

Kegan W. Boyer, P.G. Project Manager

Upstream Business Unit Environmental Management Company 1500 Louisiana Street Room 38110 Houston, Texas 77002 Tel 832-854-5630 kegan.boyer@chevron.com

August 28, 2019

Mr. Peter Campbell Environmental Program Specialist Alaska Department of Environmental Conservation 43335 Kalifornsky Beach Road, Suite 11 Soldotna, Alaska 99669

Re: 2019 Additional Beach Assessment and Permeable Reactive Barrier Pilot Study Work Plan Trading Bay Production Facility, Cook Inlet, Alaska

Mr. Campbell,

As part of Chevron Environmental Management Company's (CEMC) ongoing activities at the Trading Bay Production Facility, we are submitting the following document:

• 2019 Trading Bay Production Facility Additional Beach Assessment and Permeable Reactive Barrier Pilot Study Work Plan

This document was prepared by Stantec Consulting Services Inc. (Stantec) on behalf of CEMC to provide detail regarding the planned 2019 additional assessment and interim remedial activities at the site.

The planned activities are anticipated to begin on or about September 23, 2019, contingent on weather and equipment and transport availability.

Should you have any questions regarding the proposed activities, please do not hesitate to contact me by phone at 832-854-5630 or via e-mail at kegan.boyer@chevron.com.

Sincerely,

Kegan W. Boyer, P.G.

Kegu- Por

Environmental Project Manager



2019 Trading Bay Production Facility Additional Beach Assessment and Permeable Reactive Barrier Pilot Study Work Plan

August 27, 2019

Prepared for:

Chevron Environmental Management Company

Prepared by:

Stantec Consulting Services Inc.





| Revision | Description | Author | | Quality C | heck | Independent Review | | |
|----------|-------------|-----------------|---------|-------------|---------|--------------------|---------|--|
| 1 | Draft | Ally Auffermann | 15Aug19 | Tom Madsen | 19Aug19 | Craig Wilson | 20Aug19 | |
| 2 | Final | Craig Wilson | 26Aug19 | Kegan Boyer | 26Aug19 | • | | |
| | | | | | | | | |

Table of Contents

| 1 | INTRODUCTION | 1 |
|-------------|--|----|
| 2 | SITE DESCRIPTION AND BACKGROUND | |
| 2.1 | GEOLOGY AND HYDROGEOLOGY | |
| 2.2 | CRUDE OIL NAPL DISTRIBUTION ON THE NORTHERN BEACH AREA | |
| 2.3 2.4 | DISSOLVED PHASE PLUMEMAY 2019 BEACH INVESTIGATIONS | |
| 2.4 | WAY 2019 BEACH INVESTIGATIONS | 4 |
| 3 | ADDITIONAL BEACH ASSESSMENT | |
| 3.1 | OPTICAL IMAGE PROFILING | |
| 3.2 | DIRECT PUSH GROUNDWATER SAMPLING | 8 |
| 4 | PILOT STUDY OVERVIEW | 9 |
| 4.1 | OBJECTIVES | |
| 4.2 | DESCRIPTION OF TREATMENT APPROACH | 9 |
| 5 | PILOT STUDY DESIGN | 10 |
| 5 .1 | INJECTION LAYOUT AND METHODS | |
| 5.2 | MONITORING | |
| 6 | PROJECT TEAM AND SCHEDULE | 12 |
| 6.1 | PROJECT TEAM | |
| 6.2 | PROJECT SCHEDULE | |
| 7 | STANDARD OPERATING PROCEDURES FOR SAMPLING | 13 |
| 7.1 | DIRECT PUSH SAMPLING | |
| 7.2 | CONTINGENCY PLANNING | |
| 7.3 | WATER QUALITY PARAMETERS | 13 |
| 8 | QUALITY ASSURANCE AND QUALITY CONTROL | 14 |
| 8.1 | QUALITY CONTROL SAMPLES | |
| 8.2 | SAMPLE CONTAINERS, HOLD TIMES, AND PRESERVATION | 14 |
| 8.3 | FIELD DOCUMENTATION | 15 |
| 8.4 | SAMPLE LABELING | |
| 8.5 | CHAIN-OF-CUSTODY AND SAMPLE PACKAGING | |
| 8.6 | DATA REDUCTION, VALIDATION AND REPORTING | |
| 8.7 | INVESTIGATION-DERIVED WASTE | 16 |
| 9 | REPORTING | 17 |
| 10 | REFERENCES | 18 |

LIST OF TABLES

| Table 2-1 Direct Push Sample Analysis | 5 |
|---|----|
| Table 2-2 Pore Water BTEX Analysis | |
| Table 5-1 PRB Baseline and Performance Monitoring Sampling Schedule | |
| Table 6-1 Project Team | 12 |
| Table 6-2 Additional Beach Assessment and PRB Pilot Study Schedule | |
| Table 8-1 Quality Control Requirements - Groundwater Samples | 14 |
| Table 8-2 Sample Containers, Preservation, and Hold Times | |

LIST OF FIGURES

| Figure 1 | Trading Bay Production Facility Location Map |
|----------|--|
| Figure 2 | Trading Bay Production Facility Site Map |
| Figure 3 | May 2019 Benzene Isoconcentration Map |
| Figure 4 | Fall 2019 OIP and Groundwater Sampling Locations |
| Figure 5 | Proposed Permeable Reactive Barrier Location |

LIST OF APPENDICES

| Appendix A | Figures |
|------------|--|
| Appendix B | North Beach Pilot Study Remediation Alternative Review – Trading Bay |
| | Production Facility |
| Appendix C | PetroFix [™] Design and Information Sheet |
| Appendix D | PetroFix™ Safety Data Sheet |

Abbreviations

ADEC Alaska Department of Environmental Conservation

ACL Alternative Cleanup level
amsl feet above mean sea level
bgs Below ground surface

BTEX benzene, toluene, ethylbenzene, xylenes

°C Degrees Celsius

CEMC Chevron Environmental Management Company

COBC Compliance Order By Consent

CoC Chain of Custody
EM Electromagnetic

EPA U.S. Environmental Protection Agency

ft feet

GAC granulated activated carbon
GPR Ground penetrating radar
HPT Hydraulic Profiling Tool
LED Light emitting diode

LNAPL Light Non-Aqueous Phase Liquid

mg/L milligrams per liter

MS/MSD Matrix spike / matrix spike duplicate

NAPL Non-Aqueous Phase Liquid

OIP optical image profiler

PAH Polycyclic Aromatic Hydrocarbons
PRB Permeable Reactive Barrier

QA Quality Assurance
QC Quality Control

TBPF Trading Bay Production Facility

Hilcorp Alaska, LLC

µm Micrometer

UNOCAL Union Oil Company of California

1 INTRODUCTION

The Trading Bay Production Facility (TBPF) is a remote onshore crude oil and natural gas processing facility on the west side of Cook Inlet that has been in operation since 1967. Crude oil, produced water, and natural gas are transported to TBPF via pipelines from offshore platforms in Cook Inlet and separated into three product streams. The crude oil is piped to the Drift River facility about 20 miles to the south and the natural gas is piped north for distribution by utility companies. The produced water is held in onsite retention ponds, treated and discharged to Cook Inlet under a National Pollutant Discharge Elimination System permit. The TBPF is located on private property, currently owned by Hilcorp Alaska, LLC (Hilcorp) in Sections 5 and 6, Township 8 North, Range 14 West, Seward Meridian, latitude 60.816507, longitude -151.788497. A Vicinity Map and a Site Map for the facility are presented on Figures 1 and 2, respectively.

In July of 1996, Union Oil Company of California (UNOCAL) and Marathon Oil Company signed Compliance Order by Consent (COBC) No. 91-23-053-02 with the Alaska Department of Environmental Conservation (ADEC) addressing groundwater impacts at TBPF. The COBC set an alternative cleanup level of 0.8 milligrams/liter (mg/L) for benzene and 0.15 mg/L for naphthalene, at the beach seep compliance point; required the installation of an air sparging system to remediate dissolved phase benzene carried by groundwater to the beach of Cook Inlet directly east of the facility; and required a groundwater monitoring program. The TBPF property and the responsibility for compliance with the COBC, was acquired by Chevron in 2004 (Hilcorp Alaska acquired the property from Chevron in 2013).

An air sparging system was installed along the southern beach area and a monitoring program was initiated in 1996, as required by the COBC, and a system of recovery wells was installed along the eastern bluff area in 2018.

ADEC requested additional field investigation at the site in 2015. Characterization activities completed in 2016 led to the discovery of Non-Aqueous Phase Liquids (NAPL) in saturated sands extending beyond the bluff to the subsurface of the intertidal beach zone of Cook Inlet. Work completed in 2017 and 2018 subsequently delineated and characterized the presence of a discrete layer of NAPL in the beach subsurface at depths ranging from 5 to 10 feet below ground surface (bgs). The NAPL appears to be beneath a confining silt lens. Monitoring wells completed in these intervals accumulated NAPL indicating that the oil is mobile at the local scale.

Additional beach assessment activities were conducted in May 2019 (described in Section 2.4) to further delineate and characterize the extent of the confining silt lens, the extent of NAPL and any dissolved phase concentrations in the intertidal zone. Dissolved benzene concentrations exceeding the COBC alternative cleanup level of 0.8 mg/L were detected in groundwater grab samples collected from the intertidal zone approximately 220 feet beyond the beach seep compliance points (Z4-1 and Z4-2 on **Figure 3**). In addition, the elevated benzene concentrations were found at greater depths further out in the intertidal zone. Specifically, elevated concentrations at Z4-1 and Z4-2 (approximately 260 feet east of the mean high tide line) were 6 feet deeper than at Z2-3 (50 feet from the mean high tide line) and 4 feet deeper than at Z3-2 (100 feet from the mean high tide line).

As shown on **Figure 3**, when combined with the 2018 measured benzene concentrations in former beach groundwater monitoring wells (18MW-series wells) and the bluff top recovery wells (RW-1 through RW-14), the NAPL observed on the beach appears to be a contributor, but not the only source of dissolved-phase impacts that extend into the intertidal zone. Chevron Environmental Management Company (CEMC) is evaluating other alternatives to



address the source areas on the bluff top and to the west. However, to mitigate the offsite migration of the dissolved-phase benzene plume, several remediation technologies were evaluated for potential pilot study implementation on the beach. Due to the site characteristics, a permeable reactive barrier (PRB) application was determined to be an appropriate technology to mitigate the benzene plume downgradient of the NAPL accumulation. The results of May 2019 beach assessment activities show that the area of NAPL accumulation on the beach is limited and confined by an overlying silt lens.

The pilot study remediation alternative review memorandum, reviewing several potential PRB materials, is included as **Appendix B** of this work plan. Based on this review, the injection of PetroFix[™], a colloidal activated carbon product by Regenesis, to create a subsurface PRB is recommended for further evaluation during pilot study activities to be conducted at the northern beach area of TBPF this fall.

This work plan presents the proposed additional beach assessment and permeable reactive barrier (PRB) pilot study activities to be implemented in the fall of 2019. Additional beach assessment activities will include installation of direct push borings to collect baseline groundwater sample for the PRB pilot study and to further delineate the extent of the confining silt lens and dissolved benzene at the northern beach area using an optical image profiling (OIP) tool and a hydraulic profiling tool (HPT). The PRB pilot study will include injections of the treatment reagent and monitoring activities for performance evaluation.



2 SITE DESCRIPTION AND BACKGROUND

2.1 GEOLOGY AND HYDROGEOLOGY

The TBPF is constructed on an eastward sloping terrace about 60 to 100 feet above mean sea level. At the eastern edge of the site is a shoreline bluff which drops, about 40 to 50 feet, to the beach along Cook Inlet. Several site investigations of the impacts beneath the TBPF have been completed by various consulting companies. These included Montgomery Watson in 1994, Tetra Tech in 1995, Geosphere in 1996 and 1997, and Weston Solutions, Inc. (Weston) in 2016 and 2017. Refer to previous work plans for further discussion of site geology and hydrogeology.

