



Appendix J

Site Conceptual Model

SITE CONCEPTUAL MODEL

Former Avila Terminal
10 San Rafael Road
Avila Beach, California

Revised April 12, 2013

PREPARED FOR

Chevron Environmental Management Company
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Project No. 1252.009





April 12, 2013

Project No. 1252.009

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San Luis Obispo, California 93401

Site Conceptual Model
Former Avila Terminal
10 San Rafael Road
Avila Beach, California

Dear Mr. Williams:

As part of the 2012 scope of work for the former Avila Terminal, Avocet Environmental, Inc. (Avocet) was tasked with preparing a summary of the Site Conceptual Model (SCM). Since 1997, Chevron and its predecessors have been assessing the site to identify the nature and extent of contamination, the potential processes and pathways that influence contaminant fate and transport, and the potential human and environmental receptors that might be impacted by the contamination. The objective of this document is to distill the information that has been collected over almost 15 years into a comprehensive model of the sources of contamination, how and where that contamination has migrated, will potentially migrate, and the potential receptors that may be impacted.

As a summary, this document does not provide detailed descriptions of every aspect of the SCM. Rather it lists key elements and provides supporting information where appropriate. Elements are also divided into logical categories, such as physical characteristics (i.e., topography, hydrogeology), nature and extent of contamination, and migration potential. The conclusion of the document is a list (with an explanatory figure) identifying issues requiring consideration in the feasibility study.

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

Respectfully submitted,

AVOCET ENVIRONMENTAL, INC.

A handwritten signature in black ink, appearing to read "R. Van Hyman", is written over a light blue horizontal line.

Principal

RVH:sh

Enclosure

cc: Bill Almas – Chevron BRES (electronic only)

Louis Cappel – Padre Associates (electronic only)

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LIST OF ABBREVIATIONS AND ACRONYMS

ABCSD	Avila Beach Community Services District
ABSP	Avila Beach Specific Plan
ATCAT	Avila Terminal Collaborative Assessment Team
BTEX	benzene, toluene, ethyl benzene, and total xylenes
cm/s	centimeter per second
COPC	constituent of potential concern
ft ² /day	foot squared per day
LNAPL	light nonaqueous phase liquid
MCL	maximum contaminant level
mg/kg	milligram per kilogram
PAH	polynuclear aromatic hydrocarbon
PCB	polychlorinated biphenyls
RTP	Remediation Technology Panel
RWQCB	California Regional Water Quality Control Board
SCM	Site Conceptual Model
TDS	total dissolved solids
TPH	total petroleum hydrocarbons
VOC	volatile organic compound

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1.0 INTRODUCTION

Since 1997, Chevron and its predecessors have been assessing the former Avila Terminal (the site; Figure 1) to identify the nature and extent of contamination, the potential processes and pathways that influence contaminant fate and transport, and the potential human and environmental receptors that might be impacted by the contamination. This document presents the Site Conceptual Model (SCM). Its purpose is to distill the information that has been collected over almost 15 years into a comprehensive model describing the sources of contamination, their extent, and migration potential. A PDF copy of this document is provided on a CD in Appendix A.

As a summary, this document does not provide detailed descriptions of every aspect of the site or its condition. Rather it lists key elements, and provides supporting information where appropriate. Elements are also divided into logical categories, such as physical characteristics (i.e., topography, hydrogeology), nature and extent of contamination, and migration potential.

While in most respects this SCM is comprehensive, insufficient data are available to fully characterize the source and extent of the fuel-related hydrocarbons recently discovered on the beach. This document describes what is known at the time of publication and provides some potentially relevant background information. Further information will be submitted once detailed assessments have been completed. However, circumstances may require that characterization and mitigation of this specific issue be handled in a faster process parallel to remediation for the remainder of the site.

The remainder of this introduction provides a brief description of the site and concludes with an overview of the previous characterization efforts. Section 2.0 describes the physical setting of the site, its operational history, relevant information regarding geology, groundwater, and surface water hydrology. Section 3.0 addresses the occurrence and nature of site contaminants. The conclusion of the document (Section 4.0) is a list (with an explanatory figure) identifying non-risk-driven issues requiring consideration in the feasibility study.

1.1 SITE BACKGROUND

The Avila Terminal is a 95-acre facility located adjacent to the community of Avila Beach (Figure 1). It is bordered by the Pacific Ocean along most of its southern boundary. Avila Beach Drive forms most of the northern boundary of the site, and Cave Landing Road most of the eastern boundary (Figure 2).

The Avila Terminal was constructed by Union Oil Company of California (Union Oil) in 1906, and was acquired by Chevron in 2005. Its primary function was to transfer crude oil to ships for refining at major refineries in Los Angeles and the San Francisco Bay area. Crude oil was delivered to the site via pipelines from the operating fields and was transferred to ships through pipelines that were located under Front Street to the former Union Oil Pier (Figure 3).

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Some simple distillation was performed at the former onsite refinery into the 1940s. This did not, however, include final refining, which was done at the major refineries.

Finished products, such as gasoline and diesel, were delivered by ship and transferred to the Terminal via the Front Street pipelines. They were then loaded onto trucks at the truck-loading rack and distributed to retail outlets in the area.

Most operations had ceased by 1997, and the tanks were dismantled and removed from the site by late 1998.

1.2 OVERVIEW OF PREVIOUS CHARACTERIZATION EFFORTS

As noted, characterization efforts have been ongoing since 1997. These efforts started as operations at the Terminal were winding down and remediation efforts along Front Street were beginning in earnest. Those immediate characterization activities (principally groundwater wells along the northern and western property boundaries) were focused on the question of whether contaminants were migrating directly from the site into the adjacent community of Avila Beach. It was subsequently determined that the pipeline was the source of Avila Beach contamination. During that time, however, the property boundary was established with the regulatory community as an important point of compliance.

Following those first groundwater wells, the nature and extent of impacts to soil and groundwater at the former Avila Terminal were extensively studied and described (England & Associates, 1998a, 2000a; England Geosystem, Inc., 2001a, 2002b, 2003b; Avocet Environmental, Inc., 2004b, 2005, 2008a,b; Padre Associates, 2012a, 2012b, and 2012c). In brief, they covered the following topics:

- 1) Studies completed prior to 2000 were undertaken to investigate the site geology and hydrogeology, and to assess the nature and extent of contamination. The overarching objective of the initial studies was to determine whether any identified contamination presented a threat to the adjacent community or the developing Project Avila remediation plan.
- 2) In 2000, Union Oil entered into a voluntary agreement with the California Regional Water Quality Control Board (RWQCB) to establish a Remediation Technology Panel (RTP). The RTP consisted of three independent experts with expertise in characterization and remediation of petroleum-impacted sites. These experts were enlisted to help identify site characterization data gaps.
- 3) The data gaps identified by the RTP (2000, 2002) were primarily focused on further characterizing the extents of dissolved- and free-phase impacts to groundwater and the fate and transport processes affecting the migration of these contaminants. Those data gaps were addressed by England Geosystem (2001a-2001c, 2002a-2002f, and 2003a). The culmination of this work was an RTP document titled Assessment of Off-Site Migration of Hydrocarbons at the Avila Beach Tank Farm Site (RTP 2004).

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- 4) In 2003, separate but concurrent with the RTP process, Union Oil entered a voluntary cooperative process to evaluate potential human health and ecological risks with a number of the stakeholders¹ with interest in the Avila Tank Farm site. The group is collectively referred to as the Avila Terminal Collaborative Assessment Team (ATCAT).
- 5) The ATCAT developed a separate list of data gaps focused primarily on shallow soil, sediment, and surface water in the recently identified wetlands; evaluating the potential for impacts in non-industrial areas of the site; and background metals. These data gaps were addressed in reports prepared by England Geosystem (2003b) and Avocet (2004a, 2005, 2008a, and 2008b).
- 6) Subsequent assessment efforts have focused on refining the site characterization, including further investigation of volatile hydrocarbon detections in groundwater and soil gas in the cliff area south of the former pump house (Padre, 2012a), additional evaluation of light nonaqueous phase liquid (LNAPL) mobility and recovery (Padre, 2012b), and continued groundwater monitoring (Padre, 2012c).
- 7) Collectively, these assessments have included the following:
 - Excavation and sampling of 26 exploratory trenches;
 - Drilling and sampling of 369 borings with the completion of:
 - 103 borings as groundwater monitoring wells (68 single wells, 13 dual-nested wells, and 9 combination groundwater/multi-depth soil gas probe wells), and
 - 70 borings as dual-nested multi-depth soil vapor probes.
 - Over 13,200 feet of cumulative drilling and soil sampling;
 - Analysis of over 1,750 soil samples for one or more of a wide variety of constituents of potential concern (COPCs), including total petroleum hydrocarbons (TPH); benzene, toluene, ethyl benzene, and total xylenes (collectively referred to as BTEX); polynuclear aromatic hydrocarbons (PAHs); volatile organic compounds (VOCs); metals; polychlorinated biphenyls (PCBs); pesticides; and herbicides;
 - Analysis of over 355 soil vapor samples for TPH/BTEX, VOCs, and/or fixed gases; and
 - Groundwater monitoring since 1997 resulting in more than 45 sampling events from some wells.

Figure 4 depicts the distribution of borings, monitoring wells, and miscellaneous sampling points at the site. Documents summarizing the characterization activities are listed in the References section.

¹ All potential stakeholders were invited to participate in the process, and the RWQCB, the California Department of Fish and Game, and the San Luis Obispo County Department of Planning and Building Environmental Division, Environmental Health Division, and Air Pollution Control District chose to actively participate.

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2.0 SITE SETTING

This section describes the physical characteristics of the site, its current condition, and the surrounding land uses. The section also includes a brief operational summary to provide some historical context, describes the site geology and hydrogeology, and discusses the occurrence and nature of both surface and groundwater.

2.1 PHYSICAL SETTING AND SURROUNDING LAND USE

The Avila Terminal is located on a hill directly east of the community of Avila Beach, California, in an unincorporated portion of San Luis Obispo County (Figure 1). The site encompasses approximately 95 acres and is bordered by the community of Avila Beach to the west, San Luis Creek and a golf course to the north, open space to the east, and the Pacific Ocean to the south.

A site plan for the Avila Terminal, depicting its current condition and highlighting the physiographic features, is shown in Figure 2. The facility is no longer active and has been decommissioned. Relative to the site conceptual model:

- 1) The site is 95 acres.
- 2) Maximum topographic relief on the site is approximately 240 feet, which is also the maximum elevation at the site. The minimum elevation is mean sea level.
- 3) Approximately 46 percent of the site (44 acres) consists of slopes steeper than 30 percent.
- 4) The site is a local topographic highpoint and is dissected by two valleys, one north-south and the other east-west across the site (Figure 2). Grading in the center portion of the site involved filling of the valleys and cutting of the adjacent slopes to produce relatively flat pads for the Terminal facilities. The steep north-facing slopes support 13 acres of oak woodland and related vegetation and drain towards San Luis Obispo Creek. To the south, the site slopes down to a marine platform and terminates at the Pacific Ocean in 40- to 80-foot-high cliffs.
- 5) Average precipitation is about 16.82 inches per year. In general, rainfall runoff in the eastern part of the site flows via pipes and gutters to the upper drainage basin and runoff in the western part of the site flows to the lower drainage basin. These drainage basins are the storage units for the stormwater system and are managed to temporarily retain water from storm events. The upper and lower drainage basins are connected, and water from the upper basin is drained into the lower basin between storm events. The water in the basins is tested before it is released to the ocean pursuant to the RWQCB Industrial Storm Water Permit.

² “Average” refers to the 80-year (1921-2000) mean average rainfall measured in Pismo Beach, California, located on the coast approximately 5 miles southeast of the site.

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- 6) Padre conducted a wetland characterization in December 2011 and identified seven distinct wetland features. The characterization indicates the total wetland area under the state definition as 1.68 acres and as 0.82 acres under the federal definition. These are shown in Figure 5. Of the seven identified wetlands, two, the upper and lower drainage basins, were identified as freshwater marshes that have water much of the year if not all year long. Four of the wetlands located in the former operational area were identified as seasonal wetlands, meaning surface water is present part of the year, primarily in the rainy season. The seventh wetland occurs at the entrance to the culvert that drains the northern portion of the site (Padre, 2012d).
- 7) The site perimeter is 10,125 feet. Approximately 40 percent (4,020 feet) of this fronts the Pacific Ocean.
- 8) Avila Beach has a mix of residential and commercial zoning. Directly adjacent to the Terminal are single-family residences and open space. North of the property is the Avila Beach Golf Resort, and directly to the east the properties are zoned as Residential Rural. The area to the east also includes the coastal access point known as Pirate's Cove.
- 9) Although industrial activity has ceased, the site remains zoned for industrial uses in the San Luis Obispo County Avila Beach Specific Plan (ABSP), with an overlay as an Energy and Extractive Area. These designations are legacies from the previous use of the property as the Avila Tank Farm. The ABSP anticipates a change in zoning for the Terminal to support remediation and post-remediation uses.
- 10) The site is fenced and secured to discourage trespassing.

