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September 5, 2017

Ms. Carolyn d'Almeida
U.S. EPA, Region IX
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**Subject: Contract No. EP-W-07-066, Task Order No 066-016-09Q1, Williams Air Force Base Task Order, Review of the Revised Draft Final Addendum #2, Remedial Design and Remedial Action Work Plan for Operable Unit 2, Revised Groundwater Remedy, Site ST012, Former Williams Air Force Base Mesa, Arizona, August 2017**

Dear Ms. d'Almeida:

TechLaw conducted a technical review of the Revised Draft Final Addendum #2, Remedial Design and Remedial Action Work Plan for Operable Unit 2, Revised Groundwater Remedy, Site ST012, Former Williams Air Force Base, Mesa, Arizona, dated August 8, 2017 (the Addendum #2).

Please note that TechLaw did not review Appendix K (Response to EPA and ADEQ comments).

The proposed enhanced bioremediation (EBR) design is contingent on the expected flow paths developed using the groundwater model presented in Appendix F (Groundwater Model Outputs). Due to the groundwater model complexity, it is not possible to independently evaluate the predictive EBR simulations (e.g., 20-year benzene concentration predictions) because no model outputs are presented in Addendum #2. As a result, the ability of EBR to address remaining constituent of concern mass following the steam enhanced extraction is uncertain.

The comments are forwarded to you in Word format. TechLaw understands you will review and revise these comments at your discretion.

We appreciate the opportunity to provide technical support services to U.S. EPA on this Task Order. Should you have any questions or comments, please contact me or the TechLaw Project Manager, Michael Anderson, at (415) 762-0564.

Sincerely,

Indira Balkissoon
ROC 9 Senior Task Order Manager

NG/CG/NT:KB/DD:IB:as

cc: Central files, TechLaw, Inc.

**FORMER WILLIAMS AIR FORCE BASE**
**Mesa, Arizona**

# Review of the Revised Draft Final Addendum #2 Remedial Design and Remedial Action Work Plan for Operable Unit 2, Revised Groundwater Remedy, Site ST012, August 2017

**Submitted to:**

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**September 5, 2017**

**Review of the Revised Draft Final Addendum #2 Remedial Design and Remedial Action Work Plan for Operable Unit 2, Revised Groundwater Remedy, Site ST012, August 2017**

## GENERAL COMMENTS

1. Insufficient information is provided in the Revised Draft Final Addendum #2, Remedial Design and Remedial Action Work Plan for Operable Unit 2, Revised Groundwater Remedy, Site ST012, Former Williams Air Force Base, Mesa, Arizona, dated August 8, 2017 (Addendum #2) to support a comprehensive enhanced bioremediation (EBR) design. Specifically, the following information is not provided:

   **a.** The extent of constituent of concern (COC) mass remaining at ST012 following steam enhanced extraction (SEE) operations is based on numerous assumptions. As noted in Section 2.3 (Pre-EBR COC Extent Estimate) the current interpretation of COC mass is based on a pre-SEE light nonaqueous phase liquid (LNAPL) volume estimate and the application of a theoretical extent of treatment based on mass recover estimates during SEE operations. As a result, it is unclear if the nature and extent of COC mass remaining at ST012 is fully understood.

   **b.** The potential impact of biofouling on the EBR design is not sufficiently discussed. Based on Section 2.4 (Revise of EBR Pilot Test Results), rapid and abrupt changes during the pull phases of the EBR field test were likely related to fouling of the well screens. As such, it is unclear what actions, other than altering the terminal electron acceptor (TEA) dosing are proposed to prevent and monitor fouling.

   **c.** Section 3.2.2 (Phased TEA Batch Injections) indicates that the site will be assessed for changing conditions, such as "potential rebound, insufficient TEA distribution or dosing, or rate-limiting geochemical conditions (e.g., pH, oxidation-reduction potential, nitrogen and micronutrient concentration);" however, the text does not discuss whether mounding or displacement will be assessed.

   **d.** Section 3.2.2 indicates that "Subsequent phase injection strategies will be developed during EBR monitoring periods and be documented in report addenda or field variance memoranda;" however, Addendum #2 makes no commitment to discuss these subsequent phase injection strategies with the Regulatory Agencies.

   **e.** Section 4.2 (Operation) states, "Specific operations instructions will be documented in EBR [enhanced bioremediation] SOPs [standard operating procedures] developed during and following system commissioning. SOPs will be appended to this addendum and maintained on-site during active EBR activities;" however, this implies that initial EBR activities will be conducted without formalized SOPs.

