and piping system. Look for corrosion, leaks, cracks, scratches, and other physical damage that may weaken the tank or container system.

- Frequently relocate accumulated stormwater during the wet season.

- Periodically conduct integrity testing by a qualified professional.

Vehicle Leak and Spill Control

Major spills on roadways and other public areas are generally handled by highly trained Hazmat teams from local fire departments or environmental health departments. The measures listed below pertain to leaks and smaller spills at vehicle maintenance shops.

In addition to implementing the spill prevention, control, and clean up practices above, use the following measures related to specific activities:

Vehicle and Equipment Maintenance

- Perform all vehicle fluid removal or changing inside or under cover to prevent the run-on of stormwater and the runoff of spills.

- Regularly inspect vehicles and equipment for leaks, and repair immediately.

- Check incoming vehicles and equipment (including delivery trucks, and employee and subcontractor vehicles) for leaking oil and fluids. Do not allow leaking vehicles or equipment onsite.

- Always use secondary containment, such as a drain pan or drop cloth, to catch spills or leaks when removing or changing fluids.

- Immediately drain all fluids from wrecked vehicles.

- Store wrecked vehicles or damaged equipment under cover.

- Place drip pans or absorbent materials under heavy equipment when not in use.

- Use adsorbent materials on small spills rather than hosing down the spill.

- Remove the adsorbent materials promptly and dispose of properly.

- Promptly transfer used fluids to the proper waste or recycling drums. Don’t leave full drip pans or other open containers lying around.

- Oil filters disposed of in trashcans or dumpsters can leak oil and contaminate stormwater. Place the oil filter in a funnel over a waste oil recycling drum to drain excess oil before disposal. Oil filters can also be recycled. Ask your oil supplier or recycler about recycling oil filters.

- Store cracked batteries in a non-leaking secondary container. Do this with all cracked batteries, even if you think all the acid has drained out. If you drop a battery, treat it as if it is cracked. Put it into the containment area until you are sure it is not leaking.

Vehicle and Equipment Fueling

- Design the fueling area to prevent the run-on of stormwater and the runoff of spills:
  - Cover fueling area if possible.
  - Use a perimeter drain or slope pavement inward with drainage to a sump.
  - Pave fueling area with concrete rather than asphalt.
- If dead-end sump is not used to collect spills, install an oil/water separator.
- Install vapor recovery nozzles to help control drips as well as air pollution.
- Discourage “topping-off’ of fuel tanks.
- Use secondary containment when transferring fuel from the tank truck to the fuel tank.
- Use adsorbent materials on small spills and general cleaning rather than hosing down the area. Remove the adsorbent materials promptly.
- Carry out all Federal and State requirements regarding underground storage tanks, or install above ground tanks.
- Do not use mobile fueling of mobile industrial equipment around the facility; rather, transport the equipment to designated fueling areas.
- Keep your Spill Prevention Control and Countermeasure (SPCC) Plan up-to-date.
- Train employees in proper fueling and cleanup procedures.

Industrial Spill Prevention Response

For the purposes of developing a spill prevention and response program to meet the stormwater regulations, facility managers should use information provided in this fact sheet and the spill prevention/response portions of the fact sheets in this handbook, for specific activities. The program should:

- Integrate with existing emergency response/hazardous materials programs (e.g., Fire Department)
- Develop procedures to prevent/mitigate spills to storm drain systems
- Identify responsible departments
- Develop and standardize reporting procedures, containment, storage, and disposal activities, documentation, and follow-up procedures
- Address spills at municipal facilities, as well as public areas

- Provide training concerning spill prevention, response and cleanup to all appropriate personnel

References and Resources

California's Nonpoint Source Program Plan http://www.swrcb.ca.gov/nps/index.html

Clark County Storm Water Pollution Control Manual
http://www.co.clark.wa.us/pubworks/bmpman.pdf

King County Storm Water Pollution Control Manual http://dnr.metrokc.gov/wlr/dss/spcm.htm

Santa Clara Valley Urban Runoff Pollution Prevention Program http://www.scvurppp.org

The Stormwater Managers Resource Center http://www.stormwatercenter.net/

Waste Handling & Disposal

SC-34

Objectives

- Cover
- Contain
- Educate
- Reduce/Minimize
- Product Substitution

Targeted Constituents

Sediment	
Nutrients	
Trash	
Metals	✓
Bacteria	✓
Oil and Grease	✓
Organics	✓

Description

Improper storage and handling of solid wastes can allow toxic compounds, oils and greases, heavy metals, nutrients, suspended solids, and other pollutants to enter stormwater runoff. The discharge of pollutants to stormwater from waste handling and disposal can be prevented and reduced by tracking waste generation, storage, and disposal; reducing waste generation and disposal through source reduction, reuse, and recycling; and preventing run-on and runoff.

Approach

Pollution Prevention

- Accomplish reduction in the amount of waste generated using the following source controls:
  - Production planning and sequencing
  - Process or equipment modification
  - Raw material substitution or elimination
  - Loss prevention and housekeeping
  - Waste segregation and separation
  - Close loop recycling
- Establish a material tracking system to increase awareness about material usage. This may reduce spills and minimize contamination, thus reducing the amount of waste produced.
- Recycle materials whenever possible.

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Suggested Protocols

General

- Cover storage containers with leak proof lids or some other means. If waste is not in containers, cover all waste piles (plastic tarps are acceptable coverage) and prevent stormwater run-on and runoff with a berm. The waste containers or piles must be covered except when in use.
- Use drip pans or absorbent materials whenever grease containers are emptied by vacuum trucks or other means. Grease cannot be left on the ground. Collected grease must be properly disposed of as garbage.
- Check storage containers weekly for leaks and to ensure that lids are on tightly. Replace any that are leaking, corroded, or otherwise deteriorating.
- Sweep and clean the storage area regularly. If it is paved, do not hose down the area to a storm drain.
- Dispose of rinse and wash water from cleaning waste containers into a sanitary sewer if allowed by the local sewer authority. Do not discharge wash water to the street or storm drain.
- Transfer waste from damaged containers into safe containers.
- Take special care when loading or unloading wastes to minimize losses. Loading systems can be used to minimize spills and fugitive emission losses such as dust or mist. Vacuum transfer systems can minimize waste loss.

Controlling Litter

- Post "No Littering" signs and enforce anti-litter laws.
- Provide a sufficient number of litter receptacles for the facility.
- Clean out and cover litter receptacles frequently to prevent spillage.

Waste Collection

- Keep waste collection areas clean.
- Inspect solid waste containers for structural damage regularly. Repair or replace damaged containers as necessary.
- Secure solid waste containers; containers must be closed tightly when not in use.
- Do not fill waste containers with washout water or any other liquid.
- Ensure that only appropriate solid wastes are added to the solid waste container. Certain wastes such as hazardous wastes, appliances, fluorescent lamps, pesticides, etc., may not be disposed of in solid waste containers (see chemical/ hazardous waste collection section below).

- Do not mix wastes; this can cause chemical reactions, make recycling impossible, and complicate disposal.

Good Housekeeping

- Use all of the product before disposing of the container.
- Keep the waste management area clean at all times by sweeping and cleaning up spills immediately.
- Use dry methods when possible (e.g., sweeping, use of absorbents) when cleaning around restaurant/food handling dumpster areas. If water must be used after sweeping/using absorbents, collect water and discharge through grease interceptor to the sewer.

