Corrective Measures Study Report

Chevron Phillips Chemical
Puerto Rico Core, LLC
Guayama, Puerto Rico

April 2016

Prepared for:
Chevron Phillips Puerto Rico Core, LLC

Prepared by:
PEI

This page intentionally left blank.

Corrective Measures Study Report
Chevron Phillips Chemical Puerto Rico Core, LLC
Guayama, Puerto Rico

April 2016

Prepared for:
Chevron Phillips Chemical Puerto Rico Core, LLC
Guayama, Puerto Rico

Prepared by:
PEI
1414 West Sam Houston Pkwy N. Suite 170
Houston, Texas 77043

This page intentionally left blank.

CONTENTS

FIGURES

TABLES

APPENDICIES

This page intentionally left blank.

ACRONYMS

AES	AES Corporation
AOC	Area of Concern
AOI	Area of Interest
AS	Air Sparge
ASP	Activated Sodium Persulfate
AST	Aboveground Storage Tank
bgs	below ground surface
BTEX	benzene, toluene, ethylbenzene and xylene
cfu/gm	Colony Forming Units per Gram
CHP	Catalyzed Hydrogen Peroxide
CMI	Corrective Measures Implementation
CMO	Corrective Measures Objectives
CMS	Corrective Measures Study
COC	Chemical of Concern
CPCPRC	Chevron Phillips Chemical Puerto Rico Core, LLC
cy	cubic yard
EI	Environmental Indicator
EFR	Enhanced Fluid Recovery
EPA	U.S. Environmental Protection Agency
FRTR	Federal Remediation Technology Roundtable
G&A	General and Administration
GAC	Granulated Activated Carbon
HI	Hazard Index
HWMU	Hazardous Waste Management Unit
ISCO	In-Situ Chemical Oxidation
LNAPL	Light non-aqueous phase liquid
MCL	Maximum Contaminant Level
mg/Kg	Milligrams per Kilogram
MSGP	Multi-Sector General Permit
MSL	Mean Sea Level
NPDES	National Pollutant Discharge Elimination System
O&M	operations and maintenance
OU	Operable Unit
ppm	parts per million
PRASA	Puerto Rico Aqueduct and Sewer Authority
PREQB	Puerto Rico Environmental Quality Board
RACER	Remedial Action Cost Engineering and Requirements
RBSL	risk-based screening level
RCRA	Resource Conservation and Recovery Act

RFI	RCRA Facility Investigation
SRFI	Supplemental RCRA Facility Investigation
SVE	Soil Vapor Extraction
TMV	Toxicity, Mobility, and Volume
UST	Underground Storage Tank
VISM	Voluntary Interim Stabilization Measure
WWTP	Wastewater Treatment Plant
µg/Kg	Micrograms per Kilogram

1. BACKGROUND

1.1 Overview

This Corrective Measures Study (CMS) has been developed in accordance with the Final Corrective Measures Study Work Plan (*Final Corrective Measures Study Work Plan*, Chevron Phillips Chemical Puerto Rico Core [CPCPRC], December 2015b). The work plan was developed consistent with the requirements for CMS-phase work planning and reporting as specified in Attachment II of the Administrative Order on Consent II Resource Conservation and Recovery Act (RCRA) – 95-3008(h)-0307 (the Order), and the RCRA Cleanup Reforms (*RCRA Cleanup Reforms, EPA530-F-99-018,* U.S. Environmental Protection Agency [EPA], July 1999). The RCRA Cleanup Reforms were established to streamline cleanups and achieve remediation goals faster and more efficiently. The reforms are designed to develop focused, results-based cleanup remedies.

1.2 Purpose of the CMS

The overall purpose of the CMS at the CPCPRC Facility (the Facility) is to develop and evaluate corrective measures alternatives, and to recommend the alternative that is best expected to control human exposure to contaminated groundwater and soil, control the migration of contaminated groundwater, and, ultimately, clean up Facility-related contamination to the extent technically practicable. The location of the Facility is presented in Figure 1.

1.3 Report Organization

The following presents the content and organization of this CMS Report:

- Section 1.0 presents a description of the current conditions, including a summary of RCRA Facility Investigation (RFI) investigations and work performed, the conceptual site model for the Facility, results of risk assessment work, current controls, and contaminant fate and transport. The scope of this CMS is also described.
- Section 2.0 presents the corrective measures objectives (CMOs) and the remediation goals for the Facility-related chemicals of concern (COCs).
- Section 3.0 presents the identification and screening of the potential corrective measure technologies.
- Section 4.0 presents the development of the potential corrective measure alternatives that could potentially address the CMOs.
- Section 5.0 presents a description and evaluation of each corrective measure alternative relative to technical, environmental, human health, institutional concerns, and cost.
- Section 6.0 presents a comparative analysis of the corrective measure alternatives and recommendation of the preferred alternative based on cost, technical, human health, and environmental screening criteria.

1.4 Summary of Investigations and Work Performed

The CMS considers the results of Facility investigations and assessments performed during the RFI phase of work.

1.4.1 RFI Investigations

The following summarizes the investigations performed at the Facility during the RFI phase of work. The investigations were conducted in accordance with the requirements of the Order.

1.4.1.1 RFI Investigations

The RFI was initiated in 1995 and a large data set was compiled through the multiple phases of investigations that were performed between 1995 and 1999. Each phase of investigation was designed to address data gaps from previous phases. The investigations focused on determining the nature and extent of contamination in the ten Operable Units (OUs) defined in the Order. Figure 2 presents the locations OU-3 through OU-10. It is noted that OU-1 represents groundwater beneath the Facility and OU-2, the Las Mareas Harbor Area, is a man-made harbor located approximately 0.5 miles southwest of the main Facility.

CPCPRC completed the RFI investigations and submitted the Final RFI Report to the EPA in July 1999. Between 1999 and 2006, CPCPRC performed risk assessment work and performed numerous investigations to further refine the nature and extent of contamination and to refine the understanding of the lithology and physical structure of the groundwater system beneath the Facility and in the offsite areas where contamination was identified.

1.4.1.2 AOC Investigation

In August 2008, CPCPRC announced the permanent cessation of operations at the Facility and began complete demolition of the Facility. During the decommissioning and dismantlement of the Facility, areas of potential contamination were sampled. If the analytical results indicated contamination was present above conservative risk-based screening levels (RBSLs), the area was retained as an Area of Concern (AOC) for further investigation. Sampling efforts completed during the decommissioning and dismantlement of the Facility identified 19 AOCs (Figure 3).

The investigation of the 19 AOCs was performed in two phases after the complete demolition of the Facility. The first phase of work was performed in August/September 2011 and the second phase was performed in January 2012. The AOC investigation samples were analyzed for a comprehensive list of chemicals developed under the direction of EPA. This list of chemicals was termed the Facility’s Modified Skinner List of chemicals.

1.4.1.3 Supplemental RFI

The Supplemental RCRA Facility Investigation (SRFI) was performed from October through December 2013 in onsite areas and in March 2014 and December 2014 along the Puerto Rico Aqueduct and Sewer Authority (PRASA) pipeline offsite to the east of the Facility. The purpose of the SRFI work was to address a data gap identified by EPA and Puerto Rico Environmental Quality Board (PREQB) during their review of the AOC Investigation Report. The data gap identified was to finalize the nature and extent of sulfolane contamination in soil and groundwater and to finalize the risk assessment specifically for sulfolane.

During the SRFI, investigation areas were designated as Areas of Interest (AOIs). The locations of the 15 AOIs investigated during the SRFI are presented in Figure 3.

1.4.1.4 Semi-Annual Sampling

Since 1999, CPCPRC has been sampling a subset (54) of the 117 Facility monitoring wells on a semi-annual basis. The monitoring wells primarily include wells located offsite and along the boundaries of the Facility. The objective of this semi-annual sampling is to track groundwater contamination and verify that the migration of contaminated groundwater is under control until the CMS remedy for groundwater is implemented. The locations of the site monitoring wells are presented in Figure 4.

Although 54 wells are designated for semi-annual sampling, CPCPRC periodically elects to expand the sampling to provide data necessary to provide a site-wide view of the nature and extent of groundwater contamination. In addition to the groundwater sampling, the surface water and sediment in the Effluent Channel are sampled on a semi-annual basis.

1.4.1.5 Chronology of Work Performed

The following presents a brief summary of the corrective action activity performed during the RFI phase at the Facility:

1995 to 1999	Work planning, laboratory and bench-scale studies, and field investigations of groundwater, soil, sediment, air, and surface water impacts.
July 1999	CPCPRC completed the RFI and submitted the Final RFI Report to the EPA.
January 2000	EPA issued a letter (dated January 4, 2000) wherein EPA approved the RFI on the condition that the CMS address the EPA's noted concerns.
October 2003	EPA determined that the benzene, ethylbenzene, toluene, and xylenes (BTEX) plumes are stable and posted the determination (the Groundwater Environmental Indicator [EI]) on the EPA website.
November 2004	CPCPRC submitted the Final Risk Characterization Report (CPCPRC, 2004), which addressed EPA's noted concerns.
February 2005	The Final Risk Characterization Report (CPCPRC, 2004) was approved in an email dated February 1, 2005.
March 2006	EPA and CPCPRC agreed that the RFI phase of the work had been completed at the facility and that work planning for the CMS phase of work could begin.
October 2006	CPCPRC submitted the Final CMS Work Plan.
April 2007	CPCPRC submitted the Draft Site-Wide CMS Report.
September 2007	The Puerto Rico Environmental Quality Board (PREQB) provided comments on the Draft Site-Wide CMS Report.
August 2008	CPCPRC announced the permanent cessation of operations at the Facility and its intent to decommission and dismantle the process units, tanks, and related equipment.
2009-2011	The decommissioning and dismantling activities were implemented and involved the physical dismantlement of equipment, tanks, and piping for sale, reuse, or recycling. During this time, CPCPRC performed initial characterization sampling of soil in areas exposed by demolition.
October 2011	CPCPRC, EPA, and PREQB met to discuss the scope and schedule for the CMS Report considering the initial characterization sampling of soil exposed by demolition. EPA and PREQB determined the CMS should be placed on hold

	until post-demolition investigations are completed.
4th Quarter 2011	Decommissioning and dismantlement was completed and 19 AOCs were identified based on initial sampling efforts.
August 2011 and January 2012	AOC field investigation was conducted in two phases in August/September 2011 and January 2012.
July 2012	CPCPRC submitted the Draft AOC Investigation Report to the EPA and the PREQB.
January 2013	EPA and the PREQB provided review comments on the Draft AOC Investigation Report.
April 2013	CPCPRC submitted the Final AOC Investigation Report revised to address EPA comments on the Draft report.
July 2013	CPCPRC submitted the Draft Supplemental RCRA Facility Investigation (SRFI) Work Plan to the EPA and the PREQB. The focus of the work plan was to address the data gap identified during review of the AOC Report. The data gap identified was to finalize the nature and extent of sulfolane contamination in soil and groundwater.
2012 through 2014	The storm water collection and conveyance system was modified, the Facility Wastewater Treatment Plant (WWTP) was completely dismantled and removed, and the two discharge permits (National Pollutant Discharge Elimination system [NPDES] and Multi-Sector General Permit [MSGP]) were terminated.
September 2013	EPA provided approval of the SRFI Work Plan.
4th Quarter 2013 and in 2014	SRFI field investigation was conducted in two phases in October through December 2013 in onsite areas and in March 2014 and December 2014 along the PRASA pipeline offsite to the east of the Facility.
June 2014	CPCPRC submitted the Draft SRFI Report to the EPA and the PREQB.
November 2014	EPA and the PREQB provide review comments on the Draft SRFI Report.
January 2015	CPCPRC submitted the Final SRFI Report revised to address EPA comments on the Draft report.
March 2015	EPA issued a letter approving the Final SRFI Report and requesting CPCPRC begin the CMS phase of work.
June 2015	CPCPRC submitted the Draft CMS Work Plan to the EPA and the PREQB.
November 2015	CPCPRC submitted the Pilot Test Work Plan for Soil Biodegradation Treatment to the EPA and the PREQB.
December 2015	EPA issued a letter approving the CMS Work Plan and the Pilot Test Work Plan for Soil Biodegradation Treatment. CPCPRC began the development of the CMS Report and work to implement the soil biodegradation pilot test.

Current activities at the Facility include groundwater monitoring related to the Order, and ongoing interim measures conducted through implementation of the Enhanced Fluid Recovery (EFR) system and the Voluntary Interim Stabilization Measure (VISM) system. The interim measures are discussed in Section 1.9.

1.5 Conceptual Site Model

The Facility is 211 acres in size and is located on the southeast coast of Puerto Rico centered at approximately 17°56'45" north latitude and 66°08'30" west longitude (Figure 1). CPCPRC is located about 0.25 miles north of the Caribbean Sea. A facility location map is provided in Figure 1. The Facility was constructed in 1966 on land previously used for sugar cane cultivation. The Facility operated as a specialty chemicals production facility that operated from 1966 to 2008. The CPCPRC Facility was constructed to primarily process naphtha into a variety of refined hydrocarbon products including, but not limited to, benzene, toluene, xylenes, cyclohexanes, liquid petroleum gas, gasoline, and diesel fuels. Sulfolane was used as part of the chemical process, and through inadvertent releases, BTEX and sulfolane were introduced into the environment.

1.5.1 Site Setting and Use

Prior to demolition, the Facility consisted of a Process Area with structures, piping, and other appurtenances on a concrete slab and product storage in Tank Basins A through N. The administrative offices and other support services were located in the northern portion of the Facility. Near the southern portion of the Facility, there was a WWTP and associated ponds and structures. Figure 3 presents the locations of the former site features.

The Facility is fenced and there is guard presence 24/7. Activity at the Facility is limited to work related to periodic mowing and groundskeeping, work to operate and maintain the VISM and EFR systems, technology pilot testing related to this CMS, and routine groundwater monitoring.

Based on current surrounding land use and likely expectations of future land use, the Facility will remain industrial.

1.5.2 Topography and Physiography

The Facility area was previously graded to accommodate sugar cane cultivation. During construction of the Facility in 1966, the area was re-graded to construct containment berms around aboveground storage tank (AST) basins. Within the tank basins, raised soil platforms were constructed and the former ASTs were placed on the soil platforms. The soil platforms range in height from about 1 foot to approximately 10 feet above the surrounding grade. The Facility is completely demolished and currently consists of generally flat terrain except, for the raised soil platforms and gunite-lined containment berms that surround the tank basins. Elevations range from 45 feet above mean sea level (msl) in the northern portion of the Facility, to less than 5 feet msl at the southern boundary.

1.5.3 Climate and Precipitation

The Facility is in a tropical area, with mean monthly temperatures above 64° Fahrenheit, and a dry winter season. The mean annual precipitation in Guayama, located east of the facility, is 60 inches. Jobos, located west of the Facility, receives an average of 45 inches of rainfall annually. The rainy season generally extends from May through November, with the dry season from December through April. On average, approximately 75% of the annual precipitation occurs during the rainy season.

1.5.4 Surface Water Features

During its operational lifetime, storm water on the Facility was conveyed to 5 outfalls (Figure 3). As part of the final Facility closure activities, the storm water collection and conveyance system was modified, the Facility WWTP was completely dismantled and removed, and the two discharge permits (NPDES and

MSGP) were terminated. Currently, any storm water that falls on the Facility is clean storm water that drains to the Effluent Channel.

Storm water in the Effluent Channel flows to the west where it commingles with discharges from the Fibers Superfund Site, Ayerst Wyeth Pharmaceuticals, Inc. and other storm water runoff from the surrounding area. Water in the Effluent Channel discharges to the Caribbean Sea at Las Mareas Harbor.

It should be noted that since the decommissioning of the Facility WWTP in 2014, the Effluent Channel immediately south of the Facility has been dry except after storm events.

1.5.5 Geology

The geology in the subsurface at the Facility is characteristic of a transitional alluvial fan depositional environment. The stratigraphic units underlying the Facility tend to be variable in thickness, non-uniform in character, and discontinuous in both lateral and vertical extent. Although variable, data indicate the following hydrostratigraphic units are present at the Facility:

- Fill placed during Facility construction in 1966;
- Lagoon silt and clay;
- Upper Alluvial Sand;
- Tank Basin Shallow aquitard;
- Lower Alluvial Sand;
- Process Area Shallow aquitard; and
- Bedrock.

Figure 5 presents a generalized north-south illustration of the architecture of the stratigraphy beneath the Facility. Although Figure 5 is a somewhat simplified depiction of the units, this conceptual model is a useful tool for understanding groundwater flow and contaminant occurrence and transport.

Fill – Reflecting site grading and leveling, fill generally includes the top 5 feet of soil at the Facility. These deposits consist of widely varying mixtures, of silt, sand, gravel, and shell fragments.

Lagoon Silt and Clay – Shallow sediments south of the Effluent Channel. These deposits are composed primarily of low permeability silt and clay. These deposits are up to 30-feet thick south of the Facility.

Upper Alluvial Sand – Alluvial fan deposits including widely varying combinations of silt, sand, and gravel. Figure 6 presents an isopach map of sand thickness in the upper alluvial aquifer. This is the primary unit impacted by hydrocarbon contamination. Examination of Figure 6 indicates a complex surface related to meandering streams flowing south toward the coastline. Key features observed in Figure 6 include the following:

- Thicker sand (depicted by the light green to blue colors) in the vicinity of Tank Basins E and F roughly coinciding with the area where the Tank Basin Shallow aquitard deposits (discussed below) are generally thin or absent. These sand deposits trend to the west, offsite toward the AES power plant and to the southwest toward Tank Basin A and likely represent deposition in a paleo-stream channel (hereafter termed sand channel) environment.

- Along the west fence line, there appears to be a narrow sand channel that extends from Tank Basin A and trends south along the western site boundary. This sand then appears to trend to the west and offsite under the AES coal ash pile.
- There appears to be an isolated body of sand in the vicinity of Tank Basin L. The sand in this area appears to trend to the south and the southeast where it is truncated by clay deposits in the vicinity of the Effluent Channel.
- In the southeast corner of Tank Basin C, there appears to be a narrow sand channel that extends to the south along the eastern site boundary where it is truncated by clay deposits.

Tank Basin Shallow Aquitard – The Upper Alluvial sand is separated from the Lower Alluvial Sand by this unit. These deposits are composed of low permeability silt and clay with occasional minor sand stringers. With the exception of an isolated area in the vicinity of Tank Basins E and F (Figure 6), these deposits appear to be continuous south of the former Process Area. In the vicinity of Tank Basins E and F, these deposits are either thin or absent. To the south, the thickness of the deposits generally increases and thickness ranges from about 2- to 10-feet thick.

Lower Alluvial Sand – These alluvial deposits consist of varying combinations of silt, sand, and gravel. Relative to the Upper Alluvial Sand, these deposits contain coarser-grained deposits and tend to be more homogeneous. In the southern portion of the Facility, this unit lies below the Tank Basin Shallow Aquitard and the Lagoon Deposits. In the northern portion of the Facility, this unit lies below a separate shallow silt/clay aquitard that is continuous beneath the former Process Area. The Lower Alluvial Sand unit is present beneath the entire Facility and the top of this unit has been observed between 10 and 30 feet below ground surface (bgs) and extends to the top of the andesite bedrock.

Process Area Shallow Aquitard – Beneath the former Process area, this silt/clay unit separates the Upper Alluvial Sand unit from the Lower Alluvial Sand unit. This aquitard is typically on the order of 5- to 15-feet thick and is found between 15 to 25 feet bgs.

Bedrock – The bedrock is found about 60 to 80 feet bgs and lies directly below the Lower Alluvial Sand unit. The bedrock is predominantly composed of andesite. The andesite bedrock is not considered to act as an aquifer in the vicinity of the Facility (USGS, 1992).

1.5.6 Hydraulic Characteristics

The hydraulic characteristics of the two principle water-bearing units at the Facility are described in the following subsections.

1.5.6.1 Shallow Aquifer

Groundwater elevations in the upper alluvial aquifer (hereafter termed the shallow aquifer) ranged from 12.67 feet above mean sea level (msl) to 0.52 feet msl from north to south across the Facility in June 2015. In December 2014, water levels ranged from 15.46 to 3.17 feet msl from north to south across the Facility. These months were selected to demonstrate the typical groundwater conditions prior to the rainy season (June) and after the rainy season (December). Groundwater flow is to the south with components of flow to the southeast and southwest. Groundwater flow is generally coincident with the alignment of the sand channels. Based on this water level change from north to south across the site, the hydraulic gradient of the shallow aquifer is approximately 4.5×10^{-3} ft/ft.

In dry season months, the average saturated thickness of the shallow aquifer is on the order of 14-feet thick. In the rainy season months, the average saturated thickness of the shallow aquifer is on the order of 17-feet thick. It should be noted that monitoring wells in the former Process Area that are completed in the shallow aquifer are typically dry (i.e., saturated thickness of zero) during the dry season. In the rainy season, the water table is higher and these wells generally are not dry.

1.5.6.2 Deep Aquifer

Groundwater elevations in the lower alluvial aquifer (hereafter termed the deep aquifer) ranged from 12.44 feet msl to 3.07 feet msl from north to south across the Facility in June 2015. In December 2014, water levels ranged from 13.54 to 4.12 feet msl from north to south across the Facility. As demonstrated by these water level changes between these two time periods, water levels in the deep aquifer also respond to seasonal variations in rainfall. Groundwater flow is to the south-southwest coincident with the regional flow direction. Based on this water level change from north to south across the site, the hydraulic gradient of the deep aquifer is approximately 3.5×10^{-3} ft/ft.

Although water levels fluctuate, this aquifer remains saturated throughout the year and saturated thickness depends on the depth to the underlying bedrock but, averages about 30 feet.

1.5.6.3 Interactions Between Aquifers

Evaluation of water levels in the shallow and deep aquifers demonstrate the following interactions between the two aquifers:

- In the former Process Area, vertical hydraulic gradients are downward and water levels in the shallow aquifer are slightly (generally less than 1 foot) higher than the water levels in the deep aquifer.
- In the north-central portion of the Facility, water levels are general in equilibrium or near equilibrium.
- In the southern portion of the Facility, vertical hydraulic gradients are upward and water levels in the deep aquifer are slightly (generally about 1 foot) higher than the water levels in the shallow aquifer.

These observations are in agreement with the conceptualization of the subsurface architecture in that, areas of downward vertical gradients are areas where the shallow aquifer is isolated from the deep aquifer by the Process Area Aquitard. In the north-central portion of the Facility, water levels are generally in equilibrium coinciding with the areas where the Tank Basin Shallow aquitard is thin or absent and the two aquifers are in direct connection. Upward vertical gradients in the southern portion of the Facility are in areas where the deep aquifer is confined beneath the Tank Basin Shallow Aquitard.

1.6 Summary of Human Health and Ecological Risk Assessment

The following section provides a summary of the detailed risk assessment work performed during the RFI phase of work. The summary is presented specific to the media investigated and receptor populations evaluated. At the end of this summary, the chemicals of concern (COCs) identified during the risk assessment are presented. This CMS addresses the COCs identified through detailed risk assessment presented in the Final AOC Investigation Report (CPCPR, 2013a) and the Final Supplemental RFI Report CPCPRC, 2015a).

1.6.1 Groundwater

In the risk assessment, groundwater at the Facility was evaluated relative to the following potential receptor populations: the hypothetical resident and the construction worker.

For the hypothetical resident, exposure to both the shallow and deep groundwater was evaluated. For the resident, benzene is the risk driver and the majority of the cancer (94% of the total) and non-cancer risk (80% of the total) would result from exposure to benzene in groundwater. Sulfolane, ethylbenzene, m- &

p-xylene, and o-xylene also contribute to the non-cancer risk. The cumulative non-cancer risk was demonstrated by a Hazard Index (HI) of 500, while the cancer risk was 3×10^{-2}. Both of these values are outside the acceptable risk ranges.

The construction worker would be at potential risk while working in contact with the shallow groundwater. The majority of the cancer and non-cancer risk would result from contact with benzene in groundwater. The cumulative HI was 20 while the cancer risk was 2×10^{-4}. Both of these values are outside the acceptable risk ranges.

1.6.2 Surface and Subsurface Soil

In the risk assessment, surface soil at the Facility was evaluated relative to the following potential receptor populations: the construction worker, industrial worker, and trespasser. Subsurface soil was evaluated relative to the construction worker.

The construction worker would be at potential risk while working in contact with the soil. The majority of the cancer and non-cancer risk would result from contact with benzene. The cumulative HI of 3 is above the acceptable risk threshold. The soil cancer risk was 1×10^{-6}, which is within the risk acceptance range.

The cumulative risks for the industrial worker and the trespasser were within the acceptable risk ranges and contact with site soil does not pose a risk to these potential receptors.

1.6.3 Surface Water and Sediment

In the risk assessment, surface water and sediment in the Effluent Channel were evaluated relative to the trespasser. In addition, a conservative screening level ecological risk assessment (SLERA) was performed on the surface water and sediment.

For the trespasser, the RA indicated no potential risk because the cumulative potential ELCR associated with exposure to sediment (1×10^{-7}) is within EPA's acceptable risk range. The combined HI was 0.03, which is below the risk threshold value of one.

Regarding ecological risk, the SLERA concluded that surface water posed no unacceptable risk to ecological receptors. The potential risks to benthic invertebrates in the Effluent Channel due to chromium, copper, manganese, nickel, and zinc in sediment were marginal but could not be excluded.

1.6.4 Chemicals of Concern

Based on the results of the human health risk assessment, the BTEX constituents and sulfolane are the COCs addressed by this CMS. Benzene is the risk driver while sulfolane and the other BTEX constituents are minor contributors to risk.

Chromium, copper, manganese, nickel, and zinc are considered COCs exclusively with respect to the Effluent Chanel sediments. These constituents in sediment only pose a marginal risk to benthic invertebrates and pose no risk to any human receptors in any site media.

1.7 Nature and Extent of Contamination

Facility related contamination has been determined through multiple phases of RCRA Facility investigation including the original RFI performed prior to demolition and the AOC Investigation and the SRFI, both performed after demolition of the Facility.

This nature and extent of contamination discussion focuses on benzene and sulfolane contamination. Benzene is a focus because it is the primary risk driver and is the most mobile of the BTEX constituents. Sulfolane nature and extent is a focus because this chemical is highly mobile in groundwater and its fate in the environment differs from the fate of the BTEX constituents.

1.7.1 Groundwater

Figure 7 presents the extent of benzene in shallow groundwater based on the groundwater samples collected from the open boreholes during the AOC Investigation and the monitoring wells sampled during the May/June 2012 comprehensive sampling event. Figure 8 presents the extent of benzene in deep groundwater based on the comprehensive sampling performed in May/June 2012. Figure 9 and Figure 10 present the extent of sulfolane in the shallow and deep aquifers respectively, based on the same data sets.

The 2011/2012 AOC data set and the May/June 2012 comprehensive sampling event were selected to represent the nature and extent of contamination in groundwater because these data are the most comprehensive recent data. This data set includes the sampling of 80 of the 117 Facility's monitoring wells plus grab samples collected from boreholes drilled in the shallow aquifer in areas not routinely monitored.

1.7.1.1 Benzene

As shown on Figure 7, one benzene plume is observed to extend from beneath the former Process Area south for about 2,800 feet terminating near former AOC Tank 360. The second plume is observed along the western edge of the Facility and its alignment is consistent with the alignment of a sand channel mapped in this area. This plume is approximately 1,300 feet in length and extends about 200 feet offsite.

Of particular note with respect to benzene contamination is the observation that the plume previously identified in the past reports in the southeast corner of the Facility is no longer present. Benzene was not detected in monitoring wells in the southeast corner during the May/June 2012.

Figure 8 presents the benzene data in the deep aquifer based on the May/June 2012 expanded semi-annual monitoring event. As shown in Figure 8, benzene was below detectable levels in the majority of the deep aquifer monitoring wells. Where benzene is detected, it is found in isolated areas at levels generally below its Federal Maximum Contaminant Level (MCL) of 5 µg/L. Two wells did have benzene concentrations above the MCL. These two wells, MW-30D and MW-159D, had benzene concentrations of 15 and 21 µg/L, respectively, in May/June 2012.

1.7.1.2 Sulfolane

Figure 9 presents the extent of sulfolane in the shallow aquifer and includes the groundwater samples collected from the open boreholes during the AOC Investigation and the monitoring wells sampled during the May/June 2012 expanded sampling event. Similar to benzene, sulfolane contamination is present in distinct plumes coincident with the presence of sand channels in the shallow aquifer.

As shown in Figure 9, one sulfolane plume is observed beneath the former Process Area. This plume extends south and east for about 2,800 feet and extends about 600 feet beyond the eastern Facility boundary and south and west about 4,200 feet and extends offsite to the west about 1,200 feet. The second plume is observed near the northwestern Facility boundary and is approximately 2,000 feet in length and extends about 600 feet offsite to the west. The third plume is found in the southeast corner of the Facility, is approximately 2,600 feet in length and extends offsite south about 1,200 feet to monitoring well MW-166.

Figure 10 presents the sulfolane data in the deep aquifer based on the May/June 2012 expanded semi-annual monitoring event. As shown in Figure 10, sulfolane is above the remediation goal of 16 µg/L in 11 of the 15 deep wells onsite, and in two of the 8 deep wells located offsite.

1.7.2 Soil

Regarding soil, the nature and extent of soil contamination is based on 259 surface and subsurface soil samples collected during the AOC Investigation plus 63 surface and subsurface soil samples collected during the SRFI. Each soil sample was compared to the remediation goals for soil described later in this CMS (Section 2.2) and the sample locations were color-coded as follows:

- Green dot – no COC exceeded remediation goals in the sample;
- Red dot – at least one of the BTEX constituents exceeded the remediation goals;
- Blue dot – only sulfolane exceeded the remediation goals; and
- Red square – at least one BTEX constituent and sulfolane exceeded the remediation goals.

The results of the comparison for surface soil and subsurface soil are presented in Figures 11 and Figure 12, respectively.

As shown in Figure 11, no COC was found above the remediation goals at 255 of the 322 surface soil sample locations (79% of the samples had no exceedance). There are 30 locations where at least one BTEX constituent was found above remediation goals but sulfolane was not found above its remediation goal. Sulfolane was found as the only COC above the remediation goals at 22 of the 322 locations. Twelve of these exceedances were in one area, AOC 540. At 15 locations, sulfolane and at least one BTEX constituent were found above the remediation goals.

As shown in Figure 12, no COCs were found above the remediation goals at 229 of the 322 subsurface soil sample locations (71% of the samples had no exceedance). There are 59 locations where at least one BTEX constituent was found above the remediation goals but sulfolane was not found above its remediation goal. Sulfolane was found as the only COC above the remediation goals at 24 of the 322 locations. Twelve of these exceedances were in one area, AOC 540. At 11 locations, sulfolane and at least one BTEX constituent were found above the remediation goals.

1.8 Contaminant Fate and Transport

The following contaminant fate and transport discussion uses site-specific data when available and literature values to evaluate the fate and transport characteristics of the COCs in groundwater and soil.

Consistent with the nature and extent discussion, this fate and transport discussion focuses on benzene and sulfolane contamination.

1.8.1 Release and Vertical Migration

The primary release mechanism at the Facility was release of petroleum hydrocarbons through the bottom of the ASTs. Once released, the contaminants moved vertically through the soil column and generally did not spread laterally until reaching groundwater. Once in groundwater, several processes describe the fate of the COCs. These processes are discussed below.

1.8.2 Advection

Advection in groundwater describes the migration of a solute particle in groundwater due to the fluid's bulk motion. The bulk motion of groundwater is represented by the groundwater flow velocity. Groundwater flow, or seepage velocity, in an aquifer is determined by equation 1:

$$Vs = Ki/\theta \qquad (1)$$

Where:

Vs = seepage velocity (feet/day)

θ = effective porosity

K = hydraulic conductivity

i = hydraulic gradient

The parameters below were used to calculate seepage velocity for the shallow and deep aquifers.

1.8.2.1 Effective Porosity

For the shallow aquifer, a value of 0.20 (20%) was used. This value was taken from the literature (Wiedemeier, et. al, 1998) and represents a mid-range value for silty sand. For the deep aquifer, a value of 0.30 (30%) was used. This value was taken from Section 2 of the final RFI Report (RFI, July 1999).

1.8.2.2 Hydraulic Gradient

The hydraulic gradient values were presented previously in Section 1.5.3 of this CMS and these values are approximately 4.5 x 10^{-3} ft/ft for the shallow aquifer and approximately 3.5 x 10^{-3} ft/ft for the deep aquifer.

1.8.2.3 Hydraulic Conductivity

To develop a reasonable value for this parameter, CPCPRC revisited the approach used in the July 1999 RFI Report to estimate groundwater flux across the western, eastern, and southern site boundaries. In the RFI, the percentages of coarse-grained and fine-grained materials in cross sections along the site boundary were used to estimate a "bulk hydraulic conductivity." The bulk hydraulic conductivity approach essentially "homogenizes" the heterogeneous aquifer materials. Once the percentages of coarse- and fine-grained materials were developed, CPCPRC used the following equation to calculate bulk hydraulic conductivity:

$$K_{bulk}\ (\%\ Sand) = (\%\ Sand/100)*K_{sand} + (100 - \%\ Sand/100)*K_{clay} \qquad (2)$$

In the RFI Report, a value of 60 feet/day was assigned to the sand, and a value of 1 x10^{-3} feet/day was used for the clay.

For this evaluation, the information presented in the sand thickness map (Figure 6) was used to estimate the percentage sand along the plume centerlines. Examination of the sand thickness data (Figure 6) indicated that sand thickness averages about 5 feet, or about one-third the average saturated thickness of the aquifer (i.e., 33% sand). Using this value for percentage sand in the equation above, a value for bulk hydraulic conductivity of approximately 20 feet/day was calculated for the shallow aquifer.

In the deep aquifer, the hydraulic conductivity value of 270 feet/day presented in the RFI Report was used.

1.8.2.4 Seepage Velocity

Using equation 1 and the values for the input parameters, the following average seepage velocities (V_s) were calculated:

- Seepage Velocity for the Shallow Aquifer = 0.45 feet/day or approximately 164 feet/year.
- Seepage Velocity for the Deep Aquifer = 3.15 feet/day or approximately 1,150 feet/year.

1.8.3 Adsorption

Unlike a water particle, an organic solute particle may partition (or adsorb) from the groundwater to the aquifer matrix. As a result of this adsorption process, the movement of the solute particle is slowed down (retarded) relative to the movement of groundwater. The degree to which contaminants are adsorbed on soils is dependent on the fraction of organic carbon (f_{oc}) and the chemical-specific water/carbon-partitioning coefficient (K_{oc}).

To estimate the amount of soil partitioning, and hence retardation, the ratio of hydrocarbons in the soil and water phase (the soil-water distribution coefficient - K_d) are calculated using the following equation:

$$K_d = f_{oc} K_{oc} \qquad (3)$$

From information provided in the literature (Wiedemeier et. al, 1998) values for these parameters are:

f_{oc} of 0.1% (f_{oc} = 0.001 for a medium fluvial/deltaic sand).

K_{oc} = 83 Liters/kilogram (benzene)

K_{oc} = 1.17 Liters/kilogram (sulfolane).

The value for foc of 0.1% is equivalent to 1 gram of organic carbon per 1,000 grams of sample, or 1,000 milligrams/Kilogram (mg/Kg).

As a result of adsorption, contaminant transport velocity in the aquifer would be less than the seepage velocity of the groundwater. The velocity of a contaminant relative to groundwater velocity is expressed by equation 4 as:

$$V_c = V_s/R \qquad (4)$$

Where:

V_c = average velocity of contaminant

V_s = average groundwater seepage velocity

R = coefficient of retardation.

The coefficient of retardation can be defined by the following linear relationship:

$$R = 1 + (K_d \theta_b/n) \qquad (5)$$

Where:

R = coefficient of retardation

K_d = distribution coefficient for benzene (0.083 Liters/kilogram)

K_d = distribution coefficient for sulfolane (0.00117 Liters/kilogram)

n = effective porosity (20% Upper Alluvial and 30% Lower Alluvial)

θ_b = soil bulk density (value of 1.7 Kg/L from Wiedemeier, et. al, September 1998).

Using these values, the following coefficients of retardation for benzene and sulfolane were calculated:

Benzene shallow aquifer – 1.7

Benzene deep aquifer – 1.5

Sulfolane shallow aquifer – 1.0

Sulfolane deep aquifer – 1.0

Based on the calculations above, benzene is expected to move at a slower rate than a water particle. Sulfolane, on the other hand, is expected to travel at the same rate as a water particle and would not be expected to adsorbed onto the aquifer matrix.

1.8.4 Biodegradation

1.8.4.1 Soil

In soil, the biodegradation of benzene (and the other BTEX constituents) is well documented. An extensive record of case studies, performance data, and cost data can be found at the Federal Remediation Technology Roundtable (FRTR) website (https://frtr.gov) and information from these studies were used in this CMS, as necessary to evaluate biodegradation of BTEX in soil.

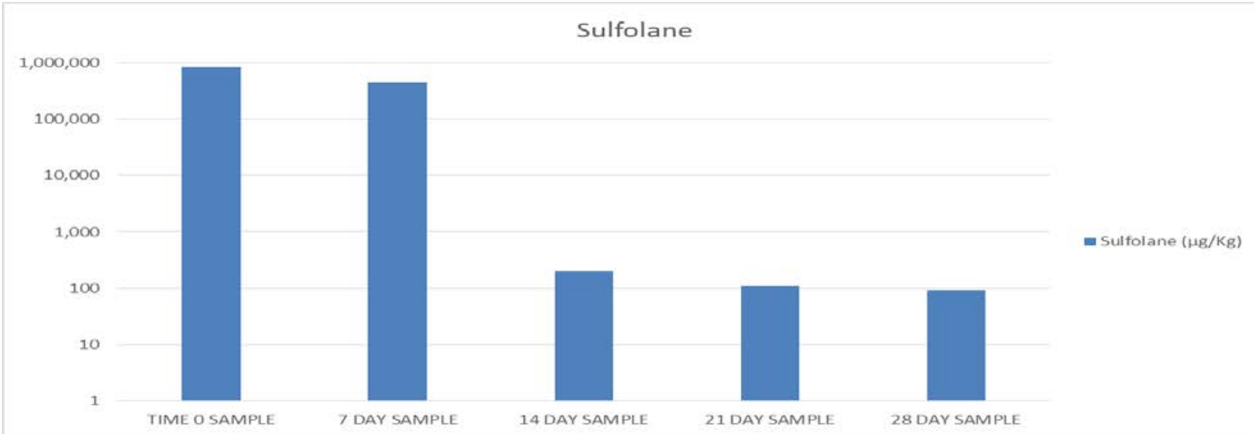
Regarding sulfolane, examination of the published information suggested that the rate of sulfolane biodegradation in soil was minimal with zero-order kinetics in both aerobic and anaerobic microcosms (Greene et al., 1998; Greene and Fedorak, 2001; Saint-Fort, 2006). To further advance the research on sulfolane biodegradation in soil, CPCPRC performed bench-scale testing of sulfolane biodegradation and has initiated an onsite field-scale pilot study demonstration.

Bench-Scale Testing

CPCPRC's bench-scale testing was performed in July 2013 and was performed on soil collected from AOC Tank 540. The first step of the testing included chemical analysis of the soil and assessment of the initial microbial content of the soil (i.e., baseline chemical and microbial conditions). Through testing, it was found that the AOC Tank 540 soil contained high levels of sulfolane and a modest indigenous microbe population with moderate diversity. The initial total microbial count in the soil was 106,000 colony forming units per gram of soil (cfu/gm) with indigenous sulfolane degraders only accounting for about 400 cfu/gm of the total.

Using the results of the baseline chemical and microbial analysis, the laboratory developed an aqueous blend of water, microbes, and fertilizer inoculant. The soil was inoculated, mixed, and sampled at weekly intervals for 28 days.

The reduction in sulfolane levels over the 28-day test period is presented graphically below. As shown, sulfolane levels in soil were reduced from 830,000 micrograms per Kilogram (µg/Kg) to 91 µg/Kg over the 28-day period.



Based on the success of the bench-scale testing, CPCPRC determined that field-scale testing of biodegradation of sulfolane should be performed.

Field-Scale Testing

In January 2016, CPCPRC initiated field-scale testing of biodegradation in accordance with the EPA and PREQB approved work plan (CPCPRC, 2015b). CPCPRC constructed land farm test cells designed to test the biodegradation of sulfolane in the three soil types identified at the AOC Tank 540 area including clay, sand, and gravelly sand. Four test cells were constructed and treated as follows:

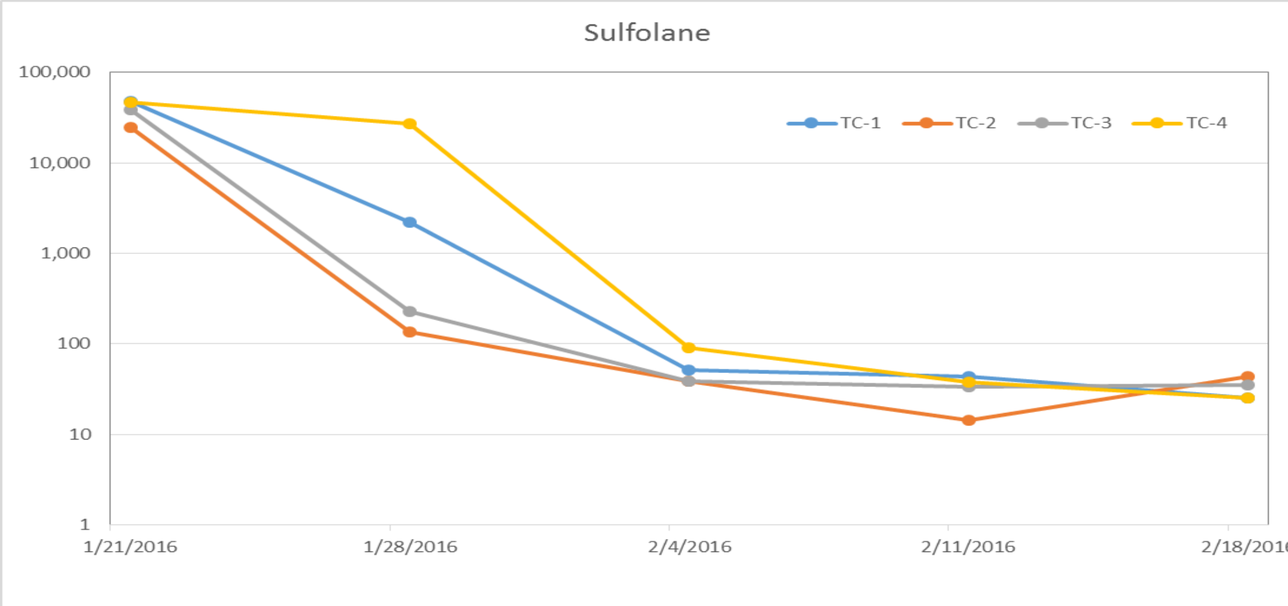
- Test Cell 1 – clay treated with flocculent, microbes and nutrients. One treatment at Time 0 and 1 treatment during Week 2, Week 3, and Week 4.
- Test Cell 2 – sand treated with microbes and nutrients. One treatment at Time 0 and 1 treatment during Week 2, Week 3, and Week 4.
- Test Cell 3 – gravelly sand treated with microbes and nutrients. One treatment at Time 0 and 1 treatment during Week 2, Week 3, and Week 4.
- Test Cell 4 – sand and clay mix treated with flocculent and nutrients. One treatment at Time 0.

Soil moisture in the test cells was monitored daily and moisture was added as needed to maintain soil moisture levels of about 10%. The soil in the test cells was tilled on a weekly basis.

The reduction in sulfolane levels over the 4-week test period are presented graphically below. As shown, the average sulfolane levels were reduced significantly in all four of the test cells. In addition to observing the significant reduction of sulfolane in soil, other observations include the following:

1. The most rapid decline in sulfolane levels occurred in the three test cells inoculated with microbes. In Test Cell 4, no microbes were added. However, it appears that the indigenous microbe populations in Facility soil were capable of degrading sulfolane and the average sulfolane levels in Test Cell 4 by the second week of testing were similar to the average sulfolane levels in the three inoculated test cells.

2. By the third week, the average sulfolane levels in all four test cells were below the remediation goal for sulfolane in soil of 65 µg/Kg (Section 2.2).



3. The presence of clay (Test Cell 1) appears to have inhibited sulfolane degradation relative to the more sandy soil in Test Cell 2 and Test Cell 3. This was anticipated because the clay can limit the performance of the microbes by limiting their contact with the contamination and by limiting their exposure to oxygen. However, sulfolane degradation in Test Cell 1 was similar to the degradation in the other test cells after about two weeks of testing.

As the field-scale testing demonstrates, sulfolane is readily degraded and the biodegradation technology is evaluated later in this CMS along with other soil remediation technologies. At the time of this CMS, CPCPRC was preparing a biodegradation effectiveness evaluation report and this report will be submitted to EPA and the PREQB separately.

1.8.4.2 Groundwater

At the CPCPRC Facility, biodegradation of benzene in groundwater is occurring naturally and the capacity of the aquifers to degrade benzene (and the other BTEX constituents) was documented by site geochemical data collected during the semi-annual monitoring events (CPCPRC, 2004). Based on these data, oxygen consumption and methanogenisis play a very active role in the natural biodegradation of benzene in Facility groundwater.

Regarding sulfolane in groundwater, Greene et al. (1998) conducted aerobic and anaerobic microcosm studies at 8° and 28°C using a variety of sediments from sulfolane-contaminated aquifers. This study documented aerobic sulfolane degradation at 8°C and 28°C following addition of the nutrient phosphate. Aerobic microcosm studies from sulfolane-contaminated aquifer materials and background locations confirmed the presence of sulfolane degrading bacteria in all contaminated samples (Greene et al. 1999). Previously uncontaminated samples did not show evidence of sulfolane degradation even after nutrient (i.e., nitrogen and phosphate) addition. This suggests that soil bacteria exposed to sulfolane adapt over time to be able to degrade sulfolane.

Under anaerobic conditions, no evidence of sulfolane biodegradation was observed at 28°C or under Fe^{3+}, SO_4^{2-}, and CO_2 reducing conditions at 8°C. Thus, Greene et al. (1998) concluded that sulfolane biodegradation would not be significant in anaerobic aquifers.

At the Facility, groundwater exists under both aerobic and anaerobic conditions. In the shallow aquifer where BTEX is detected, groundwater is under anaerobic conditions. In areas where BTEX is not detected and in the deep aquifer, groundwater is present under aerobic conditions. Although aerobic conditions exist in both aquifers, there is no specific evidence that sulfolane biodegradation is occurring in Facility groundwater.

1.8.5 Volatilization to the Atmosphere

Migration of volatile constituents is dependent on the depth of the contamination and the characteristics of the specific chemical. The partitioning of a compound between the water and air matrices depends on the vapor pressure and the water solubility of that compound. Compounds, which have a high vapor pressure and a low water solubility, readily evaporate from the liquid phase and enter the atmosphere or soil vapor. Henry's Law constant is the ratio of vapor pressure to water solubility and describes the volatilization of dissolved organic solutes from water.

In the subsurface, transport of volatile organics in the gas phase occurs when the volatile chemical partitions from the liquid phase to the gas phase. The primary mechanism affecting gas-phase transport is diffusion. The transport of volatile organics through the soil-gas phase also will be affected by adsorption to soil, dissolution into water and biodegradation. Based on the Henry's Law constants for benzene and sulfolane, benzene is expected to volatilize while the volatilization of sulfolane from groundwater is not expected to occur.

Although benzene has the potential to volatilize from groundwater, it should be noted that risk assessment results indicate that benzene volatilization is minimal and the vapor intrusion pathway poses no risk.

1.8.6 Dispersion and Diffusion

Dispersion is present as either hydrodynamic or mechanical. Hydrodynamic dispersion is the process whereby a contaminant plume spreads out in directions that are longitudinal and transverse to the direction of plume migration. Mechanical dispersion is the mixing that occurs as a result of local variations in velocity around some mean velocity of flow. With time, a given volume of solute will gradually become more dispersed as different portions of the mass are transported at differing velocities. Molecular diffusion occurs when concentration gradients cause solutes to migrate from zones of higher concentration to ones of lower concentrations, even in the absence of groundwater flow. Molecular diffusion only plays a role at low groundwater velocities.

At the Facility, hydraulic conductivity values are relatively high, and therefore, diffusion and dispersion likely exert only minor effects on contaminant migration.

1.8.7 Summary of Analysis

The following observations are made regarding contaminant fate and transport at the Facility:

- In soil, there are more exceedances of the BTEX remediation goals than the sulfolane remediation goal. This is consistent with their chemical properties in that, BTEX tends to adsorb to soil while sulfolane tends to move vertically through soil with little adsorption.
- Based on the shape of the benzene plumes, the migration of benzene in shallow groundwater is primarily governed by the orientation of sand channels. Benzene is adsorbed to the soil matrix and is being degraded naturally through biological processes, methanogenesis in particular.

- The shape of the sulfolane plumes indicate that sulfolane migration in shallow groundwater is also primarily governed by the orientation of sand channels. Sulfolane is not adsorbed to the soil matrix and without enhancements, sulfolane biodegradation is expected to be negligible.
- In deep groundwater, benzene movement is retarded relative to groundwater movement as a result of adsorption. Benzene is also likely degrading in this aquifer via natural biological processes.
- Sulfolane in the deep aquifer is found in isolated areas. Where sulfolane is found, it is expected to be transported along with groundwater with little adsorption or natural biodegradation degradation.
- In soil, sulfolane biodegradation was observed in all four of the land farm test cells. By the third week, the average sulfolane levels in all four test cells were below the remediation goal for sulfolane in soil of 65 µg/Kg.

It should be noted that the mobility and volume of both BTEX and sulfolane in groundwater are reduced by the active application of interim measures. As discussed in the following section, CPCPRC has been implementing EFR and the VISM since 1996. The EFR and VISM operation represent interim actions in the very late stages of their active life cycle. CPCPRC will continue to implement these measures until the final remedy is in place.

1.9 Current Interim Measures

1.9.1 Enhanced Fluid Recovery System

The EFR system began operation in late 1996 and is a mobile variation of what is commonly referred to as a dual-phase extraction, vacuum enhanced recovery, multi-phase extraction, or "bioslurping." The EFR technology employs elevated air extraction rates and vacuum pressures to remove contaminants. During this process, multiple phases (i.e., vapor, dissolved, adsorbed, and liquid) can be recovered. EFR also stimulates aerobic biodegradation by increasing the supply of oxygen in the subsurface. The performance of the EFR system is reported in quarterly progress reports and in an annual summary report that are submitted to EPA and PREQB.

Light non-aqueous phase liquid (LNAPL) has not been observed in any Facility monitoring well since April 2010. In April 2010, free phase liquid was observed in one well (RW-F) and was only observed as a thin sheen on the water surface.

1.9.2 Voluntary Interim Stabilization Measure System

The VISM system is located along the southeastern boundary and has been in operation since 1996 (Figure 3). The system is composed of an air-sparging trench, vapor recovery system and vapor treatment units. The VISM system is designed to allow removal of dissolved phase and any free phase light non-aqueous phase liquid by volatilization. The performance objective for this system are to reduce groundwater BTEX concentrations to below 200 parts per million (ppm). The introduction of air to the subsurface also can enhance the natural microbial bioremediation mechanisms within the shallow aquifer in this area. The performance of the VISM system is reported in semi-annual progress reports submitted to the EPA and PREQB.

The BTEX levels have been below the performance standard of 200 ppm at all of the VISM wells and piezometers since June 2009.

1.10 Scope of the CMS

The scope of this CMS is based on the results of the RFI work including the multiple investigations and comprehensive risk assessment.

1.10.1 Units Not Considered in the CMS

The following units either did not require RFI investigations, were completely removed during Facility demolition, or do not require further action based on the results of the risk assessment.

1.10.1.1 OU-1 Production Facility

OU-1 included production features that, with the exception of the underground storage tanks (USTs), were removed during Facility decommissioning between 2009 to 2011. The USTs were removed in 1991 and 1992.

The following features were designated in the Order as features within OU-1; the Container Storage Area, the Sludge Pit at the API Separator, the API Oil Separator System, the Mix Box, the Clarifier, the Knockout Pot, the two Flares, the Firefighting Training Area, the Truck Loading Area, four USTs, two Burner Cleaning Waste Management Areas. These features have been removed and no longer exist.

1.10.1.2 OU-1 Process Area and Tank Basins

OU-1 also includes the former Process Area, the former Tank Basins, and the underlying groundwater. Decommissioning and dismantlement was completed and the sampling program implemented during demolition identified 19 former ASTs as AOCs. During the SRFI, an additional 12 tanks were identified as AOIs (Figure 3).

The former ASTs that are not considered in the CMS include the following:

- AOI Tank 130 in Tank Basin B;
- AOI Tank 270 in Tank Basin C;
- AOIs Tank 400, Tank 410, Tank 420, Tank 430, Tank 440, and Tank 520 in Tank Bain F;
- AOI Tank 40 in Tank Basin G;
- AOI Tank 250 and Tank 320 in Tank Basin H; and
- AOC Tank 710 in Tank Basin M.

As depicted graphically in Figures 11 and 12, the concentrations of the COCs in surface soil and subsurface soil samples at these former tanks do not exceed remediation goals and these areas pose no potential adverse risk.

1.10.1.3 OU-2 Harbor Facility

The Las Mareas Harbor is a man-made harbor located approximately 0.5 miles southwest of the main Facility. There were two ballast water basins at the Harbor Facility including the Old and New Ballast Water Basins. The ballast water basins were clean-closed and regulatory approval of the clean closure was received by EPA and the PREQB in December 2006.

1.10.1.4 OU-3 Lime Ponds and Sewers

The Lime Ponds received solids from potable water treatment and were used to temporarily store dried solids from the WWTP (Figure 2). In 2013, the accumulated lime material was completely removed and the three ponds were backfilled with clean backfill material and graded and seeded to match surrounding terrain. Although these two ponds were not regulated, they were closed using clean closure methods under the direction and approval of EPA.

Regarding the associated sewers, RFI findings indicated that chemicals in soil samples in these areas were below conservative risk thresholds. Additionally, the sewer system was plugged and abandoned during the Facility decommissioning and dismantling activities (2009 to 2011).

1.10.1.5 OU-4 Southeast Lime Sludge Management Area

RFI findings indicated chemicals in soil samples in this area were below conservative risk thresholds.

1.10.1.6 OU-5 Southwest Lime Sludge Management Area

RFI findings indicated chemicals in soil samples in this area were below conservative risk thresholds.

1.10.1.7 OU-7 Land Treatment Unit

RFI results indicated chemicals in soil samples in this area were below conservative risk thresholds.

1.10.1.8 OU-8 Surface Impoundments

The OU-8 surface Impoundments included the Off-Specification (Off-Spec) Pond, the Oxidation Pond, the Storm Water Pond, and the Final Holding Pond (Figure 2). In 2013, the Off-Spec Pond and Oxidation Pond were clean-closed and regulatory approval of the clean closure of these ponds was received by EPA and the PREQB in July 2013.

The Storm Water Pond, the Final Holding Pond, and the stormwater collection and conveyance system associated with these ponds were addressed during the final Facility closure activities. The activities were performed in two phases in 2012. Phase 1 consisted of modifying the stormwater conveyance channel that conveyed water to the two ponds. Once stormwater was redirected, Phase 2 of the project was performed. Phase 2 activities consisted of closing the Storm Water Pond and Final Holding Pond by removing accumulated sediment, backfilling the ponds with clean backfill material, and grading and seeding the areas to match surrounding terrain. Although these two ponds were not regulated, they were closed using clean closure methods under the direction and approval of EPA.

1.10.1.9 OU-9 Cooling Towers

The RFI data indicated that chemicals in soil samples from this area were below conservative risk thresholds.

1.10.1.10 OU-10 Miscellaneous Hazardous Materials Management Areas

The RFI data indicated that there were no releases from these areas (the drum washing station, butane tanks, cooling tower tanks, and drum yard). All of these features were completely removed during the Facility decommissioning and dismantling activities (2009 to 2011).

1.10.2 Units Considered in CMS

The following units will be addressed by this CMS because BTEX and or sulfolane concentrations in media samples may pose a potential adverse risk based on the results of the risk assessment.

1.10.2.1 OU-1 Process Area Tank Basins

The former ASTs that are considered in the CMS include the following:

- AOCs Tank 10, Tank 20, and Tank 220 in Tank Basin A;
- AOCs Tank 160, Tank 170, Tank 330, and Tank 340 in Tank Basin B;
- AOC Tank 100 in Tank Basin C;
- AOC Tank 80 and AOIs Tank 690 and Tank 700 in Tank Basin F;
- AOI Tank 50 in Tank Basin G;
- AOC Tank 240 in Tank Basin H;
- AOCs Tank 41 and Tank 42 in Tank Basin I;
- AOC Tank 360 in Tank Basin K;
- AOCs Tank 401 and Tank 403 in Basin N; and
- AOC Tank 540 in the Process Area.

As depicted graphically in Figures 11 and 12, at these former tanks, at least on COC was found in one or more surface and/or subsurface soil samples at a level exceeding the remediation goals.

1.10.2.2 OU-1 Groundwater

The groundwater underlying the Facility and groundwater contamination in the offsite plumes are included in OU-1. Both shallow and deep groundwater have concentrations of COCs above the remediation goals.

1.10.2.3 Effluent Channel

As mentioned previously, Effluent Channel surface water and sediment do not pose a risk to humans.

However, because the ecological risk assessment work concluded that the potential risks to benthic invertebrates in contact with sediment could not be excluded, the Effluent Channel will be included in the CMS.

1.10.2.4 OU-6 Scrap Pile Storage Area

RFI findings indicated that benzene in subsurface soils may pose unacceptable risk. These soils were immediately above the water table and represent soils within the shallow aquifer. The shallow aquifer is included in the CMS.

This page intentionally left blank.

2. CORRECTIVE MEASURE OBJECTIVES AND PROPOSED REMEDIATION GOALS

2.1 Corrective Measures Objectives

This section presents the CMOs predicated on CPCPRC's approach to the CMS that includes controlling exposure in the short term, controlling the migration of contaminated groundwater, and working toward the reduction of contaminant extent and levels. Table 1 presents the CMOs for the Facility.

2.2 Remediation Goals

As mentioned previously, the risk assessment identified chemicals that may pose unacceptable risks (i.e., the COCs). In the CMS phase of work, media-specific maximum concentrations that would be protective of potential human receptors are developed for the COCs. These concentrations are the remediation goals that form the numerical performance basis for evaluating the corrective measures alternatives.

The remediation goals were developed considering the industrial land use setting, the hypothetical use of groundwater as a source of drinking water, RFI risk characterization, and promulgated Federal standards (e.g., groundwater maximum contaminant levels [MCLs]). The remediation goals for the COCs are presented in Table 2 for groundwater, Table 3 for soil, and Table 4 for Effluent Channel sediment.

This page intentionally left blank.

3. CORRECTIVE MEASURES TECHNOLOGY SCREENING

3.1 General

This section identifies the corrective measures technologies that are potentially effective at treating the Facility COCs and describes the screening process used to evaluate those technologies. The technologies identified are technologies considered applicable in addressing Facility COCs, are likely to perform reliably, and may be capable of achieving remediation goals. The corrective measures technologies are presented and described in Table 5 and are also discussed below.

3.2 Groundwater

Based on the characteristics of BTEX and sulfolane in groundwater the following groundwater remediation technologies could be effective.

3.2.1 Containment

- Physical barriers (Slurry Walls) – A slurry wall is a vertical subsurface barrier to contain, capture, or redirect groundwater flow in the vicinity of a contaminated site. A slurry wall is a vertical trench, which is excavated under a slurry and backfilled with a material that forms a low permeability barrier.
- Physical barriers (Sheet Pile Walls) – A sheet pile wall is a vertical subsurface barrier to contain, capture, or redirect groundwater flow in the vicinity of a contaminated site. A wall of interlocking steel plates are pressure-driven vertically into the ground to form an impermeable barrier to groundwater flow.
- Hydraulic barriers (Vertical or Horizontal Pumping Wells) – Hydraulic barriers such as vertical or horizontal pumping wells used to restrict contaminant migration. Groundwater pumping with above ground treatment ("Pump and Treat") is a common remediation technology.

3.2.2 In-Situ Chemical/Physical Treatment

- In-Situ Chemical Oxidation (ISCO) – The ISCO processes destroy contaminants by chemical reaction with hydroxyl radicals. A chemical oxidant, such as hydrogen peroxide, is introduced into the aquifer via vertical or horizontal treatment wells. During the oxidation process, chemical bonds are broken and new compounds are formed. The technology has the potential to oxidize various organic compounds, including sulfolane, to carbon dioxide, water, and salts.

  Between April and December 2015, CPCPC conducted an in-situ chemical oxidation (ISCO) field-scale pilot test utilizing catalyzed hydrogen peroxide1 (CHP) to treat groundwater. The field scale pilot test work was performed in accordance with the EPA and PREQB approved work plan (CPCPRC, 2013). The results of the pilot testing were presented in a report entitled *In-Situ Chemical Oxidation Pilot Test MW-16 Field Area*, *Effectiveness Evaluation Report* (CPCPRC, 2016). This report is included in its entirety in Appendix A. In summary, the report concludes that ISCO using CHP was very effective at treating sulfolane in groundwater. It is noted that ISCO is also well documented as a successful technology for the treatment of BTEX constituents.

- Air Sparging/Soil Vapor Extraction (AS/SVE) – Air is injected into groundwater via injection wells or trenches under pressure below the water table. Volatile compounds that are exposed to this sparged air environment convert to gas phase and are carried by the air movement into the vadose zone. From the vadose zone, the volatiles are captured by an SVE system. The sparged air maintains a high dissolved oxygen content, which enhances natural biodegradation. The VISM trench installed at the Facility as an interim measure is an AS/SVE system.

- Extraction Wells/Trenches – A series of vertical or horizontal wells are installed to recover contaminated groundwater. It is noted that groundwater extraction is not sufficient as a stand-alone remedial technology because extracted groundwater requires treatment ("Pump and Treat"). The EFR system being operated as an interim measure at the Facility is a mobile form of this technology.

3.2.2.1 In-Situ Biological Treatment

- Enhanced Bioremediation – In-situ biodegradation systems use microorganisms to degrade contaminants. An inoculant with nutrients, a carbon substrate, and/or microbes are introduced into the aquifer via vertical or horizontal treatment wells. These systems attempt to stimulate subsurface oxidation, metabolism, and degradation to accelerate the clean-up process.
- Monitored Natural Attenuation – Natural attenuation relies upon natural subsurface processes such as dilution, volatilization, biodegradation, and adsorption to reduce contaminant concentrations to remediation goals. Periodic sampling of the site contaminants, biodegradation activators, and degradation byproducts is performed to evaluate the trends in the increase/decrease of the contaminants.

3.2.2.2 Ex Situ Chemical/Physical Treatment (assuming groundwater extraction)

- Air Stripping – Air stripping is the transferring of volatile components of a liquid into an air stream. The process has been widely and successfully applied to groundwater remediation for a number of contaminants, including BTEX. An air stripper is currently operating at the Facility to treat groundwater extracted by the EFR process.
- Granular Activated Carbon/Liquid Phase Carbon Adsorption – Adsorption is a natural process in which molecules of a liquid or gas are physically attracted to and held at the surface of a solid. In liquid-phase carbon adsorption, the contaminated groundwater is pumped through a series of canisters or columns containing granulated activated carbon (GAC), to which dissolved contaminants are adsorbed.
- Vapor-Phase Carbon Adsorption – In gas-phase carbon adsorption, the contaminated gas is physically attracted to and held at the surface of a solid. The off-gasses come in contact with the carbon by passing through one or more adsorbers.
- Oxidative Destruction – Oxidation processes destroy contaminants by chemical reaction with hydroxyl radicals. Hydroxyl radicals are formed through the various combinations of ozone and hydrogen peroxide, both with and without UV light. During the oxidation process, chemical bonds are broken and new compounds are formed. The technology has the potential to oxidize various organic compounds to carbon dioxide, water, and salts.
- Activated Sludge – Activated sludge bioreactors employ microorganisms to degrade contaminants in water. Contaminated ground water is circulated in an aeration basin where a microbial population aerobically degrades organic matter and produces CO2, H2O, and a bio-sludge.

3.3 Soils

Based on the characteristics of BTEX and sulfolane in soil the following soil remediation technologies could be effective:

3.3.1 Removal and Off-Site Disposal

- Excavation and Off-Site Disposal – Excavation is a method of removing contaminated surface and subsurface materials. Excavation is a standard construction practice. Excavation involves the physical removal of contaminated materials. Following excavation, contaminated material must be either treated or disposed.

3.3.2 In-situ Enhanced Bioremediation

- Soil Mixing with Microbes – Use of large diameter augers or dual auger systems to add and mix reagents into the soil without excavation. In-situ biodegradation systems mix substrates with nutrients and microorganisms into the soil. Microorganisms degrade contaminants by stimulating subsurface oxidation, metabolism, and degradation to accelerate the clean-up process.

3.3.3 In-situ Chemical Oxidation

- Soil Mixing with Oxidant – Use of large diameter augers or dual auger systems to add and mix reagents into the soil without excavation. A chemical oxidant such as activated sodium persulfate (ASP) is added to the contaminated soil to chemically destroy the contaminants. The oxidation process breaks the chemical bonds of the contaminants transforming them to carbon dioxide, water, and salts. Oxidant may be supplied as a dry powder, which can be mixed with pH controlling additives and water to create a soil slurry.

3.3.4 Ex-situ Enhanced Bioremediation

- Land Farming with Microbes – Soil is excavated and placed in land farm treatment cells. Land farming uses conventional soil management practices to stimulate biodegradation in a layer of contaminated soil by increasing aeration, maintaining moist conditions, providing nutrients, and adding microorganisms.

3.3.5 Ex-Situ Chemical Oxidation

- Treatment with Chemical Oxidant – Soil is excavated and placed in treatment cells. A chemical oxidant such as ASP is added to the contaminated soil to chemically destroy the contaminants. The oxidation process breaks the chemical bonds of the contaminants transforming them to carbon dioxide, water, and salts. Oxidant may be supplied as a dry powder, which can be mixed with pH controlling additives and water to create a soil slurry.

3.4 Effluent Channel Sediment

Based on the characteristics of chromium, copper, manganese, nickel, and zinc in Effluent Channel sediment, the following sediment remediation technologies could be effective:

3.4.1 Removal and Off-Site Disposal

- Removal and Off-Site Disposal – Excavation is a method of removing contaminated sediment. Excavation is a standard construction practice. Excavation involves the physical removal of contaminated materials. Following excavation, contaminated material must be either treated or disposed.

3.4.2 In-situ Solidification and Stabilization

- In-situ Solidification and Stabilization – Use of augers or conventional earth moving equipment to add and mix reagents such as fly ash into the sediment without excavation. In-situ solidification transforms a sludge or sediment into a solid form. Solidification immobilizes the contaminants within the crystalline structure of the solidified material, thus reducing the contaminants mobility.

3.5 Summary of the Screening Process

The technologies listed above were subjected to an initial screening based on site-specific conditions and on the attributes of effectiveness and implementability. The initial screening results for the technologies are presented in Table 5.

Table 5 provides a description of the technology and an assessment of its effectiveness and implementability. The technologies were either excluded from further consideration or, were retained as candidates for combining into corrective measure alternatives.

Effectiveness. The effectiveness of specific technologies and process options were evaluated by considering the following:

1. Potential effectiveness of a process option to address the estimated areas or volumes of contaminated media and meet the CMOs;

2. Reliability and past performance of the technology with respect to the types of contamination and site conditions; and

3. Potential impacts to human health and the environment during the construction and/or implementation phases.

Implementability. The implementability of a technology or process option refers to both technical and administrative feasibility. The technical component is the ability of the technology to treat the site contaminants given the site-specific conditions. The administrative component is the ability to actually implement the technology at the field scale and obtain necessary permits, approvals, equipment, materials, and skilled workers.

As shown in Table 5, the following technologies were retained for consideration as candidates for combining into corrective measure alternatives:

3.5.1 Retained Groundwater Technologies

- Physical barrier – slurry wall (retained for the shallow aquifer);
- Hydraulic barriers (retained for the shallow aquifer);
- In-Situ Chemical Oxidation (ISCO);
- Extraction Wells/Trenches (retained for the shallow aquifer);
- Liquid Phase Carbon Adsorption; and
- Oxidative Destruction.

3.5.2 Retained Soil Technologies

- Removal and Offsite Disposal;

- In-situ Enhanced Bioremediation; and
- Ex-situ Enhanced Bioremediation

3.5.3 Sediment

- Removal and Offsite Disposal; and
- In-situ Solidification and Stabilization.

4. IDENTIFICATION OF CORRECTIVE MEASURE ALTERNATIVES AND COST ESTIMATION

In this section, the retained technologies are used to develop corrective measures alternatives that may achieve the CMOs for groundwater, soil, and sediment.

4.1 Identification of Corrective Measures Alternative

The alternatives described below represent technologies in the form of corrective measures alternatives considered applicable in addressing Facility contaminants, are likely to perform reliably, and may be capable of achieving the CMOs.

Consistent with the scope of work for a CMS, the alternatives include conceptual level designs. The designs represent 30% designs, the level of design required in the first phase of corrective measures implementation (CMI). A 30% design has the technical design elements necessary to determine whether the final design will provide an operable and usable corrective measure. The 30% design is used to define the anticipated studies and implementation data needed to develop the 100% final design during the CMI phase of work.

This section includes text describing the corrective measures alternative, a figure representing the primary design components, and cost estimates developed using the Remedial Action Cost Engineering and Requirements (RACER®) software. In most cases, the RACER costs elements were used without modification. In some specific cases, site-specific cost elements were used to supplement the RACER cost elements (e.g., the groundwater ISCO cost elements based on CPCPRC's field-scale pilot testing).

The design calculations and supporting materials are provided in Appendix A. These calculations reflect the same percentage of completion as the designs (i.e., 30%) they support. Cost estimates including details of the labor, equipment, and materials that comprise the 30% design are provided in Appendix B.

4.2 Cost Estimation

The cost estimates were developed using (RACER®) software. RACER is a cost estimating tool that uses parametric cost modeling software and is a patented methodology for estimating costs. The RACER cost technologies are based on generic engineering costs for environmental projects, technologies, and processes. The generic costs were derived from historical project information, industry data, government laboratories, construction management agencies, vendors, contractors, and engineering analysis. RACER incorporates technologically up-to-date engineering practices and procedures as of 2015. In addition, RACER allows for user defined costs elements. User defined cost elements are based on site-specific cost data. For example, CPCPRC used the field scale pilot testing of ISCO in groundwater to develop cost elements for the ISCO treatment technology and the ongoing soil pilot testing to develop cost elements for the bioremediation treatment technology.

CPCPRC generated RACER cost estimates based on the 30% conceptual level design and the assumed project duration. RACER cost estimates include direct costs and marked up costs.

Direct costs in RACER include all costs that can be directly attributed to a particular construction activity or item of work required to accomplish the project. Direct cost items include:

- Direct labor cost, which includes the direct wage paid to employees who perform a specific task, as well as fringe benefits (e.g., paid holidays, vacation, and sick leave; retirement benefits; group insurance; etc.), payroll taxes and insurance, travel, and overtime allowances for these employees.

- Direct material cost, which includes the cost for purchasing materials used in a specific task (excluding sales tax, which for parametric purposes, is covered in overhead).
- Direct equipment cost, which includes ownership or renting of construction equipment used in a specific construction task.
- Subcontractor bid (SubBid) items are also included in the calculation of direct cost. The SubBid category includes costs for items that are typically procured via subcontract. SubBid prices include costs for subcontractor overhead and profit, therefore, SubBid items are not additionally marked up for these factors.

Markups are all costs other than direct costs that do not become a permanent part of the facilities nor contribute directly to the study or design activities. The markups in RACER contain six factors including:

- Professional Labor Overhead/G&A costs in RACER include the non project-specific costs that are required to support labor and general operations of the professional oversight contractors' business. These costs may include the following categories or items, management and office staff salary and expense, accounting, general communications, rent, utilities, supplies, depreciation, and property taxes. General and Administrative (G&A), including corporate management, corporate accounting, purchasing, legal, general business insurance, corporate vehicles, etc.

  Research indicates that professional labor overhead and G&A typically ranges from 90% to 175%. The default value in RACER for this markup factor is 132% and this value was used in these CMS cost estimates.

- Field Office Overhead/G&A costs in RACER include all indirect costs to the general contractor(s) performing the construction work; including job overhead costs associated with field-related tasks that are required to execute a contract, as well as non project-specific costs that are required to support labor and general operations of the general contractors' business. Field Office Overhead/G&A costs may include the following job-related overhead items; taxes project-specific insurance or bonds, permits and licenses, temporary office personnel, temporary project facilities, temporary utilities (e.g. phone, electrical), personal protective equipment and Occupational Health and Safety (OSHA) requirements, and site security.

  Research indicates that field office overhead and G&A typically ranges from 8% to 60%. The default value in RACER for this markup factor is 25% and this value was used in these CMS cost estimates.

- Prime Contractor Profit in RACER reflect the positive return made on an investment after all costs are incurred.

  The default value for this markup factor is 8%. Because Chevron Phillips Chemical would act as the Prime Contractor, this markup was not included in these CMS cost estimates.

- Subcontractor Profit in RACER reflect the positive return made on an investment after all costs are incurred. The profit margin for a given project may depend on a number of factors, including degree of risk, relative difficulty of work, size of the job, and period of performance.

  Research indicates that subcontractor profit typically ranges from 3.5% to 15%. The default value in RACER for this markup factor is 8% and this value was used in these CMS cost estimates.

- Contingency in RACER is an amount added to an estimate to allow for unknown or unforeseen items, conditions, or events that will likely result in additional costs. Contingency allowances are estimated based on the defined project scope at the time of the estimate. Factors that may affect the contingency percentage used include, type of contract (e.g. fixed price vs. "cost-plus"), project complexity and technological uncertainty, engineering design detail, available project site information, and type, nature, and extent of contamination

Contingency allowance varies greatly from project to project based on the factors listed above. Therefore, the system default percentage for Contingency is 0%. In this CMS, a Contingency of 8% was included in the cost estimates.

- Owner Costs is the owner's workforce cost to initiate, contract, oversee, direct, implement and closeout the project. Owner costs may include the following categories or items; supervision, Inspection, and Overhead (SIOH), laboratory quality assurance, and other costs (e.g. technical, real estate, administrative, contracting, accounting, etc.).

  The system default percentage for Owner Cost is 11% and this value was used in these CMS cost estimates.

The default markups were developed from research of remediation and general construction industry data obtained from various educational institutions, professional societies and associations, subject-matter experts, commercial organizations, and government agencies.

4.3 Corrective Measures Alternatives

The following describes the corrective measures alternative developed for groundwater, soil, and sediment. With the exception of the No Further Action alternative, the alternatives are media-specific and the estimates of potential costs are based on 30% design concepts. The calculations supporting the 30% designs are provided in Appendix A. The detailed cost information is provided in Appendix B.

4.3.1 The No Further Action Alternative

The No Further Action alternative is included as a baseline for comparison purposes. Under this alternative, CPCPRC would continue to implement the EFR program and operate and maintain the VISM system. The groundwater, surface water, and sediment sampling and reporting tasks currently in place would continue. The assumed life-cycle of the No Further Action alternative is 30 years.

4.3.1.1 Groundwater Measures

Under this alternative, the mobile EFR would continue to be implemented where needed. The system is flexible, in that it can be applied to any well that requires removal of contaminated groundwater. EFR also stimulates aerobic biodegradation by increasing the supply of oxygen in the subsurface. Extracted fluids are treated at the Facility's Air Stripper. This treated water would continue to be discharged to the PRASA.

The VISM would continue to operate in its current location along the southeast boundary of the Facility. In this technology, contaminated groundwater is intercepted in a gravel-filled trench with a horizontal air sparging system at the bottom of the trench. Air is bubbled through the shallow groundwater and the volatile organic vapors are captured through a horizontal vapor collection system at the top of the trench. The vapors are passed through biofilters to biodegrade the organics. Any remaining organics are then polished off in vapor-phase activated carbon canisters and the clean off-gas is emitted to the atmosphere.

Under this alternative, the O&M currently implemented for the VISM and EFR systems would continue and it has been assumed the EFR water would continue to be discharged to PRASA after treatment at the Facility air stripper.

This alternative would also include the following:

- Semi-annual monitoring of 54 wells, 3 surface water locations, and 3 sediment locations.
- Quarterly monitoring of 11 VISM wells.
- Analysis of semi-annual groundwater samples for BTEX and sulfolane.

