NATURAL ATTENUATION EVALUATION REPORT

Part 1

Inactive Exxon Facility #28077
14258 Jarrettsville Pike
Phoenix, Maryland
Case Number 2006-0303-BA2
Facility I.D. No. 12342

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INACTIVE EXXON FACILITY #28077
14258 JARRETTSVILLE PIKE
PHOENIX, BALTIMORE COUNTY, MARYLAND
MDE CASE # 2006-0303-BA2
KLEINFELDER PROJECT NO.: 20193011.001A

JULY 25, 2019

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1 INTRODUCTION

This report presents the testing, results, and evaluation of data that serve as multiple lines of evidence indicative of biodegradation and potential for natural attenuation at the former Exxon service station (#28077) located in Phoenix, Baltimore County, Maryland (**Figure 1**).

1.1 BACKGROUND

Since the 2006 release of gasoline, a combination of total fluids pumping, multi-phase vacuum extraction, and soil vapor extraction have been effective at removing hydrocarbon mass. Dissolved-phase hydrocarbons have been significantly reduced in concentration and retracted in extent as the result of remediation activities.

Residual concentrations above MDE action levels generally remain in the following areas:

- Proximate to the release on the service station property;
- Within or near the MD-145/MD-146 intersection;
- On properties bounding the intersection to the east;
- Monitoring wells in the “near northeast” area (3506, 3506 and 3508 Hampshire Glen Court).

A natural attenuation evaluation monitoring wells was proposed (Kleinfelder, February 4,2019) to determine whether groundwater conditions at the Site are conducive to natural attenuation, principally biodegradation. The proposal was approved by the MDE in letter dated March 20, 2019.

1.2 PURPOSES AND OBJECTIVES

Natural attenuation processes, including biodegredation are expected to effectively complement reductions in active remediation and are supportive to the protection of supply wells and potential surface water receptors in the area. It is well established that these processes are active at the vast majority of hydrocarbon release sites (Wiedemeier, et al., 1999), capable of stabilizing plumes where sources are not fully remediated and contracting and degrading plumes where active source reduction has occurred (e.g., the Phoenix site). Consequently, these processes are expected to complement continued reductions in active remediation, allowing ExxonMobil and the MDE to make decisions regarding the ongoing need for active remediation in select wells across the project area and instill confidence in ongoing natural processes subsequent to active and aggressive remediation.

The natural attenuation evaluation was designed to assess the biodegradation potential of the aquifer through multiple lines of evidence:

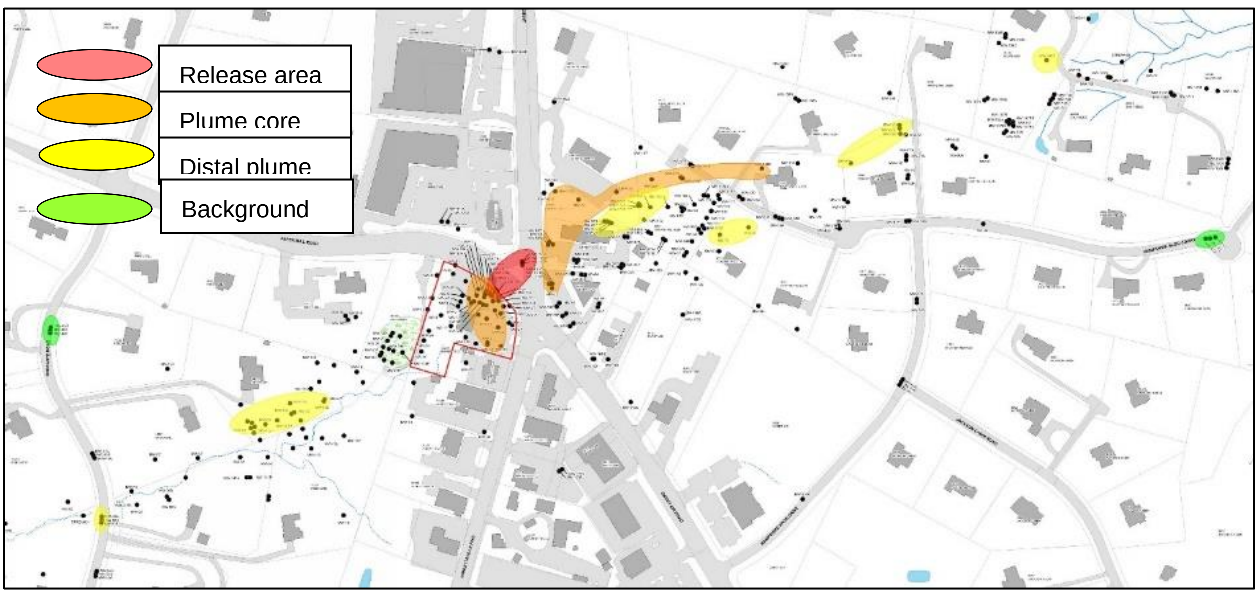
1) the presence of microbes capable of degrading gasoline constituents, including methyl tertiary butyl ether (MtBE);
2) whether these degraders are active;
3) geochemical indicators of biodegradation through aerobic and/or anaerobic processes; and,
4) whether aquifer conditions are favorable for microbial activity.

2 TESTING SAMPLING AND ANALYSIS PLAN

This section presents the testing, sampling, and analysis plan, including the monitoring well network selected; testing, measurements, and analysis conducted; and field and laboratory methods utilized. **Table 1** summarizes the full testing, sampling, and analysis plan in the form of a matrix organized by site area, monitoring wells, and testing/analyses.

2.1 MONITORING WELL TESTING NETWORK

A network of 40 monitoring wells was selected to evaluate natural attenuation potential in areas affected to different degrees by gasoline constituents as a result of the 2006 release. These monitoring wells are grouped into four general areas: 1) release area; 2) plume core; 3) downgradient distal plume; and, 4) "background" conditions in areas without historical impact from the release. These areas are general categories based on relative historical and residual concentrations, historical extent of light non-aqueous phase liquid (LNAPL), and groundwater flow directions (see embedded figure below).



Graphic 1 Segments of Gasoline Constituent Plume

For reference, **Table 2,** and **Figures 2a & b** present the 2019 semi-annual groundwater sampling analytical results for MtBE and **Table 2** provides the 2019 semi-annual groundwater sampling analytical results for benzene.

1. Release Area – The selected six wells are located in the former tank field area and in the intersection of roads MD-146 (Jarrettsville Pike) and MD-145 (Sweet Air Road / Paper Mill Road), directly downgradient of the release to the northeast. This area was directly affected by gasoline as a separate phase liquid (SPL). MW-27R had sustained elevated MtBE and benzene concentrations since the time of the release and other wells in this area continue to exhibit concentrations of MtBE above the MDE action level (20 µg/L) (**Table 2**). MW-187A, B and C were selected to provide a vertical profile near the source area; due to logistical constraints, this area was not targeted for remediation until 2014 when MW-187B was connected to the GWPT system. Consequently, the intersection remained as an un-remediated source area for an extended duration, allowing for natural biodegradation processes to occur without interference from remedial intervention. Monitoring wells selected for the natural attenuation evaluation of the release area include:

    - MW-27R (station)
    - MW-27B (station)
    - SVE-1 (station)
    - MW-187A (intersection)
    - MW-187B (intersection)
    - MW-187C (intersection)

2. Plume Core (Station and Northeast) – These nine wells fall within the core of the original plume, on the service station property and off the property to the northeast along the strike line. Select wells in this area also exhibit concentrations of MtBE above the MDE action level, and MW-1 shows persistent benzene. Monitoring wells MW-54, 54B and 54C have been targeted to provide a vertical profile of the shallow-to-deep transition point for the plume and elevated MtBE concentrations persist at this location. Monitoring well MW-138D, sampled via water FLUTe™ liner, has persistent MtBE concentrations above action levels in several deeper intervals, and has not responded to active remediation on the nearby 3501 Hampshire Glen Court property (**Table 2**).

    - MW-1 (station)
    - MW-7 (station)
    - MW-13 (station)
    - SVE-3 (station)
    - MW-54 (northeast)
    - MW-54B (northeast)
    - MW-54C (northeast)
    - MW-73C (northeast)
    - MW-138D (northeast)
    - MW-181C (northeast
    - MW-188D (northeast)

3. Distal Plume (northeast and southwest) – These 17 wells lie at the outer limits of the plume, to both the northeast and southwest directions from the Site. Some of these monitoring wells have been impacted above the MDE action level for MtBE over the past 12 years, while some have not. A few monitoring wells continue to exhibit occasional detections of MtBE above 20 µg/L, and some, like MW-178C, are consistently above the action level (**Table 2**). In the southwest, only MW-40 continues to exhibit concentrations at or approaching the MDE action level for MtBE. Monitoring wells MW-56A, B and C provide a vertical profile of groundwater conditions at the distal extent of the former plume.

   In the northeast, MW-178C, MW-184, and MW-168 exhibit historical "deeper" impact offset from the original "strike line" of contaminant migration through 3501 Hampshire Glen Court. The distal shallow to intermediate groundwater conditions are represented by MW-89, MW-82B, and MW-82D. MW-189D, the farthest monitoring well to the northeast, represents a deep well where MtBE has been detected above MDE action levels during later stages of investigation (**Table 2**). A vertical profile of the "near northeast" area is provided by MW-38, 38B and 38C, while MW-74 and MW-75 are located in the shallow water table along the "strike line" contaminant migration track.

- MW-40 (southwest)
- MW-71 (southwest)
- MW-56A (southwest)
- MW-56B (southwest)
- MW-56C (southwest)
- MW-38 (northeast)
- MW-38B (northeast)
- MW-38C (northeast)
- MW-74 (northeast)
- MW-75 (northeast)
- MW-82B (northeast)
- MW-82D (northeast)
- MW-89 (northeast)
- MW-168 (northeast)
- MW-178C (northeast)
- MW-184 (northeast)
- MW-189D (northeast)

4. Background (northeast and southwest) – The last group of six wells proposed for inclusion in the evaluation represent "background" conditions, and are removed, both in distance and concentration, from the remaining residual impact. None of the wells in this group have ever been above the MDE action level for MtBE and all have been ND/j-flag since at least August 2006. The MW-42 cluster (MW-42A through MW-42C) will provide a vertical profile in an area with minimal historical impact located off the "strike line" in the southwest. Similarly, MW-92, 92A and 92C will supply the same for the northeast.

- MW-42A (southwest)
- MW-42B (southwest)
- MW-42C (southwest)

- MW-92 (northeast)
- MW-92A (northeast)
- MW-92C (northeast)

2.2 FIELD PARAMETERS

The 40 monitoring wells included in the study were sampled by conventional methods (low-flow, HydraSleeve™, or via the sampling port for recovery wells). Prior to the collection of laboratory samples, a YSI meter was used to measure pH, dissolved oxygen (DO), and oxidation-reduction potential (ORP). A Hach DS9000 unit and reagent was used in the field to measure ferrous iron.

In addition to the wells included in the full study, ORP was widely measured in most monitoring wells as a general indicator of aerobic or anaerobic conditions throughout the aquifer, which is an indication of biodegradation.

2.3 LABORATORY ANALYSIS

2.3.1 Electron Donor/Acceptor Indicators

Evidence of aerobic and/or anaerobic biodegradation was evaluated by analyzing groundwater samples for the presence and depletion of electron acceptors (dissolved oxygen, nitrate, sulfate, CO_2) and the accumulation of products of anaerobic biodegradation (ferrous iron and methane). Samples were submitted under chain-of-custody to Eurofins Lancaster Laboratories (Eurofins) in Lancaster, Pennsylvania for analysis via EPA method 300.0 (nitrate, sulfate), and RKSOP-175 (CO_2 by headspace, methane). Ferrous iron was measured in the field using a Hach DS9000 unit and reagent.

2.3.2 Environmental Conditions for Microbial Activity

The favorability of conditions for microbial activity was evaluated by measuring pH, temperature, and the presence of microbial nutrients such as orthophosphate. A YSI meter was used to measure pH and temperature, while orthophosphate was measured in the field using a Hach DS9000 unit and reagent.

2.3.3 Hydrocarbon Analytes

Hydrocarbon analysis was conducted in most monitoring wells sitewide (including the 40 monitoring wells in this study) during February and March 2019 to determine the concentrations of dissolved-phase hydrocarbon analytes including benzene, toluene, ethylbenzene, xylenes (BTEX), 5 fuel oxygenates known as “Oxy5” (tert-Amyl methyl ether [TAME], tert-Butyl alcohol [TBA], Ethyl tert-butyl ether [ETBE], di-Isopropyl ether [DIPE], MtBE, and naphthalene. Samples were submitted under chain-of-custody to Eurofins for analysis via EPA method 8260B.

2.3.4 Microbial Testing

Microbial Insights of Knoxville, TN performs microbial analysis via two different media – aqueous “grab” samples and Bio-Traps®. Bio-Traps® are passive samplers that collect microbes over 30-45 days. They are constructed from “beads” made of Nomex® and activated carbon, which, when deployed in a well, absorb contaminants and nutrients from the groundwater and provide a matrix to be colonized by microbes. Results obtained from Bio-Traps® are less variable than those obtained from aqueous “grab” samples, and better reflect spatial and temporal changes in the aquifer than grab samples can. Bio-Traps® were used when possible; however, they cannot be deployed in wells under active recovery, or which already have other passive sampling equipment installed. For these wells, aqueous grab samples were collected.

Microbial Insights’ QuantArray® provides evidence of microbes capable of degrading MtBE, BTEX, polycyclic aromatic hydrocarbons (PAHs), and a variety of short and long chain alkanes by quantification of the specific functional genes responsible for both aerobic and anaerobic biodegradation of these compounds.

In addition to the existence and abundance of specific microbial contaminant degraders, Microbial Insights conducts stable isotope probing to demonstrate biodegradation by loading the Bio-Trap® with ^{13}C and analyzing for the partitioning of ^{13}C into biomass or inorganic carbon.

2.4 FIELD METHODS AND APPARATUS

Monitoring wells included in the natural attenuation evaluation were sampled via low-flow techniques, HydraSleeve™ or from the sample port (active recovery wells), using a YSI water quality meter to record pH, temperature, ORP, and DO. For wells usually sampled via HydraSleeve™, the samples were collected (via HydraSleeve™) from the interval with the highest historical MtBE concentrations. For non-recovery wells without target sample depths, the pump intake was set at the middle of the water column within the screened/open hole portion of the well. The wells were allowed to stabilize before samples were collected. Samples were shipped on ice under chain-of-custody to Eurofins for analysis of nitrate, sulfate, methane and CO_2. Samples were also submitted under chain-of-custody to Eurofins for analysis of BTEX, Oxy5, and naphthalene via EPA method 8260B. A Hach DS9000 unit and reagents were used in the field to measure ferrous iron and orthophosphate.

Monitoring wells MW-27B, MW-40, MW-54B, MW-54C, MW-138D, MW-187A, MW-187B, MW-187C, MW-188D, and MW-189D were selected for microbial analysis by QuantArray® and/or Stable Isotope Probing (SIP) (**Appendix B**).

Bio-Traps® were installed in MW-27B, MW-40, MW-54C, MW-188D, and MW-189D. The Bio-Traps® were suspended with nylon string inside the monitoring wells after the sampling for chemical laboratory analysis was completed (see **Appendix C –** Microbial Insights' Protocols for details). After 30 days, the Bio-Traps® were collected and shipped overnight on ice to Microbial Insights for analysis.

One-liter aqueous samples were collected from MW-40, MW-54B, MW-138D, MW-187A, MW-187B, MW-187C, MW-188D, and MW-189D and shipped on ice overnight to Microbial Insights in Knoxville, TN for QuantArray® analysis.

3 RESULTS

This section summarizes the measurement, analysis, and testing results obtained for the evaluation of natural attenuation via biodegradation at the Site. Results include discussion of concentration trends, electron donor / acceptor (redox) indicators, and microbial testing results. **Table 3** consolidates the testing and analytical in the framework of the testing, sampling, and analysis plan matrix. The laboratory analytical reports for chemical parameters are included as **Appendix A** and the microbial laboratory reports are provided as **Appendix B**.

3.1 HISTORICAL CONCENTRATION TRENDS

Marked concentration reduction and plume contraction have been observed during the project, as documented in quarterly remedial action project reports (RAPRs) and annual concentration trend analysis provided to MDE . Such concentration reduction typically represents a primary line of evidence for the effectiveness of natural attenuation. However, the ability to attribute concentration reductions to biodegradation is confounded by active, aggressive, and extensive groundwater remediation (groundwater extraction, dual phase extraction, and vapor extraction), which was initiated shortly after the release and has been ongoing since.