Chemical/Hazardous Wastes

- Select designated hazardous waste collection areas on-site.
- Store hazardous materials and wastes in covered containers and protect them from vandalism.
- Place hazardous waste containers in secondary containment.
- Make sure that hazardous waste is collected, removed, and disposed of only at authorized disposal areas.
- Stencil or demarcate storm drains on the facility's property with prohibitive message regarding waste disposal.

Run-on/Runoff Prevention

- Prevent stormwater run-on from entering the waste management area by enclosing the area or building a berm around the area.
- Prevent waste materials from directly contacting rain.
- Cover waste piles with temporary covering material such as reinforced tarpaulin, polyethylene, polyurethane, polypropyleneor hypalon.
- Cover the area with a permanent roof if feasible.
- Cover dumpsters to prevent rain from washing waste out of holes or cracks in the bottom of the dumpster.
- Move the activity indoor after ensuring all safety concerns such as fire hazard and ventilation are addressed.

Inspection

- Inspect and replace faulty pumps or hoses regularly to minimize the potential of releases and spills.
- Check waste management areas for leaking containers or spills.

- Repair leaking equipment including valves, lines, seals, or pumps promptly.

Training

- Train staff in pollution prevention measures and proper disposal methods.
- Train employees and contractors in proper spill containment and cleanup. The employee should have the tools and knowledge to immediately begin cleaning up a spill should one occur.
- Train employees and subcontractors in proper hazardous waste management.

Spill Response and Prevention

- Keep your Spill Prevention Control and Countermeasure (SPCC) Plan up-to-date.
- Have an emergency plan, equipment and trained personnel ready at all times to deal immediately with major spills
- Collect all spilled liquids and properly dispose of them.
- Store and maintain appropriate spill cleanup materials in a location known to all near the designated wash area.
- Ensure that vehicles transporting waste have spill prevention equipment that can prevent spills during transport. Spill prevention equipment includes:
    - Vehicles equipped with baffles for liquid waste
    - Trucks with sealed gates and spill guards for solid waste

Other Considerations (Limitations and Regulations)

Hazardous waste cannot be reused or recycled; it must be disposed of by a licensed hazardous waste hauler.

Requirements

Costs

Capital and O&M costs for these programs will vary substantially depending on the size of the facility and the types of waste handled. Costs should be low if there is an inventory program in place.

Maintenance

- None except for maintaining equipment for material tracking program.

Supplemental Information

Further Detail of the BMP

Land Treatment System

Minimize runoff of polluted stormwater from land application by:

- Choosing a site where slopes are under 6%, the soil is permeable, there is a low water table, it is located away from wetlands or marshes, and there is a closed drainage system

- Avoiding application of waste to the site when it is raining or when the ground is saturated with water
- Growing vegetation on land disposal areas to stabilize soils and reduce the volume of surface water runoff from the site
- Maintaining adequate barriers between the land application site and the receiving waters (planted strips are particularly good)
- Using erosion control techniques such as mulching and matting, filter fences, straw bales, diversion terracing, and sediment basins
- Performing routine maintenance to ensure the erosion control or site stabilization measures are working

Examples

The port of Long Beach has a state-of-the-art database for identifying potential pollutant sources, documenting facility management practices, and tracking pollutants.

References and Resources

California's Nonpoint Source Program Plan http://www.swrcb.ca.gov/nps/index.html

Clark County Storm Water Pollution Control Manual
http://www.co.clark.wa.us/pubworks/bmpman.pdf

Solid Waste Container Best Management Practices – Fact Sheet On-Line Resources – Environmental Health and Safety. Harvard University. 2002.

King County Storm Water Pollution Control Manual http://dnr.metrokc.gov/wlr/dss/spcm.htm

Pollution from Surface Cleaning Folder. 1996. Bay Area Stormwater Management Agencies Association (BASMAA). http://www.basmaa.org

Santa Clara Valley Urban Runoff Pollution Prevention Program http://www.scvurppp.org

The Storm Water Managers Resource Center http://www.stormwatercenter.net/

Safer Alternative Products SC-35

Description

Promote the use of less harmful products and products that contain little or no TMDL pollutants. Alternatives exist for most product classes including chemical fertilizers, pesticides, cleaning solutions, janitorial chemicals, automotive and paint products, and consumables (batteries, fluorescent lamps).

Approach

Pattern a new program after the many established programs around the state and country. Integrate this best management practice as much as possible with existing programs at your facility.

Develop a comprehensive program based on:

- The "Precautionary Principle," which is an alternative to the "Risk Assessment" model that says it's acceptable to use a potentially harmful product until physical evidence of its harmful effects are established and deemed too costly from an environmental or public health perspective. For instance, a risk assessment approach might say it's acceptable to use a pesticide until there is direct proof of an environmental impact. The Precautionary Principle approach is used to evaluate whether a given product is safe, whether it is really necessary, and whether alternative products would perform just as well.

- Environmentally Preferable Purchasing Program to minimize the purchase of products containing hazardous ingredients used in the facility's custodial services, fleet maintenance, and facility maintenance in favor of using alternate products that pose less risk to employees and to the environment.

- Integrated Pest Management (IPM) or Less-Toxic Pesticide Program, which uses a pest management approach that minimizes the use of toxic chemicals and gets rid of pests by methods that pose a lower risk to employees, the public, and the environment.

- Energy Efficiency Program including no-cost and low-cost energy conservation and efficiency actions that can reduce both energy consumption and electricity bills, along with long-term energy efficiency investments.

Consider the following mechanisms for developing and implementing a comprehensive program:

- Policies

Objectives

- Educate
- Reduce/Minimize
- Product Substitution

Targeted Constituents

Sediment	
Nutrients	✓
Trash	
Metals	✓
Bacteria	
Oil and Grease	✓
Organics	✓

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- Procedures
  - Standard operating procedures (SOPs)
  - Purchasing guidelines and procedures
  - Bid packages (services and supplies)
- Materials
  - Preferred or approved product and supplier lists
  - Product and supplier evaluation criteria
  - Training sessions and manuals
  - Fact sheets for employees

Implement this BMP in conjunction with the Vehicle and Equipment Management fact sheets (SC20 – SC22) and SC41, Building and Grounds Maintenance.

Training

- Employees who handle potentially harmful materials in the use of safer alternatives.
- Purchasing departments should be encouraged to procure less hazardous materials and products that contain little or no harmful substances or TMDL pollutants.

Regulations

This BMP has no regulatory requirements. Existing regulations already encourage facilities to reduce the use of hazardous materials through incentives such as reduced:

- Specialized equipment storage and handling requirements,
- Storm water runoff sampling requirements,
- Training and licensing requirements, and
- Record keeping and reporting requirements.

Equipment

- There are no major equipment requirements to this BMP.

Limitations

- Alternative products may not be available, suitable, or effective in every case.

Requirements

Cost Considerations

- The primary cost is for staff time to: 1) develop new policies and procedures and 2) educate purchasing departments and employees who handle potentially harmful materials about the availability, procurement, and use of safer alternatives.

- Some alternative products may be slightly more expensive than conventional products.

Supplemental Information

Employees and contractors / service providers can both be educated about safer alternatives by using information developed by a number of organizations including the references and resources listed below.

The following discussion provides some general information on safer alternatives. More specific information on particular hazardous materials and the available alternatives may be found in the references and resources listed below.