- Analysis of quarterly VISM groundwater samples for BTEX, sulfolane, and field measurements of dissolved oxygen.
- Semi-annual site-wide water level measurements at 117 wells.
- Analysis of the groundwater produced by the EFR operations for various analyses assumed to be required by a PRASA discharge permit.
- Site reporting to include the continued submittal of reports to EPA and PREQB to include the annual reporting of BTEX and sulfolane results in the Current Conditions Update Report and the VISM and EFR reports.
- Under this alternative, six 5-Year Update Reports would be prepared and submitted to EPA and PREQB over the 30-year project life.

4.3.1.2 Soil Measures

Under this alternative, there would be no active remedial measures for soil. The steel tank bottoms and concrete cover at AOC Tank 540 would remain in place and the current 24/7 guard presence and routine site maintenance and grounds keeping would continue.

4.3.1.3 Sediment Measures

Under this alternative, there would be no active remedial measures for sediment. The current 24/7 guard presence and routine site maintenance and site grounds keeping in the immediate vicinity of the Effluent Channel would continue.

4.3.1.4 Estimate of Potential Cost – No Further Action

The estimated Total Direct Costs to implement the No Further Action Alternative is $11.3 million. The cost elements are summarized below:

- O&M of the VISM and EFR = $7.7 million over the next 30 years
- LTM and associated reporting for groundwater, surface water, and sediment = $3.5 million over the next 30 years
- 5-Year Review Reports = $144,097

With the standard RACER system markups and contingency of 8%, the Total Marked up Cost for the No Further Action Alternative is = $26.4 million.

As described in Section 4.2, above the markups represent cost items such as labor overhead and G&A, permits, health and safety equipment, utilities, site security, grounds keeping, field office facilities, temporary power, etc. The details of the estimate of potential cost for this alternative are provided in Appendix B.

4.3.2 Groundwater Alternatives

The following describes the corrective measures alternatives developed for groundwater. Detailed analysis of these alternatives against the CMS evaluation criteria is presented in Section 5. The comparative analysis of the relative performance of these alternatives is presented in Section 6 along with the recommendation for the preferred corrective measures alternative for groundwater.

4.3.2.1 Alternative 1 GW – Shallow Groundwater Extraction with ISCO in the Deep Groundwater

Under this alternative, a groundwater pump and treat system would be installed in the shallow aquifer and ISCO treatment using CHP would be implemented at 10 locations in the deep aquifer. The 30% conceptual level design for Alternative 1 GW is presented in Figure 13.

It is assumed that COC levels in the shallow aquifer would meet remediation goals after 30 years of continuous pumping (Appendix A) and that COC levels in the deep aquifer would meet remediation goals after one round of ISCO treatment.

Under this alternative, 50, 6-inch diameter extraction wells with protective surface casing would be drilled and installed in the shallow aquifer. The wells will be fitted with 4-inch diameter submersible pumps and associated piping and valves. The pumping rate for each of the 50 extraction wells would be 5 gallons per minute. At this rate, it is estimated that the mass of BTEX and sulfolane in shallow groundwater could be removed after 30 years of continuous pumping (Appendix A).

The extracted groundwater would be conveyed in an above ground piping system to a newly constructed onsite groundwater treatment facility. Three 30,000-gallon steel tanks would be installed along the conveyance piping system for temporary storage during system maintenance.

The newly constructed groundwater treatment facility would consist of a hydrogen peroxide (H_2O_2) based advanced oxidation treatment system. The treated groundwater would be discharged to PRASA.

For the deep groundwater, ISCO treatment would be performed at ten locations. Under this alternative, 10, 2-inch diameter ISCO treatment points and 10, 2-inch diameter ISCO vent points with protective surface casing would be drilled and installed in the deep aquifer. At each of the treatment points, 6,000 lbs (~640 gallons) of 35% catalyzed hydrogen peroxide (CHP) would be placed.

The cost for this alternative includes pre-design study tasks anticipated to be in the form of drilling, aquifer testing, and other pre-design tasks needed to refine the understanding of pumping well placement, pumping rates, contaminant removal rates, groundwater treatment facility details, and ISCO treatment point placement. Costs to refine the 30% design to a 100% design are included.

This alternative includes all electrical power, system instrumentation and controls, equipment, field support facilities, permitting, and labor necessary to construct, implement, and support the groundwater measures. Costs to close out the groundwater pump and treat system and the 10 deep ISCO treatment and vent points are also included in this alternative.

Under this alternative, the following O&M and monitoring program is included:

- All materials, equipment, and labor necessary to operate and maintain the shallow groundwater pump and treat system and associated WWTP for 30 years. One full-time WWTP operator and some field support staff is included and these staff would have office and support structures located onsite.
- Monthly wastewater effluent monitoring and semi-annual groundwater monitoring at 54 groundwater monitoring wells.
- Analysis of wastewater and groundwater samples for BTEX and sulfolane.
- Monthly site-wide water level measurements at 150 wells.
- Continue current 24/7 guard presence and routine site maintenance and grounds keeping.

- Reports to EPA and PREQB to include quarterly reporting on the performance of the shallow groundwater pump and treat system and semi-annual reporting of the groundwater sampling for BTEX and sulfolane. One report detailing the ISCO activity in the deep aquifer would also be submitted.
- Under this alternative, six 5-Year Update Reports would be prepared and submitted to EPA and PREQB over the 30-year project life.

The estimated Total Direct Costs to implement Alternative 1 GW is $20.2 million. The cost elements are summarized below:

- Study and Design = $700,000
- Install the Pump and Treat System and Perform the Deep ISCO Treatment = $1.8 million
- O&M of the Pump and Treat System (30 years) = $12.9 million
- Groundwater LTM and Reporting (30 years) = $3.2 million
- Closeout of the Pump and Treat and Deep ISCO and 5-Year Review Reports = $1.6 million

With the standard RACER system markups and contingency of 8%, the Total Marked up Cost for Alternative 1 GW is = $34.4 million.

As described in Section 4.2, above the markups represent cost items such as labor overhead and G&A, permits, health and safety equipment, utilities, site security, grounds keeping, field office facilities, temporary power, etc. The details of the estimate of potential cost for this alternative are provided in Appendix B.

4.3.2.2 Alternative 2 GW – ISCO in the Shallow and Deep Groundwater

Under this alternative, ISCO treatment using CHP would be implemented in both the shallow and deep aquifers. Under this alternative, it is assumed that COC levels in the shallow aquifer would meet remediation goals in the second year of implementation. In the deep groundwater, it is assumed that COC levels would meet remediation goals after one round of ISCO treatment. The 30% conceptual level design for Alternative 2 GW is presented in Figure 14.

The life-cycle for this alternative is assumed to be 5 years with one round of treatment at all shallow and deep treatment points in the first year. In the second year, a second round of ISCO treatment would be implemented at one-third of the shallow treatment locations. Groundwater monitoring would be implemented through year 5 when it is assumed COC levels in the shallow and deep groundwater would meet remediation goals.

Under this alternative, 427, 2-inch diameter ISCO treatment points and 93, 2-inch diameter ISCO vent points with protective surface casing would be drilled and installed in the shallow aquifer. The shallow treatment points would be installed in grid patterns and would be distributed within the areas presented on Figure 14. In the deep aquifer, 10, 2-inch diameter ISCO treatment points and 10, 2-inch diameter ISCO vent points with protective surface casing would be drilled and installed. At each of the 437 treatment points, 6,000 pounds (~640 gallons) of 35% CHP would be placed.

It is assumed that for COC levels to meet remediation goals in the shallow aquifer, a second round of ISCO treatment would be required in Year 2 of the remedy. This second treatment event is assumed to be required at 142 (approximately one-third) of the shallow treatment point locations. At each of the 142 treatment points, 6,000 pounds (~640 gallons) of 35% CHP would be placed.

The cost for this alternative includes pre-design study tasks anticipated to be in the form of drilling to refine lithology in the ISCO treatment areas, finalize treatment grids and treatment point placement, and refine catalyst formulation. Costs to refine the 30% design to a 100% design are included.

This alternative includes all electrical power, treatment trailer systems and controls, equipment, field support facilities, permitting, and labor necessary to construct, implement, and support the groundwater measures. Costs to close out the ISCO treatment and vent points are also included in this alternative.

Under this alternative, the following O&M and monitoring program would be included:

- Six rounds of groundwater monitoring at 100 monitoring locations in Year 1 and semi-annual groundwater monitoring at 75 monitoring locations in Years 2 through 5.
- Analysis of the groundwater samples for BTEX and sulfolane.
- Semi-annual site-wide water level measurements at 150 wells.
- Reports to EPA and PREQB to include two reports detailing the ISCO grid construction and groundwater treatment and sampling activities in Year 1 and the ISCO treatment activity in Year 2 and semi-annual reporting of BTEX and sulfolane results for groundwater in Years 2 through 5.

Because it is assumed that remediation goals would be achieved by Year 5, this alternative is assumed to include the submittal of one, 5-year Update Report.

The estimated Total Direct Costs to implement Alternative 2 GW is $13.2 million. The cost elements are summarized below:

- ➢ Study and Design = $1.0 million
- ➢ Install ISCO Treatment and Vent Points and Perform ISCO Treatment = $ 10.7 million
- ➢ Groundwater LTM and Reporting (5 years) = $1.1 million
- ➢ Closeout of the ISCO and 5-Year Review Report = $357,000

With the standard RACER system markups and contingency of 8%, the Total Marked up Cost for Alternative 2 GW is = $16.9 million.

As described in Section 4.2, above the markups represent cost items such as labor overhead and G&A, permits, health and safety equipment, utilities, site security, grounds keeping, field office facilities, temporary power, etc. The details of the estimate of potential cost for this alternative are provided in Appendix B.

4.3.2.3 Alternative 3 GW – Slurry Wall in the Shallow Aquifer, Shallow Groundwater Extraction with ISCO in the Deep Groundwater

Under this alternative, 4,000 feet of bentonite slurry wall would be installed in the shallow aquifer in key areas intended to cut-off groundwater flow (e.g., along Facility boundaries, and in areas of sand channels). With the exception of the slurry wall, Alternative 3 GW is the same as Alternative 1 GW. The slurry wall is intended to provide for additional groundwater containment by blocking groundwater flow with low permeability bentonite slurry. The 30% conceptual level design for Alternative 3 GW is presented in Figure 15. In addition to the slurry wall, a groundwater pump and treat system would be installed in the shallow aquifer and ISCO treatment using CHP would be implemented at 10 locations in the deep aquifer.

It is assumed that COC levels in the shallow aquifer would meet remediation goals after 30 years of continuous pumping (Appendix A) and that COC levels in the deep aquifer would meet remediation goals after one round of ISCO treatment.

The pump and treat system under this alternative includes 50, 6-inch diameter extraction wells with protective surface casing drilled and installed in the shallow aquifer. The wells will be fitted with 4-inch diameter submersible pumps and associated piping and valves. The pumping rate for each of the 50 extraction wells would be 5 gallons per minute. At this rate, it is estimated that the mass of BTEX and sulfolane in shallow groundwater could be removed after 30 years of continuous pumping (Appendix A).

The extracted groundwater would be conveyed in an above ground piping system to a newly constructed onsite groundwater treatment facility. Three 30,000-gallon steel tanks would be installed along the conveyance piping system for temporary storage during system maintenance.

The newly constructed groundwater treatment facility would consist of a hydrogen peroxide (H_2O_2) based advanced oxidation treatment system. The treated groundwater would be discharged to PRASA.

For the deep groundwater, ISCO treatment would be performed at ten locations. Under this alternative, 10, 2-inch diameter ISCO treatment points and 10, 2-inch diameter ISCO vent points with protective surface casing would be drilled and installed in the deep aquifer. At each of the treatment points, 6,000 lbs (~640 gallons) of 35% catalyzed hydrogen peroxide (CHP) would be placed.

The cost for this alternative includes pre-design study tasks anticipated to be in the form of drilling, aquifer testing, and other pre-design tasks needed to evaluate groundwater geochemistry and slurry wall compatibility, refine the understanding of pumping well placement, pumping rates, contaminant removal rates, groundwater treatment facility details, and ISCO treatment point placement. Costs to refine the 30% design to a 100% design are included.

This alternative includes all electrical power, system instrumentation and controls, equipment, field support facilities, permitting, and labor necessary to construct, implement, and support the groundwater measures. Costs to close out the groundwater pump and treat system and the 10 deep ISCO treatment and vent points are also included in this alternative.

Under this alternative, the following O&M and monitoring program is included:

- All materials, equipment, and labor necessary to operate and maintain the shallow groundwater pump and treat system and associated WWTP for 30 years. One full-time WWTP operator and some field support staff is included and these staff would have office and support structures located onsite.
- Monthly wastewater effluent monitoring and semi-annual groundwater monitoring at 54 groundwater monitoring wells.
- Analysis of wastewater and groundwater samples for BTEX and sulfolane.
- Monthly site-wide water level measurements at 150 wells.
- Continue current 24/7 guard presence and routine site maintenance and grounds keeping.
- Reports to EPA and PREQB to include quarterly reporting on the performance of the shallow groundwater pump and treat system and semi-annual reporting on groundwater sampling for BTEX and sulfolane. One report detailing the ISCO activity in the deep aquifer would also be submitted.

- Under this alternative, six 5-Year Update Reports would be prepared and submitted to EPA and PREQB over the 30-year project life.

The estimated Total Direct Costs to implement Alternative 3 GW is $21.1 million. The cost elements are summarized below:

- ➢ Study and Design = $850,000
- ➢ Install the Slurry Wall, Pump and Treat System, and Perform the Deep ISCO = $2.6 million
- ➢ O&M of the Pump and Treat System (30 years) = $12.9 million
- ➢ Groundwater LTM and Reporting (30 years) = $3.2 million
- ➢ Closeout of the Pump and Treat and Deep ISCO and 5-Year Review Reports = $1.6 million

With the standard RACER system markups and contingency of 8%, the Total Marked up Cost for Alternative 3 GW is = $35.6 million.

As described in Section 4.2, above the markups represent cost items such as labor overhead and G&A, permits, health and safety equipment, utilities, site security, grounds keeping, field office facilities, temporary power, etc. The details of the estimate of potential cost for this alternative are provided in Appendix B.

4.3.3 Soil Alternatives

The following sections describe the corrective measures alternatives developed for soil. Detailed analysis of these alternatives against the CMS evaluation criteria is presented in Section 5. The comparative analysis of the relative performance of these alternatives is presented in Section 6 along with the recommendation for the preferred corrective measures alternative for soil.

For costing the soil alternatives, the volume of soil requiring corrective measures was assumed to include the entire AOC or AOI where soil contamination was identified. For example, at AOC Tank 10, COC levels exceeded the remediation goals in only 3 surface soil samples and one subsurface soil sample. Even though the exceedances are limited to these locations, it has been assumed that the entire 200 ft diameter soil platform at AOC Tank 10 will be addressed.

4.3.3.1 Alternative 1 SO – Soil Excavation and Offsite Disposal

Under this alternative, soil with COC levels exceeding the remediation goals would be excavated, loaded to dump trucks or roll-off containers, and disposed of offsite as non-hazardous waste in a local landfill approved by PREQB. The 30% conceptual level design for Alternative 1 SO is presented in Figure 16.

The estimated volume of soil to be removed under this alternative is 44,323 cy (Appendix A). With the exception of the Tank 540 area, the tank platforms targeted for removal are above natural grade. Therefore, no backfill for those areas will be necessary. Backfill of the AOC Tank 540 area with an estimated 2,000 cubic yards (cy) of clean fill obtained on site, placed, and compacted is included in this alternative.

Under this alternative, it is assumed that the soil excavation and offsite disposal work would occur in Year 1 and that the COC levels in soil would meet remediation goals after excavation and removal.

Under this alternative, one construction completion report would be prepared and submitted to EPA and PREQB.

The cost for this alternative includes pre-design study work anticipated to be primarily in the form of soil analytical testing to refine the extent of soil requiring removal. Costs to refine the 30% design to a 100% design are also included.

This alternative includes all the materials, equipment, field support facilities, permitting, confirmation sampling, waste characterization sampling, and labor necessary to remove and recycle the steel tank bottoms, remove and dispose of the soil and grade, seed, and restore the excavation areas.

The estimated Total Direct Costs to implement Alternative 1 SO is $3.9 million. The cost elements are summarized below:

- Study and Design = $630,000
- Soil Excavation and Offsite Disposal = $3.2 million
- Construction Completion Report = $24,000

With the standard RACER system markups and contingency of 8%, the Total Marked up Cost for Alternative 1 SO is = $4.9 million.

As described in Section 4.2, above the markups represent cost items such as labor overhead and G&A, permits, health and safety equipment, utilities, site security, grounds keeping, field office facilities, temporary power, etc. The details of the estimate of potential cost for this alternative are provided in Appendix B.

4.3.3.2 Alternative 2 SO - Soil Biological Treatment in Land Farm Treatment Cells

Under this alternative, soil with COC levels exceeding the remediation goals would be excavated, loaded to dump trucks or roll-off containers, and placed in onsite land farm treatment cells. The 30% conceptual level design for Alternative 2 SO is presented in Figure 17.

The estimated volume of soil to be treated under this alternative is 44,323 cy (Appendix A). With the exception of the Tank 540 area, the tank platform soil targeted for treatment are above natural grade. Therefore, no backfill for those areas will be necessary. Backfill of the AOC Tank 540 area with an estimated 2,000 cubic yards (cy) of clean fill obtained on site, placed, and compacted is included in this alternative.

The land farm treatment cells would be constructed inside portions of former Tank Basin A, B, and C. The base of the treatment cells would be lined and the existing gunite-lined berms would provide for lateral control of storm water, as well as, control of ingress and egress into and out of the treatment cells. The soil from the tank platforms and the Tank 540 area would then be transported and placed in the land farm treatment cells in lifts of up to two feet.

The soil would be inoculated with microbes and fertilizer and would be tilled and watered on a regular basis using water obtained on site. Based on the success of the soil pilot test, it is anticipated that COC levels in the soil would meet remediation goals after one year of treatment. The treatment cell soil would be sampled monthly during the year of treatment. This alternative includes the collection of ten composite soil samples per month from each treatment cell. The samples will be analyzed for BTEX and sulfolane.

The treatment cells will be constructed to include the necessary piping and sump pumps for water management. Any excess water from a storm event will be placed in the existing hippo storage tank and will either be reused on the test cells to keep moisture at the proper levels or will be treated through the existing permitted water treatment unit and discharged to PRASA. A discharge authorization renewal with an amendment to include remediation water as an additional source was submitted to PRASA in February 2016 and their concurrence is pending.

The cost for this alternative includes pre-design study work anticipated to be primarily in the form of soil analytical testing to refine the extent of soil requiring treatment and to refine the fertilizer and inoculant formulation. Costs to refine the 30% design to a 100% design are also included.

This alternative includes all the materials, equipment, field support facilities, permitting, and labor necessary to remove and recycle the steel tank bottoms, construct and operate the land farm treatment cells, inoculate, till, and water the land farm soil, and seed and restore the excavation areas.

The estimated Total Direct Costs to implement Alternative 2 SO is $4.1 million. The cost elements are summarized below:

- Study and Design = $585,000
- Soil Treatment in Land Farm Treatment Cells = $3.5 million
- Construction Completion Report = $24,000

With the standard RACER system markups and contingency of 8%, the Total Marked up Cost for Alternative 2 SO is = $6.0 million.

As described in Section 4.2, above the markups represent cost items such as labor overhead and G&A, permits, health and safety equipment, utilities, site security, grounds keeping, field office facilities, temporary power, etc. The details of the estimate of potential cost for this alternative are provided in Appendix B.

4.3.3.3 Alternative 3 SO - Soil Biological Treatment In-Situ using Soil Mixing

Under this alternative, soil with COC levels exceeding the remediation goals would be treated in place using large diameter augers. The 30% conceptual level design for Alternative 2 SO is presented in Figure 18.

The estimated volume of soil to be treated in place under this alternative is 44,323 cy (Appendix A). The soil would be inoculated with microbes and fertilizer and would be mixed in place with large diameter augers. With the exception of the Tank 540 area, the tank platforms targeted for treatment are above natural grade. It is assumed that 5 separate inoculations and mixing events would be required to adequately treat the soil to remediation goals. Because the soil will be treated in-situ, no backfill will be necessary.

Although the soil pilot test involved the land farm treatment approach, it has been assumed that COC levels in the soil would meet remediation goals after five mixing events. It is assumed the five mixing events would occur in Year 1 and that soil COC levels would meet remediation goals at the end of Year 1.

The soil treatment areas would be sampled monthly during the year of treatment. This alternative includes the collection of a total of 360 composite soil samples collected from the soil treatment areas. The samples will be analyzed for BTEX and sulfolane.

The cost for this alternative includes pre-design study work anticipated to include soil analytical testing to refine the extent of soil requiring treatment, studies to determine the most effective mixing tools and equipment, and studies to refine the fertilizer and inoculant formulation. Costs to refine the 30% design to a 100% design are also included.

This alternative includes all the materials, equipment, permitting, and labor necessary to remove and recycle the steel tank bottoms, inoculate, till, and water the soil in place and seed, and restore the treated areas.

The estimated Total Direct Costs to implement Alternative 3 SO is $5.7 million. The cost elements are summarized below:

- Study and Design = $1,000,000

- Soil Treatment In-Situ using Soil Mixing = $4.7 million

- Construction Completion Report = $24,000

With the standard RACER system markups and contingency of 8%, the Total Marked up Cost for Alternative 3 SO is = $9.6 million.

As described in Section 4.2, above the markups represent cost items such as labor overhead and G&A, permits, health and safety equipment, utilities, site security, grounds keeping, field office facilities, temporary power, etc. The details of the estimate of potential cost for this alternative are provided in Appendix B.

4.3.4 Sediment Alternatives

The following sections describe the corrective measures alternatives developed for Effluent Channel sediment. Detailed analysis of these alternatives against the CMS evaluation criteria is presented in Section 5. The comparative analysis of the relative performance of these alternatives is presented in Section 6 along with the recommendation for the preferred corrective measures alternative for sediment.

The location of the Effluent Channel is depicted most of the figures in this CMS. For costing the sediment alternatives, the extent of the Effluent Channel includes the 1,900 feet of channel within the Facility boundary. Using survey data for the channel width, an average width of 50 feet was determined. Analytical data used in the risk assessment were collected from the 0 to 0.5 ft depth interval; however, for conservativism, a depth of 1 foot is used in this CMS. Based on these dimensions, a total of approximately 3,520 cy of sediment will be addressed.

4.3.4.1 Alternative 1 SD - Sediment Excavation and Offsite Disposal

Under this alternative, sediment with COC levels exceeding the remediation goals would be excavated and disposed offsite. For design purposes, the estimated volume of sediment to be removed under this alternative is 3,520 cy (Appendix A). The sediment would be disposed of as non-hazardous waste in a landfill approved by PREQB. The excavation area would then be backfilled with an estimated 4,224 cy of clean soil obtained on site. This fill volume represents 20% expansion over the 3,520 cy removed and this fill will be compacted to the original removed in place volume of 3,520 cy.

This alternative includes all the materials, equipment, waste characterization sampling, permitting, and labor necessary to clear and grub the excavation area, remove and dispose of the sediment and backfill, grade, and contour the base of the Effluent Channel to its pre-excavation contour. The cost for this alternative also includes costs to refine the 30% design to a 100% design.

The estimated Total Direct Costs to implement Alternative 1 SD is $598,000. The cost elements are summarized below:

- Design = $50,000
- Sediment Excavation and Offsite Disposal = $524,000
- Construction Completion Report = $24,000

With the standard RACER system markups and contingency of 8%, the Total Marked up Cost for Alternative 1 SD is = $988,000.

As described in Section 4.2, above the markups represent cost items such as labor overhead and G&A, permits, health and safety equipment, utilities, site security, grounds keeping, field office facilities, temporary power, etc. The details of the estimate of potential cost for this alternative are provided in Appendix B.

4.3.4.2 Alternative 2 SD – In-Situ Stabilization of Sediment

Under this alternative, sediment with COC levels exceeding the remediation goals would be stabilized and solidified in place. For design purposes, the estimated volume of sediment to be solidified and stabilized under this alternative is 3,520 cy (Appendix A). The sediment would mixed with water, proprietary chemical binder, fly ash, and Portland cement (RACER default additives). The Effluent Channel would then be graded and contoured to its pre-stabilization grade.

This alternative includes all the materials, equipment, permitting, and labor necessary to clear and grub the treatment area, stabilize the sediment and grade and contour the base of the Effluent Channel to drain.

The cost for this alternative includes pre-design study work anticipated to be primarily in the form of testing to refine the sediment stabilizer formulation. Costs to refine the 30% design to a 100% design are also included.

The estimated Total Direct Costs to implement Alternative 2 SD is $1.06 million. The cost elements are summarized below:

- Study and Design = $80,000
- Sediment Stabilization in Place = $955,000
- Construction Completion Report = $24,000

With the standard RACER system markups and contingency of 8%, the Total Marked up Cost for Alternative 2 SD is = $1.5 million.

As described in Section 4.2, above the markups represent cost items such as labor overhead and G&A, permits, health and safety equipment, utilities, site security, grounds keeping, field office facilities, temporary power, etc. The details of the estimate of potential cost for this alternative are provided in Appendix B.

This page intentionally left blank

5. EVALUATION OF CORRECTIVE MEASURES ALTERNATIVES

In this section, a detailed analysis of the alternatives described in Section 4 is presented. The detailed analysis of alternatives provides the information needed to compare the corrective measures alternatives. Detailed analysis of alternatives consists of the following components:

- A detailed evaluation of each alternative against the evaluation criteria; and
- A comparative analysis among the alternatives to assess the relative performance of each alternative with respect to each of the nine evaluation criteria.

5.1 Detailed Evaluation of Alternatives

In accordance with the RCRA guidance (OSWER Directive 9902.3-2A, *RCRA Corrective Action Plan [Final]*, Office of Waste Programs Enforcement, Office of Solid Waste, May 1994), corrective measures should meet the following evaluation criteria:

- Be protective of human health and the environment;
- Attain the numeric remediation goals;
- Control the source(s) of releases so as to reduce or eliminate, to the extent practicable, further releases of hazardous waste (including hazardous constituents) that might pose threats to human health and the environment;
- Comply with applicable standards for waste management;
- Long-term reliability and effectiveness; and
- Reduction of toxicity, mobility, or volume (TMV) of wastes;
- Short-term effectiveness;
- Implementability; and
- Cost.

The evaluation is intended to provide sufficient information on the advantages and disadvantages of each alternative so that they can be compared with each other to eventually select the most appropriate alternative for the site. The evaluation criteria are described below.

- **Protection of Human Health and the Environment** – Corrective measures must be protective of human health and the environment. Remedies should include those measures that are needed to be protective, but not directly related to media cleanup, source control, or management of wastes.
- **Attain Remediation Goals** – The remediation goals, if not based on human and ecological risk, may be the regulatory standards such as the Federal MCLs.
- **Control of Source Release** – A critical objective of any remedy must be to stop further environmental degradation by controlling or eliminating further releases that may pose a threat to human health and the environment. An effective source release control program is essential to ensure the long-term effectiveness.
- **Comply with Applicable Standards for Management of Wastes** – Implementation of a remedy must consider new permits or modifications to the existing permits that effect the work and the potential wastes generated by the corrective measures. Work must be performed and waste managed

in a manner protective of human health and in compliance with the Federal, state and local requirements. Permit requirements encompass construction as well as operation of the corrective measures.

- **Long-term Reliability and Effectiveness** – Demonstrated and expected reliability is a way of assessing the risk and effect of failure. Most corrective measures technologies deteriorate with time and eventually may require replacement. Each corrective measures alternative is evaluated in terms of the projected useful life of the overall alternative and its component technologies. Useful life is defined as the length of time the level of effectiveness can be maintained.
- **Reduction in the TMV of Wastes** – In general, remedies are preferred that employ techniques or technologies that are capable of eliminating or substantially reducing the inherent potential for the wastes to cause future environmental releases or other risks to human health and the environment. There may be some situations where achieving substantial reductions in TMV may not be practical or even desirable. The assessment against this criterion evaluates the anticipated performance of the specific treatment technologies an alternative may employ. The criterion is specific to evaluating only how treatment reduces TMV and does not address containment actions such as capping.
- **Short-term Effectiveness** – This criterion addresses short-term impacts of the alternatives. The assessment against this criterion examines the effectiveness of alternatives in protecting human health and the environment (i.e., minimizing any risks associated with an alternative) during the construction and implementation of a remedy until the response objectives have been met.
- **Implementability** – The assessment against this criterion evaluates the technical and administrative feasibility of the alternative, and the availability of the goods and services needed to implement it.
- **Cost** – Cost estimates were developed in RACER for the 30% designs and these estimates of potential cost encompass study, design, engineering, construction, and O&M costs incurred over the life of the project. The cost estimates represent the present worth direct costs and total cost with markups for each alternative.

The alternatives analysis is conducted in sufficient detail to understand the significant aspects of each alternative and to identify the uncertainties associated with the alternative. Table 6 presents the results of the evaluation of the Groundwater Corrective Measures Alternatives against the criteria. Table 7 presents the results of the evaluation of the Soil Corrective Measures Alternatives against the criteria. Table 8 presents the results of the evaluation of the Sediment Corrective Measures Alternatives against the criteria. The RACER costs for each alternative are summarized in the tables and the details of these costs can be found in Appendix B.

6. COMPARATIVE ANALYSIS AND PREFERRED ALTERNATIVE

In this section, the relative performance of the alternatives in relation to each specific evaluation criterion is evaluated. The comparative analysis allows the advantages and disadvantages of each alternative to be balanced. The result of this comparative analysis is a recommendation for the preferred alternative.

6.1 Comparative Analysis of Alternatives

The comparative analysis of alternatives evaluates relative performance of each corrective measure alternative and its components based on technical, environmental, human health, institutional concerns, and cost. It is noted that the No Further Action alternative is not evaluated further. This is because this alternative scored lowest when evaluated against the evaluation criteria.

6.1.1 Groundwater Alternatives

Of the three groundwater alternatives, Alternative 2 GW scored the highest relative to the evaluation criteria. The estimate of potential cost with markups for Alternative 2 GW is $16.9 million.

Protection of human health and the environment – Of the three groundwater alternatives, Alternative 2 GW offers the most protection. This is because groundwater pump and treat (Alternatives 1 GW and 3 GW) systems require significant O&M to maintain effectiveness. The protectiveness of a pump and treat system relies on effective capture of groundwater and the assumption that there is no system downtime. In addition, pump and treat systems produce contaminated groundwater and this extracted groundwater requires treatment. Treatment system downtime or malfunctions can result in reduced protection of human health and the environment.

The ISCO technology using CHP, on the other hand, results in the in-situ destruction of the COCs. Because of this in-situ destruction, no groundwater is produced and there is no long-term reliance on O&M to maintain protectiveness.

Attain media protection standards – Of the three groundwater alternatives, Alternative 2 GW offers the most certainty that remediation goals will be met. The field-scale pilot testing demonstrated that ISCO using CHP is very effective at treating sulfolane. The destruction of BTEX constituents using ISCO is well documented.

The ability to meet remediation goals using groundwater pump and treat (Alternatives 1 GW and 3 GW), depends on the long-term capture and treatment of groundwater. There is significant uncertainty that a groundwater pump and treat system can result in groundwater ceanup to remediation goals.

Control the source(s) of releases so as to reduce or eliminate, to the extent practicable, further releases of hazardous waste (including hazardous constituents) that might pose threats to human health and the environment – Other than the potential leaching of the COCs from soil to groundwater, there are no active releases and the Facility is completely demolished.

Comply with applicable standards for waste management – Alternative 2 GW is expected to most easily meet this criteria. Alternatives 1 GW and 3 GW score lower because both these alternatives rely on the ability to discharge produced groundwater over a 30-year project lifetime. It is uncertain whether a long-term permit for the estimated 250 gpm of produced water could be obtained from PRASA. If not permitted through PRASA, an NPDES discharge permit option could be pursed. However, this permit option could also be difficult to obtain and comply with over a 30-year tie-frame.

Long-term reliability and effectiveness – Of the four alternatives, only Alternative 2 GW is expected to meet this criteria. This is because the long-term effectiveness of a groundwater pump and treat (Alternatives 1 GW and 3 GW) is uncertain and these systems require significant O&M to maintain effectiveness.

Reduction of toxicity, mobility, or volume (TMV) of wastes – Of the three groundwater alternatives, only Alternative 2 GW is expected to meet this criteria for both shallow and deep groundwater. Groundwater treatment using ISCO results in the destruction of the COCs.

In the shallow groundwater, pump and treat is expected to result in the reduction of TMV in the early years. However, case studies of pump and treat systems often show rapid declines in the pump and treat system performance.

Short-term effectiveness – All of the alternatives, including the No Further Action alternative are expected to meet this criteria. Of the three groundwater alternatives however; Alternative 2 GW scores highest because COCs would be destroyed in a relatively short time frame via ISCO treatment.

Implementability – Of the three groundwater alternatives, Alternative 2 GW is expected to most easily meet this criteria. This technology has already been effectively implemented at the field-scale and requirements for full-scale implementation are well understood.

Alternatives 1 GW and 3 GW score lower because of the uncertainty related to obtaining a permit from PRASA for the long-term discharge of extracted groundwater. If not permitted through PRASA, an NPDES discharge permit option could be pursed. However, this permit option is also considered more difficult to implement than the work under Alternative 2 GW.

Cost – Of the three groundwater alternatives, Alternatives 2 GW is the lowest cost. Alternative 2 GW also scored the highest relative to the other alternatives. Under Alternative 2 GW, there are no long-term O&M costs because of the rapid destruction of the COCs using ISCO.

6.1.2 Soil Alternatives

Of the three soil alternatives, Alternative 2 SO scored the highest relative to the evaluation criteria. The estimate of potential cost with markups for Alternative 2 SO is $6 million.

Protection of human health and the environment – Alternatives SO 1 and SO 2 both provide for reliable protection of human health and the environment. Of these two alternatives, Alternative 2 SO scores highest. This is because soil biodegradation in land farm treatment cells results in the destruction of the COCs. In contrast, placing the soil in a landfill only contains the soil and COCs are not destroyed.

Alternative 3 SO scores lowest because of the significant uncertainty related to the ability for soil mixing to provide the optimum environment for biodegradation.

Attain media protection standards – Of the three groundwater alternatives, Alternative 2 SO offers the most certainty that remediation goals will be met. The field-scale pilot testing demonstrated that the biodegradation of sulfolane using the land farm treatment technology was very effective. The destruction of BTEX constituents via biodegradation is well documented.

Alternative 1 SO meets this criteria; however, the COCs in soil are only removed from the Facility to a landfill and under this alternative, the COCs in soil are not destroyed.

Alternative 3 SO scores lowest because of the significant uncertainty related to the ability for soil mixing to provide the optimum environment for biodegradation.

Control the source(s) of releases so as to reduce or eliminate, to the extent practicable, further releases of hazardous waste (including hazardous constituents) that might pose threats to human health and the environment – Alternative 1 SO and Alternative 2 SO both meet this criteria because implementing these alternatives would eliminate the potential for soil to act a source of groundwater contamination. Alternative 3 SO scores lowest because of the significant uncertainty related to the ability for soil mixing to provide the optimum environment for biodegradation.

Comply with applicable standards for waste management – Alternative 1 SO scores the highest for this criteria because permitting soil excavation, removal, and disposal work under is anticipated to be the most straightforward.

Alternatives 2 SO and 3 SO score lower because of the uncertainty related to the exact scope of permitting. However, permits for work under these alternatives is expected to be obtainable.

Long-term reliability and effectiveness – Alternative 2 SO is expected to provide the most reliable long-term effectiveness. This is because soil biodegradation in land farm treatment cells results in the destruction of the COCs. In contrast, placing the soil in a landfill only contains the soil and COCs are not destroyed.

Alternative 3 SO scores lowest because of the significant uncertainty related to the ability for soil mixing to provide the optimum environment for the destruction of COCs via biodegradation processes.

Reduction of toxicity, mobility, or volume (TMV) of wastes – Alternative 2 SO is expected to result in the reduction of TMV of the COCs because soil biodegradation in land farm treatment cells results in the destruction of the COCs.

Alternative 1 SO provides for reduction in TMV at the Facility. However, this alternative scores lower because there will be no reduction in toxicity or volume of the COCs in the soil at the landfill.

Alternative 3 SO scores lowest because of the significant uncertainty related to the ability for soil mixing to provide the optimum environment for the destruction of COCs via biodegradation processes. If not destroyed under this alternative, the soils with COCs would remain in place.

Short-term effectiveness – All of the alternatives, including the No Further Action alternative are expected to meet this criteria. Of the three soil alternatives however; Alternative 2 SO scores highest because COCs would be destroyed in a relatively short time frame via biodegradation in the land farm treatment cells.

Implementability – Alternative 1 SO is considered the easiest to implement because this type of work has already been implemented during the clean closure of the of the RCRA impoundments and NPDES ponds.

Alternatives 2 SO scores lower because of the need to obtain the microbial inoculant from off-Island sources. However, field pilot testing of soil biodegradation demonstrated that the all the equipment, materials, and personnel to implement this work can be obtained.

Alternative 3 SO scores the lowest because of the anticipated effort to obtain the proper specialty equipment for soil mixing.

Cost – Of the three soil alternatives, Alternatives 1 SO is the lowest cost. Although lower in cost, Alternative 1 SO did not score as high as Alternative 2 SO. Alternative 2 SO costs are in the mid-range of the cost with Alternative 1 SO having lower cost and Alternative 3 SO being higher cost.

6.1.3 Effluent Channel Sediment Alternatives

Of the two sediment alternatives, Alternative 1 SD scored the highest relative to the evaluation criteria. The estimate of potential cost with markups for Alternative 1 SD is $988,000.

Protection of human health and the environment – Alternatives SD 1 and SD 2 both provide for reliable protection of human health and the environment. Of these two alternatives, Alternative 1 SD scores highest. This is because the sediment with COC levels above remediation goals will be removed and disposed offsite. Under Alternative 2 SD, the sediment with COCs will stabilized but will be left in place.

Attain media protection standards – Only Alternative 1 SD meets this criteria.

Control the source(s) of releases so as to reduce or eliminate, to the extent practicable, further releases of hazardous waste (including hazardous constituents) that might pose threats to human health and the environment – Alternative 1 SD and Alternative 2 SD both meet this criteria because implementing these alternatives would eliminate the very unlikely potential for sediment to act a source of groundwater contamination.

Comply with applicable standards for waste management – Alternative 1 SD scores the highest for this criteria because permitting sediment excavation, removal, and disposal work under is anticipated to be the most straightforward.

Alternatives 2 SD scores lower because of the uncertainty related to the exact scope of permitting the sediment stabilization work. However, permits for work under this alternative is expected to be obtainable.

Long-term reliability and effectiveness – Alternatives SD 1 and SD 2 both provide for long- term reliability and effectiveness. Of these two alternatives, Alternative 1 SD scores highest. This is because the sediment with COC levels above remediation goals will be removed and disposed offsite. Under Alternative 2 SD, the sediment with COCs will be stabilized and left in place.

Reduction of toxicity, mobility, or volume (TMV) of wastes – Alternative 1 SD scores the highest because removal and offsite disposal will result in the reduction of TMV of COCs at the Facility. Alternative 2 SD only provides for the reduction in mobility.

Short-term effectiveness – Both of the sediment alternatives meet this criteria through the implementation of occupational and safety controls. Of the two sediment alternatives however; Alternative SD 1 scores highest because COCs would be removed from the Facility.

Implementability – Alternative 1 SD is considered the easiest to implement because this type of work has already been implemented during the clean closure of the of the RCRA impoundments and NPDES ponds.

Alternatives 2 SD scores lower because the stabilized material will remain in the Effluent Channel and will need to be graded and contoured to drain. This may be difficult to implement.

Cost – Of the two soil alternatives, Alternatives 1 SD is the lowest cost. Alternative 1 SD also scored the highest relative to the other sediment alternative.

6.2 Recommended Corrective Measures Alternatives

Based on the detailed evaluation of alternatives, CPCPRC recommends implementing the following corrective measures alternatives for groundwater, soil, and effluent channel sediment:

- Alternative 2 GW – Under this alternative, ISCO using CHP will be implemented in the shallow and deep aquifers. The estimate of potential cost with markups for this alternative is $16.9 million.

- Alternative 2 SO – Under this alternative, soil with COCs above remediation goals will undergo biological treatment in land farm treatment cells. The estimate of potential cost with markups for this alternative is $6 million.

- Alternative 1 SD – Under this alternative, Effluent Channel sediment with COCs above remediation goals will be excavated, removed, and disposed offsite in a PREQB permitted landfill. The estimate of potential cost with markups for this alternative is $988,000.

6.2.1 Reconciliation with Corrective Measure Objectives

The CMOs for the corrective measures were presented in Section 2. The expected performance of the preferred alternative (Alternative 3) relative to the CMOs is presented in Table 9.

6.3 Corrective Measures Implementation

The purpose of the Corrective Measures Implementation (CMI) portion of the RCRA corrective action process is to design, construct, operate, maintain, and monitor the performance of the selected corrective measure. It will be necessary to prepare and submit various documents for agency review throughout the design, construction, and implementation phases of the corrective action. These documents may include the Conceptual Design, Intermediate Plans and Specifications, Construction Work Plan, Construction Completion Plan, Corrective Measure Completion Report, Health and Safety Plan, Progress Reports, etc.

Upon approval of this CMS, CPCPRC will submit a detailed CMI Work Plan with a schedule for other plans and reports.

7. REFERENCES

CH2M HILL, 1999. Phillips Puerto Rico Core RCRA Facility Investigation (RFI) Report. July 1999.

CPCPRC, 2004. Final Risk Characterization Report, Chevron Phillips Chemical Puerto Rico Core LLC, November 2004.

CPCPRC, 2013a. Final Area of Concern Investigation Report, Chevron Phillips Chemical Puerto Rico Core LLC, April 2013.

CPCPRC, 2013b. Pilot Test Work Plan for In-situ Groundwater Treatment, Chevron Phillips Chemical Puerto Rico Core LLC, November 2013.

CPCPRC, 2015a. Final Supplemental RCRA Facility Investigation Report, Chevron Phillips Chemical Puerto Rico Core LLC, January 2015.

CPCPRC, 2015b. Pilot Test Work Plan for Soil Biodegradation Treatment, Chevron Phillips Chemical Puerto Rico Core LLC, November 2015.

CPCPRC, 2015c. Corrective Measures Study Work Plan, Chevron Phillips Chemical Puerto Rico Core LLC, December 2015.

CPCPRC, 2016. In-Situ Chemical Oxidation Pilot Test MW-16 Field Area, Effectiveness Evaluation Report, Chevron Phillips Chemical Puerto Rico Core LLC, February 2016.

Greene, E.A., Gieg, L.M., Coy, D.L., and Fedorak, P.M. 1998. Sulfolane Biodegradation Potential in Aquifer Sediments at Sour Natural Gas Sites. Wat. Res. 32(12) 3680-3688.

Greene E.A. and Fedorak, P.M. 2001. Nutrient Stimulation of Sulfolane Biodegradation in a Contaminated Soil from a Sour Natural Gas Plant and in a Pristine Soil. Environmental Technology 22 619-629.

Saint-Fort, R. 2006. Sulfolane Attenuation by Surface and Subsurface Soil Matrices. Journal of Environmental Science and Health Part A, 41 1211-1231.

USEPA, 1994. OSWER Directive 9902.3-2A, RCRA Corrective Action Plan [Final], Office of Waste Programs Enforcement, Office of Solid Waste, May 1994.

USEPA, 1999. RCRA Cleanup Reforms, EPA 530-F-99-018. July 1999.

U.S. Geological Survey, 1992. Geohydrology of Augirre. USGS WRI 91-4124.P.

Wiedemeier, T.H., Swanson, M.A., Moutoux, D.E., Gordon, E.K., Wilson, J.T., Wilson, B.H., Kampbell, D.H., Haas, P.E., Miller, R.N., Hansen, J.E., and Chapelle, F.H., 1998. Technical Protocol for Evaluating Natural Attenuation of Chlorinated Solvents in Ground Water. U.S. Environmental Protection Agency, National Risk Management Research Laboratory, Office of Research and Development. EPA/600/R-98/128. September 1998.

This page intentionally left blank.

FIGURES

TABLES

This page intentionally left blank.

Table 1. Corrective Measures Objectives.	
1	Reduce contaminant levels in groundwater and soil to the remediation goals whenever technically practicable, within as short a timeframe that is reasonable, given the particular circumstances of the site.
2	Prevent future migration of groundwater with contamination above the remediation goals beyond the Facility boundaries.
3	Monitor and document the effectiveness of corrective measures, and modify as necessary to meet the remediation goals.
4	In the short term, control exposures to groundwater and soil in excess of the remediation goals.
5	Eliminate the potential risk to benthic invertebrates from sediment in the Effluent Channel.

Table 2. Remediation Goals for Groundwater.

Media	Chemical	Unit	Lowest Human Health Goal	Federal MCL	Remediation Goal Basis
Water	Sulfolane	µg/L	16 (Res)	--	Risk Based Goal - Resident
	Benzene	µg/L	0.45 (Res)	5	MCL
	Ethylbenzene	µg/L	1.49 (Res)	700	MCL
	m-Xylene & p-Xylene	µg/L	189 (Res)	10,000	MCL
	o-Xylene	µg/L	189 (Res)	10,000	MCL
	Toluene	µg/L	856 (Res)	1,000	MCL
Lowest human health goal based on site-specific risk assessment (CPCPRC 2013a and CPCPRC 2015a).					

Table 3. Remediation Goals for Soil.

Media	Chemical	Unit	Lowest Human Health Goal	Goal Considering Leaching to GW	Remediation Goal Basis
Soil	Sulfolane	µg/Kg	45,736 (Res)	65	Protection of Groundwater
	Benzene	µg/Kg	1,302 (Res)	168	Protection of Groundwater
	Ethylbenzene	µg/Kg	7,822 (Res)	7,822	Risk Based Goal – Resident
	m-Xylene & p-Xylene	µg/Kg	253,454 (CW)	253,454	Risk Based Goal – Construction Worker
	o-Xylene	µg/Kg	253,454 (CW)	253,454	Risk Based Goal – Construction Worker
	Toluene	µg/Kg	5,324,580 (Res)	51,284	Protection of Groundwater
Lowest human health goal based on site-specific risk assessment (CPCPRC 2013a and CPCPRC 2015a).					

Table 4. Remediation goals for Sediment.

Media	Chemical	Unit	Remediation Goal	Remediation Goal Basis
Sediment	Chromium	µg/Kg	37,300	EPA Region4, 5, and 6 ESL
	Copper	µg/Kg	18,700	EPA Region4, 5, and 6 ESL
	Manganese	µg/Kg	460,000	EPA Region4, 5, and 6 ESL
	Nickel	µg/Kg	15,900	EPA Region4, 5, and 6 ESL
	Zinc	µg/Kg	121,000	EPA Region4, 5, and 6 ESL

Table 5. Screening of Groundwater, Soil, and Sediment Remediation Technologies and Process Options.

Technology Type/Media	Technology	Process Option	Description	Effectiveness	Implementability	Screening Comments
Groundwater Containment	Physical Barriers	Slurry Wall	A slurry wall is a vertical subsurface barrier to contain, capture, or redirect groundwater flow in the vicinity of a contaminated site. A slurry wall is a vertical trench, which is excavated under a slurry and backfilled with a material that forms a low permeability barrier. The slurry, which is usually a mixture of bentonite and water, hydraulically shores the trench to prevent collapse. In addition, the slurry forms a filter cake on the trench walls to prevent high fluid losses into the surrounding ground	➢ Slurry walls are proven effective at containing and diverting contaminated groundwater. Barrier can be used to supplement containment by a groundwater pump and treatment system. ➢ Is not an effective stand-alone technology because the contaminant(s) is only contained by the slurry wall and is not removed or treated. ➢ Effectiveness can be reduced in areas of high-level groundwater contamination. Slurry may degrade or deteriorate as a result of exposure to chemicals in groundwater.	➢ Most implementations involve a large amount of heavy construction. ➢ Typically placed at depths from 20 to 80 feet and are generally 2 to 4 feet in thickness. ➢ Cost of backfill materials (e.g., bentonite) may be quite large.	**Retained**. Slurry walls are proven, common groundwater containment technologies. If keyed properly in to a low permeable stratum, they are effective in minimizing leakage through or under the wall. However, localized failure is possible as a result of degradation of the soil/bentonite particularly in areas of more elevated groundwater contaminant levels. Removal of the slurry wall after corrective measure completion is not practical. This technology is retained for shallow groundwater control and would not be a stand-alone technology but, would be used in conjunction with groundwater pumping.
		Sheet Pile Wall	A sheet pile wall is a vertical subsurface barrier to contain, capture, or redirect groundwater flow in the vicinity of a contaminated site. A wall of interlocking steel plates are pressure-driven vertically into the ground to form an impermeable barrier to groundwater flow.	➢ Sheet pile walls are proven effective at containing and diverting contaminated groundwater. Barrier can be used to supplement containment by a groundwater pump and treatment system. ➢ Is not an effective stand-alone technology because the contaminant(s) is only contained by the sheet pile wall and is not removed or treated. ➢ Not typically susceptible to degradation by chemicals in groundwater. However, steel corrosion can reduce effectiveness over time.	➢ Most implementations involve a large amount of heavy construction. ➢ Typically placed at depths from 20 to 80 feet.	Not Retained. Sheet pile walls are a common groundwater containment technology. However, corrosion and the large amount of construction required to install the wall render this technology impractical. In addition, the removal of the sheet pile wall after corrective measure completion is not practical.
	Hydraulic Barriers	Vertical or Horizontal Pumping Wells	Pumping wells are installed to contain contaminated groundwater via pumping. Groundwater pumping with above ground treatment ("Pump and Treat") is a common remediation technology. It is used to contain the contaminant plume and reduce the mass of contamination in the aquifer via extraction.	➢ Pumping to contain a dissolved groundwater contaminant plume, extract dissolved contamination, and reduce the mass of the contaminants in groundwater is a proven technology. ➢ Contaminant mass removal rates typically decline rapidly over time because contaminants are likely to remain sorbed onto soil particles and be immobilized in the vadose zone ➢ Is not an effective stand-alone technology because the extracted contaminated groundwater would require treatment.	➢ Shallow aquifer hydrogeology and contaminant characteristics and distribution may inhibit groundwater flow and reduce the ability to implement an effectiveness containment and contaminant recovery system. ➢ Pumping of the deep aquifer could potentially draw in contamination from the Fibers Superfund site. ➢ Biofouling and/or inorganic fouling may increase operating and maintenance efforts.	**Retained (for shallow aquifer).** Groundwater pumping is a common groundwater containment technology. This technology can be implemented using commonly available equipment and materials. This technology is not retained for the deep aquifer because of the potential for pumping to draw in contamination from the Fibers Superfund site.

Table 5. Screening of Groundwater, Soil, and Sediment Remediation Technologies and Process Options.

Technology Type/Media	Technology	Process Option	Description	Effectiveness	Implementability	Screening Comments
Groundwater In-Situ Chemical/Physical Treatment	Chemical	In-situ Chemical Oxidation (ISCO)	The ISCO processes destroy contaminants by chemical reaction with hydroxyl radicals. A chemical oxidant, such as hydrogen peroxide is introduced into the aquifer via vertical or horizontal treatment wells. During the oxidation process, chemical bonds are broken and new compounds are formed. The technology has the potential to oxidize various organic compounds, including sulfolane, to carbon dioxide, water, and salts.	➢ CPCPRC performed a field-scale pilot test of this technology using catalyzed hydrogen peroxide. The technology was effective in reducing contaminant levels in groundwater. ➢ Catalyst formulation for optimum treatment can be adjusted in the field.	➢ Geologic heterogeneities may reduce the radius of influence (ROI) of treatment points. ➢ Technology can be implemented using semi-permanent treatment points, treatment through individual Geoprobe borings, or a combination of these methods. ➢ Safety precautions must be used when handling chemical oxidants such as hydrogen peroxide.	**Retained**. In field-scale pilot testing at the Facility, this technology was demonstrated to be effective using catalyzed hydrogen peroxide (CHP) to generate the hydroxyl radical to treat site contaminants.
	Physical	Air Sparging/Soil Vapor Extraction (AS/SVE)	Air is injected into groundwater via injection wells or trenches under pressure below the water table. Volatile compounds that are exposed to this sparged air environment convert to gas phase and are carried by the air movement into the vadose zone. From the vadose zone, the volatiles are captured by a soil vapor extraction system. The sparged air maintains a high dissolved oxygen content, which enhances natural biodegradation. The VISM trench installed at the Facility as an interim measure, is an AS/SVE system.	➢ Proven effective at removing volatile organic compounds (VOCs) from groundwater. ➢ Fine grained, low permeability soils may limit effectiveness and/or if airflow does not reach contaminated zones due to soil heterogeneities. ➢ May be ineffective for sulfolane, a semi-volatile organic compound (SVOC). ➢ Air sparging is generally applicable for depths to groundwater greater than 5 feet.	➢ Implementation at this Facility would involve a large amount of heavy construction. The VISM system was installed in a gravel filled trench to improve permeability and enable more effective air delivery and vapor extraction. ➢ Potential for uncontrolled flow of vapors as airflow through saturated zone may not be uniform. ➢ Need to use air compressor if above the maximum pressure range for blowers (typically above 15 psi).	Not Retained. Although this technology has been proven to be effective at the Facility as an interim measure, it is not retained as an option for full-scale implementation. Sulfolane would not be expected to be effectively treated. In addition, placement of these systems in gravel trenches would likely be needed to address geologic heterogeneities. This approach would be impractical and involve a large amount of heavy construction.
		Extraction Wells/Trenches	A series of vertical or horizontal wells are installed to recover contaminated groundwater. Groundwater extraction is not sufficient as a stand-alone remedial technology Extracted groundwater requires treatment ("Pump and Treat"). The EFR system being operated as an interim measure at the Facility is a mobile form of this technology.	➢ Commonly used technology to remove groundwater, extract dissolved contamination, and reduce the mass of the contaminants in groundwater. ➢ Site hydrogeology and contaminant characteristics and distribution may inhibit groundwater extraction. ➢ Extraction alone may be insufficient to meet remediation goals since contaminants are likely to remain sorbed onto soil particles and be immobilized in the vadose zone.	➢ Low permeability or heterogeneous aquifer materials reduce effectiveness of vertical wells and may require horizontal trenches to better intercept and extract the groundwater. ➢ Pumping of the deep aquifer could potentially draw in contamination from the Fibers Superfund site. ➢ Biofouling and/or inorganic fouling may increase operating and maintenance efforts.	**Retained (for shallow aquifer)**. Groundwater extraction is a common technology for collecting groundwater for treatment. This technology is retained for its ability to remove contaminant mass primarily in the early stages of its implementation life-cycle. Extracted groundwater requires treatment ("Pump and Treat"). This technology is not retained for the deep aquifer because of the potential for pumping to draw in contamination from the Fibers Superfund site.

Table 5. Screening of Groundwater, Soil, and Sediment Remediation Technologies and Process Options.

Technology Type/Media	Technology	Process Option	Description	Effectiveness	Implementability	Screening Comments
Groundwater In-Situ Biological Treatment	Enhanced Bioremediation	Microbial enhancements and/or addition of electron donors or acceptors	In-situ biodegradation systems use microorganisms to degrade contaminants. An inoculant with nutrients, a carbon substrate, and/or microbes are introduced into the aquifer via vertical or horizontal treatment wells. These systems attempt to stimulate subsurface oxidation, metabolism, and degradation to accelerate the clean-up process.	➢ Effective for treating groundwater contaminated with non-halogenated VOCs, non-halogenated SVOCs, and fuel contamination. ➢ Microcosm studies indicate that sulfolane biodegradation occurs in aerobic aquifers particularly after nutrient addition. In anaerobic aquifers, sulfolane biodegradation was not evident. ➢ Geologic heterogeneities may interfere with the placement of the nutrients, carbon substrate, and/or microbes.	➢ Stoichiometric requirements for nutrients and/or microbial additives vary greatly depending on site characteristics. ➢ Technology can be implemented using semi-permanent treatment points, treatment through individual Geoprobe borings, or a combination of these methods. ➢ Typically implemented through a medium to long range remediation process.	Not Retained. This technology is similar to ISCO with respect to the implementation approach (i.e., use of treatment points). However, this technology would be expected to be ineffective in areas of the Facility where groundwater is under anaerobic conditions. In areas where aerobic aquifer conditions exist, this technology may be effective but is expected to have a much longer time frame for remediation relative to ISCO.
	Natural Attenuation	Monitored Natural Attenuation	Natural attenuation relies upon natural subsurface processes such as dilution, volatilization, biodegradation, and adsorption, to reduce contaminant concentrations to remediation goals. Periodic sampling of the site contaminants, biodegradation activators, and degradation byproducts is performed to evaluate the trends in the increase/decrease of the contaminants.	➢ Normally used on groundwater contaminated with VOCs, SVOCs, or fuel hydrocarbons. ➢ Can be used at sites where other removal or treatment approaches are impractical, or where other options would not significantly accelerate remediation time.	➢ Some contaminants may be immobilized on aquifer soil and therefore may not be available to natural degradation processes. ➢ Not effective for high concentrations of contaminants. ➢ May require long periods of time to achieve remediation goals.	Not Retained. The anticipated long time frame for remediation makes this technology impractical. At this Facility, other removal or treatment approaches are more practical and implementable (e.g., ISCO).
Groundwater Ex Situ Physica/Chemical Treatment	Physical	Air Stripping	Air stripping is a process for removing VOCs from water. The process has been widely and successfully applied to groundwater remediation for a number of contaminants, including BTEX. Common air stripping configurations include packed tower air strippers and low profile tray towers. An air stripper is currently operating at the Facility to treat groundwater extracted by the EFR process.	➢ Typically only effective for organic compounds with a Henry's law (H) constant greater than 10 atm/mole fraction. ➢ May be ineffective for sulfolane, an SVOC. ➢ Air stripping at elevated temperatures can increase effectiveness by increasing the contaminant removal rates.	➢ This technology is currently implemented at the Facility. The EFR groundwater is currently treated via the Facility air stripper. ➢ Effluent off-gas may require additional treatment before release. ➢ Typical liquid loading rate, measured in gallons per minute (gpm) per square feet (ft^2), for air stripping towers varies from 5 gpm/ ft^2 to 30 gpm/ft^2.	Not Retained. Although the BTEX constituents can be effectively treated using air stripping, sulfolane would not be effectively treated using standard air stripping methods.
		Liquid- or Vapor-Phase Carbon Adsorption	Adsorption is a natural process in which molecules of a liquid or gas are physically attracted to and held at the surface of a solid. The most commonly used adsorbent is granular activated carbon (GAC). In liquid-phase carbon adsorption, the contaminated groundwater comes in contact with the carbon by flowing through one or more packed bed adsorbers. A packed bed adsorber is a column packed with GAC. In vapor phase carbon adsorption, the contaminated gas comes in contact with the carbon by passing through one or more adsorbers, which are usually the fixed bed type. A fixed bed adsorber is a stationary vessel filled with carbon granules	<u>Liquid Phase:</u> ➢ Target contaminants are hydrocarbons and SVOCs. ➢ Most effective for contaminant concentrations less than 10,000 ppm with suspended solids less than 50 ppm. ➢ Carbon type, pore size, quality, and operating temperature will affect performance <u>Gas Phase:</u> ➢ Commonly used as a secondary treatment technology to other treatments like SVE. ➢ Removal of VOCs from contaminated air.	➢ Readily available technology. ➢ Metals or biological growth can foul GAC systems. ➢ Pretreatment of air streams may be necessary. ➢ Spent GAC requires off-site disposal.	**Retained (Liquid-Phase)**. Liquid-phase carbon adsorption is retained as a possible treatment technology for groundwater extracted via a groundwater pump and treat system.

Table 5. Screening of Groundwater, Soil, and Sediment Remediation Technologies and Process Options.

Technology Type/Media	Technology	Process Option	Description	Effectiveness	Implementability	Screening Comments
	Chemical	Oxidative Destruction	Oxidation processes destroy contaminants by chemical reaction with hydroxyl radicals. Hydroxyl radicals are formed through the various combinations of ozone and hydrogen peroxide, both with and without UV light. Systems configurations include O_3/high pH, H_2O_2+ O_3, O_3/UV light, H_2O_2/ O_3/UV light. During the oxidation process, chemical bonds are broken and new compounds are formed. The technology has the potential to oxidize various organic compounds to carbon dioxide, water, and salts.	➢ Removes organics such as petroleum hydrocarbons and SVOCs. ➢ Effectiveness can be limited by the presence of suspended solids in the influent stream. ➢ Oxidant dosing systems are typically designed with multiple dosing points to ensure sufficient potential for oxidation to occur.	➢ In UV systems, the aqueous stream must provide adequate light transmission. ➢ Systems can be configured in batch or continuous operation. ➢ Handling and management of oxidizers may require special safety considerations. ➢ Bench-scale or pilot testing is usually required to determine necessary design parameters.	**Retained**. This technology is retained as a possible treatment technology for groundwater extracted via a groundwater pump and treat system. Considering the success of the groundwater ISCO pilot test, the system considered in this CMS will be a hydrogen peroxide (H_2O_2) based system.
		Activated Sludge	Activated sludge bioreactors employ microorganisms to degrade contaminants in water. Contaminated ground water is circulated in an aeration basin where a microbial population aerobically degrades organic matter and produces CO_2, H_2O, and a bio-sludge. The sludge settles out in a clarifier and is either recycled to the aeration basin or disposed.	➢ Bioreactors treat fuel hydrocarbons, SVOCs, and any biodegradable, organic material. ➢ Nuisance microorganisms may reduce bioreactor effectiveness.	➢ Startup time can be slow if the organisms need to be acclimated to the contaminants. ➢ Nutrient addition may be necessary to support microbial activity. ➢ Residuals from sludge processes require treatment or off-site disposal.	Not retained. Activated sludge treatment systems are sensitive to system upsets, require more maintenance than oxidative destruction, and produce residuals that require off-site disposal.
Soil Removal	Removal	Excavation and Off-site Disposal	Excavation is a method of removing contaminated soil. Excavation is a standard construction practice. Typical excavation equipment includes bulldozers, scrapers, excavators, track loaders, and wheel loaders, all of which are available in a wide variety of sizes. Excavation involves the physical removal of contaminated materials. Following excavation, contaminated material must be either treated or disposed.	➢ Applicable and proven technology for all contaminant groups. ➢ Most effective for removal of contaminated soil, soil-like materials, or other materials above the water table.	➢ Best for sites that are free of surface obstacles and/or for small sites with concentrated areas of contamination. ➢ Employs conventional earth moving equipment. ➢ Potential generation of vapor or off-gas emissions during excavation. ➢ Potentially high costs dependent on the distance from the site to the disposal facility, depth of excavation, and type of waste.	**Retained**. Excavation was proven effective and implementable at this Facility during the Hazardous Waste Management Unit (HWMU) and NPDES pond clean closures. Disposal costs could be high if the removed material is tested to be hazardous.
Soil In-Situ Treatment	In-situ Enhanced Bioremediation	Soil mixing with additive microbial enhancements and nutrients	Use of augers or dual auger systems to add and mix reagents into the soil without excavation. In-situ biodegradation systems use microorganisms to degrade contaminants. These systems attempt to stimulate subsurface oxidation, metabolism, and degradation to accelerate the clean-up process. This is accomplished through mixing of substrates with nutrients and microorganisms into the soil.	➢ Soil contaminated with non-halogenated VOCs, non-halogenated SVOCs, and fuel contamination. ➢ Pilot studies on Facility soil and an increasing number of case studies show sulfolane in soil is biodegradable.	➢ Treatment is typically limited to a depth of 10 feet unless specialized deep mixing equipment is used. ➢ Complete mixing to achieve the optimal environment for microbial degradation may be difficult. ➢ Toxic levels of contaminants may limit biodegradation.	**Retained**. Pilot studies showed the effective biodegradation of sulfolane. BTEX biodegradation is well documented. It is assumed that this technology can be implemented using commonly available equipment and materials.
	In-situ Chemical Treatment	Soil mixing with an oxidant	Use of large diameter augers or dual auger systems to add and mix reagents into the soil without excavation. A chemical oxidant such as activated sodium persulfate (ASP) is added to the contaminated soil to chemically destroy the contaminants. The oxidation process breaks the chemical bonds of the contaminants transforming them to carbon dioxide, water, and salts	➢ ASP is a strong oxidant applicable to petroleum hydrocarbons such as BTEX. ➢ Sulfolane in soil is expected to be oxidized. Pilot testing would be needed to verify the effectiveness of ASP to treat sulfolane. ➢ Effectiveness is dependent on contact of the COCs with the oxidant. Increased contact increases effectiveness.	➢ Oxidant may be supplied as a dry powder which can be mixed with pH controlling additives and water to create a soil slurry. ➢ Handling and management of oxidizers may require special safety considerations. ➢ Potential generation of vapor or off-gas emissions during treatment operations. ➢ Runoff control, collection and, monitoring is required.	Not retained. This technology requires the creation of a soil/oxidant slurry that would be difficult to manage safely. In addition to safety concerns, the control of the soil slurry and, any storm water runoff would be difficult to effectively manage.

Table 5. Screening of Groundwater, Soil, and Sediment Remediation Technologies and Process Options.

Technology Type/Media	Technology	Process Option	Description	Effectiveness	Implementability	Screening Comments
Soil Ex-Situ Treatment	Ex-situ Enhanced Bioremediation (Land Farming)	Land Farming with additive microbial enhancements and nutrients	Soil is excavated and placed in land farm treatment cells. Land farming uses conventional soil management practices to stimulate biodegradation in a layer of contaminated soil by increasing aeration, maintaining moist conditions, providing nutrients, and adding microorganisms.	➢ Biodegradation is applicable to petroleum hydrocarbons such as BTEX. ➢ Pilot studies on Facility soil and an increasing number of case studies show sulfolane in soil is biodegradable. ➢ Effectiveness is dependent on contact of the COCs with the biodegrading microbes. Increased contact (e.g., via tilling and mixing) increases effectiveness.	➢ Employs conventional earth moving equipment. ➢ Potential generation of vapor or off-gas emissions during excavation of soil, placement of soil in land farm cells and, during tilling operations. ➢ Requires a large area. ➢ Runoff control, collection and, monitoring is required.	**Retained**. Pilot studies showed the effective biodegradation of sulfolane. The Facility has broad areas of open space available for land farming. The existing tank basin berms and other infrastructure (e.g., skid mounted treatment unit for runoff) are in place to support this technology.
	Ex-situ Chemical Treatment	Treatment of soil with an oxidant	Soil is excavated and placed in treatment cells. A chemical oxidant such as ASP is added to the contaminated soil to chemically destroy the contaminants. The oxidation process breaks the chemical bonds of the contaminants transforming them to carbon dioxide, water, and salts	➢ ASP is a strong oxidant applicable to petroleum hydrocarbons such as BTEX. ➢ Sulfolane in soil is expected to be oxidized. Pilot testing would be needed to verify the effectiveness of ASP to treat sulfolane. ➢ Effectiveness is dependent on contact of the COCs with the oxidant. Increased contact increases effectiveness.	➢ Oxidant may be supplied as a dry powder which can be mixed with pH controlling additives and water to create a soil slurry. ➢ Handling and management of oxidizers may require special safety considerations. ➢ Potential generation of vapor or off-gas emissions during excavation of soil and during treatment operations. ➢ Requires a large area. ➢ Runoff control, collection and, monitoring is required.	Not retained. This technology requires the creation of a soil/oxidant slurry that would be difficult to manage safely. In addition to safety concerns, the control of the soil slurry and, any storm water runoff would be difficult to effectively manage.
Sediment Removal	Removal	Excavation and Off-site Disposal	Excavation is a method of removing contaminated sediment. Excavation is a standard construction practice. Typical excavation equipment includes bulldozers, scrapers, excavators, track loaders, and wheel loaders, all of which are available in a wide variety of sizes. Excavation involves the physical removal of contaminated materials. Following excavation, contaminated material must be either treated or disposed.	➢ Applicable and proven technology for all contaminant groups. ➢ Most effective for removal of contaminated soil, soil-like materials, or other materials above the water table.	➢ Usually best for sites that are free of surface obstacles and/or for small sites with concentrated areas of contamination. ➢ Employs conventional earth moving equipment. ➢ Potential generation of vapor or off-gas emissions during excavation. ➢ Potentially high costs dependent on the distance from the site to the disposal facility, depth of excavation, and type of waste.	**Retained**. Excavation was proven effective at this Facility during the HWMU and NPDES pond clean closures. This technology is retained as an option for permanently removing contaminated sediment. Disposal costs could be high if the removed material is tested to be hazardous.
Sediment In-Situ Treatment	In-situ Solidification	Solidification and stabilization	Use of augers or conventional earth moving equipment to add and mix reagents such as fly ash into the sediment without excavation. In-situ solidification transforms a sludge or sediment into a solid form. Solidification immobilizes the contaminants within the crystalline structure of the solidified material, thus reducing the contaminants mobility.	➢ Sediment contaminated with inorganic compounds. ➢ Limited effectiveness against SVOCs and pesticides and no expected effectiveness against VOCs.	➢ Treatment is typically limited to a depth of 10 feet unless specialized deep mixing equipment is used. ➢ Complete mixing to achieve complete stabilization may be difficult. ➢ Solidification increases resultant volume of immobilized material.	Retained.

Notes:

Effectiveness is 1) the potential effectiveness of the process options to address the estimated areas or volumes of contaminated media and meet the CMOs; 2) the reliability and past performance of the technology; and 3) the potential impacts to human health and the environment during the construction and/or implementation phases.

Implementability refers to both technical and administrative feasibility. The technical component is the ability of the technology to treat the site contaminants given the site conditions. The administrative component is the ability to obtain necessary permits, approvals, equipment, and skilled workers.

Table 6. Evaluation of the Groundwater Corrective Measures Alternatives Against Evaluation Criteria.

Evaluation Criteria		No Further Action	Alternative 1 GW - Shallow Groundwater Extraction with ISCO in the Deep Groundwater	Alternative 2 GW - ISCO in the Shallow and Deep Groundwater	Alternative 3 GW - Slurry Wall in the Shallow Aquifer, Shallow Groundwater Extraction, and ISCO in the Deep Groundwater	Comments
1	Protection of human health and the environment	The mobile EFR and VISM continue to remove COCs dissolved in groundwater. However, these systems are implemented in only limited areas of the Facility. Additionally, these two systems are in the late stage of their active life cycles. Because of their limited focus and their age, the protection of human health and the environment is not expected for groundwater in the long-term.	After 6 years of pumping, sulfolane levels in shallow groundwater are predicted to meet remediation goals. BTEX levels are predicated to reach remediation goals after 28 years of pumping. These predictions are based on the assumption that all 50 extraction wells pump continuously at a rate of 5 gpm (Appendix A). Although cleanup to remediation goals is predicted, significant studies to refine the understanding of pumping well placement, pumping rates, contaminant removal rates, and groundwater treatment facility details would be needed. Because of this uncertainty, long-term protection of human health and the environment is only moderately certain. ISCO was determined to be very effective during pilot testing and this remedy in the deep aquifer is anticipated to provide long-term protection of human health and the environment.	ISCO was determined to be very effective during pilot testing and this remedy in the shallow and deep aquifers is anticipated to provide long-term protection of human health and the environment.	The slurry wall along select portions of the Facility boundary, combined with shallow groundwater extraction and treatment is expected to result in cleanup of shallow groundwater to remediation goals after 28 years of pumping (Appendix A). Although cleanup to remediation goals is predicted, significant studies anticipated to be in the form of drilling, aquifer testing, and other pre-design tasks needed to evaluate groundwater geochemistry and slurry wall compatibility, refine the understanding of pumping well placement, pumping rates, contaminant removal rates, and groundwater treatment facility details. Because of this uncertainty, long-term protection of human health and the environment is only moderately certain. ISCO was determined to be very effective during pilot testing and this remedy in the deep aquifer is anticipated to be protective of human health and the environment.	Of the three groundwater alternatives, only Alternative 2 GW is expected to meet this criteria. ISCO using CHP has been field tested and the result of the pilot testing demonstrated that this technology is capable of effectively treating COCs in groundwater. The No Further Action alternative is not expected to meet this criteria for groundwater.
2	Attain remediation goals	It is unlikely the EFR and VISM systems will achieve cleanup of the groundwater to remediation goals. This is because the EFR and VISM would only be implemented in limited areas of the Facility.	Cleanup of the groundwater to remediation goals in the shallow groundwater after 28 years of continuous pumping is predicted (Appendix A). Although cleanup of shallow groundwater is predicted, the performance of groundwater pump and treat systems has been demonstrated to decline, sometimes significantly, over time. System down-time is common and pump and treat systems require significant, long-term O&M effort. Because of the uncertainty in the long-term effectiveness of this technology, attaining cleanup goals is only moderately certain. Based on the success of the groundwater pilot testing of ISCO using CHP, cleanup of the deep groundwater to remediation goals is predicted after ISCO treatment.	Based on the success of the groundwater pilot testing of ISCO using CHP, cleanup of the groundwater to remediation goals is predicted in both the shallow and deep groundwater after ISCO treatment.	Cleanup of the groundwater to remediation goals in the shallow groundwater after 28 years of pumping is predicted (Appendix A). Although cleanup of shallow groundwater is predicted, there is uncertainty related to the long-term performance of the groundwater pump and treat system. In addition, it is uncertain whether geochemical conditions in the shallow aquifer are compatible with typical slurry wall composition. Because of the uncertainty in the long-term effectiveness of this technology, attaining cleanup goals is only moderately certain. Based on the success of the groundwater pilot testing of ISCO using CHP, cleanup of the deep groundwater to remediation goals is predicted after ISCO treatment.	Of the three groundwater alternatives, only Alternative 2 GW is reliably expected to attain the cleanup goals. ISCO using CHP has been field tested and the result of the pilot testing demonstrated that this technology is capable of effectively treating COCs in groundwater. The No Further Action alternative is not expected to meet this criteria for groundwater.
3	Control the source(s) of releases so as to reduce or eliminate, to the extent practicable, further releases of hazardous waste (including hazardous constituents) that might pose threats to human health and the environment	Other than the potential leaching of the COCs from soil to groundwater, there are no active releases and the Facility is completely demolished. Because soils would not be removed or treated under this alternative, these soils could act as a long-term source of groundwater contamination.	There are no active releases and the Facility is completely demolished.	There are no active releases and the Facility is completely demolished.	There are no active releases and the Facility is completely demolished.	Other than the potential leaching of the COCs from soil to groundwater, there are no active releases and the Facility is completely demolished. Soil alternatives are screened in Table 7. The No Further Action alternative is not expected to meet this criteria.
4	Comply with applicable standards for waste management	The activities under this alternative are currently being performed in accordance with the RCRA Order.	The construction of the pump and treat system and associated Facility WWTP would require the necessary permits. In addition, the treated effluent from the WWTP would require a modification of the existing discharge permit with PRASA or possibly a separate discharge permit from PRASA. The ISCO treatment of the deep groundwater would require permits similar to the permits obtained during the groundwater pilot test.	The ISCO treatment of the shallow and deep groundwater would require permits similar to the permits obtained during the groundwater pilot test.	The construction of the slurry wall, the pump and treat system, and associated Facility WWTP would require the necessary permits. In addition, the treated effluent from the WWTP would require a modification of the existing discharge permit with PRASA or possibly a separate discharge permit from PRASA. The ISCO treatment of the deep groundwater would require permits similar to the permits obtained during the groundwater pilot test.	Of the three groundwater alternatives, Alternative 2 GW is expected to most easily meet this criteria. Alternatives 1 GW and 3 GW score lower because of the uncertainty related to obtaining a permit from PRASA for the long-term discharge of extracted groundwater. The No Further Action alternative currently meets this criteria.

Table 6. Evaluation of the Groundwater Corrective Measures Alternatives Against Evaluation Criteria.