3.2 ELECTRON DONOR / ACCEPTOR INDICATORS

Comparing relative concentration differences in electron donors and acceptors from background areas (areas of little or no impact) to areas with elevated concentrations of gasoline constituents (e.g., MtBE and benzene) provides a line of evidence for biodegradation. These patterns develop as a result of microbial transfer of an electron from hydrocarbon molecules to electron acceptors during the biodegradation process (Wiedemweier et al., 1995). Results are reflected as depleted concentrations of electron acceptors (DO, nitrate, sulfate) and accumulation of redox byproducts (ferrous iron, methane) in areas affected by gasoline constituents. Oxidation-reduction potential (ORP) provides a general indicator of the redox condition of the aquifer and the extent to which biodegradation may be occurring.

Perimeter areas of the site were identified in the far southwest and northeast to serve as background locations that are expected to be representative of the availability of electron acceptors that naturally occur within the aquifer that have not been depleted by biodegradation.

Monitoring wells MW-42A, MW-42B, and MW-42C (192') were selected to represent background conditions in the southwest. Monitoring wells MW-92, MW-92A, and MW-92C (210'-215') were selected to represent background conditions in the northeast. Associated electron acceptor and analytical data are provided in **Table 3**.

3.2.1 Oxidation Reduction Potential (ORP)

ORP data were measured in 216 shallow and deep monitoring wells during the 2019 semi-annual groundwater sampling event, providing high data density laterally and vertically throughout the site. ORP measurements are provided on **Table 4** and the interpolated ORP distribution is presented on **Figure 3a** (shallow) and **Figure 3b** (deep).

<u>Shallow Zone (A and B Series Monitoring Wells)</u>

ORP results are predominantly positive throughout the shallow zone (A and B series monitoring wells), reflecting the removal of gasoline constituents by active remediation, resulting in extensive aquifer restoration. The shallow zone is also more directly replenished by recharge of oxygenated water from precipitation and is susceptible to aeration as the water table fluctuates.

An area of relatively low ORP is noted beneath 14301 Jarrettsville Pike, directly across the intersection from the former service station, primarily represented by a negative ORP value of -125.7 mV associated with MW-121 (**Figure 3a**). This area is proximate to and was affected by gasoline constituents, including SPL, from the release at the service station.

<u>Deep Zone (C and D Series Monitoring Wells)</u>

The deep zone (C and D series monitoring wells) generally exhibits positive ORP (typically 0 to 60 mV), but less than the shallow zone. The deep zone is not as susceptible to direct recharge of oxygenated water or aerating water table fluctuations.

A distinct area of negative ORP is noted beneath 3501 Hampshire Glen Court) (**Figure 3b**) where residual gasoline constituents remain sequestered at depth, have experienced lesser influence from active remediation, and lesser recharge of oxygenated water. This spatial pattern of ORP data indicates that biodegradation processes are active in this remaining 'pocket' of residual gasoline constituents. ORP data relative to MtBE concentration in the near northeast area is summarized as follows:

Monitoring Well	MtBE (µg/L)	ORP (mV)
MW-47C	2	-44.7
MW-73C	220	-45.7
MW-91C	16	-112.5
MW-177	2	-65.9
MW-182	170	-4.9
MW-183	17	-101.4
MW-184	8	-95.8
MW-185	2	-122.3
Data from 2019 semi-annual sampling event.		

Patterns of negative ORP (<-100 mV) are also noted in the peripheral south and northwest areas of **Figure 3b**. The extent of the contouring in these areas is a function of computer extrapolation and limited data control.

3.2.2 Electron Acceptors and Redox Byproducts

Consistent with the predominantly positive ORP distribution in both the shallow and deep zones, depletion of electron acceptors (dissolved oxygen, nitrate, and sulfate) and accumulation of redox byproducts are not strongly indicated. Conversely, nitrate appears to be depleted in MW-184, which is located within the negative ORP zone beneath 3501 Hampshire Glen Court.

<u>Dissolved Oxygen</u>

Dissolved oxygen results are relatively elevated, indicating little depletion of this electron acceptor which is consistent with the ORP results. This indicates availability of dissolved oxygen for aerobic biodegradation; however, some measurements are excessively high, suggesting sample agitation during measurement or difficulties with field instrumentation.

<u>Nitrate</u>

Nitrate results are comparable to background results and the background concentrations of nitrate are modest, suggesting limited availability. As noted above, MW-184, located in the low ORP zone beneath 3501 Hampshire Glen Court (**Figure 3b**), exhibits the lowest detected nitrate concentration of all wells, which is attributed to depletion due to biodegradation.

<u>Sulfate</u>

A maximum sulfate concentration of 120 mg/L is associated with background monitoring well MW-42B, suggesting potential sulfate reduction in areas affected by gasoline constituents.

Ferrous Iron

Ferrous iron concentrations are also modest, indicating limited ferric iron reduction due to biodegradation.

Methane

Methane concentrations in background monitoring wells was modest, ranging from non-detect to 41 mg/L with sufficient dissolved CO_2 to support methanogenesis. Relatively elevated methane concentrations, up to 1,100 mg/L (MW-181C), were detected in certain wells that exhibit residual gasoline constituent concentrations.

3.2.3 Microbial Environmental Conditions

Temperature

According to Wiedemeier et al. (1995), metabolic activity is affected by groundwater temperature, and biodegradation rates increase with increasing temperature between 5°C and 25°C. Temperatures less than 5°C inhibit biodegradation. Temperature data (**Table 3**) are within this range with many results toward the upper end of the range, indicating a favorable condition for biodegradation.

pH

Wiedemeier et al. (1995) note that a pH range of 6 to 8 standard units is favorable for microbes capable of degrading petroleum hydrocarbons. With few exceptions, the vast majority of pH measurements are within this range (**Table 3**). Therefore, pH is favorable for biodegradation.

Orthophosphate

Orthophosphate is a nutrient for microbes and its presence is favorable. Orthophosphate was detected in the majority of monitoring wells sampled, indicating the availability of this nutrient for microbes.

3.3 MICROBIAL TESTING RESULTS

QuantArray®

QuantArray® is designed to quantify the specific microorganisms and functional genes responsible for anaerobic and aerobic biodegradation of petroleum products, including BTEX, MtBE, PAHs, and a variety of short and long chain alkanes. In combination with analytical chemistry, this tool can be used to evaluate the potential for biodegradation of petroleum hydrocarbons. QuantArray® laboratory testing results are presented in **Appendix B** along with more detailed explanation of results. **Figures 4a** through **4h** present QuantArray® results in the form of graphs illustrating the abundance of microbes capable of degrading various hydrocarbon constituents.

Each dot on **Figures 4a** through **4h** represents a microbial population capable of degrading the compound(s) indicated in the columns. Low results do not necessarily indicate limited degradation potential or a mixed response, as not all microbial populations are expected to be present and/or abundant. A single high (green) result, for instance, indicates the abundant presence of a microbial population capable of degrading the compound(s) listed in the respective column.

These results are summarized on **Table 3** and in the embedded table below.

Relative Abundance of Microbial Degraders

Monitoring Well	Aerobic MtBE	Aerobic BTEX	Anaerobic BTEX
MW-187A	High	High	Moderate
MW-187B	High	Moderate	Moderate
MW-187C	High	Moderate	Moderate
MW-54B	High	High	Moderate
MW-54C	High	High	Moderate
MW-138D	High	High	Moderate
MW-188D	High	High	Moderate
MW-40	High	High	High

These results indicate a high proportion of the aerobic MtBE degrader PM1 in every sample subjected to QuantArray® analysis. According to Microbial Insights, PM1 is one of the few organisms isolated to date capable of utilizing MTBE and TBA as growth supporting substrates. Nearly all samples exhibit a high proportion of aerobic BTEX degraders, except for MW-187B and MW-187C, which exhibit a moderate proportion. However, Toluene/Benzene Dioxygenase (TOD), an indicator of aerobic benzene degraders was low for nearly all samples with the exception of MW-54C in which it was measured in moderate proportion. All samples exhibit a moderate proportion of anaerobic BTEX degraders except for MW-40, which has a high proportion.

These results demonstrate the abundance of MtBE and BTEX degraders at all locations and depths analyzed, which is a positive indication of the biodegradation potential throughout the aquifer, especially under aerobic conditions.

Stable Isotope Probing

Stable isotope probing (SIP) tracks the fate of the isotope13C that is used to label MtBE and benzene that are then 'baited' into Bio-Traps®. Detection of the 13C isotope in microbial membranes in the form of phospholipid fatty acids (PLFAs) is evidence of incorporation of the isotope labeled compounds into the microbial biomass. Detection of the 13C isotope in dissolved inorganic carbon is evidence that the microbes have been mineralized (broken down) they contaminant. SIP results indicate:

- MTBE was incorporated into microbial biomass and metabolized in the MW-27B sample, but not in the MW-40 and MW-189D sample. Mineralization was not evident during the period of deployment.
- Benzene was incorporated into microbial biomass and metabolized in the MW-54C sample though mineralization was not evident at this well during the period of deployment.

4 DISCUSSION

Results of the natural attenuation study indicate that environmental conditions (temperature and pH) are within optimal ranges for microbial activity and that the microbial nutrient orthophosphate is available to support microbial activity.

ORP is predominantly positive throughout the shallow zone (A and B series monitoring wells), reflecting aquifer restoration due to the removal of gasoline constituents by active remediation. The shallow zone is also more directly replenished by recharge of oxygenated water from precipitation and is susceptible to aeration as the water table fluctuates. This is favorable for aerobic biodegradation in the shallow zone. The deep zone (C and D series monitoring wells) also exhibits positive ORP, but less than the shallow zone. The deep zone is not as susceptible to direct recharge of oxygenated water or aerating water table fluctuations.

A distinct area of negative ORP is noted beneath 3501 Hampshire Glen Court where residual gasoline constituents remain sequestered at depth, have experienced lesser influence from active remediation, and lesser recharge of oxygenated water. This spatial pattern of ORP data indicates that biodegradation processes are active in this remaining ‘pocket’ of residual gasoline constituents.

Depletion of electron acceptors (dissolved oxygen, nitrate, and sulfate) and accumulation of redox byproducts are not strongly indicated, which is consistent with the spatial distribution of predominantly positive ORP in the aquifer. This is attributed to contaminant mass removal / aquifer restoration, replenishment of oxygenated water to the shallow zone, and potential limited electron acceptor availability with regards to nitrate. This is not an indicator adverse to biodegradation, rather it is an indicator of improved aquifer conditions and an abundance of dissolved oxygen (oxygenated water) to support aerobic biodegradation. Monitoring well MW-184, located within the discrete zone of negative ORP beneath 3501 Hampshire Glen Court, exhibits the lowest detected nitrate concentration, consistent with negative ORP and indicating biodegradation.

Microbial results are favorable, indicating a high abundance of the aerobic MtBE and BTEX degraders with a moderate abundance of anaerobic BTEX degraders. MtBE and benzene were incorporated into microbial biomass and metabolized in MW-27B and MW-54C, respectively. Mineralization was not evident in these few wells during the period of deployment.

SIP results indicate:

- MTBE was incorporated into microbial biomass and metabolized in the MW-27B sample, but not in the MW-40 and MW-189D sample. Mineralization was not evident during the period of deployment.
- Benzene was incorporated into microbial biomass and metabolized in the MW-54C sample though mineralization was not evident at this well during the period of deployment.

5 CONCLUSIONS

The potential for microbial biodegradation in shallow and deep portions of the aquifer is indicated based on the following observations and conditions:

- There is an abundance of MtBE and BTEX degraders present throughout the aquifer, especially aerobic degraders.

- Microbial environmental conditions (temperature and pH) are within the optimal range for microbial activity, and he microbial nutrient, orthophosphate, is available.

- SIP results indicate that indicate:
    - MTBE was incorporated into microbial biomass and metabolized in the MW-27B sample, but not in the MW-40 and MW-189D sample. Mineralization was not evident during the period of deployment.
    - Benzene was incorporated into microbial biomass and metabolized in the MW-54C sample though mineralization was not evident at this well during the period of deployment.

- Oxygen is available for aerobic biodegradation:
    - Positive ORP conditions exist throughout much of the aquifer
    - The shallow zone is replenished with oxygenated water through recharge and water table fluctuation.

A discrete area of negative ORP occurs in the deep portion of the aquifer beneath 3501 Hampshire Glen Court, which corresponds to residual concentrations of gasoline constituents that remain sequestered at depth. Additionally, this zone does not experience as much remediation influence nor substantial replenishment of oxygenated water via recharge. This pattern is evidence of active biodegradation occurring at the last remaining 'pocket' of sequestered and recalcitrant gasoline constituents in the aquifer. Downgradient migration of gasoline constituents, particularly MtBE from this area would enter an aerobic portion of the aquifer with the dissolved oxygen capacity and aerobic MtBE degraders necessary to degrade and mineralize MtBE, limiting migration. Additionally, this area beneath 3501 Hampshire Glen Court is a candidate for enhanced biodegradation by the addition of dissolved oxygen.

6 RECOMMENDATIONS

Based on the positive indication of biodegradation potential and evidence of biodegradation activity acting upon a discrete zone of sequestered gasoline constituents, focused additional analysis and testing is recommended.

6.1 ADDITIONAL TESTING AND ANALYSIS

Targeted natural attenuation sampling for field parameters, electron donors / acceptor indicators, microbial nutrients, and microbial indicators is recommended to be conducted in the discrete area of negative ORP and residual gasoline constituents at depth beneath 3501 Hampshire Glen Court. These data will serve to validate that biodegradation is occurring in this discrete portion of the aquifer and will serve as a baseline dataset prior to enhanced biosparge testing of this area, which is recommended in the following sections. The following monitoring wells are recommended for additional full-suite biodegradation evaluation testing: MW-183, MW-184, MW-91C, and MW-185.

6.2 TARGETED BIOSPARGE TESTING

A biosparge pilot test is proposed to evaluate the ability to stimulate and/or enhance aerobic biodegradation within the deep zone beneath 3501 Hampshire Glen Court. The current groundwater remediation system is configured to distribute compressed air to multiple recovery wells containing pneumatic groundwater recovery pumps. The engineering concept would use the existing air compressor and airlines to sparge air into an existing well at a relatively low flowrate compared to air sparging. This is expected to increase the amount of dissolved oxygen in the formation and stimulate or enhance aerobic biodegradation. The objectives of the biosparge pilot test are to:

1) Evaluate the ability to deliver air to groundwater using existing apparatus and infrastructure;

2) Evaluate the ability to oxygenate the aquifer proximate to and downgradient of the biosparge well; and,

3) Monitor for evidence of enhanced biodegradation as a consequence of oxygen delivery into the aquifer.

6.2.1 Pilot Test Layout and Configuration

MW-91C, located in the middle of 3501 Hampshire Glen Court (**Figure 1**), is identified as the candidate biosparge pilot test delivery well for the following reasons:

- Exhibits negative ORP (-112 mV), indicating biodegradation that can be enhanced with additional dissolved oxygen;

- Exhibits residual concentrations of MtBE (16 µg/L [March 13, 2019]) that can be further reduced;

    - Central to the discrete 'pocket' of negative ORP and within the northeast line of MtBE plume migration along strike;
    - Has a demonstrated water-bearing fracture at approximately 145 feet below top of casing (ft-toc) that may facilitate delivery of oxygenated water into the formation (Kleinfelder, August 15, 2011);
    - Recently deactivated as a recovery well with necessary air delivery apparatus, but without having to take an active recovery well off line;
    - Downgradient monitoring wells (MW-185 and MW-177) also exhibit negative ORP and residual MtBE, making for applicable and relevant monitoring locations;
    - Downgradient migration of dissolved oxygen may be enhanced with newly activated recovery well MW-138D located farther downgradient.

6.2.2 Methodology and Sequence

The steps of the testing methodology are outlined sequentially below:

1) Collect and analyze groundwater samples for BTEX and Oxy5 per Method 8260B and measure baseline field parameter readings (DO, ORP, pH, temperature, and ferrous iron test kit) and depth to groundwater in MW-91, MW-91C, MW-185, MW-176, MW-177, and MW-168, prior to initiating biosparging.

2) Reconfigure existing pumping and tubing apparatus in MW-91C to deliver air for biosparging, targeting the prominent water-bearing fracture in MW-91C, previously identified by borehole geophysical and hydraulic testing at approximately 145 ft-toc (Kleinfelder, August 15, 2011). Place air discharge 5 feet below the fracture (target depth = 150 ft-toc).

3) Deploy transducers to measure and log temperature, pH, ORP, specific conductivity, and depth to water continuously for the duration of the test in MW-91 and MW-185.

