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Focused Feasibility Study

TX-03A Area
Shell Harbor Island Terminal

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List of Acronyms and Abbreviations

ARARs	applicable, relevant, and appropriate requirements
AS	air sparging
AST	above ground storage tank
AWQC	ambient water quality criteria
bgs	below ground surface
BP	British Petroleum
BTEX	benzene, toluene, ethylbenzene, total xylenes
CAA	cleanup action alternative
cfm	cubic feet per minute
cm/s	centimeters per second
CFR	Code of Federal Regulations
CWA	Clean Water Act
DCA	disproportionate Cost Analysis
DO	dissolved oxygen
EPA	Environmental Protection Agency
FE2+	Ferrous Iron
FFS	focused feasibility study
GAC	granular activated carbon
gpm	gallons per minute
mg/kg	milligrams per kilogram
mg/L	milligrams per liter
MNA	monitored natural attenuation
MTCA	Model Toxics Control Act
mV	millivolts
NAP	natural attenuation parameters
NPDES	national pollutant discharge elimination system
NPV	net present value
NRWQC	National Recommended Water Quality Criteria
ORP	oxidation reduction potential
POC	point of compliance
POTWs	publicly owned treatment works
PSCAA	Puget Sound Clean Air Agency
psi	pounds per square inch
PVC	poly-vinyl chloride
RAOs	remedial action objectives
RCP	reinforced concrete pipe
RCRA	Resource Conservation Recovery Act
RI	remedial investigation
SVE	soil vapor extraction
TF-OU2	Tank Farms Operable Unit 2
TPH-D	total petroleum hydrocarbons as diesel
TPH-G	total petroleum hydrocarbons as gasoline
µg/kg	micrograms per kilogram
US	United States
VOCs	volatile organic compounds
WAC	Washington Administrative Code
WC	water column

1 Introduction

AECOM has prepared this Focused Feasibility Study (FFS) on behalf of Shell Oil Company (Shell) for the TX-03A Area in the Main Tank Farm at the Shell Harbor Island Terminal (Terminal) in Seattle, Washington (the site). This FFS evaluates “contingency” remediation technologies to expedite the cleanup process and fulfill the requirements established in the current Compliance Monitoring Plan (Equilon, 1998) for the TX-03A Area. The objectives of the FFS include the following:

1. Develop and evaluate a focused group of cleanup action alternatives for petroleum cleanup sites, generated at the site in accordance with Washington Administrative Code (WAC) 173-340-360 and considering the results of recent pilot testing conducted in the TX-03A Area, and,
2. Select the best cleanup action alternative (CAA) to expedite cleanup of the petroleum hydrocarbon contamination at the Terminal to meet the requirements of the Consent Decree under which the site is regulated (Ecology, 1998).

1.1 Report Organization

This report is organized into the following sections:

- Section 2 - Project Background - describes the background, including current site characteristics of geology, hydrogeology, and nature and extent of contamination in soil and groundwater.
- Section 3 - Regulatory Framework - describes potentially applicable and relevant requirements for implementing remedial action in the TX-03A Area.
- Section 4 - Description of Cleanup Action Alternatives - describes the details of four groundwater cleanup action alternatives identified for the TX-03A Area, including continuing the current long-term monitoring program (CAA-1), bio-sparging with two options, including without and with a soil vapor extraction (SVE) system (CAA-2), enhanced biological treatment (CAA-3), and pumping and treatment (CAA-4).
- Section 5 - Evaluation of Cleanup Action Alternatives - presents an evaluation and comparative analysis of the CAAs, using the site-specific cleanup levels established by Ecology for Harbor Island.
- Section 6 - References - lists references cited in the report.

2 Project Background

The Shell Harbor Island Terminal is a petroleum distribution facility located on Harbor Island, which is approximately one mile southwest of downtown Seattle at the mouth of the Duwamish River (Figure 1). The site is comprised of three parcels located at 2555 13th Avenue SW, 1835 13th Avenue SW, and 1711 13th Avenue SW. These parcels are designated as the Main Tank Farm, North Tank Farm, and Shoreline Manifold Area, respectively. The FFS concentrates on the TX-03A Area of the Main Tank Farm. Additional information about the TX-03A Area is summarized in the following sections.

2.1 TX-03A Area Description

The TX-03A Area (Figure 2) is located between the Main Tank Farm and North Tank Farm; this area is also known as the North Boundary Area. The TX-03A Area is located on the northern side of the Main Tank Farm dike wall and includes a City of Seattle public parking lot (herein referred to as the public parking lot). A pipeline that connects two British Petroleum (BP) tank farms (the Olympic Pipeline) runs west to east under the public parking lot. The TX-03A Area abuts SW Florida Street (16th Ave SW). A stormwater pipe runs east to west under Florida Street and receives stormwater from three active catch basins located in the public parking lot.

2.2 TX-03A Area Background

Aboveground storage tanks (ASTs) 31538 and 113000 are located south of monitoring well TX-03A within the Main Tank Farm. According to Terminal personnel, these two ASTs have stored unleaded gasoline since the early 1990s.

In 1991, monitoring well TX-03 was installed as part the United States (US) Environmental Protection Agency's (EPA's) evaluation of the North Boundary Area (Figure 2). TX-03 was abandoned during the improvements to SW Florida Street and the public parking lot in 2001. Monitoring well TX-03A was installed to replace TX-03 in 2002 and is located approximately 40 feet southwest of the abandoned TX-03 well location. Monitoring well TX-03 and later TX-03A were monitored frequently from 1993 to the present.

In 2003, petroleum-impacted soil was excavated from the Main Tank Farm, in the area northwest of AST 31538 to remove soil which contained total petroleum hydrocarbons as gasoline (TPH-G) at concentrations greater than 20,000 milligrams per kilogram (mg/kg) (RETEC, 2004). Soil was excavated to a depth of approximately eight feet below ground surface (bgs). Site-wide quarterly monitoring was conducted until 2006 in accordance with the Compliance Monitoring Plan. Since analyte concentrations in groundwater in the North Boundary Area continued to exceed the Consent Decree cleanup levels downgradient of the 2003 remedial soil excavation, the contingency plan was implemented in accordance with the site Compliance Monitoring Plan (EMCON, 1999). Between 2006 and 2008 monitoring occurred in accordance with proposed changes (RETEC, 2006a and RETEC, 2006b).

Natural attenuation monitoring was conducted at background monitoring wells TES-MW-1 and MW-101 and one well in the plume, TX-03A, since 2004. In April 2008, the monitoring program was changed in accordance with the Proposed Changes to Shell's Seattle Terminal Compliance Monitoring Plan and subsequent email correspondence with Ecology (URS, 2008).

Concentrations of TPH-G and benzene, toluene, ethylbenzene, and total xylenes (BTEX) in groundwater at monitoring well TX-03A have been generally declining since peak concentrations were detected in October 2002, but the concentrations were above the cleanup levels for TPH-G and benzene. A limited soil and groundwater investigation conducted in 2010 delineated the extent of petroleum hydrocarbons in soil and groundwater in the North Boundary Area (URS, 2010).

In 2010, during the third EPA 5-Year review of the Harbor Island Superfund Site Tank Farms Operable Unit 2 (TF-OU2), the North Boundary Area was identified for additional evaluation due to groundwater exceedances stipulated in the Consent Decree (EPA, 2010). In response to the EPA 5-Year review, Shell completed a supplemental soil and groundwater investigation, as recommended in 2009 to assess the groundwater impacts in the North Boundary Area (Ecology, 2011).

Monitoring wells MW-301 through MW-304 were installed within the TX-03A Area in November 2011 (URS, 2012a) to further assess the TX-03A Area. Monitoring wells MW-307 through MW-310 were installed in November 2012 in the TX-03A Area. A soil gas assessment was conducted in May 2013, in accordance with the approved Soil Gas Assessment Work Plan for the TX-03A Area (URS, 2013a), to delineate the extent of petroleum hydrocarbon impacts in the soil and source of groundwater impacts in the Main Tank Farm. Based on routine monitoring in the TX-03A Area, it was noted that during seasonal high groundwater elevations, groundwater was potentially intersecting the City of Seattle stormwater system mainline, resulting in a preferential groundwater flow pathway along the mainline.

In fall 2014, a video survey was conducted of the adjacent City of Seattle stormwater system mainline, located adjacent to the TX-03A area under Florida Street. The stormwater system mainline was found to be approximately 24 inches in diameter and located approximately 7 feet bgs. The depth to groundwater in the TX-03A area ranges between 5 to 7 feet bgs (URS, 2014a). The video survey observed water infiltrating the stormwater system mainline underneath Florida Street in three places. A 2014 dry weather sampling event concluded that the 24-inch reinforced concrete pipe (RCP) was compromised at several locations, creating a pathway for groundwater to enter into the storm water system and causing a potential risk to utility workers (URS, 2014). Shell has agreed to voluntarily repair the City of Seattle stormwater system mainline to mitigate the potential risk. AECOM conducted stormwater system mainline, catch basins, and lateral pipe clean-out activities and has prepared the Draft Storm Water System Pipe Repair Work Plan for the recommended repairs along the stormwater system mainline, which is currently being reviewed by the City of Seattle.

Two downgradient monitoring wells, MW-311 and MW-312, were installed in October 2014 to delineate the extent of petroleum hydrocarbon constituent impacts in the groundwater downgradient of the TX-03A Area. Also, in 2015, EPA conducted a fourth 5-Year review of the Harbor Island Superfund Site Tank Farms Operable Unit 2 (TF-OU2). The TX-03A Area was identified for active remediation due to groundwater exceedances above the concentrations stipulated in the Consent Decree (EPA, 2010). In response to the EPA 5-Year review, Shell has prepared this FFS, to assess the most recent results for the TX-03A Area and determine if active remediation is warranted.

2.3 Geology and Hydrogeology

The site geology and hydrogeology are described in the following sections.

2.3.1 Geology

The 405-acre Harbor Island was constructed during the early 1900s in an area consisting of intertidal wetlands at the mouth the Duwamish River. The island was created using sediments dredged from the lower Duwamish River and West Waterway (KJC, 1990).

Soil underlying the site consists of imported soil and dredge sands overlying native estuarine deposits (LCI and EMCON, 1997). The uppermost fill consists of coarse-grained sediments varying from less than one foot to approximately two feet thick. The underlying dredge fill appears to vary from approximately 8 to 20 feet thick. It consists of fine- to medium-grained sand with some gravel. Native estuarine deposits underlie the dredge fill at depths of approximately eight to 20 feet bgs. The contact between the dredge fill and native estuarine sediments is not well defined due to the similar properties of the two materials. The native estuarine deposits are primarily fine- to medium-grained sand with thin silt interbeds.

2.3.2 Hydrogeology

Groundwater occurs as a thin lens of fresh water overlying brackish water. According to recent boring and well construction logs for MW-307 through MW-310, soils encountered were predominately sand with gravel above fine to medium sand. Groundwater was encountered during drilling within the dredge fill at depths of 6.5 and 7 feet bgs.

Groundwater within the dredge fill is unconfined. The native estuarine deposits are fully saturated and unconfined. The general water pH, turbidity and conductivity, and groundwater elevations within the dredge fill are influenced by the water level in the Duwamish River and Ocean Tides. Groundwater recharge in the dredge fill is primarily by infiltration of precipitation through unpaved areas in the center of Harbor Island. In the TX-03A Area, shallow groundwater generally flows north from a potentiometric high located within the Main Tank Farm (Figure 2).

2.4 Soil and Groundwater Conditions in the TX-03A Area

The current soil and groundwater conditions are described in the 2014 Annual Groundwater Monitoring Report (URS, 2015). A summary of the current conditions is provided below.

2.4.1 Soil

As described in Section 2.2, soil was excavated from the TX-03A Area in 2003. In 2009, a limited soil investigation was conducted to help identify the source of TPH-G detected in groundwater near TX-03A. During the 2009 soil investigation, soil samples were collected at five boring locations, TX-1 through TX-5. One additional soil sample, collected at pilot-test well TW-01, was collected in 2013. The soil samples were analyzed for TPH-G and BTEX. The soil sampling locations are shown on Figure 2 and the results of the soil sampling are summarized on Table 1.

TPH-G was detected in the 2009 soil samples from borings TX-1, TX-3, TX-4, and TX-5 at concentrations ranging between 0.52 and 2,700 mg/kg. The highest TPH-G concentration, 2,860 mg/kg, was detected from the 2013 soil sample location, TW-01, at 7.5 feet bgs. The TPH-G concentrations detected in soil were below the Consent Decree cleanup level of 20,000 mg/kg (Ecology, 1998).

Soil cleanup levels are not established for BTEX constituents. During the 2009 soil investigation, benzene was detected in soil from only one boring, TX-1, at 42 micrograms per kilogram (µg/kg). Ethylbenzene was detected in three of the 2009 borings. Xylenes were detected in TX-1 and TX-4. A benzene concentration of 2,370 µg/kg was detected at TW-01 in 2013. Ethylbenzene and xylenes were also detected at TW-01 in 2013, at concentrations that are consistent with soil sample results from other borings installed in the TX-03A Area in October 2009 (URS, 2013b).

2.4.2 Groundwater

Historically, monitoring well TX-03A has represented groundwater along the northern boundary of the TX-03A Area. Monitoring wells MW-301 through MW-304 were installed in November 2011 and monitoring wells MW-307 through MW-310 were installed in November 2012, in the vicinity of monitoring well TX-03A to assess the nature and extent of contamination observed in TX-03A. Monitoring wells TX-03A, MW-301 through MW-304, MW-307, MW 308, and MW-310 indicate concentrations of TPH-G and benzene above the site cleanup levels (Appendix A, Table A-1).

A soil gas assessment was conducted in May 2013 to further delineate the source of the petroleum hydrocarbons detected in the soil and groundwater in the TX-03A Area within the Main Tank Farm and upgradient of groundwater monitoring wells MW-307 through MW-310. The assessment indicated that the groundwater was sufficiently delineated in the North Boundary Area (URS, 2013c).

The following sections describe groundwater quality in the TX-03A Area for 2013 and 2014. Groundwater monitoring occurred generally on a quarterly basis. Groundwater monitoring reports describe groundwater sampling and results. Historical groundwater data tables are presented in Appendix A, Tables A-1 and A-2. Figures 3 and 4 show concentrations of TPH-G and benzene detected in groundwater in November 2014.

2.4.3 Potential for Natural Attenuation at TX-03A

The Ecology document Guidance on Remediation of Petroleum-Contaminated Ground Water by Natural Attenuation (Ecology, 2005) provides a framework for applying and evaluating a monitored natural attenuation (MNA) program at a site and lists the following five factors that should be considered to allow natural attenuation to be a component of a site remedy:

- Source control has been conducted to the maximum extent practicable.
- Natural attenuation will be protective of human health and the environment.
- The groundwater contaminant plume is demonstrated to be stable or shrinking. In this context a "shrinking" plume is synonymous with a configuration where the solute plume margin is receding back toward the source area over time, and contaminant concentrations at points within the solute plume are decreasing over time.
- There is geochemical evidence of biodegradation as a substantial mechanism of contaminant reductions.
- There is a reasonable restoration time frame.

Source control actions were conducted at the Terminal. The Consent Decree stipulated the preferred remedy in the Main Tank Farm which involved excavation of accessible hot spot soils with elevated concentrations of petroleum hydrocarbons. In general, the initial remedy was effective in removing free product and reducing concentrations of dissolved-phase petroleum hydrocarbons in the TX-03A area. However, not all the petroleum impacted soil was accessible and therefore, residual concentrations of petroleum hydrocarbons remain in the soil and are a potential source to the groundwater. No measurable free product has been observed in any monitoring wells in the TX-03A area since January 2004.

Groundwater monitoring was implemented following the excavation to further assess residual concentrations of dissolved hydrocarbons that remain in groundwater at the Terminal. A contingency plan was implemented to monitor natural attenuation after elevated concentrations of petroleum hydrocarbons remained in the TX-03A area. The cleanup levels referenced in the contingency plan are the recommended concentrations to protect the Duwamish Waterway. In general, the hydraulic gradient and potential contaminant transport indicates a low probability of significant contaminant transport at concentrations above the cleanup levels to the Duwamish Waterway.

Historical monitoring of natural attenuation parameters (NAP) shows that bio-attenuation is occurring at the site and has resulted in decreasing or stable concentrations in groundwater in the TX-03A Area as described in the following sections.

2.4.3.1 Natural Attenuation Monitoring

Plume characteristics can be evaluated based on the specific contaminant conditions at individual wells and in the overall footprint of the plume. In general, a stable or shrinking plume is one where concentrations and overall contaminant mass are stable or decreasing, the area of the plume is stable or decreasing, and the margins of the plume are not expanding significantly. In a plume that is considered to be stable or shrinking, concentrations might fluctuate or even increase at individual wells as contaminant mass redistributes within the plume.

A proprietary software package called GWSDAT, developed by Shell, presents iso-concentration contours and provides information about potential migration patterns of the dissolved phase hydrocarbons in groundwater over time. Dissolved phase hydrocarbon concentrations in groundwater between the third quarter 2011 and the second quarter 2015 groundwater monitoring events, when available, were input into GWSDAT. The GWSDAT results are included in Appendix A. The GWSDAT (Version 2.1) iso-concentration contours show the groundwater gradient is relatively flat and fluctuates direction, and shows a radial flow direction away from the potentiometric high. The GWSDAT iso-concentration contours indicate that benzene concentrations were present near TX-03A and MW-303 in 2011 at levels above the cleanup level. The benzene concentrations moved southwest into the vicinity of MW-307 and MW-308 during the fourth quarter 2012 and during the first quarter of 2013 groundwater sampling events, during periods of elevated groundwater levels. The benzene plume has shrunk in size between MW-308 and MW-303 and the plume also appears to be stable in size in the area between MW-307 and MW-310 since 2012.

Concentration trends for benzene in the TX-03A Area groundwater monitoring wells are also presented on Figure 5 and in Appendix A. The benzene concentrations are declining at MW-303. The benzene concentrations appear to be stable or decreasing for the wells presented on Figure 5. In addition, the historical data indicate the recent concentrations are within the range of historical fluctuations in the benzene concentrations detected at this well (URS, 2015). The benzene concentration at MW-310 has declined since the February 2013 groundwater monitoring event. The benzene concentrations at MW-312 decreased during the second quarter sampling event (Figure 5), however the overall trend for the data collected since the downgradient well was installed is inconclusive. The plume-wide concentration trends for benzene and TPH-G constituents detected in the TX-03A Area are presented in Appendix A. The plume-wide concentration trends within the TX-03A area provide additional evidence that bio-attenuation is occurring in the Main Tank Farm.

2.4.3.2 Evidence of Ongoing Biodegradation

The geochemical data continue to provide evidence that biodegradation is occurring in the TX-03A Area. The field parameters routinely measured at the site groundwater wells include, temperature, pH, dissolved oxygen (DO), oxidation reduction potential (ORP), specific conductivity, and ferrous iron (Fe2+). Assessment of natural attenuation also included sampling and analysis of carbon dioxide, dissolved iron and manganese, methane, nitrate, and sulfate, periodically. Table A-3 shows the measurements and concentrations of natural attenuation parameters for all wells during the historical sampling event. The occurrence of natural attenuation is indicated by either a relatively reduced level of the electron acceptors or an elevated level of the metabolic by-products in locations within and external to the plume.

Temperature and pH readings are within acceptable range for biological activity to occur (Table A-3). The temperature at TX-03A ranges from a high of 17.9 degrees Celsius measured in July 2004 to the lowest temperature recorded of 10.98 degrees Celsius, measured in November 2013. The pH value measured at TX-03A during the January 2005 event was 5.11. The pH measured at TX-03A during the November 2014 groundwater sampling event was 6.49. The groundwater pH was typically measured within the range of 6 to 8 standard units, at all the groundwater monitoring wells, which is in a range amenable to biodegradation.

Aerobic conditions typically occur under conditions where DO is greater than 1 milligrams per liter (mg/L) and ORP is greater than -100 millivolts (mV) (i.e., oxidizing conditions). Anaerobic conditions typically occur under conditions where DO is less than 1 mg/L and ORP is less than 100 mV (i.e., reducing conditions). Elevated DO and ORP concentrations are present in the background well TES-MW-1, upgradient of the source areas identified near MW-307 and MW-308. The DO concentrations at the Site have historically been higher at the background wells, located outside of the dissolved-phase contaminant plume, as would be expected for conditions where ongoing biodegradation consumes the available oxygen. The ORP values measured at the background well TES-MW-1 ranged historically from -7 mV to 308 mV.

Carbon dioxide concentrations at TX-03A have ranged from the lowest level of 0.27 mg/L, to the highest concentration detected, of 210 mg/L. The sulfate concentration at TX-03A has historically been below the laboratory method detection limit with few exceptions. Sulfate has not been sampled recently in the background well TES-MW-1, but was present historically at concentrations ranging from 14.6 mg/L to 46.3 mg/L. Another indicator of natural attenuation in the plume is the presence of methane at several site groundwater monitoring wells, including TX-03A, MW-307, and MW-310, above background levels. The maximum detected methane concentration in background well TES-MW-1 was 0.14 mg/L in one sample; however, methane was not detected above the laboratory method detection limit in the other samples from background well TES-MW-1. The methane concentration at MW-307 ranged from 7.92 mg/L to the most recent concentration detected of 7.27 mg/L (Table A-3). The presence of elevated methane concentrations within the plume is another indicator of strong reducing conditions within the plume, which occurs after the available oxygen, nitrate, and sulfate have been depleted by bio-degradation.

2.4.3.3 Evaluation of Biodegradation Rates

The restoration time frame is a prediction of the time it will take for the Site to reach regulatory cleanup levels. The restoration time frame depends on the initial contaminant mass, dissolution rates of the contaminants (most contaminants are attenuated by processes that act on chemicals in solution), bulk attenuation rates for the contaminants, the site-specific groundwater cleanup levels, and the point of compliance. The estimated cleanup time to reduce the benzene concentrations to below the cleanup level (0.071 mg/L) based on aerobic and anaerobic literature values for the half-lives are calculated and shown in Table 3a. The estimated cleanup time at TX-03A, based on literature values for aerobic half-lives is estimated to be between 1.5 years and 5 five years. Assuming degradation occurs at a rate equivalent to the lowest anaerobic half-life for benzene (Table 3a), the total estimated cleanup time to reduce the benzene concentration at the groundwater monitoring well location from the highest benzene concentration in 2014 (TX-03A) to the cleanup level is estimated to be between 33 and 214 years.

Biodegradation rates are also predicted for benzene and TPH-G at the Site, using site-specific groundwater monitoring well Mann-Kendall trend analysis data, shown in Appendix A. The half-life is estimated using first order degradation rate constant was derived for each well from the plot, taking the natural log of the groundwater benzene concentration versus the time lapsed at the individual monitoring well. The rate constant was estimated as the slope of the best-fit line for the data set on the graph. The predicted rates and resulting clean-up time for each of the wells evaluated are included in Appendix A. Statistically significant benzene half-lives are reported for MW-303 (2.2 years), MW-307 (1.8 years), and MW-310 (3.4 years). The estimated half-life values for benzene result in site-specific cleanup times for benzene between 3.7 years and 11.3 years (Table 3b). These values are significantly less than the cleanup time estimated for TX-03A using literature values. For TPH-G, statistically significant half-lives are reported for MW-301 (5 years), MW-307 (3.4 years), MW-310 (3.9 years). The estimated half-life values for TPH-G result in site-specific cleanup times between 5.3 and 7.4 years (Table 3b), assuming similar trends in the concentrations occur at each of the wells.

The time to achieve restoration can also be predicted by modeling the degradation process itself or by analyzing trends and estimating the time to achieve the cleanup level. The site-specific data were evaluated using the BIOSCREEN Natural Attenuation Decision Support System to assess biodegradation rates under a variety of assumed conditions. Although the gasoline concentrations appear to be slowly declining at several of the groundwater monitoring well locations (Appendix A), they remain above the cleanup levels within the TX-03A Area.

The concentrations along the centerline of the plume in the TX-03A Area were also simulated using BIOSCREEN for current petroleum concentrations and aerobic conditions, where adequate supply of oxygen is assumed (Appendix B, Aerobic Conditions, 2 years), as might be provided by a variety of oxygen delivery methods. The aerobic simulation indicates that the benzene concentration would be reduced to near the site-specific cleanup level 0.071 mg/L at a distance of approximately 15 feet downgradient of the source area after approximately two years by first-order decay. The aerobic simulation also indicates that the concentrations in the wells closest to the source decrease substantially when aerobic conditions are introduced to the aquifer. The addition of oxygen would also reduce the concentrations within the plume, in the vicinity of MW-310 (a distance of 110 feet from the source) by approximately 80 percent. Assuming degradation occurs at a rate equivalent to the low end of the aerobic half-life reported for benzene, the total time to reduce the benzene concentration at the groundwater monitoring well location with the highest benzene concentration in 2014 (TX-03A) is approximately 1.5 to 5 years.

Overall, the results of the cleanup time frame evaluation for biodegradation indicate the cleanup time is longer in the current anaerobic state within the areas of the plume with elevated petroleum hydrocarbons. The results also indicate the cleanup time could be greatly reduced by actively adding oxygen and converting the groundwater conditions within the plume from the current anaerobic state to an aerobic state.

3 Regulatory Framework

This section presents the remedial action objectives (RAOs) developed for the Study Area and establishes the performance criteria or cleanup levels for the remedial measures.

3.1 Cleanup Standards

The cleanup standards for the Site are described in the following sections.

3.1.1 Cleanup Levels

The TX-03A Area is classified as an industrial site and meets the cleanup criteria under WAC 173-340-745. There are no plans to change the site zoning. In addition, the site has a deed restriction for groundwater use and there is an extremely low probability that groundwater would ever be used for potable water. The soil cleanup levels, per the Consent Decree (Ecology, 1998), are listed in Table 1 and groundwater cleanup levels are listed on Table 2.

3.1.2 Point of Compliance

As defined in WAC 173-340-200, a point of compliance (POC) is “the point or points where cleanup levels established in accordance with WAC 173-340-720 through WAC 173-340-760 shall be attained.” As mentioned in Section 2.4.1, soil is not being evaluated in this report and no soil POC will be established. The POC for groundwater will be along the line of sentry wells for the TX-03A Area, including MW-301, TX-03A, MW-311 and MW-312. The POC for air will be the point of discharge based on the remedial alternative that is selected. This is the exit point of a granular activated carbon (GAC) tank used for treating the air extracted by a soil vapor extraction (SVE) system, for example, as discussed in Section 4.2.

3.2 Remedial Action Objectives

After repair of the stormwater system mainline within the TX-03 Area, there are no complete pathways for the site receptors in the site’s current configuration. Potential future risks from impacted groundwater and soil gas remain at the site for occupational and construction excavation workers through direct contact and potentially vapor intrusion pathways, respectively, in the event that the site is redeveloped.

During a July 1, 2015 meeting, the stakeholders, including Ecology, EPA, and the US Army Corps of Engineers reviewed the current containment of the groundwater plume, the effectiveness of the current MNA program for the TPH-G and benzene exceedances, and the results of the recent pilot testing at the TX-03A area. Following the stakeholder’s meeting, Ecology prepared a 5-year review for the Harbor Island Superfund Site, TF-OU2, Petroleum Tank Farm Terminals, for the period between 2010 and 2014, and requested a summary report be prepared for the TX-03A Area, to evaluate if additional active remediation is warranted in this area (Ecology, 2015).

The objective of the on-going remediation in the TX-03A Area is to be in compliance with the order under the contingency plan. The specific objectives listed in the plan include the following:

- Reduce the concentrations of volatile organic compounds (VOCs), specifically reduce the concentrations of the VOCs in shallow groundwater where benzene and TPH-G concentrations are above the cleanup levels described in Section 3.1.1,
- Accelerate cleanup in order to be in compliance with the Consent Decree (Ecology, 1998), as directed by the Environmental Protection Agency, 5-year review,
- Enhance the biodegradation and natural attenuation in the TX-03A Area, and

- Further reduce potential VOC concentrations in the vadose zone.

A number of different cleanup alternatives are reviewed below, in Sections 4 and 5, to determine the approach which best meet these remedial objectives.

3.3 Identification of Other Applicable or Relevant Requirements

Ecology regulations require that the most applicable, relevant, and appropriate requirements (ARARs) be used when completing a Feasibility Study /Disproportionate Cost Analysis (DCA). In addition, the WAC 340-173-710 requires cleanup actions to comply with other “applicable state and federal laws,” as detailed in WAC 340-173-710(3), (4), (7), and (9). Potentially applicable state and federal laws are described below.

3.3.1 Resource Conservation and Recovery Act/Washington Dangerous Waste Regulations

Federal Resource Conservation and Recovery Act (RCRA) regulations and the corresponding Washington regulations (WAC 173-303) involving hazardous waste management may pertain to: 1) waste identification; 2) waste generation and transportation; 3) land disposal restrictions; and 4) treatment, storage, and disposal facilities. Waste determinations will be completed for investigation and remediation wastes (i.e., drill cuttings or excavated soil) in accordance with 40 Code of Federal Regulations (CFR) Part 261 and WAC 173-303.

3.3.2 Clean Water Act/Washington Water Quality Regulations/Local Stormwater Regulations

The federal Water Pollution Control Act (aka the Clean Water Act [CWA]) created programs for permitting off-site wastewater discharges to surface water or to publicly owned treatment works (POTWs). Related Washington regulations are found in WAC 173-220.

Discharge of wastewater to a POTW, such as water generated by excavation dewatering or stormwater collection, is considered an off-site discharge. Any potential discharges to a POTW during an implementation of a cleanup action must comply with National Pretreatment Program regulations as well as local POTW requirements for an individual batch discharge permit.

The CWA also establishes ambient water quality criteria (AWQC) for surface water bodies. Current AWQC are called National Recommended Water Quality Criteria (NRWQC). Washington State Ecology Model Toxics Control Act (MTCA) uses NRWQC as ARARs for groundwater connected to surface water. Washington regulations pertaining to surface water standards are found in WAC 173-201A; the Washington standards can be used to derive cleanup standards for MTCA sites where groundwater discharges to surface water. The CWA will be the basis for any form of national pollutant discharge elimination system permit (NPDES).

3.3.3 Clean Air Act

The Clean Air Act regulates air emissions. Fugitive dust generated in the TX-03A Area is regulated. Discharge of VOCs to the atmosphere from a remediation system could be regulated as a minor source under the Clean Air Act as enforced under Washington regulations (WAC 173-400, -460, and -490), or it could add to the contaminant load discharged from an existing major source. The Puget Sound Clean Air Agency (PSCAA) regulates point-source discharges of air contaminants in the vicinity of the TX-03A Area. To meet PSCAA requirements, controls will need to be in place during construction (e.g., wetting or covering exposed soil stored on-site during trenching, etc.) to meet the substantive restrictions on off-site transport of airborne particulates.

3.3.4 Washington State Environmental Policy Act Regulations

Ecology rules apply to the construction, maintenance, and abandonment of monitoring wells and other types of wells in Washington (WAC 173-160), excluding injection wells. The requirements for the abandonment of the monitoring wells will become relevant at the time of the system decommissioning.

3.3.5 Monitoring Well Construction, Maintenance, and Decommissioning

The Archeological and Historical Preservation Act 16 USCA 496a-1 becomes applicable if any subject materials are discovered during design or system installation.

3.3.6 Washington Industrial Safety and Health Act Regulations

The cleanup will be performed in accordance with the requirements of the Washington Industrial Safety and Health Act (RCW 49.17) and the federal Occupational Safety and Health Act (29 CFR 1910 and 1926). These applicable regulations include requirements for worker protection from physical hazards (e.g. proper shoring, confined space entry, and equipment hazards), and protection from exposure to hazardous substances or other deleterious materials.

4 Description of Cleanup Action Alternatives

This FFS considers four remedial alternatives to achieve the stated remedial objectives listed in Section 3.1. The primary objective of the remediation is to comply with the Consent Decree, by reducing the concentration of VOCs in groundwater and mitigate risks to potential future occupational and construction/excavation workers.

Four cleanup action alternatives are described below, considering the results of the 2013 pilot testing conducted in the TX-03A Area (URS, 2013d). The cleanup action alternatives meet the following threshold criteria:

- Protect human health and the environment
- Comply with Ecology cleanup standards
- Comply with applicable state and federal laws
- Provide for compliance monitoring (WAC 173-340-360(2)(a))

The cleanup action alternatives developed for the TX-03A Area also consider proven technologies that will be a permanent solution that can be completed within a reasonable restoration time frame.

This section describes each cleanup action alternative, including the conceptual design, quantities, installation and operation procedures, compliance monitoring requirements, estimated cost, schedule, and any unknowns.

The following four cleanup action alternatives are evaluated:

- Alternative 1: No Additional Action (Current Contingency Plan)
- Alternative 2: Bio-sparging
- Alternative 3: Enhanced Biological Remediation
- Alternative 4: Groundwater Pumping and Treatment

Table 4 presents a description and preliminary analysis of the cleanup action alternatives. Table 4 also presents the estimated cost to complete each of the cleanup action alternatives. Conceptual cost estimates for each Alternative are provided in Appendix C.

4.1 Cleanup Action Alternative 1 - No Additional Action (Current Contingency Plan)

Cleanup Action Alternative 1 (CAA-1) represents the current remedial action that is being conducted at the TX-03A Area and is used as a basis for comparison to the other cleanup action alternatives for the TX 03A Area. Under CAA-1, no additional action would be implemented in the TX-03A Area.

4.1.1 Conceptual Design

CAA-1 consists of managing the TX-03A Area under current conditions. No additional treatments or systems would be implemented to reduce the toxicity, mobility, or volume of contaminants identified in soil or groundwater at the site. Progress toward the cleanup levels would be assessed by the current performance monitoring program. Under the current monitoring program, groundwater is sampled quarterly. Quarterly reports and 5-year Performance Reviews document the status of the cleanup action at the site.

Although CAA-1 does not actively treat the hydrocarbons in the soil and groundwater, the hydrocarbon concentrations in soil and groundwater will decline over time by the following natural attenuation processes:

- Mass transfer of hydrocarbons from the soil and/or groundwater through volatilization.
- BTEX constituents of gasoline are volatile and concentrations in soil will naturally attenuate. Benzene will volatilize the most quickly, having the lowest Henry's Law constant (0.23, unit less). Volatilization will be minimal or slow in deeper saturated soil.
- Biodegradation of hydrocarbons. Section 2.4.3 describes that shallow groundwater in the contaminated area is anaerobic. The absence of oxygen and the presence of methane, as compared to conditions outside the contaminated area, indicate ongoing anaerobic biodegradation. The anaerobic half-life for xylenes is generally the shortest of the BTEX constituents (Table 1). Ethylbenzene has the shortest aerobic half-life of the BTEX constituents at the site. As described in Section 2.4.3, Table 3a indicates the plume takes a long time (over 33 years) for the highest 2014 concentration of benzene (TX-03A) to be reduced to below the cleanup level for benzene by anaerobic biodegradation.
- Hydrocarbon desorption and dispersion by advection in groundwater. Hydrocarbon mass will partition and diffuse from potential sources remaining in the soil to the groundwater at the site and be slowly transported by flowing groundwater.

4.1.2 Groundwater and Air Compliance Monitoring

Compliance monitoring for CAA-1 consists of monitoring consistent with the requirements listed in the Consent Decree No. 99 2-07 176 SEA with Ecology and includes confirmation, performance, and sentry well monitoring for the Main Tank Farm, the North Tank Farm, and the Shoreline Manifold Area. In the Shoreline Manifold Area, the confirmation monitoring includes monthly monitoring of product thickness and sheen. However, this objective identified does not apply to the TX-03A Area, since product has not been identified recently in this area. The specific monitoring requirements for the TX-03A Area (including the Main Tank Farm and the North Tank Farm) are the following:

- **Performance monitoring to confirm that the cleanup action has attained performance of cleanup standards.** Performance monitoring consists of three components: product thickness and sheen monitoring, groundwater natural attenuation monitoring, and groundwater quality monitoring at the following performance monitoring wells: MW 101, MW-102, MW-103, MW-302, MW-304, MW-307, MW-308, MW-309, MW-310 and TES-MW-1. Performance monitoring is currently conducted on a quarterly basis. It is assumed that performance monitoring is required for up to 40 Years until the concentrations are reduced to below the cleanup levels.
- **Sentry monitoring to provide early warning of off-site contaminant migrations.** Quarterly sentry groundwater quality monitoring is conducted simultaneously with groundwater performance monitoring (URS, 2008). Wells included in the sentry monitoring are generally located at or near the northern site boundary of the TX-03A Area and include MW-301, TX-03A, MW-311, and MW-312.
- **Confirmation monitoring to assess the long-term effectiveness of the cleanup action once performance and cleanup standards are met.** This FFS assumes that one round of confirmation monitoring is performed in the Main Tank Farm at all the groundwater monitoring wells.

Under the current compliance monitoring program, all groundwater samples are analyzed for the following analyses:

- BTEX
- Gasoline, diesel, and motor oil range hydrocarbons

- Natural attenuation parameters including: including pH, temperature, DO, and ORP, ferrous iron, dissolved iron and manganese

No air compliance monitoring is required for the current conceptual design required.

4.1.3 Timeline and Costs

The estimated time for hydrocarbon concentrations in the groundwater in the target remediation area to be reduced through natural attenuation to below their respective cleanup levels is 33 years, which represents the low-end of the estimated cleanup time range under anaerobic conditions (Table 3a). Site-specific cleanup time frames indicate portions of the plume may be reduced to concentrations below cleanup levels for benzene and TPH-G within 10 year (Table 3b), if the constituent degradation continues following the current trends.

Appendix C lists the primary cost components of CAA-1. Costs assume compliance and performance monitoring for 33 years. The 33-year net present value (NPV) cost of CAA-1 is $784,000 (all costs are rounded to the nearest $1,000).

4.1.4 Uncertainties and Unknowns

The following uncertainties and unknowns exist for CAA-1:

- Potential sources, upgradient of TX-03A, MW-307 or MW-308
- Potential changes to the frequency of groundwater monitoring
- Actual length of time to reduce concentrations to below the cleanup levels

4.2 Cleanup Action Alternative 2 - Bio-Sparging

Cleanup action alternative 2 (CAA-2) is an active remedy that involves the installation of bio-sparging wells arranged in the TX-03A Area to inject air and stimulate the activity of aerobic bacteria within soils and groundwater, with an ancillary benefit of stripping hydrocarbons from groundwater. Two versions of the alternative are evaluated at the TX-03A Area: Bio-Sparging (CAA-2a) and Bio-sparging with SVE (CAA-2b).

4.2.1 Results of Air Sparging and Soil Vapor Extraction Pilot Tests

Individual short-duration air sparge (AS) and SVE pilot tests were conducted at ASW-1 and SVE-1, on September 9, 2013, in the target remediation area within the plume. The following day, on September 10, 2013, a combined AS and SVE pilot test was conducted to collect additional information about potential mass recovery, flow rates, and radius of influence at the site from the operation of both technologies simultaneously.

During the individual short-duration AS test, air was in injected at ASW-1 using an air compressor, at a pressure of approximately 2 pounds per square inch (psi, equal to about 56 inches of water [WC]). The pressurized air resulted in delivery of air to the subsurface at a corresponding flow rate of approximately 7 cubic feet per minute (cfm). After the subsurface pressures stabilized, the system was adjusted to observe the effects of air being injected at an increased pressure. During the second step of the short-duration AS test, the pressure at ASW-1 was increased from an average of 2 psi to 3 psi (about 56 to 83 inches of WC) and the corresponding flow rate increased slightly to 11 cfm. The pressure was increased a third time, from 3 psi to 3.5 psi (about 83 to 97 inches of WC) and resulted in a corresponding flow rate between 11 and 14 cfm. In general, higher pressures applied at ASW-1 resulted in higher flow rates. The largest pressure response (groundwater mound) was observed at MW-302, located approximately 7 feet from the injection well ASW-1. Groundwater elevation changes were progressively less striking in monitoring wells as a function of distance from the air sparging well. Shortly after beginning air injection at ASW-1, air bubbles were observed at TW-01; however, no appreciable pressure response was noted at TW-01, located 10 feet away from ASW-1, indicating the air may be short-circuiting between the injection and observation well. The radius of influence for the bio-sparging was based on the field measurements recorded during the air sparging tests, and included the following:

- Increase in the dissolved oxygen concentration at MW-304 located approximately 25 feet from the test well;
- Evidence of groundwater pressure/mounding at MW-302, TW-01, MW-310, and MW-304, using direct read pressure transducers;
- Changes in VOC field vapor concentration at PSV-1 and PSV-2.

The resulting radius of influence was determined to be up to 20 feet, however, a design radius spacing of the wells was estimated at approximately 15 feet, to provide some overlap in the coverage/area of influence.

During the individual short-duration SVE test, a vacuum of 18 inches of WC and 15 cfm was held until the pressures stabilized at the nearby observation wells, PSV-1 and PSV-2. Vacuum was increased after two hours to 30 inches of WC and 28 cfm, followed by an increase to 45 inches of WC with a maximum air flow rate of 60 cfm for another half hour. During the short duration SVE test, an average vacuum of 18 inches of WC was applied at SVE-1, a vacuum of 1.42 inches of WC was measured at PSV-1, located 8 feet from SVE-1 and a smaller vacuum of 0.36 inches of WC was measured at PSV-2 located 26 feet away from SVE-1. The results of the SVE test indicated a maximum vapor recovery rate of 0.183 pounds per day of total petroleum hydrocarbons, with the overall rate of vapor recovery quickly diminishing with time.

Several air injection pressure and vacuum rates were tested during the combined AS and SVE test. Evidence of mounding, represented by an increase in the groundwater elevation, occurred when the air was injected at 4.5 psi at ASW-1 and 20 inches of WC vacuum was applied at SVE 1. The groundwater mounded approximately 2 feet in the initial 6 to 8 minutes in monitoring well MW-302, located about 7 feet away from ASW-1. The mounding decreased by approximately one foot over the next hour, illustrating that more air was escaping the aquifer than was being introduced during the extended period of injection. The mounding was observed again, after a period of about two hours at a decreased injection pressure, when the air injection pressure was increased from 2.5 psi to 5 psi (equal to 138 inches of WC) and the vacuum applied at SVE-1 was 40 inches of WC. The estimated radius of influence was 20 feet and 22 feet for the applied vacuum at SVE-1 of 20 inches of WC and 40 inches of WC, respectively. The VOC concentrations, measured in the SVE system exhaust increased over the duration of the combined AS and SVE test, but were less overall from the concentrations measured during the short duration SVE test, conducted the previous day, on September 9, 2013 and the total petroleum hydrocarbon vapor recovery rates dropped by over an order of magnitude by the end of the test.

4.2.2 Conceptual Design

The conceptual design for CAA-2a consists of a system of 37 bio-sparging wells distributed within the Main Tank Farm and in the City of Seattle public parking lot. In the Main Tank Farm, 18 one-inch diameter bio-sparging wells will be installed near the MW-307 and MW-308 source areas. In the public parking lot, 18 new bio-sparging wells and one existing well (ASW-01) will be included within the system. The conceptual layout of the bio-sparging wells is shown in Figure 6. The bio-sparging wells will be spaced at a radius of 15 feet, to provide an overlap in coverage, assuming an overall radius of influence of 20 feet. The bio-sparging wells would be installed to a depth of approximately 15 feet bgs, using pre-packed well screens. Each well would be constructed of one-inch diameter polyvinyl chloride (PVC) pipe with a two-foot long factory-slotted (0.010 inch) screen. A silica sand pack would be installed around the well to a depth of 12 inches above the top of the well screen, and a bentonite-slurry seal will be pumped into the well void to within one foot to the top of the well. The well would be completed with a flush mount monument and finished in concrete to prevent short-circuiting of the injected air.

The air delivery conveyance piping inside the Main Tank Farm would be routed above grade to the dike wall. The piping would be routed over the wall to a secure equipment storage shed, located in the public parking lot.

An additional 18 one-inch diameter bio-sparging wells would be installed outside of the Main Tank Farm dike wall in the public parking lot. The air piping would be routed below grade to the secure equipment compound. A compressor would supply air to the bio-sparging wells.

The system would be divided into subsystems, to allow for pulsed air injection into separate sections of the system, minimizing the size of the compressor required. Considering the results of the pilot test, air would be injected at 4 psi for up to 15 minutes, in each subsystem, followed by one hour and 25 minutes of down time for that subsystem. Details of the system operation would be refined during operation.

The second version of cleanup action alternative, CAA-2b, includes all the bio-sparging system components described above for CAA-2a, in addition to a SVE system which would be installed to provide a method of removing impacted volatile hydrocarbon impacted soil gas from below the asphalt parking lot, in the vicinity of the pipeline and underground utilities that may be generated by the bio-sparging system. A total of 11 SVE wells will be installed in the public parking lot. The SVE wells would be installed to a total depth of approximately 5 feet bgs. The SVE wells would be constructed of two-inch diameter PVC pipe with a two-foot-long factory-slotted (0.010-inch) screen. A silica sand pack would be installed around the well to a depth of six inches above the top of the well screen, and a bentonite seal would be installed near the top of the well to prevent infiltration of ambient air. Conveyance piping would be routed below grade to the equipment compound and connected in a piping manifold. The manifold would be connected to a moisture knock-out tank, equipped with a high-level alarm, followed by connection through a vacuum pump, and a 1,000-pound GAC unit, followed by a 500-pound polish GAC unit, where exhaust would be discharged under permit to the atmosphere.

For both CAA-2a and CAA-2b, an equipment shed would be located near the public parking lot (Figure 6), where power is currently accessible. For CAA-2a, the equipment shed would house the system controls, gauges, and an air compressor for bio-sparging. For CAA-2b, the equipment shed would house the controls, gauges, an air compressor for bio-sparging, SVE blowers, and GAC units for air treatment

4.2.3 Groundwater and Air Compliance Monitoring

The groundwater monitoring for the bio-sparging component of the system, included in CAA-2a and CAA-2b, consists of collecting and analyzing samples from the existing groundwater monitoring wells, semi-annually. The results will be used to monitor the effectiveness of the system.

Specifically for CAA-2b air samples of the treated air discharged to the atmosphere, after passing through the GAC, would be collected and analyzed quarterly to assure compliance with the requirement of the air discharge permit.

4.2.4 Timeline and Costs

The estimated time to reduce groundwater concentrations to below the cleanup levels by CAA-2 is five years. The restoration time is within the predicted range of aerobic cleanup times presented in Table 3a and also presented in Appendix B. Specifically, for CAA-2b, the lower end of the range of cleanup times assumes cleanup time is likely to be shorter than with aerobic biodegradation alone, because some volatilization may also occur as a result of operating the SVE system, thereby reducing the concentrations more quickly than by enhanced aerobic biodegradation rates estimated for operating a bio-sparging system alone.

The primary cost components of CAA-2a and CAA-2b are listed in Appendix C. For costing purposes, a conservative time of five years is assumed to achieve cleanup. The estimate includes up to three years of system operation followed by a year of semi-annual monitoring to assess constituent rebound, and then one year of quarterly groundwater compliance monitoring, and assuming no rebound. The NPV cost of CAA-2a is $366,000 and the NPV cost of CAA-2b is $452,000 (rounded to the nearest $1,000).

4.2.5 Uncertainties and Unknowns

Following are uncertainties and unknowns for CAA-2a and CAA-2b:

- The potential presence of higher concentration source areas, upgradient of MW-307 and/or in the vicinity MW-308
- The actual length of time of the system operation to reduce concentrations to below the cleanup levels
- Maximum achievable radius of influence for the bio-sparging included in CAA-2a and CAA-2b;
- The maximum achievable radius of influence, and effectiveness of SVE system for CAA-2b; and,
- Actual frequency of system maintenance for both CAA-2a and CAA-2b.

4.3 Cleanup Action Alternative 3 - Enhanced Biological Remediation

Cleanup action alternative 3 (CAA-3) involves subsurface injection of an oxygen releasing compound in the TX-03A source areas, inside the Main Tank Farm dike wall. Outside the dike wall, a line of bio-sparging wells are installed to create a barrier to further stimulate aerobic biodegradation within the soil and groundwater.

4.3.1 Conceptual Design

CAA-3 involves injection of oxygen-releasing compounds to provide additional dissolved oxygen within the impacted groundwater in targeted areas of the TX-03A Area plume. Providing additional oxygen through an oxygen-releasing compound would further drive the aquifer toward aerobic conditions and increase the rate of biodegradation.

Direct injection of a slow-release source of oxygen and nutrients such as ORC or EHC-O, or equivalent, would occur at a total of 75 “primary” (i.e., first injection event) locations (Figure 7). The oxygen-releasing reagent would be mixed and administered in accordance with the manufacturer’s recommendations through two-inch diameter direct-push borings. A total of 42 injection points would be advanced at the source area inside the Main Tank Farm, spaced at approximately ten-foot intervals. An additional 33 primary injection points would be advanced within the public parking lot, downgradient of the BP Pipeline, on the northern side of the Main Tank Farm dike wall. The oxygen-releasing reagent would be injected as a slurry from a bottom elevation of approximately 15 feet bgs, to an upper elevation of approximately 5 feet bgs, which is the approximate annual high-water level at the site. After six months, a semi-annual groundwater sampling event would be conducted to evaluate the effectiveness of the primary injection event.

A secondary, “polish” round of amendment injection would be conducted, approximately one year after the primary round of injections. During the secondary round of injections, the concept design assumes that amendment would be injected at 33 locations at the same spacing and areas as the first round within the public parking lot, downgradient of the BP Pipeline, north of the Main Tank Farm dike wall. Routine groundwater monitoring would be conducted semi-annually thereafter until the concentrations are reduced to below the cleanup levels.

4.3.2 Groundwater and Air Compliance Monitoring

Groundwater is collected and analyzed semi-annually. Results are submitted to monitor the effectiveness of the system.

4.3.3 Timeline and Costs

It is estimated that the groundwater concentrations would be reduced to below the cleanup levels at the downgradient end of the plume after approximately four years, assuming no more than two rounds of injection are necessary and the only cleanup mechanism is aerobic biodegradation as a result of implementing CAA-3. It is assumed that up to two additional years of confirmation monitoring would be necessary to provide evidence of attainment of the RAOs.

The primary cost components of CAA-3 are listed in Appendix C. For costing purposes, a conservative time of four years has been estimated for the maximum cleanup time. The total NPV cost of CAA-3 is $427,000 (rounded to the nearest $1,000).

4.3.4 Uncertainties and Unknowns

The following uncertainties and unknowns that exist for CAA-3 include the uncertainties and unknowns presented above in Section 4.2.4, as well as the following additional unknowns:

- Actual achievable injection radius of influence of the directly injected amendment
- The effect of injecting amendment, specifically including potential amendment loss through more permeable backfill material and the effect of an increase in the pressure in the vicinity of the pipeline and along utility lines in the area of the injection
- Number of injections required for the amendment to effectively treat and reduce the constituent concentrations to below the cleanup levels

4.4 Cleanup Action Alternative 4 - Groundwater Pumping and Treatment

Cleanup action alternative 4 (CAA-4) involves pumping the impacted groundwater to the surface and treating it through an air stripper and treating the discharged air stream as necessary through activated carbon.

4.4.1 Results of Groundwater Pump Tests

A step-drawdown test was performed on September 12, 2013 at test well TW-01 to determine the optimal pumping rate that will be used to conduct the constant rate test and also used to estimate aquifer hydraulic properties. The pumping rates that were step-tested are one gallon per minute (gpm), three gpm and six gpm. In general, the groundwater in the pumping well began to drawdown rapidly with a decrease of two feet in groundwater elevation after 30 minutes of pumping at a pumping rate of six gpm. The total BTEX concentration was measured between each step increase during the step test and was generally consistent between each step increase in the pumping rate.

During the constant rate test, groundwater was pumped from the TW-01 extraction well at a constant rate of four gpm for a period of six hours. The water level drawdown appeared to stabilize in the surrounding wells after two hours of pumping within the well, with a decrease of 0.05 feet during the second half of the constant rate pumping test. Drawdown was also measured at surrounding monitoring wells with the maximum drawdown occurring at the end of the pumping test at MW-302 (0.56 feet), MW-310 (0.31 feet), MW-304 (0.21 feet), and TX-03A (0.05 feet). No drawdown was observed at MW-307, located approximately 80 feet north of TW-01. The aquifer rebounded quickly, with the groundwater elevation in the test well returning to within ten percent of the starting elevation, within 120 minutes after pumping was stopped at TW-01 during the constant rate test.

The data from the groundwater pumping test was used to determine the hydraulic conductivity for the aquifer. The Theis solution yielded hydraulic conductivity values ranging from a low of 5.62E-03 centimeters per second (cm/s) in TX-03A to a high of 0.01 cm/s in MW-310. The Neuman solution showed a low estimate of 0.004 cm/s also in TX-03A and a high of 0.02 cm/s in MW-310.

4.4.2 Conceptual Design

Under CAA-4, three six-inch diameter groundwater pumping wells would be installed in the public parking lot near the TX-03A Area (Figure 8). The pumping wells would be screened between five feet to approximately 15 feet bgs. Four-inch electrical submersible pumps would pump groundwater to the treatment system, located in a treatment compound. Groundwater would be extracted at approximately two gpm from each of the pumping wells and would be discharged into a holding tank, equipped with high-low pump shut-off switches. The groundwater would be pumped from the holding tank through a low-profile air tray stripper. Within the air stripper, water is trickled through a packing material while air is blown through it to volatilize contaminants. The air would be treated through a GAC unit before being discharged to the atmosphere. Treated water would be stored in a treated water holding tank and discharged into the local stormwater network under a National Pollutant Discharge Elimination System (NPDES) permit.

4.4.3 Groundwater and Air Compliance Monitoring

Groundwater that has been treated and stored is sampled and discharged according to a NPDES permit. Air samples would be collected from the air passing through the GAC and reported in the semi-annual monitoring report, to demonstrate compliance with the air permit.

4.4.4 Timeline and Costs

The estimated time to reduce groundwater concentrations to below the cleanup levels is 26 years, based on the results of the pumping test (URS, 2013d). The time estimate assumes a total volume of impacted groundwater of approximately 900,000 gallons and a sustainable pumping rate of 3 gallons per minutes and an average migration time of 20 years to the source area pumping zone. The cleanup time may be shorter than the maximum estimated time because other natural processes would be occurring while the pumping is occurring. Groundwater pumping may also introduce small amounts of oxygen into the subsurface, thereby reducing the concentrations slightly more quickly by stimulating aerobic biodegradation. One year of confirmation monitoring would be performed following the pumping.

The primary cost components of CAA-4 are listed in Appendix C. It is estimated cleanup duration is 25 years. The total NPV cost to complete CAA-4 is $1,346,000 (rounded to the nearest $1,000).

4.4.5 Uncertainties and Unknowns

The following are uncertainties and unknowns for CAA-4:

- Potential source areas upgradient of MW-307 and MW-308
- Actual sustainable pumping rate over the longer-term period of pumping
- Actual interstitial velocity and retardation factor of groundwater
- Efficiency of pumping system and potential issues with iron fouling

5 Evaluation of Cleanup Action Alternatives

Each cleanup action alternative was assessed considering the following seven screening criteria:

- protectiveness
- permanence
- long-term effectiveness
- management of short-term risks
- technical and administrative implementability
- consideration of public concerns
- cost

Section 5.1 summarizes the criteria. Each alternative was given a score based on the screening criteria. The scores are summarized in Table 5.

A qualitative comparative analysis was also completed for each of the remedial alternatives, based on the average score calculated for each of these screening criteria. The comparative analysis is described below in Section 5.2.

5.1 Screening Criteria

The alternatives were selected to be permanent solutions to the maximum extent possible based on the DCA described in WAC 173-340-360(3)(e). The alternatives were ranked from most to least permanent, and the most practicable permanent solution was selected. The criteria used to rank the evaluated alternatives in terms of permanence comply with WAC 173-340-360(3)(f), and include:

- Protectiveness of attaining the RAOs for human health and the environment, including reduction of risk, time required to reduce risk, and risks resulting from implementation of the alternative.
- Permanence of reduction in toxicity, mobility, or volume of hazardous substances, including the adequacy of the alternative in destroying hazardous substances, the reduction of hazardous substance releases and sources, the degree of irreversibility of the treatment, and the characteristics and quantity of treatment residuals generated.
- Effectiveness over the long term that considers the certainty that the alternative will be successful; its reliability during cleanup; the magnitude of residual risk with the alternative in place; and the effectiveness of controls required to manage treatment residues or remaining wastes.
- Management of short-term risks addresses the risk to human health and the environment during construction and implementation (summarized in Appendix D), and the effectiveness of measures that will be taken to manage such risks.
- Technical and administrative implementability considers whether the alternative is technically possible; whether off-site facilities, services, and materials are available; administrative and regulatory requirements; scheduling; size; complexity; monitoring requirements; access for construction operations and monitoring; integration with existing facility operations; and other current or potential remedial actions.
- Consideration of public concerns addresses the extent to which the alternative addresses any concerns the community has regarding the alternative. This includes concerns from individuals,

community groups, local governments, tribes, federal and state agencies, or any other organization has an interest in or knowledge of the site. Consideration of public concerns also includes potential sustainable impacts of the project. A sustainability summary for the CAAs is included in Appendix D.

- Cost to implement the alternative, including cost of construction, net present value of long-term costs, developed at a conceptual level for the alternatives, considering the time to complete the remedy.

5.2 Cleanup Action Alternative Comparative Screening

The following is a discussion of the proposed cleanup action alternatives with respect to the screening criteria, cost analysis, and reasonableness time frame. Table 5 summarizes the alternative comparisons.

5.2.1 Protectiveness

In general, CAA-1 CAA-2a, and CAA-3 provide the same degree of protectiveness; however, CAA-3 is estimated to reduce risks slightly faster, and with fewer risks during implementation, therefore, providing the greatest protectiveness of the alternatives. CAA-4 takes a long time to attain the cleanup levels across the entire site, and therefore is not as protective as CAA-2 or CAA-3.

5.2.2 Permanence

CAA-1 is the least permanent of the alternatives, because the toxicity, mobility and volume of the hydrocarbons are not reduced over the short term, and hydrocarbons are uncontained and may mobilize off site during the time it takes for natural attenuation processes to reduce the concentrations to below the cleanup levels.

CAA-2a permanently reduces the toxicity and volume of the hazardous substances in the area of treatment, and provides a permanent destruction for the gasoline hydrocarbon mass in the plume. For option CAA-2b, some of the hydrocarbons are partitioned from groundwater to the vapor phase, may be mobilized out to ambient air, and/or removed by the SVE system. The hydrocarbons captured by the SVE treatment processes are transferred to a secondary media, where permanent destruction of the hydrocarbons may occur, but only after a secondary treatment process, such as regeneration of the GAC, this process also uses more energy, and therefore is less sustainable, potentially creating secondary forms of emissions.

CAA-3 and CAA-2a provides the highest permanence, through complete reduction of toxicity, mobility, and volume of the hydrocarbons through aerobic biodegradation with little to no waste generation from the process.

CAA-4 is not permanent over the short term, but does provide containment of the plume during the time it takes to treat the hydrocarbons. Similar to the SVE treatment process, the volatiles removed from the groundwater in the air stripper will be transferred to GAC, which will require a secondary treatment to provide complete destruction of the hydrocarbons.

5.2.3 Effectiveness Over The Long-Term

The results of the BIOSCREEN modeling for CAA-1, representing the current conditions at the TX-03A Area, indicate risk will remain as a result of the current concentrations for up to nine years before the concentrations begin to decrease through natural attenuation processes; however, the concentration trends do not indicate that anaerobic biodegradation is occurring at a rate sufficient to reduce hydrocarbon concentrations in the TX-03A Area.

CAA-2a, CAA-2b, and CAA-3 are considered more effective alternatives than CAA-1 because CAA-2a, CAA-2b and CAA-3 facilitate aerobic biodegradation, which reduces the overall cleanup time for the TX-

03A Area, as compared to cleanup time by natural attenuation alone. The site-specific pilot testing results from the TX-03A Area indicate CAA-2a bio-sparging and CAA-2b, bio-sparging with SVE are feasible and will be successful at removing mass and residual risk at the TX-03A Area. The pilot test for enhanced bioremediation by application of a bioamendment (EHC-O) was not conclusive, and, therefore, it is not certain how many bioamendment injections would be needed to cause biodegradation to hydrocarbon concentrations below the cleanup levels.

CAA-4 successfully removed the impacted groundwater from the TX-03A Area, as demonstrated by the site-specific pilot testing. The sustainable pumping rate is high, a large amount of residual waste would be generated by the system and ancillary treatment of volatile vapors, requiring routine operation and maintenance activities to remain operational and effective over the long-term. The maintenance requirements for CAA-4 would result in increased downtime, making it less effective over the long term than CAA-2a. In addition, there is a potential for iron fouling to occur, which reduces the feasibility of pumping in the TX-03A Area.

5.2.4 Short-Term Risk Management

CAA-1 has the fewest short-term risks associated with implementation, because the only exposures are associated with routine groundwater monitoring at the TX-03A Area, and the risks are easily managed with engineering controls, including personal protective equipment. However, over a long-term the risk of accident is greater due to the number of trips and driver required to access the site.

CAA-2a, CAA-2b, CAA-3a, and CAA-4 have short term risks associated with implementation, because each of these alternatives include risks associated with drilling and installation of new wells, including installation of associated mechanical and electrical equipment at the bulk fuel terminal. The drilling of wells near active tanks and/or piping include a high level of risk for potential damage to existing infrastructure, and potential for additional releases if piping is compromised.

In general, however, all the short-term risks are manageable at the TX-03A Area, using standard safe work practices and careful project planning.

5.2.5 Technical and Administrative Implementability

Each of the alternatives, CAA-1 through CAA-4 are technically and administratively implementable.

- CAA-1 is the simplest to implement because it does not require specialty services to implement the routine monitoring.
- CAA-2a is the most implementable of the active remedies because the materials and services are readily available locally. CAA-2b requires an air permit to operate the SVE system.
- CAA-3 is slightly more difficult to implement than CAA-2a or CAA-2b because it requires specialty services to acquire and administer a proprietary amendment. Also, additional consideration of the subsurface pressures, required to administer the amendment potentially limit the application near the large tanks and the pipeline.
- CAA-4 is the most difficult to implement. Although the services and materials are readily available, two permits are required, including an air discharge permit and at NDPES permit for treated water discharge to the stormwater system.

5.2.6 Public Concerns

There are no known active public concerns about the specific contamination in the TX-03A Area. The public concerns discussed below are conceptual and reflect possible public perceptions.

Remediation of the TX-03A Area by CAA-1 likely results in the most public concern, because active remediation is not occurring, and there is a greater possibility under this alternative that impacted groundwater might eventually migrate off site, with the potential to impact surface water located downgradient of the TX-03A Area.

Potential public concerns associated with the installation of CAA-2 through CAA-4 include concerns over the volume of waste generated, additional truck traffic on public roads, and use of landfill space. Other public concerns for CAA-2b and CAA-4 may arise during the process of obtaining the necessary air permits (CAA-2b and CAA-4) and an NPDES permit (CAA-4 only). A higher energy consumption rate maybe a notable public concern for CAA-2b and CAA-4, compared to the other remedies.

5.2.7 Remedy Time-Frame and Cost

The annual cost to continue to implement CAA-1 is low; however, the cleanup time does not meet the restoration time frame identified in the Consent Decree. The cleanup time for CAA-1 is also longer than CAA-2a, CAA-2b, and, CAA-3, resulting in CAA-2a being a more cost-effective alternative than CAA-1, CAA-2b, or CAA-3. The capital cost of CAA-2 is higher for installation of wells, piping, and system equipment. The longer-term costs are associated with the routine operation and monitoring of the system equipment and the existing monitoring well network.

The capital cost of CAA-3 is higher, when compared to CAA-1, CAA-2a and CAA-2b, but the cleanup time of CAA-3 is estimated to be the shortest.

The capital cost of CAA-4 is lower than CAA-2a, CAA-2b, and CAA-3, but the long-term maintenance and monitoring requirements result in a higher NPV than any of the other cleanup alternatives.

There is some uncertainty in the cleanup time of all of the alternatives due to the possible presence of residual petroleum hydrocarbons in the unsaturated zone in the area near MW-308. Residual petroleum may be a continuing source that impacts the cleanup time and cost.

It should be noted that for each of the alternatives, there is some uncertainty in the cleanup time, due to the presence of residual petroleum hydrocarbons within the unsaturated zone in the area near MW-308, which may present a continuing source of hydrocarbons that prevents the groundwater cleanup levels from being achieved over the estimated time frame.

5.3 Recommended Cleanup Action Alternative

The comparative analysis of the alternatives (Table 5) indicates that the highest ranking remedial action is CAA-1, monitored natural attenuation, under the current groundwater monitoring program, considering there is not a complete receptor pathway at the Site. However, MNA is not an active remedy, and the overall cleanup time period to reduce the existing concentrations at the site to below cleanup levels is potentially longer than implementing any of the active CAAs (CAA-2 through CAA-4). Following CAA-1, the second highest ranking alternative is CAA-2a, bio-sparging, and although, CAA-1 would be protective and just as effective over the long-term, if an active remedial action is required, as recommended by EPA and Ecology, then CAA-2a is the highest ranking active cleanup action alternative evaluated for the TX-03A Area and the Main Tank Farm. As an active remedial action, CAA-2a ranks higher than CAA-3 and CAA-4 for the following reasons:

- It meets the threshold criteria, providing protectiveness and permanence.
- Pilot testing demonstrates that it is feasible and will be effective to reduce the toxicity and volume of the petroleum-impacted groundwater, in a shortened time period, compared to the other CAAs.
- The restoration time frame is estimated to be a maximum of five years, which is similar to CAA-2b and CAA-3 but a faster than the cleanup time estimated for alternatives CAA-1 and CAA-4.

- It is readily implementable, at a reasonable cost, compared to the other alternatives.

After installation of the bio-sparging system, semi-annual groundwater monitoring would be used to demonstrate ongoing effectiveness of this alternative in reducing constituent concentrations to below the cleanup levels. The bio-sparging alternative also allows for flexibility in the application of the bio-sparging (and air delivery), so it can be tailored to the specific source areas located inside or north of the Main Tank Farm dike wall; thereby focusing the treatment on areas with the highest petroleum hydrocarbon concentrations in groundwater.

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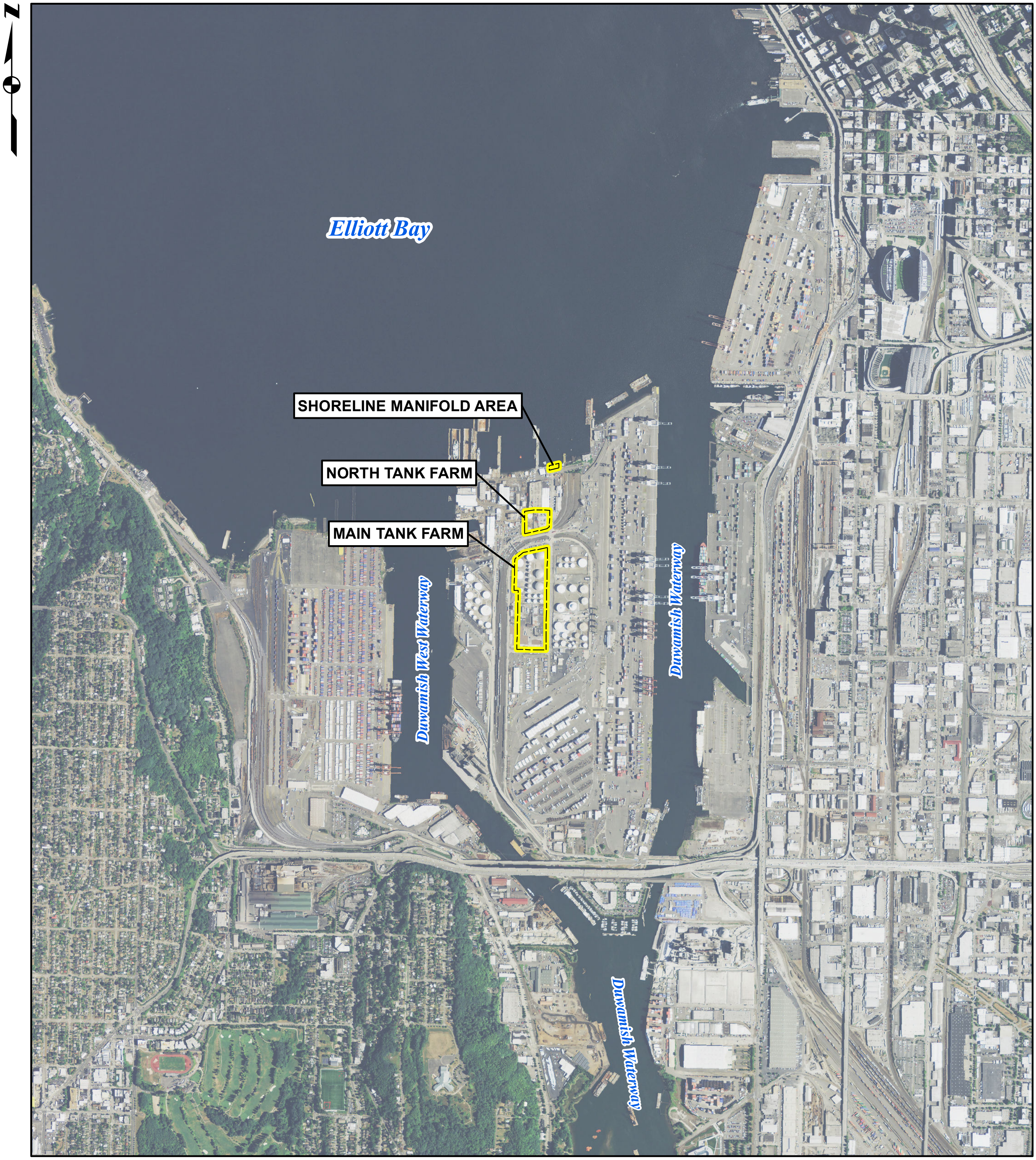
Figures



Credits: King County NAIP, 2013

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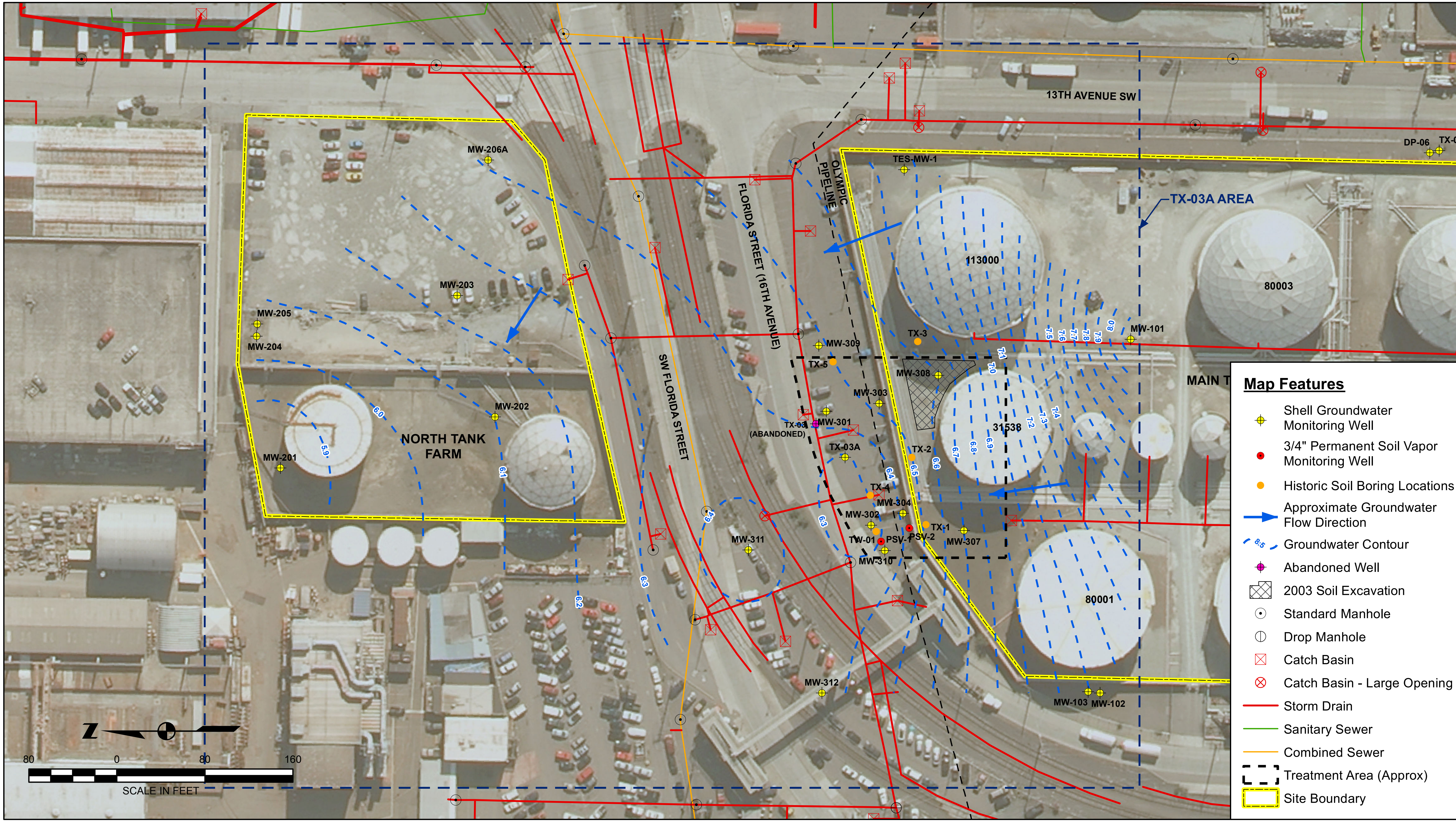
SITE VICINITY MAP

SHELL - HARBOR ISLAND TERMINAL
STORMWATER SYSTEM CLEANOUT AND VIDEO SURVEY REPORT
SEATTLE, WASHINGTON

FIGURE 1

K:\46194268 Seattle Terminal\MXD\2015\Fig 1 Vicinity Map.mxd



Source: USGS, 2009.