2.2 OPERATIONAL HISTORY

The historical operation areas are shown in Figure 3. The property was acquired by Union Oil in 1906, and between 1906 and 1910 Union Oil constructed a network of pipelines, storage tanks, and a small refinery at the site. In 1997, the facility was formally decommissioned, and in 1998-1999, the petroleum storage tanks were removed and known pipelines were cleaned. A few surface structures (pump house, lab, fire water tanks, etc.) and most of the subsurface structures (sumps, pipelines) remain in-place at the site. Chevron acquired the former Terminal together with other Union Oil assets in the 2005 merger. The following descriptions are based on the available operating records. Waste discharges during site operations to various features are largely unknown at this time.

- 1) Former industrial (petroleum-related) operation areas (e.g., buildings, tanks, appurtenances) occupy approximately 40 percent (38 acres) of the site. As seen in Figure 3, these are located primarily towards the interior and southwest margin of the property.
- 2) The facility had the following principal components:
 - Pipelines
 - Storage Tanks
 - Main Pump House and Laboratory

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- Loading Rack
- Refinery
- Miscellaneous structures (sumps, oil skimming pond, etc.)

2.2.1 Pipelines

- 1) Three pipeline corridors served the former Terminal (Figure 3):
 - The Front Street Corridor, which connected the Terminal to the pier;
 - The Eastern Corridor, which connected the facility to the Santa Maria and Orcutt oil fields; and
 - The Northern Corridor, which connected the Terminal to the San Luis Obispo Tank Farm and, ultimately, to the Central Valley oil fields.
- 2) Multiple pipelines are located within each corridor.
- 3) Approximately 11,000 feet of known steel pipeline, ranging from 2 to 10 inches in diameter and buried approximately 4 feet below grade, connected the various operations on the property.
- 4) Cleaning of the pipelines and removal of their contents was performed in 2004. It is not certain if all the pipes were cleaned during this effort. It is Chevron's intent that all pipelines greater than 4-inches diameter will be removed or grouted in place. Pipelines smaller than 4-inch diameter will be abandoned per applicable standards.
- 5) There is no evidence that diluent was used or pumped through the Avila Terminal.

2.2.2 Storage Tanks

- 1) Tanks were built with riveted or welded steel plate on concrete foundations and coated with lead-based paint to prevent corrosion.
- 2) The number of tanks changed over the years. There are 27 locations at which tanks were sited, but the maximum number of tanks in operation at any one time appears to have been 21 (circa 1940s-1950s).
- 3) Most of the tanks were higher in elevation than the Pump House. However, as shown in Figure 3, three storage tanks were located on the terrace of the southwest cliff, at locations lower than the pump house, and required individual return pumps.
- 4) Two of the cliff tanks (No. 55612 and No. 201104) were removed from service before 1954. The middle tank (No. 55614) remained in service until the facility was decommissioned in 1997.
- 5) Three tanks (Nos. 23632, 14638, and 15640) were in service until 1998 and held regular grade gasoline (leaded and unleaded), super grade gasoline (leaded and unleaded), and diesel, respectively.

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- 6) Fuel products for local wholesale or retail distribution were managed in dedicated tanks, pipelines, and pumps.
- 7) All remaining tanks were dismantled in 1998-1999.

2.2.3 Main Pump House and Laboratory

- 1) The main pump house (Figure 3) is the point through which most of the petroleum products handled onsite moved. The pump house also included boilers and heat exchangers to heat the oil to lower the viscosity for pumping.
- 2) The structure to the north of the main pump house was most recently used as a storeroom and petroleum laboratory. Prior to the late 1930s, the structure housed the boilers used to power the steam-driven pumps and heat the oil.
- 3) The laboratory was used to analyze oil samples to determine the properties of the crude being pumped. Small quantities of different solvents were reportedly stored and used in the laboratory.
- 4) Fuel product pumps were located just south of the main pump house. These connected the fuel pipelines in the Front Street Corridor to the fuel storage tanks (Nos. 14638, 15640, and 23632) and the truck-loading rack.

2.2.4 Truck-Loading Rack

- 1) Constructed near the main pump house and laboratory in 1936.
- 2) The loading rack was used to dispense bulk refined products to trucks for delivery to Central Coast marketing outlets.
- 3) The loading rack operated through 1994 when shipping of fuel products from the Union Oil pier was discontinued.

2.2.5 Refinery

- 1) The refinery was built between 1906 and 1910.
- 2) It used a simple heat distillation process to separate crude oil into few generic fractions (e.g., gasoline, kerosene, distillate). These were raw products shipped elsewhere for finishing into marketable products.
- 3) The byproduct of the distillation process, reduced crude, was sold to other refiners for further processing.
- 4) A portion of the refinery was destroyed in a fire on or about 1926.
- 5) The boilers were fueled with bunker oil, which would deposit an obsidian-like residue on the refractory (refractory glass) that was periodically removed during maintenance. Fragments of this glass occur in the former refinery area, and tests of the material indicate

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elevated concentrations of nickel and vanadium with negligible availability to fresh water (England & Associates, 2000b).

- 6) The refinery was largely obsolete by the 1940s but was kept in service to support the war effort. It was dismantled around 1947.

2.2.6 Miscellaneous Structures

- 1) Constructed in the 1920s, the skimming pond was used to separate soil from ballast water that was pumped from ships moored at the wharf. The floating oil from this pond was stored in tanks (Nos. 100620 and 55614). The skimming pond was removed sometime in the late 1970s.
- 2) A sump, located to the northeast of the skimming pond, was used to collect water that drained from the sinks in the laboratory.
- 3) The main sump, located adjacent to the lower drainage basin, collected oil water from bleed valves associated with the petroleum storage tanks, oil-water separator in the lower drainage basin, and truck loading rack filter system. The oil and water collected from this sump was pumped into Tank No. 55614.

2.2.7 Materials Handled at the Terminal

- 1) Based upon the available records (England & Associates, 1998a), the storage capacities for the different materials handled at the Terminal were in approximately these proportions:
 - 78 percent: crude oil (San Joaquin Valley, San Ardo, Orcutt)
 - 5 percent: bulk refined products (gasoline and diesel fuel)
 - 12 percent: gas oil
 - 5 percent: tank slopes (miscellaneous mixtures of petroleum and water)
- 2) A rough estimate of the typical storage capacity at the Avila site is approximately 1.5 million barrels. This is based on the average capacity of the tanks multiplied by a tank count of 27. No data are available on the volume of material moved within and through the facility over time.

2.3 CURRENT SITE CONDITION

More detailed discussions of the current site condition are found in England & Associates, 1998a, and England Geosystem, 2002b. Relative to the SCM, the following observations are made:

- 1) All of the tanks related to petroleum operations were removed in 1998 along with much of the aboveground valving.

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- 2) Most of the onsite pipelines remain in place and have not been grouted or removed. Detailed maps showing the pipelines were lost in the 1980s when the storage facilities at the San Luis Obispo Tank Farm flooded during heavy storms.
- 3) The pipeline system was cleaned and flushed in 2004, but it is not certain that the entire system has been emptied of petroleum products.
- 4) The Front Street pipeline was disconnected approximately 300 feet from the Front Street gate. There are no longer any pipelines crossing Avila Beach or connecting the Terminal to the pier.
- 5) Union Oil sold the pipelines within the Eastern and Northern pipeline corridors to Tosco in 1997. Via subsequent acquisitions, the current owner is Phillips 66. The sale included the pipelines, aboveground manifolds, and easements (Figure 6). Pipelines are not currently active but are still present. Operation, maintenance, and monitoring of the pipelines in the easement are the responsibility of Phillips 66. The lines are proposed to be abandoned; date to be determined.
- 6) A number of the operations structures have not been removed. This includes the pump house, loading rack, laboratory building, and remnants of the heaters and boilers. Most of these are centrally located (Figure 2).
- 7) Other aboveground remnants include the piping manifolds, monitors for the fire water system, a water tank that is used for fire suppression, telephone poles, the tank berms, stormwater management components, and the access roads.
- 8) Below ground are the pipelines, vaults, utilities (e.g., water lines), septic systems, and other related appurtenances. In addition, within the refinery area are the foundations of the various buildings used in the refinery operation. A detailed delineation of the foundations has not been performed, but assessments in the area have encountered extensive and massive sections of concrete.
- 9) The Avila Beach Community Services District (ABCSD) sites a water tank for Avila Beach on the Terminal (Figure 2). The ABCSD has easements (Figure 6) that provide access to the tank and connects it via a pipeline to their potable water distribution system.

2.4 GEOLOGY

- 1) The Avila facility is directly underlain by bedrock and unconsolidated sediments (Figure 8). Bedrock units include (listed from oldest to youngest) the Miocene Obispo Formation and the Pliocene Gragg Member of the Pismo Formation.
- 2) The Obispo Formation consists of fine- to coarse-grained, friable to hard, rhyolitic to dacitic tuff and lapilli tuff and outcrops primarily along the south, east, and northwest site margins.
- 3) The Gragg Member of the Pismo Formation, which unconformably overlies the Obispo Formation, consists of a basal conglomerate, which grades upward into a poorly bedded, locally diatomaceous, fine-grained silty sandstone and siltstone. Much of the central part

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of the Avila facility is underlain directly or at shallow depth by bedrock of the Gragg Member. The Pismo Formation locally contains naturally occurring hydrocarbons.

- 4) Fracturing of the consolidated units is a function of age and hardness of the units. For instance, in the Obispo Formation, the hard silicified (brittle) units are more pervasively fractured than the friable (softer) units, and in general, the older Obispo Formation is more pervasively fractured than the softer and younger Pismo Formation. As discussed in the next section, various studies suggest that while pervasive, the fractures do not support the flow of liquids across extended areas of the site.
- 5) Unconsolidated surficial sediments, consisting of admixtures of gravel, sand, silt, and clay, fill the north-south and east-west drainages in the central part of the site, mantle the terraces bordering the cliffs on the south, and occur in the northeast corner of the site where the floodplain of San Luis Obispo Creek encroaches upon the site.
- 6) Cliff erosion is an important consideration at the site. As noted previously, the site has approximately 4,020 feet of ocean frontage, primarily in the form of a cliff that ranges between about 60 and 200 feet in height. The site boundary shown in Figure 2 provides a reasonable estimate of the position of the cliff face in 1906, when the property was purchased. From inspection, it can be seen that erosion is not uniform.
- 7) While coastal erosion is a complex process, it is also fundamentally related to the hardness of the underlying geology. An analysis performed in 2008 (URS, 2008) established a setback for building construction (Figure 8). This line has been used as a conservative evaluation of potential cliff erosion over the next 75 years. A supplemental analysis is being prepared to refine this estimate without consideration of building requirements.
- 8) The rate of erosion is of particular concern for contaminants associated with the tanks that had been located on the cliff terrace (i.e., Tanks No. 55612 and No. 201104), since they are located within this potential erosion area.

2.5 HYDROGEOLOGY AND GROUNDWATER OCCURRENCE

- 1) Three hydrostratigraphic units define the hydrogeology of the Avila facility:
 - The unconsolidated sediments (colluvium and alluvium)
 - The Gragg Member of the Pismo Formation
 - The Obispo Formation
- 2) Groundwater recharge occurs primarily in the higher elevations of the site through vertical fractures in the Pismo Formation and through infiltration into the unconsolidated sediments (colluvium and alluvium).
- 3) Environmental contaminants are currently monitored by a network of 94 onsite and 3 offsite groundwater monitoring wells, and at 8 cliff spring locations (Figure 7). Except as noted, this network provides an effective sentinel monitoring system around the perimeter of the site. Further, the network demonstrates that site contaminants are not migrating from

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the site, with the exception of the cliff in the vicinity of former Tank No. 201104, which is discussed further in Section 3.0.

- 4) Depth to groundwater is variable, depending on the season, water year, and location at the site. Groundwater depths generally range from 15 to 75 feet below ground surface across the site. Exceptions include the higher elevations, where depths may be greater, and lower elevations, where, during extremely wet seasons, groundwater discharges at ground surface.
 - In years of average or above-average rainfall, groundwater flows naturally from the ground, forming seeps and/or springs, in several areas of the site (Figure 9). Once flow is initiated, the springs may flow for several weeks at progressively declining rates (England Geosystem, 2001c).
 - The lower beach cliff springs are the most persistent of the springs at the site, with localized flow persisting into the late spring.
 - At the pump house location, artesian conditions are created by a combination of a local bedrock high point and the grading (i.e., local removal) of the colluvium that created the pads upon which the buildings were constructed. During rainy periods, groundwater moving through the colluvium encounters the bedrock highpoint and expresses at the surface of the thinned layer of colluvium. This condition is shown in the cross sections found in the Site Characterization report (England & Associates, 1998) and does not indicate continuous fracture networks, but rather a localized occurrence based on the above description for this area. Understanding of the stratigraphy illustrates that this condition has a catchment no greater than 200 feet in the longest direction.
- 5) Groundwater potentiometric surface maps show that groundwater generally flows away from topographic highs toward:
 - the north to northwest for groundwater monitoring wells completed within the alluvium – area along Avila Beach Drive (Figure 10);
 - the southwest for groundwater monitoring wells completed within the colluvium filling the north-south and east-west drainages in the central part of the site (Figure 10); and
 - the north, west, and south for groundwater monitoring wells completed within the Pismo Formation (Figure 11) and Obispo Formation (Figure 12).
- 6) Nested piezometers installed across the Pismo/Obispo contact and in close proximity to wells monitoring the shallow saturated zone indicate that, despite significant vertical gradients, there is no significant vertical groundwater flow from the shallow saturated zone to deeper zones or between the consolidated formations (England Geosystem, 2002b). The characterization of significance was made by the RTP after evaluating the occurrence of TPH in paired monitoring wells exhibiting strong (i.e., 0.5-1.0 ft/ft) vertical gradients. This is generally reflected in the distribution of the contaminants, in that the upper groundwater

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monitoring wells contain elevated levels of TPH, including, and on occasion, LNAPL; whereas the lower wells were found to have intermittent low levels of TPH. An exception to the above description of pollutant occurrence is in the Cliff Area, where high concentrations ($> 1,000$ mg/kg) of low and high fraction TPH in shallow soil have migrated to groundwater at depth at high concentrations ($> 1,000$ $\mu\text{g/L}$) within the Obispo formation.