- Automotive products – Less toxic alternatives are not available for many automotive products, especially engine fluids. But there are alternatives to grease lubricants, car polishes, degreasers, and windshield washer solution. Rerefined motor oil is also available.
- Vehicle/Trailer lubrication – Fifth wheel bearings on trucks require routine lubrication. Adhesive lubricants are available to replace typical chassis grease.
- Cleaners – Vegetables-based or citrus-based soaps are available to replace petroleum-based soaps/detergents.
- Paint products – Water-based paints, wood preservatives, stains, and finishes are available.
- Pesticides – Specific alternative products or methods exist to control most insects, fungi, and weeds.
- Chemical Fertilizers – Compost and soil amendments are natural alternatives.
- Consumables – Manufacturers have either reduced or are in the process of reducing the amount of heavy metals in consumables such as batteries and fluorescent lamps. All fluorescent lamps contain mercury, however low-mercury containing lamps are now available from most hardware and lighting stores. Fluorescent lamps are also more energy efficient than the average incandescent lamp.
- Janitorial chemicals – Even biodegradable soap can harm fish and wildlife before it biodegrades. Biodegradable does not mean non-toxic. Safer products and procedures are available for floor stripping and cleaning, as well as carpet, glass, metal, and restroom cleaning and disinfecting.

Examples

There are a number of business and trade associations, and communities with effective programs. Some of the more prominent are listed below in the references and resources section.

References and Resources

Note: Many of these references provide alternative products for materials that typically are used inside and disposed to the sanitary sewer as well as alternatives to products that usually end up in the storm drain.

General Sustainable Practices and Pollution Prevention Including Pollutant-Specific Information

California Department of Toxic Substances Control (www.dtsc.ca.gov)

California Integrated Waste Management Board (www.ciwmb.ca.gov)

City of Santa Monica (www.santa-monica.org/environment)

City of Palo Alto (www.city.palo-alto.ca.us/cleanbay)

City and County of San Francisco, Department of the Environment (www.ci.sf.ca.us/sfenvironment)

Earth 911 (www.earth911.org/master.asp)

Environmental Finance Center Region IX (www.greenstart.org/efc9)

Flex Your Power (www.flexyourpower.ca.gov)

GreenBiz.com (www.greenbiz.com)

Green Business Program (www.abag.org/bayarea/enviro/gbus/gb.html)

Pacific Industrial and Business Association (www.piba.org)

Sacramento Clean Water Business Partners (www.sacstormwater.org)

USEPA BMP fact sheet – Alternative products (http://cfpub.epa.gov/npdes/stormwater/menuofbmps/poll_2.cfm)

USEPA Region IX Pollution Prevention Program (www.epa.gov/region09/p2)

Western Regional Pollution Prevention Network (www.westp2net.org)

Metals (mercury, copper)

National Electrical Manufacturers Association - Environment, Health and Safety (www.nema.org)

Sustainable Conservation (www.suscon.org)

Auto Recycling Project

Brake Pad Partnership

Pesticides and Chemical Fertilizers

Bio-Integral Resource Center (www.birc.org)

California Department of Pesticide Regulation (www.cdpr.ca.gov)

University of California Statewide IPM Program (www.ipm.ucdavis.edu/default.html)

Dioxins

Bay Area Dioxins Project (http://dioxin.abag.ca.gov/)

Building & Grounds Maintenance SC-41

Objectives

- Cover
- Contain
- Educate
- Reduce/Minimize
- Product Substitution

Targeted Constituents

Sediment	✓
Nutrients	✓
Trash	
Metals	✓
Bacteria	✓
Oil and Grease	
Organics	

Description

Stormwater runoff from building and grounds maintenance activities can be contaminated with toxic hydrocarbons in solvents, fertilizers and pesticides, suspended solids, heavy metals, abnormal pH, and oils and greases. Utilizing the protocols in this fact sheet will prevent or reduce the discharge of pollutants to stormwater from building and grounds maintenance activities by washing and cleaning up with as little water as possible, following good landscape management practices, preventing and cleaning up spills immediately, keeping debris from entering the storm drains, and maintaining the stormwater collection system.

Approach

Reduce potential for pollutant discharge through source control pollution prevention and BMP implementation. Successful implementation depends on effective training of employees on applicable BMPs and general pollution prevention strategies and objectives.

Pollution Prevention

- Switch to non-toxic chemicals for maintenance when possible.
- Choose cleaning agents that can be recycled.
- Encourage proper lawn management and landscaping, including use of native vegetation.

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- Encourage use of Integrated Pest Management techniques for pest control.
- Encourage proper onsite recycling of yard trimmings.
- Recycle residual paints, solvents, lumber, and other material as much as possible.

Suggested Protocols

Pressure Washing of Buildings, Rooftops, and Other Large Objects

- In situations where soaps or detergents are used and the surrounding area is paved, pressure washers must use a water collection device that enables collection of wash water and associated solids. A sump pump, wet vacuum or similarly effective device must be used to collect the runoff and loose materials. The collected runoff and solids must be disposed of properly.
- If soaps or detergents are not used, and the surrounding area is paved, wash runoff does not have to be collected but must be screened. Pressure washers must use filter fabric or some other type of screen on the ground and/or in the catch basin to trap the particles in wash water runoff.
- If you are pressure washing on a grassed area (with or without soap), runoff must be dispersed as sheet flow as much as possible, rather than as a concentrated stream. The wash runoff must remain on the grass and not drain to pavement.

Landscaping Activities

- Dispose of grass clippings, leaves, sticks, or other collected vegetation as garbage, or by composting. Do not dispose of collected vegetation into waterways or storm drainage systems.
- Use mulch or other erosion control measures on exposed soils.

Building Repair, Remodeling, and Construction

- Do not dump any toxic substance or liquid waste on the pavement, the ground, or toward a storm drain.
- Use ground or drop cloths underneath outdoor painting, scraping, and sandblasting work, and properly dispose of collected material daily.
- Use a ground cloth or oversized tub for activities such as paint mixing and tool cleaning.
- Clean paintbrushes and tools covered with water-based paints in sinks connected to sanitary sewers or in portable containers that can be dumped into a sanitary sewer drain. Brushes and tools covered with non-water-based paints, finishes, or other materials must be cleaned in a manner that enables collection of used solvents (e.g., paint thinner, turpentine, etc.) for recycling or proper disposal.
- Use a storm drain cover, filter fabric, or similarly effective runoff control mechanism if dust, grit, wash water, or other pollutants may escape the work area and enter a catch basin. This is particularly necessary on rainy days. The containment device(s) must be in place at the beginning of the work day, and accumulated dirty runoff and solids must be collected and disposed of before removing the containment device(s) at the end of the work day.

- If you need to de-water an excavation site, you may need to filter the water before discharging to a catch basin or off-site. If directed off-site, you should direct the water through hay bales and filter fabric or use other sediment filters or traps.

- Store toxic material under cover during precipitation events and when not in use. A cover would include tarps or other temporary cover material.

Mowing, Trimming, and Planting

- Dispose of leaves, sticks, or other collected vegetation as garbage, by composting or at a permitted landfill. Do not dispose of collected vegetation into waterways or storm drainage systems.

- Use mulch or other erosion control measures when soils are exposed.

- Place temporarily stockpiled material away from watercourses and drain inlets, and berm or cover stockpiles to prevent material releases to the storm drain system.