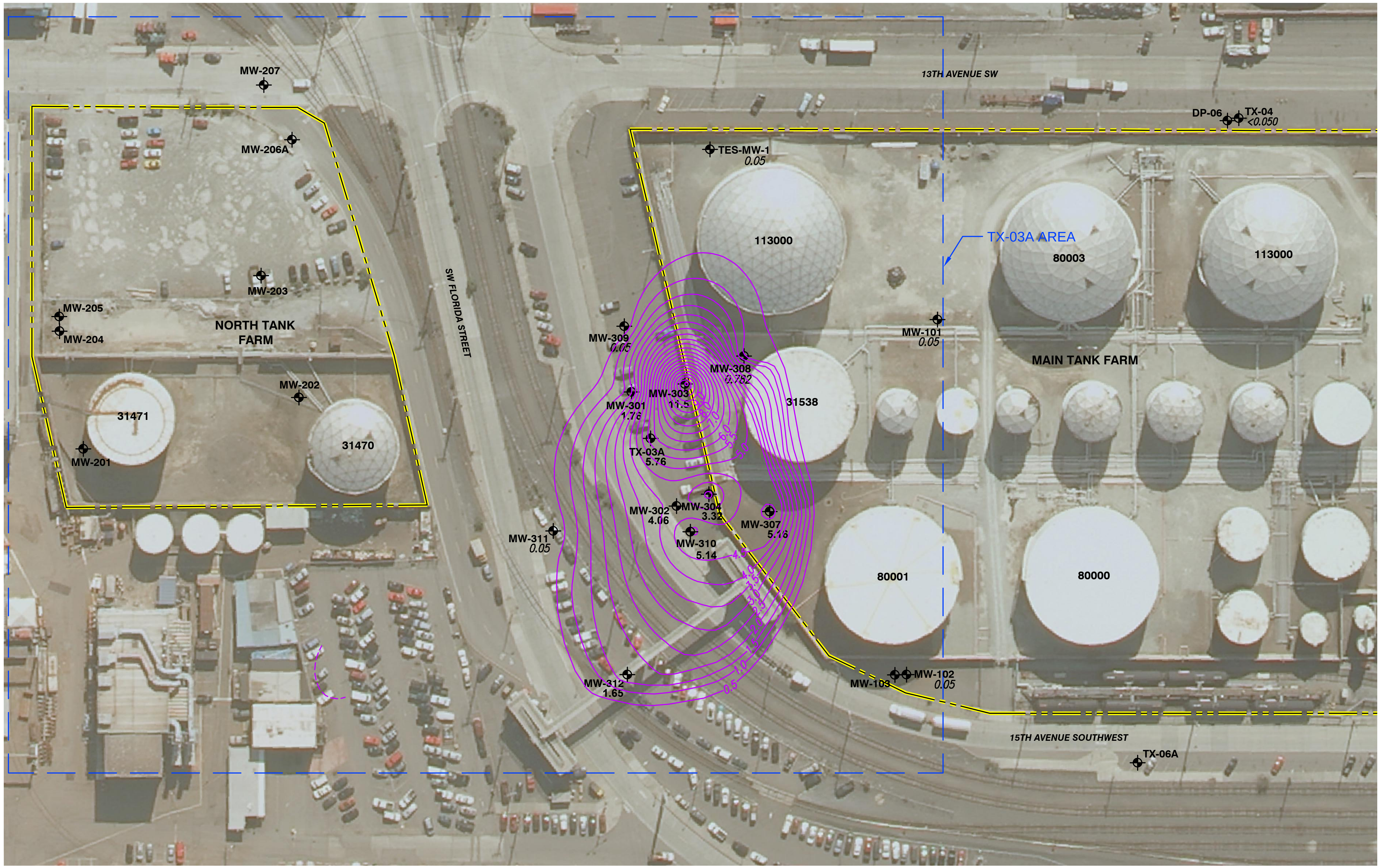
Document Path: K:\46194268 Seattle Terminal\MXD\2015\Fig 2 TX-03 Area Site Map.mxd

TX-03 AREA SITE MAP AND GROUNDWATER ELEVATION CONTOURS FOR MAY 2015

SHELL - HARBOR ISLAND TERMINAL
FOCUSED FEASIBILITY STUDY - TX-03A AREA
SEATTLE, WASHINGTON

AECOM

FIGURE 2



LEGEND

MW-212 ⌖ SHALLOW GROUNDWATER MONITORING WELL LOCATION

SHELL PROPERTY LINE

0.5 CONCENTRATION CONTOUR (CONTOUR INTERVAL IN 0.5 MG/L

TPH–Gx CLEANUP LEVEL = 1 mg/L

TPH–Gx GASOLINE

mg/L MILLIGRAMS PER LITER

BOLD INDICATE DETECTED CONCENTRATION GREATER THAN CLEANUP LEVEL

50 0 50 100

SCALE IN FEET

GASOLINE RANGE HYDROCARBON CONCENTRATIONS - NOV. 2014

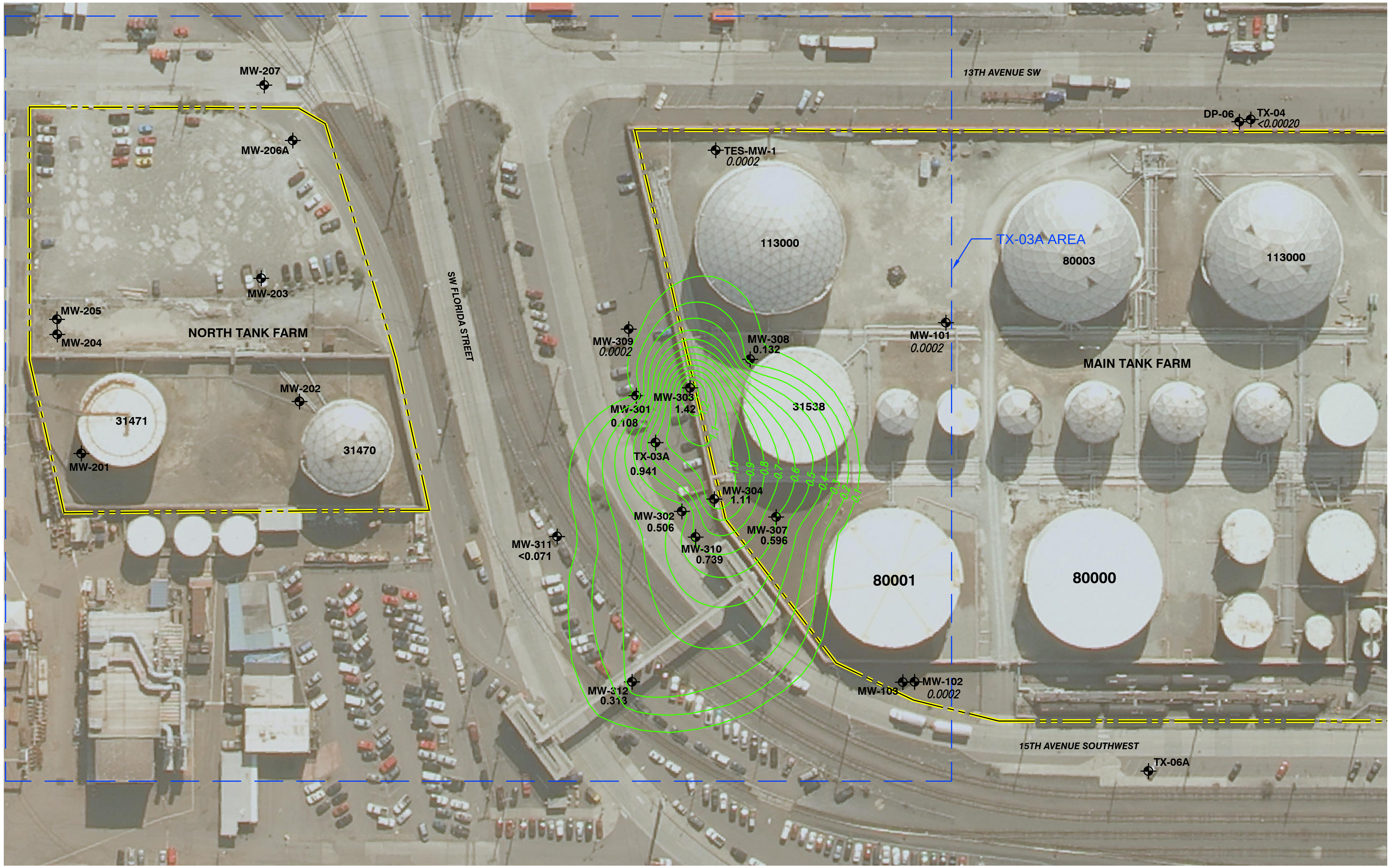
SHELL - HARBOR ISLAND TERMINAL
ANNUAL COMPLIANCE MONITORING REPORT
SEATTLE, WASHINGTON

SEPTEMBER 2015
60411001

AECOM

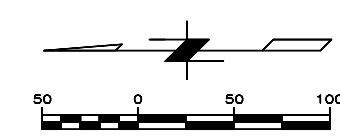
FIGURE 3

K:\46194268_Seattle_Terminal\MXD\2015\FIGURE 3-TPH.dwg Sep 30, 2015 – 2:33pm



LEGEND

MW-212 ⌖	SHALLOW GROUNDWATER MONITORING WELL LOCATION
---·---·---	SHELL PROPERTY LINE
—0.2—	CONCENTRATION CONTOUR (CONTOUR INTERVAL IN 0.1 MG/L)
BENZENE CLEANUP LEVEL = 0.071 mg/L	
mg/L	MILLIGRAMS PER LITER
BOLD	INDICATE DETECTED CONCENTRATION GREATER THAN CLEANUP LEVEL
<	NOT DETECTED AT OR ABOVE THE METHOD DETECTION LIMIT



BENZENE CONCENTRATIONS - NOV. 2014

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SEATTLE, WASHINGTON

SEPTEMBER 2015
60411001

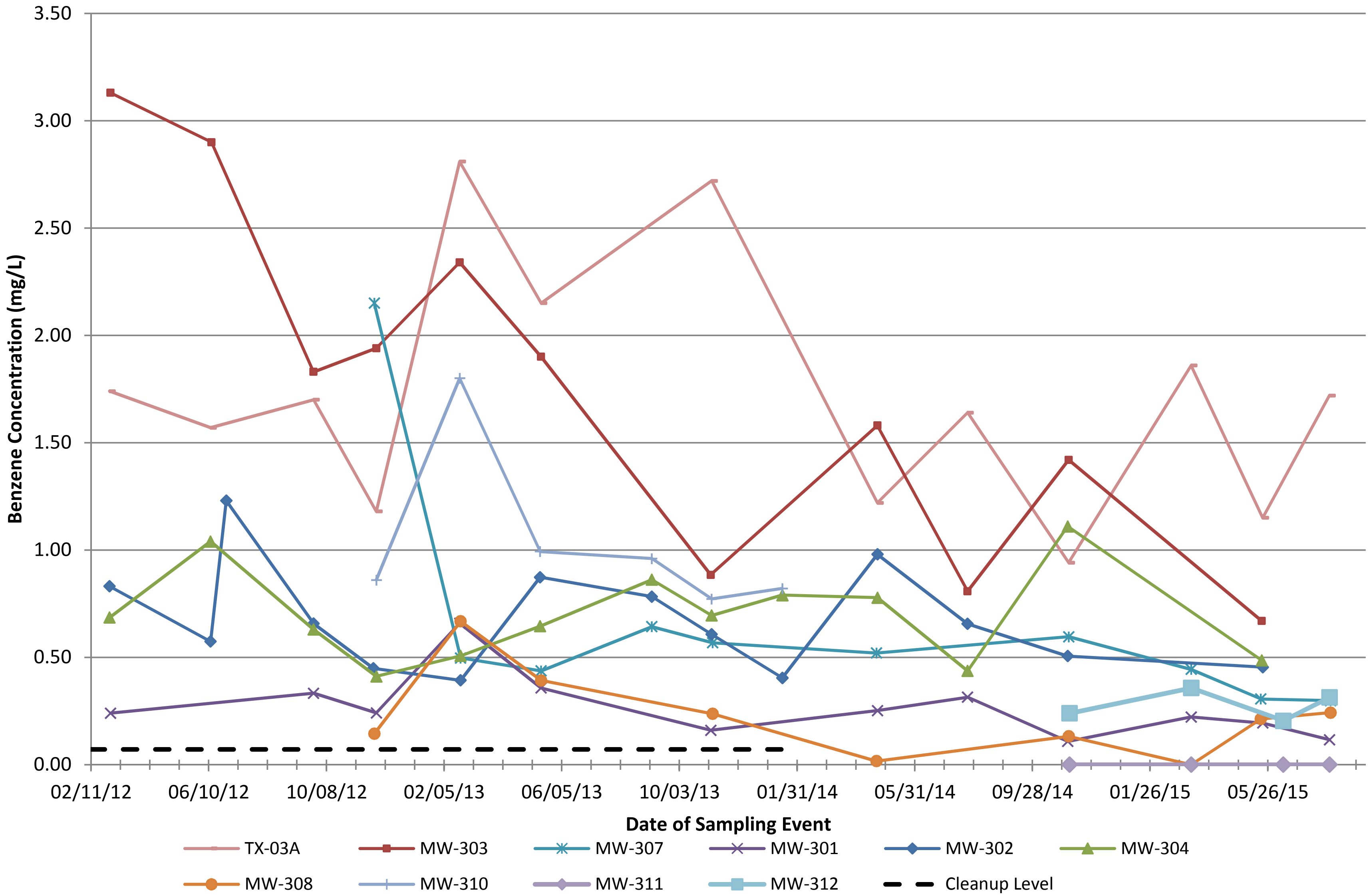
FIGURE 4

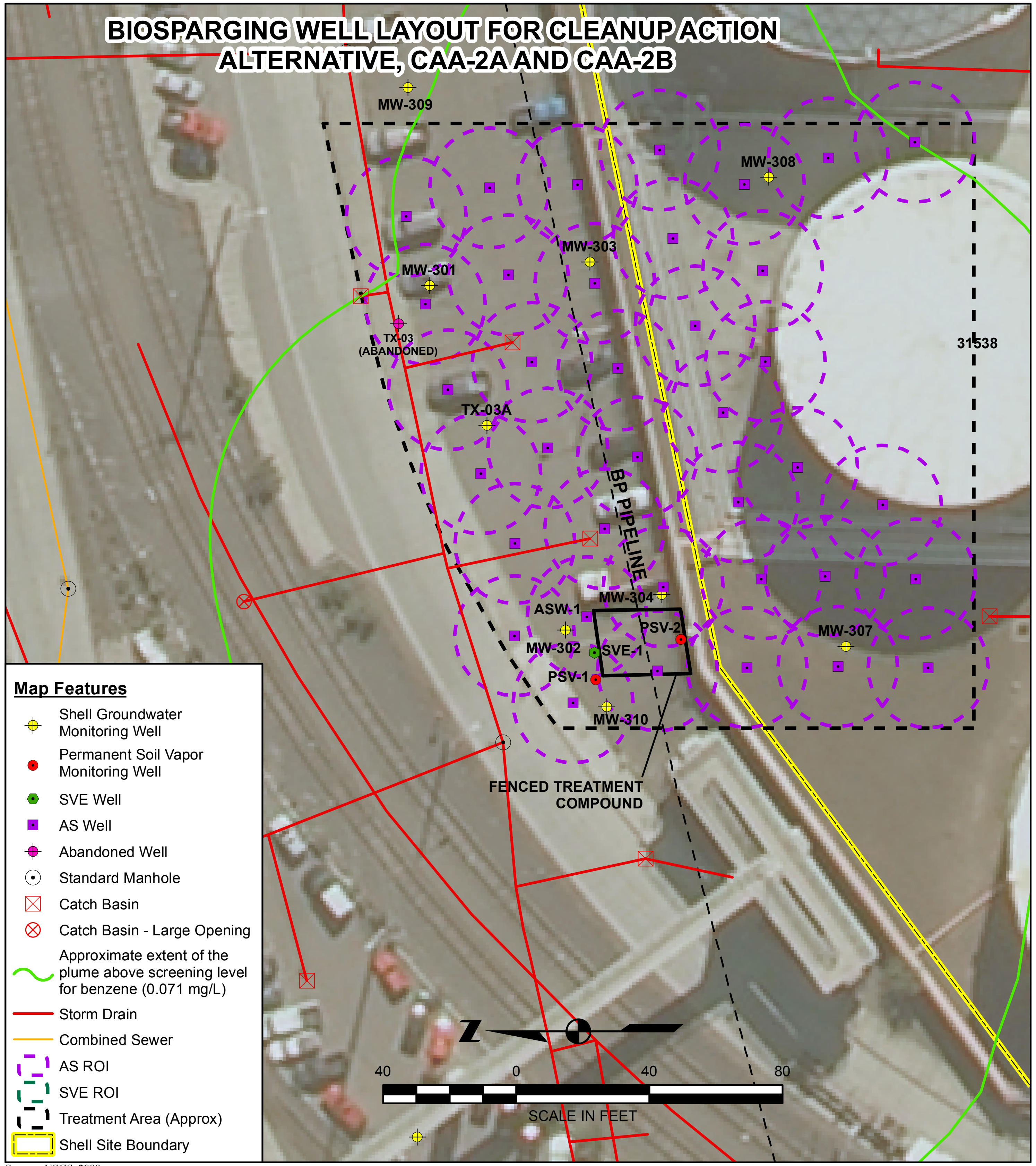
AECOM

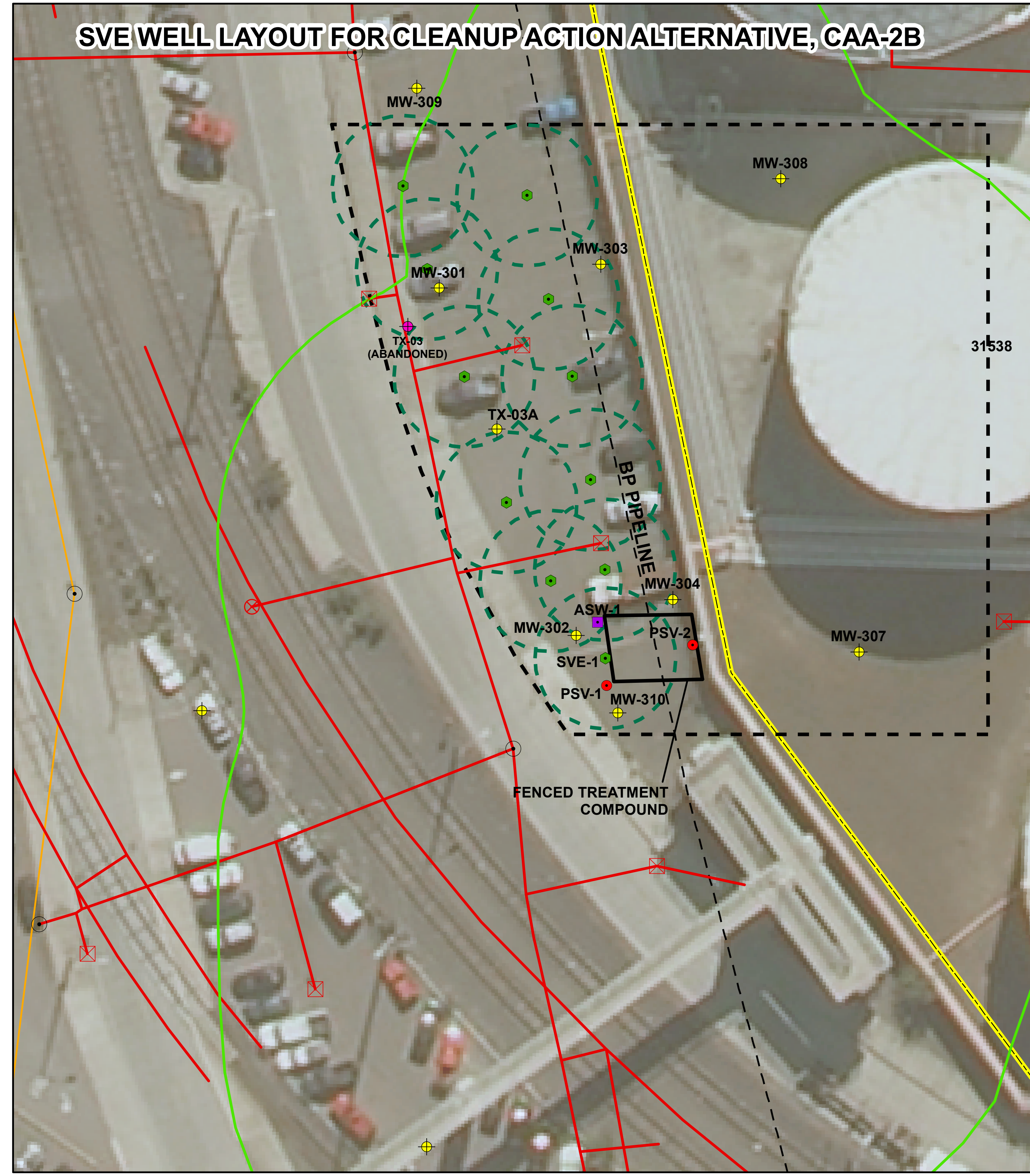
K:\46194268_Seattle_Terminal\MXD\2015\FIGURE 4-Benzene.dwg Sep 30, 2015 - 3:03pm

Figure 5: Benzene Concentration Trends for the Main Tank Farm

Shell Harbor Island Terminal
Seattle Washginton







Source: USGS, 2009.
Plume boundary based on Nov. 2014 groundwater sampling event.

K:\46194268_Seattle_Terminal\MXD\2015\Fig 6 Alternative 2.mxd

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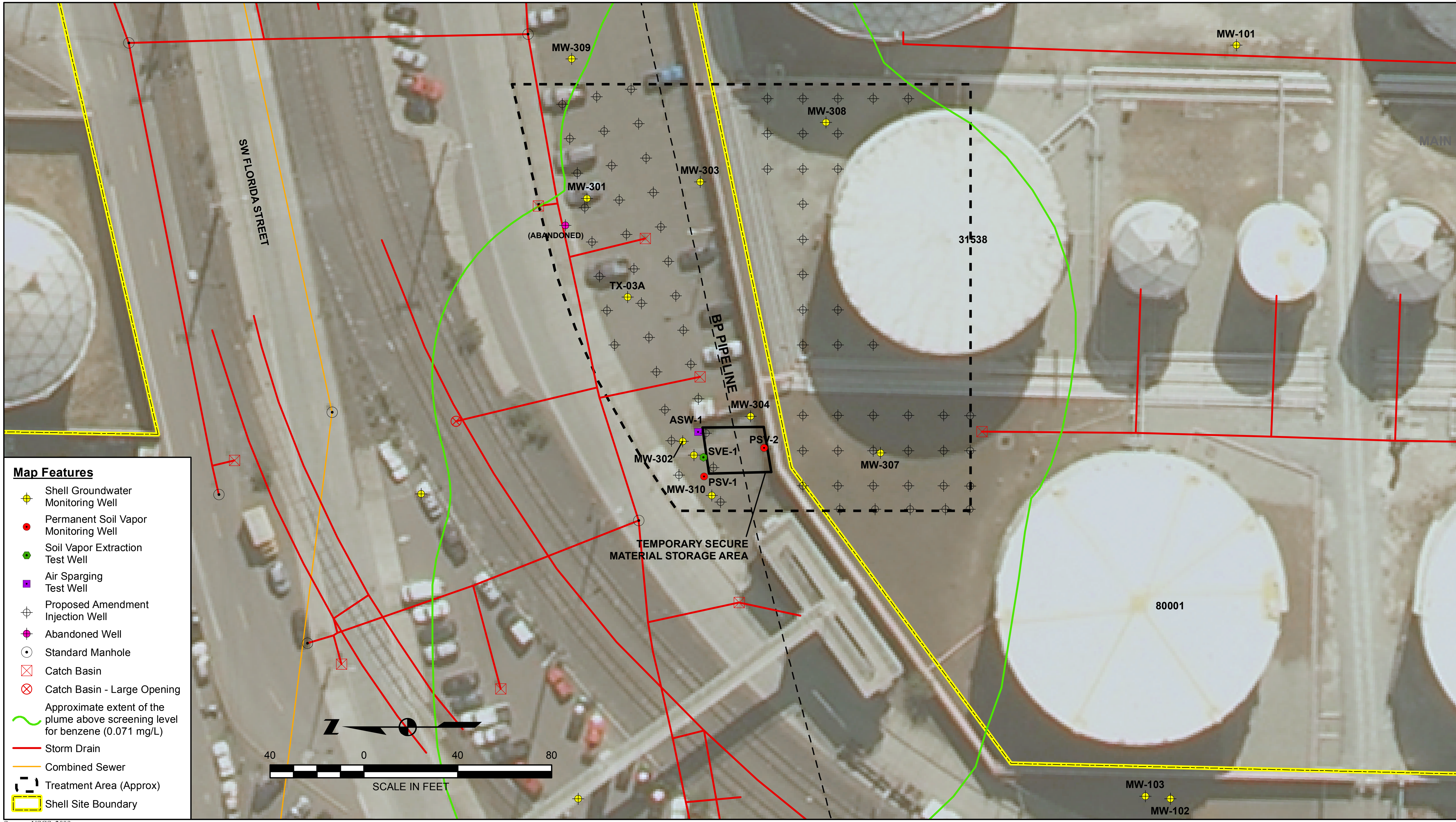
ALTERNATIVE 2 - BIO-SPARGING SYSTEM AND SOIL VAPOR EXTRACTION SYSTEM

SHELL - HARBOR ISLAND TERMINAL
FOCUSED FEASIBILITY STUDY - TX-03A AREA
SEATTLE, WASHINGTON

49241036

FIGURE 6



Source: USGS, 2009.
Plume boundary based on Nov. 2014 groundwater sampling event.

ALTERNATIVE 3 - ENHANCED BIOLOGICAL REMEDIATION

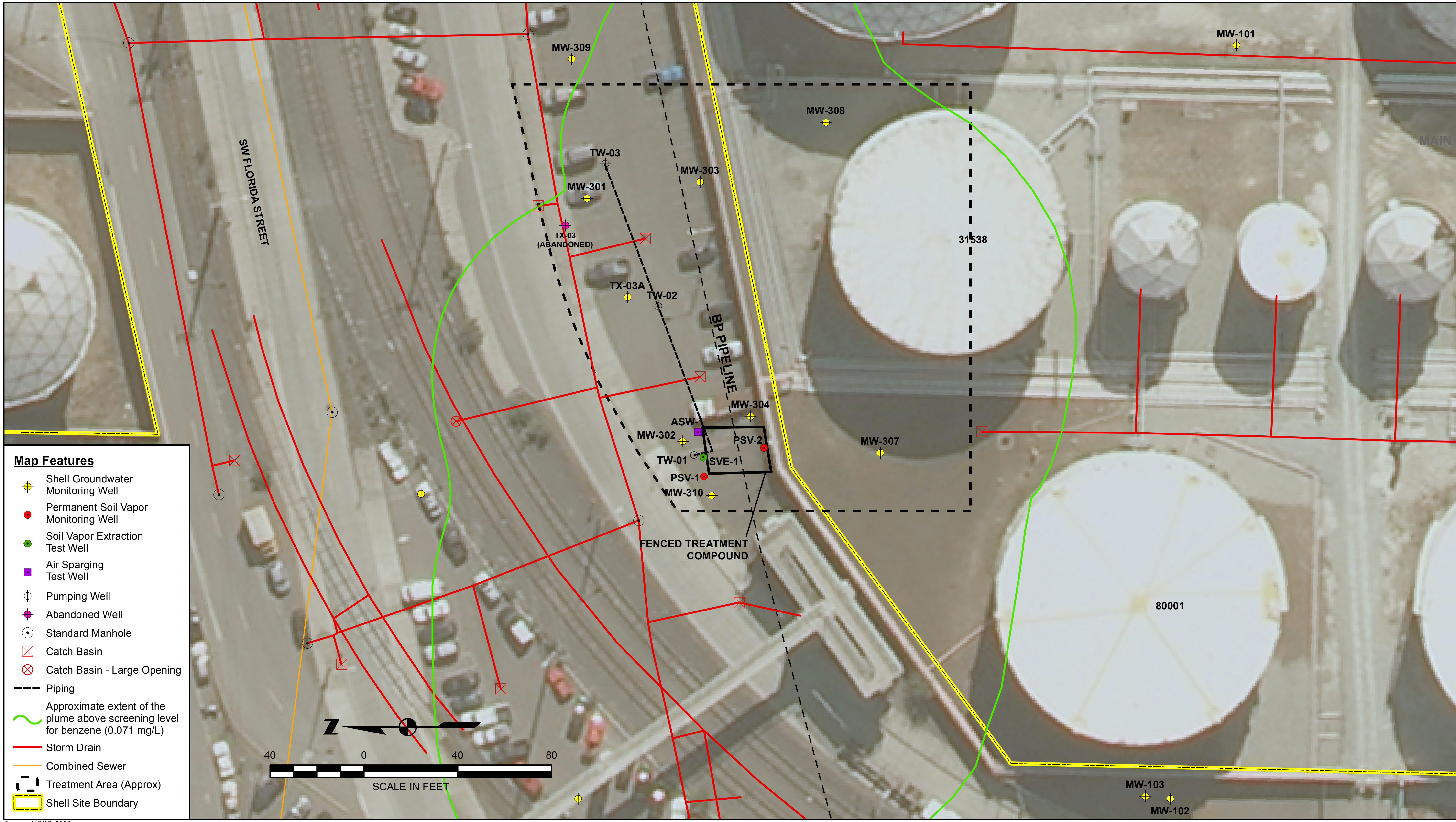
SHELL - HARBOR ISLAND TERMINAL
FOCUSED FEASIBILITY STUDY - TX-03A AREA
SEATTLE, WASHINGTON

AECOM

49241036

FIGURE 7

K:\46194268_Seattle_Terminal\MXD\2015\Fig 7 Alternative 3.mxd



Source: USGS, 2009.
Plume boundary based on Nov. 2014 groundwater sampling event.

ALTERNATIVE 4 - GROUNDWATER PUMPING AND TREATMENT

SHELL - HARBOR ISLAND TERMINAL
FOCUSED FEASIBILITY STUDY - TX-03A AREA
SEATTLE, WASHINGTON

AECOM

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FIGURE 8

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Tables

Table 1
Summary of Soil Analytical Results for VOCs and TPHs
Shell Harbor Island Terminal
Well TX-03 Area

Sample ID	Sample Date	Sample Depth (ft bgs)	Field Parameters		Volatile Organic Compounds (VOCs, µg/kg)				TPH (mg/kg)
			Sheen Test[1]	OVM (ppm)	Benzene	Toluene	Ethylbenzene	Xylenes (total)	Gasoline-Range
Soil Cleanup Levels2			NA	NA	NE	NE	NE	NE	20,000
TX-1	12/3/2009	3	S	14	42	6.2	83	49	62
TX-2	12/3/2009	3	N	5.7	<5	<5	<5	<5	<0.50
TX-3	12/3/2009	3	N	22.5	–	–	–	–	–
TX-3	12/3/2009	5.5	M	680	<1,000	<1,000	6,600	<1,000	1,200
TX-4	11/20/2009	6	N	434	<500	<500	18,000	52,000	2,700
TX-4(DUP)	11/20/2009	6	N	434	<500	<500	13,000	38,000	1,200
TX-5	11/20/2009	3.5	N	13.4	–	–	–	–	–
TX-5	11/20/2009	6	N	6.5	<5	<5	<5	<5	0.52
TW-01-7.5	9/5/2013	7.5	NC	64.3	2,370 J	<8,600	34,300	35,000	2,860

Notes:
All soil results were reported on a dry-weight basis.
< - Compound was analyzed for but not detected above the reporting limit as shown
– Sample was not analyzed for this compound.
DUP - Duplicate
mg/kg - milligrams per kilogram
NA - cleanup level not applicable
NE - cleanup level Not Established
OVM - Organic Vapor Monitoring
TPH - Total Petroleum Hydrocarbons
µg/kg - microgram per kilogram

Table 2
Summary of Groundwater Cleanup Levels and Constituent Properties
Shell Harbor Island Terminal
Well TX-03 Area

Compound	Cleanup Level (mg/L)	Anaerobic Half-Life (Days)[1]		Aerobic Half-Life (Days)[1]		Aqueous Solubility (S) (mg/L)	Henry's Law Constant (Unitless)
		Low	High	Low	High		
Benzene	0.071	2688	17280	120	384	1800	0.23
Toluene	200	1344	5040	96	528	530	0.32
Ethylbenzene	29	4224	5472	72	240	170	0.27
Xylenes	NE	627	12688	168	672	170	0.28
TPH-Gx	1	NA	NA	NA	NA	NA	NA
TPH-Dx	10	NA	NA	NA	NA	NA	NA
TPH-Rx	10	NA	NA	NA	NA	NA	NA

Notes:
NA = Not Available
NE = Not Established
[1]Handbook of Environmental Degradation Rates, Philip Howard, et. Al. 1991.

Table 3a
Summary of Anaerobic and Aerobic Cleanup Time Estimates
Shell Harbor Island Terminal
Well TX-03 Area

Compound	Highest Reported Concentration during 2014 in TX-03A Area		Cleanup Level	Number of Half-Lives Needed to Reduce Concentration Above CL to below CL	Anaerobic Half-Life (Days)[1]		Estimated Cleanup Time Under Anaerobic Conditions (Years)[2]		Aerobic Half-Life (Days)[1]		Estimated Cleanup Time Under Aerobic Conditions (Years)[2]	
Analyte	**Well**	**(mg/L)**	**(mg/L)**	**(Unit less)**	**Low**	**High**	**Low**	**High**	**Low**	**High**	**Low**	**High**
Benzene	TX-03A	1.64	0.071	4.53	2688	17280	33	214	120	384	1.5	5
Toluene	MW-303	0.0710	200	NA	1344	5040	NA	NA	96	528	NA	NA
Ethylbenzene	MW-303	1.114	29	NA	4224	5472	NA	NA	72	240	NA	NA
Xylenes	MW-306	1.97	NE	NA	627	12688	NA	NA	168	672	NA	NA
TPH-Gx	MW-303	11.8	1	3.56	NA	NA	NA	NA	NA	NA	NA	NA
TPH-Dx	MW-312	1.13	10	NA	NA	NA	NA	NA	NA	NA	NA	NA
TPH-Rx	MW-303	1.15	10	NA	NA	NA	NA	NA	NA	NA	NA	NA

Notes:
CL = cleanup level
mg/L = milligrams per liter
NA = Not applicable
NE = Not established
[1]Handbook of Environmental Degradation Rates, Philip Howard, et. Al. 1991.
[2] 365 Days in a Year

Where: Estimated Cleanup Time (T) is rounded to the nearest whole year and calculated, based on the following:
$T = t_{1/2}$ / (ln 2)/ (ln (Co/Ct))/365
$t_{1/2}$ = half life (days)
Co = Highest Reported Concentration during 2014 (mg/L)
Ct = Cleanup Level (mg/L)
365 = conversion factor from days to years

Table 3b

Summary of Well-Specific Cleanup Time Estimates

Shell Harbor Island Terminal

TX-03A Area

Well	Data-Specific Half-Life (Years)[1]	2015 Concentration (mg/L)	Cleanup Level (mg/L)	Number of Half-Lives to Reduce Below Cleanup Level[2]	Estimated Cleanup Time (years)
Benzene					
MW-303	2.2	0.669	0.071	3.2	7.1
MW-307	1.8	0.298	0.071	2.1	3.7
MW-310	3.4	0.714	0.071	3.3	11.3
TPH-Gx					
MW-301	5	2.09	1	1.1	5.3
MW-307	3.4	4.09	1	2.0	6.9
MW-310	3.9	3.72	1	1.9	7.4

[1]Data-specific Half-Life (years) based on statistically relevant data generated from Mann-Kendall Data Trend Analysis (See Appendix A)

[2]Number of Half-Lives = $\ln(C_o/C_f)/\ln(2)$

mg/L = milligrams per liter

C_0 = 2015 Concentration (mg/L)

C_f = Cleanup Level (mg/L)

Table 4
Summary of Cleanup Action Alternatives
Shell Harbor Island Terminal
Well TX-03 Area

Cleanup Action Alternative (CAA) Description			Advantages	Disadvantages	Estimated NPV Costs	Estimated Treatment Time	Unknowns
CAA-1	No Additional Action (Current Contingency Plan)	The groundwater would be monitored, with quarterly sampling and reporting until groundwater concentrations show declining trends to below the cleanup levels for the target constituents. Performance reviews would be completed by Ecology at 5-year intervals to record the status of the cleanup action at the site.	No active treatment is conducted and low capital expenditure. Although the hydrocarbons in the soil and groundwater are not actively treated, the hydrocarbon concentrations in soil and groundwater will decline over time through natural attenuation.	A long-period of time is required for natural attenuation processes under anaerobic conditions. Potential for off-site migration of plume over a longer-treatment duration.	$784,000	33 to 214 years	1) Potential of sources upgradient of MW-307 or MW-308 2) Frequency of long-term groundwater monitoring 3) Cleanup time
CAA-2a	Bio-Sparging	Inject air at pulsed intervals to add oxygen to the groundwater. Air would be injected at about 4 CFM per well through stingers installed by HSA at depths of approximately 12-14 feet below grade. Air would be injected using a compressor routed through below grade piping to the subsurface wells spaced at approximately 25 foot radii, assuming homogeneous subsurface conditions with effective porosity of approximately 35% and good accessibility.	Proven technology to reduce VOC concentrations in groundwater. Remedy takes approximately up to 5 years. Easy to install and operate. Can enhance natural attenuation by supplying additional oxygen to the subsurface. Reduces VOC mass through less invasive treatment approach. Can be used in combination with other technologies to reduce overall cleanup time. Installation can be completed to minimize intrusion.	Residual hydrocarbon mass rebound may occur, requiring longer time periods for treatment.	$366,000	2 to 5 Years	1) Potential of sources upgradient of MW-307 or MW-308 2) Actual length of time to operate the system 3) Homogeneity of aquifer, i.e., sparging radius across TX-03A 4) Frequency of system maintenance 5) Accessibility along pipeline for system installation
CAA-2b	Bio-Sparging and SVE	Air injection requirement description is the same as CAA-2a. Includes a shallow SVE wells would be placed within the source area. Wells would be spaced approximately 30 feet apart and screened between 4 feet and 6 feet bgs or installed as horizontal recovery trenches located perpendicular to the pipeline, in the public parking lot, on the northern side of the Main Tank Farm dike wall. The system would remove volatile vapors from the SVE wells at approximately 40-inches of watervacuum. Ancillary treatment of the removed vapors through granular activated carbon.	Proven technology to reduce VOC concentrations in groundwater. Remedy takes approximately up to 5 years. Easy to install and operate. Can enhance natural attenuation by supplying additional oxygen to the subsurface and also volatilizing compounds in areas where SVE is present to remove air vapors. Reduces VOC mass through less invasive treatment approach. Can be used in combination with other technologies to reduce overall cleanup time. Installation can be completed to minimize intrusion. Reduced worker exposure during implementation.	Residual hydrocarbon mass reboundmay occur, requiring longer time periods for treatment. Additional recovery and treatment of vapors is necessary below the public parking lot.	$452,000	2 to 5 Years	1) Potential of sources upgradient of MW-307 or MW-308 2) Actual length of time to operate the system 3) Homogeneity of aquifer, i.e., sparging radius across TX-03A 4) Effectiveness of SVE system and vapor recovery, ability to get good seal on shallow wells for vapor recovery 5) Frequency of system maintenance 6) Accessibility along pipeline for system installation
CAA-3	Enhanced Biological Remediation	Injection of oxygen releasing amendments in borings, at an estimated spacing of 10-feet within source area and in downgradient area of the plume. Bioamendment would be administered at 75 proposed amendment injection locations during the primary injection event. A secondary, polish injection event, would be conducted at 33 injection locations, within the parking lot located north of the Main Tank Farm dike wall. Amendment choices may include: Regenesis ORC® or FMC EHC-O.	Enhanced bioremediation theoretically results in low cleanup time. Health and safety concerns are minimized during implementation. Application may only require one injection, but to be conservative a second injection event is assumed. Benefits larger area as groundwater migrates downgradient.	Implementation may take longer than a year, during which time groundwater migration may occur. Additional monitoring parameters are required to provide evidence of progress. Pressurized injection may interfere with existing utilities.	$427,000	2 to 4 Years	1) Potential of sources upgradient of MW-307 or MW-308 2) Need for supplemental amendment injection. Actual number of rounds of amendment injection 3) Interference of pipeline and infrastructure as a results of pressurized injection 4) Cleanup time
CAA-4	Groundwater Pumping and Treatment	Hydrocarbon-impacted groundwater would be pumped from up to three groundwater pumping wells for aboveground treatment through low-profile air stripper. Ancillary treatment of the air discharged from the stripper would be routed through granular activated carbon vessels.	Effective and proven technology at removing VOCs from subsurface. Lateral hydraulic control is established by pumping. Permeable aquifer would produce higher volume for more effective removal.	Long time period required to implement remedial action. May cause VOCs from other source areas, to migrate into pumping zone. High operation and maintenance costs. Iron fouling may occur in pumping wells requiring routine maintenance.	$1,346,000	26 Years	1) Potential of sources upgradient of MW-307 or MW-308 2) Long-term sustainability of pumping rate 3) Actual interstitial velocity and retardation factor of constituents in groundwater 4) Potential for iron fouling of system components

Notes:
AS = air sparging
bgs = below ground surface
BOD = Biological Oxygen Demand
BTEX = Benzene, Toluene, Ethylbenzene, and Xylene
CFM = cubic feet per minute
COD = Chemical Oxygen Demand
SVE = soil vapor extraction
TOC = Total Organic Carbon
TPH = Total Petroleum Hydrocarbons
VOCs = volatile organic compounds
% = percent

Table 5
Comparative Analysis of Cleanup Action Alternatives
Shell Harbor Island Terminal
Well TX-03 Area

Criteria/Subcriteria (1)	CAA-1 No Additional Action (Current Contingency Plan)	CAA-2a Bio-Sparging System	CAA-2b Bio-Sparging with Soil Vapor Extraction System	CAA-3 Enhanced Biological Remediation	CAA-4 Groundwater Pumping and Treatment
PROTECTIVENESS (5=Highly Protective)					
Protective of Human Health and the Environment	3	3	2	3	2
SUBTOTAL	3	3	2	3	2
PERMANENCE (5=High Permanence of Removal)					
Reduction of Toxicity	3	3	2	3	2
Reduction of Mobility	2	3	3	3	4
Reduction of Volume	3	4	4	4	2
SUBTOTAL	8	10	9	10	8
Long Term Effectiveness (5=High Effectiveness)					
Effectively and reliably maintains treatment levels over the long term	2	3	3	3	2
SUBTOTAL	2	3	3	3	2
SHORT TERM RISK MANAGEMENT (5=Low Risk)					
Effectively mitigates short term risk	4	4	4	4	4
SUBTOTAL	4	4	4	4	4
IMPLEMENTABILITY (5=High Implementability)					
Technical Feasibility	5	3	3	2	2
Availability of Services and Materials	5	3	2	2	2
Administrative Feasibility	5	3	2	2	2
SUBTOTAL	15	9	7	6	6
CONSIDERATION OF PUBLIC CONCERNS (5 = Highly Considerate of Public Concerns)					
State Acceptance	3	3	3	3	2
Community Acceptance	2	3	2	3	2
SUBTOTAL	5	6	5	6	4
COST (5=Low Cost)					
Present Worth Cost[2]	3	4	3	3	2
SUBTOTAL	3	4	3	3	2
TOTAL	**40**	**39**	**33**	**35**	**28**

Notes:
(1) Evaluation criteria are rated numerically, according to the following system:
1 - least acceptable of all alternatives evaluated and compared
2- acceptable, yet satisfies/fulfills few elements of evaluation criteria
3 - acceptable and satisfies/fulfills a substantial amount of the elements of evaluation criteria
4 - most acceptable of all alternatives evaluated and compared
(2) Analysis of cost assigns higher rating to the more cost-effective alternative.
CAA = Cleanup Action Alternative

Appendix A
Historical Groundwater Data

Table A-1
BTEX, Petroleum Hydrocarbons, and Lead in Groundwater
Shell Harbor Island Terminal
Seattle, Washington

Location ID	Sample Date	Chemical (mg/L)							
		Benzene	Toluene	Ethyl-benzene	Total Xylenes (mixed isomers)	Gasoline Range Hydro-carbons	Diesel Range Hydro-carbons	Motor Oil Range Hydrocarbons	Total Lead
Cleanup Level*		**0.071**	**200**	**29**	**NE**	**1**	**10**	**10**	**0.0058**
MW-05	01/15/04	< 0.001	< 0.001	< 0.001	< 0.001	< 0.25	0.37	< 0.5	NA
	04/21/04	0.0015	< 0.001	0.0053	< 0.001	< 0.25	0.41	< 0.5	NA
	07/28/04	0.0015	0.001	< 0.001	0.0017	< 0.25	< 0.25	< 0.5	NA
	10/19/04	< 0.001	< 0.001	< 0.001	< 0.001	< 0.25	< 0.25	< 0.5	NA
	01/25/05	< 0.001	< 0.001	< 0.001	< 0.001	< 0.25	< 0.25	< 0.5	NA
	04/18/05	< 0.001	< 0.001	< 0.001	< 0.001	0.072	< 0.25	< 0.5	NA
	07/12/05	< 0.001	< 0.001	< 0.001	< 0.001	0.25	< 0.25	< 0.5	NA
	10/19/05	< 0.001	< 0.001	< 0.001	< 0.001	0.11	< 0.25	< 0.5	NA
	01/26/06	< 0.0005	< 0.0005	< 0.0005	< 0.001	< 0.05	< 0.238	< 0.476	NA
	11/19/08	< 0.005	< 0.005	< 0.005	< 0.005	< 0.05	< 0.25	< 0.5	NA
	11/17/09	< 0.0005	< 0.001	< 0.001	< 0.001	< 0.1	< 0.1	< 0.1	NA
	10/29/10	< 0.0005	< 0.001	< 0.001	< 0.001	< 0.1	0.14	< 0.1	NA
	05/23/11	<.0003	<.0005	<.0003	<.0007	0.0744	NA	NA	NA
	10/25/11	< 0.0010	< 0.0010	< 0.0010	< 0.0020	0.115	< 0.095	< 0.19	NA
	11/29/12	< 0.00020	< 0.00020	< 0.00020	< 0.00046	< 0.050	0.0954	< 0.095	NA
	11/07/13	< 0.00020	0.00083 J	< 0.00020	0.00087 J	0.345	< 0.049	< 0.097	NA
	11/06/14	< 0.00020	< 0.00020	< 0.00020	< 0.00046	0.0507 J	0.137	< 0.094	NA
MW-101	01/16/04	< 0.001	< 0.001	< 0.001	0.0028	0.55	< 0.25	< 0.5	NA
	04/20/04	0.0016	< 0.001	< 0.001	0.0014	0.67	< 0.25	< 0.5	NA
	07/28/04	0.0012	< 0.001	< 0.001	0.0011	1.0	< 0.25	< 0.5	NA
	10/18/04	0.0011	< 0.001	< 0.001	< 0.001	0.42	< 0.25	< 0.5	NA
	01/26/05	< 0.001	< 0.001	< 0.001	0.0011	0.51	< 0.25	< 0.5	NA
	04/19/05	0.0016	< 0.001	< 0.001	< 0.001	0.58	< 0.25	< 0.5	NA
	07/13/05	< 0.001	< 0.001	< 0.001	< 0.001	0.31	< 0.25	< 0.5	NA
	10/10/05	< 0.001	< 0.001	< 0.001	< 0.001	0.16	< 0.25	< 0.5	NA
	01/27/06	< 0.0005	< 0.0005	< 0.0005	< 0.001	0.223	< 0.236	< 0.476	NA
	11/18/08	< 0.005	< 0.005	< 0.005	< 0.005	0.1	< 0.25	< 0.5	NA
	11/18/09	< 0.0005	< 0.001	< 0.001	< 0.001	< 0.1	< 0.1	< 0.1	NA
	10/26/10	< 0.0005	< 0.001	< 0.001	< 0.001	0.15	0.13	< 0.1	NA
	10/27/11	< 0.0010	< 0.0010	< 0.0010	< 0.0020	0.0936	< 0.10	< 0.20	NA
	11/26/12	< 0.00020	< 0.00020	< 0.00020	< 0.00046	0.188 J	0.0937 J	< 0.10	NA
	11/06/13	< 0.00020	< 0.00020	< 0.00020	< 0.00046	0.118 J	< 0.0048	< 0.0095	NA
	11/04/14	< 0.00020	< 0.00020	< 0.00020	< 0.00046	< 0.050	< 0.0048	< 0.0095	NA
MW-102	01/14/04	0.0021	< 0.001	< 0.001	< 0.001	< 0.25	< 0.25	< 0.5	NA
	04/21/04	0.0036	< 0.001	< 0.001	< 0.001	< 0.25	< 0.25	< 0.5	NA
	07/28/04	< 0.001	< 0.001	< 0.001	< 0.001	< 0.25	< 0.25	< 0.5	NA
	10/18/04	0.0011	< 0.001	< 0.001	< 0.001	< 0.25	< 0.25	< 0.5	NA
	01/25/05	0.0024	< 0.001	< 0.001	< 0.001	< 0.25	< 0.25	< 0.5	NA
	04/18/05	0.0027	< 0.001	< 0.001	< 0.001	< 0.05	< 0.25	< 0.5	NA
	07/13/05	< 0.001	< 0.001	< 0.001	< 0.001	0.077	< 0.25	< 0.5	NA
	10/19/05	< 0.001	< 0.001	< 0.001	< 0.001	< 0.05	< 0.25	< 0.5	NA
	01/26/06	0.00498	< 0.0005	0.00174	0.00201	< 0.05	< 0.238	< 0.472	NA
	11/19/08	< 0.005	< 0.005	< 0.005	< 0.005	< 0.05	< 0.25	< 0.5	NA
	11/18/09	< 0.0005	< 0.001	< 0.001	< 0.001	< 0.1	< 0.1	< 0.1	NA
	10/28/10	< 0.0005	< 0.001	< 0.001	< 0.001	< 0.1	< 0.1	< 0.1	NA
	10/26/11	< 0.0010	< 0.0010	< 0.0010	< 0.0020	< 0.20	0.113	< 0.20	NA
	11/28/12	< 0.00020	< 0.00020	< 0.00020	< 0.00046	< 0.050	< 0.050	< 0.10	NA
	11/07/13	< 0.00020	< 0.00020	< 0.00020	< 0.00046	< 0.050	< 0.047	0.144 J	NA
	11/04/14	< 0.00020	< 0.00020	< 0.00020	< 0.00046	< 0.050	0.0568 J	< 0.094	NA

Table A-1
BTEX, Petroleum Hydrocarbons, and Lead in Groundwater
Shell Harbor Island Terminal
Seattle, Washington

Location ID	Sample Date	Chemical (mg/L)							
		Benzene	Toluene	Ethyl-benzene	Total Xylenes (mixed isomers)	Gasoline Range Hydro-carbons	Diesel Range Hydro-carbons	Motor Oil Range Hydrocarbons	Total Lead
Cleanup Level*		0.071	200	29	NE	1	10	10	0.0058
MW-104	01/15/04	0.0019	< 0.001	0.15	0.1028	**2.7**	1.2	< 0.5	0.00555
	01/15/04	0.0012	< 0.001	0.1	0.0706	**2**	1.3	< 0.5	< 0.005
	04/21/04	0.0066	0.0025	0.35	0.0931	**4.3**	1.7	< 0.5	0.00575
	07/28/04	0.0018	< 0.001	0.048	0.017	**2.2**	0.87	< 0.5	< 0.005
	07/28/04	0.0017	< 0.001	0.049	0.019	**2.1**	1.3	< 0.5	< 0.005
	10/19/04	< 0.001	< 0.001	0.0021	0.0016	< 0.25	0.61	< 0.5	< 0.005
	01/24/05	< 0.001	< 0.001	0.0012	< 0.001	< 0.25	0.74	< 0.5	< 0.005
	04/18/05	< 0.001	< 0.001	0.057	0.0067	**1.4**	1.2	< 0.5	< 0.005
	07/12/05	0.0014	< 0.001	0.11	0.012	**1.8**	0.7	< 0.5	< 0.005
	10/19/05	< 0.001	< 0.001	0.024	0.0049	0.29	0.62	< 0.5	< 0.005
	01/25/06	0.00245	0.00129	0.33	0.0273	**2.07**	3.73	< 0.962	0.0077
	10/30/07	NA	NA	NA	NA	**1.25**	NA	NA	< 0.002
	05/20/08	NA	NA	NA	NA	**4.00**	2.10	< 0.5	NA
	11/18/08	NA	NA	NA	NA	0.13	0.69	< 0.5	< 0.005
	04/08/09	NA	NA	NA	NA	**1.80**	1.60	< 0.1	0.00326
	11/17/09	< 0.0005	< 0.001	0.0016	< 0.001	0.21	0.17	< 0.1	0.00778
	04/27/10	NA	NA	NA	NA	**3.90**	2.50	0.27	0.00232
	10/26/10	NA	NA	NA	NA	0.23	0.23	< 0.1	NA
	05/23/11	<0.0006	0.003	0.104	0.0018	**4.44**	0.45	<0.097	< 0.01
	10/25/11	NA	NA	NA	NA	**3.38**	0.413	< 0.20	< 0.01
	03/01/12	0.00079 J	0.0015	0.0467	0.0016 J	**3.69**	NA	NA	NA
	06/13/12	NA	NA	NA	NA	**4.78**	0.423	< 0.10	< 0.01
	09/26/12	0.00066 J	0.0024	0.0509	0.0019 J	**4.54**	NA	NA	NA
	11/29/12	0.00038 J	0.00037 J	0.0113	< 0.00046	0.592	0.315	< 0.098	NA
	05/14/13	NA	NA	NA	NA	**5.07**	0.601	< 0.096	< 0.01
	11/07/13	NA	NA	NA	NA	**3.62**	0.666 J	< 0.095	< 0.01
	04/24/14	NA	NA	NA	NA	**5.68**	1.13	0.100 J	< 0.01
	11/05/14	NA	NA	NA	NA	0.441	0.527	0.221	< 0.01
	05/20/15	NA	NA	NA	NA	**2.82**	0.686	< 0.097	< 0.01
MW-105	01/15/04	< 0.001	< 0.001	< 0.001	< 0.001	< 0.25	1.4	< 0.5	0.00647
	04/21/04	< 0.001	< 0.001	< 0.001	< 0.001	< 0.25	0.65	< 0.5	0.00793
	07/27/04	< 0.001	< 0.001	< 0.001	< 0.001	< 0.25	2.2	< 0.5	0.0128
	10/19/04	< 0.001	< 0.001	< 0.001	< 0.001	< 0.25	1.8	< 0.5	0.0311
	01/24/05	< 0.001	< 0.001	< 0.001	< 0.001	< 0.25	3	< 0.5	0.00824
	04/18/05	< 0.001	< 0.001	< 0.001	< 0.001	< 0.05	1.3	0.78	0.00615
	07/12/05	< 0.001	< 0.001	< 0.001	< 0.001	< 0.05	1.7	< 0.5	< 0.005
	10/18/05	< 0.001	< 0.001	< 0.001	< 0.001	< 0.05	1.7	0.66	< 0.005
	01/25/06	< 0.0005	< 0.0005	< 0.0005	< 0.001	< 0.05	3.95	< 0.962	0.00321
	11/19/08	< 0.005	< 0.005	< 0.005	< 0.005	< 0.05	NA	NA	< 0.005
	11/17/09	< 0.0005	< 0.001	< 0.001	< 0.001	< 0.1	0.17	< 0.1	0.021
	10/26/10	< 0.0005	< 0.001	< 0.001	< 0.001	< 0.1	NA	NA	NA
	10/25/11	< 0.0010	< 0.0010	< 0.0010	< 0.0020	< 0.20	0.253	< 0.20	< 0.01
	11/26/12	< 0.00020	< 0.00020	< 0.00020	< 0.00046	< 0.050	0.291	< 0.098	< 0.01
	11/07/13	< 0.00020	< 0.00020	< 0.00020	< 0.000046	< 0.050	0.189	< 0.095	**0.0179**
	11/05/14	< 0.00020	< 0.00020	< 0.00020	< 0.000046	< 0.050	0.377	0.192	< 0.01
MW-111	01/15/04	0.047	< 0.001	< 0.001	< 0.001	< 0.25	0.98	< 0.5	NA
	04/21/04	< 0.001	< 0.001	< 0.001	< 0.001	< 0.25	0.48	< 0.5	NA
	07/27/04	0.015	< 0.001	< 0.001	0.0012	< 0.25	0.45	< 0.5	NA
	10/19/04	0.036	0.0012	< 0.001	0.0035	0.35	0.45	< 0.5	NA
	01/25/05	**0.079**	< 0.005	< 0.005	< 0.005	0.58 J	0.63	< 0.5	NA
	04/18/05	< 0.001	< 0.001	< 0.001	< 0.001	0.096	< 0.25	< 0.5	NA
	07/12/05	0.0094	< 0.001	< 0.001	< 0.001	0.23	0.26	< 0.5	NA
	10/18/05	0.017	< 0.001	< 0.001	0.0013	0.26	0.27	< 0.5	NA
	01/25/06	**0.0956**	0.00189	0.000796	0.0037	0.683	0.998	< 0.481	NA
	11/19/08	0.014	< 0.005	< 0.005	< 0.005	0.230	0.370	< 0.5	NA
	11/17/09	0.041	< 0.001	< 0.001	< 0.001	0.240	0.110	< 0.1	NA
	10/26/10	0.0043	< 0.001	< 0.001	< 0.001	< 0.1	0.120	< 0.1	NA
	05/23/11	0.0006	<.0005	<.0003	<.0007	<0.050	NA	NA	NA
	10/25/11	0.00094	< 0.0010	< 0.0010	< 0.0020	< 0.20	0.122	< 0.20	NA
	11/29/12	0.0248	0.0010	< 0.00020	0.0012 J	0.371	0.269	< 0.10	NA
	11/07/13	**0.0845**	0.0010	0.00023 J	0.00069 J	0.208	0.174	< 0.095	NA
	11/05/14	0.0574	0.0012	0.00083 J	0.00047 J	0.232	0.167	0.118 J	NA

Table A-1
BTEX, Petroleum Hydrocarbons, and Lead in Groundwater
Shell Harbor Island Terminal
Seattle, Washington

		Chemical (mg/L)							
Location ID	**Sample Date**	**Benzene**	**Toluene**	**Ethyl-benzene**	**Total Xylenes (mixed isomers)**	**Gasoline Range Hydro-carbons**	**Diesel Range Hydro-carbons**	**Motor Oil Range Hydrocarbons**	**Total Lead**
Cleanup Level*		**0.071**	**200**	**29**	**NE**	**1**	**10**	**10**	**0.0058**
MW-112A	01/15/04	0.02	< 0.001	< 0.001	< 0.001	0.25	0.63	< 0.5	NA
	04/21/04	< 0.005	< 0.005	< 0.005	< 0.005	< 1.2	0.56	< 0.75	NA
	07/27/04	< 0.001	< 0.001	< 0.001	< 0.001	< 0.25	0.51	< 0.5	NA
	10/19/04	0.0013	< 0.001	< 0.001	< 0.001	< 0.25	0.68	< 0.5	NA
	01/24/05	0.003	0.0012	< 0.001	0.001	0.44	0.65	< 0.5	NA
	04/20/05	< 0.001	< 0.001	< 0.001	< 0.001	0.42	1.4	< 0.5	NA
	07/12/05	0.0029	< 0.001	< 0.001	< 0.001	0.28	0.48	< 0.5	NA
	10/18/05	< 0.001	< 0.001	< 0.001	< 0.001	< 0.05	< 0.25	< 0.5	NA
	01/26/06	0.00211	< 0.0005	< 0.0005	< 0.001	0.236	0.602	< 0.485	NA
	11/19/08	< 0.005	< 0.005	< 0.005	< 0.005	0.300	1.300	< 0.5	NA
	11/18/09	0.00075	< 0.001	< 0.001	< 0.001	0.200	0.230	< 0.1	NA
	10/29/10	0.03600	< 0.001	< 0.001	0.0015	0.770	0.600	< 0.1	NA
	05/24/11	0.00041	<0.0005	<0.0003	<0.0007	0.129	NA	NA	NA
	10/25/11	0.0055	< 0.0010	< 0.0010	< 0.0020	0.292	0.200	< 0.20	NA
	11/25/12	0.0058	0.00022 J	0.00037 J	< 0.00046	0.197 J	0.282	< 0.10	NA
	11/04/13	0.0238	0.00068 J	0.0376	0.0012 J	0.909	1.72	< 0.19	NA
	11/06/14	0.0156	0.0014	0.0280	0.0016 J	0.760	1.43	0.295	NA
MW-201	01/14/04	< 0.001	< 0.001	< 0.001	< 0.001	< 0.25	< 0.25	< 0.5	NA
	04/20/04	< 0.001	< 0.001	< 0.001	< 0.001	< 0.25	< 0.25	< 0.5	NA
	01/26/05	< 0.001	< 0.001	< 0.001	< 0.001	< 0.25	0.33	< 0.5	NA
	04/20/05	< 0.001	< 0.001	< 0.001	0.0021	< 0.25	< 0.25	< 0.5	NA
	07/13/05	< 0.001	< 0.001	< 0.001	< 0.001	0.12	0.7	< 0.5	NA
	10/20/05	< 0.001	< 0.001	< 0.001	< 0.001	0.22	4.6	2.3	NA
	01/26/06	< 0.0005	< 0.0005	< 0.0005	< 0.001	< 0.050	0.342	< 0.476	NA
	11/20/08	< 0.005	< 0.005	< 0.005	< 0.005	< 0.05	0.41	< 0.5	NA
	11/19/09	< 0.0005	< 0.001	< 0.001	< 0.001	< 0.1	< 0.1	< 0.1	NA
	10/27/10	< 0.0005	< 0.001	< 0.001	< 0.001	< 0.1	0.18	< 0.1	NA
	10/26/11	< 0.0010	< 0.0010	< 0.0010	< 0.0020	0.0899	1.46	0.181	NA
	11/27/12	< 0.00020	< 0.00020	< 0.00020	< 0.00046	< 0.050	0.122	< 0.10	NA
	11/06/13	< 0.00020	< 0.00020	< 0.00020	< 0.00046	0.0964 J	0.520	< 0.094	NA
	11/06/14	< 0.00020	< 0.00020	< 0.00020	< 0.00046	< 0.050	0.173	0.195	NA
MW-202	01/14/04	< 0.001	< 0.001	< 0.001	< 0.001	**2.5**	**15**	< 10	NA
	04/20/04	0.014	0.0062	0.074	0.021	**4.4**	**28**	< 10	NA
	01/26/05	< 0.005	< 0.005	< 0.005	< 0.005	**7.7**	5.2	< 5	NA
	04/20/05	0.016	0.0022	0.036	0.0237	**3.7**	6.2	< 5	NA
	07/13/05	0.016	0.0033	0.067	0.0191	**3.5**	6.2	< 1	NA
	10/20/05	0.019	0.0021	0.058	0.0056	**3.3**	5.9	< 2.5	NA
	01/26/06	0.0224	0.00598	0.041	0.0191	**5.79**	**11.2**	< 4.76	NA
	04/25/06	0.007	0.0038	0.062	0.0124	**6.8**	8.7	<4.85	NA
	10/12/06	0.009	0.0034	0.083	0.0062	**5.7**	**11.5**	0.834	NA
	04/26/07	0.008	0.0048	0.063	<0.015	**4.8**	8.2	1.05	NA
	10/30/07	NA	NA	NA	NA	**4.55**	**10.9**	< 1	NA
	05/20/08	NA	NA	NA	NA	**2.3**	1.8	< 2.5	NA
	11/20/08	NA	NA	NA	NA	**5.0**	2.2	< 0.5	NA
	04/07/09	NA	NA	NA	NA	**4.8**	**14**	< 0.1	NA
	11/19/09	NA	NA	NA	NA	**6.6**	**20**	< 0.5	NA
	04/27/10	NA	NA	NA	NA	**3.3**	6.4	0.12	NA
	10/27/10	0.0081	0.0031	0.066	0.0022	**6.0**	5.4	< 0.1	NA
	05/23/11	NA	NA	NA	NA	**3.5**	1.84	< 0.097	NA
	10/26/11	NA	NA	NA	NA	**4.3**	1.02	< 0.21	NA
	03/02/12	0.0053	0.0019	0.0107	0.0013 J	**3.87**	NA	NA	NA
	06/13/12	NA	NA	NA	NA	**3.31**	1.54	< 0.10	NA
	09/26/12	0.0058	0.0029 J	0.0378	< 0.0018	**4.07**	NA	NA	NA
	11/27/12	0.0113	0.0034	0.0274	0.0022	**6.07**	2.67	< 0.30	NA
	05/15/13	NA	NA	NA	NA	**3.83**	1.62	< 0.096	NA
	11/06/13	< 0.00020	0.0027	0.0335	0.0012 J	**4.68**	1.29	< 0.095	NA
	04/22/14	NA	NA	NA	NA	**3.22**	2.18	< 0.28	NA
	11/06/14	0.0083	0.0026	0.0154	0.0011	**5.10**	2.45	0.282 J	NA
	05/19/15	NA	NA	NA	NA	**2.96**	0.842	< 0.096	NA

Table A-1
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Shell Harbor Island Terminal
Seattle, Washington

		Chemical (mg/L)							
Location ID	**Sample Date**	**Benzene**	**Toluene**	**Ethyl-benzene**	**Total Xylenes (mixed isomers)**	**Gasoline Range Hydro-carbons**	**Diesel Range Hydro-carbons**	**Motor Oil Range Hydrocarbons**	**Total Lead**
Cleanup Level*		**0.071**	**200**	**29**	**NE**	**1**	**10**	**10**	**0.0058**
MW-203	01/13/04	< 0.001	< 0.001	< 0.001	< 0.001	< 0.25	< 0.25	< 0.5	NA
	04/19/04	< 0.001	< 0.001	< 0.001	< 0.001	< 0.25	0.26	< 0.5	NA
	07/27/04	0.013	< 0.001	0.0069	< 0.001	**2.6**	0.45	< 0.5	NA
	10/19/04	0.013	< 0.001	0.015	0.0025	**1.6**	< 0.25	< 0.5	NA
	10/19/04	0.017	< 0.001	0.012	0.0018	**1.4**	< 0.25	< 0.5	NA
	01/25/05	0.0063	< 0.001	0.011	0.0013	**1.6**	0.52	0.68	NA
	04/19/05	0.0068	< 0.001	0.0018	< 0.001	0.63	< 0.25	0.55	NA
	07/13/05	0.01	< 0.001	0.0077	< 0.001	0.89	< 0.25	< 0.5	NA
	10/20/05	0.023	0.002	0.021	0.0026	**4.2**	2.1	1.1	NA
	01/23/06	0.00186	< 0.0005	0.00182	0.00125	0.76	0.565	< 0.943	NA
	04/26/06	0.00694	0.00076	0.00079	<0.003	**1.38**	0.660	0.625	NA
	10/13/06	0.02300	0.00553	0.00448	0.00652	**6.22**	7.390	1.34	NA
	04/27/07	0.00502	<0.0005	0.00053	<0.003	**1.24**	0.507	0.515	NA
	05/20/08	NA	NA	NA	NA	0.60	0.320	< 0.5	NA
	11/18/08	NA	NA	NA	NA	0.17	< 0.25	< 0.5	NA
	04/08/09	NA	NA	NA	NA	< 0.1	0.12	0.11	NA
	11/17/09	NA	NA	NA	NA	< 0.1	< 0.1	< 0.1	NA
	04/26/10	NA	NA	NA	NA	0.16	0.18	< 0.1	NA
	10/25/10	NA	NA	NA	NA	0.92	0.36	< 0.1	NA
	05/23/11	NA	NA	NA	NA	0.333	0.085	0.314	NA
	10/26/11	NA	NA	NA	NA	**1.380**	0.262	0.118	NA
	06/13/12	NA	NA	NA	NA	0.459	0.134	0.332	NA
	11/27/12	NA	NA	NA	NA	**1.05**	0.0943 J	< 0.10	NA
	05/15/13	NA	NA	NA	NA	0.144 J	< 0.048	< 0.096	NA
	11/06/13	NA	NA	NA	NA	0.680	< 0.047	< 0.094	NA
	04/22/14	NA	NA	NA	NA	0.164	0.210 J	0.732 J	NA
	11/06/14	NA	NA	NA	NA	0.102	0.0933 J	0.168 J	NA
	05/19/15	NA	NA	NA	NA	0.285	0.166	0.170 J	NA
MW-204	07/27/04	< 0.001	< 0.001	< 0.001	< 0.001	< 0.25	1.6	< 0.5	NA
	01/26/05	< 0.001	< 0.001	< 0.001	< 0.001	< 0.25	6.2	< 1	NA
	04/18/05	< 0.001	< 0.001	< 0.001	< 0.001	< 0.25	1.5	0.79	NA
	07/13/05	< 0.001	< 0.001	< 0.001	< 0.001	0.076	1.1	0.59	NA
	10/19/05	< 0.001	< 0.001	< 0.001	< 0.001	0.082	0.45	< 0.5	NA
	01/26/06	< 0.0005	< 0.0005	< 0.0005	< 0.001	< 0.05	5.53	< 0.952	NA
	04/25/06	<0.0005	<0.0005	<0.0005	<0.003	0.076	2.5	1.11	NA
	10/12/06	<0.0005	<0.0005	<0.0005	<0.003	0.0634	0.90	0.519	NA
	04/26/07	<0.0005	<0.0005	<0.0005	<0.003	0.086	1.81	0.749	NA
	10/30/07	NA	NA	NA	NA	< 0.05	NA	NA	NA
	11/20/08	< 0.005	< 0.005	< 0.005	< 0.005	0.13	1.0	< 0.5	NA
	11/19/09	< 0.0005	< 0.001	< 0.001	< 0.001	< 0.1	3.5	0.16	NA
	10/27/10	< 0.0005	< 0.001	< 0.001	< 0.001	< 0.1	0.29	< 0.1	NA
	10/27/11	< 0.0010	< 0.0010	< 0.0010	< 0.0020	0.0660	0.599	< 0.20	NA
	11/27/12	< 0.00020	< 0.00020	< 0.00020	< 0.00046	< 0.050	0.975	< 0.10	NA
	11/06/13	0.00057 J	< 0.00020	< 0.00020	< 0.00046	0.0762 J	0.280	0.0976 J	NA
	11/06/14	< 0.00020	< 0.00020	< 0.00020	< 0.00046	< 0.050	0.505	0.321	NA
MW-206A	01/22/04	< 0.001	< 0.001	< 0.001	0.004	< 0.25	< 0.25	< 0.5	NA
	04/19/04	< 0.001	< 0.001	< 0.001	< 0.001	< 0.25	< 0.25	< 0.5	NA
	07/27/04	< 0.005	< 0.005	< 0.005	< 0.005	< 1.2	1.8	0.78	NA
	10/19/04	< 0.001	< 0.001	< 0.001	< 0.001	< 0.25	2	1.1	NA
	01/25/05	< 0.001	< 0.001	< 0.001	< 0.001	< 0.25	2.1	2.2	NA
	04/18/05	< 0.001	< 0.001	< 0.001	< 0.001	< 0.05	1.3	1.5	NA
	07/13/05	< 0.001	< 0.001	< 0.001	< 0.001	< 0.05	1.2	1.9	NA
	10/20/05	< 0.001	< 0.001	< 0.001	< 0.001	< 0.05	2.1	7.9	NA
	01/26/06	< 0.0005	< 0.0005	< 0.0005	< 0.001	< 0.05	4.41	2.54	NA
	11/20/08	< 0.005	< 0.005	< 0.005	< 0.005	< 0.25	2.1	1.7	NA
	11/19/09	< 0.0005	< 0.001	< 0.001	< 0.001	< 0.1	0.1	< 0.1	NA
	10/25/10	< 0.0005	< 0.001	< 0.001	< 0.001	< 0.1	< 0.1	0.18	NA
	10/26/11	< 0.0010	< 0.0010	< 0.0010	< 0.0020	< 0.20	0.141	< 0.20	NA
	11/27/12	< 0.00020	< 0.00020	< 0.00020	< 0.00046	< 0.050	0.116	0.111 J	NA
	11/06/13	< 0.00020	< 0.00020	< 0.00020	< 0.00046	< 0.050	< 0.047	< 0.094	NA
	11/06/14	< 0.00020	< 0.00020	< 0.00020	< 0.00046	< 0.050	0.236	0.392	NA

Table A-1
BTEX, Petroleum Hydrocarbons, and Lead in Groundwater
Shell Harbor Island Terminal
Seattle, Washington

Location ID	Sample Date	Chemical (mg/L)							
		Benzene	Toluene	Ethyl-benzene	Total Xylenes (mixed isomers)	Gasoline Range Hydro-carbons	Diesel Range Hydro-carbons	Motor Oil Range Hydrocarbons	Total Lead
Cleanup Level*		**0.071**	**200**	**29**	**NE**	**1**	**10**	**10**	**0.0058**
MW-213	01/14/04	< 0.001	< 0.001	< 0.001	< 0.001	< 0.25	< 0.25	< 0.5	NA
	04/20/04	< 0.005	< 0.005	< 0.005	< 0.005	< 0.25	< 0.25	< 0.5	NA
	07/28/04	< 0.001	< 0.001	< 0.001	< 0.001	< 0.25	< 0.25	< 0.5	NA
	10/19/04	< 0.001	< 0.001	< 0.001	< 0.001	< 0.25	< 0.25	< 0.5	NA
	01/25/05	< 0.001	< 0.001	< 0.001	< 0.001	< 0.25	< 0.25	< 0.5	NA
	04/19/05	< 0.001	< 0.001	< 0.001	< 0.001	< 0.05	< 0.25	< 0.5	NA
	07/12/05	< 0.001	< 0.001	< 0.001	< 0.001	< 0.05	< 0.25	< 0.5	NA
	10/20/05	< 0.001	< 0.001	< 0.001	< 0.001	< 0.05	0.34	< 0.5	NA
	01/26/06	< 0.0005	< 0.0005	< 0.0005	< 0.001	< 0.05	0.653	< 0.495	NA
	10/30/07	< 0.001	< 0.001	< 0.001	< 0.003	NA	NA	NA	NA
	11/19/08	< 0.005	< 0.005	< 0.005	< 0.005	< 0.25	< 0.25	< 0.5	NA
	04/07/09	< 0.0005	< 0.001	< 0.001	< 0.001	< 0.1	< 0.1	< 0.1	NA
	11/18/09	< 0.0005	< 0.001	< 0.001	< 0.001	< 0.1	< 0.1	< 0.1	NA
	04/26/10	< 0.0005	< 0.001	< 0.001	< 0.001	< 0.1	< 0.1	< 0.1	NA
	10/28/10	< 0.0005	< 0.001	< 0.001	< 0.001	< 0.1	< 0.1	< 0.1	NA
	05/24/11	<0.0003	<0.0005	<0.0003	<0.0007	< 0.050	< 0.049	< 0.098	NA
	10/25/11	< 0.0010	< 0.0010	< 0.0010	< 0.0020	< 0.20	< 0.11	< 0.21	NA
	06/12/12	< 0.00020	< 0.00020	< 0.00020	< 0.00046	< 0.050	< 0.050	< 0.10	NA
	11/29/12	< 0.00020	< 0.00020	< 0.00020	< 0.00046	< 0.050	< 0.050	< 0.10	NA
	05/15/13	< 0.00020	< 0.00020	< 0.00020	< 0.00046	< 0.050	< 0.048	< 0.096	NA
	11/05/13	< 0.00020	< 0.00020	< 0.00020	< 0.00046	< 0.050	0.0625 J	< 0.095	NA
	04/23/14	< 0.00020	< 0.00020	< 0.00020	< 0.00046	< 0.050	0.0586	< 0.094	NA
	11/05/14	< 0.00020	< 0.00020	< 0.00020	< 0.00046	< 0.050	0.0782 J	< 0.094	NA
	05/19/15	< 0.00020	< 0.00020	< 0.00020	< 0.00046	< 0.050	0.102	< 0.10	NA
MW-214	01/14/04	< 0.001	< 0.001	< 0.001	< 0.001	< 0.25	< 0.25	< 0.5	NA
	04/20/04	< 0.005	< 0.005	< 0.005	< 0.005	< 0.25	< 0.25	< 0.5	NA
	07/28/04	< 0.005	< 0.005	< 0.005	< 0.005	< 1.2	< 0.25	< 0.5	NA
	10/19/04	< 0.001	< 0.001	< 0.001	< 0.001	< 0.25	< 0.25	< 0.5	NA
	01/25/05	< 0.001	< 0.001	< 0.001	< 0.001	< 0.25	0.36	< 0.5	NA
	04/19/05	< 0.001	< 0.001	< 0.001	< 0.001	< 0.05	0.3	< 0.5	NA
	07/12/05	< 0.001	< 0.001	< 0.001	< 0.001	< 0.05	0.29	< 0.5	NA
	10/20/05	< 0.001	< 0.001	< 0.001	< 0.001	< 0.05	0.33	< 0.5	NA
	01/26/06	< 0.0005	< 0.0005	< 0.0005	< 0.001	< 0.05	0.91	< 0.476	NA
	10/30/07	< 0.001	< 0.001	< 0.001	< 0.003	NA	NA	NA	NA
	05/05/08	< 0.005	< 0.005	< 0.005	< 0.005	< 0.25	0.91	< 0.5	NA
	07/10/08	-	-	-	-	-	< 0.5	< 1	NA
	11/19/08	< 0.005	< 0.005	< 0.005	< 0.005	< 0.25	0.80	< 0.5	NA
	04/07/09	< 0.0005	< 0.001	< 0.001	< 0.001	< 0.1	0.17	< 0.1	NA
	11/18/09	< 0.0005	< 0.001	< 0.001	< 0.001	< 0.1	0.11	< 0.1	NA
	04/26/10	< 0.0005	< 0.001	< 0.001	< 0.001	< 0.1	0.19	< 0.1	NA
	10/28/10	< 0.0005	< 0.001	< 0.001	< 0.001	< 0.1	< 0.1	< 0.1	NA
	05/24/11	<0.0003	<0.0005	<0.0003	<0.0007	<0.050	0.127	<0.097	NA
	10/25/11	< 0.0010	< 0.0010	< 0.0010	< 0.0020	< 0.20	0.126	< 0.21	NA
	06/12/12	< 0.00020	< 0.00020	< 0.00020	< 0.00046	< 0.050	< 0.050	0.135 J	NA
	11/29/12	< 0.00020	< 0.00020	< 0.00020	< 0.00046	< 0.050	< 0.048	< 0.095	NA
	05/15/13	< 0.00020	< 0.00020	< 0.00020	< 0.00046	< 0.050	0.0857 J	< 0.096	NA
	11/05/13	< 0.00020	< 0.00020	< 0.00020	< 0.00046	< 0.050	0.0552 J	< 0.094	NA
	04/23/14	< 0.00020	< 0.00020	< 0.00020	< 0.00046	< 0.050	0.118	< 0.094	NA
	11/05/14	< 0.00020	< 0.00020	< 0.00020	< 0.00046	< 0.050	0.168	0.103	NA
	05/19/15	< 0.00020	< 0.00020	< 0.00020	< 0.00046	< 0.050	0.106	< 0.094	NA
MW-301	03/02/12	**0.240**	0.0138	0.00990	0.0212	**3.37**	NA	NA	NA
	09/25/12	**0.333**	0.0131	0.0186	0.0192	**4.02**	NA	NA	NA
	11/28/12	**0.241**	0.0099	0.0125	0.0106	**2.76**	NA	NA	NA
	02/21/13	**0.659**	0.0175	0.0264	0.0173 J	**3.98**	0.315	< 0.10	NA
	05/15/13	**0.357**	0.0122	0.0231	0.0145	**3.63**	NA	NA	NA
	11/04/13	**0.160**	0.0097	0.0164	0.0109	**2.29**	NA	NA	NA
	04/23/14	**0.252**	0.0072	0.0135	0.0075	**3.57**	NA	NA	NA
	07/24/14	**0.314**	0.0080	0.0143	0.0096	**3.70**	0.361	< 0.094	NA
	11/03/14	**0.108**	0.0043 J	0.0046 J	0.0051 J	**1.76**	NA	NA	NA
	03/09/15	**0.222**	0.0067	0.0065	0.0062 J	**2.27**	NA	NA	NA
	05/21/15	**0.194**	0.0069	0.0100	0.0060 J	**2.24**	NA	NA	NA
	07/28/15	**0.116**	0.0036	0.0037	0.0019 J	**2.09**	NA	NA	NA
MW-302	03/01/12	**0.831**	0.0275	0.213	0.248	**5.33**	NA	NA	NA
	06/12/12	**0.574**	0.0156	0.0183	0.0244	**4.18**	NA	NA	NA
	06/28/12	**1.23**	0.0437	0.403	0.289	**5.65**	NA	NA	NA
	09/25/12	**0.657**	0.0247	0.180	0.106	**4.07**	NA	NA	NA
	11/25/12	**0.449**	0.0152	0.191	0.177	**4.58**	NA	NA	NA
	02/22/13	**0.393**	0.0149	0.124	0.116	**4.15**	0.435	< 0.10	NA
	05/14/13	**0.873**	0.0231	0.236	0.145	**4.19**	NA	NA	NA
	09/05/13	**0.783**	0.0189	0.162	0.0746	**3.70**	NA	NA	NA
	11/05/13	**0.607**	0.0112	0.0977	0.0529	**2.69**	NA	NA	NA
	01/16/14	**0.404**	0.0161	0.0843	0.0504	**3.54**	NA	NA	NA
	04/23/14	**0.980**	0.0269	0.276	0.232	**5.86**	NA	NA	NA
	07/24/14	**0.656**	0.0206	0.178	0.131	**4.66**	0.363	< 0.094	NA
	11/03/14	**0.506**	0.0159	0.221	0.176	**4.06**	0.361	< 0.094	NA
	05/21/15	**0.454**	0.0161	0.174	0.150	**3.44**	NA	NA	< 0.010

Table A-1
BTEX, Petroleum Hydrocarbons, and Lead in Groundwater
Shell Harbor Island Terminal
Seattle, Washington

Location ID	Sample Date	Chemical (mg/L)							
		Benzene	Toluene	Ethyl-benzene	Total Xylenes (mixed isomers)	Gasoline Range Hydro-carbons	Diesel Range Hydro-carbons	Motor Oil Range Hydrocarbons	Total Lead
Cleanup Level*		0.071	200	29	NE	1	10	10	0.0058
MW-303	03/02/12	**3.13**	0.0759	0.760	0.232	**12.3**	NA	NA	NA
	06/13/12	**2.90**	0.0957	0.884	0.268	**12.5**	NA	NA	NA
	09/25/12	**1.83**	0.0635	0.474	0.146	**9.14**	NA	NA	NA
	11/28/12	**1.94**	0.0873	1.18	0.319	**12.6**	NA	NA	NA
	02/21/13	**2.34**	0.0955	1.29	0.338	**12.8**	0.674	< 0.10	NA
	05/15/13	**1.90**	0.0864	0.983	0.272	**10.6**	NA	NA	NA
	11/04/13	**0.884**	0.0278	0.219	0.0544	**6.11**	NA	NA	NA
	04/23/14	**1.58**	0.0710	1.114	0.224	**11.8**	NA	NA	NA
	07/24/14	**0.808**	0.0471	0.653	0.161	**9.8**	0.622	< 0.094	NA
	11/04/14	**1.42**	0.0618	0.924	0.180	**11.5**	1.00	1.15	NA
	05/20/15	**0.669**	0.0432	0.713	0.157	**7.90**	NA	NA	NA
MW-304	03/01/12	**0.686**	0.0351	0.214	0.264	**5.64**	NA	NA	NA
	06/12/12	**1.04**	0.0408	0.270	0.218	**5.98**	NA	NA	NA
	09/25/12	**0.630**	0.0240	0.198	0.105	**3.93**	NA	NA	NA
	11/28/12	**0.411**	0.0244	0.306	0.252	**5.89**	NA	NA	NA
	02/22/13	**0.507**	0.0225	0.208	0.149	**5.56**	0.762	0.186 J	NA
	05/14/13	**0.645**	0.0283	0.209	0.144	**4.73**	NA	NA	NA
	09/05/13	**0.862**	0.0188	0.0849	0.0616	**3.09**	NA	NA	NA
	11/05/13	**0.695**	0.0163	0.0629	0.0540	**2.67**	NA	NA	NA
	01/16/14	**0.790**	0.0194	0.0472	0.0571	**4.89**	NA	NA	NA
	04/23/14	**0.778**	0.0248	0.185	0.147	**5.93**	NA	NA	NA
	07/24/14	**0.437**	0.0173	0.109	0.0666	**3.59**	0.557	< 0.094	NA
	11/03/14	**1.11**	0.0421	0.48	0.2140	**3.32**	0.366	< 0.094	NA
	05/20/15	**0.486**	0.0136	0.115	0.0373	**3.30**	NA	NA	< 0.010
MW-305	03/01/12	**1.14**	0.0227	0.0389	0.0375 J	**5.84**	NA	NA	NA
	06/11/12	**1.34**	0.0221	0.0517	0.0331 J	**5.97**	NA	NA	NA
	09/26/12	**1.27**	0.0229	0.0388	0.0355 J	**5.89**	NA	NA	NA
	11/28/12	**0.286**	0.0061	0.0032 J	0.0140	**1.53**	NA	NA	NA
	05/15/13	**0.397**	0.0263	0.290	0.0867	**6.28**	NA	NA	NA
	11/07/13	**0.0844**	0.0250	0.216	0.0919	**3.59**	NA	NA	NA
	04/23/14	**0.0884**	0.0139	0.0941	0.0454	**2.82**	NA	NA	NA
	11/06/14	0.0419	0.0052	0.0020	0.0306	**1.16**	NA	NA	NA
	05/21/15	**0.120**	0.0101	0.191	0.108	**2.81**	NA	NA	NA
MW-306	03/01/12	**0.606**	0.0150	0.0353	0.718	**4.74**	NA	NA	NA
	06/11/12	**0.393**	0.0115	0.0509	0.763	**5.09**	NA	NA	NA
	09/26/12	**1.05**	0.0261	0.135	0.147	**6.56**	NA	NA	NA
	11/28/12	**0.393**	0.0125	0.0183	0.0895	**3.06**	NA	NA	NA
	05/15/13	**0.746**	0.0472	0.837	3.70	**18.5**	NA	NA	NA
	11/07/13	**0.101**	0.0502	0.482	2.65	**12.8**	NA	NA	NA
	04/23/14	**0.0762**	0.0345	0.325	1.97	**11.0**	NA	NA	NA
	11/06/14	**0.119**	0.0226	0.302 J	0.939 J	**5.59**	NA	NA	NA
	05/21/15	**0.106**	0.0354 J	0.874	5.15	**20.6**	NA	NA	NA
MW-307	11/26/12	**2.15**	0.0858	0.833	0.513	**10.9**	NA	NA	NA
	02/22/13	**0.497**	0.0358	0.226	0.145	**6.02**	0.604	< 0.094	NA
	05/15/13	**0.437**	0.0461	0.167	0.120	**4.56**	NA	NA	NA
	09/05/13	**0.643**	0.0645	0.154	0.131	**5.30**	NA	NA	NA
	11/06/13	**0.568**	0.0448 J	0.104	0.0912	**4.39**	NA	NA	NA
	04/22/14	**0.520**	0.0408	0.241	0.152	**5.68**	NA	NA	NA
	11/04/14	**0.596**	0.0390	0.176	0.095	**5.16**	0.632	< 0.095	NA
	03/09/15	**0.444**	0.0358	0.271	0.104	**5.41**	NA	NA	NA
	05/19/15	**0.306**	0.0273	0.140	0.067	**3.44**	0.479	< 0.096	NA
	07/29/15	**0.298**	0.0245	0.109	0.0434	**4.09**	NA	NA	NA
MW-308	11/26/12	**0.144**	0.0010 J	0.0072	0.0013 J	0.778	NA	NA	NA
	02/22/13	**0.668**	0.0078 J	0.0443	0.0059 J	**3.48**	0.354	< 0.10	NA
	05/15/13	**0.392**	0.0052 J	0.0427	< 0.0046	**2.54**	NA	NA	NA
	11/06/13	**0.237**	0.0033 J	0.0056	0.0026 J	**1.65**	NA	NA	NA
	04/22/14	0.0165	< 0.00020	0.00036 J	< 0.00046	0.146	NA	NA	NA
	11/04/14	**0.132**	0.0012	0.0044	0.00058	0.782	< 0.048	< 0.095	NA
	03/09/15	**0.121 J**	0.0020	0.00064 J	0.0013 J	**1.10**	NA	NA	NA
	05/19/15	**0.213**	0.0013 J	< 0.00050	< 0.0012	0.973	NA	NA	NA
	07/29/15	**0.242**	0.0017 J	0.0014 J	< 0.0012	1.77	NA	NA	NA
MW-309	11/28/12	< 0.00020	< 0.00020	< 0.00020	< 0.00046	< 0.050	NA	NA	NA
	02/21/13	< 0.00020	< 0.00020	< 0.00020	< 0.00046	< 0.050	0.0790 J	< 0.10	NA
	05/16/13	< 0.00020	< 0.00020	< 0.00020	< 0.00046	< 0.050	NA	NA	NA
	11/06/13	< 0.00020	< 0.00020	< 0.00020	< 0.00046	< 0.050	NA	NA	NA
	04/23/14	< 0.00020	< 0.00020	< 0.00020	< 0.00046	< 0.050	NA	NA	NA
	07/24/14	< 0.00020	< 0.00020	< 0.00020	< 0.00046	< 0.050	0.102	< 0.094	NA
	11/03/14	< 0.00020	< 0.00020	< 0.00020	< 0.00046	< 0.050	< 0.048	< 0.095	NA
	05/20/15	< 0.00020	< 0.00020	0.00027 J	< 0.00046	0.0542 J	NA	NA	NA

