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Kinder Morgan Energy Partners

B and D Yards Groundwater Remediation - Engineering Design Report

Kinder Morgan Liquids Terminal, Harbor Island

Seattle, Washington

October 15, 2012

ARCADIS

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B and D Yards Groundwater Remediation - Engineering Design Report

Kinder Morgan Liquids Terminal
Harbor Island
2720 13th Avenue Southwest
Seattle, Washington

Prepared for:
Kinder Morgan Energy Partners

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Date:
October 15, 2012

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Table of Contents

Appendices

1. Introduction

On behalf of Kinder Morgan Energy Partners (Kinder Morgan), ARCADIS U.S., Inc. (ARCADIS) has prepared this Engineering Design report in accordance with the Consent Decree 00-2-07760-2SEA (CD) for Harbor Island Terminal in Seattle, Washington (Site). The CD was entered between the Washington State Department of Ecology (Ecology) and GATX Terminals Corporation (GATX) on April 4, 2000. Kinder Morgan assumed the obligations of the CD with the purchase of GATX Terminal in 2001.

The objective of this report is to provide information necessary to implement and operate the remedial action required by the CD. The technology described herein was discussed in the Sulfate Application Remediation Workplan and Addendum (Antea Group 2011b and 2012a) and approved by Ecology (collectively referred to as the Work Plan). The remedial design relies on the anaerobic biological oxidation (ABOx) of petroleum hydrocarbons for treatment but employs a different delivery approach than that described in the Work Plan (Antea Group 2011b and 2012a). This report details the differences in delivery approach and presents an updated conceptual side model which incorporates updated pre-design soil petroleum hydrocarbon results. Also included are construction details necessary to implement the remedy and the proposed performance monitoring plan.

2. Conceptual Site Model

The following sections describe the site background, interim remedial actions completed to date, geologic and hydrogeologic conditions, and petroleum hydrocarbon distribution at the Site.

2.1 Site Description

The Site is currently an active 14-acre bulk petroleum storage facility located east of 13th Avenue on Harbor Island in Seattle, King County, Washington. The Site has operated as a bulk petroleum storage terminal since 1944. Harbor Island and properties surrounding the Site are occupied by heavy industry (**Figure 1)**.

The Site currently stores unleaded gasoline, marine fuel oil, heavy cycle gas oil, ethanol, jet A, and ethanol. The Site consists of five yards referred to as A, B, C, D, and E yards (**Figure 2**). Each yard is described below.

- A Yard, located at the southern end of the property, consists of the terminal administrative office, a truck loading rack, and maintenance building.
- B Yard, located north of A Yard, includes 15 aboveground storage tanks (ASTs) and associated piping and is enclosed by a 15-foot high concrete wall.
- D Yard, located north of B Yard, is composed of a driveway, barrel storage, a maintenance building, and is the primary corridor for on-site utilities.
- C Yard, located north of D Yard, contains six ASTs and associated piping and is surrounded by a 15-foot high concrete wall.
- E Yard, located at the north end of the property, is leased and consists of an office building and vehicle storage facilities.

Documented releases have occurred on the Site as early as 1964 in all yards except E Yard, with the most recent significant release taking place in 1996 (Hart Crowser 1992, PEG 1994). Removal of source material took place as part of surface and subsurface excavations of approximately 44,000 tons of soil (KHM 2002) and through active and passive separate-phase hydrocarbon (SPH) removal (Antea 2011a). A number of interim remedial actions have been performed at the Site including:

A Yard

- Subsurface excavation of total petroleum hydrocarbon (TPH)- impacted soil (October 2009)
- Biosparge barrier for SPH-impacted groundwater (December 2006 through November 2010)
- Active SPH recovery removing approximately 22 gallons of SPH (October 2002)
- Passive product recovery removing approximately 0.04 gallon of SPH (October 2002 through ongoing)

B Yard

- Surface excavation and disposal of metals-impacted soil (April and May 2002)
- Subsurface excavation and disposal of TPH-impacted soil (May and June 2002)
- Active SPH recovery removing approximately 22 gallons of SPH (October 2002)
- Passive product recovery removing approximately 0.04 gallon of SPH (October 2002 through ongoing)
- Eight cubic yards of soil removed following an additive release (May 2007)
- Twenty-three cubic yards of soil removed following a jet fuel release (September 2010)

C Yard

- Surface excavation and disposal of metals-impacted soil completed (April and May 2002)
- Subsurface excavation and disposal of TPH-impacted soil completed (May and June 2002)
- Groundwater restoration by air sparging (October 2002 through August 2004)

2.2 Geology

The Harbor Island area was historically tidal flats at the mouth of the Duwamish River. Construction of the current form of Harbor Island started in 1903 and was mostly completed by 1910, with the Site constructed by 1906.Dredged material from the West Waterway was placed into wooden cribs and allowed to drain through the slats in the crib walls. Based on available linear footage records from bulkhead construction, the filling cells may have measured 700 by 1,000 feet. Cells were filled to an average depth of 16 feet, resulting in a ground surface elevations ranging between 9 and 17 feet above mean sea level (amsl).

Surficial soil on Harbor Island consists of sandy gravel and cobble fill material to depths ranging from 1 to 6 feet below ground surface (bgs). Dredge spoils consisting of fine- to coarse-grained sand and silty sand underlie the surface layer to thicknesses ranging from 5 to 15 feet. Native sediments consisting of sand interbedded with silt and clay are found beneath the dredged materials (Hart Crowser 1992).

2.3 Hydrogeology

The hydrogeology of Harbor Island consist of an unconfined water-bearing zone composed of primarily coarse-grained fill and dredged spoils. Groundwater depths at the Site generally range from 3 to 10 feet bgs. Groundwater mounding occurs in the vicinity of the tank farms located in the central portion of Harbor Island; and due to this, infiltration of precipitation is the primary recharge mechanism (PEG 1994). The primary groundwater discharge point is the Duwamish Waterway. Based on the results of a 1992 tidal study, Site groundwater elevations are tidally influenced (PEG 1994).

Results of falling and rising head aquifer testing indicate hydraulic conductivity ranging from 3×10^{-3} centimeter per second (cm/sec) to 1×10^{-2} cm/sec. Estimated transmissivity based on the use of a 10-foot screen length as a substitute for aquifer thickness yielded values ranging from 636 gallons per day per foot (gpd/ft) to 2,121 gpd/ft (PEG 1994). Groundwater flow directions at the Site are to south and southeast, with a horizontal hydraulic gradient of 0.005 ft/ft (Antea 2011a).

2.4 Contaminants of Concern and Cleanup Levels

The primary source of contaminants of concern (COCs) in groundwater at the Site includes the historical release of petroleum hydrocarbons from ASTs and product piping. Source material was removed as part of surface and subsurface excavations of approximately 44,000 tons of soil (KHM 2002) and through active and passive SPH removal (Antea 2011a). Recent analytical results indicate residual petroleum hydrocarbons in soil in the B and D yards do not exceed Site soil Cleanup Levels (CLs) and have been addressed through completed remedial actions.

Groundwater cleanup levels for the Site were determined by Ecology to be surface water standards that are protective of aquatic organisms in Elliott Bay and also determined by no current or future use of the groundwater for drinking water purposes. However, surface water standards are not established for TPH; therefore, the groundwater cleanup levels of gasoline-range (TPH-GRO), diesel-range (TPH-DRO),

and heavy oil-range (TPH-HO) were selected as the cleanup goals. The cleanup levels for the COCs in groundwater are:

Constituent	Cleanup Level
Benzene	0.071 mg/L
Ethylbenzene	29.0 mg/L
Lead	0.0058 mg/L
Toluene	200 mg/L
TPH-GRO	1.0 mg/L
TPH-DRO	10 mg/L
TPH-HO	10 mg/L
Product	No sheen

mg/L = milligrams per liter

Groundwater data collected during third quarter monitoring event of 2012 indicate that TPH-G exceeds the cleanup level of 1.0 mg/L in monitoring wells MW-19 (5.2 mg/L) and MW-7 (1.8 mg/L). The third quarter 2012 groundwater monitoring results are presented as **Figure 3**.

During previous groundwater monitoring events, measurable SPH or sheens have been observed in nine wells (12, A-4, A-6, A-16, MW-7, MW-9, MW-21, MW-23, and MW-24). However, during 2012, no measurable SPH has been observed during Q1-Q3. Sheens were observed in monitoring wells A-16, 12 and MW-21.

During Q1 2012, measurable SPH was not observed in any well. Sheens were observed in wells A-16, 12, and MW-21. During Q2 2012 measurable SPH was not observed in any well. Sheen was observed in well 12 (Antea 2012b).

2.5 Pre-Design Soil Sampling

In order to address dissolved-phase hydrocarbon impacts in groundwater, ARCADIS plans to implement the approved ABOx remedy via sulfate application. Five soil borings were advanced in the B and D yards within the estimated footprint of groundwater impacts greater than 1.0 mg/L TPH-G with the following objectives:

- Update the mass estimate of TPH present in soil (source strength) within the groundwater restoration area and

- Optimize the remedial design (e.g., sulfate delivery approach)

The five soil borings (AUS-SB-1, AUS-SB-2, AUS-SB-3, AUS-SB-4, and AUS-SB-5) were advanced by Environmental Services Northwest (ESN) from ground surface to 5 ft bgs using a hand auger to reduce the risk of damaging subsurface utilities. Each boring was subsequently advanced using direct-push (DP) drilling technology to a total depth of approximately 10 feet bgs. Upon completion, the borings were backfilled with hydrated bentonite chips and the surface completion was repaired to match the surrounding area. Boring logs are included as **Appendix A**.

Three soil samples were collected at each boring at the following intervals: unsaturated surficial soils (1.5-2 ft bgs), smear zone soils (4.5-7.5 ft bgs), and the total depth (9.5-10 ft bgs). Soil samples were collected either from 4-foot acetate sleeves or extracted from the hand-auger bucket. Samples were preserved in the field in accordance with U.S. Environmental Protection Agency (EPA) Method 5035A and placed in preserved 40-milliliter volatile organic analysis vials and unpreserved 4-ounce jars. Silica gel cleanup, which is typically run to remove biogenic organic material, was not run on the soil samples in order to obtain the total mass of petroleum hydrocarbons.

Soil samples were shipped to Alpha Analytical of Sparks, Nevada (Alpha), a Washington State accredited laboratory, following standard chain-of-custody procedures. Samples were submitted for the following analyses:

- TPH-GRO by Northwest Method NWTPH-Gx;
- TPH-DRO by Northwest Method NWTPH-Dx;
- TPH-HO by Northwest Method NWTPH-Dx

Laboratory reports and chain-of-custody documentation for this sampling event are included as **Appendix B.** Results of the investigation indicate that concentrations of TPH in soil did not exceed the CL of 10,000 milligrams per kilogram (mg/kg) in any of the sample locations. The results are presented in **Table 1** and **Figure 4** and can be summarized as follows:

- The highest concentrations were detected at AUS-SB-1 and AUS-SB-3 in B Yard in the 1.5-2 ft bgs and 5-5.5 ft bgs intervals with TPH-GRO detections ranging from 960 to 2,000 mg/kg. TPH-DRO detections in these samples and intervals ranged from 940 to 4,600 mg/kg.

- All sample results from the deepest interval (9.5-10 ft bgs) are non-detect.

- All TPH-HO results were non-detect with the exception of AUS-SB-1 (1.5-2 ft bgs) and AUS-SB-4 (1.5-2 ft bgs) with detected concentrations of 190 and 140 mg/kg, respectively.

The results confirm that there are soils impacted with petroleum hydrocarbons that are contributing to persistent groundwater concentrations in the area identified for active remediation. The maximum soil concentrations observed at AUS-SB-1 and AUS-SB-3 are located in the interior of the target groundwater remediation area, and their magnitude indicate the presence of residual SPH in smear zone soils. The recent soil analytical results, combined with the most recent compliance groundwater monitoring data, were used to estimate the amount of petroleum hydrocarbon mass present in the target treatment area. These estimates are used in the remedial design and discussed in the next section.

3. Remedial Design

In accordance with the approved Work Plan, ARCADIS proposes to implement ABOx by sulfate application to address groundwater impacts at the Site. However, an alternative sulfate delivery approach is presented herein. Land application of sulfate was selected as the delivery mechanism for effective distribution within the target groundwater restoration area instead of the previously proposed infiltration trenches and injection of high-concentration sulfate solution. The following sections describe the design and implementation plan of land application.

3.1 Design Basis

Land application of gypsum and Epsom salt will provide a source of terminal electron acceptors (i.e., sulfate) directly over almost the entire footprint of the targeted groundwater restoration area. The previous sulfate delivery approach relied on the injection of a soluble sulfate solution into a series of galleries and delivery of sulfate to downgradient locations under ambient groundwater flow conditions. Because of the shallow groundwater encountered beneath the Site, land application and subsequent percolation will directly provide a longer-term source of sulfate to groundwater over the majority of the target treatment areas, except where site features (e.g., ASTs) prevent ready access to the ground surface.

The solubility differences between Epsom salt and gypsum allow them to provide a short- and long-term sulfate source. Epsom salt has a relatively high solubility (approximately 250 grams per liter [g/L] at 20^{o} C) and will therefore dissolve more rapidly than gypsum after placement. The relatively low solubility of gypsum (approximately 2 g/L at 20^{o} C) will provide a longer-term source of sulfate. Gypsum and Epsom salt will be applied to the ground surface during construction and will be dissolved and carried downward through vadose zone soils and to groundwater. The increased density (due to the dissolved gypsum and Epsom salt) of the infiltrating water will enhance continued distribution through groundwater and mixing. Infiltration will result from a combination of precipitation and engineered irrigation. The area for land application is shown on **Figures 5** and **6**.

A primary design element is the amount of the gypsum and Epsom salt to apply. The following data and assumptions were used to estimate these material quantities:

- A treatment area of 100 feet wide by 300 feet long with a smear zone thickness of 8 feet;
- Average total TPH concentration of 1,500 mg/kg in soil (conservative estimate);
- Assumed soil density of 100 pound/cubic foot;
- An average TPH-GRO concentration of 2.4 mg/L from the third quarter 2012 groundwater monitoring event and,
- A stoichiometric demand of 4 lbs of sulfate for every pound of TPH mass

Based on these values, an estimated 258,000 pounds of gypsum and 42,000 pounds of Epsom salt will be required (**Appendix C**). This quantity of sulfate translates to approximately 0.15 foot of gypsum and 0.02 foot of Epsom salt over the land application area. ARCADIS will install an irrigation system to augment precipitation. This irrigation system will allow control of infiltration rates and frequency and thus, delivery of sulfate to groundwater. Monthly rainfall totals will be tracked and irrigation events will be scheduled to achieve the necessary infiltration amount.