Evaluation Criteria		No Further Action	Alternative 1 GW - Shallow Groundwater Extraction with ISCO in the Deep Groundwater	Alternative 2 GW - ISCO in the Shallow and Deep Groundwater	Alternative 3 GW - Slurry Wall in the Shallow Aquifer, Shallow Groundwater Extraction, and ISCO in the Deep Groundwater	Comments
5	Long-term reliability and effectiveness	Long-term reliability and effectiveness is not expected from this alternative. The mobile EFR and VISM are in the late stage of their active life cycles. Therefore, these systems are not expected to be reliable or effective in the long-term.	The long-term reliability and effectiveness of a pump and treat system depends on effective long-term O&M of the system and any optimizations performed over time. Even with an effective O&M and optimization program, pump and treat system performance tends to deteriorate over time. Long-term, this technology is anticipated to only be moderately reliable and effective. ISCO was determined to be very effective during pilot testing and this remedy is anticipated to provide long-term reliability and effectiveness in the deep aquifer.	ISCO was determined to be very effective during pilot testing and this remedy is anticipated to provide long-term reliability and effectiveness in the shallow and deep aquifers.	The long-term reliability and effectiveness of a slurry wall and pump and treat system depends on the proper installation of the wall, the ability of the slurry to maintain its integrity (i.e., not degrade), the effective long-term O&M of the pump and treat system, and any optimizations performed over time. Even with proper wall installation and an effective O&M and optimization program, pump and treat system performance tends to deteriorate over time. Long-term, this technology is anticipated to only be moderately reliable and effective. ISCO was determined to be very effective during pilot testing and this remedy is anticipated to provide long-term reliability and effectiveness in the deep aquifer.	Of the three groundwater alternatives, only Alternative 2 GW is expected to meet this criteria. Even with an effective O&M and optimization program, it is uncertain whether pump and treat systems would be effective over the long-term.
6	Reduction of toxicity, mobility, or volume (TMV) of wastes	Some further reduction in volume of the COCs is expected in the shallow groundwater through the removal and treatment actions of the EFR and VISM systems. There would be no reduction in TMV of the COCs in the deep groundwater.	In the early years of operation, the pump and treat system is predicted to result in significant reduction in volume and mobility of the COCs in shallow groundwater. Over time, the removal rates are predicted to decline. Treatment of the extracted groundwater in the onsite WWTP would reduce the toxicity of the COCs. The ISCO in the deep aquifer is anticipated to result in destruction of the COCs resulting in the reduction of TMV of the COCs in deep groundwater.	The ISCO in the shallow and deep aquifers is anticipated to result in destruction of the COCs resulting in the reduction of TMV of the COCs in groundwater.	In the early years of operation, the pump and treat system is predicted to result in significant reduction in volume and mobility of the COCs in shallow groundwater. Over time, the removal rates are predicted to decline. Treatment of the extracted groundwater in the onsite WWTP would reduce the toxicity of the COCs in groundwater. The ISCO in the deep aquifer is anticipated to result in destruction of the COCs resulting in the reduction of TMV of the COCs in deep groundwater.	Of the three groundwater alternatives, only Alternative 2 GW is expected to meet this criteria for both shallow and deep groundwater. In the shallow groundwater, pump and treat is expected to result in the reduction of TMV in the early years. However, case studies of pump and treat often show rapid declines in the pump and treat system performance.
7	Short-term effectiveness	Short-term effectiveness for shallow groundwater is already achieved by the mobile EFR and VISM systems.	The occupational exposure and safety concerns during the construction of the pump and treat system can be minimized through health and safety training, the use of protective gear, and safe construction practices. In the early stages of operation, the pump and treat system is expected to be effective at removing COCs from shallow groundwater. With the proper permits, training, and protective gear the occupational exposure to chemicals during the ISCO treatment program can be minimized. The CHP reaction with the COCs is fairly rapid and this technology is expected to be very effective in the short-term.	With the proper permits, training, and protective gear the occupational exposure to chemicals during the ISCO treatment program can be minimized. The CHP reaction with the COCs is fairly rapid and this technology is expected to be very effective at destroying the COCs in the short-term.	The occupational exposure and safety concerns during the construction of the slurry wall and pump and treat system can be minimized through health and safety training, the use of protective gear, and safe construction practices. In the early stages of operation, the pump and treat system is expected to be effective at removing COCs from shallow groundwater. With the proper permits, training, and protective gear the occupational exposure to chemicals during the ISCO treatment can be minimized. The CHP reaction with the COCs is fairly rapid and very effective in the short-term.	All of the alternative, including the No Further Action alternative are expected to meet this criteria. Of the three groundwater alternatives however; Alternative 2 GW scores highest because COCs would be destroyed in a relatively short time frame (assumed to be 1 year).
8	Implementability	The EFR and VISM systems and the monitoring and reporting work elements are currently implemented.	The implementability of this alternative is primarily dependent on the ability to obtain a permit from PRASA to discharge the treated groundwater generated by the pump and treat system. It is assumed that an active discharge permit will be required for 30 years. Because of the permit issue, this alternative is expected to be difficult to implement. The ISCO component is implementable based on the groundwater pilot test work performed at the Facility.	The ISCO component of this alternative is implementable based on the ISCO pilot testing work already performed at the Facility.	The implementability of this alternative is primarily dependent on the ability to obtain a permit from PRASA to discharge the treated groundwater generated by the pump and treat system. It is assumed that an active discharge permit will be required for 30 years. Because of the permit issue, this alternative is expected to be difficult to implement. The ISCO component is implementable based on the groundwater pilot test work already performed at the Facility.	Of the three groundwater alternatives, Alternative 2 GW is expected to most easily meet this criteria. Alternatives 1 GW and 3 GW score lower because of the uncertainty related to obtaining a permit from PRASA for the long-term discharge of extracted groundwater. The No Further Action alternative currently meets this criteria.
9	Total Cost with Markups (see Appendix B for cost detail)	Study and Remediation: $0. O&M, Reporting, and Closeout: $26.4 million Total Cost with Markups: $26.4 million	Study and Remediation: $3.6 million. O&M, Reporting, and Closeout: $30.8 million Total Cost with Markups: $34.4 million	Study and Remediation: $14.1 million. O&M, Reporting, and Closeout: $2.8 million Total Cost with Markups: $16.9 million	Study and Remediation: $4.8 million. O&M, Reporting, and Closeout: $30.8 million Total Cost with Markups: $35.6 million	Alternative 2 GW has the highest capital cost for Study and Remediation and the lowest capital cost for O&M, Reporting, and Closeout.

Table 7. Evaluation of the Soil Corrective Measures Alternatives Against Evaluation Criteria.

Evaluation Criteria		No Further Action	Alternative 1 SO – Soil Excavation and Offsite Disposal	Alternative 2 SO - Soil Biological Treatment in Land Farm Treatment Cells	Alternative 3 SO - Soil Biological Treatment In-Situ using Soil Mixing	Comments
1	Protection of human health and the environment	The contaminated soil is covered by the steel tank bottoms or concrete (at AOC Tank 540). Over an extended period of time (e.g., 30 years), these protective measures will likely corrode and/or degrade offering no long-term protection of human health and the environment.	Soil excavation and disposal at a permitted offsite landfill provides for long-term protection of human health and the environment. This is because the soil with COCs levels above remediation goals will be removed and disposed offsite.	Biological treatment of soil in the land farm pilot testing was very effective at destroying the COCs. Based on these results, this alternative is anticipated to provide long-term protection of human health and the environment.	Biological treatment of the COCs in soil was determined to be very effective during land farm pilot testing. However, the actual effectiveness of biological treatment using in-situ soil mixing is uncertain. The effectiveness of this technology depends on the ability to thoroughly mix the soil additives and provide the microbes with the nutrients, water, and air needed to be effective. Because of these uncertainties, this approach is assumed to be moderately protective of human health and the environment.	Alternatives SO 1 and SO 2 both provide for reliable protection of human health and the environment. Of these two alternatives, Alternative 2 SO scores highest. This is because soil biodegradation in land farm treatment cells results in the destruction of the COCs. In contrast, placing the soil in a landfill only contains the soil and COCs are not destroyed. Alternative 3 SO scores lowest because of the significant uncertainty related to the ability for soil mixing to provide the optimum environment for biodegradation. The No Further Action alternative does not meet this criteria for soil.
2	Attain remediation goals	Under this alternative, the remediation goals will not be met for soil because no removal, treatment, or waste management actions are included in this alternative.	The remediation goals will be met for soil through removal and offsite disposal.	Based on the success of the soil biodegradation pilot test, the remediation goals will be through biological destruction of the COCs in land farm treatment cells.	Cleanup of the soil to remediation goals is uncertain because complete mixing and biological treatment using in-situ soil mixing has not been demonstrated to be effective at the Facility.	Alternative 1 SO and Alternative 2 SO both meet this criteria. Of these two alternatives, Alternative 2 SO scores highest. This is because soil biodegradation in land farm treatment cells results in the destruction of the COCs. Alternative 3 SO scores lowest because of the significant uncertainty related to the ability for soil mixing to provide the optimum environment for biodegradation. The No Further Action alternative does not meet this criteria for soil.
3	Control the source(s) of releases so as to reduce or eliminate, to the extent practicable, further releases of hazardous waste (including hazardous constituents) that might pose threats to human health and the environment	Other than the potential leaching of the COCs from soil to groundwater, there are no active releases and the Facility is completely demolished. Because soils would not be removed or treated under this alternative, these soils could act as a long-term source of groundwater contamination.	There are no active releases and the Facility is completely demolished. Because soils would be removed under this alternative, soil would not act as a potential source of groundwater contamination.	There are no active releases and the Facility is completely demolished. Because the COCs in soil would be treated to remediation goals under this alternative, soil would not act as a potential source of groundwater contamination.	There are no active releases and the Facility is completely demolished. Because of the uncertainty related to complete treatment of COCs in soil using in-situ soil mixing, it is possible the COCs in soil would act as a potential long-term source of groundwater contamination.	Alternative 1 SO and Alternative 2 SO both meet this criteria because implementing these alternatives would eliminate the potential for soil to act a source of groundwater contamination. Alternative 3 SO scores lowest because of the significant uncertainty related to the ability for soil mixing to provide the optimum environment for biodegradation. The No Further Action alternative does not meet this criteria.
4	Comply with applicable standards for waste management	The activities under this alternative are currently being performed in accordance with the RCRA Order.	The soil removal would require permits similar to the permits obtained during the clean closure of the RCRA impoundments and NPDES ponds.	The soil treatment would require permits anticipated to be related to the construction of the land farm treatment cells, soil excavation, water management, and possibly air emissions.	The soil treatment would require permits anticipated to be related to the heavy equipment and soil disturbance associated with the in-situ soil mixing, water management, and possibly air emissions.	Alternative 1 SO scores the highest. This is because permitting the work under this alternative is anticipated to be the most straightforward. Alternatives 2 SO and 3 SO score lower because of the uncertainty related to the exact scope of permitting. However, permits for work under these alternatives is expected to be obtainable. The No Further Action alternative currently meets this criteria.

Table 7. Evaluation of the Soil Corrective Measures Alternatives Against Evaluation Criteria.

Evaluation Criteria		No Further Action	Alternative 1 SO – Soil Excavation and Offsite Disposal	Alternative 2 SO - Soil Biological Treatment in Land Farm Treatment Cells	Alternative 3 SO - Soil Biological Treatment In-Situ using Soil Mixing	Comments
5	Long-term reliability and effectiveness	The contaminated soil is covered by the steel tank bottoms or concrete (at AOC Tank 540). Over an extended period of time (e.g., 30 years), these protective measures will likely corrode and/or degrade offering no long-term reliability or effectiveness.	Soil excavation and disposal at a permitted offsite landfill is a reliable and effective long-term solution for soil.	Biological treatment of soil in the land farm pilot testing was very effective at destroying the COCs. This remedy is anticipated to provide long-term reliability and effectiveness for soil.	The biological treatment of soil using in-situ soil mixing technology is anticipated to only be moderately reliable and effective. This is because complete mixing and maintaining proper conditions for biodegradation is expected to be difficult. As a result, the long-term reliability and effectiveness of this alternative is uncertain.	Alternatives SO 1 and SO 2 both provide for long-term reliability and effectiveness. Of these two alternatives, Alternative 2 SO scores highest. This is because soil biodegradation in land farm treatment cells results in the destruction of the COCs. In contrast, placing the soil in a landfill only contains the soil and COCs are not destroyed. Alternative 3 SO scores lowest because of the significant uncertainty related to the ability for soil mixing to provide the optimum environment for the destruction of COCs via biodegradation processes. The No Further Action alternative does not meet this criteria for soil.
6	Reduction of toxicity, mobility, or volume of wastes	No reduction in TMV would be provided for soil under this alternative.	Soil will be removed and this removal and offsite disposal will result in the reduction of TMV of COCs at the Facility. In the landfill, the soil will continue to have levels of COCs and toxicity and volume of contaminated soil will not be reduced. The mobility of the COCs in soil would be expected to be reduced as a result of disposal in landfill cells.	Biological treatment of soil is anticipated to result in destruction of the COCs resulting in the reduction of TMV of the COCs in soil.	Biological treatment of soil is anticipated to result in destruction of the COCs resulting in the reduction of TMV of the COCs in soil. However, the effectiveness of this technology to result in the reduction of TMV of the COCs depends on the ability to thoroughly mix the soil additives and provide the microbes with the nutrients, water, and air needed to be effective.	Alternative 2 SO scores highest because this alternative results in the reduction of TMV of the COCs. Alternative 1 SO provides for reduction in TMV at the Facility. However, this alternative scores lower because there will be no reduction in toxicity or volume of the COCs in the soil at the landfill. Alternative 3 SO scores lowest because of the significant uncertainty related to the ability for soil mixing to provide the optimum environment for the destruction of COCs via biodegradation processes. The No Further Action alternative does not meet this criteria for soil.
7	Short-term effectiveness	This alternative provides short-term effectiveness for soil because the contaminated soil is covered by the steel tank bottoms or concrete (at AOC Tank 540).	The occupational exposure and safety concerns during the soil removal can be minimized through health and safety training, the use of protective gear, and safe construction practices. Soil removal will result in short-term effectiveness.	The occupational exposure and safety concerns during the biological treatment of soil work can be minimized through health and safety training, the use of protective gear, and safe construction and work practices. Based on pilot test results, the biological treatment of soil in land farm treatment cells is a rapid process and this alternative is expected to be effective in the short-term.	The occupational exposure and safety concerns during the biological treatment of soil work can be minimized through health and safety training, the use of protective gear, and safe construction and work practices. Biological treatment of soil in-situ using soil mixing is expected to be only moderately effective at degrading the COCs in the short-term.	All three soil alternatives meet this criteria through the implementation of occupational and safety controls. Of the three soil alternatives however; Alternative 2 SO scores highest because COCs would be destroyed in a relatively short time frame (assumed to be 1 year). The No Further Action alternative meets this criteria for soil.
8	Implementability	There are no soil work components to be implemented under this alternative.	Soil excavation, removal, and disposal are implementable based on similar work already performed at the Facility during the clean closure of the RCRA impoundments and NPDES ponds. The equipment, materials, and personnel to implement the work are readily available on the island.	The soil land farming is implementable based on the implementation of the soil pilot test work. The majority of the equipment, materials, and personnel to implement the work are readily available on the island. The microbial inoculant for this alternative can be easily shipped to the island.	The soil mixing is more difficult to implement. This is because it is anticipated that the specialized equipment needed to implement the work will need to be mobilized to the island. With the exception of the microbial inoculant, the materials and personnel to implement the work are available on the island. The microbial inoculant for this alternative can be easily shipped to the island.	Alternative 1 SO scores the highest because this type of work has already been implemented during the clean closure of the of the RCRA impoundments and NPDES ponds. Alternatives 2 SO scores lower because of the need to obtain some materials from off-Island sources. However, all the equipment, materials, and personnel to implement the work are expected to be obtainable. Alternative 3 SO scores the lowest because of the anticipated effort to obtain the proper specialty equipment for soil mixing.
9	Total Cost with Markups (see Appendix B for cost detail)	Total Cost: $0. There are no cost related to soil for the No Further Action Alternative	Study and Remediation: $4.9 million O&M, Reporting, and Closeout: $59,000 Total Cost with Markups: $4.9 million	Study and Remediation: $5.9 million O&M, Reporting, and Closeout: $59,000 Total Cost with Markups: $5.99 million	Study and Remediation: $9.5 million O&M, Reporting, and Closeout: $59,000 Total Cost with Markups: $9.6 million	Alternative 1 SO is the lowest estimated cost. O&M, Reporting, and Closeout consists of one construction completion report.

Table 8. Evaluation of the Sediment Corrective Measures Alternatives Against Evaluation Criteria.

Evaluation Criteria		No Further Action	Alternative 1 SD - Sediment Excavation and Offsite Disposal	Alternative 2 SD - In-Situ Stabilization of Sediment	Comments
1	Protection of human health and the environment	Under this alternative, only monitoring would occur. This alternative is not protective of ecological receptors.	Sediment excavation and disposal at a permitted offsite landfill provides for long-term protection of human health and the environment. This is because the sediment with COCs levels above remediation goals will be removed and disposed offsite.	Sediment stabilization technology has been proven to be effective and this remedy for sediment is anticipated to provide long-term protection of human health and the environment.	Alternatives SD 1 and SD 2 both provide for reliable protection of human health and the environment. Of these two alternatives, Alternative 1 SD scores highest. This is because the sediment with COC levels above remediation goals will be removed and disposed offsite. Under Alternative 2 SD, the sediment with COCs will be left in place. The No Further Action alternative does not meet this criteria for sediment.
2	Attain remediation goals	Under this alternative, the remediation goals will not be met for sediment because no removal, treatment, or waste management actions are included in this alternative.	The remediation goals will be met for sediment through removal and offsite disposal.	The remediation goals for sediments will not be met because the sediment COCs will be left in place. However, in-situ stabilization will eliminate the potential for exposure or migration.	Only Alternative 1 SD meets this criteria.
3	Control the source(s) of releases so as to reduce or eliminate, to the extent practicable, further releases of hazardous waste (including hazardous constituents) that might pose threats to human health and the environment	Other than the potential leaching of the COCs from soil to groundwater, there are no active releases and the Facility is completely demolished.	Other than the potential leaching of the COCs from soil to groundwater, there are no active releases and the Facility is completely demolished.	Other than the potential leaching of the COCs from soil to groundwater, there are no active releases and the Facility is completely demolished.	Both Alternatives 1 SD and 2 SD meet this criteria. The No Further Action alternative does not meet this criteria because contaminated media will remain onsite and could act as a potential source of contamination.
4	Comply with applicable standards for waste management	The activities under this alternative are currently being performed in accordance with the RCRA Order.	The sediment removal would require permits similar to the permits obtained during the clean closure of the RCRA impoundments and NPDES ponds.	The sediment stabilization would require permits anticipated to be related to the construction activities associated with sediment stabilization. It is anticipated the required permits would be similar to the permits obtained during the clean closure of the RCRA impoundments and NPDES ponds.	Alternative 1 SD scores the highest. This is because permitting the work under this alternative is anticipated to be the most straightforward. Alternatives 2 SD score lower because of the uncertainty related to the exact scope of permitting. However, permits for work under this alternative is expected to be obtainable. The No Further Action alternative currently meets this criteria.
5	Long-term reliability and effectiveness	For sediments, only monitoring would occur and this alternative is not reliable or effective at protecting ecological receptors	Sediment excavation and disposal at a permitted offsite landfill is a reliable and effective long-term solution for sediment.	Sediment stabilization is a proven effective technology and this alternative is anticipated to provide long-term reliability and effectiveness for sediment.	Alternatives SD 1 and SD 2 both provide for long- term reliability and effectiveness. Of these two alternatives, Alternative 1 SD scores highest. This is because the sediment with COC levels above remediation goals will be removed and disposed offsite. Under Alternative 2 SD, the sediment with COCs will be left in place. The No Further Action alternative is not expected to meet this criteria for sediment.
6	Reduction of toxicity, mobility, or volume of wastes	No reduction in TMV would be provided for sediment under this alternative.	Sediment will be removed and this removal and offsite disposal will result in the reduction of TMV of COCs at the Facility. In the landfill, the sediment will continue to have levels of COCs and toxicity and volume of contaminated sediment will not be reduced. The mobility of the COCs in sediment would be expected to be reduced as a result of disposal in landfill cells.	Sediment stabilization will result in a reduction in the mobility of the COCs. Toxicity of the COCs would not be reduced. However, it will not be possible for ecological receptors to be exposed to the stabilized sediments The volume of material will be increased as a result of the addition of the stabilizers.	Alternative 1 SD scores the highest because removal and offsite disposal will result in the reduction of TMV of COCs at the Facility. Alternative 2 SD only provides for the reduction in mobility. The No Further Action alternative does not meet this criteria for sediment.
7	Short-term effectiveness	For sediment, only monitoring would occur and this alternative does not provide short-term effectiveness for sediment.	The occupational exposure and safety concerns during the sediment removal can be minimized through health and safety training, the use of protective gear, and safe construction practices. Sediment removal will result in short-term effectiveness.	The occupational exposure and safety concerns during the sediment removal can be minimized through health and safety training, the use of protective gear, and safe construction practices. Sediment stabilization is a fairly rapid process that is expected to be effective in the short-term.	Both of the sediment alternatives meet this criteria through the implementation of occupational and safety controls. Of the two sediment alternatives however; Alternative SD 1 scores highest because COCs would be removed from the Facility. The No Further Action alternative meets this criteria for sediment.
8	Implementability	Other than sample collection, there are no sediment work components to be implemented under this alternative. Sediment sampling is implementable.	Sediment excavation, removal, and disposal are implementable based on similar work already performed at the Facility during the clean closure of the RCRA impoundments and NPDES ponds.	Stabilization is a common technology and the equipment, materials, and personnel to implement the work are anticipated to be available on the island.	Alternative 1 SD scores the highest because this type of work has already been implemented during the clean closure of the of the RCRA impoundments and NPDES ponds.

Table 8. Evaluation of the Sediment Corrective Measures Alternatives Against Evaluation Criteria.

Evaluation Criteria		No Further Action	Alternative 1 SD - Sediment Excavation and Offsite Disposal	Alternative 2 SD - In-Situ Stabilization of Sediment	Comments
			The equipment, materials, and personnel to implement the work are readily available on the island.		Alternatives 2 SD scores lower because the stabilized material will remain in the Effluent Channel and will need to be graded and contoured to drain. This may be difficult to implement.
9	Total Cost with Markups (see Appendix B for cost detail)	Study and Remediation: $0 O&M, Reporting, and Closeout: $10,000 Total Cost with Markups: $10,000	Study and Remediation: $929,000 O&M, Reporting, and Closeout: $59,000 Total Cost with Markups: $988,000	Study and Remediation: $1.4 million O&M, Reporting, and Closeout: $59,000 Total Cost with Markups: $1.5 million	Alternative 1 SD has the lowest estimated total costs with markups. O&M, Reporting, and Closeout consists of one construction completion report.

This page intentionally left blank.

Table 9. Reconciliation of the Recommended Alternatives Relative to the Corrective Measures Objectives.

Objective	Evaluation
1. Reduce contaminant levels in groundwater and soil to the remediation goals whenever technically practicable, within as short a timeframe that is reasonable, given the particular circumstances of the site.	Based on the successful pilot testing of ISCO in groundwater and biodegradation in soil, Alternative 2 GW and Alternative 2 SO are expected to result in cleanup to remediation goals in these two media. For Effluent Channel sediment, the sediment with COCs above remediation goals will removed thereby eliminating the potential for future contact by ecological receptors.
2. Prevent future migration of groundwater with contamination above the remediation goals beyond the Facility boundaries.	The CHP reaction is rapid and it is expected that COC levels in groundwater will be reduced in a short-time frame. This rapid reduction in COC levels will minimize the potential for future migration of COCs beyond the Facility boundary.
3. Monitor and document the effectiveness of corrective measures, and modify as necessary to meet the remediation goals.	Alternative 2 GW includes a second round of ISCO treatment in Year 2 of the remedy. The ISCO implementation will focus on areas where COCs in groundwater have not met the remediation goals. The ISCO treatment approach is flexible and can be easily implemented in targeted areas. For soil, land farming is expected to result in cleanup to remediation goals in one year. However, land farming can continue as needed until the remediation goals are met. For Effluent Channel sediment, the sediment will be removed and disposed offsite. The successful removal and disposal will be documented in the construction completion report.
4. In the short term, control exposures to groundwater and soil in excess of the remediation goals.	Exposure to these media is currently under control and exposure controls will remain in effect throughout the planning, design, and implementation of the recommended alternatives.
5. Eliminate the potential risk to benthic invertebrates from sediment in the Effluent Channel.	For Effluent Channel sediment, the sediment with COCs above remediation goals will removed thereby eliminating the potential for future contact by benthic invertibrates.

This page intentionally left blank.

APPENDIX A

DESIGN CALCULATIONS AND SUPPORTING MATERIALS

APPENDIX A

Design Calculations and Supporting Materials

APPENDIX A

This appendix builds on the physical data presented in the main body of this CMS Report to calculate elements of the 30% designs presented in the corrective measures alternatives.

In addition to the design calculations, the report entitled *In-Situ Chemical Oxidation Pilot Test MW-16 Field Area, Effectiveness Evaluation Report,* dated February 2016 is attached at the end of Appendix A. This report provides the results of the field pilot testing of the ISCO treatment using CHP. This report has been previously submitted to EPA and the PREQB but, is attached to provide supporting material for the ISCO technology in this CMS.

1. GROUNDWATER

1.1 Contaminant Mass

The nature and extent of groundwater contamination was presented in the main body of this CMS. This section uses those data to develop estimates of contaminant mass. Figure A-1 presents the benzene plume data presented previously in Figure 7 of the main report. However, Figure A-1 presents the plume area calculated using GIS techniques. Figure A-2 presents the sulfolane plume area calculations based on the data presented in Figure 9 of the main report. Using these area values, a saturated thickness of 15 ft, a porosity of 20% and, the upper concentration bound for each area, the mass of benzene and sulfolane was calculated. The following table presents the results of the calculations.

Mass In Solution - Shallow Aquifer								
Chemical	**Contour Interval**	**Area (ft^2)**	**Saturated Thickness (ft)**	**Porosity**	**Volume (ft^3)**	**Volume (Liters)**	**Concentration (ug/L)**	**Pounds of Benzene**
Benzene	1-10 ppb	528,432.86	15	0.20	1,585,298.58	44,895,655.79	10	0.99
	10 - 100 ppb	516,863.14	15	0.20	1,550,589.42	43,912,692.37	100	9.68
	100 - 1000 ppb	374,969.23	15	0.20	1,124,907.69	31,857,385.78	1000	70.23
	1000 - 10000 ppb	582,049.31	15	0.20	1,746,147.93	49,450,909.38	10000	1090.21
	10000 ppb	498,992.27	15	0.20	1,496,976.81	42,394,383.26	10000	934.64
		2,501,307				212,511,027		
Total Benzene Mass (lbs)								**2105.7**
Total Benzene Mass (gal)								**287.3**
Sulfolane	1-10 ppb	2,010,354.26	15	0.20	6,031,062.78	170,799,697.93	10	3.77
	10 - 100 ppb	2,915,256.88	15	0.20	8,745,770.64	247,680,224.52	100	54.60
	100 - 1000 ppb	996,340.70	15	0.20	2,989,022.10	84,649,105.87	1000	186.62
	1000 ppb	145,584.82	15	0.20	436,754.46	12,368,886.31	1000	27.27
		6,067,537				515,497,915		
Total Sulfolane Mass (lbs)								**272.3**
Total Sulfolane Mass (gal)								**25.9**

In the deep aquifer, contamination is found in localized areas; therefore, plume area calculations like those presented above were not performed. Instead, for theses 30% design calculations, the mass of contaminants in the deep aquifer was assumed to be 25% of the mass in the shallow aquifer:

Benzene mass in the deep = 287.3 gallons * 25% = 72 gallons

Sulfolane mass in the deep = 25.9 gallons * 25% = 6.5 gallons

1.2 Hydraulic Elements

In the CMS, the No Further Action alternative was evaluated. Under the No Further Action alternative, COCs in groundwater are expected to continue to migrate. The following subsection develops an estimate of the extent of COC migration over a 30-year period.

1.2.1 Advection

The following considers BTEX and sulfolane migration over 30 years if no natural degradation is considered and there were no further action taken.

As presented in the main report, the following average seepage velocities (V_s) were calculated for the two aquifers:

- Seepage Velocity for the Shallow Aquifer = 164 feet/year.
- Seepage Velocity for the Deep Aquifer = 1,150 feet/year.

Considering the coefficients of retardation for benzene and sulfolane, these constituents would be expected to migrate the following distances if natural attenuation is not considered:

Benzene shallow – R = 1.7 and associated seepage velocity would be approximately 96 feet/year

Benzene deep – R = 1.5 and associated seepage velocity would be approximately 767 feet/year

Sulfolane shallow– R = 1.0 and associated seepage velocity would be approximately 164 feet/year

Sulfolane deep – R = 1.0 and associated seepage velocity would be approximately 1,150 feet/year.

Based on these values, if there were no action taken and without natural attenuation, the benzene and sulfolane contamination is predicted to advance the following distances in 30 years:

Benzene shallow – 2,880 feet

Benzene deep – 23,000 feet

Sulfolane shallow – 4,920 feet

Sulfolane shallow – 34,500 feet

1.2.2 Groundwater Extraction

In the main body of the report, groundwater extraction was retained for the shallow aquifer and this technology. For the 30% designs, the pumping rate for the 50 extraction wells included in the 30% design (Alternative 2) was determined as the minimum pumping rate necessary to achieve CMOs within the assumed 30-year project life cycle. Based on these conditions, the following was calculated for groundwater extraction in the shallow aquifer:

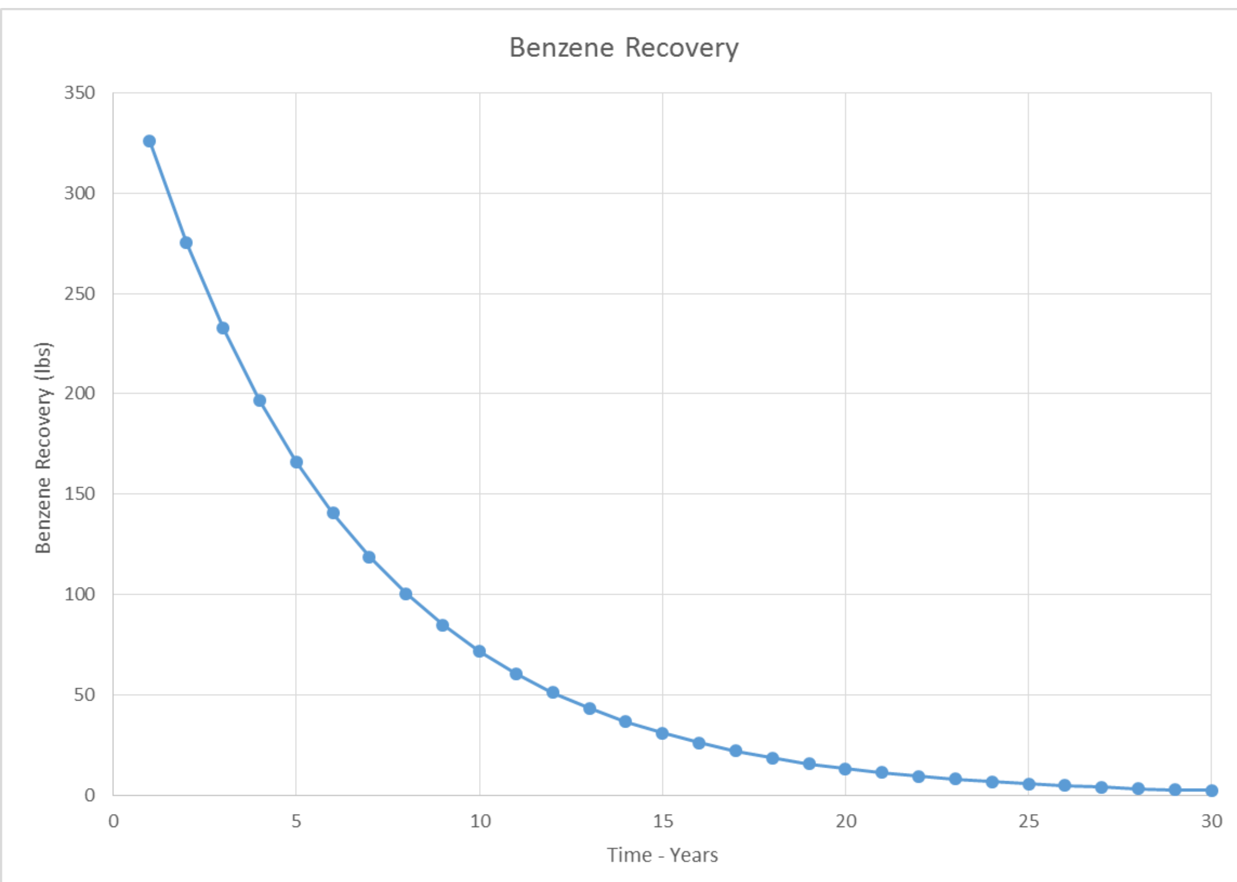
30% Conceptual Design Components - Groundwater Extraction				
Shallow Aquifer				
Pumping Rate (gpm) =	5	Average Pumping Rate to achieve CMOs within 30 years		
Pumping Rate (gpd) =	7,200			
Pumping Rate (liters per day) =	27,288			
Pumping Rate (liters per year) =	9,960,120			
Number of Benzene Plume Wells =	0	30% Design		
Number of Sulfolane Plume Wells =	17	30% Design		
Number of Comingled Wells =	33	30% Design		
Volume Pumped - Benzene Wells (liters/yr)	-			
Volume Pumped - Sulfolane Wells (liters/yr)	169,322,040			
Volume Pumped - Comingled Wells (liters/yr)	328,683,960			
Volume of Water - Benzene Plume (liters) =	212,511,027			
Initial Mass - Benzene (µg)	9.55E+11	= 2,105.7 lbs		
Average Initial Benzene Concentration (µg/L) =	4495			
Volume of Water - Sulfolane Plume (liters) =	515,497,915			
Initial Mass - Sulfolane (µg)	1.23E+11	= 272.3 lbs		
Average Initial Sulfolane Concentration (µg/L) =	240			
Year 1 - Average Concentration in Extracted Groundwater				
Initial Benzene Concentration in Extracted GW (ug/L) =	449.46	Year 1 Concentration assumed to be 10% of average initial concentration		
Initial Sulfolane Concentration in Extracted GW (µg/L) =	23.96	Year 1 Concentration assumed to be 10% of average initial concentration		
Note: Cells shown in yellow are data input cells. Cells not shaded represent calculated values based on the inputs.				

Using the input data and associated calculated values, predictions of benzene and sulfolane removal were developed. The following presents the tabulated calculations of benzene removal and the graphical representation of these data as a benzene removal curve.

Year	Benzene Mass Recovered (lbs)	Average Pumped Benzene Concentration (µg/L)
1	325.69	449.5
2	275.32	379.9
3	232.73	321.2
4	196.74	271.5
5	166.31	229.5
6	140.59	194.0
7	118.84	164.0
8	100.46	138.6
9	84.92	117.2
10	71.79	99.1
11	60.69	83.7
12	51.30	70.8
13	43.36	59.8
14	36.66	50.6
15	30.99	42.8
16	26.20	36.2
17	22.14	30.6

18	18.72	25.8
19	15.82	21.8
20	13.38	18.5
21	11.31	15.6
22	9.56	13.2
23	8.08	11.2
24	6.83	9.4
25	5.77	8.0
26	4.88	6.7
27	4.13	5.7
28	3.49	**4.8**
29	2.95	4.1
30	2.49	3.4
Total Mass Removed (lbs)	**2,092**	

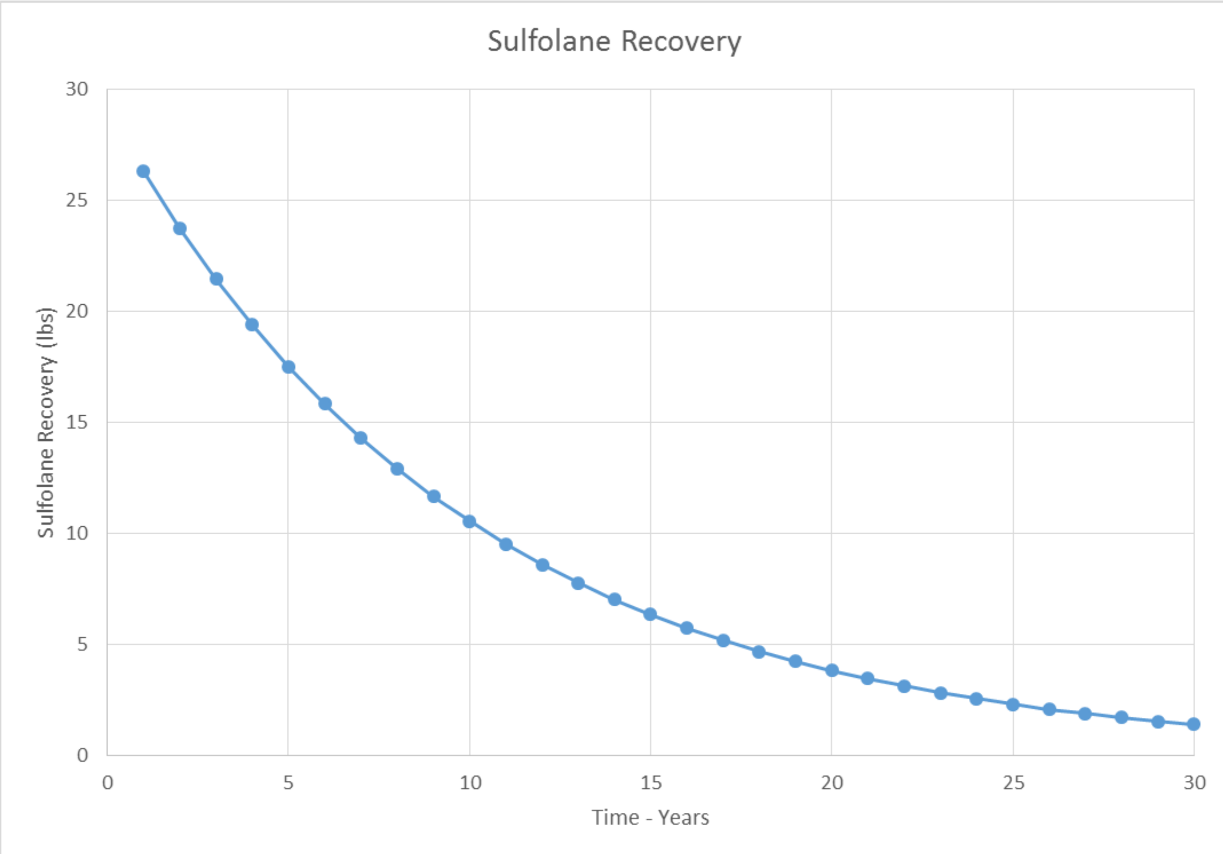
As shown in the table above, it is predicted that benzene levels would reach the remediation goal of 5 µg/L after 28 years of pumping and a total of 2,092 lbs of benzene would be recovered. The benzene removal curve is depicted graphically below:



The following presents the tabulated calculations of sulfolane removal and the graphical representation of these data as a sulfolane removal curve.

Year	**Sulfolane Mass Recovered (lbs)**	**Average Pumped Sulfolane Concentration (μg/L)**
1	26.30	24.0
2	23.76	21.6
3	21.47	19.6
4	19.39	17.7
5	17.52	16.0
6	15.83	**14.4**
7	14.30	13.0
8	12.92	11.8
9	11.67	10.6
10	10.54	9.6
11	9.52	8.7
12	8.60	7.8
13	7.77	7.1
14	7.02	6.4
15	6.34	5.8
16	5.73	5.2
17	5.18	4.7
18	4.68	4.3
19	4.22	3.8
20	3.82	3.5
21	3.45	3.1
22	3.11	2.8
23	2.81	2.6
24	2.54	2.3
25	2.30	2.1
26	2.07	1.9
27	1.87	1.7
28	1.69	1.5
29	1.53	1.4
30	1.38	1.3
Total Mass Removed (lbs)	**259**	

As shown in the table above, it is predicted that sulfolane levels would reach the remediation goal of 16 µg/L after only 6 years of pumping. Even though the sulfolane remediation goal is predicted after 6 years of pumping, it was assumed the pumping would continue for 30 years. After 30 years of pumping, a total of 259 lbs of sulfolane would be recovered. The sulfolane removal curve is depicted graphically below:



It is noted here that in the shallow aquifer, pumping rates during the EFR operations average 2 gallons per minute (gpm) with the maximum observed rate of about 6 gpm. Therefore, it may not be possible to achieve a 5 gpm pumping rate at all 50 wells during implementation of this technology. If a corrective measures alternative is selected that includes a groundwater extraction program, well pumping rates and optimum well placement would need to be better understood.

1.3 Treatment Elements

The following describes the elements of the 30% design for the groundwater treatment technologies.

1.3.1 Groundwater ISCO

The results of the field scale testing of ISCO were used to provide the design elements and cost estimation for the alternatives where groundwater ISCO is included. The following describes the 30% design elements for the ISCO technology.

ISCO Design Elements
Radius of Influence (ROI) and Vertical Treatment Interval
The ISCO treatment system will consist of treatment points used to place catalyzed hydrogen peroxide (CHP) and vent points used to vent any oxygen and carbon dioxide gas liberated during contaminant degradation. Treatment points will be spaced 25-ft apart in a grid-like pattern with approximately one vent point installed for every six

ISCO Design Elements

treatment points installed. The spacing is based on a minimum radius of influence (ROI) of 12 ft, determined during the pilot test.

The vertical treatment interval is assumed to be 15 ft thick in the shallow aquifer and 30 feet thick in the deep aquifer.

CHP Volume

The volume of CHP was determined by evaluating the pilot test results and scaling up for the full-scale 30% design. Based on this evaluation, a total of 6,000 lbs (~640 gallons) of 35% CHP will be placed at each treatment point to maximize distribution, connectivity between points, and contaminant mass destruction.

Treatment Areas

Treatment areas were selected to be generally coincident with the placement of the groundwater extraction wells. The placement of both these technologies in the 30% designs is based on the locations of highest contaminant levels and the general alignment of sand channels and more permeable aquifer deposits. The following treatment areas were developed for the ISCO 30% design. The location of the treatment areas are presented on Figure 14:

AOC Tank 540 Area (TA-1; Figure 14) - The 30% design for this area includes the following:

- Treatment area of 200 ft x 800 ft for a total area of 160,000 square foot (sq ft)
- 225 treatment points and 40 vent points
- 1,350,000 lbs of 35% hydrogen peroxide

AOC Tank 80 Area (TA-2; Figure 14) - The 30% design for this area includes the following:

- Treatment area of 200 ft x 200 ft for a total area of 40,000 sq ft
- 50 treatment points and 10 vent points
- 300,000 lbs of 35% hydrogen peroxide

Monitoring Well Areas MW-160 (TA-3), MW-27 (TA-4), and MW-5R (TA-5) - The 30% design for these areas includes the following:

- Treatment area of 100 ft x 100 ft for a total area of 10,000 square foot (sq ft) at each well
- 16 treatment points and 4 vent points at each area
- 96,000 lbs of 35% hydrogen peroxide at each area

New Well-1 (Western Boundary) Area (TA-6; Figure 14) - The 30% design for this area includes the following:

- Treatment area of 150 ft x 400 ft for a total area of 60,000 sq ft
- 80 treatment points and 15 vent points
- 480,000 lbs of 35% hydrogen peroxide

Tank Areas Tank 160, 170, 330, and 360 (Figure 14) - The 30% design for this area includes the following:

- Treatment area of 50 ft x 50 ft for a total area of 2,500 sq ft at each area
- 6 treatment points and 4 vent points at each area
- 36,000 lbs of 35% hydrogen peroxide at each area

If a corrective measures alternative is selected that includes a groundwater treatment with ISCO, treatment rates and optimum treatment point placement would need to be better understood.

2. SOIL

For the 30% design calculations, the volume of soil requiring corrective measures was assumed to include the entire AOC or AOI where soil contamination was identified. For example, at AOC Tank 10, COC levels exceeded the remediation goals in only 3 surface soil samples and one subsurface soil sample.

Even though the exceedances are limited to these locations, it has been assumed for design and cost estimating purposes that the entire 200 ft diameter soil platform at AOC Tank 10 will be addressed.

If a soil removal or treatment program were to be implemented as part of a corrective measures alternative, more detailed soil sampling may be implemented to refine removal and treatment volumes.

The following table presents the volume of soil considered when developing the 30% designs in this CMS:

AOC/AOI	Considered in CMS?	Platform Thickness (ft)	Tank Diameter (ft)	Platform Volume (CY)
0010	Y	5	200	5,815
0020	Y	4	200	4,652
0041	Y	6	67	783
0042	Y	5	67	653
0050	Y	2	119	823
0080	Y	4	67	522
0100	Y	4	119	1,647
0160	Y	5	180	4,710
0170	Y	8	173	6,961
0220	Y	5	200	5,815
0240	Y	2	36	75
0330	Y	5	100	1,454
0340	Y	4	110	1,407
0360	Y	5	212	6,534
0401	Y	3	35	107
0403	Y	3	35	107
0540	Y	12	70	2,178
0690	Y	4	20	47
0700	Y	3	20	35
Estimated Soil Volume (CY)				**44,323**

3. SEDIMENT

For the 30% design calculations, the volume of sediment in the Effluent Channel requiring corrective measures was assumed to include the length of the Effluent Channel from the east Facility fence line to the western Facility fence line. This distance is estimated as 1,900 feet. Using survey data for the channel width, an average width of 50 feet was used. Analytical data used in the risk assessment were collected from the 0 to 0.5 ft depth interval; however, for conservativism, a depth of 1 foot is used in this CMS. Based on these dimensions, a total of approximately 3,520 cy of sediment will be addressed.

FIGURES

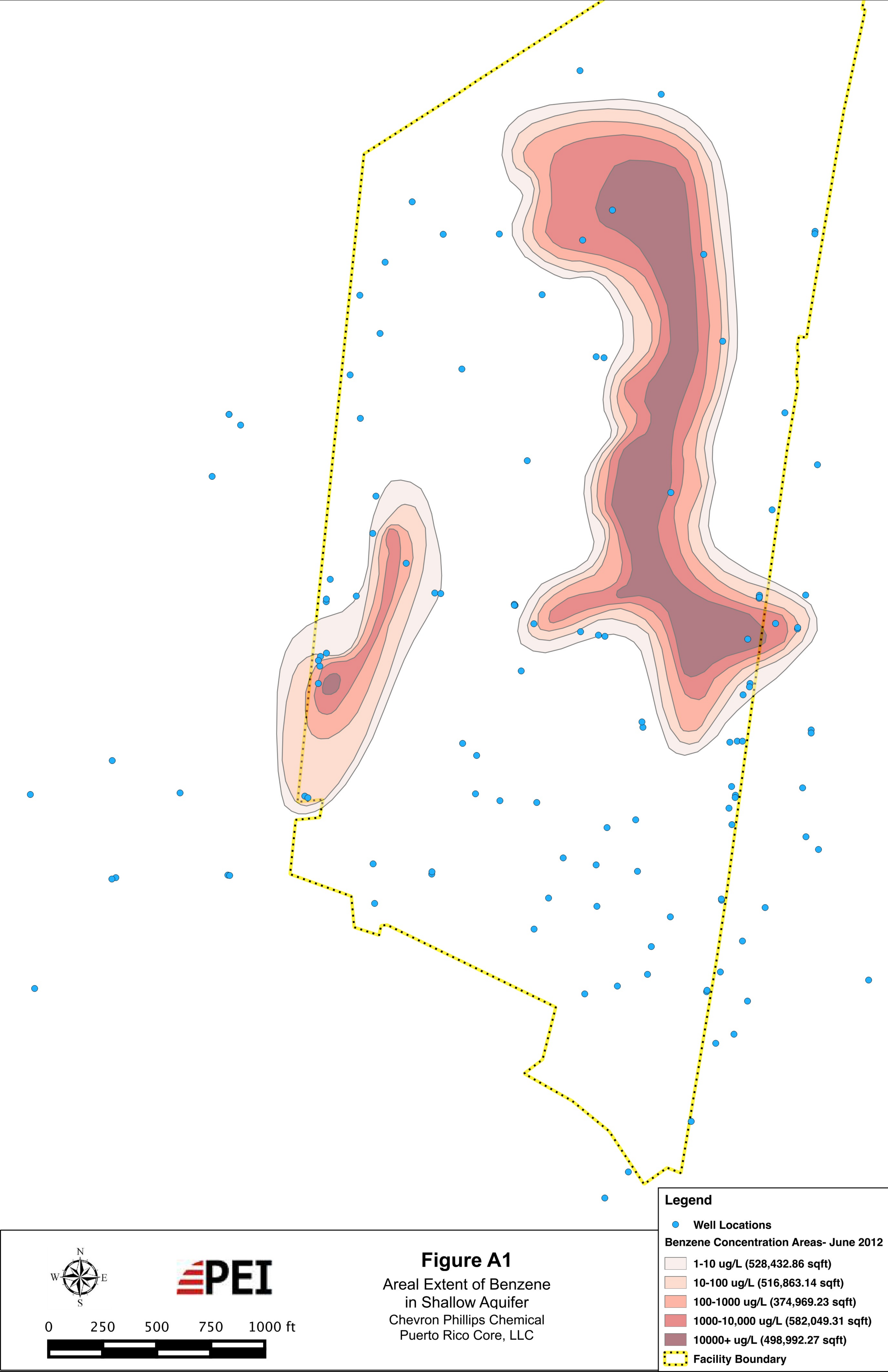


Figure A1

Areal Extent of Benzene in Shallow Aquifer

Chevron Phillips Chemical Puerto Rico Core, LLC

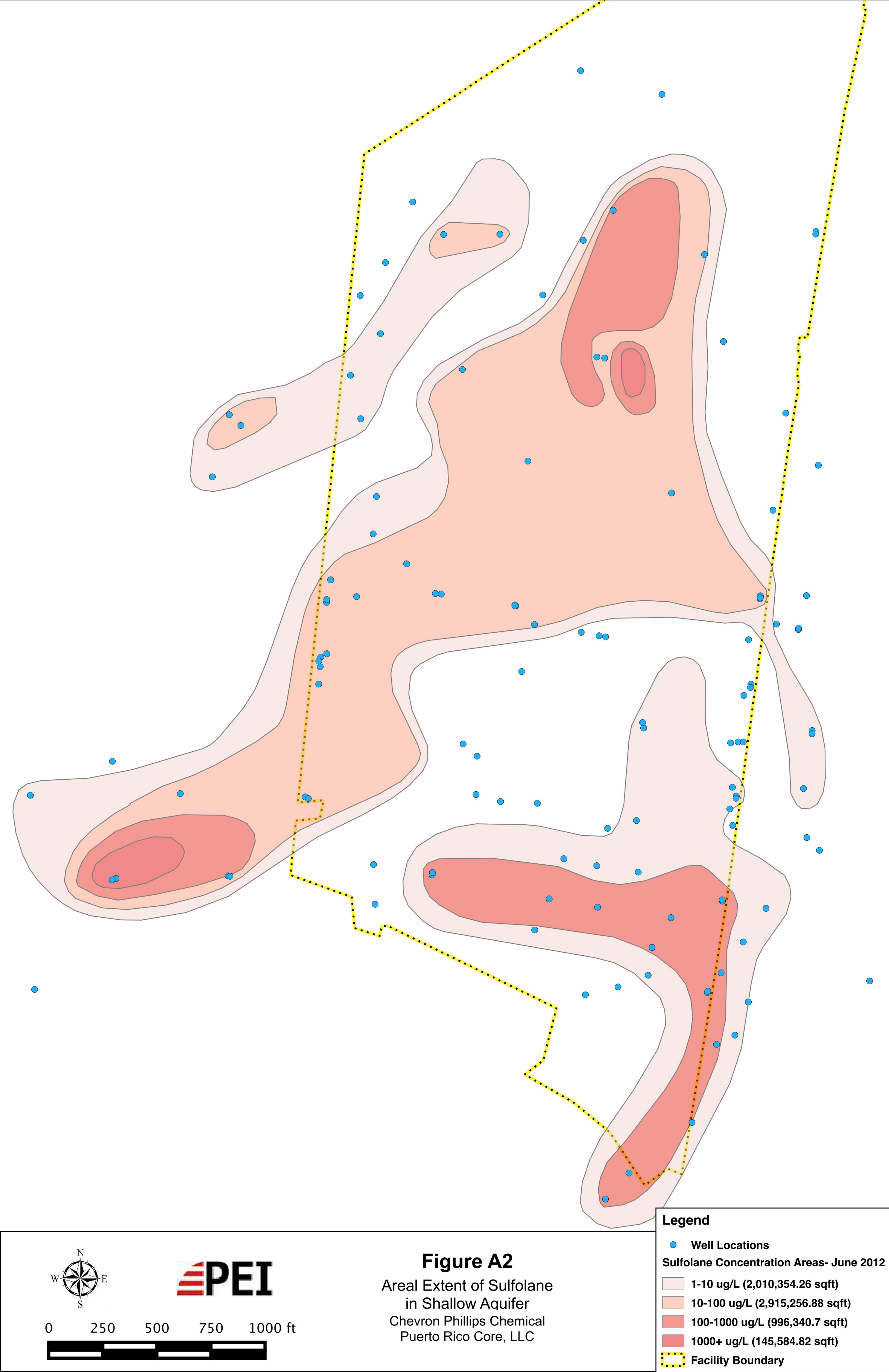


Figure A2

Areal Extent of Sulfolane
in Shallow Aquifer
Chevron Phillips Chemical
Puerto Rico Core, LLC

This page intentionally left blank.

Attachment A-1

ISCO Using CHP

Effectiveness Evaluation Report

Chevron Phillips Chemical Puerto Rico Core Facility

In-Situ Chemical Oxidation Pilot Test MW-16 Field Area

Effectiveness Evaluation Report

February, 2016

***Prepared for*:**

Chevron Phillips Chemical Puerto Rico Core LLC
Road 710 Km. 1.3, Las Mareas Ward
Guayama, Puerto Rico 00784

***Prepared by*:**

Geo-Cleanse International, Inc.
400 State Route 34, Suite B
Matawan, NJ 07747 USA

Portnoy Environmental, Inc.
1414 W. Sam Houston Pkwy. N, Suite 170
Houston, TX 77043 USA

Table of Contents

List of Figures

List of Tables

1.0. Introduction

Chevron Phillips Chemical Puerto Rico Core, LLC (CPCPRC) recently completed an in-situ chemical oxidation (ISCO) field scale pilot test utilizing catalyzed hydrogen peroxide[1] (CHP) to treat groundwater at the Chevron Phillips Chemical Puerto Rico Core Facility (CPCPRC Facility) located in Guayama, Puerto Rico (Figure 1). Groundwater at the CPCPRC Facility are impacted with benzene, toluene, ethylbenzene, xylenes (BTEX) and sulfolane (common trade name for the compound tetrahydrothiophene 1,1-dioxide).

The field scale pilot test work was performed in accordance with the *Pilot Test Work Plan for In-Situ Groundwater Treatment under RCRA Administrative Order on Consent, RCRA-95-3008(h)-0307* dated November, 2013, (hereafter referred to as the work plan).

The data quality objectives (DQOs) of this pilot test are presented below:

- Subsurface evaluation – Refine the conceptual site model of the hydrogeology and upper alluvial (shallow) aquifer characteristics in order to determine the optimum treatment point configuration for full-scale design.
- CHP effectiveness – Obtain analytical data from the site in order to evaluate the effectiveness of in situ CHP approach on BTEX and sulfolane treatment.
- Implementability – Obtain field data to evaluate the feasibility of efficient CHP application in the shallow aquifer.

Additional objectives of this pilot test are summarized as follows:

- Confirm treatment and vent point radius of influence (ROI) and spacing.
- Further refine the CHP formulation developed in the bench test based upon field observations and process monitoring data.
- Determine CHP application rates and operational pressures.
- Assess any other site-specific details that would affect full-scale design and implementation.

The remainder of this report is organized as follows:

Section 2 summarizes the underlying chemistry and destruction of BTEX and sulfolane, the chemicals of concern (COCs). Section 3 discusses the activities conducted at the site including health and safety protocols, pilot test area soil characterization, installation of treatment and ventilation points, CHP application, and the process and performance monitoring results. Section 4 provides a summary of the conclusions drawn from the pilot test results. Section 5 presents a list of references cited in the text.

---

[1]ISCO with hydrogen peroxide is commonly referred to as Fenton's reagent or modified Fenton's reagent. However, the process as implemented at CPCPRC differs significantly from classical Fenton's reagent chemistry. Catalyzed hydrogen peroxide (CHP) is a term recommended by Watts and Teel (Watts, R.J., and Teel, A.L. 2005. Chemistry of modified Fenton's Reagent (catalyzed H_2O_2 propagations – CHP) for in situ soil and groundwater remediation, *Journal of Environmental Engineering*, v. 131, p. 612-622) to more accurately reflect the suite of chemical reactions associated with hydrogen peroxide ISCO and to differentiate it from classical Fenton chemistry.

2.0. Reagent Chemistry

2.1. Catalyzed Hydrogen Peroxide Chemistry

Catalyzed hydrogen peroxide (CHP) is a solution of hydrogen peroxide and a transition metal (typically ferrous iron) catalyst, which together generate a hydroxyl radical that acts as the active oxidizing agent (Haber and Weiss, 1934):

$$H_2O_2 + Fe^{+2} \rightarrow OH\cdot + OH^- + Fe^{+3} \quad (1)$$

Where H_2O_2 is hydrogen peroxide, Fe^{+2} is ferrous iron, $OH\cdot$ is hydroxyl radical, OH^- is hydroxyl ion, and Fe^{+3} is ferric iron. CHP chemistry is complex, involving a number of additional reactions producing both oxidants and reductants that contribute to contaminant destruction (e.g., Watts et al., 1999):

$$OH\cdot + Fe^{+2} \rightarrow OH^- + Fe^{+3} \quad (2)$$

$$Fe^{+3} + H_2O_2 \rightarrow H^+ + HO_2\cdot + Fe^{+2} \quad (3)$$

$$Fe^{+2} + HO_2\cdot \rightarrow Fe^{+3} + HO_2^- \quad (4)$$

$$Fe^{+3} + HO_2\cdot \rightarrow Fe^{+2} + O_2 + H^+ \quad (5)$$

$$OH\cdot + H_2O_2 \rightarrow H_2O + HO_2\cdot \quad (6)$$

$$HO_2\cdot \rightarrow H^+ + O_2\cdot^- \quad (7)$$

Where $HO_2\cdot$ is hydroperoxyl radical, HO_2^- is hydroperoxyl anion, O_2 is molecular oxygen, $O_2\cdot^-$ is superoxide radical, H^+ is hydronium ion, and H_2O is water. Additional reactions occur with organic compounds. The suite of reactions associated with CHP is complex, but very effective at destroying many organic compounds dissolved in groundwater, sorbed to soil, or existing as nonaqueous phase liquid.

The hydroxyl radical generated by CHP is a powerful, non-selective oxidant. Oxidation of an organic compound by hydroxyl radical is a rapid and exothermic (heat-producing) reaction. Intermediate compounds are primarily naturally occurring carboxylic acids. The end products of oxidation are primarily carbon dioxide and water. None of the reagents pose an environmental hazard. Unconsumed H_2O_2 naturally degrades to oxygen and water within a few days or weeks after application.

2.2. Contaminant Degradation and Bench Test Results

In-situ treatment of BTEX with CHP and the associated degradation pathways and intermediate compounds are very well known. The oxidation pathway of benzene provides a model for the oxidation pathway of other monoaromatic hydrocarbons comprising BTEX (e.g., Merz and Waters, 1949; Lindsay Smith and Norman, 1963; Walling and Johnson, 1975; Edwards and Curci, 1992; Scheck and Frimmel, 1995; Kang and Hua, 2005). Reaction of benzene with $OH\cdot$ produced by CHP produces short-lived and highly reactive aromatic intermediates. The initial attack is by hydroxylation to phenol with subsequent oxidation to orthobenzoquinone (Figure 2). Subsequent oxidation of phenolic compounds through quinones to carboxylic acids is also well documented (e.g., Chen and Pignatello, 1997; Kang et al., 2002; Kavitha and Palanivelu, 2005; Pontes et al., 2010). Once orthobenzoquinone is formed, ring tension and oxidizing agents rapidly force fission of the aromatic ring to produce muconic acid, a linear carboxylic acid.

The pathway then proceeds through a series of intermediate carboxylic acids to carbon dioxide. Hydroxyl radicals do not readily oxidize certain carboxylic acids produced as intermediate oxidation products from organic compounds, thus mineralization may be incomplete although no hazardous intermediate compounds are formed. For example, oxalic acid produced as an intermediate product from benzene is not readily oxidized in the absence of light (e.g., Karpel vel Leitner, 1997). A similar series of intermediate products is reported for toluene, ethylbenzene, and xylenes (e.g., Merz and Waters, 1949; Lindsay Smith and Norman, 1963; Walling and Johnson, 1975; Sehested et al., 1979).

Degradation of sulfolane by reaction with hydroxyl radical is not as well-known as for BTEX. One previous bench test study of sulfolane degradation in water by hydrogen peroxide, and by a combination of hydrogen peroxide and ultraviolet light, confirmed that sulfolane was degraded most likely by hydroxyl radical processes (Agatonovic and Vaisman, 2005). More detailed analyses of sulfolane degradation pathways or reaction kinetics were not identified. Kinetic analysis of hydroxyl radical reaction with tetrahydrothiophene and thiophene, which have sulfur-substituted heterocyclic ring structures similar to sulfolane (tetrahydrothiophene 1,1-dioxide), were identified (Bonifačić et al., 1975; Saunders et al., 1978). The sulfolane, tetrahydrothiophene, and thiophene chemical structures and known hydroxyl radical reaction steps are provided in Figure 3. For tetrahydrothiophene, the initial step in reaction with hydroxyl radical is addition of the hydroxyl radical to the sulfur to form tetrahydro-1-hydroxythiophen-1-yl (Bonifačić et al., 1975), indicating that the degradation pathway is likely similar to that of benzene with an initial hydroxylation step followed by degradation of the adduct via ring cleavage processes. The hydroxyl radical reaction rate with tetrahydrothiophene was reported as 1.1×10^{10} $M^{-1}s^{-1}$, indicating an extremely rapid reaction. For thiophene (Saunders et al., 1978), the initial hydroxyl radical attack yields a hydroxythienyl radical at a rate constant of 1.8×10^{9} $M^{-1}s^{-1}$, which is very unstable and disappears with a reaction rate constant of 1.5×10^{9} $M^{-1}s^{-1}$. The primary products are 2-hydroxythiophene and 2,2'-biothiophene, both of which are themselves very unstable and rapidly degrade.

In light of the lack of detailed information on sulfolane degradation, CPCPRC performed bench tests in order to evaluate sulfolane degradation in groundwater. The conclusions drawn from those bench tests were that sulfolane was readily degraded by CHP and that optimal geochemical conditions (e.g., moderately acidic pH condition and mild peroxide reactivity) could be effectively established.

3.0. Pilot Test Field Activities

3.1. Health & Safety Protocol

CPCPRC is committed to health and safety and a site-specific Health and Safety Plan (HASP) dated April 18, 2015 was prepared. All field staff were trained on the HASP and daily safety meeting were conducted throughout the project in order to maintain a safe work environment. All field work was performed and completed health and safety incident free.

3.2. Pilot Area Delineation, Characterization, and Point Installation

3.2.1. Pilot Area and Target Treatment Interval

The pilot test encompassed a 5,625 ft^2 area (75 ft x 75 ft) focusing treatment within a low permeable zone of the shallow aquifer. This zone consisted of interbedded silty sand and silts. This treatment zone was approximately six feet thick and was separated from other permeable units in the shallow aquifer by a clay layer, which was observed at a depth of approximately 14 ft-bgs. The treatment zone for this pilot test was the lower permeability deposits encountered from a depth of 8-14 ft-bgs within the shallow aquifer. Although a more permeable unit in the shallow aquifer was identified during the drilling program, this pilot test focused on the lower permeability deposits. Focusing on the lower permeability deposits provides a conservative assessment of the ROI of treatment.

A map of the treatment area is provided as Figure 4. The grid installation program was conducted over a period of 14 field days, from April 21 to May 6, 2015.

3.2.2. Treatment and Ventilation Point Installation

The pilot treatment area consisted of 32 treatment points and 23 vent points (Figure 4). The treatment points were designed with 3-ft screens with the base of the screen installed at the top of the clay layer found at approximately 14 ft-bgs. An additional two feet of filter sand was placed above the top of the screen. The treatment points and the vent points were constructed with 1-inch chlorinated polyvinyl chloride (CPVC) and 1.5-inch CPVC, respectively. The vent points were screened continuously from approximately 3-ft bgs to the maximum terminal depth of adjacent treatment points in order to maximize the amount of gas captured at each location. In addition to an increased screen length, the vent points were constructed with larger diameter (2-inch) pipe in order to provide more surface area for more efficient offgas capture.

3.2.3. Baseline Soil Sampling Results

Five locations (TP-01, TP-19, TP-32, VP-04, and VP-20) within the treatment area were selected for baseline soil sampling and analysis for BTEX and sulfolane. The locations and associated results are provided in Figure 5. Eleven samples were collected from these five locations, over depth intervals of 8-12 ft-bgs (all five locations), 12-16 ft-bgs (TP-19, TP-32, and VP-04), 16-20 ft-bgs (TP-01 and VP-20), and 20-24 ft-bgs (TP-19). Sample locations TP-01, TP-32, VP-04, and VP-20 are located at the four corners of the treatment area. Sample location TP-19 is located in the center of the treatment area. The samples collected from 16-20 ft-bgs and 20-24 ft-bgs are deeper than the target treatment interval of 8-14 ft-bgs. These samples were collected to evaluate the vertical extent of soil contamination in the shallow aquifer.

As indicated above, soil samples were collected from all five borings from the 8 to 12 ft-bgs interval. Along the northern perimeter of the treatment area (VP-20 and TP-32) the sulfolane concentration ranged from 350 to 430 μg/kg. In the center of the treatment area (TP-19), the sulfolane concentration was 1,600 μg/kg. Along the southern perimeter (TP-01 and VP-04) the sulfolane concentrations ranged from 1,800 to 4,700 μg/kg.

Three borings were sampled from the 12 to 16 ft-bgs interval. These borings were located in the northeast corner (TP-32), the center (TP-19), and the southeast corner (VP-04) of the treatment area, and the samples yielded sulfolane concentrations of 300 μg/kg, 2,000 μg/kg, and 4,000 μg/kg, respectively.

Two borings were sampled from the 16 to 20 ft-bgs interval. The samples collected from the northwest (VP-20) and northeast corners (TP-01) of the treatment area yielded sulfolane concentrations of 1,300 μg/kg and 1,700 μg/kg, respectively. One additional sample was collected at TP-19 from the 20 to 24 ft-bgs interval. The sample was collected from the center of the site and yielded a sulfolane concentration of 630 μg/kg.

These results indicate that soil impacts were relatively higher in the southern portion of the pilot test area prior to treatment. The BTEX constituents were not detected in any of the samples (Figure 5).

3.3. Peroxide Treatment Program

Bulk hydrogen peroxide was delivered to the site at 35% concentration in 500-lb (net) drums for the first mobilization and 1,100-kg (net) intermediate bulk containers (IBCs) for the second and third mobilizations. The total volume of 35% hydrogen peroxide applied to the site was approximately 3,614 gallons.

3.3.1. First Mobilization

The first treatment mobilization was conducted from June 10 to June 26, 2015, and included a total of 10 days of active treatment. Treatment began on June 15th after health and safety training, equipment mobilization, and site preparation was completed. The initial mobilization focused on assessing and optimizing the CHP formulation initially developed from the bench test results, and determining the treatment radius of influence (ROI). The initial mobilization targeted 16 of the 32 treatment points (Figure 6). Focusing on this treatment area allowed CPCPRC to refine the appropriate CHP treatment formulation and determine the ROI at the field scale.

The total volume and average concentration of CHP solution applied during the first mobilization are provided in Table 1. A total of 530 gallons (gal) of 35% hydrogen peroxide (applied as approximately 3,900 gal at an average 5.3% hydrogen peroxide solution) was utilized during this mobilization. Each treatment point received an average of 229 gal of 5.3% CHP solution.

3.3.2. Second Mobilization

The second mobilization was conducted from July 6 to July 17, 2015, and included a total of seven days of active treatment. The active treatment area was expanded to include the western portion of the grid while continuing treatment in the eastern portion. During this mobilization the primary focus was to determine the achievable CHP application rates.

The total volume and average peroxide concentration applied at each location are provided in Table 2. A total of 1,019 gal of 35% hydrogen peroxide (applied as 5,197 gal at an average 7% hydrogen peroxide concentration) was utilized during this mobilization. Each treatment point received an average of 168 gal of 7% CHP solution (Table 2). Application rates were incrementally increased throughout this mobilization from 0.3 gpm to 1.5 gpm. Although the primary focus was to determine application rates, slight adjustments to the CHP formulation were made to optimize the hydrogen peroxide concentration, which ranged from 6.3% to 8.8% across the treatment area.

3.3.3. Third Mobilization

The final mobilization was conducted from July 28 to August 12, 2015, and included 10 days of active treatment and three days of demobilization. The treatment during this mobilization targeted every treatment point, with the objective of determining the optimum application volume per point.

The total volume and average peroxide concentration applied at each location during the third mobilization are provided in Table 3. A total of 2,070 gallons of 35% hydrogen peroxide (applied as 9,140 gal at an average 7.9% hydrogen peroxide concentration) was utilized during this mobilization. Each treatment point received an average of 305 gal of 7.9% hydrogen peroxide solution.

3.4. Process Monitoring Results

Process monitoring refers to field analyses of groundwater and offgas measurements collected daily from within and adjacent to the treatment area. Process monitoring data are utilized to determine if appropriate geochemical conditions are established, CHP is distributed effectively, and if an effective oxidation reaction is occurring. The daily average process monitoring data are provided in Tables 4 and 5. Groundwater pH, hydrogen peroxide concentration, and groundwater temperature data are summarized further in Figures 7 through 9, respectively.

3.4.1. Groundwater Process Monitoring Results

Groundwater samples were collected from select treatment and vent points within and adjacent to the active treatment area prior to the start of reagent application each day. The groundwater samples were analyzed in the field for pH, hydrogen peroxide concentration, iron concentration, and temperature (Table 4). A screening-level measurement for VOC concentration in the groundwater was also conducted by analyzing the headspace in a jar containing groundwater utilizing a photoionization detector (PID). Although VOCs (i.e., BTEX) were not present based upon laboratory analysis of the baseline samples, CPCPRC continued to monitor for VOCs for health and safety purposes.

Key observations from the groundwater process monitoring data are as follows:

- The CHP process is most efficient under mildly acidic groundwater conditions (pH 3-6); however, a groundwater pH <6 was difficult to maintain during treatment. The pH decreased to an average of approximately 5.4 to 5.6 at times throughout the treatment, but typically ranged from 6 to 7 (Figure 7). The pH of the treatment solution was approximately 4 at the time of application, however, the groundwater pH rebounded towards neutral conditions (pH of approximately 6 to 7) each night. This indicates the formation in the pilot test area has a relatively high buffering capacity.
- Hydrogen peroxide concentration provides the most direct measurement of CHP distribution and elevated hydrogen peroxide concentrations were observed across the pilot area, with concentrations as high as 12,000 ppm within individual points. Daily average concentrations ranged as high as approximately 4,200 ppm (Figure 8). Although hydrogen peroxide

concentrations were elevated during each treatment mobilization, the hydrogen peroxide was almost fully consumed within approximately two weeks after each mobilization based upon process monitoring.

- Iron acts as a catalyst for the hydrogen peroxide. Naturally occurring iron concentrations were relatively low and decreased over the course of the pilot test. Based upon the effective treatment, it appears that naturally-occurring iron and/or other transition metals in the aquifer matrix are capable of contributing to the CHP reaction.
- CHP oxidation is an exothermic reaction and an increase in groundwater temperature was anticipated. During the course of the treatment program the average groundwater temperature increased from a baseline of approximately 88°F (Figure 9) to approximately 97 degrees Fahrenheit (°F). Temperatures measured at individual monitoring points were observed to be as high as 112°F.
- Based upon the lack of VOCs present in the pilot area, as indicated by the results of the baseline sampling events, the PID measurements were generally low (<2 ppm-v) throughout the treatment program.

3.4.2. Offgas Results

Offgas samples were collected from select vent points multiple times each day and analyzed in the field for PID headspace, carbon dioxide (CO_2) concentration, and oxygen (O_2) concentration. The O_2 is produced by non-productive degradation of hydrogen peroxide in the absence of oxidizable organic material, whereas CO_2 is produced from oxidation of organic compounds. Typically, when treatment begins the O_2 concentration is relatively low (commonly 20.9% or less on the first day) and CO_2 concentration increases. As treatment proceeds and the organic mass is destroyed, the CO_2 concentration in the offgas decreases and the O_2 concentration increases. The daily average offgas data are provided in Table 5 and are summarized in Figure 10. As shown in Figure 10, the daily average CO_2 concentrations exhibit the predicted increase over the course of the pilot test from a baseline of 0% on Day 1 to a maximum of 7.1% on Day 20. Following this peak concentration on Day 20, CO_2 decreased back to 0% over the last four days of the pilot test.

3.5. Groundwater Performance Monitoring

Groundwater performance monitoring refers to groundwater samples collected and analyzed by an offsite laboratory for the COCs in order to evaluate overall performance. The performance monitoring program included a baseline event prior to the first pilot test mobilization, interim sampling events between each of the three mobilizations, and three post-treatment events (1 day, 4 weeks, and 12 weeks post-treatment).

With the exception of the baseline event, the groundwater was collected from the same 12 vent points (Figure 11) during each sampling event in order to draw direct comparisons for evaluation of treatment effectiveness. During the baseline sampling event, four treatment points were also sampled in conjunction with the 12 vent points (Section 3.5.1). All of the groundwater samples were analyzed for BTEX and sulfolane. The BTEX constituents were not detected in any of the groundwater samples collected during the six groundwater sampling events. The sulfolane concentrations observed during the six groundwater sampling events are provided in Table 6 and summarized in Figures 12 and 13.

3.5.1. Baseline Groundwater Sampling Event

The baseline sampling event was conducted on June 9-10, 2015. Groundwater was collected from 12 vent points and four treatment points prior to the first treatment event. The samples were analyzed for BTEX and sulfolane concentration. BTEX was not detectable in groundwater. The sulfolane concentration ranged from 390 to 9,700 μg/L across the pilot test area. The highest sulfolane concentration was observed in VP-02 (9,700 μg/L), which is located along the southern perimeter of the treatment area. The lowest concentration of sulfolane was observed in VP-23 (390 μg/L), which is located on the opposite side of the pilot test area, along the northeastern perimeter of the treatment area.

Four treatment points were sampled during the baseline sampling event. Samples were collected from TP-18, TP-21, TP-22, and TP-26 (Figure 11). The sulfolane concentrations observed from these samples were 2,600 μg/L, 2,100 μg/L, 1,300 μg/L, and 3,200 μg/L. These locations were only sampled during the baseline event.

3.5.2. Interim Groundwater Sampling Event #1

3.5.2.1. Groundwater Results

The initial interim groundwater sampling event was conducted from July 6-7, 2015, approximately 10 days after the completion of the first treatment mobilization. Of the 12 locations sampled, a total of four locations yielded sulfolane concentrations below the preliminary risk-based remediation goal for sulfolane of 16 μg/L (Table 6). The sampling locations and associated concentrations include VP-03 (14 μg/L), VP-09 (10 μg/L, VP-12 (6.1 μg/L), and VP-14 (0.71 μg/L).

3.5.2.2. Determination of Treatment Radius of Influence

As previously discussed, the first mobilization of the pilot test focused on the eastern portion of the treatment area with a primary objective of determining the effective ROI. The effective ROI is determined by comparing the reductions in sulfolane achieved at locations within the active treatment area (7.5 ft-spacing) to the reductions in sulfolane concentration achieved at the locations sampled outside of the active treatment area (15 ft or greater). Sulfolane concentrations that indicate reductions of >50% are considered to be within the effective radius of influence. Using this metric, analytical results indicate that an effective treatment radius is 12.5 ft (i.e., a 25 ft spacing between treatment points) for the lower permeability zone within the shallow aquifer.

3.5.3. Interim Groundwater Sampling Event #2

The second interim groundwater sampling event was conducted on July 16, 2015, one day following completion of the second treatment event. All 12 sampling locations exhibited reductions in sulfolane concentrations ranging from 84% to a nominal 100% relative to the baseline concentrations prior to the pilot test. A total of five locations yielded concentrations below the preliminary risk-based remediation goal for sulfolane of 16 μg/L. The locations and associated sulfolane concentration can be found in Table 6.

3.5.4. Post-Treatment Groundwater Sampling Event #1

The first post-treatment groundwater sampling event was conducted on August 12, 2015, one day after completion of the third mobilization. Sulfolane was non-detectable at seven of the sampling locations (VP-03, VP-09, VP-12, VP-16, VP-17, VP-21, and VP-23). The remaining locations (VP-02, VP-05, VP-11, VP-14, and VP-15) yielded sulfolane concentrations ranging from 2.79 μg/L to 25.4 μg/L. A total of 11 locations (all but VP-02) yielded concentrations below the preliminary risk-based remediation goal for sulfolane of 16 μg/L. Overall reductions exceeding 99% were achieved relative to the baseline data at all 12 monitoring locations.

3.5.5. Post-Treatment Groundwater Sampling Event #2

The second post-treatment groundwater sampling event was conducted on September 10, 2015, four weeks after completion of the third mobilization. Sulfolane was non-detectable at four of the sampling locations (VP-14, VP-17, VP-21, and VP-23). Seven of the eight remaining locations (VP-02, VP-03, VP-05, VP-09, VP-12, VP-15, and VP-16) yielded sulfolane concentrations ranging from 0.241 μg/L to 2.45 μg/L. A total of 11 monitoring points were below the preliminary risk-based remediation goal for sulfolane of 16 μg/L.