Table A-1
BTEX, Petroleum Hydrocarbons, and Lead in Groundwater
Shell Harbor Island Terminal
Seattle, Washington

Location ID	Sample Date	Chemical (mg/L)							
		Benzene	Toluene	Ethyl-benzene	Total Xylenes (mixed isomers)	Gasoline Range Hydro-carbons	Diesel Range Hydro-carbons	Motor Oil Range Hydrocarbons	Total Lead
Cleanup Level*		**0.071**	**200**	**29**	**NE**	**1**	**10**	**10**	**0.0058**
MW-310	11/28/12	**0.860**	0.0265	0.211	0.147	**5.74**	NA	NA	NA
	02/21/13	**1.80**	0.0768	0.506	0.180	**8.37**	0.603	< 0.10	NA
	05/14/13	**0.993**	0.0703	0.654	0.175	**6.49**	NA	NA	NA
	09/05/13	**0.960**	0.0598	0.310	0.110	**5.51**	NA	NA	NA
	11/05/13	**0.772**	0.0409	0.226	0.0846	**4.92**	NA	NA	NA
	01/16/14	**0.821**	0.0414	0.189	0.0775	**5.94**	NA	NA	< 0.001[1]
	04/23/14	**0.796**	0.0432	0.187	0.0607	**5.88**	NA	NA	NA
	07/24/14	**0.920**	0.0489	0.368	0.0647	**6.36**	0.605	< 0.094	NA
	11/04/14	**0.739**	0.0387	0.132	0.0538	**5.15**	0.613	< 0.094	NA
	03/09/15	**0.736**	0.0475	0.189	0.0606	**4.71**	NA	NA	NA
	05/21/15	**0.641**	0.0464	0.169	0.0572	**4.39**	NA	NA	< 0.010
	07/28/15	**0.714**	0.0428	0.181	0.0488	**3.72**	NA	NA	NA
MW-311	11/05/14	< 0.00020	< 0.00020	< 0.00020	< 0.00046	< 0.050	< 0.048	< 0.095	< 0.010
	03/09/15	< 0.00020	< 0.00020	< 0.00020	< 0.00046	< 0.050	NA	NA	NA
	06/11/15	< 0.00020	< 0.00020	< 0.00020	< 0.00046	< 0.050	NA	NA	NA
	07/28/15	< 0.00020	< 0.00020	< 0.00020	< 0.00046	< 0.050	NA	NA	NA
MW-312	11/05/14	**0.239**	0.0058	0.0065	0.0102	**1.64**	1.13	0.132 J	< 0.010
	03/09/15	**0.357**	0.0044 J	0.0086	0.0050 J	**1.91**	NA	NA	NA
	06/11/15	**0.204**	0.0034 J	0.0023 J	0.0027 J	**1.35**	NA	NA	NA
	07/28/15	**0.313**	0.0041 J	0.0030 J	0.0032 J	**1.65**	NA	NA	NA
SH-04	01/13/04	**1.20**	0.21	0.140	2.11	**15.0**	4.7	< 2.5	NA
	04/20/04	**1.50**	0.49	0.640	5.79	**26.0**	6.2	< 10	NA
	07/27/04	**1.30**	0.13	0.550	1.78	**15.0**	5.4	0.53	NA
	04/20/05	**0.98**	0.061	0.360	1.07	**11.0**	4.2	< 1.5	NA
	04/25/06	**1.25**	0.09	0.650	2.31	**20.0**	8.2	2.52	NA
	10/30/07	**0.88**	0.032	0.315	0.08	**<5.0**	NA	NA	NA
	05/20/08	**1.10**	0.05	0.520	0.66	**8.9**	4.80	0.92	NA
	11/20/08	**0.79**	0.032	0.230	0.04	**6.6**	2.70	< 0.5	NA
	04/08/09	**0.870**	0.04	0.250	0.190	**9.2**	4.70	< 0.1	NA
	11/16/09	**0.48**	0.023	0.068	0.02	**4.9**	3.70	< 0.1	NA
	04/27/10	**0.710**	0.03	0.270	0.130	**7.3**	4.70	0.39	NA
	10/25/10	**0.580**	0.019	0.180	0.0130	**4.0**	2.80	< 0.1	NA
	05/23/11	**0.655**	0.015	0.151	0.0340	**5.4**	1.84	0.13	NA
	10/27/11	**0.393**	0.0200	0.0926	0.0279	**5.35**	1.22	< 0.19	NA
	03/01/12	**0.614**	0.0227	0.0932	0.0124 J	**5.53**	NA	NA	NA
	06/11/12	**0.426**	0.0142	0.112	0.0198 J	**6.00**	1.49	0.393	NA
	09/25/12	**0.124**	0.0184	0.461	0.139	**6.52**	NA	NA	NA
	11/25/12	**0.0730**	0.0079 J	0.609	0.326	**8.15**	0.762	< 0.098	NA
	05/15/13	0.0016 J	0.00050	0.0042	0.0032 J	**2.16**	0.376	< 0.096	NA
	11/04/13	0.0032	0.00043 J	0.0071	0.0050	**1.05**	0.134	< 0.094	NA
	04/24/14	0.0091	0.00053 J	0.00090 J	0.0014 J	0.938	0.469	0.0944 J	NA
	11/06/14	0.0249	0.0023	0.0173	0.0072	0.984	0.608	< 0.094	NA
	05/21/15	0.0094	0.00048 J	0.0035	0.0021	0.780	0.171	< 0.094	NA
TES-MW-1	01/14/04	< 0.001	< 0.001	< 0.001	< 0.001	< 0.25	< 0.25	< 0.5	NA
	04/20/04	0.0067	< 0.001	0.011	0.043	< 0.25	< 0.25	< 0.5	NA
	04/20/04	0.0075	< 0.001	0.013	0.049	< 0.25	< 0.25	< 0.5	NA
	07/28/04	< 0.001	< 0.001	< 0.001	< 0.001	< 0.25	< 0.25	< 0.5	NA
	10/18/04	< 0.001	< 0.001	< 0.001	< 0.001	< 0.25	< 0.25	< 0.5	NA
	01/25/05	< 0.001	< 0.001	< 0.001	< 0.001	< 0.25	< 0.25	< 0.5	NA
	01/25/05	< 0.001	< 0.001	< 0.001	< 0.001	< 0.25	< 0.25	< 0.5	NA
	04/19/05	< 0.001	< 0.001	< 0.001	< 0.001	< 0.05	< 0.25	< 0.5	NA
	07/13/05	0.001	< 0.001	0.006	0.0189	0.10	< 0.25	< 0.5	NA
	10/20/05	0.0039	< 0.001	0.013	0.0437	0.23	< 0.25	< 0.5	NA
	01/27/06	< 0.0005	< 0.0005	< 0.0005	< 0.001	< 0.05	< 0.240	< 0.481	NA
	11/18/08	< 0.005	< 0.005	< 0.005	< 0.005	< 0.05	< 0.25	< 0.5	NA
	11/18/09	< 0.0005	< 0.001	< 0.001	< 0.001	< 0.1	< 0.1	< 0.1	NA
	10/26/10	< 0.0005	< 0.001	< 0.001	< 0.001	< 0.1	< 0.1	< 0.1	NA
	05/24/11	<0.0003	<0.0005	<0.0003	<0.0007	<0.050	NA	NA	NA
	10/27/11	< 0.0010	< 0.0010	< 0.0010	< 0.0020	< 0.20	< 0.10	< 0.20	NA
	11/26/12	< 0.00020	< 0.00020	< 0.00020	< 0.00046	< 0.050	< 0.050	< 0.10	NA
	11/06/13	< 0.00020	< 0.00020	< 0.00020	< 0.00046	< 0.050	< 0.048	< 0.095	NA
	11/04/14	< 0.00020	< 0.00020	< 0.00020	< 0.00046	< 0.050	< 0.048	< 0.095	NA

Table A-1
BTEX, Petroleum Hydrocarbons, and Lead in Groundwater
Shell Harbor Island Terminal
Seattle, Washington

Location ID	Sample Date	Chemical (mg/L)							
		Benzene	Toluene	Ethyl-benzene	Total Xylenes (mixed isomers)	Gasoline Range Hydro-carbons	Diesel Range Hydro-carbons	Motor Oil Range Hydrocarbons	Total Lead
Cleanup Level*		**0.071**	**200**	**29**	**NE**	**1**	**10**	**10**	**0.0058**
TX-03A	01/13/04	**2.9**	0.018	0.038	0.091	**2.7**	0.86	< 0.5	NA
	04/19/04	**4.4**	0.047	0.12	0.11	**12**	1.3	< 0.5	NA
	07/27/04	**1.7**	0.011	0.016	0.037	**5.2**	0.81	< 0.5	NA
	10/18/04	**3.2**	0.024	0.062	0.093	**7.5**	1.2	< 0.5	NA
	01/24/05	**2.5**	0.02	< 0.01	0.065	**8.2**	0.54	< 0.5	NA
	04/19/05	**2.5**	0.021	0.026	0.049	**6.1**	0.47	< 0.5	NA
	07/12/05	**3.1**	0.024	0.044	0.054	**10**	0.32	< 0.5	NA
	10/31/07	**2.2**	0.023	0.060	0.050	<5.0	NA	NA	NA
	05/20/08	**0.9**	0.007	0.016	0.010	**3.0**	NA	NA	NA
	11/20/08	**2.1**	0.019	0.038	0.018	**4.5**	NA	NA	NA
	04/08/09	**1.2**	< 0.025	0.028	< 0.025	**3.5**	NA	NA	NA
	11/17/09	**1.0**	0.008	0.016	0.011	**2.4**	NA	NA	NA
	04/27/10	**1.7**	0.010	0.009	0.010	**4.6**	NA	NA	NA
	10/25/10	**1.7**	0.011	0.067	0.013	**3.3**	NA	NA	NA
	05/23/11	**1.78**	<0.025	0.044	<0.035	**7.5**	NA	NA	NA
	10/27/11	**3.44**	0.0712	0.147	0.111	**8.51**	NA	NA	NA
	03/01/12	**1.74**	0.0261	0.0272	0.0345 J	**5.58**	NA	NA	NA
	06/12/12	**1.57**	0.0200 J	0.0139 J	0.0300 J	**6.78**	NA	NA	NA
	09/25/12	**1.7**	0.0298	0.0410	0.0501	**5.53**	NA	NA	NA
	11/28/12	**1.18**	0.0188 J	0.0232	0.0357 J	**4.91**	NA	NA	NA
	02/21/13	**2.81**	0.0403	0.0421	0.0489 J	**8.20**	0.320	< 0.10	NA
	05/15/13	**2.15**	0.0459 J	0.189	0.0643 J	**3.11**	NA	NA	NA
	11/05/13	**2.72**	0.0343 J	0.0364 J	0.0411 J	**6.01**	NA	NA	NA
	04/23/14	**1.22**	0.0171	0.0251	0.0270	**5.76**	NA	NA	NA
	07/24/14	**1.64**	0.0317	0.0698	0.0520	**7.55**	0.382	< 0.094	NA
	11/04/14	**0.941**	0.0137	0.0366	0.0269	**5.76**	0.448	< 0.094	NA
	03/09/15	**1.86**	0.0246 J	0.0581	0.0390 J	**7.16**	NA	NA	NA
	05/21/15	**1.15**	0.0144 J	0.0462	0.0260 J	**3.40**	NA	NA	NA
	07/28/15	**1.720**	0.0213 J	0.118	0.0355 J	**5.42**	NA	NA	NA
TX-04	01/13/04	0.025	0.0055	< 0.001	0.01940	0.650	0.59	< 0.5	NA
	04/21/04	0.0025	0.0017	< 0.001	0.0031	0.47	2.200	< 0.75	NA
	07/27/04	< 0.001	< 0.001	< 0.001	< 0.001	< 0.25	1.50	< 0.5	NA
	10/18/04	< 0.001	< 0.001	< 0.001	0.0022	0.28	1.2	< 0.5	NA
	01/24/05	0.0310	0.0071	< 0.001	0.020	0.87	0.64	< 0.5	NA
	04/20/05	0.014	0.00360	< 0.001	0.0085	0.54	0.73	< 0.5	NA
	07/12/05	< 0.001	< 0.001	< 0.001	0.00140	0.340	0.82	< 0.5	NA
	10/18/05	< 0.001	< 0.001	< 0.001	< 0.001	0.20	1.100	< 0.5	NA
	01/25/06	0.00127	0.001	< 0.0005	0.00151	0.206	0.84	< 0.476	NA
	11/18/08	< 0.005	< 0.005	< 0.005	< 0.005	0.076	< 0.25	< 0.5	NA
	11/16/09	< 0.0005	< 0.001	< 0.001	< 0.001	0.17	0.13	< 0.1	NA
	10/25/10	< 0.0005	< 0.001	< 0.001	< 0.001	< 0.1	0.17	< 0.1	NA
	05/23/11	<0.0003	<0.0005	<0.0003	<0.0007	0.055	NA	NA	NA
	10/26/11	< 0.0010	< 0.0010	< 0.0010	< 0.0020	< 0.20	0.0966	< 0.20	NA
	11/26/12	0.0013	0.00038 J	< 0.00020	0.00052 J	0.0980 J	0.0807 J	< 0.10	NA
	11/04/13	< 0.00020	< 0.00020	< 0.00020	< 0.00046	< 0.050	0.0492 J	< 0.095	NA
	11/06/14	< 0.00020	< 0.00020	< 0.00020	< 0.00046	< 0.050	< 0.048	< 0.096	NA
TX-06A	01/14/04	< 0.001	< 0.001	< 0.001	< 0.001	< 0.25	5.8	< 1	NA
	04/21/04	< 0.001	< 0.001	< 0.001	< 0.001	< 0.25	3.4	< 0.75	NA
	07/27/04	< 0.001	< 0.001	< 0.001	< 0.001	< 0.25	3.6	< 0.5	NA
	10/18/04	< 0.001	< 0.001	< 0.001	< 0.001	< 0.25	4.1	< 0.5	NA
	01/24/05	< 0.001	< 0.001	< 0.001	< 0.001	< 0.25	2.7	< 0.5	NA
	04/20/05	< 0.001	< 0.001	< 0.001	< 0.001	0.18	6.3	< 1.5	NA
	07/13/05	< 0.001	< 0.001	< 0.001	< 0.001	0.26	2.5	< 0.5	NA
	10/18/05	< 0.001	< 0.001	< 0.001	< 0.001	0.072	0.93	< 0.5	NA
	01/26/06	< 0.0005	< 0.0005	< 0.0005	< 0.001	0.126	1.57	< 0.476	NA
	11/18/08	< 0.005	< 0.005	< 0.005	< 0.005	< 0.05	0.49	< 0.5	NA
	11/17/09	< 0.0005	< 0.001	< 0.001	< 0.001	< 0.1	0.24	< 0.1	NA
	10/28/10	< 0.0005	< 0.001	< 0.001	< 0.001	< 0.1	0.72	< 0.1	NA
	10/25/11	< 0.0010	< 0.0010	< 0.0010	< 0.0020	0.0519	0.499	< 0.21	NA
	11/25/12	< 0.00020	< 0.00020	< 0.00020	< 0.00046	< 0.50	0.716	< 0.098	NA
	11/07/13	< 0.00020	< 0.00020	< 0.00020	< 0.00046	< 0.050	0.358	< 0.095	NA
	11/06/14	< 0.00020	< 0.00020	< 0.00020	< 0.00046	< 0.050	0.758	0.184	NA

Note:

= most recent sampling event
*** =** Cleanup levels per the Cleanup Action Plan (Ecology, 1998)
[1] = Dissolved lead result
Bold = indicate detected concentration greater than cleanup level
< = concentration undetected at the detection limit.
BTEX = benzene, toluene, ethylbenzene, and total xylenes
ID = identification
J = indicates an estimated value
mg/L = milligrams per liter
NA = not analyzed
NE = not established

Table A-2
Carcinogenic PAHs in Groundwater
Shell Harbor Island Terminal
Seattle, Washington

Location ID	Sample Date	Chemical (mg/L)						
		Benzo(a)-anthracene	Benzo(a)-pyrene	Benzo(b)-fluoranthene	Benzo(k)-fluoranthene	Chrysene	Dibenz(a,h)-anthracene	Indeno(1,2,3-cd)pyrene
Cleanup Level*		0.000031	0.000031	0.000031	0.000031	0.000031	0.000031	0.000031
MW-213	01/14/04	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001
	04/20/04	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001
	07/28/04	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001
	10/19/04	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001
	01/25/05	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001
	04/19/05	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001
	07/12/05	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001
	10/20/05	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001
	01/26/06	< 0.0000943	< 0.0000943	< 0.0000943	< 0.0000943	< 0.0000943	< 0.0000943	< 0.0000943
	10/30/07	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001
	11/19/08	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001
	04/07/09	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001
	11/18/09	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001
	04/26/10	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001
	10/28/10	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001
	05/24/11	<0.00003	<0.00003	<0.00003	<0.00003	<0.00003	<0.00003	<0.00003
	10/25/11	< 0.00010	< 0.00010	< 0.00010	< 0.00010	< 0.00010	< 0.00010	< 0.00010
	06/12/12	< 0.000050	< 0.000041	< 0.000035	< 0.000039	< 0.000045	< 0.000035	< 0.000035
	11/29/12	< 0.000053	< 0.000041	< 0.000035	< 0.000039	< 0.000045	< 0.000035	< 0.000035
	05/15/13	< 0.000050	< 0.000039	< 0.000033	< 0.000037	< 0.000042	< 0.000033	< 0.000033
	11/05/13	< 0.000050	< 0.000039	< 0.000033	< 0.000037	< 0.000043	< 0.000033	< 0.000033
	04/23/14	< 0.000050	< 0.000039	< 0.000033	< 0.000037	< 0.000043	< 0.000033	< 0.000033
	11/05/14	< 0.000050	< 0.000039	< 0.000033	< 0.000037	< 0.000042	< 0.000033	< 0.000033
	05/19/15	< 0.0014	< 0.0011	< 0.0013	< 0.0013	< 0.0016	< 0.0012	< 0.0013
MW-214	01/30/03	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001
	04/17/03	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001
	07/17/03	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001
	10/16/03	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001
	01/14/04	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001
	04/20/04	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001
	07/28/04	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001
	10/19/04	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001
	01/25/05	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001
	04/19/05	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001
	07/12/05	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001
	10/20/05	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001
	01/26/06	< 0.000099	< 0.000099	< 0.000099	< 0.000099	< 0.000099	< 0.000099	< 0.000099
	10/30/07	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001
	05/05/08	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001
	11/19/08	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001
	04/07/09	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001
	11/18/09	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001
	04/26/10	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001
	10/28/10	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001
	05/24/11	< 0.000029	< 0.000029	< 0.000029	< 0.000029	< 0.000029	< 0.000029	< 0.000029
	10/25/11	< 0.00010	< 0.00010	< 0.00010	< 0.00010	< 0.00010	< 0.00010	< 0.00010
	06/12/12	< 0.000051	< 0.000040	< 0.000034	< 0.000038	< 0.000044	< 0.000034	< 0.000034
	11/29/12	< 0.000050	< 0.000039	< 0.000033	< 0.000037	< 0.000042	< 0.000033	< 0.000033
	05/15/13	< 0.000050	< 0.000039	< 0.000033	< 0.000037	< 0.000042	< 0.000033	< 0.000033
	11/05/13	< 0.000050	< 0.000039	< 0.000033	< 0.000037	< 0.000042	< 0.000033	< 0.000033
	04/23/14	< 0.000050	< 0.000039	< 0.000033	< 0.000037	< 0.000043	< 0.000033	< 0.000033
	11/05/14	< 0.000050	< 0.000039	< 0.000033	< 0.000037	< 0.000042	< 0.000033	< 0.000033
	05/19/15	< 0.0013	< 0.0010	< 0.0012	< 0.0013	< 0.0015	< 0.0012	< 0.0013
MW-301	07/24/14	< 0.000050	< 0.000039	< 0.000033	< 0.000037	< 0.000042	< 0.000033	< 0.000033
	05/21/15	< 0.0014	< 0.0011	< 0.0013	< 0.0013	< 0.0016	< 0.0012	< 0.0013
MW-302	07/24/14	< 0.000050	< 0.000039	< 0.000033	< 0.000037	< 0.000042	< 0.000033	< 0.000033
	05/21/15	< 0.0013	< 0.0010	< 0.0012	< 0.0013	< 0.0015	< 0.0012	< 0.0013
MW-303	07/24/14	< 0.000050	< 0.000039	< 0.000033	< 0.000037	< 0.000043	< 0.000033	< 0.000033
	05/20/15	< 0.0014	< 0.0011	< 0.0013	< 0.0013	< 0.0016	< 0.0012	< 0.0013
MW-304	07/24/14	< 0.000050	< 0.000039	< 0.000033	< 0.000037	< 0.000042	< 0.000033	< 0.000033
	05/20/15	< 0.0013	< 0.0010	< 0.0012	< 0.0013	< 0.0015	< 0.0012	< 0.0013
MW-309	07/24/14	< 0.000050	< 0.000039	< 0.000033	< 0.000037	< 0.000042	< 0.000033	< 0.000033
	05/20/15	< 0.0014	< 0.0011	< 0.0013	< 0.0014	< 0.0016	< 0.0012	< 0.0013
MW-310	07/24/14	< 0.000050	< 0.000039	< 0.000033	< 0.000037	< 0.000042	< 0.000033	< 0.000033
	05/21/15	< 0.0013	< 0.0010	< 0.0012	< 0.0013	< 0.0015	< 0.0012	< 0.0013
MW-311	11/05/14	< 0.000050	< 0.000039	< 0.000033	< 0.000037	< 0.000042	< 0.000033	< 0.000033
MW-312	11/05/14	< 0.000050	< 0.000039	< 0.000033	< 0.000037	< 0.000042	< 0.000033	< 0.000033

Table A-2
Carcinogenic PAHs in Groundwater
Shell Harbor Island Terminal
Seattle, Washington

TX-03A	07/24/14	< 0.000050	< 0.000039	< 0.000033	< 0.000037	< 0.000042	< 0.000033	< 0.000033
	05/21/15	< 0.0014	< 0.0010	< 0.0013	< 0.0013	< 0.0016	< 0.0012	< 0.0013

Note:
*** =** Cleanup levels per the Cleanup Action Plan (Ecology, 1998)
< = concentration undetected at the detection limit.
ID = identification
mg/L = milligrams per liter
PAHs = polycyclic aromatic hydrocarbons

Table A-3
Compliance Monitoring Natural Attenuation Parameters
Shell Harbor Island Terminal
Seattle, Washington

Well	Date	Gasoline Range Hydrocarbons (mg/L)	Benzene (mg/L)	Toluene (mg/L)	Ethylbenzene (mg/L)	Total Xylenes (mg/L)	Total BTEX (mg/L)	Total Alkalinity (mg/L)	Carbon Dioxide (mg/L)	Dissolved Oxygen (mg/L)	Hardness (mg/L)	Iron Total (mg/L)	Ferrous Iron (mg/L)	Methane (mg/L)	ORP (mv)	pH	Specific Conductance (µS/cm)	Sulfate (mg/L)	Temperature (°C)	Turbidity (NTU)	Iron Dissolved (mg/L)	Manganese Dissolved (mg/L)	Calcium Total (mg/L)	Magnesium Total (mg/L)	Nitrogen, Nitrate (mg/L)	Nitrogen, Nitrite (mg/L)
Upgradient Wells																										
TES-MW-1	01/14/04	< 0.25	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	NM	NM	9.4	NM	NM	NM	NM	100	4.79	223	NM	10.5	4.4	NM	NM	NM	NM	NM	NM
	04/20/04	< 0.25	0.0067	< 0.001	0.011	0.043	0.0607	40	12.5	3.1	60	0.135	ND	< 0.0012	132.6	4.57	149	39.1	10.7	4.0	NM	NM	NM	NM	NM	NM
	04/20/04	< 0.26	0.0075	< 0.001	0.013	0.049	0.0695	NM	NM	NM	NM	0.138	NM	0.14	NM	NM	NM	46.3	NM	NM	NM	NM	NM	NM	NM	NM
	07/28/04	< 0.25	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	NM	NM	1.6	NM	NM	NM	NM	164.7	5.40	171	NM	17.6	4.1	NM	NM	NM	NM	NM	NM
	10/18/04	< 0.25	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	NM	NM	5.4	NM	NM	NM	NM	245	5.04	106	NM	14.6	-10.0	NM	NM	NM	NM	NM	NM
	01/25/05	< 0.25	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	NM	NM	5.5	NM	NM	NM	NM	208	4.98	93	NM	11.0	8.0	NM	NM	NM	NM	NM	NM
	04/20/05	0.18	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	10	50	4.9	<20	0.844	0	<0.0012	62	5.33	8.2	14.6	11.9	NM	NM	NM	NM	NM	NM	NM
	07/13/05	0.26	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	NM	NM	0.1	NM	NM	NM	NM	155.8	5.52	118	NM	16.4	3.8	NM	NM	NM	NM	NM	NM
	10/18/05	0.072	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	NM	NM	0.16	NM	NM	NM	NM	99.2	6.44	157	NM	16.1	9.6	NM	NM	NM	NM	NM	NM
	01/26/06	0.126	< 0.0005	< 0.0005	< 0.0005	< 0.001	< 0.001	NM	NM	5.52	NM	NM	NM	NM	212.7	5.53	41	NM	8.3	4.5	NM	NM	NM	NM	NM	NM
	11/18/08	< 0.05	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	NM	NM	7.81	NM	NM	NM	NM	308.0	4.92	311	NM	13.7	13.1	NM	NM	NM	NM	NM	NM
	11/18/09	< 0.1	< 0.0005	< 0.001	< 0.001	< 0.001	< 0.001	NM	NM	6.19	NM	NM	NM	NM	169.0	4.78	16.3	NM	11.2	0.0	NM	NM	NM	NM	NM	NM
	10/26/10	< 0.1	< 0.0005	< 0.001	< 0.001	< 0.001	< 0.001	NM	NM	4.80	NM	NM	NM	NM	161.0	4.65	12.0	NM	11.9	15.1	NM	NM	NM	NM	NM	NM
	10/27/11	< 0.20	< 0.0010	< 0.0010	< 0.0010	< 0.0020	< 0.0020	NM	NM	3.38	NM	NM	NM	NM	-7.2	8.47	104	NM	11.57	10.9	NM	NM	NM	NM	NM	NM
	11/26/12	< 0.050	< 0.00020	< 0.00020	< 0.00020	< 0.00046	< 0.00020	NM	NM	NM	NM	NM	NM	NM	NM	NM	NM	NM	NM	NM	NM	NM	NM	NM	NM	NM
	11/06/13	< 0.050	< 0.00020	< 0.00020	< 0.00020	< 0.00046	< 0.00020	NM	NM	2.91	NM	NM	NM	NM	181	5.84	137	NM	12.27	0	NM	NM	NM	NM	NM	NM
Plume Wells																										
MW-101	01/14/04	NA	NA	NA	NA	NA	NA	NM	NM	1.72	NM	NM	NM	NM	-99.7	5.42	202	NM	12.3	1.9	NM	NM	NM	NM	NM	NM
	01/16/04	0.55	< 0.001	< 0.001	< 0.001	0.0028	0.0028	NM	NM	0.87	NM	NM	NM	NM	-61.5	6.52	225	NM	12.4	6.9	NM	NM	NM	NM	NM	NM
	04/20/04	0.67	0.0016	< 0.001	< 0.001	0.0014	0.003	140	65	0.78	> 400	15.5	4.5	0.06	120	6.1	247	17.2	12.0	5.8	NM	NM	NM	NM	NM	NM
	07/28/04	1	0.0012	< 0.001	< 0.001	0.0011	0.0023	NM	NM	0.4	NM	NM	NM	NM	60.3	6.86	280	NM	17.8	4.3	NM	NM	NM	NM	NM	NM
	10/18/04	0.42	0.0011	< 0.001	< 0.001	< 0.001	0.0011	NM	NM	0.24	NM	NM	NM	NM	132.3	14.25	386	NM	15.1	5.5	NM	NM	NM	NM	NM	NM
	01/26/05	0.51	< 0.001	< 0.001	< 0.001	0.0011	0.0011	NM	NM	1.51	NM	NM	NM	NM	36	7.74	356	NM	11.8	-1.0	NM	NM	NM	NM	NM	NM
	04/19/05	0.58	0.0016	< 0.001	< 0.001	< 0.001	0.0016	160	100	NM	>600	24.6	4	0.58	-98	6.71	389	39	12.8	NM	NM	NM	NM	NM	NM	NM
	07/13/05	0.31	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	NM	NM	0.07	NM	NM	NM	NM	-75	6.68	319	NM	16.0	1.4	NM	NM	NM	NM	NM	NM
	10/10/05	0.16	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	NM	NM	0.25	NM	NM	NM	NM	-89.8	7.01	661	NM	16.2	1.0	NM	NM	NM	NM	NM	NM
	01/27/06	0.223	< 0.0005	< 0.0005	< 0.0005	< 0.001	< 0.001	NM	NM	0.18	NM	NM	NM	NM	-47.7	6.57	187	NM	10.8	17.4	NM	NM	NM	NM	NM	NM
	11/18/08	0.100	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	NM	NM	1.49	NM	NM	NM	NM	-55.0	6.98	725	NM	13.6	33.4	NM	NM	NM	NM	NM	NM
	11/18/09	< 0.1	< 0.0005	< 0.001	< 0.001	< 0.001	< 0.001	NM	NM	1.45	NM	NM	NM	NM	-95	6.53	38.3	NM	12.4	2.7	NM	NM	NM	NM	NM	NM
	10/26/10	0.150	< 0.0005	< 0.001	< 0.001	< 0.001	< 0.001	NM	NM	1.79	NM	NM	NM	NM	-125	6.57	31.7	NM	11.5	21.0	NM	NM	NM	NM	NM	NM
	10/27/11	0.094	< 0.0010	< 0.0010	< 0.0010	< 0.0020	< 0.0050	NM	NM	5.65	NM	NM	NM	NM	-108	8.81	228.0	NM	11.6	15.1	NM	NM	NM	NM	NM	NM
	11/26/12	0.188 J	< 0.00020	< 0.00020	< 0.00020	< 0.00046	< 0.00020	NM	NM	NM	NM	NM	NM	NM	NM	NM	NM	NM	NM	NM	NM	NM	NM	NM	NM	NM
	11/06/13	0.118 J	< 0.00020	< 0.00020	< 0.00020	< 0.00046	< 0.00020	NM	NM	6.44	NM	NM	NM	NM	-78.7	6.31	256	NM	13.13	1.51	NM	NM	NM	NM	NM	NM
TX-03A	01/13/04	**2.7**	**2.9**	0.018	0.038	0.091	3.052	NM	NM	1.400	NM	NM	NM	NM	-59	6.39	480	NM	14.0	1.8	NM	NM	NM	NM	NM	NM
	04/19/04	**12**	**4.4**	0.047	0.12	0.11	4.677	360	150	1.440	> 600	36.1	6.000	13	21	6.18	560	< 1	13.7	2.4	NM	NM	NM	NM	NM	NM
	07/27/04	**5.2**	**1.7**	0.011	0.016	0.037	1.764	NM	NM	1.310	NM	NM	NM	NM	68	6.26	589	NM	17.9	3.0	NM	NM	NM	NM	NM	NM
	10/18/04	**7.5**	**3.2**	0.024	0.062	0.093	3.379	NM	NM	2.770	NM	NM	NM	NM	-100	6.63	595	NM	16.7	42.0	NM	NM	NM	NM	NM	NM
	01/24/05	**8.2**	**2.5**	0.02	< 0.01	0.065	2.585	NM	NM	1.79	NM	NM	NM	NM	5.0	5.11	563	NM	14.6	43.1	NM	NM	NM	NM	NM	NM
	04/19/05	**6.1**	**2.5**	0.021	0.026	0.049	2.596	320	150	0	>600	35.3	4	1.9	-86	6.47	552	< 1	13.8	20	NM	NM	NM	NM	NM	NM
	07/12/05	**10**	**3.1**	0.024	0.044	0.054	3.222	NM	NM	0.16	NM	NM	NM	NM	-121.0	6.55	477	NM	17.3	55.6	NM	NM	NM	NM	NM	NM
	10/31/07	< 5	**2.2**	0.023	0.060	0.050	2.330	NM	NM	NM	NM	NM	NM	NM	NM	NM	NM	NM	NM	NM	NM	NM	NM	NM	NM	NM
	11/20/08	**4.5**	**2.1**	0.019	0.038	0.018	2.175	169	210	0.5	NM	39.3	30.4	3.5	-59	6.87	821	< 1	15.8	31.8	NM	NM	NM	NM	NM	NM
	04/08/09	**3.5**	**1.2**	< 0.025	0.028	< 0.025	1.228	NM	NM	0	NM	NM	NM	NM	-145	6.58	236	NM	12.8	43.1	NM	NM	NM	NM	NM	NM
	11/17/09	**2.4**	**0.97**	0.0078	0.016	0.011	1.005	202	65.8	1.29	160	32.2	36	12.8	-102	6.39	50.6	1.2	16.3	9.7	NM	NM	NM	NM	NM	NM
	04/27/10	**4.6**	**1.7**	0.0096	0.0087	0.0099	1.7282	NM	NM	0.21	NM	NM	NM	NM	-153	5.76	52.8	NM	13.2	9.5	NM	NM	NM	NM	NM	NM
	10/25/10	**3.3**	**1.7**	0.011	0.067	0.013	1.7910	181	0.27	1.39	140	34.6	30	5.84	-115	6.68	42.5	6.8	15.5	48.0	NM	NM	NM	NM	NM	NM
	05/23/11	**7.5**	**1.78**	<0.025	0.044	<0.035	1.8240	NM	NM	NM	NM	NM	NM	NM	NM	NM	NM	NM	NM	NM	NM	NM	NM	NM	NM	NM
	10/27/11	**8.51**	**3.44**	0.0712	0.147	0.111	3.7692	247	9.29	1.72	196	30.8	20.3	12.2	-100.9	8.50	478	< 0.50	15.44	NM	NM	NM	NM	NM	NM	NM
	03/01/12	**5.58**	**1.74**	0.0261	0.0272	0.0345	1.83	NM	NM	0.00	NM	NM	NM	NM	-118	6.71	564	NM	12.29	12.6	NM	NM	NM	NM	NM	NM
	06/12/12	**6.78**	**1.57**	0.0200	0.0139	0.0300	1.63	NM	NM	4.00	NM	NM	NM	NM	-103	7.19	507	NM	14.0	4.5	NM	NM	NM	NM	NM	NM
	09/25/12	**5.53**	**1.7**	0.0298	0.041	0.0501	1.82	NM	NM	0.00	NM	NM	NM	NM	-139	6.48	514	NM	17.83	15.2	NM	NM	NM	NM	NM	NM
	11/28/12	**4.91**	**1.18**	0.0188 J	0.0232	0.0357 J	1.26	164	16.4	0.00	127	33.9	NM	6.08	-104	6.70	439	< 0.50	13.79	NM	NM	NM	NM	NM	NM	NM
	11/05/13	**6.01**	**2.72**	0.0343 J	0.0364 J	0.0411 J	2.83	188	16.4	0.06	152	44.9	4.0	6.27	-114	6.57	528	< 0.50	10.98	0.0	< 0.200	0.470	NM	NM	NM	NM
	11/04/14	**5.76**	**0.941**	0.0137	0.0366	0.0269	1.02	170	NM	0.38	132	39.4	6.0	NM	-39.0	6.49	424	< 0.50	16.80	5.83	6.18	0.523	25.3	16.6	< 0.10	< 0.10

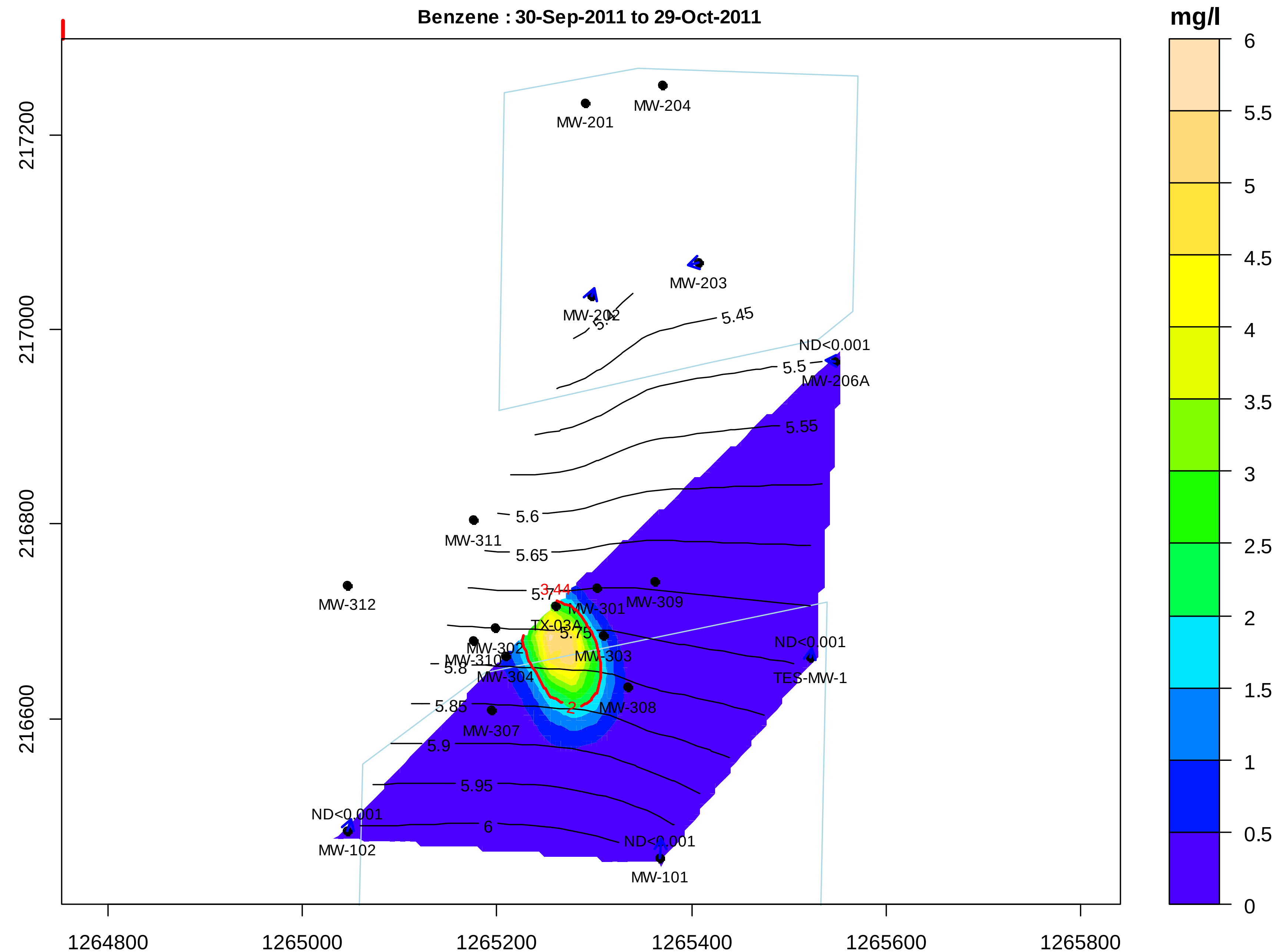
Table A-3
Compliance Monitoring Natural Attenuation Parameters
Shell Harbor Island Terminal
Seattle, Washington

Well	Date	Parameter																									
		Gasoline Range Hydrocarbons (mg/L)	Benzene (mg/L)	Toluene (mg/L)	Ethylbenzene (mg/L)	Total Xylenes (mg/L)	Total BTEX (mg/L)	Total Alkalinity (mg/L)	Carbon Dioxide (mg/L)	Dissolved Oxygen (mg/L)	Hardness (mg/L)	Iron Total (mg/L)	Ferrous Iron (mg/L)	Methane (mg/L)	ORP (mv)	pH	Specific Conductance (µS/cm)	Sulfate (mg/L)	Temperature (°C)	Turbidity (NTU)	Iron Dissolved (mg/L)	Manganese Dissolved (mg/L)	Calcium Total (mg/L)	Magnesium Total (mg/L)	Nitrogen, Nitrate (mg/L)	Nitrogen, Nitrite (mg/L)
MW-302	03/01/12	**5.33**	**0.831**	0.0275	0.213	0.248	1.32	NM	NM	NM	NM	NM	NM	NM	NM	NM	NM	NM	NM	NM	NM	NM	NM	NM	NM	NM
	06/12/12	**4.18**	**0.574**	0.0156	0.0183	0.0244	0.63	NM	NM	NM	NM	NM	NM	NM	NM	NM	NM	NM	NM	NM	NM	NM	NM	NM	NM	NM
	06/28/12	**5.65**	**1.23**	0.0437	0.403	0.289	1.97	NM	NM	NM	NM	NM	NM	NM	NM	NM	NM	NM	NM	NM	NM	NM	NM	NM	NM	NM
	09/25/12	**4.07**	**0.657**	0.0247	0.180	0.106	0.97	NM	NM	NM	NM	NM	NM	NM	NM	NM	NM	NM	NM	NM	NM	NM	NM	NM	NM	NM
	11/25/12	**4.58**	**0.449**	0.0152	0.191	0.177	0.83	NM	NM	NM	NM	NM	NM	NM	NM	NM	NM	NM	NM	NM	NM	NM	NM	NM	NM	NM
	11/05/13	**2.69**	**0.607**	0.0112	0.0977	0.0529	0.769	102	15.7	0.10	84.3	2.11	6.0-6.5	3.41	-67	6.42	346	13.2	14.81	0.0	< 0.200	0.349	NM	NM	NM	NM
	11/03/14	**4.06**	**0.506**	0.0159	0.2210	0.1760	0.92	148	NM	0.53	103	26.9	2.5	NM	-27.8	6.50	342	< 0.50	15.91	5.06	0.765	0.493	23.4	10.9	< 0.10	< 0.10
MW-304	11/05/13	**2.67**	**0.695**	0.0163	0.0629	0.0540	0.828	128	12.7	0.10	88.6	35.5	7.0	7.65	-119	6.60	396	< 0.50	12.20	0.0	0.345	0.273	NM	NM	NM	NM
	11/03/14	**3.32**	**1.11**	0.0421	0.48	0.2140	1.846	125	NM	0.62	88.1	35.9	5.0	NM	-36.9	6.46	310	0.51	14.86	11.2	3.60 J	0.297 J	16.8	11.2	< 0.10	< 0.10
MW-307	11/26/12	**10.9**	**2.15**	0.0858	0.833	0.513	3.58	144	16.0	0.00	84.9	33.5	NM	7.92	-62	7.18	332	1.5	12.70	36.6	NM	NM	NM	NM	NM	NM
	11/06/13	**4.4**	**0.568**	0.0448 J	0.104	0.091	0.808	60.0	8.44	0.07	45.4	27.0	3.5	7.27	-106	6.42	231	< 0.50	12.31	0.8	< 0.200	0.217	NM	NM	NM	NM
	11/04/14	**5.16**	**0.596**	0.0390	0.176	0.095	0.906	104	NM	0.26	78.2	44.1	4.5	NM	-107	6.86	383	< 0.50	14.49	6.9	18.2	0.513	19.1	7.41	< 0.10	< 0.10
MW-308	11/26/12	0.778	**0.144**	0.0010 J	0.007	0.0013 J	0.153	298	6.17	0.00	384	0.542	NM	2.49	23	6.79	728	97.0	10.65	25.2	NM	NM	NM	NM	NM	NM
	11/06/13	**1.650**	**0.237**	0.0033 J	0.006	0.0026 J	0.249	NM	NM	4.89	NM	NM	NM	NM	NM	6.09	307	NM	12.98	0.99	NM	NM	NM	NM	NM	NM
MW-309	11/28/12	< 0.050	< 0.00020	< 0.00020	< 0.00020	< 0.00046	< 0.00046	84.0	7.34	0.00	94.7	36.6	NM	0.188	-126	7.80	358	32.1	15.25	36.8	NM	NM	NM	NM	NM	NM
	11/06/13	< 0.050	< 0.00020	< 0.00020	< 0.00020	< 0.00046	< 0.00046	NM	NM	1.51	NM	NM	NM	NM	NM	6.18	325	NM	15.75	6.6	NM	NM	NM	NM	NM	NM
MW-310	11/28/12	**5.74**	**0.86**	0.0265	0.211	0.147	1.24	158	13.3	0.00	132	29.3	NM	6.70	-88	7.22	385	< 0.50	13.97	80.6	NM	NM	NM	NM	NM	NM
	11/05/13	**4.92**	**0.772**	0.0409	0.226	0.085	1.12	134	11.3	0.05	114	29.6	2.0-2.5	4.52	-95	6.44	396	< 0.50	14.07	0.0	0.982	0.528	NM	NM	NM	NM
	11/04/14	**5.15**	**0.739**	0.0387	0.132	0.054	0.96	122	NM	0.03	102	41.4	1.5	NM	-101	6.88	393	< 0.50	15.97	0.0	11.5	0.615	26.0	8.89	< 0.10	< 0.10
TW-01	11/07/13	**3.24**	**0.431**	0.0245	0.132	0.072	0.66	80.0	9.31	1.25	58.0	27.0	3.0	5.29	-45.1	6.03	228	2.7	15.38	3.01	4.58	0.320	NM	NM	NM	NM
MW-202	01/14/04	**2.5**	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	NM	NM	12.4	NM	NM	NM	NM	-40.2	5.32	52	NM	8.0	9.1	NM	NM	NM	NM	NM	NM
	04/20/04	**4.4**	0.014	0.0062	0.074	0.021	0.1152	180	160	1.31	> 400	47.8	3	0.92	112	5.27	317	< 1	12.1	9.8	NM	NM	NM	NM	NM	NM
	01/26/05	**7.7**	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	NM	NM	1.69	NM	NM	NM	NM	3	4.8	218	NM	11.6	126	NM	NM	NM	NM	NM	NM
	04/20/05	**3.7**	0.016	0.0022	0.036	0.0237	0.0779	200	180	0	>600	42.2	8	0.9	-60	7.78	44	<1	12.6	26.0	NM	NM	NM	NM	NM	NM
	07/13/05	**3.5**	0.016	0.0033	0.067	0.0191	0.1054	NM	NM	0.11	NM	NM	NM	NM	-22	6.09	281	NM	15.7	6.3	NM	NM	NM	NM	NM	NM
	10/20/05	**3.3**	0.019	0.0021	0.058	0.0056	0.0847	NM	NM	0.44	NM	NM	NM	NM	-47.9	6.42	576	NM	15.5	5.5	NM	NM	NM	NM	NM	NM
	01/26/06	**5.79**	0.0224	0.00598	0.041	0.0191	0.0885	NM	NM	0.18	NM	NM	NM	NM	-104.7	7.73	213	NM	10.78	70	NM	NM	NM	NM	NM	NM
	11/20/08	**5.00**	NM	NM	NM	NM	NM	73	220	3.65	228	32.5	36.6	1.8	232.0	6.40	532	< 1	14.50	10	NM	NM	NM	NM	NM	NM
	04/07/09	**4.80**	NM	NM	NM	NM	NM	NM	NM	0	NM	NM	NM	NM	-82	6.12	0.175	NM	11.86	56.1	NM	NM	NM	NM	NM	NM
	11/19/09	**6.60**	NM	NM	NM	NM	NM	64	194	1.65	120	45.2	19	2.31	-53	5.81	51.6	82	12.4	29.5	NM	NM	NM	NM	NM	NM
	04/27/10	**3.30**	NM	NM	NM	NM	NM	NM	NM	0.22	NM	NM	NM	NM	-96	5.46	34	NM	12.3	55.4	NM	NM	NM	NM	NM	NM
	10/27/10	**6.00**	0.0081	0.0031	0.066	0.0022	0.0794	75	71.8	2.35	70	34.8	7.4	4.36	-48	6.15	29.5	< 1.0	15	24	NM	NM	NM	NM	NM	NM
	10/26/11	**4.30**	NM	NM	NM	NM	NM	84	21.3	2.45	45.4	27.4	8.5	6.08	-104.2	8.22	214	< 0.50	12.90	2.72	NM	NM	NM	NM	NM	NM
	03/02/12	**3.87**	0.0053	0.0019	0.0107	0.0013	0.0192	NM	NM	0.00	NM	NM	NM	NM	-39	6.30	334	NM	10.03	27.2	NM	NM	NM	NM	NM	NM
	06/13/12	**3.31**	NM	NM	NM	NM	NM	NM	NM	4.36	NM	NM	NM	NM	-59	7.22	284	NM	12.5	25.7	NM	NM	NM	NM	NM	NM
	09/26/12	**4.07**	0.0058	0.0029	0.0378	< 0.0018	0.0465	NM	NM	0.00	NM	NM	NM	NM	-112	6.74	332	NM	14.20	25.0	NM	NM	NM	NM	NM	NM
	11/27/12	**6.07**	0.0113	0.0034	0.0274	0.0022	0.0443	110	10.6	0.00	101	35.9	NM	1.07	-70	7.33	383	15.0	12.99	77.7	NM	NM	NM	NM	NM	NM
	11/06/13	**4.68**	< 0.00020	0.0027	0.0335	0.0012 J	0.0374	80.0	22.1	2.28	71.8	37.9	3.0	3.57	-43.6	5.79	263	0.76	13.67	4.9	< 0.200	0.439	NM	NM	NM	NM
	11/06/14	**5.10**	0.0083	0.0026	0.0154	0.0011	0.027	92.0	NM	0.00	92.3	34.9	5.0	NM	-49	6.47	373	7.0	15.87	107.0	0.288	0.631	14.2	13.8	< 0.25	< 0.25

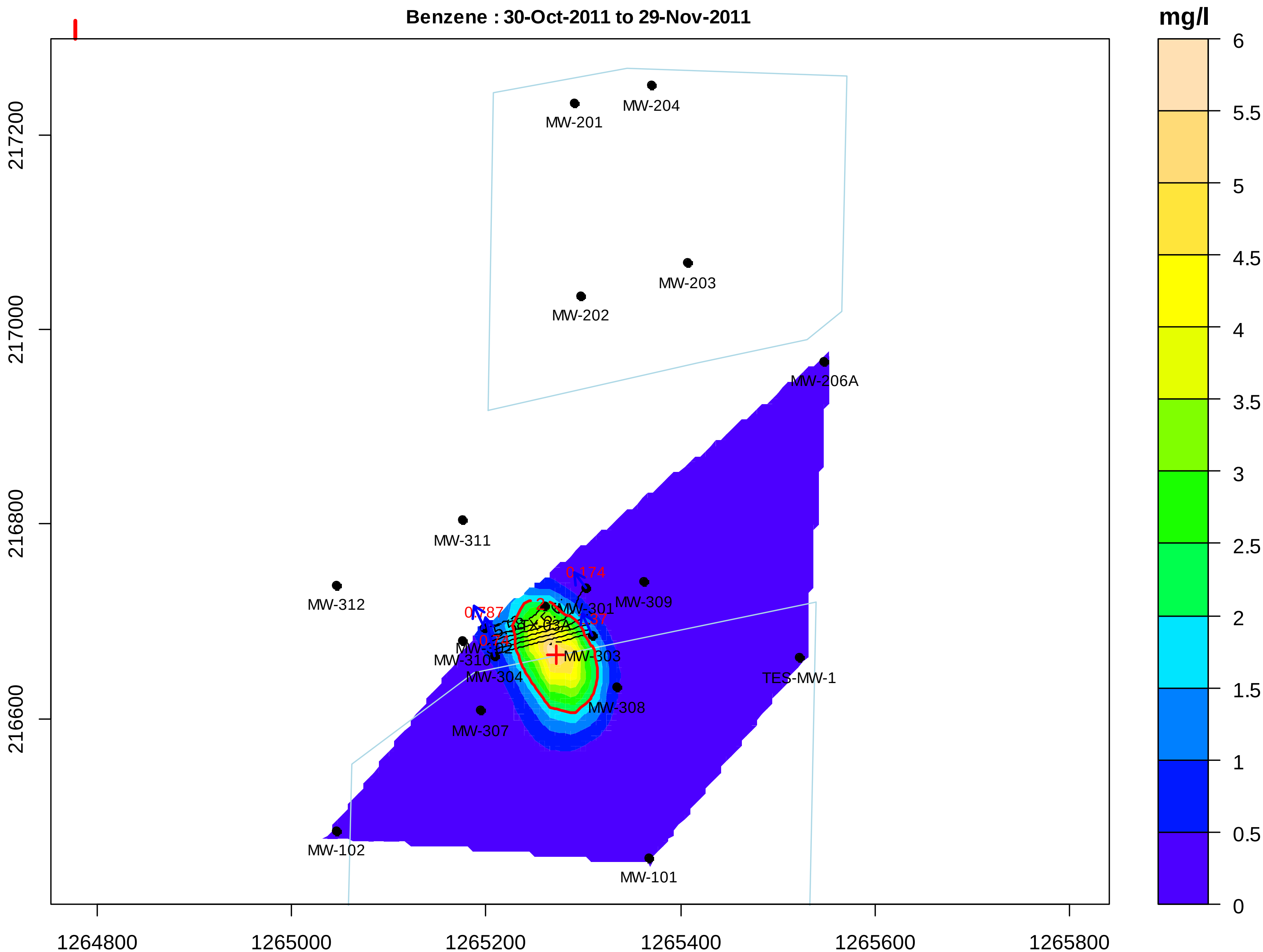
Table A-3
Compliance Monitoring Natural Attenuation Parameters
Shell Harbor Island Terminal
Seattle, Washington

Well	Date	Gasoline Range Hydrocarbons (mg/L)	Benzene (mg/L)	Toluene (mg/L)	Ethylbenzene (mg/L)	Total Xylenes (mg/L)	Total BTEX (mg/L)	Total Alkalinity (mg/L)	Carbon Dioxide (mg/L)	Dissolved Oxygen (mg/L)	Hardness (mg/L)	Iron Total (mg/L)	Ferrous Iron (mg/L)	Methane (mg/L)	ORP (mv)	pH	Specific Conductance (µS/cm)	Sulfate (mg/L)	Temperature (°C)	Turbidity (NTU)	Iron Dissolved (mg/L)	Manganese Dissolved (mg/L)	Calcium Total (mg/L)	Magnesium Total (mg/L)	Nitrogen, Nitrate (mg/L)	Nitrogen, Nitrite (mg/L)
		Parameter																								
MW-203	01/13/04	< 0.25	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	NM	NM	2.91	NM	NM	NM	NM	-6.9	6.38	243	NM	12.4	13.7	NM	NM	NM	NM	NM	NM
	04/19/04	< 0.25	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	220	85	1.02	180	12	1	< 0.0012	110	6.58	369	2.4	13.0	39.2	NM	NM	NM	NM	NM	NM
	07/27/04	**2.6**	0.013	< 0.001	0.0069	< 0.001	0.0199	NM	NM	1.12	NM	NM	NM	NM	90.9	6.11	514	NM	16.4	32.2	NM	NM	NM	NM	NM	NM
	10/18/04	**1.6**	0.013	< 0.001	0.015	0.0025	0.0305	NM	NM	0.35	NM	NM	NM	NM	136.8	9.42	643	NM	14.8	110	NM	NM	NM	NM	NM	NM
	01/25/05	**1.6**	0.0063	< 0.001	0.011	0.0013	0.0186	NM	NM	2.79	NM	NM	NM	NM	21	6.37	476	NM	12.9	210	NM	NM	NM	NM	NM	NM
	04/19/05	0.63	0.0068	< 0.001	0.0018	< 0.001	0.0086	220	145	0	>600	26.7	5.5	0.43	0	6.22	44	6.48	12.8	5	NM	NM	NM	NM	NM	NM
	07/13/05	0.89	0.01	< 0.001	0.0077	< 0.001	0.0177	NM	NM	0.67	NM	NM	NM	NM	-46	6.34	351	NM	15.0	15	NM	NM	NM	NM	NM	NM
	10/20/05	**4.2**	0.023	0.002	0.021	0.0026	0.0486	NM	NM	1.12	NM	NM	NM	NM	-48.7	6.69	902	NM	15.9	34	NM	NM	NM	NM	NM	NM
	01/23/06	0.76	0.00186	< 0.0005	0.00182	0.00125	0.00493	NM	NM	2.2	NM	NM	NM	NM	7.6	6.45	131	NM	11.4	60	NM	NM	NM	NM	NM	NM
	11/18/08	0.17	NM	NM	NM	NM	NM	80	< 10	10.3	208	1.56	1.35	< 0.0012	87.0	7.11	448	17.1	13.9	190	NM	NM	NM	NM	NM	NM
	04/08/09	< 0.1	NM	NM	NM	NM	NM	NM	NM	1.87	NM	NM	NM	NM	-31.0	6.83	136	NM	12.2	338	NM	NM	NM	NM	NM	NM
	11/17/09	< 0.1	NM	NM	NM	NM	NM	86	22.1	5.5	86	2.36	< 0.1	< 0.001	197	6.28	25.8	8.3	12.2	45.6	NM	NM	NM	NM	NM	NM
	04/26/10	0.16	NM	NM	NM	NM	NM	NM	NM	0.30	NM	NM	NM	NM	-109.0	6.81	40.9	NM	12.7	80.1	NM	NM	NM	NM	NM	NM
	10/25/10	0.92	NM	NM	NM	NM	NM	139	0.04	1.58	150	7.83	4.3	0.104	-4	6.10	43.8	14	14.1	51.8	NM	NM	NM	NM	NM	NM
	05/23/11	0.333	NM	NM	NM	NM	NM	NM	NM	NM	NM	NM	NM	NM	NM	NM	NM	NM	NM	NM	NM	NM	NM	NM	NM	NM
	10/26/11	**1.38**	NM	NM	NM	NM	NM	180	26.2	2.94	146	28.1	8.8	0.701	-81	8.40	384.0	< 0.50	13.98	10.9	NM	NM	NM	NM	NM	NM
	06/13/12	0.459	NM	NM	NM	NM	NM	NM	NM	4.27	NM	NM	NM	NM	-38	7.20	375	NM	12.8	22.3	NM	NM	NM	NM	NM	NM
	11/27/12	**1.05**	NM	NM	NM	NM	NM	170	16.7	0.00	140	21.2	NM	0.582	22	6.61	250	24.4	14.83	41.7	NM	NM	NM	NM	NM	NM
	11/06/13	0.680	NM	NM	NM	NM	NM	190	20.1	0.18	161	21.9	3.0	0.800	-51	6.35	486	< 0.50	12.59	0.0	3.68	0.178	NM	NM	NM	NM
	11/06/14	0.102	NM	NM	NM	NM	NM	134	NM	4.55	150	15.0	1.5	NM	135.1	6.71	236	14.5	16.13	28.4	< 0.200	0.127	50.9	5.49	0.42 J	< 0.25
Downgradient Wells																										
MW-311	11/05/14	< 0.050	< 0.00020	< 0.00020	< 0.00020	< 0.00046	< 0.00046	188	NM	0.00	222	32.6	1.5	NM	-146	7.42	606	42.3	16.57	7.0	< 0.200	1.57	75.2	8.27	< 0.25	< 0.25
MW-312	11/05/14	**1.64**	**0.239**	0.0058	0.0065	0.0102	0.262	202	NM	0.58	195	25.6	5.7	NM	-92.0	6.78	459	< 1.3	17.07	0.0	< 0.200	0.787	58.8	11.6	< 0.25	< 0.25
MW-201	01/14/04	< 0.25	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	NM	NM	1.98	NM	NM	NM	NM	-95.5	5.59	282	NM	12.0	1.5	NM	NM	NM	NM	NM	NM
	04/20/04	< 0.25	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	40	30	5.52	> 400	0.0772	ND	< 0.0012	61.3	5	101	5.71	11.4	7.0	NM	NM	NM	NM	NM	NM
	01/26/05	< 0.25	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	NM	NM	9.12	NM	NM	NM	NM	129	5.48	720	NM	9.0	9.0	NM	NM	NM	NM	NM	NM
	04/20/05	< 0.25	< 0.001	< 0.001	< 0.001	0.0021	0.0021	15	24	6.24	40	0.205	0	<0.0012	83	6.66	700	7.67	11.9	8.0	NM	NM	NM	NM	NM	NM
	07/13/05	0.12	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	NM	NM	0.16	NM	NM	NM	NM	178.1	5.64	99	NM	15.4	1.9	NM	NM	NM	NM	NM	NM
	10/20/05	0.22	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	NM	NM	0.42	NM	NM	NM	NM	49.2	7.21	535	NM	14.1	3.9	NM	NM	NM	NM	NM	NM
	01/26/06	< 0.050	< 0.0005	< 0.0005	< 0.0005	< 0.001	< 0.001	NM	NM	7.47	NM	NM	NM	NM	-72.5	7.02	24	NM	8.3	4	NM	NM	NM	NM	NM	NM
	11/20/08	< 0.05	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	NM	NM	14.08	NM	NM	NM	NM	268.0	6.12	172	NM	9.3	38	NM	NM	NM	NM	NM	NM
	04/07/09	**3.5**	0.0074	< 0.001	0.023	0.0016	0.032	NM	NM	NM	NM	NM	NM	NM	NM	NM	NM	NM	NM	NM	NM	NM	NM	NM	NM	NM
	11/19/09	< 0.1	< 0.0005	< 0.001	< 0.001	< 0.001	< 0.001	NM	NM	7.79	NM	NM	NM	NM	61.0	5.21	13.2	NM	10.6	6.5	NM	NM	NM	NM	NM	NM
	10/27/10	< 0.1	< 0.0005	< 0.001	< 0.001	< 0.001	< 0.001	NM	NM	6.92	NM	NM	NM	NM	157	4.79	15.2	NM	12.7	0.5	NM	NM	NM	NM	NM	NM
	10/26/11	0.0899	< 0.0010	< 0.0010	< 0.0010	< 0.0020	< 0.0050	NM	NM	2.77	NM	NM	NM	NM	-76.0	7.59	655	NM	11.53	5.9	NM	NM	NM	NM	NM	NM
	11/27/12	< 0.050	< 0.00020	< 0.00020	< 0.00020	< 0.00046	< 0.00020	NM	NM	NM	NM	NM	NM	NM	NM	NM	NM	NM	NM	NM	NM	NM	NM	NM	NM	NM
	11/06/13	0.0964 J	< 0.00020	< 0.00020	< 0.00020	< 0.00046	< 0.00020	NM	NM	0	NM	NM	NM	NM	-74	6.68	800	NM	11.78	0	NM	NM	NM	NM	NM	NM
	11/06/14	< 0.050	< 0.00020	< 0.00020	< 0.00020	< 0.00046	< 0.00046	NM	NM	0.00	NM	NM	NM	NM	297	6.08	121	NM	14.10	3.3	NM	NM	NM	NM	NM	NM

Note:
< = concentration undetected at the detection limit.
Bold = detected concentration greater than cleanup level defined by Cleanup Action Plan (Ecology, 1998) for Gasoline (1 mg/L) or benzene (0.071 mg/L)
*** =** Cleanup levels per the Cleanup Action Plan (Ecology, 1998)
°C = degrees Celsius
BTEX = benzene, toluene, ethylbenzene, and total xylenes
B/X = benezene to xylene
ID = identification
mg/L = milligrams per liter
mV = millivolts
NA = not analyzed
ND = Not detected
NM = Not measured
NTU = nephelometric turbidity unit
ORP = oxidation-reduction potential
µS/cm = microsiemens per centimeter

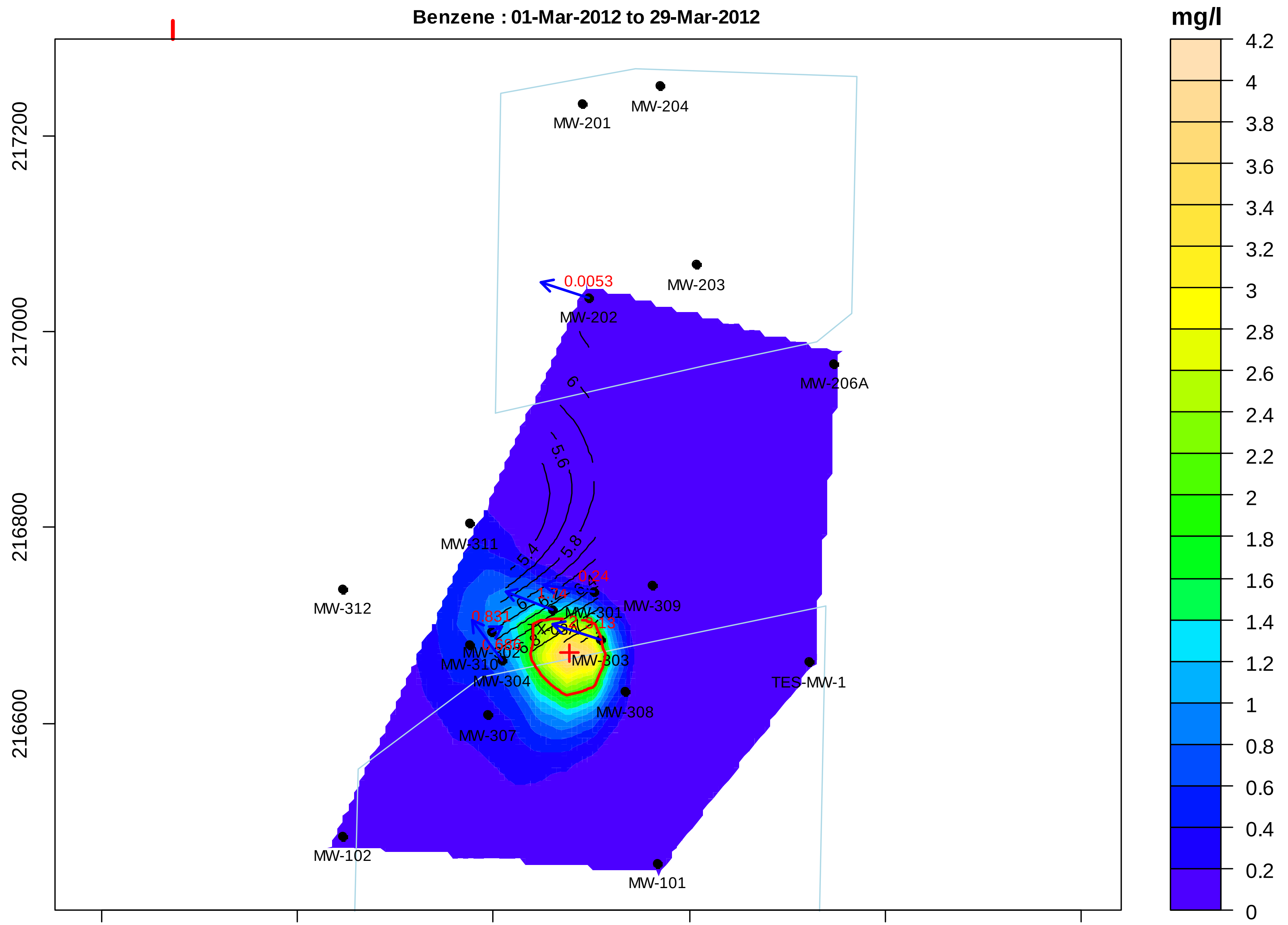


Plume Mass=NA (Mass/Unit Depth); Plume Area=NA (Unit Area)

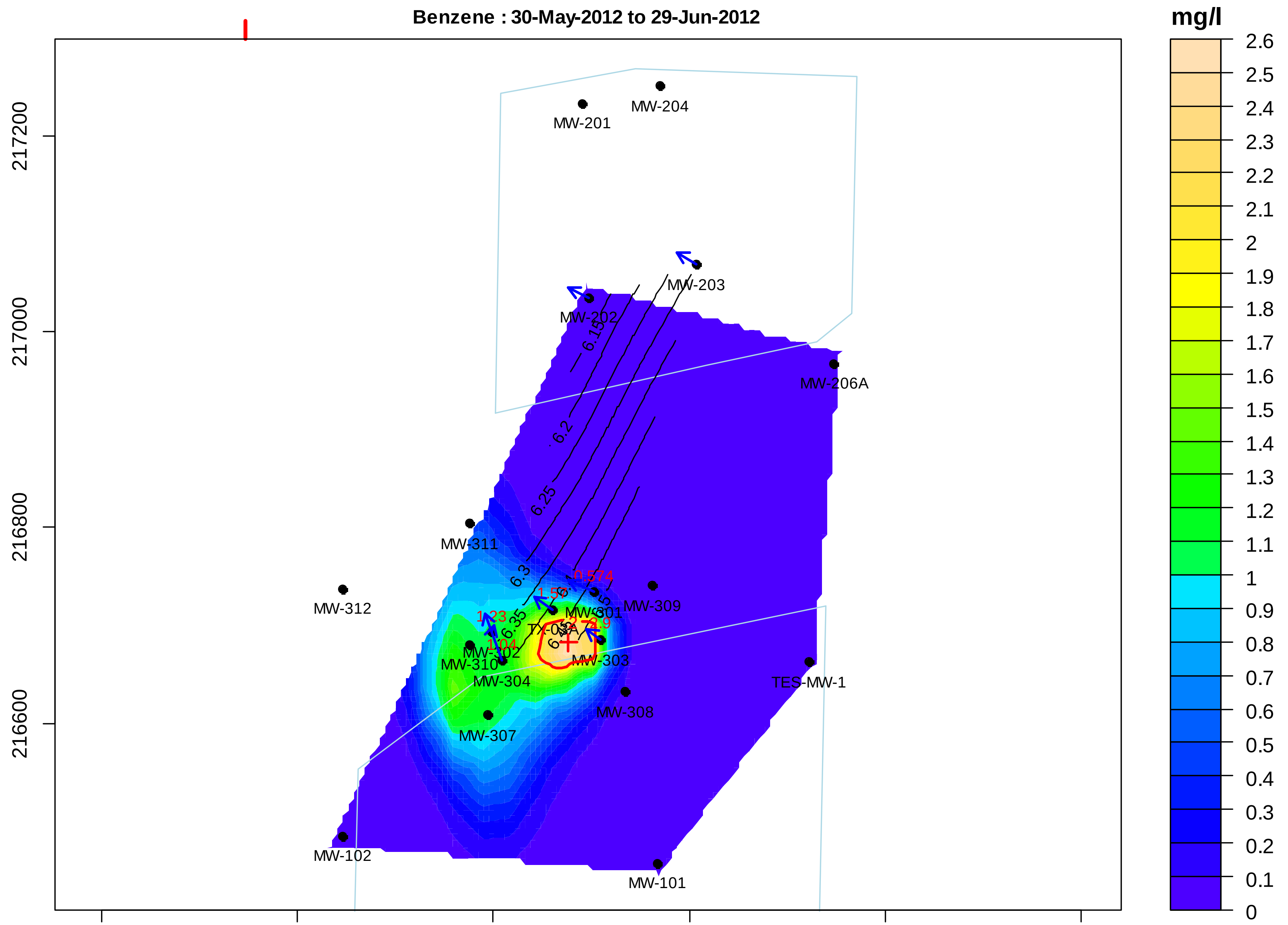


Plume Mass=6.5034 (Mass/Unit Depth); Plume Area=7024.4 (Unit Area)

Benzene : 01-Mar-2012 to 29-Mar-2012

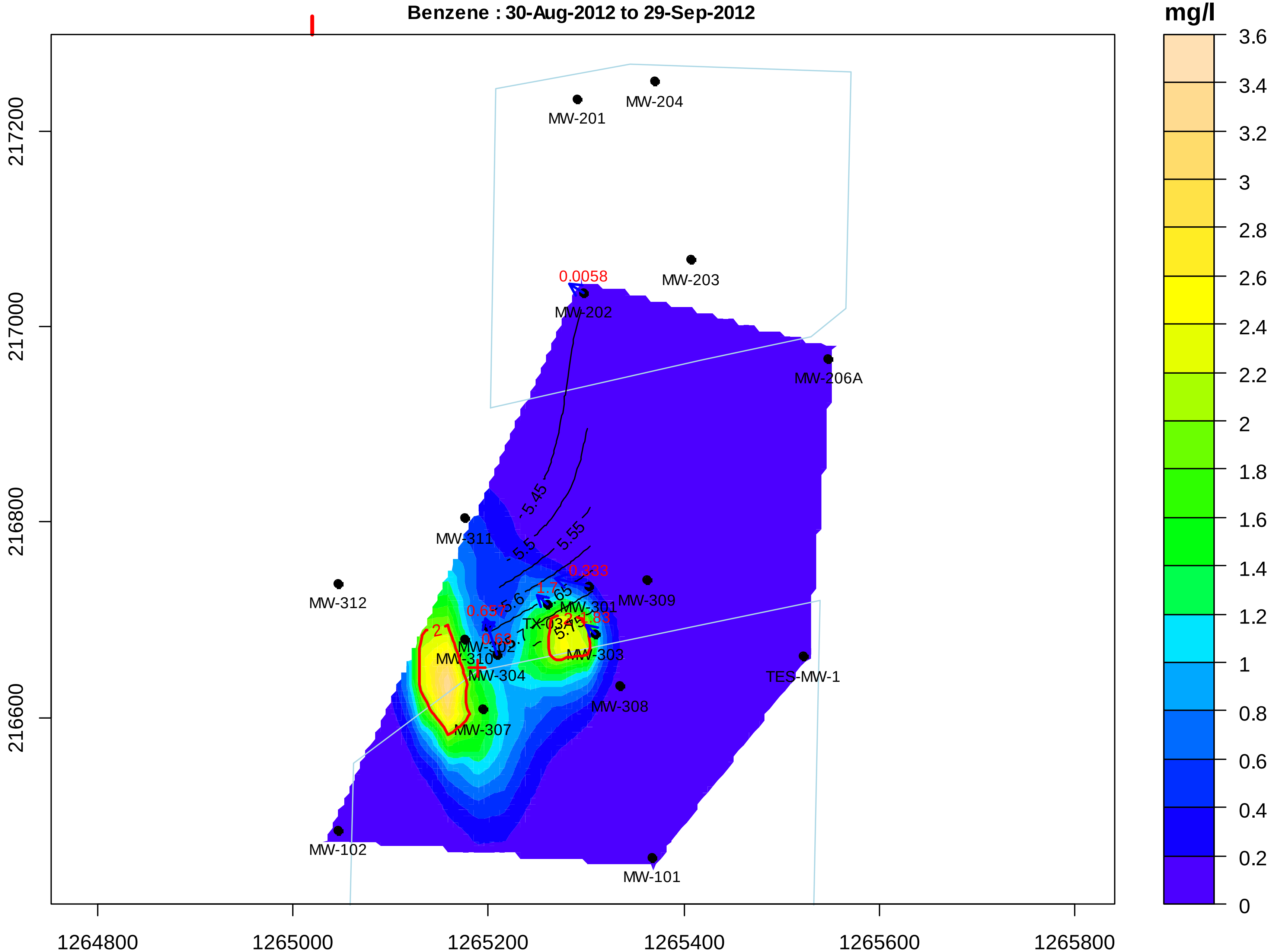


Plume Mass=3.6794 (Mass/Unit Depth); Plume Area=4686.7 (Unit Area)

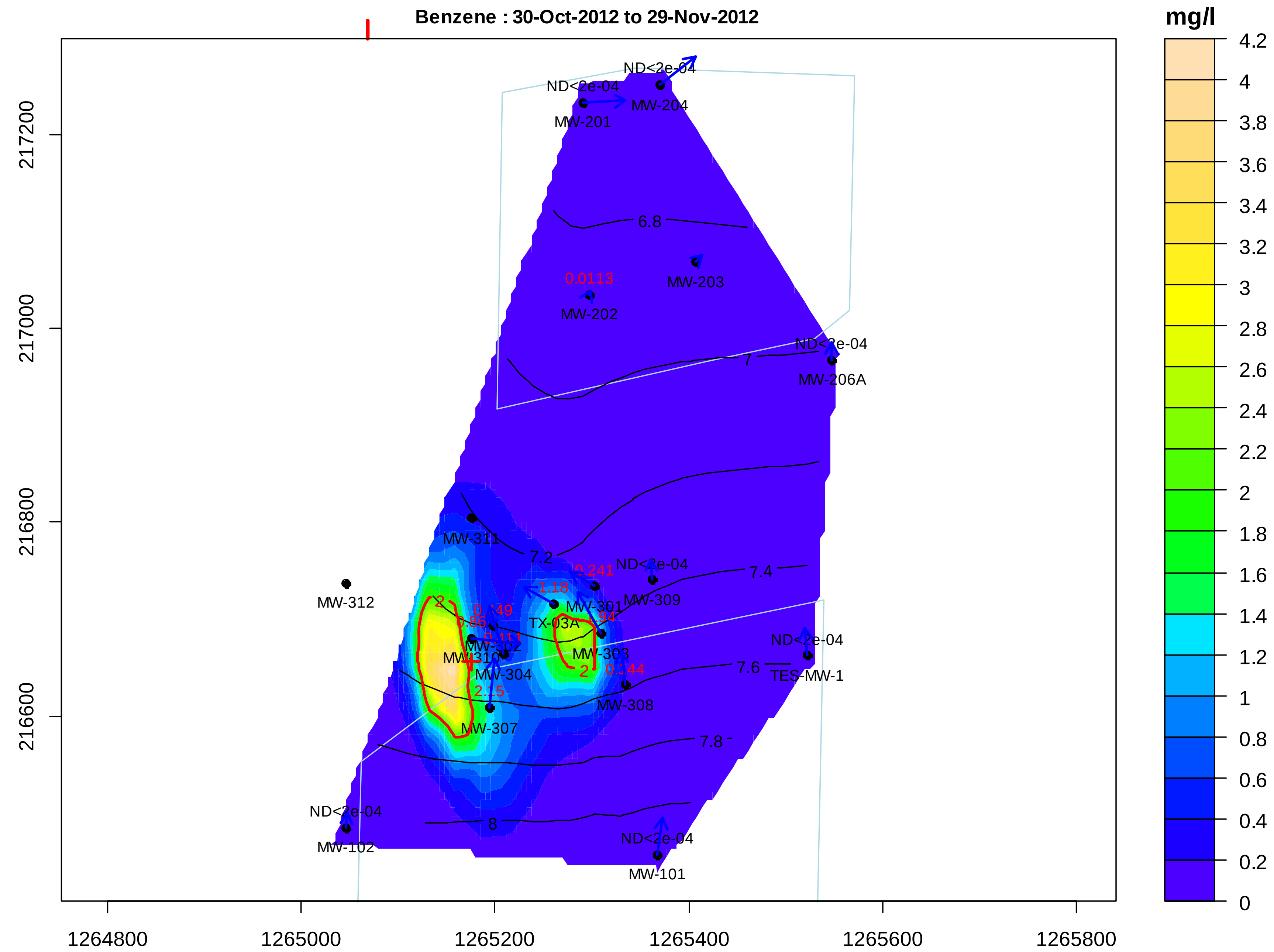


Plume Mass=1.5018 (Mass/Unit Depth); Plume Area=2338.2 (Unit Area)