3.2 Deviations from Previously Proposed Cleanup Action

This section describes the deviations in the remedy design and implementation from the previously proposed cleanup action presented in the approved Work Plan.

Sulfate Application Remediation Workplan Section	Deviations to Section
3.1 Enhanced Bioremediation by Sulfate Application	No substantive changes
3.1.1 Summary of Sulfate Application Pilot Testing	No substantive changes
3.1.2 Estimated Area Affected by Sulfate Application	Application trenches will not be used to implement the remedial action. Surface application will be used instead.
3.2 Conceptual Sulfate Application Program	Instead of 113,400 pounds of Epsom salt over four injection events, 258,000 pounds of gypsum and 42,000 pounds of Epsom salt will be applied in one ground surface application event over the targeted treatment footprint.
3.3 Estimated Time Frame to Complete Groundwater Restoration	Surface application is expected to restore groundwater to cleanup levels in approximately 5 years.

4. Construction Plan

This section describes the construction activities necessary to implement the remedial action.

4.1 Permitting

The only permits required for the land application for sulfate will be the “start-cards” for the performance monitoring well installation.

4.2 Mobilization

Personnel, materials, and equipment will be mobilized to the Site upon approval of the design report. ARCADIS personnel will assist with the setup prior to the start of construction activities. An area within the D Yard will be used as a contractor staging

area for the duration of the project. This area will be identified by Site operations prior to mobilization. All equipment and material that cannot be left in the work area will be staged in this area.

4.3 Site Setup

The area of land application will be marked in the field. Site setup will include establishing temporary sanitary facilities and installing temporary erosion and sediment control (TE&SC) features. Subsurface utilities will be identified prior to the start of work. The utilities underground notification center will be contacted, and a private utility locate will be conducted for the entire land application area.

4.4 Surface Application

Gypsum and Epsom salt will be procured from the manufacturer and stored within a containment berm in the D Yard staging area. The gypsum shall be agricultural grade and granular. The material safety data sheets (MSDSs) for gypsum and Epsom salt are included in **Appendix D**.

Sulfate will be moved from the staging area to the land application areas using forklifts or a backhoe. Asphalt will be removed from the land application area located within the D Yard and disposed of at an appropriate facility. In advance of sulfate spreading, the land application irrigation system will be constructed using a combination of sprinkler heads and 1-inch schedule 80 polyvinyl chloride (PVC) piping. The piping connection to water source will be routed aboveground. The piping for sprinkler system will be trenched to a minimum depth of 1 foot bgs where possible. The excavated material or an equivalent material will be used to backfill the trenching The sprinklers shall be full circle, single stream, water lubricated, gear drive type (or equivalent) capable of covering an approximate 65-foot radius with an approximate discharge rate of 5 gallons per minute. The controller for the sprinkler should be capable of automatic operation. The proposed layout of land application irrigation area is shown on **Figure 7**.

Sulfate materials will be applied using a backhoe to facilitate even distribution of the specified quantity of both Epsom salt and gypsum across the area. Following the application of the sulfate materials, the subcontractor will place approximately 6 inches of crushed rock (approximately 860 tons) over the same area in both D and B yards; This rock will provide the structural stability of the land application as the sulfate amendments dissolve. It is assumed the rock has a porosity of 45% and a unit weight of 120 lb/ cubic foot. The crushed rock gradation will meet the following requirements:

U.S. Standard Sieve Size	Percent Passing
3”	100
1 ½”	40-60
No. 200	0-3

A bench test will be performed prior to remedy construction to ensure that the selected crushed rock and gypsum/Epsom salt quantities will provide the structural requirements for these areas in B and D yards. Based on the results of this test and if necessary, the quantity of crushed rock will be modified to achieve the desired surface completion. Additional surface applications may be warranted based on results of performance monitoring to achieve groundwater CLs. Any future applications would be constructed similar to the initial application and the sulfate source type and quantity would be evaluated based on performance monitoring data. Additionally, no future applications are expected to occur sooner than 2 years after the initial application.

4.5 Construction Quality Assurance

Sulfate will be applied under the supervision of a field engineer or field geologist. All aspects of surface application will be inspected and documented daily in field reports, and photographs will be taken daily to document the progress. Grids will be established in the field for every 100 square feet, and the field representative will verify the mass of sulfate application within the grid by tracking material inventory.

Daily field reports will be prepared and communicated to Kinder Morgan electronically. The daily field reports will summarize equipment used, construction activities completed, schedule delays or deviations from project plans, results of any required testing and monitoring, and other pertinent information. Weekly progress conference calls will be conducted to review the project and schedule status, resolve any issues, and discuss any design changes.

5. Performance Monitoring

Performance monitoring is an important element of surface application to collectively assess the effectiveness of land surface application to sustain elevated sulfate concentrations in shallow groundwater, evaluate the performance of land application over time, and plan for potential future applications. The objectives of the proposed groundwater performance monitoring plan are to evaluate the following:

- Distribution of sulfate to groundwater
- Biogeochemical environment necessary for anaerobic bio-oxidation
- Infiltration and modify irrigation rates
- COC concentrations and plan for future applications for sulfate as needed.

Performance monitoring will be performed as described in the Work Plan (Antea Group 2011b and 2012). The proposed performance monitoring well locations are shown on **Figure 8**.

Monitoring well installation and baseline sampling will be conducted prior to implementation of the remedial design. ARCADIS proposes one month post-application performance monitoring, followed by quarterly performance monitoring to be done in conjunction with the routine groundwater monitoring. The monitoring program will be comprised of eight new temporary monitoring wells (TMW-1 through TMW-8) and existing monitoring wells MW-7, MW-19 and 12. The final temporary monitoring well locations will be determined in the field based on location of subsurface utilities and other site features.

Depths to water from the performance monitoring well network will be collected before groundwater samples are collected. Additionally, groundwater samples will be collected for sulfate from monitoring wells MW-9 and A-27 to ensure that groundwater quality for sulfate not exceeded. The performance monitoring program is presented in **Table 2**.

Biological Activity Reaction Testing (BART) will also be performed on groundwater samples collected from the monitoring wells to determine the population and activity of sulfate reducing bacteria. The results of aqueous analytical monitoring discussed above will the primary data for evaluating performance; the results of the BART testing will be used as a secondary line of evidence for evaluating performance.

6. Reporting and Schedule

Remedy construction will take place within 90 days of receipt of Ecology's written approval of the Remedial Design Report. Site mobilization and preparation and sulfate spreading activities are anticipated to take up to 2 weeks to complete.

A report documenting construction of the remedy and installation of performance monitoring wells will be submitted within 60 days of construction completion. The construction completion report will include a summary of construction activities, field logs, as-built drawings, design modifications, and deviations from the approved plans and photographs taken during the construction activities. Performance monitoring data will be reported in the quarterly groundwater monitoring reports.

7. References

Antea Group. 2011a. Sulfate Application Pilot Test Report, Kinder Morgan Liquid Terminals, LLC, Harbor Island Terminal. January.

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Antea Group. 2012b. Annual Groundwater Monitoring Report Second Quarter 2012. Kinder Morgan Liquids Terminals, LLC Harbor Island Terminal. July 2012.

Hart Crowser. 1992. Final Background Summary Report, Shell Oil Company Harbor Island Terminal, Seattle, Washington. August 6.

KHM Environmental Management Inc. 2002. Construction Documentation Report, Soil and Groundwater Remediation, B,C and D Yards, Kinder Morgan Liquid Terminals, LLC. November.

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Tables

TABLE 1
Soil Analytical Data

Kinder Morgan Liquids Terminals, LLC - Harbor Island
2720 13th Avenue Southwest
Seattle, Washington 98134

Sample ID	Sample Depth ft bgs	Date Collected	GRO mg/kg	DRO mg/kg	HO mg/kg
AUS-SB-1 (1.5-2)	1.5-2.0	8/28/2012	2,000	3,200	190
AUS-SB-1 (5-5.5)	5.0-5.5	8/28/2012	960	4,600	330
AUS-SB-1 (9.5-10)	9.5-10.0	8/28/2012	<5.0	<25	<100
AUS-SB-2 (1.5-2)	1.5-2.0	8/28/2012	<5.0	<25	<100
AUS-SB-2 (6.5-7)	6.5-7.0	8/28/2012	<5.0	<25	<100
AUS-SB-2 (9.5-10)	9.5-10.0	8/28/2012	<5.0	<25	<100
AUS-SB-3 (1.5-2)	1.5-2.0	8/28/2012	<5.0	<25	<100
AUS-SB-3 (4.5-5)	4.5-5.0	8/28/2012	1,300	940	<100
AUS-SB-3 (9.5-10)	9.5-10.0	8/28/2012	<5.0	<25	<100
AUS-SB-4 (1.5-2)	1.5-2.0	8/28/2012	<5.0	100	140
AUS-SB-4 (4.5-5)	4.5-5.0	8/28/2012	19	48	<100
AUS-SB-4 (9.5-10)	9.5-10.0	8/28/2012	<5.0	<25	<100
AUS-SB-5 (1.5-2)	1.5-2.0	8/28/2012	44	<25	<100
AUS-SB-5 (7.5-8)	7.5-8.0	8/28/2012	5.0	<25	<100
AUS-SB-5 (9.5-10)	9.5-10.0	8/28/2012	<5.0	<25	<100
Site Cleanup Levels			**10,000**		

Notes:

ft bgs = feet below ground surface

mg/kg = milligrams per kilogram

GRO = gasoline range organics analyzed by Method NWTPH-Gx

DRO = diesel range organics analyzed by Method NWTPH-Dx

HO - heavy oil range organics analyzed by Method NWTPH-Dx

-- = not applicable/not analyzed

< = not detected above laboratory method reporting limits

Table 2
Performance Monitoring Program
Kinder Morgan Liquids Terminal Harbor Island
2720 13th Avenue Southwest
Seattle, Washington 98134

Well ID	GRO by NWTPH-GX	BTEX by EPA 8260	Sulfide by EPA 376.1	Sulfate by EPA 300.0	Additional Geochemical Parameters [1]	Field Paramters by downhole meter	Depth to Water/SPH by downhole meter
Baseline Sampling							
TMW-1	x	x	x	x	x	x	x
TMW-2	x	x	x	x	x	x	x
TMW-3	x	x	x	x	x	x	x
TMW-4	x	x	x	x	x	x	x
TMW-5	x	x	x	x	x	x	x
TMW-6	x	x	x	x	x	x	x
TMW-7	x	x	x	x	x	x	x
TMW-8	x	x	x	x	x	x	x
MW-7	x	x	x	x	x	x	x
MW-9							x
MW-19	x	x	x	x	x	x	x
12			x	x		x	x
A-27			x	x		x	x
Performance Monitoring - 30 Day							
TMW-1			x	x	x	x	x
TMW-2			x	x	x	x	x
TMW-3			x	x	x	x	x
TMW-4			x	x	x	x	x
TMW-5			x	x	x	x	x
TMW-6			x	x	x	x	x
TMW-7			x	x	x	x	x
TMW-8			x	x	x	x	x
MW-7			x	x	x	x	x
MW-9			x	x	x	x	x
MW-19							x
Performance Monitoring - Quarterly Events							
TMW-1	x	x	x	x	x	x	x
TMW-2	x	x	x	x	x	x	x
TMW-3	x	x	x	x	x	x	x
TMW-4	x	x	x	x	x	x	x
TMW-5	x	x	x	x	x	x	x
TMW-6	x	x	x	x	x	x	x
TMW-7	x	x	x	x	x	x	x
TMW-8	x	x	x	x	x	x	x
MW-7	x	x	x	x	x	x	x
MW-9	x	x	x	x	x	x	x
MW-19	x	x	x	x			x
A-27	x	x	x	x			x
12			x	x			x

[1] Additional Geochemical Parameters will be analyzed as needed. The parameters include Nitrate as Nitrogen by EPA Method 300.0, Methane by RSK 175, Total and Dissolved Iron by EPA Method 6010
GRO = Total Petroleum Hydrocarbons - Gasoline Range Organics by Northwest Method NWTPH-Gx
BTEX = Benzene, Toluene, Ethylbenzene, and Xylenes by Environmental Protection Agency (EPA) Method 8260.
Sulfate = Sulfate by EPA Method 300.0
Sulfide = Sulfide by EPA Method 376.1
SPH = Separate Phase Hydrocarbons
Field Parameters = dissolved oxygen, oxygen reduction potential, pH, temperature and conductivity

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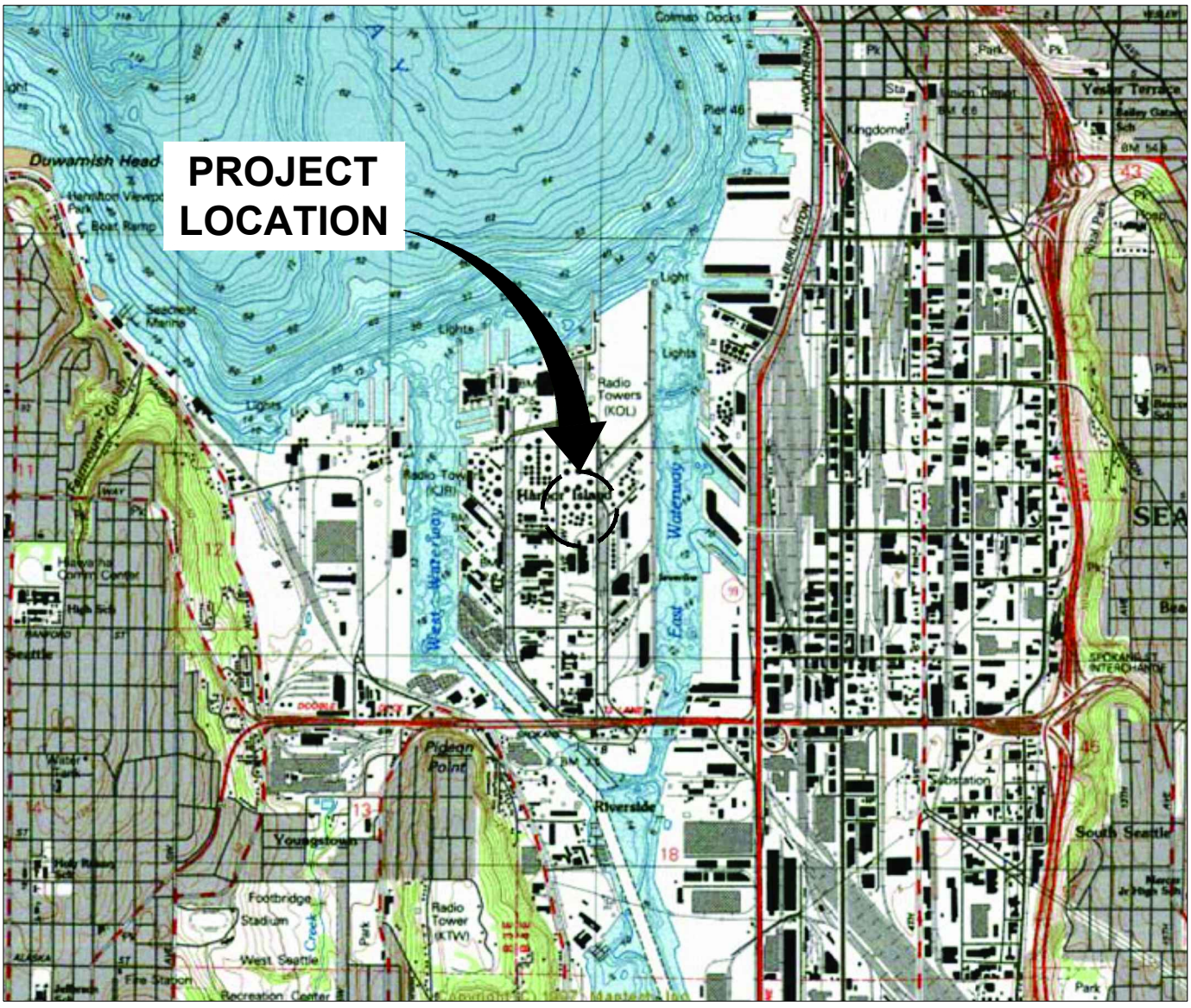
Figures



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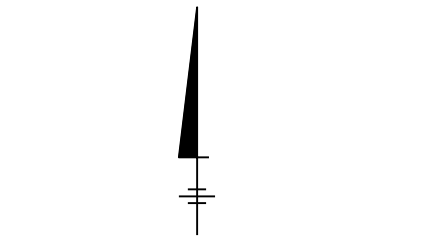
SEATTLE SOUTH, WASHINGTON 1083

WASHINGTON



Approximate Scale: 1 in. = 2000 ft.