3.5.7 Post-Treatment Groundwater Sampling Event #3

The third post-treatment groundwater sampling event was conducted on December 1, 2015, twelve weeks after completion of the third mobilization. Sulfolane was non-detectable at one of the sampling locations (VP-12). At the remaining 11 locations sulfolane concentrations ranged from 0.228 μg/L to 1,420 μg/L. A total of 8 monitoring points were below the preliminary risk-based remediation goal for sulfolane of 16 μg/L.

This sampling event was intended to assess sulfolane rebound several months after treatment had been completed. As shown in Table 6 and Figure 12 and Figure 13, sulfolane levels at 4 locations did rebound during the eight weeks between the September 2015 and December 2015 sampling events. At these four locations (VP-02, VP-05, VP-15, and VP-23), sulfolane levels were below the preliminary risk-based remediation goal for sulfolane of 16 μg/L in September 2015 but, rebounded above the preliminary risk-based remediation goal in the samples collected in December 2015. Although the levels rebounded above the preliminary risk-based remediation goal, the sulfolane levels were still well below their baseline levels.

Spatially, it is observed that the four locations where rebound was observed (VP-02, VP-05, VP-15, and VP-23), are all along the perimeter of the treatment grid.

Examination of Table 6 also shows that at two locations (VP-11 and VP-12), sulfolane levels continued to decrease during the eight weeks between the September 2015 and December 2015 sampling events.

4.0. Conclusions

The following conclusions are drawn relative to the DQOs for the pilot testing work.

4.1. Subsurface Evaluation

Regarding the first DQO, specifically to refine the conceptual site model of the hydrogeology and upper alluvial (shallow) aquifer characteristics, the following is concluded:

- Consistent with the shallow aquifer in other areas of the Facility, the shallow aquifer in the pilot test area is comprised of interbedded sand and silt deposits. Specifically in this area, the interbedding includes one zone of fairly low permeability silt and silty sand identified from about 8-14 ft bgs. From approximately 14-16 ft bgs, a hard clay was encountered. Below this clay layer, a more permeable zone was identified (16-24 ft-bgs). This layer is inferred to be more permeable based on its lithology which generally consisted of medium to coarse-grained sand. The base of this unit is anticipated to be approximately 25 ft bgs.
- The baseline groundwater analytical results for VP-02 (9,700 µg/L; Table 6) and the rebound in sulfolane levels at four locations along the perimeter of the treatment grid indicate that elevated sulfolane concentrations may be present outside and immediately adjacent to the pilot treatment area.

4.2. CHP Effectiveness

The second DQO pertains to the effectiveness of CHP. CPCPRC concludes that the CHP process was very effective at reducing the sulfolane concentrations within the shallow aquifer, based upon the following:

- Immediately following the completion of the pilot study, the sulfolane concentrations were reduced by >99% (Figure 12 and 13).
    - Eleven of the monitoring locations yielded sulfolane concentrations below the preliminary risk-based remediation goal for sulfolane of 16 µg/L.
    - Sulfolane was not detectable at seven of the 12 locations.
- Four weeks after the pilot study a total of 11 locations remained below the preliminary risk-based remediation goal for sulfolane of 16 µg/L (Figure 12 and 13).
- Twelve weeks after the pilot study, some rebound in sulfolane levels was observed. Although some rebound was observed, a total of 8 locations remained below the preliminary risk-based remediation goal for sulfolane of 16 µg/L (Figure 12 and 13). The locations where rebound was observed were at locations along the perimeter of the treatment area.

4.3. Implementability

The third DQO pertains to the implementability of placing chemical oxidant into the shallow aquifer to treat sulfolane in groundwater and to determine the optimum treatment point configuration for full-scale design. Regarding this DQO, the following is concluded:

- Installed treatment points, as opposed to treatment via direct-push, allow for identification of and focused treatment within the target zones. Concurrent to the treatment, adjacent (unoccupied) treatment and vent points can be monitored for groundwater geochemical information to ensure an efficient and effective treatment is occurring. The installed points also allow for real-time treatment program modifications based on daily groundwater sampling of the points.

- The offgas data indicates that hydrogen peroxide was well distributed across the site and that an effective reaction was occurring (Figure 10).
- The volume determined by the bench test was calculated to be 16,796 gal of 35% hydrogen peroxide to treat a vertical zone of 12 ft. However in the field application, it was found that the treatment efficiency increased over the bench-scale test results and only 3,614 gal of 35% hydrogen peroxide was needed.
- The groundwater results from the first interim sampling event indicate an effective radius of influence of about 12.5 ft from an active treatment point within the low permeability deposits (8-14 ft-bgs) within the shallow aquifer.

5.0. References Cited

Agatonovic, V. and Vaisman, E. 2005. Sulfolane impacted soil and groundwater treatability study. Available at http://www.esaa.org/wp-content/uploads/2015/06/05-Paper43.pdf.

Bonifačić, M., Möckel, H., Bahnemann, D., and Asmus, K.-D. 1975. Formation of positive ions and other primary species in the oxidation of sulphides by hydroxyl radicals. *Journal of the Chemical Society, Perkin Transactions 2*, 1975, p. 675-685.

Buxton, G.V., Greenstock, C.L., Helman, W.P., and Ross, A.B. 1988. Critical review of rate constants for reactions of hydrated electrons, hydrogen atoms and hydroxyl radicals ($\cdot OH/\cdot O^-$) in aqueous solution. *Journal of Physical and Chemical Reference Data*, v. 17, p. 513-886.

Chen, R., and Pignatello, J.J. 1997. Role of quinone intermediates as electron shuttles in Fenton and photoassisted Fenton oxidations of aromatic compounds. *Environmental Science & Technology*, v. 31, p. 2399-2406.

Edwards, J.O., and Curci, R. 1992. Fenton type activation and chemistry of hydroxyl radical, in Strukul, G. (ed.), *Catalytic Oxidations with Hydrogen Peroxide as Oxidant*, p. 97-151.Haag, W.W.R., and Yao, C.C.D. 1992. Rate constants for reaction of hydroxyl radicals with several drinking water contaminants. *Environmental Science & Technology*, v. 26, p. 1005-1013.

Haber, F., and Weiss, J. 1934. The catalytic decomposition of hydrogen peroxide by iron salts. *Proceedings of the Royal Society of London, Series A*, v. 147, p. 332-351.

Huling, S.G., Ko, S., and Pivetz, B. 2011. Groundwater sampling at ISCO sites: Binary mixtures of volatile organic compounds and persulfate. *Ground Water Monitoring & Remediation*, v. 31, p. 72-79.

Johnson, K.T., Wickham-St. Germain, M., Ko, S., and Huling, S.G 2012. Binary mixtures of permanganate and chlorinated volatile organic compounds in groundwater samples: Sample preservation and analysis. *Ground Water Monitoring & Remediation*, v. 32, p. 84-92.

Kang, N., Lee, D.S., and Yoon, J. 2002. Kinetic modeling of Fenton oxidation of phenol and monochlorophenols. *Chemosphere*, v. 47, p. 915-924.

Kang, N., and Hua, I. 2005. Enhanced chemical oxidation of aromatic hydrocarbons in soil systems. *Chemosphere*, v. 61, p. 909-922.

Kavitha, V., and Palanivelu, K. 2005. Destruction of cresols by Fenton oxidation process. *Water Research*, v. 39, p. 3062-3072.

Ko, S., Huling, S.G., and Pivetz, B. 2012. *Ground Water Sample Preservation at In-Situ Chemical Oxidation Sites – Recommended Guidelines.* U.S. Environmental Protection Agency, Ground Water Issue, EPA/600/R-12/049.15 pages.

Lindsay Smith, J.R., and Norman, R.O.C. 1963. Hydroxylation. Part I. The oxidation of benzene and toluene by Fenton's reagent. *Journal of the Chemical Society*, v. 1963, p. 2897-2905.

Merz, J.H., and Waters, W.A. 1949. The oxidation of aromatic compounds by means of the free hydroxyl radical. *Journal of the Chemical Society*, 1949, part IV, 2427-2433.Nowack, B. 2002. Environmental chemistry of aminopolycarboxylate Chelating Agents. *Environmental Science & Technology*, v. 36, no. 19, pp. 4009-4016.

Pontes, R.F.F., Moreas, J.E.F., Machulek, A., and Pinto, J.M. 2010. A mechanistic kinetic model for phenol degradation by the Fenton process. *Journal of Hazardous Materials*, v. 176, p. 402-413.

Saunders, B.B., Kaufman, P.C., and Matheson, M.S. 1978. Reactions of thiophene with radiolytically produced radicals. I. The hydroxyl radical. *Journal of Physical Chemistry*, v. 82, p. 142-150.

Scheck, C.K., and Frimmel, F.H. 1995. Degradation of phenol and salicylic acid by ultraviolet radiation/hydrogen peroxide/oxygen. *Water Research*, v. 29, p. 2346-2352.

Sillanpää, M. and Pirkanniemi, K. 2001. Recent Developments in Chelate Degradation. *Environmental Technology*, 22: 7, pp. 791- 801.

Walling, C., and Johnson, R.A. 1975. Fenton's reagent. V. Hydroxylation and side-chain cleavage of aromatics. *Journal of the American Chemical Society*, v. 97, p. 363-367.

Watts, R.J., Bottenberg, B.C., Hess, T.F., Jensen, M.D., and Teel, A.L. 1999. Role of reductants in the enhanced desorption and transformation of chloroaliphatic compounds by modified Fenton's reactions. *Environmental Science & Technology*, v. 33, p. 3432-3437.

Watts, R. J., and Teel, A. L. 2005. Chemistry of modified Fenton's reagent (catalyzed H_2O_2 propagations CHP) for in situ soil and groundwater remediation. *Journal of Environmental Engineering*, v. 131, pp. 612-622.

Figures

Figure 1. Site Location Map

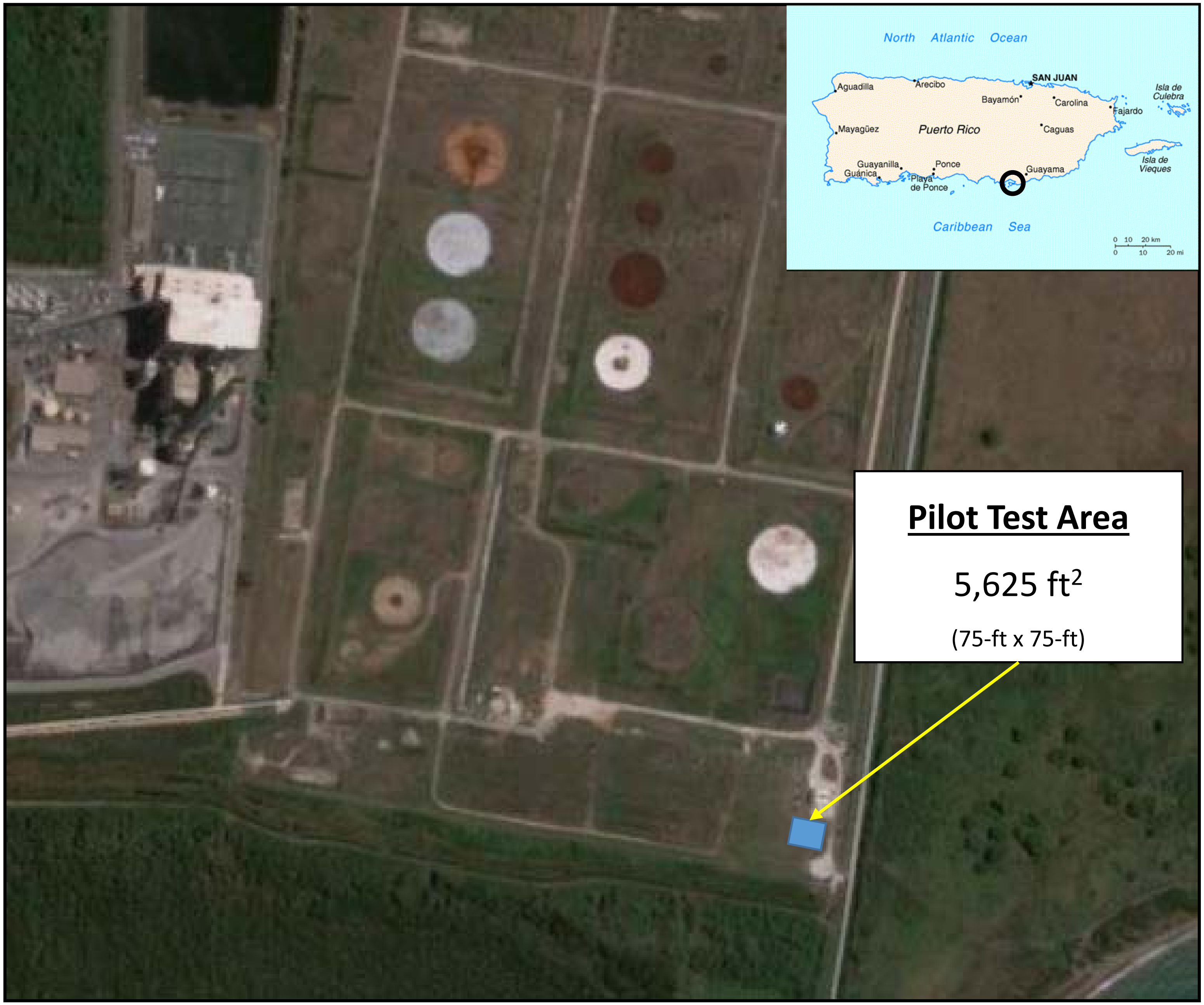
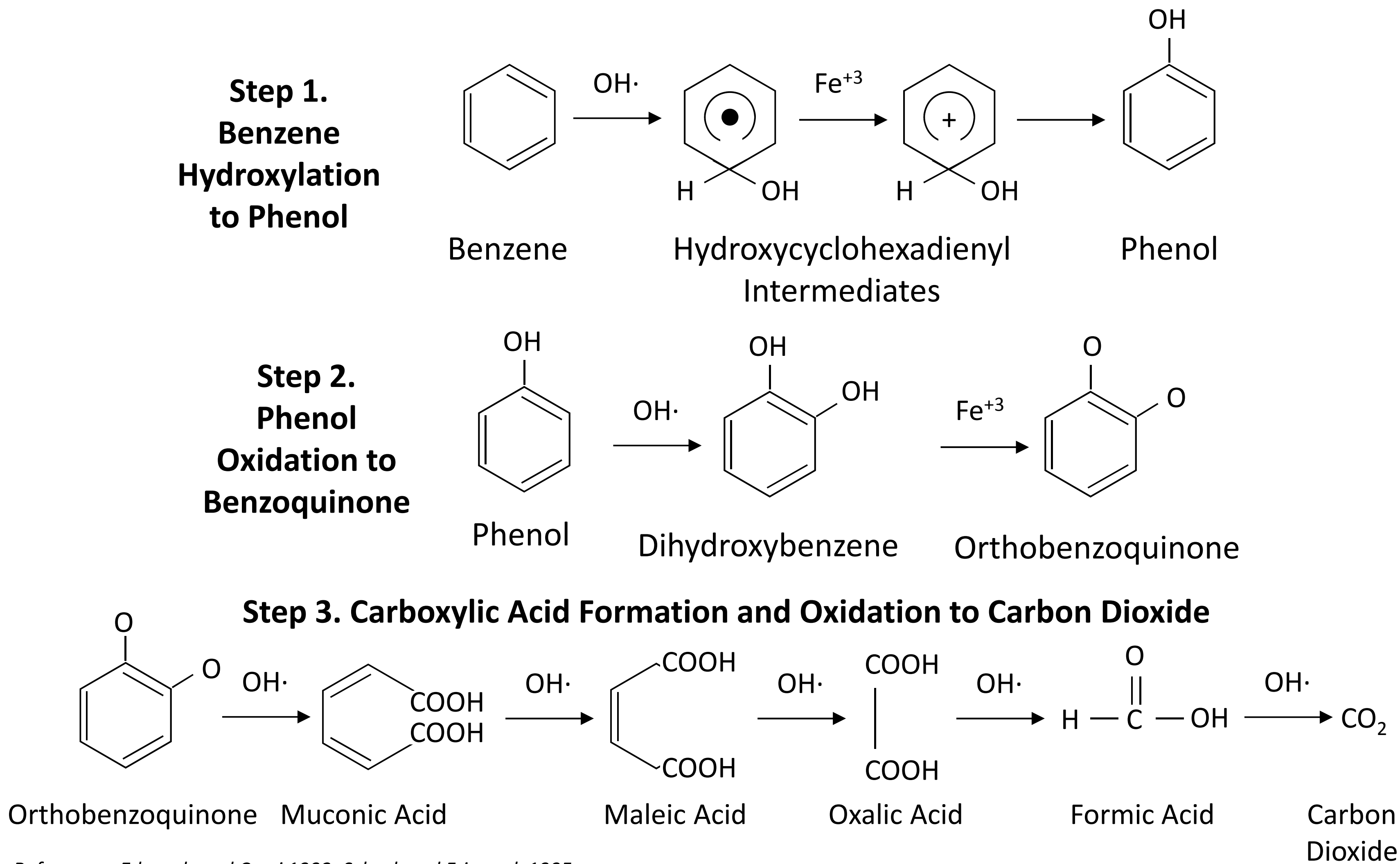


Figure 2. Hydroxyl Radical Oxidation Pathway for Benzene



References: Edwards and Curci 1992; Scheck and Frimmel, 1995

Figure 3. Chemical Structures and Hydroxyl Radical Oxidation Pathway for Sulfur-Substituted Heterocyclic Compounds Similar to Sulfolane

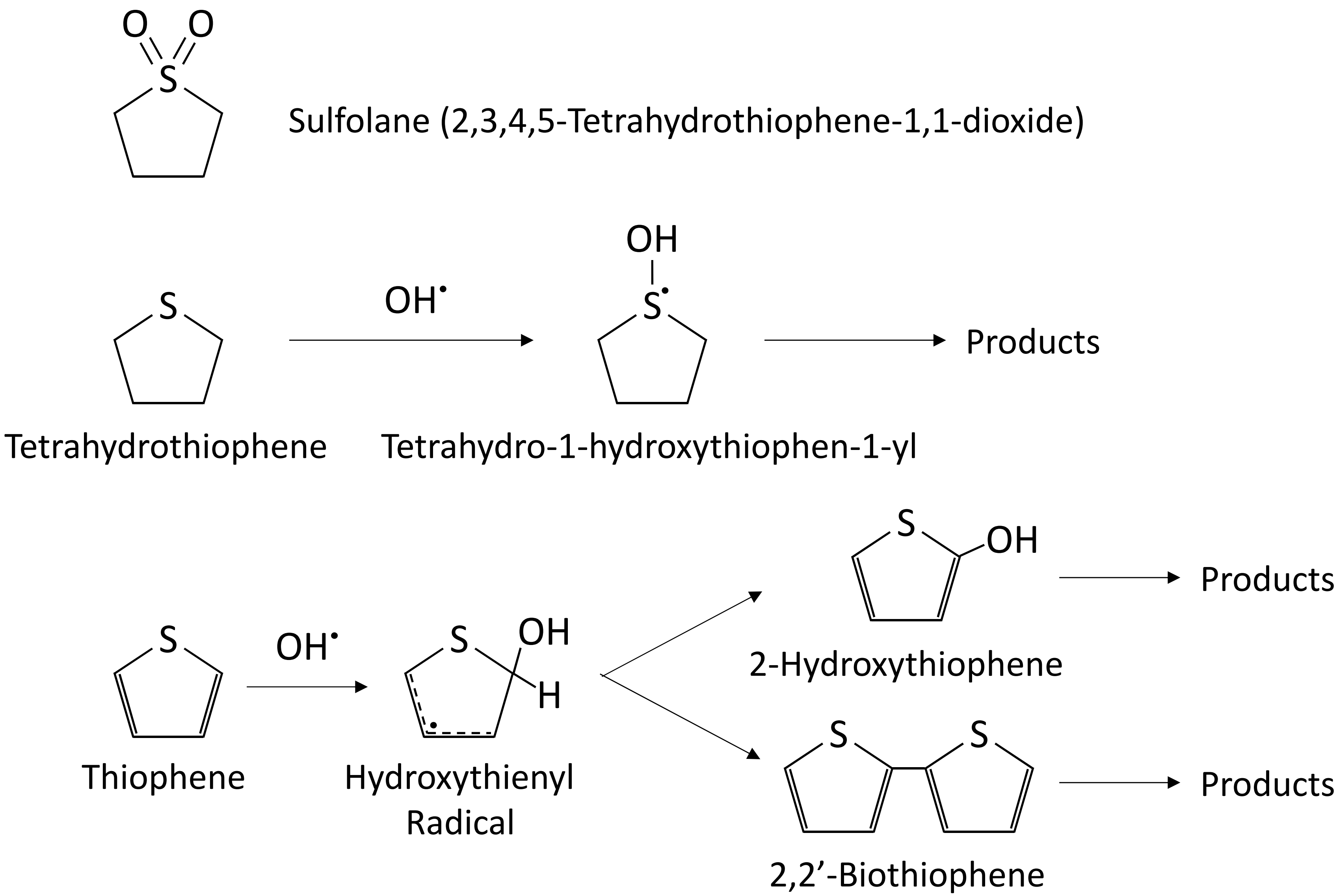


Figure 4. Pilot Test Area Layout

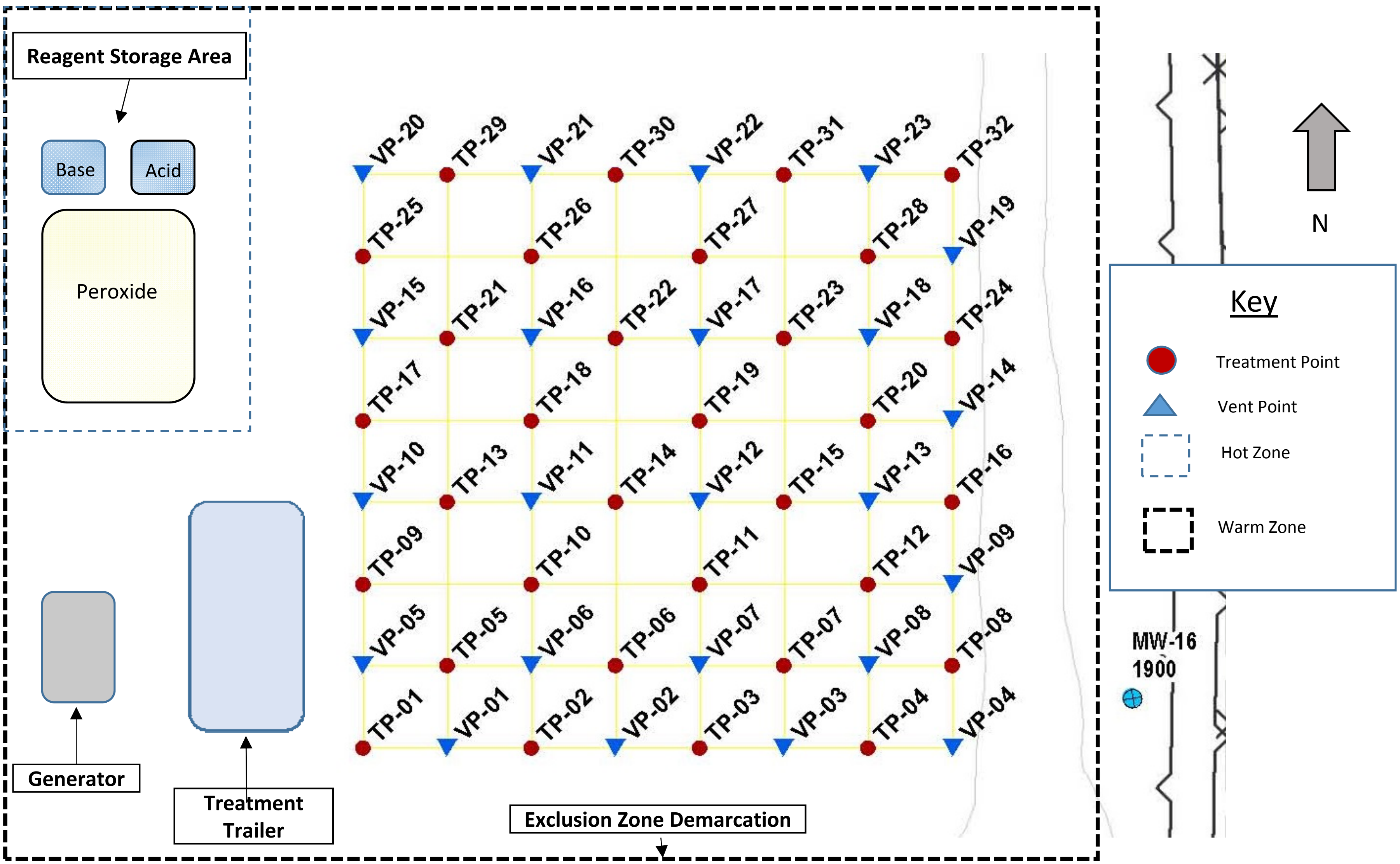
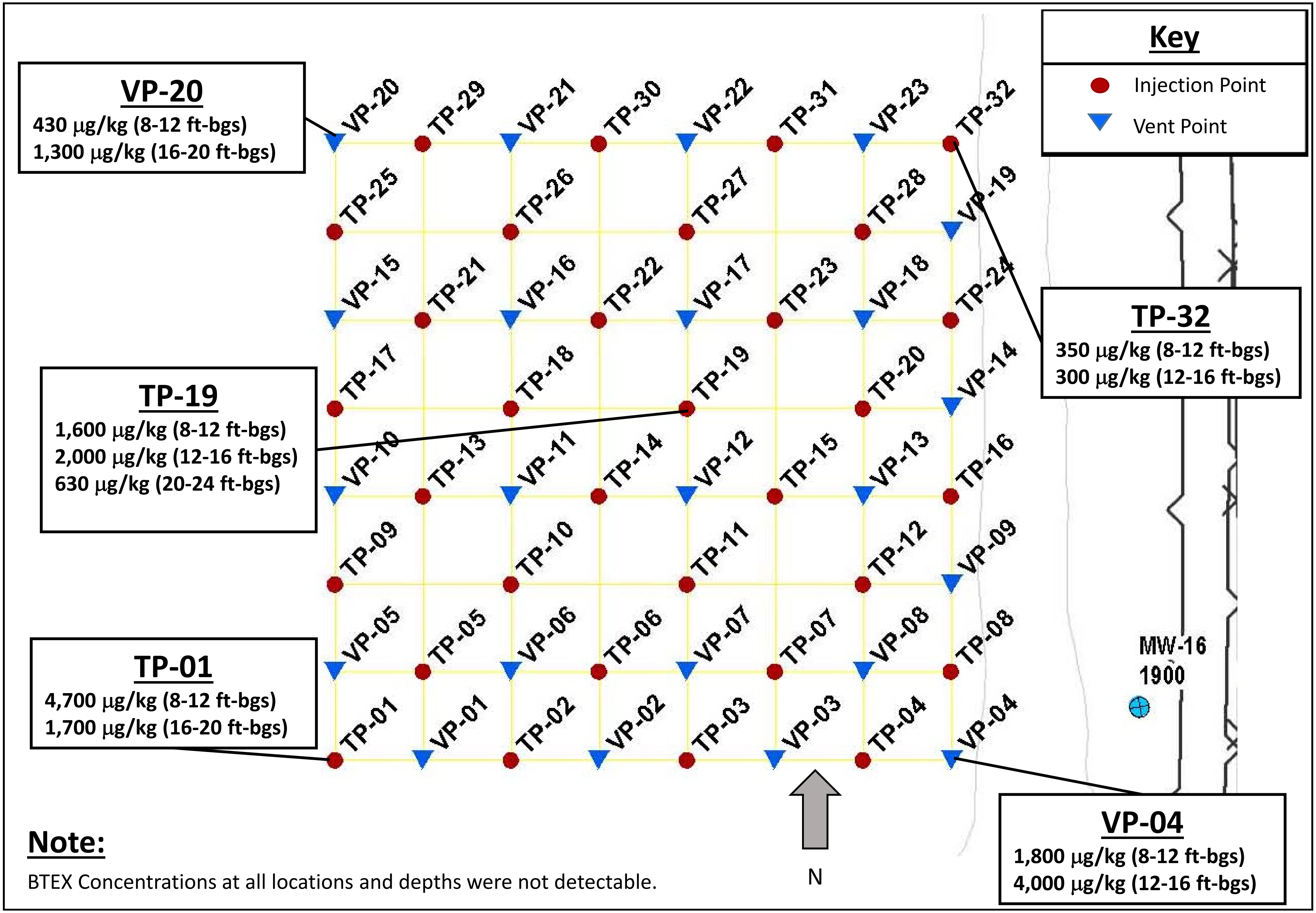


Figure 5. Baseline BTEX and Sulfolane Results (Soil)



Note:

BTEX Concentrations at all locations and depths were not detectable.

Figure 6. Active Treatment Points During Initial Mobilization

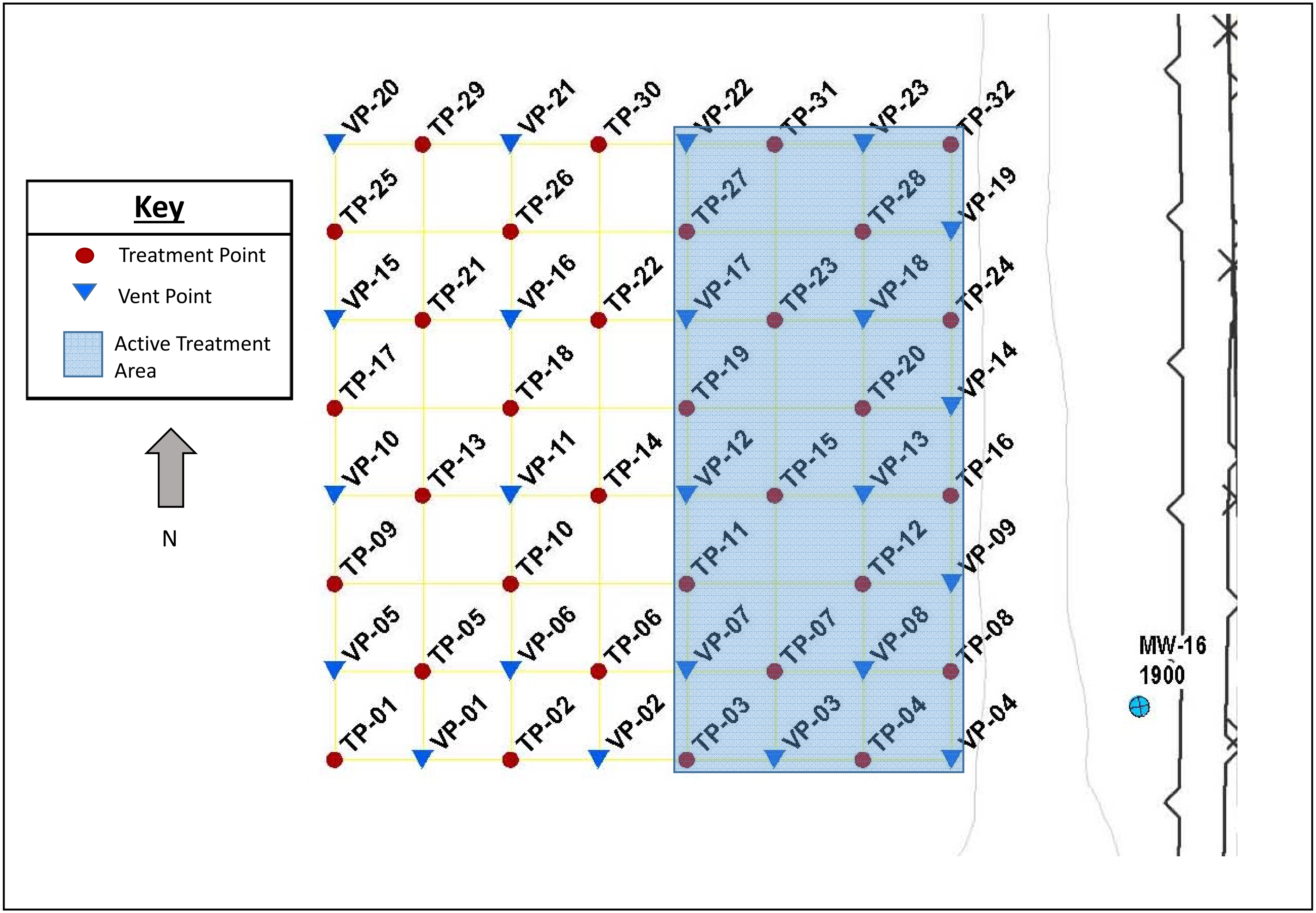


Figure 7. Daily Average Groundwater Results - pH

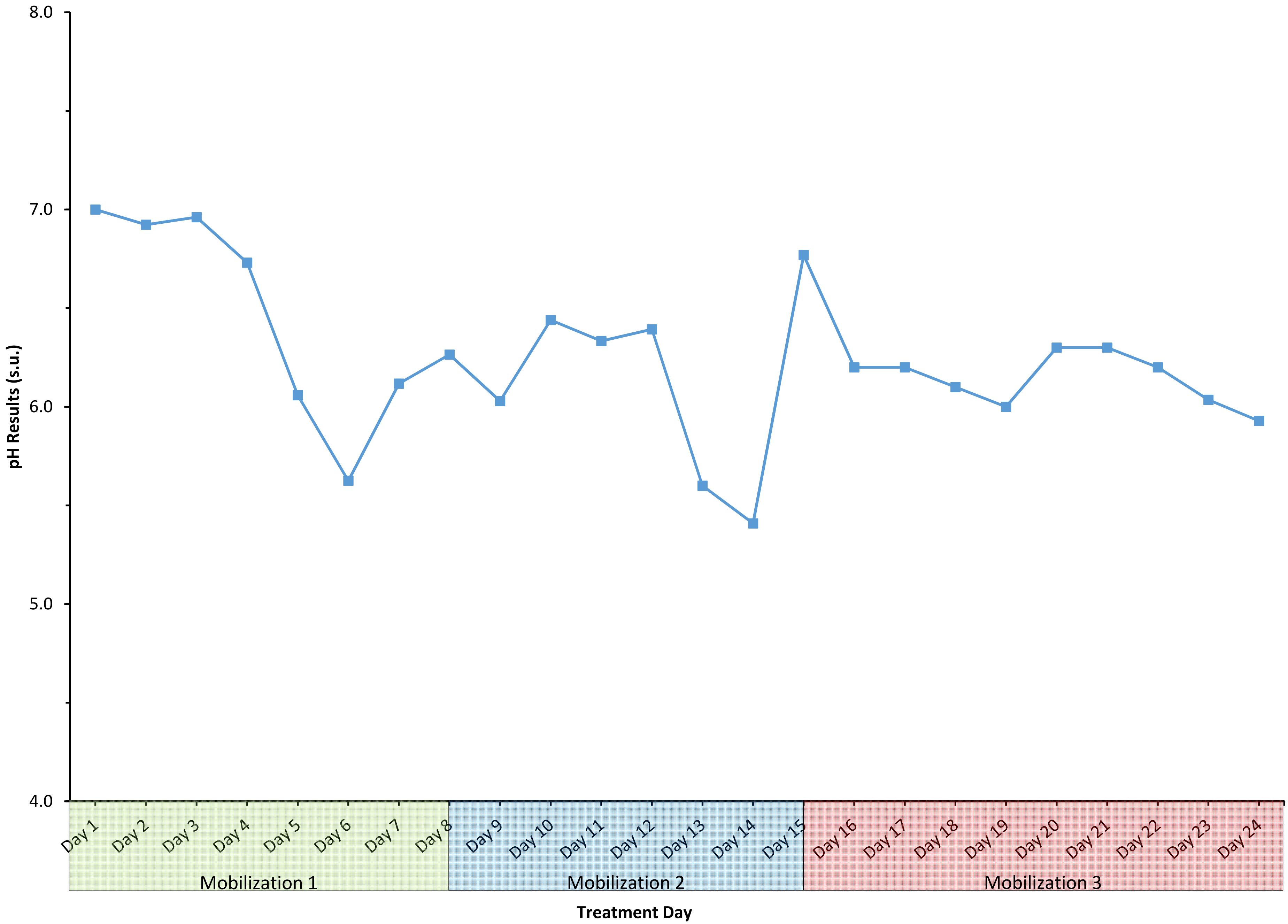


Figure 8. Daily Average Groundwater Results – Hydrogen Peroxide Concentration

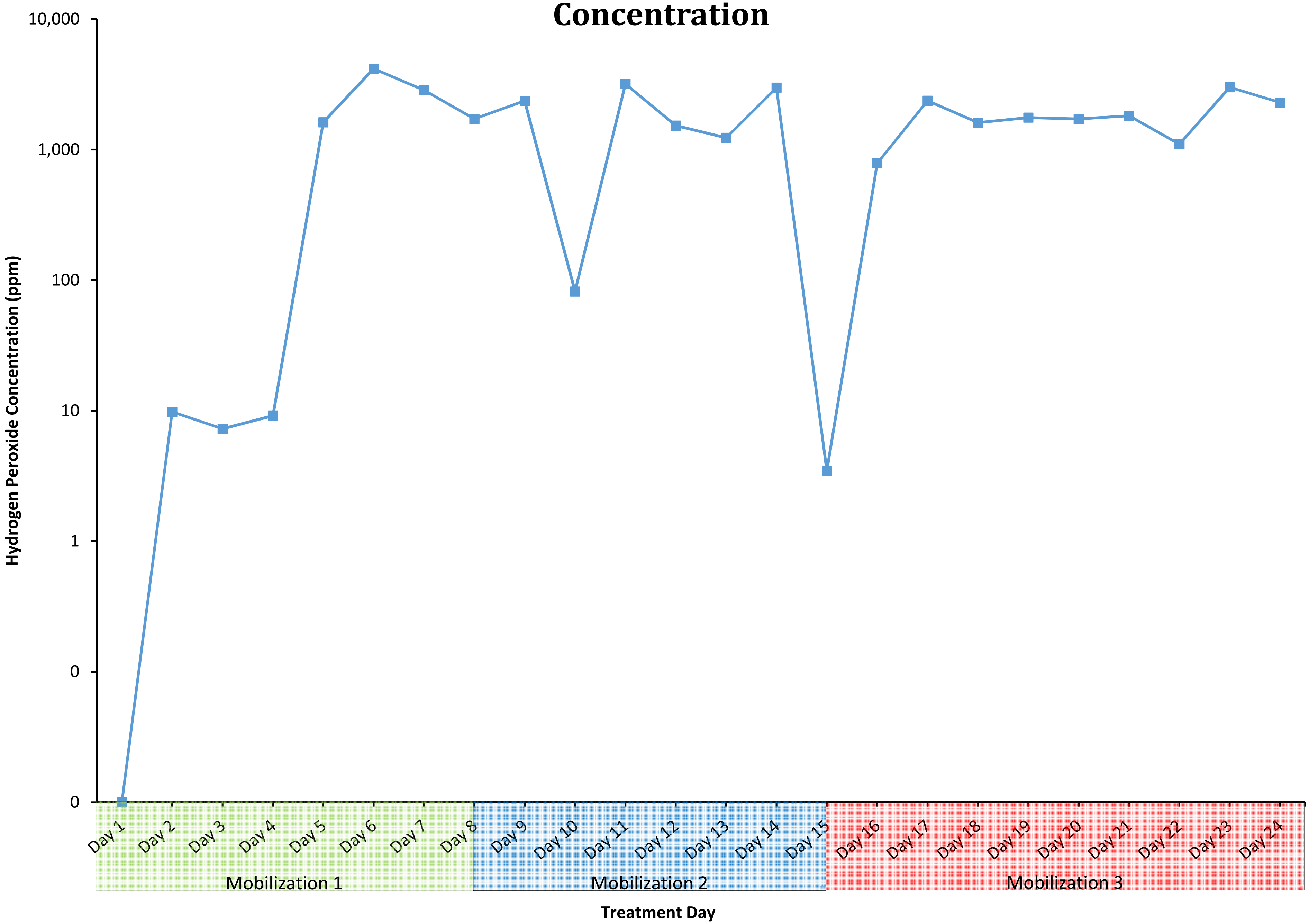


Figure 9. Daily Average Groundwater Results - Temperature

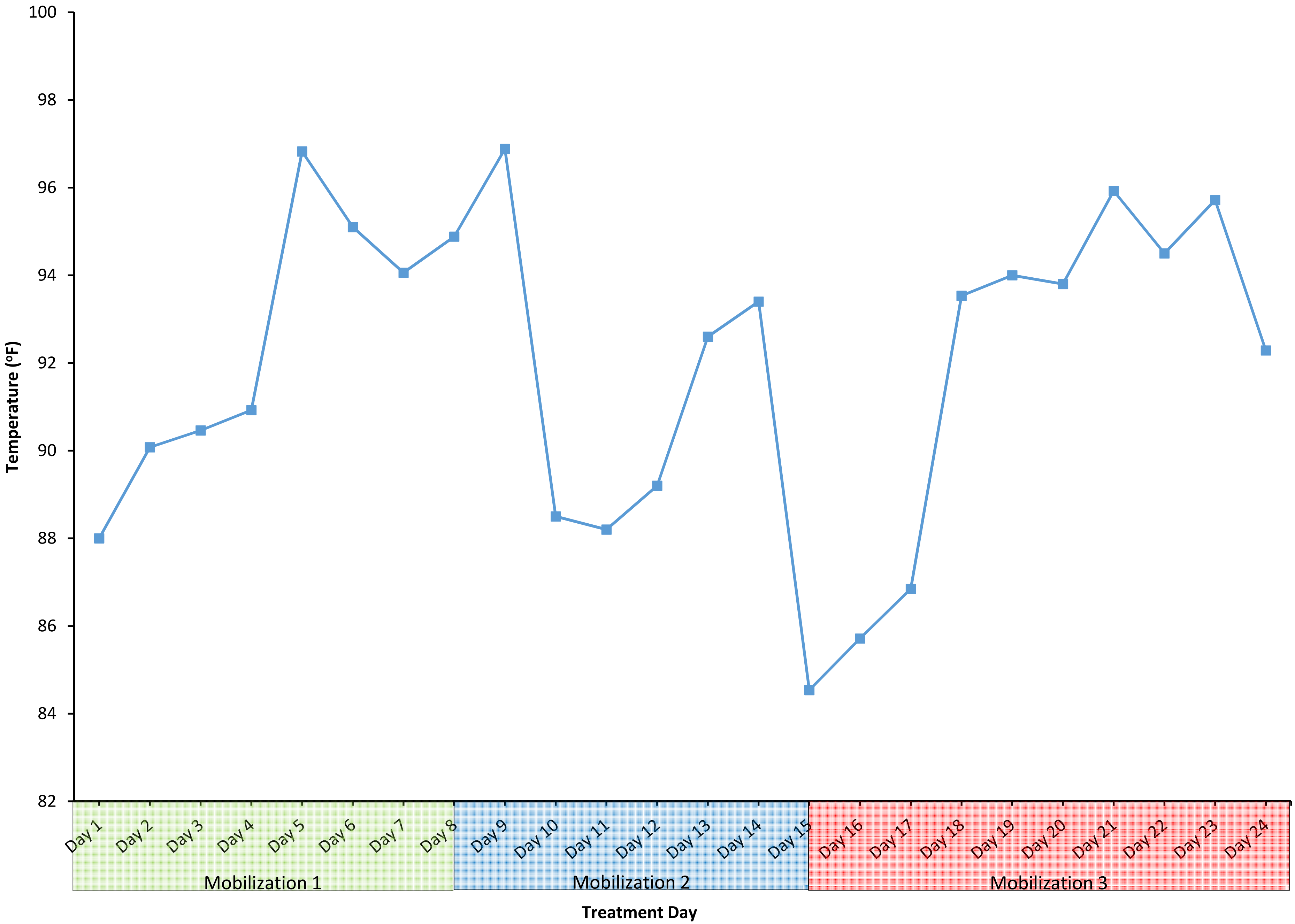


Figure 10. Daily Average Offgas Results – Carbon Dioxide and Oxygen

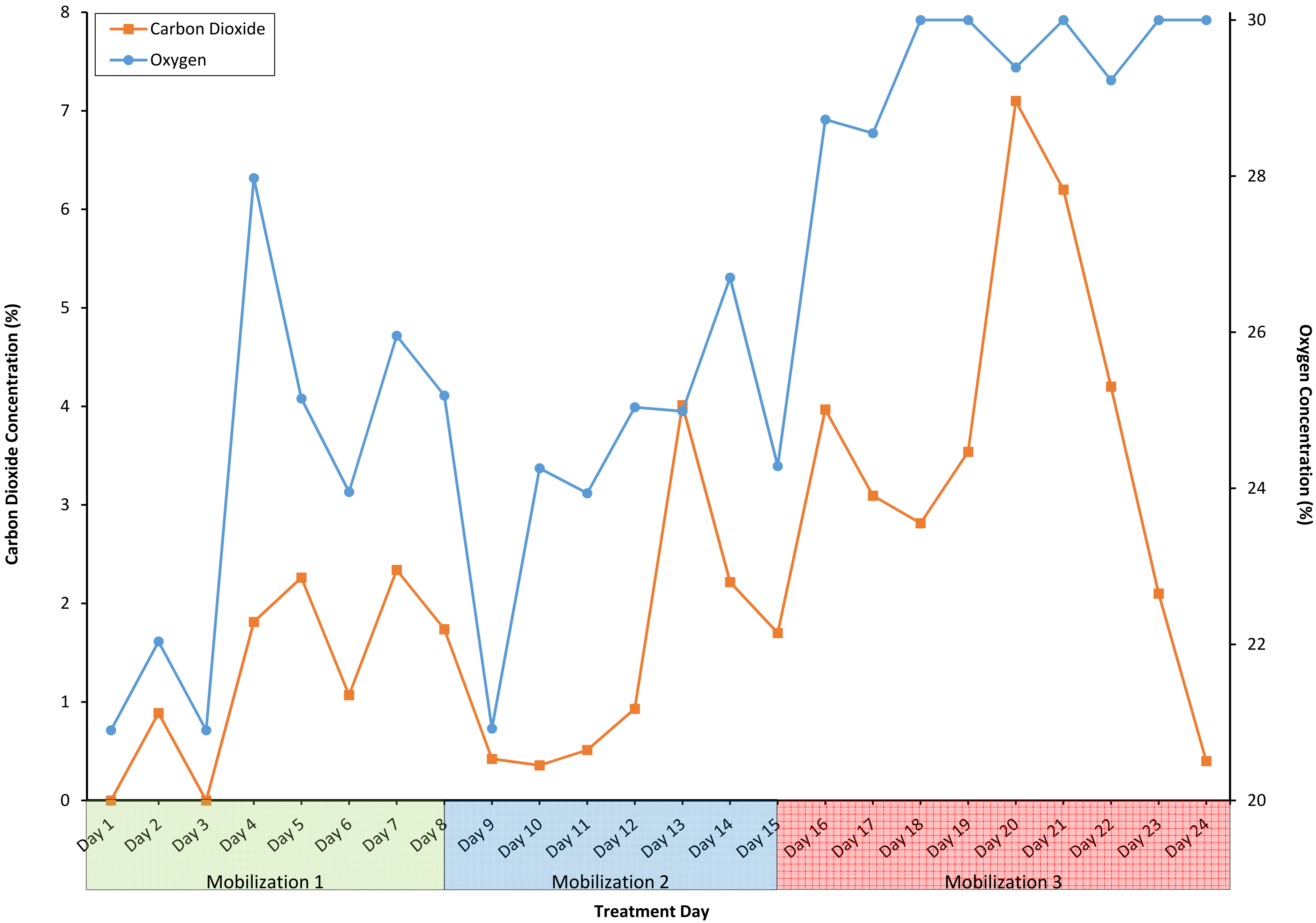


Figure 11. Groundwater Performance Monitoring Locations

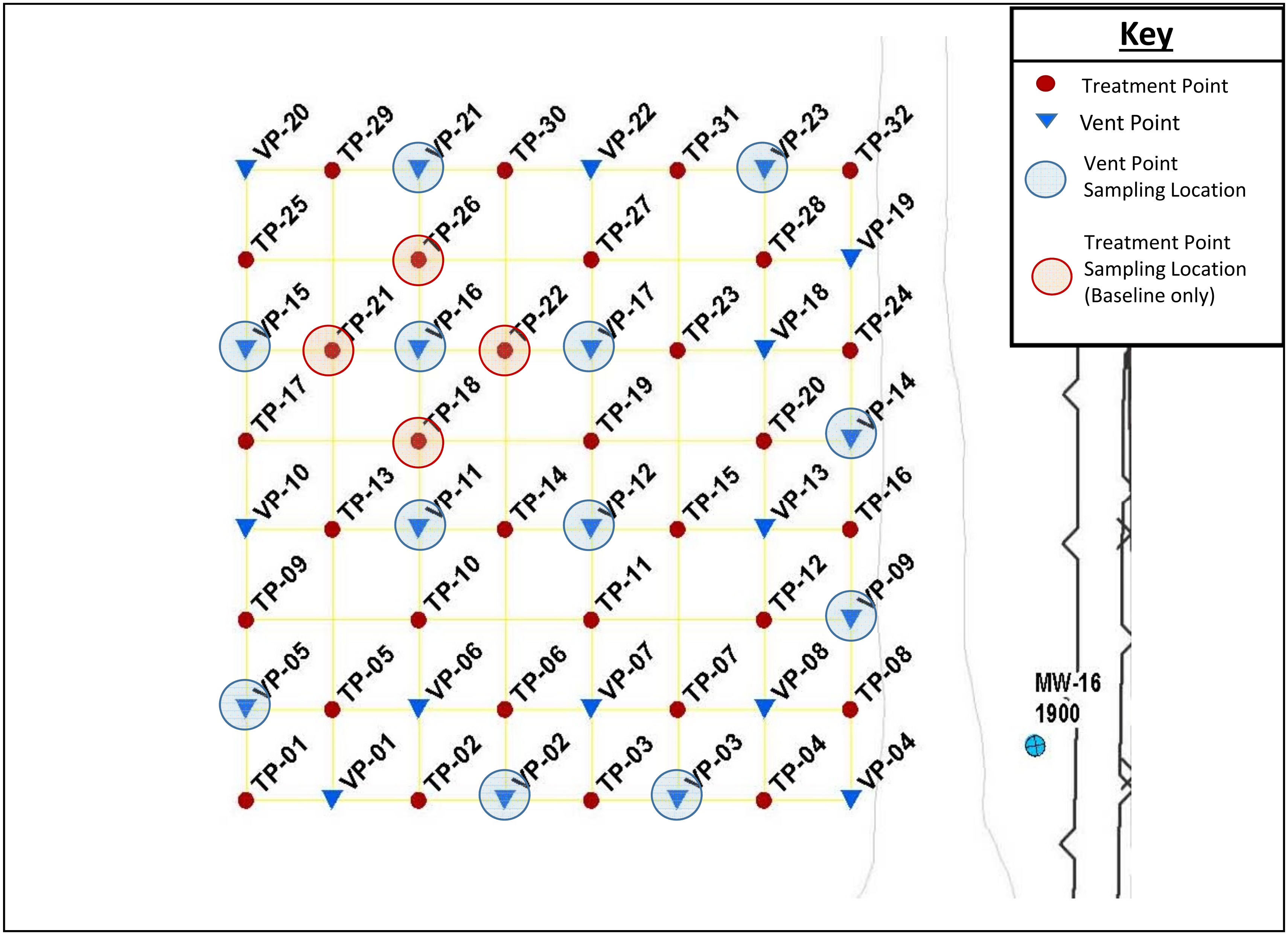


Figure 12. Groundwater Performance Monitoring Results (1)

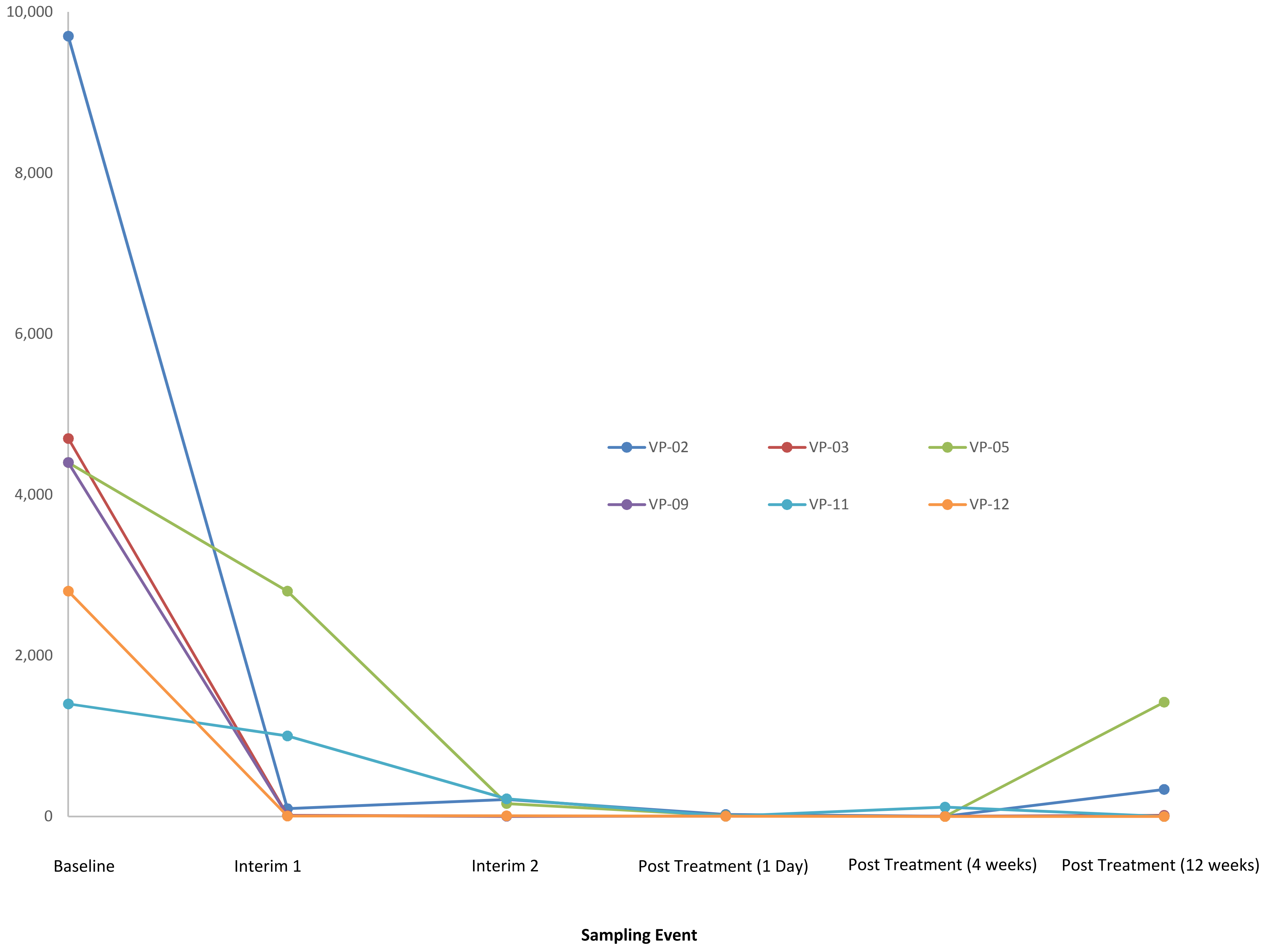
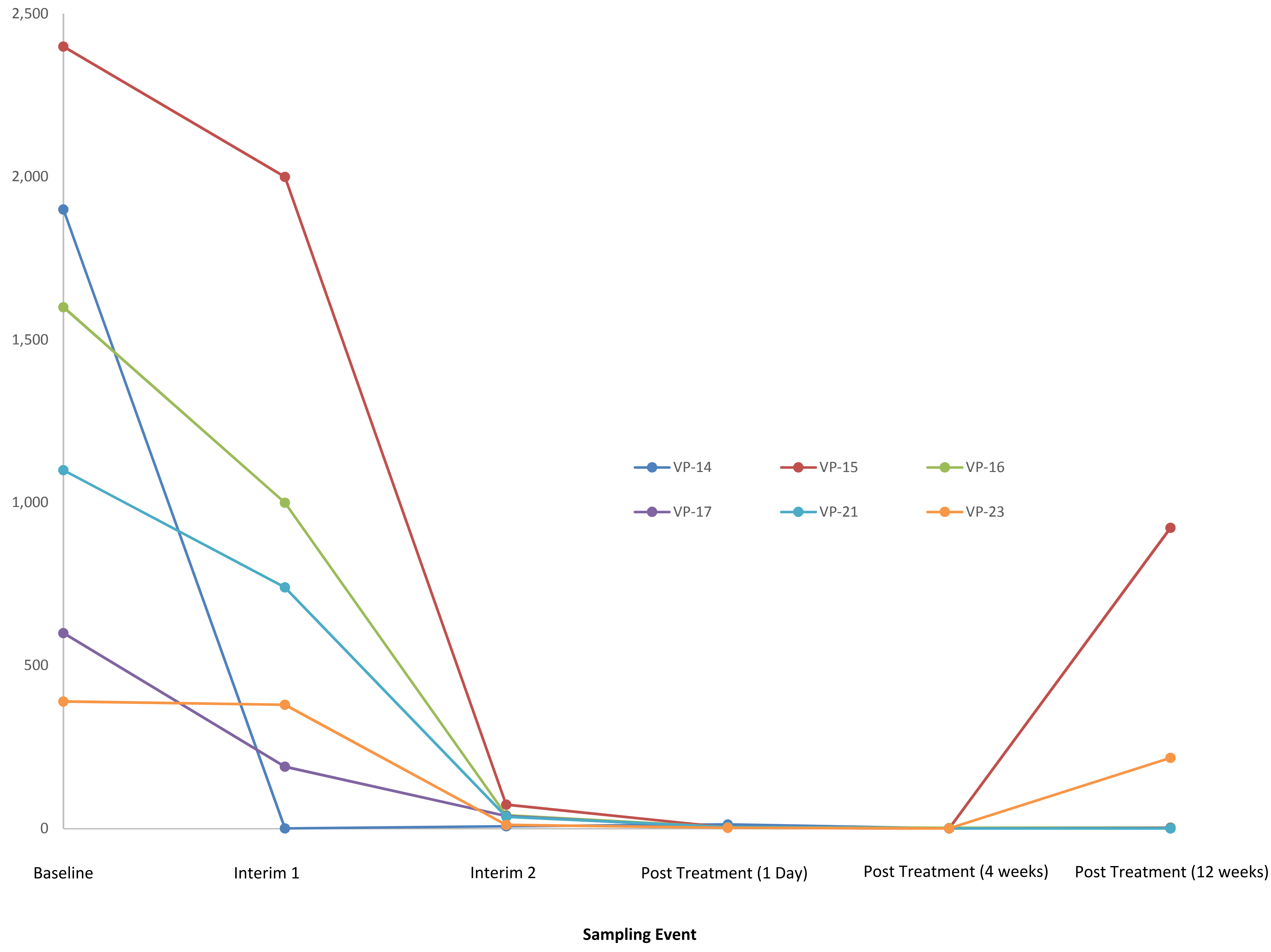


Figure 13. Groundwater Performance Monitoring Results (2)



Tables

Table 1. Application Volumes and Concentrations - Mobilization 1

Treatment Point Location	Peroxide Volume (gal/35%)	Catalyst Volume (gal)	Total Volume (gal)	Average Peroxide Concentration (%)
TP-03	54	900	954	2.0%
TP-04	54	279	332	5.4%
TP-07	55	284	338	5.4%
TP-08	45	236	280	5.3%
TP-11	42	221	262	5.3%
TP-12	45	242	286	5.2%
TP-15	46	244	289	5.3%
TP-16	54	287	340	5.3%
TP-19	22	108	130	5.6%
TP-20	23	115	138	5.6%
TP-23	17	83	100	5.7%
TP-24	18	90	108	5.6%
TP-27	12	60	72	5.6%
TP-28	22	108	130	5.6%
TP-29	4	18	22	6.1%
TP-31	15	73	88	5.7%
TP-32	6	28	34	5.9%
Totals:	**530**	**3,370**	**3,900**	**5.3%**

Table 2. Application Volumes and Concentrations - Mobilization 2

Treatment Point Location	Peroxide Volume (gal/35%)	Catalyst Volume (gal)	Total Volume (gal)	Average Peroxide Concentration (%)
TP-01	58	234	292	7.0%
TP-02	43	180	223	6.7%
TP-03	28	111	139	7.1%
TP-04	22	89	111	6.9%
TP-05	51	213	264	6.8%
TP-06	45	183	228	6.9%
TP-07	23	95	118	6.8%
TP-08	10	38	48	7.3%
TP-09	34	135	169	7.0%
TP-10	36	138	174	7.2%
TP-11	41	163	204	7.0%
TP-12	32	130	162	6.9%
TP-13	27	105	132	7.2%
TP-14	18	73	91	6.9%
TP-15	24	98	122	6.9%
TP-16	18	78	96	6.6%
TP-17	58	238	296	6.9%
TP-18	49	210	259	6.6%
TP-19	35	137	172	7.1%
TP-20	35	144	179	6.8%
TP-21	57	236	293	6.8%
TP-22	33	149	182	6.3%
TP-23	23	88	111	7.3%
TP-24	25	101	126	6.9%
TP-25	57	229	286	7.0%
TP-26	38	170	208	6.4%
TP-27	3	9	12	8.8%
TP-28	21	78	99	7.4%
TP-29	29	133	162	6.3%
TP-30	43	184	227	6.6%
TP-32	3	9	12	8.8%
Totals:	**1,019**	**4,178**	**5,197**	**7.0%**

Table 3. Application Volumes and Concentrations - Mobilization 3

Treatment Point Location	Peroxide Volume (gal/35%)	Catalyst Volume (gal)	Total Volume (gal)	Average Peroxide Concentration (%)
TP-01	150	502	652	8.1%
TP-02	85	294	379	7.8%
TP-03	91	300	391	8.1%
TP-04	16	50	66	8.5%
TP-05	125	423	548	8.0%
TP-06	137	466	603	8.0%
TP-07	6	18	24	8.8%
TP-09	82	277	359	8.0%
TP-10	141	470	611	8.1%
TP-11	140	485	625	7.8%
TP-12	49	178	227	7.6%
TP-13	140	470	610	8.0%
TP-14	103	360	463	7.8%
TP-15	72	256	328	7.7%
TP-16	7	21	28	8.8%
TP-17	130	451	581	7.8%
TP-18	85	299	384	7.7%
TP-19	78	272	350	7.8%
TP-20	17	59	76	7.8%
TP-21	75	246	321	8.2%
TP-22	8	24	32	8.8%
TP-23	40	131	171	8.2%
TP-24	25	80	105	8.3%
TP-25	80	270	350	8.0%
TP-26	6	24	30	7.0%
TP-28	28	93	121	8.1%
TP-29	51	179	230	7.8%
TP-30	69	236	305	7.9%
TP-31	20	80	100	7.0%
TP-32	14	56	70	7.0%
Totals:	**2,070**	**7,070**	**9,140**	**7.9%**

Table 4. Daily Average Groundwater Results

Date	pH (s.u.)	Iron (ppm)	Peroxide (ppm)	PID Headspace (ppm)	Temperature (°F)
6/15/2015	7.0	4.2	0.0	1.7	88.0
6/16/2015	6.9	0.0	9.8	0.0	90.1
6/17/2015	7.0	0.0	7.3	0.5	90.5
6/18/2015	6.7	0.0	9.2	0.2	90.9
6/20/2015	6.1	0.0	1,619	0.5	96.8
6/22/2015	5.6	0.0	4,167	0.8	95.1
6/23/2015	6.1	0.0	2,854	0.6	94.1
6/24/2015	6.3	0.0	1,720	1.0	94.9
6/25/2015	6.0	0.0	2,363	0.9	96.9
7/8/2015	6.4	0.2	81.9	0.0	88.5
7/10/2015	6.3	0.0	3,190	0.0	88.2
7/11/2015	6.4	0.0	1,527	0.0	89.2
7/13/2015	5.6	0.0	1,233	0.0	92.6
7/15/2015	5.4	0.0	2,982	0.0	93.4
7/28/2015	6.8	2.3	3.5	0.3	84.5
7/30/2015	6.2	1.1	786	0.2	85.7
7/31/2015	6.2	1.9	2,369	0.2	86.8
8/1/2015	6.1	1.0	1,611	0.4	93.5
8/3/2015	6.0	0.7	1,759	0.5	94.0
8/4/2015	6.3	1.4	1,715	0.4	93.8
8/5/2015	6.3	1.2	1,816	0.0	95.9
8/6/2015	6.2	0.8	1,100	0.0	94.5
8/7/2015	6.0	0.4	3,004	0.0	95.7
8/8/2015	5.9	0.7	2,295	0.0	92.3

Figure 5 - Daily Average Offgas Results

Date	Carbon Dioxide (%)	Oxygen (%)	PID Headspace (ppm)
6/15/2015	0.0	20.9	0.0
6/16/2015	0.9	22.0	0.3
6/17/2015	0.0	20.9	0.2
6/18/2015	1.8	28.0	0.6
6/20/2015	2.3	25.2	0.3
6/22/2015	1.1	24.0	1.3
6/23/2015	2.3	26.0	1.4
6/24/2015	1.7	25.2	0.9
7/8/2015	0.4	20.9	0.0
7/9/2015	0.4	24.3	0.0
7/10/2015	0.5	23.9	0.0
7/11/2015	0.9	25.0	0.0
7/13/2015	4.0	25.0	0.0
7/15/2015	2.2	26.7	0.0
7/29/2015	1.7	24.3	0.0
7/30/2015	4.0	28.7	0.0
7/31/2015	3.1	28.6	0.0
8/1/2015	2.8	30.0	0.0
8/3/2015	3.5	30.0	0.0
8/4/2015	7.1	29.4	0.0
8/5/2015	6.2	30.0	0.0
8/6/2015	4.2	29.2	0.0
8/7/2015	2.1	30.0	0.0
8/8/2015	0.4	30.0	0.0

Table 6. Groundwater Sulfolane Concentrations & Associated Reductions

Performance Monitoring Point	Baseline Sampling Event (6/10/15)	Interim Sampling Event (7/6 - 7/7)	Percent Reduction (Relative to Baseline)	Interim Sampling Event (7/16)	Percent Reduction (Relative to Baseline)	Post Treatment Sampling Event (8/12)	Percent Reduction (Relative to Baseline)	Post Treatment Sampling Event (9/10)	Percent Reduction (Relative to Baseline)	Post Treatment Sampling Event (12/01)	Percent Reduction (Relative to Baseline)
VP-02	9,700	98	99.0%	210	97.8%	25.4	99.7%	2.45	99.9%	335	96.5%
VP-03	4,700	14	99.7%	4.1	99.9%	Not Detected	100%	2.30	99.9%	14.3	99.7%
VP-05	4,400	2,800	36.4%	160	96.4%	10.8	99.8%	0.592 J	99.9%	1420	67.7%
VP-09	4,400	10	99.8%	Not Detected	100%	Not Detected	100%	1.28	99.9%	5.9	99.9%
VP-11	1,400	1,000	28.6%	220	84.3%	2.79	99.8%	115	91.8%	0.78	99.9%
VP-12	2,800	6.1	99.8%	7.7	99.7%	Not Detected	100%	0.777 J	99.9%	Not Detected	100%
VP-14	1,900	0.73	99.9%	7.4	99.6%	12.4	99.3%	Not Detected	100%	0.50	99.97%
VP-15	2,400	2,000	16.7%	73	97.0%	2.86	99.9%	0.241 J	99.9%	923	61.5%
VP-16	1,600	1,000	37.5%	41	97.4%	Not Detected	100%	1.92	99.9%	3.25	99.8%
VP-17	600	190	68.3%	38	93.7%	Not Detected	100%	Not Detected	100%	2.04	99.7%
VP-21	1,100	740	32.7%	36	96.7%	Not Detected	100%	Not Detected	100%	0.228	100%
VP-23	390	380	2.6%	11	97.2%	Not Detected	100%	Not Detected	100%	217	44.4%

All concentrations reported with units of μg/L

APPENDIX B
Cost Estimates

No Further Action Alternative

Cost Estimate

Cost Summary Report - No Further Action Alternative (with Markups)

System:

RACER Version: RACER® Version 11.2.16.0
Database Location: C:\Users\Jake Gallegos\Desktop\CPCPRC\CMS Report\RACER Files\RACER.mdb

Project:

Location

State / Country: PUERTO RICO
City: PUERTO RICO AVERAGE

Location Modifier	Default	User
	1.160	1.160

Options

Database: System Costs
Cost Database Date: 2015
Report Option: Calendar

Description CMS Report - Estimate of Potential Costs
ID: CPCPRC
Name: **No Further Action**
Type: None

Media/Waste Type

Primary: Groundwater
Secondary: Soil

Contaminant

Primary: Fuels
Secondary: Semi-Volatile Organic Compounds (SVOCs)

Documentation

Description: Alternative 1 - No Further Action
Support Team: Documentation of personnel used to provide support for estimator and preparation of the estimate.
References: Documentation of reference sources used in the preparation of the estimate.

Estimator Information

Estimator Name: Jake Gallegos P.G
Estimator Title: VP
Agency/Org./Office: PEI
Business Address: 785 Cherry St
Denver 80220
Telephone Number: 720-324-3949
Email Address: jgallegos@pei-tx.com
Estimate Prepared Date 03/11/2016

Phase	Direct Cost	Markups	Total Cost
Operations & Maintenance	$7,661,275	$11,018,430	$18,679,705
Long Term Monitoring	$3,527,353	$3,865,114	$7,392,467
5-Year Review Reports	$144,097	$211,664	$355,760
Total Site Cost	**$11,332,725**	**$15,095,207**	**$26,427,932**

Phase Markups Report

Phase Markups Report

Project: Chevron Phillips Puerto Rico Core LLC
Site: No Further Action
Phase: 01 - O&M of the VISM and EFR Systems

Subcontracted Portion of Work

	Professional Labor	MLE*	SubBid	Total
Total Direct Cost Over 30 Year Project Life	$0	$0	$562,534	$562,534
Overhead %	132.00%	25.00%	0.00%	
Overhead	$0	$0	$0	$0
Subtotal	$0	$0	$562,534	$562,534
Subcontractor Profit %	8.00%	8.00%	0.00%	
Subcontractor Profit	$0	$0	$0	$0
Total Subcontract Cost	$0	$0	$562,534	$562,534

Prime Contractor Portion of Work

	Professional Labor	MLE*	SubBid	Total
Total Direct Cost Over 30 Year Project Life	$5,743,965	$1,354,776	$0	$7,098,741
Overhead %	132.00%	25.00%	0.00%	
Overhead	$7,582,033	$338,694	$0	$7,920,727
Prime Subtotal	$13,325,998	$1,693,470	$0	$15,019,468
Prime + Subcontract	$13,325,998	$1,693,470	$562,534	$15,582,002
Contingency %	8.00%	8.00%	8.00%	
Prime Contingency Cost	$1,066,080	$135,478	$45,003	$1,246,560
Prime + Subcontract + Contingency	$14,392,078	$1,828,948	$607,537	$16,828,563

Other Project Costs

	Professional Labor	MLE*	SubBid	Total
Contingency Allowance	$0	$0	$0	$0
Total Contract Cost + Contingency	$14,392,078	$1,828,948	$607,537	$16,828,563
Owner Cost %	11.00%	11.00%	11.00%	
Owner Cost	$1,583,129	$201,184	$66,829	$1,851,142
Total Contract Cost + Contingency + Owner Cost	$15,975,207	$2,030,132	$674,366	$18,679,705
Total No-Markup Items				$0
Grand Total				$18,679,705

MLE = Materials, Trade Labor, and Expenses

Phase Cost Over Time Report - No Further Action O&M of the VISM and EFR Systems for 30 Years

RACER Version: RACER® Version 11.2.16.0
Database Location: C:\Users\Jake Gallegos\Desktop\CPCPRC\CMS Report\RACER Files\RACER.mdb

Project:

ID: CPCPRC 15605.04
Name: Chevron Phillips Puerto Rico Core LLC
Category: None

Location

State / Country: PUERTO RICO
City: PUERTO RICO AVERAGE

Location Modifier

Default	User
1.160	1.160

Options

Database: System Costs
Cost Database Date: 2015
Report Option: Calendar

Description CMS Report - Estimate of Potential Costs

Site:

ID: CPCPRC
Name: **No Further Action**
Type: None

Documentation

Description: **No Further Action**
Support Team: Documentation of personnel used to provide support for estimator and preparation of the estimate.
References: Documentation of reference sources used in the preparation of the estimate.

Technology Name	Technology	2016	2017	2018	2019	2020	2021
Operations and Maintenance		$134,408	$268,817	$268,817	$268,817	$268,817	$268,817

Technology Name	Technology	2022	2023	2024	2025	2026	2027
Operations and Maintenance		$268,817	$268,817	$268,817	$268,817	$268,817	$268,817

Technology Name	Technology	2028	2029	2030	2031	2032	2033
Operations and Maintenance		$268,817	$268,817	$268,817	$268,817	$268,817	$268,817

Technology Name	Technology	2034	2035	2036	2037	2038	2039
Operations and Maintenance		$268,817	$268,817	$268,817	$268,817	$268,817	$268,817

Technology Name	Technology	2040	2041	2042	2043	2044	Total
Operations and Maintenance		$268,817	$268,817	$268,817	$268,817	$268,817	$7,661,275

Phase Technology Cost Detail Report - No Further Action O&M of the VISM and EFR Systems

System:

RACER Version:	RACER® Version 11.2.16.0
Database Location:	C:\Users\Jake Gallegos\Desktop\CPCPRC\CMS Report\RACER Files\RACER.mdb

Project:

ID:	CPCPRC 15605.04
Name:	Chevron Phillips Puerto Rico Core LLC
Category:	None

Location

State / Country:	PUERTO RICO
City:	PUERTO RICO AVERAGE

Location Modifier

Default	User
1.160	1.160

Options

Database:	System Costs
Cost Database Date:	2015
Report Option:	Calendar

Description CMS Report - Estimate of Potential Costs

Site:

ID:	CPCPRC
Name:	**No Further Action**
Type:	None

Media/Waste Type

Primary:	Groundwater
Secondary:	Soil

Contaminant

Primary:	Fuels
Secondary:	Semi-Volatile Organic Compounds (SVOCs)

Documentation

Description:	**No Further Action**
Support Team:	Documentation of personnel used to provide support for estimator and preparation of the estimate.
References:	Documentation of reference sources used in the preparation of the estimate.