- 7) The Pismo and Obispo formations consist of consolidated but generally porous rocks that are substantially fractured. Groundwater occurs in these formations in both primary (intergranular) and secondary (fracture) porosity, but the following lines of evidence indicate that both formations are dominated by fracture permeability and that the intergranular pore spaces provide little additional permeability:
 - Observations during drilling that most wells reported no groundwater until a fracture was encountered, and once encountered, groundwater levels rose by an average of 18 feet (England & Associates, 1998b);
 - Monitoring wells drilled onsite that were dry, despite being drilled below the water table (as interpolated from nearby wells), likely because they did not intersect any fractures. This indicates that, absent fracturing, water is simply not capable of flowing through the intergranular pore spaces to the well, even though the rock was water-saturated (England Geosystem, 2001a);
 - Monitoring wells with locally anomalous water levels and low yield, indicating poor hydraulic communication with recharge areas and near-by wells (Padre, 2012a); and
 - Significant formational anisotropy as revealed by constant-rate aquifer performance tests (England Geosystem, 2001a). Estimates of anisotropy are illustrated in Figure 8.
- 8) Groundwater quality is generally considered poor, based on general mineral analyses. Iron, manganese, chloride, sulfate, and total dissolved solids (TDS) concentrations frequently exceed drinking water standards (England Geosystem, 2001a). High sulfate levels in groundwater are reported to be supportive of natural attenuation processes in the aquifer (RTP, 2004).
- 9) The Pismo and Obispo formations are low yielding aquifers with relatively low hydraulic conductivities between approximately 7.6×10^{-5} centimeters per second (cm/s) to 2.0×10^{-4} cm/s, and low storativities (1.3×10^{-3} to 5.5×10^{-2}) (England Geosystem, 2001a).
- 10) Given the poor quality and low well yield, it is unlikely that groundwater at the site will be utilized as a source of drinking water. For these reasons, groundwater was not evaluated as a source of drinking water in Human Health Risk Assessments prepared for the site (McDaniel Lambert, 2011).

2.6 SURFACE WATER

As noted previously, the site is a local topographic highpoint and, therefore, does not experience significant runoff during precipitation events. Commensurate with the industrial uses,

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stormwater within the operational areas of the site was managed in a stormwater management system. Figure 13 is a hydrology map showing the catchments, stormwater management features and discharge points at the site.

Stormwater is currently managed under the State General Industrial Permit, WDID No. 3 40S013327. Under the conditions of the current permit, stormwater is sampled at least twice per year during the first hour of a storm event.

The following observations are made regarding surface water management and surface water quality:

- 1) Approximately 26 acres on the northern portion of the property (labeled Catchment A in Figure 13) drain towards a culvert that conveys water across Avila Beach Drive. No industrial processes were located within this catchment.
- 2) Approximately 9 acres on the northwest corner of the site (labeled Catchment B in Figure 13) drain to one of two discharge points. Catchments B1 and B2 drain to a small culvert at the intersection of San Luis Street and Avila Beach Drive. Catchments B3 and B4, which include the Scout House and the ABCSD water tank, drain to a small culvert at the corner of San Rafael Street and San Luis Street. No Industrial processes were located within this catchment.
- 3) Catchment C is approximately 5.2 acres on the western side of the property. It drains a small hillside and the lowest portion of the access road entering off Front Street. Water from this area discharges into a catch basin on San Rafael Street, which then discharges to the ocean. No industrial processes were located in this area.
- 4) Catchment D encompasses the former operations area of the site. It covers approximately 32 acres and includes most of the stormwater management infrastructure other than the odd ditch. As shown in Figure 13, Catchment D is broken into approximately 26 smaller sub-catchments, which define the principal pond and stormwater pipe features. The entire catchment drains to a single pond on the southwestern cliff, which is referred to as the Lower Drainage Basin. Stormwater from the first two storm events is held in the Upper Drainage Basin and Lower Drainage Basin until testing demonstrates that the water meets the discharge standards of the General Industrial Storm Water Permit. Detained stormwater is discharged from the Lower Drainage Basin via an outfall to the ocean. Subsequent storm events are allowed to discharge without detention.
- 5) Approximately 24 acres of the site fronting the beach (Figure 13) drain directly to the ocean. These are areas that were not part of the industrial uses of the site. Except along the eastern property boundary, these ocean-fronting catchments are generally open space and drain via natural swales. Along the eastern property boundary, a small ditch was constructed to ensure stormwater stays onsite until discharging to the ocean.

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- 6) The existing stormwater infrastructure is at least 15 years old, and most, if not all, is likely significantly older. This includes the outfall serving Catchment D, which is being undermined by cliff erosion.
- 7) Stormwater has been monitored since 1997. No COPCs have been detected above discharge limits in any of those monitoring events. Based on those data, it does not appear that site COPCs are dissolved by or transported by stormwater.

3.0 NATURE, OCCURRENCE, AND MOBILITY OF CONTAMINATION

The majority of site contamination is from releases of petroleum at the site. As was described in Section 2.2, crude oil was the predominant type of petroleum handled at the Terminal. However, because the site was a significant distribution point for refined products, lighter end hydrocarbons and fuel-related components are also found. These compounds also tend to be more problematic considering risk and potential mobility.

A distinction is made between asphaltic and non-asphaltic TPH at this site. Most TPH within 2 feet of the surface is asphaltic; that is, it has a C_{25} - C_{40} fraction greater than 70 percent. The consensus within the ATCAT has been that asphaltic TPH is not a COPC in that it presents no human health risk, has not been shown to impact water quality, and is generally unavailable metabolically to ecological receptors.

PAH's and metals are also found onsite. The PAH's are compounds typically associated with crude oil. The significant concentrations of anthropomorphic metals are associated with the former refinery (vanadium and nickel), or with the paint used on the tanks (lead).

Another issue is methane, which is associated with the anaerobic breakdown of petroleum. In particular, the area around the truck-loading rack and pump house where most of the fuel-related materials were released shows signs of natural attenuation occurring. Consequently, high concentrations of methane are also observed in this area. During the soil gas investigation work conducted in 2008 (Avocet, 2008b), methane was detected at a concentration of 41 and 29 percent in the soil gas at 5 and 15 feet below ground surface, respectively, in the vicinity of the loading rack. Similarly, in the vicinity of the pump station, the soil gas was found to have 28 percent methane at 15 feet below ground surface. Methane poses a potential hazard at the site due to its flammability and, consequently, warrants further discussion in this summary.

The following sections provide detailed descriptions of the nature, occurrence, and mobility of site contaminants. As noted in the introduction, however, the depth of supporting documentation is found in the various assessment reports published over the last decade, which are listed in the reference section.

3.1 CONTAMINANT OCCURRENCE AND MOBILITY - SOIL AND BEDROCK

- 1) Impacts to soil/bedrock are primarily from hydrocarbons associated with crude oil and refined petroleum products (gasoline, diesel fuel, gas oil, distillate, reduced crude, etc.) produced or handled at the site.
- 2) Figure 14 depicts the distribution of residual TPH (C_4 - C_{40}) in soil/bedrock. TPH concentrations greater than ($>$) 1,000 milligrams per kilogram (mg/kg) are most prevalent in the north-south and east-west colluvium-filled valleys, which are also the primary

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pipeline corridors. The highest concentrations ($>10,000$ mg/kg) generally occur along the pipelines. The vast majority of soil containing C_4 - C_{40} TPH concentrations greater than 1,000 mg/kg occurs in the upper 40 to 50 feet of the site, with much of that in the upper 10 to 20 feet (Figure 15). It is estimated that a nominal volume of 275,000 cubic yards of soil/bedrock are impacted by TPH at concentrations greater than 1,000 mg/kg. This is a conservative estimate in that it assumes all material in the delineated areas is impacted.

- 3) Defining the extent of C_4 - C_{40} TPH greater than 100 mg/kg is complicated by the occurrence of natural bituminous material in the Pismo Formation. The complication is in differentiating the anthropomorphic sources of TPH from the naturally occurring ones. Solid bituminous material was encountered in many of the borings drilled at the site. Analytical testing of these samples revealed TPH concentrations ranging from 10 to 2,000 mg/kg, with most reported concentrations being in the range of 30 to several hundred mg/kg. The TPH generally fell into the pattern of 25 to 35 percent C_{10} - C_{25} hydrocarbons and 65 to 75 percent C_{25} - C_{40} hydrocarbons. It is estimated that a nominal volume of 532,000 cubic yards of soil/bedrock are impacted by TPH at concentrations greater than 100 mg/kg.
- 4) The highest concentrations of C_4 - C_{10} (low molecular weight) TPH ($>1,000$ mg/kg) occur beneath and south of the truck-loading rack, beneath former Tanks No. 55614 and No. 201104 (southern cliffs), below the west end of the central pipeline corridor (east and northeast of the pump house), south of the former refinery, and beneath the pipeline corridors in the central part of the Avila facility. The majority of the C_4 - C_{10} TPH occurs within unconsolidated sediments (colluvium or terrace deposits) at depths of less than 20 feet below ground surface. However C_4 - C_{10} TPH occurs at depths greater than 10 feet (i.e., 15 to 30 feet) in the vicinity of Tank No. 55614, and at depths between 5 to 45 feet in the vicinity of Tank No. 201104
- 5) COPCs associated with the TPH include:
 - BTEX
 - PAHs
 - gasoline components and additives (organic lead, methyl tert-butyl ether, 1,2-dichloroethane, 1,2,4- and 1,2,5-trimethylbenzene
 - Low concentrations of other VOCs, including halogenated compounds.
- 6) The slopes surrounding the former operation areas at the Terminal were periodically coated with an asphaltic material to control weed growth and erosion. In time, this asphalt degrades into a fine powder and is dispersed by wind and rain. Surface soils (≤ 2.5 feet) exhibiting no visual or olfactory evidence of hydrocarbon contamination, including soils in nonoperations areas, commonly contain detectable concentrations of TPH with a chemical composition consistent with the degraded asphalt and substantially different than the TPH in soils at greater depth (Applied Geochemical Strategies, 2004).

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- 7) Several metals (copper, lead, mercury, nickel, vanadium, and zinc) were detected at concentrations above background levels in surface soils across the site (Avocet and BBL Sciences, 2004b).
- The lead is associated with paint used on the tanks and is generally located within the tank rings. In ten locations (Figure 16), lead is sufficiently elevated to present either a potential health or ecological risk. The lead contamination in these areas appears to be localized with little migration potential. The primary line of evidence that lead has limited potential for migration is that the ongoing long-term monitoring programs for groundwater and stormwater have not detected lead in any samples. Given the low solubility of lead, migration would likely be limited to surface water or wind transport. However, monitoring data indicate that wind and water movement in the current site configuration are incapable of providing sufficient energy to move the lead paint chips or the larger pieces of refractory glass. It is estimated that (except for the refractory glass discussed below) approximately 1,000 cubic yards of near-surface soil have been impacted by lead that may require remediation.
 - Mercury has been detected in several locations and is likely associated with the sprayed asphalt used throughout the site. To a limited extent, the mercury could also be associated with the use and maintenance of pressure gauges during the operational history. The concentrations detected are below action levels and have been shown to not present a human health or ecological risk.
 - Refractory glass left from the former refinery operation has been shown to contain elevated metals. Nickel and vanadium pose potential human health risks, and copper, zinc, and lead pose potential ecological risks (Figure 16). It is estimated that up to 3,000 cubic yards of soil may be affected by the refractory glass.
- 8) No evidence exists of soil impacts extending beyond the property boundaries.

3.2 CONTAMINANT OCCURRENCE AND MOBILITY - GROUNDWATER/LNAPL

- 1) LNAPL is used herein to describe any liquid petroleum hydrocarbon with a specific gravity less than water.
- 2) Historically, up to 43 well casings have contained discernible accumulations of LNAPL at thicknesses ranging from sheen (a thin film) to 31.85 feet (B-163 in the former refinery area). Of these 43 wells, 18 routinely contain a measurable (>0.01 feet) thickness of LNAPL. Figure 17, which depicts the locations of wells containing LNAPL in November 2011, illustrates that measurable thicknesses of NAPL are limited to areas very close to the central distribution facilities at the site, areas southwest of these facilities, and areas near distribution pipelines.
- 3) All wells containing LNAPL are surrounded by downgradient wells that are free of LNAPL.