KINDER MORGAN LIQUID TERMINALS, LLC
HARBOR ISLAND TERMINAL
2720 13TH AVENUE SOUTHWEST, SEATTLE, WASHINGTON
REMEDIAL DESIGN REPORT

SITE LOCATION MAP

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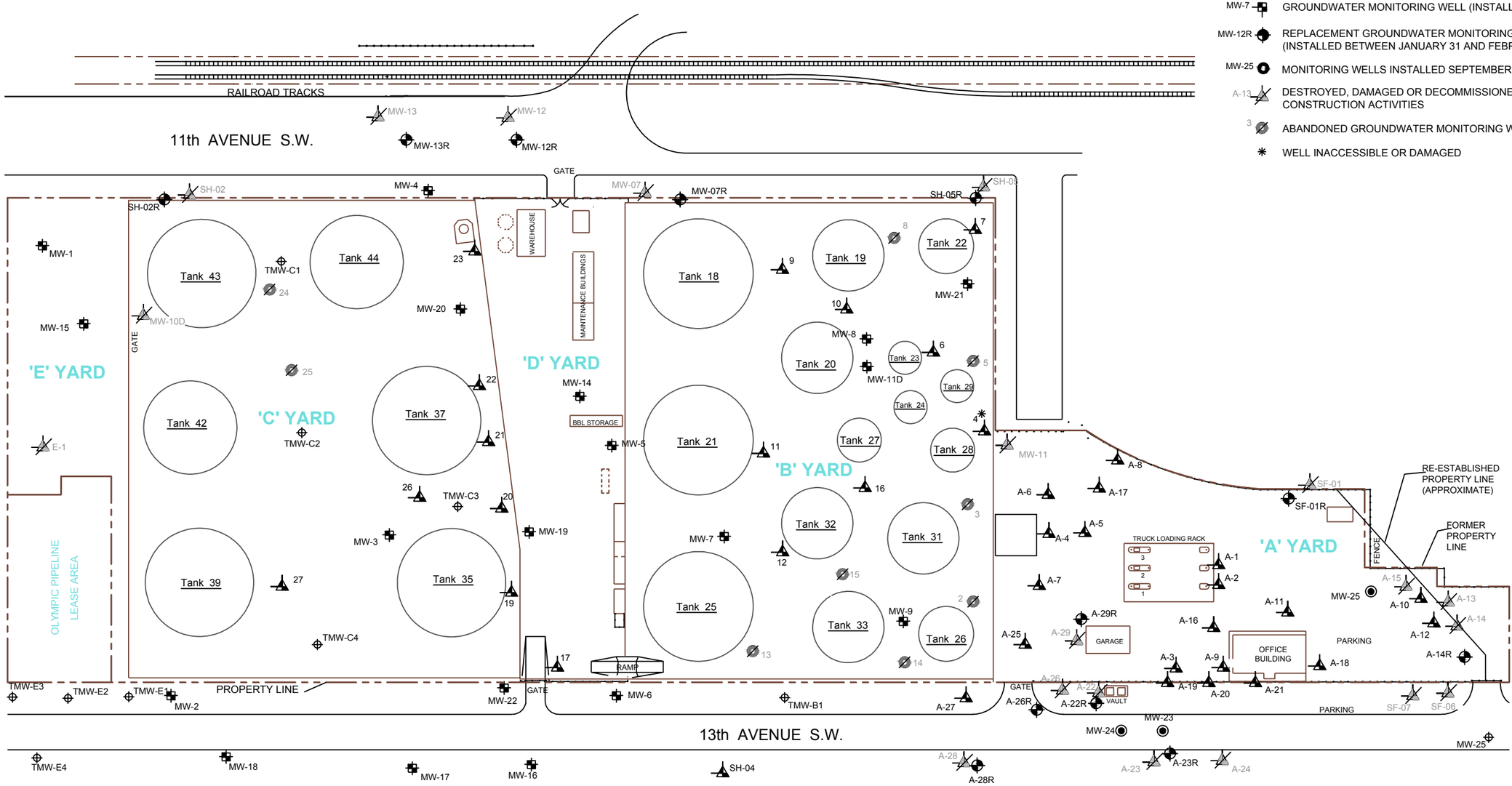
FIGURE
1

CITY:(Reqd) DIV/GROUP:(Reqd) DB:(Reqd) LD:(Opt) PIC:(Opt) PM:(Reqd) TM:(Opt) LYR:(Opt)ON=*;OFF=*REF*
G:\ENVCAD\Emeryville\ACT\WA000804000010004\RemDesRPT\DWG\WA000804 N01.dwg LAYOUT: 1 SAVED: 9/19/2012 5:30 PM ACADVER: 18.1S (LMS TECH) PAGESETUP: ---- PLOTSTYLETABLE: ARCADIS.CTB PLOTTED: 9/26/2012 12:00 PM BY: REYES, ALEC
XREFS: IMAGES: PROJECTNAME: ----
WA000804 GoogleAerial.jpg
WA000804 USGS.jpg

LEGEND

- SH-02 — GROUNDWATER MONITORING WELL (INSTALLED BEFORE 1993)
- MW-7 — GROUNDWATER MONITORING WELL (INSTALLED AFTER 1993)
- MW-12R — REPLACEMENT GROUNDWATER MONITORING WELL (INSTALLED BETWEEN JANUARY 31 AND FEBRUARY 21, 2002)
- MW-25 — MONITORING WELLS INSTALLED SEPTEMBER 30, 2003
- A-13 — DESTROYED, DAMAGED OR DECOMMISSIONED DUE TO CONSTRUCTION ACTIVITIES
- 3 — ABANDONED GROUNDWATER MONITORING WELL, JUNE 2003
- ✱ — WELL INACCESSIBLE OR DAMAGED



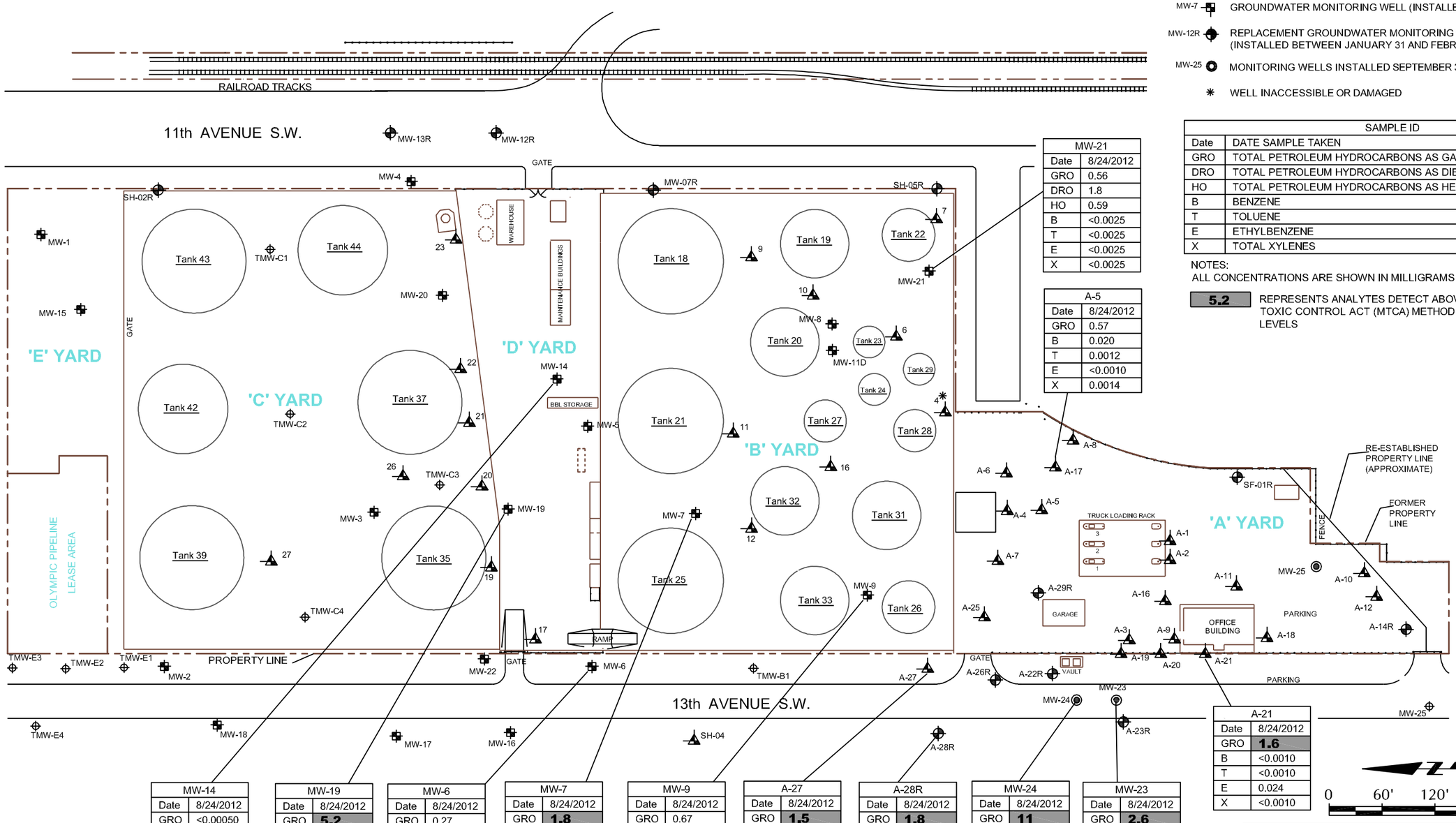
0 60' 120' 240'

KINDER MORGAN LIQUID TERMINALS, LLC
HARBOR ISLAND TERMINAL
2720 13TH AVENUE SOUTHWEST, SEATTLE, WASHINGTON
REMEDIAL DESIGN REPORT

SITE PLAN

ARCADIS

FIGURE
2



LEGEND

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- MW-25 — MONITORING WELLS INSTALLED SEPTEMBER 30, 2003
- ✱ — WELL INACCESSIBLE OR DAMAGED

SAMPLE ID	
Date	DATE SAMPLE TAKEN
GRO	TOTAL PETROLEUM HYDROCARBONS AS GASOLINE RANGE ORGANICS
DRO	TOTAL PETROLEUM HYDROCARBONS AS DIESEL RANGE ORGANICS
HO	TOTAL PETROLEUM HYDROCARBONS AS HEAVY OIL
B	BENZENE
T	TOLUENE
E	ETHYLBENZENE
X	TOTAL XYLENES

NOTES:
ALL CONCENTRATIONS ARE SHOWN IN MILLIGRAMS PER LITER (mg/L)