2.2 CRUDE OIL NAPL DISTRIBUTION ON THE NORTHERN BEACH AREA

Early production processing practices at the TBPF involved separating produced crude oil and water from offshore production platforms in large unlined earthen pits. That practice (long since abandoned), as well as historic leaks and spills from facility pipelines and tanks, caused hydrocarbon to be released to the soils under the TBPF, creating the current source of impact present in soils and groundwater.

The northern beach area impacts appear to be predominantly associated with Tank Battery 2, a series of heater-treaters just east of Tank Battery 2, and potentially the produced water retention basins. The NAPL in the northern source area extends to the bluff top monitoring wells in several locations (e.g. M-102D, M-110, M-111, and RW-7). Geosphere postulated in 1997 that the NAPL plume under the TBPF had stabilized such that immobile, continuous NAPL is present where free product is observed in site monitoring wells and discontinuous, residual saturation is present around the perimeter of the source.

During the 2016 site investigation, NAPL was encountered in four soil borings drilled on the beach on the northern portion of the Trading Bay site. The NAPL impacted soil strata varied in thickness from approximately 0.2 to 2 feet; had a medium to coarse sand texture; were overlain and underlain by silt lenses; and was logged in one borehole as shallow as 6 feet below ground surface in the beach prism sands.

During the 2017 site investigation, 11 monitoring wells were installed within the northern NAPL upper beach area. Of the wells installed 4 monitoring wells contained NAPL and were subsequently decommissioned later that fall.

Ten monitoring wells were installed within the northern NAPL upper beach area in 2018 to further delineate the impacts encountered in 2016, along with optical image profiling. Three of the ten wells contained NAPL and all were subsequently decommissioned in the Fall 2018.

2019 beach investigations are described in Section 2.4 of this report.

2.3 DISSOLVED PHASE PLUME

Crude oil NAPL constituents tend to dissolve into the groundwater flowing through the TBPF site, forming dissolved phase plumes downgradient of the NAPL source areas. The dissolved phase plumes extend eastward from the source areas toward the Cook Inlet beach. Since 1998, the COBC mandated groundwater monitoring program has



focused on two source area monitoring wells, eight bluff top wells and six beach seep sampling locations (expanded to ten locations in 2015 at ADEC request).

In 1995, the TBPF *Human Health and Ecological Risk Assessment*, conducted by Tetra Tech, identified benzene and naphthalene as the primary chemicals of concern in groundwater at TBPF, based on potential exposures to marine organisms in Cook Inlet. Based on the risk assessment, alternative cleanup levels (ACLs) were established in the COBC, at 0.8 and 0.15 mg/L for benzene and naphthalene, respectively, in groundwater discharging from beach seeps.

Data collected in May 2019 indicates the presence of a benzene plume downgradient of the LNAPL under the north beach area. The current conceptual site model (CSM) posits that this benzene plume is sourced from both the LNAPL under the north beach and further upgradient on the facility itself.

2.4 MAY 2019 BEACH INVESTIGATIONS

The May 2019 beach investigations included ground-penetrating radar (GPR) and electromagnetic (EM) surveys of the beach along with OIP, direct-push (DP), and pore water sampling. The GPR survey evaluated silt lens depth and the EM survey provided soil conductivity data.

The DP sampling was accomplished using SP16 groundwater samplers, collecting groundwater samples from approximately 6 to 8 feet bgs. The samples were analyzed for benzene, toluene, ethylbenzene, and xylenes (BTEX), and the resulting data is shown in Table 2-1. The pore water samples were collected approximately 18 inches bgs and also analyzed for BTEX. Those results are detailed in Table 2-2.

The GPR and EM survey data indicates the probable presence of a groundwater pathway in the vicinity of the LNAPL on the beach. The benzene plume identified using DP sampling corresponds with this pathway.

Our current understanding of the site indicates that the LNAPL on the beach may be commingled with but separate from the dissolved benzene plume, with at least part of the benzene plume being sourced from groundwater flows from the vicinity of Tank Battery 2. OIP fluorescence indicates little movement of the LNAPL downgradient.



Table 2-1 Direct Push Sample Analysis

| Sample | Benzene ug/L | Ethylbenzene ug/L | Isopropylbenzene ug/L | Methyl-t-butyl ether ug/L | Naphthalene ug/L | P & M -Xylene ug/L | Toluene ug/L | Xylenes (total) ug/L | n-Butylbenzene ug/L | o-Xylene ug/L | sec-Butylbenzene ug/L | tert-Butylbenzene ug/L |
|--------------------|-----------------|----------------------|--------------------------|------------------------------|---------------------|-----------------------|-----------------|-------------------------|------------------------|------------------|--------------------------|---------------------------|
| Location DP-Z3_1 | 0.471 | 0.500 U | 0.500 U | 5.00 U | 0.500 U | 1.00 U | 0.500 U | 1.50 U | 0.500 U | 0.500 U | 0.500 U | 0.500 U |
| DP-Z3_1 DP-Z3_2 | 317 | 0.500 U | 10.4 | 5.00 U | 6.12 | 1.00 U | 0.500 U | 1.50 U | 0.500 U | 0.500 U | 0.300 J | 0.500 U |
| | 16.7 | 0.500 U | 0.500 U | 5.00 U | 0.12 0.500 U | 1.00 U | 0.500 U | 1.50 U | 0.500 U | 0.500 U | 0.790 J 0.500 U | 0.500 U |
| DP-Z3_3 | | | | | | | | | | | 2.50 U | |
| DP-Z3_4 | 0.844 J | 2.50 U | 2.50 U | 25.0 U | 2.50 U | 5.00 U | 2.50 U | 7.50 U | 2.50 U | 2.50 U | | 2.50 U |
| DP-Z3_5 | 0.150 J | 0.500 U | 0.500 U | 5.00 U | 0.500 U | 1.00 U | 0.330 J | 1.50 U | 0.500 U | 0.500 U | 0.500 U | 0.500 U |
| DP-Z3_6 | 82.4 | 0.500 U | 0.500 U | 5.00 U | 0.500 U | 0.840 J | 0.500 U | 1.50 U | 0.500 U | 0.500 U | 0.500 U | 0.500 U |
| DP-Z1_1 | 0.200 U | 0.500 U | NS | NS | NS | 1.00 U | 0.500 U | 1.50 U | NS | 0.500 U | NS | NS |
| DP-Z1_2 | 4.58 | 1.02 | NS | NS | NS | 35.3 | 0.500 U | 35.3 | NS | 0.500 U | NS | NS |
| DP-Z4_2 | 1260 | 0.400 J | 1.24 | 5.00 U | 0.500 U | 40.5 | 0.500 U | 40.5 | 0.500 U | 0.500 U | 0.500 U | 0.500 U |
| DP-Z4_1 | 1550 | 1.85 | 13.1 | 5.00 U | 1.85 | 270 | 0.500 U | 270 | 0.500 U | 0.500 U | 0.470 J | 0.500 U |
| DP-Z4_3 | 121 | 0.500 U | 0.500 U | 5.00 U | 0.500 U | 1.00 U | 0.500 U | 1.50 U | 0.500 U | 0.500 U | 0.500 U | 0.500 U |
| DP-Z2_1 | 0.200 U | 0.500 U | 0.500 U | 5.00 U | 0.500 U | 1.00 U | 0.500 U | 1.50 U | 0.500 U | 0.500 U | 0.500 U | 0.500 U |
| DP-Z2_2 | 38.0 | 0.500 U | 0.686 J | 5.00 U | 0.500 U | 1.69 J | 0.500 U | 1.69 J | 0.500 U | 0.500 U | 0.500 U | 0.500 U |
| DP-Z2_3 | 1060 | 3.70 | 33.6 | 5.00 U | 56.7 | 227 | 0.326 J | 227 | 0.500 U | 0.500 U | 4.36 | 0.717 J |
| DP-Z2_4 | 0.360 J | 0.500 U | NS | NS | NS | 1.00 U | 0.500 U | 1.50 U | NS | 0.500 U | NS | NS |
| DP-Z2_5 | 0.920 | 0.500 U | NS | NS | NS | 1.00 U | 0.340 J | 1.50 U | NS | 0.500 U | NS | NS |
| DP-Z1_6 | 1030 | 0.600 J | NS | NS | NS | 17.9 | 0.380 J | 17.9 | NS | 0.500 U | NS | NS |
| DP-Z1_4 | 1710 | 11.7 | NS | NS | NS | 679 | 0.500 U | 679 | NS | 0.340 J | NS | NS |
| DP-Z1_5 | 22.2 | 0.500 U | NS | NS | NS | 0.750 J | 0.400 J | 1.50 U | NS | 0.500 U | NS | NS |
| DP-Z1_8 | 0.610 | 0.500 U | NS | NS | NS | 1.00 U | 0.500 U | 1.50 U | NS | 0.500 U | NS | NS |
| DP-Z1_9 | 0.180 J | 0.500 U | NS | NS | NS | 1.00 U | 0.500 U | 1.50 U | NS | 0.500 U | NS | NS |



| Sample Location | Benzene ug/L | Ethylbenzene ug/L | Isopropylbenzene ug/L | Methyl-t-butyl ether ug/L | Naphthalene ug/L | P & M -Xylene ug/L | Toluene ug/L | Xylenes (total) ug/L | n-Butylbenzene ug/L | o-Xylene ug/L | sec-Butylbenzene ug/L | tert-Butylbenzene ug/L |
|--------------------|-----------------|----------------------|--------------------------|------------------------------|---------------------|-----------------------|-----------------|-------------------------|------------------------|------------------|--------------------------|---------------------------|
| DP-Z2_9 | 0.790 | 0.500 U | NS | NS | NS | 1.00 U | 0.500 U | 1.50 U | NS | 0.500 U | NS | NS |
| DP-Z2_8 | 354 | 0.500 U | NS | NS | NS | 149 | 0.500 U | 149 | NS | 0.500 U | NS | NS |
| DP-Z2_7 | 92.3 | 2.20 | NS | NS | NS | 180 | 0.500 U | 180 | NS | 0.500 U | NS | NS |
| DP-Z4_9 | 0.200 U | 0.500 U | 0.500 U | 5.00 U | 0.500 U | 1.00 U | 0.500 U | 1.50 U | 0.500 U | 0.500 U | 0.500 U | 0.500 U |
| DP-Z4_8 | 0.200 U | 0.500 U | 0.500 U | 5.00 U | 0.500 U | 1.00 U | 0.500 U | 1.50 U | 0.500 U | 0.500 U | 0.500 U | 0.500 U |
| DP-Z4_7 | 0.156 J | 0.500 U | 0.500 U | 5.00 U | 0.500 U | 1.00 U | 0.500 U | 1.50 U | 0.500 U | 0.500 U | 0.500 U | 0.500 U |
| DP-Z3_7 | 19.0 | 0.500 U | 0.597 J | 5.00 U | 0.500 U | 12.4 | 0.500 U | 12.4 | 0.500 U | 0.500 U | 0.500 U | 0.500 U |
| DP-Z3_8 | 179 | 0.500 U | 1.07 | 5.00 U | 0.500 U | 32.2 | 0.500 U | 32.2 | 0.500 U | 0.500 U | 0.500 U | 0.500 U |
| DP-Z3_9 | 0.200 U | 0.500 U | 0.500 U | 5.00 U | 0.500 U | 1.00 U | 0.500 U | 1.50 U | 0.500 U | 0.500 U | 0.500 U | 0.500 U |
| DP-Z4_4 | 0.675 | 0.500 U | 0.500 U | 5.00 U | 0.500 U | 1.00 U | 0.500 U | 1.50 U | 0.500 U | 0.500 U | 0.500 U | 0.500 U |
| DP-Z4_5 | 0.200 U | 0.500 U | 0.500 U | 5.00 U | 0.500 U | 1.00 U | 0.500 U | 1.50 U | 0.500 U | 0.500 U | 0.500 U | 0.500 U |
| DP-Z4_6 | 0.200 U | 0.500 U | 0.500 U | 5.00 U | 0.500 U | 1.00 U | 0.500 U | 1.50 U | 0.500 U | 0.500 U | 0.500 U | 0.500 U |

Notes:

J – Sample results are above the detection limit but below the limit of quantification