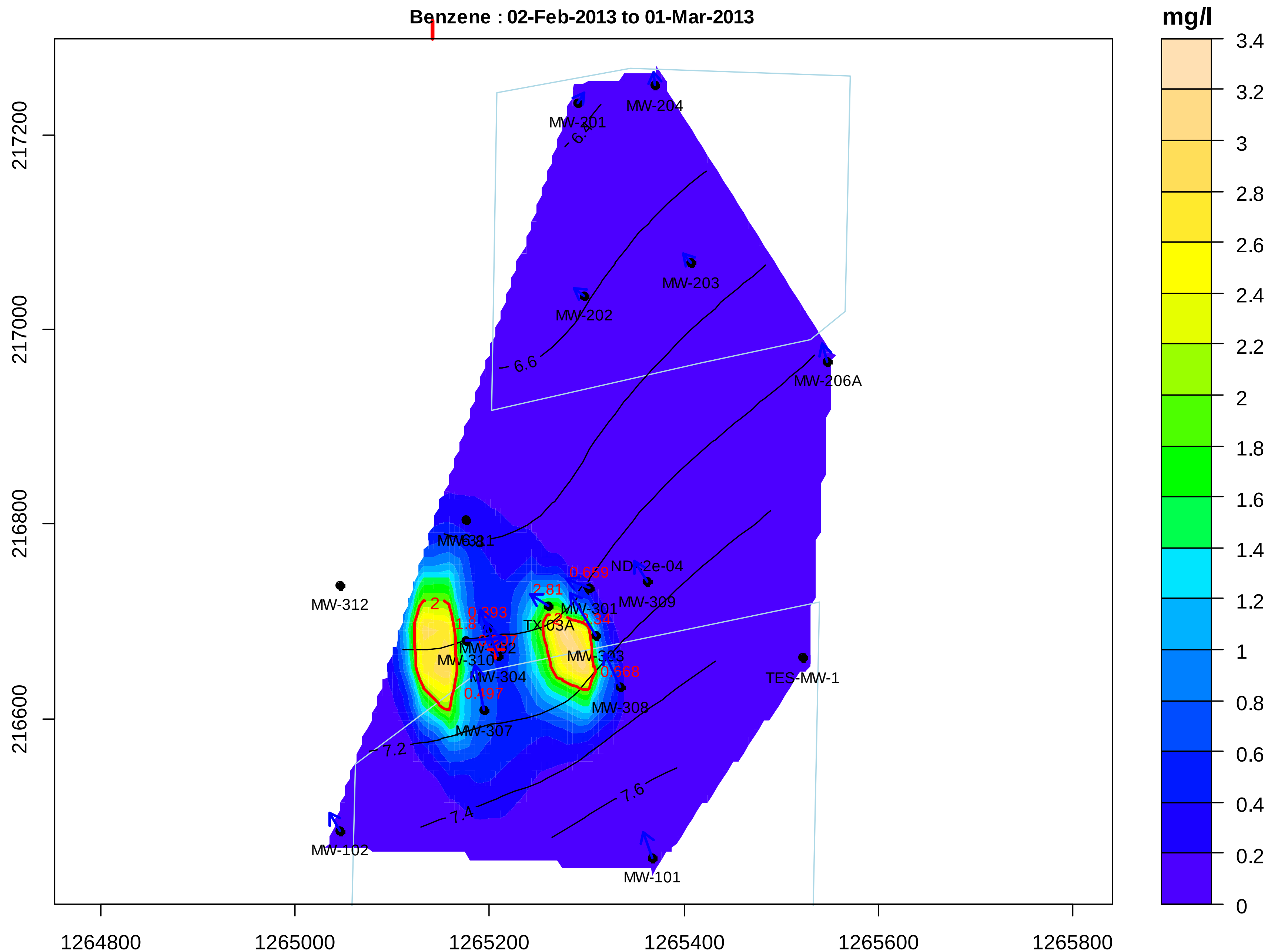
Benzene : 30-Aug-2012 to 29-Sep-2012



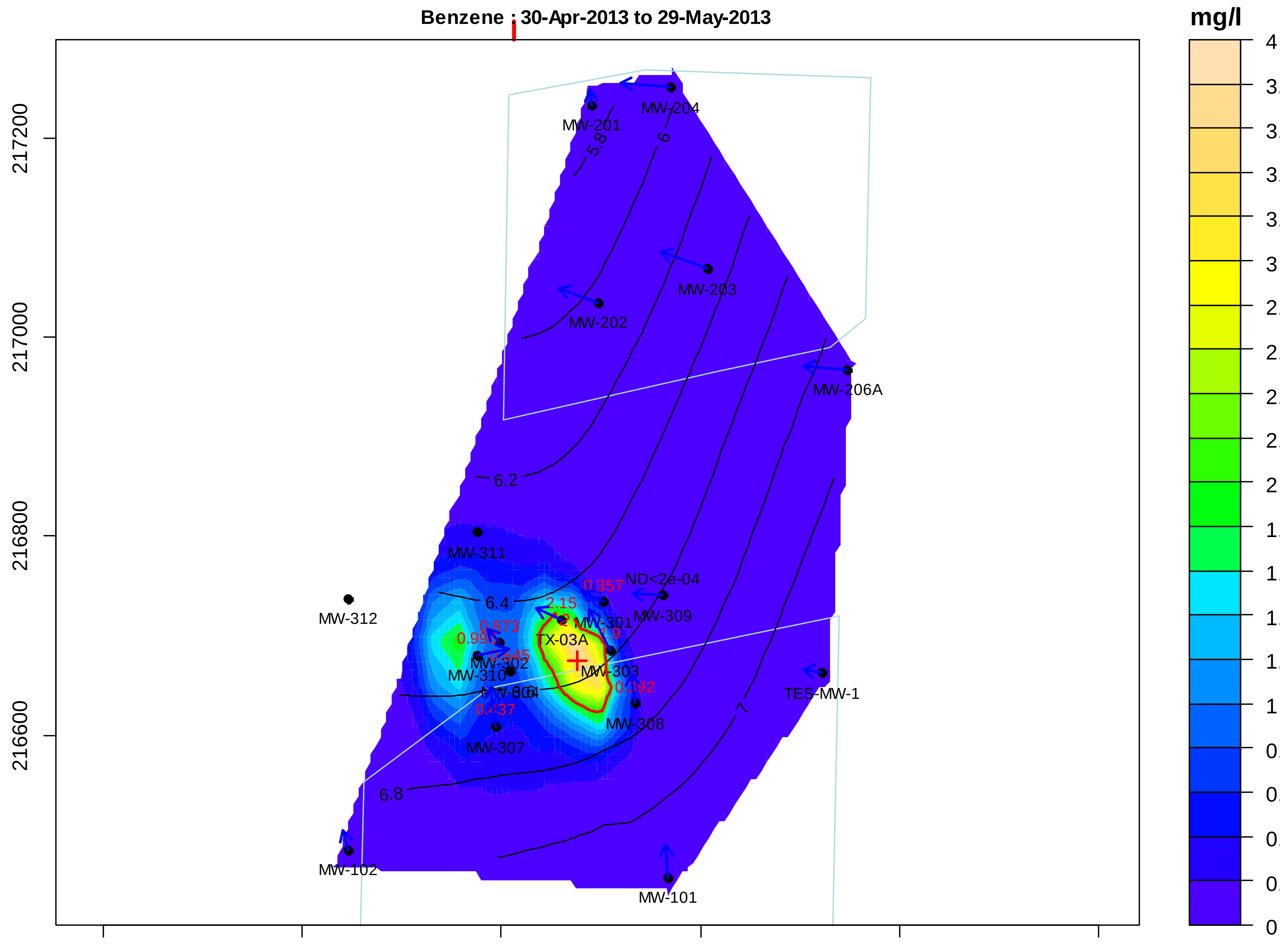
Plume Mass=3.8578 (Mass/Unit Depth); Plume Area=5612.5 (Unit Area)



Plume Mass=6.2798 (Mass/Unit Depth); Plume Area=7678 (Unit Area)

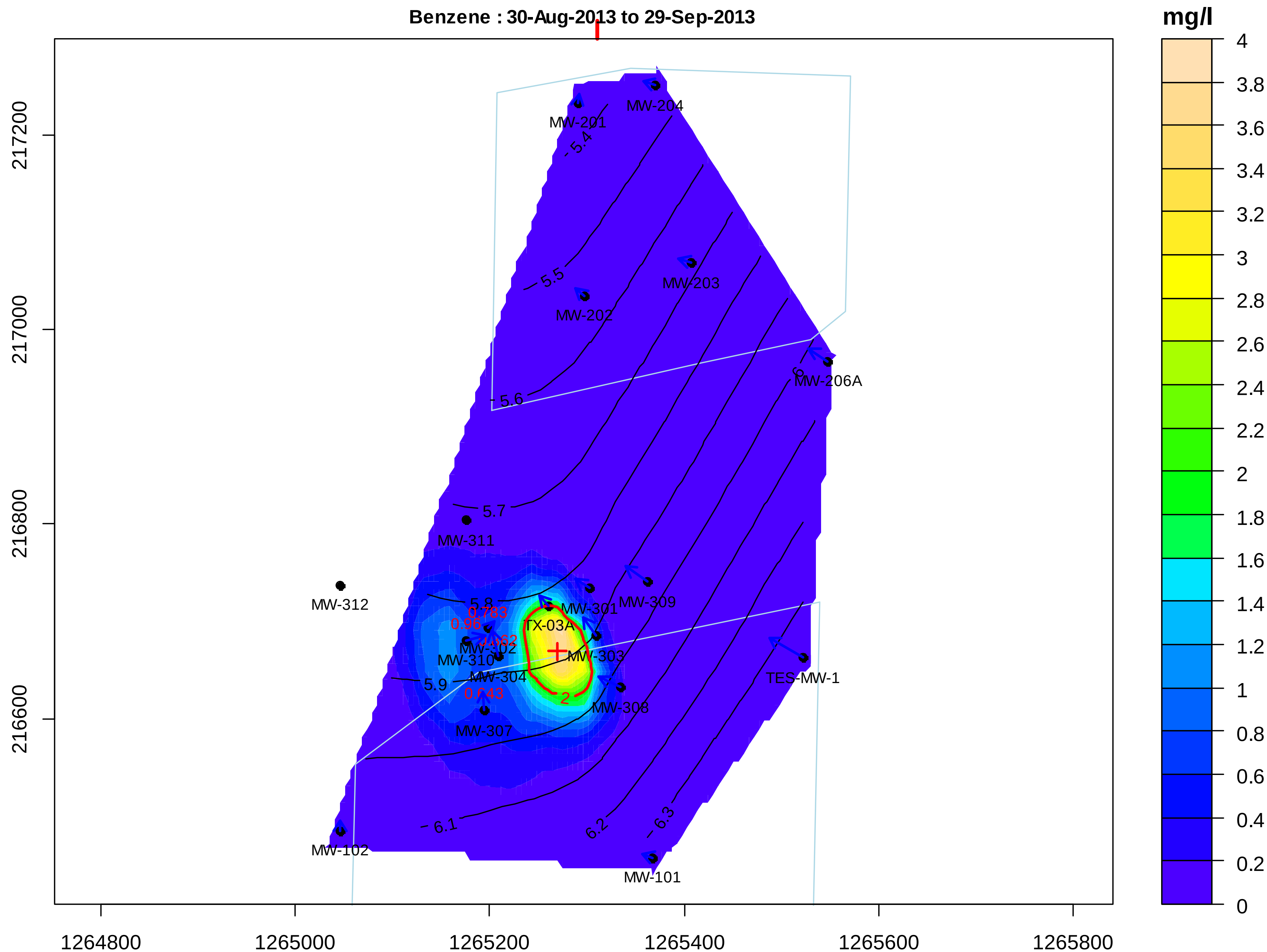


Plume Mass=5.2686 (Mass/Unit Depth); Plume Area=6966.6 (Unit Area)

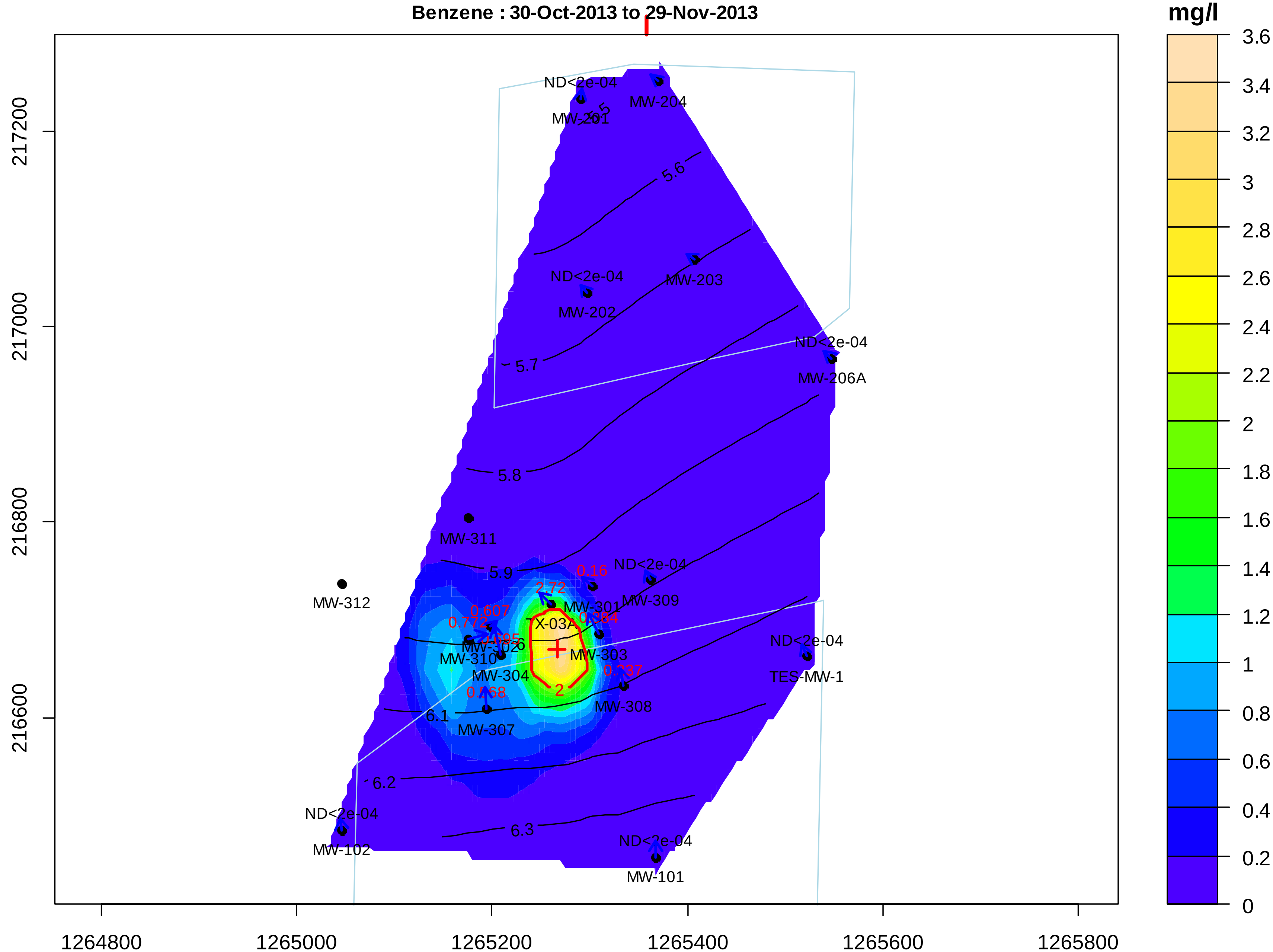


Plume Mass=3.7118 (Mass/Unit Depth); Plume Area=4610 (Unit Area)

Benzene : 30-Aug-2013 to 29-Sep-2013

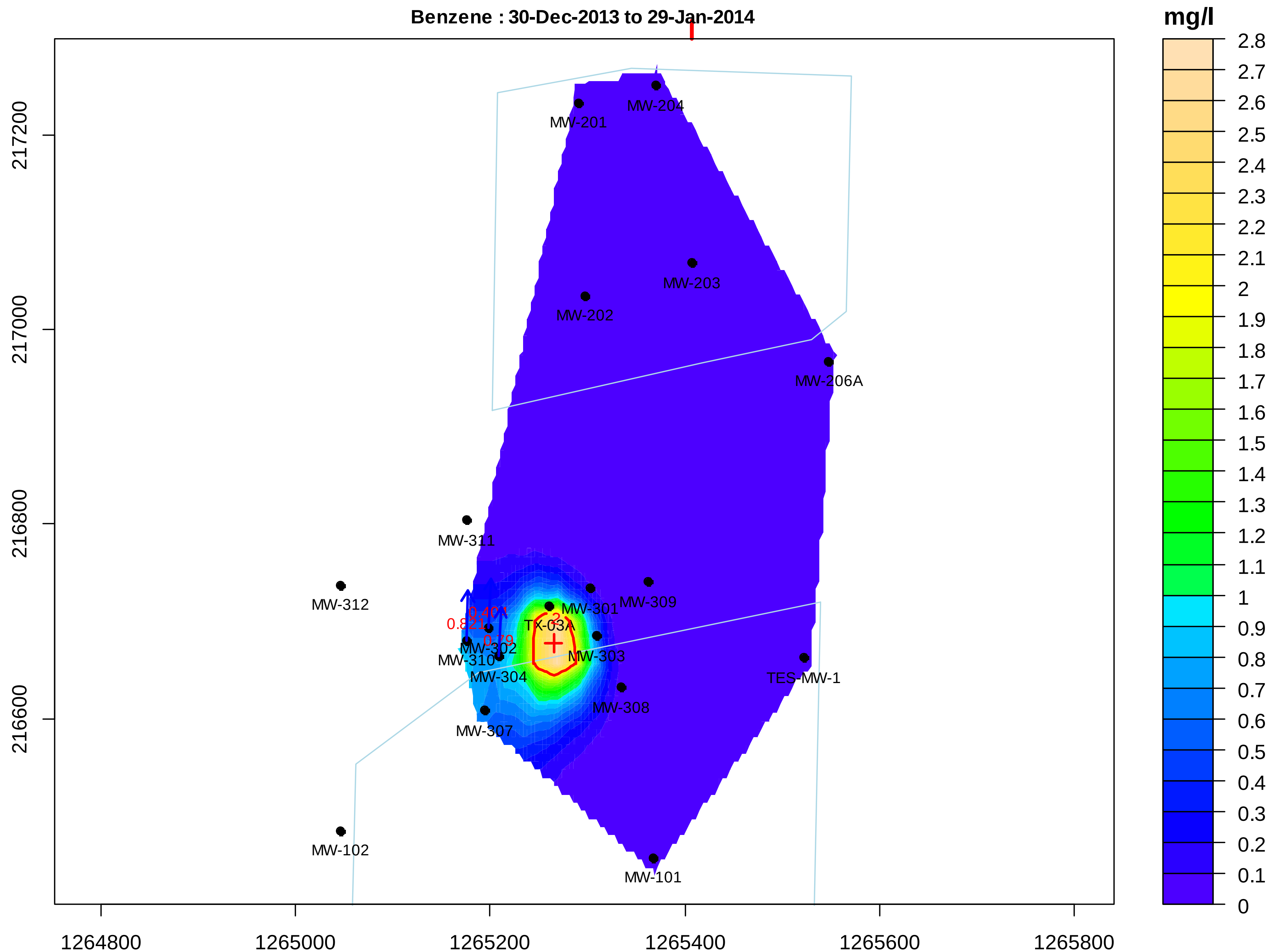


Plume Mass=3.9524 (Mass/Unit Depth); Plume Area=4798.3 (Unit Area)

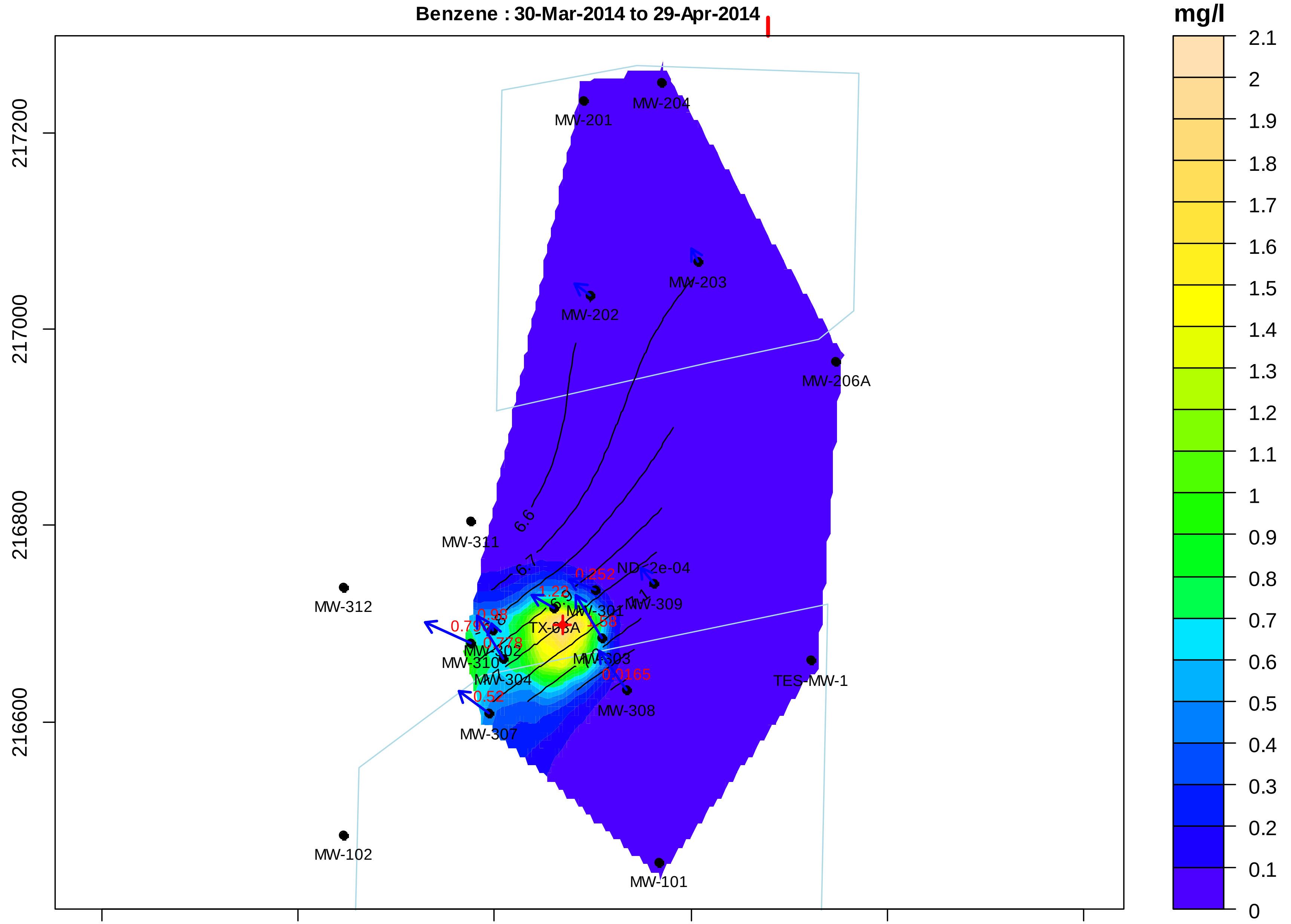


Plume Mass=3.0023 (Mass/Unit Depth); Plume Area=3761.9 (Unit Area)

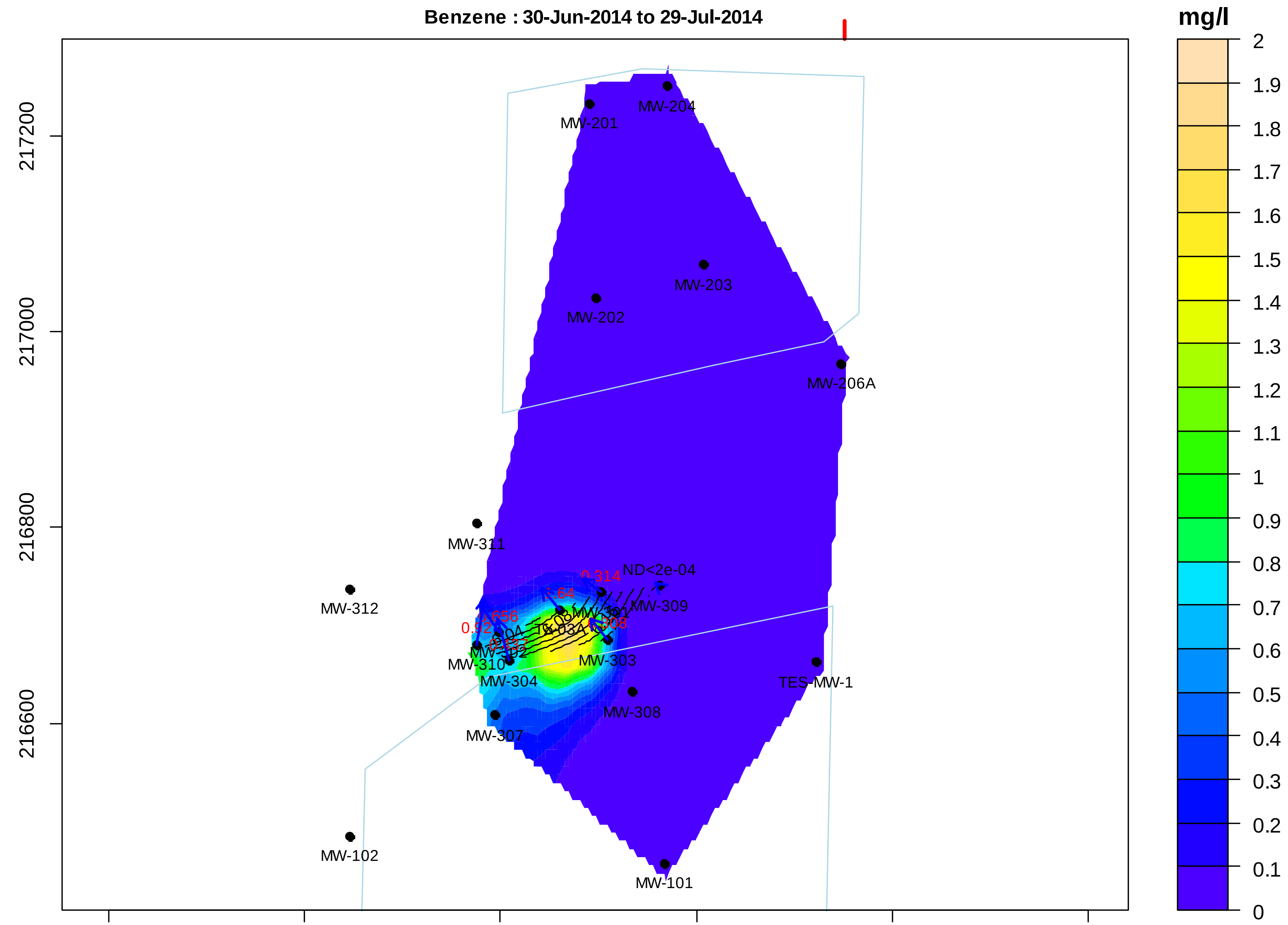
Benzene : 30-Dec-2013 to 29-Jan-2014



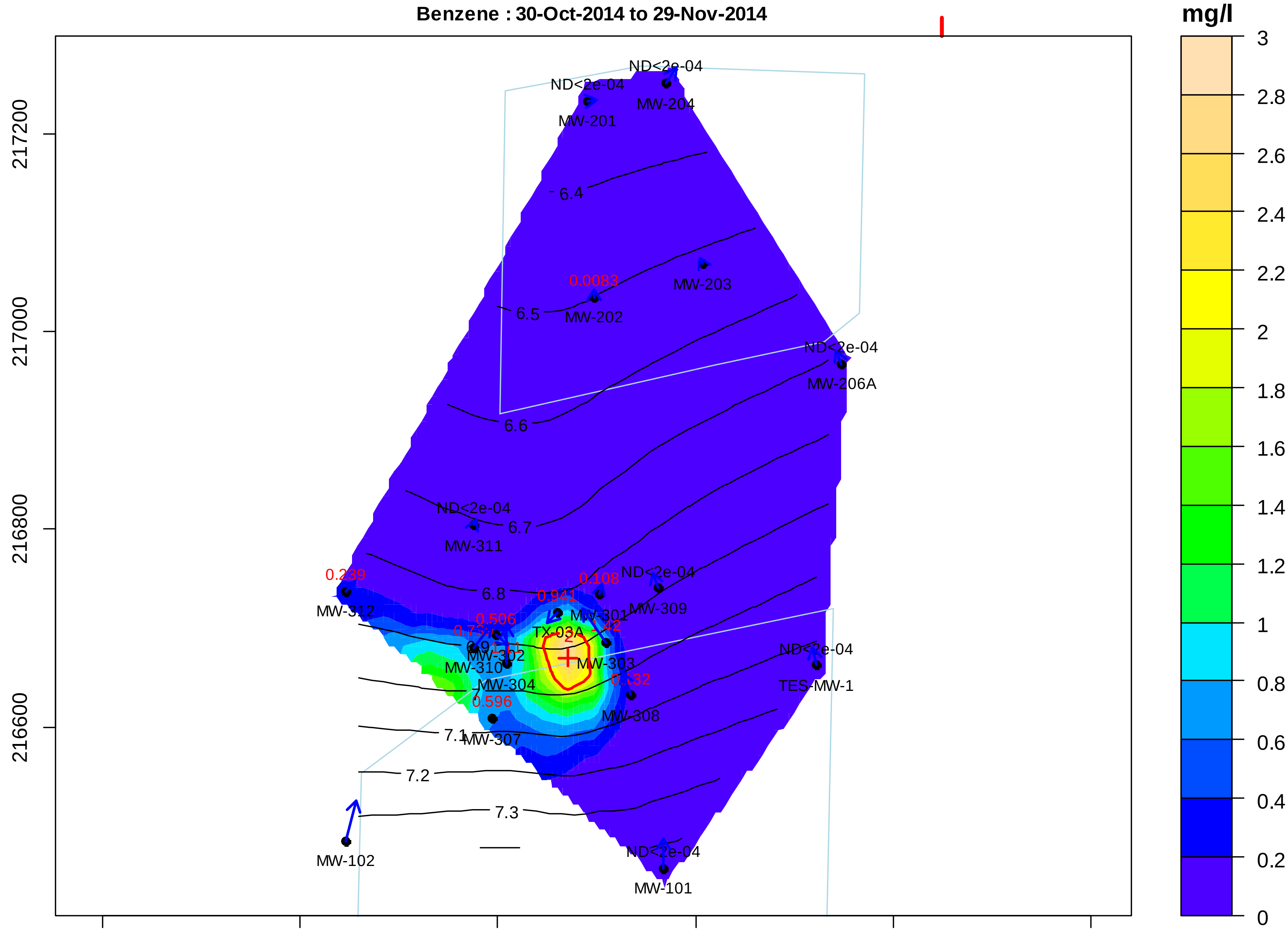
Plume Mass=1.6268 (Mass/Unit Depth); Plume Area=2268.3 (Unit Area)



Plume Mass=0.015869 (Mass/Unit Depth); Plume Area=26.622 (Unit Area)

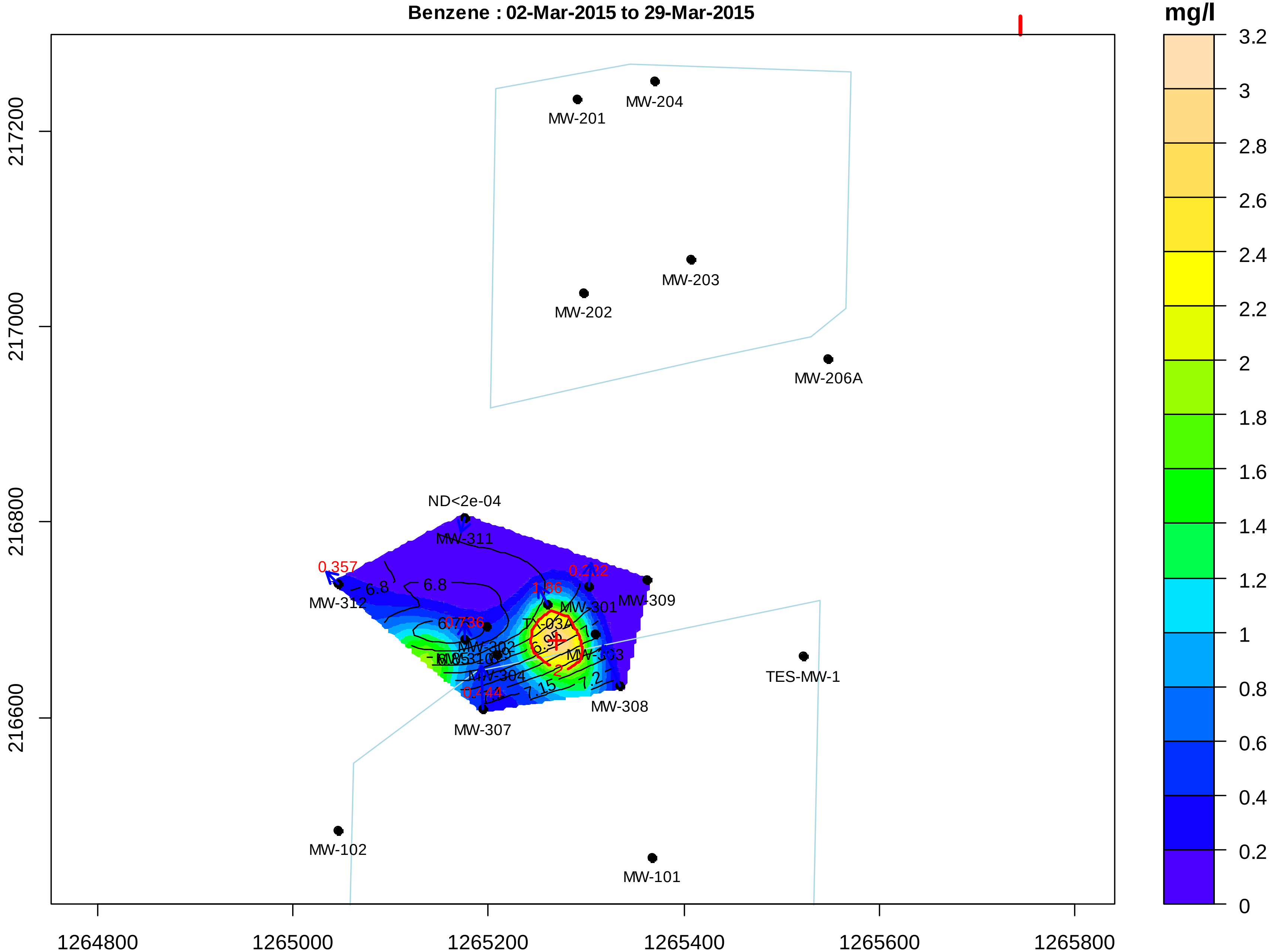


Plume Mass=NA (Mass/Unit Depth); Plume Area=NA (Unit Area)

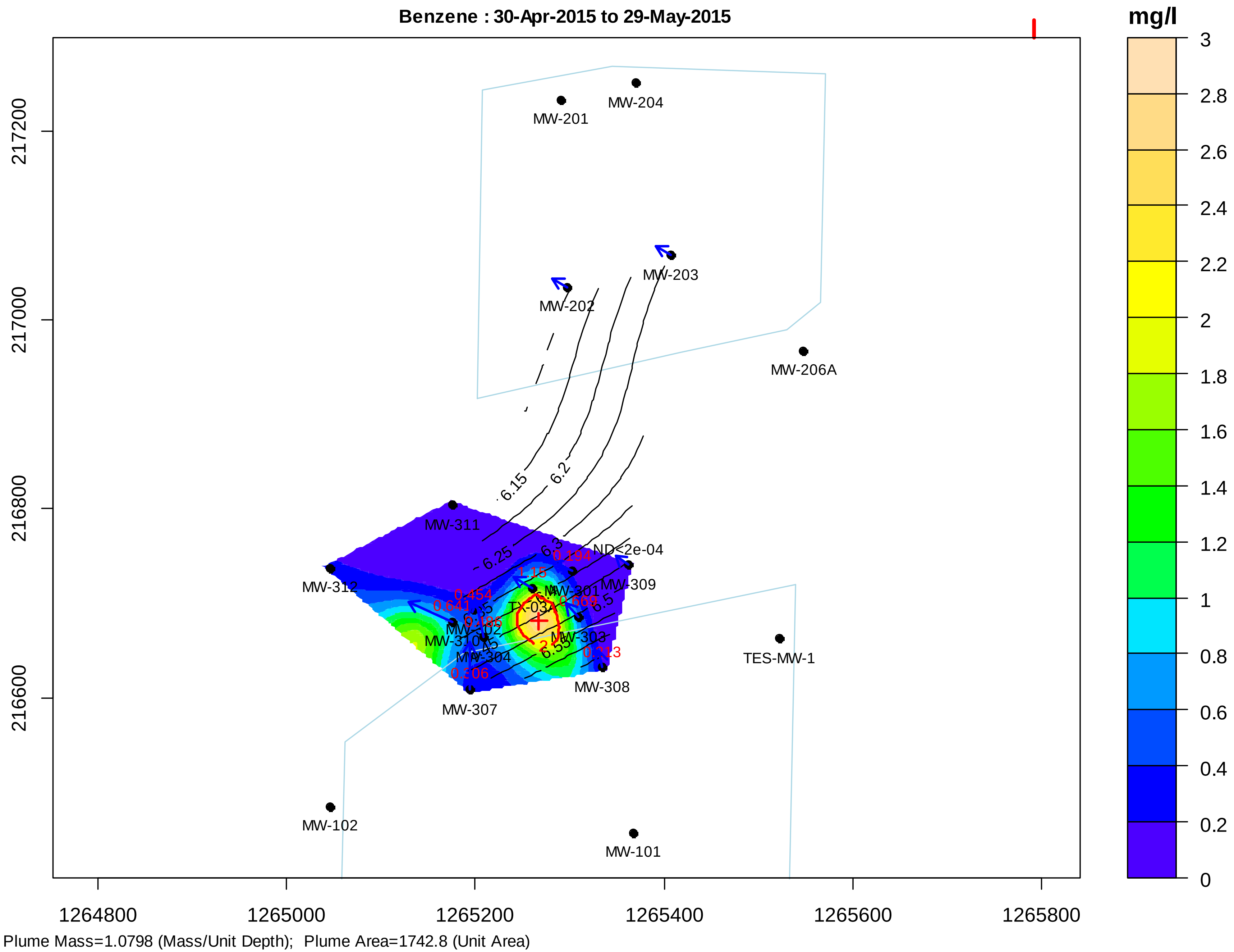


Plume Mass=1.5075 (Mass/Unit Depth); Plume Area=2084.6 (Unit Area)

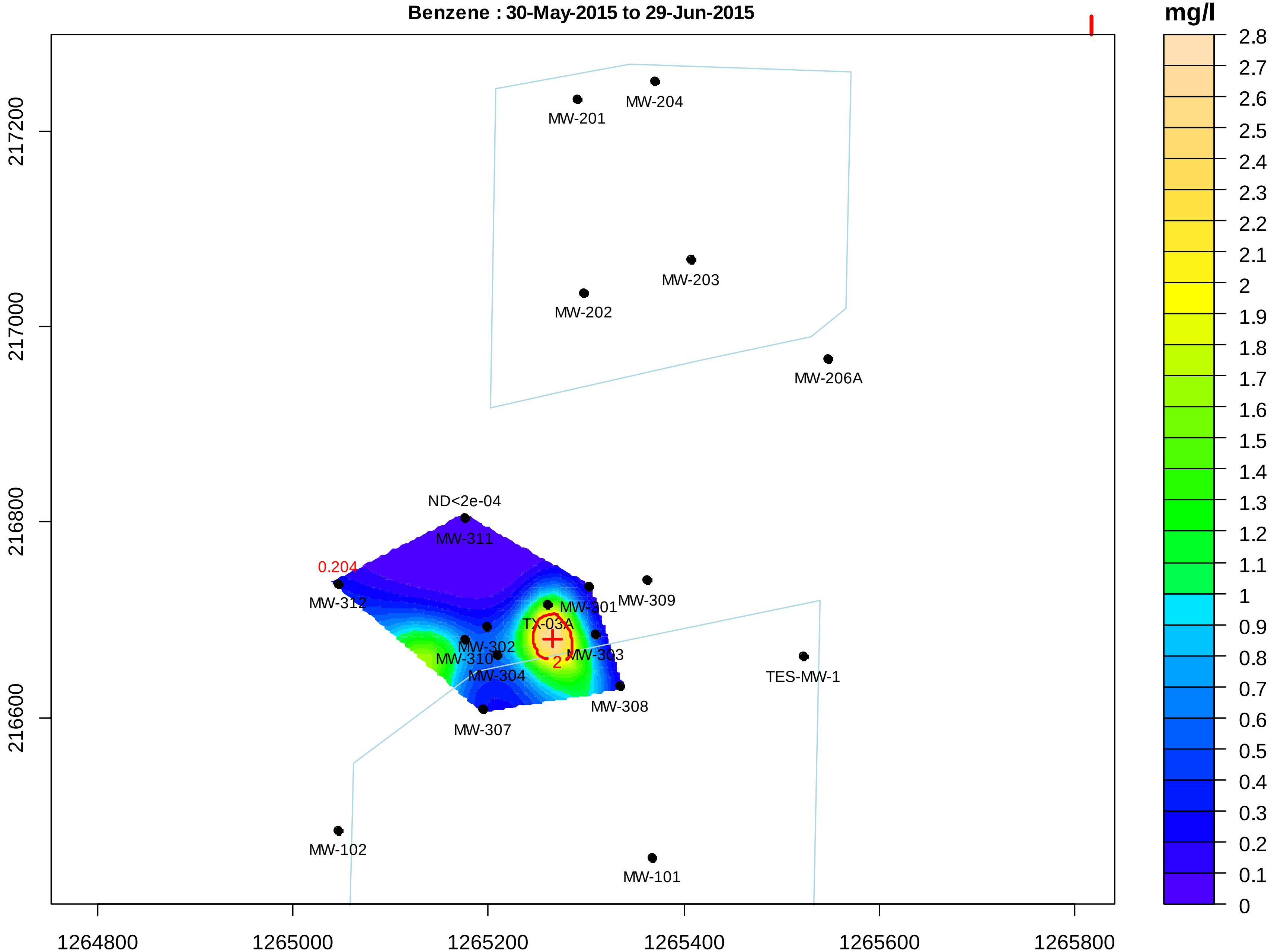
Benzene : 02-Mar-2015 to 29-Mar-2015



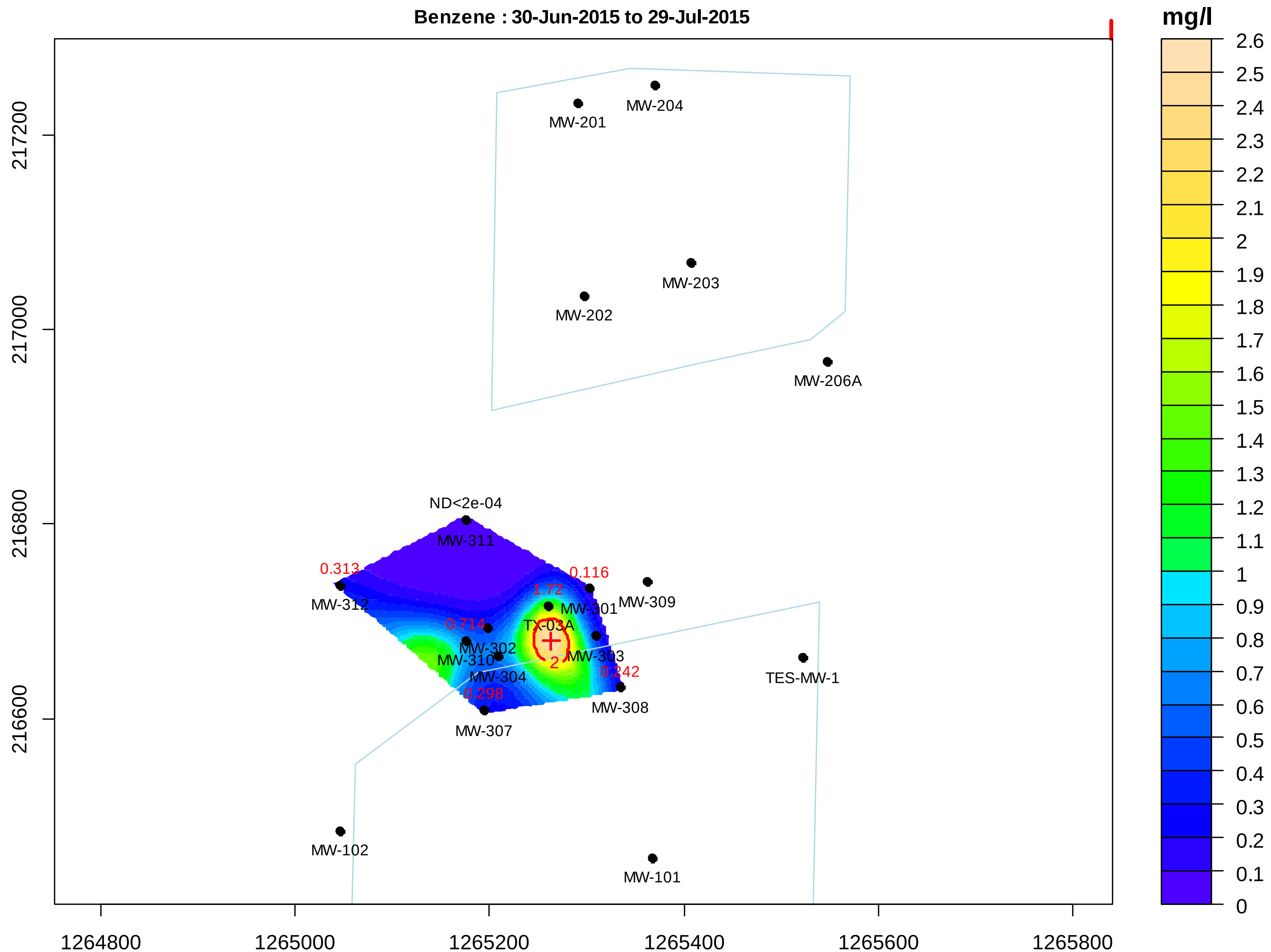
Plume Mass=1.4734 (Mass/Unit Depth); Plume Area=2281.3 (Unit Area)


Benzene : 30-Apr-2015 to 29-May-2015
mg/l
3
2.8
2.6
2.4
2.2
2
1.8
1.6
1.4
1.2
1
0.8
0.6
0.4
0.2
0
217200
217000
216800
216600
1264800
1265000
1265200
1265400
1265600
1265800
MW-201
MW-204
MW-203
MW-202
MW-206A
MW-311
MW-312
MW-309
MW-301
TX-03A
MW-302
MW-310
MW-304
MW-303
MW-308
MW-307
TES-MW-1
MW-102
MW-101
ND<2e-04
6.15
6.2
6.25
6.3
6.5
6.55
0.194
1.15
0.454
0.641
0.669
0.213
0.206
Plume Mass=1.0798 (Mass/Unit Depth); Plume Area=1742.8 (Unit Area)

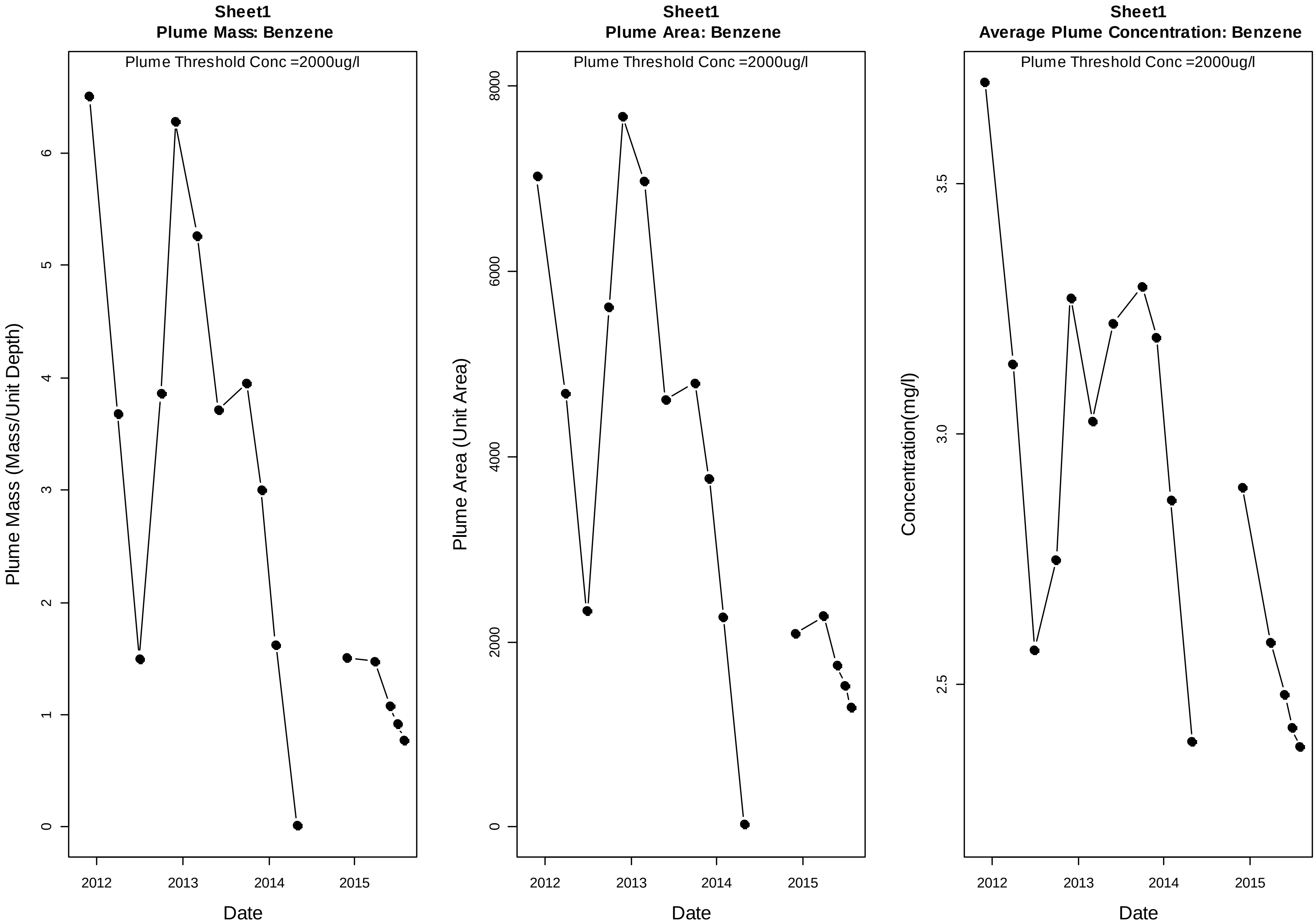
Benzene : 30-May-2015 to 29-Jun-2015



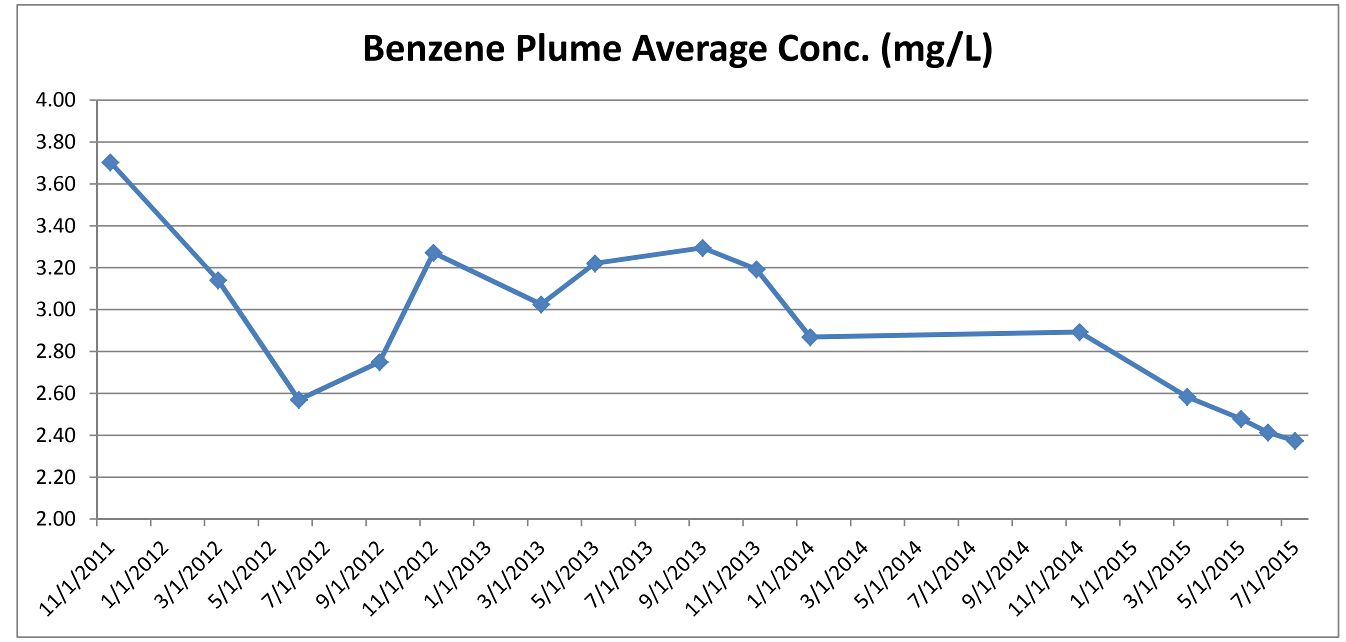
Plume Mass=0.92319 (Mass/Unit Depth); Plume Area=1529.9 (Unit Area)

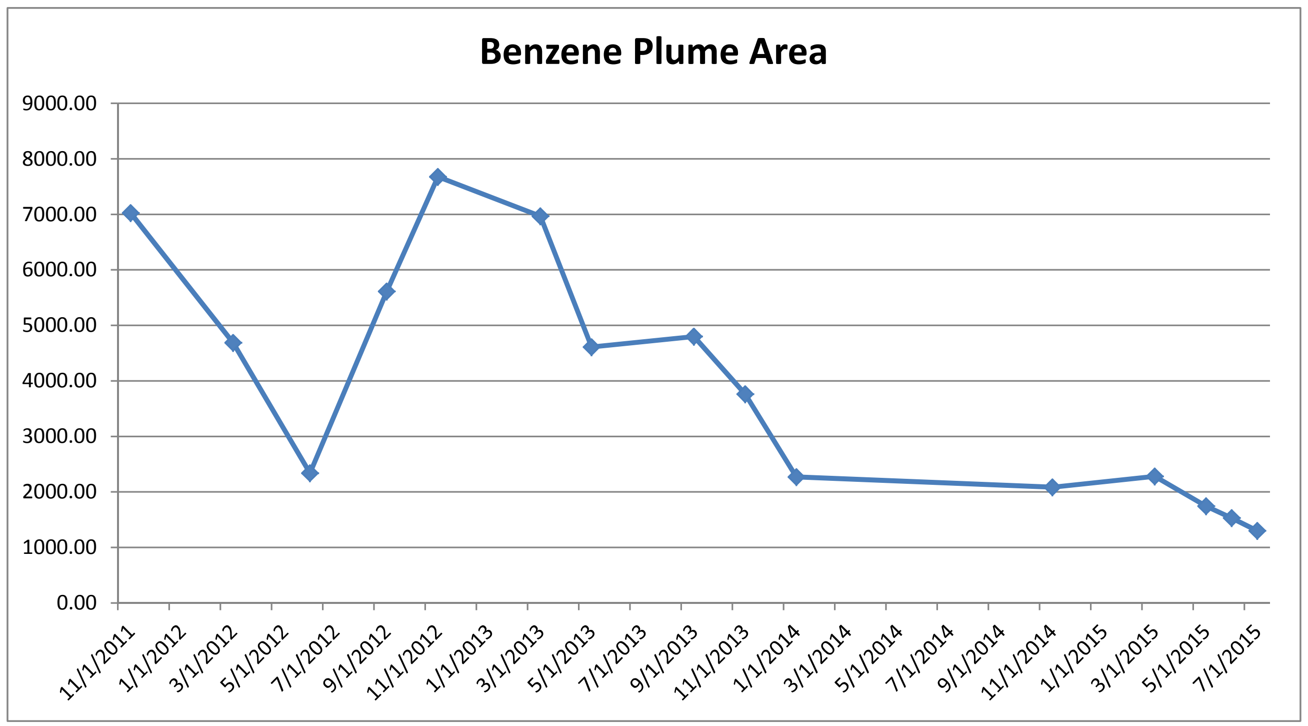


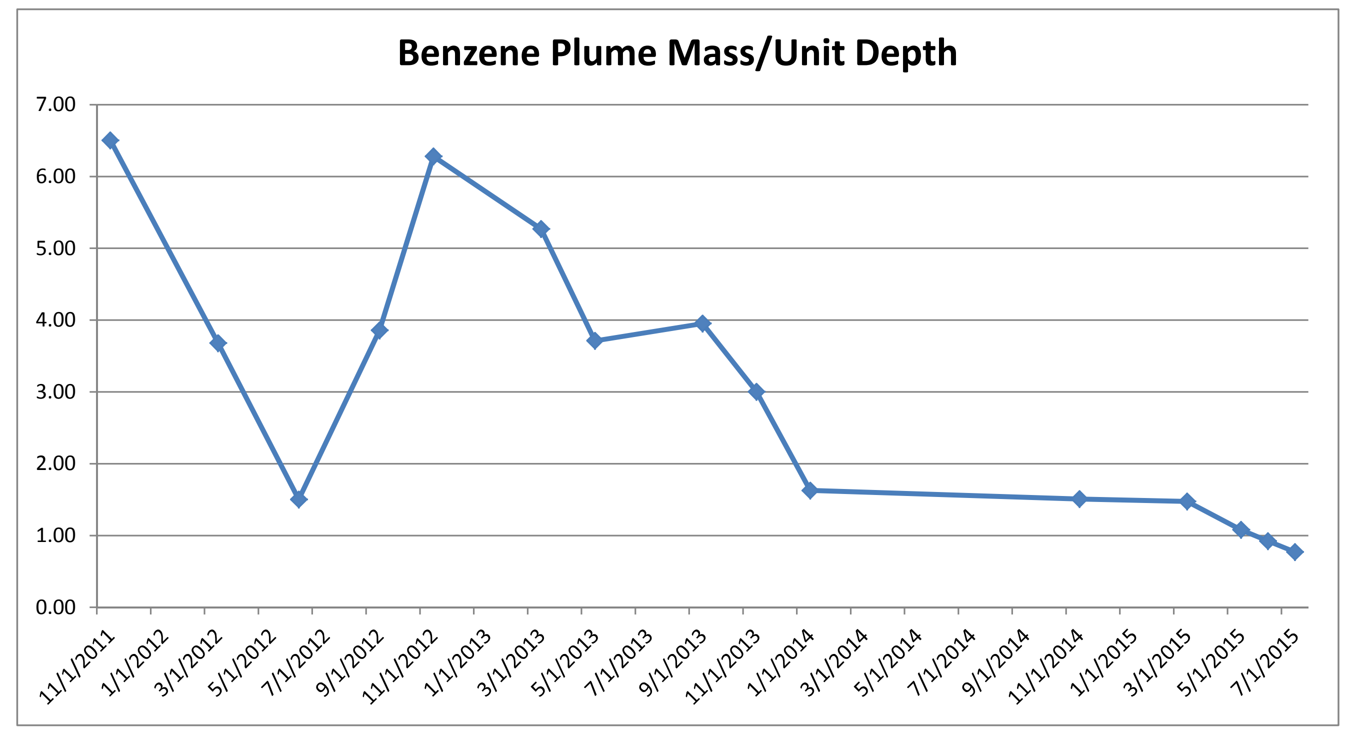
Plume Mass=0.77142 (Mass/Unit Depth); Plume Area=1299.8 (Unit Area)

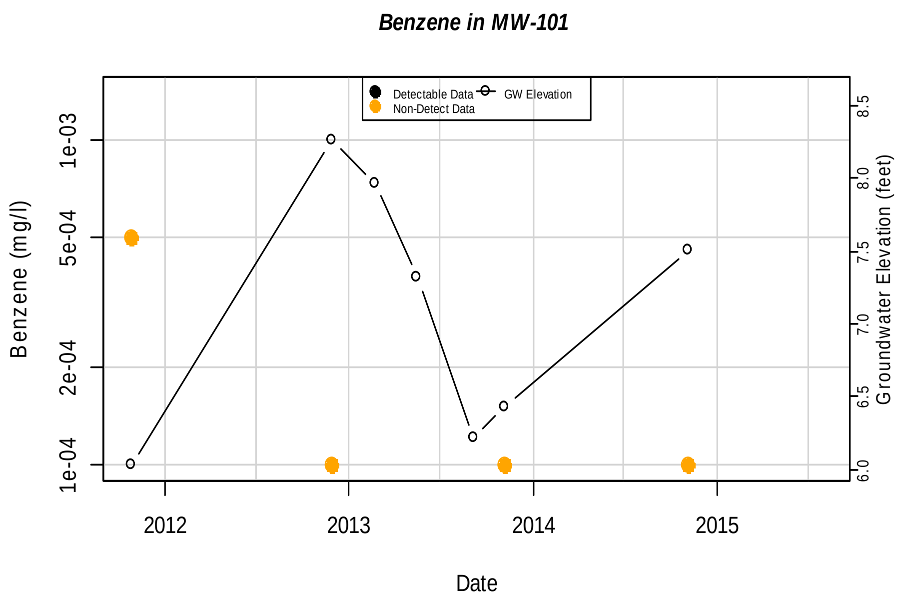

Sheet1
Plume Mass: Benzene
Plume Threshold Conc =2000ug/l
Plume Mass (Mass/Unit Depth)
0
1
2
3
4
5
6
2012
2013
2014
2015
Date
Sheet1
Plume Area: Benzene
Plume Threshold Conc =2000ug/l
Plume Area (Unit Area)
0
2000
4000
6000
8000
2012
2013
2014
2015
Date
Sheet1
Average Plume Concentration: Benzene
Plume Threshold Conc =2000ug/l
Concentration(mg/l)
2.5
3.0
3.5
2012
2013
2014
2015
Date

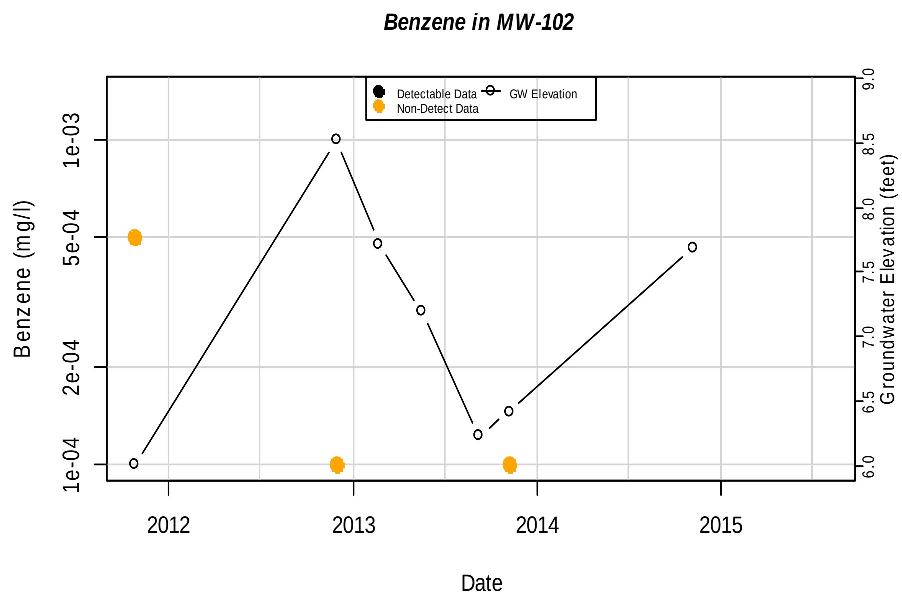
Agg.Date	PlumeAverageConc(mg/l)	COMy	COMx	PlumeArea (Unit Area)	PlumeMass (Mass/Unit Depth)	Plume Threshold Conc (ug/l)
11/29/2011	3.70	216665.72	1265272.00	7024.42	6.50	
3/29/2012	3.14	216671.82	1265277.57	4686.67	3.68	
6/29/2012	2.57	216682.31	1265276.62	2338.22	1.50	
9/29/2012	2.75	216650.82	1265188.70	5612.50	3.86	
11/29/2012	3.27	216656.18	1265175.87	7677.96	6.28	
3/1/2013	3.03	216670.87	1265206.65	6966.62	5.27	
5/29/2013	3.22	216675.09	1265276.20	4609.97	3.71	
9/29/2013	3.29	216669.33	1265269.71	4798.31	3.95	
11/29/2013	3.19	216670.38	1265266.78	3761.85	3.00	
1/29/2014	2.87	216677.81	1265265.37	2268.27	1.63	
11/29/2014	2.89	216670.34	1265270.90	2084.56	1.51	
3/29/2015	2.58	216678.47	1265269.97	2281.25	1.47	
5/29/2015	2.48	216681.04	1265267.32	1742.79	1.08	
6/29/2015	2.41	216680.88	1265265.74	1529.87	0.92	
7/29/2015	2.37	216679.78	1265263.53	1299.85	0.77	

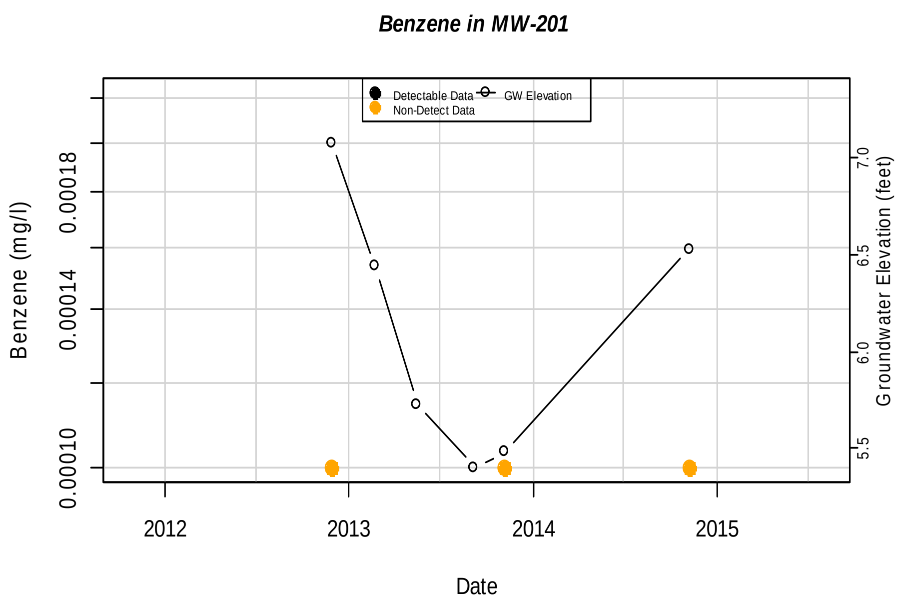


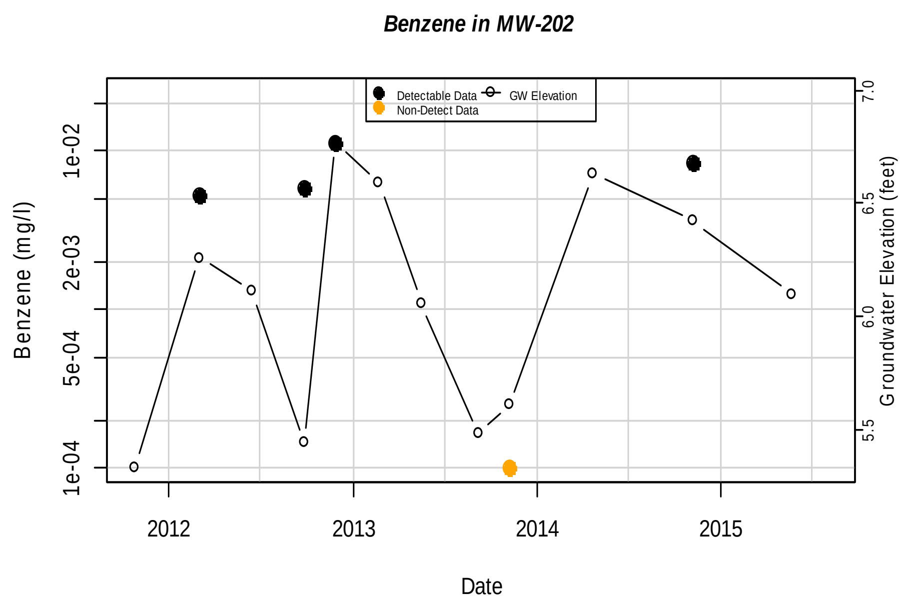


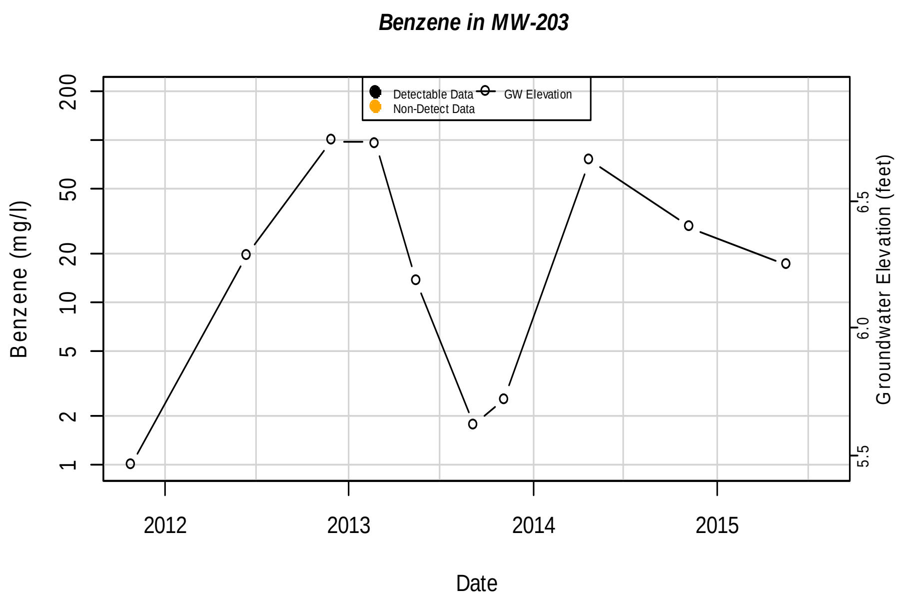



Benzene in MW-101
Detectable Data
Non-Detect Data
GW Elevation
Benzene (mg/l)
1e-03
5e-04
2e-04
1e-04
Groundwater Elevation (feet)
8.5
8.0
7.5
7.0
6.5
6.0
2012
2013
2014
2015
Date

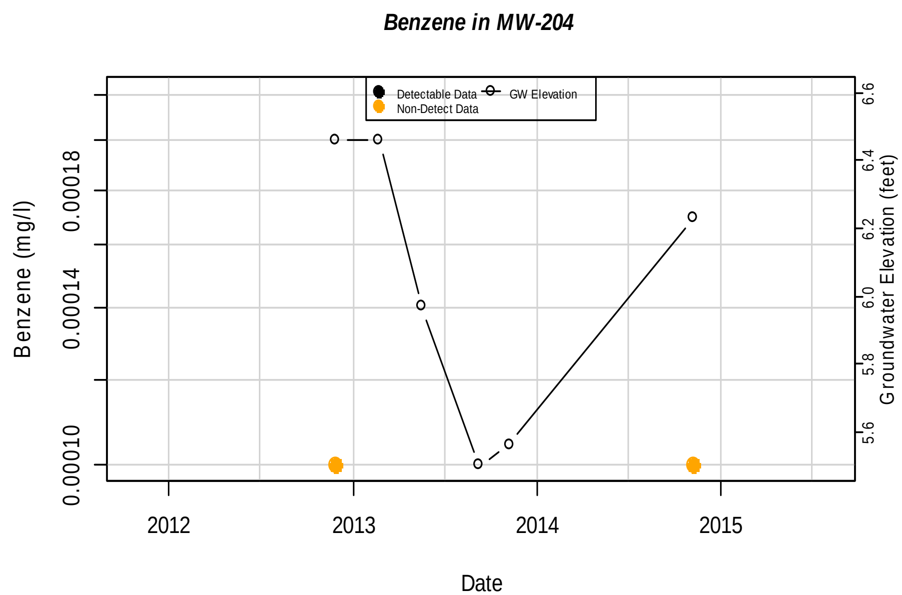

Benzene in MW-102
Detectable Data
Non-Detect Data
GW Elevation
Benzene (mg/l)
1e-03
5e-04
2e-04
1e-04
Groundwater Elevation (feet)
9.0
8.5
8.0
7.5
7.0
6.5
6.0
2012
2013
2014
2015
Date


Benzene in MW-201
Detectable Data
Non-Detect Data
GW Elevation
Benzene (mg/l)
0.00018
0.00014
0.00010
Groundwater Elevation (feet)
7.0
6.5
6.0
5.5
2012
2013
2014
2015
Date

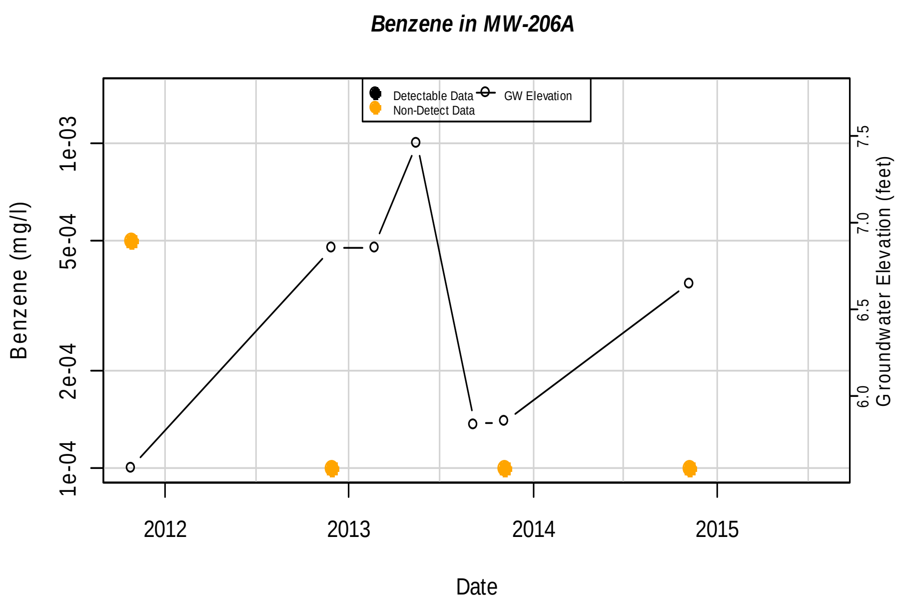

Benzene in MW-202
Detectable Data
Non-Detect Data
GW Elevation
Benzene (mg/l)
1e-02
2e-03
5e-04
1e-04
Groundwater Elevation (feet)
7.0
6.5
6.0
5.5
2012
2013
2014
2015
Date



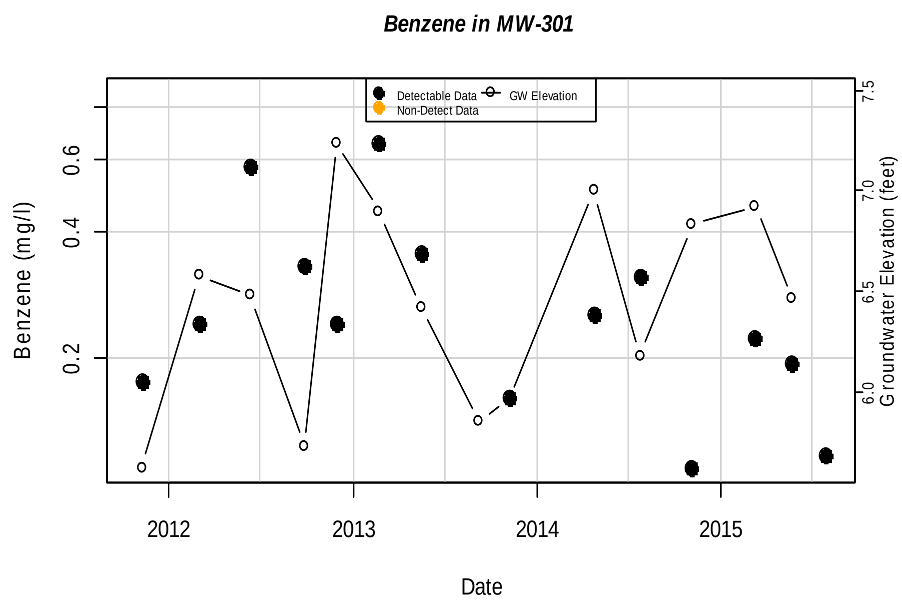
Benzene in MW-203
Detectable Data
Non-Detect Data
GW Elevation
Benzene (mg/l)
Groundwater Elevation (feet)
Date



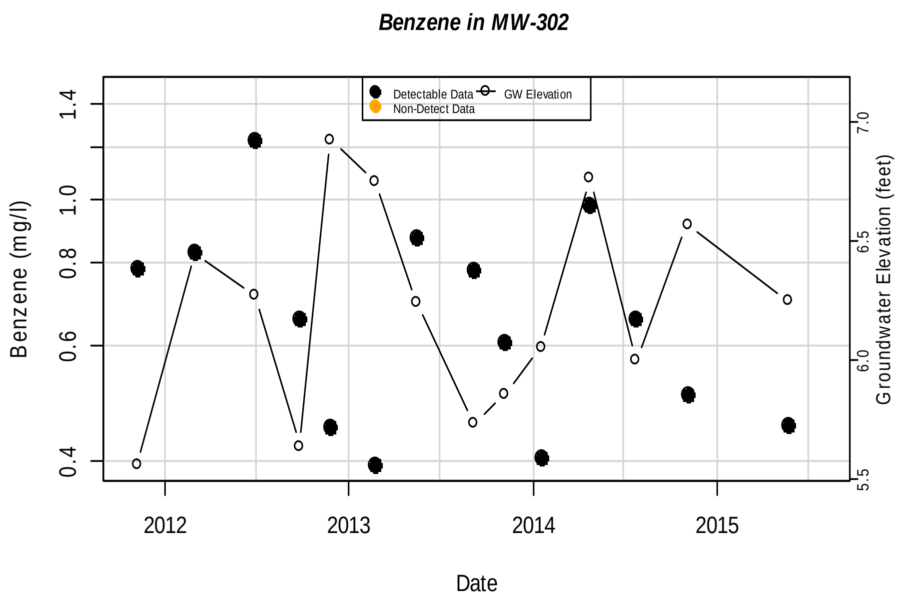
Benzene in MW-204
Detectable Data
Non-Detect Data
GW Elevation
Benzene (mg/l)
Groundwater Elevation (feet)
Date

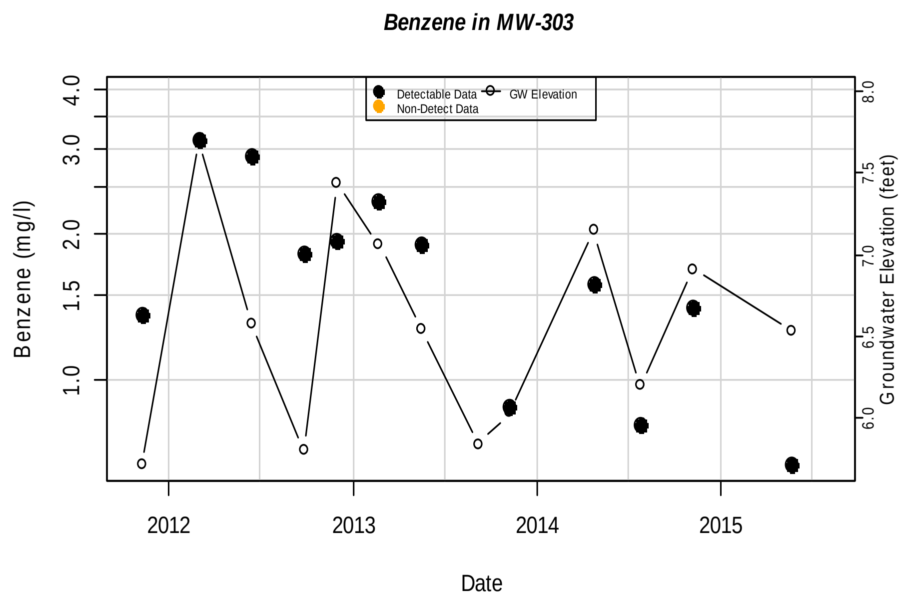


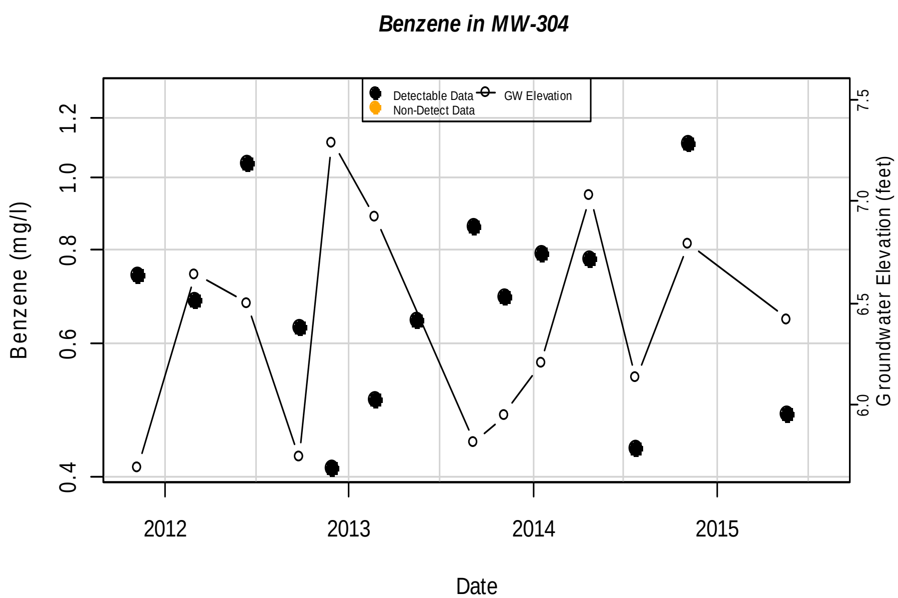
Benzene in MW-206A
Detectable Data
Non-Detect Data
GW Elevation
Benzene (mg/l)
Groundwater Elevation (feet)
Date