5.2 REPRESENTS ANALYTES DETECT ABOVE MODEL TOXIC CONTROL ACT (MTCA) METHOD C CLEANUP LEVELS

MW-21	
Date	8/24/2012
GRO	0.56
DRO	1.8
HO	0.59
B	<0.0025
T	<0.0025
E	<0.0025
X	<0.0025

A-5	
Date	8/24/2012
GRO	0.57
B	0.020
T	0.0012
E	<0.0010
X	0.0014

A-21	
Date	8/24/2012
GRO	**1.6**
B	<0.0010
T	<0.0010
E	0.024
X	<0.0010

MW-14	
Date	8/24/2012
GRO	<0.00050
B	<0.00050
T	0.0028
E	0.270
X	0.0017

MW-19	
Date	8/24/2012
GRO	**5.2**
B	0.054
T	0.0076
E	0.270
X	0.089

MW-6	
Date	8/24/2012
GRO	0.27
B	<0.00050
T	<0.00050
E	<0.00050
X	<0.00050

MW-7	
Date	8/24/2012
GRO	**1.8**
B	0.0024
T	0.0062
E	0.030
X	0.160

MW-9	
Date	8/24/2012
GRO	0.67
B	<0.00050
T	<0.00050
E	0.0062
X	0.0057

A-27	
Date	8/24/2012
GRO	**1.5**
B	0.029
T	0.0018
E	0.0027
X	0.0048

A-28R	
Date	8/24/2012
GRO	**1.8**
B	0.030
T	0.00089
E	0.010
X	0.0031

MW-24	
Date	8/24/2012
GRO	**11**
B	**0.560**
T	<0.020
E	0.410
X	1.4

MW-23	
Date	8/24/2012
GRO	**2.6**
B	0.050
T	<0.0025
E	0.059
X	0.0046

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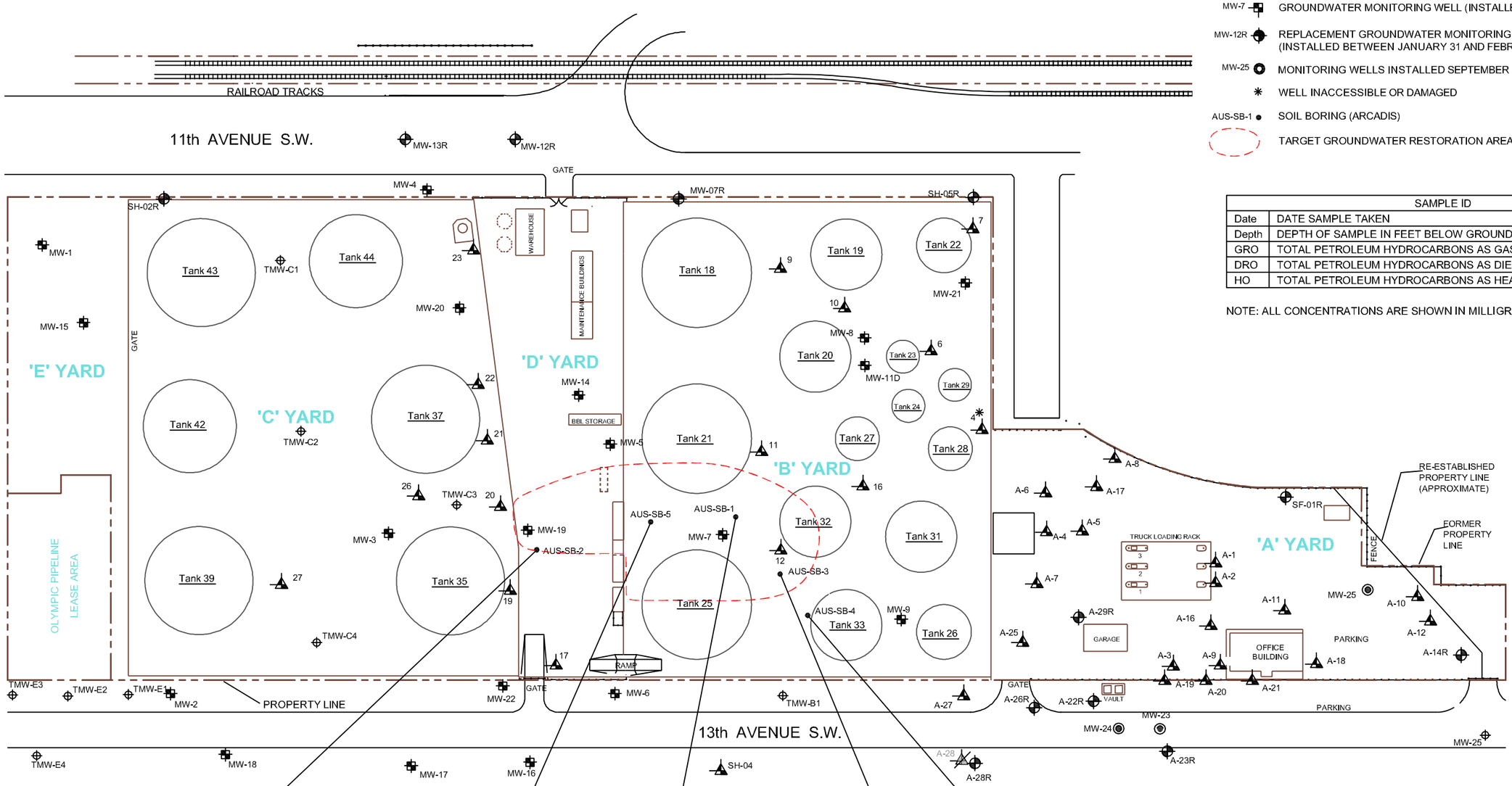
REMEDIAL DESIGN REPORT

THIRD QUARTER 2012 GROUNDWATER ANALYTICAL RESULTS

ARCADIS

FIGURE 3



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- MW-25 — MONITORING WELLS INSTALLED SEPTEMBER 30, 2003
- WELL INACCESSIBLE OR DAMAGED
- AUS-SB-1 — SOIL BORING (ARCADIS)
- TARGET GROUNDWATER RESTORATION AREA

SAMPLE ID	
Date	DATE SAMPLE TAKEN
Depth	DEPTH OF SAMPLE IN FEET BELOW GROUND SURFACE
GRO	TOTAL PETROLEUM HYDROCARBONS AS GASOLINE RANGE ORGANICS
DRO	TOTAL PETROLEUM HYDROCARBONS AS DIESEL RANGE ORGANICS
HO	TOTAL PETROLEUM HYDROCARBONS AS HEAVY OIL

NOTE: ALL CONCENTRATIONS ARE SHOWN IN MILLIGRAMS PER KILOGRAM (mg/kg)

AUS-SB-2			
Date	8/28/2012		
Depth	1.5'-2'	6.5'-7'	9.5'-10'
GRO	<5.0	<5.0	<5.0
DRO	<25	<25	<25
HO	<100	<100	<100

AUS-SB-5			
Date	8/28/2012		
Depth	1.5'-2'	7.5'-8'	9.5'-10'
GRO	44	5.0	<5.0
DRO	<25	<25	<25
HO	<100	<100	<100

AUS-SB-1			
Date	8/28/2012		
Depth	1.5'-2'	5'-5.5'	9.5'-10'
GRO	2,000	960	<5.0
DRO	3,200	4,600	<25
HO	190	330	<100

AUS-SB-3			
Date	8/28/2012		
Depth	1.5'-2'	4.5'-5'	9.5'-10'
GRO	<5.0	1,300	<5.0
DRO	<25	940	<25
HO	<100	<100	<100

AUS-SB-4			
Date	8/28/2012		
Depth	1.5'-2'	4.5'-5'	9.5'-10'
GRO	<5.0	19	<5.0
DRO	100	48	<25
HO	140	<100	<100

0 60' 120' 240'

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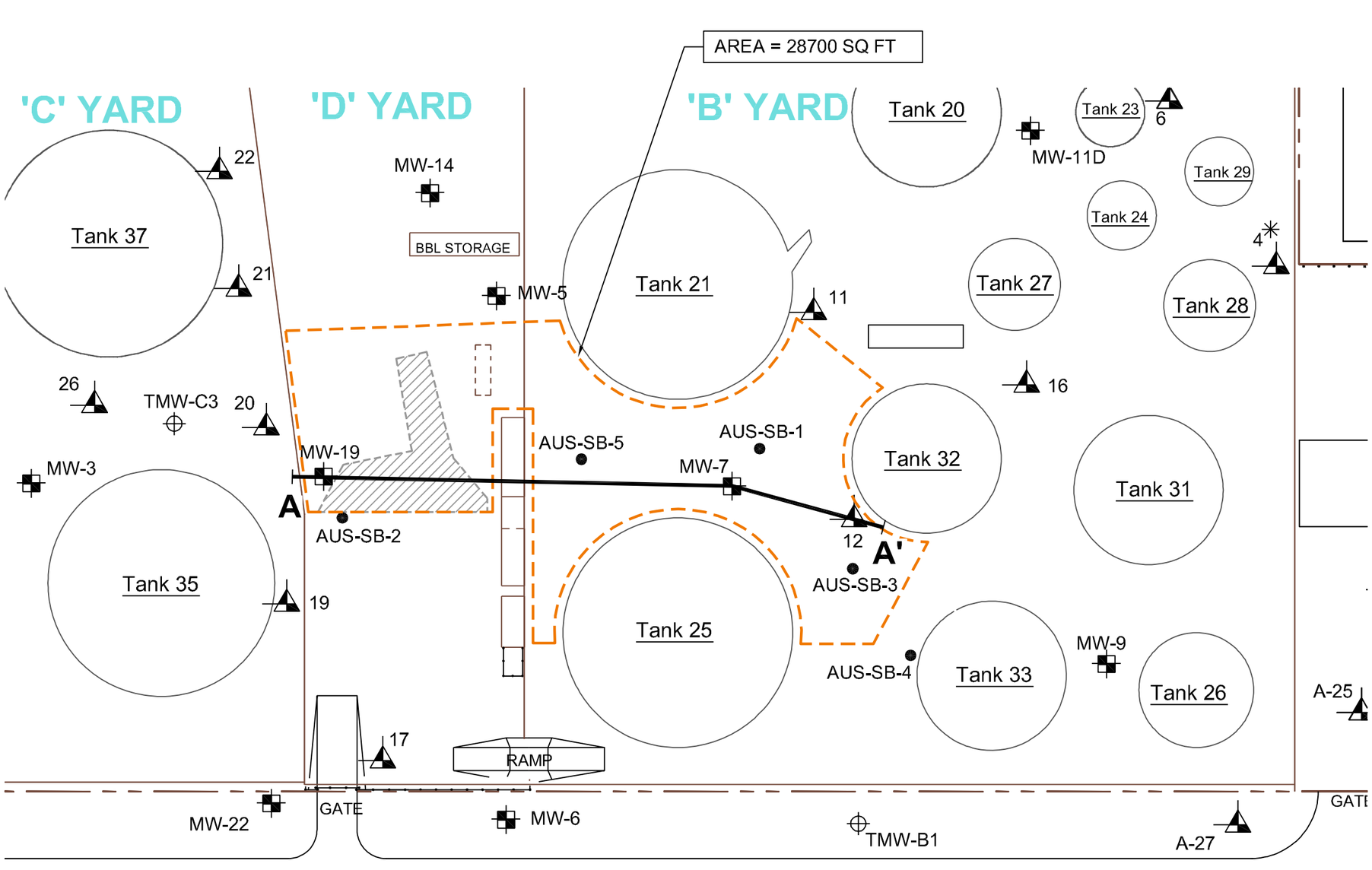
HARBOR ISLAND TERMINAL
2720 13TH AVENUE SOUTHWEST, SEATTLE, WASHINGTON
REMEDIAL DESIGN REPORT

SOIL ANALYTICAL RESULTS

ARCADIS

FIGURE 4



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- WELL INACCESSIBLE OR DAMAGED
- AUS-SB-1 — SOIL BORING (ARCADIS)
- ABOx LAND APPLICATION AREA
- SQ FT — SQUARE FEET
- ASPHALT REMOVAL AREA
- A — A' — LAND APPLICATION SCHEMATIC CROSS SECTION

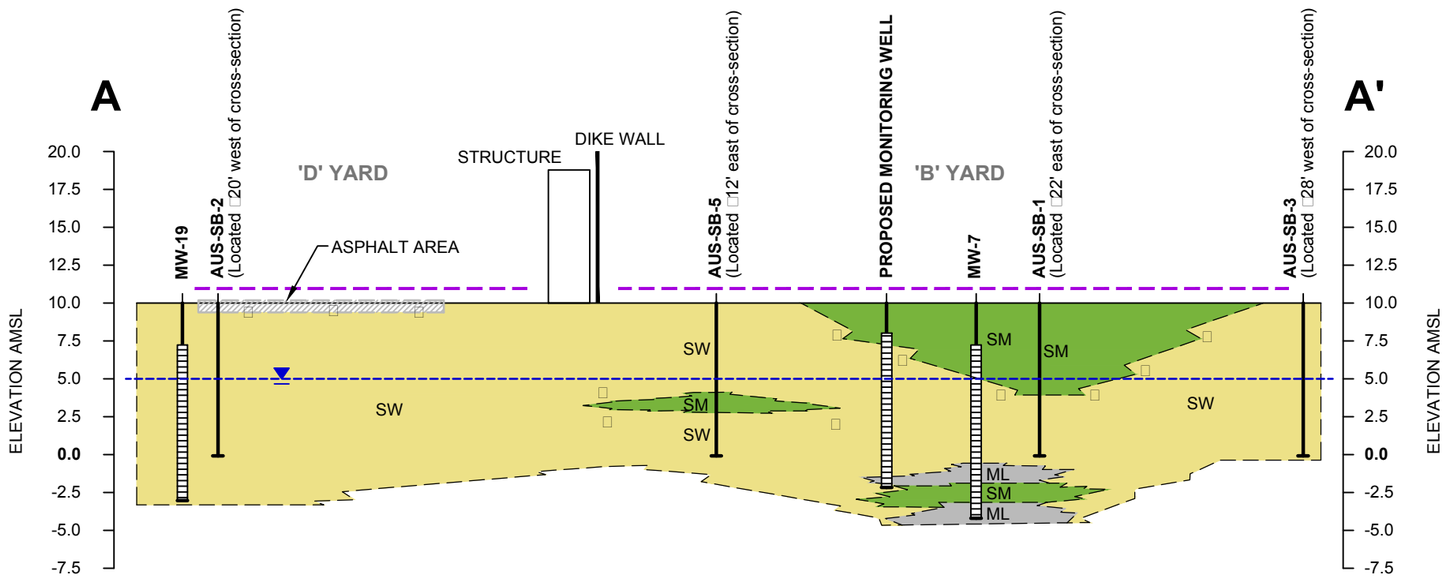
0 60' 120'

KINDER MORGAN LIQUID TERMINALS, LLC
HARBOR ISLAND TERMINAL
2720 13TH AVENUE SOUTHWEST, SEATTLE, WASHINGTON
REMEDIAL DESIGN REPORT

ABOX LAND APPLICATION AREA

ARCADIS

FIGURE
5



LEGEND

- ASPHALT REMOVAL AREA
- SULFATE APPLICATION EXTENT (APPROXIMATELY 3 INCHES GYPSUM, 1/4-INCH EPSOM SALT)
- GEOLOGICAL CONTACT INFERRED
- AMSL — ABOVE MEAN SEA LEVEL
- ML — SILT WITH TRACE FINE SAND AND ORGANICS MEDIUM PLASTICITY
- SM — SILTY SAND AND SAND WITH SILT
- SW — FINE TO COARSE GRAINED SAND WITH TRACE SILT
- APPROXIMATE GROUNDWATER TABLE ELEVATION
- MW-7 — MONITORING WELL LOCATION AND ID
- WELL SCREEN
- AUS-SB-5 — BORING LOCATION AND ID