NS – Not sampled

U – Sample results are below the detection limit



Table 2-2 Pore Water BTEX Analysis

| Sample Location | Benzene (ug/L) | Toluene (ug/L) | Ethylbenzene (ug/L) | P&M Xylene (ug/L) | Total Xylenes (ug/L) | o-Xylene (ug/L) |
|--------------------|-------------------|-------------------|------------------------|----------------------|-------------------------|--------------------|
| PW-Z1_1 | 0.200 U | 0.500 U | 0.500 U | 1.00 U | 1.50 U | 0.500 U |
| PW-Z1_2 | 0.200 U | 0.500 U | 0.500 U | 1.00 U | 1.50 U | 0.500 U |
| PW-Z3_1 | 0.200 U | 0.500 U | 0.500 U | 1.00 U | 1.50 U | 0.500 U |
| PW-Z3_2 | 2.74 | 0.500 U | 0.500 U | 1.00 U | 1.50 U | 0.500 U |
| PW-Z3_3 | 20.3 | 0.500 U | 0.500 U | 1.00 U | 1.50 U | 0.500 U |
| PW-Z3_4 | 0.200 U | 0.500 U | 0.500 U | 1.00 U | 1.50 U | 0.500 U |
| PW-Z3_5 | 0.200 U | 0.500 U | 0.500 U | 1.00 U | 1.50 U | 0.500 U |
| PW-Z3_6 | 0.200 U | 0.500 U | 0.500 U | 1.00 U | 1.50 U | 0.500 U |
| PW-Z2_1 | 0.200 U | 0.500 U | 0.500 U | 1.00 U | 1.50 U | 0.500 U |
| PW-Z2_2 | 3.83 | 0.500 U | 0.500 U | 1.00 U | 1.50 U | 0.500 U |
| PW-Z2_3 | 0.290 J | 0.500 U | 0.500 U | 1.00 U | 1.50 U | 0.500 U |
| PW-Z2_4 | 0.200 U | 0.500 U | 0.500 U | 1.00 U | 1.50 U | 0.500 U |
| PW-Z2_5 | 0.200 U | 0.500 U | 0.500 U | 1.00 U | 1.50 U | 0.500 U |
| PW-Z2_6 | 0.200 U | 0.500 U | 0.500 U | 1.00 U | 1.50 U | 0.500 U |
| PW-Z1_3 | 34.2 | 0.500 U | 0.500 U | 1.00 U | 1.50 U | 0.500 U |
| PW-Z1_5 | 135 | 0.500 U | 0.500 U | 1.00 U | 1.50 U | 0.500 U |
| PW-Z1_6 | 674 | 0.500 U | 0.500 U | 1.00 U | 1.50 U | 0.500 U |
| PW-Z2_7 | 0.200 U | 0.500 U | 0.500 U | 1.00 U | 1.50 U | 0.500 U |
| PW-Z2_8 | 0.200 U | 0.500 U | 0.500 U | 1.00 U | 1.50 U | 0.500 U |
| PW-Z2_9 | 0.200 U | 0.500 U | 0.500 U | 1.00 U | 1.50 U | 0.500 U |
| PW-Z3_8 | 0.200 U | 0.500 U | 0.500 U | 1.00 U | 1.50 U | 0.500 U |
| PW-Z3_7 | 1.13 | 0.500 U | 0.500 U | 1.00 U | 1.50 U | 0.500 U |
| PW-Z3_9 | 0.200 U | 0.500 U | 0.500 U | 1.00 U | 1.50 U | 0.500 U |

Notes:



J – Sample results are above the detection limit but below the limit of quantification

U – Sample results are below the detection limit

3 ADDITIONAL BEACH ASSESSMENT

The following is a discussion of the proposed additional beach assessment scope of work, methods, and approach. The following investigation activities are planned for September/October 2019 to complete a baseline assessment of the impacted area:

- Installation of additional direct push borings using OIP near and downgradient of the proposed PRB location
 to further delineate the bottom of the silt lens and use the HPT to determine the actual intervals for the
 injections.
- Installation of direct push borings in Zone 3 below the silt lens, and collection of grab groundwater samples
 to establish baseline dissolved concentrations for the pilot PRB.
- Installation of direct push borings north and east of Zone 4, and collection of grab groundwater samples to delineate the extent of dissolved benzene concentrations.

Additional direct push borings and grab groundwater sampling will be conducted in spring 2020 to determine the effectiveness of the PRB (see Section 5.2 of this report).

3.1 OPTICAL IMAGE PROFILING

The OIP is a direct push tool used for vertical delineation of soil conductivity, permeability, and any NAPL occurrences. An OIP, manufactured by Geoprobe®, will be advanced using direct push methods along the proposed PRB location in Zone 3, and north and east of Zone 4 of the intertidal zone (**Figure 4**) to confirm the depth of the silt lens for proper placement of the PRB injections. The profiler also produces a detailed log of ultraviolet induced petroleum fluorescence (induced by light emitting diode [LED]), simultaneously with formation electrical conductivity and formation permeability via the HPT.

The profiler will be calibrated prior to starting each location. The three data sets produced by the probe, which can include visible spectrum imagery at specified locations, will allow for a detailed characterization of the subsurface conditions, including estimates on NAPL distribution, lithology transitions, and horizontal hydraulic conductivity in vertical profile.

3.2 DIRECT PUSH GROUNDWATER SAMPLING

Similar to the sampling conducted in May 2019, direct push groundwater grab samples will be collected at locations along Zone 3 and north and east of Zone 4 to further evaluate the lateral extent of dissolved benzene in groundwater. Proposed sampling locations are shown on **Figure 4**.

The sampling will be done during low tides, both for safe access and to reduce saltwater influence on the samples, using a Geoprobe SP16 (or equal) temporary well point sampling device. Grab samples will be collected at approximately 4 to 6 feet below ground surface or below the interpreted bottom of the silt lens. The samples will be analyzed for benzene, toluene, ethylbenzene, and xylenes (BTEX).



4 PILOT STUDY OVERVIEW

4.1 OBJECTIVES

The objectives of this PRB pilot study are to:

- Assess the effectiveness of PetroFixTM in mitigating the migration of dissolved benzene towards Cook Inlet;
- Evaluate the ability to deliver and distribute the treatment reagent in the formation;
- Assess the longevity of the treatment reagent and how the tidal cycles affect the distribution of the reagent in the subsurface; and
- Evaluate whether biodegradation of petroleum hydrocarbon is an important degradation pathway at the site;

4.2 DESCRIPTION OF TREATMENT APPROACH

The treatment approach proposed to address the dissolved benzene plume is in-situ chemical adsorption by PetroFixTM injected into the treatment zone to create a PRB perpendicular to groundwater flow. In-situ chemical adsorption typically uses activated carbon for the adsorption of contaminants. The activated carbon particles bind to soil particles and adsorb contaminants from the groundwater as it flows through the PRB. PetroFixTM is an activated carbon product marketed by Regenesis. The reagent is composed of colloidal activated carbon particles of 1-2 micrometer (μ m) in size and supplied with nitrate and sulfate amendments as electron acceptors to promote anaerobic biodegradation of petroleum hydrocarbons. PetroFixTM has a viscosity similar to that of water and can be injected into the subsurface with low pressure. The product information sheets and safety data sheets are included as **Appendix C** and **Appendix D**.



5 PILOT STUDY DESIGN

5.1 INJECTION LAYOUT AND METHODS

A staggered array of injection points will be advanced with a direct push injection probe to deliver the reagent into the target treatment zone, creating a 200-foot long PRB intercepting the groundwater plume downgradient from the NAPL concentration on the beach. The PRB will be installed along the northern beach zone approximately 50 feet east of the mean high tide line at Zone 2 of the intertidal beach assessment zone (**Figure 4**). Based on the application design parameters provided by Regenesis (**Appendix C**), the PRB will consist of two rows of injection points spaced every 8 feet in an offset grid pattern. The rows will be 5 feet apart, with a total of 50 injection borings. The proposed treatment zone is at approximately 5 to 11 feet bgs, under the confining silt lens. An HPT will be used to detect the bottom of the silt lens and to ensure that the reagent is being delivered into the more permeable sand underlying the silt lens.

Prior to injecting the reagent, a clean water injection step test will be conducted to determine the range of injection pressure and flow rate, and to evaluate whether daylighting of the injection solution would occur. Clean water will be injected into the target injection interval at increasing flow rates and pressures. The optimal injection flow rate will be determined based on the timeframe needed to complete the injections and the maximum allowable pressure without fracturing the formation.

The reagent will be delivered to the site as a 30% by mass concentrate in powder form. In a 300-gallon mix tank, 17 gallons of reagent will be mixed with 284 gallons of water onsite to form an injection solution, along with 8 pounds of electron acceptor material. The injection points will be advanced with a direct push injection probe rod to deliver the injection solution into the target treatment interval. The injection solution will be pumped through the probe rod using a positive displacement pump and injected into the formation under pressure no greater the maximum allowable pressure determined during the clean water injection test. Each injection boring will receive approximately 267 gallons of injection solution. The total amount of PetroFixTM to be injected is estimated to be up to approximately 7,200 pounds.

5.2 MONITORING

The monitoring program is designed to evaluate the pilot study objectives presented in **Section 4.1**. Details of the monitoring program are presented in the following sections.

5.2.1 Baseline Monitoring

Baseline groundwater samples will be collected from the direct push borings to be installed in Zones 3, 4 and 5 downgradient of the proposed PRB (**Figure 4**) to further establish the pre-pilot study baseline conditions. The sampling will be conducted during low tides, both for safe access and to reduce saltwater influence on the samples, using a Geoprobe SP16 (or equal) temporary well point sampling device. Grab samples will be collected below the interpreted bottom of the silt lens or a maximum depth of 16 feet bgs. Samples will be analyzed for BTEX, polycyclic aromatic hydrocarbons (PAHs), nitrate and sulfate (**Table 5.1**). BTEX sampling will assist in more accurate delineation of benzene in the groundwater plume, and the PAH samples will continue the site investigation work from



May 2019 to confirm no other hydrocarbon contamination. Nitrate and sulfate are electron acceptors utilized by bacteria during the anaerobic biodegradation of petroleum hydrocarbons. The monitoring of these electron acceptors allows for the evaluation of whether biodegradation is an important degradation pathway at the tidally influenced beach zone.

5.2.2 Operational Monitoring

Operational monitoring will be conducted during the injections to guide and modify the injection operations as necessary. The injection rate and pressure at each injection point will be monitored continuously and recorded periodically throughout the injections. Injection pressures will be managed to achieve reasonable injection rates and avoid formation fracturing. The actual volume of injection solution delivered into each injection boring will also be recorded.

5.2.3 Performance Monitoring

Due to limited access to the site in the winter months, performance monitoring for the pilot study will be conducted during the field season in 2020. The performance monitoring sampling events will be conducted approximately 8- and 12-months post injection, corresponding to spring and fall 2020. Direct push groundwater grab samples will be collected from the same locations and depths sampled during the baseline sampling event. Grab samples will be analyzed for BTEX, PAHs, nitrate and sulfate (**Table 5.1**).