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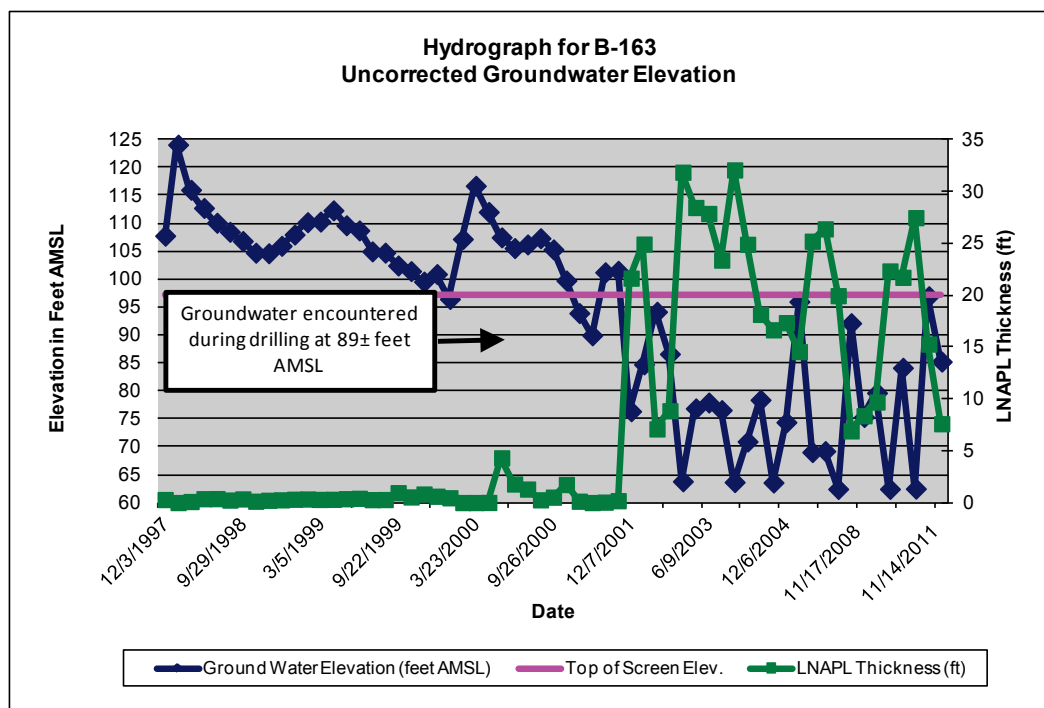
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- 4) Chemical and physical tests of LNAPL samples recovered from several wells indicate that the LNAPL exhibits properties commonly associated with crude oil, the commodity handled in the greatest volume at the site (England Geosystem, 2002b).
- 5) Measured LNAPL viscosities range from 19 to 229 centipoise (i.e., 19 to 229 times the viscosity of fresh water) and density ranges from 0.89 to 0.93 grams per cubic centimeter (England Geosystem, 2002b; Padre, 2012b).
- 6) In areas where colluvium overlies bedrock and the unconfined groundwater elevation is below the colluvium/bedrock contact for some portion of the seasonal fluctuation cycle, boring logs and monitoring data suggest that LNAPL moves vertically through the colluvium until it reaches underlying bedrock, at which point it spreads laterally through the colluvium and bedrock interface and within the bedrock fractures where aperture widths allow for LNAPL entry (Figure 18). Where seasonal groundwater fluctuation within the unconfined groundwater zone occurs above and below the colluvium/bedrock contact in LNAPL areas, the LNAPL tends to float during periods when the groundwater elevation is above the contact.
- 7) Comparison of residual LNAPL saturations to measured core LNAPL saturations and field observations of LNAPL distribution in cores indicate that most of the LNAPL found in the bedrock units beneath the Avila Beach Terminal site occurs within fractures (RTP, 2004).
- 8) That LNAPL is restricted almost entirely to fractures and does not permeate the rock matrix is supported by the recent increases in LNAPL thickness recorded in several wells as water levels declined in response to several years of below average precipitation. The process is described in the following bullets and illustrated in the following graph:
 - Free LNAPL was observed during drilling in all of the wells that contain measurable LNAPL.
 - Most wells reported no groundwater until a fracture was encountered, and once encountered, groundwater levels rose significantly, submerging the fracture and any oil contained therein.
 - The increase of LNAPL thicknesses in selected groundwater monitoring wells over the last decade does not appear to be associated with significant lateral migration of LNAPL, but rather a localized occurrence related to decreasing groundwater elevations exposing bedrock fractures containing LNAPL to the groundwater monitoring well screen, which releases LNAPL into the groundwater monitoring well. Therefore, the groundwater monitoring wells are behaving like sumps that collect LNAPL over long time periods.

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- 9) Analysis of data collected during LNAPL baildown tests performed in 2001 estimated LNAPL transmissivities between 0.03 and 0.83 feet squared per day (ft²/day). Subsequent calculations indicated that the fractured bedrock underlying the Avila Terminal are locally capable of transmitting LNAPL at velocities that are significant relative to the scale of the site boundaries (the geometric mean of the calculated velocities is 0.3 feet/day). It is important to note, however, that baildown tests evaluate subsurface conditions immediately adjacent to the borehole only. In a heterogeneous environment, such as that produced by fractured bedrock, it would be erroneous to extrapolate these transmissivities very far from the boreholes tested. Furthermore, empirical evidence, such as the general absence of LNAPL at large distances from source areas, suggests that fractures similar to those that produced the high velocities are not laterally extensive or widely interconnected (RTP, 2004).
- 10) LNAPL baildown tests at the locations of Monitoring Wells B-78, B-83, B-163, and B-203 performed in 2011 produced LNAPL transmissivity results (0.16 to 1.1 ft²/day, mean: 0.51 ft²/day) that are within or just slightly greater than the low range of values (0.1 to 0.8 ft²/day) where LNAPL is considered potentially recoverable (Padre, 2012b). These LNAPL transmissivity results are also similar to the 2001 study.
- 11) The 2011 baildown tests also measured LNAPL recoverability. A total of approximately 15.75 gallons of LNAPL were recovered during the course of the three LNAPL baildown test events from Groundwater Monitoring Wells B-78 (1.40 gallons), B-83 (2.20 gallons), B-163 (9.30 gallons), and B-203 (2.85 gallons). The volume of LNAPL recovered between the first event and second event diminished significantly (as much as 80 percent at

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Groundwater Monitoring Well B-78), and remained similar between the second event and third event for all test groundwater monitoring wells.

- 12) The estimated volume of LNAPL in the subsurface is approximately 40,000 to 60,000 barrels, but this could easily vary substantially, given the uncertainty associated with the various parameters³. The bulk (approximately 95 percent) of the volume has been calculated to be in the colluvium.
- 13) What is likely, however, is that the greater portion of the LNAPL beneath the pump house and loading rack area is found in the colluvium that was used to fill the original valley features. The intergranular pore space of fine-grained soils such as the colluvium is expected to be an order of magnitude or more greater than the fracture porosity of the bedrock units.

3.3 CONTAMINANT OCCURRENCE AND MOBILITY - GROUNDWATER/DISSOLVED PHASE

- 1) Presently, the groundwater monitoring network consists of 94 onsite wells and 3 offsite wells (Figure 7). Groundwater monitoring has been performed regularly since the third quarter of 1997, resulting in more than 45 monitoring events for some wells. Groundwater samples are routinely tested for one or more of the following: TPH, BTEX, VOCs, metals, and PAHs.
- 2) The primary COPCs in groundwater at the site are related to crude and refined petroleum, including fuel additives.
 - The majority of dissolved-phase TPH is associated with mid- to high-molecular-weight petroleum hydrocarbons (C₁₀-C₄₀), which occur in groundwater around the margin of the LNAPL area, in the vicinity of the former refinery, former pump house, and appurtenant fuel pipelines. Although it is unlikely to have any impact on the selection of an appropriate remedial alternative, it should be noted that characterizing the extent of dissolved C₁₀-C₄₀ TPH is complicated by:
 - the presence of naturally occurring bituminous material in the native rock.
 - naturally occurring soluble nonpetroleum hydrocarbons.
 - Filtering and silica gel cleanups have shown that some of the extractable range TPH detected in downgradient monitoring wells is entrained bituminous material and polar nonhydrocarbons (a byproduct of petroleum biodegradation).

³ The analysis looked at monitoring wells known to have LNAPL. The boring logs for those wells were evaluated for staining or the presence of free oil. An area was measured around which the boring log was assumed to be representative. The thickness of staining or free oil and the area were used to derive a gross volume. That volume was factored by porosities appropriate to the geologic units (0.41 for the colluvium and 0.01 for the bedrock). The resulting volume was factored again by the ratio of free oil versus staining observed in the boring logs.

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- There are two localized areas of lighter-end (C₄-C₁₀) petroleum-hydrocarbon-impacted groundwater. These areas are the:
 - truck-loading rack
 - southwest cliff area adjacent to former Tanks Nos. 55614 and 201104.It is noted that oxygenates are found in the soil and groundwater around Tank 201104, which is inconsistent with its demolition in the late 1940's. This suggests that some contamination may have been contributed by abandoned pipelines left in the area after the tanks were demolished.
- 3) The east, west, and north limits of dissolved-phase TPH impacts to groundwater are well defined since sentinel groundwater monitoring wells in those directions have never detected significant concentrations (nondetect to 297 micrograms per liter [µg/L]) of constituents attributable to historical site operations. When detected in sentinel groundwater monitoring wells, the dissolved-phase TPH concentrations have not followed any discernible trends over time.
- 4) However, the localized groundwater impact associated with former Tanks Nos. 55614 and 201104 are too near the cliff face to establish sentinel wells.
- In the case of Tank No. 55614, the cliff springs D and F have historically acted as sentinel monitoring points and have never detected significant concentrations (nondetect to 1,030 µg/L) of dissolved-phase petroleum hydrocarbons associated with historical site operations.
 - Former Tank No. 201104 lacks a cliff spring sentinel monitoring point. Recent inspection and sampling at the base of the cliff have found elevated levels of petroleum compounds in tide pools in a 300-foot-square area. One of the intertidal zone samples (IZ-3), collected in 2012, detected 500 µg/L of C₄-C₁₀ TPH. Tert-butyl alcohol (TBA) has been also been detected at 91 g/L in sample IZ-3. Since the removal of Tank No. 201104 (prior to 1954) predates the use of TBA, presence of TBA in the intertidal zone sample could be due to a leaking valve or pipeline between the pump and tank. Further assessment is being planned for this area.
- 5) Other VOCs have been detected locally:
- Fire extinguishing agents/fire retardants – south of the former refinery
 - Fuel components/additives – south of the former refinery, near the truck-loading rack, and beneath former Tank No. 10622 (south-southeast of the main pump house)
 - Chlorinated solvents – south of the former refinery.
- 6) PAH compounds are rarely (14 percent of samples) detected in groundwater samples. When present, they are detected at very low concentrations. Historically, the total PAH concentrations in all the sampled wells was between nondetect and 666 µg/L.

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- 7) PCBs were not detected in any of the 50 soil samples that were collected at depths of 1 to 10 feet bgs from various locations across the site (England & Associates, 1998a).
- 8) Metals concentrations in groundwater are locally elevated. The Pismo and Obispo formations were deposited in a marine environment that provides a ready source of soluble minerals under the correct geochemical conditions, and is consistent with the elevated TDS concentrations observed in groundwater samples. Nickel and arsenic are most frequently elevated.
 - Nickel has been detected in about 60 percent of the water samples tested and has exceeded the maximum contaminant level (MCL) in about 17 percent of the samples.
 - Arsenic has been detected in about 10 percent of the water samples tested. Since the detection limit equals the MCL, all samples with detectable arsenic exceed the MCL.
- 9) Elevated concentrations of lead have been detected at Monitoring Well B-230. The use of Tank No. 201104 (which occupied the tank ring within which B-230 is located) for gasoline storage suggest that the elevated lead concentrations may be associated with leaded gasoline.
- 10) Arsenic occurs naturally at the site in the Obispo Formation. Nickel has been associated with the presence of refractory glass in the former refinery area. However, given its limited occurrence at the site and the fact that the nickel is tightly bound in the glass makes the refractory material an unlikely source for the nickel in groundwater.
- 11) The consistency of water quality data for monitoring wells located downgradient of secondary contaminant sources suggests that the dissolved-phase plume is stable. Plume stability indicates that the rate of contaminant attenuation is approximately equal to the rate of dissolution from the contaminant source. At petroleum sites, the process most responsible for contaminant attenuation is intrinsic bioremediation.
- 12) A study of natural attenuation processes at the Avila site indicates that plume stability (e.g., the observation that dissolved contaminants do not extend much beyond the areas of LNAPL occurrence) is likely the result of natural attenuation.
- 13) Groundwater and soil gas testing have been completed at the Avila Terminal to investigate possible geochemical lines of evidence for the occurrence of intrinsic bioremediation. These lines of evidence include:
 - depletion of electron acceptors (dissolved oxygen, nitrate, Fe[III], and sulfate)
 - increasing concentrations of metabolic byproducts (carbon dioxide, Fe[II], hydrogen sulfide, and methane)

The composited Figure 19 illustrates that the parameters associated with a healthy anaerobic microbial community are present within the plume.