VERTICAL SCALE IS 4x EXAGGERATED

0 10' 20'
VERTICAL SCALE

0 40' 80'
HORIZONTAL SCALE

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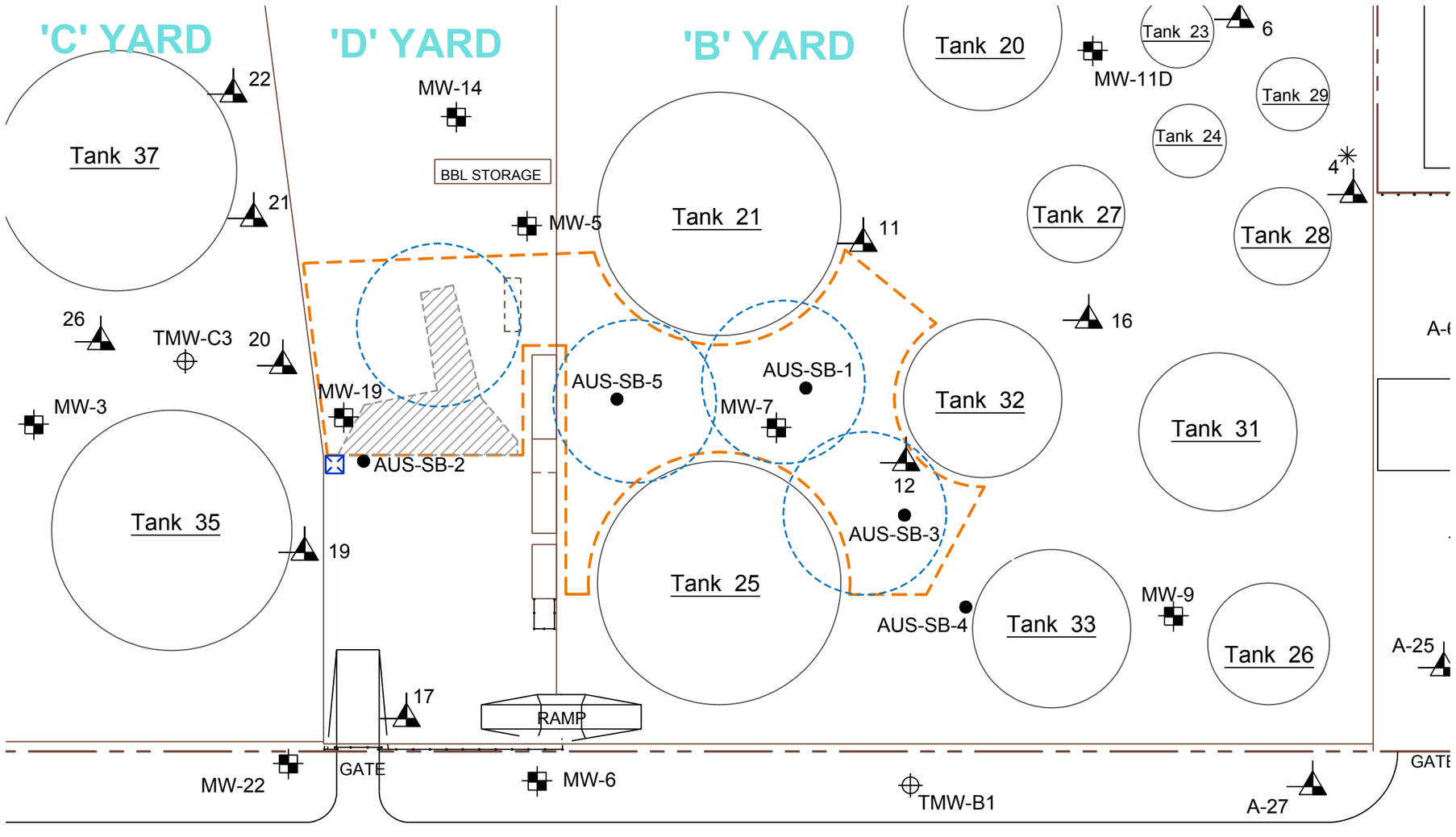
HARBOR ISLAND TERMINAL
2720 13TH AVENUE SOUTHWEST, SEATTLE, WASHINGTON
REMEDIAL DESIGN REPORT

LAND APPLICATION SCHEMATIC CROSS-SECTION A-A'

ARCADIS

FIGURE
6



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- MW-25 — MONITORING WELLS INSTALLED SEPTEMBER 30, 2003
- WELL INACCESSIBLE OR DAMAGED
- AUS-SB-1 — SOIL BORING (ARCADIS)
- ABOx LAND APPLICATION AREA
- ASPHALT REMOVAL AREA
- WATER SOURCE LOCATION
- IRRIGATION SPRINKLER RADIUS

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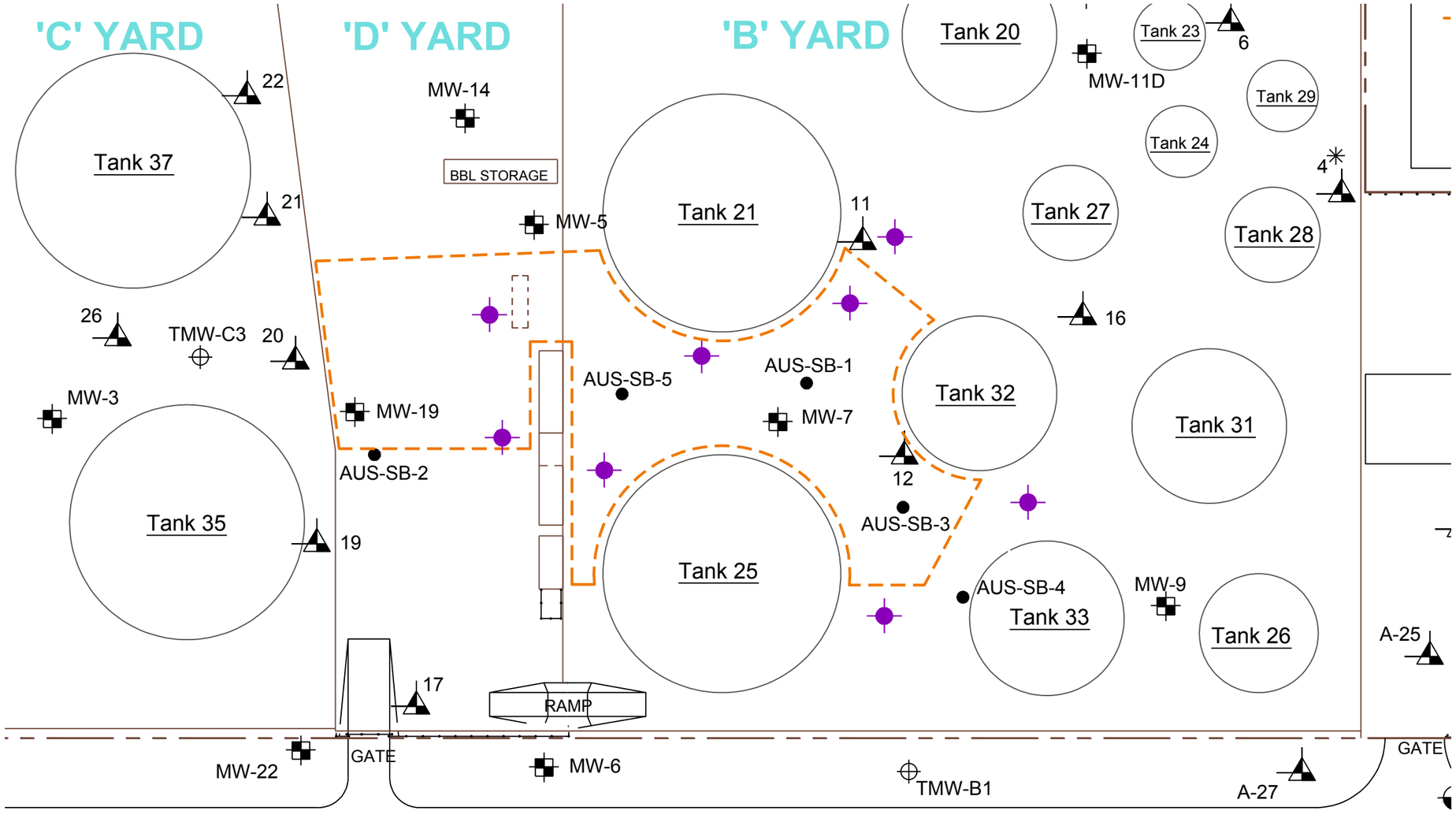
HARBOR ISLAND TERMINAL
2720 13TH AVENUE SOUTHWEST, SEATTLE, WASHINGTON
REMEDIAL DESIGN REPORT

IRRIGATION SYSTEM LAYOUT

ARCADIS

FIGURE
7



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- MW-25 — MONITORING WELLS INSTALLED SEPTEMBER 30, 2003
- WELL INACCESSIBLE OR DAMAGED
- AUS-SB-1 — SOIL BORING (ARCADIS)
- PROPOSED PERFORMANCE MONITORING WELL LOCATION
- ABOx LAND APPLICATION AREA

KINDER MORGAN LIQUID TERMINALS, LLC
HARBOR ISLAND TERMINAL
2720 13TH AVENUE SOUTHWEST, SEATTLE, WASHINGTON
REMEDIAL DESIGN REPORT

PERFORMANCE MONITORING WELL NETWORK

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FIGURE
8

Appendix A

Boring Logs

Date Start/Finish: 08/28/2012 **Drilling Company:** ESN Northwest **Driller's Name:** Chris **Drilling Method:** Direct-push **Sampling Method:** Acetate Sleeve **Rig Type:** Truck-mounted	**Northing:** **Easting:** **Casing Elevation:** NE **Borehole Depth:** 10 feet bgs **Surface Elevation:** **Descriptions By:** KDH	**Well/Boring ID:** **AUS-SB-1** **Client:** Kinder Morgan Energy Partners, L.P. **Location:** KMLT - Harbor Island

DEPTH	ELEVATION	Sample Run Number	Sample/Int/Type	Recovery (feet)	PID Headspace (ppm)	Analytical Sample	USCS Code	Geologic Column	Stratigraphic Description	Well/Boring Construction
0	0	AK	0'-5'		308		SM		SAND with silt, very fine to medium grain, low plasticity, damp, dark brown (7.5YR 3/2).	Hydrated Bentonite Chips
					82.7				Same as above.	
5	-5	1	5'-9'	4	481		SW		SAND, well graded, very fine to medium grain, saturated (10YR 5/1).	
					17.1					
		2	9'-10'	1	12.1				Same as above. Saturated.	
10	10								End of boring @ 10' bgs.	

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Remarks: AK = Air Knife
bgs = Below Ground Surface
NE = Not Established
ppm = Parts Per Million

Date Start/Finish: 08/28/2012
Drilling Company: ESN Northwest
Driller's Name: Chris
Drilling Method: Direct-push
Sampling Method: Acetate Sleeve
Rig Type: Truck-mounted

Northing:
Easting:
Casing Elevation: NE

Borehole Depth: 10 feet bgs
Surface Elevation:

Descriptions By: KDH

Well/Boring ID: **AUS-SB-2**

Client: Kinder Morgan Energy Partners, L.P.

Location: KMLT - Harbor Island

DEPTH	ELEVATION	Sample Run Number	Sample/Int/Type	Recovery (feet)	PID Headspace (ppm)	Analytical Sample	USCS Code	Geologic Column	Stratigraphic Description	Well/Boring Construction
0	0								Asphalt.	Hydrated Bentonite Chips
									SAND, well graded, very fine to coarse grain, moist, dark brown (7.5YR 3/2).	
		AK	0'-5'		0.0					
5	-5						SW		SAND, well graded, very fine to coarse grain, saturated, black (10YR 5/1).	
		1	5'-9'	4	0.8				Same as above. Trace silt.	
		2	9'-10'	1	1.0				SAND, well graded, very fine to coarse grain, saturated, black (10YR 5/1).	
10	10								End of boring @ 10' bgs.	

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Remarks: AK = Air Knife
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Date Start/Finish: 08/28/2012
Drilling Company: ESN Northwest
Driller's Name: Chris
Drilling Method: Direct-push
Sampling Method: Acetate Sleeve
Rig Type: Truck-mounted

Northing:
Easting:
Casing Elevation: NE

Borehole Depth: 10 feet bgs
Surface Elevation:

Descriptions By: KDH

Well/Boring ID: **AUS-SB-3**

Client: Kinder Morgan Energy Partners, L.P.

Location: KMLT - Harbor Island

DEPTH	ELEVATION	Sample Run Number	Sample/Int/Type	Recovery (feet)	PID Headspace (ppm)	Analytical Sample	USCS Code	Geologic Column	Stratigraphic Description	Well/Boring Construction
0	0									
		AK	0'-5'		1.1				SAND, well graded, very fine to medium grain, damp, dark brown (7.5YR 3/2).	
					1,180					
5	-5						SW		SAND, well graded, very fine to medium grain, saturated, black (10YR 5/1).	Hydrated Bentonite Chips
		1	5'-9'	4	1.2					
		2	9'-10'	1	0.4					
					6.6				Same as above.	
10	10								End of boring @ 10' bgs.	

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Remarks: AK = Air Knife
bgs = Below Ground Surface
NE = Not Established
ppm = Parts Per Million

Date Start/Finish: 08/28/2012
Drilling Company: ESN Northwest
Driller's Name: Chris
Drilling Method: Direct-push
Sampling Method: Acetate Sleeve
Rig Type: Truck-mounted

Northing:
Easting:
Casing Elevation: NE

Borehole Depth: 10 feet bgs
Surface Elevation:

Descriptions By: KDH

Well/Boring ID: **AUS-SB-4**

Client: Kinder Morgan Energy Partners, L.P.

Location: KMLT - Harbor Island

DEPTH	ELEVATION	Sample Run Number	Sample/Int/Type	Recovery (feet)	PID Headspace (ppm)	Analytical Sample	USCS Code	Geologic Column	Stratigraphic Description	Well/Boring Construction
0	0									
		AK	0'-5'		0.0				SAND, well graded, very fine to medium grain, damp, black (10YR 5/1).	
					10.7					
5	-5						SW		Same as above. Saturated.	Hydrated Bentonite Chips
		1	5'-9'	4	5.1					
		2	9'-10'	1	4.2				SAND, well graded, very fine to coarse grain, saturated, black (10YR 5/1).	
10	10								End of boring @ 10' bgs.	

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Remarks: AK = Air Knife
bgs = Below Ground Surface
NE = Not Established
ppm = Parts Per Million

Project: WA000804.0003 Template:
Data File:

Date: 9/5/2012

Created/Edited by: KDH

Date Start/Finish: 08/28/2012 **Drilling Company:** ESN Northwest **Driller's Name:** Chris **Drilling Method:** Direct-push **Sampling Method:** Acetate Sleeve **Rig Type:** Truck-mounted	**Northing:** **Easting:** **Casing Elevation:** NE **Borehole Depth:** 10 feet bgs **Surface Elevation:** **Descriptions By:** KDH	**Well/Boring ID:** **AUS-SB-5** **Client:** Kinder Morgan Energy Partners, L.P. **Location:** KMLT - Harbor Island

DEPTH	ELEVATION	Sample Run Number	Sample/Int/Type	Recovery (feet)	PID Headspace (ppm)	Analytical Sample	USCS Code	Geologic Column	Stratigraphic Description	Well/Boring Construction
0	0									
		AK	0'-5'		0.2		SW		SAND with trace silt, well graded, very fine to coarse grain, damp, reddish brown (2.5YR 4/4).	
					0.0					
5	-5								Same as above. Saturated.	Hydrated Bentonite Chips
		1	5'-9'	4	0.2		SM		SAND with silt, well graded, very fine to coarse grain, low plasticity, saturated, black (10YR 5/1)	
					0.4		SW		SAND, well graded, very fine to coarse grain, saturated, black (10YR 5/1).	
					0.2					
		2	9'-10'	1	0.0				Same as above. Saturated.	
10	10								End of boring @ 10' bgs.	