Table 5-1 PRB Baseline and Performance Monitoring Sampling Schedule

| Direct Push Groundwater | S | september 20° (baseline) | 19 | May and September 2020 (8 and 12 months post-injection) | | | |
|----------------------------|------|-----------------------------|-----------------------|---|------|-----------------------|--|
| Sampling Location | BTEX | PAHs | Electron Acceptors | BTEX | PAHs | Electron Acceptors | |
| Z3-10 | Х | Х | X | Х | Х | X | |
| Z3-11 | Х | | | Х | | | |
| Z3-12 | Х | | | X | | | |
| Z3-13 | Х | | | Х | | | |
| Z3-14 | Х | | | Х | | | |
| Z4-10 | Х | Х | Х | Х | Х | Х | |
| Z4-11 | Х | | | Х | | | |
| Z4-12 | Х | | | Х | | | |
| Z4-13 | Х | | | Х | | | |
| Z4-14 | Х | | | Х | | | |
| Z5-1 | Х | Х | X | Х | Х | X | |
| Z5-2 | Х | | | Х | | | |
| Z5-3 | Х | | | Х | | | |
| Z5-4 | Х | | | Х | | | |
| Z5-5 | Х | | | Х | | | |
| Z5-6 | Х | | | Х | | | |



6 PROJECT TEAM AND SCHEDULE

6.1 PROJECT TEAM

The Stantec team member roles and responsibilities are listed below, in **Table 6-1**:

Table 6-1 Project Team

| Name / Position | Role |
|--|--|
| Craig Wilson Project Technical Lead | Manages development of deliverables and completion of field work to ensure that field goals are being met; relays information to CEMC Project Manager; ensures that project requirements are being met; assists in design questions; coordinates job safety briefings and tailgate safety meetings; and oversees general project status. |
| Michael Zidek Managing Principal | Manages resources and supports project technical lead in review of deliverables, project design, sample collection, and scientific approach, and coordinates field team members to ensure that field goals are being met. |
| Tom Madsen Project Manager | Manages and oversees project scope, schedule, and budget. Supports project technical lead in project design, sample collection, and scientific approach. |
| Jakob Keldsen, EIT Project Staff | Field operations and collection of samples. Supports all activities required for project completion, including sample preparation, decontamination, sample collection, packing and transport, and assurance/quality control (QA/QC) related tasks; informs Project Manager of project status. |
| Roxanne Russell, EIT Project Staff | Assist in field operations and collection of samples. Supports all activities required for project completion, including sample preparation, decontamination, sample collection, packing and transport, and QA/QC related tasks; informs Project Manager of project status. |
| Doug Quist Project Chemist and Site Safety Officer | Supports all activities required for project completion, including sample preparation, decontamination, sample collection, packing and transport, QA/QC related tasks; informs Project Manager of project status; organizes and oversees tailgate safety meetings and job safety briefings; and ensures QA/QC goals are met. |

6.2 PROJECT SCHEDULE

The additional beach assessment, PRB pilot study injection, and groundwater sampling events are scheduled to occur in late September 2019 and May – September 2020 during a period of minus tides. Equipment for the beach assessment and pilot study will be mobilized and demobilized by barge or chartered aircraft. Personnel will fly to and from the project site in chartered aircraft. **Table 6-2** presents the proposed project schedule for 2019 and 2020 activities:

Table 6-2 Additional Beach Assessment and PRB Pilot Study Schedule

| Task | Start Date | Approximate Duration | |
|---------------------------------------|-------------------------------------|----------------------|--|
| Additional beach assessment | Late September 2019 | 2 days | |
| PRB pilot study injections | Late September / Early October 2019 | 10 days | |
| Performance monitoring – first round | May 2020 | 2 Days | |
| Performance monitoring – second round | September 2020 | 2 Days | |



7 STANDARD OPERATING PROCEDURES FOR SAMPLING

7.1 DIRECT PUSH SAMPLING

Groundwater sampling on the beach will be accomplished using direct push technology. A Geoprobe SP16 (or equal) temporary well point sampling device will be used, following the standard operating procedures described in Geoprobe Technical Bulletin No. MK3142 (Geoprobe 2006). As described in the work plan for the May 2019 activities, grouting in accordance with ADEC well abandonment guidelines will be followed to the extent practicable, although some wells may self-collapse and prevent grouting.

7.2 CONTINGENCY PLANNING

The following procedures will be utilized to prevent hydrocarbons from reaching Cook Inlet during groundwater sampling activities.

- 1. For boring locations on the upper portion of the beach prism, where non-flowing conditions are expected and NAPL is encountered, the length of the borehole will be backfilled with pelletized bentonite placed and then hydrated as necessary in lifts.
- 2. For soil borings close to the mudflats where flowing (artesian) conditions may be anticipated and NAPL is encountered:
 - If a sheen or other visible indications of NAPL is observed seeping out of the borehole while still advancing
 the tool, the boring will be grouted while pulling the tooling.
 - If a sheen is observed at a boring location after completing a boring, then tooling will be advanced down the existing borehole and grout reinjected via tremie as the tooling is withdrawn.

7.3 WATER QUALITY PARAMETERS

Water quality parameters will be collected by the field team during well purging. Calibration of the water quality meter sensors will be verified prior to use with calibration standards. Personnel operating the water quality meter will understand the working ranges and maximum saturation values for the various sensors and monitor results during purging and testing to ensure they remain within these ranges or beneath maximum theoretical values. In the event the response for any individual sensor fails to meet precision and accuracy criteria specified by the equipment manufacturer, or actual project sample responses fall near or outside the theoretical working range for each sensor, the unit will be recalibrated or repaired as necessary before purging and sampling activities continue.

The normal pH range for groundwater is generally between 4 and 9 with a theoretical range from 0 to 14. The normal dissolved oxygen range for groundwater is between 0 and 12 milligrams per liter (mg/L), with a theoretical saturation point at approximately 12 mg/L.

Date, time, instrument model, serial number and calibration results for all instruments will be recorded. Calibration will be checked daily using a confidence solution, if any of the parameters are not with in the acceptable range, the sensor(s) will be recalibrated.

Stantec

8 QUALITY ASSURANCE AND QUALITY CONTROL

8.1 QUALITY CONTROL SAMPLES

Quality control samples will be collected to assess potential errors introduced during sample collection, handling, and analyses. As part of the field Quality Assurance / Quality Control (QA/QC) program, field duplicate samples, trip blanks, and extra sample volume for matrix spike/matrix spike duplicate (MS/MSD) procedures will be collected.

QC samples, summarized in **Table 8-1**, will be collected to assess potential errors introduced during sample collection, handling, and analyses. In summary, QC samples will include:

- · One trip blank for each cooler containing BTEX samples,
- One duplicate field sample for every 10 samples collected per laboratory analysis,
- Additional sample volumes for MS/MSD analysis for water samples at a rate of one per 20 samples collected per requested laboratory analysis.

Table 8-1 Quality Control Requirements - Groundwater Samples

| Sampling Event | Analytical Method | Number of Primary Samples | QC Samples | Total Number of Samples |
|---------------------------------------|-----------------------------|------------------------------|------------------|-------------------------|
| | BTEX (8260B) | 16 | 2 dup + 1 MS/MSD | 19 |
| PRB Baseline Monitoring | PAH (8270C) | 3 | 1 dup + 1 MS/MSD | 5 |
| Worldoning | Nitrate and sulfate (300.0) | 3 | 1 dup + 1 MS/MSD | 5 |
| | BTEX (8260B) | 16 | 2 dup + 1 MS/MSD | 19 |
| PRB Performance Monitoring (May 2020) | PAH (8270C) | 3 | 1 dup + 1 MS/MSD | 5 |
| morning (may 2020) | Nitrate and sulfate (300.0) | 3 | 1 dup + 1 MS/MSD | 5 |
| PRB Performance | BTEX (8260B) | 16 | 2 dup + 1 MS/MSD | 19 |
| Monitoring (September | PAH (8270C) | 3 | 1 dup + 1 MS/MSD | 5 |
| 2020) | Nitrate and sulfate (300.0) | 3 | 1 dup + 1 MS/MSD | 5 |

8.2 SAMPLE CONTAINERS, HOLD TIMES, AND PRESERVATION

Table 8-2 summarizes the sample containers, preservation, and holding times required for each analytical method by which samples will be collected.



Table 8-2 Sample Containers, Preservation, and Hold Times

| Analytical Parameter | Analytical Method | Preparation Holding Time | Containers | Preservation | | | |
|-------------------------|----------------------|-----------------------------|---------------------------------------|--------------------------|--|--|--|
| Groundwater | | | | | | | |
| BTEX | 8260B | 14 days | 3 – 40 mL VOA vials | pH<2, HCl; Cool to 0-6°C | | | |
| PAH | 8270C | 7 days | 2 –250 ml amber glass | Cool to 0-6°C | | | |
| Nitrate and sulfate | 300.0 | 48 hours | Lab-supplied glass or plastic bottles | Cool to 4°C | | | |

8.3 FIELD DOCUMENTATION

Field documentation will include sample identification labels, photographs, laboratory analysis requests, and permanently bound field logs. A field logbook will be maintained by the field team lead to record a detailed description of all field activities and samples collected. Pages will not be removed from any data logbook for any reason. Any corrections will be made by drawing a single line through the original entry, so that the original entry can still be read. The corrections will be written alongside the crossed-out entry and will be initialed and dated.

8.4 SAMPLE LABELING

Each sample container will be sealed and labeled immediately after collection. Sample labels will be completed using waterproof ink and will be affixed firmly to the sample containers. A sample code will be assigned to each sample as an identification number to track collected samples. The sample label will provide the following information: sample identification number; date and time of collection; analysis required; and preservation method used. Field duplicate samples will be submitted as blind duplicates – that is they will be consecutively numbered and will not be identified on the Chain-of-Custody (CoC) as being duplicates (but the fact that they are duplicates will be recorded in the field logbook).

8.5 CHAIN-OF-CUSTODY AND SAMPLE PACKAGING

A Chain of Custody (CoC) record will be completed and shipped with the samples. Proper sample custody is maintained through adherence to the procedures listed below:

- If the samples are not hand delivered, a minimum of one custody seal will be placed over the lid/cooler edge and secured with clear packaging tape.
- A CoC record must accompany the coolers in which the samples are packed. When transferring samples, the individuals relinquishing and receiving the coolers must sign, date, and note the time on the CoC record. This record documents sample custody transfer.

Samples must be packaged carefully to avoid breakage or contamination and must be shipped to the laboratory at proper temperatures. Adherence to the following sample package requirements is essential:

- Sample container lids must never be mixed. All lids must remain with their original container.
- Environmental samples must be cooled to 0 to 6 °C to preserve many chemical constituents. All coolers will contain a temperature blank that the laboratory will use to document sample temperatures.



 Any remaining space in the cooler should be filled with inert packing material such as bubble wrap, newspaper, etc. Under no circumstances should material such as sawdust, sand, or Styrofoam peanuts be used.

8.6 DATA REDUCTION, VALIDATION AND REPORTING

Validation and review of all analytical data will be performed by a qualified professional experienced in data validation and review procedures. All data will be validated and reviewed in accordance with appropriate U.S. Environmental Protection Agency (EPA) procedural guidance documents and ADEC regulatory guidance documents. The reference documents include *EPA Functional Guidelines for Organic Data Review* (EPA 2008), and *ADEC Data Quality Objectives, Checklists, Quality Assurance Requirements for Laboratory Data, and Sample Handling, Technical Memorandum* (ADEC 2017).

8.7 INVESTIGATION-DERIVED WASTE

Purge water from all wells will be filtered through a granular activated carbon (GAC) filter prior to surface discharge. Personal protective equipment such as nitrile gloves and dedicated sampling equipment, including tubing and paper towels used to decontaminate the oil-water interface probe, will be disposed with general solid waste via a solid waste dumpster staged at the TBPF. Oily waste (sorbent pads) will be disposed with Hilcorp's oily rag waste stream. Soils which are visually impacted with NAPL will be placed in open top drums and shipped to a facility for thermal treatment.



9 REPORTING

After the completion of the additional beach assessment, PRB pilot study injections, and sampling events, a report documenting the field activities and results will be presented to ADEC. The report will include a detailed description and a photographic log of the field activities, results of the performance monitoring program, laboratory analytical and QA/QC data, and an evaluation of the effectiveness of PRB in treating the dissolved benzene plume.

As part of the reporting effort, Stantec will review and tabulate the laboratory analytical data, prepare a QA Summary Report following ADEC guidance, and complete the ADEC required checklists for each data package generated. The QA Summary Report will include a discussion of data reliability and usability by evaluating data precision, accuracy, representativeness, comparability, completeness, and sensitivity.