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- 14) This testing has shown that anaerobic biodegradation of petroleum hydrocarbons is occurring at the pump station, most likely as a result of sulfate-reducing and methanogenic respiration (England Geosystem, 2002c). As the bedrock at the Avila site provides an abundant source of sulfate, contaminant attenuation should continue to stabilize the dissolved-phase plume in the future. The RTP concluded that these processes should continue to constrain the migration of dissolved contaminants (RTP, 2004).

3.4 CONTAMINANT OCCURRENCE AND MOBILITY - VADOSE ZONE SOIL GAS

- 1) One of the major data gaps identified in the 2005 Baseline Human Health Risk Assessment (McDaniel Lambert, 2005) was the lack of adequate soil vapor data for the site. Prior to 2007, soil gas sampling was limited to collections from nine multidepth soil vapor probes (SP-1 to SP-9) initially installed to characterize the composition, concentrations, and flux of soil gas (England Geosystem, 2002e). Samples typically were analyzed for fixed gases, C₁-C₅ hydrocarbons, and limited samples for BTEX and hydrogen sulfide.
- 2) In 2007, in consultation with the ATCAT, a comprehensive soil gas study of the former Terminal was performed that involved the collection and analysis of 206 soil gas samples from 70 dual-nested (5 and 15 feet) soil gas probes (SV-1 – SV-70) (Avocet, 2008b). Seven additional soil gas probes SV-71 to SV-78 (at 5 feet) and 13 dual-nested probes SV-79 to SV-91 (5 and 15 feet) were also installed as part of a Supplemental Soil Gas Assessment (Padre, 2012e). The samples were analyzed for VOCs (EPA Method TO-15) and methane and other fixed gases. Multiple VOCs were detected, including fuel-related VOCs (e.g., BTEX and fuel additives), solvent-related VOCs (e.g., tetrachloroethene and methylene chloride), fire extinguishing agent VOCs (e.g., bromodichloromethane, chloroform, and carbon tetrachloride), and fixed gases (e.g., oxygen, carbon dioxide, and methane).
- 3) Together, these assessments found the following:
 - The lateral extent of VOCs in soil gas were similar in shallow (5 feet below ground surface) and deep (15 feet below ground surface) probes, although concentrations were about an order of magnitude greater in the deeper samples, suggesting a soil gas attenuation factor of about 0.1 between 15 and 5 feet below ground surface. Attenuation may include some degradation or breakdown of products but is primarily mixing with atmospheric air.
 - The highest concentrations of VOCs were detected in samples from probes situated south of the former refinery and surrounding the truck-loading rack (Figure 20).
 - Other areas of elevated VOCs in soil gas include beneath former Tank No. 201104, on the cliff terrace, near the geographic center of the site (SV-26), and in the eastern part of the site near the manifold connecting the eastern and northern pipeline corridors.
 - The dominant VOCs detected are fuel-related (hexane and cyclohexane – 73 percent on average), with lesser amounts of acetone (10 percent), heptane

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- (6 percent), tert-butyl alcohol (3 percent), benzene and 2,2,4-trimethylpentane (2 percent each), and 2-butanone and chloroform (1 percent each).
- Without mitigation, elevated concentrations of chloroform and benzene were shown to be prominent risk drivers in indoor air to potential future site users (McDaniel Lambert, 2011).
 - In shallow soil, methane concentrations greater than 2.5 percent (i.e., half of the methane lower explosive limit) were detected in the area south of the refinery and extending to south of the truck-loading rack (Figure 21). The distribution of methane exceeding concentrations of 2.5 percent is greater in deeper soil, extending south from the former refinery area to the truck-loading rack and southeast to the former tank locations along the cliffs.
 - Elevated methane concentrations are considered an indirect evidence of anaerobic hydrocarbon biodegradation.
 - The extent of VOC in soil gas has been delineated and has been shown to not extend offsite.

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4.0 SUMMARY

The Avila Terminal was used to store and distribute petroleum for nearly 90 years. Assessment work began shortly after operations at the facility stopped in 1997. With the exception of the area adjacent to former Tank No. 201104, the site has been characterized and is monitored by a sentinel network of monitoring wells that would provide notice of changes in the environmental condition. Those assessment efforts provide sufficient understanding of the nature, extent, and potential mobility of site contaminants to allow evaluation of potential remediation alternatives in a feasibility study.

A number of potential issues have been identified in the Supplemental Human Health Risk Assessment (McDaniel Lambert, 2011), the preliminary Ecological Risk Assessment (BBL, 2005), prepared for the site. These include potential issues such as lead contamination, the refractory glass, and VOCs in soil gas (particularly benzene and chloroform). However, there are a number of other potential issues identified in the site assessments that warrant consideration in a feasibility study that are not driven by risk.

It is anticipated that a feasibility study will also consider at least the following issues:

- groundwater (as a general operable unit)
- LNAPL
- TPH in soil and bedrock within the potential cliff erosion zone
- methane in soil gas
- impacts at and surrounding Monitoring Well B-223-88
- impacts at and surrounding Monitoring Well B-230

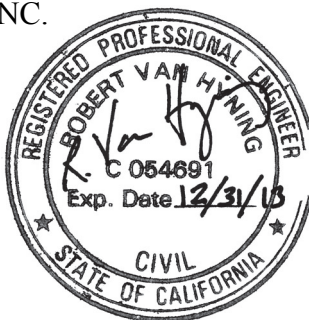
If you have any questions regarding this report or require further information, please do not hesitate to contact the undersigned.

Respectfully submitted,

AVOCET ENVIRONMENTAL, INC.



Robert Van Hynning, P.E.
Principal



**Site Conceptual Model
Former Avila Terminal**

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Avila Beach, California

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Former Avila Terminal**

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Avila Beach, California

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Avila Beach, California

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Figures

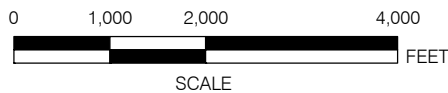


FIGURE 1

SITE LOCATION MAP

SITE CONCEPTUAL MODEL
FORMER AVILA TERMINAL
AVILA BEACH, CALIFORNIA

PREPARED FOR

CHEVRON
ENVIRONMENTAL MANAGEMENT COMPANY
SAN LUIS OBISPO, CALIFORNIA

REFERENCE:
7.5 MINUTE U.S.G.S. TOPOGRAPHIC MAP
OF PISMO BEACH, CALIFORNIA
DATED: 1965
PHOTOREVISED: 1975



S:\GIS\1252 Chevron EMC\Avila\1252.009 2012 Support\ArcMap\Documents\Site Conceptual Model\002 1252.009 2012 Site Plan Current Conditions.mxd/6/25/2012



Explanation

--- Approximate Site Boundary



FIGURE 2
SITE PLAN - CURRENT CONDITIONS

SITE CONCEPTUAL MODEL
FORMER AVILA TERMINAL
AVILA BEACH, CALIFORNIA
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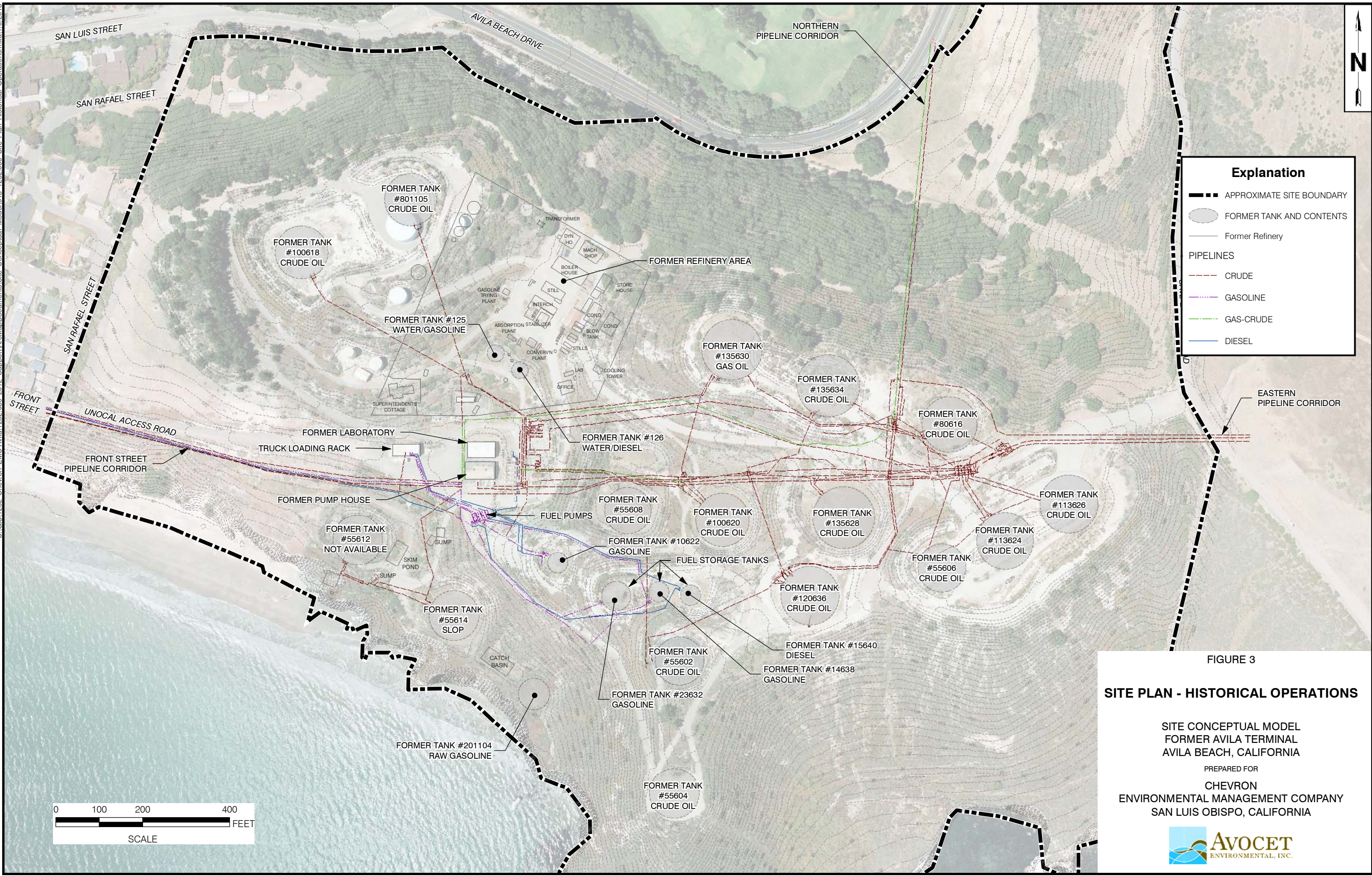


FIGURE 3

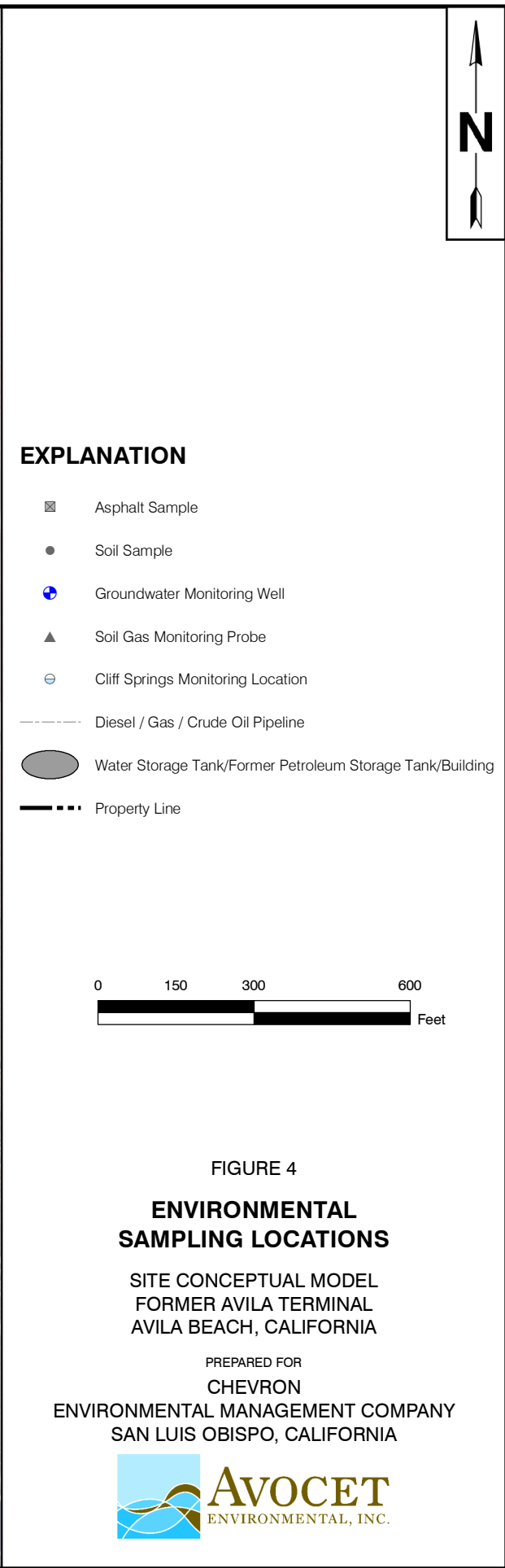
SITE PLAN - HISTORICAL OPERATIONS

SITE CONCEPTUAL MODEL
FORMER AVILA TERMINAL
AVILA BEACH, CALIFORNIA

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Legend

-----	Approximate Site Boundary	
Light Blue	Wetlands Subject to State Jurisdiction Only	0.86 Acres
Dark Blue	Wetlands Subject to State and Federal Jurisdiction	0.82 Acres
	Total (*)	1.68 Acres

(*) All Wetlands Subject to State Jurisdiction.