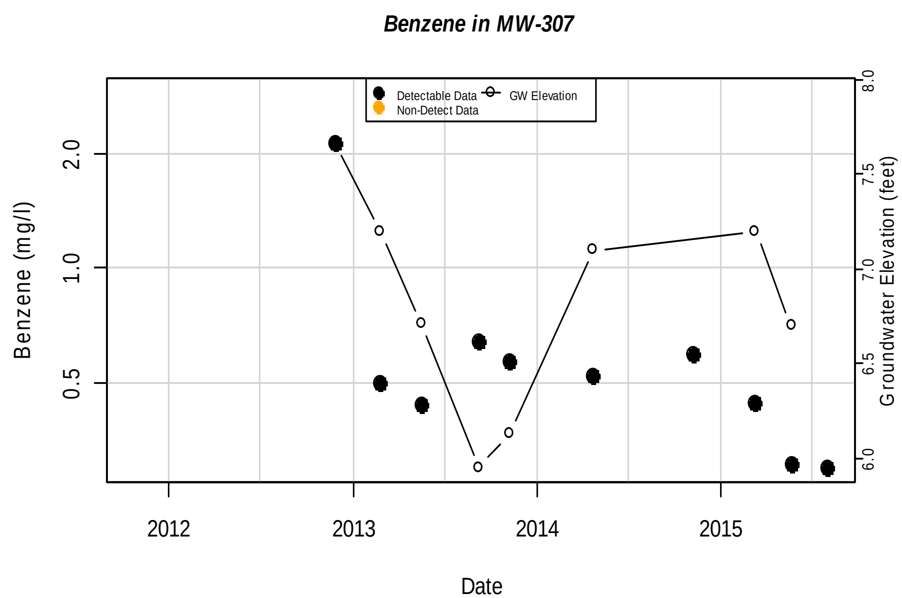


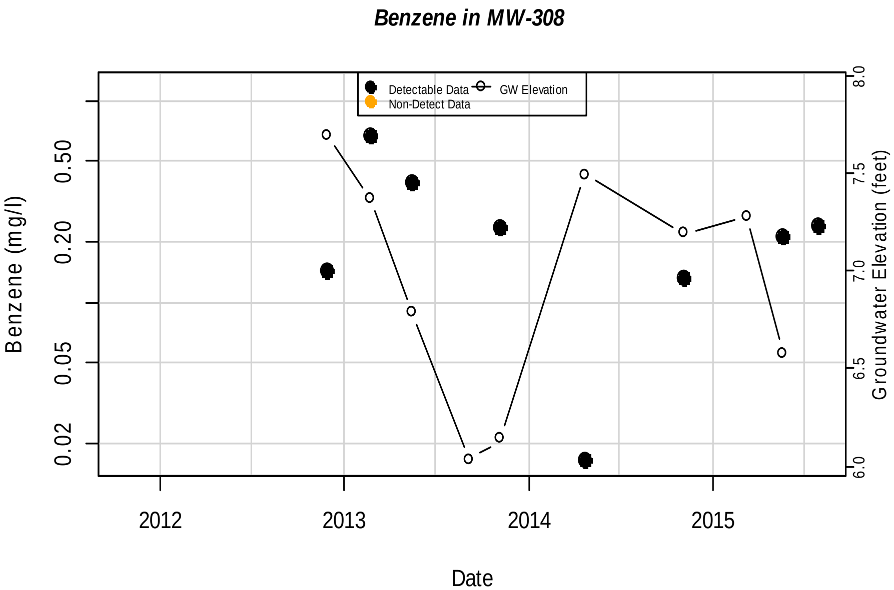
Benzene in MW-301
Detectable Data
Non-Detect Data
GW Elevation
Benzene (mg/l)
Groundwater Elevation (feet)
Date

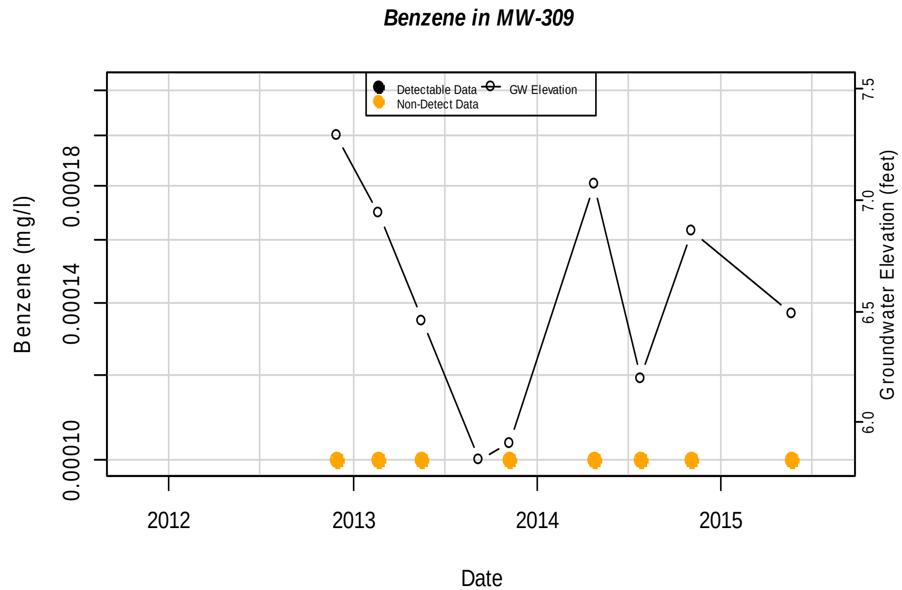

Benzene in MW-302
Detectable Data
Non-Detect Data
GW Elevation
Benzene (mg/l)
Groundwater Elevation (feet)
Date
2012
2013
2014
2015

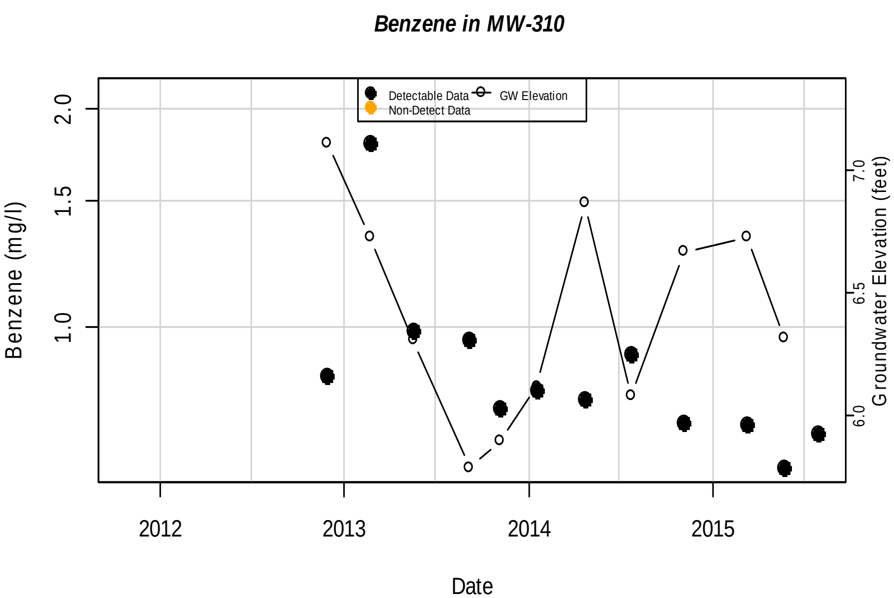

Benzene in MW-303
Detectable Data
Non-Detect Data
GW Elevation
Benzene (mg/l)
Groundwater Elevation (feet)
Date
2012
2013
2014
2015

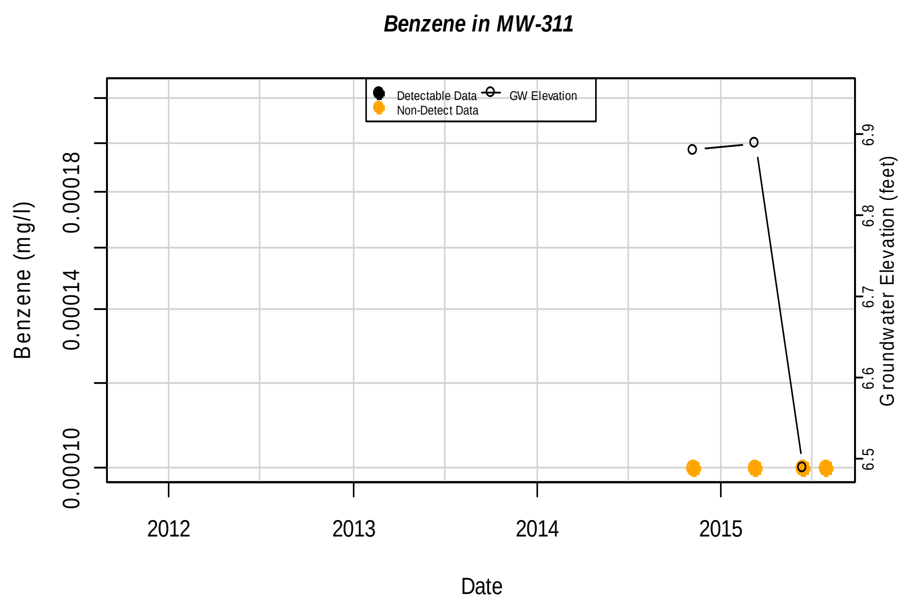

Benzene in MW-304
Detectable Data
Non-Detect Data
GW Elevation
Benzene (mg/l)
Groundwater Elevation (feet)
Date
2012
2013
2014
2015

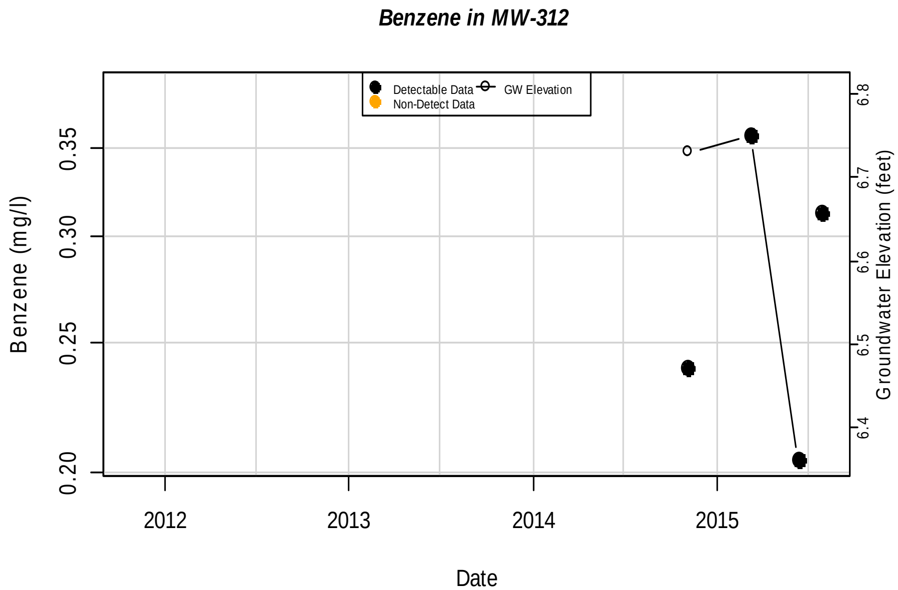

Benzene in MW-307
Detectable Data
Non-Detect Data
GW Elevation
Benzene (mg/l)
Groundwater Elevation (feet)
Date
2012
2013
2014
2015

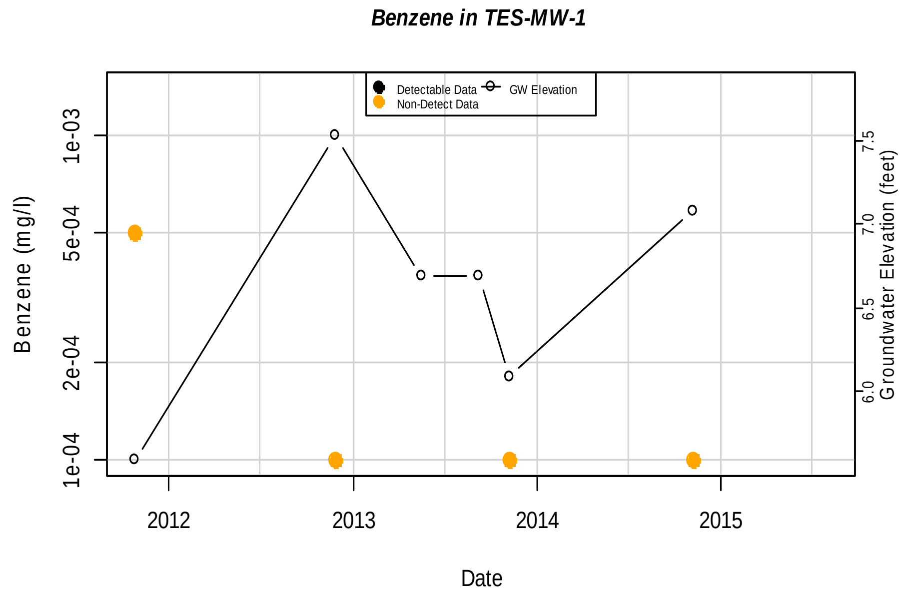

Benzene in MW-308
Detectable Data
GW Elevation
Non-Detect Data
Benzene (mg/l)
0.02
0.05
0.20
0.50
Groundwater Elevation (feet)
6.0
6.5
7.0
7.5
8.0
2012
2013
2014
2015
Date

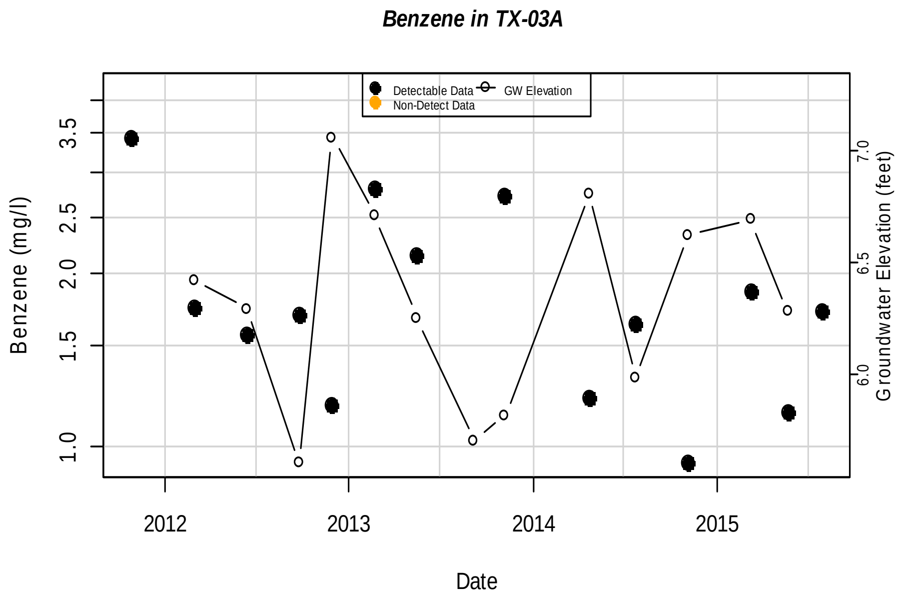

Benzene in MW-309
Detectable Data
GW Elevation
Non-Detect Data
Benzene (mg/l)
0.00010
0.00014
0.00018
Groundwater Elevation (feet)
6.0
6.5
7.0
7.5
2012
2013
2014
2015
Date

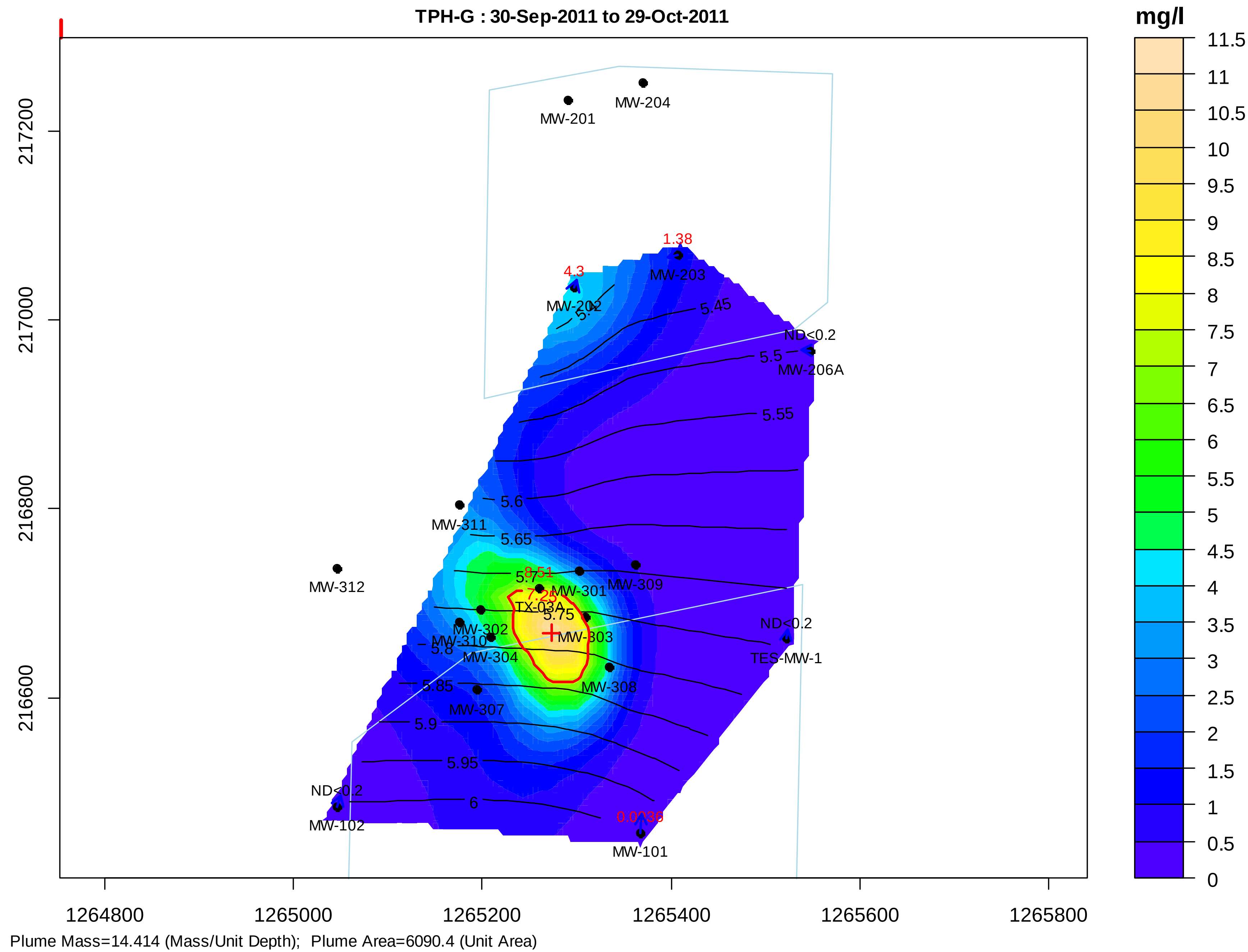

Benzene in MW-310
Detectable Data
GW Elevation
Non-Detect Data
Benzene (mg/l)
1.0
1.5
2.0
Groundwater Elevation (feet)
6.0
6.5
7.0
2012
2013
2014
2015
Date


Benzene in MW-311
Detectable Data
GW Elevation
Non-Detect Data
Benzene (mg/l)
0.00010
0.00014
0.00018
Groundwater Elevation (feet)
6.5
6.6
6.7
6.8
6.9
2012
2013
2014
2015
Date


Benzene in MW-312
Detectable Data
Non-Detect Data
GW Elevation
Benzene (mg/l)
0.20
0.25
0.30
0.35
Groundwater Elevation (feet)
6.4
6.5
6.6
6.7
6.8
2012
2013
2014
2015
Date

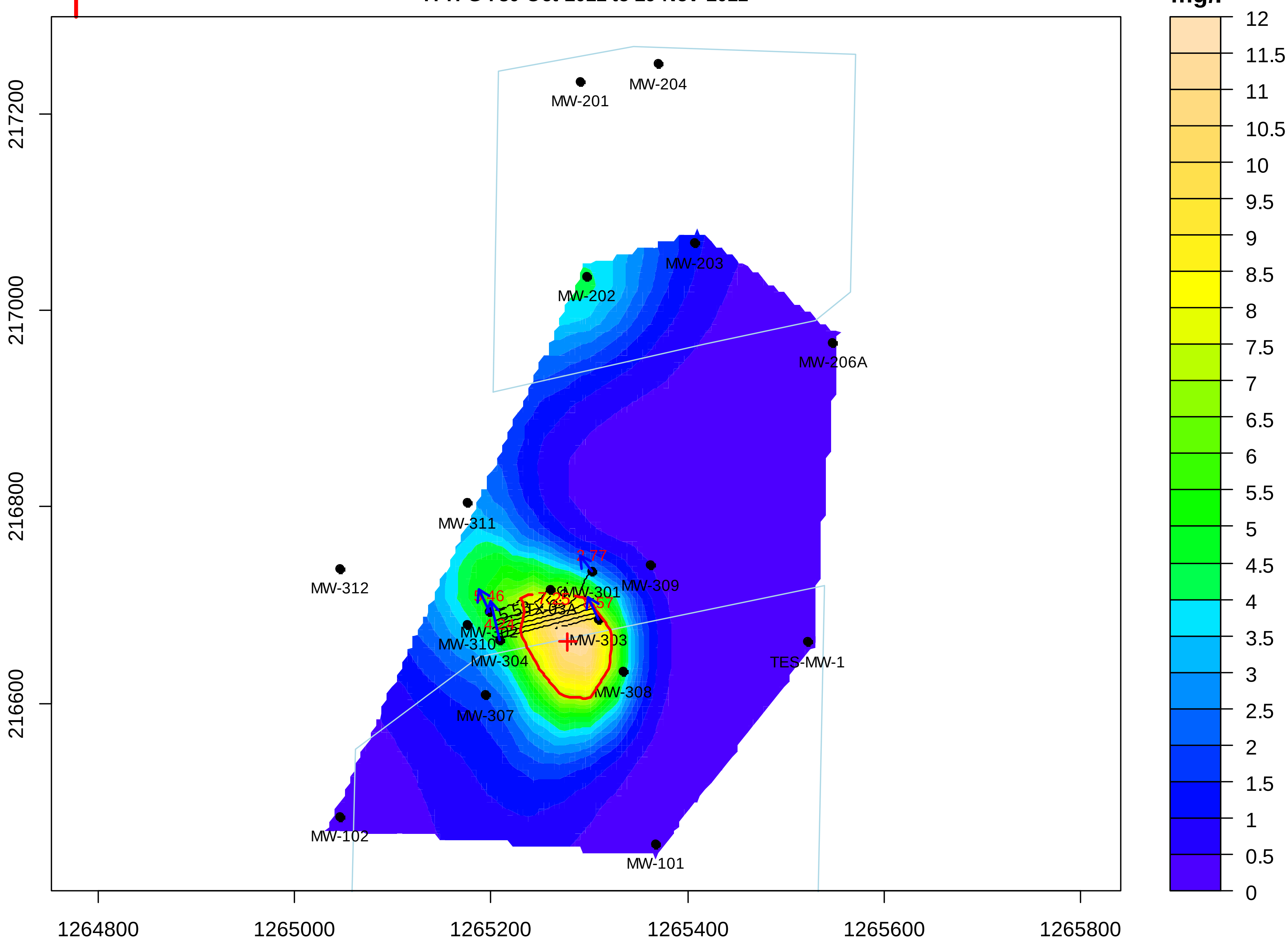

Benzene in TES-MW-1
Detectable Data
Non-Detect Data
GW Elevation
Benzene (mg/l)
1e-04
2e-04
5e-04
1e-03
Groundwater Elevation (feet)
6.0
6.5
7.0
7.5
2012
2013
2014
2015
Date


Benzene in TX-03A
Detectable Data
Non-Detect Data
GW Elevation
Benzene (mg/l)
1.0
1.5
2.0
2.5
3.5
Groundwater Elevation (feet)
6.0
6.5
7.0
2012
2013
2014
2015
Date

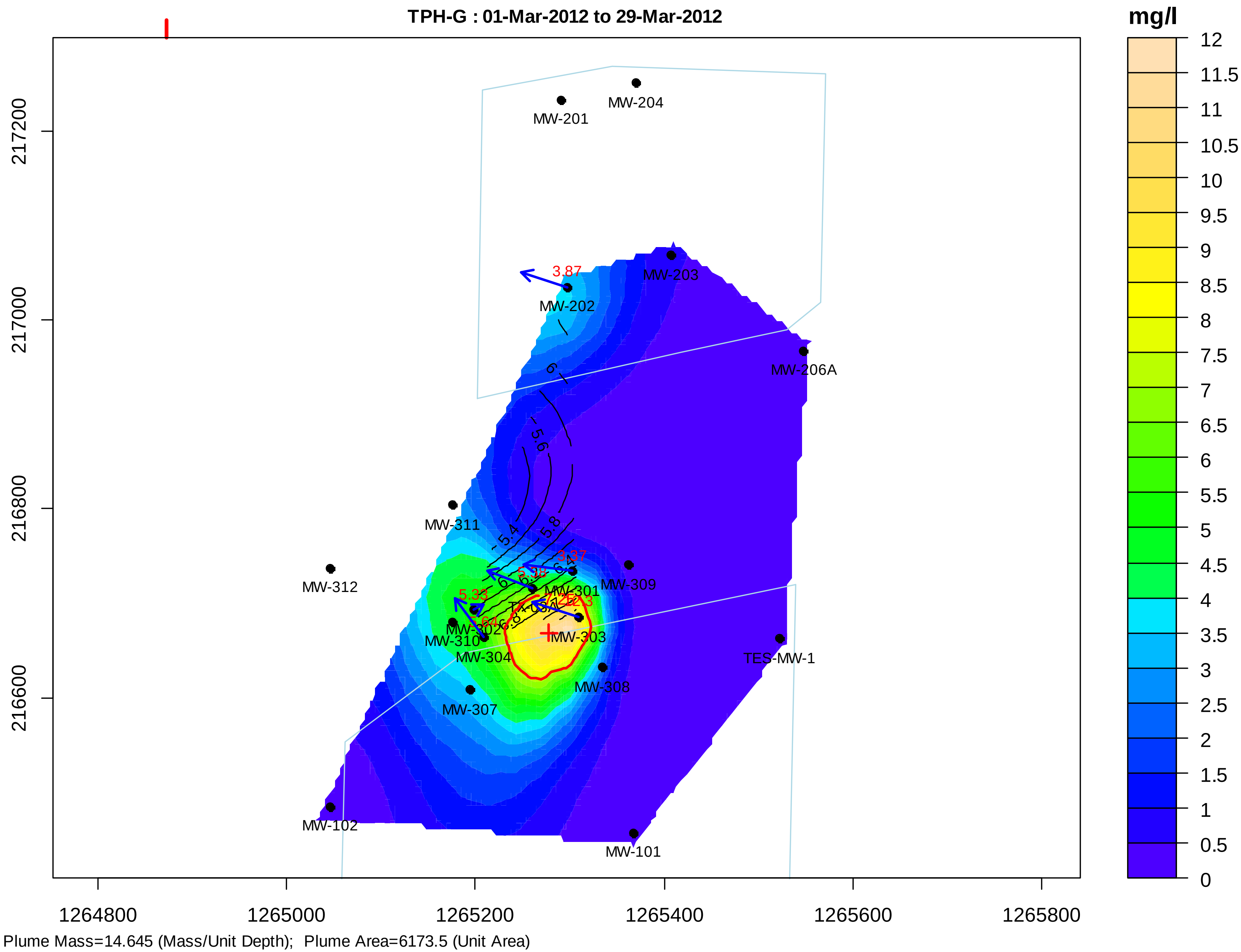


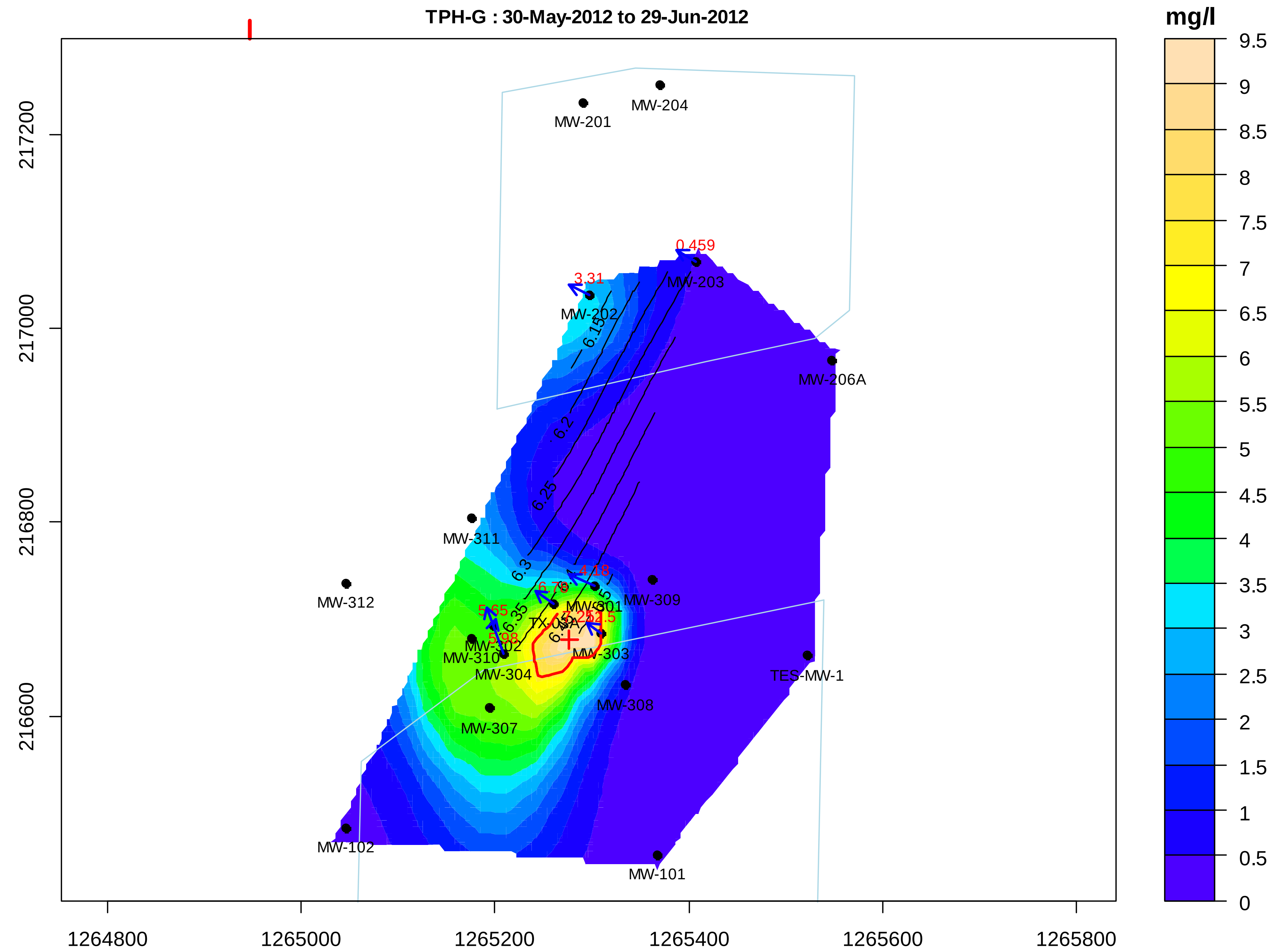
TPH-G : 30-Sep-2011 to 29-Oct-2011
mg/l
11.5
11
10.5
10
9.5
9
8.5
8
7.5
7
6.5
6
5.5
5
4.5
4
3.5
3
2.5
2
1.5
1
0.5
0
217200
217000
216800
216600
1264800
1265000
1265200
1265400
1265600
1265800
MW-201
MW-204
1.38
MW-203
4.3
MW-202
5.45
ND<0.2
MW-206A
5.5
5.55
5.6
MW-311
5.65
MW-312
8.51
5.7
MW-301
MW-309
7.25
TX-03A
5.75
MW-302
MW-310
MW-303
5.8
MW-304
ND<0.2
TES-MW-1
5.85
MW-308
MW-307
5.9
5.95
ND<0.2
6
MW-102
0.0036
MW-101
Plume Mass=14.414 (Mass/Unit Depth); Plume Area=6090.4 (Unit Area)

TPH-G : 30-Oct-2011 to 29-Nov-2011

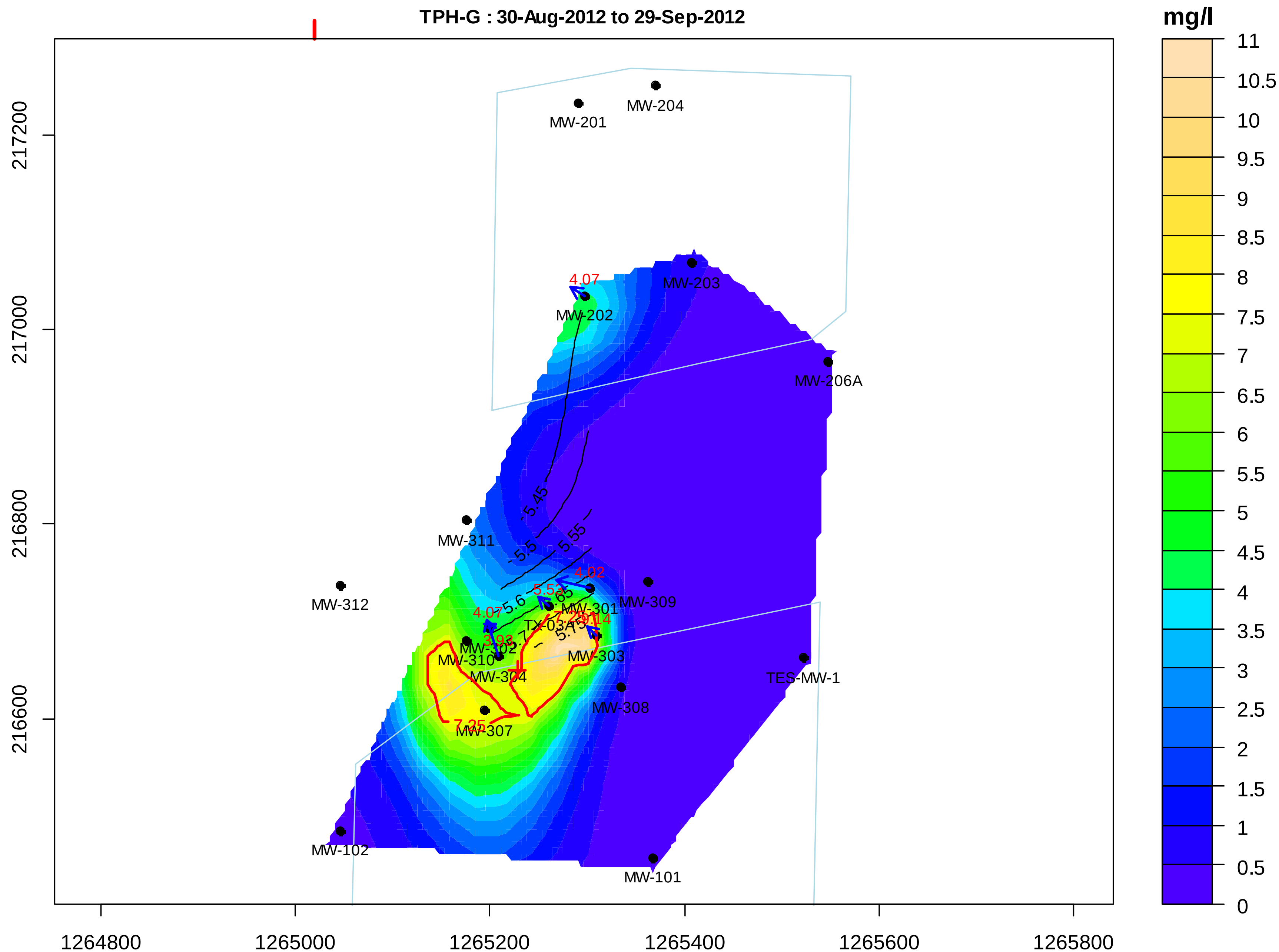


Plume Mass=18.293 (Mass/Unit Depth); Plume Area=7492.4 (Unit Area)

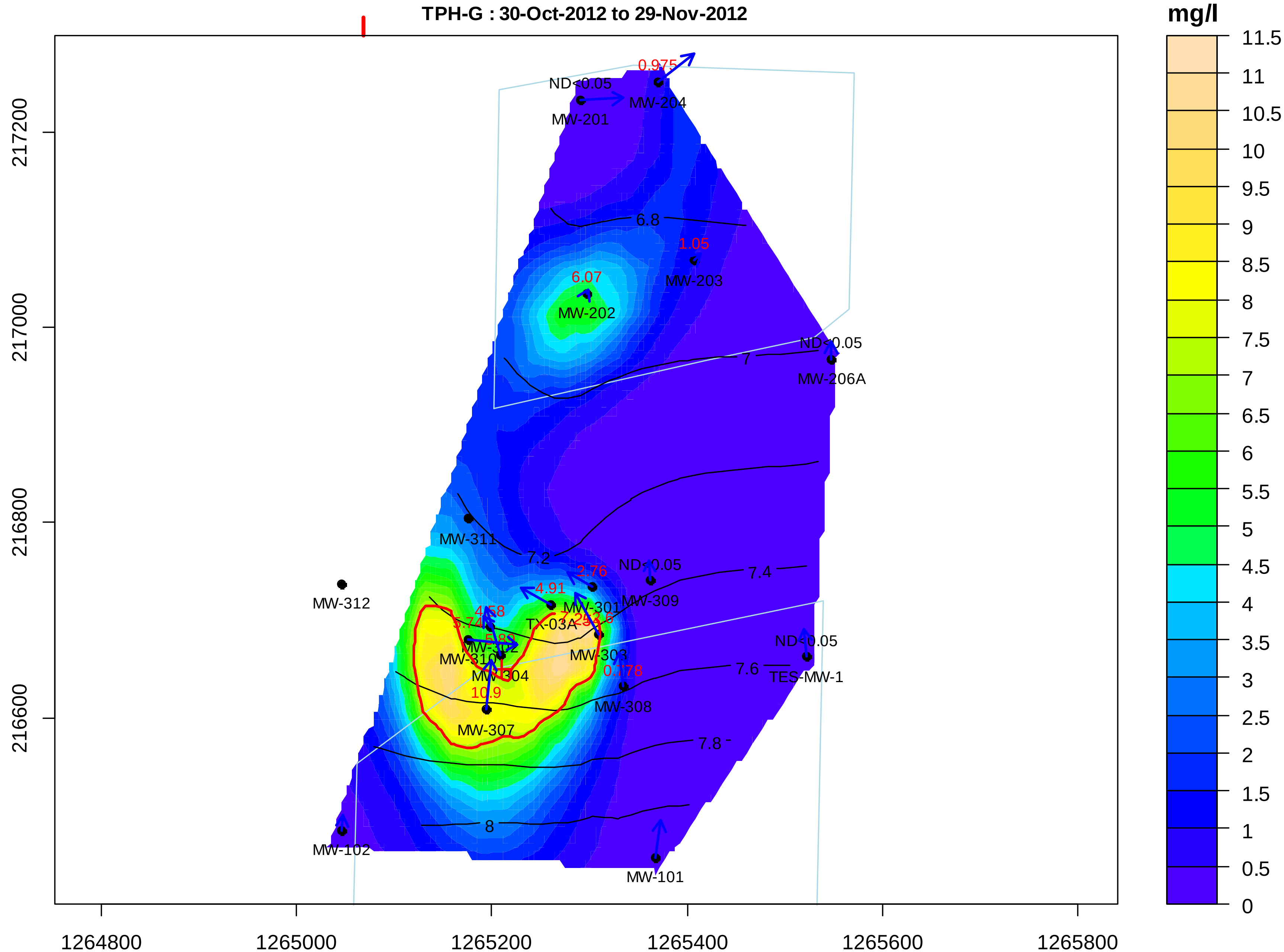

TPH-G : 01-Mar-2012 to 29-Mar-2012
mg/l
12
11.5
11
10.5
10
9.5
9
8.5
8
7.5
7
6.5
6
5.5
5
4.5
4
3.5
3
2.5
2
1.5
1
0.5
0
217200
217000
216800
216600
1264800
1265000
1265200
1265400
1265600
1265800
MW-201
MW-204
MW-203
MW-202
3.87
MW-206A
MW-311
MW-312
MW-309
MW-301
3.37
MW-303
MW-310
MW-304
MW-302
5.33
MW-308
MW-307
TES-MW-1
MW-102
MW-101
5.4
5.6
5.8
6
Plume Mass=14.645 (Mass/Unit Depth); Plume Area=6173.5 (Unit Area)



Plume Mass=8.1048 (Mass/Unit Depth); Plume Area=3524.9 (Unit Area)

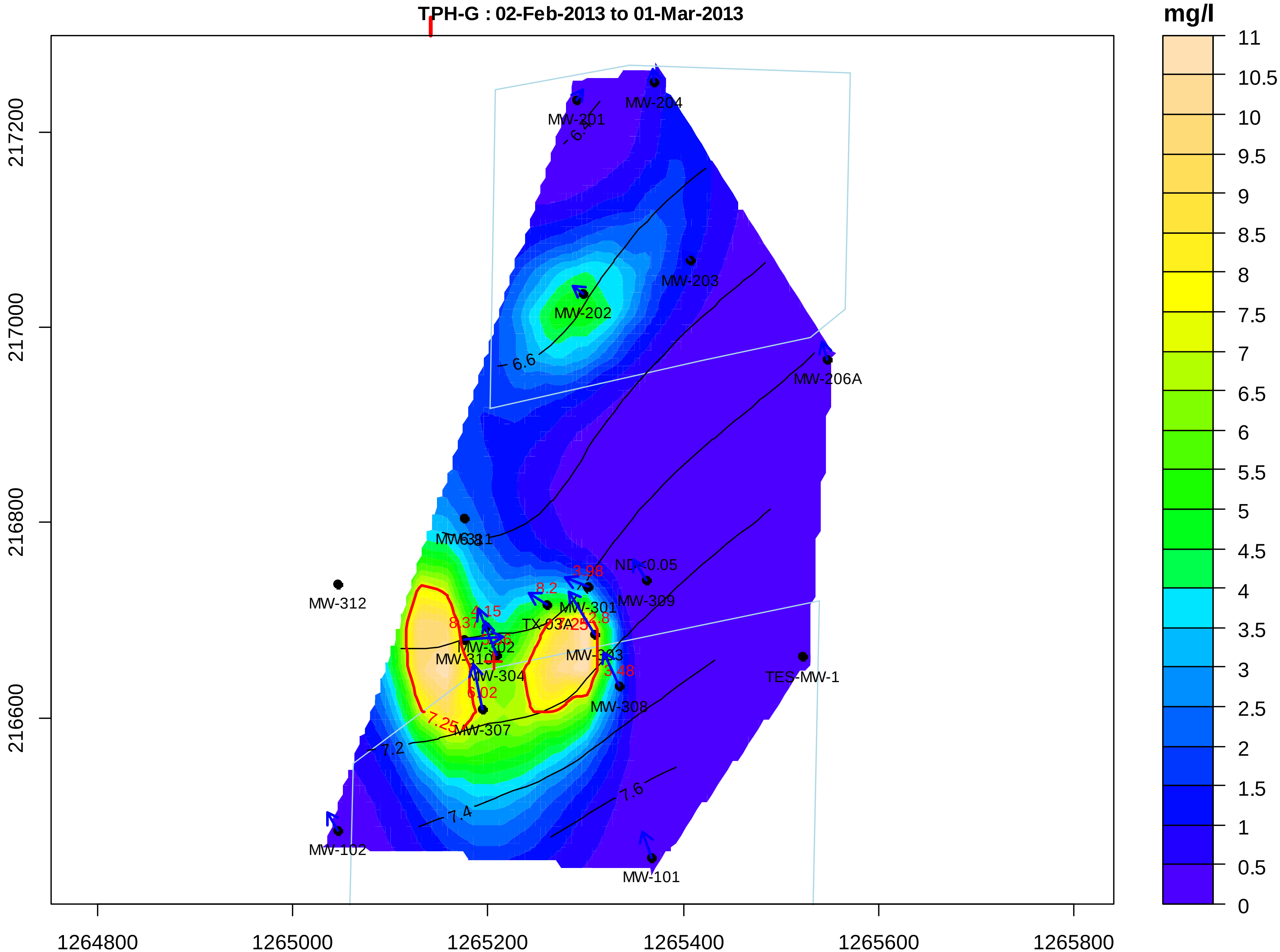


Plume Mass=22.907 (Mass/Unit Depth); Plume Area=9491 (Unit Area)



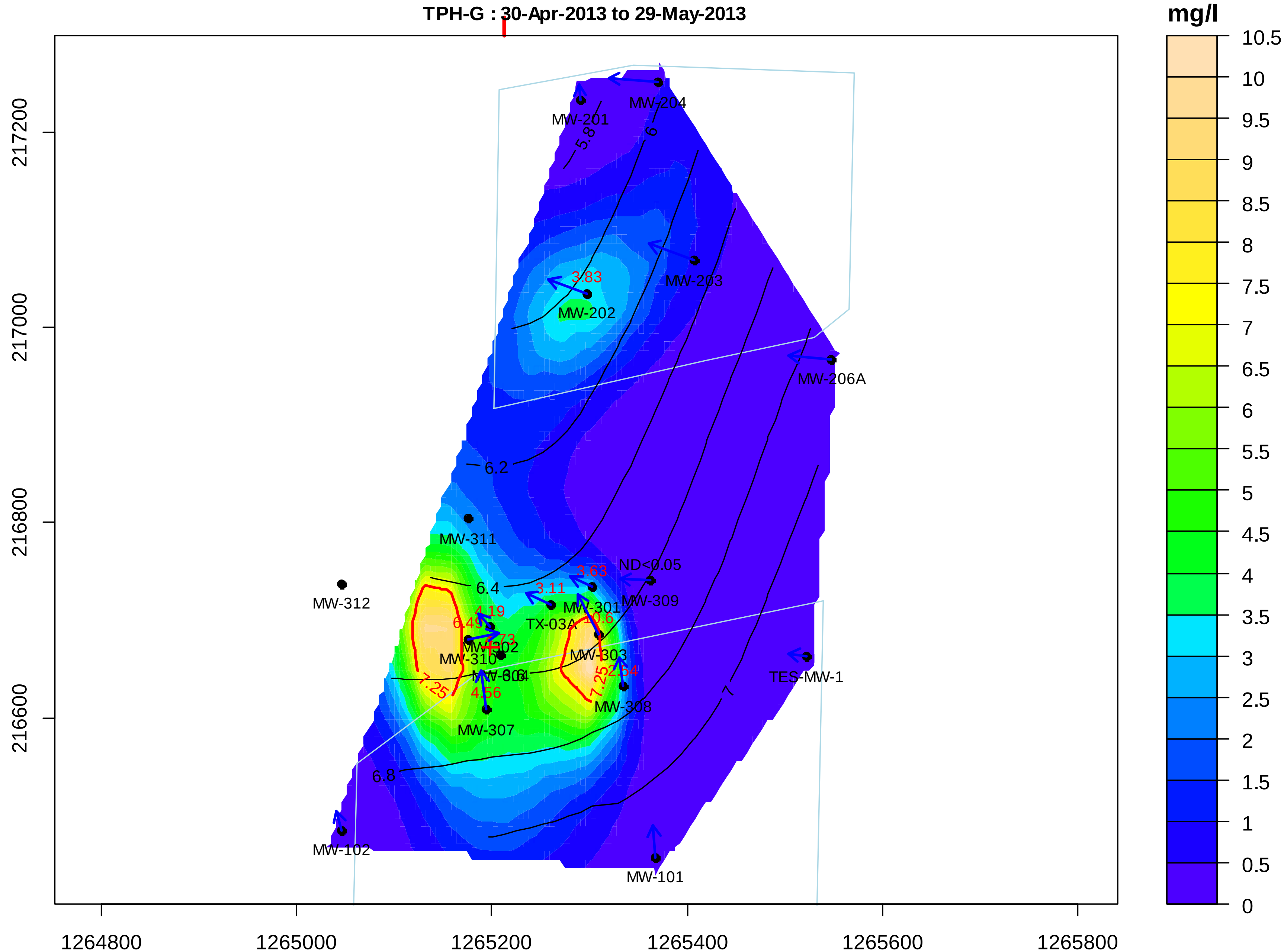
Plume Mass=48.139 (Mass/Unit Depth); Plume Area=16993 (Unit Area)

TPH-G : 02-Feb-2013 to 01-Mar-2013

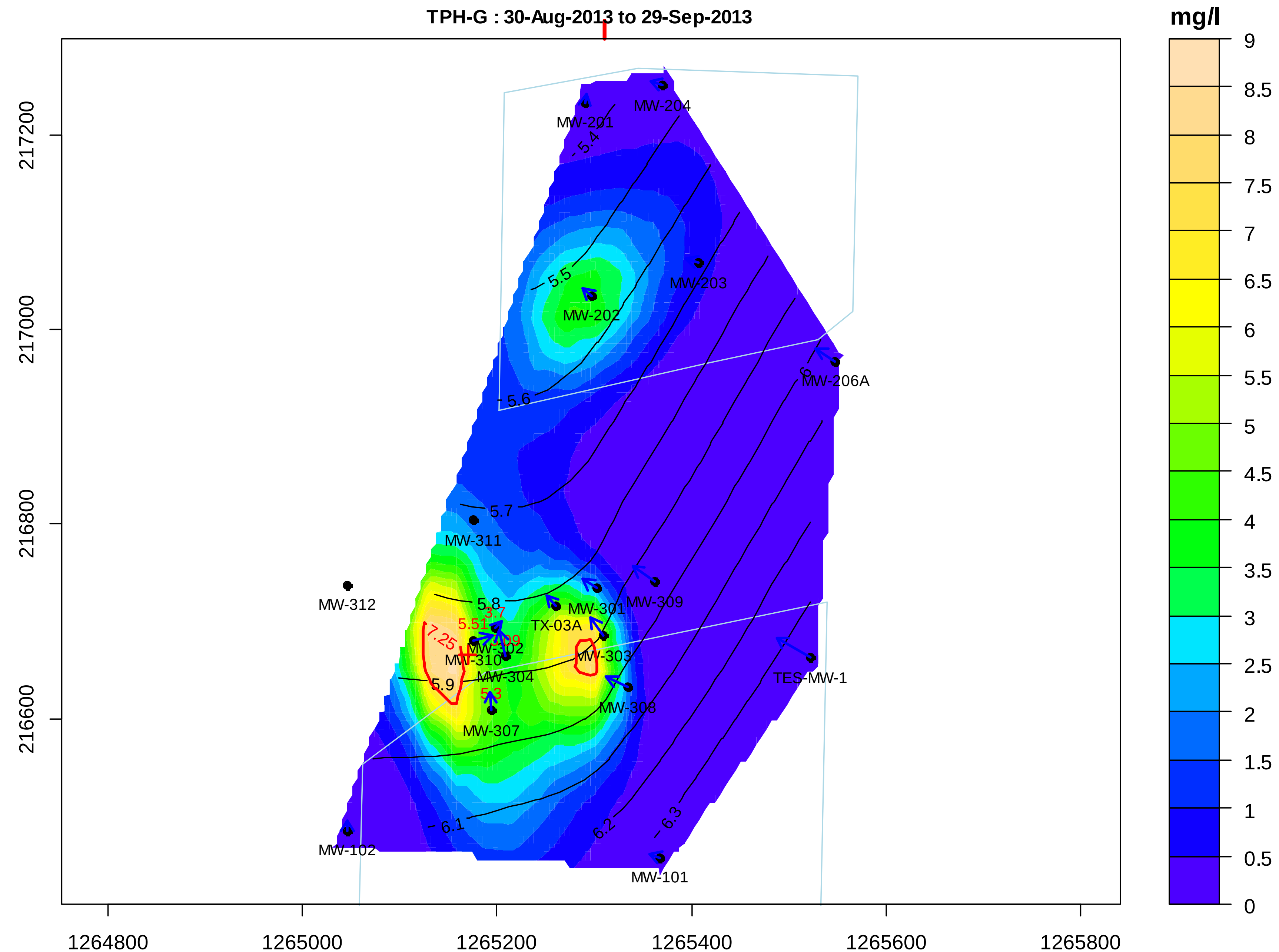


Plume Mass=31.531 (Mass/Unit Depth); Plume Area=13081 (Unit Area)

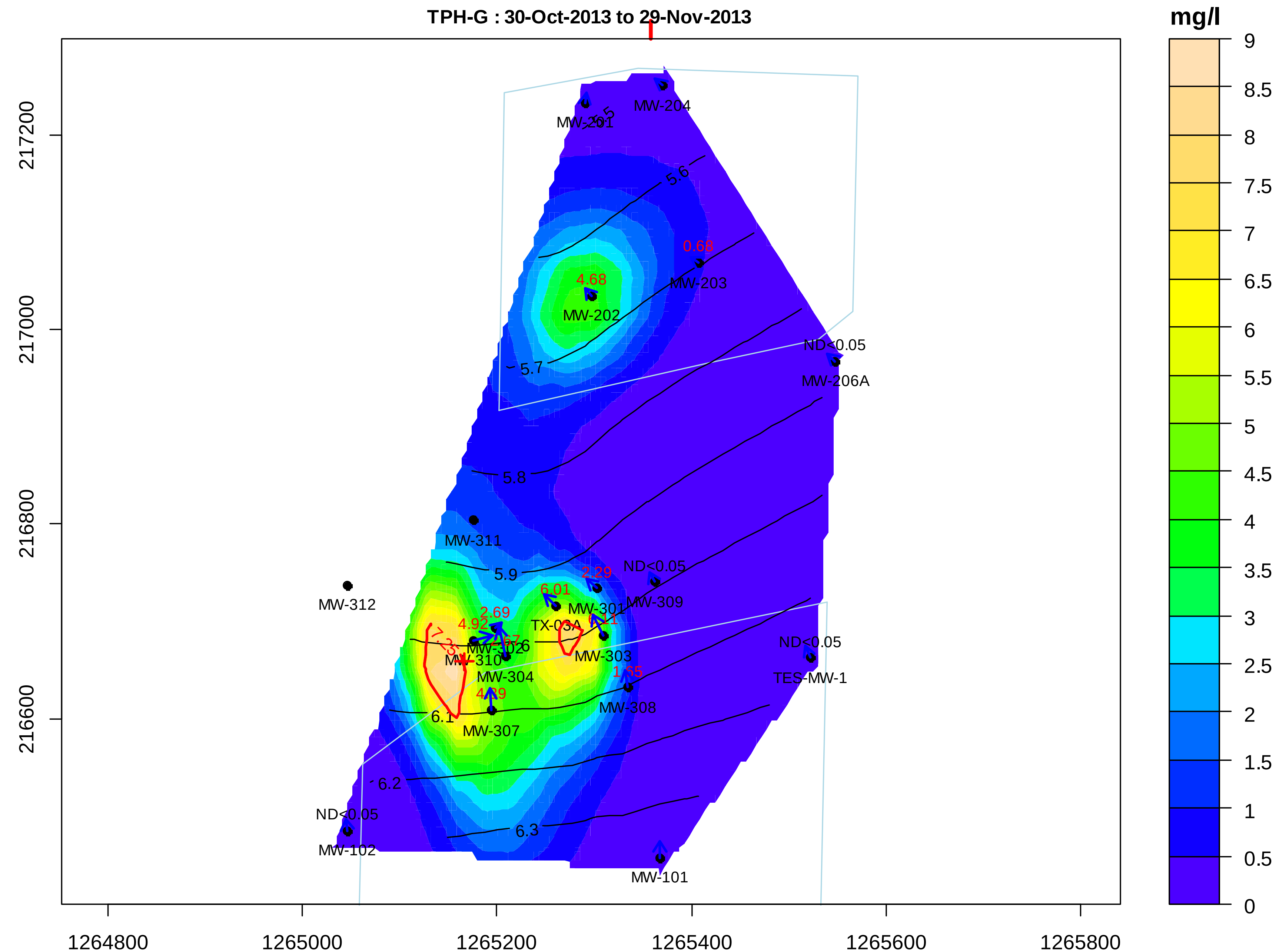
TPH-G : 30-Apr-2013 to 29-May-2013



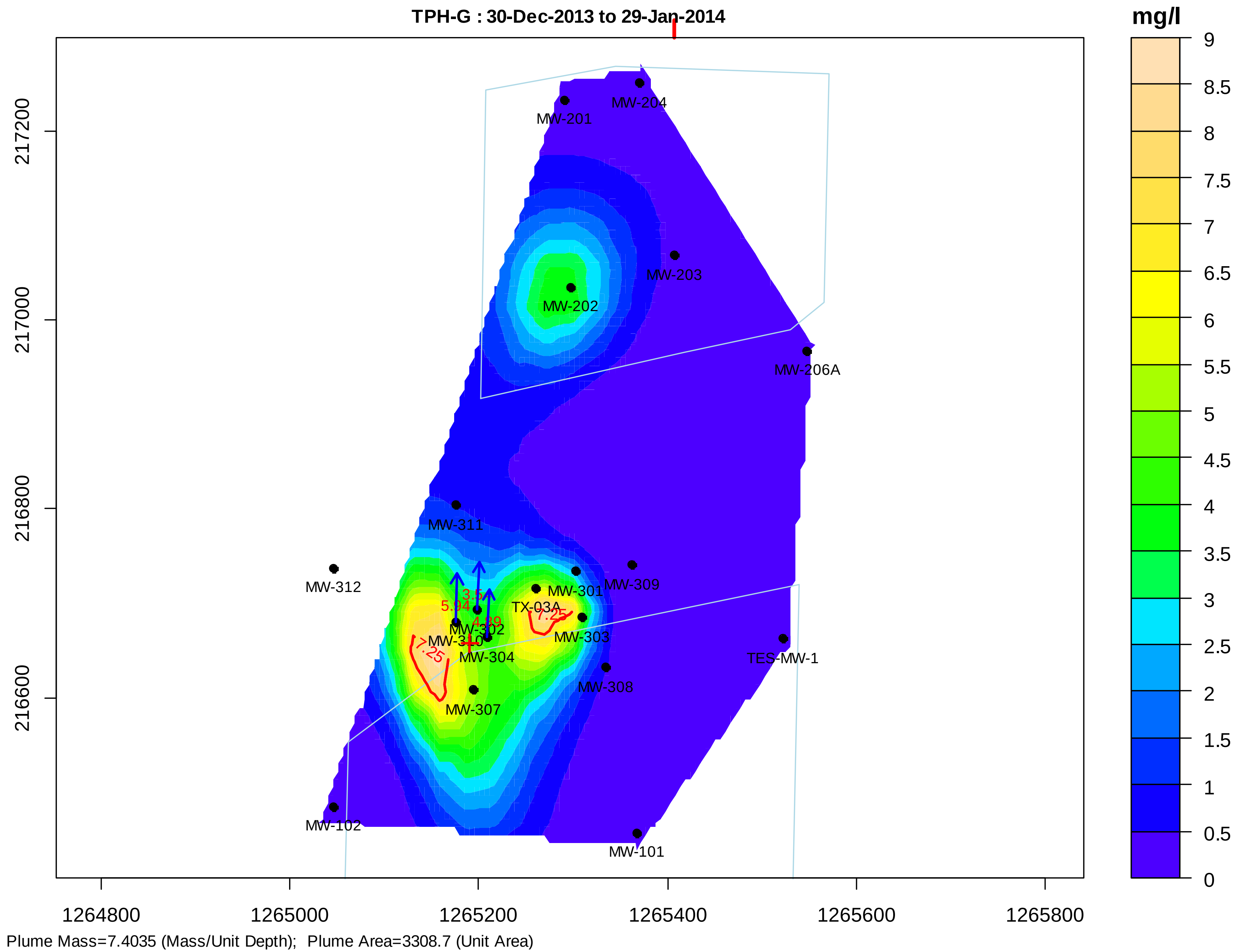
Plume Mass=16.649 (Mass/Unit Depth); Plume Area=7152.5 (Unit Area)



Plume Mass=7.98 (Mass/Unit Depth); Plume Area=3699.8 (Unit Area)

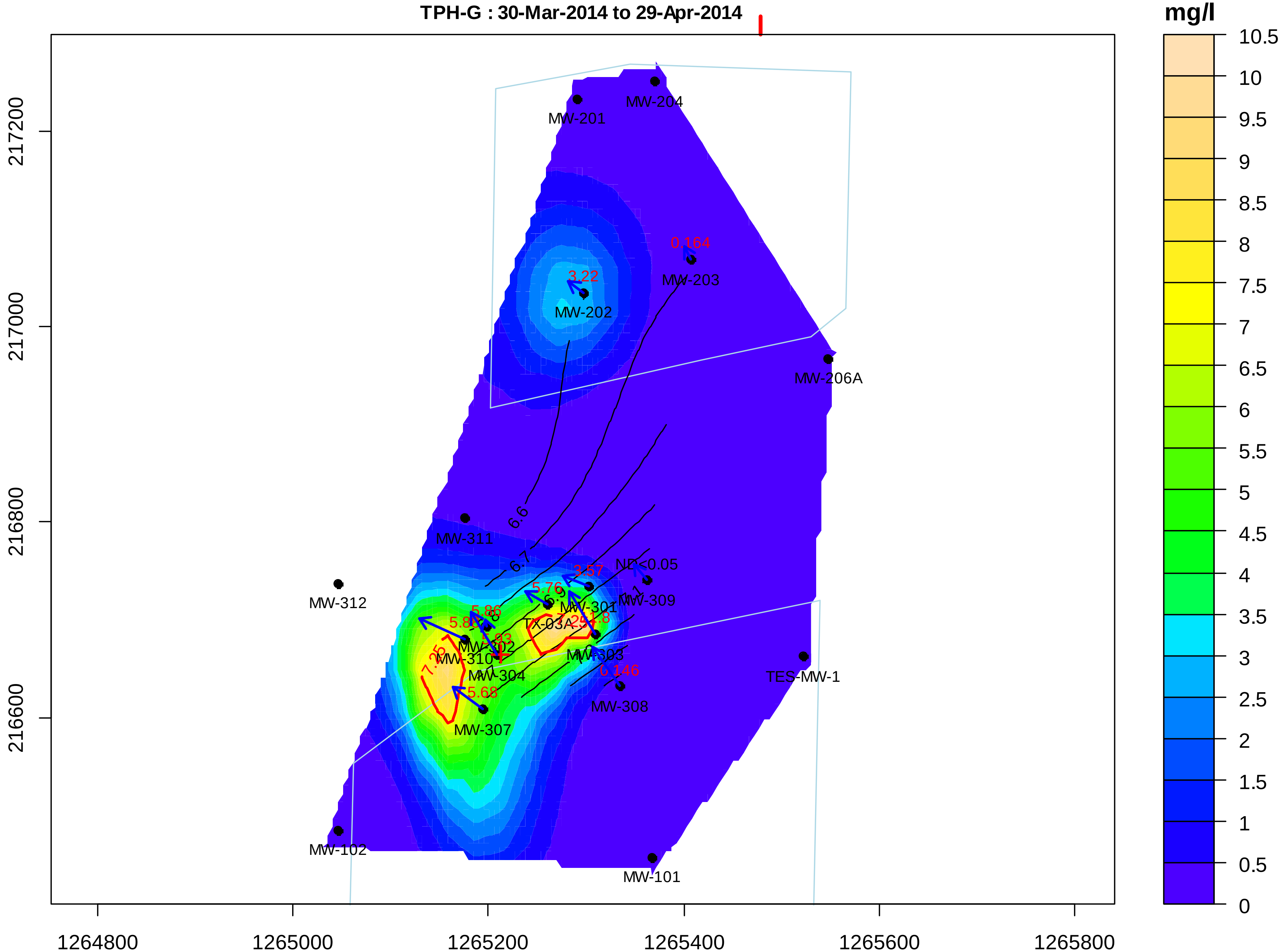


Plume Mass=7.0054 (Mass/Unit Depth); Plume Area=3246.3 (Unit Area)

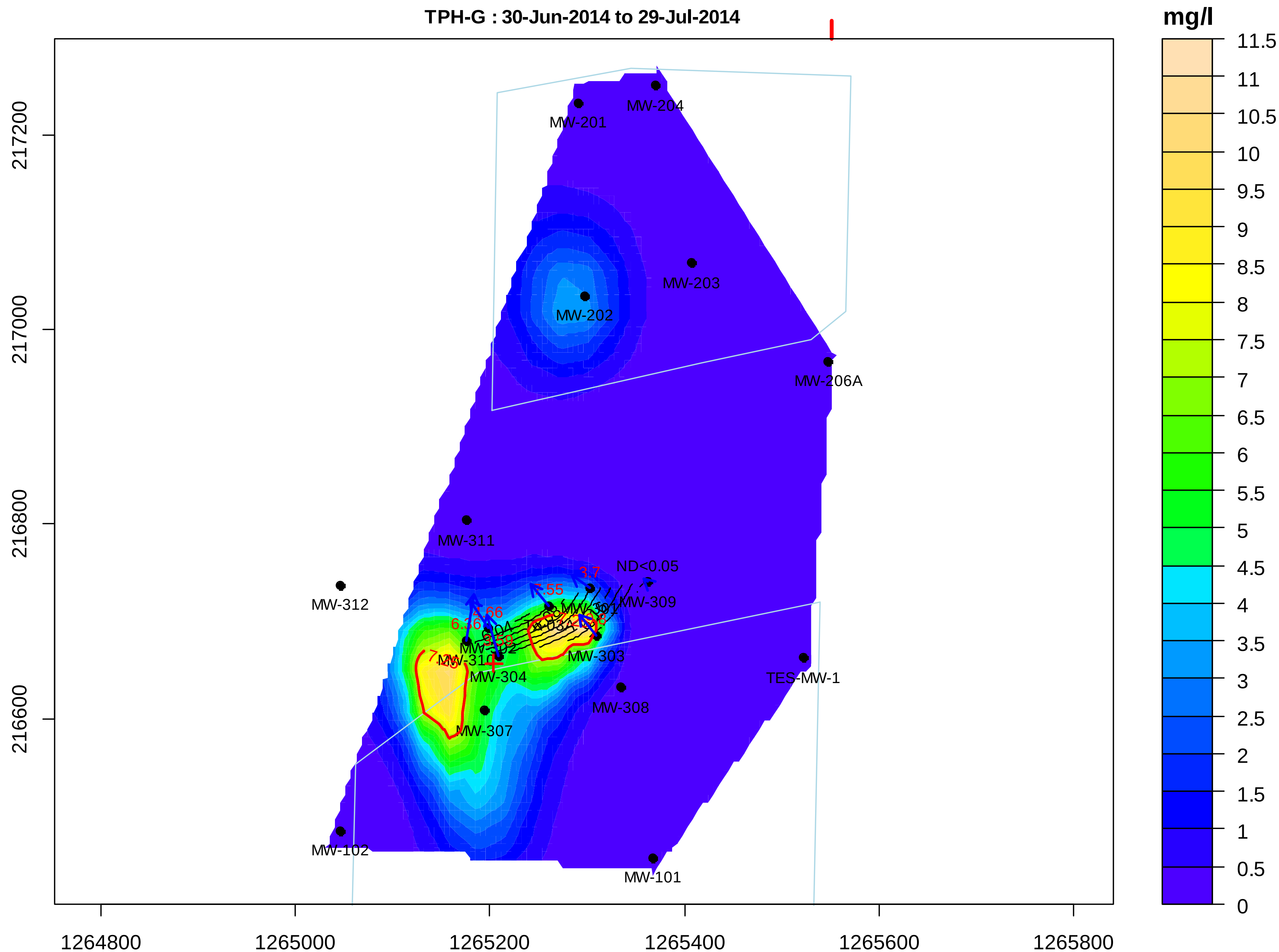


TPH-G : 30-Dec-2013 to 29-Jan-2014
mg/l
9
8.5
8
7.5
7
6.5
6
5.5
5
4.5
4
3.5
3
2.5
2
1.5
1
0.5
0
217200
217000
216800
216600
1264800
1265000
1265200
1265400
1265600
1265800
MW-204
MW-201
MW-203
MW-202
MW-206A
MW-311
MW-312
MW-309
MW-301
TX-03A
MW-302
MW-310
MW-303
MW-304
TES-MW-1
MW-308
MW-307
MW-102
MW-101
5.94
3.5
4.39
7.25
7.25
Plume Mass=7.4035 (Mass/Unit Depth); Plume Area=3308.7 (Unit Area)

TPH-G : 30-Mar-2014 to 29-Apr-2014

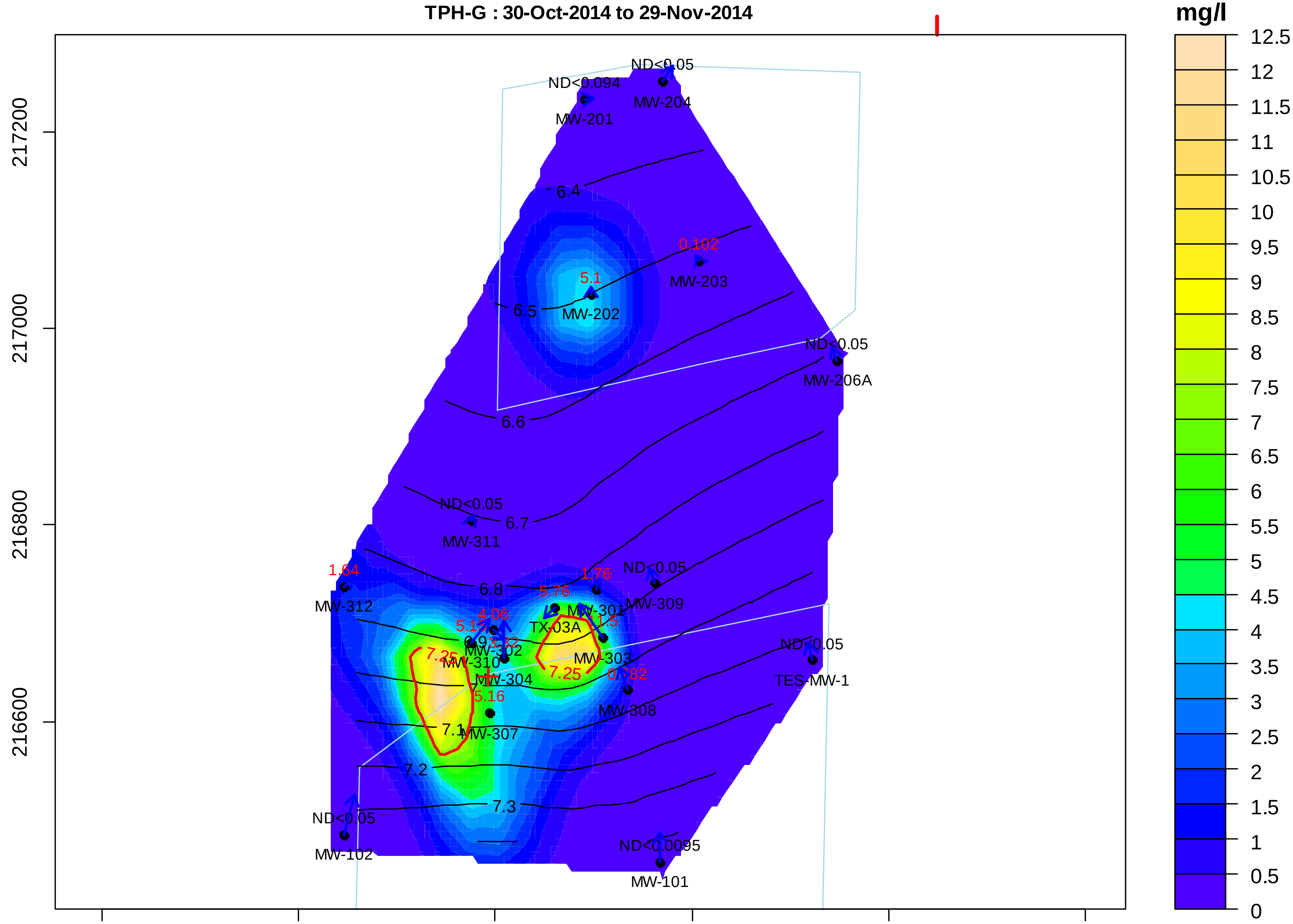


Plume Mass=10.148 (Mass/Unit Depth); Plume Area=4355.6 (Unit Area)

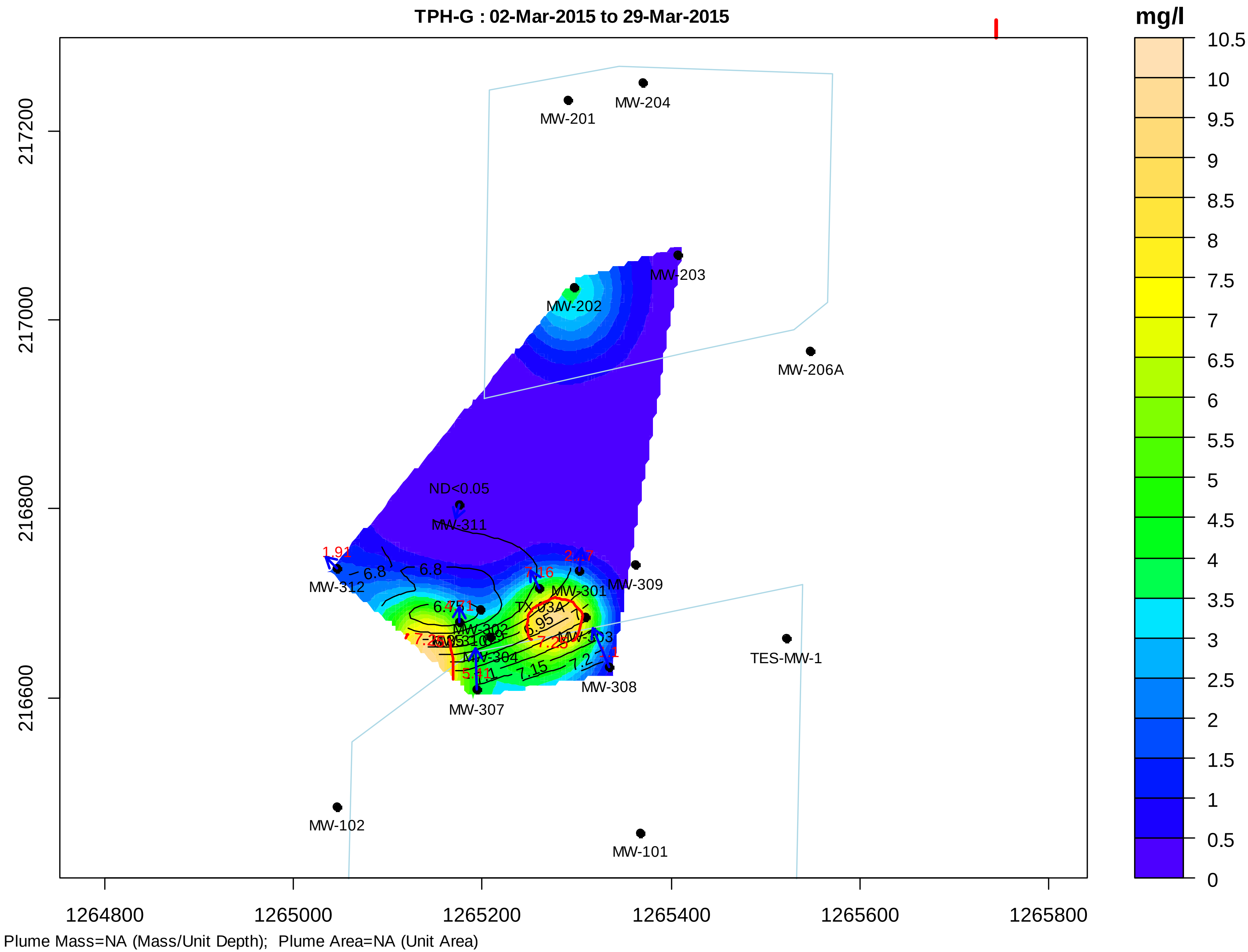


Plume Mass=15.243 (Mass/Unit Depth); Plume Area=6129.3 (Unit Area)

TPH-G : 30-Oct-2014 to 29-Nov-2014

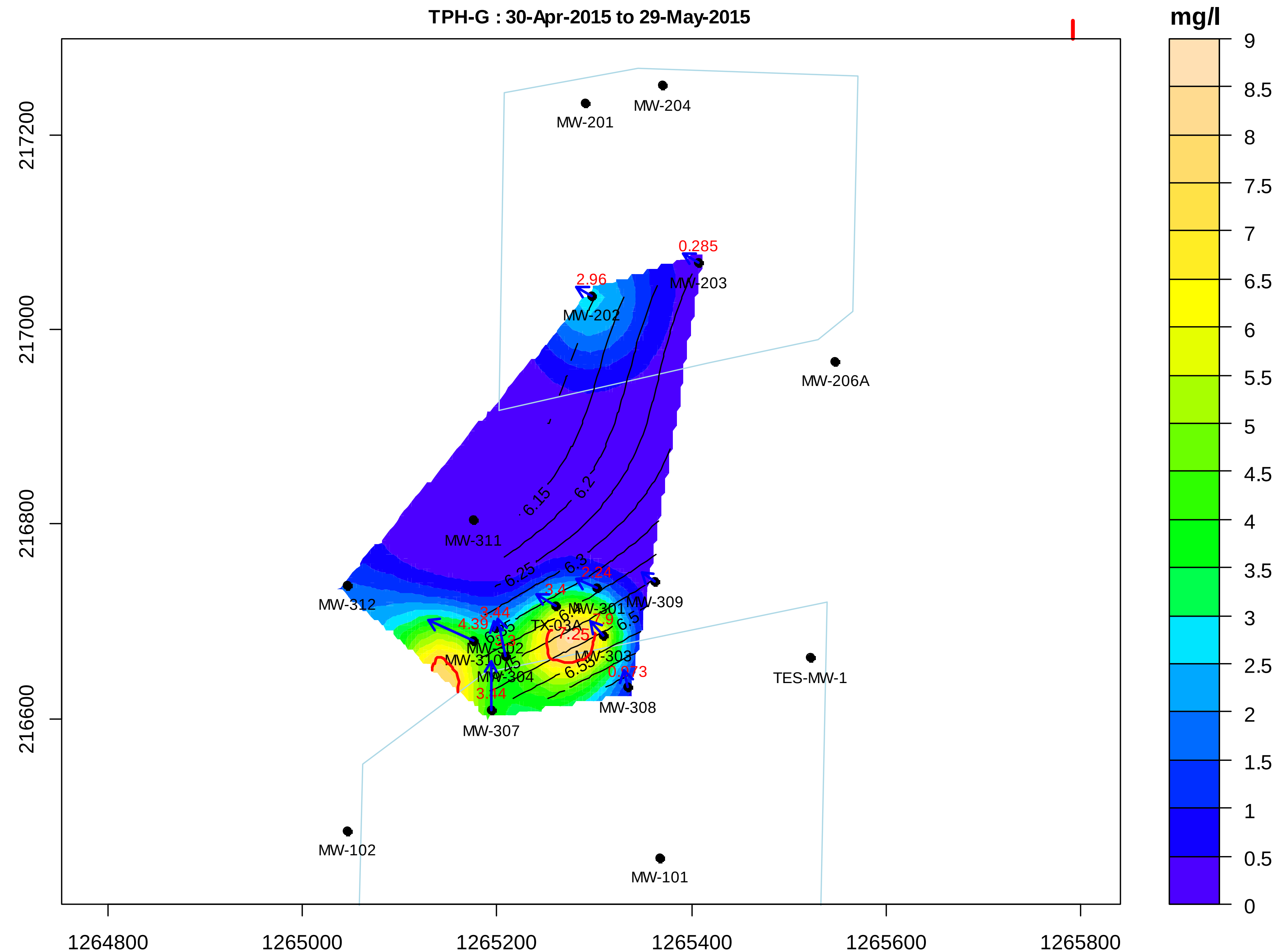


Plume Mass=21.319 (Mass/Unit Depth); Plume Area=8150.8 (Unit Area)