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Remarks: AK = Air Knife
bgs = Below Ground Surface
NE = Not Established
ppm = Parts Per Million

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Appendix B

Laboratory Report and Chain of Custody Documentation

Alpha Analytical, Inc.

255 Glendale Ave. • Suite 21 • Sparks, Nevada 89431-5778
(775) 355-1044 • (775) 355-0406 FAX • 1-800-283-1183

ANALYTICAL REPORT

Arcadis-US
2300 Eastlake Ave E. Suite 200
Seattle, WA 98102

Attn: Chris Robinson
Phone: (206) 726-4728
Fax:
Date Received : 08/29/12

Job: WA000804.0002/KMEP-Harbor Island

Total Petroleum Hydrocarbons - Extractable (TPH-E) EPA Method SW8015B
Total Petroleum Hydrocarbons - Purgeable (TPH-P) EPA Method SW8015B

		Parameter	Concentration		Reporting Limit	Date Extracted	Date Analyzed
Client ID :	**AUS-SB-1 (1.5-2)**						
Lab ID :	ARC12082921-01A	TPH-E (DRO)	3,200	K	25 mg/Kg	08/30/12	08/31/12
Date Sampled	08/28/12 11:30	TPH-E (ORO)	190		100 mg/Kg	08/30/12	08/31/12
		Surr: Nonane	0	S51	(62-161) %REC	08/30/12	08/31/12
		TPH-P (GRO)	2,000		200 mg/Kg	08/30/12	08/31/12
		Surr: 1,2-Dichloroethane-d4	78		(70-130) %REC	08/30/12	08/31/12
		Surr: Toluene-d8	105		(70-130) %REC	08/30/12	08/31/12
		Surr: 4-Bromofluorobenzene	94		(70-130) %REC	08/30/12	08/31/12
Client ID :	**AUS-SB-1 (5-5.5)**						
Lab ID :	ARC12082921-02A	TPH-E (DRO)	4,600	K	25 mg/Kg	08/30/12	08/31/12
Date Sampled	08/28/12 11:45	TPH-E (ORO)	330		100 mg/Kg	08/30/12	08/31/12
		Surr: Nonane	0	S51	(62-161) %REC	08/30/12	08/31/12
		TPH-P (GRO)	960		450 mg/Kg	08/30/12	08/31/12
		Surr: 1,2-Dichloroethane-d4	74		(70-130) %REC	08/30/12	08/31/12
		Surr: Toluene-d8	109		(70-130) %REC	08/30/12	08/31/12
		Surr: 4-Bromofluorobenzene	93		(70-130) %REC	08/30/12	08/31/12
Client ID :	**AUS-SB-1 (9.5-10)**						
Lab ID :	ARC12082921-03A	TPH-E (DRO)	ND		25 mg/Kg	08/30/12	08/31/12
Date Sampled	08/28/12 12:00	TPH-E (ORO)	ND		100 mg/Kg	08/30/12	08/31/12
		Surr: Nonane	107		(62-161) %REC	08/30/12	08/31/12
		TPH-P (GRO)	ND		5.0 mg/Kg	08/30/12	08/31/12
		Surr: 1,2-Dichloroethane-d4	74		(70-130) %REC	08/30/12	08/31/12
		Surr: Toluene-d8	119		(70-130) %REC	08/30/12	08/31/12
		Surr: 4-Bromofluorobenzene	87		(70-130) %REC	08/30/12	08/31/12
Client ID :	**AUS-SB-2 (1.5-2)**						
Lab ID :	ARC12082921-04A	TPH-E (DRO)	ND		25 mg/Kg	08/30/12	08/31/12
Date Sampled	08/28/12 09:15	TPH-E (ORO)	ND		100 mg/Kg	08/30/12	08/31/12
		Surr: Nonane	116		(62-161) %REC	08/30/12	08/31/12
		TPH-P (GRO)	ND		5.0 mg/Kg	08/30/12	08/31/12
		Surr: 1,2-Dichloroethane-d4	77		(70-130) %REC	08/30/12	08/31/12
		Surr: Toluene-d8	122		(70-130) %REC	08/30/12	08/31/12
		Surr: 4-Bromofluorobenzene	81		(70-130) %REC	08/30/12	08/31/12
Client ID :	**AUS-SB-2 (6.5-7)**						
Lab ID :	ARC12082921-05A	TPH-E (DRO)	ND		25 mg/Kg	08/30/12	08/31/12
Date Sampled	08/28/12 09:30	TPH-E (ORO)	ND		100 mg/Kg	08/30/12	08/31/12
		Surr: Nonane	113		(62-161) %REC	08/30/12	08/31/12
		TPH-P (GRO)	ND		5.0 mg/Kg	08/30/12	08/31/12
		Surr: 1,2-Dichloroethane-d4	80		(70-130) %REC	08/30/12	08/31/12
		Surr: Toluene-d8	122		(70-130) %REC	08/30/12	08/31/12
		Surr: 4-Bromofluorobenzene	82		(70-130) %REC	08/30/12	08/31/12

Alpha Analytical, Inc.

255 Glendale Ave. • Suite 21 • Sparks, Nevada 89431-5778

(775) 355-1044 • (775) 355-0406 FAX • 1-800-283-1183

Client ID :	**AUS-SB-2 (9.5-10)**						
Lab ID :	ARC12082921-06A	TPH-E (DRO)	ND		25 mg/Kg	08/30/12	08/31/12
Date Sampled	08/28/12 09:45	TPH-E (ORO)	ND		100 mg/Kg	08/30/12	08/31/12
		Surr: Nonane	111		(62-161) %REC	08/30/12	08/31/12
		TPH-P (GRO)	ND		5.0 mg/Kg	08/30/12	08/31/12
		Surr: 1,2-Dichloroethane-d4	77		(70-130) %REC	08/30/12	08/31/12
		Surr: Toluene-d8	125		(70-130) %REC	08/30/12	08/31/12
		Surr: 4-Bromofluorobenzene	84		(70-130) %REC	08/30/12	08/31/12
Client ID :	**AUS-SB-3 (1.5-2)**						
Lab ID :	ARC12082921-07A	TPH-E (DRO)	ND		25 mg/Kg	08/30/12	08/31/12
Date Sampled	08/28/12 13:15	TPH-E (ORO)	ND		100 mg/Kg	08/30/12	08/31/12
		Surr: Nonane	114		(62-161) %REC	08/30/12	08/31/12
		TPH-P (GRO)	ND		5.0 mg/Kg	08/30/12	08/31/12
		Surr: 1,2-Dichloroethane-d4	73		(70-130) %REC	08/30/12	08/31/12
		Surr: Toluene-d8	126		(70-130) %REC	08/30/12	08/31/12
		Surr: 4-Bromofluorobenzene	85		(70-130) %REC	08/30/12	08/31/12
Client ID :	**AUS-SB-3 (4.5-5)**						
Lab ID :	ARC12082921-08A	TPH-E (DRO)	940	K	25 mg/Kg	08/30/12	08/31/12
Date Sampled	08/28/12 13:30	TPH-E (ORO)	ND		100 mg/Kg	08/30/12	08/31/12
		Surr: Nonane	0	S51	(62-161) %REC	08/30/12	08/31/12
		TPH-P (GRO)	1,300		480 mg/Kg	08/30/12	08/31/12
		Surr: 1,2-Dichloroethane-d4	73		(70-130) %REC	08/30/12	08/31/12
		Surr: Toluene-d8	110		(70-130) %REC	08/30/12	08/31/12
		Surr: 4-Bromofluorobenzene	92		(70-130) %REC	08/30/12	08/31/12
Client ID :	**AUS-SB-3 (9.5-10)**						
Lab ID :	ARC12082921-09A	TPH-E (DRO)	ND		25 mg/Kg	08/30/12	08/31/12
Date Sampled	08/28/12 13:45	TPH-E (ORO)	ND		100 mg/Kg	08/30/12	08/31/12
		Surr: Nonane	112		(62-161) %REC	08/30/12	08/31/12
		TPH-P (GRO)	ND		5.0 mg/Kg	08/30/12	08/31/12
		Surr: 1,2-Dichloroethane-d4	78		(70-130) %REC	08/30/12	08/31/12
		Surr: Toluene-d8	124		(70-130) %REC	08/30/12	08/31/12
		Surr: 4-Bromofluorobenzene	82		(70-130) %REC	08/30/12	08/31/12
Client ID :	**AUS-SB-4 (1.5-2)**						
Lab ID :	ARC12082921-10A	TPH-E (DRO)	100	L	25 mg/Kg	08/30/12	08/31/12
Date Sampled	08/28/12 14:30	TPH-E (ORO)	140		100 mg/Kg	08/30/12	08/31/12
		Surr: Nonane	102		(62-161) %REC	08/30/12	08/31/12
		TPH-P (GRO)	ND		5.0 mg/Kg	08/30/12	08/31/12
		Surr: 1,2-Dichloroethane-d4	74		(70-130) %REC	08/30/12	08/31/12
		Surr: Toluene-d8	130		(70-130) %REC	08/30/12	08/31/12
		Surr: 4-Bromofluorobenzene	85		(70-130) %REC	08/30/12	08/31/12
Client ID :	**AUS-SB-4 (4.5-5)**						
Lab ID :	ARC12082921-11A	TPH-E (DRO)	48	K	25 mg/Kg	08/30/12	08/31/12
Date Sampled	08/28/12 14:45	TPH-E (ORO)	ND		100 mg/Kg	08/30/12	08/31/12
		Surr: Nonane	127		(62-161) %REC	08/30/12	08/31/12
		TPH-P (GRO)	19		5.0 mg/Kg	08/30/12	08/31/12
		Surr: 1,2-Dichloroethane-d4	77		(70-130) %REC	08/30/12	08/31/12
		Surr: Toluene-d8	107		(70-130) %REC	08/30/12	08/31/12
		Surr: 4-Bromofluorobenzene	109		(70-130) %REC	08/30/12	08/31/12
Client ID :	**AUS-SB-4 (9.5-10)**						
Lab ID :	ARC12082921-12A	TPH-E (DRO)	ND		25 mg/Kg	08/30/12	08/31/12
Date Sampled	08/28/12 15:00	TPH-E (ORO)	ND		100 mg/Kg	08/30/12	08/31/12
		Surr: Nonane	117		(62-161) %REC	08/30/12	08/31/12
		TPH-P (GRO)	ND		5.0 mg/Kg	08/30/12	08/31/12
		Surr: 1,2-Dichloroethane-d4	78		(70-130) %REC	08/30/12	08/31/12
		Surr: Toluene-d8	124		(70-130) %REC	08/30/12	08/31/12
		Surr: 4-Bromofluorobenzene	79		(70-130) %REC	08/30/12	08/31/12

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Client ID :	**AUS-SB-5 (1.5-2)**					
Lab ID :	ARC12082921-13A	TPH-E (DRO)	ND	25 mg/Kg	08/30/12	08/31/12
Date Sampled	08/28/12 10:30	TPH-E (ORO)	ND	100 mg/Kg	08/30/12	08/31/12
		Surr: Nonane	128	(62-161) %REC	08/30/12	08/31/12
		TPH-P (GRO)	44	5.0 mg/Kg	08/30/12	08/31/12
		Surr: 1,2-Dichloroethane-d4	76	(70-130) %REC	08/30/12	08/31/12
		Surr: Toluene-d8	112	(70-130) %REC	08/30/12	08/31/12
		Surr: 4-Bromofluorobenzene	102	(70-130) %REC	08/30/12	08/31/12
Client ID :	**AUS-SB-5 (7.5-8)**					
Lab ID :	ARC12082921-14A	TPH-E (DRO)	ND	25 mg/Kg	08/30/12	08/31/12
Date Sampled	08/28/12 10:45	TPH-E (ORO)	ND	100 mg/Kg	08/30/12	08/31/12
		Surr: Nonane	125	(62-161) %REC	08/30/12	08/31/12
		TPH-P (GRO)	5.0	5.0 mg/Kg	08/30/12	08/31/12
		Surr: 1,2-Dichloroethane-d4	78	(70-130) %REC	08/30/12	08/31/12
		Surr: Toluene-d8	116	(70-130) %REC	08/30/12	08/31/12
		Surr: 4-Bromofluorobenzene	88	(70-130) %REC	08/30/12	08/31/12
Client ID :	**AUS-SB-5 (9.5-10)**					
Lab ID :	ARC12082921-15A	TPH-E (DRO)	ND	25 mg/Kg	08/30/12	08/31/12
Date Sampled	08/28/12 11:00	TPH-E (ORO)	ND	100 mg/Kg	08/30/12	08/31/12
		Surr: Nonane	107	(62-161) %REC	08/30/12	08/31/12
		TPH-P (GRO)	ND	5.0 mg/Kg	08/30/12	08/31/12
		Surr: 1,2-Dichloroethane-d4	81	(70-130) %REC	08/30/12	08/31/12
		Surr: Toluene-d8	122	(70-130) %REC	08/30/12	08/31/12
		Surr: 4-Bromofluorobenzene	79	(70-130) %REC	08/30/12	08/31/12

Diesel Range Organics (DRO) C13-C22

Gasoline Range Organics (GRO) C4-C13

K = DRO concentration may include contributions from lighter-end hydrocarbons that elute in the DRO range.

L = DRO concentration may include contributions from heavier-end hydrocarbons that elute in the DRO range.

Note: Sample was received pre-preserved in Methanol.

Oil Range Organics (ORO) C22-C40+

S51 = Surrogate recovery could not be determined due to the presence of co-eluting hydrocarbons.

Sample results were calculated on a wet weight basis.

ND = Not Detected

Roger Scholl Randy Gardner Walter Hinchman

Roger L. Scholl, Ph.D., Laboratory Director • • Randy Gardner, Laboratory Manager • • Walter Hinchman, Quality Assurance Officer

Sacramento, CA • (916) 366-9089 / Las Vegas, NV • (702) 281-4848 / Carson, CA • (714) 386-2901 / info@alpha-analytical.com

Alpha Analytical, Inc. certifies that the test results meet all requirements of NELAC unless footnoted otherwise.

Statement of Data Authenticity : Alpha Analytical, Inc. attests that the data reported has not been altered an any way.