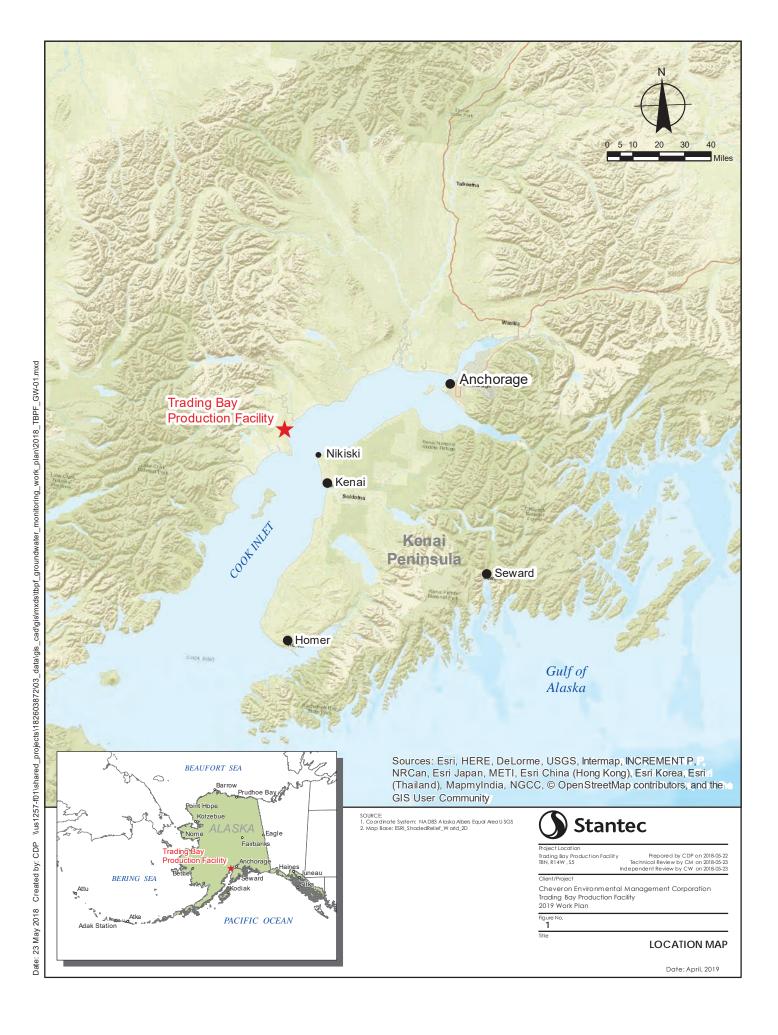
10 REFERENCES

- Alaska Department of Environmental Conservation (ADEC). 1996. *Compliance Order By Consent No. 91-23-01-053-02*. July 23.
- ADEC. 2017. Data Quality Objectives, Checklists, Quality Assurance Requirements for Laboratory Data, and Sample Handling, Technical Memorandum. March.
- ADEC. 2017. Final Field Sampling Guidance. August.
- ADEC. 2018. 18 AAC 75. Oil and Other Hazardous Substances Pollution Control. As amended through October 27, 2018.
- United States Environmental Protection Agency (EPA). 1996. Low-Flow (Minimal Drawdown) Groundwater Sampling Procedures. April.
- EPA. 2008. Contract Laboratory Program National Functional Guidelines for Organic Data Review (EPA 540/R-94/012).
- Geoprobe Systems. 2006. Geoprobe Screen Point 16 Groundwater Sampler Standard Operating Procedure, Technical Bulletin No. MK3142. November.
- Weston Solutions, Inc. (Weston). 2017. 2016 Site Investigation and Groundwater Monitoring Report, Trading Bay Production Facility, April.
- Weston Solutions, Inc. (Weston). 2018. 2017 Site Investigation and Groundwater Monitoring Report, Trading Bay Production Facility, January.



Appendix A Figures





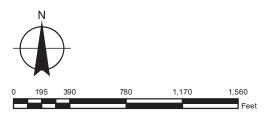


SOURCE:

1. Coordinate System: NAD 1983 StatePlane Alaska 4 FIPS 5004 Feet

2. Orthoimagery Source: World Imagerry - Est, Digit al Globe, GeoEye, Earthst ar
Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community

Date: 23 May 2018 Drawn by: CDP Nus 1257-401'shared_projects\182603872\03_data'gis_cad\gis\mxds\tbpf_groundwater_monitoring_work_plan\2018_TBPF_GW-02.mxd



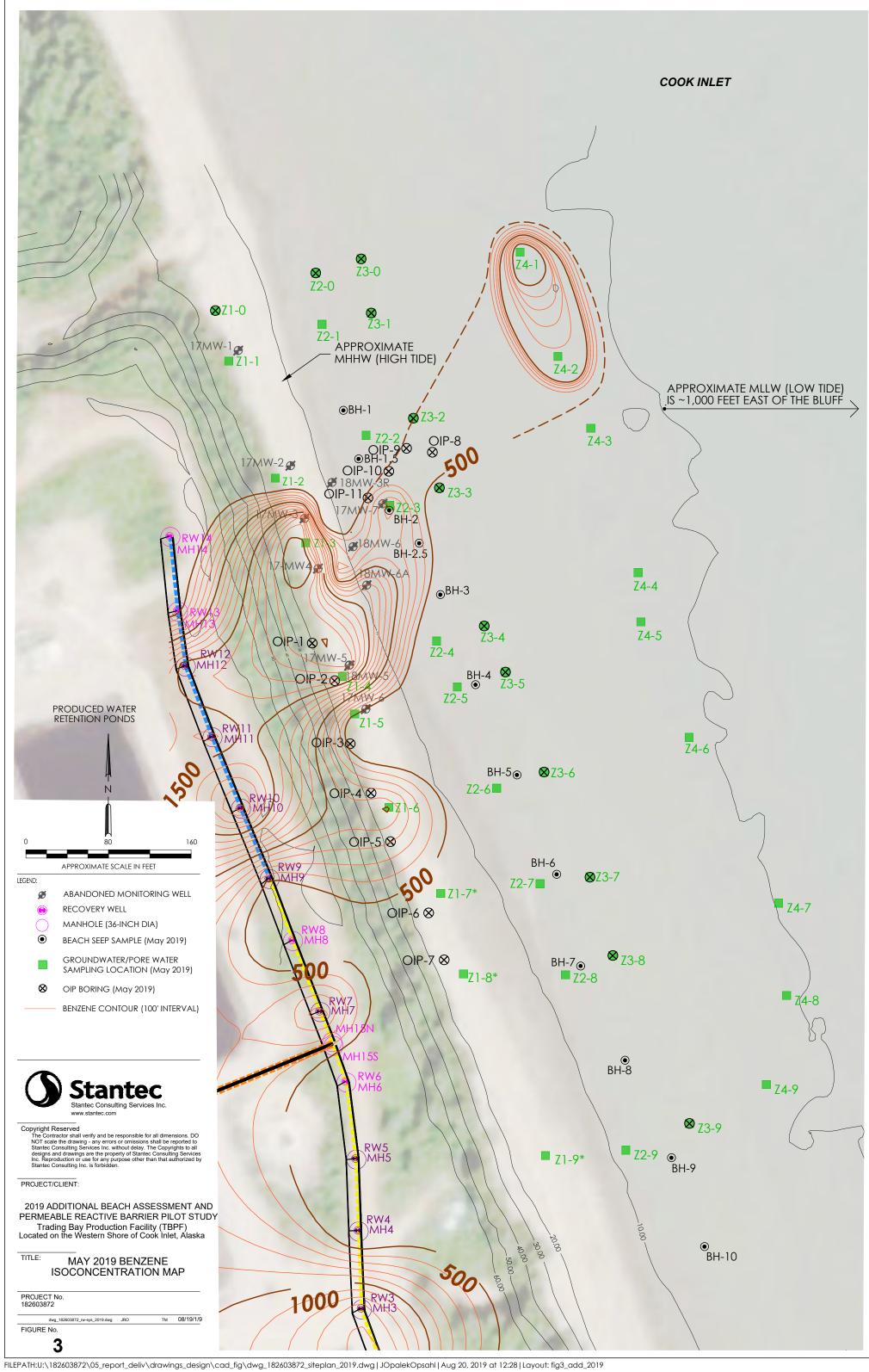
Stantec

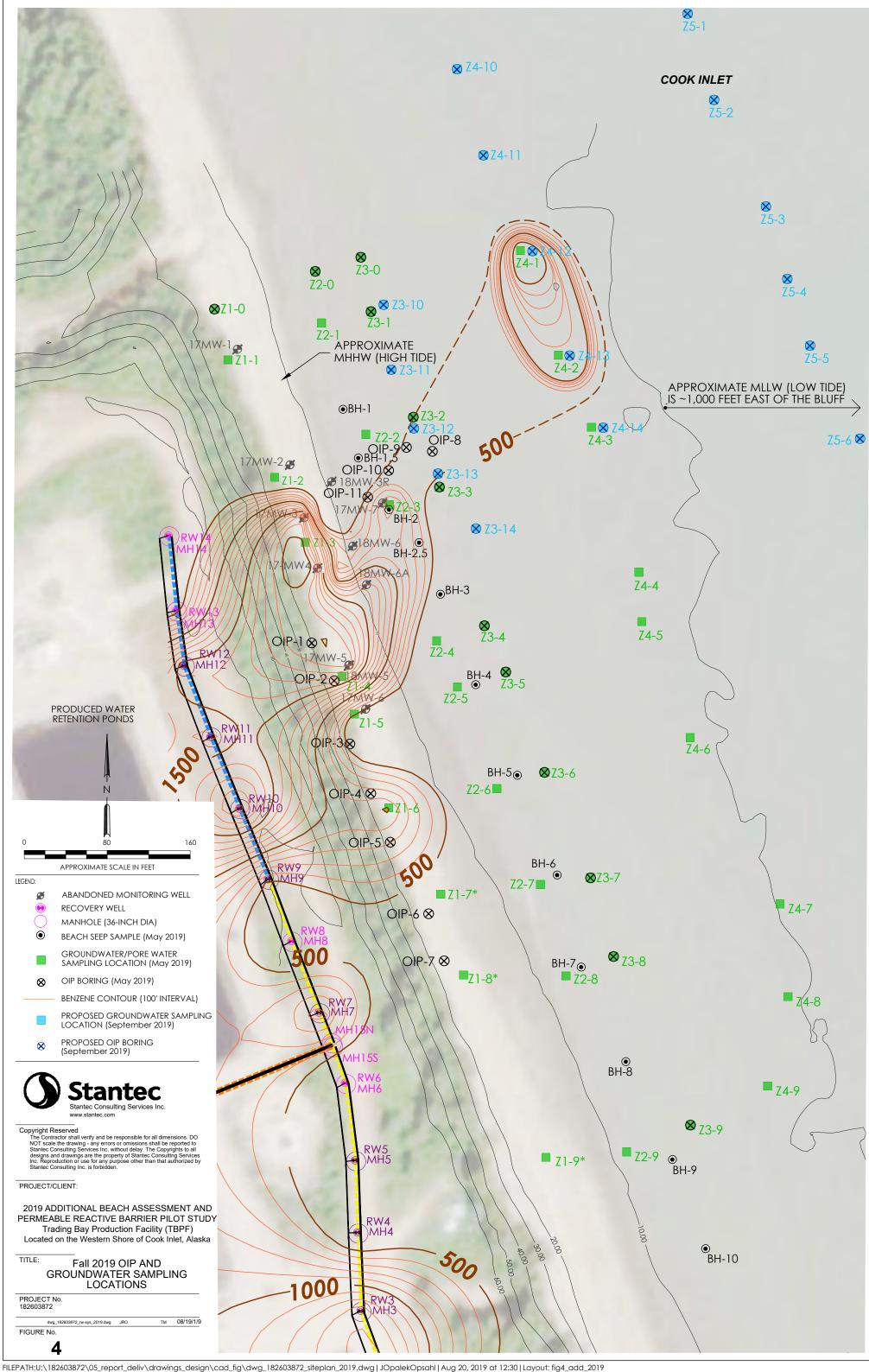
Prepared by CDP on 2018-05-22 Technical Review by CM on 2018-05-23 Independent Review by CW on 2018-05-23