   **f.** Section 4.2.2 (TEA Dosing) indicates that TEA injection at 160 or 320 grams per liter (g/L) may inhibit sulfate-reducing bacteria (SRB) activity in the immediate vicinity of the injection well to reduce fouling but achieve 16 to 32 g/L concentrations to support SRB activity a relatively short distance from the injection wells;" however, information (i.e., field test results) to support this conclusion is not provided and/or referenced.

   **g.** Section 4.2.2 includes the use of HACH® BART test kits for SRB; however, information to support the use of these test kits is not provided and/or referenced.

**h.** Section 4.2.2 indicates that one quarter of the total injection mass under Phase 1 for each well will be injected approximately every three months; however, information to support whether or not the proposed TEA dosing and frequency is sufficient is not provided and/or referenced.

**i.** Based on Section 4.2.6 (Conceptual EBR Contingency Planning), "In a couple areas (additional characterization locations ST-12-SB18 and ST012-SB19), additional work may be required to characterize LNAPL impacts as part of future EBR phases;" however, it is unclear why these areas would not be incorporated into the EBR design.

**j.** Based on Section 4.2.6, "In areas of insufficient TEA distribution, installation of additional injection/extraction wells or injection/extraction from different existing wells will be considered (e.g., pulling from an injection well and adding to another well);" however, without understanding TEA distribution, it is unclear if this proposed EBR design change is appropriate. Understanding the distribution of TEA following injection is critical to ensuring the EBR is designed to degrade COC by SRB.

**k.** Section 5.1.3 (Pre-EBR Groundwater Re-Baseline Sampling) indicates that select wells (ST012-CZ02, -CZ20, -UWBZ24, -UWBZ31, -LSZ10, and -LSZ42) will be sampled for microbial populations by quantified polymerase chain reaction (qPCR) for quantitation of SRB and total eubacteria (EBAC); however, it is unclear how these six sampling locations (i.e., two wells per hydrostratigraphic unit) are representative of the microbial populations throughout the site and hydrostratigraphic units.

**l.** Section 5.3 (Extraction Well Sampling), Table 5-1 (EBR Monitoring, Sampling, and Analysis Methods and Frequencies), and Appendix J (Operational Decision Matrix) propose monthly monitoring (sulfate field screening with confirmatory off-site laboratory analysis for every 10% of field screening samples) once sulfate from injections arrive at the extraction wells and the extraction wells are shut off. This sampling frequency limits the amount of data that can be obtained related to TEA injection travel times.

**m.** The radius of influence (ROI) associated with the injection and extraction wells is unknown. As a result, substrate travel times are unknown. This is of particular concern given that Table 5-1 indicates that sulfate field screening and sulfate sampling will occur biweekly during the first month (sulfate only), then transition to monthly thereafter with confirmatory off-site laboratory analysis for every 10 percent (%) of field screening samples at 20 extraction well locations and weekly during the first two months, then transition to monthly thereafter with confirmatory off-site laboratory analysis for every 10% of field screening samples at seven additional extraction wells. These sampling frequencies do not account for preferential pathways, groundwater mounding, or groundwater displacement, conditions which could impact sulfate travel times.

**n.** Table 5-1 indicates that groundwater/perimeter monitoring wells will be sampled for volatile organic compounds (VOCs), inductively coupled plasma (ICP) metals, and sulfate on a quarterly basis; however, Section 4.2.6 (Conceptual EBR Contingency Planning, page 4-13) indicates that VOC and semi-volatile organic compound (SVOC) results will be reviewed to see if there are indications of sulfate depletion. As such, it is unclear why SVOC or total petroleum hydrocarbon (TPH) sampling is not included in the analysis proposed for the groundwater/perimeter monitoring wells. In addition, it is unclear if the proposed quarterly sampling will provide sufficient data to establish the trends necessary to evaluate changing conditions in the hydrostratigraphic units, as outlined in Appendix J.