4) Initiate biosparging in MW-91C and collect and analyze groundwater samples from monitoring wells (MW-91, MW-185, MW-176, MW-177, and MW-168) for BTEX and Oxy5 per Method 8260B and measure field parameters (DO, ORP, pH, temperature, and ferrous iron test kit) and depth to water monthly for duration of the test (6 months).

5) Shut off biosparge in MW-91C and collect groundwater samples for biosparge well MW-91C and monitoring wells MW-91, MW-185, MW-176, MW-177, and MW-168, and analyze for BTEX + Oxy5 analyses and measure field parameter readings (DO, ORP, pH, temperature, and ferrous iron test kit) and depth to groundwater in MW-91, MW-91C, MW-185, MW-176, MW-177, and MW-168 daily for five days.

6) Provide report of results with recommendations to MDE.

6.2.3 Equipment and Apparatus

The existing pneumatic line will be extended into monitoring well MW-91C and will be connected to a ¾-inch schedule 80 (SCH 80) polyvinyl chloride (PVC) pipe. The ¾-inch SCH 80 PVC will extend to a diffuser using a variety of couplings and adapters to a target depth of 150 ft-toc, which is 5 feet below the target fracture. The dedicated airline will be temporarily connected to the air delivery line within the well vault, and the air line to the pneumatic pump would be disconnected from the air line in the vault, and pneumatic pump retrieved. The existing regulator would be used to adjust the air delivery pressure and flow. The air line within the well vault, leading to the diffuser, would be fitted with a rotameter to allow an estimate of the volume of air/oxygen injected into groundwater during the pilot test.

6.2.4 Reporting

The results of additional testing, sampling, and biosparge pilot testing will be compiled, analyzed, and summarized in a letter report to MDE with conclusions and recommendations for the potential application of biosparging to supplement the current remedial approach for the Site. Should results show the ability to distribute dissolved oxygen within groundwater with lagging biodegradation response, prolonged biosparge testing may also be recommended.

7 REFERENCES

Kleinfelder, February 4, 2019, Proposal for Natural Attenuation Evaluation, Inactive Exxon Facility #28077, 14258 Jarrettsville Pike, Phoenix, Baltimore County, Maryland, MDE Case No. 2006-0303-BA2.

Kleinfelder, August 15, 2011, Near Northeast Area Supplemental Investigation and Remedial Measures Report, Inactive Exxon Facility #28077, Phoenix, Maryland, Case Number 2006-0303-BA2, Facility I.D. No, 12342.

MDE, March 20, 2019, Approval of Proposal for Natural Attenuation Evaluation, Case No. 2006-0303-BA, Former Exxon R/S No. 2-8077, 14258 Jarrettsville Pike, Phoenix, Baltimore County, Maryland.

Wiedemeier, T.H., Rifai, H.S., Newell, C.J., and Wilson, J.T., 1999, Natural Attenuation of Fuels and Chlorinated Solvents in the Subsurface: John Wiley & Sons, New York, New York, 617 p.

Wiedemeier, T., Wilson, J.T., Kampbell, D.H., Miller, R.N., and Hansen, J.E., November 11, 1995, Technical Protocol for Implementing Intrinsic Remediation with Long-Term Monitoring for Natural Attenuation of Fuel Contamination Dissolved in Groundwater, Air Force Center for Environmental Excellence, v. 1.

8 LIMITATIONS

Kleinfelder performed the services for this project under the Enabling Agreement with Procurement, a division of ExxonMobil Global Services Company (signed on November 28, 2012). Kleinfelder states that the services preformed are consistent with professional standard of care defined as that level of services provided by similar professionals under like circumstances. This report is based on the regulatory standards in effect on the date of the report. It has been produced for the primary benefit of ExxonMobil Global Services Company and its affiliates.

TABLES

Table 1 - Natural Attenuation Biodegradation Evaluation Sampling and Testing Plan

	Field Parameters					Laboratory Analysis (Chemistry)						Laboratory Analysis (Microbial)			
	Conditions		Electron Donor / Acceptor Indicators								Microbial Nutrient	Microbial Indicators			
MW	**pH**	**Temp**	**ORP**	**D.O.**	**Ferrous Iron (test kit)**	**Nitrate**	**Sulfate**	**Ferrous Iron**	**Methane**	**CO_2**	**Orthophosphate**	**QuantArray (MtBE & TBA)**	**QuantArray (Full Petro)**	**Stable Isotope Probing**	**Rationale**
Release Area (Tank Field and Intersection)															
MW-27R	X	X	X	X	X	X	X	X	X	X	X				Max sustained source concentration at release
MW-27B	X	X	X	X	X	X	X	X	X	X	X			X (MtBE)	
SVE-1	X	X	X	X	X	X	X	X	X	X	X				
MW-187A	X	X	X	X	X	X	X	X	X	X	X		X (aqueous)		Vertical profile near source area. Not directly targeted by remediation until later in lifecycle
MW-187B	X	X	X	X	X	X	X	X	X	X	X		X (aqueous)		
MW-187C	X	X	X	X	X	X	X	X	X	X	X		X (aqueous)		
Plume Core (Station)															
MW-7	X	X	X	X	X	X	X	X	X	X	X				
MW-13	X	X	X	X	X	X	X	X	X	X	X				
SVE-3	X	X	X	X	X	X	X	X	X	X	X				
MW-1	X	X	X	X	X	X	X	X	X	X	X			X (benzene)	Persistent benzene concentration
Plume Core (Northeast)															
MW-54	X	X	X	X	X	X	X	X	X	X	X				Vertical profile of shallow to deep transition point, elevated conc
MW-54B	X	X	X	X	X	X	X	X	X	X	X	X (aqueous)			
MW-54C	X	X	X	X	X	X	X	X	X	X	X	X (biotrap)			
MW-73C	X	X	X	X	X	X	X	X	X	X	X				
MW-138D	X	X	X	X	X	X	X	X	X	X	X	X (aqueous)			Sustained elevated conc in distal deeper zone
MW-188D	X	X	X	X	X	X	X	X	X	X	X	X (biotrap)			
MW-181C	X	X	X	X	X	X	X	X	X	X	X				
Distal Plume (Southwest)															
MW-40	X	X	X	X	X	X	X	X	X	X	X	X (biotrap)		X (MtBE)	Remaining MtBE detection in SW
MW-71	X	X	X	X	X	X	X	X	X	X	X				
MW-56A	X	X	X	X	X	X	X	X	X	X	X				Vertical profile at distal extent
MW-56B	X	X	X	X	X	X	X	X	X	X	X				
MW-56C	X	X	X	X	X	X	X	X	X	X	X				
Distal Plume (Northeast)															
MW-178C	X	X	X	X	X	X	X	X	X	X	X				Deeper zone off-set from original “strike line” of migration through 3501 HGC with historical concentrations
MW-184	X	X	X	X	X	X	X	X	X	X	X				
MW-168	X	X	X	X	X	X	X	X	X	X	X				
MW-89	X	X	X	X	X	X	X	X	X	X	X				Distal shallow to intermediate depth
MW-82B	X	X	X	X	X	X	X	X	X	X	X				
MW-82D	X	X	X	X	X	X	X	X	X	X	X				
MW-189D	X	X	X	X	X	X	X	X	X	X	X	X (biotrap)		X (MtBE)	Distal deeper zone monitoring point where MtBE has been detected
MW-38	X	X	X	X	X	X	X	X	X	X	X				Vertical profile in near northeast area
MW-38B	X	X	X	X	X	X	X	X	X	X	X				
MW-38C	X	X	X	X	X	X	X	X	X	X	X				
MW-74	X	X	X	X	X	X	X	X	X	X	X				Distal, shallow (water table ‘A-Zone’) on “strike line” migration track
MW-75	X	X	X	X	X	X	X	X	X	X	X				
Background / Perimeter (Southwest)															
MW-42A	X	X	X	X	X	X	X	X	X	X	X				Vertical profile with minimal historical impact off-“strike line”
MW-42B	X	X	X	X	X	X	X	X	X	X	X				
MW-42C	X	X	X	X	X	X	X	X	X	X	X				
Background / Perimeter (Northeast)															
MW-92	X	X	X	X	X	X	X	X	X	X	X				Vertical profile with minimal historical impact off-“strike line”
MW-92A	X	X	X	X	X	X	X	X	X	X	X				
MW-92C	X	X	X	X	X	X	X	X	X	X	X				

Table 2

Summary of Groundwater Analytical Results

Inactive Exxon Facility #28077
14528 Jarrettsville Pike
Phoenix, Maryland
April 4, 2019 through June 26, 2019

Well ID	Date	Benzene (µg/L)	Toluene (µg/L)	Ethyl-benzene (µg/L)	Total Xylenes (µg/L)	Total BTEX (µg/L)	MTBE (µg/L)	DIPE (µg/L)	ETBE (µg/L)	TAME (µg/L)	TBA (µg/L)	Comments
MW-1	4/8/2019	3 J	1100	520	2200	3823 J	ND(5)	ND(5)	ND(5)	ND(5)	ND(130)	
MW-1A [R]	5/21/2019	ND(1)	ND(1)	ND(1)	ND(5)	BRL	0.2 J	ND(1)	ND(1)	ND(1)	ND(25)	
MW-2	5/16/2019	ND(1)	ND(1)	ND(1)	ND(5)	BRL	ND(1)	ND(1)	ND(1)	ND(1)	ND(25)	
MW-2A [R]	6/24/2019	ND(1)	ND(1)	ND(1)	ND(5)	BRL	0.5 J	ND(1)	ND(1)	ND(1)	ND(25)	
MW-3 [R]	6/24/2019	ND(1)	3	86	110	199	0.6 J	ND(1)	ND(1)	ND(1)	ND(25)	
MW-4 [R]	6/24/2019	ND(1)	3	69	90	162	0.6 J	ND(1)	ND(1)	ND(1)	ND(25)	
MW-6 [R]	6/24/2019	ND(1)	3	67	87	157	0.6 J	ND(1)	ND(1)	ND(1)	ND(25)	
MW-7 [R]	4/8/2019	ND(1)	0.5 J	0.5 J	5 J	6 J	3	ND(1)	ND(1)	0.4 J	ND(25)	
MW-9	5/16/2019	ND(1)	ND(1)	ND(1)	ND(5)	BRL	ND(1)	ND(1)	ND(1)	ND(1)	ND(25)	
MW-12	5/16/2019	ND(1)	ND(1)	ND(1)	ND(5)	BRL	ND(1)	ND(1)	ND(1)	ND(1)	ND(25)	
MW-13 [R]	4/10/2019	ND(1)	ND(1)	ND(1)	ND(5)	BRL	0.9 J	ND(1)	ND(1)	ND(1)	ND(25)	
MW-14	5/16/2019	ND(5)	170	77	1400	1647	1 J	ND(5)	ND(5)	ND(5)	ND(130)	
MW-16 [R]	6/24/2019	ND(1)	3	80	100	183	0.6 J	ND(1)	ND(1)	ND(1)	ND(25)	
MW-16R [R]	6/11/2019	17	2	2	3 J	24 J	230	2	4	22	ND(25)	
MW-17	5/16/2019	ND(1)	ND(1)	ND(1)	ND(5)	BRL	ND(1)	ND(1)	ND(1)	ND(1)	ND(25)	
MW-19 [R]	6/26/2019	ND(1)	ND(1)	ND(1)	ND(5)	BRL	ND(1)	ND(1)	ND(1)	ND(1)	ND(25)	
MW-21 [R]	5/21/2019	ND(1)	0.2 J	ND(1)	ND(5)	0.2 J	0.2 J	ND(1)	ND(1)	ND(1)	ND(25)	
MW-22 [R]	6/26/2019	ND(1)	ND(1)	ND(1)	ND(5)	BRL	ND(1)	ND(1)	ND(1)	ND(1)	ND(25)	
MW-23 [R]	5/21/2019	ND(1)	ND(1)	ND(1)	ND(5)	BRL	2	ND(1)	ND(1)	ND(1)	ND(25)	
MW-25	6/19/2019	ND(1)	ND(1)	ND(1)	ND(5)	BRL	ND(1)	ND(1)	ND(1)	ND(1)	ND(25)	
MW-27 [R]	6/24/2019	0.3 J	ND(1)	ND(1)	ND(5)	0.3 J	0.4 J	ND(1)	ND(1)	ND(1)	ND(25)	
MW-27B	4/4/2019	9	2	ND(1)	6	17	80	0.5 J	0.8 J	7	ND(25)	
	6/13/2019	1	ND(1)	ND(1)	0.8 J	2 J	120	0.2 J	0.4 J	2	ND(25)	
MW-27R [R]	4/8/2019	4	5	8	7	24	76	0.3 J	0.7 J	5	17 J	
MW-28	6/3/2019	ND(1)	ND(1)	ND(1)	ND(5)	BRL	ND(1)	ND(1)	ND(1)	ND(1)	ND(25)	
MW-29	5/20/2019	ND(1)	ND(1)	ND(1)	ND(5)	BRL	ND(1)	ND(1)	ND(1)	ND(1)	ND(25)	
MW-30	5/20/2019	ND(1)	ND(1)	ND(1)	ND(5)	BRL	ND(1)	ND(1)	ND(1)	ND(1)	ND(25)	

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Table 2 (Continued)

Summary of Groundwater Analytical Results

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Phoenix, Maryland
April 4, 2019 through June 26, 2019

Well ID	Date	Benzene (µg/L)	Toluene (µg/L)	Ethyl-benzene (µg/L)	Total Xylenes (µg/L)	Total BTEX (µg/L)	MTBE (µg/L)	DIPE (µg/L)	ETBE (µg/L)	TAME (µg/L)	TBA (µg/L)	Comments
MW-31	5/20/2019	ND(1)	ND(1)	ND(1)	ND(5)	BRL	ND(1)	ND(1)	ND(1)	ND(1)	ND(25)	
MW-32	6/17/2019	ND(1)	ND(1)	ND(1)	ND(5)	BRL	5	ND(1)	0.2 J	ND(1)	ND(25)	
MW-36C	6/13/2019	ND(1)	ND(1)	ND(1)	ND(5)	BRL	ND(1)	ND(1)	ND(1)	ND(1)	ND(25)	
MW-36P	6/13/2019	ND(1)	ND(1)	ND(1)	ND(5)	BRL	3	ND(1)	ND(1)	ND(1)	ND(25)	
MW-36R	6/13/2019	ND(1)	ND(1)	ND(1)	ND(5)	BRL	2	ND(1)	ND(1)	ND(1)	ND(25)	
MW-37 [R]	6/25/2019	ND(1)	ND(1)	ND(1)	ND(5)	BRL	1 J	ND(1)	ND(1)	ND(1)	ND(25)	
MW-37P	6/25/2019	ND(1)	ND(1)	ND(1)	ND(5)	BRL	ND(1)	ND(1)	ND(1)	ND(1)	ND(25)	
MW-38 [R]	4/9/2019	ND(1)	ND(1)	ND(1)	ND(5)	BRL	8	ND(1)	0.2 J	0.9 J	ND(25)	
MW-38B	4/9/2019	ND(1)	ND(1)	ND(1)	ND(5)	BRL	ND(1)	ND(1)	ND(1)	ND(1)	ND(25)	
MW-38C [R]	4/9/2019	ND(1)	ND(1)	ND(1)	ND(5)	BRL	69	0.8 J	3	3	ND(25)	
	6/25/2019	ND(1)	ND(1)	ND(1)	ND(5)	BRL	10	0.2 J	0.9 J	0.5 J	ND(25)	
MW-38P	6/25/2019	ND(1)	ND(1)	ND(1)	ND(5)	BRL	ND(1)	ND(1)	ND(1)	ND(1)	ND(25)	
MW-40	4/8/2019	ND(1)	ND(1)	ND(1)	ND(5)	BRL	0.4 J	ND(1)	ND(1)	ND(1)	ND(25)	
MW-42A	4/10/2019	ND(1)	ND(1)	ND(1)	ND(5)	BRL	ND(1)	ND(1)	ND(1)	ND(1)	ND(25)	
MW-42B	4/10/2019	ND(1)	ND(1)	ND(1)	ND(5)	BRL	ND(1)	ND(1)	ND(1)	ND(1)	ND(25)	
MW-42C(192)	4/10/2019	ND(1)	ND(1)	ND(1)	ND(5)	BRL	ND(1)	ND(1)	ND(1)	ND(1)	ND(25)	
MW-45 [R]	4/4/2019	ND(1)	ND(1)	ND(1)	ND(5)	BRL	350	2	7	10	20 J	
	5/22/2019	ND(1)	ND(1)	ND(1)	ND(5)	BRL	31	0.3 J	0.8 J	2	ND(25)	
MW-45P	6/26/2019	ND(1)	ND(1)	ND(1)	ND(5)	BRL	ND(1)	ND(1)	ND(1)	ND(1)	ND(25)	
MW-45R [R]	4/5/2019	0.5 J	ND(1)	ND(1)	ND(5)	0.5 J	330	2	7	9	18 J	
	5/21/2019	ND(1)	ND(1)	ND(1)	ND(5)	BRL	13	ND(1)	0.5 J	0.4 J	ND(25)	
MW-49	5/20/2019	ND(1)	ND(1)	ND(1)	ND(5)	BRL	ND(1)	ND(1)	ND(1)	ND(1)	ND(25)	
MW-53B	5/10/2019	ND(1)	ND(1)	ND(1)	ND(5)	BRL	ND(1)	ND(1)	ND(1)	ND(1)	ND(25)	
MW-54	4/9/2019	ND(1)	ND(1)	ND(1)	ND(5)	BRL	2	ND(1)	ND(1)	0.4 J	ND(25)	
MW-54B [R]	4/11/2019	ND(1)	ND(1)	ND(1)	ND(5)	BRL	19	1	4	0.7 J	14 J	
MW-54C	6/26/2019	ND(1)	ND(1)	ND(1)	ND(5)	BRL	ND(1)	ND(1)	ND(1)	ND(1)	ND(25)	
MW-57	5/13/2019	ND(1)	ND(1)	ND(1)	ND(5)	BRL	ND(1)	ND(1)	ND(1)	ND(1)	ND(25)	