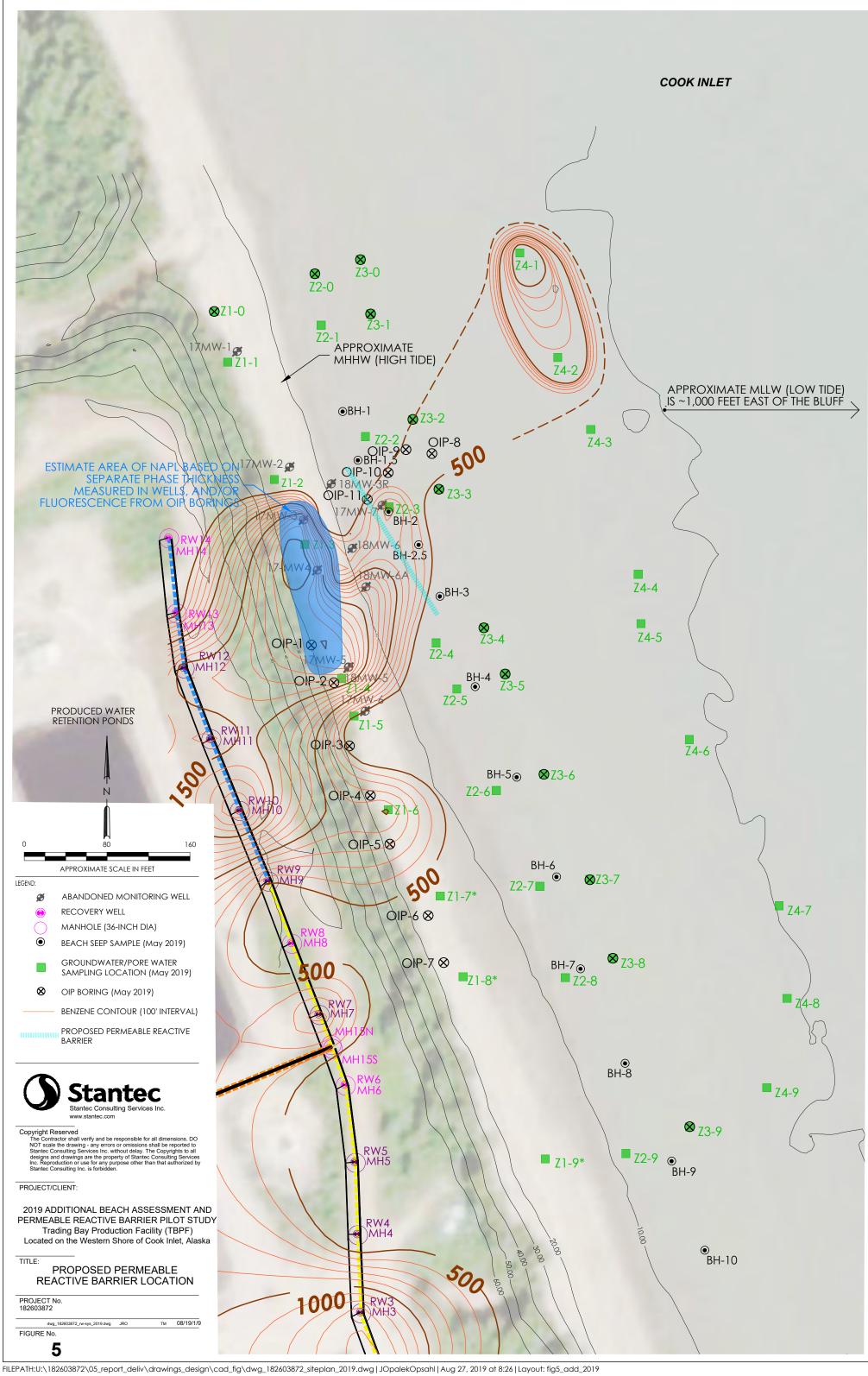
Cheveron Environmental Management Corporation Trading Bay Production Facility 2019 Work Plan

SITE MAP

Date: April, 2019







Appendix B North Beach Pilot Study Remediation Alternative Review – Trading Bay Production Facility







To: Tom Madsen From: David Schroder

Ally Auffermann

Cc: Craig Wilson Date: August 13, 2019

Michael Zidek

Reference: North Beach Pilot Study Remediation Alternative Review - Trading Bay Production Facility

The Trading Bay Production Facility (TBPF) is a remote onshore crude oil and natural gas processing facility on the west side of Cook Inlet that has been in operation since 1967. Crude oil, produced water, and natural gas are transported to TBPF via pipelines from offshore platforms in Cook Inlet and separated into three process streams. The TBPF is constructed on an eastward sloping terrace located about 60 to 100 feet above mean sea level (ft-amsl). At the eastern edge of the site is a shoreline bluff which drops about 40 to 50 ft to the beach along Cook Inlet. The underlying soils of the upper terrace consist predominantly of sands to a depth of about 50 ft, and below about 50 ft there are interlayered sandy and silty strata. The water table generally slopes from the west toward the east (toward Cook Inlet) and ranges in depth from about 15 ft below ground surface near the Tank Battery 2, to about 44 ft below grade at the bluff top.

In the northern portion of the TBPF, the bluff top is at an elevation of about 70 ft-amsl, the water table is at about 25 ft-amsl, and the deeper piezometric surface is at about 17 ft-amsl. The base of the bluff and top of the beach sand prism is at about 20 to 24 ft-amsl and the water table at the base of the bluff is at about 10 ft-amsl. Beach seep sampling locations are estimated to occur at about 6 to 8 ft-amsl elevation, and the tidal flats start at about 4 to 6 ft-amsl. The tidal flats extend eastward and are inundated by large diurnal tides.

Historical investigation activities conducted in the North Beach area have identified the presence of a mobile light non-aqueous phase liquid (LNAPL) product and a dissolved-phase petroleum plume comprised primarily of benzene. The subsurface of the beach consists of sorted sandy soils with an identified silt lens that appears to be acting like a confining "weir" to influence dissolved-phase plume and/or LNAPL migration. A pilot study application of a permeable reactive barrier (PRB) has been proposed to evaluate potential treatment technologies for interception of the dissolved-phase plume and mitigation of further plume migration to Cook Inlet.

The following sections provide a PRB technology evaluation and our recommendation for the potential technology to be implemented during pilot study operations.

REMEDIATION ALTERNATIVE REVIEW

Multiple remediation technologies were evaluated for potential pilot study implementation within the North Beach Area, as part of a PRB application designed to address the dissolved-phase petroleum hydrocarbon plume. The potential remedies involved mechanical, chemical, and biological treatment technologies, and included the following:

- In-situ chemical oxidation (ISCO) with Klozure® KP;
- In-situ chemical adsorption with PlumeStop[®];
- In-situ chemical adsorption with PetroFixTM; and
- In-situ adsorption and bioremediation with BOS 200[®].

August 13, 2019 Tom Madsen Page 2 of 5

Reference: North Beach Pilot Study Remediation Alternative Review - Trading Bay Production Facility

Ex-situ technologies, such as excavation, landfarming, soil washing, solvent extraction, or land reuse, are not considered viable at the site at this time, due to geographic and permitting issues. In-situ thermal technologies, such as electrical or steam heating, are also not considered viable.

Descriptions of the potential remediation technologies are provided in the following sections. A comparison of the technologies is provided in **Table 1**.

IN-SITU CHEMICAL OXIDATION (ISCO) WITH KLOZURE® KP

The ISCO technology is well-recognized for remediation of contaminated soils and groundwater. The technology involves the introduction of oxidizing agents into the subsurface to chemically oxidize contaminants into inert by-products. While the technology has proven to be effective for a wide variety of VOCs, certain applications exist where ISCO may be ineffective or uneconomical. Oxidizing chemicals may be consumed in a variety of secondary oxidation and degradation reactions depending upon the natural oxidant demand of the soil as determined by organic and/or mineral content and other site-specific soil geochemistry parameters. Bench-scale testing is often recommended to determine if a specific site geochemistry is suitable for field implementation of ISCO operations.

Persulfate $(S_2O_8^{-2})$ is a strong oxidizing agent capable of the destruction of a wide range of VOCs. When used by itself the persulfate anion has an oxidation potential of 2.1 volts and can remove two electrons from available donors as it decomposes to sulfate.

$$S_2O_8^{-2} + 2e^- \rightarrow 2SO_4^{-2}$$

Persulfate can also be catalyzed, following either of two reaction mechanisms, to produce the stronger sulfate radical (SO₄•²), having an increased oxidation potential of 2.6 volts.

$$S_2O_8^{-2}$$
 + Activator \rightarrow 2 $SO_4^{\bullet-2}$
or
$$S_2O_8^{-2}$$
 + Activator \rightarrow $SO_4^{\bullet-2}$ + SO_4^{-2}

The reaction to produce $SO_4^{\bullet^{-2}}$ is activated thermally (35 to $40^{\circ}C$), by alkaline conditions (pH > 10.5), by hydrogen peroxide, and through reaction with transition metal catalysts such as iron. The process has several advantages over other oxidative treatments. The $SO_4^{\bullet^{-2}}$ is more stable than the OH• allowing for greater longevity and influence within the subsurface, production of $SO_4^{\bullet^{-2}}$ occurs rapidly, it has a lower affinity for soil organic carbon when compared with other oxidants and provides an abundant source of sulfate anions as a reduced byproduct for use as an alternative electron acceptor in bioremediation of petroleum hydrocarbons.

PeroxyChem markets an extended-release potassium persulfate ISCO reagent called Klozur® KP. With a solubility limit of up to 6% by weight (25 °C), the product can be applied as a solid or as part of a slurry mixture. Following application, Klozur® KP will dissolve and maintain aqueous phase persulfate concentrations up to those theoretical limits as groundwater flows past until all of the Klozur® KP is dissolved. This steady release allows Klozur® KP to persist for extended periods of time compared to more soluble oxidants and is well suited toward applications such as PRBs.

Reference: North Beach Pilot Study Remediation Alternative Review - Trading Bay Production Facility

IN-SITU CHEMICAL ADSORPTION WITH BOS 200®

In-situ chemical adsorption typically uses activated carbon, often combined with other reactive compounds or bioremediation compounds. The available products remove contaminants by two complementary processes: adsorption by activated carbon and degradation by reactive amendments. Adsorption results in rapid initial removal of contaminants from the aqueous phase, whereas degradation subsequently destroys contaminants. Contaminant removal is controlled by the dynamic equilibrium between contaminant influx through the PRB, adsorption, and degradation. Contaminants stay within the treatment zone when combined rates of adsorption and degradation exceed the incoming mass flux.

BOS $200^{\$}$ is an in-situ chemical adsorption remediation technology, designed and marketed by Remediation Products, Inc. (RPI), for the treatment of petroleum hydrocarbons, related solvents, and oils. This material has been approved by the Alaska Department of Environmental Conservation (ADEC) and is currently in use on the east side of Cook Inlet. The BOS $200^{\$}$ material is comprised of an activated carbon matrix platform with carbon particles in the $20-40~\mu m$ size range, time release terminal electron acceptors, and an inoculum blend of facultative bacteria within the pore structure of the carbon.

The product is typically mixed with water to create a slurry that can be applied using a variety of techniques including direct-push injection, soil mixing, and trenching techniques. Plume area treatment is normally accomplished using slurry injection across the impacted thickness at multiple points located using a triangular grid pattern. Effective barriers can be constructed by injection using a tight point grid layout. Because of the large carbon particle size, the injections of BOS 200® require high pressures that may cause fracturing of the formation.

IN-SITU CHEMICAL ADSORPTION WITH PLUMESTOP®

PlumeStop® is an in-situ adsorption-based remediation product designed and marketed by Regenesis. The material is composed of very fine particles of activated carbon $(1 - 2\mu m)$ which are suspended in water using organic polymer dispersion chemistry. Because of the fine carbon particles, the product can be applied to the subsurface through low-pressure injection. Once in the subsurface, the PlumeStop® behaves as a colloidal biomatrix binding to the aquifer matrix, rapidly removing contaminants from groundwater. Once contaminants are adsorbed, the activated carbon surface area provides favorable conditions for microbial colonization and growth, creating a geochemical environment that enhances biological degradation reactions.

PlumeStop® is formulated with a polymer coating to achieve high injection radii of influence and is available as a <4% by mass concentrate. Use of the product requires detailed design and management by Regenesis and may have an extended lead time.