9/4/12

Report Date

RUSH
WA AMENDED

Billing Information :

CHAIN-OF-CUSTODY RECORD

Alpha Analytical, Inc.
255 Glendale Avenue, Suite 21 Sparks, Nevada 89431-5778
TEL: (775) 355-1044 FAX: (775) 355-0406

WorkOrder : ARCW12082921

Report Due By : 5:00 PM On : 04-Sep-12

Client:
Arcadis-US
2300 Eastlake Ave E. Suite 200

Seattle, WA 98102

Report Attention	Phone Number		EMail Address
Chris Robinson	(206) 726-4728	x	chris.robinson@arcadis-us.com
Jonathan Flomerfelt		x	jonathan.flomerfelt@arcadis-us.com

EDD Required : **No**

Sampled by : Kyle Haslan

PO :

Client's COC # : 60809, 60804 Job : WA000804.0002/KMEP-Harbor Island

Cooler Temp	Samples Received	Date Printed
5 °C	29-Aug-12	**31-Aug-12**

QC Level : S3 = Final Rpt, MBLK, LCS, MS/MSD With Surrogates

Alpha Sample ID	Client Sample ID	Matrix	Collection Date	No. of Bottles Alpha	Sub	TAT	Requested Tests TPH/E_S	TPH/P_S							Sample Remarks
ARC12082921-01A	AUS-SB-1 (1.5-2)	SO	08/28/12 11:30	2	0	3	NWTPH-Dx	NWTPH-Gx							One 4 oz jar, one MeOH voa
ARC12082921-02A	AUS-SB-1 (5-5.5)	SO	08/28/12 11:45	2	0	3	NWTPH-Dx	NWTPH-Gx							One 4 oz jar, one MeOH voa
ARC12082921-03A	AUS-SB-1 (9.5-10)	SO	08/28/12 12:00	2	0	3	NWTPH-Dx	NWTPH-Gx							One 4 oz jar, one MeOH voa
ARC12082921-04A	AUS-SB-2 (1.5-2)	SO	08/28/12 09:15	2	0	3	NWTPH-Dx	NWTPH-Gx							One 4 oz jar, one MeOH voa
ARC12082921-05A	AUS-SB-2 (6.5-7)	SO	08/28/12 09:30	2	0	3	NWTPH-Dx	NWTPH-Gx							One 4 oz jar, one MeOH voa
ARC12082921-06A	AUS-SB-2 (9.5-10)	SO	08/28/12 09:45	2	0	3	NWTPH-Dx	NWTPH-Gx							One 4 oz jar, one MeOH voa
ARC12082921-07A	AUS-SB-3 (1.5-2)	SO	08/28/12 13:15	2	0	3	NWTPH-Dx	NWTPH-Gx							One 4 oz jar, one MeOH voa
ARC12082921-08A	AUS-SB-3 (4.5-5)	SO	08/28/12 13:30	2	0	3	NWTPH-Dx	NWTPH-Gx							One 4 oz jar, one MeOH voa
ARC12082921-09A	AUS-SB-3 (9.5-10)	SO	08/28/12 13:45	2	0	3	NWTPH-Dx	NWTPH-Gx							One 4 oz jar, one MeOH voa
ARC12082921-10A	AUS-SB-4 (1.5-2)	SO	08/28/12 14:30	2	0	3	NWTPH-Dx	NWTPH-Gx							One 4 oz jar, one MeOH voa

Comments: 72 HR TAT. Security seals intact. Frozen ice. Analyze all samples listed on COC and analyze GRO from MeOH voas, per email from Jonathan. Amended 8/31/12 08:30 to add COC#, due to login error.KM :

	Signature	Print Name	Company	Date/Time
Logged in by:	K Murray	K Murray	Alpha Analytical, Inc.	8/31/12 0830

NOTE: Samples are discarded 60 days after results are reported unless other arrangements are made. Hazardous samples will be returned to client or disposed of at client expense.
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Matrix Type : AQ(Aqueous) AR(Air) SO(Soil) WS(Waste) DW(Drinking Water) OT(Other) Bottle Type: L-Liter V-Voa S-Soil Jar O-Orbo T-Tedlar B-Brass P-Plastic OT-Other

RUSH
WAAMENDED

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Alpha Sample ID	Client Sample ID	Matrix	Collection Date	No. of Bottles Alpha	Sub	TAT	Requested Tests TPH/E_S	TPH/P_S							Sample Remarks
ARC12082921-11A	AUS-SB-4 (4.5-5)	SO	08/28/12 14:45	2	0	3	NWTPH-Dx	NWTPH-Gx							One 4 oz jar, one MeOH voa
ARC12082921-12A	AUS-SB-4 (9.5-10)	SO	08/28/12 15:00	2	0	3	NWTPH-Dx	NWTPH-Gx							One 4 oz jar, one MeOH voa
ARC12082921-13A	AUS-SB-5 (1.5-2)	SO	08/28/12 10:30	2	0	3	NWTPH-Dx	NWTPH-Gx							One 4 oz jar, one MeOH voa
ARC12082921-14A	AUS-SB-5 (7.5-8)	SO	08/28/12 10:45	2	0	3	NWTPH-Dx	NWTPH-Gx							One 4 oz jar, one MeOH voa
ARC12082921-15A	AUS-SB-5 (9.5-10)	SO	08/28/12 11:00	2	0	3	NWTPH-Dx	NWTPH-Gx							One 4 oz jar, one MeOH voa

Comments: 72 HR TAT. Security seals intact. Frozen ice. Analyze all samples listed on COC and analyze GRO from MeOH voas, per email from Jonathan. Amended 8/31/12 08:30 to add COC#, due to login error.KM :

	Signature	Print Name	Company	Date/Time
Logged in by:	K Murray	K Murray	Alpha Analytical, Inc.	8/31/12 0830

NOTE: Samples are discarded 60 days after results are reported unless other arrangements are made. Hazardous samples will be returned to client or disposed of at client expense.
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Matrix Type : AQ(Aqueous) AR(Air) SO(Soil) WS(Waste) DW(Drinking Water) OT(Other) Bottle Type: L-Liter V-Voa S-Soil Jar O-Orbo T-Tedlar B-Brass P-Plastic OT-Other

Billing Information :

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WA RUSH

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Seattle, WA 98102

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Chris Robinson	(206) 726-4728	x	chris.robinson@arcadis-us.com
Jonathan Flomerfelt		x	jonathan.flomerfelt@arcadis-us.com

EDD Required : **No**

Sampled by : Kyle Haslan

PO :

Client's COC # : 60809 Job : WA000804.0002/KMEP-Harbor Island

Cooler Temp	Samples Received	Date Printed
5 °C	29-Aug-12	**29-Aug-12**

QC Level : S3 = Final Rpt, MBLK, LCS, MS/MSD With Surrogates

Alpha Sample ID	Client Sample ID	Matrix	Collection Date	No. of Bottles Alpha	Sub	TAT	Requested Tests TPH/E_S	TPH/P_S							Sample Remarks
ARC12082921-01A	AUS-SB-1 (1.5-2)	SO	08/28/12 11:30	2	0	3	NWTPH-Dx	NWTPH-Gx							One 4 oz jar, one MeOH voa
ARC12082921-02A	AUS-SB-1 (5-5.5)	SO	08/28/12 11:45	2	0	3	NWTPH-Dx	NWTPH-Gx							One 4 oz jar, one MeOH voa
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ARC12082921-04A	AUS-SB-2 (1.5-2)	SO	08/28/12 09:15	2	0	3	NWTPH-Dx	NWTPH-Gx							One 4 oz jar, one MeOH voa
ARC12082921-05A	AUS-SB-2 (6.5-7)	SO	08/28/12 09:30	2	0	3	NWTPH-Dx	NWTPH-Gx							One 4 oz jar, one MeOH voa
ARC12082921-06A	AUS-SB-2 (9.5-10)	SO	08/28/12 09:45	2	0	3	NWTPH-Dx	NWTPH-Gx							One 4 oz jar, one MeOH voa
ARC12082921-07A	AUS-SB-3 (1.5-2)	SO	08/28/12 13:15	2	0	3	NWTPH-Dx	NWTPH-Gx							One 4 oz jar, one MeOH voa
ARC12082921-08A	AUS-SB-3 (4.5-5)	SO	08/28/12 13:30	2	0	3	NWTPH-Dx	NWTPH-Gx							One 4 oz jar, one MeOH voa
ARC12082921-09A	AUS-SB-3 (9.5-10)	SO	08/28/12 13:45	2	0	3	NWTPH-Dx	NWTPH-Gx							One 4 oz jar, one MeOH voa
ARC12082921-10A	AUS-SB-4 (1.5-2)	SO	08/28/12 14:30	2	0	3	NWTPH-Dx	NWTPH-Gx							One 4 oz jar, one MeOH voa

Comments: 72 HR TAT. Security seals intact. Frozen ice. Analyze all samples listed on COC and analyze GRO from MeOH voas, per email from Jonathan. :

	Signature	Print Name	Company	Date/Time
Logged in by:	K Murray	K Murray	Alpha Analytical, Inc.	8/29/12 1530

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Matrix Type : AQ(Aqueous) AR(Air) SO(Soil) WS(Waste) DW(Drinking Water) OT(Other) Bottle Type: L-Liter V-Voa S-Soil Jar O-Orbo T-Tedlar B-Brass P-Plastic OT-Other

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ARC12082921-12A	AUS-SB-4 (9.5-10)	SO	08/28/12 15:00	2	0	3	NWTPH-Dx	NWTPH-Gx							One 4 oz jar, one MeOH voa
ARC12082921-13A	AUS-SB-5 (1.5-2)	SO	08/28/12 10:30	2	0	3	NWTPH-Dx	NWTPH-Gx							One 4 oz jar, one MeOH voa
ARC12082921-14A	AUS-SB-5 (7.5-8)	SO	08/28/12 10:45	2	0	3	NWTPH-Dx	NWTPH-Gx							One 4 oz jar, one MeOH voa
ARC12082921-15A	AUS-SB-5 (9.5-10)	SO	08/28/12 11:00	2	0	3	NWTPH-Dx	NWTPH-Gx							One 4 oz jar, one MeOH voa

Comments: 72 HR TAT. Security seals intact. Frozen ice. Analyze all samples listed on COC and analyze GRO from MeOH voas, per email from Jonathan. :

	Signature	Print Name	Company	Date/Time
Logged in by:	K Murray	K Murray	Alpha Analytical, Inc.	8/29/12 1530

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Matrix Type : AQ(Aqueous) AR(Air) SO(Soil) WS(Waste) DW(Drinking Water) OT(Other) Bottle Type: L-Liter V-Voa S-Soil Jar O-Orbo T-Tedlar B-Brass P-Plastic OT-Other

ARCADIS

Appendix C

Design Calculations

Treatment Area			Notes
Width	100	ft	Antea Workplan
Length	300	ft	Antea Workplan
Smear Zone	8	ft	Antea FS
Impacted Saturated Thickness	10	ft	Antea Workplan
Assumed Total Porosity	0.3		Assumed
Assumed Mobile Porosity	0.15		Assumed
TPH Contour	1.0	mg/L	
TPH Mass - Soil			
Average Soil TPH concentration	1,500	mg/kg	
Assumed Soil Density	100	lb/cf	
Total Soil Volume	240000	ft^3	
Estimated TPH Mass	36,000	lbs	
TPH Mass - Dissolved			
Estimated Average TPH-G Conc.	2.4	mg/L	TPH-D and O are ND
Target TPH-G Conc.	1.0	mg/L	
Estimated Mobile PV	336,600	gallons	Estimated using the saturated thickness
Estimated TPH-G Dissolved Mass	4	lbs	
Estimated Total TPH Mass	**36004**	lbs	
Sulfate Demand			
Sulfate:TPH Stochiometric Ratio	4.0		
Total Sulfate Demand	144016	lbs	
Total Sulfate Demand	**369,514**	lbs Epsom Salt	Molecular Weights on next page
Total Sulfate Demand	258,077	lbs Gypsum	Molecular Weights on next page
Design - Surface Application (Gypsum)			
Total Sulfate Demand	258,077	lbs Gypsum	
Assumed Gypsum Density	80	lbs/ft^3	
Total Gypsum Required	3226	ft^3	
Applied Area	21000	ft^2	Assume gypsum could be applied on 70% of target treatment area
Thickness of Gypsum Required	**0.15**	ft	
Surface Application (Epsom)			
Target insitu sulfate conc.	1.0	g/L	
Total Sulfate Required	16255	lbs as sulfate	
Total Epsom Required	41,706	lbs	
Assumed Epsom Density	80	lbs/ft^3	
Total Epsom Required	521	ft^3	
Applied Area	21000	ft^2	Assume gypsum could be applied on 70% of target treatment area
Thickness of Epsom Required	**0.02**	ft	

ARCADIS

Appendix D

Reagent MSDSs

MATERIAL SAFETY DATA SHEET
Agri Marketing, Inc dba USA Gypsum
1802 Texter Mountain Road,
Rheinholds, PA 17569
717-335-0379

I PRODUCT IDENTIFICATION

This material safety data sheet is applicable to the following products:

Agricultural Gypsum

Chemical Family: Chemical Salt Formula: $CaSO_4 \bullet 2H_2O$
Chemical Name: Calcium Sulfate Dihydrate

II HAZARDOUS INGREDIENTS

Contains: Chemical Identity	CAS-NO	OSHA PEL (mg/m^3)	ACGIH TLV (mg/m^3)
Gypsum	10101-41-4	5	10[A]
Quartz[B]	14808-60-7	[C]	0.1

Contains no asbestos. HMIS Hazard Class No. 1, 0, 0
[A] Total dust, all others are respirable dust.
[B] Present as a naturally occurring component of minerals. See Sec. III HEALTH HAZARD DATA
[C] Respirable dust, use the formula: $\frac{10\ mg/m^3}{\%\ SiO_2 + 2}$

Appearance and Odor
A white solid/powder with no odor.

Fire Hazard Data - Not combustible. NFPA Hazard Class No. 1, 0, 0

Extinguishing Media
Dry chemical, foam, water, fog or spray.

Special Firefighting Procedures
Wear full protective equipment and an approved pressure demand self-contained breathing apparatus.

Reactivity Data
Gypsum is stable and hazardous polymerization will not occur. When heated to decomposition oxides of sulfur will be released.

III HEALTH HAZARD DATA

Quartz (crystalline silica) - The International Agency for Research on Cancer (IARC) classifies crystalline silica inhaled in the form of quartz or cristobalite from occupational sources as carcinogenic to humans, Group 1. The National Toxicology Program (NTP) classifies respirable crystalline silica as a substance which may be reasonably anticipated to be a carcinogen. OSHA does not regulate crystalline silica as a human carcinogen.

It is recommended that a NIOSH approved respirator, for toxic dusts, be worn whenever working with product results in airborne dust exposure exceeding the prescribed limits.

Skin Contact

Continued and prolonged contact may result in dry skin.

Eye Contact

Direct contact may cause mechanical irritation.