o. Limited information is available related to the Cobble Zone hydrostratigraphic unit. For example, a slug test has not been conducted at the site to determine near-well aquifer characteristics. As such, the ROI and travel time in this unit is unclear.
p. Details regarding the existing groundwater extraction treatment system equipment (e.g., capacities, alarms, containment) to be utilized are not provided and/or referenced.
q. The need for an on-site EBR recirculation system should be evaluated prior to implementing the EBR design.
r. Issues related to arsenic in sodium sulfate are not sufficiently addressed. Baseline sampling of perimeter monitoring wells, conducted in July 2016 following the EBR field test, detected arsenic concentrations up to 110 micrograms per liter (ug/L); yet, the text indicates that there is no indication arsenic is migrating downgradient. It should also be noted that a complete understanding of the impact of naturally occurring arsenic and geochemical reactions were not factored into calculations related to the influence of arsenic concentrations in Appendix H (Aquifer Arsenic Loading Calculations).
s. Appendix D (Enhanced Bioremediation Field Test Report) states, "The limited volume extracted did not provide sufficient data set to estimate sulfate utilization during the pull phase." As a result, it is unclear if the results from the EBR field test are appropriate for designing a full-scale implementation.

Please revise Addendum #2 to provide this information to support the EBR design.

2. Based on Table 2-5 (Concentrations of Solution Used for Injection) of Appendix D (Enhanced Bioremediation Field Test Report), the calculated sulfate concentration used for injection during the EBR field test underestimated the sulfate concentration as compared to the laboratory result. Yet, Section 5.2.1 (TEA Injection Solution Sampling) only proposes monthly injection solution sampling to confirm the injection solution concentration. Given that batches of TEA will be prepared at a target concentration and modified in the field, as required, based on monitoring results, monthly injection solution sampling to confirm the injection solution concentration is insufficient. Similarly, the use of field sampling kits prior to injection to verify TEA batch concentrations is inappropriate without a percentage of injection solutions being verified with fixed laboratory analysis. This sampling frequency is of particular concern given the need to assess the arsenic concentration in the TEA injection solutions prior to injection. Please revise Addendum #2 to include sufficient injection solution sampling to confirm the injection solution and arsenic concentrations. In addition, please revise Addendum #2 to include fixed laboratory analysis verification for a percentage of injection solutions to ensure the field sampling kits are appropriate for target concentration modifications in the field.

3. Insufficient information is provided in Appendix J (Operational Decision Matrix). Specifically, the following information is not provided:

   a. Section 2.3 (Pre-EBR COC Extent Estimate) states, "The remaining COC mass at ST012 was estimated using the updated pre-SEE LNAPL volume estimate (i.e., pre-SEE LNAPL Extent Interpretation Update) described in Section 2.1 as the baseline and applying a theoretical extent of treatment based on observed mass recoveries during SEE operations. The intent is to provide a rough estimate of remaining COC mass to be

addressed. The mass estimate was used to design initial EBR approaches. Given the required assumptions to make these estimates, it is recognized that actual COC mass may be different and EBR approaches may require adjustment as the project progresses;" however, decision criteria, specifically related to these adjustments, are not included.

**b.** Section 3.2.1 (Groundwater Extraction and Treatment) states, "The gravity separator may be bypassed if deemed unnecessary based on composition of the influent water;" however, decision criterion associated with the composition of the influent water is not provided and/or referenced. Similarly, Section 3.2.1 also states that the air stripper may be bypassed, if determined to be unnecessary based on composition of the influent water. It should be noted that Table 5-1 (EBR Monitoring, Sampling, and Analysis Methods and Frequencies) only includes treatment system influent sampling for VOCs and TPHs on a monthly basis.

**c.** Section 5.4 (Groundwater Monitoring Well Sampling) indicates that perimeter monitoring wells will be gauged and bailed or pumped for LNAPL on a monthly basis for the first six months of EBR activities and will transition to a quarterly basis thereafter unless LNAPL accumulations justify more frequent gauging; however, the LNAPL accumulation levels that would justify more frequent gauging are not provided and/or referenced.

**d.** In order to establish if biological degradation by SRB is occurring, trends will be evaluated for numerous parameters (e.g., VOCs, TPH, iron, manganese, nitrate, sulfate, temperature, pH, dissolved oxygen); however, specifics regarding these trend analyses are not provided and/or referenced. Given that the outcome of these trends impacts the EBR design, specifics regarding the trend analysis are needed.

**e.** Section 4.2.4 (Groundwater Extraction Shutdown) indicates that TEA dosing using batch injections coupled with groundwater extraction will operate until satisfactory TEA distribution is achieved; however, Appendix J (Operational Decision Matrix) does not define satisfactory TEA distribution. As such, it is unclear if TEA dosing using batch injections will continue to occur after sulfate is detected in the extraction wells and the extraction wells are shutdown.

Please revise Addendum #2 to include this information.