Phase Documentation:

Phase Type:	**Operations & Maintenance**
Phase Name:	**01 - O&M of the VISM and EFR Systems**
Description:	**01 - O&M of the VISM and EFR Systems**
Approach:	Ex Situ
Start Date:	July, 2016
Labor Rate Group:	System Labor Rate
Analysis Rate Group:	System Analysis Rate
Phase Markup Templat	System Defaults

Technology Markups	**Marku**	**% Prime**	**% Sub.**
Operations and Maintenance	True	100	0

Total Marked-up Cost: $18,679,704.53

Technologies:

Technology: Operations and Maintenance

Element: Misc. Support Cost

Assembly	Description	Quantity	Unit of Measure	Material Unit Cost	Labor Unit Cost	Equipment Unit Cost	Sub Bid Cost	Extended Cost	Cost Override
33020345	Portable Air Sampler, Continuous, Daily Rental	2.00	DAY	0.00	0.00	0.00	28.94	$57.88	False
33020401	Disposable Materials per Sample	13.00	EA	12.12	0.00	0.00	0.00	$157.55	False
33020402	Decontamination Materials per Sample	12.00	EA	16.82	0.00	0.00	0.00	$201.81	False
33021535	Full Size, Portable, Automated Wastewater Sampler, Daily Rental	24.00	DAY	0.00	0.00	0.00	96.28	$2,310.72	False
33021670	Assumed Testing for PRASA, Metals Analysis	12.00	EA	0.00	0.00	0.00	548.68	$6,584.16	False
33021694	Assumed Testing for PRASA, TPH Analysis	12.00	EA	0.00	0.00	0.00	101.50	$1,218.00	False
33021721	Assumed Testing for PRASA, Sulfolane (SW8270)	12.00	EA	0.00	0.00	0.00	383.81	$4,605.71	False
33021803	Assumed Testing for PRASA, inorganics tests, GC/MS	1.00	EA	0.00	0.00	0.00	29.45	$29.45	False
33021834	Assumed Testing for PRASA, VOCs (TO-14)	1.00	EA	0.00	0.00	0.00	272.60	$272.60	False
33022042	Overnight delivery service, 21 to 50 lb packages	420.00	LB	0.00	0.00	0.00	7.03	$2,952.43	False
33022139	Assumed Testing for PRASA, BTEX (SW8260)	12.00	EA	0.00	0.00	0.00	83.76	$1,005.16	False
33220102	Project Manager	11.00	HR	0.00	106.77	0.00	0.00	$1,174.47	False
33220105	Project Engineer	118.00	HR	0.00	78.14	0.00	0.00	$9,220.52	False
33220108	Project Scientist	24.00	HR	0.00	89.04	0.00	0.00	$2,136.93	False
33220110	QA/QC Officer	6.00	HR	0.00	89.04	0.00	0.00	$534.23	False
33220112	Field Technician	2.00	HR	0.00	44.76	0.00	0.00	$89.52	False
33220114	Word Processing/Clerical	17.00	HR	0.00	48.06	0.00	0.00	$817.05	False
33220115	Draftsman/CADD	5.00	HR	0.00	51.54	0.00	0.00	$257.70	False
33223001	Treatment System Operator	151.00	HR	0.00	49.64	0.00	0.00	$7,495.67	False
33240101	Other Direct Costs	1.00	LS	543.15	0.00	0.00	0.00	$543.15	True

Total Element Cost: $41,665.00

Element: Air Sparging

Assembly	Description	Quantity	Unit of Measure	Material Unit Cost	Labor Unit Cost	Equipment Unit Cost	Sub Bid Cost	Extended Cost	Cost Override
33220105	Project Engineer	900.00	HR	0.00	105.15	0.00	0.00	$94,631.60	False
33420101	Electrical Charge	430,000.00	KWH	0.08	0.00	0.00	0.00	$34,916.00	True

Total Element Cost: $129,548.00

Element: Bioslurping

Assembly	Description	Quantity	Unit of Measure	Material Unit Cost	Labor Unit Cost	Equipment Unit Cost	Sub Bid Cost	Extended Cost	Cost Override
33220112	Field Technician	1,880.00	HR	0.00	51.92	0.00	0.00	$97,604.35	False

Total Element Cost: $97,604.00

Total 1st Year Tech Cost: $268,817.00

Total Phase Element Cost **$268,817.00**

Phase Markups Report

Phase Markups Report

Project: Chevron Phillips Puerto Rico Core LLC
Site: No Further Action
Phase: 02 - Semi-Annual Sampling and Quarterly VISM Sampling

Subcontracted Portion of Work

	Professional Labor	MLE*	SubBid	Total
Total Direct Cost	$0	$0	$1,359,803	$1,359,803
Overhead %	132.00%	25.00%	0.00%	
Overhead	$0	$0	$0	$0
Subtotal	$0	$0	$1,359,803	$1,359,803
Subcontractor Profit %	8.00%	8.00%	0.00%	
Subcontractor Profit	$0	$0	$0	$0
Total Subcontract Cost	$0	$0	$1,359,803	$1,359,803

Prime Contractor Portion of Work

	Professional Labor	MLE*	SubBid	Total
Total Direct Cost	$1,961,186	$203,590	$0	$2,164,776
Overhead %	132.00%	25.00%	0.00%	
Overhead	$2,588,765	$50,898	$0	$2,639,663
Prime Subtotal	$4,549,951	$254,488	$0	$4,804,438
Prime + Subcontract	$4,549,951	$254,488	$1,359,803	$6,164,241
Contingency %	8.00%	8.00%	8.00%	
Prime Contingency Cost	$363,996	$20,359	$108,784	$493,139
Prime + Subcontract + Contingency	$4,913,947	$274,847	$1,468,587	$6,657,380

Other Project Costs

	Professional Labor	MLE*	SubBid	Total
Contingency Allowance	$0	$0	$0	$0
Total Contract Cost + Contingency	$4,913,947	$274,847	$1,468,587	$6,657,380
Owner Cost %	11.00%	11.00%	11.00%	
Owner Cost	$540,534	$30,233	$161,545	$732,312
Total Contract Cost + Contingency + Owner Cost	$5,454,481	$305,080	$1,630,132	$7,389,692
Total No-Markup Items				$2,775
Grand Total				$7,392,467

MLE = Materials, Trade Labor, and Expenses

Phase Cost Over Time Report - No Further Action Alternative Long-Term Monitoring

System:

RACER Version: RACER® Version 11.2.16.0
Database Location: C:\Users\Jake Gallegos\Desktop\CPCPRC\CMS Report\RACER Files\RACER.mdb

Folder:

Folder Name: CMS V1

Project:

ID: CPCPRC 15605.04
Name: Chevron Phillips Puerto Rico Core LLC
Category: None

Location

State / Country: PUERTO RICO
City: PUERTO RICO AVERAGE

Location Modifier

Default	User
1.160	###

Options

Database: System Costs
Cost Database Date: 2015
Report Option: Calendar

Description CMS Report - Estimate of Potential Costs

Site:

ID: CPCPRC
Name: **No Further Action**
Type: None

Media/Waste Type

Primary: Groundwater
Secondary: Soil

Contaminant

Primary: Fuels
Secondary: Semi-Volatile Organic Compounds (SVOCs)

Documentation

Description: **No Further Action**
Support Team: Documentation of personnel used to provide support for estimator and preparation of the estimate.
References: Documentation of reference sources used in the preparation of the estimate.

Technology Name	Technology	2017	2018	2019	2020	2021	2022
MONITORING		$130,330	$117,139	$117,139	$117,139	$117,139	$117,139

Technology Name	Technology	2023	2024	2025	2026	2027	2028
MONITORING		$117,139	$117,139	$117,139	$117,139	$117,139	$117,139

Technology Name	Technology	2029	2030	2031	2032	2033	2034
MONITORING		$117,139	$117,139	$117,139	$117,139	$117,139	$117,139

Technology Name	Technology	2035	2036	2037	2038	2039	2040
MONITORING		$117,139	$117,139	$117,139	$117,139	$117,139	$117,139

Technology Name	Technology	2041	2042	2043	2044	2045	2046
MONITORING		$117,139	$117,139	$117,139	$117,139	$117,139	$117,139

Total Phase Cost	Technology	Total
MONITORING		**$3,527,353**

Phase Technology Cost Detail Report - No Further Action Alternative Long-Term Monitoring

System:

RACER Version: RACER® Version 11.2.16.0
Database Location: C:\Users\Jake Gallegos\Desktop\CPCPRC\CMS Report\RACER Files\RACER.mdb

Project:

ID: CPCPRC 15605.04
Name: Chevron Phillips Puerto Rico Core LLC
Category: None

Location

State / Country: PUERTO RICO
City: PUERTO RICO AVERAGE

Location Modifier

Default	User
1.160	1.160

Options

Database: System Costs
Cost Database Date: 2015
Report Option: Calendar

Description CMS Report - Estimate of Potential Costs

Site:

ID: CPCPRC
Name: **No Further Action**
Type: None

Media/Waste Type

Primary: Groundwater
Secondary: Soil

Contaminant

Primary: Fuels
Secondary: Semi-Volatile Organic Compounds (SVOCs)

Documentation

Description: **No Further Action**
Support Team: Documentation of personnel used to provide support for estimator and preparation of the estimate.
References: Documentation of reference sources used in the preparation of the estimate.

Phase Documentation:

Phase Type: Long Term Monitoring
Phase Name: 02 - Semi-Annual Sampling and Quarterly VISM Sampling
Description: 02 - Semi-Annual Sampling and Quarterly VISM Sampling
Approach: Ex Situ
Start Date: January, 2017
Labor Rate Group: System Labor Rate
Analysis Rate Group: System Analysis Rate
Phase Markup Templ: System Defaults

Technology Markups	Marku	% Prime	% Sub.
MONITORING	True	100	0

Total Marked-up Cost $7,392,466.93

Technologies:
Technology: MONITORING

Assembly	Description	Quantity	Unit of Measure	Material Unit Cost	Labor Unit Cost	Equipment Unit Cost	Sub Bid Cost		Extended Cost	Cost Override
33020401	Disposable Materials per Sample	143.00	EA	12.12	0.00	0.00	0.00		$1,733.00	False
33020402	Decontamination Materials per Sample	143.00	EA	16.82	0.00	0.00	0.00		$2,404.85	False
33020561	Sampling accessories, nylon tubing, 1/4" OD	2,185.00	LF	0.41	0.00	0.00	0.00		$887.11	False
33021509	Monitor well sampling equipment, rental, water quality testing parameter device rental	4.00	WK	0.00	0.00	0.00	98.60		$394.40	False
33022135	Testing, Sulfolane (SW8270)	143.00	EA	0.00	0.00	0.00	100.00		$14,300.00	True
33022150	Testing, BTEX (SW8260)	143.00	EA	0.00	0.00	0.00	50.00		$7,150.00	True
33220102	Project Manager	23.00	HR	0.00	106.77	0.00	0.00		$2,455.75	False
33220109	Staff Scientist	312.00	HR	0.00	98.00	0.00	0.00		$30,576.00	True
33220112	Field Technician	382.00	HR	0.00	44.76	0.00	0.00		$17,096.87	False
33230614	Peristaltic Pump, Weekly Rental	4.00	WK	0.00	0.00	0.00	104.40		$417.60	False
				Total Element Cost:				$77,416.00		

Element: Surface Water

Assembly	Description	Quantity	Unit of Measure	Material Unit Cost	Labor Unit Cost	Equipment Unit Cost	Sub Bid Cost		Extended Cost	Cost Override
33020401	Disposable Materials per Sample	10.00	EA	12.12	0.00	0.00	0.00		$121.19	False
33020402	Decontamination Materials per Sample	10.00	EA	16.82	0.00	0.00	0.00		$168.17	False
33020520	Hip Waders	1.00	EA	78.08	0.00	0.00	0.00		$78.08	False
33021509	Sampling equipment, rental, water quality testing parameter device rental	1.00	WK	0.00	0.00	0.00	98.60		$98.60	False
33022135	Testing, Sulfolane (SW8270)	10.00	EA	0.00	0.00	0.00	100.00		$1,000.00	True
33022150	Testing, BTEX (SW8260)	10.00	EA	0.00	0.00	0.00	50.00		$500.00	True
33220102	Project Manager	3.00	HR	0.00	106.77	0.00	0.00		$320.32	False
33220112	Field Technician	40.00	HR	0.00	44.76	0.00	0.00		$1,790.25	False
				Total Element Cost:				$4,077.00		

Element: Sediment

Assembly	Description	Quantity	Unit of Measure	Material Unit Cost	Labor Unit Cost	Equipment Unit Cost	Sub Bid Cost		Extended Cost	Cost Override
33020401	Disposable Materials per Sample	10.00	EA	12.12	0.00	0.00	0.00		$121.19	False
33020402	Decontamination Materials per Sample	10.00	EA	16.82	0.00	0.00	0.00		$168.17	False
33020520	Hip Waders	1.00	EA	78.08	0.00	0.00	0.00		$78.08	False
33020602	Sludge sampler, stainless steel, thread on, 3.25" x 12"	1.00	EA	745.64	0.00	0.00	0.00		$745.64	False
33021732	Testing, Sulfolane (SW8270)	10.00	EA	0.00	0.00	0.00	100.00		$1,000.00	True
33021776	Testing, BTEX (SW8260)	10.00	EA	0.00	0.00	0.00	50.00		$500.00	True
33220102	Project Manager	3.00	HR	0.00	106.77	0.00	0.00		$320.32	False
33220112	Field Technician	38.00	HR	0.00	44.76	0.00	0.00		$1,700.74	False
				Total Element Cost:				$4,634.00		

Element: Data Management

Assembly	Description	Quantity	Unit of Measure	Material Unit Cost	Labor Unit Cost	Equipment Unit Cost	Sub Bid Cost	Extended Cost	Cost Override
33220102	Project Manager	20.00	HR	0.00	106.77	0.00	0.00	$2,135.43	False
33220105	Project Engineer	30.00	HR	0.00	78.14	0.00	0.00	$2,344.22	False
33220108	Project Scientist	117.00	HR	0.00	89.04	0.00	0.00	$10,417.52	False
33220109	Staff Scientist	80.00	HR	0.00	51.54	0.00	0.00	$4,123.14	False
33220110	QA/QC Officer	28.00	HR	0.00	89.04	0.00	0.00	$2,493.08	False
33220112	Field Technician	12.00	HR	0.00	44.76	0.00	0.00	$537.07	False
33220114	Word Processing/Clerical	24.00	HR	0.00	48.06	0.00	0.00	$1,153.49	False
33220115	Draftsman/CADD	20.00	HR	0.00	51.54	0.00	0.00	$1,030.78	False

Total Element Cost: $24,235.00

Technology: MONITORING

Element: General Monitoring

Assembly	Description	Quantity	Unit of Measure	Material Unit Cost	Labor Unit Cost	Equipment Unit Cost	Sub Bid Cost	Extended Cost	Cost Override
33010104	Sample collection, vehicle mileage charge, car or van	180.00	MI	0.00	0.00	0.00	0.51	$91.80	True
33022043	Overnight delivery service, 51 to 70 lb packages	2,640.00	LB	0.00	0.00	0.00	7.12	$18,803.14	False
33220112	Field Technician	24.00	HR	0.00	44.76	0.00	0.00	$1,074.15	False

Total Element Cost: $19,969.00
Total 1st Year Tech Cost: $130,331.00

Total Phase Element Cost **$130,331.00**

Phase Markups Report

Phase Markups Report

Project: Chevron Phillips Puerto Rico Core LLC
Site: No Further Action
Phase: 03 - 5-Year Reviews

Subcontracted Portion of Work

	Professional Labor	MLE*	SubBid	Total
Total Direct Cost Over 30 Year Project Life	$0	$0	$1,357	$1,357
Overhead %	132.00%	25.00%	0.00%	
Overhead	$0	$0	$0	$0
Subtotal	$0	$0	$1,357	$1,357
Subcontractor Profit %	8.00%	8.00%	0.00%	
Subcontractor Profit	$0	$0	$0	$0
Total Subcontract Cost	$0	$0	$1,357	$1,357

Prime Contractor Portion of Work

	Professional Labor	MLE*	SubBid	Total
Total Direct Cost Over 30 Year Project Life	$118,680	$0	$0	$118,680
Overhead %	132.00%	25.00%	0.00%	
Overhead	$156,657	$0	$0	$156,657
Prime Subtotal	$275,337	$0	$0	$275,337
Prime + Subcontract	$275,337	$0	$1,357	$276,694
Contingency %	8.00%	8.00%	8.00%	
Prime Contingency Cost	$22,027	$0	$109	$22,135
Prime + Subcontract + Contingency	$297,364	$0	$1,465	$298,829

Other Project Costs

	Professional Labor	MLE*	SubBid	Total
Contingency Allowance	$0	$0	$0	$0
Total Contract Cost + Contingency	$297,364	$0	$1,465	$298,829
Owner Cost %	11.00%	11.00%	11.00%	
Owner Cost	$32,710	$0	$161	$32,871
Total Contract Cost + Contingency + Owner Cost	$330,074	$0	$1,627	$331,700
Total No-Markup Items				$24,060
Grand Total				$355,760

MLE = Materials, Trade Labor, and Expenses

Phase Cost Over Time Report - No Further Action 5-Year Reviews

	RACER Version:	RACER® Version 11.2.16.0
	Database Location:	C:\Users\Jake Gallegos\Desktop\CPCPRC\CMS Report\RACER Files\RACER.mdb
Project:		
	ID:	CPCPRC 15605.04
	Name:	Chevron Phillips Puerto Rico Core LLC
	Category:	None
Location		
	State / Country:	PUERTO RICO
	City:	PUERTO RICO AVERAGE
Location Modifier		**Default** 1.160 / **User** 1.160
Options		
	Database:	System Costs
	Cost Database Date:	2015
	Report Option:	Calendar
Description		CMS Report - Estimate of Potential Costs
Site:		
	ID:	CPCPRC
	Name:	**No Further Action**
	Type:	None
Media/Waste Type		
	Primary:	Groundwater
	Secondary:	Soil
Contaminant		
	Primary:	Fuels
	Secondary:	Semi-Volatile Organic Compounds (SVOCs)
Documentation		
	Description:	**No Further Action**
	Support Team:	Documentation of personnel used to provide support for estimator and preparation of the estimate.
	References:	Documentation of reference sources used in the preparation of the estimate.

Technology Name	Technology	2017	2018	2019	2020	2021	2022
Five-Year Review		$24,016	$0	$0	$0	$0	$24,016

Technology Name	Technology	2023	2024	2025	2026	2027	2028
Five-Year Review		$0	$0	$0	$0	$24,016	$0

Technology Name	Technology	2029	2030	2031	2032	2033	2034
Five-Year Review		$0	$0	$0	$24,016	$0	$0

Technology Name	Technology	2035	2036	2037	2038	2039	2040
Five-Year Review		$0	$0	$24,016	$0	$0	$0

Technology Name	Technology	2041	2042	Total
Five-Year Review		$0	$24,016	$144,097
Total Phase Cost				$144,097

Phase Technology Cost Detail Report - No Further Action 5-Year Reviews

System:

RACER Version:	RACER® Version 11.2.16.0
Database Location:	C:\Users\Jake Gallegos\Desktop\CPCPRC\CMS Report\RACER Files\RACER.mdb

Project:

ID:	CPCPRC 15605.04
Name:	Chevron Phillips Puerto Rico Core LLC
Category:	None

Location

State / Country:	PUERTO RICO
City:	PUERTO RICO AVERAGE

Location Modifier

Default	User
1.160	1.160

Options

Database:	System Costs
Cost Database Date:	2015
Report Option:	Calendar

Description CMS Report - Estimate of Potential Costs

Site:

ID:	CPCPRC
Name:	**No Further Action**
Type:	None

Media/Waste Type

Primary:	Groundwater
Secondary:	Soil

Contaminant

Primary:	Fuels
Secondary:	Semi-Volatile Organic Compounds (SVOCs)

Documentation

Description:	**No Further Action**
Support Team:	Documentation of personnel used to provide support for estimator and preparation of the estimate.
References:	Documentation of reference sources used in the preparation of the estimate.

Phase Documentation:

Phase Type:	**Site Closeout**
Phase Name:	**03 - 5-Year Reviews**
Description:	**03 - 5-Year Reviews**
Approach:	Ex Situ
Start Date:	January, 2022
Labor Rate Group:	System Labor Rate
Analysis Rate Group:	System Analysis Rate
Phase Markup Template:	System Defaults

Technology Markups	Markup	% Prime	% Sub.
Five-Year Review	True	100	0

Total Marked-up Cost: $355,760.40

Technologies:
Technology: Five-Year Review

Element: Document Review

Assembly	Description	Quantity	Unit of Measure	Material Unit Cost	Labor Unit Cost	Equipment Unit Cost	Sub Bid Cost	Extended Cost	Cost Override
33220102	Project Manager	12.00	HR	0.00	106.77	0.00	0.00	$1,281.24	False
33220105	Project Engineer	15.00	HR	0.00	78.14	0.00	0.00	$1,172.10	False
33220108	Project Scientist	11.00	HR	0.00	89.04	0.00	0.00	$979.42	False
33220109	Staff Scientist	23.00	HR	0.00	51.54	0.00	0.00	$1,185.40	False

Total Element Cost: $4,618.00

Element: Interviews

Assembly	Description	Quantity	Unit of Measure	Material Unit Cost	Labor Unit Cost	Equipment Unit Cost	Sub Bid Cost	Extended Cost	Cost Override
33220102	Project Manager	8.00	HR	0.00	106.77	0.00	0.00	$854.16	False

Total Element Cost: $854.00

Element: Site Inspection

Assembly	Description	Quantity	Unit of Measure	Material Unit Cost	Labor Unit Cost	Equipment Unit Cost	Sub Bid Cost	Extended Cost	Cost Override
33220102	Project Manager	12.00	HR	0.00	106.77	0.00	0.00	$1,281.24	False
33220105	Project Engineer	23.00	HR	0.00	78.14	0.00	0.00	$1,797.22	False
33220108	Project Scientist	19.00	HR	0.00	89.04	0.00	0.00	$1,691.73	False
33220109	Staff Scientist	20.00	HR	0.00	51.54	0.00	0.00	$1,030.78	False

Total Element Cost: $5,801.00

Element: Report

Assembly	Description	Quantity	Unit of Measure	Material Unit Cost	Labor Unit Cost	Equipment Unit Cost	Sub Bid Cost	Extended Cost	Cost Override
33220102	Project Manager	12.00	HR	0.00	106.77	0.00	0.00	$1,281.24	False
33220105	Project Engineer	31.00	HR	0.00	78.14	0.00	0.00	$2,422.34	False
33220108	Project Scientist	25.00	HR	0.00	89.04	0.00	0.00	$2,225.97	False
33220109	Staff Scientist	50.00	HR	0.00	51.54	0.00	0.00	$2,576.96	False

Total Element Cost: $8,507.00

Element: Travel

Assembly	Description	Quantity	Unit of Measure	Material Unit Cost	Labor Unit Cost	Equipment Unit Cost	Sub Bid Cost	Extended Cost	Cost Override
33010108	Sedan, Automobile, Rental	5.00	DAY	0.00	0.00	0.00	45.23	$226.14	False
33010202	Per Diem (per person)	10.00	DAY	0.00	0.00	0.00	221.00	$2,210.00	True
33041101	Airfare	2.00	LS	0.00	0.00	0.00	900.00	$1,800.00	True

Total Element Cost: $4,236.14
Total 1st Year Tech Cost: $24,016.14

Total Phase Element Cost **$24,016.14**

Alternative – 1 GW

Cost Estimate

Site Cost Summary Report - Alternative 1 GW Pump and Treat with ISCO in the Deep (with Markups)

System:

RACER Version:	RACER® Version 11.2.16.0
Database Location:	C:\Users\Jake Gallegos\Desktop\CPCPRC\CMS Report\RACER Files\RACER.mdb

Project:

ID:	CPCPRC 15605.04
Name:	Chevron Phillips Puerto Rico Core LLC
Category:	None

Location

State / Country:	PUERTO RICO
City:	PUERTO RICO AVERAGE

Location Modifier

Default	User	Reason for changes
1.160	1.160	

Options

Database:	System Costs
Cost Database Date:	2015
Report Option:	Calendar

Description CMS Report - Estimate of Potential Costs

ID:	CPCPRC
Name:	**Alternative 1 GW - Pump and Treat, ISCO in the Deep, 30 Years of LTM, and Closeout**
Type:	None

Media/Waste Type

Primary:	Groundwater
Secondary:	N/A

Contaminant

Primary:	Fuels
Secondary:	Semi-Volatile Organic Compounds (SVOCs)

Phase Names

Pre-Study
Study
Design
Removal/Interim Action
Remedial Action
Operations & Maintenance
Long Term Monitoring
Site Closeout

Documentation

Description:	**Alternative 1 GW - Pump and Treat in the Shallow, ISCO in the Deep, 30 Years of Groundwater LTM, and Closeout of the Pump and Treat System and Deep ISCO**
Support Team:	Documentation of personnel used to provide support for estimator and preparation of the estimate.
References:	Documentation of reference sources used in the preparation of the estimate.

Phase	Direct Cost	Markups	Total Cost
Study and Design	$700,000	$139,160	$839,160
Remedial Action - Install Pump and Treat and Deep ISCO	$1,837,069	$919,048	$2,756,117
Operations & Maintenance - Pump and Treat System (30 years)	$12,906,234	$8,584,034	$21,490,268
Long Term Monitoring - Groundwater LTM and Reporting (30 years)	$3,173,027	$3,553,749	$6,726,776
Closeout of Pump and Treat and ISCO Treatment and Vent Points	$1,604,408	$949,274	$2,553,681
Total Site Cost	$20,220,738	$14,145,265	$34,366,002

Phase Markups Report

Phase Markups Report

Project: Chevron Phillips Puerto Rico Core LLC
Site: Alternative 1 GW - Pump and Treat, ISCO in the Deep, 30 Years of LTM, and Closeout of P&T
Phase: 2 - Groundwater Pump & Treat System Installation

Subcontracted Portion of Work

	Professional Labor	MLE*	SubBid	Total
Total Direct Cost	$0	$0	$562,472	$562,472
Overhead %	132.00%	25.00%	0.00%	
Overhead	$0	$0	$0	$0
Subtotal	$0	$0	$562,472	$562,472
Subcontractor Profit %	8.00%	8.00%	0.00%	
Subcontractor Profit	$0	$0	$0	$0
Total Subcontract Cost	$0	$0	$562,472	$562,472

Prime Contractor Portion of Work

	Professional Labor	MLE*	SubBid	Total
Total Direct Cost	$21,070	$971,821	$0	$992,891
Overhead %	132.00%	25.00%	0.00%	
Overhead	$27,812	$242,955	$0	$270,767
Prime Subtotal	$48,882	$1,214,776	$0	$1,263,658
Prime + Subcontract	$48,882	$1,214,776	$562,472	$1,826,130
Contingency %	8.00%	8.00%	8.00%	
Prime Contingency Cost	$3,911	$97,182	$44,998	$146,090
Prime + Subcontract + Contingency	$52,792	$1,311,958	$607,470	$1,972,220

Other Project Costs

	Professional Labor	MLE*	SubBid	Total
Contingency Allowance	$0	$0	$0	$0
Total Contract Cost + Contingency	$52,792	$1,311,958	$607,470	$1,972,220
Owner Cost %	11.00%	11.00%	11.00%	
Owner Cost	$5,807	$144,315	$66,822	$216,944
Total Contract Cost + Contingency + Owner Cost	$58,599	$1,456,274	$674,292	$2,189,165
Total No-Markup Items				$0
Grand Total				$2,189,165

MLE = Materials, Trade Labor, and Expenses

Phase Technology Cost Detail Report - Alternative 1 GW Pump and Treat System Installation

System:

RACER Version: RACER® Version 11.2.16.0
Database Location: C:\Users\Jake Gallegos\Desktop\CPCPRC\CMS Report\RACER Files\RACER.mdb

Project:

ID: CPCPRC 15605.04
Name: Chevron Phillips Puerto Rico Core LLC
Category: None

Location

State / Country: PUERTO RICO
City: PUERTO RICO AVERAGE

Location Modifier	**Default**	**User**
	1.160	1.160

Options

Database: System Costs
Cost Database Date: 2015
Report Option: Calendar

Description CMS Report - Estimate of Potential Costs

Site:

ID: CPCPRC
Name: Alternative 1 GW - Pump and Treat, ISCO in the Deep, 30 Years of LTM, and Site Closeout
Type: None

Media/Waste Type

Primary: Groundwater
Secondary: N/A

Contaminant

Primary: Fuels
Secondary: Semi-Volatile Organic Compounds (SVOCs)

Documentation

Description: **Alternative 1 GW - Pump and Treat in the Shallow, ISCO in the Deep, 30 Years of Groundwater LTM, and Closeout of the Pump and Treat System**
Support Team: Documentation of personnel used to provide support for estimator and preparation of the estimate.
References: Documentation of reference sources used in the preparation of the estimate.

Phase Documentation:

Phase Type: Remedial Action
Phase Name: 2 - Groundwater Pump & Treat System Installation
Description: Groundwater Pump and Treat
Approach: Ex Situ
Start Date: January, 2017
Labor Rate Group: System Labor Rate
Analysis Rate Group: System Analysis Rate
Phase Markup Template: System Defaults

Technology Markups	**Mark**	**% Prime**	**% Sub.**
Groundwater Extraction Wells	True	100	0
Advanced Oxidation Processes	True	100	0

Total Marked-up Cost: $2,181,082.04

Technologies:

Technology: Groundwater Extraction Wells

Element:

Assembly	Description	Quantity	Unit of Measure	Material Unit Cost	Labor Unit Cost	Equipment Unit Cost	Sub Bid Cost	Extended Cost	Cost Override
17010101	Selective clearing, brush, light clearing, with dozer and brush rake, excludes removal offsite	100.00	ACR	0.00	119.42	106.70	0.00	$22,611.88	False
33020303	Organic Vapor Analyzer Rental, per Day	111.00	DAY	0.00	0.00	0.00	40.05	$4,445.28	False
33109666	30,000 Gallon Single-wall Steel Aboveground Tank, Includes Cradles, Coating, Fittings, Excludes Foundation, Pumps, Piping	3.00	EA	78,300.00	2,788.35	0.00	0.00	$243,265.04	False
33170808	Decontaminate Rig, Augers, Screen (Rental Equipment)	85.00	DAY	36.54	696.78	0.00	0.00	$62,332.59	False
33220112	Field Technician	260.00	HR	0.00	81.04	0.00	0.00	$21,069.70	False
33230103	6" PVC, Schedule 40, Well Casing	150.00	LF	15.78	13.92	12.31	0.00	$6,301.03	False
33230157	2" Pitless Adapter	50.00	EA	1,769.00	80.94	0.00	0.00	$92,497.01	False
33230203	6" PVC, Schedule 40, Well Screen	700.00	LF	24.71	13.92	12.31	0.00	$35,657.23	False
33230303	6" PVC, Well Plug	50.00	EA	58.00	21.76	19.24	0.00	$4,949.94	False
33230521	4" Submersible Pump, 0.3-7 GPM, Head <=140', 1/3 hp, w/ controls	50.00	EA	1,669.24	96.36	0.00	0.00	$88,279.87	False
33231103	Hollow Stem Auger, 11" Dia Borehole, Depth <= 100 ft	850.00	LF	0.00	23.96	28.55	0.00	$44,636.42	False
33231172	Split Spoon Sample, 2" x 24", During Drilling	85.00	LF	0.00	0.00	0.00	349.16	$29,678.60	False
33231182	DOT steel drums, 55 gal., open, 17C	235.00	EA	98.39	0.00	0.00	0.00	$23,121.93	False
33231186	Well Development Equipment Rental (weekly)	50.00	WK	0.00	0.00	0.00	295.80	$14,790.00	False
33231403	6" Screen, Filter Pack	700.00	LF	12.92	11.14	9.85	0.00	$23,736.36	False
33232103	6" Well, Bentonite Seal	50.00	EA	53.04	66.66	58.96	0.00	$8,932.92	False
33232206	Restricted Area, Well Protection (with 4 Posts & Explosionproof Receptacle)	50.00	EA	1,289.92	961.43	1.66	0.00	$112,650.09	False
33260425	1" PVC, Schedule 80, Connection Piping	3,500.00	LF	1.60	4.94	0.00	0.00	$22,876.61	False
33270441	4" PVC, Sch 80, Ball Valve	50.00	EA	161.24	70.19	0.00	0.00	$11,571.70	False

Total Element Cost: $873,404.00
Total 1st Year Tech Cost: $873,404.00

Technology: Advanced Oxidation Processes

Assembly	Description	Quantity	Unit of Measure	Material Unit Cost	Labor Unit Cost	Equipment Unit Cost	Sub Bid Cost	Extended Cost	Cost Override
10010102	Fire Protection Wtr Supply, Ord Hazard Fac 152.40mm (6" Pipe)	4.00	EA	239.73	67.27	0.05	0.00	$1,228.20	False
11010532	Panel board 277/480V 100A Mlo 24 Cir W/Bkr	1.00	EA	2,613.48	2,766.90	0.00	0.00	$5,380.38	False
11019001	Transformer Grounding	1.00	EA	63.25	218.70	0.00	0.00	$281.95	False
11020212	Fluorescent Hazardous Industrial Fixture	2.00	EA	4,853.62	658.78	0.00	0.00	$11,024.79	False
17030106	Fine Grading, 12G, 2 Passes	2,400.00	SY	0.00	0.64	0.41	0.00	$2,513.59	False
18020321	6" Structural Slab on Grade	1,500.00	SF	4.17	3.34	0.09	0.00	$11,397.92	False
19040439	3,000 Gallon Conical Bottom Vertical XLPE Tank	2.00	EA	5,695.02	435.65	113.98	0.00	$12,489.31	False
19040446	3,000 Gallon Conical Tank Stand	2.00	EA	3,049.92	145.29	38.01	0.00	$6,466.44	False
33120803	Peroxide System Mob/Assembly/Shakedown	1.00	EA	0.00	19,690.19	0.00	0.00	$19,690.19	False
33120805	Operator Health and Safety Course	1.00	EA	0.00	0.00	0.00	319.00	$319.00	False
33120828	225 KW High Intensity Ultraviolet, H2O2 Capital Equipment	1.00	EA	0.00	0.00	0.00	513,239.20	$513,239.20	False
33120848	Fugitive Emission Control System	1.00	EA	61,619.40	4,612.40	1,206.73	0.00	$67,438.53	False
33130116	0 - 50 GPM Cartridge Filter Equipment	5.00	EA	29.72	114.43	0.00	0.00	$720.73	False
33260204	4" Stainless Steel Piping, Schedule 40, Threaded, Includes Coupling 10' OC, Excludes Hangers	100.00	LF	115.42	41.29	0.00	0.00	$15,671.06	False
33290126	350 GPM, 10 HP, Transfer Pump with Motor, Valves, Piping	1.00	EA	8,936.06	5,161.26	0.00	0.00	$14,097.32	False

Total Element Cost: $681,958.60
Total 1st Year Tech Cost: $681,958.60

Total Phase Element Cost **$1,555,362.60**

Phase Markups Report

Phase Markups Report

Project: Chevron Phillips Puerto Rico Core LLC
Site: Alternative 1 GW - Pump and Treat, ISCO in the Deep, 30 Years of LTM, and Closeout of P&T
Phase: 4 - ISCO in the Deep Aquifer

Subcontracted Portion of Work

	Professional Labor	MLE	SubBid	Total
Total Direct Cost	$0	$0	$49,375	$49,375
Overhead %	132.00%	25.00%	0.00%	
Overhead	$0	$0	$0	$0
Subtotal	$0	$0	$49,375	$49,375
Subcontractor Profit %	8.00%	8.00%	0.00%	
Subcontractor Profit	$0	$0	$0	$0
Total Subcontract Cost	$0	$0	$49,375	$49,375

Prime Contractor Portion of Work

	Professional Labor	MLE	SubBid	Total
Total Direct Cost	$124,434	$107,898	$0	$232,332
Overhead %	132.00%	25.00%	0.00%	
Overhead	$164,252	$26,975	$0	$191,227
Prime Subtotal	$288,686	$134,873	$0	$423,559
Prime + Subcontract	$288,686	$134,873	$49,375	$472,933
Contingency %	8.00%	8.00%	8.00%	
Prime Contingency Cost	$23,095	$10,790	$3,950	$37,835
Prime + Subcontract + Contingency	$311,781	$145,663	$53,325	$510,768

Other Project Costs

	Professional Labor	MLE	SubBid	Total
Contingency Allowance	$0	$0	$0	$0
Total Contract Cost + Contingency	$311,781	$145,663	$53,325	$510,768
Owner Cost %	11.00%	11.00%	11.00%	
Owner Cost	$34,296	$16,023	$5,866	$56,184
Total Contract Cost + Contingency + Owner Cost	$346,077	$161,685	$59,190	$566,952
Total No-Markup Items				$0
Grand Total				$566,952

MLE = Materials, Trade Labor, and Expenses

Phase Technology Cost Detail Report - Alternative 1 GW ISCO in the Deep Aquifer

System:

RACER Version: RACER® Version 11.2.16.0
Database Location: C:\Users\Jake Gallegos\Desktop\CPCPRC\CMS Report\RACER Files\RACER.mdb

Project:

ID: CPCPRC 15605.04
Name: Chevron Phillips Puerto Rico Core LLC
Category: None

Location

State / Country: PUERTO RICO
City: PUERTO RICO AVERAGE

Location Modifier

Default	User
1.160	1.160

Options

Database: System Costs
Cost Database Date: 2015
Report Option: Calendar

Description CMS Report - Estimate of Potential Costs

Site:

ID: CPCPRC
Name: **Alternative 1 GW - Pump and Treat, ISCO in the Deep, 30 Years of LTM, and Closeout**
Type: None

Media/Waste Type

Primary: Groundwater
Secondary: N/A

Contaminant

Primary: Fuels
Secondary: Semi-Volatile Organic Compounds (SVOCs)

Documentation

Description: **Alternative 1 GW - Pump and Treat in the Shallow, ISCO in the Deep, 30 Years of Groundwater LTM, and Closeout of the Pump and Treat System**
Support Team: Documentation of personnel used to provide support for estimator and preparation of the estimate.
References: Documentation of reference sources used in the preparation of the estimate.

Phase Documentation:

Phase Type: Remedial Action
Phase Name: 4 - ISCO in the Deep Aquifer
Description: ISCO at 10 Deep Treatment Points
Approach: In Situ
Start Date: January, 2017
Labor Rate Group: System Labor Rate
Analysis Rate Group: System Analysis Rate
Phase Markup Template: System Defaults

Technology Markups	Marku	% Prime	% Sub.
Groundwater Monitoring Well	True	100	0
USER DEFINED ESTIMATE	True	100	0

Total Marked-up Cost: $566,952.47

Technologies:
Technology: Groundwater Monitoring Well

Element: Aquifer 1

Assembly	Description	Quantity	Unit of Measure	Material Unit Cost	Labor Unit Cost	Equipment Unit Cost	Sub Bid Cost	Extended Cost	Cost Override
33020303	Organic Vapor Analyzer Rental, per Day	6.00	DAY	0.00	0.00	0.00	40.05	$240.29	False
33021720	Testing, BTEX (SW8260)	30.00	EA	0.00	0.00	0.00	174.00	$5,220.00	False
33021721	Testing, Sulfolane (SW8270)	30.00	EA	0.00	0.00	0.00	383.81	$11,514.28	False
33170808	Decontaminate Rig, Augers, Screen (Rental Equipment)	6.00	DAY	36.54	696.78	0.00	0.00	$4,399.95	False
33220107	Senior Scientist	96.00	HR	0.00	120.13	0.00	0.00	$11,532.59	False
33220108	Project Scientist	96.00	HR	0.00	89.04	0.00	0.00	$8,547.71	False
33220111	Certified Industrial Hygienist	96.00	HR	0.00	150.00	0.00	0.00	$14,400.00	True
33220112	Field Technician	96.00	HR	0.00	65.00	0.00	0.00	$6,240.00	True
33221004	Equip. Operators, Oilers	96.00	HR	0.00	67.86	0.00	0.00	$6,514.41	False
33230111	2" PVC, Schedule 80, Well Casing	300.00	LF	5.45	5.80	5.13	0.00	$4,915.50	False
33230211	2" PVC, Schedule 80, Well Screen	100.00	LF	7.19	5.80	5.13	0.00	$1,812.50	False
33230301	2" PVC, Well Plug	10.00	EA	11.31	17.41	15.39	0.00	$441.09	False
33231101	Hollow Stem Auger, 8" Dia Borehole, Depth <= 100 ft	410.00	LF	0.00	19.61	23.36	0.00	$17,618.72	False
33231173	Split Spoon Sampling	90.00	LF	0.00	15.42	5.28	0.00	$1,862.85	False
33231401	2" Screen, Filter Pack	120.00	LF	5.19	4.48	3.96	0.00	$1,636.12	False
33231811	2" Well, Portland Cement Grout	270.00	LF	6.43	0.00	0.00	0.00	$1,735.99	False
33232101	2" Well, Bentonite Seal	10.00	EA	16.16	115.73	102.35	0.00	$2,342.37	False

Total Element Cost: $100,974.36

Element: General Aquifers

Assembly	Description	Quantity	Unit of Measure	Material Unit Cost	Labor Unit Cost	Equipment Unit Cost	Sub Bid Cost	Extended Cost	Cost Override
33010101	Mobilize/DeMobilize Drilling Rig & Crew	1.00	LS	0.00	1,740.59	752.79	0.00	$2,493.38	False
33231178	Move Rig/Equipment Around Site	9.00	EA	105.39	250.21	108.21	0.00	$4,174.28	False
33231182	DOT steel drums, 55 gal., open, 17C	20.00	EA	98.39	0.00	0.00	0.00	$1,967.82	False
33231504	Surface Pad, Concrete, 2' x 2' x 4"	10.00	EA	55.33	19.45	0.21	0.00	$749.90	False
33232301	5' Guard Posts, Cast Iron, Concrete Fill	40.00	EA	154.62	101.17	0.04	0.00	$10,233.28	False

Total Element Cost: $19,618.66
Total 1st Year Tech Cost: $120,593.03

Technology: USER DEFINED ESTIMATE - CHP Treatment Based on 2015 GW Pilot Test

Element:

Technology: USER DEFINED ESTIMATE

Assembly	Description	Quantity	Unit of Measure	Material Unit Cost	Labor Unit Cost	Equipment Unit Cost	Sub Bid Cost	Extended Cost	Cost Override
33220101	Senior Project Manager	80.00	HR	0.00	150.00	0.00	0.00	$12,000.00	True
33220107	Senior Scientist	160.00	HR	0.00	120.13	0.00	0.00	$19,220.98	False
33220108	Project Scientist	320.00	HR	0.00	89.04	0.00	0.00	$28,492.36	False
33220111	Certified Industrial Hygienist	160.00	HR	0.00	150.00	0.00	0.00	$24,000.00	True
33240101	Other Direct Costs	25.00	LS	0.00	0.00	1,800.00	0.00	$45,000.00	True
33240108	Capital Expenses - CHP - 6,000 lbs per treatment point	60,000.00	LBS	0.00	0.00	0.00	0.54	$32,400.00	True

Total Element Cost: $161,113.34
Total 1st Year Tech Cost: $161,113.34

Total Phase Element Cost **$281,706.37**

Phase Markups Report

Phase Markups Report

Project: Chevron Phillips Puerto Rico Core LLC
Site: Alternative 1 GW - Pump and Treat, ISCO in the Deep, 30 Years of LTM, and Closeout of P&T
Phase: 3 - Groundwater Pump & Treat O&M

Subcontracted Portion of Work

	Professional Labor	MLE*	SubBid	Total
Total Direct Cost Over 30 Year Project Life	$0	$0	$580,647	$580,647
Overhead %	132.00%	25.00%	0.00%	
Overhead	$0	$0	$0	$0
Subtotal	$0	$0	$580,647	$580,647
Subcontractor Profit %	8.00%	8.00%	0.00%	
Subcontractor Profit	$0	$0	$0	$0
Total Subcontract Cost	$0	$0	$580,647	$580,647

Prime Contractor Portion of Work

	Professional Labor	MLE*	SubBid	Total
Total Direct Cost Over 30 Year Project Life	$1,812,011	$10,513,577	$0	$12,325,588
Overhead %	132.00%	25.00%	0.00%	
Overhead	$2,391,855	$2,628,394	$0	$5,020,249
Prime Subtotal	$4,203,866	$13,141,971	$0	$17,345,837
Prime + Subcontract	$4,203,866	$13,141,971	$580,647	$17,926,483
Contingency %	8.00%	8.00%	8.00%	
Prime Contingency Cost	$336,309	$1,051,358	$46,452	$1,434,119
Prime + Subcontract + Contingency	$4,540,175	$14,193,329	$627,098	$19,360,602

Other Project Costs

Contingency Allowance	$0	$0	$0	$0
Total Contract Cost + Contingency	$4,540,175	$14,193,329	$627,098	$19,360,602
Owner Cost %	11.00%	11.00%	11.00%	
Owner Cost	$499,419	$1,561,266	$68,981	$2,129,666
Total Contract Cost + Contingency + Owner Cost	$5,039,594	$15,754,595	$696,079	$21,490,268
Total No-Markup Items				$0
Grand Total				$21,490,268

MLE = Materials, Trade Labor, and Expenses

Phase Cost Over Time Report - Alternative 1 GW Pump and Treat Sytem O&M

System:

RACER Version: RACER® Version 11.2.16.0
Database Location: C:\Users\Jake Gallegos\Desktop\CPCPRC\CMS Report\RACER Files\RACER.mdb

Folder:

Folder Name: CMS V1

Project:

ID: CPCPRC 15605.04
Name: Chevron Phillips Puerto Rico Core LLC
Category: None

Location

State / Country: PUERTO RICO
City: PUERTO RICO AVERAGE

Location Modifier

Default	User
1.160	1.160

Options

Database: System Costs
Cost Database Date: 2015
Report Option: Calendar

Description CMS Report - Estimate of Potential Costs

Site:

ID: CPCPRC
Name: **Alternative 1 GW - Pump and Treat, ISCO in the Deep, 30 Years of LTM, and Closeout**
Type: None

Media/Waste Type

Primary: Groundwater
Secondary: N/A

Contaminant

Primary: Fuels
Secondary: Semi-Volatile Organic Compounds (SVOCs)

Documentation

Description: **Alternative 1 GW - Pump and Treat in the Shallow, ISCO in the Deep, 30 Years of Groundwater LTM, and Closeout of the Pump and Treat System**
Support Team: Documentation of personnel used to provide support for estimator and preparation of the estimate.
References: Documentation of reference sources used in the preparation of the estimate.

Technology Name	Technology	2017	2018	2019	2020	2021	2022
Operations and Maintenance		$430,208	$430,208	$430,208	$430,208	$430,208	$430,208

Technology Name	Technology	2023	2024	2025	2026	2027	2028
Operations and Maintenance		$430,208	$430,208	$430,208	$430,208	$430,208	$430,208

Technology Name	Technology	2029	2030	2031	2032	2033	2034
Operations and Maintenance		$430,208	$430,208	$430,208	$430,208	$430,208	$430,208

Technology Name	Technology	2035	2036	2037	2038	2039	2040
Operations and Maintenance		$430,208	$430,208	$430,208	$430,208	$430,208	$430,208

Technology Name	Technology	2041	2042	2043	2044	2045	2046
Operations and Maintenance		$430,208	$430,208	$430,208	$430,208	$430,208	$430,208

Total Phase Cost	Technology	Total
Operations and Maintenance		$12,906,234

Phase Technology Cost Detail Report - Alternative 1 GW Pump and Treat Sytem O&M

System:

RACER Version:	RACER® Version 11.2.16.0
Database Location:	C:\Users\Jake Gallegos\Desktop\CPCPRC\CMS Report\RACER Files\RACER.mdb

Project:

ID:	CPCPRC 15605.04
Name:	Chevron Phillips Puerto Rico Core LLC
Category:	None

Location

State / Country:	PUERTO RICO
City:	PUERTO RICO AVERAGE

Location Modifier

Default	User
1.160	1.160

Options

Database:	System Costs
Cost Database Date:	2015
Report Option:	Calendar

Description CMS Report - Estimate of Potential Costs

Site:

ID:	CPCPRC
Name:	**Alternative 1 GW - Pump and Treat, ISCO in the Deep, 30 Years of LTM, and Closeout**
Type:	None

Media/Waste Type

Primary:	Groundwater
Secondary:	N/A

Contaminant

Primary:	Fuels
Secondary:	Semi-Volatile Organic Compounds (SVOCs)

Documentation

Description:	**Alternative 1 GW - Pump and Treat in the Shallow, ISCO in the Deep, 30 Years of Groundwater LTM, and Closeout of the Pump and Treat System**
Support Team:	Documentation of personnel used to provide support for estimator and preparation of the estimate.
References:	Documentation of reference sources used in the preparation of the estimate.

Phase Documentation:

Phase Type:	Operations & Maintenance
Phase Name:	3 - Groundwater Pump & Treat O&M
Description:	Operations and Maintenance - Groundwater Pump and Treat
Approach:	Ex Situ
Start Date:	#########
Labor Rate Group:	System Labor Rate
Analysis Rate Group:	System Analysis Rate
Phase Markup Templa	System Defaults

Technology Markups	Marku	Prime	% Sub.
Operations and Maintenance	True	100	0

Total Marked-up Cost $21,490,268.04

Technologies:
Technology: Operations and Maintenance

Assembly	Description	Quantity	Unit of Measure	Material Unit Cost	Labor Unit Cost	Equipment Unit Cost	Sub Bid Cost	Extended Cost	Cost Override
33020401	Disposable Materials per Sample	12.00	EA	12.12	0.00	0.00	0.00	$145.43	False
33020402	Decontamination Materials per Sample	12.00	EA	16.82	0.00	0.00	0.00	$201.81	False
33021535	Full Size, Portable, Automated Wastewater Sampler, Daily Rental	24.00	DAY	0.00	0.00	0.00	96.28	$2,310.72	False
33021670	Assumed testing, Metals Screen In Method EPA 200.7, Water Analysis	12.00	EA	0.00	0.00	0.00	548.68	$6,584.16	False
33021694	Assumed testing, Total Petroleum Hydrocarbons (SW8015B), Water Analysis	12.00	EA	0.00	0.00	0.00	101.50	$1,218.00	False
33021721	Testing, Sulfolane (SW8270)	12.00	EA	0.00	0.00	0.00	383.81	$4,605.71	False
33022042	Overnight delivery service, 21 to 50 lb packages	420.00	LB	0.00	0.00	0.00	7.03	$2,952.43	False
33022139	Testing, BTEX (SW8260)	12.00	EA	0.00	0.00	0.00	83.76	$1,005.16	False
33220102	Project Manager	100.00	HR	0.00	123.86	0.00	0.00	$12,385.55	False
33220108	Project Scientist	100.00	HR	0.00	89.04	0.00	0.00	$8,903.86	False
33220110	QA/QC Officer	100.00	HR	0.00	89.04	0.00	0.00	$8,903.86	False
33220112	Field Technician	640.00	HR	0.00	51.92	0.00	0.00	$33,227.02	False
33220114	Word Processing/Clerical	24.00	HR	0.00	48.06	0.00	0.00	$1,153.49	False
33223001	Treatment System Operator	1,880.00	HR	0.00	49.64	0.00	0.00	$93,323.61	False
33240101	Other Direct Costs	1.00	LS	241.19	0.00	0.00	0.00	$241.19	True
33420101	Electrical Charge	27,752.89	KWH	0.08	0.00	0.00	0.00	$2,253.53	False

Total Element Cost: $179,416.00

Element: Advanced Oxidation Processes
Technology: Operations and Maintenance

Assembly	Description	Quantity	Unit of Measure	Material Unit Cost	Labor Unit Cost	Equipment Unit Cost	Sub Bid Cost	Extended Cost	Cost Override
33120852	20 KW Ultraviolet Source High Intensity Lamp	33.00	EA	232.00	0.00	0.00	0.00	$7,656.00	False
33330171	Hydrogen Peroxide, 50% Solution, 500 Lb Drums	324.00	EA	388.60	0.00	0.00	0.00	$125,906.40	False
33420101	Electrical Charge	1,443,718.08	KWH	0.08	0.00	0.00	0.00	$117,229.90	False

Total Element Cost: $250,792.30
Total 1st Year Tech Cost: $430,208.30

Total Phase Element Cost **$430,208.30**

Phase Markups Report

Phase Markups Report

Project: Chevron Phillips Puerto Rico Core LLC
Site: Alternative 1 GW - Pump and Treat, ISCO in the Deep, 30 Years of LTM, and Closeout of P&T
Phase: 5 - Groundwater LTM

Subcontracted Portion of Work

	Professional Labor	MLE*	SubBid	Total
Total Direct Cost Over 30 Year Project Life	$0	$0	$1,196,147	$1,196,147
Overhead %	132.00%	25.00%	0.00%	
Overhead	$0	$0	$0	$0
Subtotal	$0	$0	$1,196,147	$1,196,147
Subcontractor Profit %	8.00%	8.00%	0.00%	
Subcontractor Profit	$0	$0	$0	$0
Total Subcontract Cost	$0	$0	$1,196,147	$1,196,147

Prime Contractor Portion of Work

	Professional Labor	MLE*	SubBid	Total
Total Direct Cost Over 30 Year Project Life	$1,817,912	$156,190	$0	$1,974,102
Overhead %	132.00%	25.00%	0.00%	
Overhead	$2,399,644	$39,047	$0	$2,438,692
Prime Subtotal	$4,217,557	$195,237	$0	$4,412,794
Prime + Subcontract	$4,217,557	$195,237	$1,196,147	$5,608,941
Contingency %	8.00%	8.00%	8.00%	
Prime Contingency Cost	$337,405	$15,619	$95,692	$448,715
Prime + Subcontract + Contingency	$4,554,961	$210,856	$1,291,839	$6,057,657
Other Project Costs				
Contingency Allowance	$0	$0	$0	$0
Total Contract Cost + Contingency	$4,554,961	$210,856	$1,291,839	$6,057,657
Owner Cost %	11.00%	11.00%	11.00%	
Owner Cost	$501,046	$23,194	$142,102	$666,342
Total Contract Cost + Contingency + Owner Cost	$5,056,007	$234,050	$1,433,941	$6,723,999
Total No-Markup Items				$2,777
Grand Total				$6,726,776

MLE = Materials, Trade Labor, and Expenses

Phase Cost Over Time Report - Alternative 1 GW Groundwater LTM

System:

RACER Version: RACER® Version 11.2.16.0
Database Location: C:\Users\Jake Gallegos\Desktop\CPCPRC\CMS Report\RACER Files\RACER.mdb

Folder:

Folder Name: CMS V1

Project:

ID: CPCPRC 15605.04
Name: Chevron Phillips Puerto Rico Core LLC
Category: None

Location

State / Country: PUERTO RICO
City: PUERTO RICO AVERAGE

Location Modifier

Default	User
1.160	1.160

Options

Database: System Costs
Cost Database Date: 2015
Report Option: Calendar

Description CMS Report - Estimate of Potential Costs

Site:

ID: CPCPRC
Name: **Alternative 1 GW - Pump and Treat, ISCO in the Deep, 30 Years of LTM, and Closeout**
Type: None

Media/Waste Type

Primary: Groundwater
Secondary: N/A

Contaminant

Primary: Fuels
Secondary: Semi-Volatile Organic Compounds (SVOCs)

Documentation

Description: **Alternative 1 GW - Pump and Treat in the Shallow, ISCO in the Deep, 30 Years of Groundwater LTM, and Closeout of the Pump and Treat System**
Support Team: Documentation of personnel used to provide support for estimator and preparation of the estimate.
References: Documentation of reference sources used in the preparation of the estimate.

Technology Name	Technology	2017	2018	2019	2020	2021	2022
MONITORING		$118,519	$105,328	$105,328	$105,328	$105,328	$105,328

Technology Name	Technology	2023	2024	2025	2026	2027	2028
MONITORING		$105,328	$105,328	$105,328	$105,328	$105,328	$105,328

Technology Name	Technology	2029	2030	2031	2032	2033	2034
MONITORING		$105,328	$105,328	$105,328	$105,328	$105,328	$105,328

Technology Name	Technology	2035	2036	2037	2038	2039	2040
MONITORING		$105,328	$105,328	$105,328	$105,328	$105,328	$105,328

Technology Name	Technology	2041	2042	2043	2044	2045	2046
MONITORING		$105,328	$105,328	$105,328	$105,328	$105,328	$105,328

Total Phase Cost	Technology	Total
MONITORING		**$3,173,027**

Phase Technology Cost Detail Report - Alternative 1 GW Groundwater LTM

System:

RACER Version:	RACER® Version 11.2.16.0
Database Location:	C:\Users\Jake Gallegos\Desktop\CPCPRC\CMS Report\RACER Files\RACER.mdb

Project:

ID:	CPCPRC 15605.04
Name:	Chevron Phillips Puerto Rico Core LLC
Category:	None

Location

State / Country:	PUERTO RICO
City:	PUERTO RICO AVERAGE

Location Modifier

Default	User
1.160	1.160

Options

Database:	System Costs
Cost Database Date:	2015
Report Option:	Calendar

Description CMS Report - Estimate of Potential Costs

Site:

ID:	CPCPRC
Name:	**Alternative 1 GW - Pump and Treat, ISCO in the Deep, 30 Years of LTM, and Closeout**
Type:	None

Media/Waste Type

Primary:	Groundwater
Secondary:	N/A

Contaminant

Primary:	Fuels
Secondary:	Semi-Volatile Organic Compounds (SVOCs)

Documentation

Description:	**Alternative 1 GW - Pump and Treat in the Shallow, ISCO in the Deep, 30 Years of Groundwater LTM, and Closeout of the Pump and Treat System**
Support Team:	Documentation of personnel used to provide support for estimator and preparation of the estimate.
References:	Documentation of reference sources used in the preparation of the estimate.

Phase Documentation:

Phase Type:	Long Term Monitoring
Phase Name:	5 - Groundwater LTM
Description:	5 - Groundwater LTM
Approach:	Ex Situ
Start Date:	January, 2017
Labor Rate Group:	System Labor Rate
Analysis Rate Group:	System Analysis Rate
Phase Markup Template:	System Defaults

Technology Markups	Marku	% Prime	% Sub.
MONITORING	True	100	0

Total Marked-up Cost: $6,726,775.91

Technologies:
Technology: MONITORING

Assembly	Description	Quantity	Unit of Measure	Material Unit Cost	Labor Unit Cost	Equipment Unit Cost	Sub Bid Cost	Extended Cost	Cost Override
33020401	Disposable Materials per Sample	143.00	EA	12.12	0.00	0.00	0.00	$1,733.00	False
33020402	Decontamination Materials per Sample	143.00	EA	16.82	0.00	0.00	0.00	$2,404.85	False
33020561	Lysimeter accessories, nylon tubing, 1/4" OD	2,185.00	LF	0.41	0.00	0.00	0.00	$887.11	False
33021509	Monitor well sampling equipment, rental, water quality testing parameter device rental	4.00	WK	0.00	0.00	0.00	98.60	$394.40	False
33022135	Testing, Sulfolane (SW8270)	143.00	EA	0.00	0.00	0.00	100.00	$14,300.00	True
33022150	Testing, BTEX (SW8260)	143.00	EA	0.00	0.00	0.00	50.00	$7,150.00	True
33220102	Project Manager	23.00	HR	0.00	106.77	0.00	0.00	$2,455.75	False
33220109	Staff Scientist	312.00	HR	0.00	98.00	0.00	0.00	$30,576.00	True
33220112	Field Technician	382.00	HR	0.00	44.76	0.00	0.00	$17,096.87	False
33230614	Peristaltic Pump, Weekly Rental	4.00	WK	0.00	0.00	0.00	104.40	$417.60	False

Total Element Cost: $77,416.00

Element: Data Management

Assembly	Description	Quantity	Unit of Measure	Material Unit Cost	Labor Unit Cost	Equipment Unit Cost	Sub Bid Cost	Extended Cost	Cost Override
33220102	Project Manager	19.00	HR	0.00	106.77	0.00	0.00	$2,028.66	False
33220105	Project Engineer	30.00	HR	0.00	78.14	0.00	0.00	$2,344.22	False
33220108	Project Scientist	110.00	HR	0.00	89.04	0.00	0.00	$9,794.25	False
33220109	Staff Scientist	80.00	HR	0.00	51.54	0.00	0.00	$4,123.14	False
33220110	QA/QC Officer	27.00	HR	0.00	89.04	0.00	0.00	$2,404.04	False
33220112	Field Technician	11.00	HR	0.00	44.76	0.00	0.00	$492.32	False
33220114	Word Processing/Clerical	23.00	HR	0.00	48.06	0.00	0.00	$1,105.43	False
33220115	Draftsman/CADD	19.00	HR	0.00	51.54	0.00	0.00	$979.25	False

Total Element Cost: $23,271.00

Element: General Monitoring

Assembly	Description	Quantity	Unit of Measure	Material Unit Cost	Labor Unit Cost	Equipment Unit Cost	Sub Bid Cost	Extended Cost	Cost Override
33010104	Sample collection, vehicle mileage charge, car or van	180.00	MI	0.00	0.00	0.00	0.51	$91.80	True
33022043	Overnight delivery service, 51 to 70 lb packages	2,340.00	LB	0.00	0.00	0.00	7.12	$16,666.42	False
33220112	Field Technician	24.00	HR	0.00	44.76	0.00	0.00	$1,074.15	False

Total Element Cost: $17,832.00
Total 1st Year Tech Cost: $118,519.00

Total Phase Element Cost **$118,519.00**

Phase Markups Report

Phase Markups Report

Project: Chevron Phillips Puerto Rico Core LLC
Site: Alternative 1 GW - Pump and Treat, ISCO in the Deep, 30 Years of LTM, and Closeout of P&T
Phase: 7 - Closeout of Pump and Treat System

Subcontracted Portion of Work

	Professional Labor	MLE*	SubBid	Total
Total Direct Cost	$0	$0	$0	$0
Overhead %	132.00%	25.00%	0.00%	
Overhead	$0	$0	$0	$0
Subtotal	$0	$0	$0	$0
Subcontractor Profit %	8.00%	8.00%	0.00%	
Subcontractor Profit	$0	$0	$0	$0
Total Subcontract Cost	$0	$0	$0	$0

Prime Contractor Portion of Work

	Professional Labor	MLE*	SubBid	Total
Total Direct Cost	$7,519	$1,452,792	$0	$1,460,311
Overhead %	132.00%	25.00%	0.00%	
Overhead	$9,925	$363,198	$0	$373,123
Prime Subtotal	$17,444	$1,815,990	$0	$1,833,434
Prime + Subcontract	$17,444	$1,815,990	$0	$1,833,434
Contingency %	8.00%	8.00%	8.00%	
Prime Contingency Cost	$1,396	$145,279	$0	$146,675
Prime + Subcontract + Contingency	$18,840	$1,961,269	$0	$1,980,109

Other Project Costs

	Professional Labor	MLE*	SubBid	Total
Contingency Allowance	$0	$0	$0	$0
Total Contract Cost + Contingency	$18,840	$1,961,269	$0	$1,980,109
Owner Cost %	11.00%	11.00%	11.00%	
Owner Cost	$2,072	$215,740	$0	$217,812
Total Contract Cost + Contingency + Owner Cost	$20,912	$2,177,009	$0	$2,197,921
Total No-Markup Items				$0
Grand Total				$2,197,921

MLE = Materials, Trade Labor, and Expenses

Phase Technology Cost Detail Report - Alternative 1 GW - Closeout of the Pump and Treat and Deep ISCO

System:

RACER Version: RACER® Version 11.2.16.0
Database Location: C:\Users\Jake Gallegos\Desktop\CPCPRC\CMS Report\RACER Files\RACER.mdb

Project:

ID: CPCPRC 15605.04
Name: Chevron Phillips Puerto Rico Core LLC
Category: None

Location

State / Country: PUERTO RICO
City: PUERTO RICO AVERAGE

Location Modifier

	Default	User
	1.160	1.160

Options

Database: System Costs
Cost Database Date: 2015
Report Option: Calendar

Description CMS Report - Estimate of Potential Costs

Site:

ID: CPCPRC
Name: **Alternative 1 GW - Pump and Treat, ISCO in the Deep, 30 Years of LTM, and Closeout**
Type: None

Media/Waste Type

Primary: Groundwater
Secondary: N/A

Contaminant

Primary: Fuels
Secondary: Semi-Volatile Organic Compounds (SVOCs)

Documentation

Description: **Alternative 1 GW - Pump and Treat in the Shallow, ISCO in the Deep, 30 Years of Groundwater LTM, and Closeout of the Pump and Treat System**
Support Team: Documentation of personnel used to provide support for estimator and preparation of the estimate.
References: Documentation of reference sources used in the preparation of the estimate.

Phase Documentation:

Phase Type: Site Closeout
Phase Name: 7 - Closeout of Pump and Treat System
Description: 7 - Closeout of GW P&T
Approach: Ex Situ
Start Date: January, 2017
Labor Rate Group: System Labor Rate
Analysis Rate Group: System Analysis Rate
Phase Markup Template: System Defaults

Technology Markups	Markup	% Prime	% Sub.
Cleanup and Landscaping	True	100	0
Well Abandonment	True	100	0

Total Marked-up Cost: $2,197,920.95

Technologies:

Technology: Cleanup, Peparation, and Landscaping

Assembly	Description	Quantity	Unit of Measure	Material Unit Cost	Labor Unit Cost	Equipment Unit Cost	Sub Bid Cost	Extended Cost	Cost Override
17040101	Cleaning Up, site debris clean up and removal	125.00	ACR	0.00	623.50	49.28	0.00	$84,097.60	False
18050101	Area Preparation, 67% Level & 33% Slope	125.00	ACR	0.00	23.19	26.67	0.00	$6,233.39	False
18050401	Seeding, 67% Level & 33% Slope, Hydroseeding	125.00	ACR	3,233.89	985.40	742.14	0.00	$620,179.22	False
18050408	Fertilizer, Hydro Spread	250.00	ACR	707.41	95.21	33.87	0.00	$209,122.38	False
18050413	Watering with 3,000-Gallon Tank Truck, per Pass	1,000.00	ACR	220.81	53.62	56.30	0.00	$330,732.37	False
18050415	Mowing	250.00	ACR	0.00	301.99	0.00	0.00	$75,497.07	False

Total Element Cost: $1,325,862.03

Total 1st Year Tech Cost: $1,325,862.03

Technology: Well Abandonment

Element:

Assembly	Description	Quantity	Unit of Measure	Material Unit Cost	Labor Unit Cost	Equipment Unit Cost	Sub Bid Cost	Extended Cost	Cost Override
33010101	Mobilize/DeMobilize Drilling Rig & Crew	1.00	LS	0.00	1,740.59	752.79	0.00	$2,493.38	False
33220112	Field Technician	168.00	HR	0.00	44.76	0.00	0.00	$7,518.93	False
33231101	Hollow Stem Auger, 8" Dia Borehole, Depth <= 100 ft	400.00	LF	0.00	19.61	23.36	0.00	$17,189.00	False
33231105	Hollow Stem Auger, 13-3/4" Dia Borehole, Depth <= 100 ft	900.00	LF	0.00	30.80	36.70	0.00	$60,750.08	False
33231178	Move Rig/Equipment Around Site	60.00	EA	105.39	250.21	108.21	0.00	$27,828.54	False
33231820	Grout Continuous Borehole	482.00	CF	38.73	0.00	0.00	0.00	$18,669.02	False

Total Element Cost: $134,449.00

Total 1st Year Tech Cost: $1,460,311.03

Total Phase Element Cost **$1,460,311.03**

Phase Markups Report

Phase Markups Report

Project: Chevron Phillips Puerto Rico Core LLC
Site: Alternative 1 GW - Pump and Treat, ISCO in the Deep, 30 Years of LTM, and Closeout
Phase: 06 - 5-Year Reviews

Subcontracted Portion of Work

	Professional Labor	MLE*	SubBid	Total
Total Direct Cost Over 30 Year Project Life	$0	$0	$1,357	$1,357
Overhead %	132.00%	25.00%	0.00%	
Overhead	$0	$0	$0	$0
Subtotal	$0	$0	$1,357	$1,357
Subcontractor Profit %	8.00%	8.00%	0.00%	
Subcontractor Profit	$0	$0	$0	$0
Total Subcontract Cost	$0	$0	$1,357	$1,357

Prime Contractor Portion of Work

	Professional Labor	MLE*	SubBid	Total
Total Direct Cost Over 30 Year Project Life	$118,680	$0	$0	$118,680
Overhead %	132.00%	25.00%	0.00%	
Overhead	$156,657	$0	$0	$156,657
Prime Subtotal	$275,337	$0	$0	$275,337
Prime + Subcontract	$275,337	$0	$1,357	$276,694
Contingency %	8.00%	8.00%	8.00%	
Prime Contingency Cost	$22,027	$0	$109	$22,135
Prime + Subcontract + Contingency	$297,364	$0	$1,465	$298,829

Other Project Costs

Contingency Allowance	$0	$0	$0	$0
Total Contract Cost + Contingency	$297,364	$0	$1,465	$298,829
Owner Cost %	11.00%	11.00%	11.00%	
Owner Cost	$32,710	$0	$161	$32,871
Total Contract Cost + Contingency + Owner Cost	$330,074	$0	$1,627	$331,700
Total No-Markup Items				$24,060
Grand Total				$355,760

MLE = Materials, Trade Labor, and Expenses

Phase Cost Over Time Report - Alternative 1 GW - 5-Year Reviews

RACER Version: RACER® Version 11.2.16.0
Database Location: C:\Users\Jake Gallegos\Desktop\CPCPRC\CMS Report\RACER Files\RACER.mdb

Project:

ID: CPCPRC 15605.04
Name: Chevron Phillips Puerto Rico Core LLC
Category: None

Location

State / Country: PUERTO RICO
City: PUERTO RICO AVERAGE

Location Modifier

Default	**User**
1.160	1.160

Options

Database: System Costs
Cost Database Date: 2015
Report Option: Calendar

Description CMS Report - Estimate of Potential Costs

Site:

ID: CPCPRC
Name: **Alternative 1 GW - Pump and Treat, ISCO in the Deep, 30 Years of LTM, and Closeout**
Type: None

Media/Waste Type

Primary: Groundwater
Secondary: Soil

Contaminant

Primary: Fuels
Secondary: Semi-Volatile Organic Compounds (SVOCs)

Documentation

Description: **Alternative 1 GW - Pump and Treat, ISCO in the Deep, 30 Years of LTM, and Closeout**
Support Team: Documentation of personnel used to provide support for estimator and preparation of the estimate.
References: Documentation of reference sources used in the preparation of the estimate.

Technology Name	Technology	2017	2018	2019	2020	2021	2022
Five-Year Review		$24,016	$0	$0	$0	$0	$24,016

Technology Name	Technology	2023	2024	2025	2026	2027	2028
Five-Year Review		$0	$0	$0	$0	$24,016	$0

Technology Name	Technology	2029	2030	2031	2032	2033	2034
Five-Year Review		$0	$0	$0	$24,016	$0	$0

Technology Name	Technology	2035	2036	2037	2038	2039	2040
Five-Year Review		$0	$0	$24,016	$0	$0	$0

Technology Name	Technology	2041	2042	Total
Five-Year Review		$0	$24,016	$144,097

Total Phase Cost $144,097

Phase Technology Cost Detail Report - Alternative 1 GW 5-Year Reviews

System:

RACER Version:	RACER® Version 11.2.16.0
Database Location:	C:\Users\Jake Gallegos\Desktop\CPCPRC\CMS Report\RACER Files\RACER.mdb

Project:

ID:	CPCPRC 15605.04
Name:	Chevron Phillips Puerto Rico Core LLC
Category:	None

Location

State / Country:	PUERTO RICO
City:	PUERTO RICO AVERAGE

Location Modifier

Default	User
1.160	1.160

Options

Database:	System Costs
Cost Database Date:	2015
Report Option:	Calendar

Description CMS Report - Estimate of Potential Costs

Site:

ID:	CPCPRC
Name:	Alternative 1 - No Further Action
Type:	None

Media/Waste Type

Primary:	Groundwater
Secondary:	Soil

Contaminant

Primary:	Fuels
Secondary:	Semi-Volatile Organic Compounds (SVOCs)

Documentation

Description:	**Alternative 1 GW - Pump and Treat, ISCO in the Deep, 30 Years of LTM, and Closeout**
Support Team:	Documentation of personnel used to provide support for estimator and preparation of the estimate.
References:	Documentation of reference sources used in the preparation of the estimate.

Phase Documentation:

Phase Type:	**Site Closeout**
Phase Name:	**06 - 5-Year Reviews**
Description:	**06 - 5-Year Reviews**
Approach:	Ex Situ
Start Date:	January, 2022
Labor Rate Group:	System Labor Rate
Analysis Rate Group:	System Analysis Rate
Phase Markup Template:	System Defaults

Technology Markups	Markup	% Prime	% Sub.
Five-Year Review	True	100	0

Total Marked-up Cost: $355,760.40

Technologies:
Technology: Five-Year Review

Element: Document Review

Assembly	Description	Quantity	Unit of Measure	Material Unit Cost	Labor Unit Cost	Equipment Unit Cost	Sub Bid Cost	Extended Cost	Cost Override
33220102	Project Manager	12.00	HR	0.00	106.77	0.00	0.00	$1,281.24	False
33220105	Project Engineer	15.00	HR	0.00	78.14	0.00	0.00	$1,172.10	False
33220108	Project Scientist	11.00	HR	0.00	89.04	0.00	0.00	$979.42	False
33220109	Staff Scientist	23.00	HR	0.00	51.54	0.00	0.00	$1,185.40	False

Total Element Cost: $4,618.00

Element: Interviews

Assembly	Description	Quantity	Unit of Measure	Material Unit Cost	Labor Unit Cost	Equipment Unit Cost	Sub Bid Cost	Extended Cost	Cost Override
33220102	Project Manager	8.00	HR	0.00	106.77	0.00	0.00	$854.16	False

Total Element Cost: $854.00

Element: Site Inspection

Assembly	Description	Quantity	Unit of Measure	Material Unit Cost	Labor Unit Cost	Equipment Unit Cost	Sub Bid Cost	Extended Cost	Cost Override
33220102	Project Manager	12.00	HR	0.00	106.77	0.00	0.00	$1,281.24	False
33220105	Project Engineer	23.00	HR	0.00	78.14	0.00	0.00	$1,797.22	False
33220108	Project Scientist	19.00	HR	0.00	89.04	0.00	0.00	$1,691.73	False
33220109	Staff Scientist	20.00	HR	0.00	51.54	0.00	0.00	$1,030.78	False

Total Element Cost: $5,801.00

Element: Report

Assembly	Description	Quantity	Unit of Measure	Material Unit Cost	Labor Unit Cost	Equipment Unit Cost	Sub Bid Cost	Extended Cost	Cost Override
33220102	Project Manager	12.00	HR	0.00	106.77	0.00	0.00	$1,281.24	False
33220105	Project Engineer	31.00	HR	0.00	78.14	0.00	0.00	$2,422.34	False
33220108	Project Scientist	25.00	HR	0.00	89.04	0.00	0.00	$2,225.97	False
33220109	Staff Scientist	50.00	HR	0.00	51.54	0.00	0.00	$2,576.96	False

Total Element Cost: $8,507.00

Element: Travel

Assembly	Description	Quantity	Unit of Measure	Material Unit Cost	Labor Unit Cost	Equipment Unit Cost	Sub Bid Cost	Extended Cost	Cost Override
33010108	Sedan, Automobile, Rental	5.00	DAY	0.00	0.00	0.00	45.23	$226.14	False
33010202	Per Diem (per person)	10.00	DAY	0.00	0.00	0.00	221.00	$2,210.00	True
33041101	Airfare	2.00	LS	0.00	0.00	0.00	900.00	$1,800.00	True

Total Element Cost: $4,236.14
Total 1st Year Tech Cost: $24,016.14

Total Phase Element Cost **$24,016.14**

Alternative – 2 GW

Cost Estimate

Cost Summary Report - Alternative 2 ISCO in the Shallow and Deep Aquifers (with Markups)

System:

RACER Version: RACER® Version 11.2.16.0
Database Location: C:\Users\Jake Gallegos\Desktop\CPCPRC\CMS Report\RACER Files\RACER.mdb

Folder:

Folder Name: CMS V1

Project:

ID: CPCPRC 15605.04
Name: Chevron Phillips Puerto Rico Core LLC
Category: None

Location

State / Country: PUERTO RICO
City: PUERTO RICO AVERAGE

Location Modifier	**Default**	**User**
	1.160	1.160

Options

Database: System Costs
Cost Database Date: 2015
Report Option: Calendar

Description CMS Report - Estimate of Potential Costs

Site:

ID: CPCPRC
Name: **Alternative 2 GW - ISCO using CHP in the Shallow and Deep, 5 Years of LTM**
Type: None

Media/Waste Type

Primary: Groundwater
Secondary: N/A

Contaminant

Primary: Fuels
Secondary: Semi-Volatile Organic Compounds (SVOCs)

Documentation

Description: **Alternative 2 GW - ISCO using CHP in the Shallow and Deep Aquifers, 5 years of Groundwater Monitoring, and one 5-Year Review**
Support Team: Documentation of personnel used to provide support for estimator and preparation of the estimate.
References: Documentation of reference sources used in the preparation of the estimate.