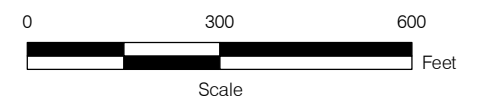


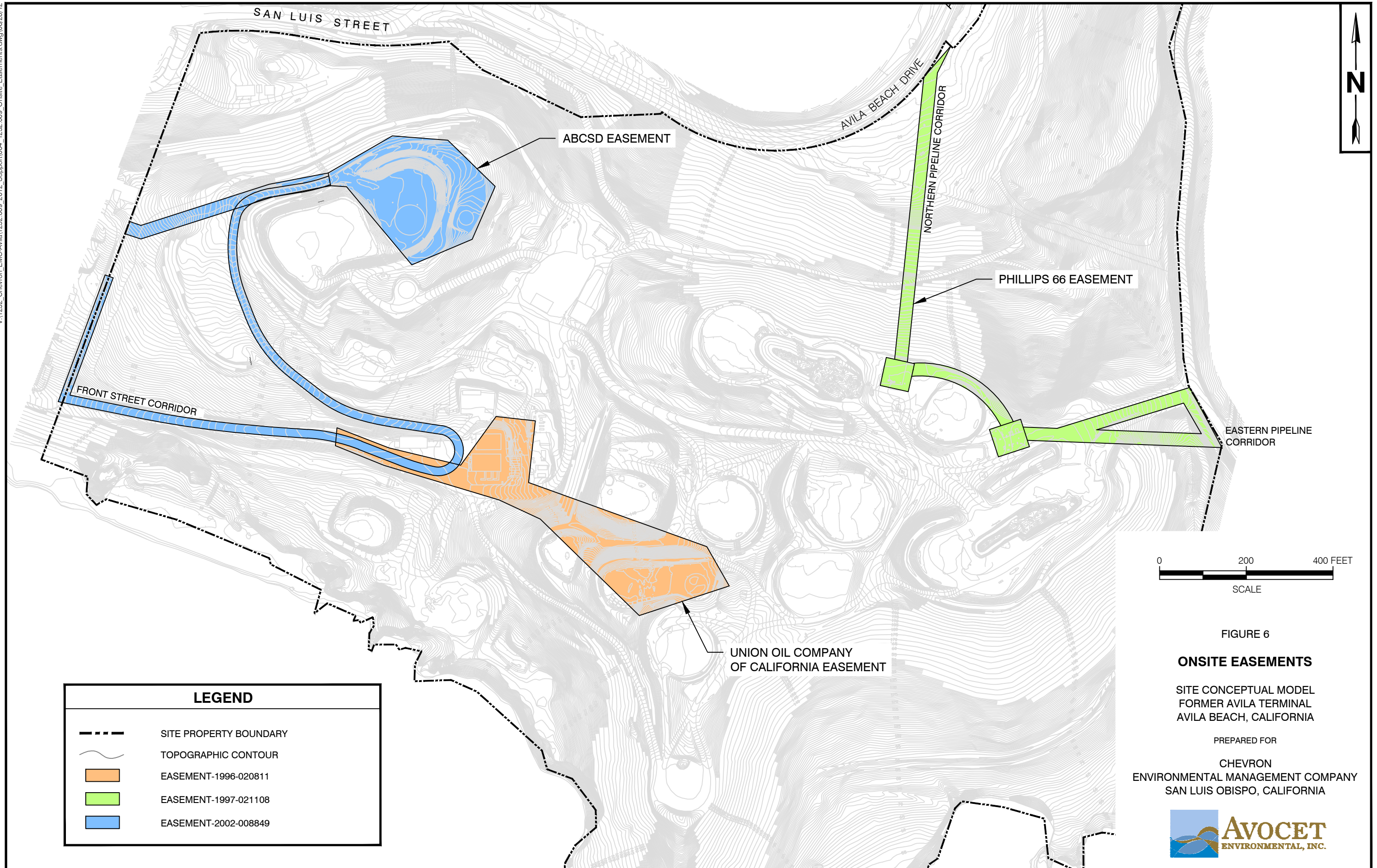
FIGURE 5

WETLAND OCCURRENCE AND JURISDICTION

SITE CONCEPTUAL MODEL
FORMER AVILA TERMINAL
AVILA BEACH, CALIFORNIA

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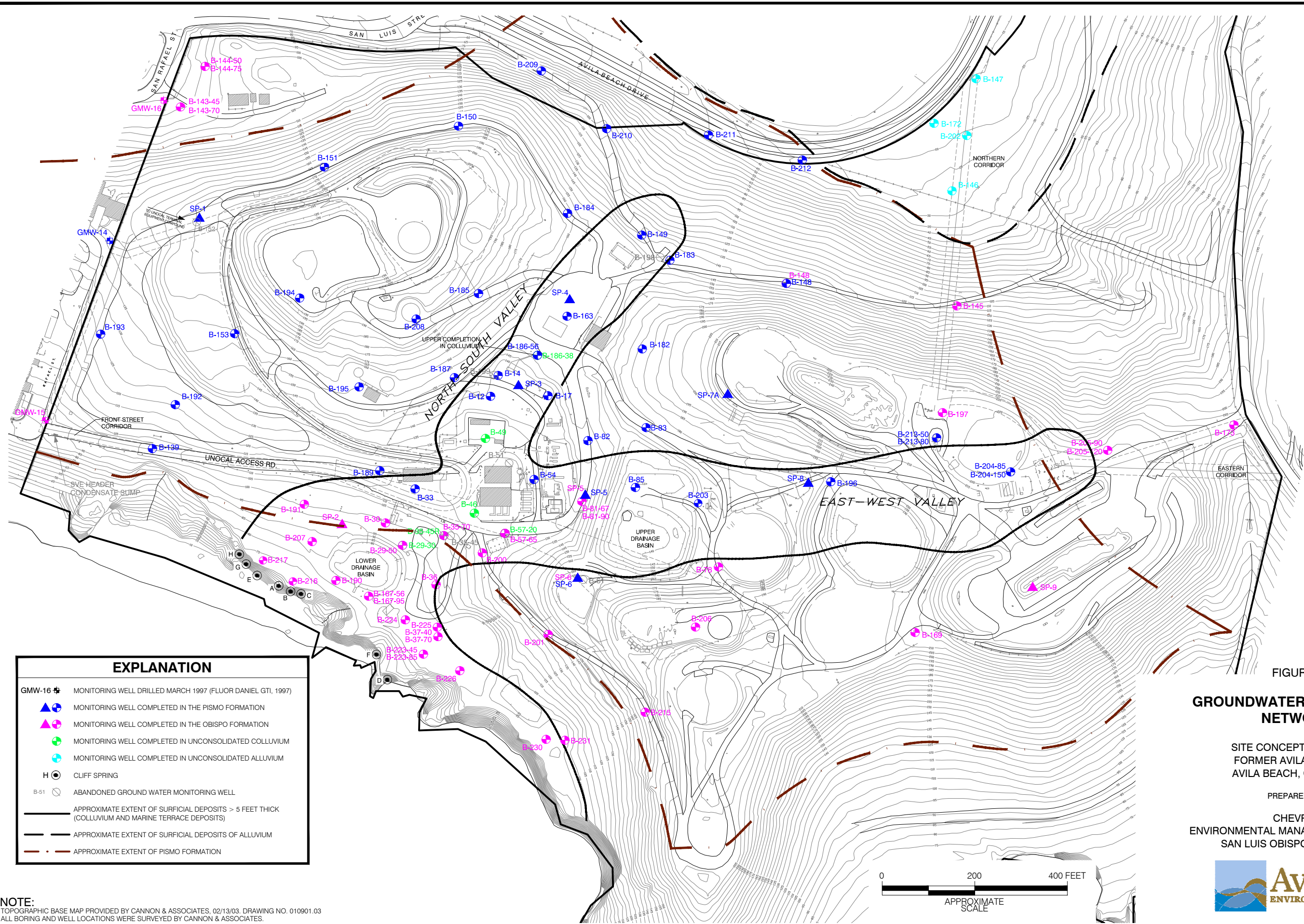


FIGURE 7

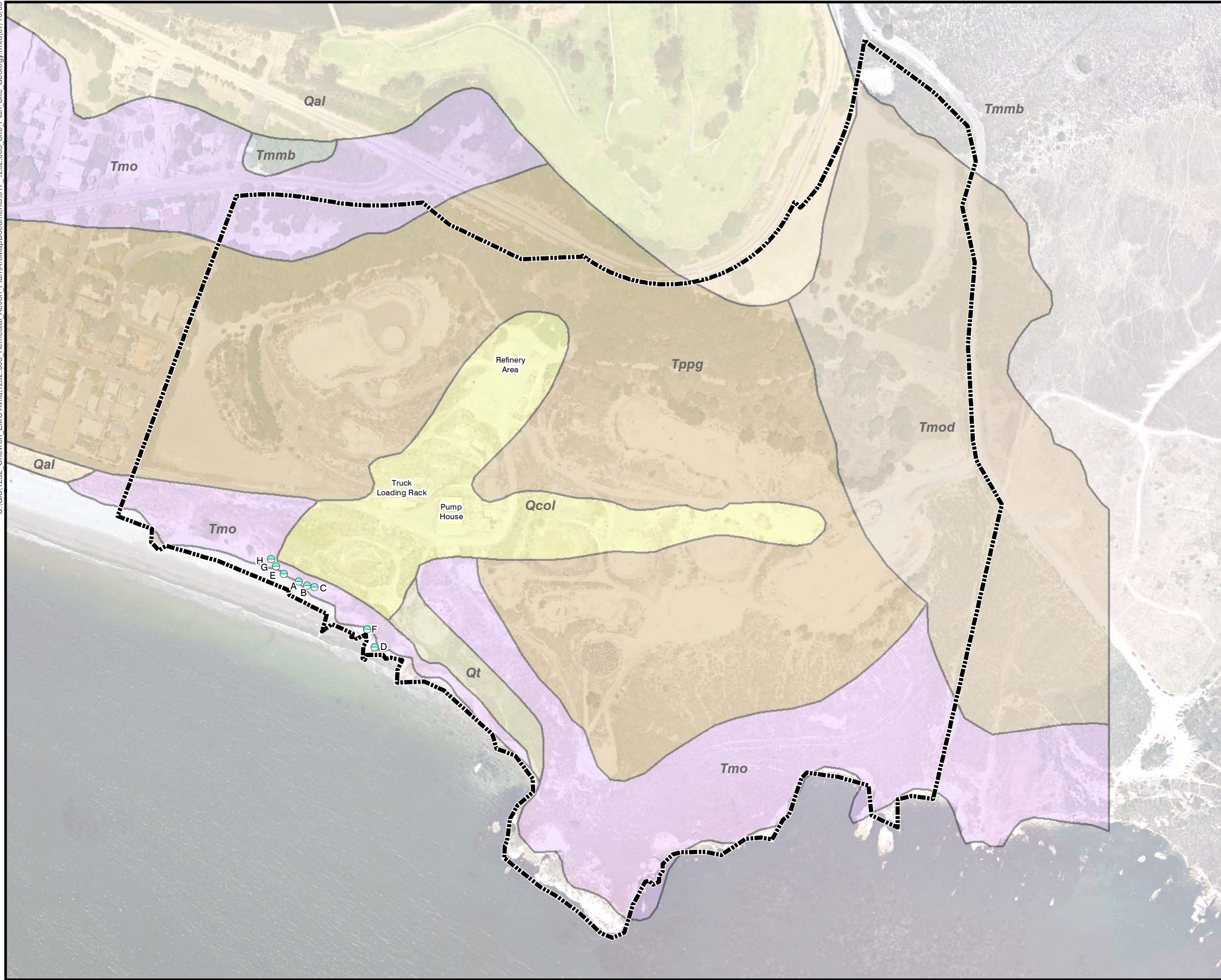
GROUNDWATER MONITORING NETWORK

SITE CONCEPTUAL MODEL
FORMER AVILA TERMINAL
AVILA BEACH, CALIFORNIA

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Explanation

● Cliff Spring Monitoring Location

--- Approximate Site Boundary

Local Geology

Qal - Alluvium

Qcol - Colluvium

Qt - Terrace Deposit

Tppg - Gragg Member, Pismo Formation

Tmo - Obispo Formation, Tuffaceous Sandstone

Tmod - Obispo Formation, Diabase

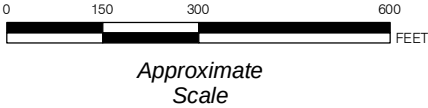


FIGURE 8

SITE GEOLOGY

SITE CONCEPTUAL MODEL
FORMER AVILA TERMINAL
AVILA BEACH, CALIFORNIA

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Legend

-  Cliff Spring Monitoring Location
-  Intertidal Zone Monitoring Location
-  Approximate Site Boundary