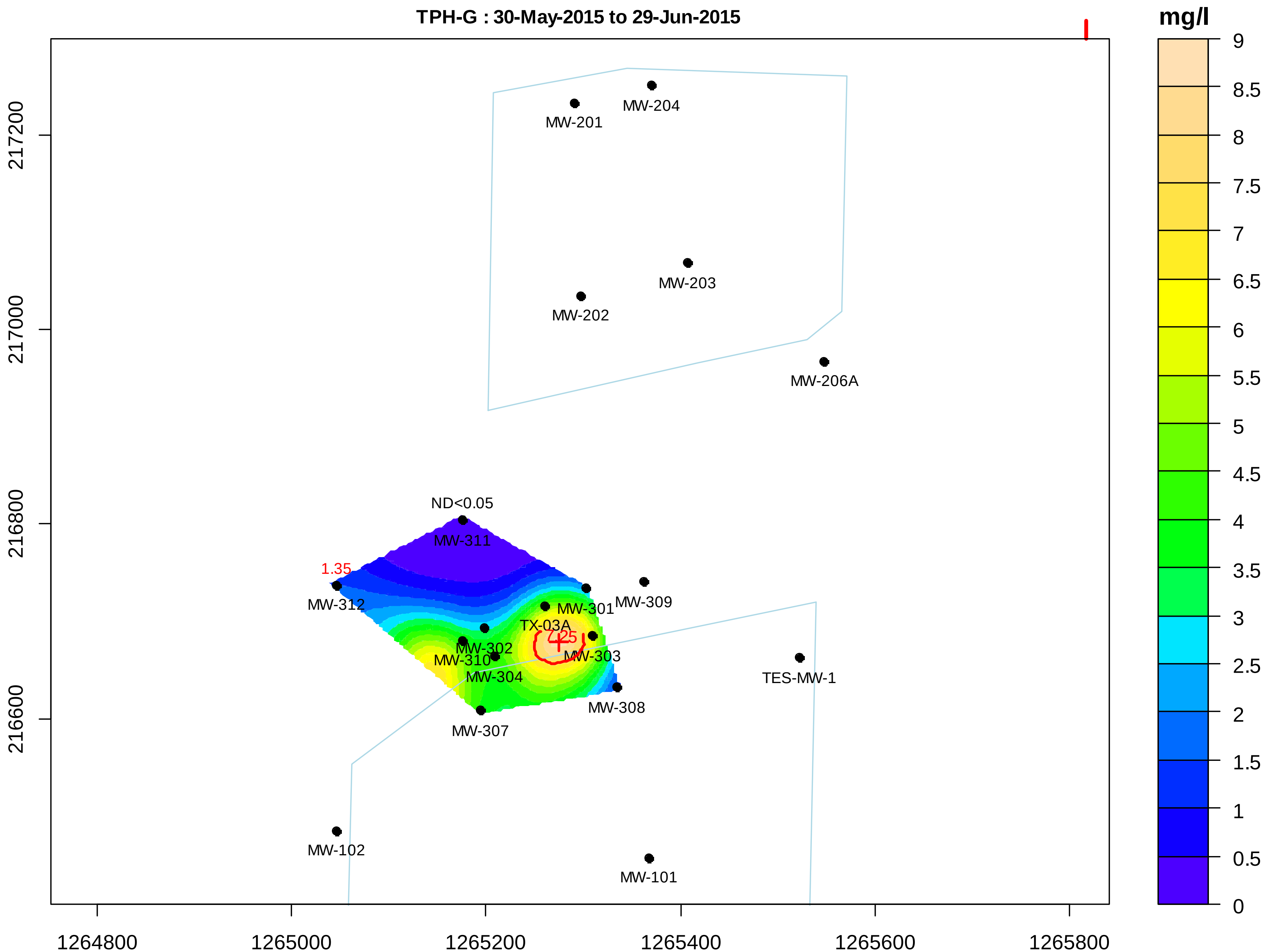
TPH-G : 02-Mar-2015 to 29-Mar-2015
mg/l
10.5
10
9.5
9
8.5
8
7.5
7
6.5
6
5.5
5
4.5
4
3.5
3
2.5
2
1.5
1
0.5
0
217200
217000
216800
216600
1264800
1265000
1265200
1265400
1265600
1265800
MW-201
MW-204
MW-203
MW-202
MW-206A
ND<0.05
MW-311
MW-312
MW-309
MW-301
TX-03A
MW-302
MW-303
MW-304
MW-308
MW-307
TES-MW-1
MW-102
MW-101
1.91
2.17
7.16
5.11
6.8
7.2
7.15
6.95
Plume Mass=NA (Mass/Unit Depth); Plume Area=NA (Unit Area)

TPH-G : 30-Apr-2015 to 29-May-2015

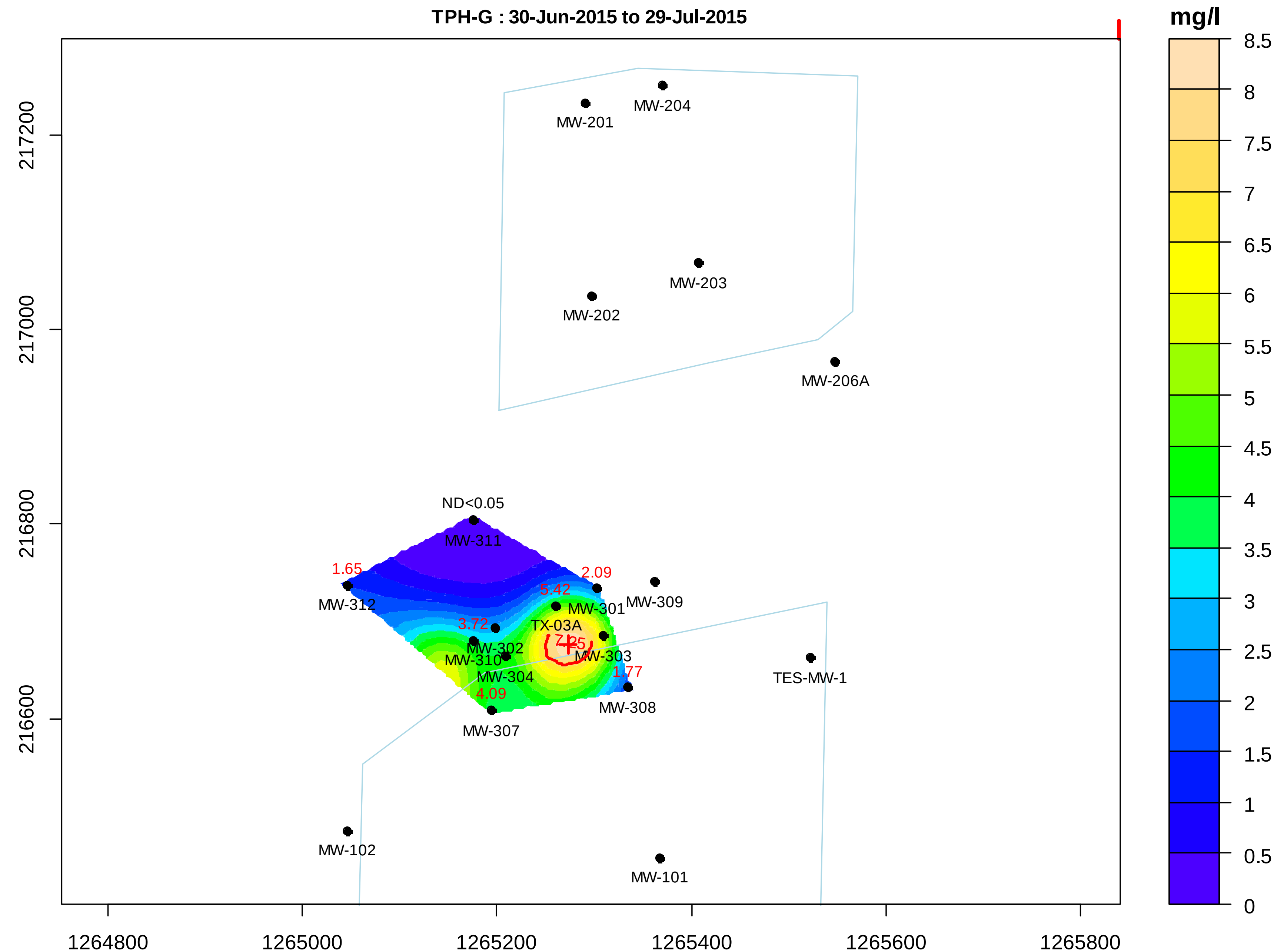


Plume Mass=NA (Mass/Unit Depth); Plume Area=NA (Unit Area)

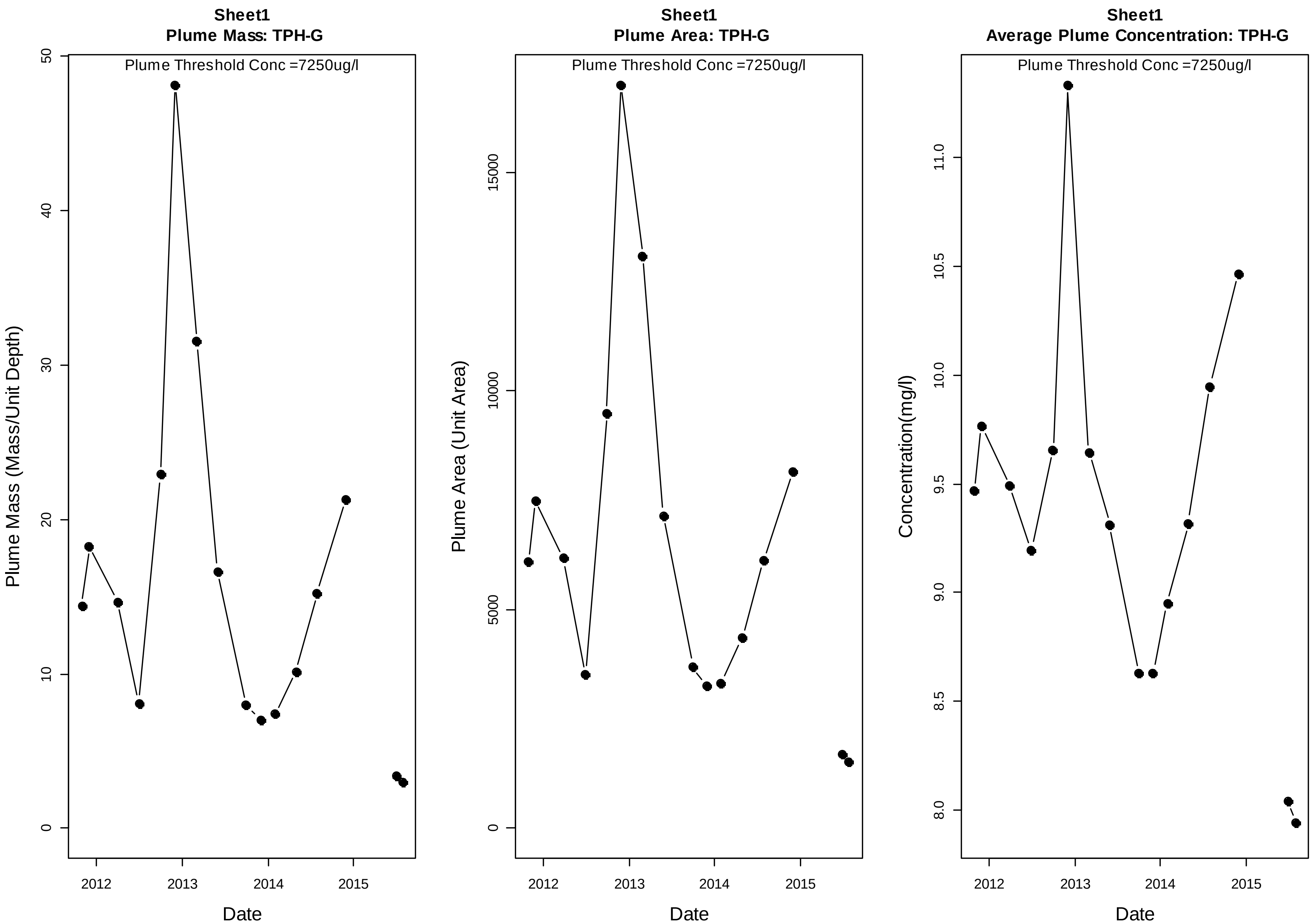
TPH-G : 30-May-2015 to 29-Jun-2015



Plume Mass=3.4284 (Mass/Unit Depth); Plume Area=1705.1 (Unit Area)

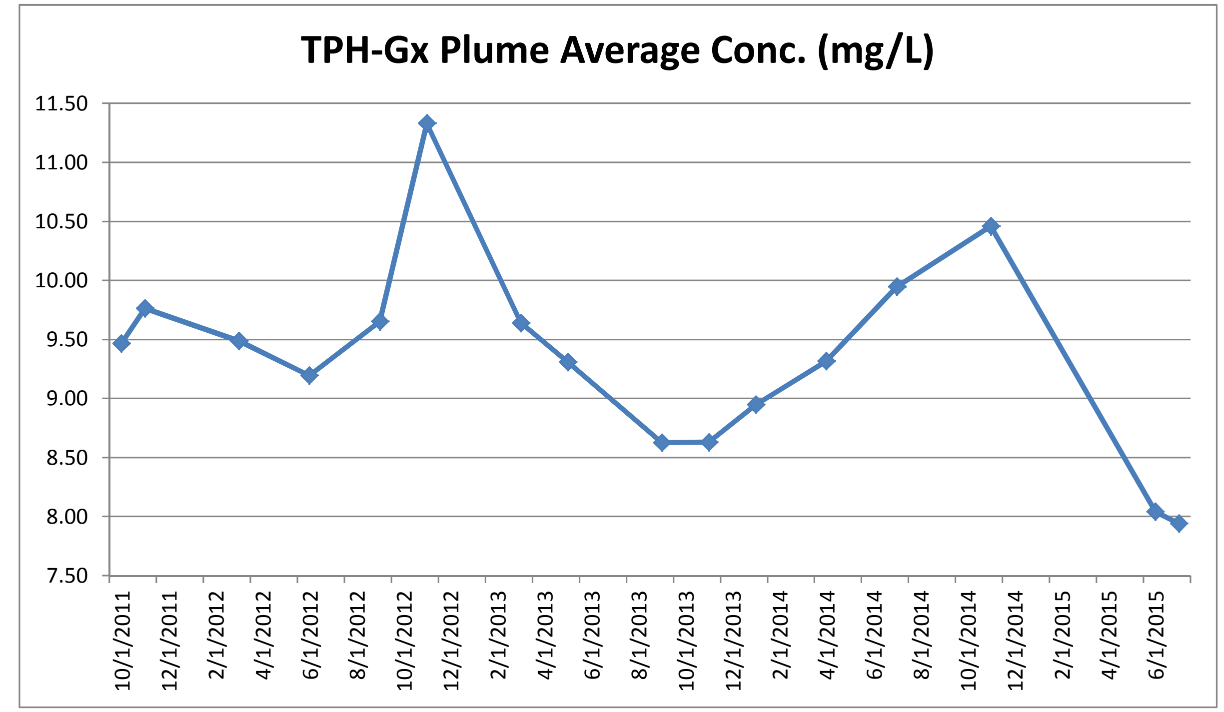


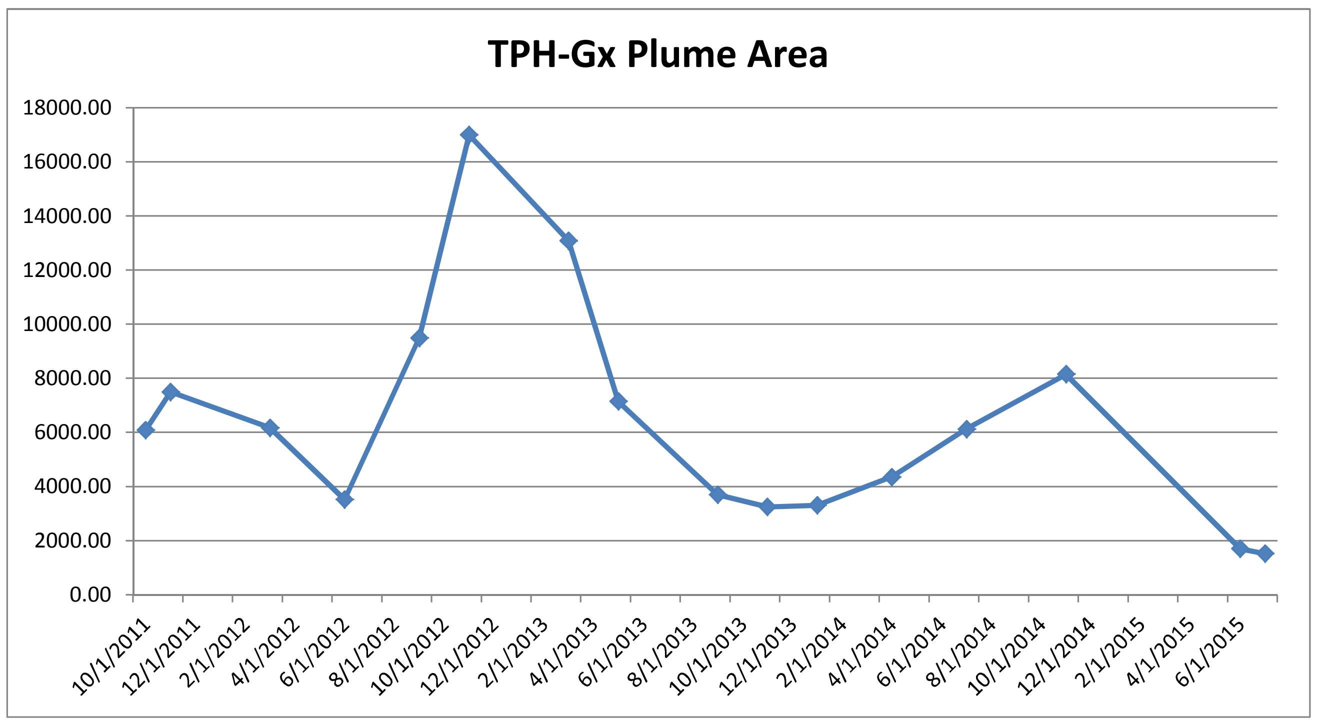
Plume Mass=3.0242 (Mass/Unit Depth); Plume Area=1523.1 (Unit Area)

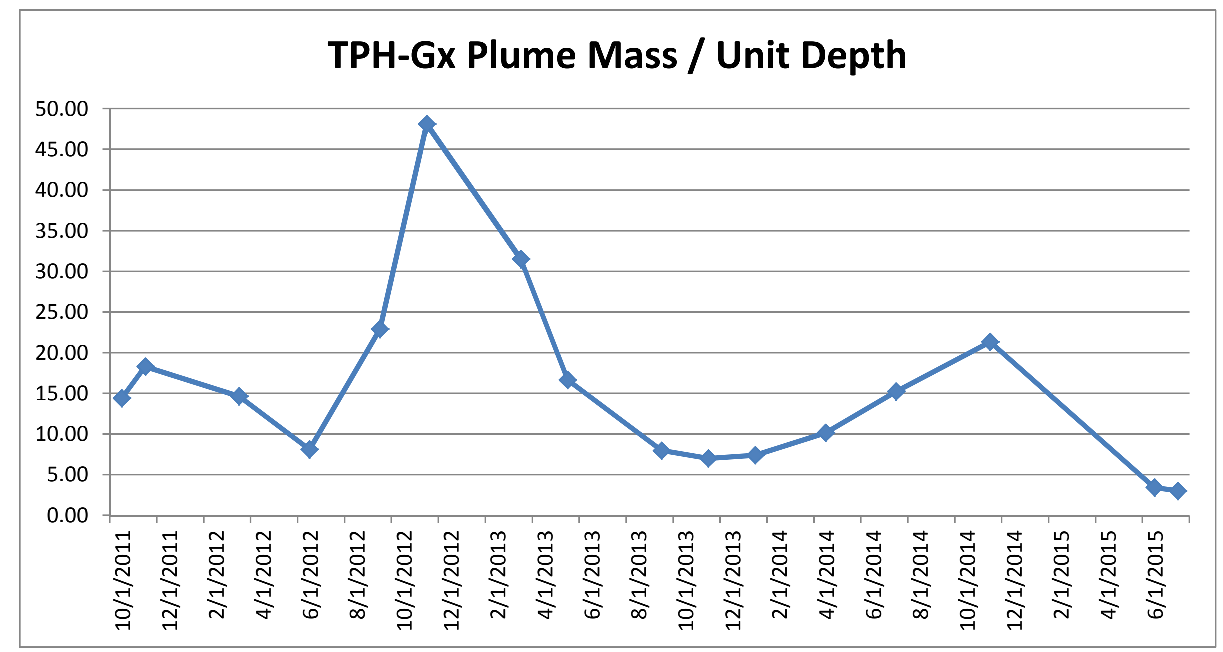


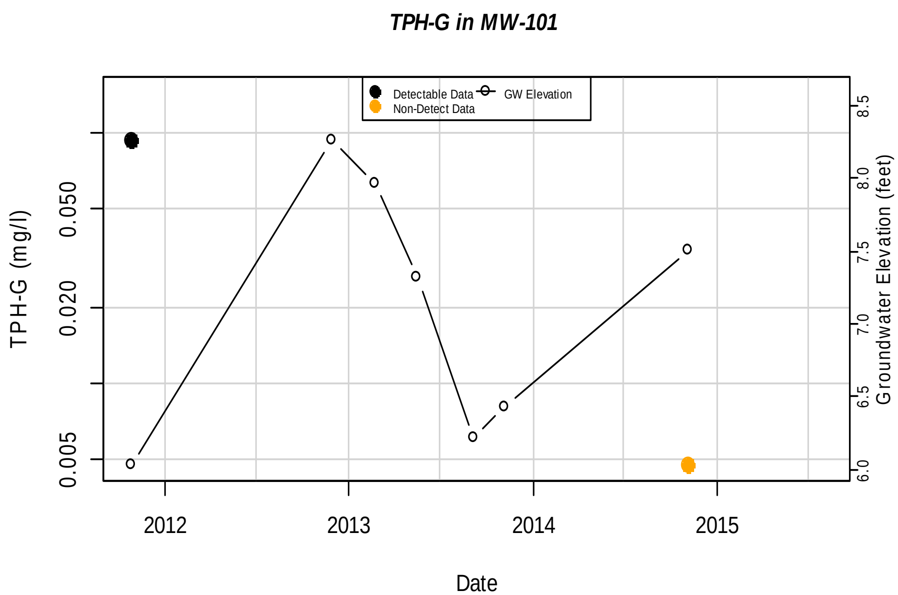
Sheet1
Plume Mass: TPH-G
Plume Threshold Conc =7250ug/l
Plume Mass (Mass/Unit Depth)
0
10
20
30
40
50
2012
2013
2014
2015
Date
Sheet1
Plume Area: TPH-G
Plume Threshold Conc =7250ug/l
Plume Area (Unit Area)
0
5000
10000
15000
2012
2013
2014
2015
Date
Sheet1
Average Plume Concentration: TPH-G
Plume Threshold Conc =7250ug/l
Concentration(mg/l)
8.0
8.5
9.0
9.5
10.0
10.5
11.0
2012
2013
2014
2015
Date

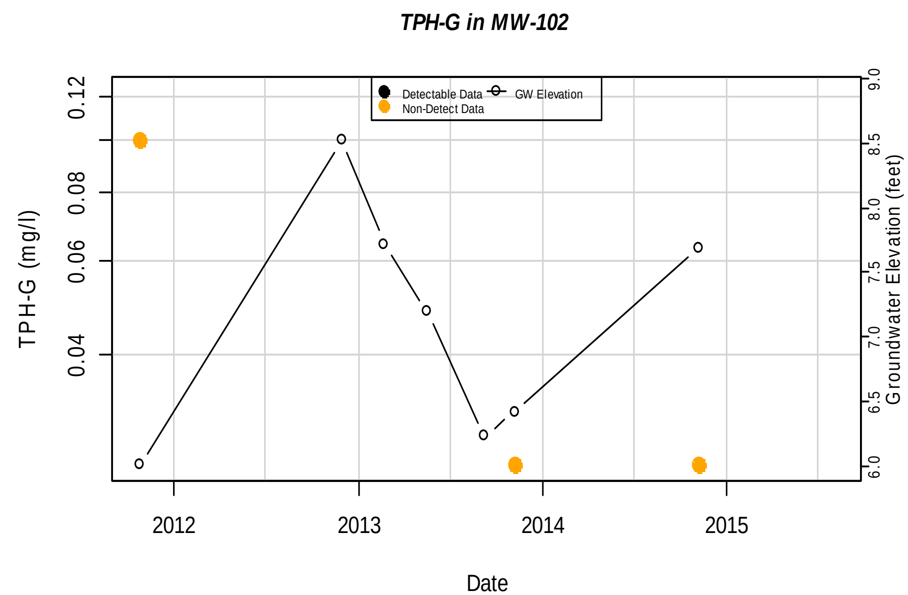
Agg.Date	PlumeAverageConc(mg/l)	COMy	COMx	PlumeArea (Unit Area)	PlumeMass (Mass/Unit Depth)	Plume Threshold Conc (ug/l)
10/29/2011	9.47	216669.02	1265273.12	6090.41	14.41	7250
11/29/2011	9.77	216662.94	1265278.12	7492.44	18.29	
3/29/2012	9.49	216668.98	1265278.26	6173.54	14.64	
6/29/2012	9.20	216678.85	1265276.57	3524.92	8.10	
9/29/2012	9.65	216650.38	1265228.56	9490.96	22.91	
11/29/2012	11.33	216650.35	1265210.67	16992.87	48.14	
3/1/2013	9.64	216658.09	1265206.09	13080.81	31.53	
5/29/2013	9.31	216672.83	1265198.72	7152.49	16.65	
9/29/2013	8.63	216665.67	1265169.99	3699.76	7.98	
11/29/2013	8.63	216658.73	1265166.63	3246.34	7.01	
1/29/2014	8.95	216657.91	1265191.00	3308.67	7.40	
4/29/2014	9.32	216664.89	1265212.49	4355.56	10.15	
7/29/2014	9.95	216656.82	1265204.26	6129.30	15.24	
11/29/2014	10.46	216645.36	1265192.99	8150.77	21.32	
6/29/2015	8.04	216678.48	1265275.05	1705.08	3.43	
7/29/2015	7.94	216676.45	1265273.48	1523.11	3.02	

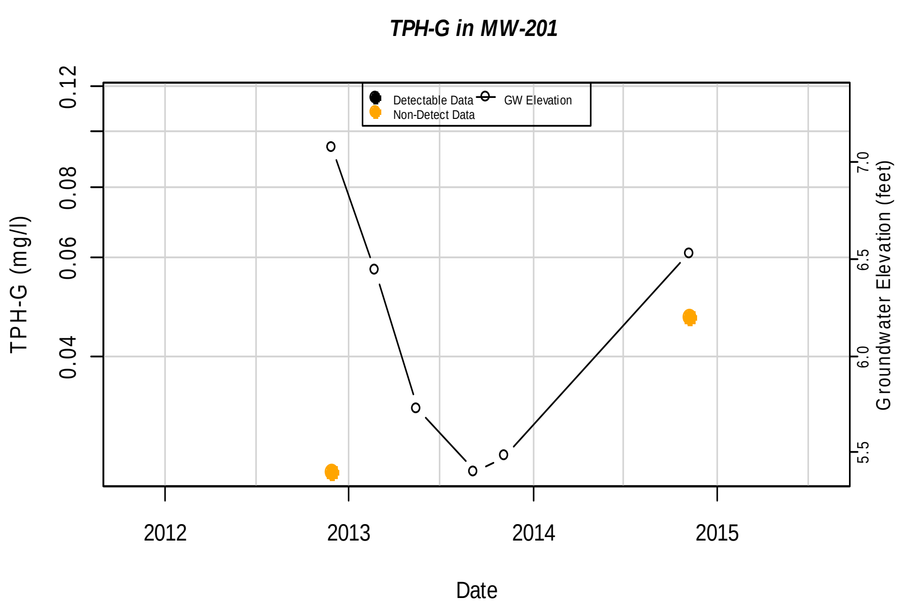


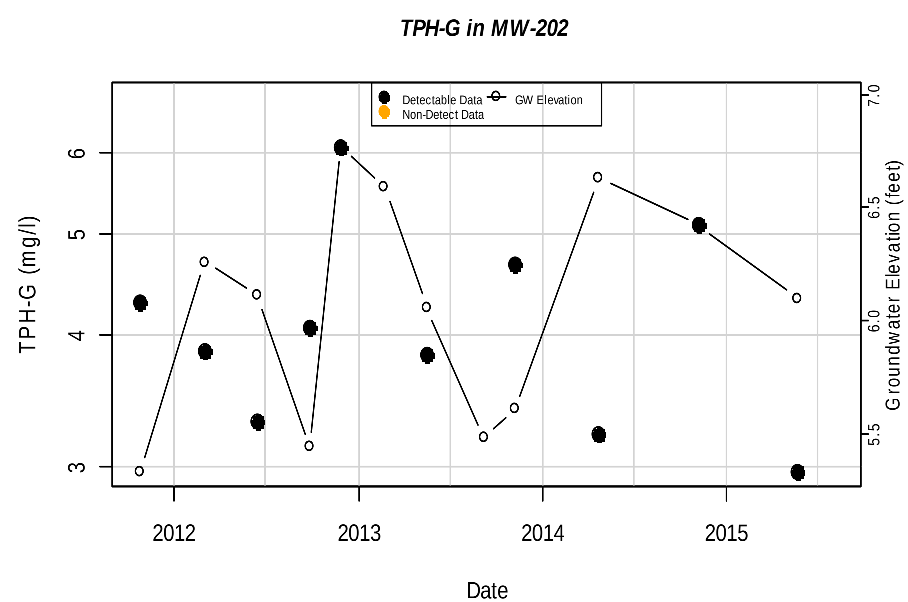


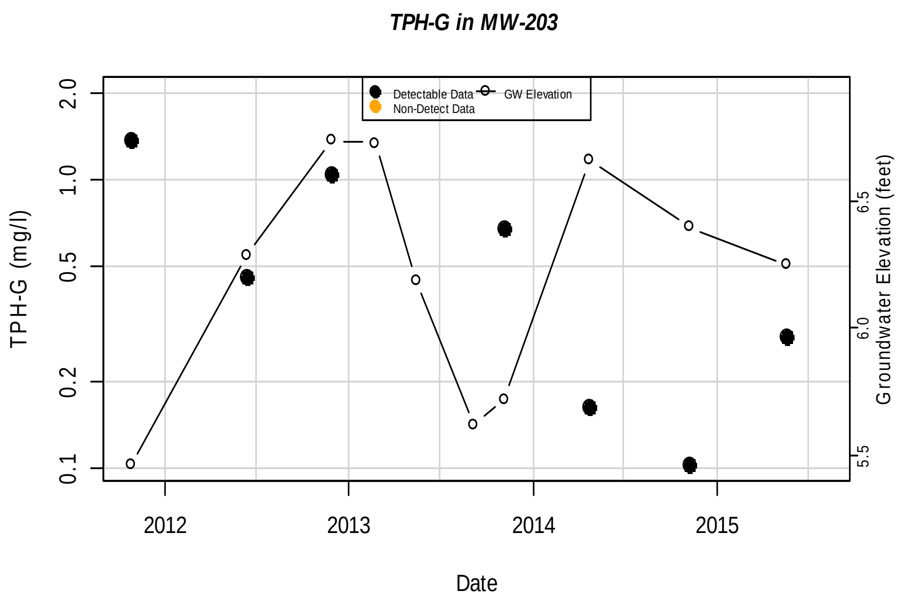


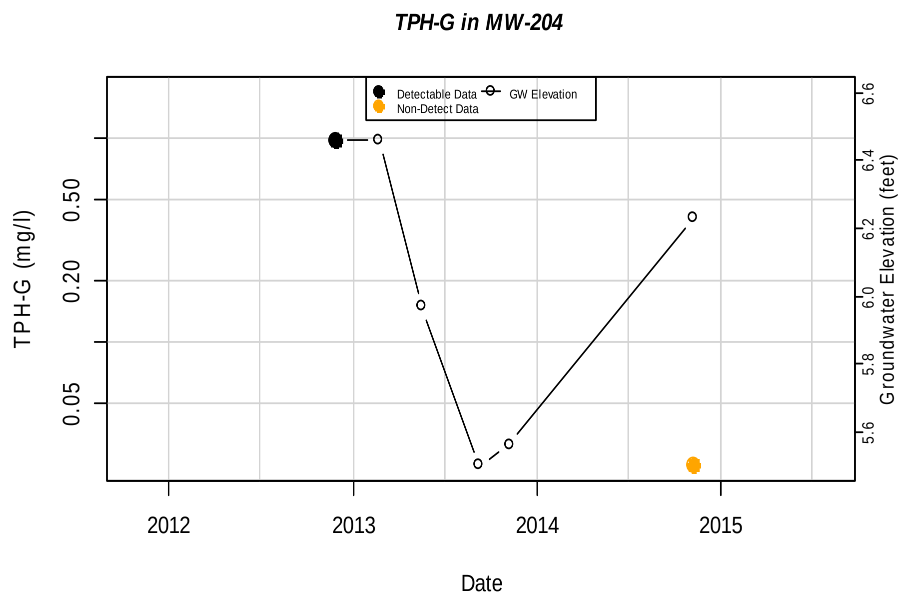

TPH-G in MW-101
Detectable Data
Non-Detect Data
GW Elevation
TPH-G (mg/l)
0.005
0.020
0.050
Groundwater Elevation (feet)
6.0
6.5
7.0
7.5
8.0
8.5
2012
2013
2014
2015
Date

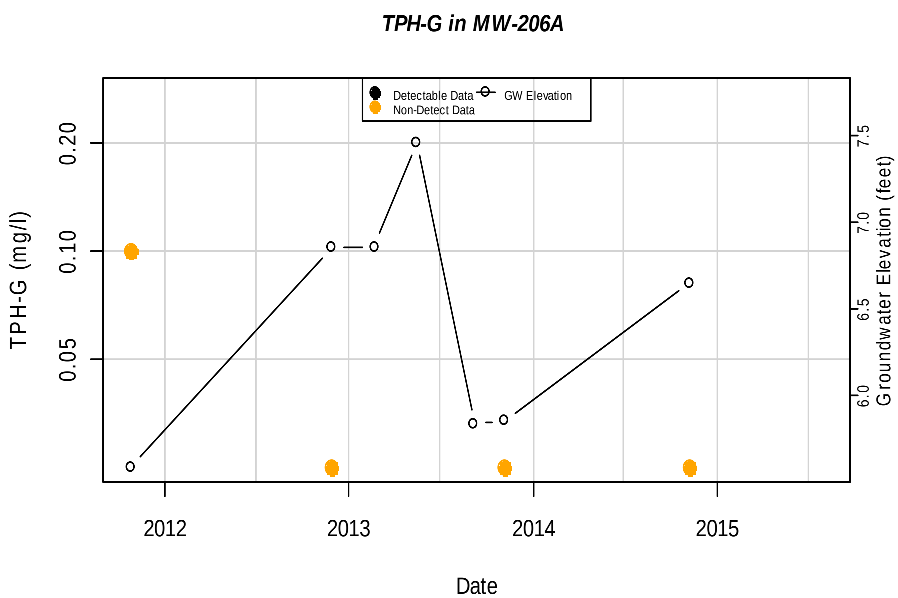

TPH-G in MW-102
Detectable Data
Non-Detect Data
GW Elevation
TPH-G (mg/l)
0.04
0.06
0.08
0.12
Groundwater Elevation (feet)
6.0
6.5
7.0
7.5
8.0
8.5
9.0
2012
2013
2014
2015
Date

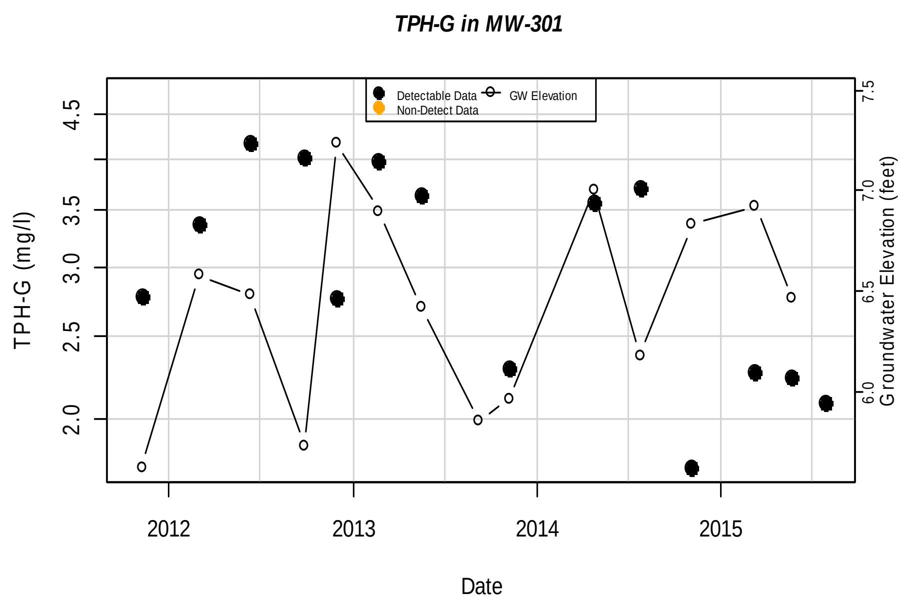

TPH-G in MW-201
Detectable Data
Non-Detect Data
GW Elevation
TPH-G (mg/l)
0.04
0.06
0.08
0.12
Groundwater Elevation (feet)
5.5
6.0
6.5
7.0
2012
2013
2014
2015
Date

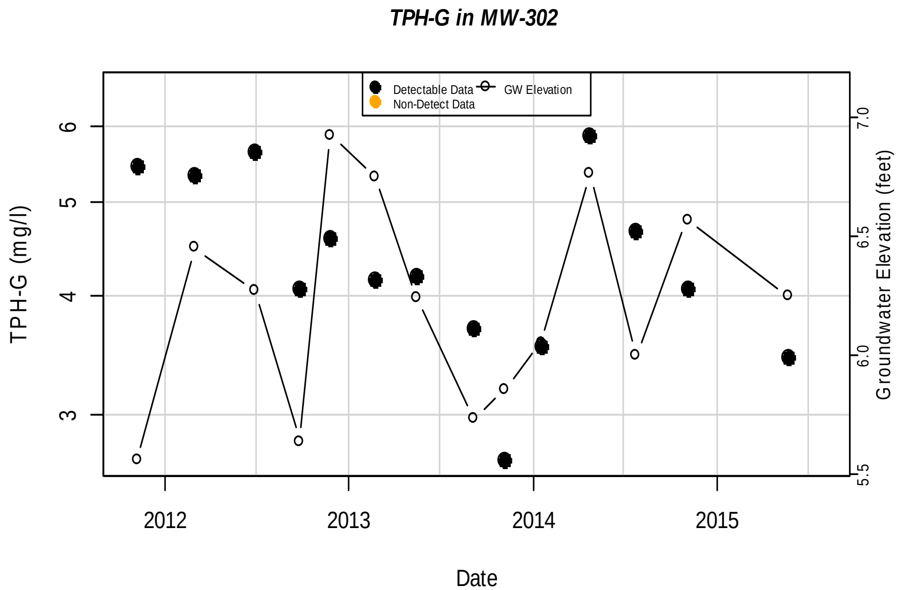

TPH-G in MW-202
Detectable Data
Non-Detect Data
GW Elevation
TPH-G (mg/l)
3
4
5
6
Groundwater Elevation (feet)
5.5
6.0
6.5
7.0
2012
2013
2014
2015
Date


TPH-G in MW-203
Detectable Data
Non-Detect Data
GW Elevation
TPH-G (mg/l)
Groundwater Elevation (feet)
Date

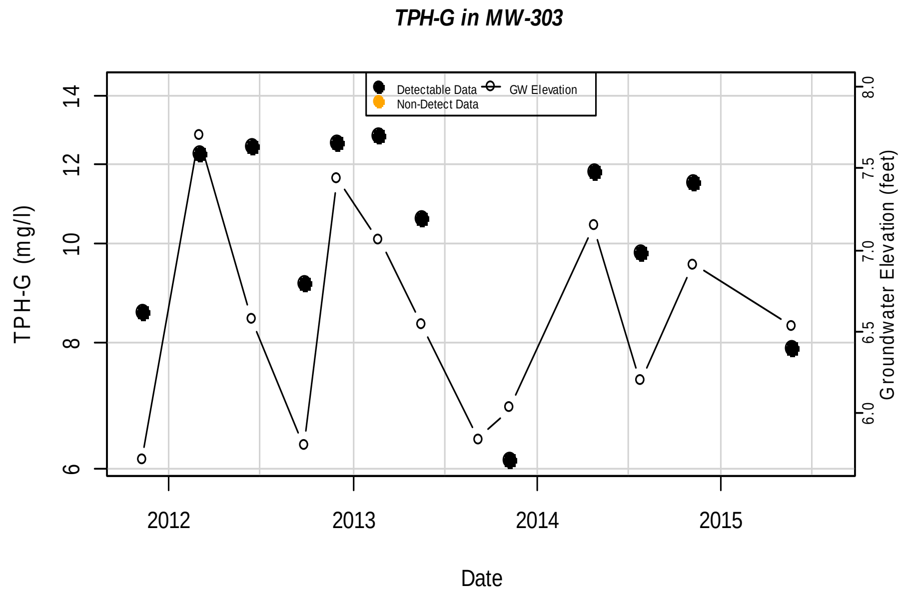

TPH-G in MW-204
Detectable Data
Non-Detect Data
GW Elevation
TPH-G (mg/l)
Groundwater Elevation (feet)
Date


TPH-G in MW-206A
Detectable Data
Non-Detect Data
GW Elevation
TPH-G (mg/l)
Groundwater Elevation (feet)
Date

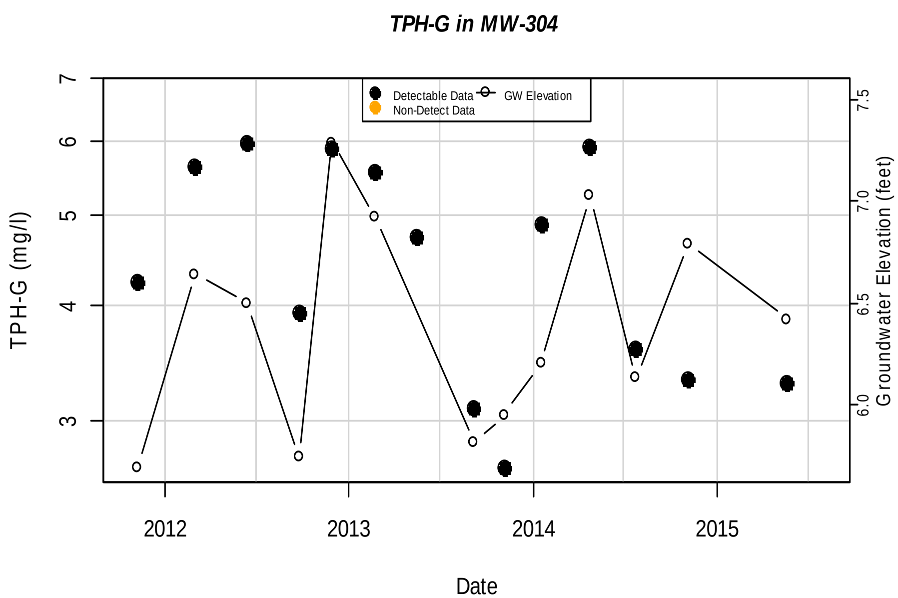

TPH-G in MW-301
Detectable Data
Non-Detect Data
GW Elevation
TPH-G (mg/l)
Groundwater Elevation (feet)
Date



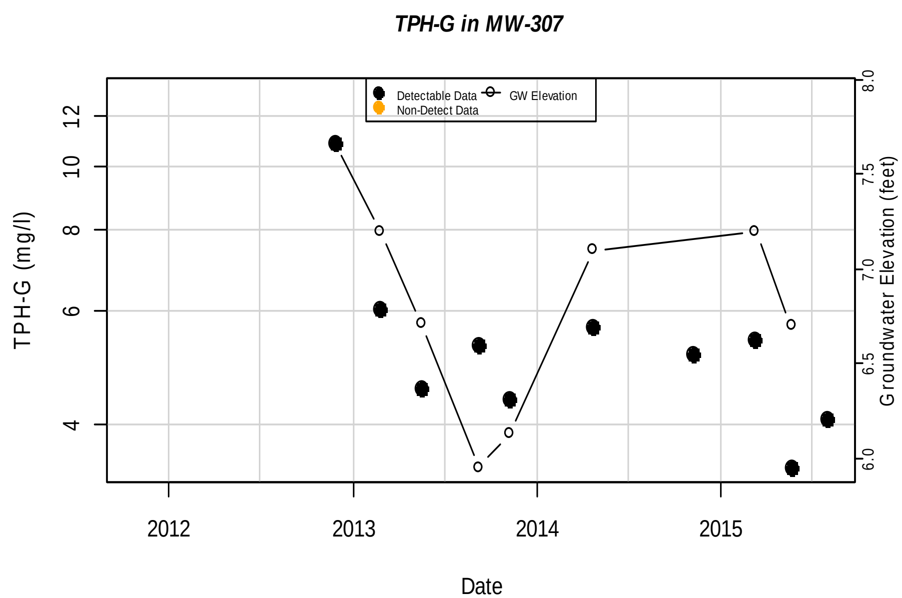
TPH-G in MW-302
Detectable Data
GW Elevation
Non-Detect Data
TPH-G (mg/l)
Groundwater Elevation (feet)
Date
2012
2013
2014
2015



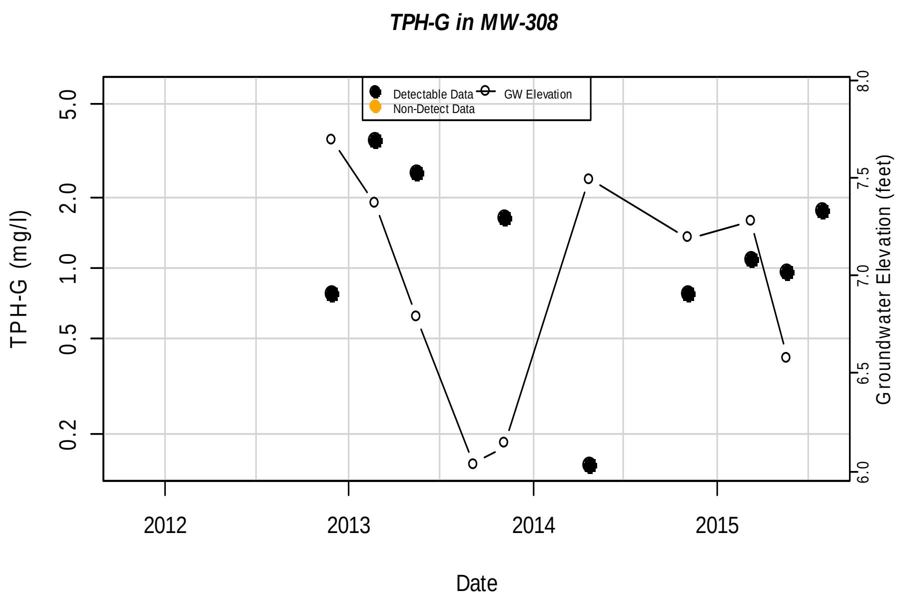
TPH-G in MW-303
Detectable Data
GW Elevation
Non-Detect Data
TPH-G (mg/l)
Groundwater Elevation (feet)
Date
2012
2013
2014
2015

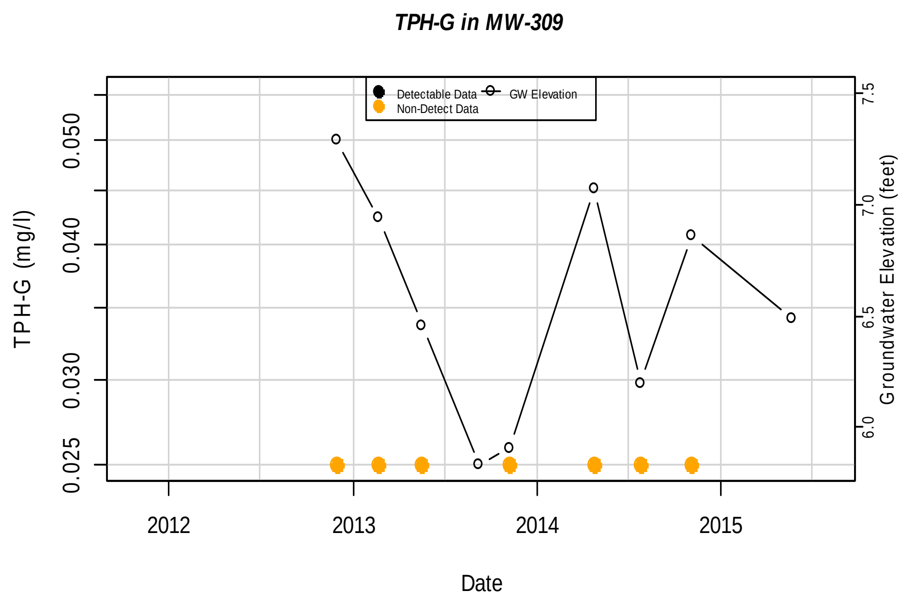


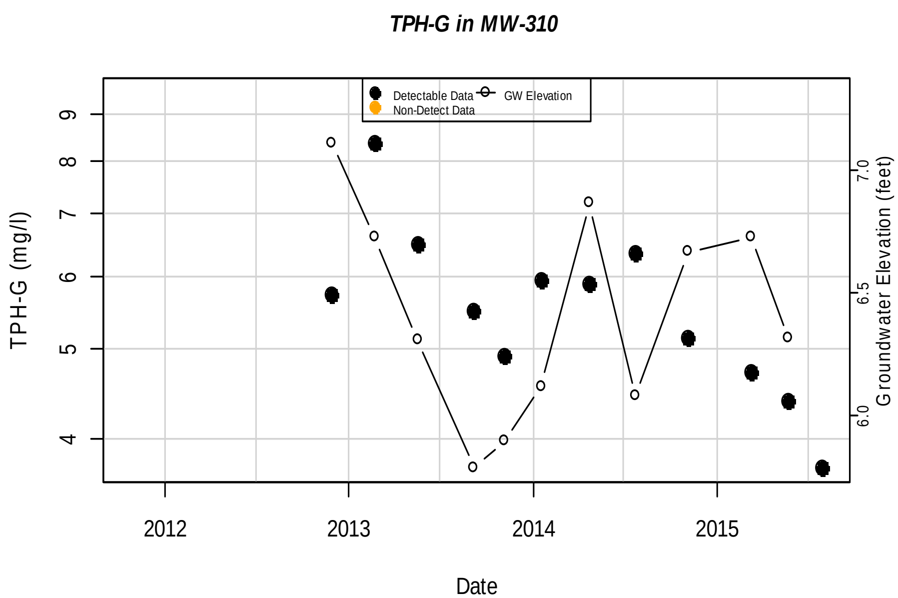
TPH-G in MW-304
Detectable Data
GW Elevation
Non-Detect Data
TPH-G (mg/l)
Groundwater Elevation (feet)
Date
2012
2013
2014
2015

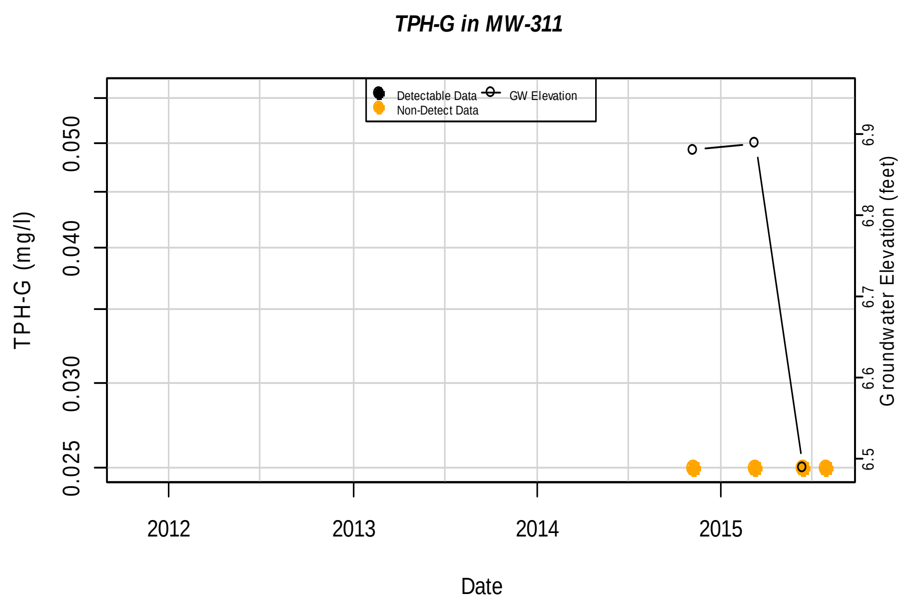


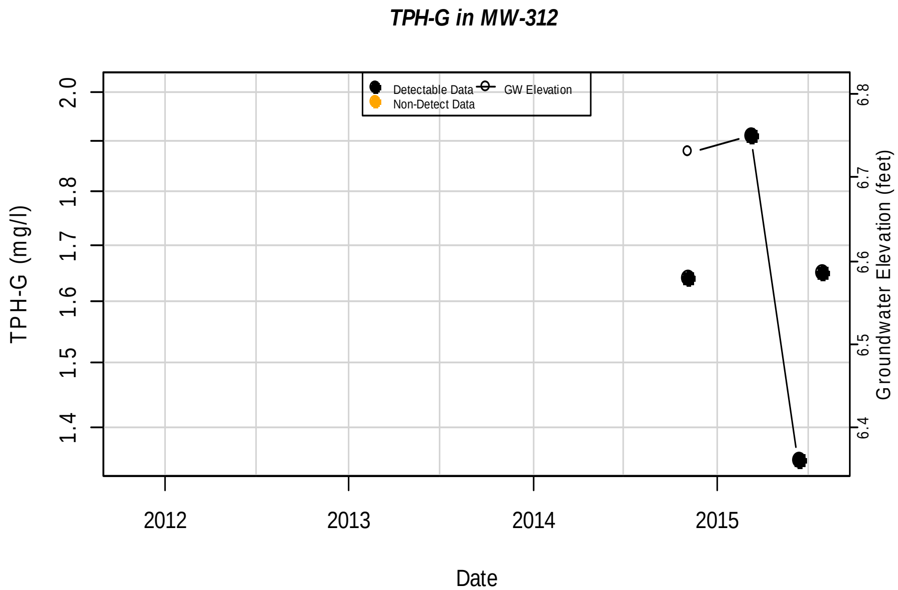
TPH-G in MW-307
Detectable Data
GW Elevation
Non-Detect Data
TPH-G (mg/l)
Groundwater Elevation (feet)
Date
2012
2013
2014
2015

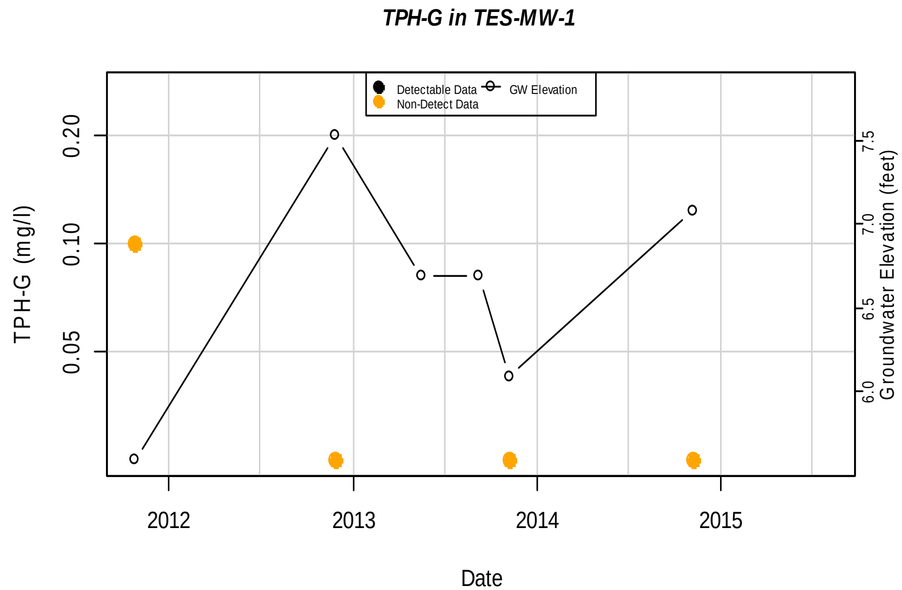

TPH-G in MW-308
Detectable Data
Non-Detect Data
GW Elevation
TPH-G (mg/l)
Groundwater Elevation (feet)
5.0
2.0
1.0
0.5
0.2
8.0
7.5
7.0
6.5
6.0
2012
2013
2014
2015
Date

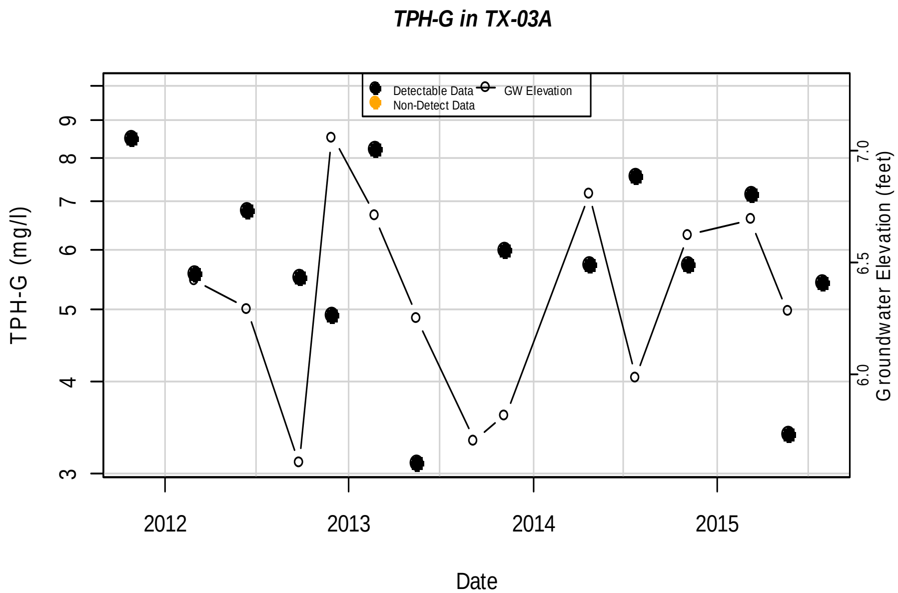

TPH-G in MW-309
Detectable Data
Non-Detect Data
GW Elevation
TPH-G (mg/l)
Groundwater Elevation (feet)
0.050
0.040
0.030
0.025
7.5
7.0
6.5
6.0
2012
2013
2014
2015
Date

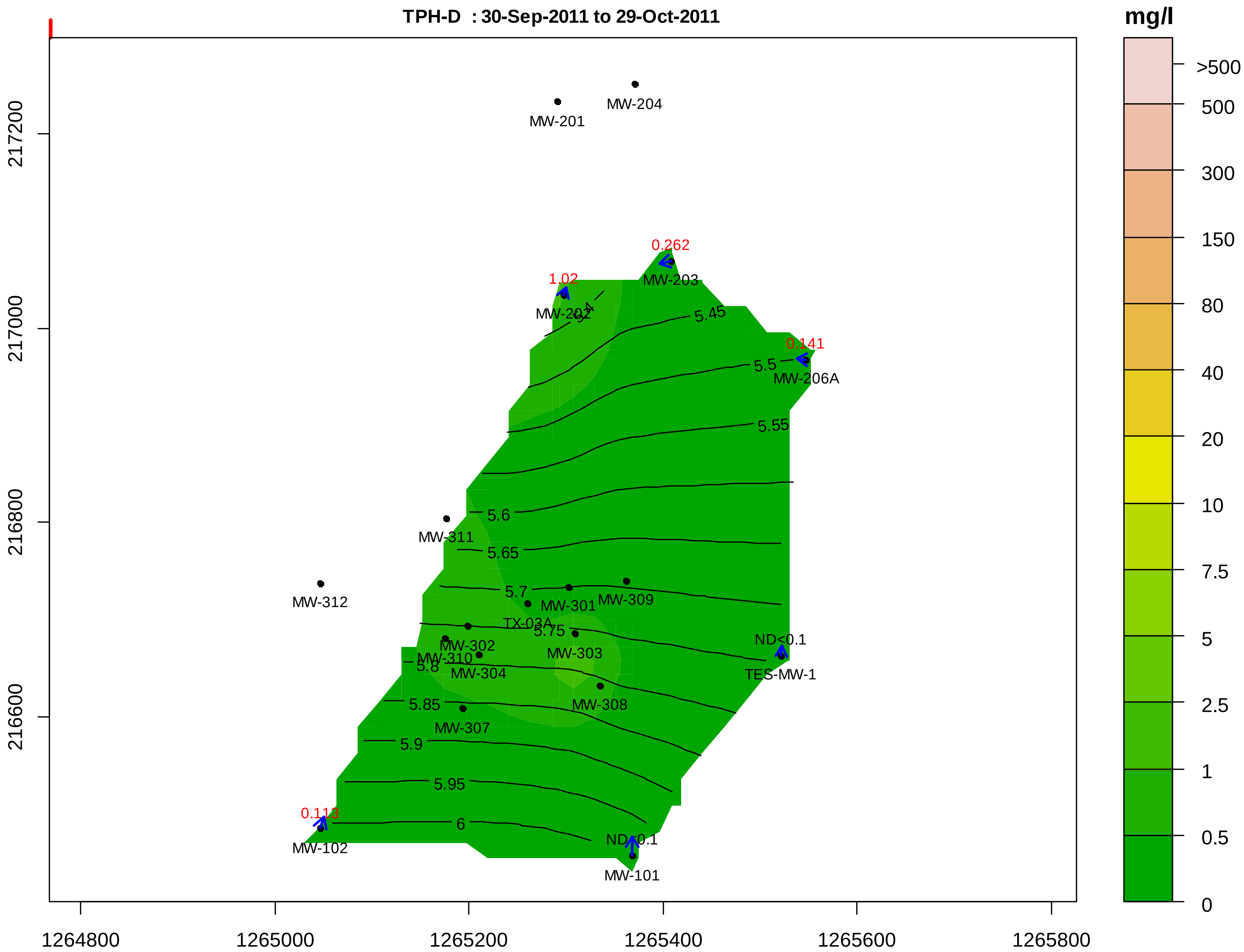

TPH-G in MW-310
Detectable Data
Non-Detect Data
GW Elevation
TPH-G (mg/l)
Groundwater Elevation (feet)
9
8
7
6
5
4
7.0
6.5
6.0
2012
2013
2014
2015
Date


TPH-G in MW-311
Detectable Data
Non-Detect Data
GW Elevation
TPH-G (mg/l)
Groundwater Elevation (feet)
0.050
0.040
0.030
0.025
6.9
6.8
6.7
6.6
6.5
2012
2013
2014
2015
Date

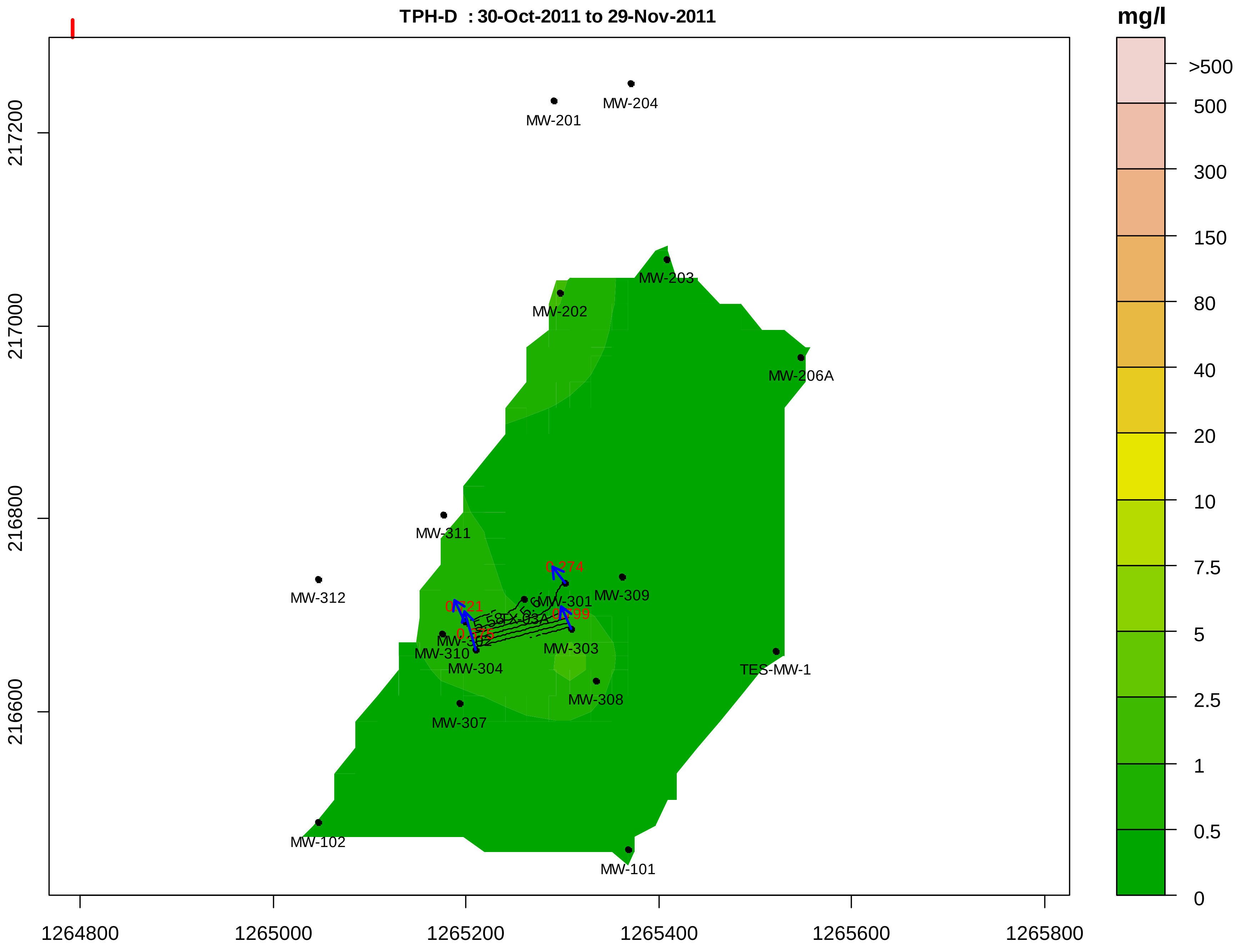

TPH-G in MW-312
Detectable Data
Non-Detect Data
GW Elevation
TPH-G (mg/l)
Groundwater Elevation (feet)
Date
2012
2013
2014
2015
2.0
1.8
1.7
1.6
1.5
1.4
6.8
6.7
6.6
6.5
6.4


TPH-G in TES-MW-1
Detectable Data
Non-Detect Data
GW Elevation
TPH-G (mg/l)
Groundwater Elevation (feet)
Date
2012
2013
2014
2015
0.20
0.10
0.05
7.5
7.0
6.5
6.0

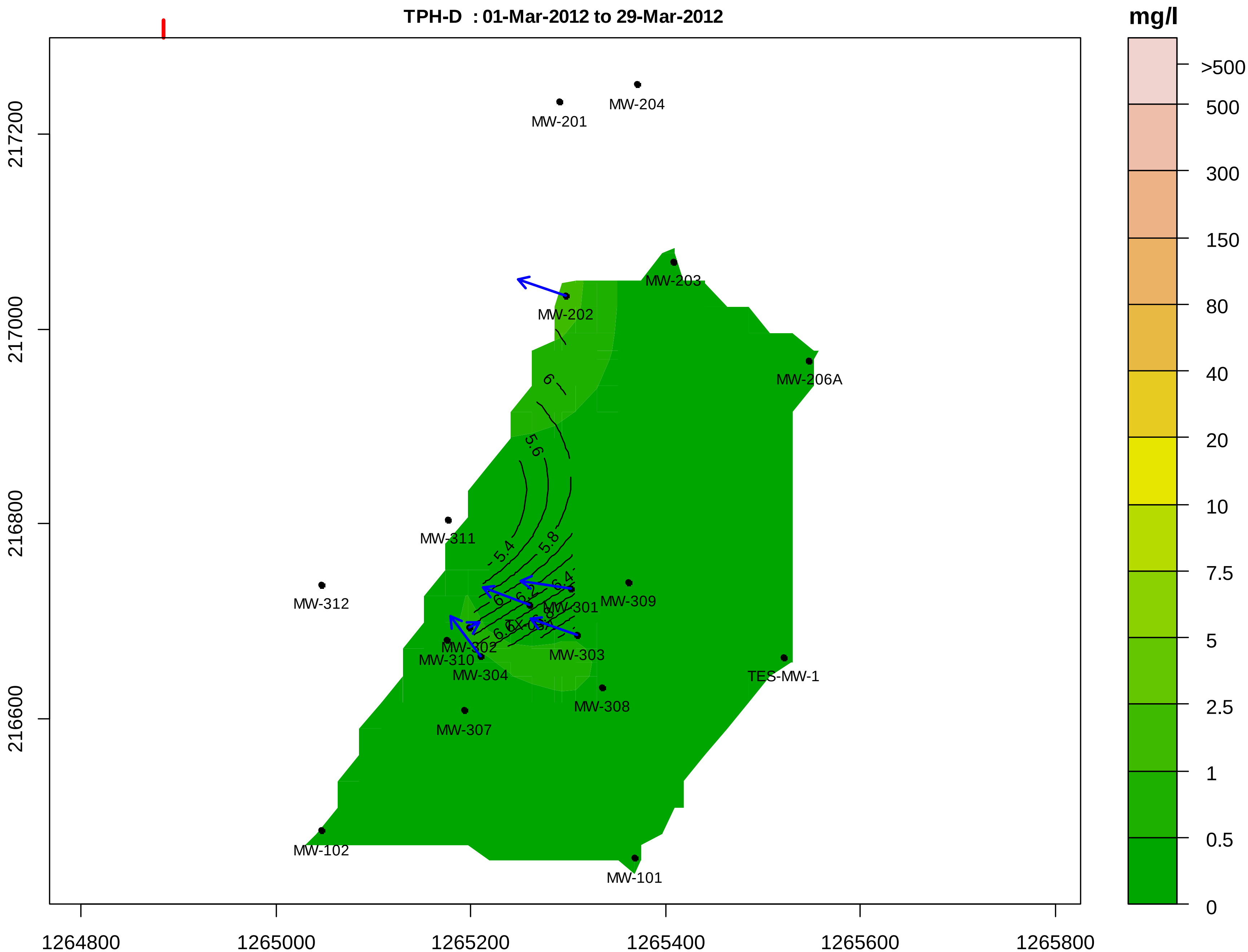

TPH-G in TX-03A
Detectable Data
Non-Detect Data
GW Elevation
TPH-G (mg/l)
Groundwater Elevation (feet)
Date
2012
2013
2014
2015
9
8
7
6
5
4
3
7.0
6.5
6.0

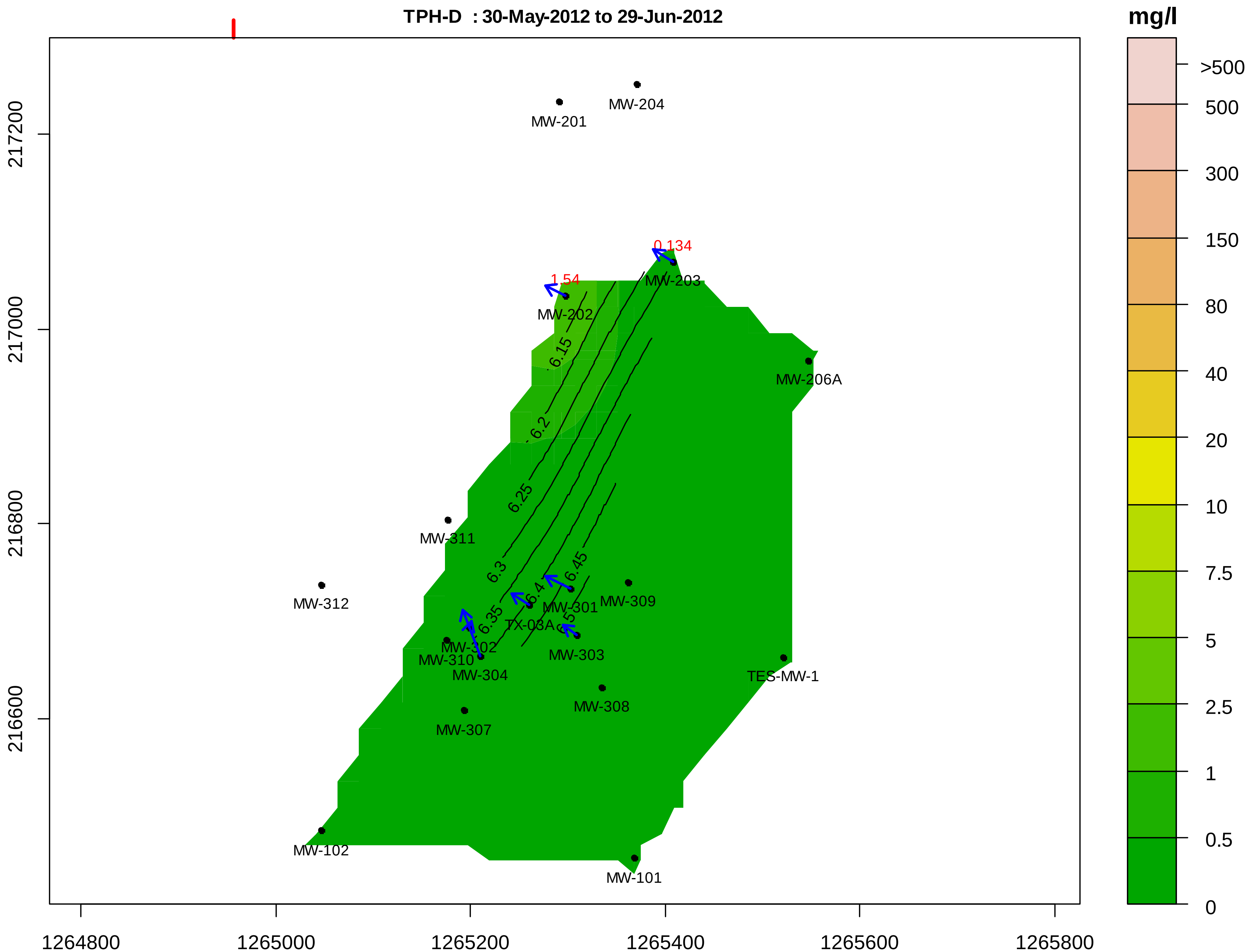


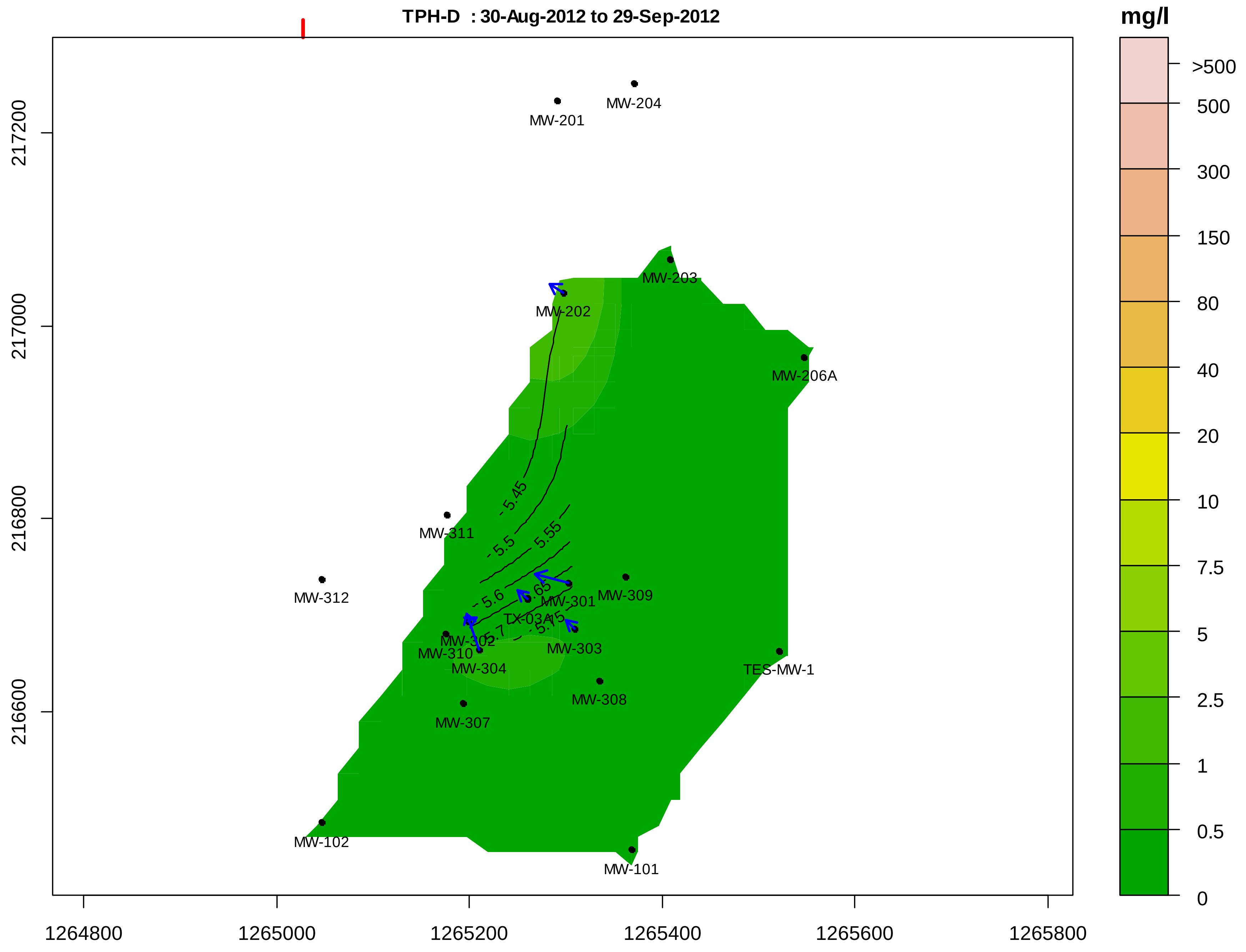
TPH-D : 30-Sep-2011 to 29-Oct-2011
mg/l
>500
500
300
150
80
40
20
10
7.5
5
2.5
1
0.5
0
MW-201
MW-204
MW-202
MW-203
MW-206A
MW-311
MW-312
MW-301
MW-309
TX-03A
MW-302
MW-303
MW-310
MW-304
MW-308
MW-307
TES-MW-1
MW-102
MW-101
1.02
0.262
0.141
0.113
ND<0.1
5.45
5.5
5.55
5.6
5.65
5.7
5.75
5.8
5.85
5.9
5.95
6
217200
217000
216800
216600
1264800
1265000
1265200
1265400
1265600
1265800


TPH-D : 30-Oct-2011 to 29-Nov-2011
mg/l
>500
500
300
150
80
40
20
10
7.5
5
2.5
1
0.5
0
217200
217000
216800
216600
1264800
1265000
1265200
1265400
1265600
1265800
MW-201
MW-204
MW-203
MW-202
MW-206A
MW-311
MW-312
MW-309
MW-301
MW-303
MW-302
MW-310
MW-304
MW-308
MW-307
TES-MW-1
MW-102
MW-101