- Consider an alternative approach when bailing out muddy water: do not put it in the storm drain; pour over landscaped areas.

- Use hand weeding where practical.

Fertilizer and Pesticide Management

- Follow all federal, state, and local laws and regulations governing the use, storage, and disposal of fertilizers and pesticides and training of applicators and pest control advisors.

- Use less toxic pesticides that will do the job when applicable. Avoid use of copper-based pesticides if possible.

- Do not use pesticides if rain is expected.

- Do not mix or prepare pesticides for application near storm drains.

- Use the minimum amount needed for the job.

- Calibrate fertilizer distributors to avoid excessive application.

- Employ techniques to minimize off-target application (e.g., spray drift) of pesticides, including consideration of alternative application techniques.

- Apply pesticides only when wind speeds are low.

- Fertilizers should be worked into the soil rather than dumped or broadcast onto the surface.

- Irrigate slowly to prevent runoff and then only as much as is needed.

- Clean pavement and sidewalk if fertilizer is spilled on these surfaces before applying irrigation water.

- Dispose of empty pesticide containers according to the instructions on the container label.

- Use up the pesticides. Rinse containers, and use rinse water as product. Dispose of unused pesticide as hazardous waste.

- Implement storage requirements for pesticide products with guidance from the local fire department and County Agricultural Commissioner. Provide secondary containment for pesticides.

Inspection

- Inspect irrigation system periodically to ensure that the right amount of water is being applied and that excessive runoff is not occurring. Minimize excess watering and repair leaks in the irrigation system as soon as they are observed.

Training

- Educate and train employees on pesticide use and in pesticide application techniques to prevent pollution.

- Train employees and contractors in proper techniques for spill containment and cleanup.

- Be sure the frequency of training takes into account the complexity of the operations and the nature of the staff.

Spill Response and Prevention

- Keep your Spill Prevention Control and Countermeasure (SPCC) Plan up-to-date.

- Place a stockpile of spill cleanup materials, such as brooms, dustpans, and vacuum sweepers (if desired) near the storage area where it will be readily accessible.

- Have employees trained in spill containment and cleanup present during the loading/unloading of dangerous wastes, liquid chemicals, or other materials.

- Familiarize employees with the Spill Prevention Control and Countermeasure Plan.

- Clean up spills immediately.

Other Considerations

Alternative pest/weed controls may not be available, suitable, or effective in many cases.

Requirements

Costs

- Cost will vary depending on the type and size of facility.

- Overall costs should be low in comparison to other BMPs.

Maintenance

Sweep paved areas regularly to collect loose particles. Wipe up spills with rags and other absorbent material immediately, do not hose down the area to a storm drain.

Supplemental Information

Further Detail of the BMP

Fire Sprinkler Line Flushing

Building fire sprinkler line flushing may be a source of non-stormwater runoff pollution. The water entering the system is usually potable water, though in some areas it may be non-potable reclaimed wastewater. There are subsequent factors that may drastically reduce the quality of the water in such systems. Black iron pipe is usually used since it is cheaper than potable piping, but it is subject to rusting and results in lower quality water. Initially, the black iron pipe has an oil coating to protect it from rusting between manufacture and installation; this will contaminate the water from the first flush but not from subsequent flushes. Nitrates, polyphosphates and other corrosion inhibitors, as well as fire suppressants and antifreeze may be added to the sprinkler water system. Water generally remains in the sprinkler system a long time (typically a year) and between flushes may accumulate iron, manganese, lead, copper, nickel, and zinc. The water generally becomes anoxic and contains living and dead bacteria and breakdown products from chlorination. This may result in a significant BOD problem and the water often smells. Consequently dispose fire sprinkler line flush water into the sanitary sewer. Do not allow discharge to storm drain or infiltration due to potential high levels of pollutants in fire sprinkler line water.

References and Resources

California's Nonpoint Source Program Plan http://www.swrcb.ca.gov/nps/index.html

Clark County Storm Water Pollution Control Manual
http://www.co.clark.wa.us/pubworks/bmpman.pdf

King County Storm Water Pollution Control Manual http://dnr.metrokc.gov/wlr/dss/spcm.htm

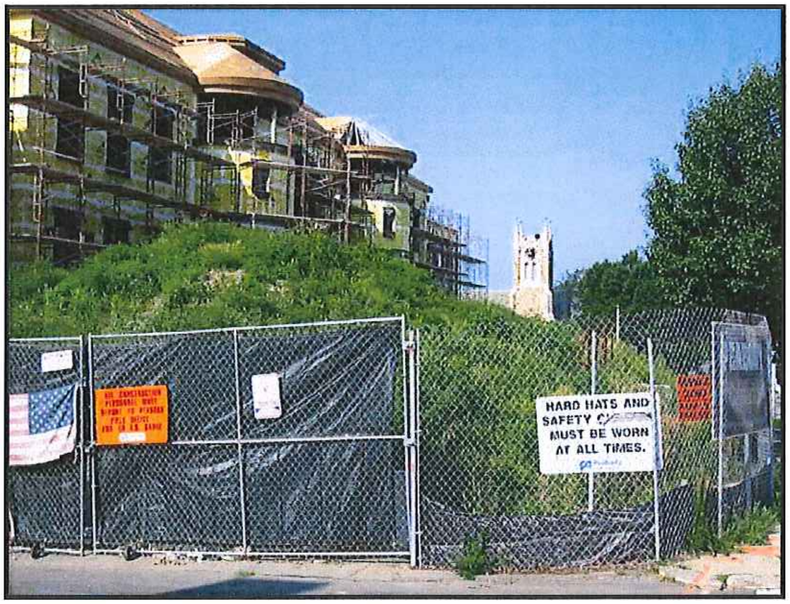
Mobile Cleaners Pilot Program: Final Report. 1997. Bay Area Stormwater Management Agencies Association (BASMAA). http://www.basmaa.org/

Pollution from Surface Cleaning Folder. 1996. Bay Area Stormwater Management Agencies Association (BASMAA). http://www.basmaa.org/

Santa Clara Valley Urban Runoff Pollution Prevention Program http://www.scvurppp.org

The Storm Water Managers Resource Center http://www.stormwatercenter.net/

Building Repair and Construction SC-42



Objectives

- Cover
- Contain
- Educate
- Reduce/Minimize
- Recycle

Targeted Constituents

Sediment	✓
Nutrients	
Trash	✓
Metals	✓
Bacteria	
Oil and Grease	✓
Organics	✓

Description

Modifications are common particularly at large industrial sites. The activity may vary from minor and normal building repair to major remodeling, or the construction of new facilities. These activities can generate pollutants including solvents, paints, paint and varnish removers, finishing residues, spent thinners, soap cleaners, kerosene, asphalt and concrete materials, adhesive residues, and old asbestos installation. Protocols in this fact sheet are intended to prevent or reduce the discharge of pollutants to stormwater from building repair, remodeling, and construction by using soil erosion controls, enclosing or covering building material storage areas, using good housekeeping practices, using safer alternative products, and training employees.

Approach

Pollution Prevention

- Recycle residual paints, solvents, lumber, and other materials to the maximum extent practical.
- Buy recycled products to the maximum extent practical.
- Inform on-site contractors of company policy on these matters and include appropriate provisions in their contract to ensure certain proper housekeeping and disposal practices are implemented.