**4.** Section 2.1 (LNAPL Extent Update) and Appendix A (2017 Mass Update Calculations) assume LNAPL is at residual saturation. Section 2.1 states, "[M]ass calculations based on residual saturation at lower temperatures are appropriate to estimate residual LNAPL mass;" however, Appendix A notes that LNAPL accumulation occurred in well LSZ47 following SEE. This directly contradicts the assumption that LNAPL is at residual saturation. In addition, Addendum #2 does not account for the fact that LNAPL viscosity was likely impacted due to the increased temperatures from SEE. Similarly, Section 2.1 states, "The presence of mobile LNAPL during the PDI [Pre-Design Investigation] and the volumes removed during and after SEE operations indicates that there is mobile LNAPL at ST012." Please acknowledge that mobile LNAPL is present through Addendum #2 or provide information to substantiate the assumption that LNAPL is at residual saturation given LNAPL accumulation occurred. In addition, please revise Addendum #2 to discuss how the LNAPL viscosity following SEE has impacted the nature and extent of LNAPL at the site.

5. Section 2.2.4 (Temperature Data) indicates that during EBR, the former Thermal Treatment Zone (TTZ) and adjacent subsurface temperatures are expected to remain well above ambient temperatures; however, the impact of these temperatures on EBR implementation and microbial growth/inhibition are not discussed. Specifically, the following information is not provided:

   a. Section 3.1.2 (Sulfate) does not discuss how temperature impacts sodium sulfate (anhydrous) solubility. Based on available literature ([ HYPERLINK "http://pubs.acs.org/doi/abs/10.1021/jp507949h" ]), the solubility of sodium sulfate increases up to 32.38 degrees Celsius and decreases slightly thereafter at higher temperatures.
   b. Section 4.0 (EBR Implementation) does not discuss the impact of temperature on the EBR infrastructure (e.g., piping, influent equilibrium tank, oil water separator, air strippers, granular activated carbon). While Section 3.2.1 (Groundwater Extraction and Treatment) states that water leaving the equalization tank will pass a temperature transmitter, which will shut down the system if the temperature is too high for subsequent treatment equipment and discharge into the City of Mesa sewer, Figure 3-1 (EBR System Process Flow Diagram) does not include an equalization tank or temperature transmitter; the temperature which will trigger a shutdown of the system is not specified; and, the temperature thresholds for subsequent treatment equipment and discharge into the City of Mesa sewer is not specified. It should be noted that Figure 3-1 does not include infrastructure to cool extracted water prior to TEA dosing.
   c. Sections 3.0 (EBR Design) and 4.0 do not discuss the impact of temperature on the microorganisms and micronutrients. As such, it is unclear if current temperatures have or will inhibit microbial population growth. It should be noted that without a microbial growth evaluation, it is unclear if the microbial population is appropriate for biodegradation of COCs to occur.
   d. Section 2.5 (Background Groundwater Geochemical Analyses) states, "Sulfate concentrations have also been shown previously to be highly depleted in the source area indicating the presence of sulfate reducing bacteria (BEM, 1998);" however, this statement is based on data obtained during a treatability study conducted prior to 1998 and SEE. As such, it is unclear if the sufficient sulfate reducing bacteria remain.

   Please revise Addendum #2 to discuss the impact of current subsurface temperatures on EBR implementation.

6. Section 4.2.3 (Micronutrient Dosing) indicates that a mix of micronutrients (e.g., Bionetix MICRO 14) may be added to TEA injection solutions and injected into the subsurface to increase biological activity; however, the references for the microbial analysis indicating that the proposed micronutrients are appropriate for the microbial populations at the site are not provided. As such, it is unclear if the proposed micronutrients will provide a balanced nutrient blend for the microbial activity and boost bacterial performance and rates of degradation of target substances. Please revise Addendum #2 to include the microbial analysis that supports the use of the mix of micronutrients proposed for use.

7. Section 6.2 (Selective Decommissioning of EBR System) indicates that the EBR system will be decommissioned and dismantled once subsurface conditions have met remedial goals for transition to monitoring; however, this decision appears short-sighted as it does not allow for future substrate applications to occur should COC concentrations rebound. In addition, the specific subsurface conditions that will be utilized to determine that the EBR system can be decommissioned and dismantled are not provided and/or referenced. Given the potential for rebound to occur, please revise Addendum #2 to clarify why the EBR system will not be placed in standby rather than decommissioned and dismantled. In addition, please revise Addendum #2 to provide and/or reference the specific subsurface conditions that will be utilized to determine that the EBR system can be decommissioned and dismantled.