Table 2 (Continued)

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MW-57P	5/13/2019	ND(1)	ND(1)	ND(1)	ND(5)	BRL	ND(1)	ND(1)	ND(1)	ND(1)	ND(25)	
MW-58	5/13/2019	ND(1)	ND(1)	ND(1)	0.6 J	0.6 J	ND(1)	ND(1)	ND(1)	ND(1)	ND(25)	
MW-58R	5/13/2019	ND(1)	ND(1)	ND(1)	ND(5)	BRL	ND(1)	ND(1)	ND(1)	ND(1)	ND(25)	
MW-58P	5/13/2019	ND(1)	ND(1)	ND(1)	ND(5)	BRL	ND(1)	ND(1)	ND(1)	ND(1)	ND(25)	
MW-59B [R]	6/25/2019	ND(1)	ND(1)	ND(1)	2 J	2 J	10	ND(1)	ND(1)	0.8 J	ND(25)	
MW-62A	5/20/2019	ND(1)	ND(1)	ND(1)	ND(5)	BRL	ND(1)	ND(1)	ND(1)	ND(1)	ND(25)	
MW-63	6/3/2019	ND(1)	ND(1)	ND(1)	ND(5)	BRL	ND(1)	ND(1)	ND(1)	ND(1)	ND(25)	
	6/26/2019	ND(1)	ND(1)	ND(1)	ND(5)	BRL	ND(1)	ND(1)	ND(1)	ND(1)	ND(25)	
MW-72	6/3/2019	ND(1)	ND(1)	ND(1)	ND(5)	BRL	0.2 J	ND(1)	ND(1)	ND(1)	ND(25)	
MW-73C	4/10/2019	8	ND(1)	ND(1)	ND(5)	8	190	1	5	10	190	
	4/19/2019	ND(1)	ND(1)	ND(1)	ND(5)	BRL	0.3 J	ND(1)	ND(1)	ND(1)	ND(25)	
	5/21/2019	ND(1)	ND(1)	ND(1)	ND(5)	BRL	86	1	4	5	300	
MW-73C(HS-S)	5/10/2019	7	ND(1)	0.4 J	ND(5)	7 J	200	2	7	10	340	
MW-73C(HS-D)	5/10/2019	7	ND(1)	0.4 J	ND(5)	7 J	200	2	6	10	300	
MW-74 [R]	4/9/2019	ND(1)	ND(1)	ND(1)	ND(5)	BRL	ND(1)	ND(1)	ND(1)	ND(1)	ND(25)	
MW-75 [R]	4/9/2019	ND(1)	ND(1)	ND(1)	ND(5)	BRL	3	ND(1)	ND(1)	ND(1)	ND(25)	
MW-76	5/17/2019	ND(1)	ND(1)	ND(1)	ND(5)	BRL	ND(1)	ND(1)	ND(1)	ND(1)	ND(25)	
MW-77A	5/14/2019	ND(1)	ND(1)	ND(1)	ND(5)	BRL	0.3 J	ND(1)	ND(1)	ND(1)	ND(25)	
MW-77B	5/14/2019	ND(1)	ND(1)	ND(1)	ND(5)	BRL	ND(1)	ND(1)	ND(1)	ND(1)	ND(25)	
MW-77R	5/14/2019	ND(1)	ND(1)	ND(1)	ND(5)	BRL	ND(1)	ND(1)	ND(1)	ND(1)	ND(25)	
MW-78B	5/9/2019	ND(1)	ND(1)	ND(1)	ND(5)	BRL	ND(1)	ND(1)	ND(1)	ND(1)	ND(25)	
MW-80A	6/18/2019	ND(1)	ND(1)	ND(1)	ND(5)	BRL	ND(1)	ND(1)	ND(1)	ND(1)	ND(25)	
MW-80B	6/18/2019	ND(1)	ND(1)	ND(1)	ND(5)	BRL	ND(1)	ND(1)	ND(1)	ND(1)	ND(25)	
MW-82	5/14/2019	ND(1)	ND(1)	ND(1)	ND(5)	BRL	ND(1)	ND(1)	ND(1)	ND(1)	ND(25)	
MW-82R [R]	5/21/2019	ND(1)	ND(1)	ND(1)	ND(5)	BRL	0.5 J	ND(1)	ND(1)	ND(1)	ND(25)	
	6/25/2019	0.2 J	ND(1)	ND(1)	ND(5)	0.2 J	1 J	ND(1)	ND(1)	ND(1)	ND(25)	
MW-82B [R]	4/12/2019	ND(1)	ND(1)	ND(1)	ND(5)	BRL	ND(1)	ND(1)	ND(1)	ND(1)	ND(25)	

Table 2 (Continued)

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April 4, 2019 through June 26, 2019

Well ID	Date	Benzene (µg/L)	Toluene (µg/L)	Ethyl-benzene (µg/L)	Total Xylenes (µg/L)	Total BTEX (µg/L)	MTBE (µg/L)	DIPE (µg/L)	ETBE (µg/L)	TAME (µg/L)	TBA (µg/L)	Comments
MW-84	6/17/2019	ND(1)	ND(1)	ND(1)	ND(5)	BRL	ND(1)	ND(1)	ND(1)	ND(1)	ND(25)	
MW-84P	6/17/2019	ND(1)	ND(1)	ND(1)	ND(5)	BRL	ND(1)	ND(1)	ND(1)	ND(1)	ND(25)	
MW-85	6/17/2019	ND(1)	ND(1)	ND(1)	ND(5)	BRL	ND(1)	ND(1)	ND(1)	ND(1)	ND(25)	
MW-87	6/17/2019	ND(1)	ND(1)	ND(1)	ND(5)	BRL	ND(1)	ND(1)	ND(1)	ND(1)	ND(25)	
MW-89 [R]	4/12/2019	ND(1)	ND(1)	ND(1)	ND(5)	BRL	ND(1)	ND(1)	ND(1)	ND(1)	ND(25)	
MW-90	5/17/2019	ND(1)	ND(1)	ND(1)	ND(5)	BRL	ND(1)	ND(1)	ND(1)	ND(1)	ND(25)	
MW-91	5/13/2019	ND(1)	ND(1)	ND(1)	ND(5)	BRL	ND(1)	ND(1)	ND(1)	ND(1)	ND(25)	
MW-91C [R]	5/21/2019	ND(1)	ND(1)	ND(1)	ND(5)	BRL	7	1	5	ND(1)	ND(25)	
MW-91D	6/3/2019	ND(1)	ND(1)	ND(1)	ND(5)	BRL	ND(1)	ND(1)	ND(1)	ND(1)	ND(25)	
MW-92A	6/18/2019	ND(1)	ND(1)	ND(1)	ND(5)	BRL	ND(1)	ND(1)	ND(1)	ND(1)	ND(25)	
MW-100A	5/9/2019	ND(1)	ND(1)	ND(1)	ND(5)	BRL	ND(1)	ND(1)	ND(1)	ND(1)	ND(25)	
MW-100B	5/9/2019	ND(1)	ND(1)	ND(1)	ND(5)	BRL	ND(1)	ND(1)	ND(1)	ND(1)	ND(25)	
MW-101A	5/8/2019	ND(1)	ND(1)	ND(1)	ND(5)	BRL	ND(1)	ND(1)	ND(1)	ND(1)	ND(25)	
MW-101B	5/8/2019	ND(1)	ND(1)	ND(1)	ND(5)	BRL	ND(1)	ND(1)	ND(1)	ND(1)	ND(25)	
MW-103	5/14/2019	ND(1)	ND(1)	ND(1)	ND(5)	BRL	ND(1)	ND(1)	ND(1)	ND(1)	ND(25)	
MW-106	5/17/2019	ND(1)	ND(1)	ND(1)	ND(5)	BRL	ND(1)	ND(1)	ND(1)	ND(1)	ND(25)	
MW-107	5/13/2019	ND(1)	ND(1)	ND(1)	ND(5)	BRL	ND(1)	ND(1)	ND(1)	ND(1)	ND(25)	
MW-108	5/14/2019	ND(1)	ND(1)	ND(1)	ND(5)	BRL	ND(1)	ND(1)	ND(1)	ND(1)	ND(25)	
MW-109	6/19/2019	ND(1)	ND(1)	ND(1)	ND(5)	BRL	ND(1)	ND(1)	ND(1)	ND(1)	ND(25)	
MW-110	6/13/2019	ND(1)	ND(1)	ND(1)	ND(5)	BRL	ND(1)	ND(1)	ND(1)	ND(1)	ND(25)	
MW-121 [R]	5/21/2019	0.4 J	ND(1)	ND(1)	ND(5)	0.4 J	0.4 J	ND(1)	ND(1)	ND(1)	ND(25)	
MW-125	5/20/2019	ND(1)	ND(1)	ND(1)	ND(5)	BRL	ND(1)	ND(1)	ND(1)	ND(1)	ND(25)	
MW-132A	6/18/2019	ND(1)	ND(1)	ND(1)	ND(5)	BRL	ND(1)	ND(1)	ND(1)	ND(1)	ND(25)	
MW-137	5/17/2019	ND(1)	ND(1)	ND(1)	ND(5)	BRL	ND(1)	ND(1)	ND(1)	ND(1)	ND(25)	
MW-138	5/13/2019	ND(1)	ND(1)	ND(1)	ND(5)	BRL	ND(1)	ND(1)	ND(1)	ND(1)	ND(25)	
MW-138D	4/11/2019	4	0.5 J	0.2 J	0.7 J	5 J	270	0.9 J	3	19	ND(25)	
	5/8/2019	4	0.6 J	0.8 J	3 J	8 J	420	1	5	28	ND(25)	
	6/26/2019	0.7 J	ND(1)	ND(1)	ND(5)	0.7 J	410	2	5	27	ND(25)	

Table 2 (Continued)

Summary of Groundwater Analytical Results

Inactive Exxon Facility #28077
14528 Jarrettsville Pike
Phoenix, Maryland
April 4, 2019 through June 26, 2019

Well ID	Date	Benzene (µg/L)	Toluene (µg/L)	Ethyl-benzene (µg/L)	Total Xylenes (µg/L)	Total BTEX (µg/L)	MTBE (µg/L)	DIPE (µg/L)	ETBE (µg/L)	TAME (µg/L)	TBA (µg/L)	Comments
MW-139	6/26/2019	ND(1)	ND(1)	ND(1)	ND(5)	BRL	ND(1)	ND(1)	ND(1)	ND(1)	ND(25)	
MW-142	5/14/2019	ND(1)	ND(1)	ND(1)	ND(5)	BRL	2	ND(1)	ND(1)	ND(1)	ND(25)	
MW-143	5/14/2019	ND(1)	ND(1)	ND(1)	ND(5)	BRL	0.6 J	ND(1)	ND(1)	ND(1)	ND(25)	
MW-144	6/26/2019	ND(1)	ND(1)	ND(1)	ND(5)	BRL	ND(1)	ND(1)	ND(1)	ND(1)	ND(25)	
MW-147PB	5/8/2019	ND(1)	ND(1)	ND(1)	ND(5)	BRL	ND(1)	ND(1)	ND(1)	ND(1)	ND(25)	
MW-151 [R]	6/26/2019	ND(1)	ND(1)	ND(1)	ND(5)	BRL	ND(1)	ND(1)	ND(1)	ND(1)	ND(25)	
MW-152 [R]	6/26/2019	ND(1)	ND(1)	ND(1)	ND(5)	BRL	ND(1)	ND(1)	ND(1)	ND(1)	ND(25)	
MW-159	6/3/2019	ND(1)	ND(1)	ND(1)	ND(5)	BRL	0.3 J	ND(1)	ND(1)	ND(1)	ND(25)	
MW-160	6/3/2019	ND(1)	ND(1)	ND(1)	ND(5)	BRL	ND(1)	ND(1)	ND(1)	ND(1)	ND(25)	
MW-166A	5/14/2019	ND(1)	ND(1)	ND(1)	ND(5)	BRL	ND(1)	ND(1)	ND(1)	ND(1)	ND(25)	
MW-166B	5/14/2019	ND(1)	ND(1)	ND(1)	ND(5)	BRL	ND(1)	ND(1)	ND(1)	ND(1)	ND(25)	
MW-167	5/13/2019	ND(1)	ND(1)	ND(1)	ND(5)	BRL	ND(1)	ND(1)	ND(1)	ND(1)	ND(25)	
MW-168	4/19/2019	ND(1)	ND(1)	ND(1)	ND(5)	BRL	0.5 J	ND(1)	ND(1)	ND(1)	ND(25)	
MW-168(235)	6/14/2019	ND(1)	ND(1)	ND(1)	ND(5)	BRL	ND(1)	ND(1)	ND(1)	ND(1)	ND(25)	
MW-169 [R]	6/12/2019	ND(1)	ND(1)	ND(1)	ND(5)	BRL	ND(1)	ND(1)	ND(1)	ND(1)	ND(25)	
MW-170 [R]	5/2/2019	ND(1)	ND(1)	ND(1)	ND(5)	BRL	0.4 J	ND(1)	ND(1)	ND(1)	ND(25)	
MW-171	5/13/2019	ND(1)	ND(1)	ND(1)	ND(5)	BRL	ND(1)	ND(1)	ND(1)	ND(1)	ND(25)	
MW-171C	6/14/2019	ND(1)	ND(1)	ND(1)	ND(5)	BRL	0.9 J	ND(1)	ND(1)	ND(1)	ND(25)	
MW-173B	5/14/2019	ND(1)	ND(1)	ND(1)	ND(5)	BRL	ND(1)	ND(1)	ND(1)	ND(1)	ND(25)	
MW-176 [R]	5/2/2019	ND(1)	ND(1)	ND(1)	ND(5)	BRL	0.5 J	ND(1)	0.2 J	ND(1)	ND(25)	
MW-176CC(HS)	5/13/2019	ND(1)	ND(1)	ND(1)	ND(5)	BRL	0.2 J	ND(1)	ND(1)	ND(1)	ND(25)	
MW-177	6/14/2019	ND(1)	ND(1)	ND(1)	ND(5)	BRL	4	ND(1)	0.2 J	ND(1)	ND(25)	
MW-178A	5/20/2019	ND(1)	ND(1)	ND(1)	ND(5)	BRL	ND(1)	ND(1)	ND(1)	ND(1)	ND(25)	
MW-178B	5/20/2019	ND(1)	ND(1)	ND(1)	ND(5)	BRL	22	ND(1)	0.3 J	0.7 J	ND(25)	
MW-178C [R]	4/12/2019	ND(1)	ND(1)	ND(1)	ND(5)	BRL	200	3	13	10	680	
	6/14/2019	ND(1)	ND(1)	ND(1)	ND(5)	BRL	210	2	10	9	520	
MW-179A	5/20/2019	ND(1)	ND(1)	ND(1)	ND(5)	BRL	ND(1)	ND(1)	ND(1)	ND(1)	ND(25)	

Table 2 (Continued)

Summary of Groundwater Analytical Results

Inactive Exxon Facility #28077
14528 Jarrettsville Pike
Phoenix, Maryland
April 4, 2019 through June 26, 2019