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- Make sure that nearby storm drains are well marked to minimize the chance of inadvertent disposal of residual paints and other liquids.

Suggested Protocols

Repair & Remodeling

- Follow BMPs identified in Construction BMP Handbook.
- Maintain good housekeeping practices while work is underway.
- Keep the work site clean and orderly. Remove debris in a timely fashion. Sweep the area.
- Cover materials of particular concern that must be left outside, particularly during the rainy season.
- Do not dump waste liquids down the storm drain.
- Dispose of wash water, sweepings, and sediments properly.
- Store materials properly that are normally used in repair and remodeling such as paints and solvents.
- Sweep out the gutter or wash the gutter and trap the particles at the outlet of the downspout if when repairing roofs, small particles have accumulated in the gutter. A sock or geofabric placed over the outlet may effectively trap the materials. If the downspout is tight lined, place a temporary plug at the first convenient point in the storm drain and pump out the water with a vactor truck, and clean the catch basin sump where you placed the plug.
- Properly store and dispose waste materials generated from construction activities. See Construction BMP Handbook.
- Clean the storm drain system in the immediate vicinity of the construction activity after it is completed.

Painting

- Enclose painting operations consistent with local air quality regulations and OSHA.
- Local air pollution regulations may, in many areas of the state, specify painting procedures which if properly carried out are usually sufficient to protect water quality.
- Develop paint handling procedures for proper use, storage, and disposal of paints.
- Transport paint and materials to and from job sites in containers with secure lids and tied down to the transport vehicle.
- Test and inspect spray equipment prior to starting to paint. Tighten all hoses and connections and do not overfill paint containers.
- Mix paint indoors before using so that any spill will not be exposed to rain. Do so even during dry weather because cleanup of a spill will never be 100% effective.
- Transfer and load paint and hot thermoplastic away from storm drain inlets.

- Do not transfer or load paint near storm drain inlets.
- Plug nearby storm drain inlets prior to starting painting and remove plugs when job is complete when there is significant risk of a spill reaching storm drains.
- Cover nearby storm drain inlets prior to starting work if sand blasting is used to remove paint.
- Use a ground cloth to collect the chips if painting requires scraping or sand blasting of the existing surface. Dispose the residue properly.
- Cover or enclose painting operations properly to avoid drift.
- Clean the application equipment in a sink that is connected to the sanitary sewer if using water based paints.
- Capture all cleanup-water and dispose of properly.
- Dispose of paints containing lead or tributyl tin and considered a hazardous waste properly.
- Store leftover paints if they are to be kept for the next job properly, or dispose properly.
- Recycle paint when possible. Dispose of paint at an appropriate household hazardous waste facility.

Training

Proper education of off-site contractors is often overlooked. The conscientious efforts of well trained employees can be lost by unknowing off-site contractors, so make sure they are well informed about what they are expected to do.

Spill Response and Prevention

- Keep your Spill Prevention Control and Countermeasure (SPCC) Plan up-to-date.
- Place a stockpile of spill cleanup materials where it will be readily accessible.
- Clean up spills immediately.
- Excavate and remove the contaminated (stained) soil if a spill occurs on dirt.

Limitations

- This BMP is for minor construction only. The State's General Construction Activity Stormwater Permit has more requirements for larger projects. The companion "Construction Best Management Practice Handbook" contains specific guidance and best management practices for larger-scale projects.
- Hazardous waste that cannot be reused or recycled must be disposed of by a licensed hazardous waste hauler.
- Be certain that actions to help stormwater quality are consistent with Cal- and Fed-OSHA and air quality regulations.

Requirements

Costs

These BMPs are generally low to modest in cost.

Maintenance

N/A

Supplemental Information

Further Detail of the BMP

Soil/Erosion Control

If the work involves exposing large areas of soil, employ the appropriate soil erosion and control techniques. See the Construction Best Management Practice Handbook. If old buildings are being torn down and not replaced in the near future, stabilize the site using measures described in SC-40 Contaminated or Erodible Areas.

If a building is to be placed over an open area with a storm drainage system, make sure the storm inlets within the building are covered or removed, or the storm line is connected to the sanitary sewer. If because of the remodeling a new drainage system is to be installed or the existing system is to be modified, consider installing catch basins as they serve as effective "in-line" treatment devices. See Treatment Control Fact Sheet TC-20 Wet Pond/Basin in Section 5 of the New Development and Redevelopment Handbook regarding design criteria. Include in the catch basin a "turn-down" elbow or similar device to trap floatables.

References and Resources

California's Nonpoint Source Program Plan http://www.swrcb.ca.gov/nps/index.html

Clark County Storm Water Pollution Control Manual
http://www.co.clark.wa.us/pubworks/bmpman.pdf

King County Storm Water Pollution Control Manual http://dnr.metrokc.gov/wlr/dss/spcm.htm

Santa Clara Valley Urban Runoff Pollution Prevention Program http://www.scvurppp.org

The Storm Water Managers Resource Center http://www.stormwatercenter.net/

Parking/Storage Area Maintenance SC-43

Objectives

- Cover
- Contain
- Educate
- Reduce/Minimize
- Product Substitution

Targeted Constituents

Sediment	✓
Nutrients	
Trash	✓
Metals	✓
Bacteria	
Oil and Grease	✓
Organics	✓

Description

Parking lots and storage areas can contribute a number of substances, such as trash, suspended solids, hydrocarbons, oil and grease, and heavy metals that can enter receiving waters through stormwater runoff or non-stormwater discharges. The protocols in this fact sheet are intended to prevent or reduce the discharge of pollutants from parking/storage areas and include using good housekeeping practices, following appropriate cleaning BMPs, and training employees.

Approach

The goal of this program is to ensure stormwater pollution prevention practices are considered when conducting activities on or around parking areas and storage areas to reduce potential for pollutant discharge to receiving waters. Successful implementation depends on effective training of employees on applicable BMPs and general pollution prevention strategies and objectives.

Pollution Prevention

- Encourage alternative designs and maintenance strategies for impervious parking lots. (See New Development and Redevelopment BMP Handbook)
- Keep accurate maintenance logs to evaluate BMP implementation.

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Suggested Protocols

General

- Keep the parking and storage areas clean and orderly. Remove debris in a timely fashion.
- Allow sheet runoff to flow into biofilters (vegetated strip and swale) and/or infiltration devices.
- Utilize sand filters or oleophilic collectors for oily waste in low quantities.
- Arrange rooftop drains to prevent drainage directly onto paved surfaces.
- Design lot to include semi-permeable hardscape.
- Discharge soapy water remaining in mop or wash buckets to the sanitary sewer through a sink, toilet, clean-out, or wash area with drain.

Controlling Litter

- Post "No Littering" signs and enforce anti-litter laws.
- Provide an adequate number of litter receptacles.
- Clean out and cover litter receptacles frequently to prevent spillage.
- Provide trash receptacles in parking lots to discourage litter.
- Routinely sweep, shovel, and dispose of litter in the trash.

Surface Cleaning

- Use dry cleaning methods (e.g., sweeping, vacuuming) to prevent the discharge of pollutants into the stormwater conveyance system if possible.
- Establish frequency of public parking lot sweeping based on usage and field observations of waste accumulation.
- Sweep all parking lots at least once before the onset of the wet season.
- Follow the procedures below if water is used to clean surfaces:
  - Block the storm drain or contain runoff.
  - Collect and pump wash water to the sanitary sewer or discharge to a pervious surface. Do not allow wash water to enter storm drains.
  - Dispose of parking lot sweeping debris and dirt at a landfill.
- Follow the procedures below when cleaning heavy oily deposits:
  - Clean oily spots with absorbent materials.
  - Use a screen or filter fabric over inlet, then wash surfaces.