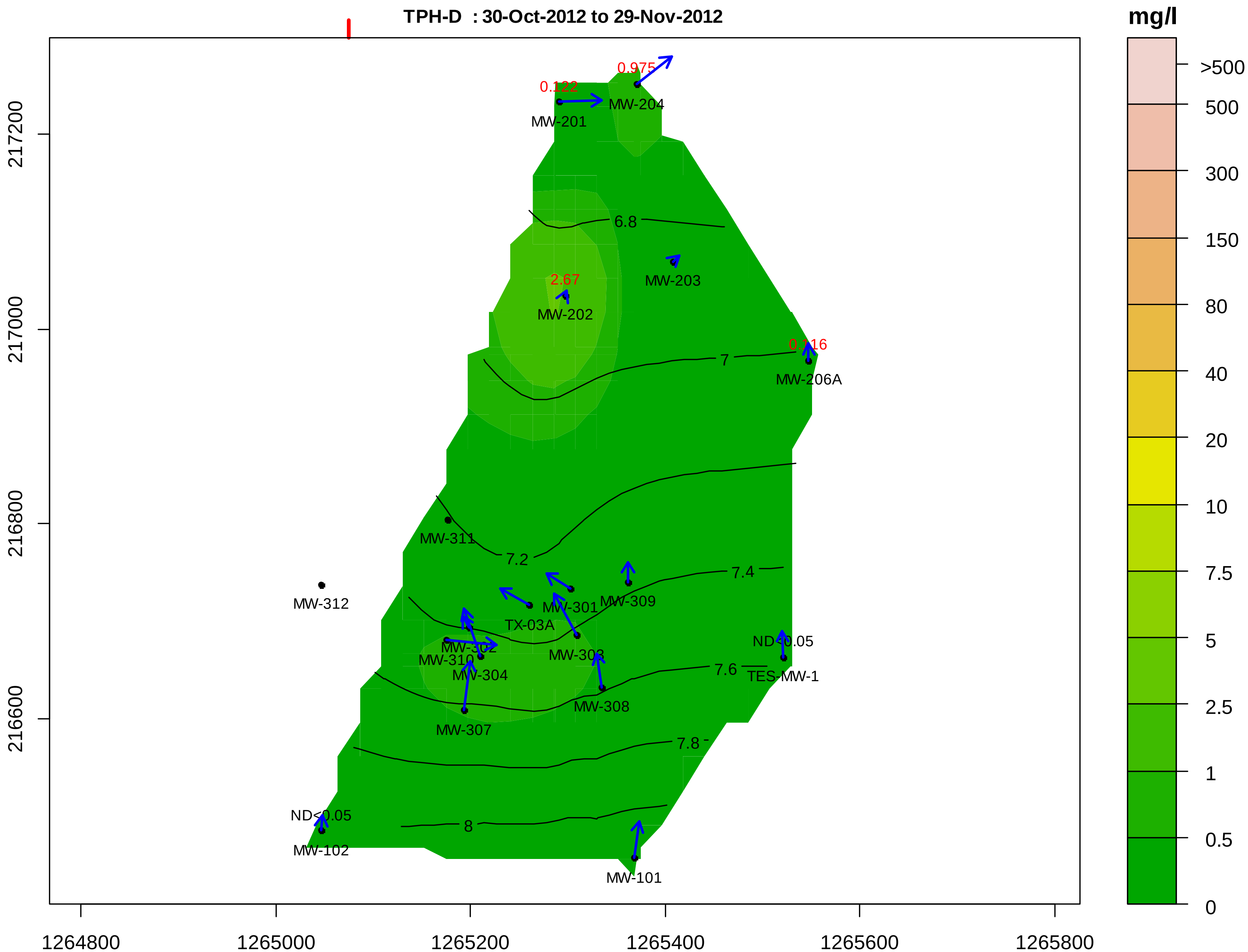
TPH-D : 01-Mar-2012 to 29-Mar-2012



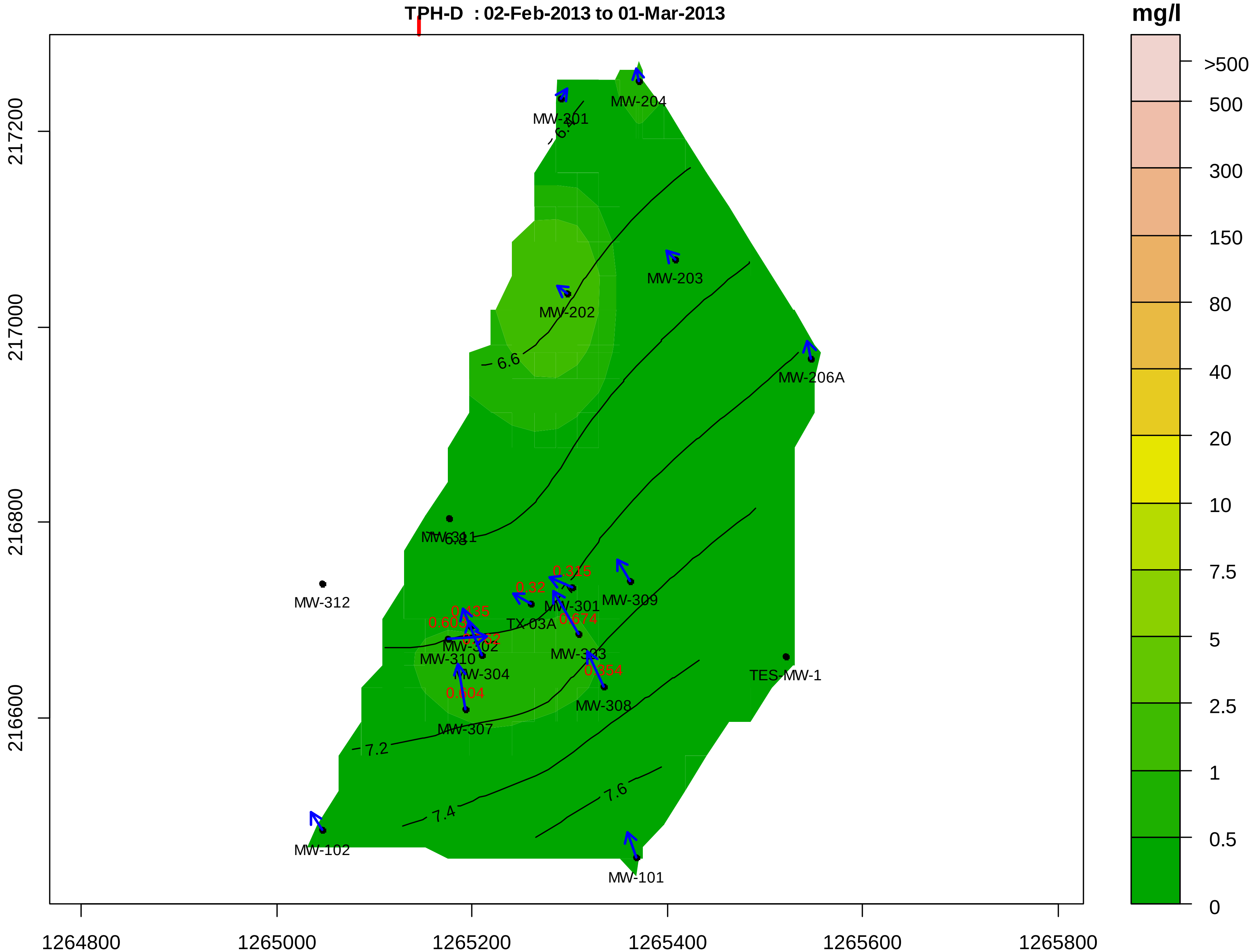

TPH-D : 30-May-2012 to 29-Jun-2012
mg/l
>500
500
300
150
80
40
20
10
7.5
5
2.5
1
0.5
0
217200
217000
216800
216600
1264800
1265000
1265200
1265400
1265600
1265800
MW-201
MW-204
0.134
MW-203
1.54
MW-202
MW-206A
MW-311
MW-312
MW-309
MW-301
TX-03A
MW-302
MW-310
MW-304
MW-303
TES-MW-1
MW-308
MW-307
MW-102
MW-101
6.15
6.2
6.25
6.3
6.35
6.4
6.45

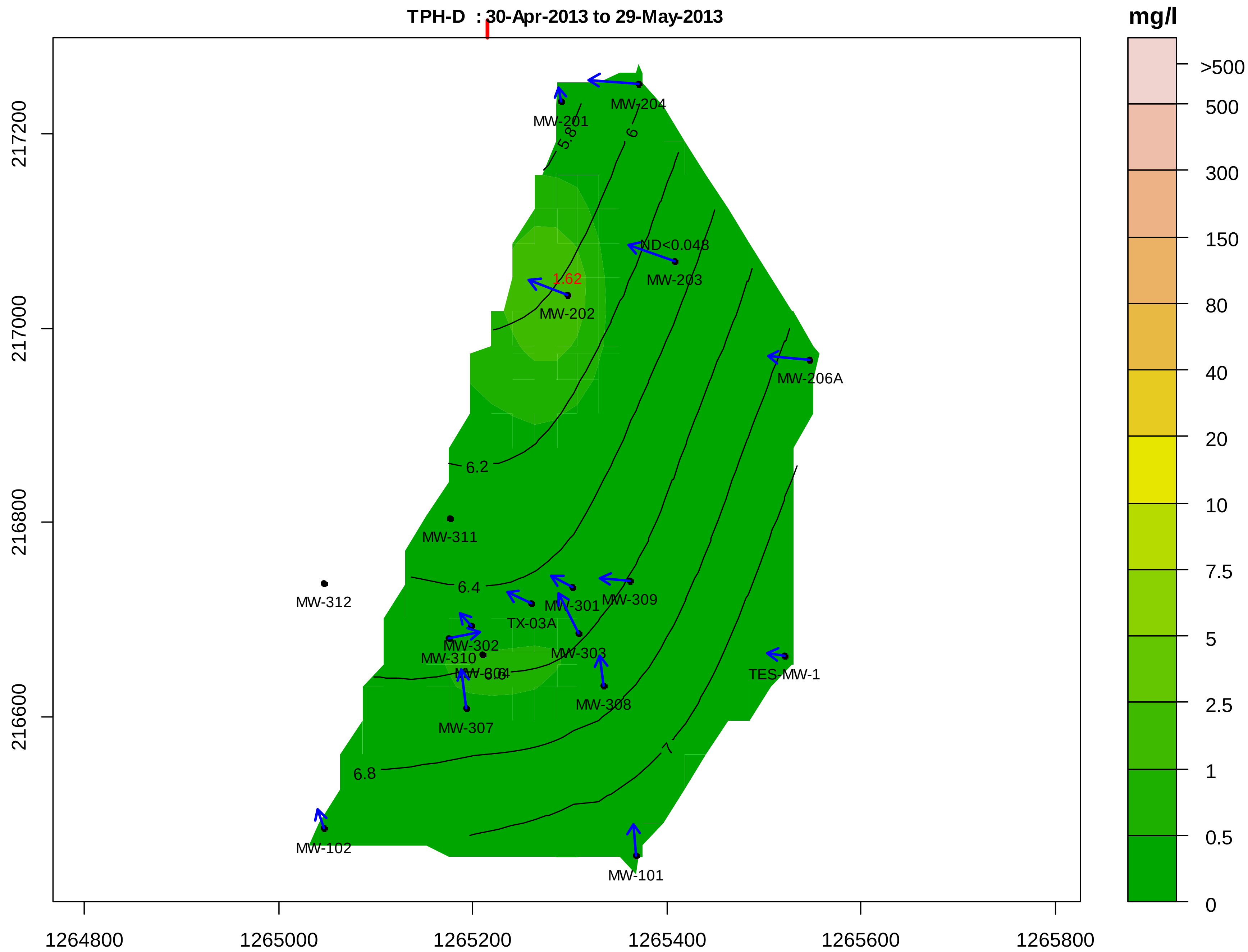


TPH-D : 30-Aug-2012 to 29-Sep-2012
mg/l
>500
500
300
150
80
40
20
10
7.5
5
2.5
1
0.5
0
217200
217000
216800
216600
1264800
1265000
1265200
1265400
1265600
1265800
MW-201
MW-204
MW-203
MW-202
MW-206A
MW-311
MW-312
MW-309
MW-301
TX-03A
MW-302
MW-310
MW-304
MW-303
TES-MW-1
MW-308
MW-307
MW-102
MW-101
5.45
5.5
5.55
5.6
5.65
5.7
5.75

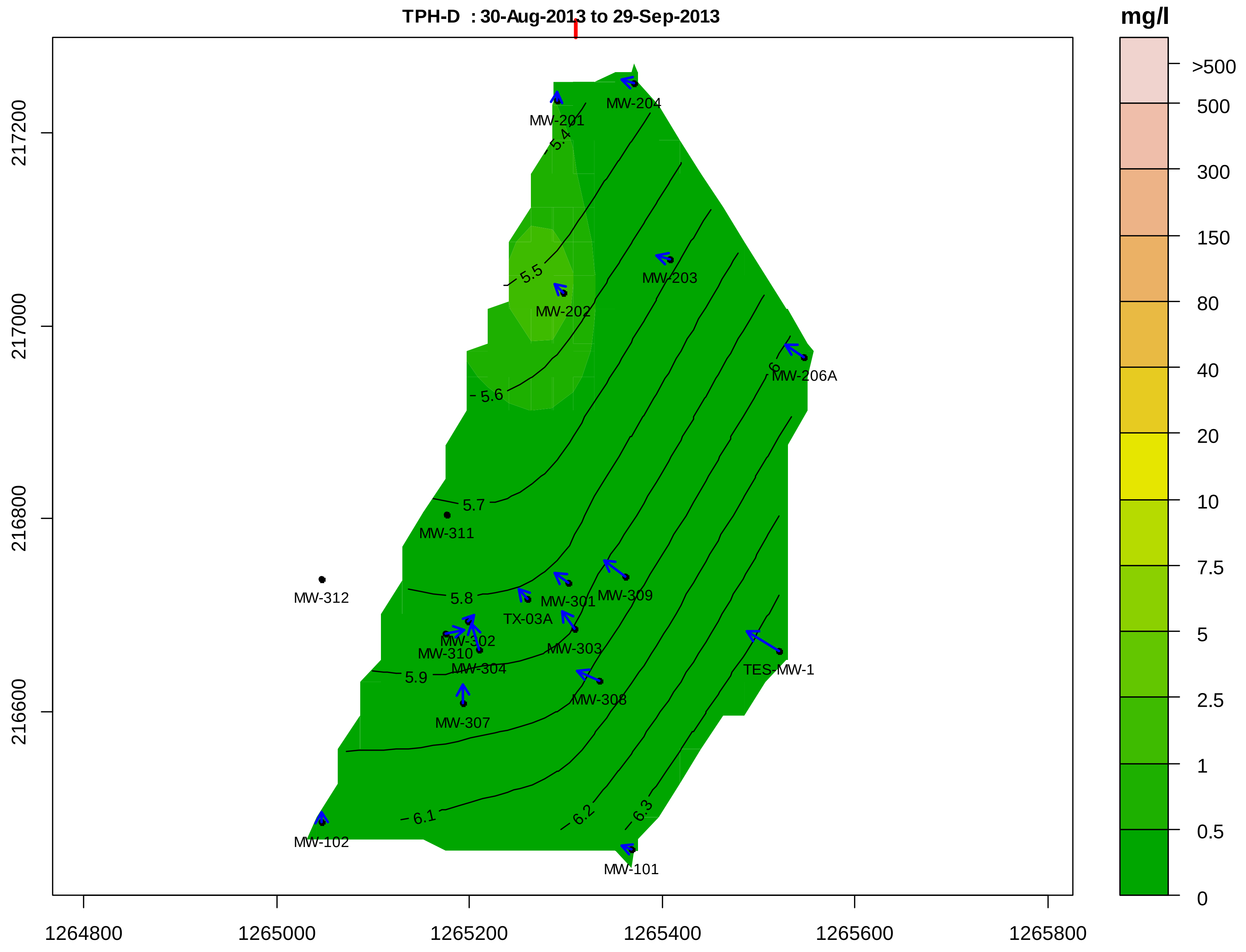

TPH-D : 30-Oct-2012 to 29-Nov-2012
mg/l
>500
500
300
150
80
40
20
10
7.5
5
2.5
1
0.5
0
0.975
0.122
MW-204
MW-201
6.8
2.67
MW-203
MW-202
0.116
7
MW-206A
MW-311
7.2
7.4
MW-312
MW-301
MW-309
TX-03A
ND<0.05
MW-302
MW-310
MW-303
MW-304
7.6
TES-MW-1
MW-308
MW-307
7.8
ND<0.05
8
MW-102
MW-101
217200
217000
216800
216600
1264800
1265000
1265200
1265400
1265600
1265800

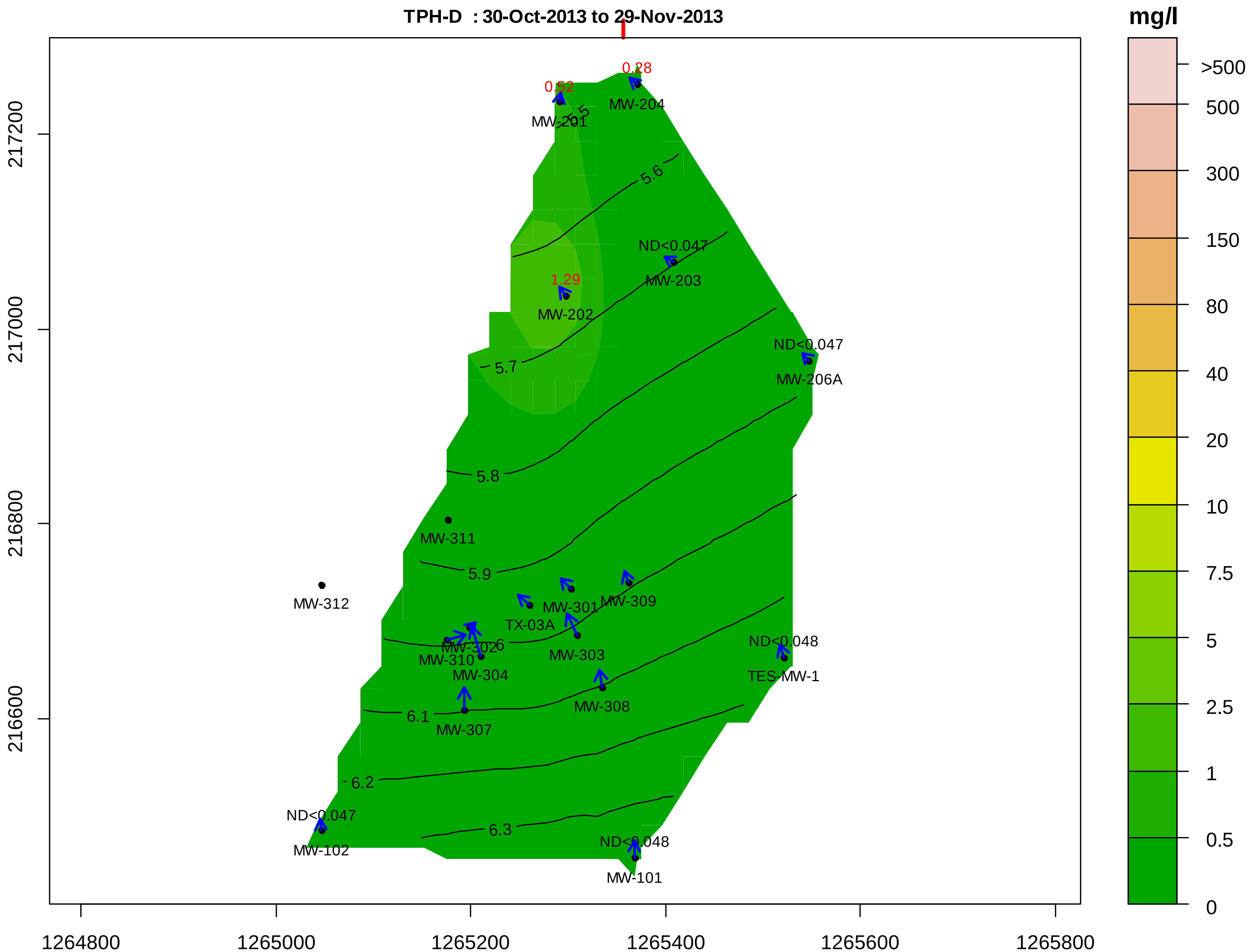
TPH-D : 02-Feb-2013 to 01-Mar-2013



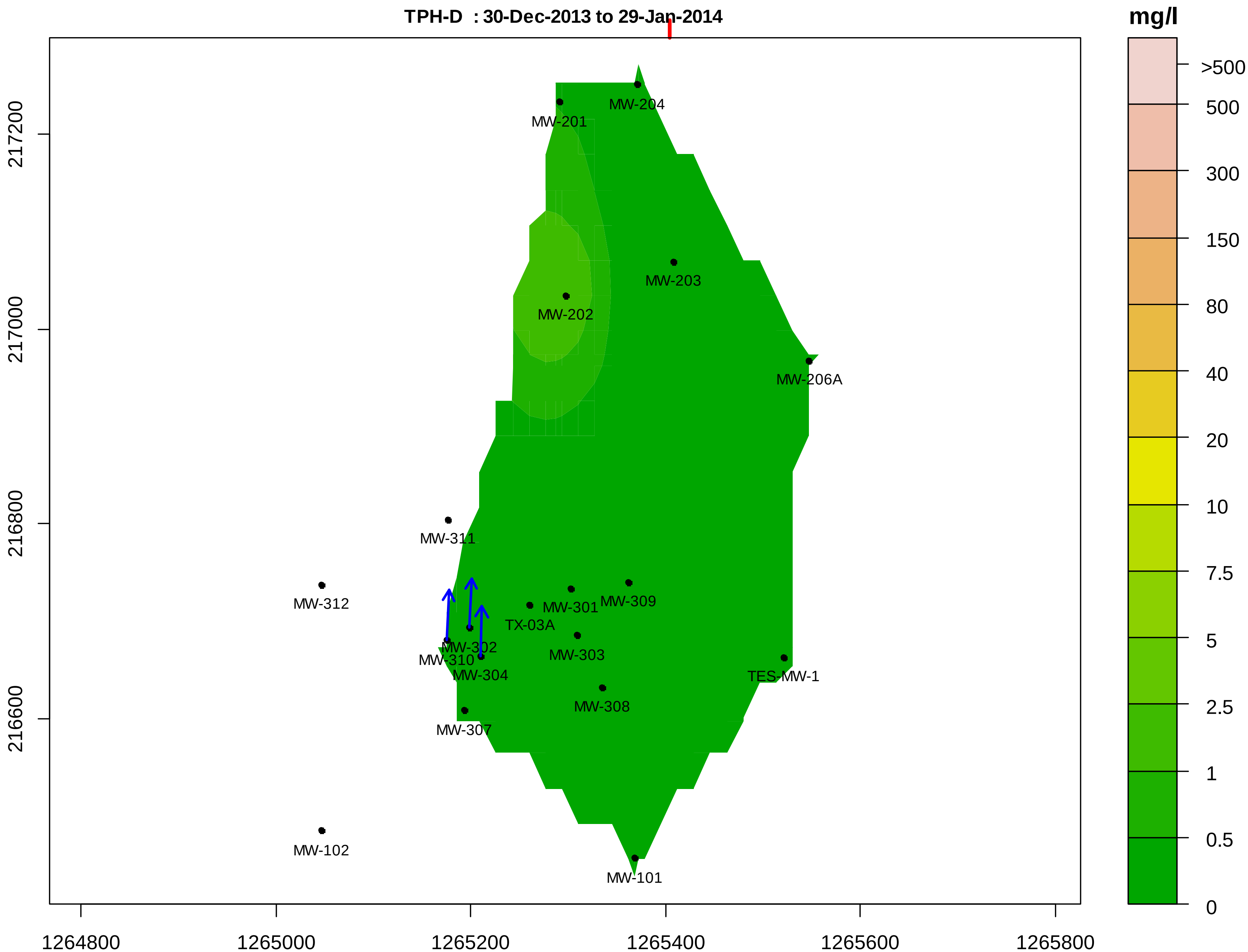


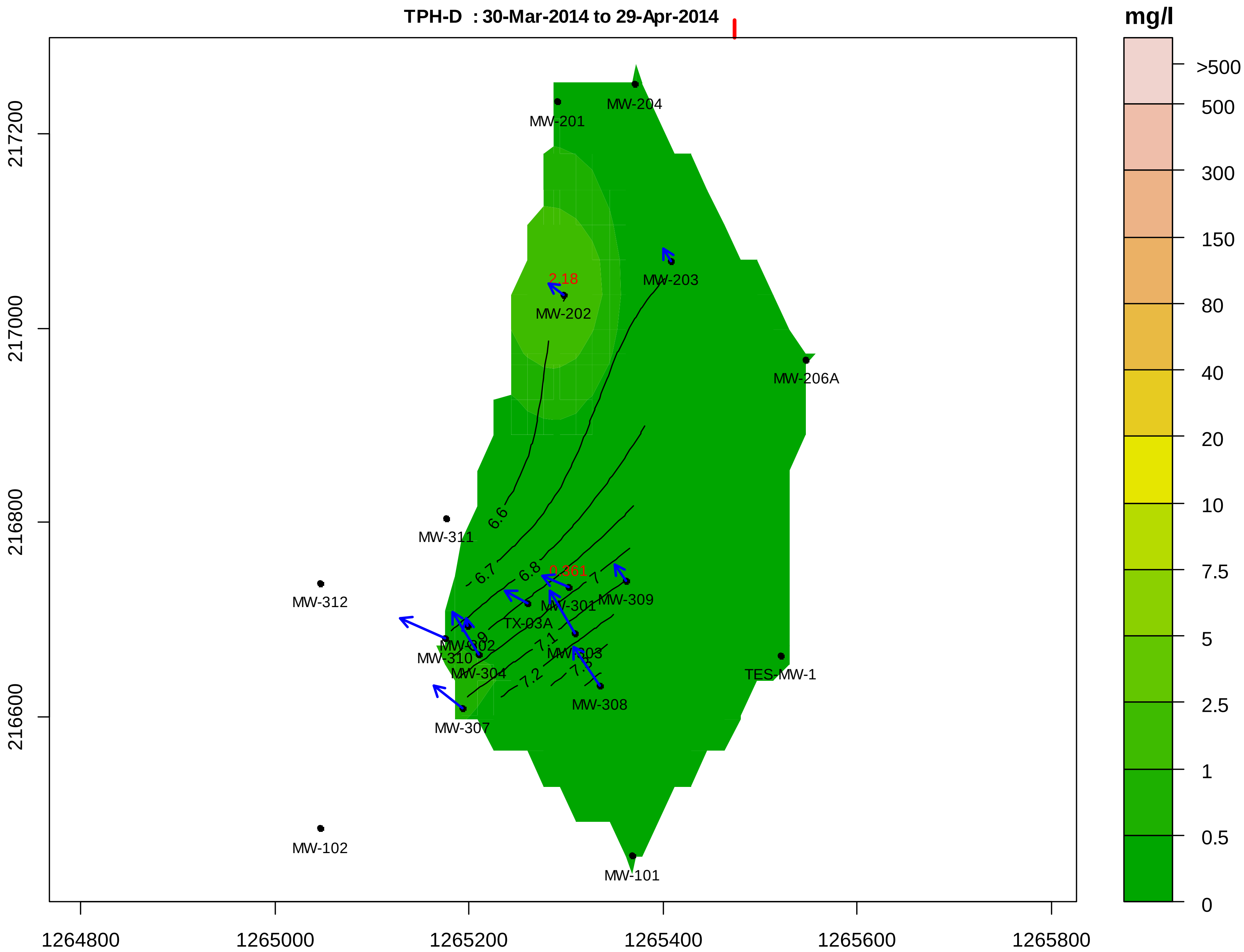
TPH-D : 30-Apr-2013 to 29-May-2013
mg/l
>500
500
300
150
80
40
20
10
7.5
5
2.5
1
0.5
0
217200
217000
216800
216600
1264800
1265000
1265200
1265400
1265600
1265800
MW-201
MW-204
5.8
6
ND<0.048
MW-203
1.62
MW-202
MW-206A
6.2
MW-311
MW-312
6.4
TX-03A
MW-301
MW-309
MW-302
MW-310
MW-303
TES-MW-1
MW-307
MW-308
7
6.8
MW-102
MW-101


TPH-D : 30-Aug-2013 to 29-Sep-2013
mg/l
>500
500
300
150
80
40
20
10
7.5
5
2.5
1
0.5
0
217200
217000
216800
216600
1264800
1265000
1265200
1265400
1265600
1265800
MW-201
MW-204
MW-203
MW-202
MW-206A
MW-311
MW-312
MW-301
MW-309
TX-03A
MW-302
MW-310
MW-304
MW-303
TES-MW-1
MW-308
MW-307
MW-102
MW-101
5.4
5.5
5.6
5.7
5.8
5.9
6
6.1
6.2
6.3

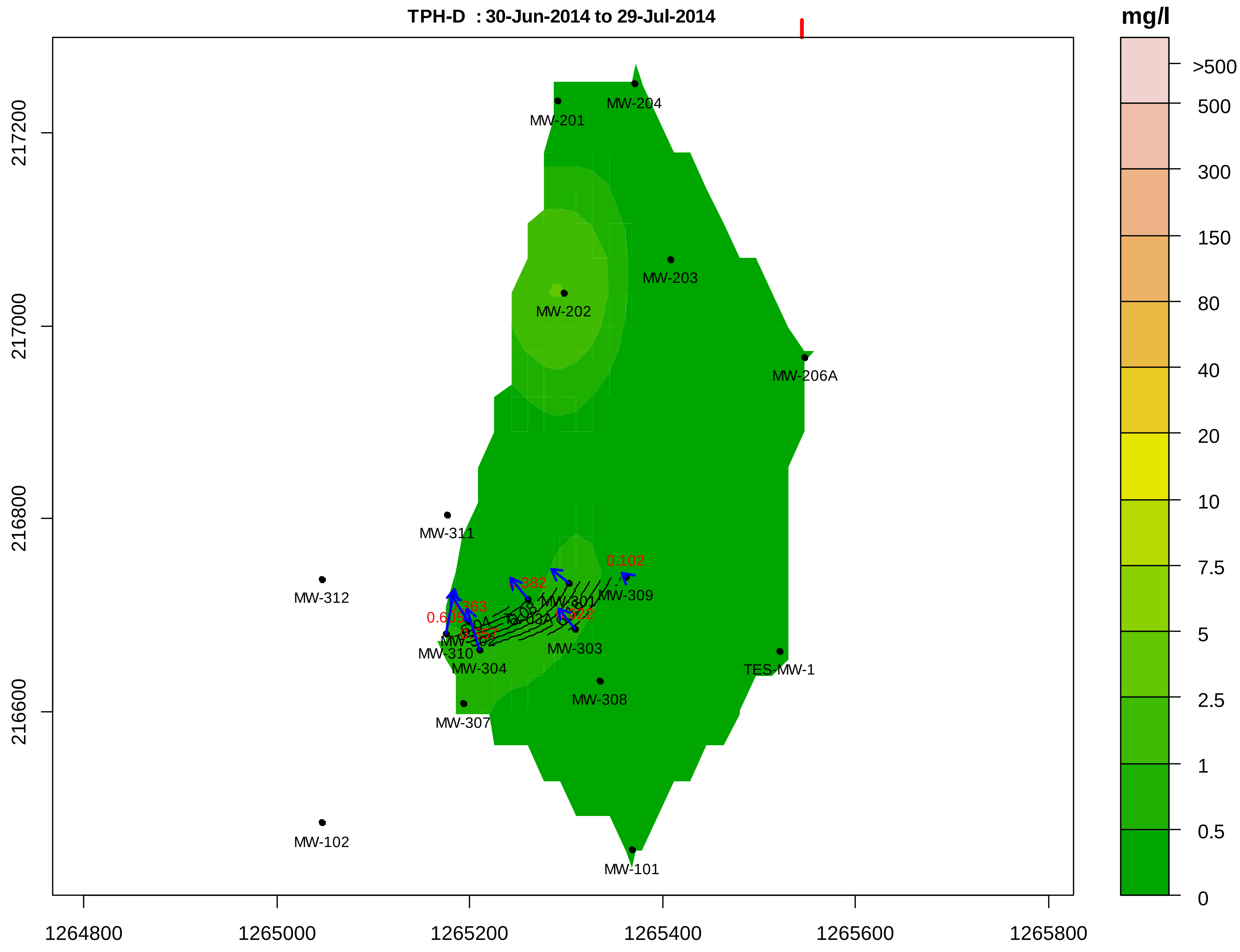


TPH-D : 30-Oct-2013 to 29-Nov-2013
mg/l
>500
500
300
150
80
40
20
10
7.5
5
2.5
1
0.5
0
217200
217000
216800
216600
1264800
1265000
1265200
1265400
1265600
1265800
0.52
MW-201
0.28
MW-204
5.5
5.6
ND<0.047
MW-203
1.29
MW-202
5.7
ND<0.047
MW-206A
5.8
MW-311
5.9
MW-312
MW-301
MW-309
TX-03A
MW-302
MW-310
6
MW-303
MW-304
ND<0.048
TES-MW-1
MW-308
6.1
MW-307
6.2
ND<0.047
MW-102
6.3
ND<0.048
MW-101

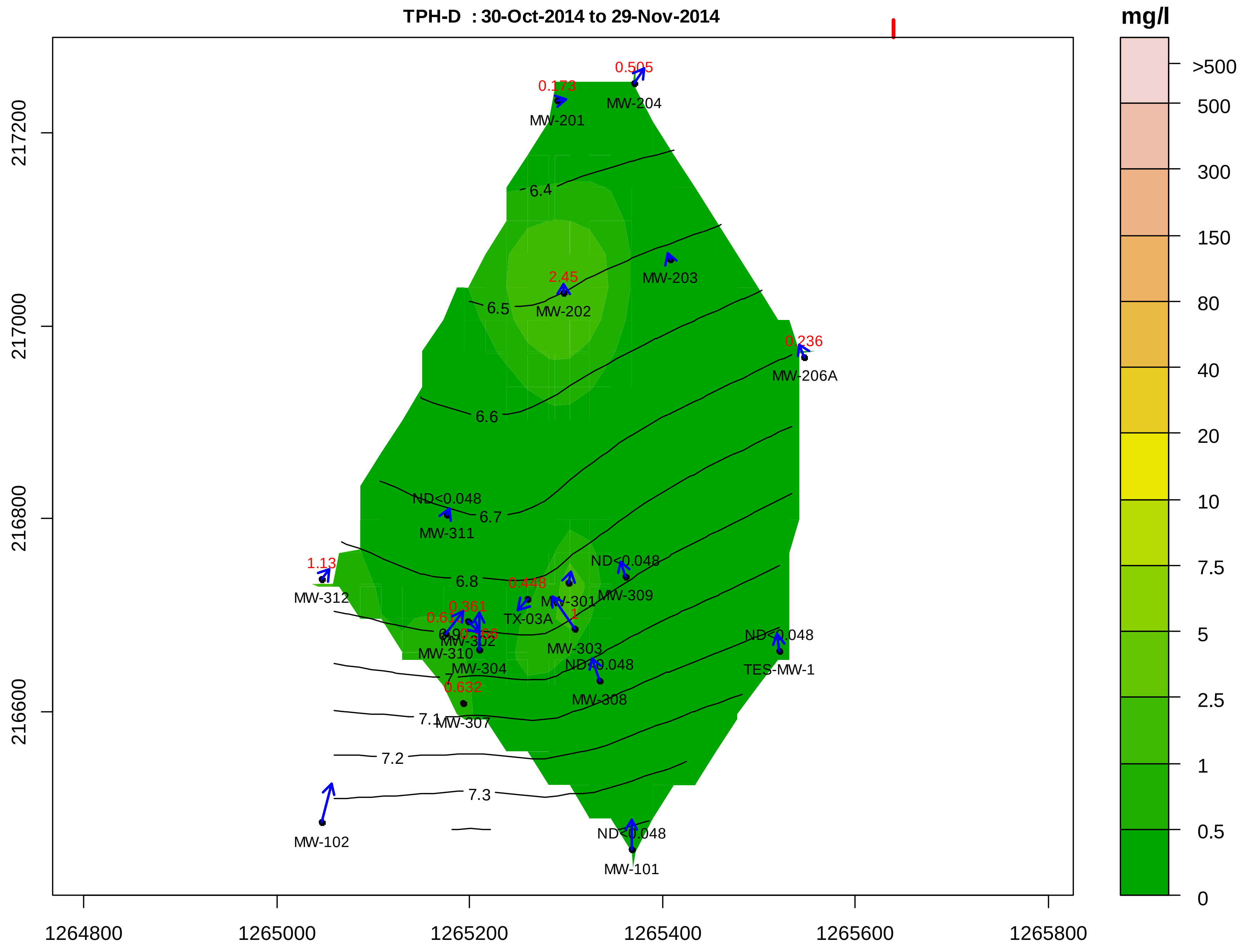

TPH-D : 30-Dec-2013 to 29-Jan-2014
mg/l
>500
500
300
150
80
40
20
10
7.5
5
2.5
1
0.5
0
217200
217000
216800
216600
1264800
1265000
1265200
1265400
1265600
1265800
MW-204
MW-201
MW-203
MW-202
MW-206A
MW-311
MW-312
MW-301
MW-309
TX-03A
MW-302
MW-310
MW-304
MW-303
TES-MW-1
MW-308
MW-307
MW-102
MW-101



TPH-D : 30-Mar-2014 to 29-Apr-2014
mg/l
>500
500
300
150
80
40
20
10
7.5
5
2.5
1
0.5
0
217200
217000
216800
216600
1264800
1265000
1265200
1265400
1265600
1265800
MW-204
MW-201
MW-203
2.18
MW-202
MW-206A
6.6
MW-311
6.7
6.8
0.361
7
MW-312
MW-309
MW-301
TX-03A
MW-302
MW-310
MW-304
MW-303
7.1
7.2
7.3
TES-MW-1
MW-308
MW-307
MW-102
MW-101

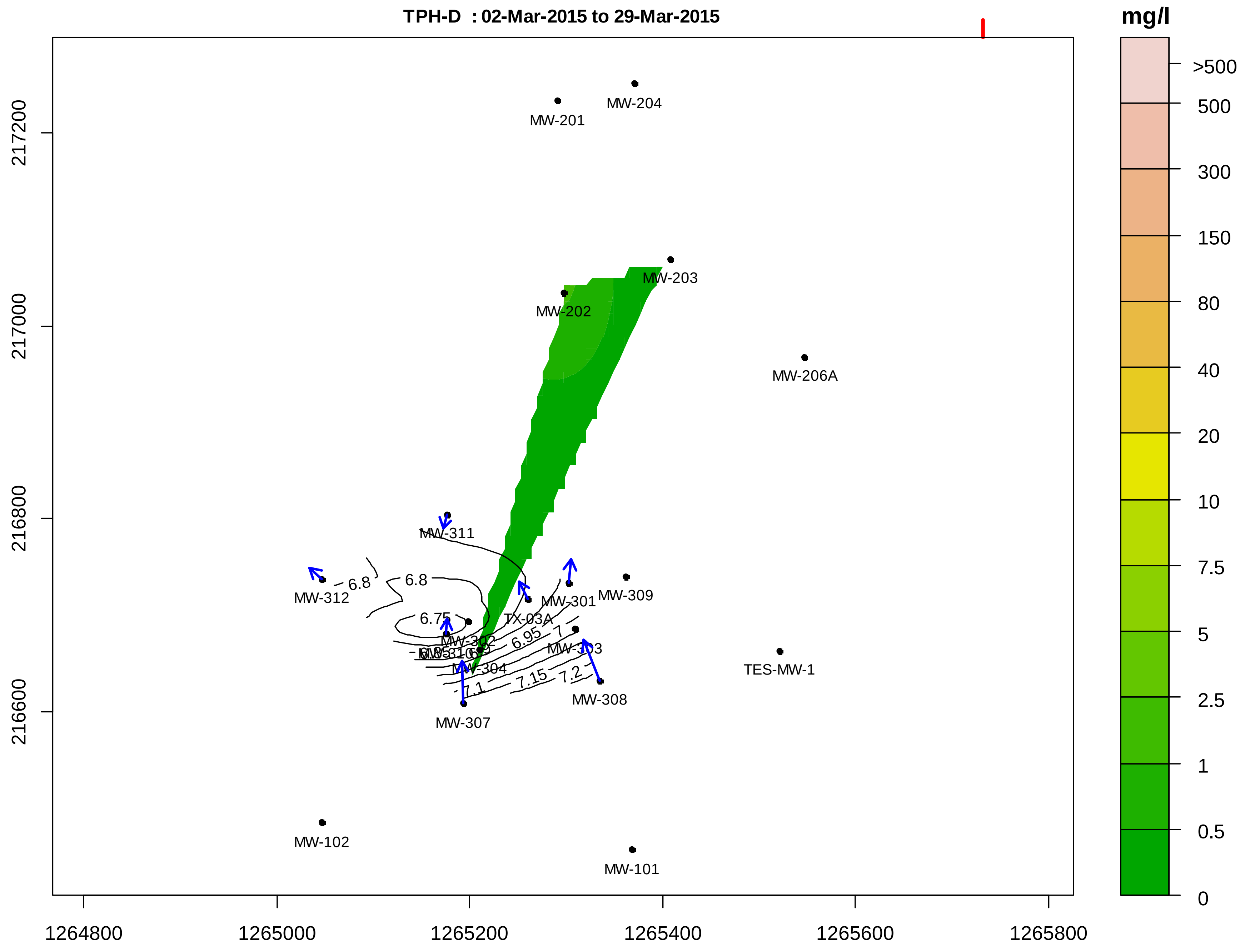


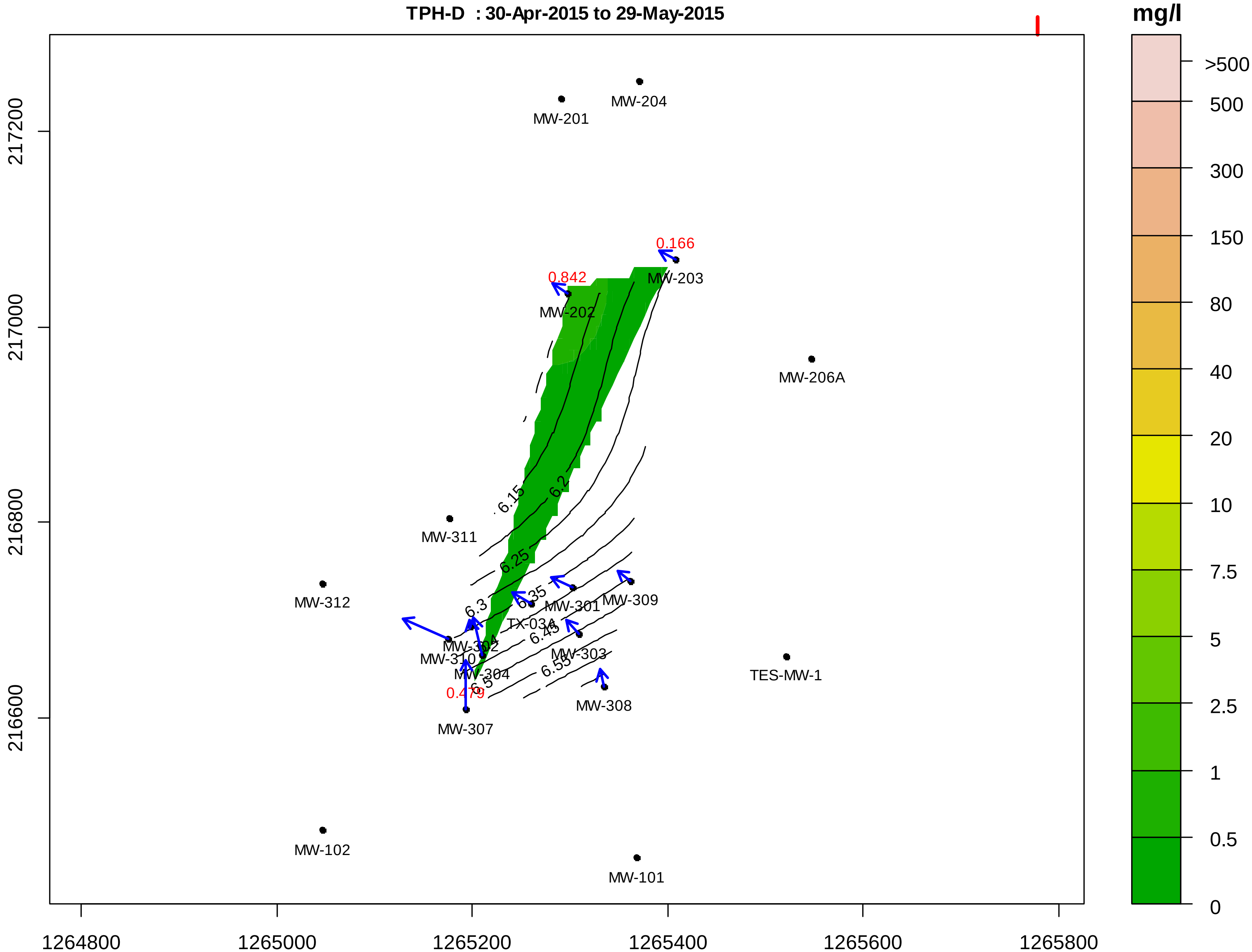
TPH-D : 30-Jun-2014 to 29-Jul-2014
mg/l
>500
500
300
150
80
40
20
10
7.5
5
2.5
1
0.5
0
217200
217000
216800
216600
1264800
1265000
1265200
1265400
1265600
1265800
MW-204
MW-201
MW-203
MW-202
MW-206A
MW-311
MW-312
0.102
MW-309
MW-301
MW-303
MW-310
MW-304
TES-MW-1
MW-308
MW-307
MW-102
MW-101



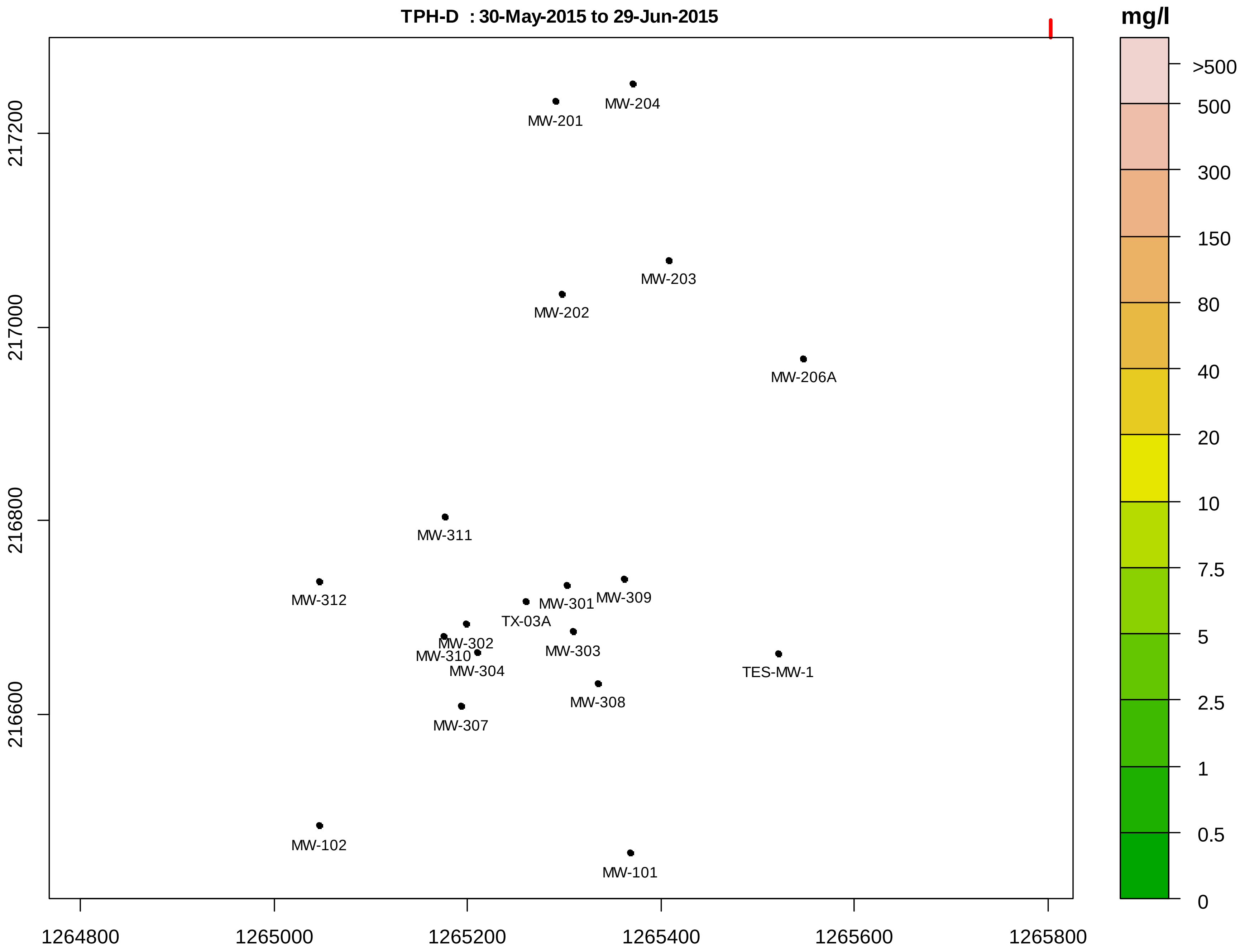
TPH-D : 30-Oct-2014 to 29-Nov-2014
mg/l
>500
500
300
150
80
40
20
10
7.5
5
2.5
1
0.5
0
217200
217000
216800
216600
1264800
1265000
1265200
1265400
1265600
1265800
0.505
MW-204
0.173
MW-201
6.4
2.45
MW-202
MW-203
6.5
0.236
MW-206A
6.6
ND<0.048
MW-311
6.7
1.13
MW-312
6.8
ND<0.048
MW-309
0.448
MW-301
TX-03A
0.361
MW-302
MW-310
MW-304
MW-303
ND<0.048
TES-MW-1
ND<0.048
MW-308
0.632
MW-307
7.1
7.2
7.3
MW-102
ND<0.048
MW-101

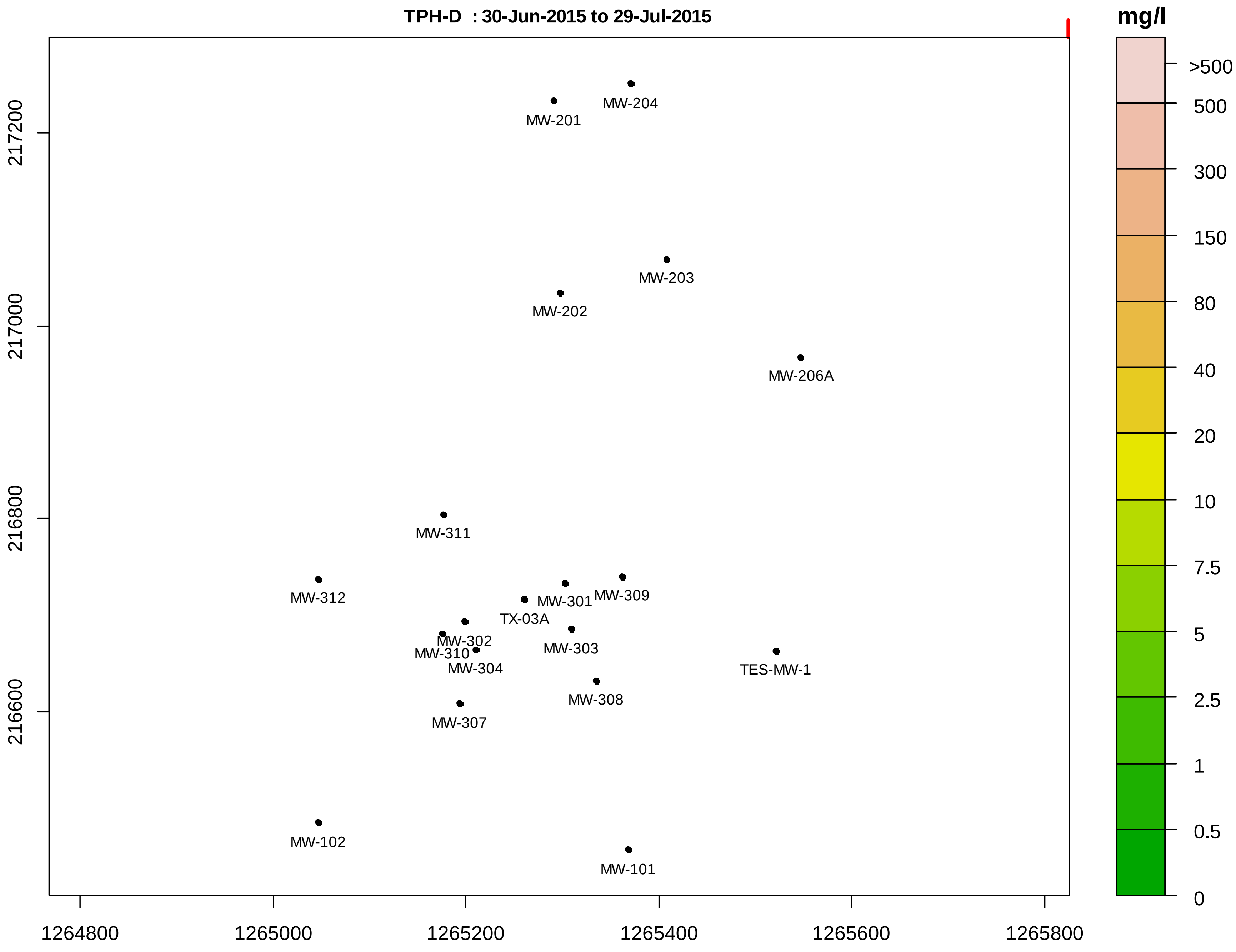
TPH-D : 02-Mar-2015 to 29-Mar-2015

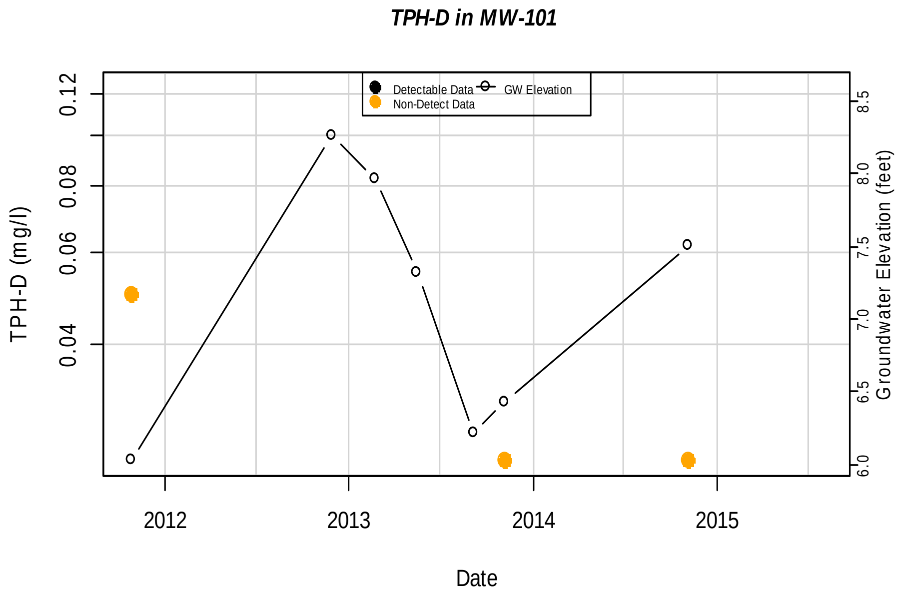


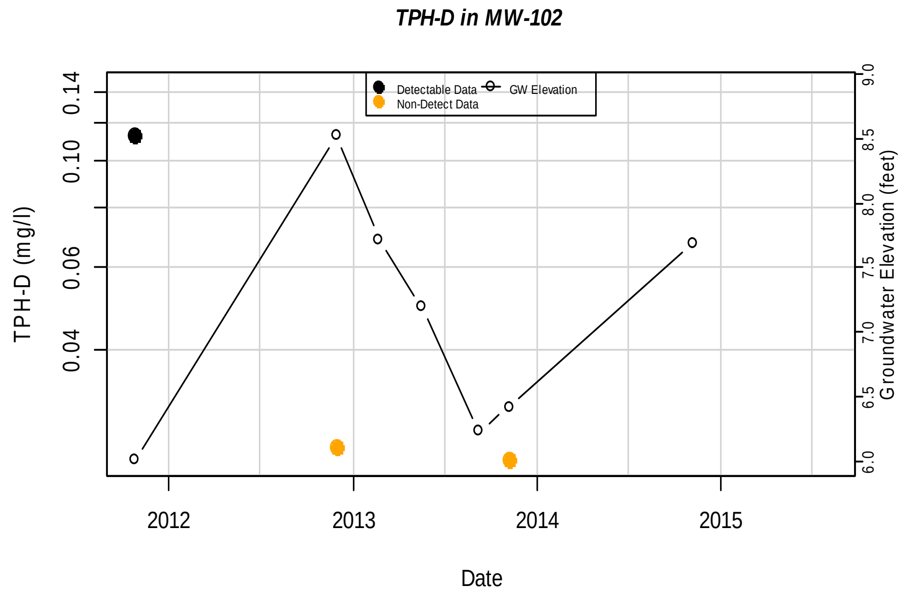


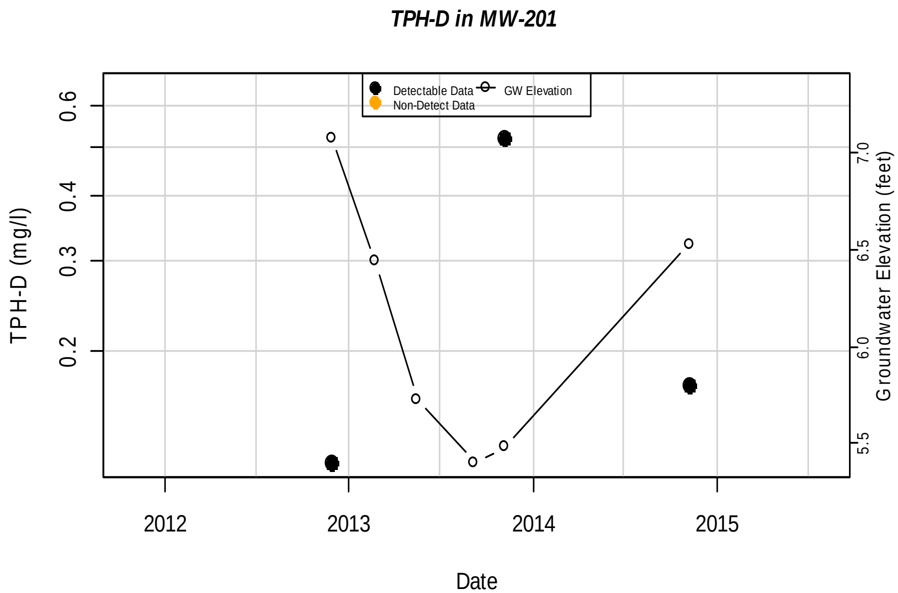
TPH-D : 30-Apr-2015 to 29-May-2015
mg/l
>500
500
300
150
80
40
20
10
7.5
5
2.5
1
0.5
0
MW-201
MW-204
MW-202
MW-203
MW-206A
MW-311
MW-312
MW-301
MW-309
TX-03A
MW-302
MW-310
MW-304
MW-303
TES-MW-1
MW-308
MW-307
MW-102
MW-101
0.166
0.842
0.479
6.15
6.2
6.25
6.3
6.35
6.45
6.5
6.55
217200
217000
216800
216600
1264800
1265000
1265200
1265400
1265600
1265800

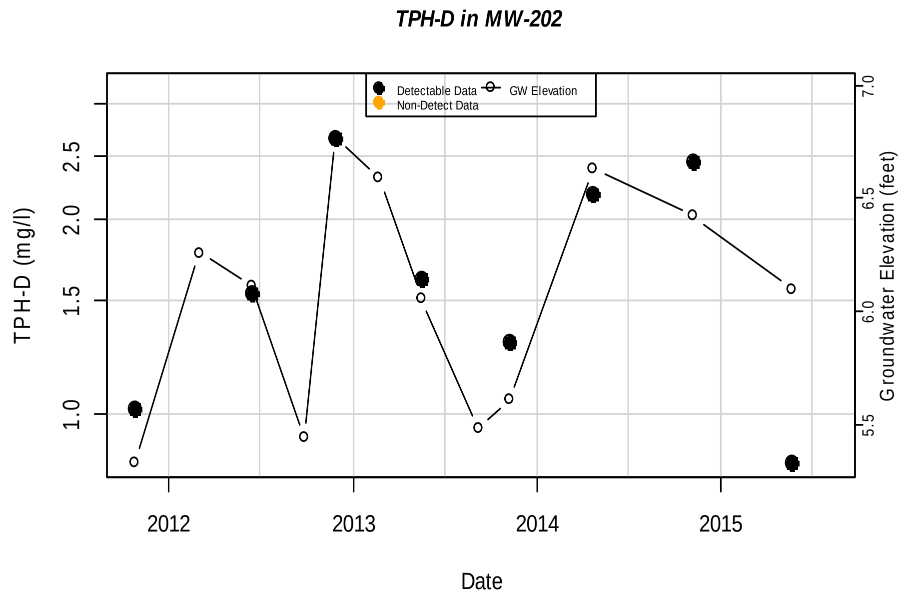

TPH-D : 30-May-2015 to 29-Jun-2015
mg/l
>500
500
300
150
80
40
20
10
7.5
5
2.5
1
0.5
0
MW-204
MW-201
MW-203
MW-202
MW-206A
MW-311
MW-312
MW-301
MW-309
TX-03A
MW-302
MW-310
MW-304
MW-303
TES-MW-1
MW-308
MW-307
MW-102
MW-101
217200
217000
216800
216600
1264800
1265000
1265200
1265400
1265600
1265800

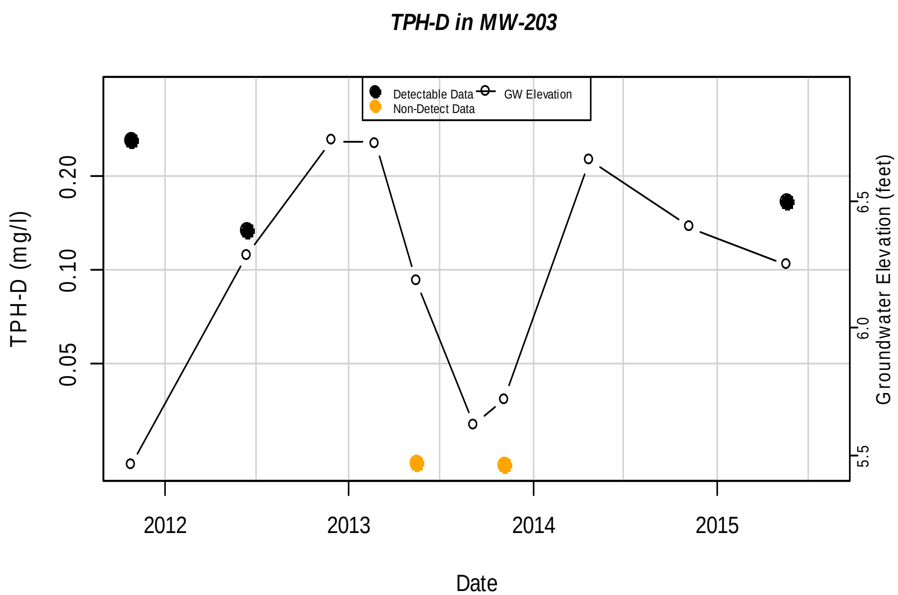

TPH-D : 30-Jun-2015 to 29-Jul-2015
mg/l
>500
500
300
150
80
40
20
10
7.5
5
2.5
1
0.5
0
MW-204
MW-201
MW-203
MW-202
MW-206A
MW-311
MW-312
MW-301
MW-309
TX-03A
MW-302
MW-310
MW-304
MW-303
TES-MW-1
MW-308
MW-307
MW-102
MW-101
217200
217000
216800
216600
1264800
1265000
1265200
1265400
1265600
1265800

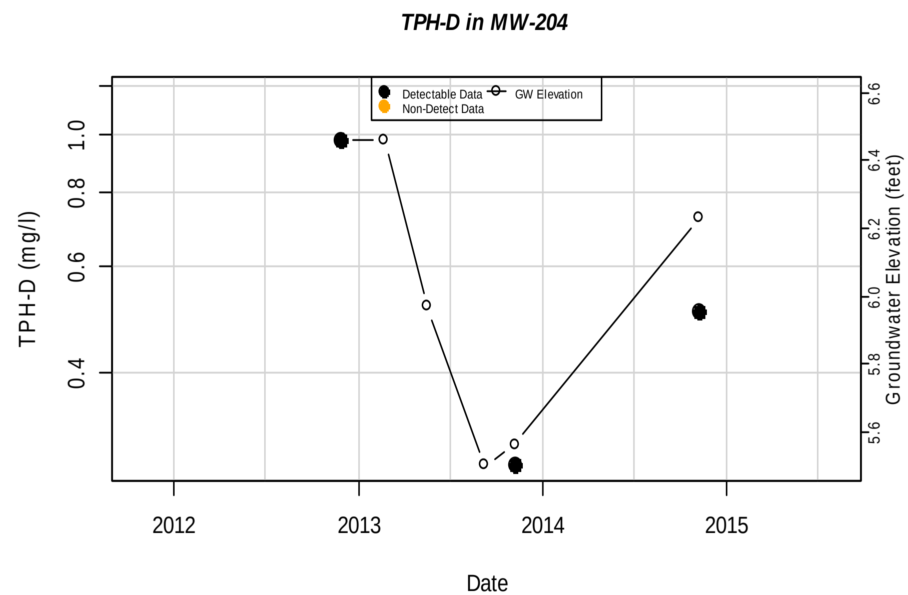

TPH-D in MW-101
Detectable Data
Non-Detect Data
GW Elevation
TPH-D (mg/l)
Groundwater Elevation (feet)
Date
0.04
0.06
0.08
0.12
6.0
6.5
7.0
7.5
8.0
8.5
2012
2013
2014
2015

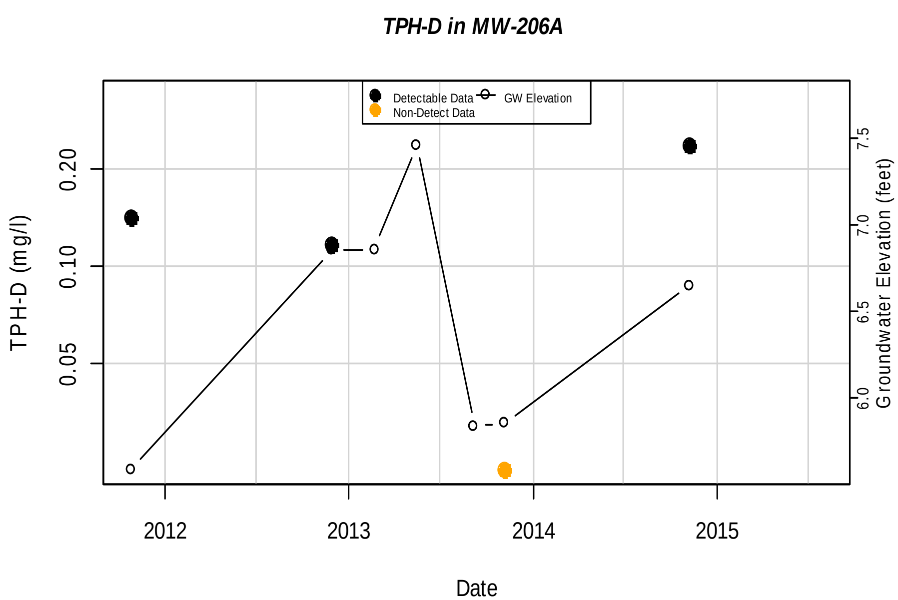

TPH-D in MW-102
Detectable Data
Non-Detect Data
GW Elevation
TPH-D (mg/l)
Groundwater Elevation (feet)
Date
0.04
0.06
0.10
0.14
6.0
6.5
7.0
7.5
8.0
8.5
9.0
2012
2013
2014
2015

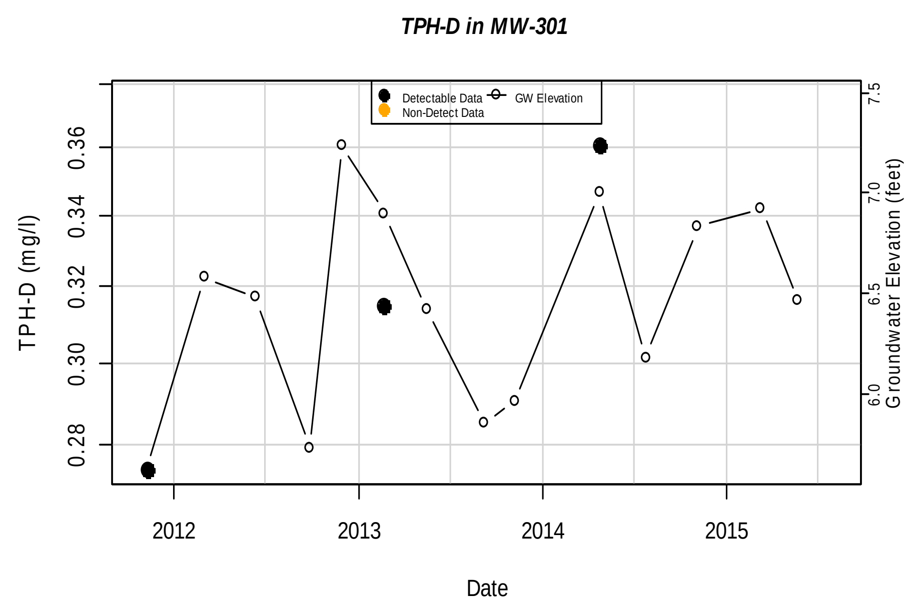

TPH-D in MW-201
Detectable Data
Non-Detect Data
GW Elevation
TPH-D (mg/l)
Groundwater Elevation (feet)
Date
0.2
0.3
0.4
0.6
5.5
6.0
6.5
7.0
2012
2013
2014
2015


TPH-D in MW-202
Detectable Data
Non-Detect Data
GW Elevation
TPH-D (mg/l)
Groundwater Elevation (feet)
Date
1.0
1.5
2.0
2.5
5.5
6.0
6.5
7.0
2012
2013
2014
2015

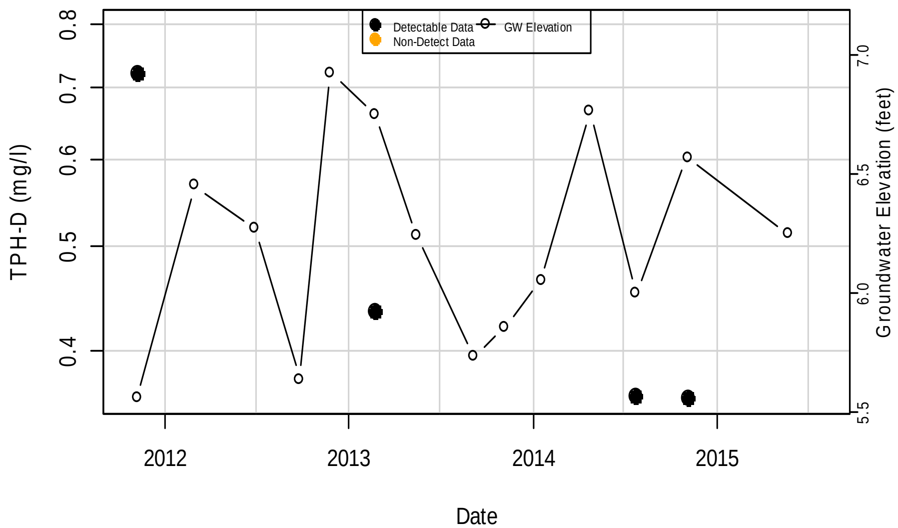

TPH-D in MW-203
Detectable Data
GW Elevation
Non-Detect Data
TPH-D (mg/l)
0.05
0.10
0.20
Groundwater Elevation (feet)
5.5
6.0
6.5
2012
2013
2014
2015
Date


TPH-D in MW-204
Detectable Data
GW Elevation
Non-Detect Data
TPH-D (mg/l)
0.4
0.6
0.8
1.0
Groundwater Elevation (feet)
5.6
5.8
6.0
6.2
6.4
6.6
2012
2013
2014
2015
Date

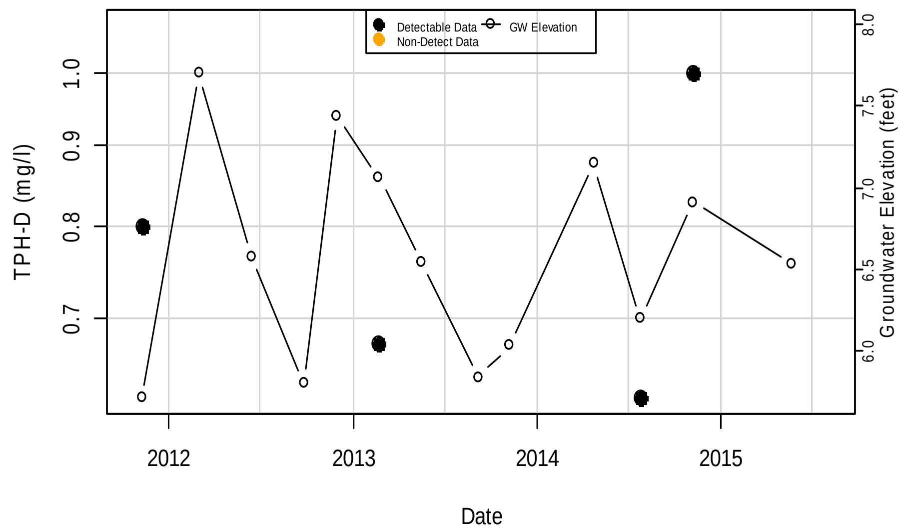

TPH-D in MW-206A
Detectable Data
GW Elevation
Non-Detect Data
TPH-D (mg/l)
0.05
0.10
0.20
Groundwater Elevation (feet)
6.0
6.5
7.0
7.5
2012
2013
2014
2015
Date


TPH-D in MW-301
Detectable Data
GW Elevation
Non-Detect Data
TPH-D (mg/l)
0.28
0.30
0.32
0.34
0.36
Groundwater Elevation (feet)
6.0
6.5
7.0
7.5
2012
2013
2014
2015
Date