Phase	Direct Cost	Markups	Total Cost
Study and Design	$1,000,000	$198,800	$1,198,800
Remedial Action - Install ISCO treatment Points and Implement ISCO	$10,735,851	$2,184,610	$12,920,461
5-Years of Groundwater LTM and Reporting	$1,112,924	$1,164,940	$2,277,863
Closeout of the ISCO and 5-Year Review Report	$356,879	$191,716	$548,595
Total Site Cost	$13,205,654	$3,740,066	$16,945,719

Phase Markups Report

Phase Markups Report

Project: Chevron Phillips Puerto Rico Core LLC
Site: Alternative 2 GW - ISCO using CHP in the Shallow and Deep, 5 Years of LTM
Phase: 2 - ISCO in the Shallow Aquifer

Subcontracted Portion of Work

	Professional Labor	MLE*	SubBid	Total
Total Direct Cost	$0	$0	$9,554,145	$9,554,145
Overhead %	132.00%	25.00%	0.00%	
Overhead	$0	$0	$0	$0
Subtotal	$0	$0	$9,554,145	$9,554,145
Subcontractor Profit %	8.00%	8.00%	0.00%	
Subcontractor Profit	$0	$0	$0	$0
Total Subcontract Cost	$0	$0	$9,554,145	$9,554,145

Prime Contractor Portion of Work

	Professional Labor	MLE*	SubBid	Total
Total Direct Cost	$0	$0	$0	$0
Overhead %	132.00%	25.00%	0.00%	
Overhead	$0	$0	$0	$0
Prime Subtotal	$0	$0	$0	$0
Prime + Subcontract	$0	$0	$9,554,145	$9,554,145
Contingency %	8.00%	8.00%	8.00%	
Prime Contingency Cost	$0	$0	$764,332	$764,332
Prime + Subcontract + Contingency	$0	$0	$10,318,477	$10,318,477

Other Project Costs

	Professional Labor	MLE*	SubBid	Total
Contingency Allowance	$0	$0	$0	$0
Total Contract Cost + Contingency	$0	$0	$10,318,477	$10,318,477
Owner Cost %	11.00%	11.00%	11.00%	
Owner Cost	$0	$0	$1,135,032	$1,135,032
Total Contract Cost + Contingency + Owner Cost	$0	$0	$11,453,509	$11,453,509
Total No-Markup Items				$900,000
Grand Total				$12,353,509

MLE = Materials, Trade Labor, and Expenses

Phase Technology Cost Detail Report - Alternative 2 GW ISCO in the Shallow

System:

RACER Version: RACER® Version 11.2.16.0
Database Location: C:\Users\Jake Gallegos\Desktop\CPCPRC\CMS Report\RACER Files\RACER.mdb

Folder:

Folder Name: CMS V1

Project:

ID: CPCPRC 15605.04
Name: Chevron Phillips Puerto Rico Core LLC
Category: None

Location

State / Country: PUERTO RICO
City: PUERTO RICO AVERAGE

Location Modifier

	Default	User
	1.160	1.160

Options

Database: System Costs
Cost Database Date: 2015
Report Option: Calendar

Description CMS Report - Estimate of Potential Costs

Site:

ID: CPCPRC
Name: **Alternative 2 GW - ISCO using CHP in the Shallow and Deep, 5 Years of LTM**
Type: None

Media/Waste Type

Primary: Groundwater
Secondary: N/A

Contaminant

Primary: Fuels
Secondary: Semi-Volatile Organic Compounds (SVOCs)

Documentation

Description: **Alternative 2 GW - ISCO using CHP in the Shallow and Deep Aquifers, 5 years of Groundwater Monitoring, and one 5-Year Review**
Support Team: Documentation of personnel used to provide support for estimator and preparation of the estimate.
References: Documentation of reference sources used in the preparation of the estimate.

Phase Documentation:

Phase Type: Remedial Action
Phase Name: 2 - ISCO in the Shallow Aquifer
Description: ISCO using CHP
Approach: Ex Situ
Start Date: January, 2017
Labor Rate Group: System Labor Rate
Analysis Rate Group: System Analysis Rate
Phase Markup Template: System Defaults

Technology Markups	Marku	% Prime	% Sub.
ISCO Using CHP - Based on Field Pilot Test	True	100	0
Professional Labor Management	False	0	0

Total Marked-up Cost: $12,353,509.03

Technologies:

Technology: ISCO Using CHP - Based on Field Pilot Test

Assembly	Description	Quantity	Unit of Measure	Material Unit Cost	Labor Unit Cost	Equipment Unit Cost	Sub Bid Cost	Extended Cost	Cost Override
33240108	First Round of ISCO in all Treatment Points	1.00	LS	0.00	0.00	0.00	7,276,000.00	$7,276,000.00	True
33240107	2nd round of ISCO in 1/3 of the Shallow Treatment Points	1.00	LS	0.00	0.00	0.00	2,278,145.00	$2,278,145.00	True

Total Element Cost: $9,554,145.00
Total 1st Year Tech Cost: $9,554,145.00

Technology: Professional Labor Management

Element:

Assembly	Description	Quantity	Unit of Measure	Material Unit Cost	Labor Unit Cost	Equipment Unit Cost	Sub Bid Cost	Extended Cost	Cost Override
33220149	Lump Sum Percentage Labor - ISCO Field Efforts Field Manager, ISCO Crews, and CIHs	1.00	LS	0.00	0.00	0.00	900,000.00	$900,000.00	True

Total Element Cost: $900,000.00
Total 1st Year Tech Cost: $900,000.00

Total Phase Element Cost **$10,454,145.00**

Phase Markups Report

Phase Markups Report

Project: Chevron Phillips Puerto Rico Core LLC
Site: Alternative 2 GW - ISCO using CHP in the Shallow and Deep, 5 Years of LTM
Phase: 2 - ISCO in the Deep Aquifer

Subcontracted Portion of Work

	Professional Labor	MLE*	SubBid	Total
Total Direct Cost	$0	$0	$49,375	$49,375
Overhead %	132.00%	25.00%	0.00%	
Overhead	$0	$0	$0	$0
Subtotal	$0	$0	$49,375	$49,375
Subcontractor Profit %	8.00%	8.00%	0.00%	
Subcontractor Profit	$0	$0	$0	$0
Total Subcontract Cost	$0	$0	$49,375	$49,375

Prime Contractor Portion of Work

	Professional Labor	MLE*	SubBid	Total
Total Direct Cost Over	$124,434	$107,898	$0	$232,332
Overhead %	132.00%	25.00%	0.00%	
Overhead	$164,252	$26,975	$0	$191,227
Prime Subtotal	$288,686	$134,873	$0	$423,559
Prime + Subcontract	$288,686	$134,873	$49,375	$472,933
Contingency %	8.00%	8.00%	8.00%	
Prime Contingency Cost	$23,095	$10,790	$3,950	$37,835
Prime + Subcontract + Contingency	$311,781	$145,663	$53,325	$510,768

Other Project Costs

	Professional Labor	MLE*	SubBid	Total
Contingency Allowance	$0	$0	$0	$0
Total Contract Cost + Contingency	$311,781	$145,663	$53,325	$510,768
Owner Cost %	11.00%	11.00%	11.00%	
Owner Cost	$34,296	$16,023	$5,866	$56,184
Total Contract Cost + Contingency + Owner Cost	$346,077	$161,685	$59,190	$566,952
Total No-Markup Items				$0
Grand Total				$566,952

MLE = Materials, Trade Labor, and Expenses

Phase Technology Cost Detail Report - Alternative 2 GW ISCO in the Deep Aquifer

System:

RACER Version:	RACER® Version 11.2.16.0
Database Location	C:\Users\Jake Gallegos\Desktop\CPCPRC\CMS Report\RACER Files\RACER.mdb

Project:

ID:	CPCPRC 15605.04
Name:	Chevron Phillips Puerto Rico Core LLC
Category:	None

Location

State / Country:	PUERTO RICO
City:	PUERTO RICO AVERAGE

Location Modifier

Default	User
1.160	1.160

Options

Database:	System Costs
Cost Database Date:	2015
Report Option:	Calendar

Description CMS Report - Estimate of Potential Costs

Site:

ID:	CPCPRC
Name:	**Alternative 2 GW - ISCO using CHP in the Shallow and Deep, 5 Years of LTM**
Type:	None

Media/Waste Type

Primary:	Groundwater
Secondary:	N/A

Contaminant

Primary:	Fuels
Secondary:	Semi-Volatile Organic Compounds (SVOCs)

Documentation

Description:	**Alternative 2 GW - ISCO using CHP in the Shallow and Deep, 5 Years of LTM**
Support Team:	Documentation of personnel used to provide support for estimator and preparation of the estimate.
References:	Documentation of reference sources used in the preparation of the estimate.

Phase Documentation:

Phase Type:	Remedial Action
Phase Name:	ISCO in the Deep Aquifer
Description:	ISCO at 10 Deep Treatment Points
Approach:	In Situ
Start Date:	January, 2017
Labor Rate Group:	System Labor Rate
Analysis Rate Group:	System Analysis Rate
Phase Markup Templa	System Defaults

Technology Markups	**Marku**	**% Prime**	**% Sub.**
Groundwater Monitoring Well	True	100	0
USER DEFINED ESTIMATE	True	100	0

Total Marked-up Cost $566,952.47

Technologies:

Technology: Groundwater Monitoring Well

Element: Aquifer 1

Assembly	Description	Quantity	Unit of Measure	Material Unit Cost	Labor Unit Cost	Equipment Unit Cost	Sub Bid Cost	Extended Cost	Cost Override
33020303	Organic Vapor Analyzer Rental, per Day	6.00	DAY	0.00	0.00	0.00	40.05	$240.29	False
33021720	Testing, BTEX (SW8260)	30.00	EA	0.00	0.00	0.00	174.00	$5,220.00	False
33021721	Testing, Sulfolane (SW8270)	30.00	EA	0.00	0.00	0.00	383.81	$11,514.28	False
33170808	Decontaminate Rig, Augers, Screen (Rental Equipment)	6.00	DAY	36.54	696.78	0.00	0.00	$4,399.95	False
33220107	Senior Scientist	96.00	HR	0.00	120.13	0.00	0.00	$11,532.59	False
33220108	Project Scientist	96.00	HR	0.00	89.04	0.00	0.00	$8,547.71	False
33220111	Certified Industrial Hygienist	96.00	HR	0.00	150.00	0.00	0.00	$14,400.00	True
33220112	Field Technician	96.00	HR	0.00	65.00	0.00	0.00	$6,240.00	True
33221004	Equip. Operators, Oilers	96.00	HR	0.00	67.86	0.00	0.00	$6,514.41	False
33230111	2" PVC, Schedule 80, Well Casing	300.00	LF	5.45	5.80	5.13	0.00	$4,915.50	False
33230211	2" PVC, Schedule 80, Well Screen	100.00	LF	7.19	5.80	5.13	0.00	$1,812.50	False
33230301	2" PVC, Well Plug	10.00	EA	11.31	17.41	15.39	0.00	$441.09	False
33231101	Hollow Stem Auger, 8" Dia Borehole, Depth <= 100 ft	410.00	LF	0.00	19.61	23.36	0.00	$17,618.72	False
33231173	Split Spoon Sampling	90.00	LF	0.00	15.42	5.28	0.00	$1,862.85	False
33231401	2" Screen, Filter Pack	120.00	LF	5.19	4.48	3.96	0.00	$1,636.12	False
33231811	2" Well, Portland Cement Grout	270.00	LF	6.43	0.00	0.00	0.00	$1,735.99	False
33232101	2" Well, Bentonite Seal	10.00	EA	16.16	115.73	102.35	0.00	$2,342.37	False

Total Element Cost: $100,974.36

Element: General Aquifers

Assembly	Description	Quantity	Unit of Measure	Material Unit Cost	Labor Unit Cost	Equipment Unit Cost	Sub Bid Cost	Extended Cost	Cost Override
33010101	Mobilize/DeMobilize Drilling Rig & Crew	1.00	LS	0.00	1,740.59	752.79	0.00	$2,493.38	False
33231178	Move Rig/Equipment Around Site	9.00	EA	105.39	250.21	108.21	0.00	$4,174.28	False
33231182	DOT steel drums, 55 gal., open, 17C	20.00	EA	98.39	0.00	0.00	0.00	$1,967.82	False
33231504	Surface Pad, Concrete, 2' x 2' x 4"	10.00	EA	55.33	19.45	0.21	0.00	$749.90	False
33232301	5' Guard Posts, Cast Iron, Concrete Fill	40.00	EA	154.62	101.17	0.04	0.00	$10,233.28	False

Total Element Cost: $19,618.66

Total 1st Year Tech Cost: $120,593.03

Technology: USER DEFINED ESTIMATE - CHP Treatment Based on 2015 GW Pilot Test

Element:

Technology: USER DEFINED ESTIMATE

Assembly	Description	Quantity	Unit of Measure	Material Unit Cost	Labor Unit Cost	Equipment Unit Cost	Sub Bid Cost	Extended Cost	Cost Override
33220101	Senior Project Manager	80.00	HR	0.00	150.00	0.00	0.00	$12,000.00	True
33220107	Senior Scientist	160.00	HR	0.00	120.13	0.00	0.00	$19,220.98	False
33220108	Project Scientist	320.00	HR	0.00	89.04	0.00	0.00	$28,492.36	False
33220111	Certified Industrial Hygienist	160.00	HR	0.00	150.00	0.00	0.00	$24,000.00	True
33240101	Other Direct Costs	25.00	LS	0.00	0.00	1,800.00	0.00	$45,000.00	True
33240108	Capital Expenses - CHP - 6,000 lbs per treatment point	60,000.00	LBS	0.00	0.00	0.00	0.54	$32,400.00	True

Total Element Cost: $161,113.34

Total 1st Year Tech Cost: $161,113.34

Total Phase Element Cost **$281,706.37**

Phase Markups Report

Phase Markups Report

Project: Chevron Phillips Puerto Rico Core LLC
Site: Alternative 2 GW - ISCO using CHP in the Shallow and Deep, 5 Years of LTM
Phase: 4 - Groundwater LTM

Subcontracted Portion of Work

	Professional Labor	MLE*	SubBid	Total
Total Direct Cost Over 5 Years	$0	$0	$471,717	$471,717
Overhead %	132.00%	25.00%	0.00%	
Overhead	$0	$0	$0	$0
Subtotal	$0	$0	$471,717	$471,717
Subcontractor Profit %	8.00%	8.00%	0.00%	
Subcontractor Profit	$0	$0	$0	$0
Total Subcontract Cost	$0	$0	$471,717	$471,717

Prime Contractor Portion of Work

	Professional Labor	MLE*	SubBid	Total
Total Direct Cost Over 5 Years	$586,103	$54,538	$0	$640,640
Overhead %	132.00%	25.00%	0.00%	
Overhead	$773,655	$13,634	$0	$787,290
Prime Subtotal	$1,359,758	$68,172	$0	$1,427,930
Prime + Subcontract	$1,359,758	$68,172	$471,717	$1,899,648
Contingency %	8.00%	8.00%	8.00%	
Prime Contingency Cost	$108,781	$5,454	$37,737	$151,972
Prime + Subcontract + Contingency	$1,468,539	$73,626	$509,455	$2,051,620
Other Project Costs				
Contingency Allowance	$0	$0	$0	$0
Total Contract Cost + Contingency	$1,468,539	$73,626	$509,455	$2,051,620
Owner Cost %	11.00%	11.00%	11.00%	
Owner Cost	$161,539	$8,099	$56,040	$225,678
Total Contract Cost + Contingency + Owner Cost	$1,630,078	$81,725	$565,495	$2,277,298
Total No-Markup Items				$566
Grand Total				$2,277,863

MLE = Materials, Trade Labor, and Expenses

Phase Cost Over Time Report - Alternative 2 GW Groundwater LTM

System:

RACER Version: RACER® Version 11.2.16.0
Database Location: C:\Users\Jake Gallegos\Desktop\CPCPRC\CMS Report\RACER Files\RACER.mdb

Folder:

Folder Name: CMS V1

Project:

ID: CPCPRC 15605.04
Name: Chevron Phillips Puerto Rico Core LLC
Category: None

Location

State / Country: PUERTO RICO
City: PUERTO RICO AVERAGE

Location Modifier

Default	User
1.160	1.160

Options

Database: System Costs
Cost Database Date: 2015
Report Option: Calendar

Description CMS Report - Estimate of Potential Costs

Site:

ID: CPCPRC
Name: **Alternative 2 GW - ISCO using CHP in the Shallow and Deep, 5 Years of LTM**
Type: None

Media/Waste Type

Primary: Groundwater
Secondary: N/A

Contaminant

Primary: Fuels
Secondary: Semi-Volatile Organic Compounds (SVOCs)

Documentation

Description: **Alternative 2 GW - ISCO using CHP in the Shallow and Deep Aquifers, 5 years of Groundwater Monitoring, and one 5-Year Review**
Support Team: Documentation of personnel used to provide support for estimator and preparation of the estimate.
References: Documentation of reference sources used in the preparation of the estimate.

Technology Name	Technology	2017	2018	2019	2020	2021	Total
MONITORING		$563,126	$137,449	$137,449	$137,449	$137,449	$1,112,924
Total Phase Cost							**$1,112,924**

Phase Technology Cost Detail Report - Alternative 2 GW Groundwater LTM

System:

RACER Version:	RACER® Version 11.2.16.0
Database Location:	C:\Users\Jake Gallegos\Desktop\CPCPRC\CMS Report\RACER Files\RACER.mdb

Project:

ID:	CPCPRC 15605.04
Name:	Chevron Phillips Puerto Rico Core LLC
Category:	None

Location

State / Country:	PUERTO RICO
City:	PUERTO RICO AVERAGE

Location Modifier

Default	User
1.160	1.160

Options

Database:	System Costs
Cost Database Date:	2015
Report Option:	Calendar

Description CMS Report - Estimate of Potential Costs

Site:

ID:	CPCPRC
Name:	**Alternative 2 GW - ISCO using CHP in the Shallow and Deep, 5 Years of LTM**
Type:	None

Media/Waste Type

Primary:	Groundwater
Secondary:	N/A

Contaminant

Primary:	Fuels
Secondary:	Semi-Volatile Organic Compounds (SVOCs)

Documentation

Description:	**Alternative 2 GW - ISCO using CHP in the Shallow and Deep Aquifers, 5 years of Groundwater Monitoring, and one 5-Year Review**
Support Team:	Documentation of personnel used to provide support for estimator and preparation of the estimate.
References:	Documentation of reference sources used in the preparation of the estimate.

Phase Documentation:

Phase Type:	Operations & Maintenance
Phase Name:	4 - Groundwater LTM
Description:	4 - Groundwater LTM
Approach:	Ex Situ
Start Date:	January, 2017
Labor Rate Group:	System Labor Rate
Analysis Rate Group:	System Analysis Rate
Phase Markup Template:	System Defaults

Technology Markups	Markup	% Prime	% Sub.
MONITORING	True	100	0

Total Marked-up Cost: $2,277,863.31

Technologies:
Technology: MONITORING

Element: Groundwater

Assembly	Description	Quantity	Unit of Measure	Material Unit Cost	Labor Unit Cost	Equipment Unit Cost	Sub Bid Cost	Extended Cost	Cost Override
33020401	Disposable Materials per Sample	831.00	EA	12.12	0.00	0.00	0.00	$10,070.80	False
33020402	Decontamination Materials per Sample	831.00	EA	16.82	0.00	0.00	0.00	$13,975.01	False
33020561	Lysimeter accessories, nylon tubing, 1/4" OD	3,025.00	LF	0.41	0.00	0.00	0.00	$1,228.15	False
33021509	Monitor well sampling equipment, rental, water quality testing parameter device rental	18.00	WK	0.00	0.00	0.00	98.60	$1,774.80	False
33022135	Testing, Sulfolane (SW8270)	831.00	EA	0.00	0.00	0.00	100.00	$83,100.00	True
33022150	Testing, BTEX (SW8260)	831.00	EA	0.00	0.00	0.00	50.00	$41,550.00	True
33220102	Project Manager	800.00	HR	0.00	123.86	0.00	0.00	$99,084.37	False
33220112	Field Technician	1,662.00	HR	0.00	44.76	0.00	0.00	$74,384.80	False
33230614	Peristaltic Pump, Weekly Rental	18.00	WK	0.00	0.00	0.00	104.40	$1,879.20	False

Total Element Cost: $327,047.00

Element: Data Management

Assembly	Description	Quantity	Unit of Measure	Material Unit Cost	Labor Unit Cost	Equipment Unit Cost	Sub Bid Cost	Extended Cost	Cost Override
33220102	Project Manager	240.00	HR	0.00	123.86	0.00	0.00	$29,725.31	False
33220105	Project Engineer	150.00	HR	0.00	78.14	0.00	0.00	$11,721.11	False
33220108	Project Scientist	317.00	HR	0.00	89.04	0.00	0.00	$28,225.24	False
33220109	Staff Scientist	440.00	HR	0.00	51.54	0.00	0.00	$22,677.26	False
33220110	QA/QC Officer	196.00	HR	0.00	89.04	0.00	0.00	$17,451.57	False
33220114	Word Processing/Clerical	108.00	HR	0.00	48.06	0.00	0.00	$5,190.70	False
33220115	Draftsman/CADD	60.00	HR	0.00	59.79	0.00	0.00	$3,587.13	False

Total Element Cost: $118,578.00

Element: General Monitoring

Assembly	Description	Quantity	Unit of Measure	Material Unit Cost	Labor Unit Cost	Equipment Unit Cost	Sub Bid Cost	Extended Cost	Cost Override
33010104	Sample collection, vehicle mileage charge, car or van	540.00	MI	0.00	0.00	0.00	0.51	$275.40	True
33022043	Overnight delivery service, 51 to 70 lb packages	13,320.00	LB	0.00	0.00	0.00	7.12	$94,870.37	False
33220112	Field Technician	320.00	HR	0.00	69.86	0.00	0.00	$22,355.11	False

Total Element Cost: $117,501.00
Total 1st Year Tech Cost: $563,126.00

Total Phase Element Cost **$563,126.00**

Phase Markups Report

Phase Markups Report

Project: Chevron Phillips Puerto Rico Core LLC
Site: Alternative 2 GW - ISCO using CHP in the Shallow and Deep, 5 Years of LTM
Phase: 6 - Closeout of ISCO System

Subcontracted Portion of Work

	Professional Labor	MLE*	SubBid	Total
Total Direct Cost	$0	$0	$165,000	$165,000
Overhead %	132.00%	25.00%	0.00%	
Overhead	$0	$0	$0	$0
Subtotal	$0	$0	$165,000	$165,000
Subcontractor Profit %	8.00%	8.00%	0.00%	
Subcontractor Profit	$0	$0	$0	$0
Total Subcontract Cost	$0	$0	$165,000	$165,000

Prime Contractor Portion of Work

	Professional Labor	MLE*	SubBid	Total
Total Direct Cost	$31,150	$136,712	$0	$167,863
Overhead %	132.00%	25.00%	0.00%	
Overhead	$41,118	$34,178	$0	$75,297
Prime Subtotal	$72,269	$170,890	$0	$243,159
Prime + Subcontract	$72,269	$170,890	$165,000	$408,159
Contingency %	8.00%	8.00%	8.00%	
Prime Contingency Cost	$5,782	$13,671	$13,200	$32,653
Prime + Subcontract + Contingency	$78,050	$184,562	$178,200	$440,812

Other Project Costs

	Professional Labor	MLE*	SubBid	Total
Contingency Allowance	$0	$0	$0	$0
Total Contract Cost + Contingency	$78,050	$184,562	$178,200	$440,812
Owner Cost %	11.00%	11.00%	11.00%	
Owner Cost	$8,586	$20,302	$19,602	$48,489
Total Contract Cost + Contingency + Owner Cost	$86,636	$204,863	$197,802	$489,301
Total No-Markup Items				$0
Grand Total				$489,301

MLE = Materials, Trade Labor, and Expenses

Phase Technology Cost Detail Report - Alternative 2 GW Closeout ISCO

System:

RACER Version:	RACER® Version 11.2.16.0
Database Location:	C:\Users\Jake Gallegos\Desktop\CPCPRC\CMS Report\RACER Files\RACER.mdb

Project:

ID:	CPCPRC 15605.04
Name:	Chevron Phillips Puerto Rico Core LLC
Category:	None

Location

State / Country:	PUERTO RICO
City:	PUERTO RICO AVERAGE

Location Modifier

Default	User
1.160	1.160

Options

Database:	System Costs
Cost Database Date:	2015
Report Option:	Calendar

Description CMS Report - Estimate of Potential Costs

Site:

ID:	CPCPRC
Name:	**Alternative 2 GW - ISCO using CHP in the Shallow and Deep, 5 Years of LTM**
Type:	None

Media/Waste Type

Primary:	Groundwater
Secondary:	N/A

Contaminant

Primary:	Fuels
Secondary:	Semi-Volatile Organic Compounds (SVOCs)

Documentation

Description:	**Alternative 2 GW - ISCO using CHP in the Shallow and Deep Aquifers, 5 years of Groundwater Monitoring, and one 5-Year Review**
Support Team:	Documentation of personnel used to provide support for estimator and preparation of the estimate.
References:	Documentation of reference sources used in the preparation of the estimate.

Phase Documentation:

Phase Type:	Site Closeout
Phase Name:	6 - Closeout of ISCO System
Description:	6 - Closeout of ISCO System
Approach:	Ex Situ
Start Date:	January, 2017
Labor Rate Group:	System Labor Rate
Analysis Rate Group:	System Analysis Rate
Phase Markup Template:	System Defaults

Technology Markups	**Markup**	**% Prime**	**% Sub.**
Well Abandonment	True	100	0

Total Marked-up Cost: $489,301.29

Technologies:
Technology: Treatment and Vent Point Abandonment

Assembly	Description	Quantity	Unit of Measure	Material Unit Cost	Labor Unit Cost	Equipment Unit Cost	Sub Bid Cost	Extended Cost	Cost Override
33010101	Mobilize/DeMobilize Drilling Rig & Crew	1.00	LS	0.00	1,740.59	752.79	0.00	$2,493.38	False
33220112	Field Technician	600.00	HR	0.00	51.92	0.00	0.00	$31,150.33	False
33231101	Hollow Stem Auger, 8" Dia Borehole, Depth <= 100 ft	400.00	LF	0.00	19.61	23.36	0.00	$17,189.00	False
33231105	Hollow Stem Auger, 13-3/4" Dia Borehole, Depth <= 100 ft	11,000.00	LF	0.00	0.00	0.00	15.00	$165,000.00	True
33231178	Move Rig/Equipment Around Site	510.00	EA	0.00	75.00	0.00	0.00	$38,250.00	True
33231820	Grout Continuous Borehole	5,252.00	CF	15.00	0.00	0.00	0.00	$78,780.00	True

Total Element Cost:	$332,862.71
Total 1st Year Tech Cost:	$332,862.71

Total Phase Element Cost **$332,862.71**

Phase Markups Report

Phase Markups Report

Project: Chevron Phillips Puerto Rico Core LLC
Site: Alternative 2 GW - ISCO using CHP in the Shallow and Deep, 5 Years of LTM
Phase: 5 - 5-Year Reviews

Subcontracted Portion of Work

	Professional Labor	MLE*	SubBid	Total
Total Direct Cost	$0	$0	$226	$226
Overhead %	132.00%	25.00%	0.00%	
Overhead	$0	$0	$0	$0
Subtotal	$0	$0	$226	$226
Subcontractor Profit %	8.00%	8.00%	0.00%	
Subcontractor Profit	$0	$0	$0	$0
Total Subcontract Cost	$0	$0	$226	$226

Prime Contractor Portion of Work

	Professional Labor	MLE*	SubBid	Total
Total Direct Cost	$19,780	$0	$0	$19,780
Overhead %	132.00%	25.00%	0.00%	
Overhead	$26,110	$0	$0	$26,110
Prime Subtotal	$45,889	$0	$0	$45,889
Prime + Subcontract	$45,889	$0	$226	$46,116
Contingency %	8.00%	8.00%	8.00%	
Prime Contingency Cost	$3,671	$0	$18	$3,689
Prime + Subcontract + Contingency	$49,561	$0	$244	$49,805

Other Project Costs

	Professional Labor	MLE*	SubBid	Total
Contingency Allowance	$0	$0	$0	$0
Total Contract Cost + Contingency	$49,561	$0	$244	$49,805
Owner Cost %	11.00%	11.00%	11.00%	
Owner Cost	$5,452	$0	$27	$5,479
Total Contract Cost + Contingency + Owner Cost	$55,012	$0	$271	$55,283
Total No-Markup Items				$4,010
Grand Total				$59,293

MLE = Materials, Trade Labor, and Expenses

Phase Technology Cost Detail Report - Alternative 2 GW 5-Year Review

System:

RACER Version:	RACER® Version 11.2.16.0
Database Location:	C:\Users\Jake Gallegos\Desktop\CPCPRC\CMS Report\RACER Files\RACER.mdb

Project:

ID:	CPCPRC 15605.04
Name:	Chevron Phillips Puerto Rico Core LLC
Category:	None

Location

State / Country:	PUERTO RICO
City:	PUERTO RICO AVERAGE

Location Modifier

Default	User
1.160	1.160

Options

Database:	System Costs
Cost Database Date:	2015
Report Option:	Calendar

Description CMS Report - Estimate of Potential Costs

Site:

ID:	CPCPRC
Name:	**Alternative 2 GW - ISCO using CHP in the Shallow and Deep, 5 Years of LTM**
Type:	None

Media/Waste Type

Primary:	Groundwater
Secondary:	N/A

Contaminant

Primary:	Fuels
Secondary:	Semi-Volatile Organic Compounds (SVOCs)

Documentation

Description:	**Alternative 2 GW - ISCO using CHP in the Shallow and Deep Aquifers, 5 years of Groundwater Monitoring, and one 5-Year Review**
Support Team:	Documentation of personnel used to provide support for estimator and preparation of the estimate.
References:	Documentation of reference sources used in the preparation of the estimate.

Phase Documentation:

Phase Type:	Site Closeout
Phase Name:	5 - 5-Year Reviews
Description:	5 - 5-Year Reviews
Approach:	Ex Situ
Start Date:	January, 2022
Labor Rate Group:	System Labor Rate
Analysis Rate Group:	System Analysis Rate
Phase Markup Template:	System Defaults

Technology Markups	**Marku**	**% Prime**	**% Sub.**
Five-Year Review	True	100	0

Total Marked-up Cost: $59,293.40

Technologies:
Technology: Five-Year Review

Element: Document Review

Assembly	Description	Quantity	Unit of Measure	Material Unit Cost	Labor Unit Cost	Equipment Unit Cost	Sub Bid Cost		Extended Cost	Cost Override
33220102	Project Manager	12.00	HR	0.00	106.77	0.00	0.00		$1,281.26	False
33220105	Project Engineer	15.00	HR	0.00	78.14	0.00	0.00		$1,172.11	False
33220108	Project Scientist	11.00	HR	0.00	89.04	0.00	0.00		$979.42	False
33220109	Staff Scientist	23.00	HR	0.00	51.54	0.00	0.00		$1,185.40	False
				Total Element Cost:				$4,618.00		

Element: Interviews

Assembly	Description	Quantity	Unit of Measure	Material Unit Cost	Labor Unit Cost	Equipment Unit Cost	Sub Bid Cost		Extended Cost	Cost Override
33220102	Project Manager	8.00	HR	0.00	106.77	0.00	0.00		$854.17	False
				Total Element Cost:				$854.00		

Element: Site Inspection

Assembly	Description	Quantity	Unit of Measure	Material Unit Cost	Labor Unit Cost	Equipment Unit Cost	Sub Bid Cost		Extended Cost	Cost Override
33220102	Project Manager	12.00	HR	0.00	106.77	0.00	0.00		$1,281.26	False
33220105	Project Engineer	23.00	HR	0.00	78.14	0.00	0.00		$1,797.24	False
33220108	Project Scientist	19.00	HR	0.00	89.04	0.00	0.00		$1,691.73	False
33220109	Staff Scientist	20.00	HR	0.00	51.54	0.00	0.00		$1,030.78	False
				Total Element Cost:				$5,801.00		

Element: Report

Assembly	Description	Quantity	Unit of Measure	Material Unit Cost	Labor Unit Cost	Equipment Unit Cost	Sub Bid Cost		Extended Cost	Cost Override
Technology: Five-Year Review										
33220102	Project Manager	12.00	HR	0.00	106.77	0.00	0.00		$1,281.26	False
33220105	Project Engineer	31.00	HR	0.00	78.14	0.00	0.00		$2,422.36	False
33220108	Project Scientist	25.00	HR	0.00	89.04	0.00	0.00		$2,225.97	False
33220109	Staff Scientist	50.00	HR	0.00	51.54	0.00	0.00		$2,576.96	False
				Total Element Cost:				$8,507.00		

Element: Travel

Assembly	Description	Quantity	Unit of Measure	Material Unit Cost	Labor Unit Cost	Equipment Unit Cost	Sub Bid Cost		Extended Cost	Cost Override
33010108	Sedan, Automobile, Rental	5.00	DAY	0.00	0.00	0.00	45.23		$226.14	False
33010202	Per Diem (per person)	10.00	DAY	0.00	0.00	0.00	221.00		$2,210.00	True
33041101	Airfare	2.00	LS	0.00	0.00	0.00	900.00		$1,800.00	True
				Total Element Cost:				$4,236.14		
				Total 1st Year Tech Cost:				$24,016.14		

Total Phase Element Cost **$24,016.14**

Alternative – 3 GW

Cost Estimate

Cost Summary Report - Alternative 3 GW Slurry Wall in the Shallow with Groundwater Pump and Treat (with Markups)

System:

RACER Version: RACER® Version 11.2.16.0
Database Location C:\Users\Jake Gallegos\Desktop\CPCPRC\CMS Report\RACER Files\RACER.mdb

Project:

ID: CPCPRC 15605.04
Name: Chevron Phillips Puerto Rico Core LLC
Category: None

Location

State / Country: PUERTO RICO
City: PUERTO RICO AVERAGE

Location Modifier	**Default**	**User**
	1.160	1.160

Options

Database: System Costs
Cost Database Date: 2015
Report Option: Calendar

Description CMS Report - Estimate of Potential Costs

Documentation

Description: **Alternative 3 GW - Slurry Wall in the Shallow Aquifer, Groundwater Pump and Treat in the Shallow, ISCO in the Deep, Groundwater LTM, and Closeout of the Pump and Treat System**

Support Team: Documentation of personnel used to provide support for estimator and preparation of the estimate.

References: Documentation of reference sources used in the preparation of the estimate.

Phase	Direct Cost	Markups	Total Cost
Study and Design	$850,000	$168,980	$1,018,980
Remedial Action - Install Slurry Wall, Pump and Treat, and Deep ISCO	$2,586,501	$1,213,276	$3,799,778
Operations & Maintenance - Pump and Treat System (30 Years)	$12,906,234	$8,584,034	$21,490,268
Long Term Monitoring - 30 Years of Groundwater LTM and Reporting	$3,173,027	$3,553,749	$6,726,776
Closeout of Pump and Treat and 10 Deep ISCO Treatment and Vent Points	$1,604,408	$949,274	$2,553,681
Total Site Cost	$21,120,170	$14,469,313	$35,589,483

Phase Markups Report

Phase Markups Report

Project: Chevron Phillips Puerto Rico Core LLC
Site: Alterntavie 3 GW - Slurry Wall, Pump and Treat, ISCO in the Deep, 30 Years of LTM, Closeout of P&T
Phase: 03 - Slurry Wall Installation (Shallow Aquifer)

Subcontracted Portion of Work

	Professional Labor	MLE*	SubBid	Total
Total Direct Cost	$0	$0	$5	$5
Overhead %	132.00%	25.00%	0.00%	
Overhead	$0	$0	$0	$0
Subtotal	$0	$0	$5	$5
Subcontractor Profit %	8.00%	8.00%	0.00%	
Subcontractor Profit	$0	$0	$0	$0
Total Subcontract Cost	$0	$0	$5	$5

Prime Contractor Portion of Work

	Professional Labor	MLE*	SubBid	Total
Total Direct Cost	$0	$590,225	$0	$590,225
Overhead %	132.00%	25.00%	0.00%	
Overhead	$0	$147,556	$0	$147,556
Prime Subtotal	$0	$737,782	$0	$737,782
Prime + Subcontract	$0	$737,782	$5	$737,786
Contingency %	8.00%	8.00%	8.00%	
Prime Contingency Cost	$0	$59,023	$0	$59,023
Prime + Subcontract + Contingency	$0	$796,804	$5	$796,809

Other Project Costs

	Professional Labor	MLE*	SubBid	Total
Contingency %	0.00%	0.00%	0.00%	
Contingency Allowance	$0	$0	$0	$0
Total Contract Cost + Contingency	$0	$796,804	$5	$796,809
Owner Cost %	11.00%	11.00%	11.00%	
Owner Cost	$0	$87,648	$1	$87,649
Total Contract Cost + Contingency + Owner Cost	$0	$884,453	$6	$884,458
Total No-Markup Items				$159,202
Grand Total				$1,043,660

MLE = Materials, Trade Labor, and Expenses

Phase Technology Cost Detail Report - Alternative 3 GW Slurry Wall Installation (Shallow Aquifer)

System:

RACER Version:	RACER® Version 11.2.16.0
Database Location:	C:\Users\Jake Gallegos\Desktop\CPCPRC\CMS Report\RACER Files\RACER.mdb

Project:

ID:	CPCPRC 15605.04
Name:	Chevron Phillips Puerto Rico Core LLC
Category:	None

Location

State / Country:	PUERTO RICO
City:	PUERTO RICO AVERAGE

Location Modifier

Default	User
1.160	1.160

Options

Database:	System Costs
Cost Database Date:	2015
Report Option:	Calendar

Description CMS Report - Estimate of Potential Costs

Site:

ID:	CPCPRC
Name:	**Alterntavie 3 GW - Slurry Wall, Pump and Treat, ISCO in the Deep, 30 Years of Monitoring, and Closeout**
Type:	None

Media/Waste Type

Primary:	Groundwater
Secondary:	N/A

Contaminant

Primary:	Fuels
Secondary:	Semi-Volatile Organic Compounds (SVOCs)

Documentation

Description:	**Alternative 3 GW - Slurry Wall in the Shallow Aquifer, Groundwater Pump and Treat in the Shallow, ISCO in the Deep, Groundwater LTM, and Closeout of the Pump and Treat System**
Support Team:	Documentation of personnel used to provide support for estimator and preparation of the estimate.
References:	Documentation of reference sources used in the preparation of the estimate.

Phase Documentation:

Phase Type:	Remedial Action
Phase Name:	03 - Slurry Wall Installation (Shallow Aquifer)
Description:	Slurry Wall in the Shallow Aquifer
Approach:	In Situ
Start Date:	January, 2017
Labor Rate Group:	System Labor Rate
Analysis Rate Group:	System Analysis Rate
Phase Markup Template:	System Defaults

Technology Markups	Marku	% Prime	% Sub.
Slurry Walls	True	100	0
Professional Labor Management	False	0	0

Total Marked-up Cost: $1,043,660.39

Technologies:
Technology: Slurry Walls

Assembly	Description	Quantity	Unit of Measure	Material Unit Cost	Labor Unit Cost	Equipment Unit Cost	Sub Bid Cost	Extended Cost	Cost Override
17030420	Backfill Trench, Borrow Material, Delivered & Dumped Only	2,566.67	CY	29.00	2.86	1.78	0.00	$86,352.68	False
18050302	Topsoil, 6" Lifts, On-Site	277.78	CY	0.00	3.25	2.62	0.02	$1,635.51	False
18050402	Seeding, Vegetative Cover	0.28	ACR	3,853.33	584.20	243.22	0.00	$1,310.61	False
18050413	Watering with 3,000-Gallon Tank Truck, per Pass	0.28	ACR	220.81	53.62	56.30	0.00	$92.61	False
33060301	Slurry wall installation, level and compact working surface	11,111.11	CY	0.00	4.46	4.56	0.00	$100,263.11	False
33060302	Slurry wall installation, construct dike for mixing basin	444.44	CY	0.00	4.46	4.56	0.00	$4,010.48	False
33060303	Excavating, trench, blasted rock, 6' to 10' deep, 2 1/2 C.Y. bucket, gradall, excludes sheeting or dewatering	6,666.67	BCY	0.00	1.52	0.80	0.00	$15,488.52	False
33060309	Bentonite, Material Purchase Price per Ton	1,297.43	TON	174.00	0.00	0.00	0.00	$225,752.81	False
33060310	Slurry wall installation, slurry mixing, hydration, and placement, per gallon	461,142.03	GAL	0.00	0.11	0.01	0.00	$58,148.50	False
33060311	Slurry wall installation, soil, bentonite backfill mixing per cubic yard	7,333.33	CY	0.00	1.94	2.41	0.00	$31,851.75	False
33060312	Slurry wall installation, backfill trench, 1000' average haul distance	7,333.33	CY	0.00	1.41	2.27	0.00	$26,982.95	False
33060313	Slurry wall installation, cleanup and re-grade working surface	300,000.00	SF	0.00	0.08	0.04	0.00	$38,340.56	False

Total Element Cost: $590,230.09
Total 1st Year Tech Cost: $590,230.09

Technology: Professional Labor Management

Element:

Assembly	Description	Quantity	Unit of Measure	Material Unit Cost	Labor Unit Cost	Equipment Unit Cost	Sub Bid Cost	Extended Cost	Cost Override
33220149	Lump Sum Percentage Labor Cost	1.00	LS	0.00	159,202.00	0.00	0.00	$159,202.00	True

Total Element Cost: $159,202.00
Total 1st Year Tech Cost: $159,202.00

Total Phase Element Cost **$749,432.09**

Phase Markups Report

Phase Markups Report

Project: Chevron Phillips Puerto Rico Core LLC
Site: Alternative 3 GW - Slurry Wall (Shallow), Pump and Treat, ISCO in the Deep, 30 Years of LTM, and Closeout of P&T
Phase: 02 - Groundwater Pump & Treat System Installation

Subcontracted Portion of Work

	Professional Labor	MLE*	SubBid	Total
Total Direct Cost	$0	$0	$562,472	$562,472
Overhead %	132.00%	25.00%	0.00%	
Overhead	$0	$0	$0	$0
Subtotal	$0	$0	$562,472	$562,472
Subcontractor Profit %	8.00%	8.00%	0.00%	
Subcontractor Profit	$0	$0	$0	$0
Total Subcontract Cost	$0	$0	$562,472	$562,472

Prime Contractor Portion of Work

	Professional Labor	MLE*	SubBid	Total
Total Direct Cost	$21,070	$971,821	$0	$992,891
Overhead %	132.00%	25.00%	0.00%	
Overhead	$27,812	$242,955	$0	$270,767
Prime Subtotal	$48,882	$1,214,776	$0	$1,263,658
Prime + Subcontract	$48,882	$1,214,776	$562,472	$1,826,130
Contingency %	8.00%	8.00%	8.00%	
Prime Contingency Cost	$3,911	$97,182	$44,998	$146,090
Prime + Subcontract + Contingency	$52,792	$1,311,958	$607,470	$1,972,220
Other Project Costs				
Contingency Allowance	$0	$0	$0	$0
Total Contract Cost + Contingency	$52,792	$1,311,958	$607,470	$1,972,220
Owner Cost %	11.00%	11.00%	11.00%	
Owner Cost	$5,807	$144,315	$66,822	$216,944
Total Contract Cost + Contingency + Owner Cost	$58,599	$1,456,274	$674,292	$2,189,165
Total No-Markup Items				$0
Grand Total				$2,189,165

MLE = Materials, Trade Labor, and Expenses

Phase Technology Cost Detail Report - Alternative 3 GW Pump and Treat System Installation

System:

RACER Version:	RACER® Version 11.2.16.0
Database Location:	C:\Users\Jake Gallegos\Desktop\CPCPRC\CMS Report\RACER Files\RACER.mdb

Project:

ID:	CPCPRC 15605.04
Name:	Chevron Phillips Puerto Rico Core LLC
Category:	None

Location

State / Country:	PUERTO RICO
City:	PUERTO RICO AVERAGE

Location Modifier

Default	User
1.160	1.160

Options

Database:	System Costs
Cost Database Date:	2015
Report Option:	Calendar

Description CMS Report - Estimate of Potential Costs

Site:

ID:	CPCPRC
Name:	**Alternative 3 GW - Slurry Wall, Shallow Groundwater Pump and Treat, ISCO in the Deep, 30 Years of LTM, and Site Closeout**
Type:	None

Media/Waste Type

Primary:	Groundwater
Secondary:	N/A

Contaminant

Primary:	Fuels
Secondary:	Semi-Volatile Organic Compounds (SVOCs)

Documentation

Description:	**Alternative 3 GW - Slurry Wall in the Shallow Aquifer, Groundwater Pump and Treat in the Shallow, ISCO in the Deep, Groundwater LTM, and Closeout of the Pump and Treat System**
Support Team:	Documentation of personnel used to provide support for estimator and preparation of the estimate.
References:	Documentation of reference sources used in the preparation of the estimate.

Phase Documentation:

Phase Type:	Remedial Action
Phase Name:	02 - Groundwater Pump & Treat System Installation
Description:	Groundwater Pump and Treat
Approach:	Ex Situ
Start Date:	January, 2017
Labor Rate Group:	System Labor Rate
Analysis Rate Group:	System Analysis Rate
Phase Markup Template:	System Defaults

Technology Markups	Marku	% Prime	% Sub.
Groundwater Extraction Wells	True	100	0
Advanced Oxidation Processes	True	100	0

Total Marked-up Cost: $2,181,082.04

Technologies:
Technology: Groundwater Extraction Wells

Element:

Assembly	Description	Quantity	Unit of Measure	Material Unit Cost	Labor Unit Cost	Equipment Unit Cost	Sub Bid Cost	Extended Cost	Cost Override
17010101	Selective clearing, brush, light clearing, with dozer and brush rake, excludes removal offsite	100.00	ACR	0.00	119.42	106.70	0.00	$22,611.88	False
33020303	Organic Vapor Analyzer Rental, per Day	111.00	DAY	0.00	0.00	0.00	40.05	$4,445.28	False
33109666	30,000 Gallon Single-wall Steel Aboveground Tank, Includes Cradles, Coating, Fittings, Excludes Foundation, Pumps, Piping	3.00	EA	78,300.00	2,788.35	0.00	0.00	$243,265.04	False
33170808	Decontaminate Rig, Augers, Screen (Rental Equipment)	85.00	DAY	36.54	696.78	0.00	0.00	$62,332.59	False
33220112	Field Technician	260.00	HR	0.00	81.04	0.00	0.00	$21,069.70	False
33230103	6" PVC, Schedule 40, Well Casing	150.00	LF	15.78	13.92	12.31	0.00	$6,301.03	False
33230157	2" Pitless Adapter	50.00	EA	1,769.00	80.94	0.00	0.00	$92,497.01	False
33230203	6" PVC, Schedule 40, Well Screen	700.00	LF	24.71	13.92	12.31	0.00	$35,657.23	False
33230303	6" PVC, Well Plug	50.00	EA	58.00	21.76	19.24	0.00	$4,949.94	False
33230521	4" Submersible Pump, 0.3-7 GPM, Head <=140', 1/3 hp, w/ controls	50.00	EA	1,669.24	96.36	0.00	0.00	$88,279.87	False
33231103	Hollow Stem Auger, 11" Dia Borehole, Depth <= 100 ft	850.00	LF	0.00	23.96	28.55	0.00	$44,636.42	False
33231172	Split Spoon Sample, 2" x 24", During Drilling	85.00	LF	0.00	0.00	0.00	349.16	$29,678.60	False
33231182	DOT steel drums, 55 gal., open, 17C	235.00	EA	98.39	0.00	0.00	0.00	$23,121.93	False
33231186	Well Development Equipment Rental (weekly)	50.00	WK	0.00	0.00	0.00	295.80	$14,790.00	False
33231403	6" Screen, Filter Pack	700.00	LF	12.92	11.14	9.85	0.00	$23,736.36	False
33232103	6" Well, Bentonite Seal	50.00	EA	53.04	66.66	58.96	0.00	$8,932.92	False
33232206	Restricted Area, Well Protection (with 4 Posts & Explosionproof Receptacle)	50.00	EA	1,289.92	961.43	1.66	0.00	$112,650.09	False
33260425	1" PVC, Schedule 80, Connection Piping	3,500.00	LF	1.60	4.94	0.00	0.00	$22,876.61	False
33270441	4" PVC, Sch 80, Ball Valve	50.00	EA	161.24	70.19	0.00	0.00	$11,571.70	False

Total Element Cost: $873,404.00
Total 1st Year Tech Cost: $873,404.00

Technology: Advanced Oxidation Processes

Assembly	Description	Quantity	Unit of Measure	Material Unit Cost	Labor Unit Cost	Equipment Unit Cost	Sub Bid Cost	Extended Cost	Cost Override
10010102	Fire Protection Wtr Supply, Ord Hazard Fac 152.40mm (6" Pipe)	4.00	EA	239.73	67.27	0.05	0.00	$1,228.20	False
11010532	Panel board 277/480V 100A Mlo 24 Cir W/Bkr	1.00	EA	2,613.48	2,766.90	0.00	0.00	$5,380.38	False
11019001	Transformer Grounding	1.00	EA	63.25	218.70	0.00	0.00	$281.95	False
11020212	Fluorescent Hazardous Industrial Fixture	2.00	EA	4,853.62	658.78	0.00	0.00	$11,024.79	False
17030106	Fine Grading, 12G, 2 Passes	2,400.00	SY	0.00	0.64	0.41	0.00	$2,513.59	False
18020321	6" Structural Slab on Grade	1,500.00	SF	4.17	3.34	0.09	0.00	$11,397.92	False
19040439	3,000 Gallon Conical Bottom Vertical XLPE Tank	2.00	EA	5,695.02	435.65	113.98	0.00	$12,489.31	False
19040446	3,000 Gallon Conical Tank Stand	2.00	EA	3,049.92	145.29	38.01	0.00	$6,466.44	False
33120803	Peroxide System Mob/Assembly/Shakedown	1.00	EA	0.00	19,690.19	0.00	0.00	$19,690.19	False
33120805	Operator Health and Safety Course	1.00	EA	0.00	0.00	0.00	319.00	$319.00	False
33120828	225 KW High Intensity Ultraviolet, H2O2 Capital Equipment	1.00	EA	0.00	0.00	0.00	513,239.20	$513,239.20	False
33120848	Fugitive Emission Control System	1.00	EA	61,619.40	4,612.40	1,206.73	0.00	$67,438.53	False
33130116	0 - 50 GPM Cartridge Filter Equipment	5.00	EA	29.72	114.43	0.00	0.00	$720.73	False
33260204	4" Stainless Steel Piping, Schedule 40, Threaded, Includes Coupling 10' OC, Excludes Hangers	100.00	LF	115.42	41.29	0.00	0.00	$15,671.06	False
33290126	350 GPM, 10 HP, Transfer Pump with Motor, Valves, Piping	1.00	EA	8,936.06	5,161.26	0.00	0.00	$14,097.32	False

Total Element Cost: $681,958.60
Total 1st Year Tech Cost: $681,958.60

Total Phase Element Cost **$1,555,362.60**

Phase Markups Report

Phase Markups Report

Project: Chevron Phillips Puerto Rico Core LLC
Site: Alternative 3 GW - Slurry Wall (Shallow), Pump and Treat, ISCO in the Deep, 30 Years of LTM, and Closeout of P&T
Phase: 04 - Groundwater Pump & Treat O&M

Subcontracted Portion of Work

	Professional Labor	MLE*	SubBid	Total
Total Direct Cost Over 30 Year Project Life	$0	$0	$580,647	$580,647
Overhead %	132.00%	25.00%	0.00%	
Overhead	$0	$0	$0	$0
Subtotal	$0	$0	$580,647	$580,647
Subcontractor Profit %	8.00%	8.00%	0.00%	
Subcontractor Profit	$0	$0	$0	$0
Total Subcontract Cost	$0	$0	$580,647	$580,647

Prime Contractor Portion of Work

	Professional Labor	MLE*	SubBid	Total
Total Direct Cost Over 30 Year Project Life	$1,812,011	$10,513,577	$0	$12,325,588
Overhead %	132.00%	25.00%	0.00%	
Overhead	$2,391,855	$2,628,394	$0	$5,020,249
Prime Subtotal	$4,203,866	$13,141,971	$0	$17,345,837
Prime + Subcontract	$4,203,866	$13,141,971	$580,647	$17,926,483
Contingency %	8.00%	8.00%	8.00%	
Prime Contingency Cost	$336,309	$1,051,358	$46,452	$1,434,119
Prime + Subcontract + Contingency	$4,540,175	$14,193,329	$627,098	$19,360,602
Other Project Costs				
Contingency Allowance	$0	$0	$0	$0
Total Contract Cost + Contingency	$4,540,175	$14,193,329	$627,098	$19,360,602
Owner Cost %	11.00%	11.00%	11.00%	
Owner Cost	$499,419	$1,561,266	$68,981	$2,129,666
Total Contract Cost + Contingency + Owner Cost	$5,039,594	$15,754,595	$696,079	$21,490,268
Total No-Markup Items				$0
Grand Total				$21,490,268

MLE = Materials, Trade Labor, and Expenses

Phase Cost Over Time Report - Alternative 3 GW Pump and Treat Sytem O&M

System:

RACER Version: RACER® Version 11.2.16.0
Database Location: C:\Users\Jake Gallegos\Desktop\CPCPRC\CMS Report\RACER Files\RACER.mdb

Folder:

Folder Name: CMS V1

Project:

ID: CPCPRC 15605.04
Name: Chevron Phillips Puerto Rico Core LLC
Category: None

Location

State / Country: PUERTO RICO
City: PUERTO RICO AVERAGE

Location Modifier

Default	User
1.160	1.160

Options

Database: System Costs
Cost Database Date: 2015
Report Option: Calendar

Description CMS Report - Estimate of Potential Costs

Site:

ID: CPCPRC
Name: **Alternative 3 GW - Slurry Wall (Shallow), Pump and Treat, ISCO in the Deep, 30 Years of LTM, and Closeout**
Type: None

Media/Waste Type

Primary: Groundwater
Secondary: N/A

Contaminant

Primary: Fuels
Secondary: Semi-Volatile Organic Compounds (SVOCs)

Documentation

Description: **Alternative 3 GW - Slurry wall (Shallow), Pump and Treat in the Shallow, ISCO in the Deep, 30 Years of Groundwater LTM, and Closeout of the Pump and Treat System**
Support Team: Documentation of personnel used to provide support for estimator and preparation of the estimate.
References: Documentation of reference sources used in the preparation of the estimate.

Technology Name	Technology	2017	2018	2019	2020	2021	2022
Operations and Maintenance		$430,208	$430,208	$430,208	$430,208	$430,208	$430,208

Technology Name	Technology	2023	2024	2025	2026	2027	2028
Operations and Maintenance		$430,208	$430,208	$430,208	$430,208	$430,208	$430,208

Technology Name	Technology	2029	2030	2031	2032	2033	2034
Operations and Maintenance		$430,208	$430,208	$430,208	$430,208	$430,208	$430,208

Technology Name	Technology	2035	2036	2037	2038	2039	2040
Operations and Maintenance		$430,208	$430,208	$430,208	$430,208	$430,208	$430,208

Technology Name	Technology	2041	2042	2043	2044	2045	2046
Operations and Maintenance		$430,208	$430,208	$430,208	$430,208	$430,208	$430,208

Total Phase Cost	Technology	Total
Operations and Maintenance		$12,906,234

Phase Technology Cost Detail Report - Alternative 3 GW Pump and Treat Sytem O&M

System:

	RACER Version:	RACER® Version 11.2.16.0
	Database Location:	C:\Users\Jake Gallegos\Desktop\CPCPRC\CMS Report\RACER Files\RACER.mdb

Project:

	ID:	CPCPRC 15605.04
	Name:	Chevron Phillips Puerto Rico Core LLC
	Category:	None
Location		
	State / Country:	PUERTO RICO
	City:	PUERTO RICO AVERAGE

Location Modifier

Default	User
1.160	1.160

Options

Database:	System Costs
Cost Database Date:	2015
Report Option:	Calendar

Description CMS Report - Estimate of Potential Costs

Site:

	ID:	CPCPRC
	Name:	**Alternative 3 GW - Slurry Wall (Shallow), Pump and Treat, ISCO in the Deep, 30 Years of LTM, and Closeout**
	Type:	None
Media/Waste Type		
	Primary:	Groundwater
	Secondary:	N/A
Contaminant		
	Primary:	Fuels
	Secondary:	Semi-Volatile Organic Compounds (SVOCs)
Documentation		
	Description:	**Alternative 3 GW - Slurry Wall (Shallow), Pump and Treat in the Shallow, ISCO in the Deep, 30 Years of Groundwater LTM, and Closeout of the Pump and Treat System**
	Support Team:	Documentation of personnel used to provide support for estimator and preparation of the estimate.
	References:	Documentation of reference sources used in the preparation of the estimate.

Phase Documentation:

Phase Type:	Operations & Maintenance
Phase Name:	04 - Groundwater Pump & Treat O&M
Description:	Operations and Maintenance - Groundwater Pump and Treat
Approach:	Ex Situ
Start Date:	January, 2017
Labor Rate Group:	System Labor Rate
Analysis Rate Group:	System Analysis Rate
Phase Markup Template:	System Defaults

Technology Markups	**Marku**	**Prime**	**% Sub.**
Operations and Maintenance	True	100	0

Total Marked-up Cost: $21,490,268.04

Technologies:
Technology: Operations and Maintenance

Assembly	Description	Quantity	Unit of Measure	Material Unit Cost	Labor Unit Cost	Equipment Unit Cost	Sub Bid Cost	Extended Cost	Cost Override
33020401	Disposable Materials per Sample	12.00	EA	12.12	0.00	0.00	0.00	$145.43	False
33020402	Decontamination Materials per Sample	12.00	EA	16.82	0.00	0.00	0.00	$201.81	False
33021535	Full Size, Portable, Automated Wastewater Sampler, Daily Rental	24.00	DAY	0.00	0.00	0.00	96.28	$2,310.72	False
33021670	Assumed testing, Metals Screen In Method EPA 200.7, Water Analysis	12.00	EA	0.00	0.00	0.00	548.68	$6,584.16	False
33021694	Assumed testing, Total Petroleum Hydrocarbons (SW8015B), Water Analysis	12.00	EA	0.00	0.00	0.00	101.50	$1,218.00	False
33021721	Testing, semi-volatile organics (625, 8270)	12.00	EA	0.00	0.00	0.00	383.81	$4,605.71	False
33022042	Overnight delivery service, 21 to 50 lb packages	420.00	LB	0.00	0.00	0.00	7.03	$2,952.43	False
33022139	Testing, BTEX/MTBE (mod EPA 602)	12.00	EA	0.00	0.00	0.00	83.76	$1,005.16	False
33220102	Project Manager	100.00	HR	0.00	123.86	0.00	0.00	$12,385.55	False
33220108	Project Scientist	100.00	HR	0.00	89.04	0.00	0.00	$8,903.86	False
33220110	QA/QC Officer	100.00	HR	0.00	89.04	0.00	0.00	$8,903.86	False
33220112	Field Technician	640.00	HR	0.00	51.92	0.00	0.00	$33,227.02	False
33220114	Word Processing/Clerical	24.00	HR	0.00	48.06	0.00	0.00	$1,153.49	False
33223001	Treatment System Operator	1,880.00	HR	0.00	49.64	0.00	0.00	$93,323.61	False
33240101	Other Direct Costs	1.00	LS	241.19	0.00	0.00	0.00	$241.19	True
33420101	Electrical Charge	27,752.89	KWH	0.08	0.00	0.00	0.00	$2,253.53	False

Total Element Cost: $179,416.00

Element: Advanced Oxidation Processes
Technology: Operations and Maintenance

Assembly	Description	Quantity	Unit of Measure	Material Unit Cost	Labor Unit Cost	Equipment Unit Cost	Sub Bid Cost	Extended Cost	Cost Override
33120852	20 KW Ultraviolet Source High Intensity Lamp	33.00	EA	232.00	0.00	0.00	0.00	$7,656.00	False
33330171	Hydrogen Peroxide, 50% Solution, 500 Lb Drums	324.00	EA	388.60	0.00	0.00	0.00	$125,906.40	False
33420101	Electrical Charge	1,443,718.0	KWH	0.08	0.00	0.00	0.00	$117,229.90	False

Total Element Cost: $250,792.30
Total 1st Year Tech Cost: $430,208.30

Total Phase Element Cost **$430,208.30**

Phase Markups Report

Phase Markups Report

Project: Chevron Phillips Puerto Rico Core LLC
Site: Alternative 3 GW - Slurry Wall (Shallow), Pump and Treat, ISCO in the Deep, 30 Years of LTM, and Closeout of P&T
Phase: 05 - ISCO in the Deep Aquifer

Subcontracted Portion of Work

	Professional Labor	MLE	SubBid	Total
Total Direct Cost	$0	$0	$49,375	$49,375
Overhead %	132.00%	25.00%	0.00%	
Overhead	$0	$0	$0	$0
Subtotal	$0	$0	$49,375	$49,375
Subcontractor Profit %	8.00%	8.00%	0.00%	
Subcontractor Profit	$0	$0	$0	$0
Total Subcontract Cost	$0	$0	$49,375	$49,375

Prime Contractor Portion of Work

	Professional Labor	MLE	SubBid	Total
Total Direct Cost	$124,434	$107,898	$0	$232,332
Overhead %	132.00%	25.00%	0.00%	
Overhead	$164,252	$26,975	$0	$191,227
Prime Subtotal	$288,686	$134,873	$0	$423,559
Prime + Subcontract	$288,686	$134,873	$49,375	$472,933
Contingency %	8.00%	8.00%	8.00%	
Prime Contingency Cost	$23,095	$10,790	$3,950	$37,835
Prime + Subcontract + Contingency	$311,781	$145,663	$53,325	$510,768
Other Project Costs				
Contingency Allowance	$0	$0	$0	$0
Total Contract Cost + Contingency	$311,781	$145,663	$53,325	$510,768
Owner Cost %	11.00%	11.00%	11.00%	
Owner Cost	$34,296	$16,023	$5,866	$56,184
Total Contract Cost + Contingency + Owner Cost	$346,077	$161,685	$59,190	$566,952
Total No-Markup Items				$0
Grand Total				$566,952

MLE = Materials, Trade Labor, and Expenses

Phase Technology Cost Detail Report - Alternative 3 GW ISCO in the Deep Aquifer

System:

RACER Version:	RACER® Version 11.2.16.0
Database Location:	C:\Users\Jake Gallegos\Desktop\CPCPRC\CMS Report\RACER Files\RACER.mdb

Project:

ID:	CPCPRC 15605.04
Name:	Chevron Phillips Puerto Rico Core LLC
Category:	None

Location

State / Country:	PUERTO RICO
City:	PUERTO RICO AVERAGE

Location Modifier

Default	User
1.160	1.160

Options

Database:	System Costs
Cost Database Date:	2015
Report Option:	Calendar

Description CMS Report - Estimate of Potential Costs

Site:

ID:	CPCPRC
Name:	**Alternative 3 GW - Slurry Wall (Shallow), Pump and Treat, ISCO in the Deep, 30 Years of LTM, and Closeout**
Type:	None

Media/Waste Type

Primary:	Groundwater
Secondary:	N/A

Contaminant

Primary:	Fuels
Secondary:	Semi-Volatile Organic Compounds (SVOCs)

Documentation

Description:	**Alternative 3 GW - Slurry Wall (Shallow), Pump and Treat in the Shallow, ISCO in the Deep, 30 Years of Groundwater LTM, and Closeout of the Pump and Treat System**
Support Team:	Documentation of personnel used to provide support for estimator and preparation of the estimate.
References:	Documentation of reference sources used in the preparation of the estimate.

Phase Documentation:

Phase Type:	Remedial Action
Phase Name:	05 - ISCO in the Deep Aquifer
Description:	ISCO at 10 Deep Treatment Points
Approach:	In Situ
Start Date:	January, 2017
Labor Rate Group:	System Labor Rate
Analysis Rate Group:	System Analysis Rate
Phase Markup Template:	System Defaults

Technology Markups	**Marku**	**% Prime**	**% Sub.**
Groundwater Monitoring Well	True	100	0
USER DEFINED ESTIMATE	True	100	0

Total Marked-up Cost: $566,952.47

Technologies:
Technology: Groundwater Monitoring Well

Element: Aquifer 1

Assembly	Description	Quantity	Unit of Measure	Material Unit Cost	Labor Unit Cost	Equipment Unit Cost	Sub Bid Cost		Extended Cost	Cost Override
33020303	Organic Vapor Analyzer Rental, per Day	6.00	DAY	0.00	0.00	0.00	40.05		$240.29	False
33021720	Testing, purgeable organics (624, 8260)	30.00	EA	0.00	0.00	0.00	174.00		$5,220.00	False
33021721	Testing, semi-volatile organics (625, 8270)	30.00	EA	0.00	0.00	0.00	383.81		$11,514.28	False
33021803	Testing, non-rad lab tests, tentative id of compounds GC/MS 30/5040/8240	0.00	EA	0.00	0.00	0.00	29.45		$0.00	False
33170808	Decontaminate Rig, Augers, Screen (Rental Equipment)	6.00	DAY	36.54	696.78	0.00	0.00		$4,399.95	False
33220107	Senior Scientist	96.00	HR	0.00	120.13	0.00	0.00		$11,532.59	False
33220108	Project Scientist	96.00	HR	0.00	89.04	0.00	0.00		$8,547.71	False
33220111	Certified Industrial Hygienist	96.00	HR	0.00	150.00	0.00	0.00		$14,400.00	True
33220112	Field Technician	96.00	HR	0.00	65.00	0.00	0.00		$6,240.00	True
33221004	Equip. Operators, Oilers	96.00	HR	0.00	67.86	0.00	0.00		$6,514.41	False
33230111	2" PVC, Schedule 80, Well Casing	300.00	LF	5.45	5.80	5.13	0.00		$4,915.50	False
33230211	2" PVC, Schedule 80, Well Screen	100.00	LF	7.19	5.80	5.13	0.00		$1,812.50	False
33230301	2" PVC, Well Plug	10.00	EA	11.31	17.41	15.39	0.00		$441.09	False
33231101	Hollow Stem Auger, 8" Dia Borehole, Depth <= 100 ft	410.00	LF	0.00	19.61	23.36	0.00		$17,618.72	False
33231173	Split Spoon Sampling	90.00	LF	0.00	15.42	5.28	0.00		$1,862.85	False
33231401	2" Screen, Filter Pack	120.00	LF	5.19	4.48	3.96	0.00		$1,636.12	False
33231811	2" Well, Portland Cement Grout	270.00	LF	6.43	0.00	0.00	0.00		$1,735.99	False
33232101	2" Well, Bentonite Seal	10.00	EA	16.16	115.73	102.35	0.00		$2,342.37	False
				Total Element Cost:				$100,974.36		

Element: General Aquifers

Assembly	Description	Quantity	Unit of Measure	Material Unit Cost	Labor Unit Cost	Equipment Unit Cost	Sub Bid Cost		Extended Cost	Cost Override
33010101	Mobilize/DeMobilize Drilling Rig & Crew	1.00	LS	0.00	######	752.79	0.00		$2,493.38	False
33231178	Move Rig/Equipment Around Site	9.00	EA	105.39	250.21	108.21	0.00		$4,174.28	False
33231182	DOT steel drums, 55 gal., open, 17C	20.00	EA	98.39	0.00	0.00	0.00		$1,967.82	False
33231504	Surface Pad, Concrete, 2' x 2' x 4"	10.00	EA	55.33	19.45	0.21	0.00		$749.90	False
33232301	5' Guard Posts, Cast Iron, Concrete Fill	40.00	EA	154.62	101.17	0.04	0.00		$10,233.28	False
				Total Element Cost:				$19,618.66		
				Total 1st Year Tech Cost:				$120,593.03		

Technology: USER DEFINED ESTIMATE - CHP Treatment Based on 2015 GW Pilot Test

Element:

Assembly	Description	Quantity	Unit of Measure	Material Unit Cost	Labor Unit Cost	Equipment Unit Cost	Sub Bid Cost		Extended Cost	Cost Override
Technology: USER DEFINED ESTIMATE										
33220101	Senior Project Manager	80.00	HR	0.00	150.00	0.00	0.00		$12,000.00	True
33220107	Senior Scientist	160.00	HR	0.00	120.13	0.00	0.00		$19,220.98	False
33220108	Project Scientist	320.00	HR	0.00	89.04	0.00	0.00		$28,492.36	False
33220111	Certified Industrial Hygienist	160.00	HR	0.00	150.00	0.00	0.00		$24,000.00	True
33240101	Other Direct Costs	25.00	LS	0.00	0.00	1,800.00	0.00		$45,000.00	True
33240108	Capital Expenses - CHP - 6,000 lbs per treatment point	60,000.00	LBS	0.00	0.00	0.00	0.54		$32,400.00	True
				Total Element Cost:				$161,113.34		
				Total 1st Year Tech Cost:				$161,113.34		
					Total Phase Element Cost				**$281,706.37**	

Phase Markups Report

Phase Markups Report

Project: Chevron Phillips Puerto Rico Core LLC
Site: Alternative 3 GW - Slurry Wall (Shallow), Pump and Treat, ISCO in the Deep, 30 Years of LTM, and Closeout of P&T
Phase: 06 - Groundwater LTM

Subcontracted Portion of Work

	Professional Labor	MLE*	SubBid	Total
Total Direct Cost Over 30 Year Project Life	$0	$0	$1,196,147	$1,196,147
Overhead %	132.00%	25.00%	0.00%	
Overhead	$0	$0	$0	$0
Subtotal	$0	$0	$1,196,147	$1,196,147
Subcontractor Profit %	8.00%	8.00%	0.00%	
Subcontractor Profit	$0	$0	$0	$0
Total Subcontract Cost	$0	$0	$1,196,147	$1,196,147

Prime Contractor Portion of Work

	Professional Labor	MLE*	SubBid	Total
Total Direct Cost Over 30 Year Project Life	$1,817,912	$156,190	$0	$1,974,102
Overhead %	132.00%	25.00%	0.00%	
Overhead	$2,399,644	$39,047	$0	$2,438,692
Prime Subtotal	$4,217,557	$195,237	$0	$4,412,794
Prime + Subcontract	$4,217,557	$195,237	$1,196,147	$5,608,941
Contingency %	8.00%	8.00%	8.00%	
Prime Contingency Cost	$337,405	$15,619	$95,692	$448,715
Prime + Subcontract + Contingency	$4,554,961	$210,856	$1,291,839	$6,057,657

Other Project Costs

	Professional Labor	MLE*	SubBid	Total
Contingency Allowance	$0	$0	$0	$0
Total Contract Cost + Contingency	$4,554,961	$210,856	$1,291,839	$6,057,657
Owner Cost %	11.00%	11.00%	11.00%	
Owner Cost	$501,046	$23,194	$142,102	$666,342
Total Contract Cost + Contingency + Owner Cost	$5,056,007	$234,050	$1,433,941	$6,723,999
Total No-Markup Items				$2,777
Grand Total				$6,726,776

MLE = Materials, Trade Labor, and Expenses

Phase Cost Over Time Report - Alternative 3 GW Groundwater LTM

System:

RACER Version: RACER® Version 11.2.16.0
Database Location: C:\Users\Jake Gallegos\Desktop\CPCPRC\CMS Report\RACER Files\RACER.mdb

Folder:

Folder Name: CMS V1

Project:

ID: CPCPRC 15605.04
Name: Chevron Phillips Puerto Rico Core LLC
Category: None

Location

State / Country: PUERTO RICO
City: PUERTO RICO AVERAGE

Location Modifier

Default	User
1.160	1.160

Options

Database: System Costs
Cost Database Date: 2015
Report Option: Calendar

Description CMS Report - Estimate of Potential Costs

Site:

ID: CPCPRC
Name: **Alternative 3 GW - Slurry Wall (Shallow), Pump and Treat, ISCO in the Deep, 30 Years of LTM, and Closeout**
Type: None

Media/Waste Type

Primary: Groundwater
Secondary: N/A

Contaminant

Primary: Fuels
Secondary: Semi-Volatile Organic Compounds (SVOCs)

Documentation

Description: **Alternative 3 GW - Slurry Wall (shallow), Pump and Treat in the Shallow, ISCO in the Deep, 30 Years of Groundwater LTM, and Closeout of the Pump and Treat System**
Support Team: Documentation of personnel used to provide support for estimator and preparation of the estimate.
References: Documentation of reference sources used in the preparation of the estimate.

Technology Name	Technology	2017	2018	2019	2020	2021	2022
MONITORING		$118,519	$105,328	$105,328	$105,328	$105,328	$105,328

Technology Name	Technology	2023	2024	2025	2026	2027	2028
MONITORING		$105,328	$105,328	$105,328	$105,328	$105,328	$105,328

Technology Name	Technology	2029	2030	2031	2032	2033	2034
MONITORING		$105,328	$105,328	$105,328	$105,328	$105,328	$105,328

Technology Name	Technology	2035	2036	2037	2038	2039	2040
MONITORING		$105,328	$105,328	$105,328	$105,328	$105,328	$105,328

Technology Name	Technology	2041	2042	2043	2044	2045	2046
MONITORING		$105,328	$105,328	$105,328	$105,328	$105,328	$105,328

Total Phase Cost	Technology	Total
MONITORING		**$3,173,027**

Phase Technology Cost Detail Report - Alternative 3 GW Groundwater LTM

System:

RACER Version:	RACER® Version 11.2.16.0
Database Location:	C:\Users\Jake Gallegos\Desktop\CPCPRC\CMS Report\RACER Files\RACER.mdb

Project:

ID:	CPCPRC 15605.04
Name:	Chevron Phillips Puerto Rico Core LLC
Category:	None

Location

State / Country:	PUERTO RICO
City:	PUERTO RICO AVERAGE

Location Modifier

Default	User
1.160	1.160

Options

Database:	System Costs
Cost Database Date:	2015
Report Option:	Calendar

Description CMS Report - Estimate of Potential Costs

Site:

ID:	CPCPRC
Name:	**Alternative 3 GW - Slurry Wall (Shallow), Pump and Treat, ISCO in the Deep, 30 Years of LTM, and Closeout**
Type:	None

Media/Waste Type

Primary:	Groundwater
Secondary:	N/A

Contaminant

Primary:	Fuels
Secondary:	Semi-Volatile Organic Compounds (SVOCs)

Documentation

Description:	**Alternative 3 GW - Slurry Wall (shallow), Pump and Treat in the Shallow, ISCO in the Deep, 30 Years of Groundwater LTM, and Closeout of the Pump and Treat System**
Support Team:	Documentation of personnel used to provide support for estimator and preparation of the estimate.
References:	Documentation of reference sources used in the preparation of the estimate.

Phase Documentation:

Phase Type:	Long Term Monitoring
Phase Name:	06 - Groundwater LTM
Description:	06 - Groundwater LTM
Approach:	Ex Situ
Start Date:	January, 2017
Labor Rate Group:	System Labor Rate
Analysis Rate Group:	System Analysis Rate
Phase Markup Template:	System Defaults

Technology Markups	Marku	% Prime	% Sub.
MONITORING	True	100	0

Total Marked-up Cost: $6,726,775.91

Technologies:

Technology: MONITORING

Assembly	Description	Quantity	Unit of Measure	Material Unit Cost	Labor Unit Cost	Equipment Unit Cost	Sub Bid Cost	Extended Cost	Cost Override
33020401	Disposable Materials per Sample	143.00	EA	12.12	0.00	0.00	0.00	$1,733.00	False
33020402	Decontamination Materials per Sample	143.00	EA	16.82	0.00	0.00	0.00	$2,404.85	False
33020561	Lysimeter accessories, nylon tubing, 1/4" OD	2,185.00	LF	0.41	0.00	0.00	0.00	$887.11	False
33021509	Monitor well sampling equipment, rental, water quality testing parameter device rental	4.00	WK	0.00	0.00	0.00	98.60	$394.40	False
33022135	Testing, Sulfolane (SW8270)	143.00	EA	0.00	0.00	0.00	100.00	$14,300.00	True
33022150	Testing, BTEX (SW8270)	143.00	EA	0.00	0.00	0.00	50.00	$7,150.00	True
33220102	Project Manager	23.00	HR	0.00	106.77	0.00	0.00	$2,455.75	False
33220109	Staff Scientist	312.00	HR	0.00	98.00	0.00	0.00	$30,576.00	True
33220112	Field Technician	382.00	HR	0.00	44.76	0.00	0.00	$17,096.87	False
33230614	Peristaltic Pump, Weekly Rental	4.00	WK	0.00	0.00	0.00	104.40	$417.60	False

Total Element Cost: $77,416.00

Element: Data Management

Assembly	Description	Quantity	Unit of Measure	Material Unit Cost	Labor Unit Cost	Equipment Unit Cost	Sub Bid Cost	Extended Cost	Cost Override
33220102	Project Manager	19.00	HR	0.00	106.77	0.00	0.00	$2,028.66	False
33220105	Project Engineer	30.00	HR	0.00	78.14	0.00	0.00	$2,344.22	False
33220108	Project Scientist	110.00	HR	0.00	89.04	0.00	0.00	$9,794.25	False
33220109	Staff Scientist	80.00	HR	0.00	51.54	0.00	0.00	$4,123.14	False
33220110	QA/QC Officer	27.00	HR	0.00	89.04	0.00	0.00	$2,404.04	False
33220112	Field Technician	11.00	HR	0.00	44.76	0.00	0.00	$492.32	False
33220114	Word Processing/Clerical	23.00	HR	0.00	48.06	0.00	0.00	$1,105.43	False
33220115	Draftsman/CADD	19.00	HR	0.00	51.54	0.00	0.00	$979.25	False

Total Element Cost: $23,271.00

Element: General Monitoring

Assembly	Description	Quantity	Unit of Measure	Material Unit Cost	Labor Unit Cost	Equipment Unit Cost	Sub Bid Cost	Extended Cost	Cost Override
33010104	Sample collection, vehicle mileage charge, car or van	180.00	MI	0.00	0.00	0.00	0.51	$91.80	True
33022043	Overnight delivery service, 51 to 70 lb packages	2,340.00	LB	0.00	0.00	0.00	7.12	$16,666.42	False
33220112	Field Technician	24.00	HR	0.00	44.76	0.00	0.00	$1,074.15	False

Total Element Cost: $17,832.00

Total 1st Year Tech Cost: $118,519.00

Total Phase Element Cost **$118,519.00**

Phase Markups Report

Phase Markups Report

Project: Chevron Phillips Puerto Rico Core LLC
Site: Alternative 3 GW - Slurry Wall (Shallow), Pump and Treat, ISCO in the Deep, 30 Years of LTM, and Closeout of P&T
Phase: 08 - Closeout of Pump and Treat System

Subcontracted Portion of Work

	Professional Labor	MLE	SubBid	Total
Total Direct Cost	$0	$0	$0	$0
Overhead %	132.00%	25.00%	0.00%	
Overhead	$0	$0	$0	$0
Subtotal	$0	$0	$0	$0
Subcontractor Profit %	8.00%	8.00%	0.00%	
Subcontractor Profit	$0	$0	$0	$0
Total Subcontract Cost	$0	$0	$0	$0

Prime Contractor Portion of Work

	Professional Labor	MLE	SubBid	Total
Total Direct Cost	$7,519	$1,452,792	$0	$1,460,311
Overhead %	132.00%	25.00%	0.00%	
Overhead	$9,925	$363,198	$0	$373,123
Prime Subtotal	$17,444	$1,815,990	$0	$1,833,434
Prime + Subcontract	$17,444	$1,815,990	$0	$1,833,434
Prime Profit %	8.00%	8.00%	8.00%	
Prime Profit Cost	$1,396	$145,279	$0	$146,675
Prime + Subcontract + Prime Profit	$18,840	$1,961,269	$0	$1,980,109

Other Project Costs

	Professional Labor	MLE	SubBid	Total
Contingency %	0.00%	0.00%	0.00%	
Contingency Allowance	$0	$0	$0	$0
Total Contract Cost + Contingency	$18,840	$1,961,269	$0	$1,980,109
Owner Cost %	11.00%	11.00%	11.00%	
Owner Cost	$2,072	$215,740	$0	$217,812
Total Contract Cost + Contingency + Owner Cost	$20,912	$2,177,009	$0	$2,197,921
Total No-Markup Items				$0
Grand Total				$2,197,921

Phase Technology Cost Detail Report - Alternative 3 GW - Closeout of the Pump and Treat and Deep ISCO

System:

RACER Version: RACER® Version 11.2.16.0
Database Location: C:\Users\Jake Gallegos\Desktop\CPCPRC\CMS Report\RACER Files\RACER.mdb

Project:

ID: CPCPRC 15605.04
Name: Chevron Phillips Puerto Rico Core LLC
Category: None

Location

State / Country: PUERTO RICO
City: PUERTO RICO AVERAGE

Location Modifier	**Default**	**User**	**Reason for changes**
	1.160	1.160	

Options

Database: System Costs
Cost Database Date: 2015
Report Option: Calendar

Description CMS Report - Estimate of Potential Costs

Site:

ID: CPCPRC
Name: **Alternative 3 GW - Slurry Wall (Shallow), Pump and Treat, ISCO in the Deep, 30 Years of LTM, and Closeout**
Type: None

Media/Waste Type

Primary: Groundwater
Secondary: N/A

Contaminant

Primary: Fuels
Secondary: Semi-Volatile Organic Compounds (SVOCs)

Documentation

Description: **Alternative 3 GW - Slurry Wall (Shallow), Pump and Treat in the Shallow, ISCO in the Deep, 30 Years of Groundwater LTM, and Closeout of the Pump and Treat System**
Support Team: Documentation of personnel used to provide support for estimator and preparation of the estimate.
References: Documentation of reference sources used in the preparation of the estimate.