IN-SITU CHEMICAL ADSORPTION WITH PETROFIX™

PetroFixTM is another colloidal activated carbon product marketed by Regenesis. Similar to PlumeStop®, PetroFixTM is composed of very fine particles of activated carbon and it provides large surface areas for the adsorption of contaminants. The main differences between the products are listed on **Table 1**. Specifically, PetroFixTM has about 8 times more colloidal carbon particles by mass than PlumeStop®. PetroFixTM is formulated without a polymer coating, hence requires a tighter injection spacing than PlumeStop®. In addition, PetroFixTM is supplied with nitrate and sulfate amendments designed to promote anaerobic biodegradation of petroleum hydrocarbons, while electron acceptor amendments are not included with PlumeStop®.

Reference: North Beach Pilot Study Remediation Alternative Review - Trading Bay Production Facility

RECOMMENDED TECHNOLOGY FOR PILOT STUDY EVALUTION

Based on the comparison of the technologies in **Table 1**, the recommended technology for pilot study at TBPF is in-situ chemical adsorption with PetroFixTM. Klozure KP and BOS 200® are not recommended due to the high pressures required for the injections. PlumeStop® is also not considered for the pilot study due to product availability.

Table 1. Comparison of Remediation Technologies

| | ISCO with Klozure® KP | In-situ Chemical Adsorption with BOS 200 [®] | In-situ Chemical Adsorption with PlumeStop® | In-situ Chemical Adsorption with PetroFix™ |
|---------------------------------|--|--|--|---|
| Product Description | Potassium persulfate with alkali activation | Powdered activated carbon | Colloidal activated carbon with polymer coating (for larger injection radii of influence) | Colloidal activated carbon without polymer coating |
| Carbon Particle Size | Not applicable | 20 – 40 μm | 1 – 2 μm | 1 – 2 μm |
| Bacteria Amendments | Not applicable | yes | no | no |
| Electron Acceptor Amendments | Not applicable | Sulfate | No amendments | Nitrate and sulfate |
| Shipped Product | Solid product | Dry powder | <4% by mass concentrate | >30% by mass concentrate |
| Dosing Design Basis | Approximately 50 lbs per foot of injection interval | Based on a minimum of 15 lbs of product per injection interval | Not available | 16.2 lb/cubic yard of treatment volume based on concentration and adsorption isotherm |
| Injection Geometry | Continuous distribution within formation | Discrete injection intervals resulting in staggered distribution of reagent in formation | Continuous distribution within formation | Continuous distribution within formation |
| Estimated Dosing | 6,612 lb | 4,200 lb | Not available | 7,200 lb |
| Product Availability | | | Use of product requires detailed design by Regenesis; not likely to be available by end of September | 2-week lead time |
| Injection Pressure | High; 80 – 400 psi depending on concentration of injection solution | | Low; <25 psi | Low; <25 psi |

Reference: North Beach Pilot Study Remediation Alternative Review - Trading Bay Production Facility

| | ISCO with Klozure® KP | In-situ Chemical Adsorption with BOS 200® | In-situ Chemical Adsorption with PlumeStop® | In-situ Chemical Adsorption with PetroFix™ |
|----------------------------------|--|--|--|---|
| Recommended Injection Spacing | 10 ft | 5 - 7 ft | 10 - 12 ft | 5 - 7 ft |
| Longevity | Not available | 10 years | Not available | Not available |
| Other Considerations | Injections require high-pressure pumps, bulk material handling equipment, and injection infrastructure that is compatible with strong oxidants High injection pressures may result in fracturing of the formation and creation of preferential pathways | Injections require high-pressure pumps and bulk material handling equipment and only contractors with the special equipment can perform the injections. Gray water may show up on beach if product daylighting occurs | Regenesis provides detailed design and mobilizes to sites to perform injections Gray water may show up on beach if product daylighting occurs | Injections do not require high-pressure pumps and can be performed by general drilling contractors Gray water may show up on beach if product daylighting occurs |
| Health and Safety Concerns | Oxidants require special handling | Powdered activated carbon is an inhalation hazard | No specific health and safety concerns identified | No specific health and safety concerns identified |
| Regulatory / Permitting | Need ADEC approval | Approved by ADEC | Need ADEC approval | Need ADEC approval |
| Basis for Recommendation | Not recommended due to high pressures required for injections | Not recommended due to high pressures required for injections | Not recommended due to product availability | Recommended for pilot study due to low injection pressures and readily available products |

Appendix C PetroFix[™] Design and Information Sheet







13,358 gal

PetroFix™ Application Summary **Barrier Estimate**

Cook Inlet - Alaska

| PetroFix Amount | 7,200 lbs |
|------------------------------|-------------------------|
| | |
| Barrier Length | 200 ft |
| Delivery Points | 50 |
| Point Spacing | 8.0 ft |
| Number of Rows | 2 |
| Top of Treatment Interval | 5.0 ft bgs |
| Bottom of Treatment Interval | 11.0 ft bgs |
| Treatment Area | 2,000 ft ² |
| PetroFix Dose | 16.2 lb/yd ³ |

| Mix Tank Volume | 300 gal |
|--------------------------------|---------|
| | |
| PetroFix per Mix Tank | 17 gal |
| Water per Mix Tank | 284 gal |
| Electron Acceptor per Mix Tank | 8.0 lbs |
| Number of Batches Required | 44.5 |

Product Volume 735 gal Water Volume 12,623 gal Injection Volume Per Point 267 gal Injection Volume Per Vertical Foot 45 gal Product/Point 14.7 gal Water/Point 252.5 gal Soil Type Coarse >75% Sand/Gravel Effective Pore Volume Fill % 60%

AREA NOTES

Total Volume

Two off-set rows (25 injection points each) with 5-ft spacing between rows and 8-ft spacing within rows.

Reported Ground Water Concentrations (mg/L)

| Benzene | 1.500 |
|-------------------|-------|
| Toluene | 0.000 |
| Ethylbenzene | 0.100 |
| Xylenes | 0.700 |
| Trimethylbenzenes | 0.020 |

NAPL Present? No

| Napthalene | 0.050 |
|------------|-------|
| MTBE | 0.000 |
| TPH-GRO | 0.000 |
| TPH-DRO | 0.000 |
| TPH-ORO | 0.000 |

In generating this design proposal REGENESIS relied upon professional judgment and site specific information provided by others. Using this information as input, we performed calculations based upon known chemical and geologic relationships to generate an estimate of the mass of product and subsurface placement required to affect remediation of the site. The attached design summary tables specify the assumptions used in preparation of this technical design. We request that these modeling input assumptions be verified by your firm. Barrier modeling is highly dependent on seepage velocity, which can be measured in field using passive flux meter technology (www.enviroflux.com).

REGENESIS developed this Scope of Work in reliance upon the data and professional judgments provided by those whom completed the earlier environmental site assessment(s). The fees and charges associated with the Scope of Work were generated through REGENESIS' proprietary formulas and thus may not conform to billing quidelines, constraints or other limits on fees. REGENESIS does not seek reimbursement directly from any government agency or any governmental reimbursement fund (the "Government"). In any circumstance where REGENESIS may serve as a supplier or subcontractor to an entity which seeks reimbursement from the Government for all or part of the services performed or products provided by REGENESIS, it is the sole responsibility of the entity seeking reimbursement to ensure the Scope of Work and associated charges are in compliance with and acceptable to the Government prior to submission. When serving as a supplier or subcontractor to an entity which seeks reimbursement from the Government, REGENESIS does not knowingly present or cause to be presented any claim for payment to the Government.

Date Generated: August 16, 2019

Prepared By: Ryan Hardenburger 949-342-4982 rhardenburger@regenesis.com

www.petrofix.com





PetroFix: The Technology at a Glance

PetroFix[™] is a cost-effective solution for petroleum spills that equips environmental professionals with tools to take control of the remediation process. This technology works hand-in-hand with the PetroFix Design Assistant,[™] an online tool that enables users to design and apply individually-tailored remediation plans.

A Dual-Functioning, Activated Carbon Remedial Technology for Treating Petroleum Hydrocarbons

PetroFix has a dual function: it removes hydrocarbons from the dissolved phase by adsorbing them onto activated carbon particles and then stimulates hydrocarbon biodegradation by adding electron acceptors. PetroFix is a highly concentrated water-based suspension consisting of micron-scale activated

carbon and biostimulating electron acceptors. The environmentally-compatible formulation of micron-scale activated carbon (1-2 microns) is combined with both slow and quick-release inorganic electron acceptors. Practitioners can select between a sulfate and nitrate combination blend (recommended) or sulfate only for the additional electron acceptors required.



- Affordable and Reliable
- Applied under Low Pressure
- Simple Online Design Assistant
- Tailored Site Design







The PetroFix Design Assistant: You Design.

Take control of your remediation plan with the PetroFix Design Assistant.



Simple Easy to Use



FlexibleDesigns Tailored to Your Site



FastNo Waiting For A Design

To make applying PetroFix simple and easy to use, REGENESIS created an innovative and effective online tool for developing recommended dosage and designs for your site. The PetroFix Design Assistant equips environmental professionals with the tools to design individually-tailored remediation plans. This self-design, self-apply tool

guides users toward effective designs that will yield the best results and allows users to easily order PetroFix through REGENESIS' customer service. Educational resources and best practices are also offered along with an online video tutorial which walks with the user step by step through the design and ordering process.



Create your account

Begin by creating an account with details about your site including the surface area and average vertical thickness and whether or not NAPL is present at this time.



Recommended treatment

After providing the soil grain size and the groundwater contaminant levels, the Design Assistant will provide results showing the suggested treatment including the recommended volume, dosing, and product required for treatment.



Order PetroFix

Once all areas for the site are submitted, start the order process directly within the Design Assistant.



Phone (949) 366-8000

www.PetroFix.com

©2018 All Rights Reserved. REGENESIS is a registered trademark and PetroFix Remediation Fluid and PetroFix Design Assistant are trademarks of REGENESIS Bioremediation Products Inc. All other trademarks are the property of their respective owners.

Appendix D PetroFix[™] Safety Data Sheet



SAFETY DATA SHEET

1. Identification

Product identifier PetroFix Electron Acceptor Blend

Other means of identification

Recommended use Remediation of soils and groundwater.

Recommended restrictions None known.

Manufacturer/Importer/Supplier/Distributor information

Company Name Regenesis

Address 1011 Calle Sombra

San Clemente, CA 92673 USA

General information 949-366-8000

E-mail CustomerService@regenesis.com

Emergency phone number For Hazardous Materials Incidents ONLY (spill, leak, fire, exposure or accident), call

CHEMTREC 24/7 at:

USA, Canada, Mexico 1-800-424-9300

1-703-527-3887 International

2. Hazard(s) identification

Physical hazards Not classified.

Health hazards Serious eye damage/eye irritation Category 2B

OSHA defined hazards Not classified.

Label elements

Hazard symbol None. Signal word Warning

Hazard statement Causes eye irritation.

Precautionary statement

Prevention Wash thoroughly after handling.

Response If in eyes: Rinse cautiously with water for several minutes. Remove contact lenses, if present and

easy to do. Continue rinsing. If eye irritation persists: Get medical advice/attention.

Store away from incompatible materials. **Storage**

Dispose of waste and residues in accordance with local authority requirements. **Disposal**

Hazard(s) not otherwise

classified (HNOC)

None known.

Supplemental information None.

3. Composition/information on ingredients

Mixtures

| Chemical name | CAS number | % |
|------------------|------------|---------|
| Ammonium sulfate | 7783-20-2 | 40 - 60 |
| Sodium nitrate | 7631-99-4 | 40 - 60 |

Composition comments All concentrations are in percent by weight unless otherwise indicated.

4. First-aid measures

Inhalation Move to fresh air. Call a physician if symptoms develop or persist.

Skin contact Wash off with soap and water. Get medical attention if irritation develops and persists.

1/6 944697 Version #: 01 Revision date: -Issue date: 15-August-2018

Eye contact Do not rub eyes. Immediately flush eyes with plenty of water for at least 15 minutes. Remove

contact lenses, if present and easy to do. Continue rinsing. Get medical attention if irritation

develops and persists.

Ingestion Rinse mouth

Most important

symptoms/effects, acute and

delayed

Indication of immediate medical attention and special

treatment needed

General information

Rinse mouth. Get medical attention if symptoms occur.

Irritation of eyes. Exposed individuals may experience eye tearing, redness, and discomfort. Dusts

may irritate the respiratory tract, skin and eyes.