  - Do not allow discharges to the storm drain.
  - Vacuum/pump discharges to a tank or discharge to sanitary sewer.
  - Appropriately dispose of spilled materials and absorbents.

Surface Repair

- Preheat, transfer or load hot bituminous material away from storm drain inlets.
- Apply concrete, asphalt, and seal coat during dry weather to prevent contamination from contacting stormwater runoff.
- Cover and seal nearby storm drain inlets where applicable (with waterproof material or mesh) and manholes before applying seal coat, slurry seal, etc. Leave covers in place until job is complete and all water from emulsified oil sealants has drained or evaporated. Clean any debris from these covered manholes and drains for proper disposal.
- Use only as much water as necessary for dust control, to avoid runoff.
- Catch drips from paving equipment that is not in use with pans or absorbent material placed under the machines. Dispose of collected material and absorbents properly.

Inspection

- Have designated personnel conduct inspections of parking facilities and stormwater conveyance systems associated with parking facilities on a regular basis.
- Inspect cleaning equipment/sweepers for leaks on a regular basis.

Training

- Provide regular training to field employees and/or contractors regarding cleaning of paved areas and proper operation of equipment.
- Train employees and contractors in proper techniques for spill containment and cleanup.

Spill Response and Prevention

- Keep your Spill Prevention Control and Countermeasure (SPCC) Plan up-to-date.
- Place a stockpile of spill cleanup materials where it will be readily accessible or at a central location.
- Clean up fluid spills immediately with absorbent rags or material.
- Dispose of spilled material and absorbents properly.

Other Considerations

Limitations related to sweeping activities at large parking facilities may include high equipment costs, the need for sweeper operator training, and the inability of current sweeper technology to remove oil and grease.

Requirements

Costs

Cleaning/sweeping costs can be quite large. Construction and maintenance of stormwater structural controls can be quite expensive as well.

Maintenance

- Sweep parking lot regularly to minimize cleaning with water.
- Clean out oil/water/sand separators regularly, especially after heavy storms.
- Clean parking facilities regularly to prevent accumulated wastes and pollutants from being discharged into conveyance systems during rainy conditions.

Supplemental Information

Further Detail of the BMP

Surface Repair

Apply concrete, asphalt, and seal coat during dry weather to prevent contamination from contacting stormwater runoff. Where applicable, cover and seal nearby storm drain inlets (with waterproof material or mesh) and manholes before applying seal coat, slurry seal, etc. Leave covers in place until job is complete and all water from emulsified oil sealants has drained or evaporated. Clean any debris from these covered manholes and drains for proper disposal. Only use only as much water as is necessary for dust control to avoid runoff.

References and Resources

California's Nonpoint Source Program Plan http://www.swrcb.ca.gov/nps/index.html

Clark County Storm Water Pollution Control Manual
http://www.co.clark.wa.us/pubworks/bmpman.pdf

King County Storm Water Pollution Control Manual http://dnr.metrokc.gov/wlr/dss/spcm.htm

Pollution from Surface Cleaning Folder. 1996. Bay Area Stormwater Management Agencies Association (BASMAA). http://www.basmaa.org/

Oregon Association of Clean Water Agencies. Oregon Municipal Stormwater Toolbox for Maintenance Practices. June 1998.

Santa Clara Valley Urban Runoff Pollution Prevention Program http://www.scvurppp.org

The Storm Water Managers Resource Center http://www.stormwatercenter.net/

Drainage System Maintenance SC-44

Objectives

- Cover
- Contain
- Educate
- Reduce/Minimize

Targeted Constituents

Sediment	✓
Nutrients	
Trash	✓
Metals	
Bacteria	✓
Oil and Grease	
Organics	

Description

As a consequence of its function, the stormwater conveyance system collects and transports urban runoff and stormwater that may contain certain pollutants. The protocols in this fact sheet are intended to reduce pollutants reaching receiving waters through proper conveyance system operation and maintenance.

Approach

Pollution Prevention

Maintain catch basins, stormwater inlets, and other stormwater conveyance structures on a regular basis to remove pollutants, reduce high pollutant concentrations during the first flush of storms, prevent clogging of the downstream conveyance system, restore catch basins' sediment trapping capacity, and ensure the system functions properly hydraulically to avoid flooding.

Suggested Protocols

Catch Basins/Inlet Structures

- Staff should regularly inspect facilities to ensure compliance with the following:
  - Immediate repair of any deterioration threatening structural integrity.
  - Cleaning before the sump is 40% full. Catch basins should be cleaned as frequently as needed to meet this standard.
  - Stenciling of catch basins and inlets (see SC34 Waste Handling and Disposal).

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- Clean catch basins, storm drain inlets, and other conveyance structures before the wet season to remove sediments and debris accumulated during the summer.

- Conduct inspections more frequently during the wet season for problem areas where sediment or trash accumulates more often. Clean and repair as needed.

- Keep accurate logs of the number of catch basins cleaned.

- Store wastes collected from cleaning activities of the drainage system in appropriate containers or temporary storage sites in a manner that prevents discharge to the storm drain.

- Dewater the wastes if necessary with outflow into the sanitary sewer if permitted. Water should be treated with an appropriate filtering device prior to discharge to the sanitary sewer. If discharge to the sanitary sewer is not allowed, water should be pumped or vacuumed to a tank and properly disposed. Do not dewater near a storm drain or stream.

Storm Drain Conveyance System

- Locate reaches of storm drain with deposit problems and develop a flushing schedule that keeps the pipe clear of excessive buildup.

- Collect and pump flushed effluent to the sanitary sewer for treatment whenever possible.

Pump Stations

- Clean all storm drain pump stations prior to the wet season to remove silt and trash.

- Do not allow discharge to reach the storm drain system when cleaning a storm drain pump station or other facility.

- Conduct routine maintenance at each pump station.

- Inspect, clean, and repair as necessary all outlet structures prior to the wet season.

Open Channel

- Modify storm channel characteristics to improve channel hydraulics, increase pollutant removals, and enhance channel/creek aesthetic and habitat value.

- Conduct channel modification/improvement in accordance with existing laws. Any person, government agency, or public utility proposing an activity that will change the natural (emphasis added) state of any river, stream, or lake in California, must enter into a Steam or Lake Alteration Agreement with the Department of Fish and Game. The developer-applicant should also contact local governments (city, county, special districts), other state agencies (SWRCB, RWQCB, Department of Forestry, Department of Water Resources), and Federal Corps of Engineers and USFWS.

Illicit Connections and Discharges

- Look for evidence of illegal discharges or illicit connections during routine maintenance of conveyance system and drainage structures:

    - Is there evidence of spills such as paints, discoloring, etc?

  - Are there any odors associated with the drainage system?
  - Record locations of apparent illegal discharges/illicit connections?
  - Track flows back to potential dischargers and conduct aboveground inspections. This can be done through visual inspection of upgradient manholes or alternate techniques including zinc chloride smoke testing, fluorometric dye testing, physical inspection testing, or television camera inspection.
  - Eliminate the discharge once the origin of flow is established.