Phase Documentation:

Phase Type: Site Closeout
Phase Name: 08 - Closeout of Pump and Treat System
Description: 08 - Closeout of GW P&T
Approach: Ex Situ
Start Date: January, 2017
Labor Rate Group: System Labor Rate
Analysis Rate Group: System Analysis Rate
Phase Markup Template: System Defaults

Technology Markups	**Markup**	**% Prime**	**% Sub.**
Cleanup and Landscaping	True	100	0
Well Abandonment	True	100	0

Total Marked-up Cost: $2,197,920.95

Technologies:

Technology: Cleanup and Landscaping

Assembly	Description	Quantity	Unit of Measure	Material Unit Cost	Labor Unit Cost	Equipment Unit Cost	Sub Bid Cost	Extended Cost	Cost Override
17040101	Cleaning Up, site debris clean up and removal	125.00	ACR	0.00	623.50	49.28	0.00	$84,097.60	False
18050101	Area Preparation, 67% Level & 33% Slope	125.00	ACR	0.00	23.19	26.67	0.00	$6,233.39	False
18050401	Seeding, 67% Level & 33% Slope, Hydroseeding	125.00	ACR	3,233.89	985.40	742.14	0.00	$620,179.22	False
18050408	Fertilizer, Hydro Spread	250.00	ACR	707.41	95.21	33.87	0.00	$209,122.38	False
18050413	Watering with 3,000-Gallon Tank Truck, per Pass	1,000.00	ACR	220.81	53.62	56.30	0.00	$330,732.37	False
18050415	Mowing	250.00	ACR	0.00	301.99	0.00	0.00	$75,497.07	False

Total Element Cost: $1,325,862.03

Total 1st Year Tech Cost: $1,325,862.03

Technology: Well Abandonment

Element:

Assembly	Description	Quantity	Unit of Measure	Material Unit Cost	Labor Unit Cost	Equipment Unit Cost	Sub Bid Cost	Extended Cost	Cost Override
33010101	Mobilize/DeMobilize Drilling Rig & Crew	1.00	LS	0.00	1,740.59	752.79	0.00	$2,493.38	False
33220112	Field Technician	168.00	HR	0.00	44.76	0.00	0.00	$7,518.93	False
33231101	Hollow Stem Auger, 8" Dia Borehole, Depth <= 100 ft	400.00	LF	0.00	19.61	23.36	0.00	$17,189.00	False
33231105	Hollow Stem Auger, 13-3/4" Dia Borehole, Depth <= 100 ft	900.00	LF	0.00	30.80	36.70	0.00	$60,750.08	False
33231178	Move Rig/Equipment Around Site	60.00	EA	105.39	250.21	108.21	0.00	$27,828.54	False
33231820	Grout Continuous Borehole	482.00	CF	38.73	0.00	0.00	0.00	$18,669.02	False

Total Element Cost: $134,449.00

Total 1st Year Tech Cost: $1,460,311.03

Total Phase Element Cost **$1,460,311.03**

Phase Markups Report

Phase Markups Report

Project: Chevron Phillips Puerto Rico Core LLC
Site: Alternative 3 GW - Slurry Wall (Shallow), Pump and Treat, ISCO in the Deep, 30 Years of LTM, and Closeout
Phase: 07 - 5-Year Reviews

Subcontracted Portion of Work

	Professional Labor	MLE*	SubBid	Total
Total Direct Cost Over 30 Year Project Life	$0	$0	$1,357	$1,357
Overhead %	132.00%	25.00%	0.00%	
Overhead	$0	$0	$0	$0
Subtotal	$0	$0	$1,357	$1,357
Subcontractor Profit %	8.00%	8.00%	0.00%	
Subcontractor Profit	$0	$0	$0	$0
Total Subcontract Cost	$0	$0	$1,357	$1,357

Prime Contractor Portion of Work

	Professional Labor	MLE*	SubBid	Total
Total Direct Cost Over 30 Year Project Life	$118,680	$0	$0	$118,680
Overhead %	132.00%	25.00%	0.00%	
Overhead	$156,657	$0	$0	$156,657
Prime Subtotal	$275,337	$0	$0	$275,337
Prime + Subcontract	$275,337	$0	$1,357	$276,694
Contingency %	8.00%	8.00%	8.00%	
Prime Contingency Cost	$22,027	$0	$109	$22,135
Prime + Subcontract + Contingency	$297,364	$0	$1,465	$298,829

Other Project Costs

	Professional Labor	MLE*	SubBid	Total
Contingency Allowance	$0	$0	$0	$0
Total Contract Cost + Contingency	$297,364	$0	$1,465	$298,829
Owner Cost %	11.00%	11.00%	11.00%	
Owner Cost	$32,710	$0	$161	$32,871
Total Contract Cost + Contingency + Owner Cost	$330,074	$0	$1,627	$331,700
Total No-Markup Items				$24,060
Grand Total				$355,760

MLE = Materials, Trade Labor, and Expenses

Phase Cost Over Time Report - Alternative 3 GW - Slurry Wall (Shallow), Pump and Treat, ISCO in the Deep, 30 Years of LTM, and Closeout

RACER Version: RACER® Version 11.2.16.0
Database Location: C:\Users\Jake Gallegos\Desktop\CPCPRC\CMS Report\RACER Files\RACER.mdb

Project:

ID: CPCPRC 15605.04
Name: Chevron Phillips Puerto Rico Core LLC
Category: None

Location

State / Country: PUERTO RICO
City: PUERTO RICO AVERAGE

Location Modifier

Default	User
1.160	1.160

Options

Database: System Costs
Cost Database Date: 2015
Report Option: Calendar

Description CMS Report - Estimate of Potential Costs

Site:

ID: CPCPRC
Name: **Alternative 3 GW - Slurry Wall (Shallow), Pump and Treat, ISCO in the Deep, 30 Years of LTM, and Closeout**
Type: None

Media/Waste Type

Primary: Groundwater
Secondary: Soil

Contaminant

Primary: Fuels
Secondary: Semi-Volatile Organic Compounds (SVOCs)

Documentation

Description: **Alternative 3 GW - Slurry Wall (Shallow), Pump and Treat, ISCO in the Deep, 30 Years of LTM, and Closeout**
Support Team: Documentation of personnel used to provide support for estimator and preparation of the estimate.
References: Documentation of reference sources used in the preparation of the estimate.

Technology Name	Technology	2017	2018	2019	2020	2021	2022
Five-Year Review		$24.016	$0	$0	$0	$0	$24.016

Technology Name	Technology	2023	2024	2025	2026	2027	2028
Five-Year Review		$0	$0	$0	$0	$24,016	$0

Technology Name	Technology	2029	2030	2031	2032	2033	2034
Five-Year Review		$0	$0	$0	$24,016	$0	$0

Technology Name	Technology	2035	2036	2037	2038	2039	2040
Five-Year Review		$0	$0	$24,016	$0	$0	$0

Technology Name	Technology	2041	2042	Total
Five-Year Review		$0	$24.016	$144.097

Total Phase Cost $144,097

Phase Technology Cost Detail Report - Alternative 3 GW 5-Year Reviews

System:

RACER Version: RACER® Version 11.2.16.0
Database Location: C:\Users\Jake Gallegos\Desktop\CPCPRC\CMS Report\RACER Files\RACER.mdb

Project:

ID: CPCPRC 15605.04
Name: Chevron Phillips Puerto Rico Core LLC
Category: None

Location

State / Country: PUERTO RICO
City: PUERTO RICO AVERAGE

Location Modifier

Default	User
1.160	1.160

Options

Database: System Costs
Cost Database Date: 2015
Report Option: Calendar

Description CMS Report - Estimate of Potential Costs

Site:

ID: CPCPRC
Name: Alternative 1 - No Further Action
Type: None

Media/Waste Type

Primary: Groundwater
Secondary: Soil

Contaminant

Primary: Fuels
Secondary: Semi-Volatile Organic Compounds (SVOCs)

Documentation

Description: **Alternative 3 GW - Slurry Wall (Shallow), Pump and Treat, ISCO in the Deep, 30 Years of LTM, and Closeout**
Support Team: Documentation of personnel used to provide support for estimator and preparation of the estimate.
References: Documentation of reference sources used in the preparation of the estimate.

Phase Documentation:

Phase Type: **Site Closeout**
Phase Name: 07 - 5-Year Reviews
Description: 07 - 5-Year Reviews
Approach: Ex Situ
Start Date: January, 2022
Labor Rate Group: System Labor Rate
Analysis Rate Group: System Analysis Rate
Phase Markup Template: System Defaults

Technology Markups	Markup	% Prime	% Sub.
Five-Year Review	True	100	0

Total Marked-up Cost: $355,760.40

Technologies:
Technology: Five-Year Review

Element: Document Review

Assembly	Description	Quantity	Unit of Measure	Material Unit Cost	Labor Unit Cost	Equipment Unit Cost	Sub Bid Cost	Extended Cost	Cost Override
33220102	Project Manager	12.00	HR	0.00	106.77	0.00	0.00	$1,281.24	False
33220105	Project Engineer	15.00	HR	0.00	78.14	0.00	0.00	$1,172.10	False
33220108	Project Scientist	11.00	HR	0.00	89.04	0.00	0.00	$979.42	False
33220109	Staff Scientist	23.00	HR	0.00	51.54	0.00	0.00	$1,185.40	False

Total Element Cost: $4,618.00

Element: Interviews

Assembly	Description	Quantity	Unit of Measure	Material Unit Cost	Labor Unit Cost	Equipment Unit Cost	Sub Bid Cost	Extended Cost	Cost Override
33220102	Project Manager	8.00	HR	0.00	106.77	0.00	0.00	$854.16	False

Total Element Cost: $854.00

Element: Site Inspection

Assembly	Description	Quantity	Unit of Measure	Material Unit Cost	Labor Unit Cost	Equipment Unit Cost	Sub Bid Cost	Extended Cost	Cost Override
33220102	Project Manager	12.00	HR	0.00	106.77	0.00	0.00	$1,281.24	False
33220105	Project Engineer	23.00	HR	0.00	78.14	0.00	0.00	$1,797.22	False
33220108	Project Scientist	19.00	HR	0.00	89.04	0.00	0.00	$1,691.73	False
33220109	Staff Scientist	20.00	HR	0.00	51.54	0.00	0.00	$1,030.78	False

Total Element Cost: $5,801.00

Element: Report

Assembly	Description	Quantity	Unit of Measure	Material Unit Cost	Labor Unit Cost	Equipment Unit Cost	Sub Bid Cost	Extended Cost	Cost Override
33220102	Project Manager	12.00	HR	0.00	106.77	0.00	0.00	$1,281.24	False
33220105	Project Engineer	31.00	HR	0.00	78.14	0.00	0.00	$2,422.34	False
33220108	Project Scientist	25.00	HR	0.00	89.04	0.00	0.00	$2,225.97	False
33220109	Staff Scientist	50.00	HR	0.00	51.54	0.00	0.00	$2,576.96	False

Total Element Cost: $8,507.00

Element: Travel

Assembly	Description	Quantity	Unit of Measure	Material Unit Cost	Labor Unit Cost	Equipment Unit Cost	Sub Bid Cost	Extended Cost	Cost Override
33010108	Sedan, Automobile, Rental	5.00	DAY	0.00	0.00	0.00	45.23	$226.14	False
33010202	Per Diem (per person)	10.00	DAY	0.00	0.00	0.00	221.00	$2,210.00	True
33041101	Airfare	2.00	LS	0.00	0.00	0.00	900.00	$1,800.00	True

Total Element Cost: $4,236.14
Total 1st Year Tech Cost: $24,016.14

Total Phase Element Cost **$24,016.14**

Alternative – 1 SO

Cost Estimate

Site Cost Summary Report - Alternative 1 SO Soil Excavate and Offsite Disposal (with Markups)

System:

RACER Version: RACER® Version 11.2.16.0
Database Location: C:\Users\Jake Gallegos\Desktop\CPCPRC\CMS Report\RACER Files\RACER.mdb

Project:

ID: CPCPRC 15605.04
Name: Chevron Phillips Puerto Rico Core LLC
Category: None

Location

State / Country: PUERTO RICO
City: PUERTO RICO AVERAGE

Location Modifier

Default	User
1.160	1.160

Options

Database: System Costs
Cost Database Date: 2015
Report Option: Calendar

Description

CMS Report - Estimate of Potential Costs
ID: CPCPRC
Name: **Alternative 1 SO - Soil Excavate and Offsite Disposal**
Type: None

Media/Waste Type

Primary: Soil
Secondary: N/A

Contaminant

Primary: Fuels
Secondary: Semi-Volatile Organic Compounds (SVOCs)

Phase Names

Pre-Study
Study
Design
Removal/Interim Action
Remedial Action
Operations & Maintenance
Long Term Monitoring
Site Closeout

Documentation

Description: Alternative 1 SO - Soil Excavation and Offsite Disposal
Support Team: Documentation of personnel used to provide support for estimator and preparation of the estimate.
References: Documentation of reference sources used in the preparation of the estimate.

Phase	Direct Cost	Markups	Total Cost
Study and Design	$630,000	$125,244	$755,244
Remedial Action - Soil Excavation and Offsite Disposal	$3,208,693	$889,978	$4,098,670
Construction Completion Report	$24,016	$35,277	$59,293
Total Site Cost	$3,862,709	$1,050,499	$4,913,208

Phase Markups Report

Phase Markups Report

Project: Chevron Phillips Puerto Rico Core LLC
Site: Alternative 1 SO - Soil Excavate and Offsite Disposal
Phase: 2 - Soil Dig and Off Site Disposal

Subcontracted Portion of Work

	Professional Labor	MLE*	SubBid	Total
Total Direct Cost	$0	$0	$1,599,196	$1,599,196
Overhead %	132.00%	25.00%	0.00%	
Overhead	$0	$0	$0	$0
Subtotal	$0	$0	$1,599,196	$1,599,196
Subcontractor Profit %	8.00%	8.00%	0.00%	
Subcontractor Profit	$0	$0	$0	$0
Total Subcontract Cost	$0	$0	$1,599,196	$1,599,196

Prime Contractor Portion of Work

	Professional Labor	MLE*	SubBid	Total
Total Direct Cost	$0	$1,147,558	$0	$1,147,558
Overhead %	132.00%	25.00%	0.00%	
Overhead	$0	$286,889	$0	$286,889
Prime Subtotal	$0	$1,434,447	$0	$1,434,447
Prime + Subcontract	$0	$1,434,447	$1,599,196	$3,033,643
Contingency %	8.00%	8.00%	8.00%	
Prime Contingency Cost	$0	$114,756	$127,936	$242,691
Prime + Subcontract + Contingency	$0	$1,549,203	$1,727,131	$3,276,334
Other Project Costs				
Contingency Allowance	$0	$0	$0	$0
Total Contract Cost + Contingency	$0	$1,549,203	$1,727,131	$3,276,334
Owner Cost %	11.00%	11.00%	11.00%	
Owner Cost	$0	$170,412	$189,984	$360,397
Total Contract Cost + Contingency + Owner Cost	$0	$1,719,615	$1,917,116	$3,636,731
Total No-Markup Items				$461,939
Grand Total				$4,098,670

MLE = Materials, Trade Labor, and Expenses

Phase Technology Cost Detail Report - Alternative 1 SO - Soil Dig and Haul

System:

RACER Version:	RACER® Version 11.2.16.0
Database Location:	C:\Users\Jake Gallegos\Desktop\CPCPRC\CMS Report\RACER Files\RACER.mdb

Folder:

Folder Name:	CMS V1

Project:

ID:	CPCPRC 15605.04
Name:	Chevron Phillips Puerto Rico Core LLC
Category:	None

Location

State / Country:	PUERTO RICO
City:	PUERTO RICO AVERAGE

Location Modifier

Default	User
1.160	1.160

Options

Database:	System Costs
Cost Database Date:	2015
Report Option:	Calendar

Description CMS Report - Estimate of Potential Costs

Site:

ID:	CPCPRC
Name:	**Alternative 1 SO - Soil Excavate and Offsite Disposal**
Type:	None

Media/Waste Type

Primary:	Soil
Secondary:	N/A

Contaminant

Primary:	Fuels
Secondary:	Semi-Volatile Organic Compounds (SVOCs)

Documentation

Description:	**Alternative 1 SO - Soil Excavation and Offsite Disposal**
Support Team:	Documentation of personnel used to provide support for estimator and preparation of the estimate.
References:	Documentation of reference sources used in the preparation of the estimate.

Phase Documentation:

Phase Type:	Remedial Action
Phase Name:	2 - Soil Dig and Off Site Disposal
Description:	2 - Excavate, Load, and Haul Soil
Approach:	Ex Situ
Start Date:	January, 2017
Labor Rate Group:	System Labor Rate
Analysis Rate Group:	System Analysis Rate
Phase Markup Template:	System Defaults

Technology Markups	Marku	% Prime	% Sub.
Excavation	True	100	0
Load and Haul	True	100	0
Off-site Transportation and Waste Disposal	True	100	0
Professional Labor Management	False	0	0

Total Marked-up Cost: $4,098,670.00

Technologies:

Technology: Excavation

Assembly	Description	Quantity	Unit of Measure	Material Unit Cost	Labor Unit Cost	Equipment Unit Cost	Sub Bid Cost	Extended Cost	Cost Override
17030242	22 CY Scraper by BCY	44,324.00	CY	0.00	1.28	2.38	0.00	$162,364.70	False
17030415	On-Site Backfill for Large Excavations, Includes Compaction	2,000.00	ECY	0.00	1.07	0.98	0.04	$4,172.22	False
18050402	Seeding, Vegetative Cover	32.97	ACR	3,853.33	584.20	243.22	0.00	$154,324.31	False

Total Element Cost: $320,861.22
Total 1st Year Tech Cost: $320,861.22

Technology: Load and Haul

Assembly	Description	Quantity	Unit of Measure	Material Unit Cost	Labor Unit Cost	Equipment Unit Cost	Sub Bid Cost	Extended Cost	Cost Override
17020401	Materials Handling Charge	44,323.00	CY	6.00	0.00	0.00	0.00	$265,937.28	False
17030226	988, 7.0 CY, Wheel Loader	141.00	HR	0.00	82.67	104.37	0.00	$26,372.45	False
17030289	32 CY, Semi Dump	2,133.00	HR	0.00	76.94	80.23	0.00	$335,244.43	False

Total Element Cost: $627,554.17
Total 1st Year Tech Cost: $627,554.17

Technology: Off-site Transportation and Waste Disposal

Element:

Assembly	Description	Quantity	Unit of Measure	Material Unit Cost	Labor Unit Cost	Equipment Unit Cost	Sub Bid Cost	Extended Cost	Cost Override
33190102	Bulk Solid Waste Loading Into Disposal Vehicle or Bulk Disposal Container	44,323.00	BCY	1.10	1.45	0.45	0.00	$133,036.16	False
33190205	Transport Bulk Solid Hazardous Waste, Maximum 20 CY (per Mile)	44,340.00	MI	0.00	0.00	0.00	3.02	$133,729.44	False
33190317	Waste Stream Evaluation Fee, Not Including 50% Rebate on 1st Shipment	1.00	EA	0.00	0.00	0.00	58.00	$58.00	False
33190807	32 Ft. Dump Truck, 6 Mil Liner, disposable	2,217.00	EA	29.86	0.00	0.00	0.00	$66,196.07	False
33197270	Landfill Nonhazardous Solid Bulk Waste by CY	44,323.00	CY	0.00	0.00	0.00	33.06	$1,465,318.34	False

Total Element Cost: $1,798,338.01
Total 1st Year Tech Cost: $1,798,338.01

Technology: Professional Labor Management

Element:

Assembly	Description	Quantity	Unit of Measure	Material Unit Cost	Unit Cost	Equipment Unit Cost	Sub Bid Cost	Extended Cost	Cost Override
33021670	Waste Characterization Samples	90.00	EA	0.00	0.00	0.00	548.68	$49,381.20	False
33022135	Testing, Sulfolane (SW8270)	90.00	EA	0.00	0.00	0.00	100.00	$9,000.00	True
33022150	Testing, BTEX (SW8260)	90.00	EA	0.00	0.00	0.00	50.00	$4,500.00	True
33220149	Lump Sum Percentage Labor Construction Field Manager	1.00	LS	0.00	399,058.00	0.00	0.00	$399,058.00	True

Total Element Cost: $461,939.20
Total 1st Year Tech Cost: $461,939.20

Total Phase Element Cost **$3,208,692.60**

Phase Markups Report

Phase Markups Report

Project: Chevron Phillips Puerto Rico Core LLC
Site: Alternative 1 SO - Soil Excavation and Offsite Disposal
Phase: 3 - 5-Year Review (Construction Completion Report)

Subcontracted Portion of Work

	Professional Labor	MLE*	SubBid	Total
Total Direct Cost	$0	$0	$226	$226
Overhead %	132.00%	25.00%	0.00%	
Overhead	$0	$0	$0	$0
Subtotal	$0	$0	$226	$226
Subcontractor Profit %	8.00%	8.00%	0.00%	
Subcontractor Profit	$0	$0	$0	$0
Total Subcontract Cost	$0	$0	$226	$226

Prime Contractor Portion of Work

	Professional Labor	MLE*	SubBid	Total
Total Direct Cost	$19,780	$0	$0	$19,780
Overhead %	132.00%	25.00%	0.00%	
Overhead	$26,110	$0	$0	$26,110
Prime Subtotal	$45,889	$0	$0	$45,889
Prime + Subcontract	$45,889	$0	$226	$46,116
Contingency %	8.00%	8.00%	8.00%	
Prime Contingency Cost	$3,671	$0	$18	$3,689
Prime + Subcontract + Contingency	$49,561	$0	$244	$49,805

Other Project Costs

	Professional Labor	MLE*	SubBid	Total
Contingency Allowance	$0	$0	$0	$0
Total Contract Cost + Contingency	$49,561	$0	$244	$49,805
Owner Cost %	11.00%	11.00%	11.00%	
Owner Cost	$5,452	$0	$27	$5,479
Total Contract Cost + Contingency + Owner Cost	$55,012	$0	$271	$55,283
Total No-Markup Items				$4,010
Grand Total				$59,293

MLE = Materials, Trade Labor, and Expenses

Phase Technology Cost Detail Report - Alternative 1 SO 5-Year Review (Construction Completion Report)

System:

RACER Version: RACER® Version 11.2.16.0
Database Location: C:\Users\Jake Gallegos\Desktop\CPCPRC\CMS Report\RACER Files\RACER.mdb

Project:

ID: CPCPRC 15605.04
Name: Chevron Phillips Puerto Rico Core LLC
Category: None

Location

State / Country: PUERTO RICO
City: PUERTO RICO AVERAGE

Location Modifier

Default	User
1.160	1.160

Options

Database: System Costs
Cost Database Date: 2015
Report Option: Calendar

Description CMS Report - Estimate of Potential Costs

Site:

ID: CPCPRC
Name: **Alternative 1 SO - Soil Excavate and Offsite Disposal**
Type: None

Media/Waste Type

Primary: Groundwater
Secondary: N/A

Contaminant

Primary: Fuels
Secondary: Semi-Volatile Organic Compounds (SVOCs)

Documentation

Description: **Alternative 1 SO - Soil Excavation and Offsite Disposal**
Support Team: Documentation of personnel used to provide support for estimator and preparation of the estimate.
References: Documentation of reference sources used in the preparation of the estimate.

Phase Documentation:

Phase Type: Site Closeout
Phase Name: 3 - 5-Year Reviews
Description: 3 - 5-Year Reviews
Approach: Ex Situ
Start Date: January, 2022
Labor Rate Group: System Labor Rate
Analysis Rate Group: System Analysis Rate
Phase Markup Template: System Defaults

Technology Markups	Marku	% Prime	% Sub.
Five-Year Review	True	100	0

Total Marked-up Cost: $59,293.40

Technologies:
Technology: Five-Year Review

Element: Document Review

Assembly	Description	Quantity	Unit of Measure	Material Unit Cost	Labor Unit Cost	Equipment Unit Cost	Sub Bid Cost	Extended Cost	Cost Override
33220102	Project Manager	12.00	HR	0.00	106.77	0.00	0.00	$1,281.26	False
33220105	Project Engineer	15.00	HR	0.00	78.14	0.00	0.00	$1,172.11	False
33220108	Project Scientist	11.00	HR	0.00	89.04	0.00	0.00	$979.42	False
33220109	Staff Scientist	23.00	HR	0.00	51.54	0.00	0.00	$1,185.40	False

Total Element Cost: $4,618.00

Element: Interviews

Assembly	Description	Quantity	Unit of Measure	Material Unit Cost	Labor Unit Cost	Equipment Unit Cost	Sub Bid Cost	Extended Cost	Cost Override
33220102	Project Manager	8.00	HR	0.00	106.77	0.00	0.00	$854.17	False

Total Element Cost: $854.00

Element: Site Inspection

Assembly	Description	Quantity	Unit of Measure	Material Unit Cost	Labor Unit Cost	Equipment Unit Cost	Sub Bid Cost	Extended Cost	Cost Override
33220102	Project Manager	12.00	HR	0.00	106.77	0.00	0.00	$1,281.26	False
33220105	Project Engineer	23.00	HR	0.00	78.14	0.00	0.00	$1,797.24	False
33220108	Project Scientist	19.00	HR	0.00	89.04	0.00	0.00	$1,691.73	False
33220109	Staff Scientist	20.00	HR	0.00	51.54	0.00	0.00	$1,030.78	False

Total Element Cost: $5,801.00

Element: Report

Assembly	Description	Quantity	Unit of Measure	Material Unit Cost	Labor Unit Cost	Equipment Unit Cost	Sub Bid Cost	Extended Cost	Cost Override
Technology: Five-Year Review									
33220102	Project Manager	12.00	HR	0.00	106.77	0.00	0.00	$1,281.26	False
33220105	Project Engineer	31.00	HR	0.00	78.14	0.00	0.00	$2,422.36	False
33220108	Project Scientist	25.00	HR	0.00	89.04	0.00	0.00	$2,225.97	False
33220109	Staff Scientist	50.00	HR	0.00	51.54	0.00	0.00	$2,576.96	False

Total Element Cost: $8,507.00

Element: Travel

Assembly	Description	Quantity	Unit of Measure	Material Unit Cost	Labor Unit Cost	Equipment Unit Cost	Sub Bid Cost	Extended Cost	Cost Override
33010108	Sedan, Automobile, Rental	5.00	DAY	0.00	0.00	0.00	45.23	$226.14	False
33010202	Per Diem (per person)	10.00	DAY	0.00	0.00	0.00	221.00	$2,210.00	True
33041101	Airfare	2.00	LS	0.00	0.00	0.00	900.00	$1,800.00	True

Total Element Cost: $4,236.14
Total 1st Year Tech Cost: $24,016.14

Total Phase Element Cost **$24,016.14**

Alternative – 2 SO

Cost Estimate

Site Cost Summary Report - Biological Treatment of Soil in Land Farm Treatment Cells (with Markups)

System:

RACER Version:	RACER® Version 11.2.16.0
Database Location:	C:\Users\Jake Gallegos\Desktop\CPCPRC\CMS Report\RACER Files\RACER.mdb

Project:

ID:	CPCPRC 15605.04
Name:	Chevron Phillips Puerto Rico Core LLC
Category:	None

Location

State / Country:	PUERTO RICO
City:	PUERTO RICO AVERAGE

Location Modifier

Default	User
1.160	1.160

Options

Database:	System Costs
Cost Database Date:	2015
Report Option:	Calendar

Description CMS Report - Estimate of Potential Costs

ID:	CPCPRC
Name:	**Alternative 2 SO - Ex-Situ Biological Treatment - Land Farming**
Type:	None

Media/Waste Type

Primary:	Soil
Secondary:	N/A

Contaminant

Primary:	Fuels
Secondary:	Semi-Volatile Organic Compounds (SVOCs)

Documentation

Description:	Alternaitve 2 SO - Ex-Situ Biological Treatment of Soil in Land Farm Treatment Cells
Support Team:	Documentation of personnel used to provide support for estimator and preparation of the estimate.
References:	Documentation of reference sources used in the preparation of the estimate.

Phase	Direct Cost	Markups	Total Cost
Design	$585,000	$116,298	$701,298
Remedial Action - Soil Biological Treatment in Land Farm	$3,530,114	$1,704,984	$5,235,098
Construction Completion Report	$24,016	$35,277	$59,293
Total Site Cost	$4,139,130	$1,856,559	$5,995,689

Phase Markups Report

Phase Markups Report

Project: Chevron Phillips Puerto Rico Core LLC
Site: Alternative 2 SO - Ex-Situ Biological Treatment - Land Farming
Phase: 2 - Ex-Situ Landfarming of Soil

Subcontracted Portion of Work

	Professional Labor	MLE*	SubBid	Total
Total Direct Cost	$0	$0	$54,090	$54,090
Overhead %	132.00%	25.00%	0.00%	
Overhead	$0	$0	$0	$0
Subtotal	$0	$0	$54,090	$54,090
Subcontractor Profit %	8.00%	8.00%	0.00%	
Subcontractor Profit	$0	$0	$0	$0
Total Subcontract Cost	$0	$0	$54,090	$54,090

Prime Contractor Portion of Work

	Professional Labor	MLE*	SubBid	Total
Total Direct Cost	$0	$3,398,658	$0	$3,398,658
Overhead %	132.00%	25.00%	0.00%	
Overhead	$0	$849,664	$0	$849,664
Prime Subtotal	$0	$4,248,322	$0	$4,248,322
Prime + Subcontract	$0	$4,248,322	$54,090	$4,302,412
Contingency %	8.00%	8.00%	8.00%	
Prime Contingency Cost	$0	$339,866	$4,327	$344,193
Prime + Subcontract + Contingency	$0	$4,588,188	$58,417	$4,646,605
Other Project Costs				
Contingency Allowance	$0	$0	$0	$0
Total Contract Cost + Contingency	$0	$4,588,188	$58,417	$4,646,605
Owner Cost %	11.00%	11.00%	11.00%	
Owner Cost	$0	$504,701	$6,426	$511,127
Total Contract Cost + Contingency + Owner Cost	$0	$5,092,889	$64,843	$5,157,732
Total No-Markup Items				$77,366
Grand Total				$5,235,098

MLE = Materials, Trade Labor, and Expenses

Phase Technology Cost Detail Report - Alternative 2 SO Biological Treatment of Soil in Land Farm Treatment Cells

System:

RACER Version: RACER® Version 11.2.16.0
Database Location: C:\Users\Jake Gallegos\Desktop\CPCPRC\CMS Report\RACER Files\RACER.mdb

Project:

ID: CPCPRC 15605.04
Name: Chevron Phillips Puerto Rico Core LLC
Category: None

Location

State / Country: PUERTO RICO
City: PUERTO RICO AVERAGE

Location Modifier

Default	User
1.160	1.160

Options

Database: System Costs
Cost Database Date: 2015
Report Option: Calendar

Description CMS Report - Estimate of Potential Costs

Site:

ID: CPCPRC
Name: **Alternative 2 SO - Ex-Situ Biological Treatment - Land Farming**
Type: None

Media/Waste Type

Primary: Soil
Secondary: N/A

Contaminant

Primary: Fuels
Secondary: Semi-Volatile Organic Compounds (SVOCs)

Documentation

Description: **Alternaitve 2 SO - Ex-Situ Biological Treatment of Soil in Land Farm Treatment Cells**
Support Team: Documentation of personnel used to provide support for estimator and preparation of the estimate.
References: Documentation of reference sources used in the preparation of the estimate.

Phase Documentation:

Phase Type: Remedial Action
Phase Name: 2 - Ex-Situ Landfarming of Soil
Description: 2 - Ex-Situ Landfarming of Soil
Approach: Ex Situ
Start Date: January, 2017
Labor Rate Group: System Labor Rate
Analysis Rate Group: System Analysis Rate
Phase Markup Template: System Defaults

Technology Markups	Marku	% Prime	% Sub.
Professional Labor Management	False	0	0
Ex Situ Land Farming	True	100	0

Total Marked-up Cost: $5,235,097.76

Technologies:

Technology: Ex Situ Land Farming

Assembly	Description	Quantity	Unit of Measure	Material Unit Cost	Labor Unit Cost	Equipment Unit Cost	Sub Bid Cost	Extended Cost	Cost Override
17010501	Grub and stack, 140 H.P. dozer	10,000.00	CY	0.00	3.71	2.05	0.00	$57,623.79	False
17030217	953, 2.0 CY, Track Loader	905.00	HR	0.00	82.67	74.69	0.00	$142,413.60	False
17030405	950, 3.00 CY, Delivered & Dumped, Backfill with Sand	10,000.00	CY	95.70	8.65	5.22	0.00	$1,095,745.70	False
17030415	On-Site Backfill for Large Excavations, Includes Compaction	2,000.00	ECY	0.00	1.07	0.98	0.04	$4,172.22	False
17030420	Backfill Trench, Borrow Material, Delivered & Dumped Only	369.00	CY	29.00	2.86	1.78	0.00	$12,414.58	False
17039903	Trench, Hand Excavation, Heavy Clay, 2' - 6' Deep, Piled Only, Excludes Sheeting, Excludes Dewatering	585.00	BCY	0.00	133.89	0.00	0.00	$78,327.57	False
18050410	Fertilize, 800 Lbs/Acre, Spray from Truck	258.00	ACR	63.16	47.88	50.26	0.00	$41,615.55	False
18050413	Watering with 3,000-Gallon Tank Truck, per Pass	1,085.00	ACR	220.81	53.62	56.30	0.00	$358,844.62	False
19020602	18" x 18" Underground French Drain	2,078.46	LF	3.67	26.24	3.03	0.00	$68,465.92	False
19040610	Pump, pedestal sump, single stage, 75 GPM, 1-1/2 H.P., 2" discharge	3.00	EA	4,234.00	935.92	0.00	0.00	$15,509.76	False
19040624	4,000 Gallon Horizontal Plastic Sump with 6" NPT Connection	3.00	EA	8,816.00	1,097.23	91.31	0.00	$30,013.61	False
33022135	Testing, Sulfolane (SW8270)	360.00	EA	0.00	0.00	0.00	100.00	$36,000.00	True
33022150	Testing, BTEX (SW8260)	360.00	EA	0.00	0.00	0.00	50.00	$18,000.00	True
33080503	Polymeric Liner Anchor Trench, 3' x 1.5'	2,103.00	LF	0.23	2.56	0.40	0.00	$6,717.89	False
33080563	40 Mil Polymeric Liner, PVC	295,518.00	SF	0.50	0.52	0.04	0.00	$313,617.65	False
33080590	Waste Pile Cover, 135 Lb Tear, 2 - 2.5 Year Life	31,402.00	SY	1.25	0.48	0.00	0.00	$54,452.90	False
33110301	Soil Tilling, D3 Dozer with Tiller Attachment	1,080.00	HR	0.00	82.67	37.44	0.00	$129,720.09	False
33119901	Application of Bioculture to Contaminated Soil	277.00	ACR	220.81	53.62	56.30	0.00	$91,612.87	False
33119902	Light Petroleum Hydrocarbon Degraders, Microorganisms	12,411.00	LB	66.47	0.00	0.00	0.00	$824,934.32	False
33170802	Decontaminate Medium Equipment	180.00	EA	0.00	403.03	0.00	0.00	$72,545.09	False

Total Element Cost: $3,452,747.73
Total 1st Year Tech Cost: $3,452,747.73

Technology: Professional Labor Management

Assembly	Description	Quantity	Unit of Measure	Material Unit Cost	Labor Unit Cost	Equipment Unit Cost	Sub Bid Cost	Extended Cost	Cost Override
33220149	Lump Sum Percentage Labor Cost	1.00	LS	0.00	77,366.00	0.00	0.00	$77,366.00	True

Total Element Cost: $77,366.00
Total 1st Year Tech Cost: $77,366.00

Total Phase Element Cost **$3,530,113.73**

Phase Markups Report

Phase Markups Report

Project: Chevron Phillips Puerto Rico Core LLC
Site: Alternative 2 SO - Ex-Situ Biological Treatment - Land Farming
Phase: 3 - 5-Year Reviews (Construction Completion Report)

Subcontracted Portion of Work

	Professional Labor	MLE*	SubBid	Total
Total Direct Cost	$0	$0	$226	$226
Overhead %	132.00%	25.00%	0.00%	
Overhead	$0	$0	$0	$0
Subtotal	$0	$0	$226	$226
Subcontractor Profit %	8.00%	8.00%	0.00%	
Subcontractor Profit	$0	$0	$0	$0
Total Subcontract Cost	$0	$0	$226	$226

Prime Contractor Portion of Work

	Professional Labor	MLE*	SubBid	Total
Total Direct Cost	$19,780	$0	$0	$19,780
Overhead %	132.00%	25.00%	0.00%	
Overhead	$26,110	$0	$0	$26,110
Prime Subtotal	$45,889	$0	$0	$45,889
Prime + Subcontract	$45,889	$0	$226	$46,116
Contingency %	8.00%	8.00%	8.00%	
Prime Contingency Cost	$3,671	$0	$18	$3,689
Prime + Subcontract + Contingency	$49,561	$0	$244	$49,805

Other Project Costs

	Professional Labor	MLE*	SubBid	Total
Contingency Allowance	$0	$0	$0	$0
Total Contract Cost + Contingency	$49,561	$0	$244	$49,805
Owner Cost %	11.00%	11.00%	11.00%	
Owner Cost	$5,452	$0	$27	$5,479
Total Contract Cost + Contingency + Owner Cost	$55,012	$0	$271	$55,283
Total No-Markup Items				$4,010
Grand Total				$59,293

MLE = Materials, Trade Labor, and Expenses

Phase Technology Cost Detail Report - Alternative 2 SO 5-Year Review (Construction Completion Report)

System:

RACER Version: RACER® Version 11.2.16.0
Database Location: C:\Users\Jake Gallegos\Desktop\CPCPRC\CMS Report\RACER Files\RACER.mdb

Project:

ID: CPCPRC 15605.04
Name: Chevron Phillips Puerto Rico Core LLC
Category: None

Location

State / Country: PUERTO RICO
City: PUERTO RICO AVERAGE

Location Modifier

Default	User
1.160	1.160

Options

Database: System Costs
Cost Database Date: 2015
Report Option: Calendar

Description CMS Report - Estimate of Potential Costs

Site:

ID: CPCPRC
Name: **Alternative 2 SO - Ex-Situ Biological Treatment - Land Farming**
Type: None

Media/Waste Type

Primary: Groundwater
Secondary: N/A

Contaminant

Primary: Fuels
Secondary: Semi-Volatile Organic Compounds (SVOCs)

Documentation

Description: **Alternative 2 SO - Ex-Situ Biological Treatment - Land Farming**
Support Team: Documentation of personnel used to provide support for estimator and preparation of the estimate.
References: Documentation of reference sources used in the preparation of the estimate.

Phase Documentation:

Phase Type: Site Closeout
Phase Name: 3 - 5-Year Reviews
Description: 3 - 5-Year Reviews
Approach: Ex Situ
Start Date: January, 2022
Labor Rate Group: System Labor Rate
Analysis Rate Group: System Analysis Rate
Phase Markup Template: System Defaults

Technology Markups	Marku	% Prime	% Sub.
Five-Year Review	True	100	0

Total Marked-up Cost: $59,293.40

Technologies:
Technology: Five-Year Review

Element: Document Review

Assembly	Description	Quantity	Unit of Measure	Material Unit Cost	Labor Unit Cost	Equipment Unit Cost	Sub Bid Cost	Extended Cost	Cost Override
33220102	Project Manager	12.00	HR	0.00	106.77	0.00	0.00	$1,281.26	False
33220105	Project Engineer	15.00	HR	0.00	78.14	0.00	0.00	$1,172.11	False
33220108	Project Scientist	11.00	HR	0.00	89.04	0.00	0.00	$979.42	False
33220109	Staff Scientist	23.00	HR	0.00	51.54	0.00	0.00	$1,185.40	False

Total Element Cost: $4,618.00

Element: Interviews

Assembly	Description	Quantity	Unit of Measure	Material Unit Cost	Labor Unit Cost	Equipment Unit Cost	Sub Bid Cost	Extended Cost	Cost Override
33220102	Project Manager	8.00	HR	0.00	106.77	0.00	0.00	$854.17	False

Total Element Cost: $854.00

Element: Site Inspection

Assembly	Description	Quantity	Unit of Measure	Material Unit Cost	Labor Unit Cost	Equipment Unit Cost	Sub Bid Cost	Extended Cost	Cost Override
33220102	Project Manager	12.00	HR	0.00	106.77	0.00	0.00	$1,281.26	False
33220105	Project Engineer	23.00	HR	0.00	78.14	0.00	0.00	$1,797.24	False
33220108	Project Scientist	19.00	HR	0.00	89.04	0.00	0.00	$1,691.73	False
33220109	Staff Scientist	20.00	HR	0.00	51.54	0.00	0.00	$1,030.78	False

Total Element Cost: $5,801.00

Element: Report

Assembly	Description	Quantity	Unit of Measure	Material Unit Cost	Labor Unit Cost	Equipment Unit Cost	Sub Bid Cost	Extended Cost	Cost Override

Technology: Five-Year Review

Assembly	Description	Quantity	Unit of Measure	Material Unit Cost	Labor Unit Cost	Equipment Unit Cost	Sub Bid Cost	Extended Cost	Cost Override
33220102	Project Manager	12.00	HR	0.00	106.77	0.00	0.00	$1,281.26	False
33220105	Project Engineer	31.00	HR	0.00	78.14	0.00	0.00	$2,422.36	False
33220108	Project Scientist	25.00	HR	0.00	89.04	0.00	0.00	$2,225.97	False
33220109	Staff Scientist	50.00	HR	0.00	51.54	0.00	0.00	$2,576.96	False

Total Element Cost: $8,507.00

Element: Travel

Assembly	Description	Quantity	Unit of Measure	Material Unit Cost	Labor Unit Cost	Equipment Unit Cost	Sub Bid Cost	Extended Cost	Cost Override
33010108	Sedan, Automobile, Rental	5.00	DAY	0.00	0.00	0.00	45.23	$226.14	False
33010202	Per Diem (per person)	10.00	DAY	0.00	0.00	0.00	221.00	$2,210.00	True
33041101	Airfare	2.00	LS	0.00	0.00	0.00	900.00	$1,800.00	True

Total Element Cost: $4,236.14
Total 1st Year Tech Cost: $24,016.14

Total Phase Element Cost **$24,016.14**

Alternative – 3 SO

Cost Estimate

Site Cost Summary Report - Biological Treatment of Soil using Soil Mixing (with Markups)

System:

RACER Version: RACER® Version 11.2.16.0
Database Location: C:\Users\Jake Gallegos\Desktop\CPCPRC\CMS Report\RACER Files\RACER.mdb

Project:

ID: CPCPRC 15605.04
Name: Chevron Phillips Puerto Rico Core LLC
Category: None

Location

State / Country: PUERTO RICO
City: PUERTO RICO AVERAGE

Location Modifier

Default	User
1.160	1.160

Options

Database: System Costs
Cost Database Date: 2015
Report Option: Calendar

Description

CMS Report - Estimate of Potential Costs
ID: CPCPRC
Name: **Alternative 3 SO - In-Situ Biological Treatment - Soil Mixing**
Type: None

Media/Waste Type

Primary: Soil
Secondary: N/A

Contaminant

Primary: Fuels
Secondary: Semi-Volatile Organic Compounds (SVOCs)

Documentation

Description: **Alternative 3 SO - In-Situ Biological Treatment of Soil using Soil Mixing Technology**
Support Team: Documentation of personnel used to provide support for estimator and preparation of the estimate.
References: Documentation of reference sources used in the preparation of the estimate.

Phase	Direct Cost	Markups	Total Cost
Study and Design	$1,000,000	$198,800	$1,198,800
Remedial Action - Biological Treatment via Five Soil Mixing Events	$4,723,257	$3,624,100	$8,347,357
Construction Completion Report	$24,016	$35,277	$59,293
Total Site Cost	$5,747,273	$3,858,178	$9,605,451

Phase Markups Report

Phase Markups Report

Project: Chevron Phillips Puerto Rico Core LLC
Site: Alternative 3 SO - In-Situ Biological Treatment - Soil Mixing
Phase: 02 - In-Situ Biological Treatment of Soil

Subcontracted Portion of Work

	Professional Labor	MLE*	SubBid	Total
Total Direct Cost	$0	$0	$523,800	$523,800
Overhead %	132.00%	25.00%	0.00%	
Overhead	$0	$0	$0	$0
Subtotal	$0	$0	$523,800	$523,800
Subcontractor Profit %	8.00%	8.00%	0.00%	
Subcontractor Profit	$0	$0	$0	$0
Total Subcontract Cost	$0	$0	$523,800	$523,800

Prime Contractor Portion of Work

	Professional Labor	MLE*	SubBid	Total
Total Direct Cost	$1,266,601	$2,535,363	$0	$3,801,964
Overhead %	132.00%	25.00%	0.00%	
Overhead	$1,671,913	$633,841	$0	$2,305,754
Prime Subtotal	$2,938,515	$3,169,204	$0	$6,107,719
Prime + Subcontract	$2,938,515	$3,169,204	$523,800	$6,631,519
Contingency %	8.00%	8.00%	8.00%	
Prime Contingency Cost	$235,081	$253,536	$41,904	$530,521
Prime + Subcontract + Contingency	$3,173,596	$3,422,740	$565,704	$7,162,040
Other Project Costs				
Contingency Allowance	$0	$0	$0	$0
Total Contract Cost + Contingency	$3,173,596	$3,422,740	$565,704	$7,162,040
Owner Cost %	11.00%	11.00%	11.00%	
Owner Cost	$349,096	$376,501	$62,227	$787,824
Total Contract Cost + Contingency + Owner Cost	$3,522,691	$3,799,242	$627,931	$7,949,864
Total No-Markup Items				$397,493
Grand Total				$8,347,357

MLE = Materials, Trade Labor, and Expenses

Phase Technology Cost Detail Report - Alternative 3 SO Biological Treatment of Soil using Soil Mixing

System:

RACER Version:	RACER® Version 11.2.16.0
Database Location:	C:\Users\Jake Gallegos\Desktop\CPCPRC\CMS Report\RACER Files\RACER.mdb

Project:

ID:	CPCPRC 15605.04
Name:	Chevron Phillips Puerto Rico Core LLC
Category:	None

Location

State / Country:	PUERTO RICO
City:	PUERTO RICO AVERAGE

Location Modifier

Default	User
1.160	1.160

Options

Database:	System Costs
Cost Database Date:	2015
Report Option:	Calendar

Description CMS Report - Estimate of Potential Costs

Site:

ID:	CPCPRC
Name:	**Alternative 3 SO - In-Situ Biological Treatment - Soil Mixing**
Type:	None

Media/Waste Type

Primary:	Soil
Secondary:	N/A

Contaminant

Primary:	Fuels
Secondary:	Semi-Volatile Organic Compounds (SVOCs)

Documentation

Description:	**Alternative 3 SO - In-Situ Biological Treatment of Soil using Soil Mixing Technology**
Support Team:	Documentation of personnel used to provide support for estimator and preparation of the estimate.
References:	Documentation of reference sources used in the preparation of the estimate.

Phase Documentation:

Phase Type:	Remedial Action
Phase Name:	02 - In-Situ Biological Treatment of Soil
Description:	02 - Five Soil Mixing Events - with nutrients and biological additives
Approach:	In Situ
Start Date:	January, 2017
Labor Rate Group:	System Labor Rate
Analysis Rate Group:	System Analysis Rate
Phase Markup Template:	System Defaults

Technology Markups	Markup	% Prime	% Sub.
In Situ Biodegradation	True	100	0
Professional Labor Management	False	0	0

Total Marked-up Cost: $8,347,357.50

Technologies:

Technology: In Situ Biodegradation

Assembly	Description	Quantity	Unit of Measure	Material Unit Cost	Labor Unit Cost	Equipment Unit Cost	Sub Bid Cost	Extended Cost	Cost Override
33010117	In-Situ Biodegradation Soil Mixing Equipment Mobilization/Demobilization	1.00	LS	0.00	205.17	202.54	0.00	$407.71	False
33022135	Testing, Sulfolane (SW8270)	360.00	EA	0.00	0.00	0.00	100.00	$36,000.00	True
33022150	Testing, BTEX (SW8260)	360.00	EA	0.00	0.00	0.00	50.00	$18,000.00	True
33119903	Light Petroleum Hydrocarbon Degraders, 100 Lb Bag, Microorganisms	115.00	EA	6,646.80	0.00	0.00	0.00	$764,381.98	False
33119951	Biological treatment, bionutrients, 50 lb bag	22,150.00	EA	79.94	0.00	0.00	0.00	$1,770,573.49	False
33119961	In-Situ Biodegradation Soil Mixing Equipment Rental (5 events over 12 Months)	60.00	MO	0.00	0.00	0.00	7,830.00	$469,799.99	False
33220105	Project Engineer	3,365.00	HR	0.00	78.14	0.00	0.00	$262,943.49	False
33220112	Field Technician	22,425.00	HR	0.00	44.76	0.00	0.00	$1,003,657.65	False

Total Element Cost: $4,325,764.30
Total 1st Year Tech Cost: $4,325,764.30

Technology: Professional Labor Management

Assembly	Description	Quantity	Unit of Measure	Material Unit Cost	Labor Unit Cost	Equipment Unit Cost	Sub Bid Cost	Extended Cost	Cost Override
33220149	Lump Sum Percentage Labor Cost	1.00	LS	0.00	397,493.00	0.00	0.00	$397,493.00	True

Total Element Cost: $397,493.00
Total 1st Year Tech Cost: $397,493.00

Total Phase Element Cost **$4,723,257.30**

Phase Markups Report

Phase Markups Report

Project: Chevron Phillips Puerto Rico Core LLC
Site: Alternative 3 SO - In-Situ Biological Treatment - Soil Mixing
Phase: 3 - 5-Year Reviews (Construction Completion Report)

Subcontracted Portion of Work

	Professional Labor	MLE*	SubBid	Total
Total Direct Cost	$0	$0	$226	$226
Overhead %	132.00%	25.00%	0.00%	
Overhead	$0	$0	$0	$0
Subtotal	$0	$0	$226	$226
Subcontractor Profit %	8.00%	8.00%	0.00%	
Subcontractor Profit	$0	$0	$0	$0
Total Subcontract Cost	$0	$0	$226	$226

Prime Contractor Portion of Work

	Professional Labor	MLE*	SubBid	Total
Total Direct Cost	$19,780	$0	$0	$19,780
Overhead %	132.00%	25.00%	0.00%	
Overhead	$26,110	$0	$0	$26,110
Prime Subtotal	$45,889	$0	$0	$45,889
Prime + Subcontract	$45,889	$0	$226	$46,116
Contingency %	8.00%	8.00%	8.00%	
Prime Contingency Cost	$3,671	$0	$18	$3,689
Prime + Subcontract + Contingency	$49,561	$0	$244	$49,805

Other Project Costs

Contingency Allowance	$0	$0	$0	$0
Total Contract Cost + Contingency	$49,561	$0	$244	$49,805
Owner Cost %	11.00%	11.00%	11.00%	
Owner Cost	$5,452	$0	$27	$5,479
Total Contract Cost + Contingency + Owner Cost	$55,012	$0	$271	$55,283
Total No-Markup Items				$4,010
Grand Total				$59,293

MLE = Materials, Trade Labor, and Expenses

Phase Technology Cost Detail Report - Alternative 3 SO 5-Year Review (Construction Completion Report)

System:

RACER Version: RACER® Version 11.2.16.0
Database Location: C:\Users\Jake Gallegos\Desktop\CPCPRC\CMS Report\RACER Files\RACER.mdb

Project:

ID: CPCPRC 15605.04
Name: Chevron Phillips Puerto Rico Core LLC
Category: None

Location

State / Country: PUERTO RICO
City: PUERTO RICO AVERAGE

Location Modifier	Default	User
	1.160	1.160

Options

Database: System Costs
Cost Database Date: 2015
Report Option: Calendar

Description CMS Report - Estimate of Potential Costs

Site:

ID: CPCPRC
Name: **Alternative 3 SO - In-Situ Biological Treatment - Soil Mixing**
Type: None

Media/Waste Type

Primary: Groundwater
Secondary: N/A

Contaminant

Primary: Fuels
Secondary: Semi-Volatile Organic Compounds (SVOCs)

Documentation

Description: **Alternative 3 SO - In-Situ Biological Treatment - Soil Mixing**
Support Team: Documentation of personnel used to provide support for estimator and preparation of the estimate.
References: Documentation of reference sources used in the preparation of the estimate.

Phase Documentation:

Phase Type: Site Closeout
Phase Name: 3 - 5-Year Reviews
Description: 3 - 5-Year Reviews
Approach: Ex Situ
Start Date: January, 2022
Labor Rate Group: System Labor Rate
Analysis Rate Group: System Analysis Rate
Phase Markup Template: System Defaults

Technology Markups	Marku	% Prime	% Sub.
Five-Year Review	True	100	0

Total Marked-up Cost: $59,293.40

Technologies:
Technology: Five-Year Review

Element: Document Review

Assembly	Description	Quantity	Unit of Measure	Material Unit Cost	Labor Unit Cost	Equipment Unit Cost	Sub Bid Cost	Extended Cost	Cost Override
33220102	Project Manager	12.00	HR	0.00	106.77	0.00	0.00	$1,281.26	False
33220105	Project Engineer	15.00	HR	0.00	78.14	0.00	0.00	$1,172.11	False
33220108	Project Scientist	11.00	HR	0.00	89.04	0.00	0.00	$979.42	False
33220109	Staff Scientist	23.00	HR	0.00	51.54	0.00	0.00	$1,185.40	False

Total Element Cost: $4,618.00

Element: Interviews

Assembly	Description	Quantity	Unit of Measure	Material Unit Cost	Labor Unit Cost	Equipment Unit Cost	Sub Bid Cost	Extended Cost	Cost Override
33220102	Project Manager	8.00	HR	0.00	106.77	0.00	0.00	$854.17	False

Total Element Cost: $854.00

Element: Site Inspection

Assembly	Description	Quantity	Unit of Measure	Material Unit Cost	Labor Unit Cost	Equipment Unit Cost	Sub Bid Cost	Extended Cost	Cost Override
33220102	Project Manager	12.00	HR	0.00	106.77	0.00	0.00	$1,281.26	False
33220105	Project Engineer	23.00	HR	0.00	78.14	0.00	0.00	$1,797.24	False
33220108	Project Scientist	19.00	HR	0.00	89.04	0.00	0.00	$1,691.73	False
33220109	Staff Scientist	20.00	HR	0.00	51.54	0.00	0.00	$1,030.78	False

Total Element Cost: $5,801.00

Element: Report

Technology: Five-Year Review

Assembly	Description	Quantity	Unit of Measure	Material Unit Cost	Labor Unit Cost	Equipment Unit Cost	Sub Bid Cost	Extended Cost	Cost Override
33220102	Project Manager	12.00	HR	0.00	106.77	0.00	0.00	$1,281.26	False
33220105	Project Engineer	31.00	HR	0.00	78.14	0.00	0.00	$2,422.36	False
33220108	Project Scientist	25.00	HR	0.00	89.04	0.00	0.00	$2,225.97	False
33220109	Staff Scientist	50.00	HR	0.00	51.54	0.00	0.00	$2,576.96	False

Total Element Cost: $8,507.00

Element: Travel

Assembly	Description	Quantity	Unit of Measure	Material Unit Cost	Labor Unit Cost	Equipment Unit Cost	Sub Bid Cost	Extended Cost	Cost Override
33010108	Sedan, Automobile, Rental	5.00	DAY	0.00	0.00	0.00	45.23	$226.14	False
33010202	Per Diem (per person)	10.00	DAY	0.00	0.00	0.00	221.00	$2,210.00	True
33041101	Airfare	2.00	LS	0.00	0.00	0.00	900.00	$1,800.00	True

Total Element Cost: $4,236.14
Total 1st Year Tech Cost: $24,016.14

Total Phase Element Cost **$24,016.14**

Alternative – 1 SD

Cost Estimate

Cost Summary Report - Alternative 1 SD - Effluent Channel Sediment Removal and Disposal (with Markups)

System:

	RACER Version:	RACER® Version 11.2.16.0
	Database Location:	C:\Users\Jake Gallegos\Desktop\CPCPRC\CMS Report\RACER Files\RACER.mdb

Project:

	ID:	CPCPRC 15605.04
	Name:	Chevron Phillips Puerto Rico Core LLC
	Category:	None
Location		
	State / Country:	PUERTO RICO
	City:	PUERTO RICO AVERAGE
Location Modifier		**Default** 1.160 / **User** 1.160
Options		
	Database:	System Costs
	Cost Database Date:	2015
	Report Option:	Calendar
Description		CMS Report - Estimate of Potential Costs
	ID:	CPCPRC
	Name:	**Alternative 1 SD - Sediment Removal and Offsite Disposal**
	Type:	None
Media/Waste Type		
	Primary:	Sediment/Sludge
	Secondary:	N/A
Contaminant		
	Primary:	Metals
	Secondary:	None
Documentation		
	Description:	**Alternative 1 SD - Excavation of Sediment and Offiste Disposal**
	Support Team:	Documentation of personnel used to provide support for estimator and preparation of the estimate.
	References:	Documentation of reference sources used in the preparation of the estimate.

Phase	Direct Cost	Markups	Total Cost
Study and Design	$50,000	$9,940	$59,940
Remedial Action - Clear and grub, Excavate, Transport and Dispose Offsite, Backfill	$524,086	$344,206	$868,292
Construction Completion Report	$24,016	$35,277	$59,293
Total Site Cost	$598,102	$389,423	$987,526

Phase Markups Report

Phase Markups Report

Project: Chevron Phillips Puerto Rico Core LLC
Site: Alternative 1 SD - Sediment Removal and Offsite Disposal
Phase: 02 - Effluent Channel Sediment Removal and Offsite Disposal, Backfilling

Subcontracted Portion of Work

	Professional Labor	MLE*	SubBid	Total
Total Direct Cost	$0	$0	$61,533	$61,533
Overhead %	132.00%	25.00%	0.00%	
Overhead	$0	$0	$0	$0
Subtotal	$0	$0	$61,533	$61,533
Subcontractor Profit %	8.00%	8.00%	0.00%	
Subcontractor Profit	$0	$0	$0	$0
Total Subcontract Cost	$0	$0	$61,533	$61,533

Prime Contractor Portion of Work

	Professional Labor	MLE*	SubBid	Total
Total Direct Cost	$105,874	$287,639	$0	$393,513
Overhead %	132.00%	25.00%	0.00%	
Overhead	$139,754	$71,910	$0	$211,664
Prime Subtotal	$245,629	$359,549	$0	$605,177
Prime + Subcontract	$245,629	$359,549	$61,533	$666,710
Contingency %	8.00%	8.00%	8.00%	
Prime Contingency Cost	$19,650	$28,764	$4,923	$53,337
Prime + Subcontract + Contingency	$265,279	$388,313	$66,456	$720,047

Other Project Costs

	Professional Labor	MLE*	SubBid	Total
Contingency Allowance	$0	$0	$0	$0
Total Contract Cost + Contingency	$265,279	$388,313	$66,456	$720,047
Owner Cost %	11.00%	11.00%	11.00%	
Owner Cost	$29,181	$42,714	$7,310	$79,205
Total Contract Cost + Contingency + Owner Cost	$294,460	$431,027	$73,766	$799,252
Total No-Markup Items				$69,040
Grand Total				$868,292

MLE = Materials, Trade Labor, and Expenses

Phase Technology Cost Detail Report - Alternative 1 SD Effluent Channel Sediment Removal and Offsite Disposal

System:

RACER Version: RACER® Version 11.2.16.0
Database Location: C:\Users\Jake Gallegos\Desktop\CPCPRC\CMS Report\RACER Files\RACER.mdb

Project:

ID: CPCPRC 15605.04
Name: Chevron Phillips Puerto Rico Core LLC
Category: None

Location

State / Country: PUERTO RICO
City: PUERTO RICO AVERAGE

Location Modifier	**Default**	**User**
	1.160	1.160

Options

Database: System Costs
Cost Database Date: 2015
Report Option: Calendar

Description CMS Report - Estimate of Potential Costs

Site:

ID: CPCPRC
Name: **Alternative 1 SD - Sediment Removal and Offsite Disposal**
Type: None

Media/Waste Type

Primary: Sediment/Sludge
Secondary: N/A

Contaminant

Primary: Metals
Secondary: None

Documentation

Description: **Alternative 1 SD - Excavation of Sediment and Offiste Disposal**
Support Team: Documentation of personnel used to provide support for estimator and preparation of the estimate.
References: Documentation of reference sources used in the preparation of the estimate.

Phase Documentation:

Phase Type: Remedial Action
Phase Name: 02 - Effluent Channel Sediment Removal and Offsite Disposal, Backfilling
Description: 02 - Effluent Channel Sediment Removal, Offsite Disposal, Backfilling of Excavation Area
Approach: Ex Situ
Start Date: January, 2017
Labor Rate Group: System Labor Rate
Analysis Rate Group: System Analysis Rate
Phase Markup Template: System Defaults

Technology Markups	**Markup**	**% Prime**	**% Sub.**
Clear and Grub	True	100	0
Excavation	True	100	0
Professional Labor Management	False	0	0

Total Marked-up Cost: $868,292.43

Technologies:

Technology: Clear and Grub

Assembly	Description	Quantity	Unit of Measure	Material Unit Cost	Labor Unit Cost	Equipment Unit Cost	Sub Bid Cost	Extended Cost	Cost Override
Technology:	Clear and Grub								
17010102	Selective clearing, brush, medium clearing, with dozer and brush rake, excludes removal offsite	1.96	ACR	0.00	149.28	133.37	0.00	$553.99	False
17010106	Heavy Brush, Light Trees, Clear, Grub, Haul	1.72	ACR	0.00	4,455.28	1,499.95	0.00	$10,242.99	False
17010111	Clear trees, wet conditions, medium growth, 200 H.P. dozer, excludes grubbing	0.22	ACR	0.00	1,636.48	132.74	0.00	$389.23	False
17010202	Tree removal, congested area, 6" to 12" diameter, tree removal, cutting and chipping	200.00	EA	0.00	208.70	51.65	0.00	$52,069.50	False
17010211	Site clearing trees, with 335 H.P. dozer, to 12" diameter	219.00	EA	0.00	6.19	8.21	0.00	$3,151.54	False
17010311	Remove stumps, wet conditions, with dozer, 6" to 12" diameter	22.00	EA	0.00	57.99	66.69	0.00	$2,742.78	False
17010315	Grub stumps, with 335 H.P. dozer, to 12" diameter	197.00	EA	0.00	3.71	6.54	0.00	$2,018.81	False
17010501	Grub and stack, 140 H.P. dozer	254.99	CY	0.00	3.71	2.05	0.00	$1,469.35	False

Total Element Cost: $72,638.18
Total 1st Year Tech Cost: $72,638.18

Technology: Excavation

Element:

Assembly	Description	Quantity	Unit of Measure	Material Unit Cost	Labor Unit Cost	Equipment Unit Cost	Sub Bid Cost	Extended Cost	Cost Override
Technology:	Excavation								
17020416	12 CY Dump Truck Haul/Hour	219.00	HR	0.00	76.94	50.72	0.00	$27,958.38	False
17030277	Excavate and load, bank measure, medium material, 2 C.Y. bucket, hydraulic excavator	3,519.00	BCY	0.00	1.16	0.79	0.00	$6,884.60	False
17030423	Disposal Off-Site, Includes Expansion after Excavation	4,574.07	CY	30.37	1.28	1.04	0.02	$149,575.69	False
17030514	Place and Compact backfill, structural, 6" lifts, self propelled roller	4,222.00	ECY	0.00	0.99	0.74	0.00	$7,280.43	False
18050402	Grading and Contour	2.62	ACR	3,853.33	584.20	243.22	0.00	$12,263.56	False
33020401	Disposable Materials per Sample	5.00	EA	12.12	0.00	0.00	0.00	$60.59	False
33021620	Testing, TAL metals (6010/7000s)	7.00	EA	0.00	0.00	0.00	145.78	$1,020.48	False
33021702	TCLP (RCRA) (EPA 1311), Soil Analysis	7.00	EA	0.00	0.00	0.00	114.84	$803.88	False
33021709	Testing, TAL metals (6010/7000s)	7.00	EA	0.00	0.00	0.00	145.78	$1,020.48	False
33021717	Testing, Assumed TCLP BTEX/Sulfolane Soil Analysis	7.00	EA	0.00	0.00	0.00	162.21	$1,135.44	False
33021719	Testing, soil & sediment analysis, chlorinated phenoxy acid herbicides EPA 8150	7.00	EA	0.00	0.00	0.00	183.64	$1,285.49	False
33021720	Testing, purgeable organics (624, 8260)	7.00	EA	0.00	0.00	0.00	191.40	$1,339.80	False
33021739	Testing, semi-volatile organics, pkd. column (8250)	7.00	EA	0.00	0.00	0.00	346.19	$2,423.34	False
33021750	Testing, paint filter liquids test (9095)	7.00	EA	0.00	0.00	0.00	23.18	$162.29	False
33021756	Testing, RCRA evaluations, corrosivity, ignitability & reactivity, ignitibility (1010)	7.00	EA	0.00	0.00	0.00	42.08	$294.58	False
33021757	Testing, RCRA evaluations, corrosivity, ignitability & reactivity, corrosivity (1110, NACE)	7.00	EA	0.00	0.00	0.00	146.74	$1,027.18	False
33021758	Testing, RCRA evaluations, corrosivity, ignitability & reactivity, reactivity (cyanide/sulfide)	1.00	EA	0.00	0.00	0.00	76.56	$76.56	False
33190209	Dump Truck Transportation Non-Hazardous Waste Minimum Tipping Charge	30.00	EA	0.00	0.00	0.00	1,092.35	$32,770.46	False
33190307	Commercial RCRA landfills, min charges for bulk shipments	30.00	EA	0.00	0.00	0.00	603.20	$18,096.00	False
33220111	Certified Industrial Hygienist	160.00	HR	0.00	661.72	0.00	0.00	$105,874.43	False
33221004	Equip. Operators, Oilers	160.00	HR	0.00	67.86	0.00	0.00	$10,857.35	False
33260550	2" Polyethylene, flexible piping, SDR15, 125 psi	100.00	LF	1.97	0.00	0.00	0.00	$197.20	False

Total Element Cost: $382,408.21
Total 1st Year Tech Cost: $382,408.21

Technology: Professional Labor Management

Element:

Assembly	Description	Quantity	Unit of Measure	Material Unit Cost	Labor Unit Cost	Equipment Unit Cost	Sub Bid Cost	Extended Cost	Cost Override
33220149	Lump Sum Percentage Labor Construction Field Manager and CIH	1.00	LS	0.00	69,040.00	0.00	0.00	$69,040.00	True

Total Element Cost: $69,040.00
Total 1st Year Tech Cost: $69,040.00

Total Phase Element Cost **$524,086.40**

Phase Markups Report

Phase Markups Report

Project: Chevron Phillips Puerto Rico Core LLC
Site: Alternative 1 SD - Sediment Removal and Offsite Disposal
Phase: 3 - 5-Year Review (Construction Completion Report)

Subcontracted Portion of Work

	Professional Labor	MLE*	SubBid	Total
Total Direct Cost	$0	$0	$226	$226
Overhead %	132.00%	25.00%	0.00%	
Overhead	$0	$0	$0	$0
Subtotal	$0	$0	$226	$226
Subcontractor Profit %	8.00%	8.00%	0.00%	
Subcontractor Profit	$0	$0	$0	$0
Total Subcontract Cost	$0	$0	$226	$226

Prime Contractor Portion of Work

	Professional Labor	MLE*	SubBid	Total
Total Direct Cost	$19,780	$0	$0	$19,780
Overhead %	132.00%	25.00%	0.00%	
Overhead	$26,110	$0	$0	$26,110
Prime Subtotal	$45,889	$0	$0	$45,889
Prime + Subcontract	$45,889	$0	$226	$46,116
Contingency %	8.00%	8.00%	8.00%	
Prime Contingency Cost	$3,671	$0	$18	$3,689
Prime + Subcontract + Contingency	$49,561	$0	$244	$49,805
Other Project Costs				
Contingency Allowance	$0	$0	$0	$0
Total Contract Cost + Contingency	$49,561	$0	$244	$49,805
Owner Cost %	11.00%	11.00%	11.00%	
Owner Cost	$5,452	$0	$27	$5,479
Total Contract Cost + Contingency + Owner Cost	$55,012	$0	$271	$55,283
Total No-Markup Items				$4,010
Grand Total				$59,293

MLE = Materials, Trade Labor, and Expenses

Phase Technology Cost Detail Report - Alternative 1 SD 5-Year Review (Construction Completion Report)

System:

RACER Version:	RACER® Version 11.2.16.0
Database Location:	C:\Users\Jake Gallegos\Desktop\CPCPRC\CMS Report\RACER Files\RACER.mdb

Project:

ID:	CPCPRC 15605.04
Name:	Chevron Phillips Puerto Rico Core LLC
Category:	None

Location

State / Country:	PUERTO RICO
City:	PUERTO RICO AVERAGE

Location Modifier

Default	User
1.160	1.160

Options

Database:	System Costs
Cost Database Date:	2015
Report Option:	Calendar

Description CMS Report - Estimate of Potential Costs

Site:

ID:	CPCPRC
Name:	**Alternative 1 SD - Sediment Removal and Offsite Disposal**
Type:	None

Media/Waste Type

Primary:	Groundwater
Secondary:	N/A

Contaminant

Primary:	Fuels
Secondary:	Semi-Volatile Organic Compounds (SVOCs)

Documentation

Description:	**Alternative 1 SD - Sediment Removal and Offsite Disposal**
Support Team:	Documentation of personnel used to provide support for estimator and preparation of the estimate.
References:	Documentation of reference sources used in the preparation of the estimate.

Phase Documentation:

Phase Type:	Site Closeout
Phase Name:	3 - 5-Year Reviews
Description:	3 - 5-Year Reviews
Approach:	Ex Situ
Start Date:	January, 2022
Labor Rate Group:	System Labor Rate
Analysis Rate Group:	System Analysis Rate
Phase Markup Template:	System Defaults

Technology Markups	Marku	% Prime	% Sub.
Five-Year Review	True	100	0

Total Marked-up Cost: $59,293.40

Technologies:
Technology: Five-Year Review

Element: Document Review

Assembly	Description	Quantity	Unit of Measure	Material Unit Cost	Labor Unit Cost	Equipment Unit Cost	Sub Bid Cost	Extended Cost	Cost Override
33220102	Project Manager	12.00	HR	0.00	106.77	0.00	0.00	$1,281.26	False
33220105	Project Engineer	15.00	HR	0.00	78.14	0.00	0.00	$1,172.11	False
33220108	Project Scientist	11.00	HR	0.00	89.04	0.00	0.00	$979.42	False
33220109	Staff Scientist	23.00	HR	0.00	51.54	0.00	0.00	$1,185.40	False

Total Element Cost: $4,618.00

Element: Interviews

Assembly	Description	Quantity	Unit of Measure	Material Unit Cost	Labor Unit Cost	Equipment Unit Cost	Sub Bid Cost	Extended Cost	Cost Override
33220102	Project Manager	8.00	HR	0.00	106.77	0.00	0.00	$854.17	False

Total Element Cost: $854.00

Element: Site Inspection

Assembly	Description	Quantity	Unit of Measure	Material Unit Cost	Labor Unit Cost	Equipment Unit Cost	Sub Bid Cost	Extended Cost	Cost Override
33220102	Project Manager	12.00	HR	0.00	106.77	0.00	0.00	$1,281.26	False
33220105	Project Engineer	23.00	HR	0.00	78.14	0.00	0.00	$1,797.24	False
33220108	Project Scientist	19.00	HR	0.00	89.04	0.00	0.00	$1,691.73	False
33220109	Staff Scientist	20.00	HR	0.00	51.54	0.00	0.00	$1,030.78	False

Total Element Cost: $5,801.00

Element: Report

Assembly	Description	Quantity	Unit of Measure	Material Unit Cost	Labor Unit Cost	Equipment Unit Cost	Sub Bid Cost	Extended Cost	Cost Override

Technology: Five-Year Review

Assembly	Description	Quantity	Unit of Measure	Material Unit Cost	Labor Unit Cost	Equipment Unit Cost	Sub Bid Cost	Extended Cost	Cost Override
33220102	Project Manager	12.00	HR	0.00	106.77	0.00	0.00	$1,281.26	False
33220105	Project Engineer	31.00	HR	0.00	78.14	0.00	0.00	$2,422.36	False
33220108	Project Scientist	25.00	HR	0.00	89.04	0.00	0.00	$2,225.97	False
33220109	Staff Scientist	50.00	HR	0.00	51.54	0.00	0.00	$2,576.96	False

Total Element Cost: $8,507.00

Element: Travel

Assembly	Description	Quantity	Unit of Measure	Material Unit Cost	Labor Unit Cost	Equipment Unit Cost	Sub Bid Cost	Extended Cost	Cost Override
33010108	Sedan, Automobile, Rental	5.00	DAY	0.00	0.00	0.00	45.23	$226.14	False
33010202	Per Diem (per person)	10.00	DAY	0.00	0.00	0.00	221.00	$2,210.00	True
33041101	Airfare	2.00	LS	0.00	0.00	0.00	900.00	$1,800.00	True

Total Element Cost: $4,236.14
Total 1st Year Tech Cost: $24,016.14

Total Phase Element Cost **$24,016.14**

Alternative – 2 SD

Cost Estimate

Cost Summary Report - Alternative 2 SD Effluent Channel Sediment Stabilization (with Markups)

System:

RACER Version:	RACER® Version 11.2.16.0
Database Location:	C:\Users\Jake Gallegos\Desktop\CPCPRC\CMS Report\RACER Files\RACER.mdb

Project:

ID:	CPCPRC 15605.04
Name:	Chevron Phillips Puerto Rico Core LLC
Category:	None

Location

State / Country:	PUERTO RICO
City:	PUERTO RICO AVERAGE

Location Modifier

Default	**User**
1.160	1.160

Options

Database:	System Costs
Cost Database Date:	2015
Report Option:	Calendar

Description CMS Report - Estimate of Potential Costs

ID:	CPCPRC
Name:	**Alternative 2 SD - Sediment Stabilization in Place**
Type:	None

Media/Waste Type

Primary:	Sediment/Sludge
Secondary:	N/A

Contaminant

Primary:	Metals
Secondary:	None

Documentation

Description:	**Alternative 2 SD - Stabilize Sediment in Place**
Support Team:	Documentation of personnel used to provide support for estimator and preparation of the estimate.
References:	Documentation of reference sources used in the preparation of the estimate.