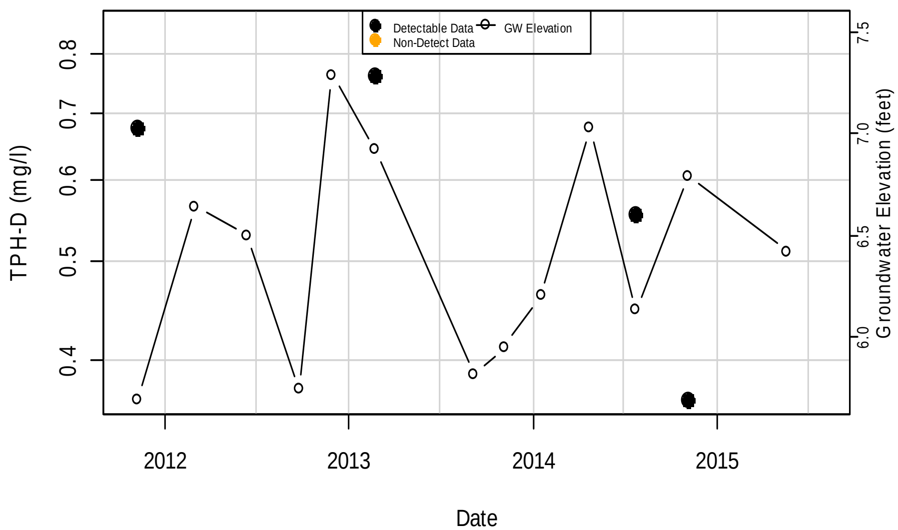
TPH-D in MW-302



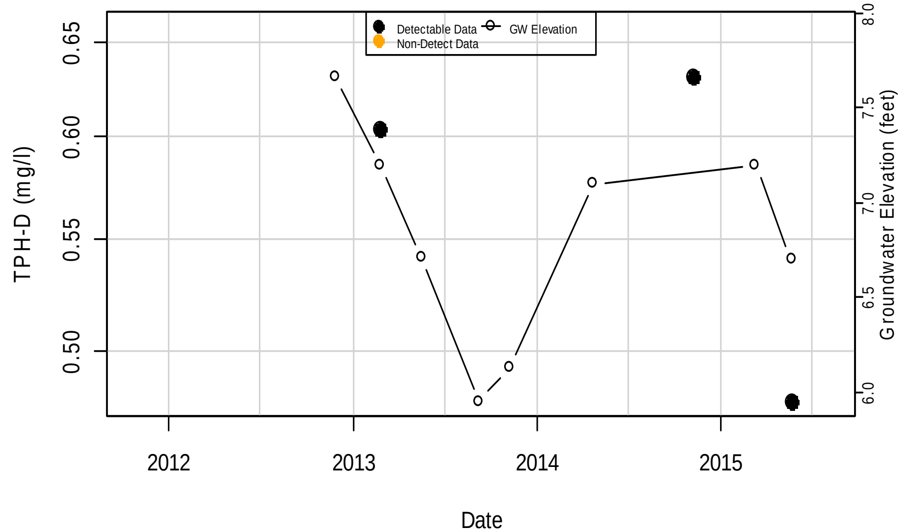
TPH-D in MW-303

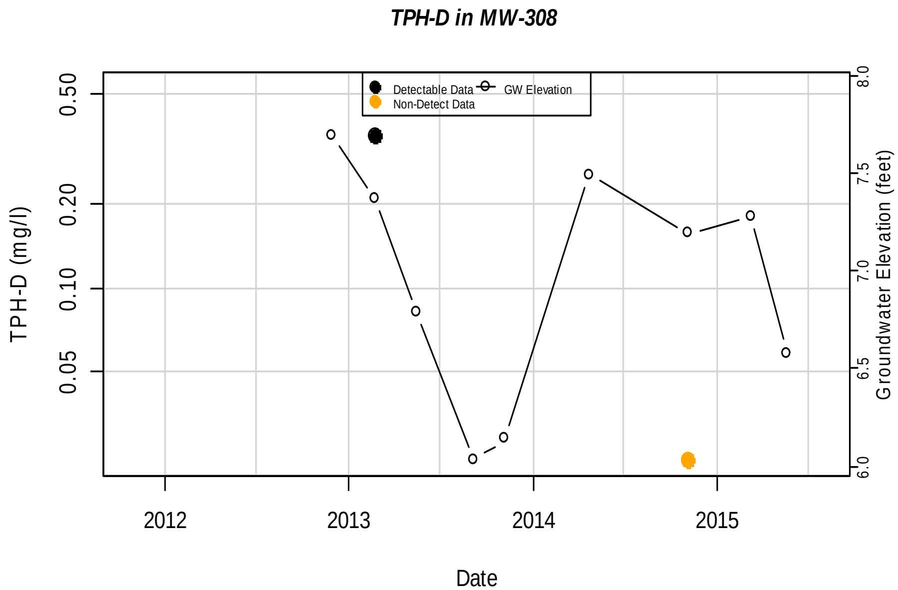


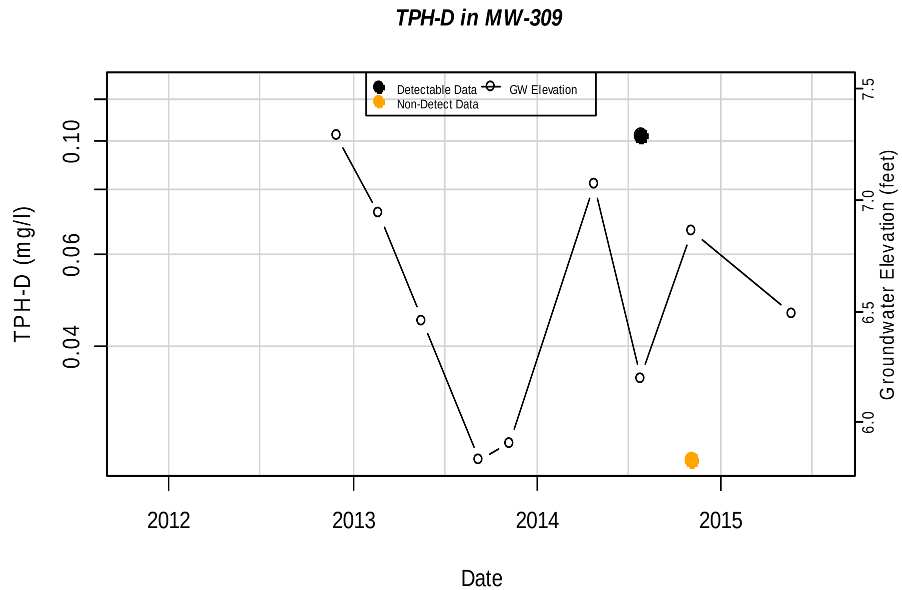
TPH-D in MW-304

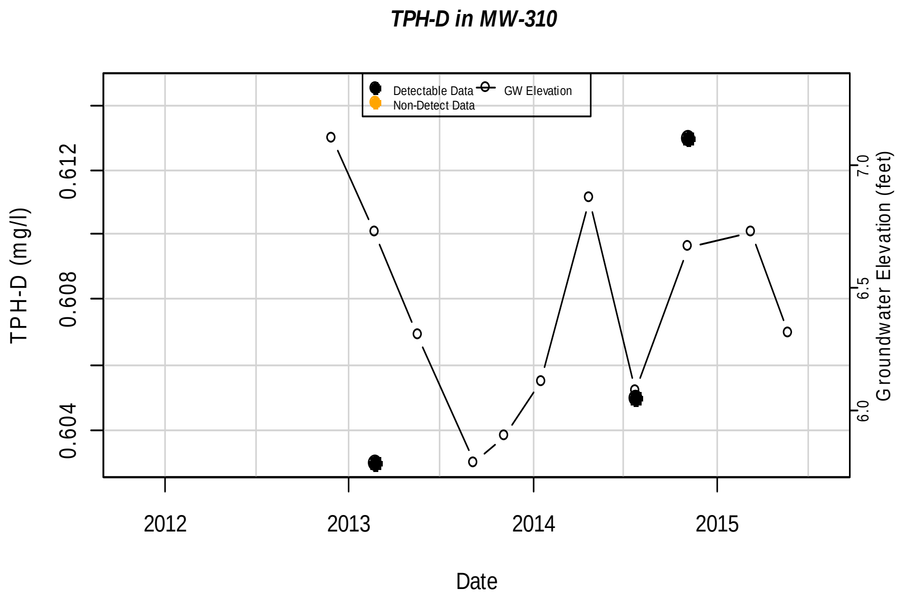


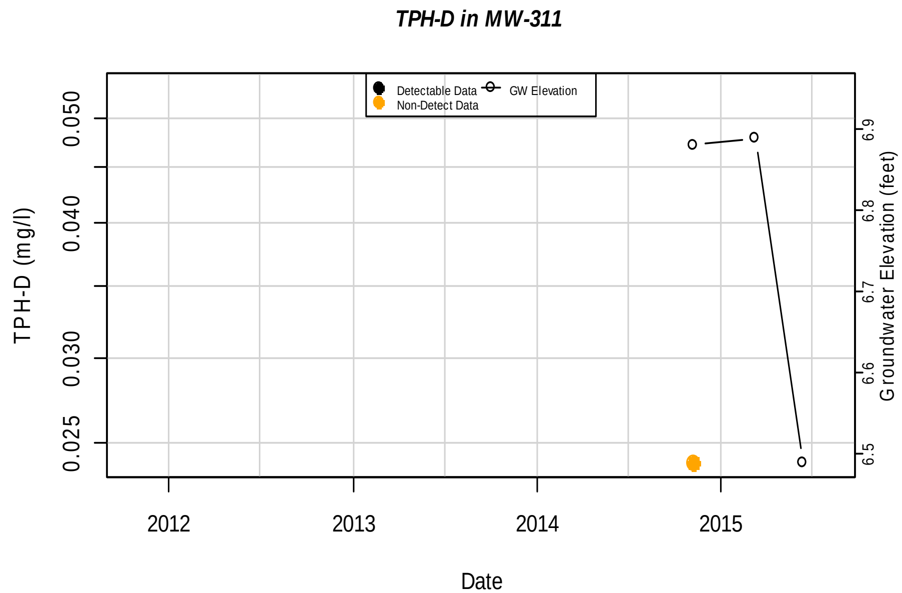
TPH-D in MW-307

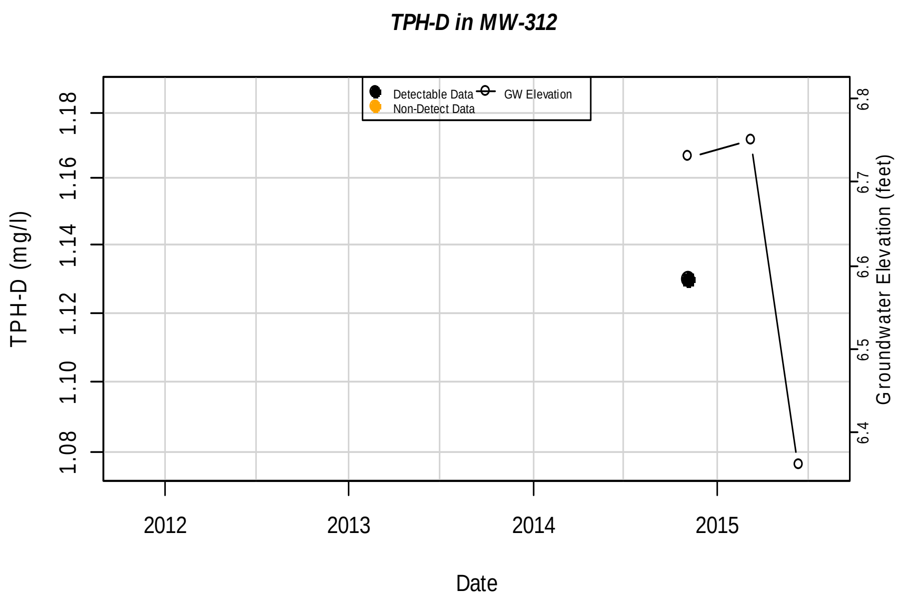


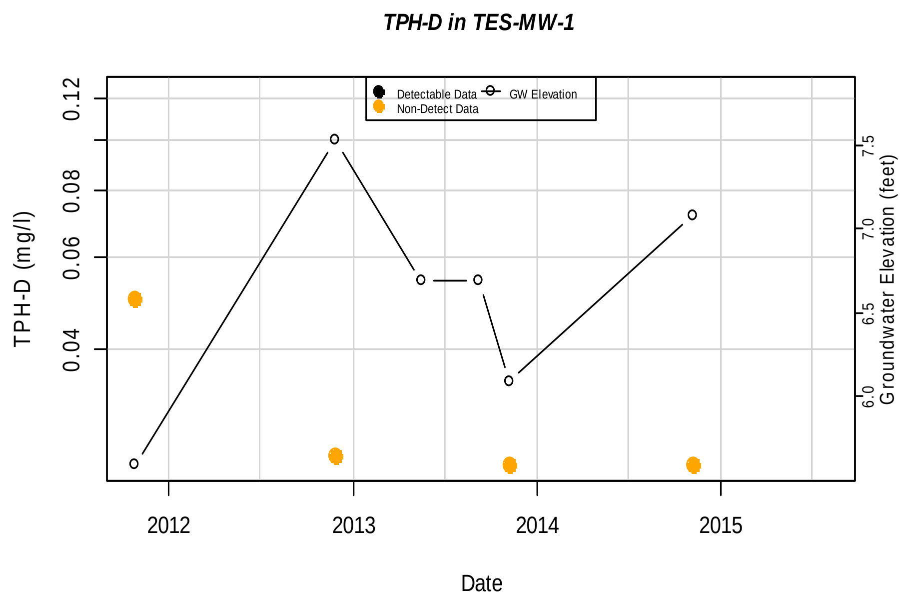

TPH-D in MW-308
Detectable Data
Non-Detect Data
GW Elevation
TPH-D (mg/l)
0.05
0.10
0.20
0.50
Groundwater Elevation (feet)
6.0
6.5
7.0
7.5
8.0
2012
2013
2014
2015
Date

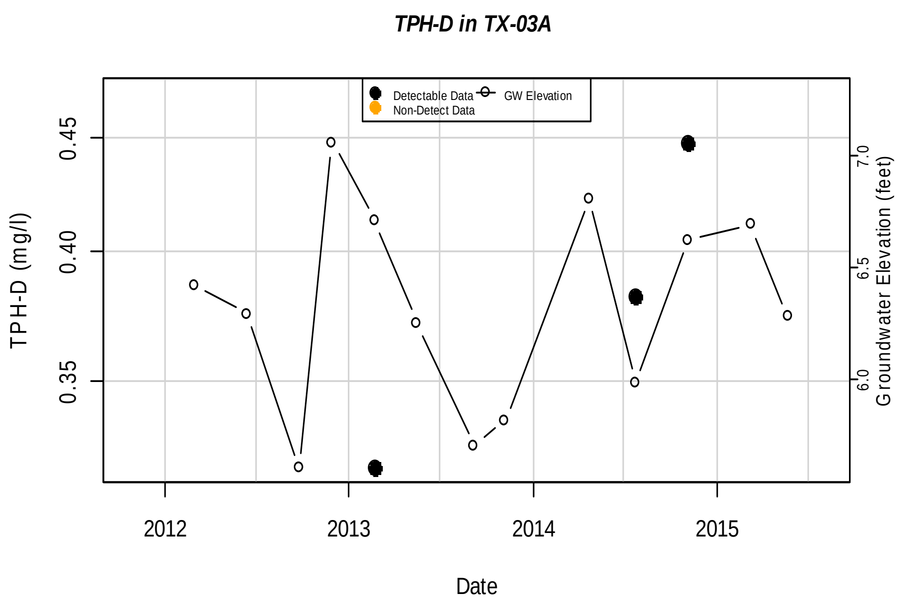

TPH-D in MW-309
Detectable Data
Non-Detect Data
GW Elevation
TPH-D (mg/l)
0.04
0.06
0.10
Groundwater Elevation (feet)
6.0
6.5
7.0
7.5
2012
2013
2014
2015
Date


TPH-D in MW-310
Detectable Data
Non-Detect Data
GW Elevation
TPH-D (mg/l)
0.604
0.608
0.612
Groundwater Elevation (feet)
6.0
6.5
7.0
2012
2013
2014
2015
Date


TPH-D in MW-311
Detectable Data
Non-Detect Data
GW Elevation
TPH-D (mg/l)
0.025
0.030
0.040
0.050
Groundwater Elevation (feet)
6.5
6.6
6.7
6.8
6.9
2012
2013
2014
2015
Date


TPH-D in MW-312
Detectable Data
Non-Detect Data
GW Elevation
TPH-D (mg/l)
1.08
1.10
1.12
1.14
1.16
1.18
Groundwater Elevation (feet)
6.4
6.5
6.6
6.7
6.8
2012
2013
2014
2015
Date


TPH-D in TES-MW-1
Detectable Data
Non-Detect Data
GW Elevation
TPH-D (mg/l)
0.04
0.06
0.08
0.12
Groundwater Elevation (feet)
6.0
6.5
7.0
7.5
2012
2013
2014
2015
Date


TPH-D in TX-03A
Detectable Data
Non-Detect Data
GW Elevation
TPH-D (mg/l)
0.35
0.40
0.45
Groundwater Elevation (feet)
6.0
6.5
7.0
2012
2013
2014
2015
Date

Appendix B
BIOSCREEN Results

Steady State Model Run — Bioscreen Input Parameters for Steady State Evaluation

Parameter	Symbol	Units	Value Selected	Source	Notes
Seepage Velocity	Vs	ft/yr	Calculated	1	Calculated by program using the following three parameters.
Hydraulic Conductivity	K	cm/sec	8.51E-03		Average value determined from historical pumping tests.
Hydraulic Gradient	i	ft/ft	-0.0004		2014 gradient between TX-03A and MW-310 during annual monitoring event
Porosity	n	unitless	0.25	3	Common value for silts and sands.
Longintudinal Dispersivity	alpha x	ft	24.1		Xu and Eckstein (1995)
Transverse Dispersivity	alpha y	ft	2.41	3	Gelhar et. al. (1992)
Vertical Dispersivity	alpha z	ft	0.24		EPA (1986)
Estimated Plume Length	Lp	ft	Calculcated	1	Length of plume in not known.
Retardation Factor	R	unitless	Calculated	1	Calculated by program using the following three parameters.
Soil Bulk Density	rho	kg/l	1.4	1	Typical value assigned for soil.
Partition Coefficient	Koc	L/kg	60		EPA (2002)
Fraction of Organic Carbon	foc	unitless	0.001	1	Typical values are between 0.0002 - 0.02, if unknown a value of 0.001 is often used.
1st Order Decay Coefficient	lambda	per yr	1.0		Average values for aerobic decay FFS (Table 2). Runs use 1 = t1/2 = 0.69 years for aerobic conditions.
Solute Half-Life	t-half	year	0.69	1	Yes, typical $t_{1/2}$ is 0.02 to 2 yr under aerobic, but calibrated better to 10 year; conc. have remained fairly constant.
Delta Oxygen	DO	mg/L	0.38		Mean concentration measured along transect during annual groundwater sampling event in November 2014.
Delta Nitrate	NO3	mg/L	0.1		Mean concentration measured along transect during annual groundwater sampling event in November 2014.
Observed Ferrous Iron	Fe2+	mg/L	2.5		Mean concentration measured along transect during annual groundwater sampling event in November 2014.
Delta Sulfate	SO4	mg/L	0.5		Mean concentration measured along transect during annual groundwater sampling event in November 2014.
Observed Methane	CH4	mg/L	4.52		Mean concentration measured along transect during annual groundwater sampling event in November 2013.
Model Area Length	L	ft	220		Estimated from monitoring well data produced by GWStat
Model Area Width	W	ft	120		Estimated from monitoring well data produced by GWStat
Simulation Time	t	yr	2		Dependent on source of mass (finite used).
Saturated Zone Thickness	T	ft	10	2	Average value determined from recent well installation activities.
Source Zones:					
Width/Conc Zone 1	W and C	ft and mg/L	40 and 0.02		Extroplated from monitoring well data; only used for plume mass and cleanup time section of Bioseen
Width/Conc Zone 2	W and C	ft and mg/L	35 and 0.16		Extroplated from monitoring well data; only used for plume mass and cleanup time section of Bioseen
Width/Conc Zone 3	W and C	ft and mg/L	10 and 1.72		Center line source concentration based on most recent moniotring data at TX-03A (assumed source area)
Field Data for Comparison	$C_{benzene}$	mg/L	Varies		Estimated from monitoring well concetrations at wells TX-03A, MW-302, MW-310, and MW-312.

Transect for Benzene

Area	Well	Distance from Source (ft)	Benzene (mg/L) 05/20/2015[1]	Benzene (mg/L) 11/04/2014	Benzene (mg/L) 04/23/2014	Mean Benzene Concentration (mg/L)
Source	TX-03A	0	1.72	0.94	1.22	1.22
Mid-plume-Source Area	MW-302	90	0.454	0.506	0.98	0.51
Mid-plume-Downgradient Area	MW-310	120	0.641	0.739	0.796	0.74
Downgradient	MW-312	220	0.204	0.239	Not Sampled	0.22

[1]Sampled on 6-11-2015

Sample Event Date	TX-03A Elevation (ft)	MW-310 Elevation (ft)	Distance Between Wells (ft)	Hydraulic Gradient (ft/ft)
11/04/14	6.62	6.57	120	-0.0004

Parameter	Concentration in mg/L, for 11-06-2014 Sampling Event			Median Concentration (mg/L)
	TX-03A	MW-302	MW-310	
Delta Oxygen	0.38	0.53	0.03	0.38
Delta Nitrate	0.1	0.1	0.1	0.10
Observed Ferrous Iron	6	2.5	1.5	2.50
Delta Sulfate	0.5	0.5	0.5	0.50
Observed Methane[1]	6.27	3.41	4.52	4.52

1 Data from 11/3/2013, not collected in 2014.

Sources:

1 - Bioscreen Natural Attenuation Decision Support system User's Manual (Version 1.3), EPA/300/R-96/087

2 - Pilot Testing Results TX-03A Area, Shell Harbor Island Terminal, Seattle, Washington, URS, November 2013

3 - User's Manual: Natural Attenuation Analysis Tool Package for Petroleum-Contaminated Ground Water, Washington Department of Ecology, Publication Number 05-09-091A, July 2005

Notes:

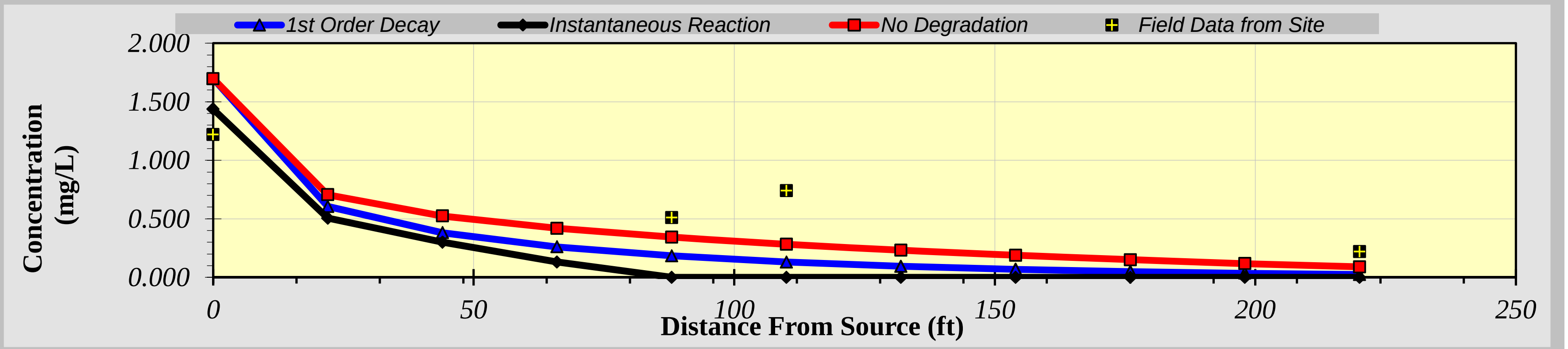
NA = Not available or Not analyzed

DISSOLVED BENZENE CONCENTRATION ALONG PLUME CENTERLINE (mg/L at Z=0)

Aerobic Conditions, 2 years

Distance from Source (ft)

TYPE OF MODEL	0	22	44	66	88	110	132	154	176	198	220
No Degradation	1.697	0.706	0.524	0.419	0.343	0.282	0.232	0.188	0.150	0.118	0.090
1st Order Decay	1.697	0.606	0.381	0.261	0.184	0.132	0.095	0.069	0.050	0.035	0.025
Inst. Reaction	1.437	0.506	0.300	0.132	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Field Data from Site	1.220				0.510	0.740					0.220



Calculate

Time:

2 Years

Return to

Recalculate This

BIOSCREEN Natural Attenuation Decision Support System

Air Force Center for Environmental Excellence

Version 1.4

Run 3. Aerobic Conditions
Harbor Island
Benzene

Data Input Instructions:

115	1. Enter value directly....or
or	2. Calculate by filling in grey cells below. (To restore formulas, hit button below).
0.02	
Variable*	Data used directly in model.
20	Value calculated by model. (Don't enter any data).

1. HYDROGEOLOGY

Seepage Velocity*	Vs	140.9	(ft/yr)
or		or	
Hydraulic Conductivity	K	8.5E-03	(cm/sec)
Hydraulic Gradient	i	0.004	(ft/ft)
Porosity	n	0.25	(-)

2. DISPERSION

Longitudinal Dispersivity*	alpha x	24.1	(ft)
Transverse Dispersivity*	alpha y	2.4	(ft)
Vertical Dispersivity*	alpha z	0.2	(ft)
or		or	
Estimated Plume Length	Lp	220	(ft)

3. ADSORPTION

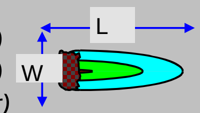
Retardation Factor*	R	1.4	(-)
or		or	
Soil Bulk Density	rho	1.7	(kg/l)
Partition Coefficient	Koc	60	(L/kg)
FractionOrganicCarbon	foc	1.0E-3	(-)

4. BIODEGRADATION

1st Order Decay Coeff*	lambda	1.0E+0	(per yr)
or		or	
Solute Half-Life	t-half	0.69	(year)
or Instantaneous Reaction Model			
Delta Oxygen*	DO	4	(mg/L)
Delta Nitrate*	NO3		(mg/L)
Observed Ferrous Iron*	Fe2+		(mg/L)
Delta Sulfate*	SO4		(mg/L)
Observed Methane*	CH4		(mg/L)

5. GENERAL

Modeled Area Length*	220	(ft)
Modeled Area Width*	120	(ft)
Simulation Time*	2	(yr)



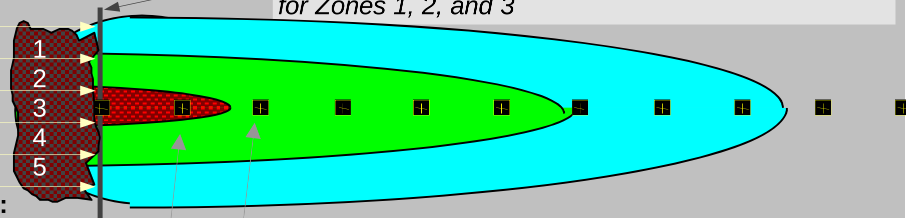
6. SOURCE DATA

Source Thickness in Sat.Zone* 10 (ft)

Source Zones:

Width* (ft)	Conc. (mg/L)*
40	0.02
35	0.16
10	1.72
35	0.16
40	0.02

Vertical Plane Source: Look at Plume Cross-Section and Input Concentrations & Widths for Zones 1, 2, and 3



View of Plume Looking Down

Source Halflife (see Help):

Inst. React.	1st Order	
20	200	(yr)

Soluble Mass In Source NAPL, Soil: 65 (Kg)

Observed Centerline Concentrations at Monitoring Wells
If No Data Leave Blank or Enter "0"

7. FIELD DATA FOR COMPARISON

Concentration (mg/L)	1.22				.51	.74					.22
Dist. from Source (ft)	0	22	44	66	88	110	132	154	176	198	220

8. CHOOSE TYPE OF OUTPUT TO SEE:

RUN — **View Output**

RUN ARRAY — **View Output**

Help

Recalculate

Paste Example Dataset

Restore Formulas for Vs,

Appendix C
Cost Estimates

Shell Harbor Island

Cleanup Action Alternative 1: Compliance Monitoring and Natural Attenuation

Recurring and Future Costs				
Item	**Unit**	**Cost per Unit**	**Quantity**	**Cost per Item**
Annual Reporting and Project Coordination				
Annual Groundwater Montioring Report	Each	$6,500.00	1	$6,500
Semi-Annual Progress Report	Each	$3,500.00	1	$3,500
Health and Safety Plan Update	Each	$225.00	1	$225
PM	Per hour	$88.70	80	$7,000
Annual Meeting at DOE	Each	$1,000.00	1	$1,000
Teleconferences	Each	$250.00	4	$1,000
			Subtotal	***$19,000***
Quarterly Sampling Costs				
Semi-Annual Sampling Events Labor	Per hour	$67.59	200	$13,500
Semi-Annual Event	Per Well	$42.21	68	$2,900
ODCs	Per Day	$220.00	20	$4,400
Lab Costs	Per Well	$60.50	68	$4,100
			Subtotal	***$25,000***
			Subtotal	$44,000
Contingency	10%			$4,400
		Annual Cleanup Action Cost ($)		**$49,000**
		Estimated Cleanup Time (years)		**33**
		Interest Rate of Return ($%)		**5.00%**
		Total Net Present Value Cost of Annual Remediation ($)		**$784,000**

Cleanup Alternative 1 (Net Present Value Rounded to the Nearest $1,000)	**$**	**$784,000**

Notes:

This estimate is -30%/+50% and is for budgeting purposes only.

Assumptions:

Semi-Annual groundwater sampling at up to 15 wells (plus one duplicate and one trip blank) and reporting for a period of 40 years, even though the actual cleanup time is estimated to take longer.

5% interest rate of return beginning Year 1, with annual payout at the beginning of each year for O&M.

Discount factors: NPV = cost multiplied by discount factor (f).

Present worth: $f = (1 + i)^{-n}$.

Equal series present worth: $f = (1 + i)^{n} - 1/ i(1 + i)^{n}$.

i = interest rate = 0.075.

Calculated cost rounded to nearest $100.

Sums are rounded to nearest $1,000

Shell Harbor Island

Cleanup Action Alternative 2a: Biosparging

Capital Costs				
Item	**Unit**	**Cost per Unit**	**Quantity**	**Cost per Item**
Installation Costs- Biosparging System				
Mobilization / Demobilization Drill Rig	LS	$1,500.00	1	$1,500
Well Install	Per Well	$995.00	36	$35,800
Well Installation Materials and Start Cards	Per Well	$200.00	36	$7,200
Well Vaults	Each	$350.00	36	$12,600
Trenching	LF	$60.00	260	$15,600
Piping	LF	$2.00	1600	$3,200
Asphalt Trenching	SF	$8.00	520	$4,200
Gauges, Meters	Per Well	$200.00	36	$7,200
Header	Each	$1,500.00	1	$1,500
Compressor, Installed	Each	$7,500.00	1	$7,500
Waste Drum	Each	$75.00	10	$800
Waste Management	LS	$500.00	1	$500
			Subtotal	***$98,000***
Installation Costs - Misc.				
Mobilization / Demobilization /Use - Crane	Per Hour	$1,000.00	20	$20,000
Utility Locates and Air Knife Operation	Each	$7,500.00	1	$7,500
Tough Shed for Equipment	Each	$3,500.00	1	$3,500
Fencing/Security at Compound	Each	$1,600.00	1	$1,600
Electrical connections and Control Panel	Each	$7,500.00	1	$7,500
Electrician	Each	$5,000.00	1	$5,000
Engineering Design	15%			$14,700
Permitting and Access Agreements	5%			$4,900
Health and Safety	5%			$4,900
PM	Per Hour	$88.72	60	$5,300
Engineering	Per Hour	$99.09	40	$4,000
Geologist	Per Hour	$67.59	138	$9,300
Baseline Analytical and 1-Semi-Annual Event				
Semi-Annual Sampling Events Labor	Per hour	$67.59	100	$6,800
Semi-Annual Event	Per Well	$42.21	34	$1,400
ODCs	Per Day	$250.00	10	$2,500
Lab Costs	Per Well	$60.50	34	$2,100
Air Monitoring				
Monitoring Labor	Per Hour	$67.59	80	$5,400
Lab Costs	Per Sampl	$650.00	6	$3,900
ODCs	Per Day	$120.00	6	$700
Engineering Install Report and O&M Manual	5%			$4,900
Routine O&M	Per Hour	$67.59	175	$11,800
			Subtotal	***$128,000***
			Subtotal	$226,000
Contingency	5%			$11,300
			Total	**$237,000**

Shell Harbor Island

Cleanup Action Alternative 2a: Biosparging

Recurring and Future Costs				
Item	**Unit**	**Cost per Unit**	**Quantity**	**Cost per Item**
Annual Operations and Maintenance Costs - AS and SVE System, Project Year Incurred: 2 and 3				
Gauges, Meters	LS	$1,500.00	1	$1,500
Electrician	Each	$1,200.00	1	$1,200
			Subtotal	***$3,000***
Annual Groundwater Monitoring and Reporting, Project Year Incurred: 2 and 3				
Project Management	20%			$6,600
Reporting	25%			$6,600
Health and Safety	5%			$1,300
Monthly O&M	Per Hour	$67.59	120	$8,111
Semi-Annual Sampling Event	Per Hour			
Semi-Annual Sampling Events Labor	Per hour	$67.59	100	$6,759
Semi-Annual Event	Per Well	$42.21	34	$1,435
ODCs	Per Day	$250.00	10	$2,500
Lab Costs	Per Well	$60.50	34	$2,057
Annual System Evaluation	Per Hour	$99.09	40	$4,000
			Subtotal	***$39,362***
		Subtotal of O&M and GW Monitoring		**$43,000**
Contingency	5%			$2,200
		Annual Cleanup Action Cost ($)		**$46,000**
		Estimated Cleanup Time (years)		**2 and 3**
		Interest Rate of Return ($%)		**5.00%**
		Total Net Present Value Cost of Annual Remediation ($)		**$81,000**
Groundwater Monitoring Costs: Project Year Incurred: Year 4				
Project Management	15%			$2,500
Reporting	25%			$3,400
Health and Safety	5%			$600
Semi-Annual Sampling Events Year 4				
Semi-Annual Sampling Events Labor	Per hour	$67.59	100	$6,800
Semi-Annual Event	Per Well	$42.21	34	$1,400
ODCs	Per Day	$250.00	10	$2,500
Lab Costs	Per Well	$60.50	34	$2,100
			Subtotal	***$19,000***
Contingency	5%			$1,000
		Annual Cleanup Action Cost ($)		**$20,000**
		Interest Rate of Return (%)		**5.00%**
		Total Net Present Value Cost of Annual Remediation ($)		**$16,000**
Groundwater Monitoring Costs: Project Year Incurred: Year 5				
Project Management	15%			$5,000
Reporting	25%			$6,700
Health and Safety	5%			$1,300
Quarterly Confirmation Sampling Events Year 5				
Quarterly Sampling Event Labor	Per Hour	$67.59	200	$13,500
Quarterly Event	Per Well	$42.21	68	$2,900
ODCs	Per Day	$250.00	20	$5,000
Lab Costs	Per Well	$60.50	68	$4,100
			Subtotal	***$39,000***
Contingency	5%			$2,000
		Annual Cleanup Action Cost ($)		**$41,000**
		Interest Rate of Return (%)		**5.00%**
		Total Net Present Value Cost of Annual Remediation ($)		**$32,000**

Cleanup Alternative 2a (Net Present Value Rounded to the Nearest $1,000)	**$**	**$366,000**

Shell Harbor Island
Cleanup Action Alternative 2a: Biosparging

Notes:
This estimate is -30%/+50% and is for budgeting purposes only.

Assumptions:
Well installation using Hollow Stem Auger to a maximum depth of 15 feet below grade for the AS wells.
Air knife to a maximum depth of 5 feet below grade.
Pipe is routed through trench to the compound for the AS located outside the dike wall. Excavated soil is re-used in the trench outside the dike wall.
AS system extends inside and outside the dike wall. Piping inside the dike wall is routed above ground and over the wall to the compound.
Electrical available at compound and no additional electrical drop is required.

5% interest rate of return for all monies deposited at Year 1, with annual payout at the beginning of each year for O&M.
Discount factors: NPV = cost multiplied by discount factor (f).
Present worth: $f = (1 + i)^{-n}$.
Equal series present worth: $f = (1 + i)^{n} - 1/ i(1 + i)^{n}$.
i = interest rate = 0.075.
Calculated cost rounded to nearest $100.

Sums are rounded to nearest $1,000

Shell Harbor Island

Cleanup Action Alternative 2b: Biosparging and SVE System Installatior

Capital Costs				
Item	**Unit**	**Cost per Unit**	**Quantity**	**Cost per Item**
Installation Costs- Biosparging System				
Mobilization / Demobilization Drill Rig	LS	$1,500.00	1	$1,500
Well Install	Per Well	$995.00	36	$35,800
Well Installation Materials and Start Cards	Per Well	$200.00	36	$7,200
Well Vaults	Each	$350.00	36	$12,600
Trenching	LF	$60.00	260	$15,600
Piping	LF	$2.00	1600	$3,200
Asphalt Trenching	SF	$8.00	520	$4,200
Gauges, Meters	Per Well	$200.00	36	$7,200
Header	Each	$1,500.00	1	$1,500
Compressor, Installed	Each	$7,500.00	1	$7,500
Waste Drum	Each	$75.00	10	$800
Waste Management	LS	$500.00	1	$500
			Subtotal	***$98,000***
Installation Costs - SVE System				
Mobilization / Demobilization	LS	$1,500.00	1	$1,500
Pipe Instalaltion	LF	$2.00	260	$500
Well Install	Per Well	$750.00	11	$8,300
Well Installation Materials and Start Cards	Per Well	$165.00	11	$1,800
Well Vaults	Each	$350.00	11	$3,900
Gauges, Meters	Per Well	$90.00	11	$1,000
Blower, Installed	Each	$4,500.00	1	$4,500
Knock-out tank	Each	$650.00	1	$700
1000 LB and 500 LB GAC unit for Air Treatment	LS	$6,500.00	1	$6,500
Waste Drums	Each	$75.00	5	$400
Waste Management	LS	$500.00	1	$500
			Subtotal	***$30,000***
Installation Costs - Misc.				
Mobilization / Demobilization /Use - Crane	Per Hour	$1,000.00	20	$20,000
Utility Locates and Air Knife Operation	Each	$7,500.00	1	$7,500
Tough Shed for Equipment	Each	$3,500.00	1	$3,500
Fencing/Security at Compound	Each	$1,600.00	1	$1,600
Electrical connections and Control Panel	Each	$7,500.00	1	$7,500
Electrician	Each	$5,000.00	1	$5,000
Engineering Design	15%			$19,200
Permitting and Access Agreements	5%			$6,400
Health and Safety	5%			$6,400
PM	Per hour	$88.72	60	$5,300
Engineering	Per Hour	$99.09	40	$4,000
Geologist	Per Hour	$67.59	172	$11,600
Baseline Analytical and 1-Semi-Annual Event				
Semi-Annual Sampling Events Labor	Per hour	$67.59	100	$6,800
Semi-Annual Event	Per Well	$42.21	34	$1,400
ODCs	Per Day	$250.00	10	$2,500
Lab Costs	Per Well	$60.50	34	$2,100
Air Monitoring				
Monitoring Labor	Per Hour	$67.59	80	$5,400
Lab Costs	Per Sampl	$650.00	6	$3,900
ODCs	Per Day	$120.00	6	$700
Engineering Install Report and O&M Manual	5%			$6,400
Routine O&M	Per Hour	$67.59	175	$11,800
			Subtotal	***$139,000***
			Subtotal	$267,000
Contingency	5%			$13,350
			Total	**$280,000**

Shell Harbor Island

Cleanup Action Alternative 2b: Biosparging and SVE System Installatior

Recurring and Future Costs				
Item	**Unit**	**Cost per Unit**	**Quantity**	**Cost per Item**
Annual Operations and Maintenance Costs - AS and SVE System, Project Year Incurred: 2 and 3				
Gauges, Meters	LS	$1,500.00	1	$1,500
Electrician	Each	$1,200.00	1	$1,200
Mobilization / Demobilization - GAC Sub	LS	$650.00	1	$650
Carbon changeout	Per LB	$2.50	3000	$7,500
Waste Drums	Each	$75.00	4	$300
Waste Management	LS	$500.00	1	$500
			Subtotal	***$12,000***
Annual Groundwater Monitoring and Reporting, Project Year Incurred: 2 and 3				
Project Management	20%			$8,900
Reporting	25%			$8,900
Health and Safety	5%			$1,700
Monthly O&M	Per hour	$67.59	120	$8,111
Semi-Annual Sampling Event Labor	Per Hour	$67.59	100	$6,759
Semi-Annual Event	Per Well	$42.21	34	$1,500
ODCs	Per Day	$250.00	22	$5,500
Lab Costs	Per Well	$60.50	34	$2,100
Air Monitoring				
Quarterly Monitoring Labor	Per Hour	$67.59	40	$2,704
Lab Costs	Per Sampl	$650.00	4	$2,600
ODCs	Per Day	$120.00	4	$480
Annual System Evaluation	Per Hour	$99.09	40	$4,000
			Subtotal	***$53,253***
			Subtotal	$66,000
Contingency	5%			$3,300
			Annual Cleanup Action Cost ($)	**$70,000**
			Estimated Cleanup Time (years)	**2 and 3**
			Interest Rate of Return ($%)	**5.00%**
			Total Net Present Value Cost of Annual Remediation ($)	**$124,000**
Groundwater Monitoring Costs: Project Year Incurred: Year 4				
Project Management	15%			$2,500
Reporting	25%			$3,400
Health and Safety	5%			$600
Semi-Annual Sampling Events Year 4				
Semi-Annual Sampling Events Labor	Per hour	$67.59	100	$6,800
Semi-Annual Event	Per Well	$42.21	34	$1,400
ODCs	Per Day	$250.00	10	$2,500
Lab Costs	Per Well	$60.50	34	$2,100
			Subtotal	***$19,000***
			Subtotal	$19,000
Contingency	5%			$1,000
			Annual Cleanup Action Cost ($)	**$20,000**
			Interest Rate of Return (%)	**5.00%**
			Total Net Present Value Cost of Annual Remediation ($)	**$16,000**
Groundwater Monitoring Costs: Project Year Incurred: Year 5				
Project Management	15%			$5,000
Reporting	25%			$6,700
Health and Safety	5%			$1,300
Quarterly Confirmation Sampling Events Year 5				
Quarterly Sampling Event Labor	Per Hour	$67.59	200	$13,500
Quarterly Event	Per Well	$42.21	68	$2,900
ODCs	Per Day	$250.00	20	$5,000
Lab Costs	Per Well	$60.50	68	$4,100
			Subtotal	***$39,000***
			Subtotal	$39,000
Contingency	5%			$2,000
			Annual Cleanup Action Cost ($)	**$41,000**
			Interest Rate of Return (%)	**5.00%**
			Total Net Present Value Cost of Annual Remediation ($)	**$32,000**

Cleanup Alternative 2b (Net Present Value Rounded to the Nearest $1,000) **$** **$452,000**

Shell Harbor Island

Cleanup Action Alternative 2b: Biosparging and SVE System Installatior

Notes:

This estimate is -30%/+50% and is for budgeting purposes only.

Assumptions:

Well installation using Hollow Stem Auger to a maximum depth of 15 feet below grade for the AS wells.

Air knife to a maximum depth of 5 feet below grade.

Pipe is routed through trench to the compound for both AS and SVE located outside the dike wall. Excavated soil is re-used in the trench outside the dike wall.

AS system extends inside and outside the dike wall. Piping inside the dike wall is routed above ground and over the wall to the compound.

Electrical available at compound and no additional electrical drop is required.

5% interest rate of return for all monies deposited at Year 1, with annual payout at the beginning of each year for O&M.

Discount factors: NPV = cost multiplied by discount factor (f).

Present worth: $f = (1 + i)^{-n}$.

Equal series present worth: $f = (1 + i)^{n} - 1/ i(1 + i)^{n}$.

i = interest rate = 0.075.

Calculated cost rounded to nearest $100.

Sums are rounded to nearest $1,000

Shell Harbor Island

Cleanup Action Alternative 3: Enhanced Biological Remediation Implementation

Capital Costs				
Item	**Unit**	**Cost per Unit**	**Quantity**	**Cost per Item**
Installation Costs- BioAmendment Injection				
Mobilization / Demobilization Drill Rig	LS	$2,200.00	1	$2,200
Utility Locates and Air Knife Operation	Each	$7,500.00	1	$7,500
Injection Point Installation	Per Point	$750.00	75	$56,300
Injection Point Materials and Start Cards	Per Point	$200.00	75	$15,000
BioAmendment	Per Gallon	$5.00	8625	$43,100
BioAmendment Injection Standby Time	LS	$5,000.00	1	$5,000
Shipping	Each	$5,000.00	1	$5,000
Mobilization / Demobilization /Use - Crane	Per Hour	$1,000.00	20	$20,000
Temporary Conex Box for Equipment	Each	$500.00	1	$500
Mixing Tank Rental, pump, and Pipe (Delivered)	LS	$2,681.00	1	$2,700
Fencing/Security at Compound	Each	$1,600.00	1	$1,600
Waste Drum	Each	$75.00	19	$1,400
Waste Management	LS	$285.00	19	$5,300
			Subtotal	***$166,000***
Installation Costs - Design, Sampling and Oversight				
Engineering Design	15%			$24,900
Permitting and Access Agreements	5%			$8,300
Health and Safety	5%			$8,300
PM	Per hour	$88.70	60	$5,322
Engineering	Per Hour	$99.09	60	$5,945
Geologist-Oversight	Per Hour	$67.59	300	$20,277
Baseline and Semi-Annual Sampling Event Sampling				
Semi-Annual Sampling Event Labor	Per Hour	$67.59	100	$6,800
Semi-Annual Event	Per Well	$42.21	34	$1,400
ODCs	Per Day	$120.00	10	$1,200
Lab Costs	Per Well	$60.50	34	$2,100
Installation Report	10%			$8,300
			Subtotal	***$93,000***
			Subtotal	$259,000
Contingency	5%			$13,000
			Total	**$272,000**

Shell Harbor Island

Cleanup Action Alternative 3: Enhanced Biological Remediation Implementation

Recurring and Future Costs				
Item	**Unit**	**Cost per Unit**	**Quantity**	**Cost per Item**
Polish Injection Event, Project Year Incurred: 2				
Installation Costs- BioAmendment Injection				
Mobilization / Demobilization Drill Rig	LS	$2,200.00	1	$2,200
Utility Locates and Air Knife Operation	Each	$5,000.00	1	$5,000
Injection Point Installation	Per Point	$550.00	33	$18,200
Injection Point Materials and Start Cards	Per Point	$200.00	33	$6,600
BioAmendment	Per Gallon	$5.00	3960	$19,800
Temporary Conex Box for Equipment	Each	$500.00	1	$500
Fencing/Security at Compound	Each	$1,600.00	1	$1,600
Mixing Tank Rental, pump, and Pipe (Delivered)	LS	$2,681.00	1	$2,700
Waste Drum	Each	$75.00	8	$600
Waste Management	LS	$500.00	8	$4,100
			Subtotal	***$62,000***
Installation Costs - Design, Sampling and Oversight				
Engineering Design	10%			$6,200
Permitting and Access Agreements	5%			$3,100
Health and Safety	5%			$3,100
PM	Per hour	$88.72	47	$4,200
Engineering, Planning and Scheduling	Per Hour	$99.09	70	$7,000
Geologist-Oversight	Per Hour	$67.59	234	$15,841
Semi-Annual Sampling Event Sampling				
Semi-Annual Sampling Event Labor	Per Hour	$67.59	100	$6,759
Semi-Annual Event	Per Well	$42.21	34	$1,435
ODCs	Per Day	$120.00	10	$1,200
Lab Costs	Per Well	$60.50	34	$2,057
Installation Report	10%	$62,000		$6,200
			Subtotal	***$58,000***
			Subtotal	$120,000
Contingency	5%			$6,000
			Annual Cleanup Action Cost ($)	**$126,000**
			Interest Rate of Return (%)	**5.00%**
			Total Net Present Value Cost of Annual Remediation ($)	**$114,000**
Groundwater Monitoring Costs: Project Year Incurred: Year 3				
Project Management	15%			$2,500.00
Reporting	25%			$3,400.00
Health and Safety	5%			$600.00
Semi-Annual Sampling Events Year 3				
Semi-Annual Sampling Event Labor	Per Hour	$67.59	100	$6,800.00
Semi-Annual Event	Per Well	$42.21	34	$1,400.00
ODCs	Per Day	$250.00	10	$2,500.00
Lab Costs	Per Well	$60.50	34	$2,100.00
			Subtotal	***$7,000***
			Subtotal	$7,000
Contingency	5%			$400
			Annual Cleanup Action Cost ($)	**$8,000**
			Interest Rate of Return (%)	**5.00%**
			Total Net Present Value Cost of Annual Remediation ($)	**$7,000**
Groundwater Monitoring Costs: Project Year Incurred: Year 4				
Project Management	15%			$5,000.00
Reporting	25%			$6,700.00
Health and Safety	5%			$1,300.00
Quarterly Confirmation Sampling Events Year 4				
Quarterly Sampling Event Labor	Per Hour	$67.59	200	$13,500.00
Quarterly Event	Per Well	$42.21	68	$2,900.00
ODCs	Per Day	$250.00	20	$5,000.00
Lab Costs	Per Well	$60.50	68	$4,100.00
			Subtotal	***$39,000***
			Subtotal	$39,000
Contingency	5%			$2,000
			Annual Cleanup Action Cost ($)	**$41,000**
			Interest Rate of Return (%)	**5.00%**
			Total Net Present Value Cost of Annual Remediation ($)	**$34,000**

Cleanup Alternative 3 (Net Present Value Rounded to the Nearest $1,000)	**$**	**$427,000**

Shell Harbor Island
Cleanup Action Alternative 3: Enhanced Biological Remediation Implementation

Notes:
This estimate is -30%/+50% and is for budgeting purposes only.

Assumptions:
Well installation using direct push to maximum depth of 15 feet below grade.
Air knife in areas oustide of Dike Wall, along utility Cooridor to a maximum depth of 5 feet below grade.
Pipe is routed through trench to the compound for both AS and SVE located outside the dike wall. Excavated soil is re-used in
AS system extends inside and outside the dike wall. Piping
inside the dike wall is routed above ground and over the wall
Electrical available at compound and no additional electrical drop is required.

5% interest rate of return for all monies deposited at Year 1, with annual payout at the beginning of each year for O&M.
Discount factors: NPV = cost multiplied by discount factor (f).
Present worth: $f = (1 + i)^{-n}$.
Equal series present worth: $f = (1 + i)^{n} - 1/ i(1 + i)^{n}$.
i = interest rate = 0.075.
Calculated cost rounded to nearest $100.

Sums are rounded to nearest $1,000

Shell Harbor Island

Cleanup Action Alternative 4: Groundwater Pumping and Treatment System

Capital Costs				
Item	**Unit**	**Cost per Unit**	**Quantity**	**Cost per Item**
Installation Costs- AS				
Mobilization / Demobilization Drill Rig	LS	$3,000.00	1	$3,000
Utility Locates and Air knife	LS	$2,500.00	1	$2,500
Drilling	Per Well	$1,275.00	3	$3,900
Well Installation Materials and Start Cards	Per Well	$500.00	3	$1,500
Well Vaults	Each	$560.00	3	$1,700
Construction Crew, daily	Day	$2,800.00	2	$5,600
Asphalt Removal	SF	$8.00	200	$1,600
Trenching	LF	$60.00	200	$12,000
Pipe	LF	$2.00	200	$400
Header	Each	$500.00	1	$500
Pipe Installation	LF	$8.50	500	$4,300
Holding tank	Each	$5,000.00	1	$5,000
4-inch Submersible Pumps and Controllers	Per Well	$1,500.00	3	$4,500
Low-profile 2-drawer, Air-Stripper Tower (20 gpm)	Each	$15,000.00	1	$15,000
Activated Carbon Vessel	Each	$2,500.00	2	$5,000
Tough Shed for Equipment	Each	$3,500.00	1	$3,500
Fencing/Security at Compound	Each	$1,600.00	1	$1,600
Electrical Control Panel	Each	$7,500.00	1	$7,500
Waste Drum	Each	$75.00	10	$800
Waste Management	LS	$2,500.00	1	$2,500
			Subtotal	***$83,000***
Installation Costs - Misc.				
Engineering Design	10%			$8,300
Electrician	Each	$5,000.00	1	$5,000
Permitting and Access Agreements	5%			$4,200
Health and Safety	5%			$4,200
PM	Per hour	$88.72	40	$3,600
Engineering	Per Hour	$99.09	52	$5,200
Geologist	Per Hour	$67.59	48	$3,300
Baseline Analytical and 1-Semi-Annual Event				
Semi-Annual Sampling Event Labor	Per Hour	$67.59	100	$6,800
Semi-Annual Event	Per Well	$42.21	34	$1,500
ODCs	Per Day	$250.00	10	$2,500
Lab Costs	Per Well	$60.50	34	$2,100
Air Monitoring				
Monitoring Labor	Per Hour	$67.59	80	$5,500
Lab Costs	Per Sample	$650.00	6	$3,900
ODCs	Per Day	$120.00	6	$800
Routine O&M	Per Hour	$67.59	175	$11,900
Engineering Install Report and O&M Manual	5%			$4,200.00
			Subtotal	***$73,000***
			Subtotal	$156,000
Contingency	5%			$8,000
			Total	**$164,000**

Shell Harbor Island

Cleanup Action Alternative 4: Groundwater Pumping and Treatment System

Recurring and Future Costs				
Item	**Unit**	**Cost per Unit**	**Quantity**	**Cost per Item**
Annual Operations and Maintenance Costs - P&T System, Project Year Incurred: 2 through 25				
Pump Liquid Ends	Per Well	$300.00	3	$900
Electrician	Each	$5,000.00	1	$5,000
Misc. Equipment Repair	Each	$2,500.00	1	$2,500
Stripper Cleaning	Each	$2,500.00	1	$2,500
Vapor Phase Carbon Changeout	Each	$5,500.00	1	$5,500
Bi-Monthly Site Visits and Readings	Per hour	$110.00	96	$10,600
Monthly NPDES Samples	Each	$200.00	12	$2,400
Waste Drums	Each	$75.00	2	$200
Waste Management	LS	$500.00	1	$500
			Subtotal	***$31,000***
Routine Groundwater Monitoring and Reporting, Project Year Incurred: 2 through 25				
Project Management	20%			$8,674
Reporting	25%			$8,674
Health and Safety	5%			$1,700
Monthly O&M	Per hour	$67.59	120	$8,111
Semi-Annual Sampling Event #2-Labor				
Semi-Annual Sampling Event Labor	Per Hour	$67.59	100	$6,800
Semi-Annual Event	Per Well	$42.21	34	$1,500
ODCs	Per Day	$250.00	22	$5,500
Lab Costs	Per Well	$60.50	34	$2,100
Air Monitoring				
Quarterly Monitoring Labor	Per Hour	$67.59	40	$2,704
Lab Costs	Per Sample	$650.00	4	$2,600
ODCs	Per Day	$120.00	4	$480
Annual System Evaluation	Per Hour	$99.09	32	$3,200
			Subtotal	***$53,000***
			Subtotal	$84,000
Contingency	5%			$4,200
			Annual Cleanup Action Cost ($)	**$89,000**
			Estimated Cleanup Time (years)	**2 to 25**
			Interest Rate of Return ($%)	**5.00%**
			Total Net Present Value Cost of Annual Remediation ($)	**$1,170,000**
Groundwater Monitoring Costs: Project Year Incurred: Year 26				
Project Management	15%			$5,000
Reporting	25%			$6,700
Health and Safety	5%			$1,300
Quarterly Confirmation Sampling Events Year 4				
Quarterly Sampling Event Labor	Per Hour	$67.59	200	$13,500
Quarterly Event	Per Well	$42.21	68	$2,900
ODCs	Per Day	$250.00	20	$5,000
Lab Costs	Per Well	$60.50	68	$4,100
			Subtotal	***$38,500***
			Subtotal	$38,500
Contingency	5%			$1,900
			Annual Cleanup Action Cost ($)	**$41,000**
			Interest Rate of Return (%)	**5.00%**
			Total Net Present Value Cost of Annual Remediation ($)	**$12,000**

Cleanup Alternative 4 (Net Present Value Rounded to the Nearest $1,000)	**$ $1,346,000**

Shell Harbor Island
Cleanup Action Alternative 4: Groundwater Pumping and Treatment System

Notes:
This estimate is -30%/+50% and is for budgeting purposes only.

Assumptions:
Well installation using Hollow Stem Auger to a maximum depth of 15 feet below grade.
Air knife at well locations to a maximum depth of 5 feet below grade.
Extraction Pipe is routed through trench to the treatment compound. Excavated soil is re-used in the shallow trenchline outside the dike wall.
Electrical available at compound and no additional electrical drop is required.
5% interest rate of return for all monies deposited at Year 1, with annual payout at the beginning of each year for O&M.
Discount factors: NPV = cost multiplied by discount factor (f).
Present worth: $f = (1 + i)^{-n}$.
Equal series present worth: $f = (1 + i)^n - 1/ i(1 + i)^n$.
i = interest rate = 0.075.
Calculated cost rounded to nearest $100.

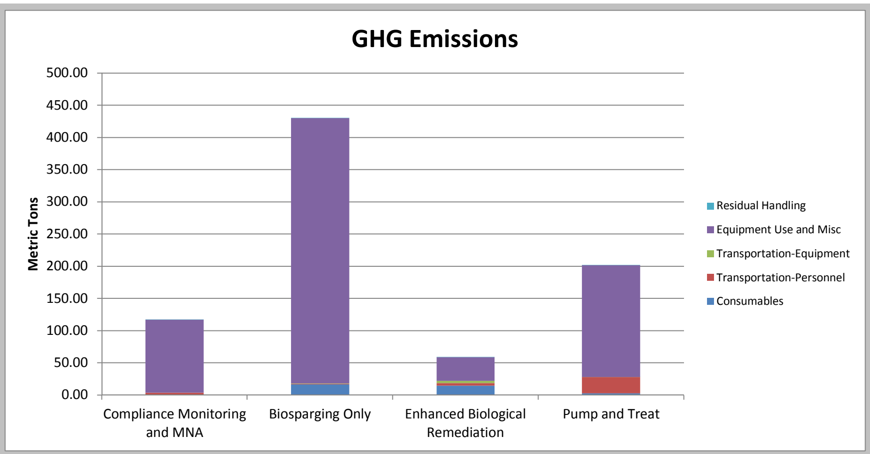
Sums are rounded to nearest $1,000

Appendix D
Sustainable Remediation
Environmental Footprint Summary

Sustainable Remediation - Environmental Footprint Summary
Baseline Sustainability Conditions

anup Alterna	Activities	GHG Emissions	Total Energy Used	Water Consumption	Electricity Usage	Onsite NOx Emissions	Onsite SOx Emissions	Onsite PM10 Emissions	Total NOx Emissions	Total SOx Emissions	Total PM10 Emissions	Accident Risk Fatality	Accident Risk Injury
		metric ton	MMBTU	gallons	MWH	metric ton	metric ton	metric ton	metric ton	metric ton	metric ton		
Compliance Monitoring and MNA	Consumables	0.04	3.0E-01	NA	NA	NA	NA	NA	8.6E-05	1.7E-04	3.4E-05	NA	NA
	Transportation-Personnel	3.66	4.6E+01	NA	NA	NA	NA	NA	1.4E-03	4.8E-05	2.7E-04	1.5E-04	1.2E-02
	Transportation-Equipment	0.00	0.0E+00	NA	NA	NA	NA	NA	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
	Equipment Use and Misc	113.41	1.6E+03	2.5E+03	0.0E+00	0.0E+00	0.0E+00	0.0E+00	5.4E-01	4.1E-01	4.5E-02	1.4E-04	3.6E-02
	Residual Handling	0.85	1.2E+01	NA	NA	0.0E+00	0.0E+00	0.0E+00	5.7E-04	1.8E-04	9.3E-04	2.8E-06	2.3E-04
	Sub-Total	117.96	1.68E+03	2.49E+03	0.00E+00	0.00E+00	0.00E+00	0.00E+00	5.46E-01	4.09E-01	4.66E-02	2.98E-04	4.87E-02
Biosparging Only	Consumables	16.60	1.9E+04	NA	NA	NA	NA	NA	3.3E-02	4.4E-02	5.6E-03	NA	NA
	Transportation-Personnel	1.21	1.5E+01	NA	NA	NA	NA	NA	4.6E-04	1.6E-05	8.5E-05	4.5E-05	3.6E-03
	Transportation-Equipment	0.35	3.5E+00	NA	NA	NA	NA	NA	6.7E-03	1.4E-03	1.8E-04	3.1E-07	2.5E-05
	Equipment Use and Misc	412.08	4.5E+03	4.0E+02	4.4E-04	4.3E+00	5.7E-01	2.3E-01	4.6E+00	7.4E-01	2.7E-01	9.9E-05	2.8E-02
	Residual Handling	0.44	5.9E+00	NA	NA	0.0E+00	0.0E+00	0.0E+00	1.4E-04	4.0E-06	1.2E-05	1.9E-06	1.5E-04
	Sub-Total	430.67	2.31E+04	4.00E+02	4.43E-04	4.26E+00	5.67E-01	2.31E-01	4.60E+00	7.89E-01	2.74E-01	1.46E-04	3.22E-02
Enhanced Biological Remediation	Consumables	14.60	2.7E+02	NA	NA	NA	NA	NA	2.9E-02	4.4E-02	6.5E-03	NA	NA
	Transportation-Personnel	3.90	4.9E+01	NA	NA	NA	NA	NA	1.4E-03	5.1E-05	2.9E-04	1.6E-04	1.3E-02
	Transportation-Equipment	3.90	2.2E+01	NA	NA	NA	NA	NA	1.1E-01	2.4E-02	2.9E-03	0.0E+00	0.0E+00
	Equipment Use and Misc	36.74	5.2E+02	1.7E+03	4.4E-05	3.4E-02	3.5E-03	3.4E-03	2.0E-01	1.2E-01	1.7E-02	7.1E-05	2.1E-02
	Residual Handling	0.39	5.5E+00	NA	NA	0.0E+00	0.0E+00	0.0E+00	2.5E-04	7.3E-05	3.7E-04	1.4E-06	1.1E-04
	Sub-Total	59.54	8.65E+02	1.65E+03	4.43E-05	3.41E-02	3.49E-03	3.41E-03	3.37E-01	1.91E-01	2.70E-02	2.32E-04	3.45E-02
Pump and Treat	Consumables	2.94	2.4E+03	NA	NA	NA	NA	NA	6.5E-03	9.4E-03	1.4E-03	NA	NA
	Transportation-Personnel	25.12	3.2E+02	NA	NA	NA	NA	NA	9.3E-03	3.3E-04	1.9E-03	6.6E-04	5.3E-02
	Transportation-Equipment	0.04	5.1E-01	NA	NA	NA	NA	NA	1.2E-05	2.2E-07	1.1E-06	1.2E-06	1.0E-04
	Equipment Use and Misc	173.72	2.5E+03	3.7E+03	4.2E+00	6.4E-03	4.9E-04	2.6E-04	8.2E-01	6.1E-01	6.9E-02	5.3E-05	1.8E-02
	Residual Handling	0.58	7.8E+00	NA	NA	0.0E+00	0.0E+00	0.0E+00	4.8E-04	1.7E-04	9.2E-04	1.9E-06	1.5E-04
	Sub-Total	202.40	5.18E+03	3.68E+03	4.16E+00	6.35E-03	4.90E-04	2.58E-04	8.41E-01	6.24E-01	7.33E-02	7.20E-04	7.20E-02

Remedial Alternative Phase	Non-Hazardous Waste Landfill Space	Hazardous Waste Landfill Space	Topsoil Consumption	Costing	Lost Hours - Injury	Percent electricity from renewable sources	Total Cost with Footprint Reduction
	tons	tons	cubic yards	$		%	
Compliance Monitoring	5.0E+00	0.0E+00	0.0E+00	1	3.9E-01	0.0%	**$1,500,000**
Biosparging Only	0.0E+00	0.0E+00	0.0E+00	0	2.6E-01	65.9%	
Enhanced Biological Remediation	2.0E+00	0.0E+00	0.0E+00	0	2.8E-01	65.9%	
Pump and Treat	5.0E+00	0.0E+00	0.0E+00	0	5.8E-01	65.9%	
Total	**1.2E+01**	**0.0E+00**	**0.0E+00**	**$1**	**1.5E+00**	**49.4%**	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Metric Tons
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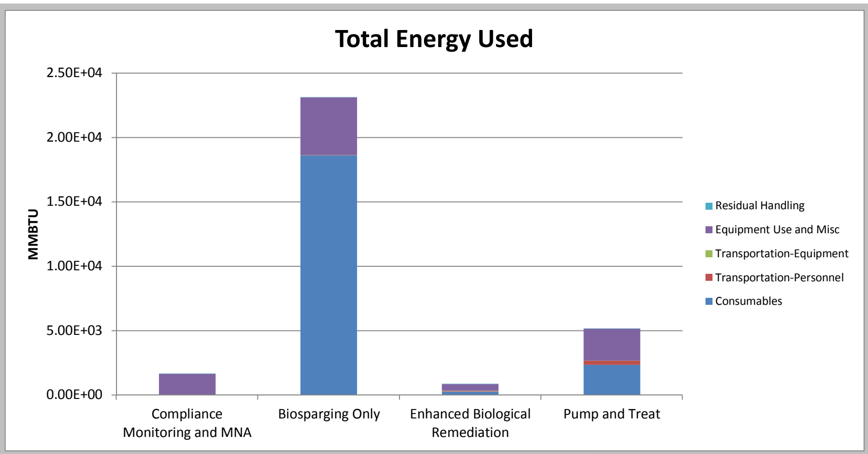
450.00
400.00
350.00
300.00
250.00
200.00
150.00
100.00
50.00
0.00
Compliance Monitoring and MNA
Biosparging Only
Enhanced Biological Remediation
Pump and Treat
Residual Handling
Equipment Use and Misc
Transportation-Equipment
Transportation-Personnel
Consumables


Total Energy Used
MMBTU
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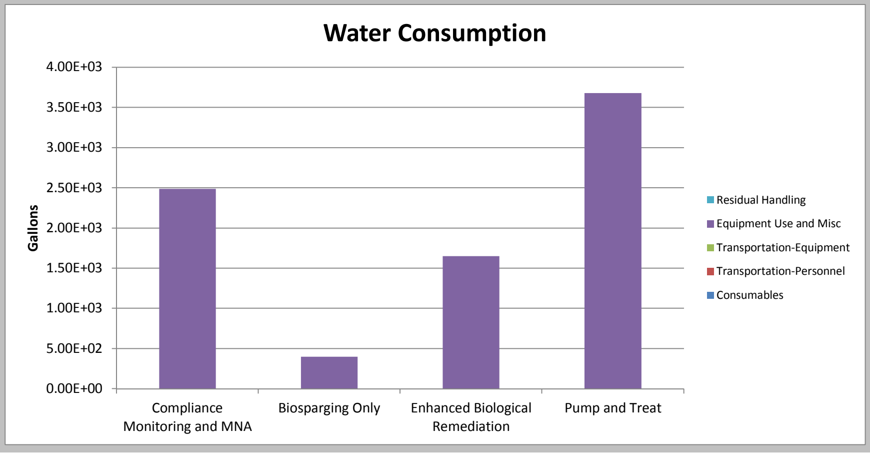
Compliance Monitoring and MNA
Biosparging Only
Enhanced Biological Remediation
Pump and Treat
Residual Handling
Equipment Use and Misc
Transportation-Equipment
Transportation-Personnel
Consumables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Gallons
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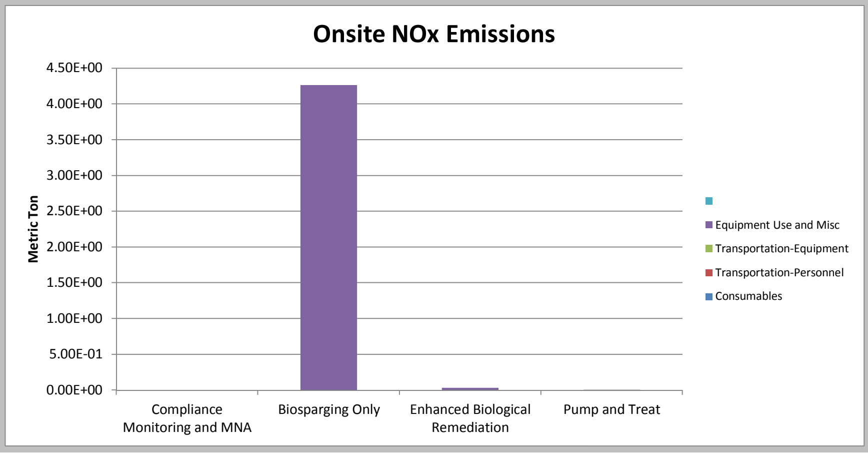
3.50E+03
3.00E+03
2.50E+03
2.00E+03
1.50E+03
1.00E+03
5.00E+02
0.00E+00
Compliance Monitoring and MNA
Biosparging Only
Enhanced Biological Remediation
Pump and Treat
Residual Handling
Equipment Use and Misc
Transportation-Equipment
Transportation-Personnel
Consumables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Metric Ton
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3.00E+00
2.50E+00
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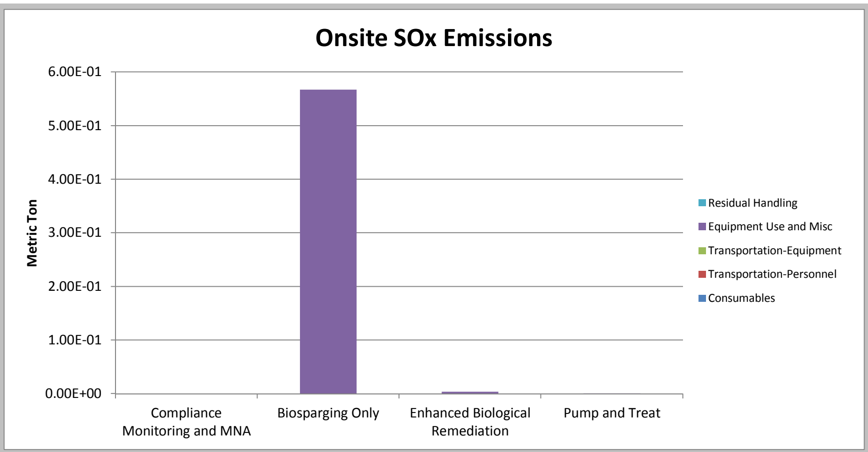
1.00E+00
5.00E-01
0.00E+00
Compliance Monitoring and MNA
Biosparging Only
Enhanced Biological Remediation
Pump and Treat
Equipment Use and Misc
Transportation-Equipment
Transportation-Personnel
Consumables


Onsite SOx Emissions
Metric Ton
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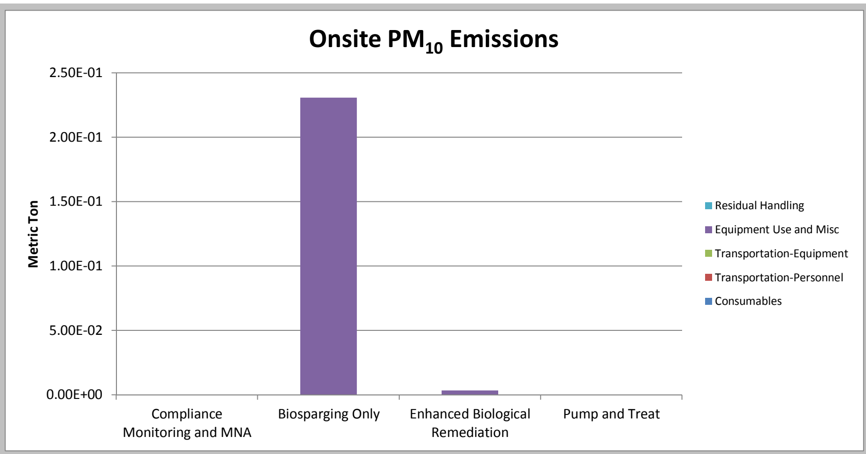
3.00E-01
2.00E-01
1.00E-01
0.00E+00
Compliance Monitoring and MNA
Biosparging Only
Enhanced Biological Remediation
Pump and Treat
Residual Handling
Equipment Use and Misc
Transportation-Equipment
Transportation-Personnel
Consumables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Metric Ton
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5.00E-02
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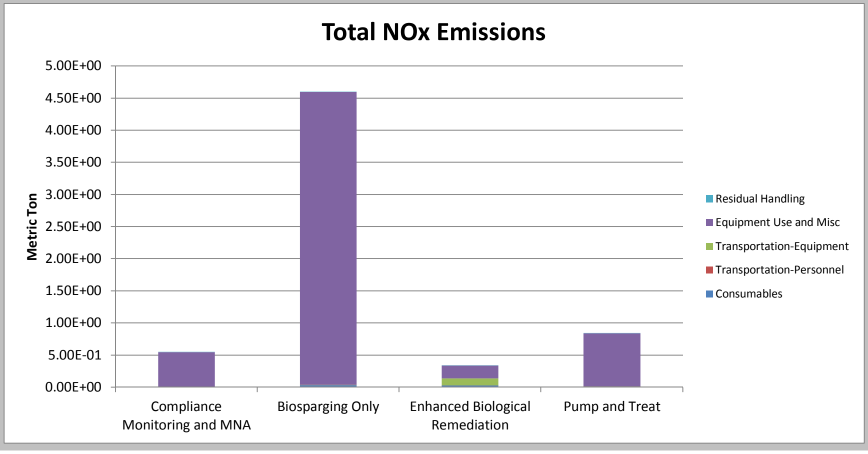
Compliance Monitoring and MNA
Biosparging Only
Enhanced Biological Remediation
Pump and Treat
Residual Handling
Equipment Use and Misc
Transportation-Equipment
Transportation-Personnel
Consumables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Metric Ton
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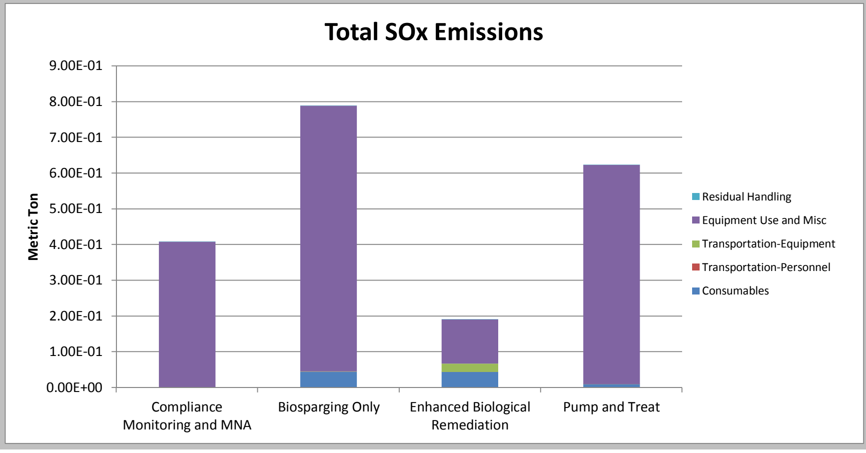
4.00E+00
3.50E+00
3.00E+00
2.50E+00
2.00E+00
1.50E+00
1.00E+00
5.00E-01
0.00E+00
Compliance Monitoring and MNA
Biosparging Only
Enhanced Biological Remediation
Pump and Treat
Residual Handling
Equipment Use and Misc
Transportation-Equipment
Transportation-Personnel
Consumables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Metric Ton
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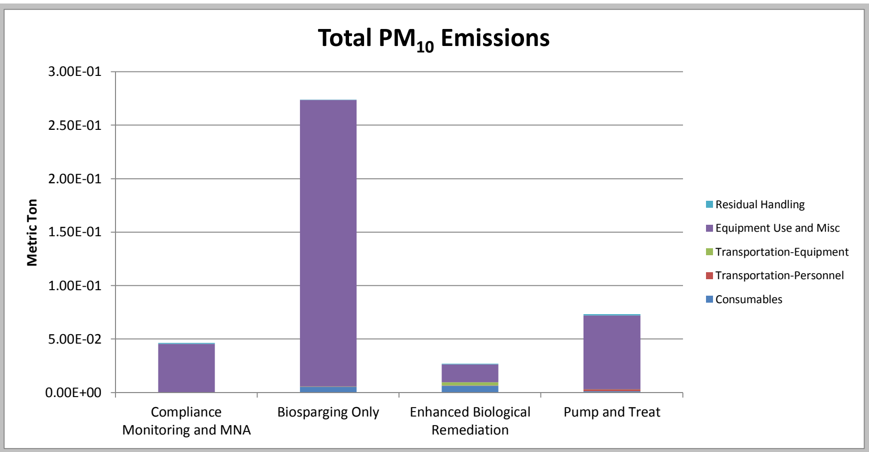
7.00E-01
6.00E-01
5.00E-01
4.00E-01
3.00E-01
2.00E-01
1.00E-01
0.00E+00
Compliance Monitoring and MNA
Biosparging Only
Enhanced Biological Remediation
Pump and Treat
Residual Handling
Equipment Use and Misc
Transportation-Equipment
Transportation-Personnel
Consumables



Total PM10 Emissions
Metric Ton
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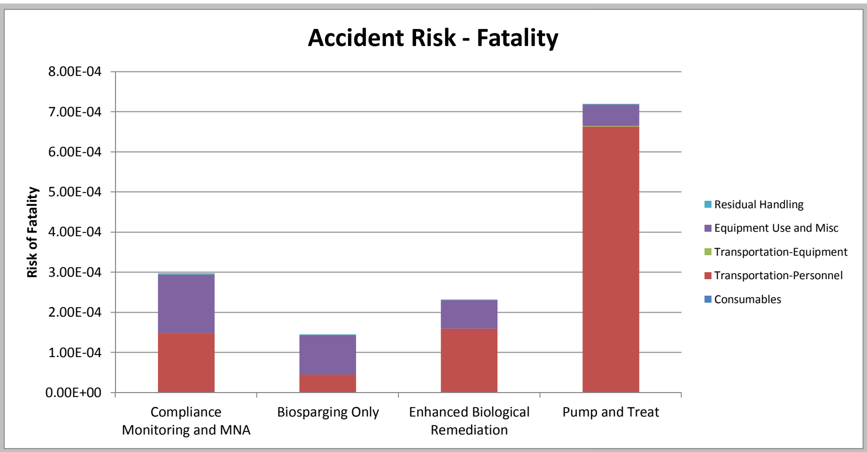
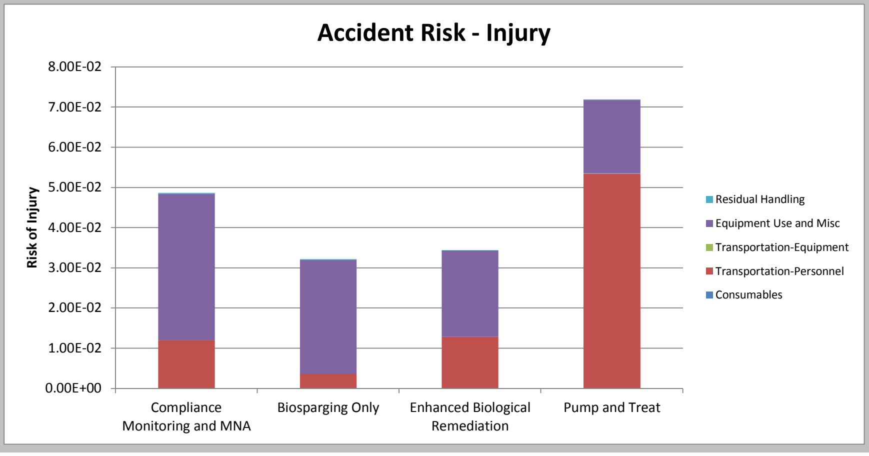
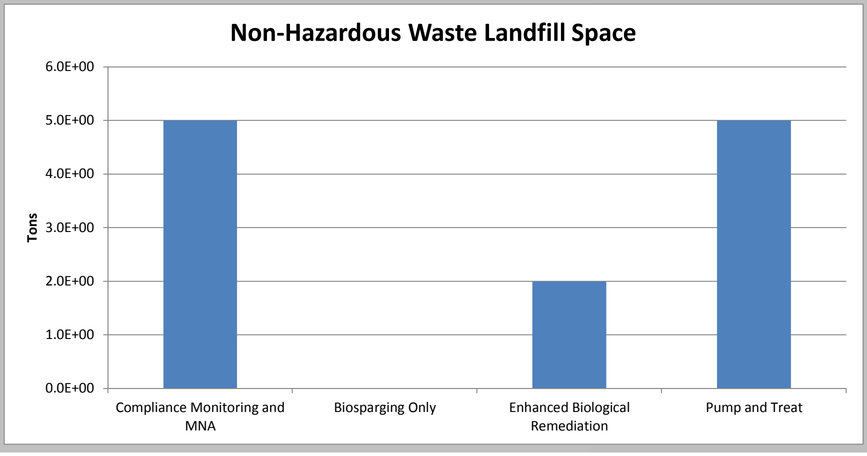
2.00E-01
1.50E-01
1.00E-01
5.00E-02
0.00E+00
Compliance Monitoring and MNA
Biosparging Only
Enhanced Biological Remediation
Pump and Treat
Residual Handling
Equipment Use and Misc
Transportation-Equipment
Transportation-Personnel
Consumables



Accident Risk - Fatality
Risk of Fatality
8.00E-04
7.00E-04
6.00E-04
5.00E-04
4.00E-04
3.00E-04
2.00E-04
1.00E-04
0.00E+00
Compliance Monitoring and MNA
Biosparging Only
Enhanced Biological Remediation
Pump and Treat
Residual Handling
Equipment Use and Misc
Transportation-Equipment
Transportation-Personnel
Consumables

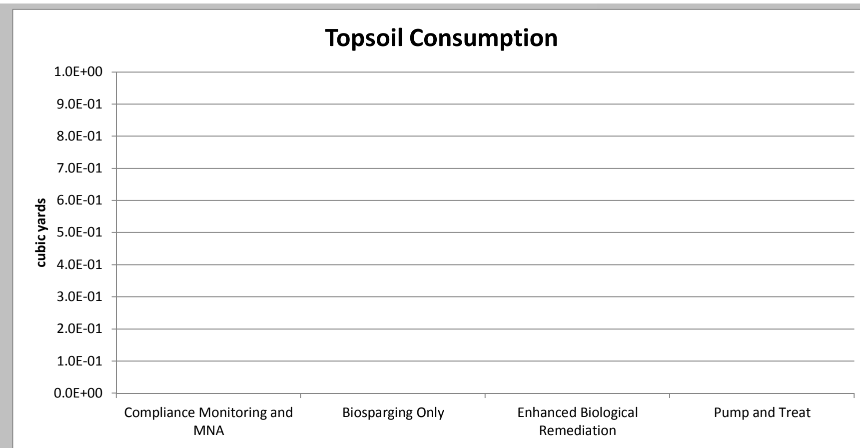


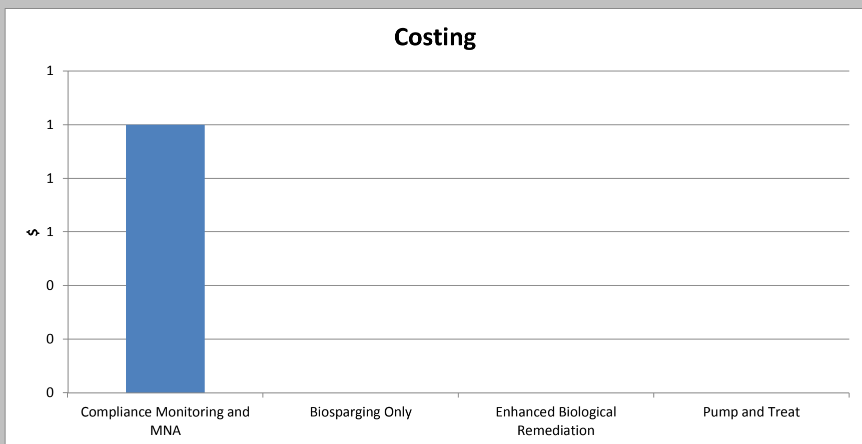
Accident Risk - Injury
Risk of Injury
8.00E-02
7.00E-02
6.00E-02
5.00E-02
4.00E-02
3.00E-02
2.00E-02
1.00E-02
0.00E+00
Compliance Monitoring and MNA
Biosparging Only
Enhanced Biological Remediation
Pump and Treat
Residual Handling
Equipment Use and Misc
Transportation-Equipment
Transportation-Personnel
Consumables

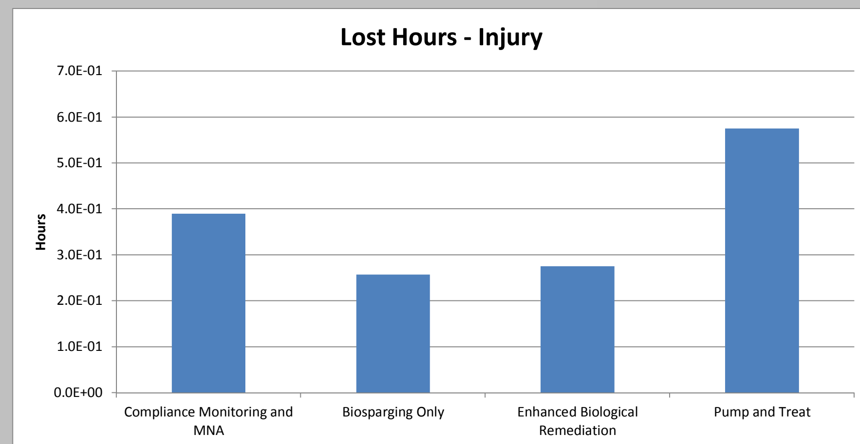


Non-Hazardous Waste Landfill Space
Tons
6.0E+00
5.0E+00
4.0E+00
3.0E+00
2.0E+00
1.0E+00
0.0E+00
Compliance Monitoring and MNA
Biosparging Only
Enhanced Biological Remediation
Pump and Treat


Hazardous Waste Landfill Space
Tons
1.0E+00
9.0E-01
8.0E-01
7.0E-01
6.0E-01
5.0E-01
4.0E-01
3.0E-01
2.0E-01
1.0E-01
0.0E+00
Compliance Monitoring and MNA
Biosparging Only
Enhanced Biological Remediation
Pump and Treat


Topsoil Consumption
cubic yards
1.0E+00
9.0E-01
8.0E-01
7.0E-01
6.0E-01
5.0E-01
4.0E-01
3.0E-01
2.0E-01
1.0E-01
0.0E+00
Compliance Monitoring and MNA
Biosparging Only
Enhanced Biological Remediation
Pump and Treat


Costing
$
1
1
1
1
0
0
0
Compliance Monitoring and MNA
Biosparging Only
Enhanced Biological Remediation
Pump and Treat


Lost Hours - Injury
Hours
7.0E-01
6.0E-01
5.0E-01
4.0E-01
3.0E-01
2.0E-01
1.0E-01
0.0E+00
Compliance Monitoring and MNA
Biosparging Only
Enhanced Biological Remediation
Pump and Treat