Inhalation

Target Organ: respiratory system

Signs and Symptoms of Exposure to Airborne Dust

Continued and prolonged exposure to airborne dust concentrations in excess of the PEL/TLV may result in cough, dyspnea, wheezing, and impaired pulmonary function.

Medical Conditions Generally Aggravated by Exposure

Overexposure would generally aggravate respiratory system dysfunctions.

First Aid Procedures

Eye: Immediately flush eyes with water for 15 minutes and get medical attention.

Skin: Flush and wash skin with soap and water. Get medical attention if irritation persists.

Breathing: Move the exposed person to fresh air at once. If not breathing initiate pulmonary resuscitation. Get medical attention.

IV PRECAUTIONS for SAFE HANDLING

Steps to be Taken in Case Material is Released or Spilled

Shovel or scoop up back into container for use if possible or disposal.

Waste Disposal Method

Not a hazardous waste. Dispose of in accordance with applicable federal, state, and local regulations.

Precautions to be Taken in Handling and Storing

Keep dry to preserve usefulness.

V CONTROL MEASURES

Work/Hygiene Practices

Avoid creating dust.

Ventilation

Provide ventilation to maintain a dust level below the PEL/TLV.

Respiratory Protection

A NIOSH approved respirator for toxic dusts is recommended if the PEL/TLV is exceeded.

Eye Protection

Safety glasses or goggles.

VI REGULATORY INFORMATION

SARA Title III Section 313 Ingredients

None at or above the de minimus level.

Disclaimer of Liability:

As the conditions or methods of use are beyond our control, we do not assume any responsibility and expressly disclaim any liability for any use of the material. Information contained herein is believed to be true and accurate, but all statements or suggestions are made without any warranty, express or implied, regarding accuracy of the information, the hazards connected with the use of the material or the results to be obtained for the use thereof.

Univar USA Inc Material Safety Data Sheet

MSDS No:	MZM0234
Version No:	006 2008-08-01
Order No:	

Univar USA Inc., 17425 NE Union Hill Rd., Redmond WA 98052
(425) 889 3400

Emergency Assistance

For emergency assistance involving chemicals call
Chemtrec - (800) 424-9300

The Version Date and Number for this MSDS is : 08/01/2008 - #006

PRODUCT NAME: MAGNESIUM SULFATE

MSDS NUMBER: MZM0234

DATE ISSUED: 08/01/2008

SUPERSEDES: 08/22/2005

ISSUED BY: 008614

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MAGNESIUM SULFATE

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1. PRODUCT IDENTIFICATION

SYNONYMS: MAGNESIUM SULFATE (1:1) HEPTAHYDRATE; EPSOM SALTS;
SULFURIC ACID, MAGNESIUM SALT (1:1), HEPTAHYDRATE;
MAGNESIUM SULFATE, 7- HYDRATE
CAS NO: 7487-88-9 (ANHYDROUS) 10034-99-8 (HEPTAHYDRATE)
MOLECULAR WEIGHT: 246.47
CHEMICAL FORMULA: MGSO4.7H2O

Distributed by:
Univar USA Inc.
17425 NE Union Hill Rd.
Redmond, WA 98052
425-889-3400

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2. COMPOSITION/INFORMATION ON INGREDIENTS

INGREDIENT	CAS NO	PERCENT	HAZARDOUS
MAGNESIUM SULFATE ANHYDROUS	7487-88-9	99 - 100%	YES

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3. HAZARDS IDENTIFICATION

EMERGENCY OVERVIEW

CAUTION! MAY BE HARMFUL IF SWALLOWED.

POTENTIAL HEALTH EFFECTS

INHALATION:
DUST MAY BE SLIGHTLY IRRITATING. SORE THROAT OR COUGHING MAY OCCUR.

INGESTION:
SINCE MAGNESIUM SALTS ARE SLOWLY ABSORBED, ABDOMINAL PAIN, VOMITING AND DIARRHEA MAY BE THE ONLY SYMPTOMS. HOWEVER, IF ELIMINATION IS BLOCKED BY BOWEL BLOCKAGE OR OTHER REASONS, CNS DEPRESSION, LACK OF REFLEXES, HYPOCALCEMIA (DEFICIENCY OF CALCIUM IN THE BLOOD) MAY OCCUR.

SKIN CONTACT:
NO ADVERSE EFFECTS EXPECTED BUT MAY CAUSE MINOR SKIN IRRITATION.

EYE CONTACT:
NO ADVERSE EFFECTS EXPECTED BUT DUST MAY CAUSE MECHANICAL IRRITATION.

CHRONIC EXPOSURE:
NO INFORMATION FOUND.

AGGRAVATION OF PRE-EXISTING CONDITIONS:
NO INFORMATION FOUND.

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4. FIRST AID MEASURES

INHALATION:
REMOVE TO FRESH AIR. GET MEDICAL ATTENTION FOR ANY BREATHING DIFFICULTY.

INGESTION:
GIVE SEVERAL GLASSES OF WATER TO DRINK TO DILUTE. IF LARGE AMOUNTS WERE SWALLOWED, GET MEDICAL ADVICE.

SKIN CONTACT:
REMOVE ANY CONTAMINATED CLOTHING. WASH SKIN WITH SOAP AND WATER FOR AT LEAST 15 MINUTES. GET MEDICAL ATTENTION IF IRRITATION DEVELOPS OR PERSISTS.

EYE CONTACT:
WASH THOROUGHLY WITH RUNNING WATER. GET MEDICAL ADVICE IF IRRITATION DEVELOPS.

NOTE TO PHYSICIAN:
IV ADMINISTRATION OF CALCIUM GLUCONATE WILL PARTIALLY REVERSE THE EFFECTS OF ACUTE MAGNESIUM TOXICITY. VENTRICULAR SUPPORT WITH CALCIUM CHLORIDE INFUSION AND MANNITOL FORCED DIURESIS HAS ALSO BEEN SUCCESSFUL.

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5. FIRE FIGHTING MEASURES

FIRE:
NOT CONSIDERED TO BE A FIRE HAZARD.

EXPLOSION:
NOT CONSIDERED TO BE AN EXPLOSION HAZARD.

FIRE EXTINGUISHING MEDIA:
USE ANY MEANS SUITABLE FOR EXTINGUISHING SURROUNDING FIRE.

SPECIAL INFORMATION:
USE PROTECTIVE CLOTHING AND BREATHING EQUIPMENT APPROPRIATE FOR THE SURROUNDING FIRE.

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6. ACCIDENTAL RELEASE MEASURES

VENTILATE AREA OF LEAK OR SPILL. WEAR APPROPRIATE PERSONAL PROTECTIVE EQUIPMENT AS SPECIFIED IN SECTION 8. SPILLS: SWEEP UP AND CONTAINERIZE FOR RECLAMATION OR DISPOSAL. VACUUMING OR WET SWEEPING MAY BE USED TO AVOID DUST DISPERSAL.

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7. HANDLING AND STORAGE

KEEP IN A TIGHTLY CLOSED CONTAINER, STORED IN A COOL, DRY, VENTILATED AREA. PROTECT AGAINST PHYSICAL DAMAGE. ISOLATE FROM INCOMPATIBLE SUBSTANCES. CONTAINERS OF THIS MATERIAL MAY BE HAZARDOUS WHEN EMPTY SINCE THEY RETAIN PRODUCT RESIDUES (DUST, SOLIDS); OBSERVE ALL WARNINGS AND PRECAUTIONS LISTED FOR THE PRODUCT.

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8. EXPOSURE CONTROLS/PERSONAL PROTECTION

AIRBORNE EXPOSURE LIMITS:
NONE ESTABLISHED.

VENTILATION SYSTEM:
A SYSTEM OF LOCAL AND/OR GENERAL EXHAUST IS RECOMMENDED TO KEEP EMPLOYEE EXPOSURES AS LOW AS POSSIBLE. LOCAL EXHAUST VENTILATION IS GENERALLY PREFERRED BECAUSE IT CAN CONTROL THE EMISSIONS OF THE CONTAMINANT AT ITS SOURCE, PREVENTING DISPERSION OF IT INTO THE GENERAL WORK AREA. PLEASE REFER TO THE ACGIH DOCUMENT, "INDUSTRIAL VENTILATION, A MANUAL OF RECOMMENDED PRACTICES", MOST RECENT EDITION, FOR DETAILS.

PERSONAL RESPIRATORS (NIOSH APPROVED):
FOR CONDITIONS OF USE WHERE EXPOSURE TO DUST OR MIST IS APPARENT AND ENGINEERING CONTROLS ARE NOT FEASIBLE, A PARTICULATE RESPIRATOR (NIOSH TYPE

Annotation:
N95 OR BETTER FILTERS) MAY BE WORN. IF OIL PARTICLES (E.G. LUBRICANTS, CUTTING FLUIDS, GLYCERINE, ETC.) ARE PRESENT, USE A NIOSH TYPE R OR P FILTER. FOR EMERGENCIES OR INSTANCES WHERE THE EXPOSURE LEVELS ARE NOT KNOWN, USE A FULL-FACE POSITIVE-PRESSURE, AIR-SUPPLIED RESPIRATOR. WARNING: AIR-PURIFYING RESPIRATORS DO NOT PROTECT WORKERS IN OXYGEN-DEFICIENT ATMOSPHERES.

SKIN PROTECTION:
WEAR PROTECTIVE GLOVES AND CLEAN BODY-COVERING CLOTHING.

EYE PROTECTION:
USE CHEMICAL SAFETY GOGGLES. MAINTAIN EYE WASH FOUNTAIN AND QUICK-DRENCH FACILITIES IN WORK AREA.

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9. PHYSICAL AND CHEMICAL PROPERTIES

APPEARANCE:
TRANSPARENT CRYSTALS, OR WHITE POWDER.

BOILING POINT:
NOT APPLICABLE.

ODOR:
ODORLESS.

MELTING POINT:
1124C (2055F) DECOMPOSES. LOSES ALL WATERS OF HYDRATION @ 250C (482F)

SOLUBILITY:
VERY SOLUBLE IN WATER.

VAPOR DENSITY (AIR=1):
NO INFORMATION FOUND.

DENSITY:
1.67 G/ML @ 4C

VAPOR PRESSURE (MM HG):
NO INFORMATION FOUND.

PH:
AQUEOUS SOLUTION IS NEUTRAL OR SLIGHTLY ACID.

EVAPORATION RATE (BUAC=1):
NO INFORMATION FOUND.

% VOLATILES BY VOLUME @ 21C (70F):
0

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10. STABILITY AND REACTIVITY

STABILITY:
STABLE UNDER ORDINARY CONDITIONS OF USE AND STORAGE. LOSES SOME MOISTURE ON EXPOSURE TO DRY AIR AT ROOM TEMPERATURES.

HAZARDOUS DECOMPOSITION PRODUCTS:
OXIDES OF SULFUR AND THE CONTAINED METAL.

HAZARDOUS POLYMERIZATION:

WILL NOT OCCUR.

INCOMPATIBILITIES:
ETHOXY ETHYL ALCOHOLS, ARSENATES, PHOSPHATES, TARTRATES, LEAD, BARIUM, STRONTIUM, AND CALCIUM

CONDITIONS TO AVOID:
HEAT, MOISTURE, INCOMPATIBLES.

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11. TOXICOLOGICAL INFORMATION

NO LD50/LC50 INFORMATION FOUND RELATING TO NORMAL ROUTES OF OCCUPATIONAL EXPOSURE. INVESTIGATED AS A MUTAGEN, REPRODUCTIVE EFFECTOR.

--------\CANCER LISTS\----------

	---NTP CARCINOGEN---		
INGREDIENT	KNOWN	ANTICIPATED	IARC CATEGORY
MAGNESIUM SULFATE ANHYDROUS (7487-88-9)	NO	NO	NONE

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12. ECOLOGICAL INFORMATION

ENVIRONMENTAL FATE:
NO INFORMATION FOUND.

ENVIRONMENTAL TOXICITY:
NO INFORMATION FOUND.

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13. DISPOSAL CONSIDERATIONS

WHATEVER CANNOT BE SAVED FOR RECOVERY OR RECYCLING SHOULD BE MANAGED IN AN APPROPRIATE AND APPROVED WASTE DISPOSAL FACILITY. PROCESSING, USE OR CONTAMINATION OF THIS PRODUCT MAY CHANGE THE WASTE MANAGEMENT OPTIONS. STATE AND LOCAL DISPOSAL REGULATIONS MAY DIFFER FROM FEDERAL DISPOSAL REGULATIONS.

DISPOSE OF CONTAINER AND UNUSED CONTENTS IN ACCORDANCE WITH FEDERAL, STATE AND LOCAL REQUIREMENTS.

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14. TRANSPORT INFORMATION

NOT REGULATED.

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15. REGULATORY INFORMATION

--------\CHEMICAL INVENTORY STATUS - PART 1\--------------------------------

INGREDIENT	TSCA	EC	JAPAN	AUSTRALIA
MAGNESIUM SULFATE ANHYDROUS (7487-88-9)	YES	YES	YES	YES

--------\CHEMICAL INVENTORY STATUS - PART 2\--------------------------------

--CANADA--

INGREDIENT	KOREA	DSL	NDSL	PHIL.
MAGNESIUM SULFATE ANHYDROUS (7487-88-9)	YES	YES	NO	YES

-------\FEDERAL, STATE & INTERNATIONAL REGULATIONS - PART 1\---------------

	-SARA 302-		------SARA 313-----	
INGREDIENT	RQ	TPQ	LIST	CHEMICAL CATG
MAGNESIUM SULFATE ANHYDROUS (7487-88-9)	NO	NO	NO	NO

--------\FEDERAL, STATE & INTERNATIONAL REGULATIONS - PART 2\--------------

		-RCRA-	-TSCA-
INGREDIENT	CERCLA	261.33	8(D)
MAGNESIUM SULFATE ANHYDROUS (7487-88-9)	NO	NO	NO

CHEMICAL WEAPONS CONVENTION: NO TSCA 12(B): NO CDTA: NO
SARA 311/312: ACUTE: YES CHRONIC: NO FIRE: NO PRESSURE: NO
REACTIVITY: NO (PURE / SOLID)

AUSTRALIAN HAZCHEM CODE: NONE ALLOCATED.
POISON SCHEDULE: NONE ALLOCATED.

WHMIS: THIS MSDS HAS BEEN PREPARED ACCORDING TO THE HAZARD CRITERIA OF
THE CONTROLLED PRODUCTS REGULATIONS (CPR) AND THE MSDS CONTAINS
ALL OF THE INFORMATION REQUIRED BY THE CPR.

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16. OTHER INFORMATION

NFPA RATINGS:
HEALTH: 1 FLAMMABILITY: 0 REACTIVITY: 0

Univar USA Inc Material Safety Data Sheet

For Additional Information contact MSDS Coordinator during business hours, Pacific time: (425) 889-3400

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