Phase	**Direct Cost**	**Markups**	**Total Cost**
Study and Design	$80,000	$15,904	$95,904
Remedial Action - Stabilize Sediment in Place	$955,369	$391,383	$1,346,751
Closeout - Construction Completion Report	$24,016	$35,277	$59,293
Total Site Cost	$1,059,385	$442,564	$1,501,949

Phase Markups Report

Phase Markups Report

Project: Chevron Phillips Puerto Rico Core LLC
Site: Alternative 2 SD - Sediment Stabilization in Place
Phase: 02 - Effluent Channel Stabilize Sediment in Place

Subcontracted Portion of Work

	Professional Labor	MLE	SubBid	Total
Total Direct Cost	$0	$0	$157,490	$157,490
Overhead %	132.00%	25.00%	0.00%	
Overhead	$0	$0	$0	$0
Subtotal	$0	$0	$157,490	$157,490
Subcontractor Profit %	8.00%	8.00%	0.00%	
Subcontractor Profit	$0	$0	$0	$0
Total Subcontract Cost	$0	$0	$157,490	$157,490

Prime Contractor Portion of Work

	Professional Labor	MLE	SubBid	Total
Total Direct Cost	$38,901	$583,314	$0	$622,215
Overhead %	132.00%	25.00%	0.00%	
Overhead	$51,350	$145,828	$0	$197,178
Prime Subtotal	$90,251	$729,142	$0	$819,393
Prime + Subcontract	$90,251	$729,142	$157,490	$976,884
Contingency %	8.00%	8.00%	8.00%	
Prime Contingency Cost	$7,220	$58,331	$12,599	$78,151
Prime + Subcontract + Contingency	$97,471	$787,474	$170,090	$1,055,035

Other Project Costs

	Professional Labor	MLE	SubBid	Total
Contingency Allowance	$0	$0	$0	$0
Total Contract Cost + Contingency	$97,471	$787,474	$170,090	$1,055,035
Owner Cost %	11.00%	11.00%	11.00%	
Owner Cost	$10,722	$86,622	$18,710	$116,054
Total Contract Cost + Contingency + Owner Cost	$108,193	$874,096	$188,800	$1,171,088
Total No-Markup Items				$175,663
Grand Total				$1,346,751

MLE = Materials, Trade Labor, and Expenses

Phase Technology Cost Detail Report - Alternative 2 SD EffluentChannel Sediment Stabilization

System:

RACER Version: RACER® Version 11.2.16.0
Database Location: C:\Users\Jake Gallegos\Desktop\CPCPRC\CMS Report\RACER Files\RACER.mdb

Folder:

Folder Name: CMS V1

Project:

ID: CPCPRC 15605.04
Name: Chevron Phillips Puerto Rico Core LLC
Category: None

Location

State / Country: PUERTO RICO
City: PUERTO RICO AVERAGE

Location Modifier

Default	User
1.160	1.160

Options

Database: System Costs
Cost Database Date: 2015
Report Option: Calendar

Description CMS Report - Estimate of Potential Costs

Site:

ID: CPCPRC
Name: **Alternative 2 SD - Sediment Stabilization in Place**
Type: None

Media/Waste Type

Primary: Sediment/Sludge
Secondary: N/A

Contaminant

Primary: Metals
Secondary: None

Documentation

Description: **Alternative 2 SD - Stabilize Sediment in Place**
Support Team: Documentation of personnel used to provide support for estimator and preparation of the estimate.
References: Documentation of reference sources used in the preparation of the estimate.

Phase Documentation:

Phase Type: Remedial Action
Phase Name: 02 - Effluent Channel Stabilization and Backfill
Description: 02 - Effluent Channel Stabilization
Approach: Ex Situ
Start Date: January, 2017
Labor Rate Group: System Labor Rate
Analysis Rate Group: System Analysis Rate
Phase Markup Template: System Defaults

Technology Markups	Marku	% Prime	% Sub.
In Situ Solidification	True	100	0
Professional Labor Management	False	0	0

Total Marked-up Cost: $1,346,751.39

Technologies:
Technology: In Situ Solidification

Element:

Assembly	Description	Quantity	Unit of Measure	Material Unit Cost	Labor Unit Cost	Equipment Unit Cost	Sub Bid Cost	Extended Cost	Cost Override
17010106	Heavy Brush, Light Trees, Clear, Grub, Haul	1.72	ACR	0.00	4,455.28	1,499.95	0.00	$10,242.99	False
17010202	Tree removal, congested area, 6" to 12" diameter, tree removal, cutting and chipping	200.00	EA	0.00	208.70	51.65	0.00	$52,069.50	False
17030107	Fine Grading, 120G, 2 Passes	75,000.00	SY	0.00	0.50	0.18	0.00	$50,686.41	False
18050402	Seeding, Vegetative Cover	1.72	ACR	3,853.33	584.20	243.22	0.00	$8,050.89	False
33021705	Targeted TCLP (Metals, Volatiles, Semi-Volatiles only), Soil Analysis	30.00	EA	0.00	0.00	0.00	643.74	$19,312.26	False
33150405	Portland Cement Type I (Bulk)	712.50	TON	112.42	0.00	0.00	0.00	$80,096.11	False
33150408	Urrichem by Soliditech	47.50	TON	92.80	0.00	0.00	0.00	$4,408.00	False
33150421	Bulk Chemical Transport (40,000 Lb Truckload)	39.00	EA	0.00	0.00	0.00	2,919.06	$113,843.29	False
33150437	Maintenance of Solidification/Stabilization Unit	0.20	YR	0.00	11,452.69	0.00	0.00	$2,290.54	False
33150438	Solidification/Stabilization Equipment Cost	3.00	MO	0.00	0.00	0.00	8,111.63	$24,334.88	False
33150439	Operational Labor -In Situ Solidification/Stabilization	416.00	HR	0.00	791.03	0.00	0.00	$329,067.78	False
33150440	Mobilize/DeMobilize of In Situ Solidification/Stabilization Equipment	1.00	EA	0.00	2,265.76	1,911.71	0.00	$4,177.46	False
33170816	Spray washers, diesel, 3000 psi, 4-1/2 GPM, pressure washer	1.00	EA	5,046.46	0.00	0.00	0.00	$5,046.46	False
33170823	Operation of Pressure Washer, Including Water, Soap, Electricity, Labor	50.00	HR	0.00	87.10	0.00	0.00	$4,354.90	False
33220111	Certified Industrial Hygienist	416.00	HR	0.00	93.51	0.00	0.00	$38,901.34	False
33420101	Electrical Charge	702.00	KWH	0.08	0.00	0.00	0.00	$57.00	False
33420201	Diesel Fuel	7,280.00	GAL	4.50	0.00	0.00	0.00	$32,765.82	False

Total Element Cost: $779,705.64
Total 1st Year Tech Cost: $779,705.64

Technology: Professional Labor Management

Element:

Assembly	Description	Quantity	Unit of Measure	Material Unit Cost	Labor Unit Cost	Equipment Unit Cost	Sub Bid Cost	Extended Cost	Cost Override
33220149	Lump Sum Percentage Labor Cost - Construction Manager and CIH	1.00	LS	0.00	175,663.00	0.00	0.00	$175,663.00	True

Total Element Cost: $175,663.00
Total 1st Year Tech Cost: $175,663.00

Total Phase Element Cost **$955,368.64**

Phase Markups Report

Phase Markups Report

Project: Chevron Phillips Puerto Rico Core LLC
Site: Alternative 2 SD - Effluent Channel Stabilize Sediment in Place
Phase: 3 - 5-Year Review (Construction Completion Report)

Subcontracted Portion of Work

	Professional Labor	MLE*	SubBid	Total
Total Direct Cost	$0	$0	$226	$226
Overhead %	132.00%	25.00%	0.00%	
Overhead	$0	$0	$0	$0
Subtotal	$0	$0	$226	$226
Subcontractor Profit %	8.00%	8.00%	0.00%	
Subcontractor Profit	$0	$0	$0	$0
Total Subcontract Cost	$0	$0	$226	$226

Prime Contractor Portion of Work

	Professional Labor	MLE*	SubBid	Total
Total Direct Cost	$19,780	$0	$0	$19,780
Overhead %	132.00%	25.00%	0.00%	
Overhead	$26,110	$0	$0	$26,110
Prime Subtotal	$45,889	$0	$0	$45,889
Prime + Subcontract	$45,889	$0	$226	$46,116
Contingency %	8.00%	8.00%	8.00%	
Prime Contingency Cost	$3,671	$0	$18	$3,689
Prime + Subcontract + Contingency	$49,561	$0	$244	$49,805
Other Project Costs				
Contingency Allowance	$0	$0	$0	$0
Total Contract Cost + Contingency	$49,561	$0	$244	$49,805
Owner Cost %	11.00%	11.00%	11.00%	
Owner Cost	$5,452	$0	$27	$5,479
Total Contract Cost + Contingency + Owner Cost	$55,012	$0	$271	$55,283
Total No-Markup Items				$4,010
Grand Total				$59,293

MLE = Materials, Trade Labor, and Expenses

Phase Technology Cost Detail Report - Alternative 2 SD 5-Year Review (Construction Completion Report)

System:

RACER Version:	RACER® Version 11.2.16.0
Database Location:	C:\Users\Jake Gallegos\Desktop\CPCPRC\CMS Report\RACER Files\RACER.mdb

Project:

ID:	CPCPRC 15605.04
Name:	Chevron Phillips Puerto Rico Core LLC
Category:	None

Location

State / Country:	PUERTO RICO
City:	PUERTO RICO AVERAGE

Location Modifier

Default	User
1.160	1.160

Options

Database:	System Costs
Cost Database Date:	2015
Report Option:	Calendar

Description CMS Report - Estimate of Potential Costs

Site:

ID:	CPCPRC
Name:	**Alternative 2 SD - Effluent Channel Stabilize Sediment in Place**
Type:	None

Media/Waste Type

Primary:	Groundwater
Secondary:	N/A

Contaminant

Primary:	Fuels
Secondary:	Semi-Volatile Organic Compounds (SVOCs)

Documentation

Description:	**Alternative 2 SD - Effluent Channel Stabilize Sediment in Place**
Support Team:	Documentation of personnel used to provide support for estimator and preparation of the estimate.
References:	Documentation of reference sources used in the preparation of the estimate.

Phase Documentation:

Phase Type:	Site Closeout
Phase Name:	3 - 5-Year Reviews
Description:	3 - 5-Year Reviews
Approach:	In Situ
Start Date:	January, 2022
Labor Rate Group:	System Labor Rate
Analysis Rate Group:	System Analysis Rate
Phase Markup Template:	System Defaults

Technology Markups	Marku	% Prime	% Sub.
Five-Year Review	True	100	0

Total Marked-up Cost: $59,293.40

Technologies:
Technology: Five-Year Review

Element: Document Review

Assembly	Description	Quantity	Unit of Measure	Material Unit Cost	Labor Unit Cost	Equipment Unit Cost	Sub Bid Cost	Extended Cost	Cost Override
33220102	Project Manager	12.00	HR	0.00	106.77	0.00	0.00	$1,281.26	False
33220105	Project Engineer	15.00	HR	0.00	78.14	0.00	0.00	$1,172.11	False
33220108	Project Scientist	11.00	HR	0.00	89.04	0.00	0.00	$979.42	False
33220109	Staff Scientist	23.00	HR	0.00	51.54	0.00	0.00	$1,185.40	False

Total Element Cost: $4,618.00

Element: Interviews

Assembly	Description	Quantity	Unit of Measure	Material Unit Cost	Labor Unit Cost	Equipment Unit Cost	Sub Bid Cost	Extended Cost	Cost Override
33220102	Project Manager	8.00	HR	0.00	106.77	0.00	0.00	$854.17	False

Total Element Cost: $854.00

Element: Site Inspection

Assembly	Description	Quantity	Unit of Measure	Material Unit Cost	Labor Unit Cost	Equipment Unit Cost	Sub Bid Cost	Extended Cost	Cost Override
33220102	Project Manager	12.00	HR	0.00	106.77	0.00	0.00	$1,281.26	False
33220105	Project Engineer	23.00	HR	0.00	78.14	0.00	0.00	$1,797.24	False
33220108	Project Scientist	19.00	HR	0.00	89.04	0.00	0.00	$1,691.73	False
33220109	Staff Scientist	20.00	HR	0.00	51.54	0.00	0.00	$1,030.78	False

Total Element Cost: $5,801.00

Element: Report

Assembly	Description	Quantity	Unit of Measure	Material Unit Cost	Labor Unit Cost	Equipment Unit Cost	Sub Bid Cost	Extended Cost	Cost Override
Technology: Five-Year Review									
33220102	Project Manager	12.00	HR	0.00	106.77	0.00	0.00	$1,281.26	False
33220105	Project Engineer	31.00	HR	0.00	78.14	0.00	0.00	$2,422.36	False
33220108	Project Scientist	25.00	HR	0.00	89.04	0.00	0.00	$2,225.97	False
33220109	Staff Scientist	50.00	HR	0.00	51.54	0.00	0.00	$2,576.96	False

Total Element Cost: $8,507.00

Element: Travel

Assembly	Description	Quantity	Unit of Measure	Material Unit Cost	Labor Unit Cost	Equipment Unit Cost	Sub Bid Cost	Extended Cost	Cost Override
33010108	Sedan, Automobile, Rental	5.00	DAY	0.00	0.00	0.00	45.23	$226.14	False
33010202	Per Diem (per person)	10.00	DAY	0.00	0.00	0.00	221.00	$2,210.00	True
33041101	Airfare	2.00	LS	0.00	0.00	0.00	900.00	$1,800.00	True

Total Element Cost: $4,236.14
Total 1st Year Tech Cost: $24,016.14

Total Phase Element Cost **$24,016.14**

N
W E
S

PEI

0 500 1000 1500 2000 ft

Figure 1
Facility Location Map
Chevron Phillips Chemical
Puerto Rico Core, LLC

Legend

Facility Boundary

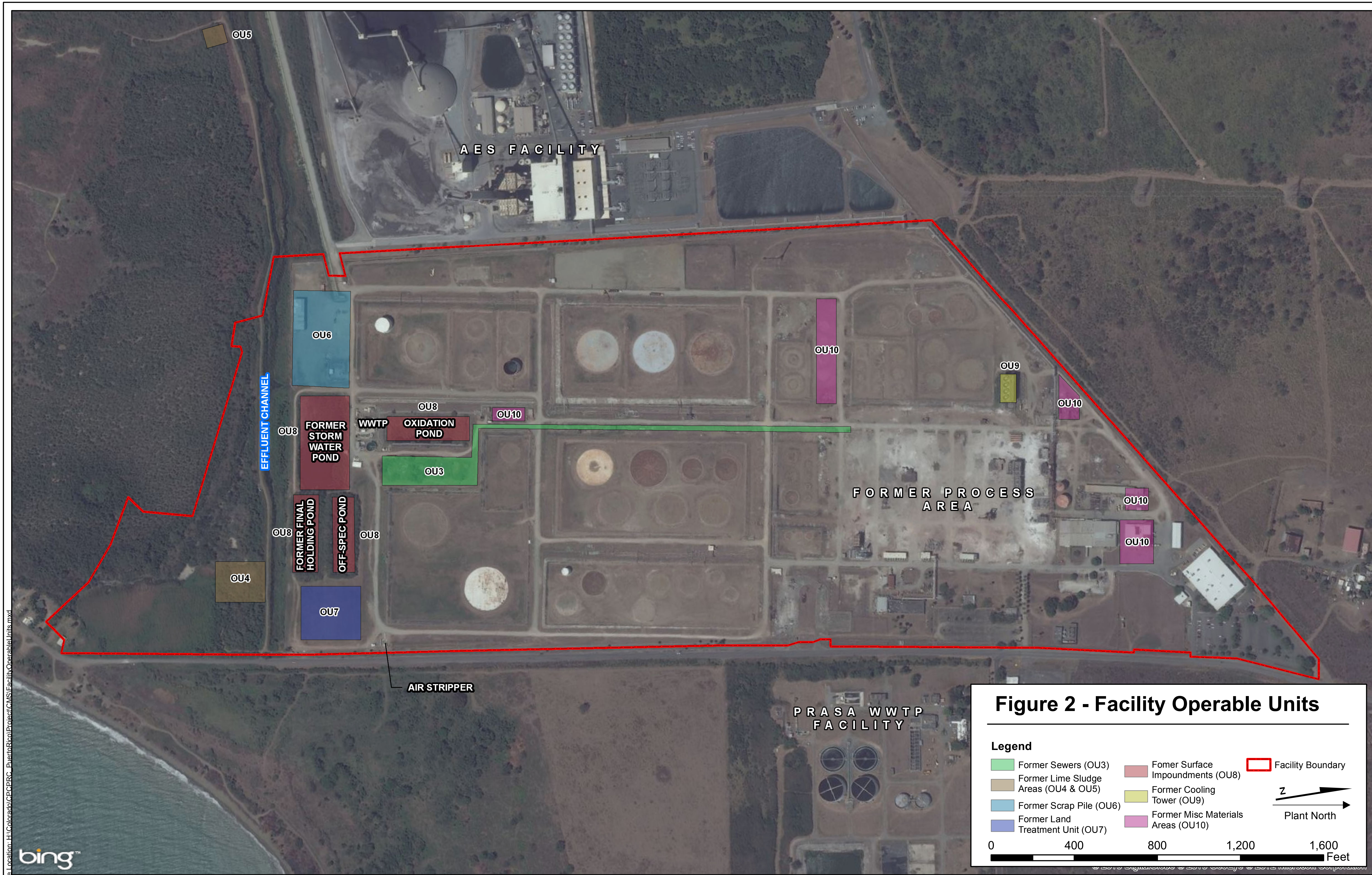
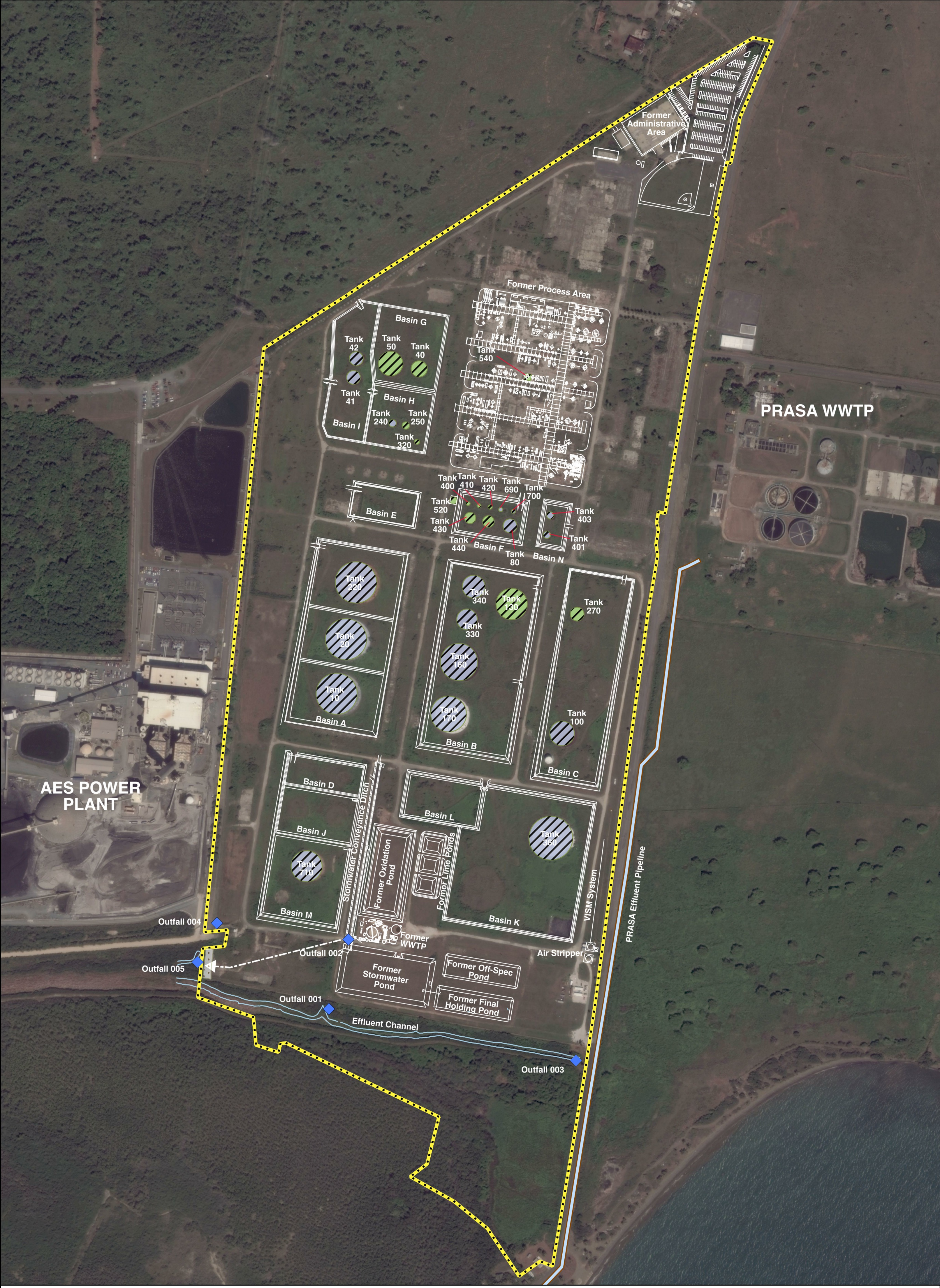


Figure 2 - Facility Operable Units



N W E S

PEI

0 250 500 750 1000 ft

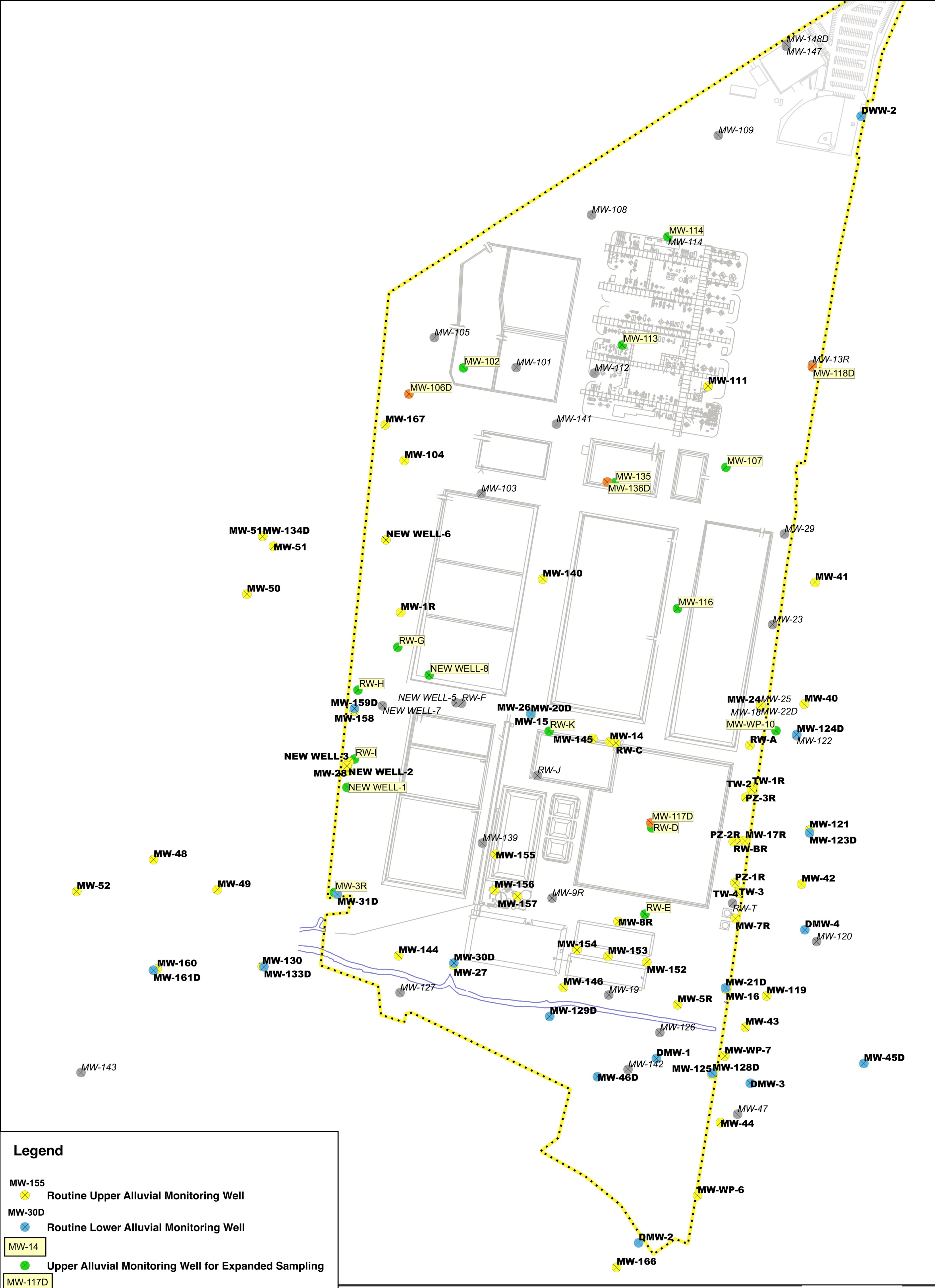
Figure 3

Former Site Features and Investigation Areas

Chevron Phillips Chemical Puerto Rico Core, LLC

Legend

- Former NPDES Outfalls
- Former Plant Features
- Facility Boundary
- Areas of Interest
- Areas of Concern



Legend

MW-155 Routine Upper Alluvial Monitoring Well

MW-30D Routine Lower Alluvial Monitoring Well

MW-14 Upper Alluvial Monitoring Well for Expanded Sampling

MW-117D Lower Alluvial Monitoring Well for Expanded Sampling

MW-143 Active Wells Not Typically Targeted for Sampling

Former Facility Features

Effluent Channel

Facility Boundary

Figure 4

Facility Monitoring Wells

Chevron Phillips Chemical Puerto Rico Core, LLC

PEI

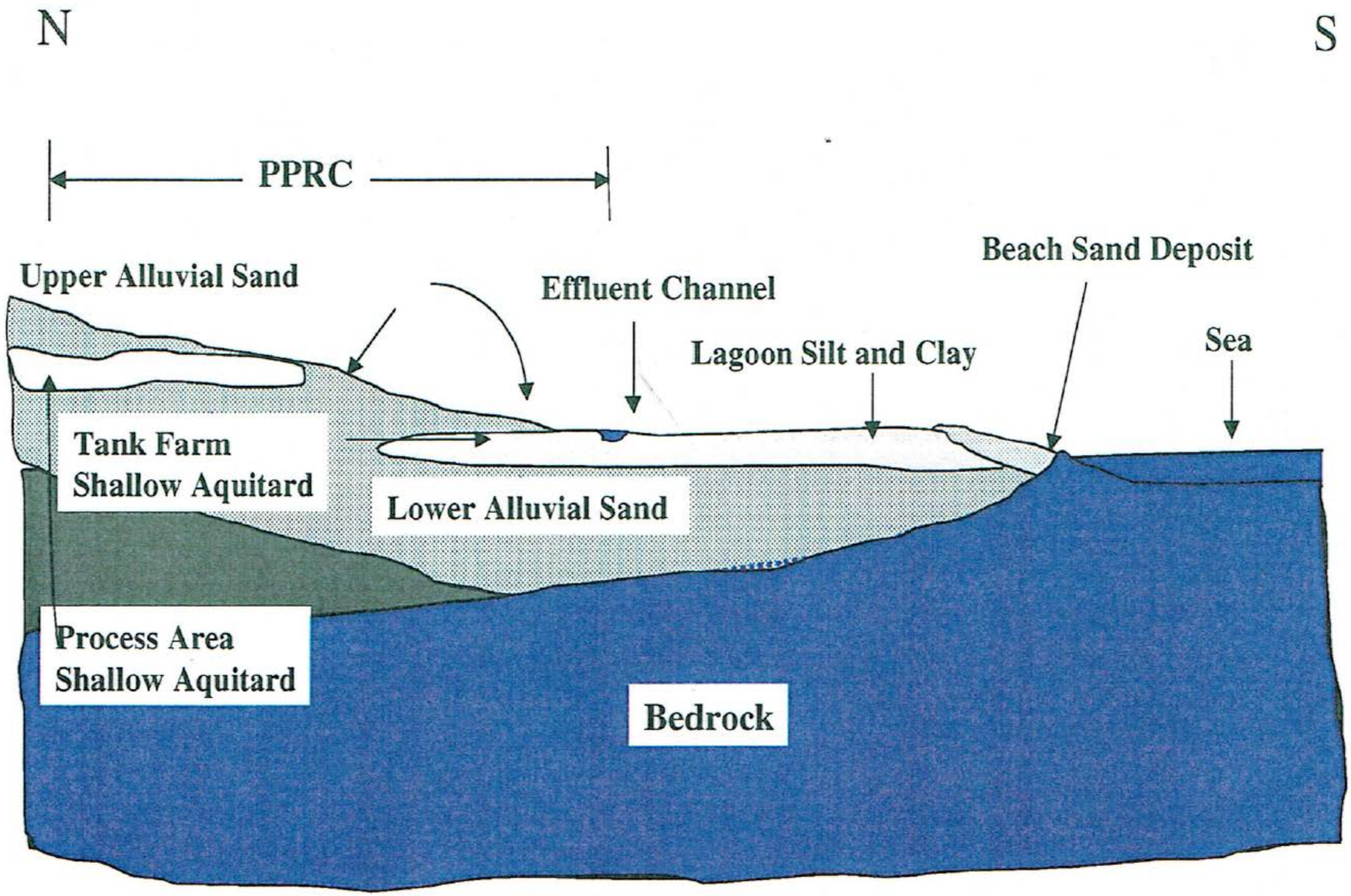


Figure 5. Stratigraphic Model, Chevron Phillips Puerto Rico Core, LLC.

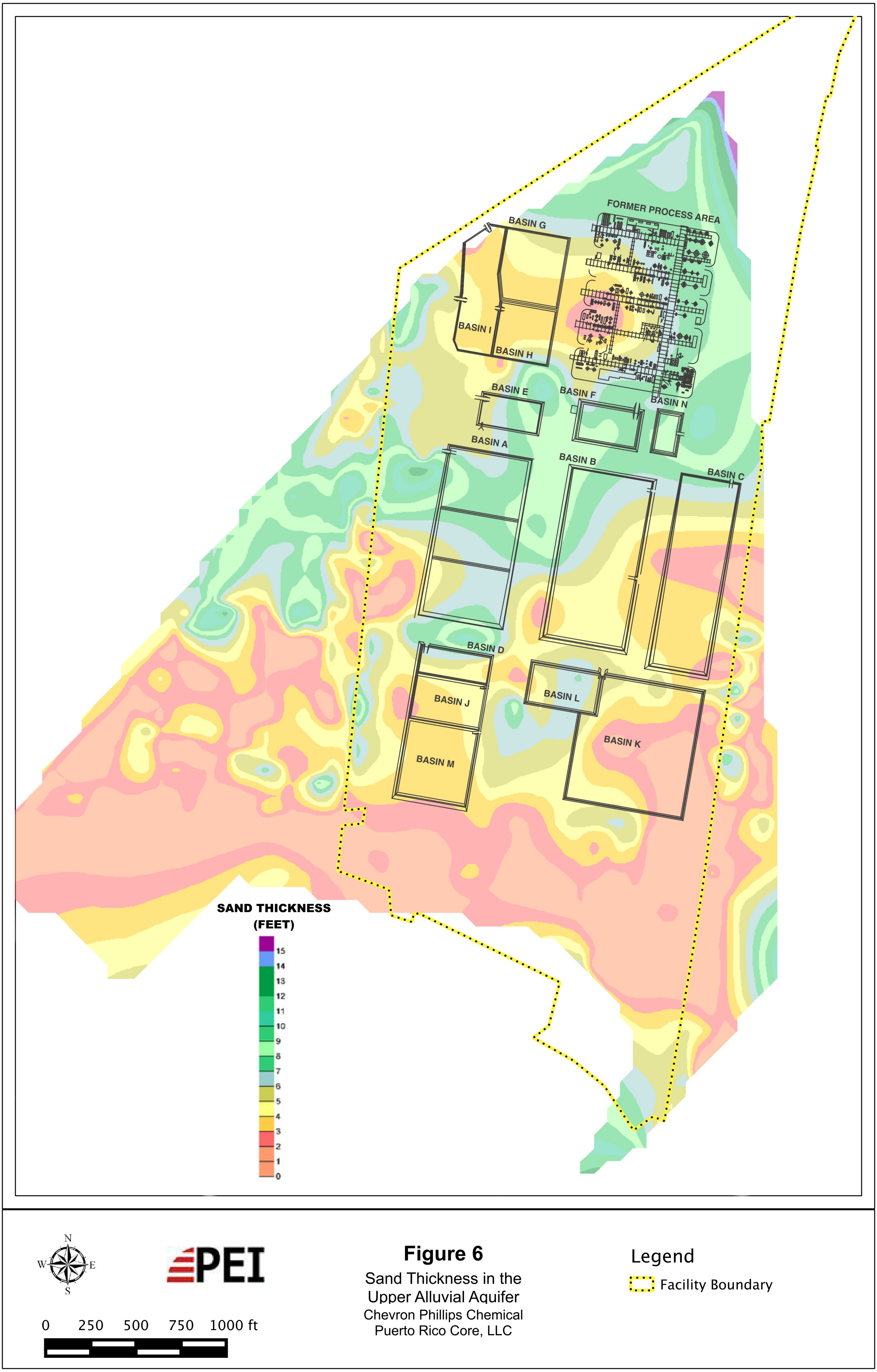
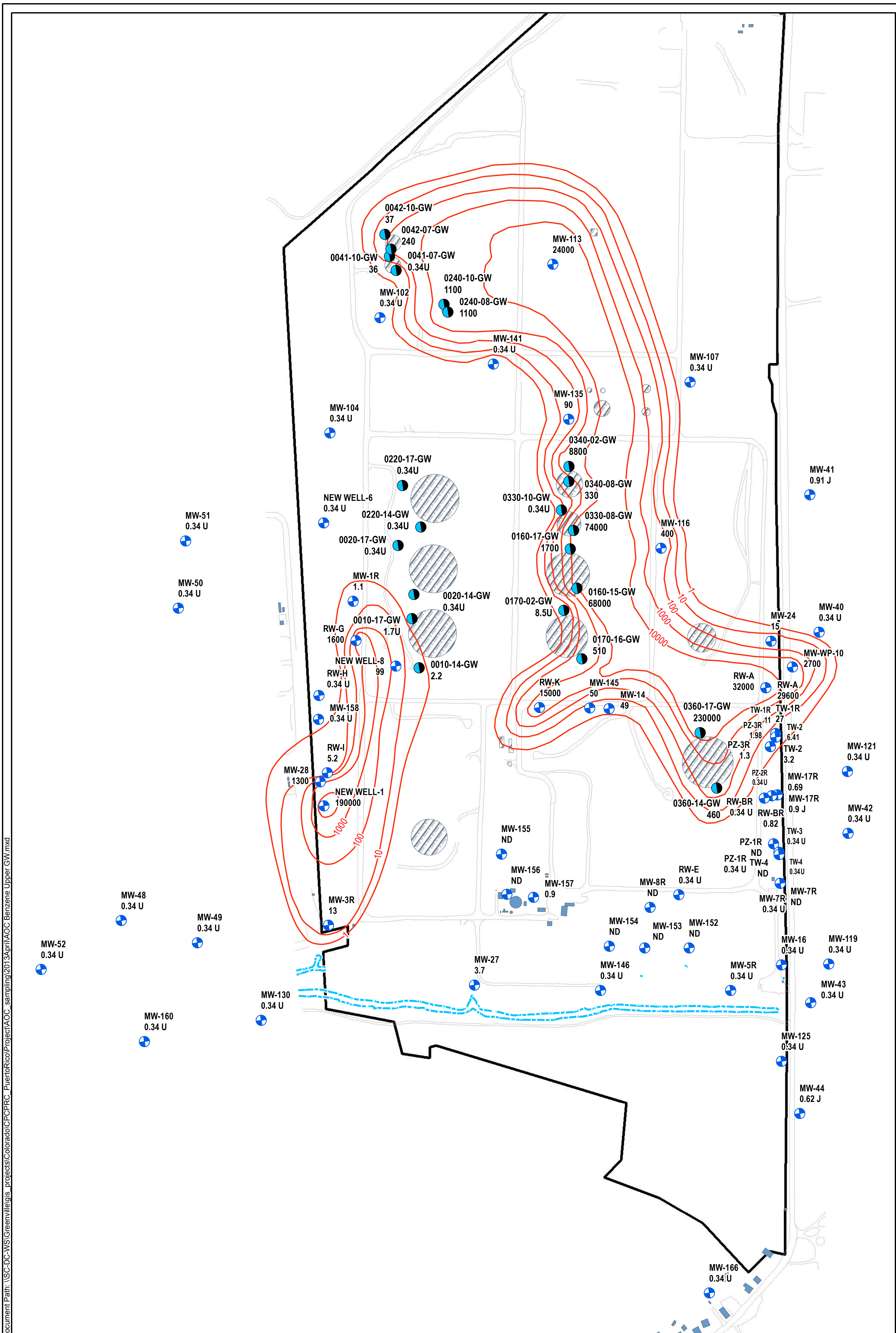


Figure 6

Sand Thickness in the Upper Alluvial Aquifer

Chevron Phillips Chemical Puerto Rico Core, LLC



Printed: 4/23/2013 3:53:41 PM

Legend

- Monitoring Well
- Hydropunch Location
- Benzene Isoconcentration Lines
- Effluent Channel
- Road Right-of-Ways
- Structures
- Areas of Concern
- Facility Boundary

Figure 7 - Benzene Extent
Upper Alluvial (µg/L)

Chevron Phillips Chemical
Puerto Rico Core, LLC

PEI

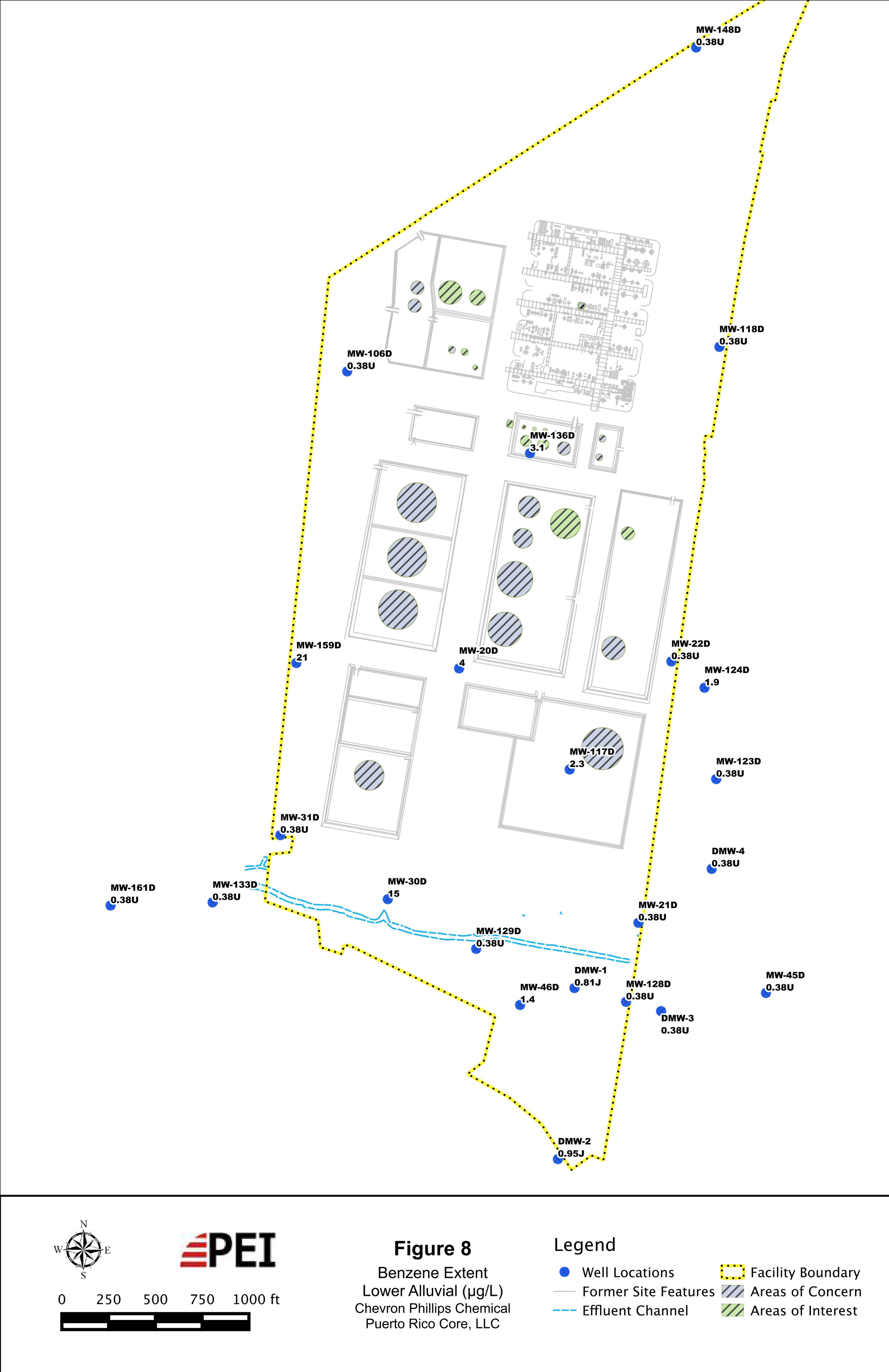
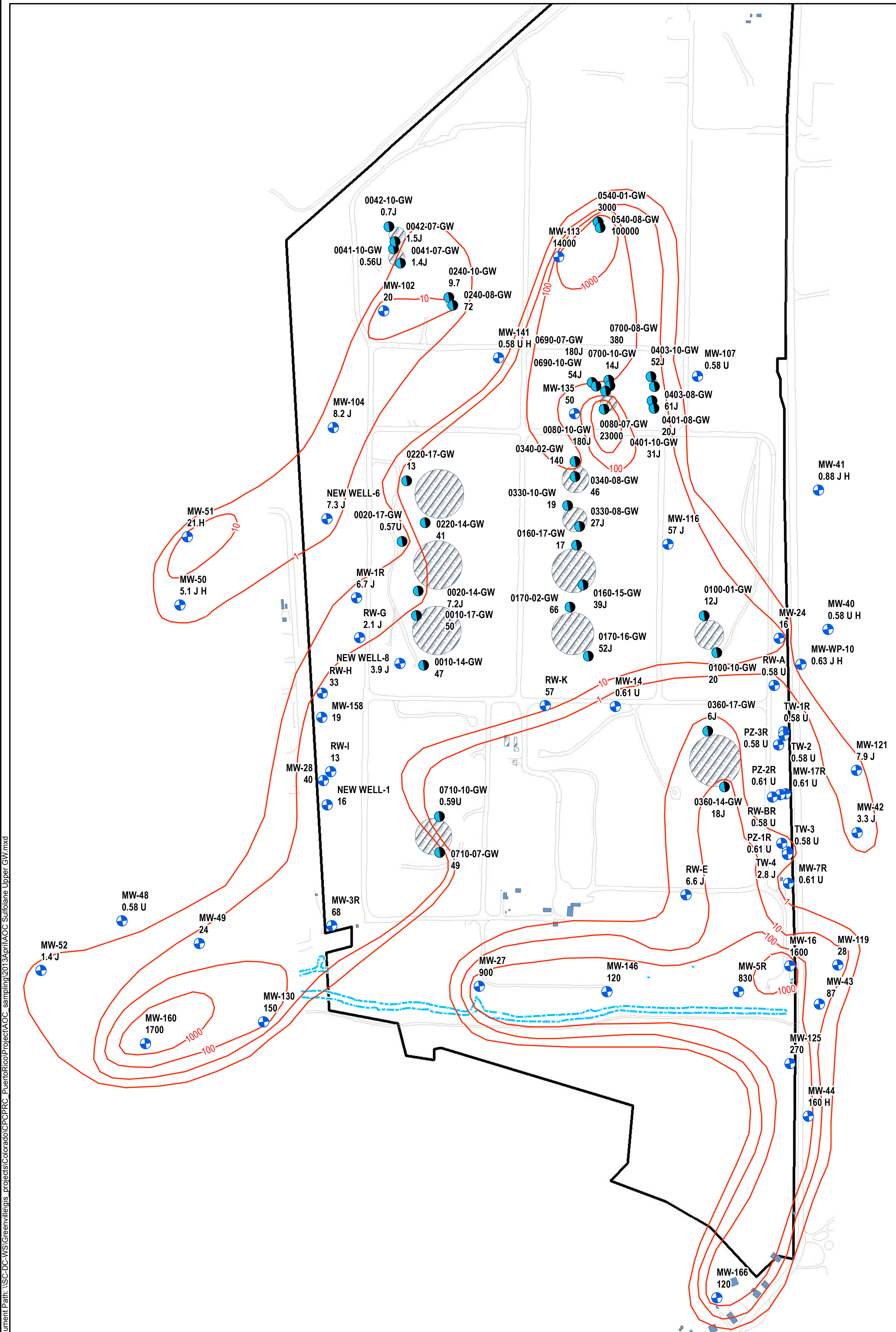


Figure 8

Benzene Extent
Lower Alluvial (µg/L)
Chevron Phillips Chemical
Puerto Rico Core, LLC



Document Path: \\SC-DC-WS\Greenville\gis_projects\Colorado\CPC\PRC_PuertoRico\Project\AOC_sampling\2013April\AOC Sulfolane Upper GW.mxd

Printed: 4/23/2013 4:08:24 PM

Legend

- Monitoring Well
- Hydropunch Location
- Sulfolane Isoconcentration Line
- Effluent Channel
- Road Right-of-Way
- Structure
- Areas of Concern
- Facility Boundary

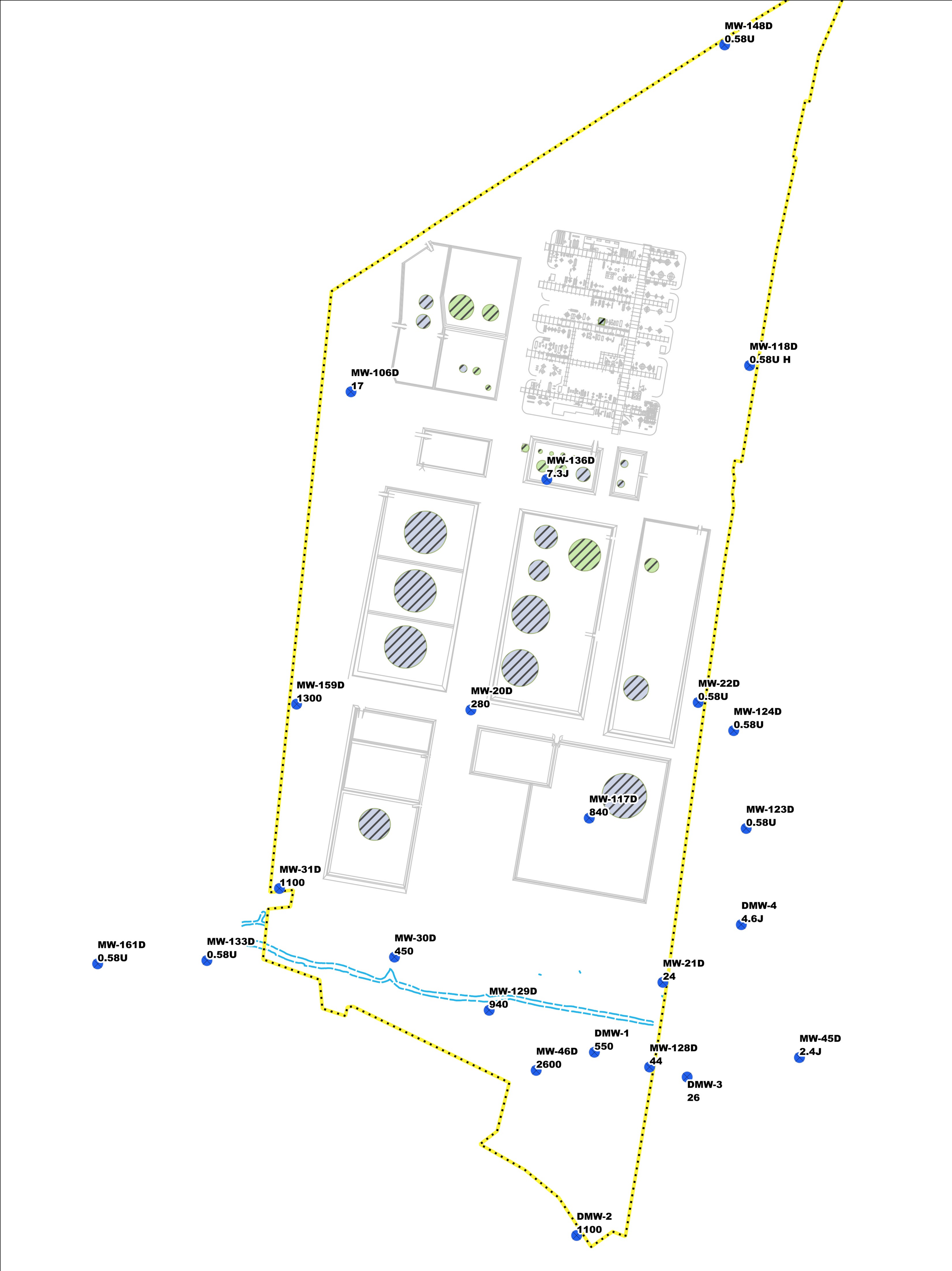
Figure 9 - Sulfolane Extent Upper Alluvial (µg/L)

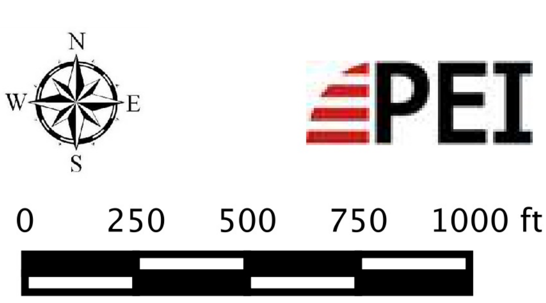
Chevron Phillips Chemical Puerto Rico Core, LLC

N
Plant North

PEI

0 200 400 600 Feet





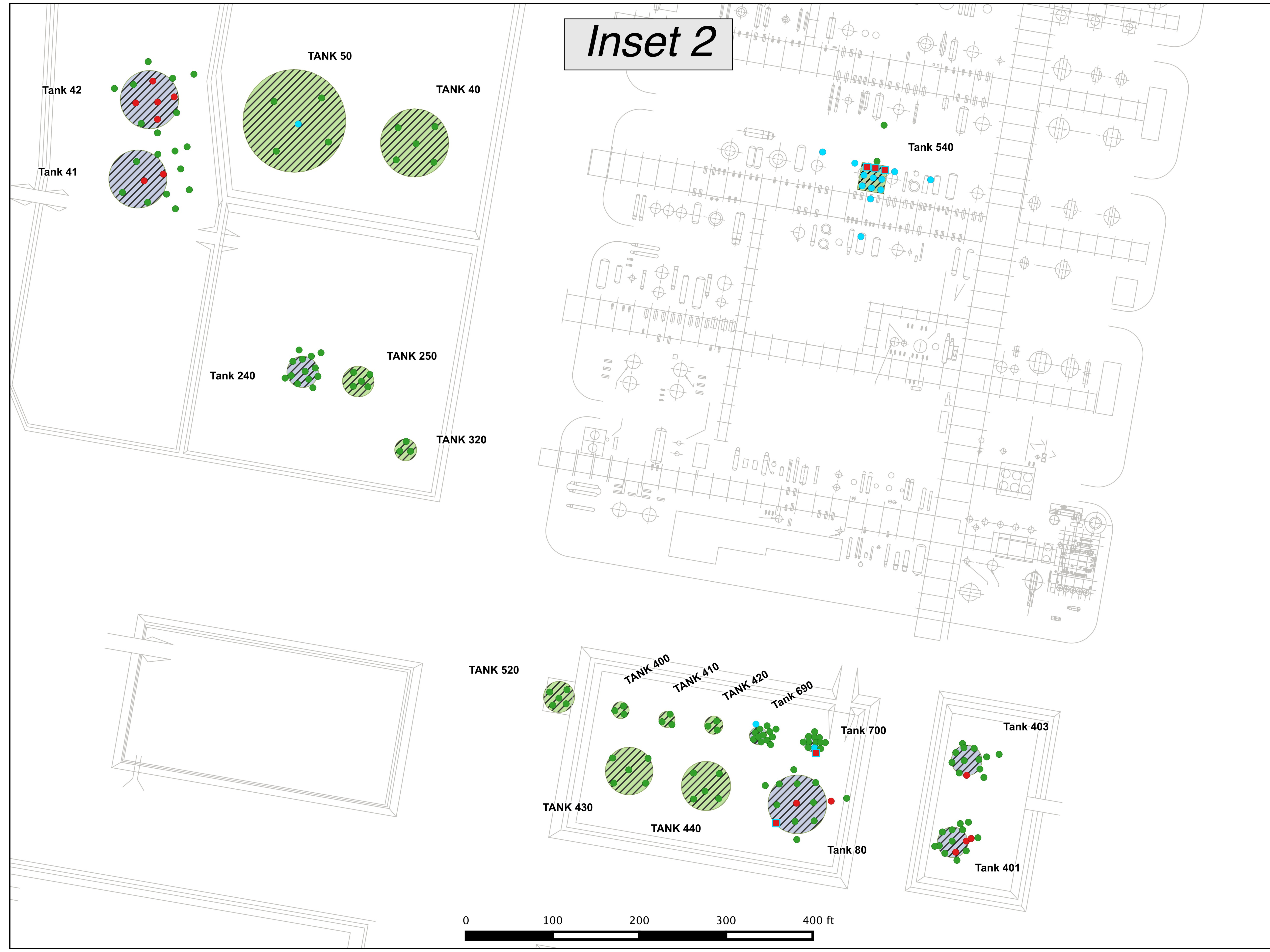
PEI

Figure 10

Sulfolane Extent
Lower Alluvial (µg/L)
Chevron Phillips Chemical
Puerto Rico Core, LLC

Legend

- Well Locations
- Former Site Features
- Effluent Channel
- Facility Boundary
- Areas of Concern
- Areas of Interest



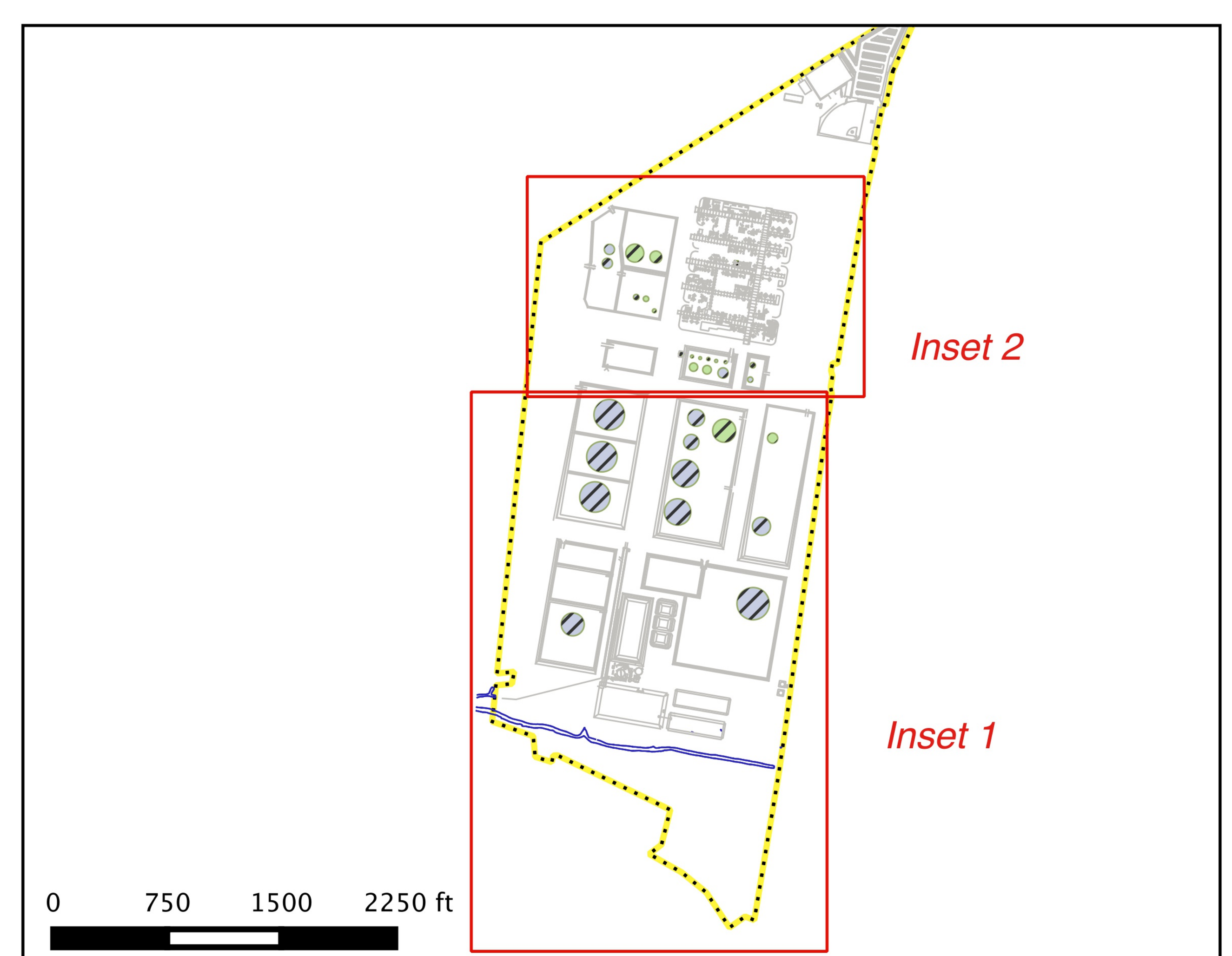


Figure 11
Surface Soil Exceedances

Chevron Phillips Chemical
Puerto Rico Core, LLC

PEI

Legend

Surface Sample Locations
- No Exceedances
- Sulfolane Exceedance
- VOC Exceedance
- VOC and Sulfolane Exceedance

- Former Facility Features
- Effluent Channel
- Area of Interest
- Area of Concern
- Facility Boundary

N
W E
S

Note: Sample locations 0040-07, 0050-06, 0050-07, 0130-06, 0130-07, 0250-06, 0250-07, 0270-06, 0270-07, 0320-04, 0320-05, 0410-04, 0410-05, 0410-06, 0410-07 are groundwater sample locations and not represented on this map

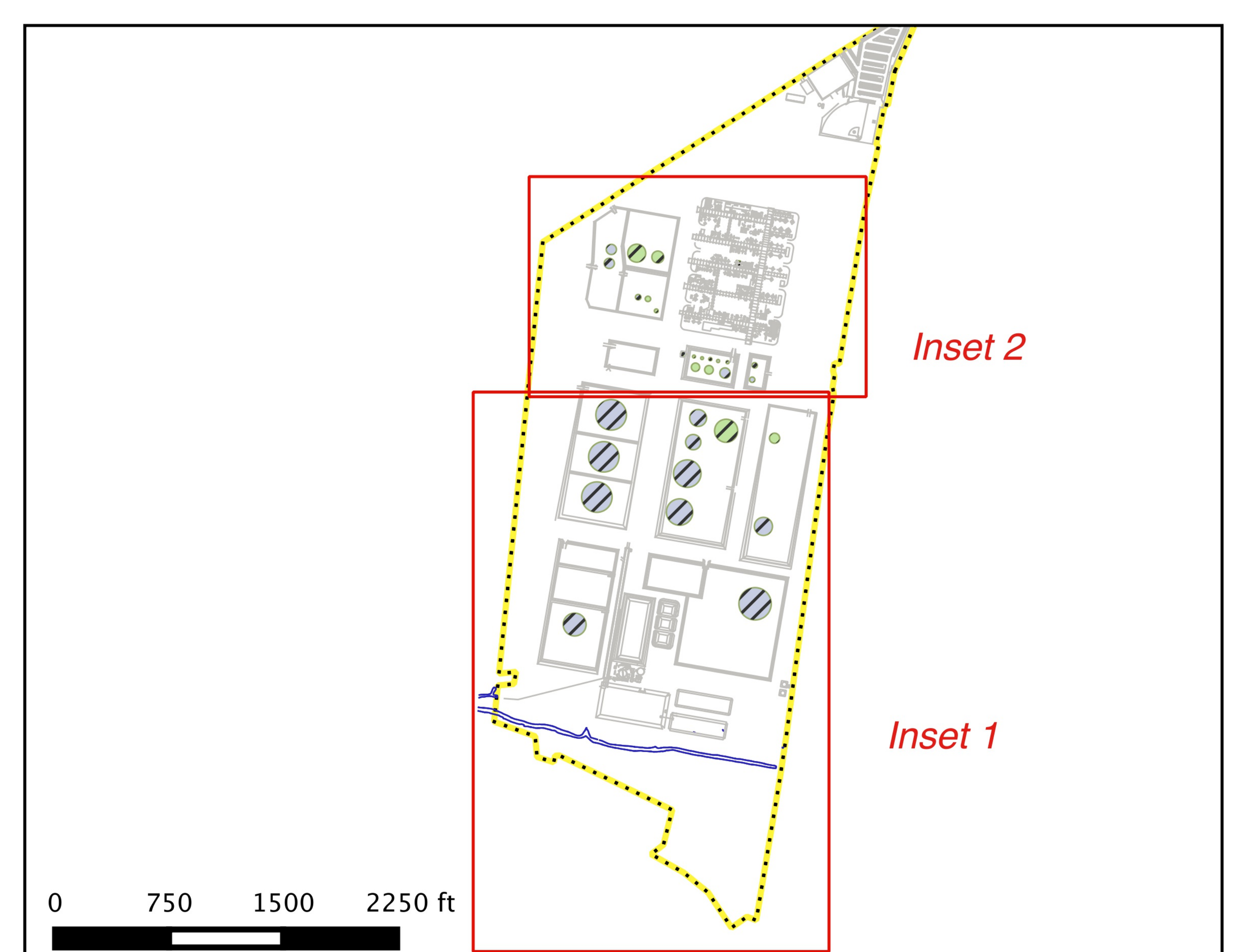


Figure 12
Subsurface Soil Exceedances

Chevron Phillips Chemical
Puerto Rico Core, LLC

Legend

Subsurface Sample Locations
- No Exceedances
- Sulfolane Exceedance
- VOC Exceedance
- VOC and Sulfolane Exceedance

- Former Facility Features
- Effluent Channel
- Area of Interest
- Area of Concern
- Facility Boundary

Note: Sample locations 0040-07, 0050-06, 0050-07, 0130-06, 0130-07, 0250-06, 0250-07, 0270-06, 0270-07, 0320-04, 0320-05, 0410-04, 0410-05, 0410-06, 0410-07 are groundwater sample locations and not represented on this map

PEI

N
W
E
S

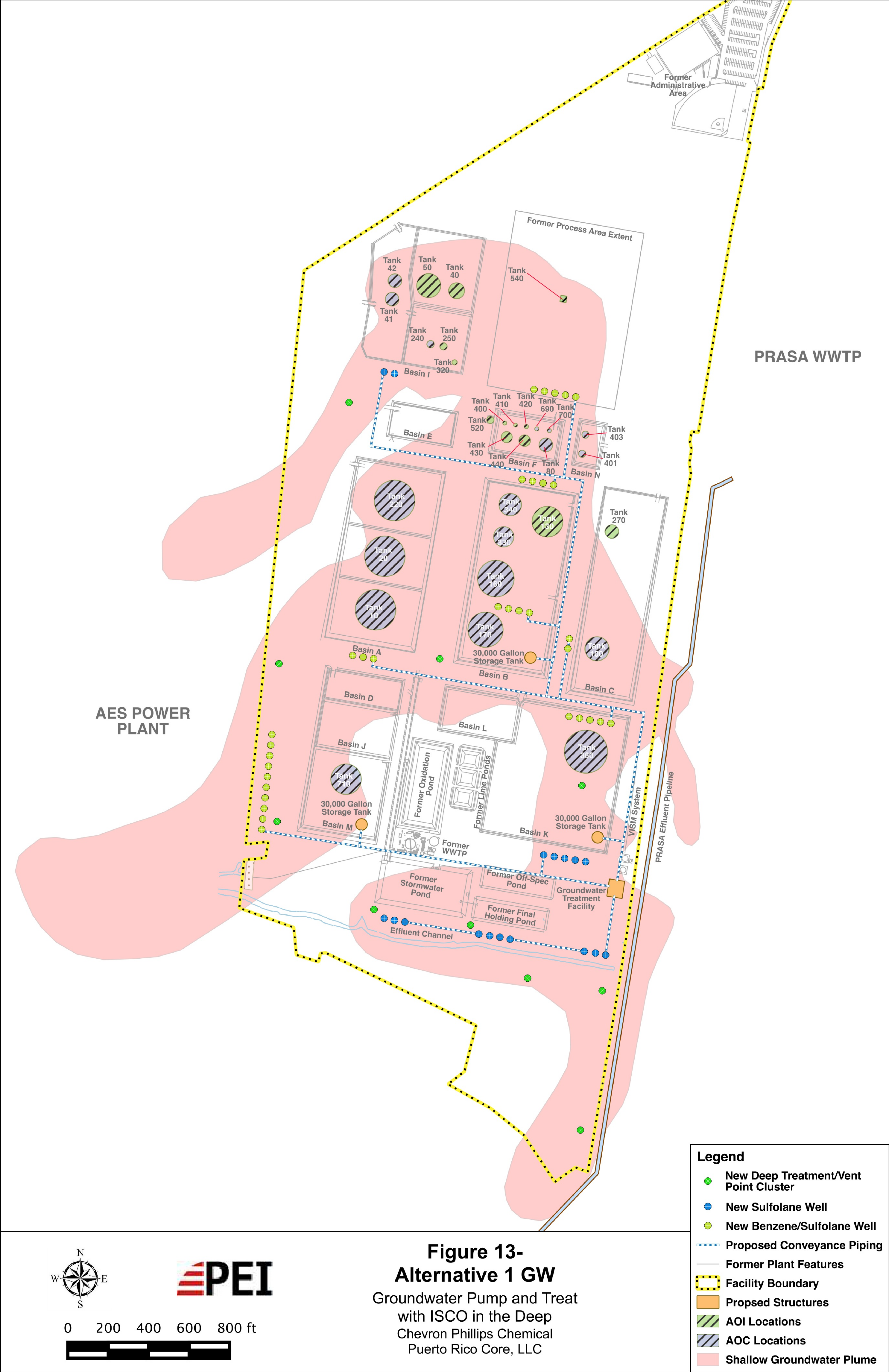


Figure 13- Alternative 1 GW

Groundwater Pump and Treat with ISCO in the Deep

Chevron Phillips Chemical Puerto Rico Core, LLC

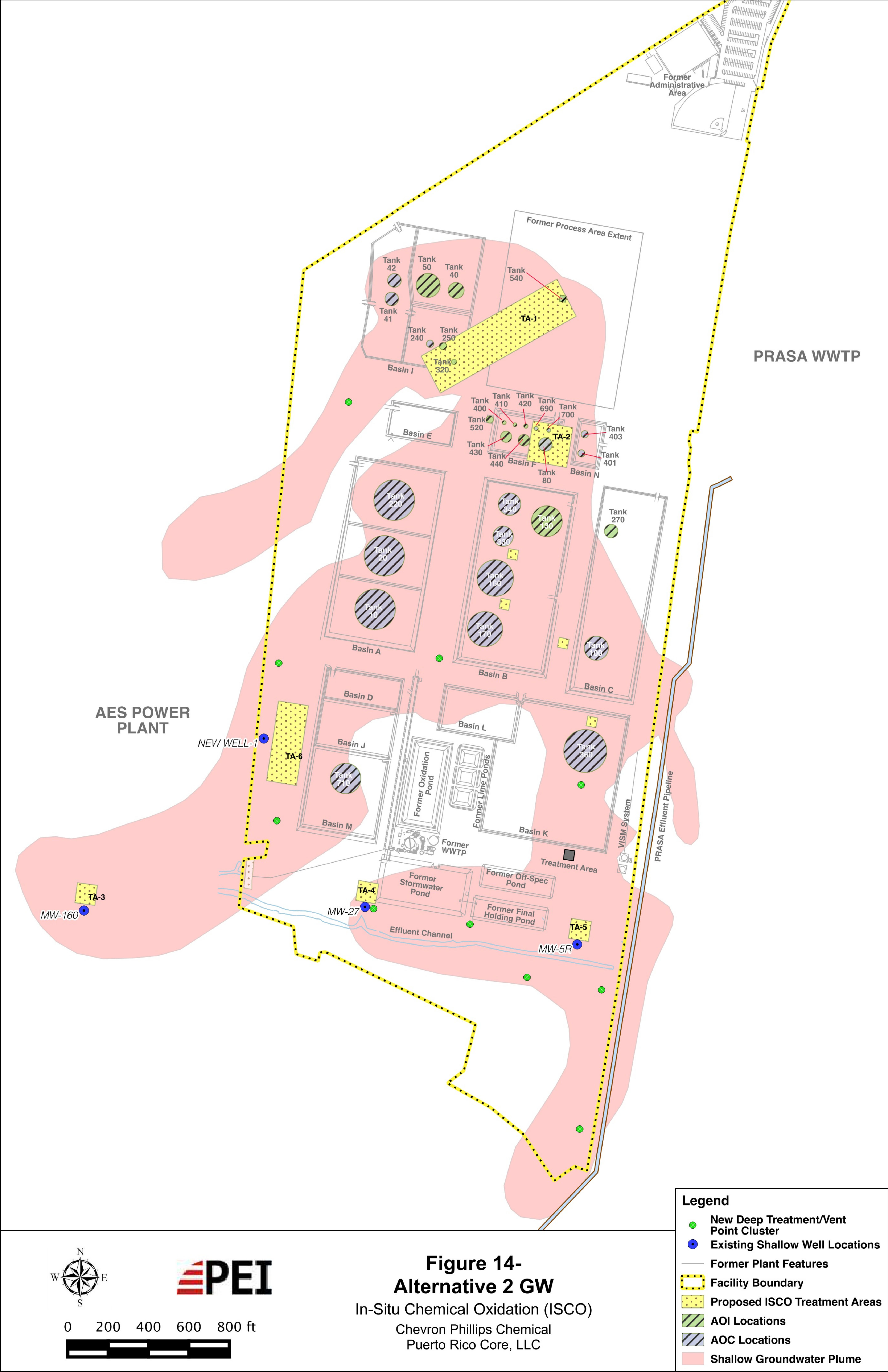


Figure 14-
Alternative 2 GW

In-Situ Chemical Oxidation (ISCO)

Chevron Phillips Chemical
Puerto Rico Core, LLC

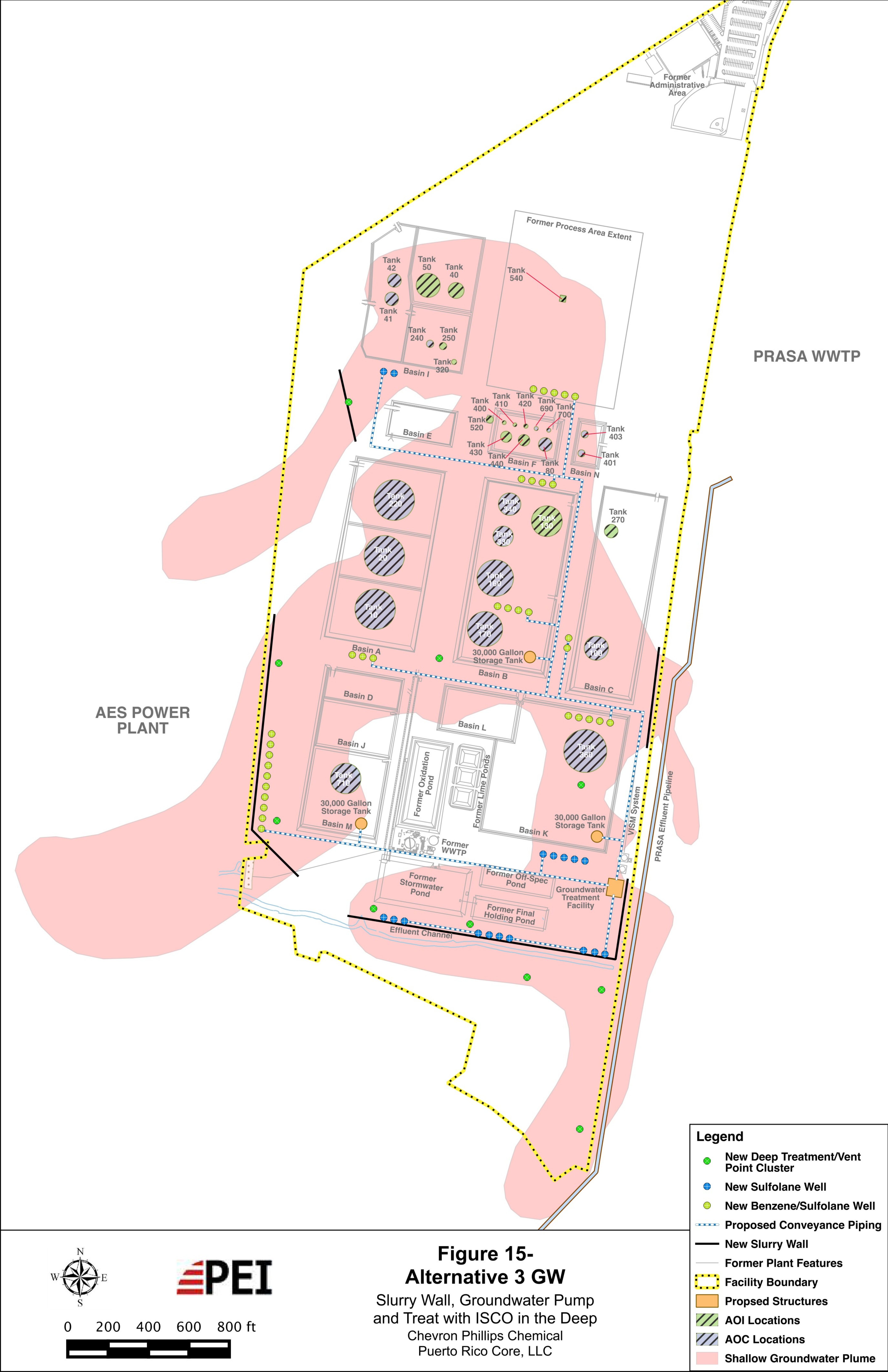


Figure 15- Alternative 3 GW

Slurry Wall, Groundwater Pump and Treat with ISCO in the Deep

Chevron Phillips Chemical Puerto Rico Core, LLC

Figure 16
Alternative 1- SO

Soil Excavation
and Offsite Disposal
Chevron Phillips Chemical
Puerto Rico Core, LLC

Legend

- Former Plant Features
- Proposed Soil Removal Area
- Facility Boundary

Figure 17
Alternative 2- SO
Soil Landfarming
Chevron Phillips Chemical
Puerto Rico Core, LLC

Legend
- Former Plant Features
- Facility Boundary
- Proposed Soil Removal Area
- Soil Land Farm Treatment Cell Area

N
W E
S

0 200 400 600 800 ft

Figure 18
Alternative 3- SO
Soil Mixing
Chevron Phillips Chemical
Puerto Rico Core, LLC

Legend
- Former Plant Features
- Proposed Soil Mixing Areas
- Facility Boundary