Well ID	Date	Benzene (µg/L)	Toluene (µg/L)	Ethyl-benzene (µg/L)	Total Xylenes (µg/L)	Total BTEX (µg/L)	MTBE (µg/L)	DIPE (µg/L)	ETBE (µg/L)	TAME (µg/L)	TBA (µg/L)	Comments
MW-179C	6/14/2019	ND(1)	ND(1)	ND(1)	ND(5)	BRL	0.7 J	ND(1)	ND(1)	ND(1)	ND(25)	
MW-180A	5/20/2019	ND(1)	ND(1)	ND(1)	ND(5)	BRL	1 J	ND(1)	ND(1)	ND(1)	ND(25)	
MW-181A [R]	5/21/2019	ND(1)	ND(1)	ND(1)	ND(5)	BRL	25	0.3 J	0.7 J	1	ND(25)	
MW-181B	6/17/2019	ND(1)	ND(1)	ND(1)	ND(5)	BRL	4	ND(1)	ND(1)	ND(1)	ND(25)	
MW-181C	4/22/2019	ND(1)	ND(1)	ND(1)	ND(5)	BRL	12	ND(1)	0.3 J	0.3 J	ND(25)	
MW-181C(215)	6/17/2019	ND(1)	ND(1)	ND(1)	ND(5)	BRL	17	ND(1)	0.4 J	0.4 J	ND(25)	
MW-182(200)	6/14/2019	ND(1)	ND(1)	ND(1)	ND(5)	BRL	2	0.5 J	2	ND(1)	ND(25)	
MW-183 [R]	5/2/2019	ND(1)	0.3 J	ND(1)	ND(5)	0.3 J	80	1	6	3	120	
	6/14/2019	ND(1)	ND(1)	ND(1)	ND(5)	BRL	39	0.9 J	5	0.8 J	ND(25)	
MW-184 [R]	4/12/2019	ND(1)	ND(1)	ND(1)	ND(5)	BRL	4	0.3 J	2	ND(1)	ND(25)	
MW-185 [R]	6/12/2019	ND(1)	ND(1)	ND(1)	ND(5)	BRL	ND(1)	ND(1)	ND(1)	ND(1)	ND(25)	
MW-187A [R]	4/11/2019	38	200	10	110	358	45	1	2	28	11 J	
	5/9/2019	150	1300	110	850	2410	210	3 J	3 J	55	ND(130)	
MW-187B [R]	4/11/2019	6	69	3	60	138	280	0.9 J	3	25	95	
	5/9/2019	ND(1)	0.3 J	ND(1)	ND(5)	0.3 J	110	0.2 J	1	6	94	
MW-187C [R]	4/11/2019	ND(1)	ND(1)	ND(1)	ND(5)	BRL	550	2	9	19	ND(25)	
MW-188D(141.5)	6/19/2019	ND(1)	ND(1)	ND(1)	ND(5)	BRL	0.8 J	ND(1)	ND(1)	ND(1)	ND(25)	
MW-188D(201)	6/19/2019	ND(1)	ND(1)	ND(1)	ND(5)	BRL	0.8 J	ND(1)	ND(1)	ND(1)	ND(25)	
MW-188D(212.5)	6/19/2019	ND(1)	ND(1)	ND(1)	ND(5)	BRL	0.8 J	ND(1)	ND(1)	ND(1)	ND(25)	
MW-188D(221)	6/19/2019	ND(1)	ND(1)	ND(1)	ND(5)	BRL	0.8 J	ND(1)	ND(1)	ND(1)	ND(25)	
MW-188D(228.5)	6/19/2019	ND(1)	ND(1)	ND(1)	ND(5)	BRL	0.6 J	ND(1)	ND(1)	ND(1)	ND(25)	
MW-188D(239)	6/19/2019	ND(1)	ND(1)	ND(1)	ND(5)	BRL	0.6 J	ND(1)	ND(1)	ND(1)	ND(25)	
MW-188D(279.5)	6/19/2019	ND(1)	ND(1)	ND(1)	ND(5)	BRL	0.7 J	ND(1)	ND(1)	ND(1)	ND(25)	
MW-188D(306.5)	6/19/2019	ND(1)	ND(1)	ND(1)	ND(5)	BRL	0.7 J	ND(1)	ND(1)	ND(1)	ND(25)	
MW-188D(344)	6/19/2019	ND(1)	ND(1)	ND(1)	ND(5)	BRL	0.7 J	ND(1)	ND(1)	ND(1)	ND(25)	
MW-188D(387)	6/19/2019	ND(1)	ND(1)	ND(1)	ND(5)	BRL	0.6 J	ND(1)	ND(1)	ND(1)	ND(25)	
MW-188D(396)	6/19/2019	ND(1)	ND(1)	ND(1)	ND(5)	BRL	0.7 J	ND(1)	ND(1)	ND(1)	ND(25)	

Table 2 (Continued)

Summary of Groundwater Analytical Results

Inactive Exxon Facility #28077
14528 Jarrettsville Pike
Phoenix, Maryland
April 4, 2019 through June 26, 2019

Well ID	Date	Benzene (µg/L)	Toluene (µg/L)	Ethyl-benzene (µg/L)	Total Xylenes (µg/L)	Total BTEX (µg/L)	MTBE (µg/L)	DIPE (µg/L)	ETBE (µg/L)	TAME (µg/L)	TBA (µg/L)	Comments
MW-189D(79)	6/18/2019	ND(1)	ND(1)	ND(1)	ND(5)	BRL	ND(1)	ND(1)	ND(1)	ND(1)	ND(25)	
MW-189D(91.5)	6/18/2019	ND(1)	ND(1)	ND(1)	ND(5)	BRL	0.5 J	ND(1)	ND(1)	ND(1)	ND(25)	
MW-189D(117-119)	6/18/2019	ND(1)	ND(1)	ND(1)	ND(5)	BRL	0.8 J	ND(1)	ND(1)	ND(1)	ND(25)	
MW-189D(122)	6/18/2019	ND(1)	ND(1)	ND(1)	ND(5)	BRL	0.6 J	ND(1)	ND(1)	ND(1)	ND(25)	
MW-189D(138-140)	6/18/2019	ND(1)	ND(1)	ND(1)	ND(5)	BRL	0.7 J	ND(1)	ND(1)	ND(1)	ND(25)	
MW-189D(161)	6/18/2019	ND(1)	ND(1)	ND(1)	ND(5)	BRL	0.5 J	ND(1)	ND(1)	ND(1)	ND(25)	
MW-189D(216)	6/18/2019	ND(1)	ND(1)	ND(1)	ND(5)	BRL	0.5 J	ND(1)	ND(1)	ND(1)	ND(25)	
MW-189D(256-258)	6/18/2019	ND(1)	ND(1)	ND(1)	ND(5)	BRL	0.7 J	ND(1)	ND(1)	ND(1)	ND(25)	
MW-189D(278)	6/18/2019	ND(1)	ND(1)	ND(1)	ND(5)	BRL	0.7 J	ND(1)	ND(1)	ND(1)	ND(25)	
MW-189D(315)	6/18/2019	ND(1)	ND(1)	ND(1)	ND(5)	BRL	0.6 J	ND(1)	ND(1)	ND(1)	ND(25)	
MW-189D(357)	6/18/2019	ND(1)	ND(1)	ND(1)	ND(5)	BRL	0.7 J	ND(1)	ND(1)	ND(1)	ND(25)	
MW-189D(374)	6/18/2019	ND(1)	ND(1)	ND(1)	ND(5)	BRL	0.7 J	ND(1)	ND(1)	ND(1)	ND(25)	
PW-01	5/20/2019	ND(0.5)	ND(0.5)	ND(0.5)	ND(0.5)	BRL	ND(0.5)	ND(0.5)	0.4 J	ND(0.5)	6.7 J	
	6/26/2019	ND(0.5)	ND(0.5)	ND(0.5)	ND(0.5)	BRL	ND(0.5)	ND(0.5)	ND(0.5)	ND(0.5)	ND(25)	
SVE-1 [R]	4/11/2019	ND(1)	ND(1)	ND(1)	ND(5)	BRL	10	0.7 J	1	ND(1)	ND(25)	
SVE-3 [R]	4/22/2019	5	19	0.3 J	15	39 J	48	0.9 J	2	7	10 J	
	6/26/2019	ND(1)	ND(1)	ND(1)	ND(5)	BRL	ND(1)	ND(1)	ND(1)	ND(1)	ND(25)	
STREAM01	5/10/2019	ND(1)	ND(1)	ND(1)	ND(5)	BRL	ND(1)	ND(1)	ND(1)	ND(1)	ND(25)	
	6/26/2019	ND(1)	ND(1)	ND(1)	ND(5)	BRL	ND(1)	ND(1)	ND(1)	ND(1)	ND(25)	
STREAM02	6/18/2019	ND(1)	ND(1)	ND(1)	ND(5)	BRL	ND(1)	ND(1)	ND(1)	ND(1)	ND(25)	

Table 2 (Continued)

Summary of Groundwater Analytical Results

Inactive Exxon Facility #28077
14528 Jarrettsville Pike
Phoenix, Maryland
April 4, 2019 through June 26, 2019

Notes:

[R] - Indicates the well was used for remediation at the time of reporting.
µg/L - micrograms per liter
AP - above packer
BP - below packer
BRL - Below laboratory reporting limits
BTEX - Benzene, toluene, ethylbenzene, and total xylenes
DIPE - di-isopropyl ether
ETBE - ethyl tert butyl ether
HS - Composite HydraSleeve
HS-D - deep composite HydraSleeve sampler; set at bottom of open borehole
HS-S - shallow composite HydraSleeve sampler; set at ½ of open borehole
J - Indicates an estimated value
MTBE - methyl tertiary butyl ether
NA - Not analyzed
ND(5.0) - Not detected at or above the laboratory reporting limit, laboratory reporting limit included.
NS - Not sampled
PW - Inactive supply well being used as a monitoring/sampling location
TAME - tert-amyl methyl ether
TBA - tert butyl alcohol

Table 3 - Natural Attenuation Biodegradation Evaluation Results

	Field Parameters				Laboratory Analysis (Chemistry)							Laboratory Analysis (Microbial)		
	Conditions		Electron Donor / Acceptor Indicators							Microbial Nutrient	Hydrocarbons	Microbial Indicators		
MW	pH	Temp (°C)	ORP (mV)	D.O. (mg/L)	Nitrate (mg/L)	Sulfate (mg/L)	Ferrous Iron (mg/L)	Methane (µg/L)	CO_2 (µg/L)	Orthophosphate (mg/L)	MtBE / Benzene[1] (µg/L)	QuantArray (Aerobic MtBE)	QuantArray (Aerobic BTEX)	QuantArray (Anaerobic BTEX)
Release Area (Tank Field and Intersection)														
MW-27R	6.71	22.04	79.9	8.67	2.9	64.9	-	ND	3,200 J	-	74 / 6	-	-	-
MW-27B	6.94	19.49	83.8	20.2	ND	98.7	4	ND	13,000	0.3	33 / 1	-	-	-
SVE-1	6.39	15.37	116.6	4.6	1.7	110	0	ND	9,600 J	0.21	350 / 5	-	-	-
MW-187A	5.9	18.33	189.3	3.17	2.9	6.4	0.1	4.7 J	18,000	0.07	190 / 190	High	High	Moderate
MW-187B	7.01	17.07	98.1	4.03	1.8	9.1	0	ND	ND	0.29	37 / ND	High	Moderate	Moderate
MW-187C	7.44	15.73	139.9	5.42	ND	17.5	0	ND	2,600 J	0.5	420 / ND	High	Moderate	Moderate
Plume Core (Station)														
MW-7	5.8	19.79	169.9	8.51	5.1	8.2	0.5	ND	7,500 J	0.15	39 / 2	-	-	-
MW-13	6.07	18.05	170.1	2.45	2.2	33.9	2	ND	16,000	0.46	2-Feb	-	-	-
SVE-3	6.26	18.6	160.3	5.77	2.2	22.6	0	ND	18,000	0.13	2 / ND	-	-	-
MW-1	6.27	19.67	163.2	9.93	4.4	79.6	0.5	28	28,000	0.16	ND / 19	-	-	-
Plume Core (Northeast)														
MW-54	6.21	18.41	88.1	5.97	1.6	3.6 J	0.5	65	5,600 J	2.61	ND / ND	-	-	-
MW-54B	6.47	13.75	132.3	5.39	2.6	7.9	0	ND	5,500 J	0.43	70 / ND	High	High	Moderate
MW-54C (HS-S)	7.63	9.57	13.6	66.1	ND	2 J	0.5	ND	ND	0	ND / ND	High	High	Moderate
MW-73C (HS-S)	7.29	20.04	13.2	1.87	ND	5.6	1.75	240	ND	0	220 / 9	-	-	-
MW-138D (151-156)	6.84	12.81	34.6	6.23	1.5	16.4	0	ND	5,200 J	0.45	250 / 7	High	High	Moderate
MW-188D (228.5)	6.53	6.92	39.8	-	ND	14.7	3.5	4.4 J	6,700 J	0.33	ND / ND	High	High	Moderate
MW-181C (284.5)	7.15	19.79	77.2	1.51	ND	ND	0	1,100	ND	0.13	11 / ND	-	-	-
Distal Plume (Southwest)														
MW-40	5.78	13.94	103.8	3.48	1.7	38.1	0.4	ND	100,000	0.1	0.2 J / ND	High	High	High
MW-71	6.1	13	74.5	5.66	2.5	21.5	0	ND	64,000	0.03	ND / ND	-	-	-
MW-56A	4.67	16.18	191.1	0.05	11.4	27.1	0.5	ND	110,000	1.38	NS	-	-	-
MW-56B	5.86	17.19	63.8	2.15	5.9	23.9	0.5	ND	92,000	0.17	0.3 J / ND	-	-	-
MW-56C (310-315)	6.59	20.39	64.7	2.08	ND	2.6 J	-	520	15,000	-	ND / ND	-	-	-
Distal Plume (Northeast)														
MW-178C	7.44	16.99	112.9	7.19	ND	19.1	0	ND	2,800 J	0.21	44 / ND	-	-	-
MW-184	7.26	19.11	-95.8	6.59	0.69	23.5	0	ND	3,000 J	0	8 / ND	-	-	-
MW-168 (115)	6.24	16.58	120.8	7.25	4.5	7.7	0.5	ND	21,000	0.7	0.5 J / ND	-	-	-
MW-89	5.98	16.44	143.7	4.64	13.9	16	0.5	ND	45,000	0.15	1 / ND	-	-	-
MW-82B	6.12	15.53	147.9	6.3	8.2	12.3	0.5	ND	19,000	0.21	1 / ND	-	-	-
MW-82D (HS-D)	7.83	6.78	-15.7	76.9	ND	ND	0.5	910	ND	0.49	110 / 0.5 J	-	-	-
MW-189D (256-258)	6.77	16.87	37.4	45.4	0.8	9.6	1.5	ND	24,000	0.05	91 / ND	High	Moderate	High
MW-38	6.4	9.46	59.9	-	8	10.1	0.5	ND	23,000	0	8 / ND	-	-	-
MW-38B	6.14	15.64	80.4	2.51	2.3	9.3	0.25	ND	15,000	2.37	ND / ND	-	-	-
MW-38C	6.25	18.89	56.2	4.47	ND	22.6	0	ND	20,000	0.17	100 / ND	-	-	-
MW-74	5.94	21.28	166.9	7.57	10.2	8.5	0	ND	ND	0.03	4 / ND	-	-	-
MW-75	6.28	20.88	167.2	5.94	8.5	7.4	0	ND	8,300 J	0	4 / ND	-	-	-
Background / Perimeter (Southwest)														
MW-42A	4.87	17.34	238.9	4.78	1.8	ND	0	ND	18,000	0	NS	-	-	-
MW-42B	6.77	21.58	74.4	1.5	ND	120	0	ND	11,000 J	0.16	ND / ND	-	-	-
MW-42C (192)	6.58	15.61	10.4	1.47	4.1	16	0	ND	13,000	0	ND / ND	-	-	-
Background / Perimeter (Northeast)														
MW-92	4.58	17.3	77.6	4.15	7.6	ND	0.5	ND	81,000	0	ND / ND	-	-	-
MW-92A	6.22	22.43	157.1	0.42	1.6	15.2	0.5	6	23,000	0.6	ND / ND	-	-	-
MW-92C (210-215)	6.3	16.61	54.9	0.07	ND	ND	4	41	7,600 J	1.03	ND / ND	-	-	-
MtBE and benzene from 2019 semi-annual sampling event.														