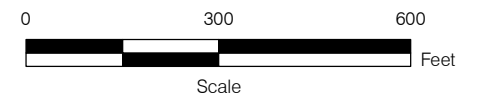
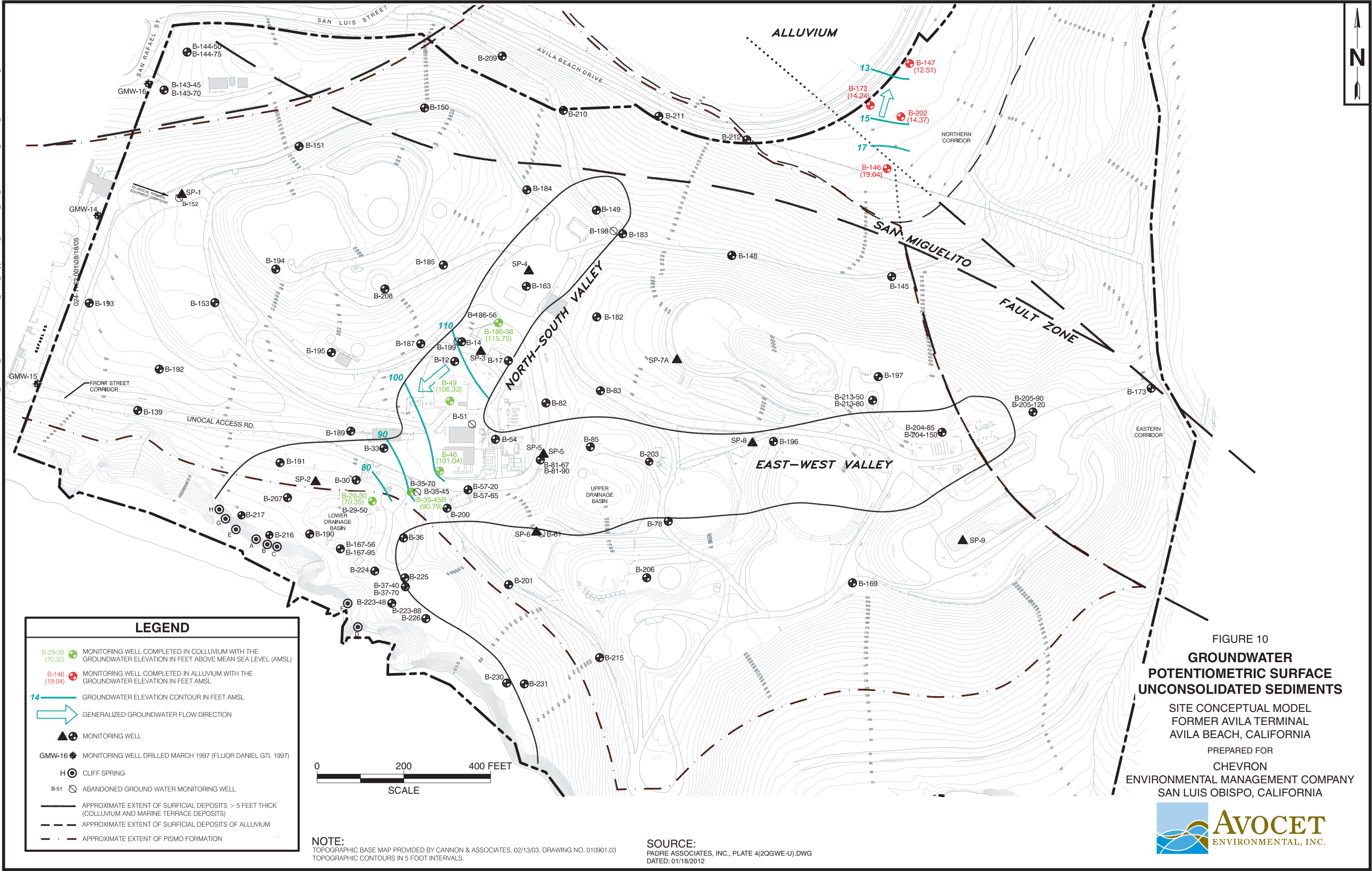


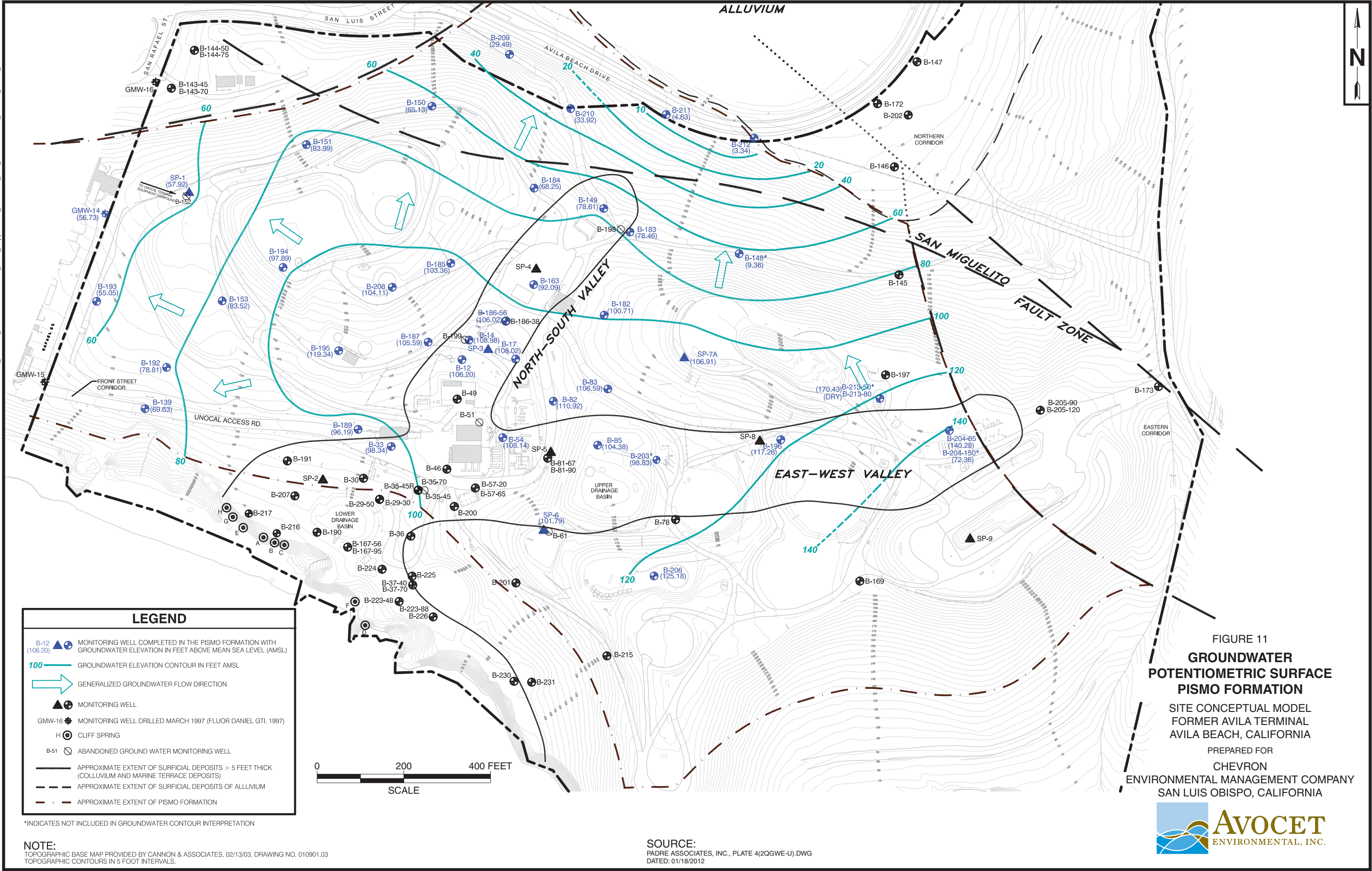
FIGURE 9
LOCATIONS OF SEEPS OR SPRINGS

SITE CONCEPTUAL MODEL
FORMER AVILA TERMINAL
AVILA BEACH, CALIFORNIA

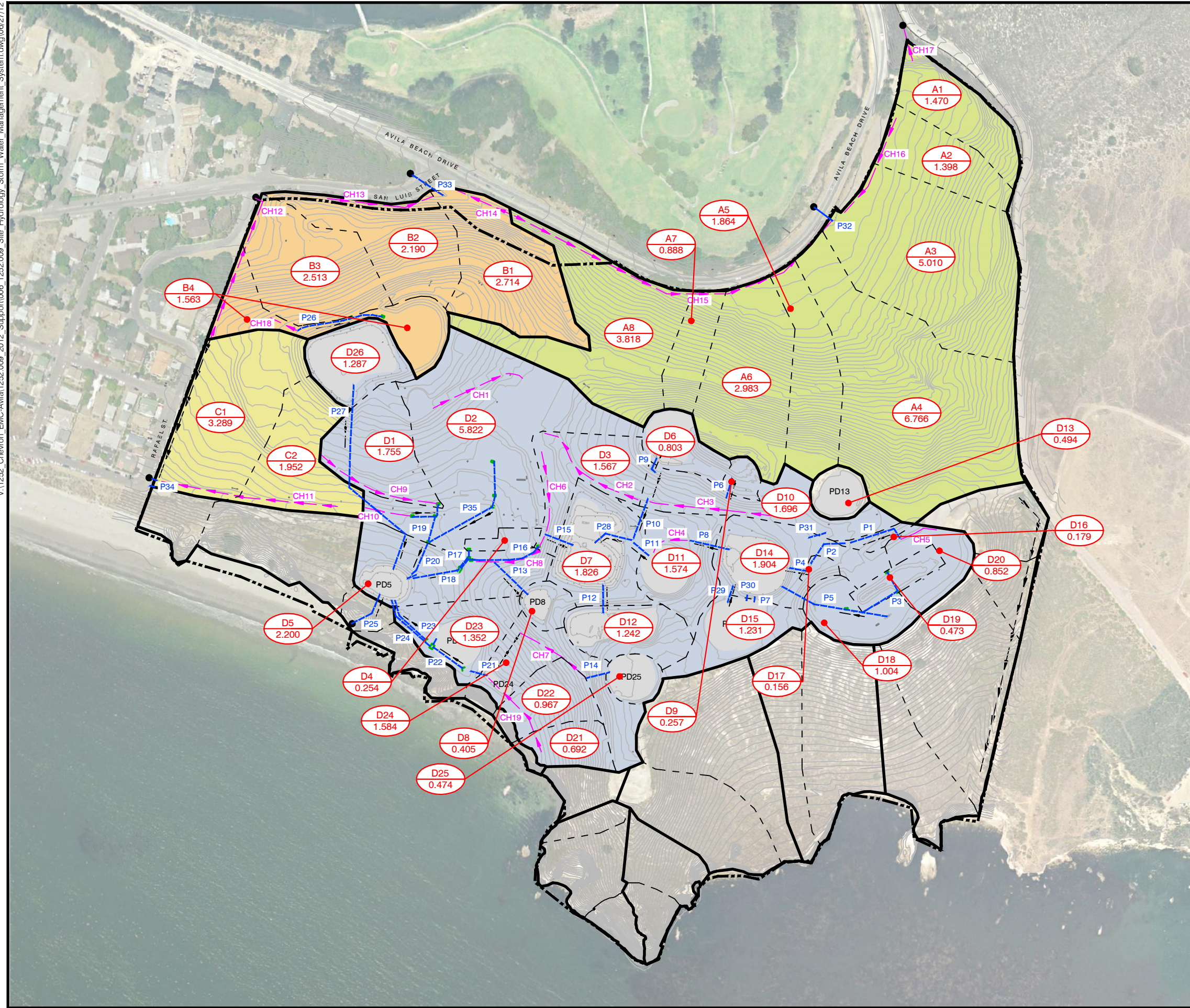
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LEGEND

APPROXIMATE PROPERTY BOUNDARY

PRIMARY CATCHMENT AREA

POND/RESERVOIR

SUB-CATCHMENT AREA

STORM DRAIN

NATURAL CHANNEL

STORM DRAIN INLET

FLOW DIRECTION

OFFSITE DISCHARGE POINT

CATCHMENT I.D. (TOP) AND
AREA IN ACRES (BOTTOM)

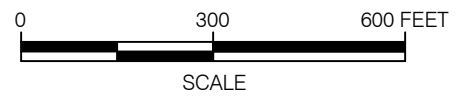


FIGURE 13

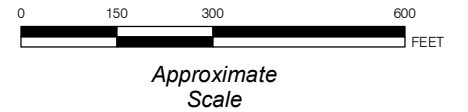
**SITE HYDROLOGY AND
STORMWATER MANAGEMENT
SYSTEM**