Provide general supportive measures and treat symptomatically. Keep victim under observation.

Symptoms may be delayed.

Ensure that medical personnel are aware of the material(s) involved, and take precautions to

protect themselves.

5. Fire-fighting measures

Suitable extinguishing media

Unsuitable extinguishing media

Use extinguishing agent suitable for type of surrounding fire.

None known

Specific hazards arising from

the chemical

During fire, gases hazardous to health may be formed. Combustion products may include: nitrogen oxides, sulfur oxides, ammonia.

Self-contained breathing apparatus and full protective clothing must be worn in case of fire.

Special protective equipment and precautions for firefighters

Fire fighting equipment/instructions

equipment/instructions
Specific methods

Use water spray to cool unopened containers.

Use standard firefighting procedures and consider the hazards of other involved materials.

General fire hazards Material will not burn.

6. Accidental release measures

Personal precautions, protective equipment and emergency procedures Keep unnecessary personnel away. Keep people away from and upwind of spill/leak. Wear appropriate protective equipment and clothing during clean-up. Do not touch damaged containers or spilled material unless wearing appropriate protective clothing. Ensure adequate ventilation. Local authorities should be advised if significant spillages cannot be contained. For personal protection, see section 8 of the SDS.

Methods and materials for containment and cleaning up

Avoid the generation of dusts during clean-up. Collect dust using a vacuum cleaner equipped with HEPA filter. Stop the flow of material, if this is without risk.

Large Spills: Wet down with water and dike for later disposal. Absorb in vermiculite, dry sand or earth and place into containers. Shovel the material into waste container. Following product recovery, flush area with water.

Small Spills: Sweep up or vacuum up spillage and collect in suitable container for disposal. Wipe up with absorbent material (e.g. cloth, fleece). Clean surface thoroughly to remove residual contamination.

Never return spills to original containers for re-use. For waste disposal, see section 13 of the SDS.

Environmental precautions

Avoid discharge into drains, water courses or onto the ground.

7. Handling and storage

Precautions for safe handling

Minimize dust generation and accumulation. Provide appropriate exhaust ventilation at places where dust is formed. Avoid contact with eyes. Wear appropriate personal protective equipment. Observe good industrial hygiene practices.

Conditions for safe storage, including any incompatibilities

Store in tightly closed container. Store in a well-ventilated place. Store away from incompatible materials (see Section 10 of the SDS).

8. Exposure controls/personal protection

Occupational exposure limits

No exposure limits noted for ingredient(s).

Biological limit values No

No biological exposure limits noted for the ingredient(s).

PetroFix Electron Acceptor Blend

Appropriate engineering controls

Good general ventilation should be used. Ventilation rates should be matched to conditions. If applicable, use process enclosures, local exhaust ventilation, or other engineering controls to maintain airborne levels below recommended exposure limits. If exposure limits have not been established, maintain airborne levels to an acceptable level. If engineering measures are not sufficient to maintain concentrations of dust particulates below the Occupational Exposure Limit (OEL), suitable respiratory protection must be worn. If material is ground, cut, or used in any operation which may generate dusts, use appropriate local exhaust ventilation to keep exposures below the recommended exposure limits. Provide eyewash station.

Individual protection measures, such as personal protective equipment

Eye/face protection

Unvented, tight fitting goggles should be worn in dusty areas.

Skin protection

Hand protection Wear appropriate chemical resistant gloves. Suitable gloves can be recommended by the glove

supplier.

Skin protection

Other Wear suitable protective clothing.

Respiratory protection In case of insufficient ventilation, wear suitable respiratory equipment. Wear NIOSH approved

respirator appropriate for airborne exposure at the point of use. Appropriate respirator selection should be made by a qualified professional. Recommended use: Wear respirator with dust filter.

Thermal hazards Wear appropriate thermal protective clothing, when necessary.

General hygiene considerations

Always observe good personal hygiene measures, such as washing after handling the material and before eating, drinking, and/or smoking. Routinely wash work clothing and protective

equipment to remove contaminants.

9. Physical and chemical properties

Appearance

Physical stateSolid.FormPowder.ColorWhite.

Odor Not available.
Odor threshold Not available.
pH Not available.
Melting point/freezing point Not available.
Initial boiling point and boiling Not available.

range

Flash point Not available.

Evaporation rate Not available.

Flammability (solid, gas) This material will not burn.

Upper/lower flammability or explosive limits

Flammability limit - lower

Not available.

(%)

Flammability limit - upper

Not available.

(%)

Vapor pressureNot available.Vapor densityNot available.Relative densityNot available.

Solubility(ies)

Solubility (water) Not available.

Partition coefficient Not available.

(n-octanol/water)

Auto-ignition temperatureNot available.Decomposition temperatureNot available.ViscosityNot available.

Other information

Explosive propertiesNot explosive. **Oxidizing properties**Not oxidizing.

PetroFix Electron Acceptor Blend

SDS US

10. Stability and reactivity

ReactivityThe product is stable and non-reactive under normal conditions of use, storage and transport.

Chemical stability Material is stable under normal conditions.

Possibility of hazardous

reactions

No dangerous reaction known under conditions of normal use.

Conditions to avoid Contact with incompatible materials. Heat.

Incompatible materials Strong reducing agents. Strong acids.

Hazardous decomposition

products

No hazardous decomposition products are known.

11. Toxicological information

Information on likely routes of exposure

InhalationDust may irritate respiratory system.Skin contactDust or powder may irritate the skin.

Eye contact Causes eye irritation.

Ingestion May cause discomfort if swallowed.

Symptoms related to the physical, chemical and toxicological characteristics

Irritation of eyes. Exposed individuals may experience eye tearing, redness, and discomfort. Dusts

may irritate the respiratory tract, skin and eyes.

Information on toxicological effects

Acute toxicity Not expected to be acutely toxic.

Skin corrosion/irritation Prolonged skin contact may cause temporary irritation.

Serious eye damage/eye

irritation

Causes eye irritation.

Respiratory or skin sensitization

Respiratory sensitization Not a respiratory sensitizer.

Skin sensitization This product is not expected to cause skin sensitization.

Germ cell mutagenicityNo data available to indicate product or any components present at greater than 0.1% are

mutagenic or genotoxic.

Carcinogenicity Not classifiable as to carcinogenicity to humans.

IARC Monographs. Overall Evaluation of Carcinogenicity

Not listed.

NTP Report on Carcinogens

Not listed.

OSHA Specifically Regulated Substances (29 CFR 1910.1001-1053)

Not regulated.

Reproductive toxicity

This product is not expected to cause reproductive or developmental effects.

Specific target organ toxicity -

single exposure

Not classified.

Specific target organ toxicity -

repeated exposure

Not classified.

Aspiration hazard Not an aspiration hazard.

Further information Nitrate poisoning resulting in methemoglobinemia manifested as cyanosis is rare, but possible for

people with specific susceptibility traits.

12. Ecological information

Ecotoxicity The product is not classified as environmentally hazardous. However, this does not exclude the

possibility that large or frequent spills can have a harmful or damaging effect on the environment.

Persistence and degradability The product solely consists of inorganic compounds which are not biodegradable.

Bioaccumulative potential No data available.

Mobility in soil No data available.

Other adverse effects None known.

PetroFix Electron Acceptor Blend

13. Disposal considerations

Disposal instructions Collect and reclaim or dispose in sealed containers at licensed waste disposal site. Dispose of

contents/container in accordance with local/regional/national/international regulations.

Local disposal regulations

Dispose in accordance with all applicable regulations.

Hazardous waste code The waste code should be assigned in discussion between the user, the producer and the waste

disposal company.

Waste from residues / unused

products

Dispose of in accordance with local regulations. Empty containers or liners may retain some product residues. This material and its container must be disposed of in a safe manner (see:

Disposal instructions).

Contaminated packaging Since emptied containers may retain product residue, follow label warnings even after container is

emptied. Empty containers should be taken to an approved waste handling site for recycling or

disposal.

14. Transport information

DOT

Not regulated as dangerous goods.

IATA

Not regulated as dangerous goods.

IMDG

the IBC Code

Not regulated as dangerous goods.

Transport in bulk according to Annex II of MARPOL 73/78 and Not applicable.

15. Regulatory information

US federal regulations This product is a "Hazardous Chemical" as defined by the OSHA Hazard Communication

Standard, 29 CFR 1910.1200.

TSCA Section 12(b) Export Notification (40 CFR 707, Subpt. D)

Not regulated.

CERCLA Hazardous Substance List (40 CFR 302.4)

SARA 304 Emergency release notification

Not regulated.

OSHA Specifically Regulated Substances (29 CFR 1910.1001-1053)

Not regulated.

Superfund Amendments and Reauthorization Act of 1986 (SARA)

SARA 302 Extremely hazardous substance

Not listed.

SARA 311/312 Hazardous Yes

chemical

Classified hazard categories

Serious eye damage or eye irritation

SARA 313 (TRI reporting)

| Chemical name | CAS number | % by wt. | |
|------------------|------------|----------|--|
| Ammonium sulfate | 7783-20-2 | 40 - 60 | |
| Sodium nitrate | 7631-99-4 | 40 - 60 | |

Other federal regulations

Clean Air Act (CAA) Section 112 Hazardous Air Pollutants (HAPs) List

Not regulated.

Clean Air Act (CAA) Section 112(r) Accidental Release Prevention (40 CFR 68.130)

Not regulated.

Safe Drinking Water Act

Not regulated.

(SDWA)

US state regulations

US. Massachusetts RTK - Substance List

Ammonium sulfate (CAS 7783-20-2) Sodium nitrate (CAS 7631-99-4)

PetroFix Electron Acceptor Blend 5/6

944697 Version #: 01 Revision date: -Issue date: 15-August-2018

US. New Jersey Worker and Community Right-to-Know Act

Sodium nitrate (CAS 7631-99-4)

US. Pennsylvania Worker and Community Right-to-Know Law

Ammonium sulfate (CAS 7783-20-2) Sodium nitrate (CAS 7631-99-4)

US. Rhode Island RTK

Ammonium sulfate (CAS 7783-20-2) Sodium nitrate (CAS 7631-99-4)

California Proposition 65

California Safe Drinking Water and Toxic Enforcement Act of 2016 (Proposition 65): This material is not known to contain any chemicals currently listed as carcinogens or reproductive toxins. For more information go to www.P65Warnings.ca.gov.

International Inventories

| Country(s) or region | Inventory name | On inventory (yes/no)* |
|-----------------------------|--|------------------------|
| Australia | Australian Inventory of Chemical Substances (AICS) | Yes |
| Canada | Domestic Substances List (DSL) | Yes |
| Canada | Non-Domestic Substances List (NDSL) | No |
| China | Inventory of Existing Chemical Substances in China (IECSC) | Yes |
| Europe | European Inventory of Existing Commercial Chemical Substances (EINECS) | Yes |
| Europe | European List of Notified Chemical Substances (ELINCS) | No |
| Japan | Inventory of Existing and New Chemical Substances (ENCS) | Yes |
| Korea | Existing Chemicals List (ECL) | Yes |
| New Zealand | New Zealand Inventory | Yes |
| Philippines | Philippine Inventory of Chemicals and Chemical Substances (PICCS) | Yes |
| Taiwan | Taiwan Chemical Substance Inventory (TCSI) | Yes |
| United States & Puerto Rico | Toxic Substances Control Act (TSCA) Inventory | Yes |

^{*}A "Yes" indicates this product complies with the inventory requirements administered by the governing country(s).

16. Other information, including date of preparation or last revision

Issue date 15-August-2018

Revision date Version # 01

Flammability: 0

Health: 1

Physical hazard: 0

NFPA ratings

HMIS® ratings



Disclaimer

Regenesis cannot anticipate all conditions under which this information and its product, or the products of other manufacturers in combination with its product, may be used. It is the user's responsibility to ensure safe conditions for handling, storage and disposal of the product, and to assume liability for loss, injury, damage or expense due to improper use. The information in the sheet was written based on the best knowledge and experience currently available.

PetroFix Electron Acceptor Blend SDS US

A "No" indicates that one or more components of the product are not listed or exempt from listing on the inventory administered by the governing country(s).