Table 4
ORP Measurements

Well ID	ORP
MW-1	163.2
MW-1A	121.1
MW-2	110.9
MW-2A	123
MW-3	117.8
MW-4	167.2
MW-4A	144.1
MW-5	92.9
MW-6	167.1
MW-7	169.9
MW-8	159.1
MW-9	153.1
MW-12	149.4
MW-13	170.1
MW-14	190.5
MW-15	149.9
MW-16	135.9
MW-16R	95.6
MW-17	182.7
MW-19	123.5
MW-21	129.5
MW-22	128.9
MW-23	133.5
MW-24	117.3
MW-25	130.4
MW-26	91.9
MW-27	80.3
MW-27B	83.8
MW-27R	79.9
MW-28	104.7
MW-29	110.1
MW-30	111
MW-31	122.2
MW-32	64.4
MW-36	79.4
MW-36C	45.2
MW-36P	128.3
MW-36R	95.1
MW-37	95.4
MW-37P	106.7

Well ID	ORP
MW-38	59.9
MW-38B	80.4
MW-38C	56.2
MW-38P	108.1
MW-40	103.8
MW-41B	90.4
MW-41C	63.4
MW-42A	238.9
MW-42B	74.4
MW-42C	10.4
MW-43A	117.1
MW-45	129.3
MW-45P	46.1
MW-45R	123.4
MW-47A	150.2
MW-47B	128.6
MW-47BB	32.1
MW-47C	-44.7
MW-48A	161.4
MW-48B	163.9
MW-48D	53.6
MW-49	99.7
MW-50B	34.8
MW-50C	37.6
MW-52	59.2
MW-53B	9.3
MW-53C	89.7
MW-54	88.1
MW-54B	132.3
MW-54C	13.6
MW-56A	191.1
MW-56B	63.8
MW-56C	53.6
MW-57	257.8
MW-57P	271.1
MW-58	243.5
MW-58P	229.2
MW-58R	219.3
MW-59A	113.8
MW-59D	127.6

Table 4
ORP Measurements

Well ID	ORP
MW-60	71.7
MW-61A	117.2
MW-61B	33.8
MW-62A	73.5
MW-62B	33.3
MW-63	67.3
MW-71	74.5
MW-72	85.7
MW-73	61.7
MW-73C	-45.7
MW-74	166.9
MW-75	167.2
MW-76	97.3
MW-77A	151
MW-77B	125.2
MW-77R	152.2
MW-80A	99.9
MW-80B	120.5
MW-81	110.3
MW-82	150.3
MW-82B	147.9
MW-82D	-15.7
MW-83	162.2
MW-83R	156.5
MW-84	46.9
MW-84P	86.7
MW-85	54.6
MW-86	56.6
MW-87	148.1
MW-88	39.1
MW-90	106.8
MW-91	81.7
MW-91C	-112.5
MW-91D	24.3
MW-92	77.6
MW-92A	157.1
MW-92C	54.9
MW-93	74.7
MW-93B	75.5
MW-93C	66.5

Well ID	ORP
MW-94	87.2
MW-95	100.1
MW-95B	124.2
MW-101A	126.6
MW-101B	110.2
MW-103	175.4
MW-105	94.6
MW-106	162.6
MW-107	247.9
MW-108	84.1
MW-108	84.1
MW-108	84.1
MW-108	84.1
MW-108	84.1
MW-108	84.1
MW-108	84.1
MW-108	84.1
MW-108	84.1
MW-108	84.1
MW-108	84.1
MW-108	84.1
MW-109	89.5
MW-110	84.1
MW-114	132.1
MW-118	92.4
MW-119	70.4
MW-121	-125.7
MW-125	111.8
MW-128C	-11
MW-132A	121.9
MW-132B	111.7
MW-133A	124.2
MW-133B	40.5
MW-133C	38.4
MW-134A	92.3
MW-134B	89.5
MW-135A	116.3
MW-135B	113.2
MW-135C	67.1
MW-136	116.1

Table 4
ORP Measurements

Well ID	ORP
MW-137	114.4
MW-139	118.1
MW-140B	69.6
MW-141A	97.8
MW-141B	63.6
MW-141C	-54.8
MW-142	129.4
MW-143	142.6
MW-144	111.6
MW-148A	149.7
MW-148B	31.9
MW-150A	73.4
MW-150B	75
MW-151	106.1
MW-154	74.7
MW-156	78.1
MW-159	82.4
MW-160	112.7
MW-162A	119.2
MW-162B	107.8
MW-164B	165.1
MW-165C	69.9
MW-166B	84.4
MW-166C	58.5
MW-167	57.9
MW-169	112.3
MW-170	114.1
MW-171	62.7
MW-171C	18.6
MW-173B	62.9
MW-174B	67.2
MW-174C	6.3
MW-175C	-126.8
MW-176	117.9
MW-176CC	39.8
MW-177	-65.9
MW-178A	108.4
MW-178B	86.9
MW-179A	127.1

Well ID	ORP
MW-179C	-10
MW-180A	119.9
MW-180C	78.8
MW-181A	71
MW-181B	72.6
MW-182	-4.9
MW-183	-101.4
MW-184	-95.8
MW-185	-122.3
MW-186D	-5.9
MW-187A	189.3
MW-187B	98.1
MW-187C	139.9
PW-14311	72.9
PW-3501	129
SVE-1	116.6
SVE-3	160.3

FIGURES

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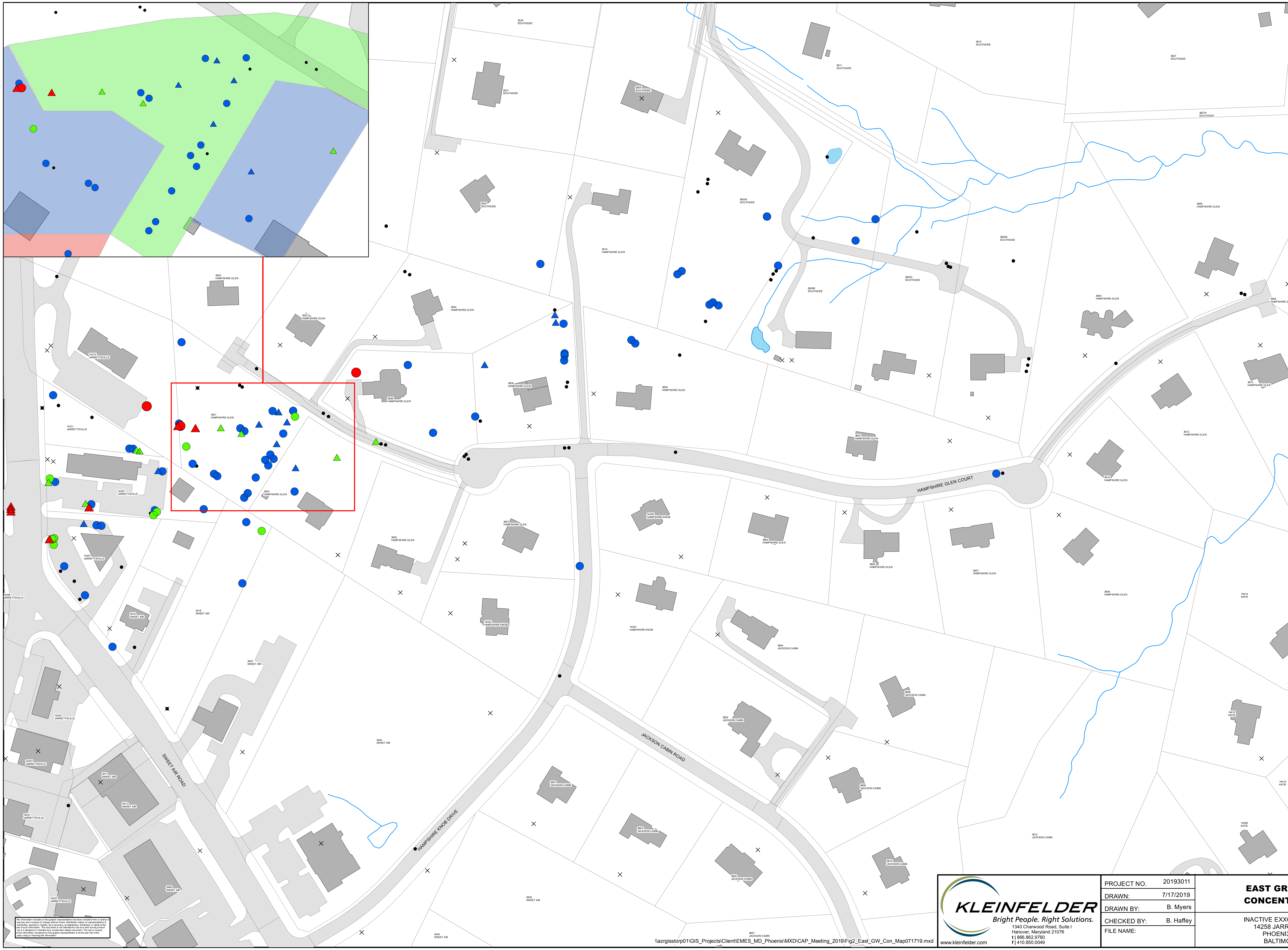
PROJECT NO.	20183146
DRAWN:	4/19/2019
DRAWN BY:	B. Myers
CHECKED BY:	C. Low

SITE PLAN
AS OF MARCH 31, 2019

INACTIVE EXXON FACILITY #28077
14258 JARRETTSVILLE PIKE
PHOENIX, MARYLAND
BALTIMORE COUNTY

FIGURE
1



Legend

MTBE Concentrations (µg/L)

- ND(RL≤1.0) - 1.0
- >1.0 - <20
- >20
- Not Sampled
- Monitoring Only
- Recovery Activity
- Private Supply Well

Groundwater Recovery Zones

- Zone 1
- Zone 2
- Zone 3
- Parcel Boundary (Approx.)
- Building Foot Prints
- Streams
- Water Bodies

NOTES:

1. LOCATIONS WITH DEPTH INTERVAL SAMPLES DISPLAY LABEL FOR MAX. MTBE CONCENTRATION. IF ALL INTERVALS ARE "ND(RL)", LABEL WILL BE DEFAULTED TO THE MOST SHALLOW INTERVAL
2. MW-99B, MW-78B, MW-78C, MW-78R WERE FLOODED AT THE TIME OF SAMPLING

GROUNDWATER RECOVERY ZONES:

ZONE 1:
MW-37, MW-38, MW-38C, MW-54B, MW-74, MW-75, MW-82B, MW-82R, MW-89, MW-178C

ZONE 2:
MW-59B, MW-91C, MW-169, MW-170, MW-176, MW-183, MW-184, MW-185

ZONE 3:
MW-45, MW-45R, MW-121, MW-181A

0 45 90 180 Feet

\\azrgisstorp01\GIS_Projects\Client\EMES_MD_Phoenix\MXD\CAP_Meeting_2019\Fig2_East_GW_Con_Map071719.mxd

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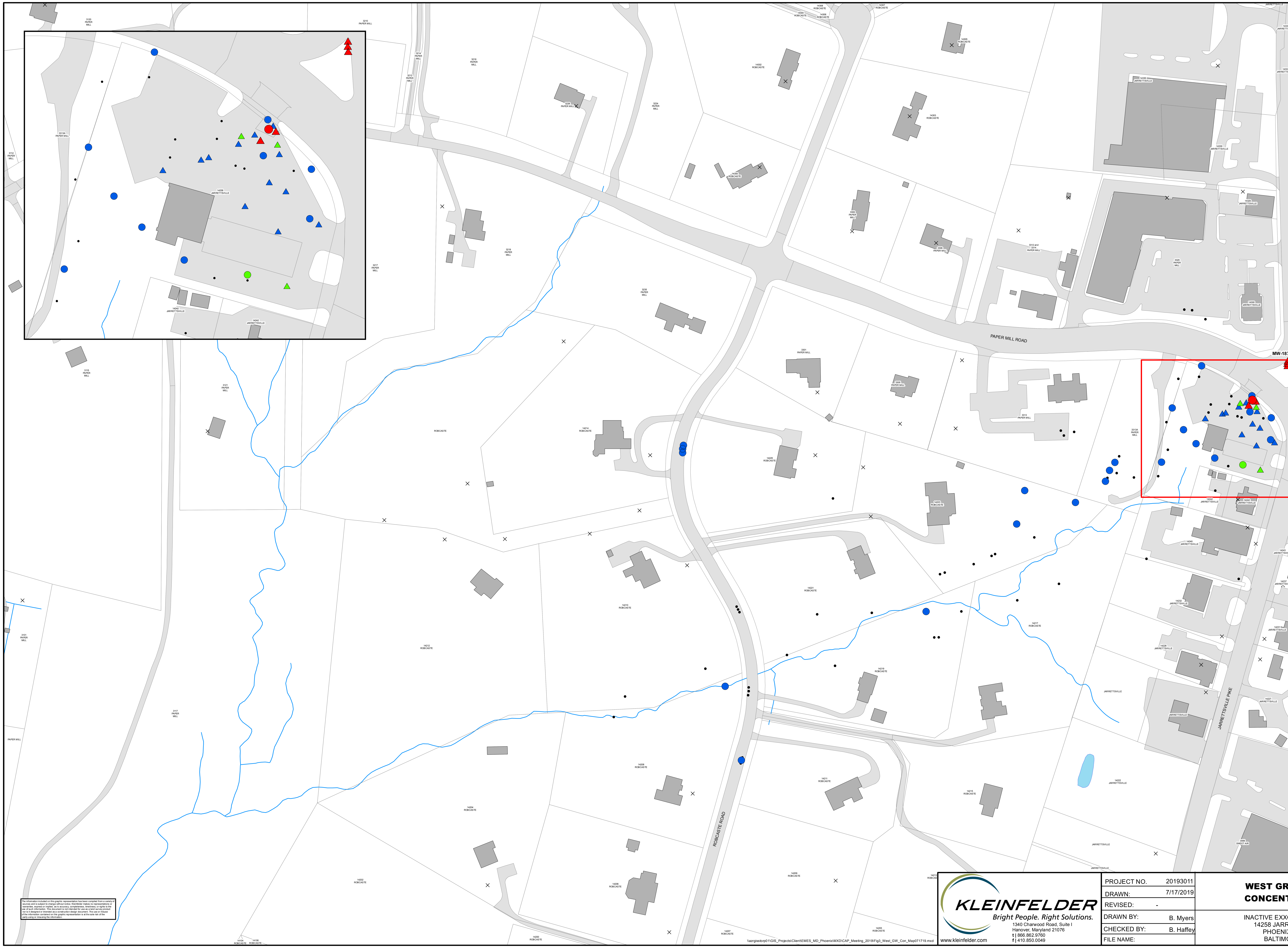
PROJECT NO.	20193011
DRAWN:	7/17/2019
DRAWN BY:	B. Myers
CHECKED BY:	B. Haffey
FILE NAME:	

EAST GROUNDWATER CONCENTRATION MAP

INACTIVE EXXON FACILITY #28077
14258 JARRETTSVILLE PIKE
PHOENIX, MARYLAND
BALTIMORE COUNTY

FIGURE
2a



Legend

MTBE Concentrations (µg/L)

- ND(RL≤1.0) - 1.0
- >1.0 - <20
- >20
- Not Sampled
- Monitoring Only
- Recovery Activity
- Private Supply Well

Groundwater Recovery Zones

- Zone A
- Dispenser Island
- DPE
- Parcel Boundary (Approx.)
- Building Foot Prints
- Streams
- Water Bodies

NOTES:

1. LOCATIONS WITH DEPTH INTERVAL SAMPLES DISPLAY LABEL FOR MAX. MTBE CONCENTRATION. IF ALL INTERVALS ARE "ND(RL)", LABEL WILL BE DEFAULTED TO THE MOST SHALLOW INTERVAL.
2. MW-20, MW-41A, MW-42A, MW-44, MW-46, MW-50, MW-53A, MW-56A, MW-63, MW-65, MW-66, MW-67, MW-68, MW-69, MW-70, MW-96A, MW-97, MW-120, MW-122, MW-128A, MW-128B, MW-130, MW-140A, MW-157P, AND PIEZOMETER ('P') MONITORING WELLS ARE NOT SAMPLED AND ARE USED FOR GROUNDWATER GAUGING ONLY

GROUNDWATER RECOVERY ZONES:

ZONE DISPENSER ISLAND:
MW-1A, MW-2A, MW-19, MW-21, MW-22, MW-23, MW-139, MW-151, MW-152, MW-187A, MW-187B, SVE-1, SVE-2, SVE-3