- Stencil or demarcate storm drains, where applicable, to prevent illegal disposal of pollutants. Storm drain inlets should have messages such as "Dump No Waste Drains to Stream" stenciled next to them to warn against ignorant or intentional dumping of pollutants into the storm drainage system.

- Refer to fact sheet SC-10 Non-Stormwater Discharges.

Illegal Dumping

- Inspect and clean up hot spots and other storm drainage areas regularly where illegal dumping and disposal occurs.

- Establish a system for tracking incidents. The system should be designed to identify the following:
  - Illegal dumping hot spots
  - Types and quantities (in some cases) of wastes
  - Patterns in time of occurrence (time of day/night, month, or year)
  - Mode of dumping (abandoned containers, "midnight dumping" from moving vehicles, direct dumping of materials, accidents/spills)
  - Responsible parties

- Post "No Dumping" signs in problem areas with a phone number for reporting dumping and disposal. Signs should also indicate fines and penalties for illegal dumping.

- Refer to fact sheet SC-10 Non-Stormwater Discharges.

Training

- Train crews in proper maintenance activities, including record keeping and disposal.

- Allow only properly trained individuals to handle hazardous materials/wastes.

- Have staff involved in detection and removal of illicit connections trained in the following:
  - OSHA-required Health and Safety Training (29 CFR 1910.120) plus annual refresher training (as needed).

  - OSHA Confined Space Entry training (Cal-OSHA Confined Space, Title 8 and Federal OSHA 29 CFR 1910.146).
  - Procedural training (field screening, sampling, smoke/dye testing, TV inspection).

Spill Response and Prevention

- Investigate all reports of spills, leaks, and/or illegal dumping promptly.
- Clean up all spills and leaks using "dry" methods (with absorbent materials and/or rags) or dig up, remove, and properly dispose of contaminated soil.
- Refer to fact sheet SC-11 Spill Prevention, Control, and Cleanup.

Other Considerations (Limitations and Regulations)

- Clean-up activities may create a slight disturbance for local aquatic species. Access to items and material on private property may be limited. Trade-offs may exist between channel hydraulics and water quality/riparian habitat. If storm channels or basins are recognized as wetlands, many activities, including maintenance, may be subject to regulation and permitting.
- Storm drain flushing is most effective in small diameter pipes (36-inch diameter pipe or less, depending on water supply and sediment collection capacity). Other considerations associated with storm drain flushing may include the availability of a water source, finding a downstream area to collect sediments, liquid/sediment disposal, and prohibition against disposal of flushed effluent to sanitary sewer in some areas.
- Regulations may include adoption of substantial penalties for illegal dumping and disposal.
- Local municipal codes may include sections prohibiting discharge of soil, debris, refuse, hazardous wastes, and other pollutants into the storm drain system.

Requirements

Costs

- An aggressive catch basin cleaning program could require a significant capital and O&M budget.
- The elimination of illegal dumping is dependent on the availability, convenience, and cost of alternative means of disposal. The primary cost is for staff time. Cost depends on how aggressively a program is implemented. Other cost considerations for an illegal dumping program include:
  - Purchase and installation of signs.
  - Rental of vehicle(s) to haul illegally-disposed items and material to landfills.
  - Rental of heavy equipment to remove larger items (e.g., car bodies) from channels.
  - Purchase of landfill space to dispose of illegally-dumped items and material.

- Methods used for illicit connection detection (smoke testing, dye testing, visual inspection, and flow monitoring) can be costly and time-consuming. Site-specific factors, such as the level of impervious area, the density and ages of buildings, and type of land use will determine the level of investigation necessary.

Maintenance

- Two-person teams may be required to clean catch basins with vactor trucks.
- Teams of at least two people plus administrative personnel are required to identify illicit discharges, depending on the complexity of the storm sewer system.
- Arrangements must be made for proper disposal of collected wastes.
- Technical staff are required to detect and investigate illegal dumping violations.

Supplemental Information

Further Detail of the BMP

Storm Drain Flushing

Flushing is a common maintenance activity used to improve pipe hydraulics and to remove pollutants in storm drainage systems. Flushing may be designed to hydraulically convey accumulated material to strategic locations, such as an open channel, another point where flushing will be initiated, or the sanitary sewer and the treatment facilities, thus preventing resuspension and overflow of a portion of the solids during storm events. Flushing prevents "plug flow" discharges of concentrated pollutant loadings and sediments. Deposits can hinder the designed conveyance capacity of the storm drain system and potentially cause backwater conditions in severe cases of clogging.

Storm drain flushing usually takes place along segments of pipe with grades that are too flat to maintain adequate velocity to keep particles in suspension. An upstream manhole is selected to place an inflatable device that temporarily plugs the pipe. Further upstream, water is pumped into the line to create a flushing wave. When the upstream reach of pipe is sufficiently full to cause a flushing wave, the inflated device is rapidly deflated with the assistance of a vacuum pump, thereby releasing the backed up water and resulting in the cleaning of the storm drain segment.

To further reduce impacts of stormwater pollution, a second inflatable device placed well downstream may be used to recollect the water after the force of the flushing wave has dissipated. A pump may then be used to transfer the water and accumulated material to the sanitary sewer for treatment. In some cases, an interceptor structure may be more practical or required to recollect the flushed waters.

It has been found that cleansing efficiency of periodic flush waves is dependent upon flush volume, flush discharge rate, sewer slope, sewer length, sewer flow rate, sewer diameter, and population density. As a rule of thumb, the length of line to be flushed should not exceed 700 feet. At this maximum recommended length, the percent removal efficiency ranges between 65-75% for organics and 55-65% for dry weather grit/inorganic material. The percent removal efficiency drops rapidly beyond that. Water is commonly supplied by a water truck, but fire hydrants can also supply water. To make the best use of water, it is recommended that reclaimed water be used or that fire hydrant line flushing coincide with storm sewer flushing.

References and Resources

California's Nonpoint Source Program Plan http://www.swrcb.ca.gov/nps/index.html

Clark County Storm Water Pollution Control Manual
http://www.co.clark.wa.us/pubworks/bmpman.pdf

Ferguson, B.K. 1991. Urban Stream Reclamation, p. 324-322, Journal of Soil and Water Conservation.

King County Storm Water Pollution Control Manual http://dnr.metrokc.gov/wlr/dss/spcm.htm

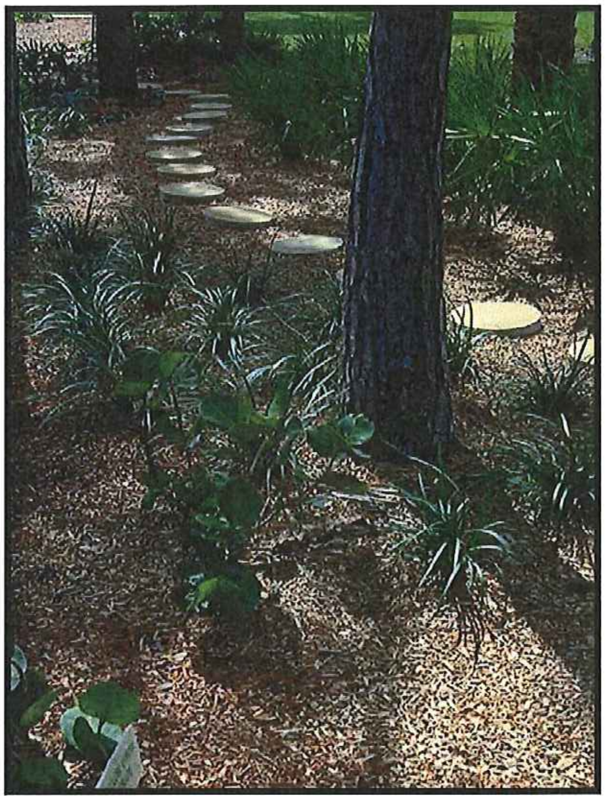
Oregon Association of Clean Water Agencies. Oregon Municipal Stormwater Toolbox for Maintenance Practices. June 1998.