8. Figures 3-2 through 3-4 do not include the groundwater flow direction, the targeted treatment areas, and expected flow paths between the injection and extraction wells. Without this information, it is unclear if there are sufficient monitoring wells or extraction wells. For example, only two monitoring wells are designated for the Cobble Zone (CZ) that are located between extraction and injection wells; however, without the groundwater flow direction, the targeted treatment areas, and expected flow paths between the injection and extraction wells, it is unclear if these monitoring wells are sufficient. It is possible that some of the perimeter and "other" monitoring wells can be used to monitor EBR progress, but it is unclear if wells in these categories are in suitable locations. Please revise Figures 3-2 through 3-4 to provide sufficient information so that an assessment of the monitoring wells and extraction wells can be made.

9. Insufficient information is provided in Addendum #2 and Appendix F (Groundwater Model Outputs) to support the groundwater model presented. A discussion regarding the development of the groundwater model including site-specific information utilized is not provided. Sensitivity analyses and groundwater model validation are not presented. Similarly, no groundwater model outputs are presented in the reports [including horizontal and vertical groundwater (aqueous-phase) concentration contour plots (i.e., for all constituents; benzene, toluene, ethylbenzene, total xylenes, and naphthalene (BTEX-N) and sulfate) for selected layers in each hydrogeologic unit and for several times during the simulation (including initial conditions); hydraulic head contour and velocity vector plots; LNAPL saturation contour plots for different layers and times; LNAPL constituent mole- or mass-fraction contour plots for different layers and times; and various time-dependent mass balance x-y graphs (total LNAPL volume/mass; various LNAPL constituent (e.g., BTEX-N) mass plots; total aqueous-phase mass for each constituent (BTEX-N and sulfate); total BTEX-N constituent mass sorbed to soil; and total mass (BTEX-N and sulfate) versus time into and out of the model for these sources and sinks: biodegradation (sink), BTEX-N dissolution from LNAPL, extraction/injection wells, inflow/outflow through model domain boundaries, and change in mass storage (aqueous- and sorbed-phases)]. Due to the groundwater model complexity, it is not possible to independently evaluate the predictive EBR simulations (e.g., 20-year benzene concentration predictions) because the input parameters, assumptions, and model outputs listed above are not presented in Addendum #2. As a result, the ability of EBR to address remaining COC mass following the SEE is uncertain. Please revise Addendum #2 to include sufficient information to support the groundwater model presented in Appendix F.

**10.** Additional monitoring wells are needed in suitable locations to monitor the effectiveness of EBR. In the CZ, shown on Figure 3-2 (EBR Injection, Extraction and Monitoring Well Locations – CZ), there are no monitoring wells between injection well ST012-CZ16 and extraction well ST012-CZ21 or between injection well ST012-SVE04 DEEP and extraction well ST012-CZ018. In Figure 3-3 [EBR Injection, Extraction and Monitoring Well Locations – UWBZ], the Upper Water Bearing Zone (UWBZ) has no monitoring wells proposed between any of the injection and extraction well pairs. The Lower Saturated Zone (LSZ) has only two injection well - extraction well "pairs" with a monitoring well between them. Please propose additional monitoring wells and revise Table 5-1 (EBR Monitoring, Sampling, and Analysis Methods and Frequencies), Figures 3-2 through 3-4 and Appendix I (QAPP/SAP Worksheets), Worksheet #17 (Sampling Design and Rationale), Table 17.1 (EBR Sampling Summary Table) to accommodate the additional wells.

**11.** The checklist sent to the Air Force by the EPA on June 21, 2017 (the Checklist) indicates that slug tests or other aquifer tests are needed to provide hydraulic parameters for future modeling. Please revise Addendum #2 to include a proposed aquifer testing method for each extraction and injection well or to provide the results of aquifer tests that have already been conducted.

**12.** Addendum #2 does not discuss the future modeling plans for the various stages of EBR remediation. Text describing EBR modeling should include calculation of time estimates for remediation, proof of the concept supporting the sulfate reduction for EBR, details used to determine the optimal sulfate injection strategy and the time estimate for sufficient COC depletion in LNAPL, groundwater, and soil. Details about future modeling should be provided to support future evaluations of the progression and effectiveness of EBR. Please revise the report to provide details about the modeling that will be done at the various stages of remediation.