ZONE DPE:
MW-3, MW-4, MW-6, MW-7, MW-13, MW-16, MW-16R, MW-27, MW-27R

0 45 90 180 Feet

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PROJECT NO.	20193011
DRAWN:	7/17/2019
REVISED:	-
DRAWN BY:	B. Myers
CHECKED BY:	B. Haffey
FILE NAME:	

WEST GROUNDWATER CONCENTRATION MAP

INACTIVE EXXON FACILITY #28077
14258 JARRETTSVILLE PIKE
PHOENIX, MARYLAND
BALTIMORE COUNTY

FIGURE
2b

NOTES:
ORP = Oxidation-Reduction Potential
mV = millivolts

0 120 240 360 480 Feet

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PROJECT NO.	20193011
DRAWN:	7/16/2019
DRAWN BY:	B. Myers
CHECKED BY:	S. Schiding

ORP SAMPLE RESULTS 2019 (SHALLOW)

INACTIVE EXXON FACILITY #28077
14258 JARRETTSVILLE PIKE
PHOENIX, MARYLAND
BALTIMORE COUNTY

FIGURE
3a

NOTES:
ORP = Oxidation-Reduction Potential
mV = millivolts

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PROJECT NO.	20193011	ORP SAMPLE RESULTS 2019 (DEEP)	FIGURE 3b
DRAWN:	7/16/2019		
DRAWN BY:	B. Myers		
CHECKED BY:	S. Schiding	INACTIVE EXXON FACILITY #28077 14258 JARRETTSVILLE PIKE PHOENIX, MARYLAND BALTIMORE COUNTY	

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Microbial Populations MW-187A [R]

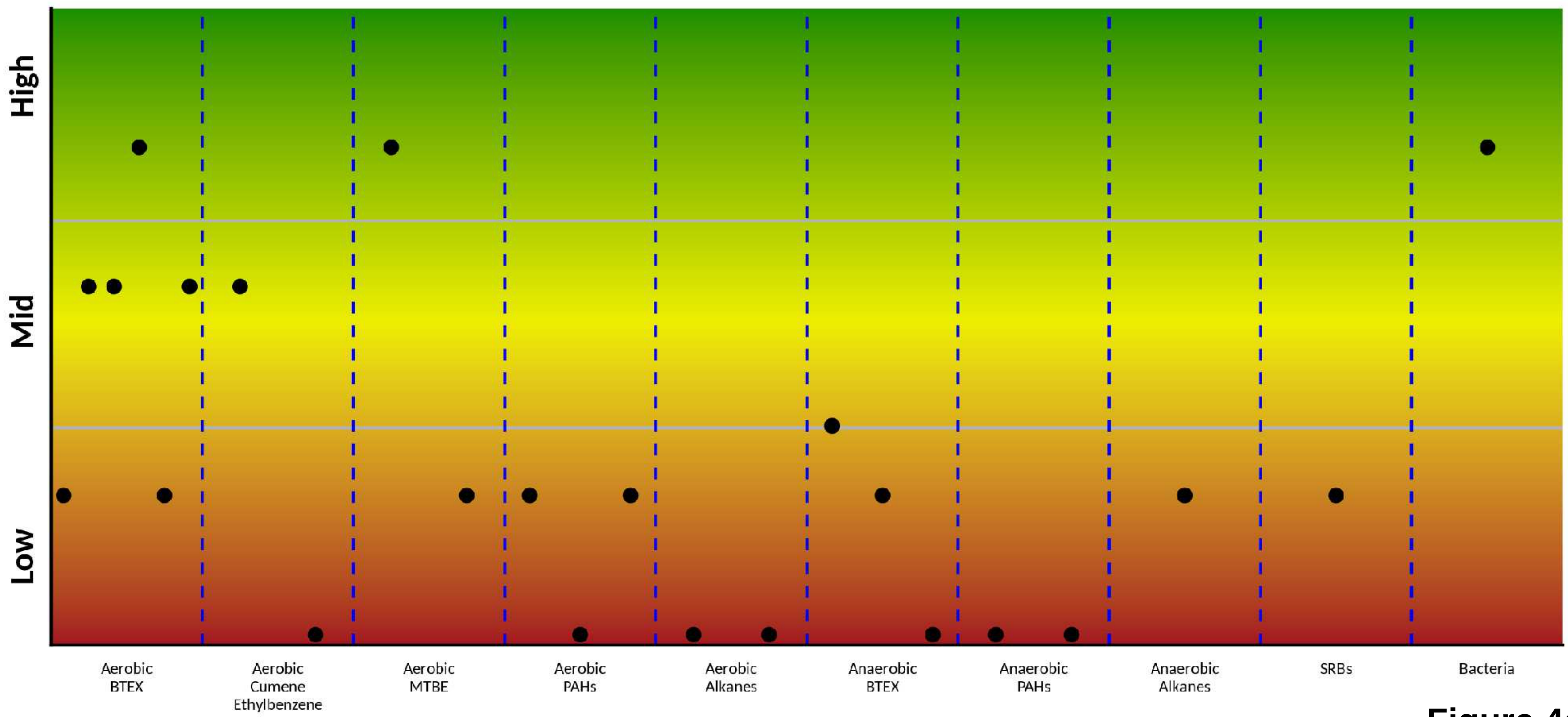
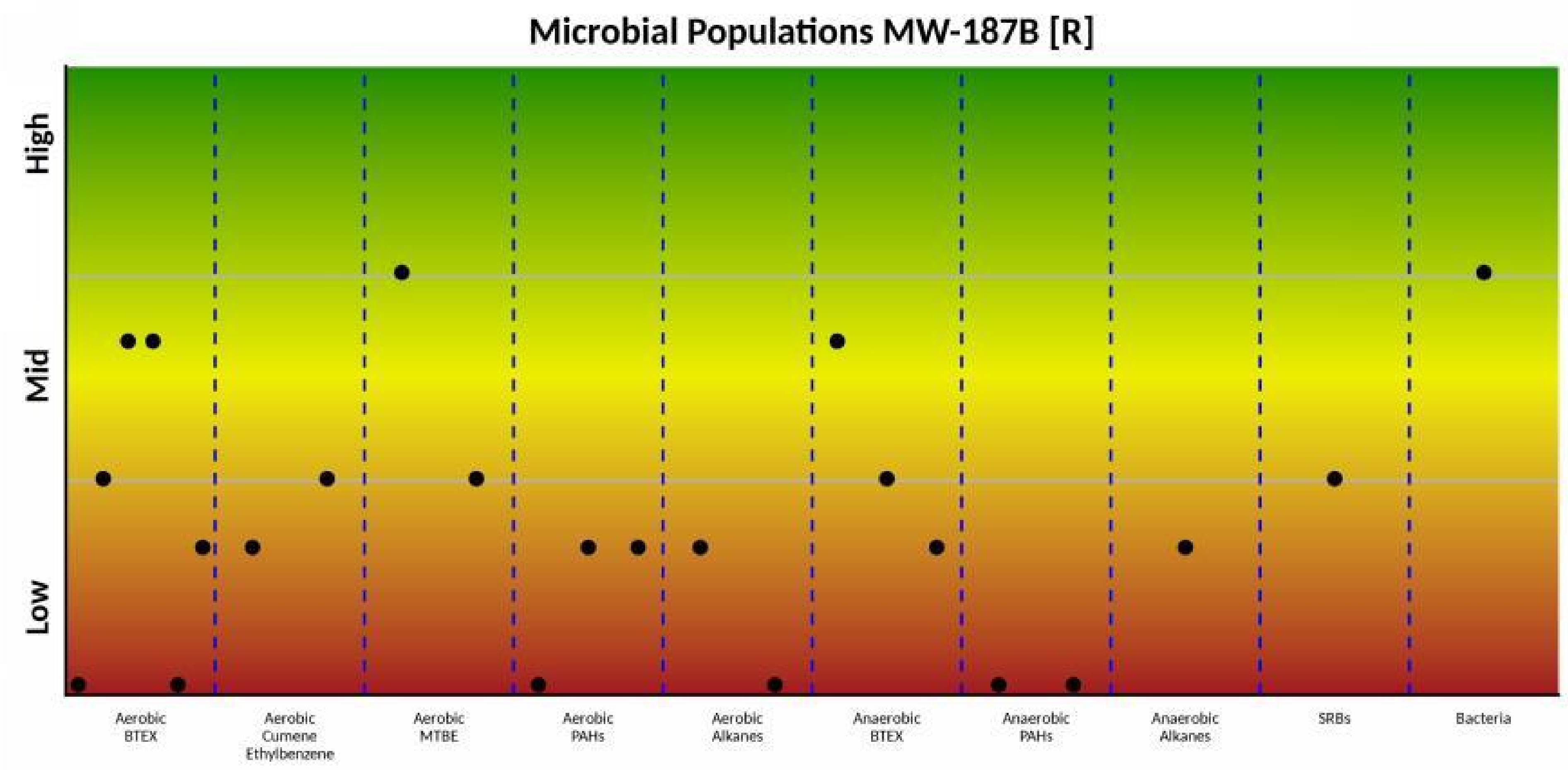


Figure 4a



Microbial Populations MW-187B [R]
High
Mid
Low
Aerobic BTEX
Aerobic Cumene Ethylbenzene
Aerobic MTBE
Aerobic PAHs
Aerobic Alkanes
Anaerobic BTEX
Anaerobic PAHs
Anaerobic Alkanes
SRBs
Bacteria

Figure 4b

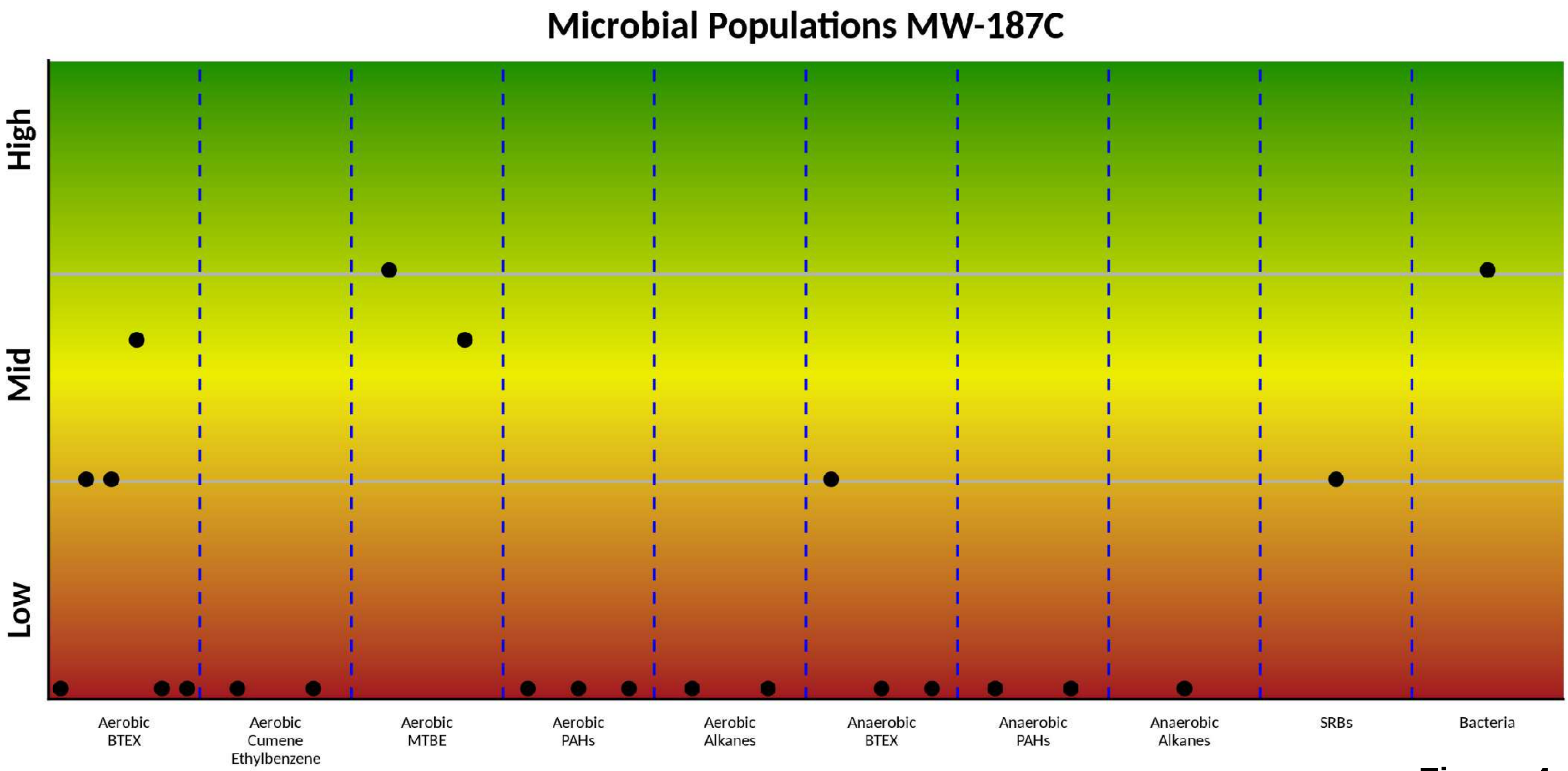

Microbial Populations MW-187C
High
Mid
Low
Aerobic BTEX
Aerobic Cumene Ethylbenzene
Aerobic MTBE
Aerobic PAHs
Aerobic Alkanes
Anaerobic BTEX
Anaerobic PAHs
Anaerobic Alkanes
SRBs
Bacteria

Figure 4c

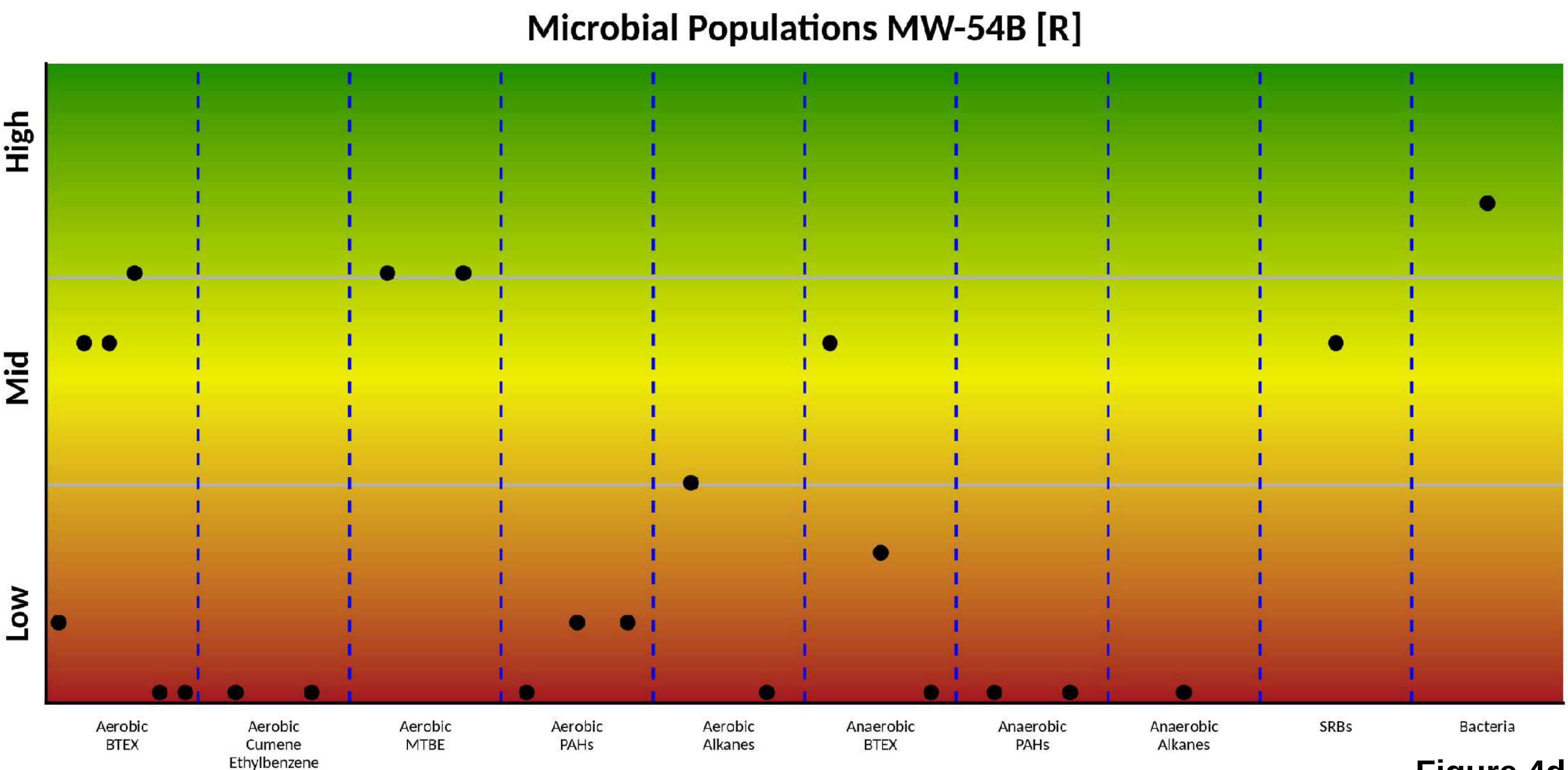

Microbial Populations MW-54B [R]
High
Mid
Low
Aerobic BTEX
Aerobic Cumene Ethylbenzene
Aerobic MTBE
Aerobic PAHs
Aerobic Alkanes
Anaerobic BTEX
Anaerobic PAHs
Anaerobic Alkanes
SRBs
Bacteria