Santa Clara Valley Urban Runoff Pollution Prevention Program http://www.scvurppp.org

The Storm Water Managers Resource Center http://www.stormwatercenter.net

United States Environmental Protection Agency (USEPA). 2002. Pollution Prevention/Good Housekeeping for Municipal Operations Storm Drain System Cleaning. On line:
http://www.epa.gov/npdes/menuofbmps/poll_16.htm

Site Design & Landscape Planning SD-10



Design Objectives

- ☑ Maximize Infiltration
- ☑ Provide Retention
- ☑ Slow Runoff
- ☑ Minimize Impervious Land Coverage
- Prohibit Dumping of Improper Materials
- Contain Pollutants
- Collect and Convey

Description

Each project site possesses unique topographic, hydrologic, and vegetative features, some of which are more suitable for development than others. Integrating and incorporating appropriate landscape planning methodologies into the project design is the most effective action that can be done to minimize surface and groundwater contamination from stormwater.

Approach

Landscape planning should couple consideration of land suitability for urban uses with consideration of community goals and projected growth. Project plan designs should conserve natural areas to the extent possible, maximize natural water storage and infiltration opportunities, and protect slopes and channels.

Suitable Applications

Appropriate applications include residential, commercial and industrial areas planned for development or redevelopment.

Design Considerations

Design requirements for site design and landscapes planning should conform to applicable standards and specifications of agencies with jurisdiction and be consistent with applicable General Plan and Local Area Plan policies.

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Designing New Installations

Begin the development of a plan for the landscape unit with attention to the following general principles:

- Formulate the plan on the basis of clearly articulated community goals. Carefully identify conflicts and choices between retaining and protecting desired resources and community growth.
- Map and assess land suitability for urban uses. Include the following landscape features in the assessment: wooded land, open unwooded land, steep slopes, erosion-prone soils, foundation suitability, soil suitability for waste disposal, aquifers, aquifer recharge areas, wetlands, floodplains, surface waters, agricultural lands, and various categories of urban land use. When appropriate, the assessment can highlight outstanding local or regional resources that the community determines should be protected (e.g., a scenic area, recreational area, threatened species habitat, farmland, fish run). Mapping and assessment should recognize not only these resources but also additional areas needed for their sustenance.

Project plan designs should conserve natural areas to the extent possible, maximize natural water storage and infiltration opportunities, and protect slopes and channels.

Conserve Natural Areas during Landscape Planning

If applicable, the following items are required and must be implemented in the site layout during the subdivision design and approval process, consistent with applicable General Plan and Local Area Plan policies:

- Cluster development on least-sensitive portions of a site while leaving the remaining land in a natural undisturbed condition.
- Limit clearing and grading of native vegetation at a site to the minimum amount needed to build lots, allow access, and provide fire protection.
- Maximize trees and other vegetation at each site by planting additional vegetation, clustering tree areas, and promoting the use of native and/or drought tolerant plants.
- Promote natural vegetation by using parking lot islands and other landscaped areas.
- Preserve riparian areas and wetlands.

Maximize Natural Water Storage and Infiltration Opportunities Within the Landscape Unit

- Promote the conservation of forest cover. Building on land that is already deforested affects basin hydrology to a lesser extent than converting forested land. Loss of forest cover reduces interception storage, detention in the organic forest floor layer, and water losses by evapotranspiration, resulting in large peak runoff increases and either their negative effects or the expense of countering them with structural solutions.
- Maintain natural storage reservoirs and drainage corridors, including depressions, areas of permeable soils, swales, and intermittent streams. Develop and implement policies and

regulations to discourage the clearing, filling, and channelization of these features. Utilize them in drainage networks in preference to pipes, culverts, and engineered ditches.

- Evaluating infiltration opportunities by referring to the stormwater management manual for the jurisdiction and pay particular attention to the selection criteria for avoiding groundwater contamination, poor soils, and hydrogeological conditions that cause these facilities to fail. If necessary, locate developments with large amounts of impervious surfaces or a potential to produce relatively contaminated runoff away from groundwater recharge areas.

Protection of Slopes and Channels during Landscape Design

- Convey runoff safely from the tops of slopes.
- Avoid disturbing steep or unstable slopes.
- Avoid disturbing natural channels.
- Stabilize disturbed slopes as quickly as possible.
- Vegetate slopes with native or drought tolerant vegetation.
- Control and treat flows in landscaping and/or other controls prior to reaching existing natural drainage systems.
- Stabilize temporary and permanent channel crossings as quickly as possible, and ensure that increases in run-off velocity and frequency caused by the project do not erode the channel.
- Install energy dissipaters, such as riprap, at the outlets of new storm drains, culverts, conduits, or channels that enter unlined channels in accordance with applicable specifications to minimize erosion. Energy dissipaters shall be installed in such a way as to minimize impacts to receiving waters.
- Line on-site conveyance channels where appropriate, to reduce erosion caused by increased flow velocity due to increases in tributary impervious area. The first choice for linings should be grass or some other vegetative surface, since these materials not only reduce runoff velocities, but also provide water quality benefits from filtration and infiltration. If velocities in the channel are high enough to erode grass or other vegetative linings, riprap, concrete, soil cement, or geo-grid stabilization are other alternatives.
- Consider other design principles that are comparable and equally effective.

Redeveloping Existing Installations

Various jurisdictional stormwater management and mitigation plans (SUSMP, WQMP, etc.) define "redevelopment" in terms of amounts of additional impervious area, increases in gross floor area and/or exterior construction, and land disturbing activities with structural or impervious surfaces. The definition of " redevelopment" must be consulted to determine whether or not the requirements for new development apply to areas intended for redevelopment. If the definition applies, the steps outlined under "designing new installations" above should be followed.

SD-10 Site Design & Landscape Planning

Redevelopment may present significant opportunity to add features which had not previously been implemented. Examples include incorporation of depressions, areas of permeable soils, and swales in newly redeveloped areas. While some site constraints may exist due to the status of already existing infrastructure, opportunities should not be missed to maximize infiltration, slow runoff, reduce impervious areas, disconnect directly connected impervious areas.

Other Resources

A Manual for the Standard Urban Stormwater Mitigation Plan (SUSMP), Los Angeles County Department of Public Works, May 2002.

Stormwater Management Manual for Western Washington, Washington State Department of Ecology, August 2001.

Model Standard Urban Storm Water Mitigation Plan (SUSMP) for San Diego County, Port of San Diego, and Cities in San Diego County, February 14, 2002.

Model Water Quality Management Plan (WQMP) for County of Orange, Orange County Flood Control District, and the Incorporated Cities of Orange County, Draft February 2003.

Ventura Countywide Technical Guidance Manual for Stormwater Quality Control Measures, July 2002.