SITE CONCEPTUAL MODEL
FORMER AVILA TERMINAL
AVILA BEACH, CALIFORNIA

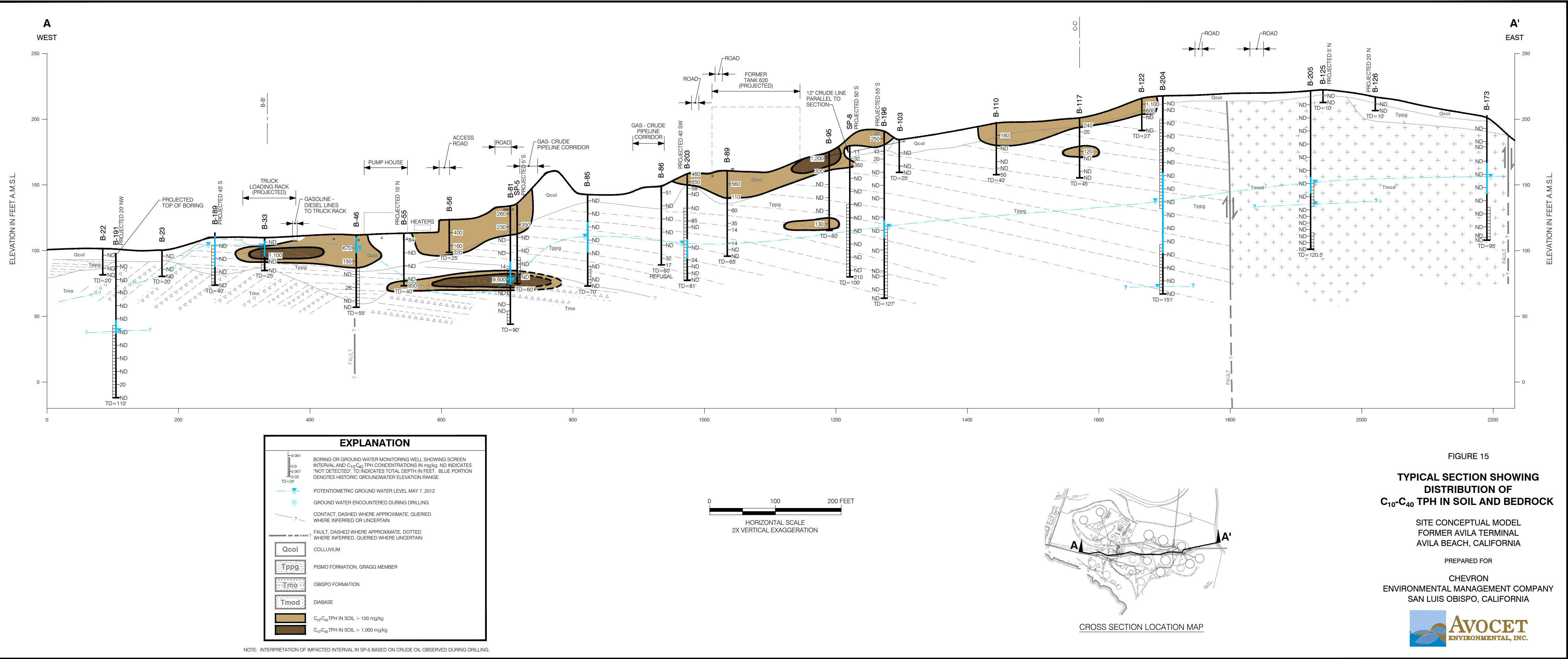
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S:\GIS\1252 Chevron EMC-Avila\1252.009 2012 Support\ArcMapDocuments\Site Conceptual Model\009_1252.009 Metals of Concern.mxd 1/9/2013



Explanation

- Soil Sample with a Least 1 Metal Concentration above Background
- Soil Sample with Lead Exposure Risk
- Approximate Site Boundary
- Storage Tanks / Areas

ABBREVIATIONS
Cu - Copper
Ni - Nickel
Va - Vanadium
Zn - Zink

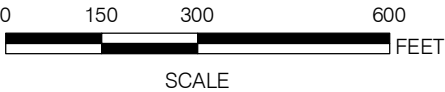


FIGURE 16

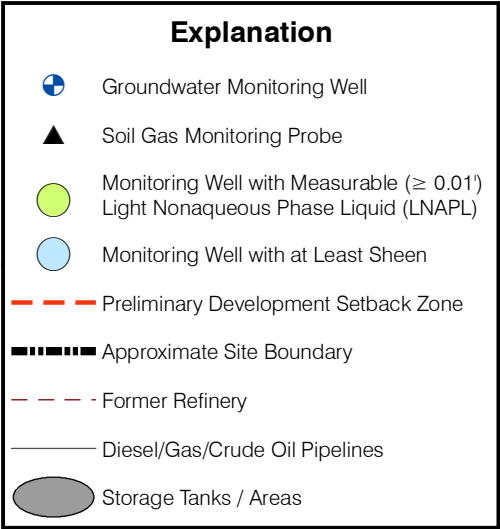
METALS OF CONCERN

SITE CONCEPTUAL MODEL
FORMER AVILA TERMINAL
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S:\GIS\1252 Chevron EMC-Avila\1252.009 2012 Support\ArcMapDocuments\Site Conceptual Model\010_1252.009 Distribution of LNAPL.mxd/2/28/2013



NOTES:
1. FIGURE ILLUSTRATES MOST SIGNIFICANT LNAPL OCCURRENCES OVER ENTIRE MONITORING PERIOD.
2. NOTE THAT B-223-88, AND B-32-40 EACH HAD ONE OCCURRENCE OF SHEEN REPORTED. SHEEN HAS NOT BEEN OBSERVED IN THOSE WELLS IN OVER 50 OTHER MONITORING EVENTS.

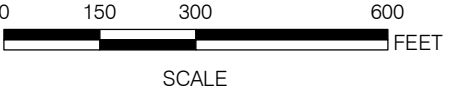


FIGURE 17
DISTRIBUTION OF LNAPL
SITE CONCEPTUAL MODEL
FORMER AVILA TERMINAL
AVILA BEACH, CALIFORNIA
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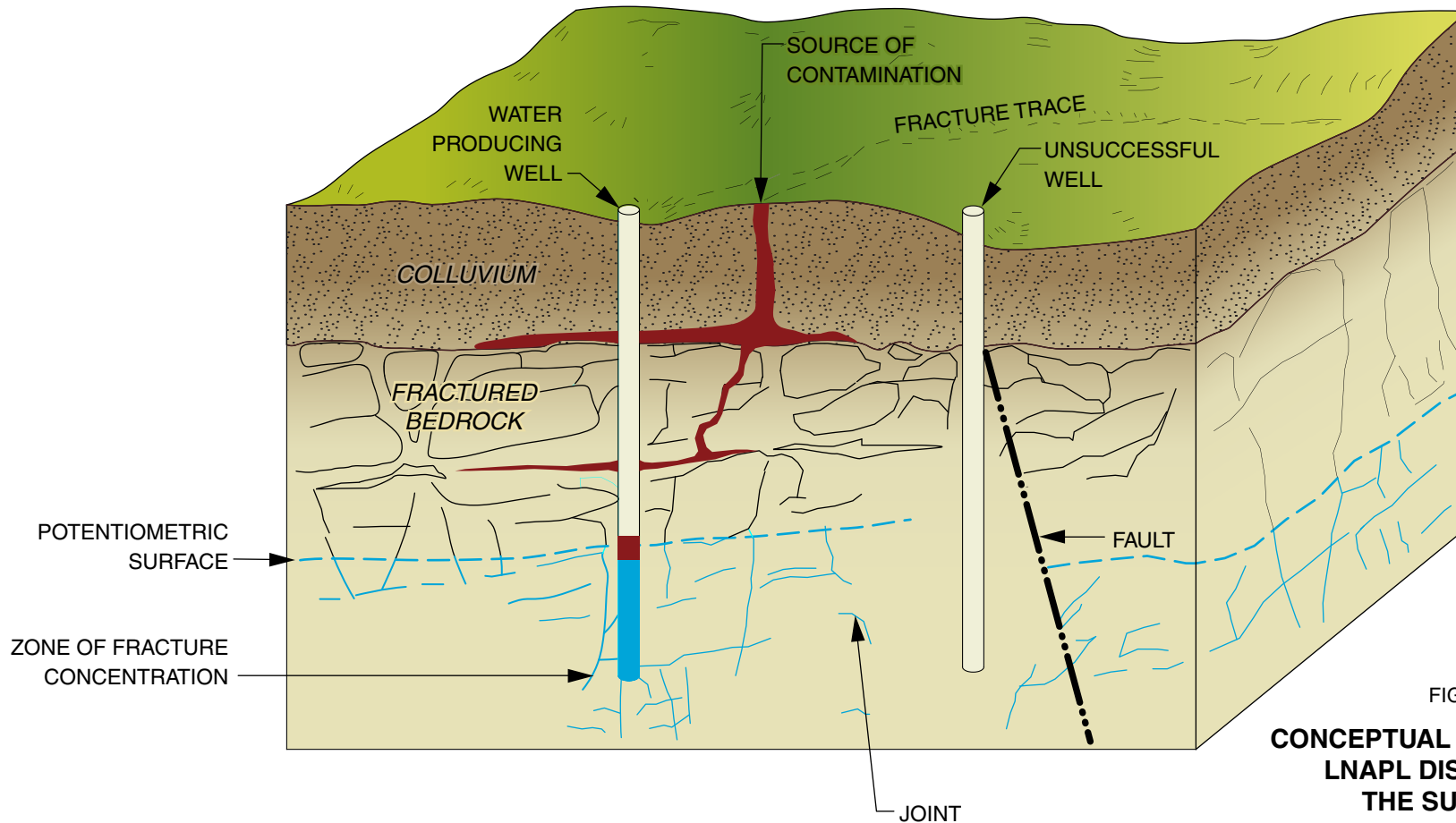


FIGURE 18
**CONCEPTUAL ILLUSTRATION OF
LNAPL DISTRIBUTION IN
THE SUBSURFACE**

FORMER AVILA TERMINAL
AVILA BEACH, CALIFORNIA

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Explanation

- Nested Soil Gas Probe
- Nested Soil Gas Probe with Soil Sample Collection to 5'
- Nested Soil Gas Probe with Soil Sample Collection to 10'
- Soil Gas Monitoring Probe
- Supplemental 15' Soil Gas Probes
- Concentration of Total VOCs in ug/L. ND Indicates That No VOCs Where Detected in The Sample.
- (0.35) Value Not Used in Contouring
- Approximate Contour of Total VOCs Concentration in ug/L
- Approximate Site Boundary
- Diesel / Gas / Crude Oil Pipeline
- Storage Tanks / Areas
- Initial Evaluation Area

NOTES:
1. Total VOCs Reflects The Sum of All VOCs Detected in A Sample.
2. For probes with multiple sampling events, the median of the sum values is used.
3. "Shallow" refers to probes <10 feet deep. "Deep" refers to probes >10 feet deep.
4. Data corresponds to soil gas samples collected from deep probes.

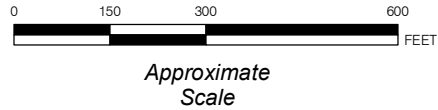


FIGURE 20
**DISTRIBUTION OF TOTAL VOCs
IN SOIL GAS**
SITE CONCEPTUAL MODEL
FORMER AVILA TERMINAL
AVILA BEACH, CALIFORNIA
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Explanation

- ▲ Soil Gas Monitoring Probe
- Supplemental 15' Soil Gas Probes
- Supplemental 15' Soil Gas Probes
- Nested Soil Gas Probe
- Nested Soil Gas Probe with Soil Sample Collection to 5'
- Nested Soil Gas Probe with Soil Sample Collection to 10'
- 9.5 Concentration of Methane in Percent. < Indicates That Analyte Was Not Detected at The Indicated Value. NA Indicates That Data Are Not Available.
- 5 Approximate Contour of Methane Concentration in Percent.
- Approximate Site Boundary
- Residential
- Commercial Use with Potentially Occupied Structure
- Parking
- Diesel / Gas / Crude Oil Pipeline
- Storage Tanks / Areas
- Initial Evaluation Area

- NOTES:
1. The Lower Explosive Limit (LEL) of Methane Is 5 Percent.
 2. Isoconcentration Contour Interval Is Variable.
 3. "Shallow" refers to probes <10 feet deep. "Deep" refers to probes >10 feet deep.
 4. Data corresponds to soil gas samples collected from deep probes.

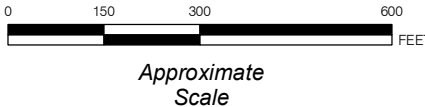


FIGURE 21

DISTRIBUTION OF METHANE IN SOIL GAS

SITE CONCEPTUAL MODEL
FORMER AVILA TERMINAL
AVILA BEACH, CALIFORNIA

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Appendix A

*CD Containing PDF Version of the
Subject Report*