Figure 4d

Microbial Populations MW-54C

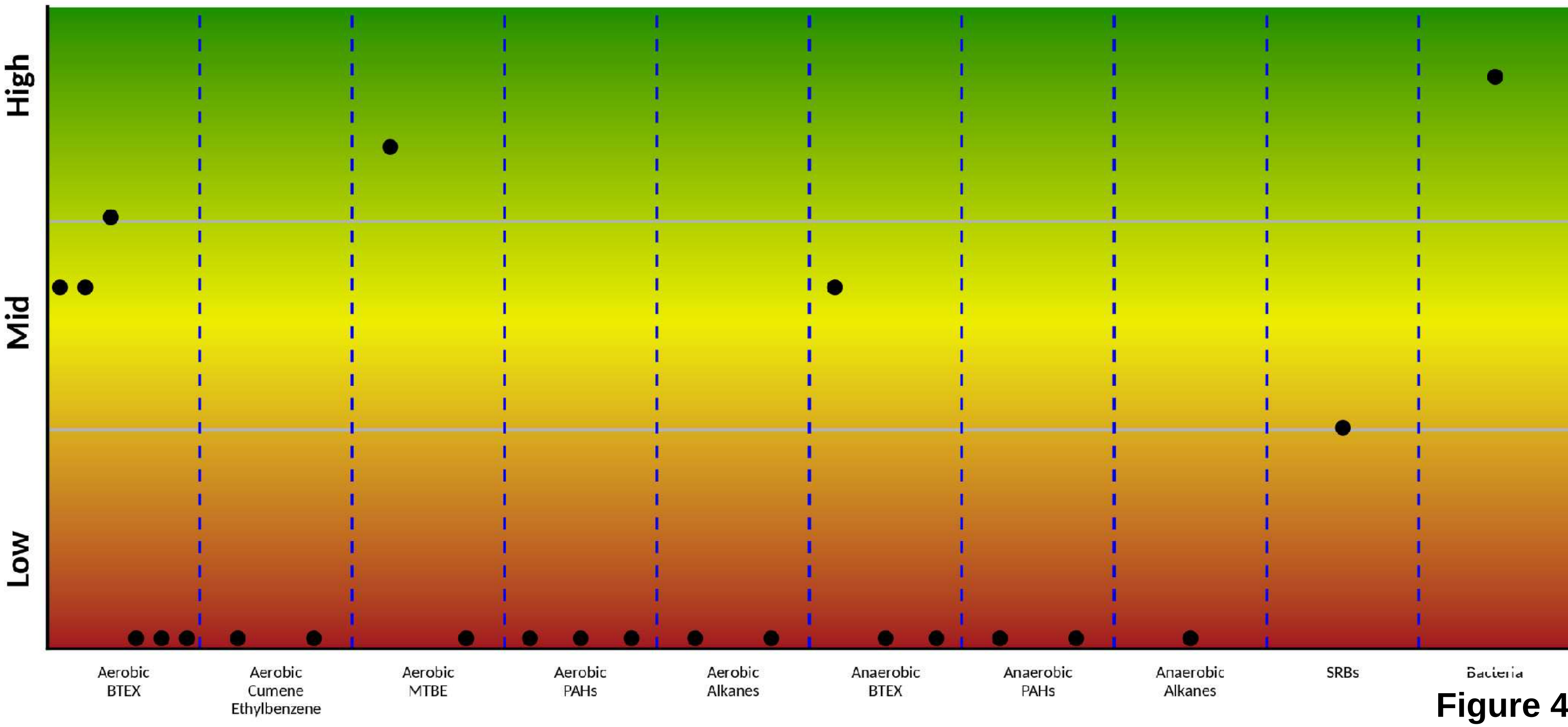


Figure 4e

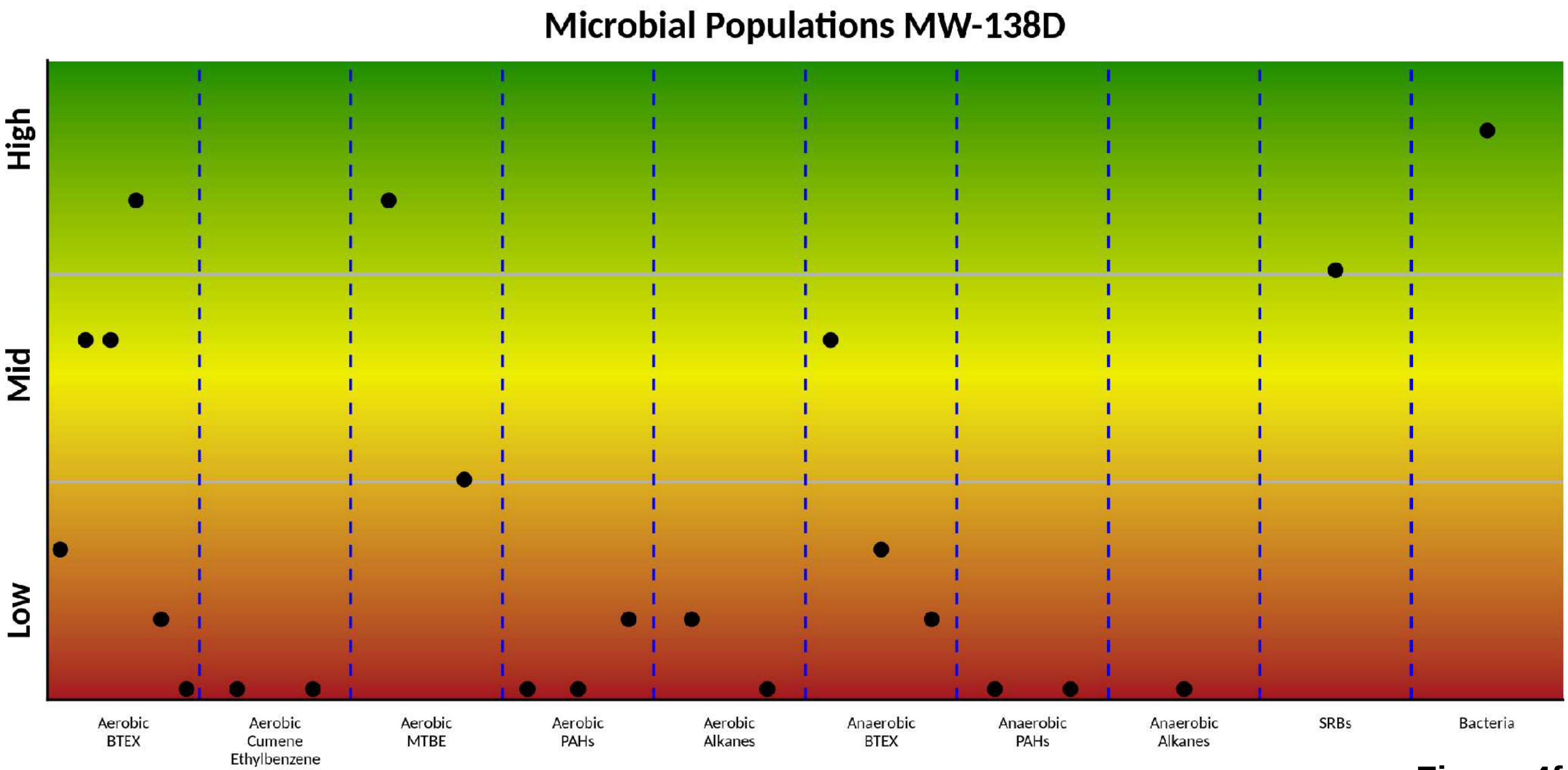

Microbial Populations MW-138D
High
Mid
Low
Aerobic BTEX
Aerobic Cumene Ethylbenzene
Aerobic MTBE
Aerobic PAHs
Aerobic Alkanes
Anaerobic BTEX
Anaerobic PAHs
Anaerobic Alkanes
SRBs
Bacteria

Figure 4f

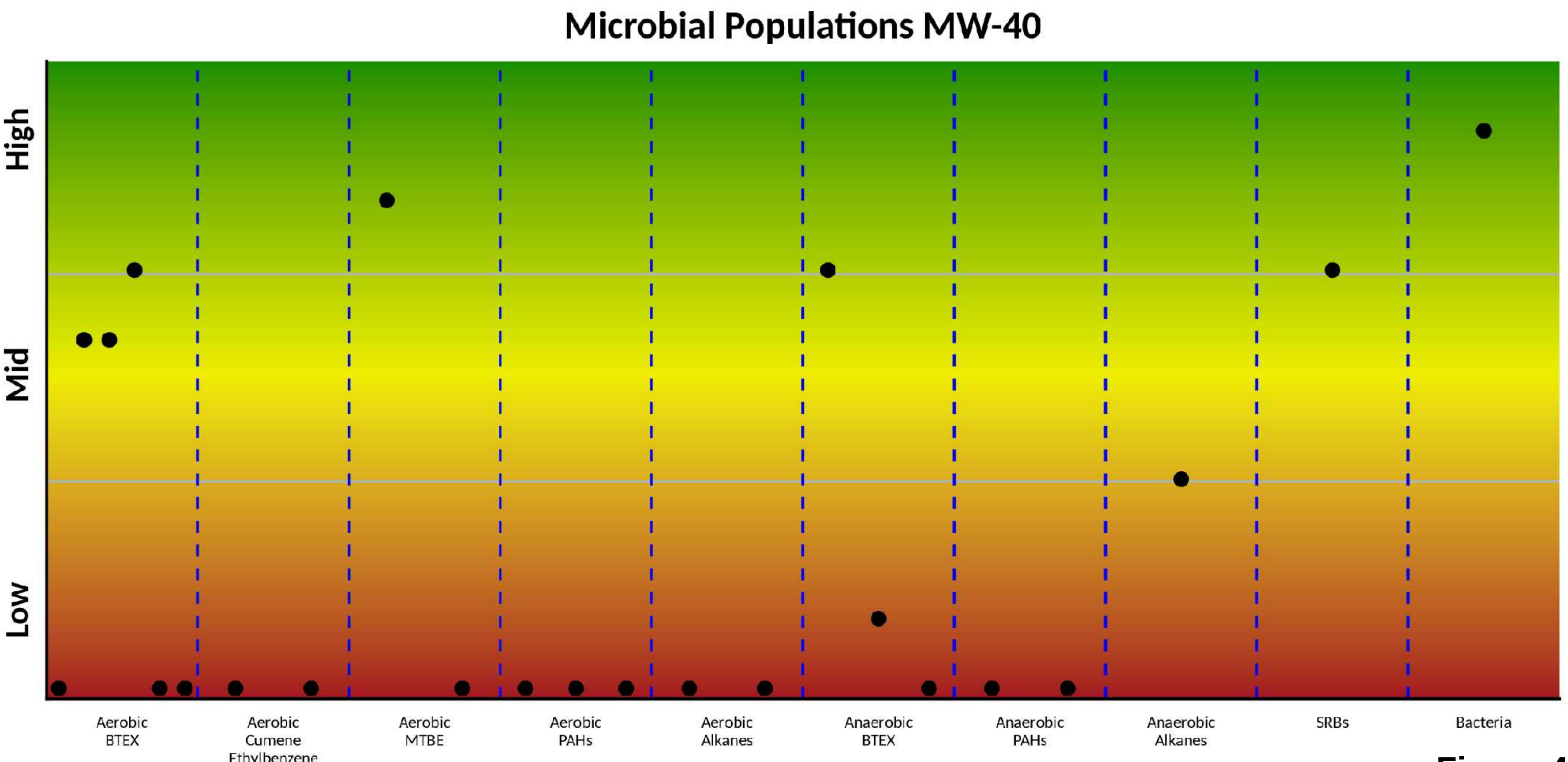

Microbial Populations MW-40
High
Mid
Low
Aerobic BTEX
Aerobic Cumene Ethylbenzene
Aerobic MTBE
Aerobic PAHs
Aerobic Alkanes
Anaerobic BTEX
Anaerobic PAHs
Anaerobic Alkanes
SRBs
Bacteria

Figure 4g

Microbial Populations MW-189D

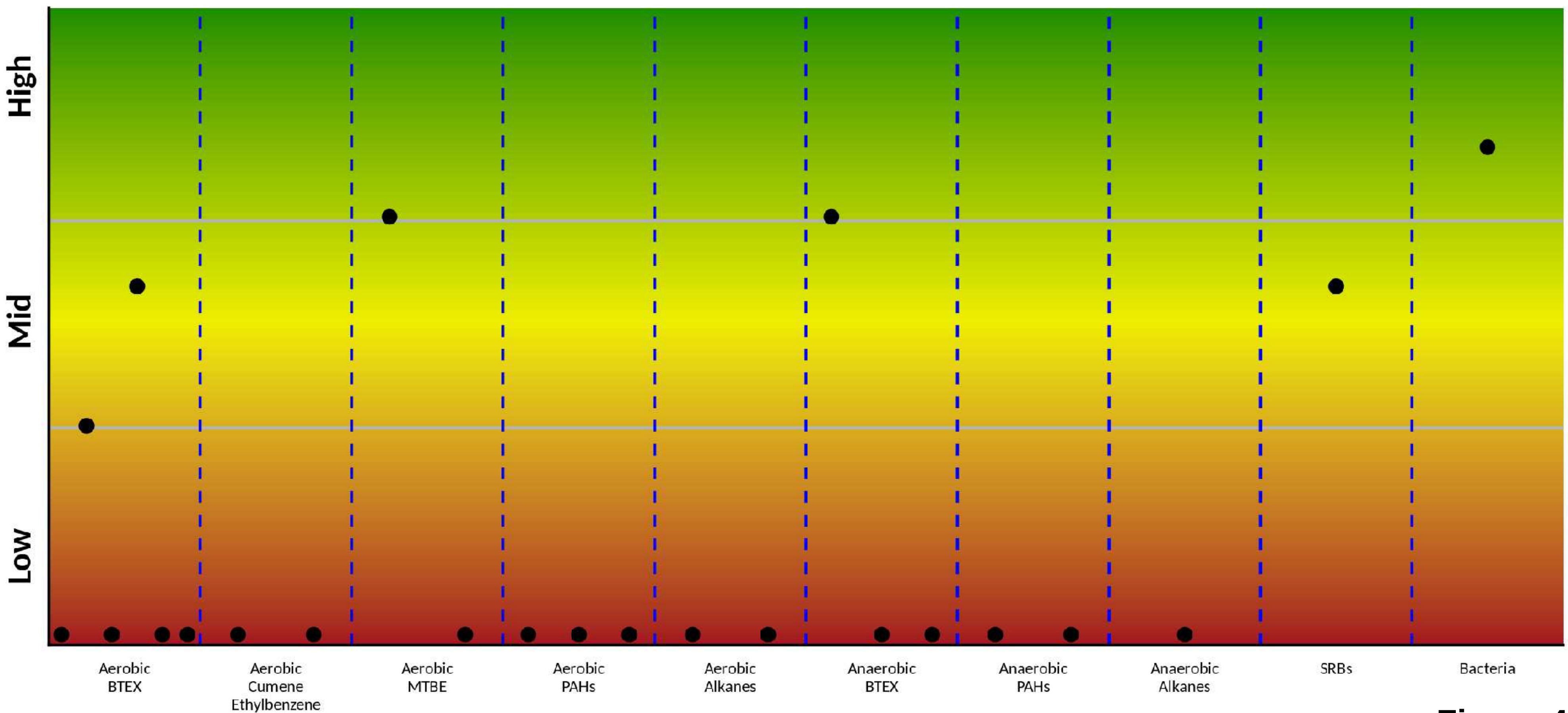


Figure 4h