**13.** The Quality Assurance Project Plan (QAPP) found in Appendix I (QAPP/SAP Worksheets) indicates that several worksheets were not included because the information is provided in the program document. However, the program document was not provided, and therefore, it is unclear if the information meets the requirements of the Uniform Federal Policy Quality Assurance Project Plan Manual, dated March 2005 (UFP QAPP Manual). Specifically, the following information is not provided:

a. The numerical measurement performance criteria have not been specified in Worksheet #12 (Measurement Performance Criteria) for samples to be analyzed by TestAmerica.
b. The laboratory-specific SOPs are not all provided. Without this information, the adequacy of the laboratory method cannot be evaluated. It is also unclear if any of the analytical SOPs will be modified for this project. Further, SOP SOC-8081 from ALS is included in Attachment B to Worksheet #30 (Analytical Services Table), but ALS is not identified as a laboratory to be used during this investigation.
c. The sampling design and rationale for the number, type, and locations of samples has not been provided. The rationale should indicate why the chosen sampling design is sufficient to meet the project goals.

d. The QAPP does not provide a table listing the field equipment required for the proposed sampling activities.
e. It is unclear if the analytical instrument calibration information is complete. For example, is a low-level calibration standard specified for Method 6010C?
f. The analytical quality control (QC) requirements and corrective actions have not been specified. For example, it is unclear if a post-digestion spike (PDS) will be performed when a matrix spike (MS) does not meet acceptance criteria.
g. It is unclear if all of the data will be validated, or if only a portion of the data will be validated. The amount of data that will be validated, as well as data validation checklists and the criteria for accepting, rejecting, or qualifying data (e.g., data validation checklist) should be provided.
h. The document management discussion should specify all of the information that will be included in the project reports. Further, the specific length of time that project documents will be held should be provided. Data reduction discussions should indicate how project personnel will ensure that all data were entered correctly into databases, calculations were completed correctly, and validation qualifiers are applied correctly so that data limitations are clear to potential data users.
i. The discussion of data usability is insufficiently detailed. For example, the QAPP does not discuss how the data quality indicators (DQIs) (e.g., precision, accuracy, representativeness, completeness, comparability, and sensitivity) will be calculated and/or assessed.

Please revise the QAPP to provide all elements required by the UFP QAPP Manual.

**14.** The QAPP indicates that it was prepared in accordance with the requirements of Version 4.2 of the Department of Defense (DoD) Quality Systems Manual (QSM), but a newer version is available (Version 5.1, dated January 2017). Please revise the QAPP to clarify why the older version of the QSM is referenced, and revise the QAPP if necessary to use the newer version.

**15.** The analytical methods are inconsistently presented throughout the QAPP. Worksheet #12 (Measurement Performance Criteria) lists the method for VOCs as Method 8260 and the method for SVOCs as Method 8270; however, Worksheets #17 (Sampling Design and Rationale) and #30 (Analytical Services Table) list Method 8260B for VOCs and Method 8270C for SVOCs. Additionally, Page 6 of Worksheet #17, Table 18.11, and Worksheet #30 list the method for TPH as 8015D, but elsewhere in the QAPP, the method for TPH is listed as 8015B. Page 6 of Worksheet #17 also lists Method E1664 for the analysis of oil and grease in process water samples, but the collection of samples for oil and grease analysis is not discussed in any other QAPP worksheet. Further, Worksheets #19 (Analytical SOP Requirements Table) and #30 list the method for metals analysis as 6010B, but elsewhere in the QAPP, the metals method is listed as 6010C. Please revise the QAPP to provide complete information for all analytical methods to be used during this investigation, and ensure that the analytical methods are consistently presented throughout the QAPP.

## SPECIFIC COMMENTS

1. **Section 2.1, LNAPL Extent Update, Page 2-2:** The text states, "SEE multi-phase extraction (MPE) wells were checked following removal of down-well eductors and associated piping. Some initial LNAPL measured in and removed from SEE MPE wells may have been present in the wells during SEE but above the liquid intake elevation of the eductors;" however, the impact of this on the SEE and LNAPL are not discussed. In addition, this appears to contradict additional text in Section 2.1 which states, "The volume initially removed from SEE wells may represent LNAPL present in the SEE wells or the well sand pack at the end of SEE rather than LNAPL that migrated to the well after SEE shutdown." The volume of LNAPL present in the sand pack should be estimated so that the volume present in the wells versus the volume present in the sand pack can be evaluated. Please revise Section 2.1 to discuss the impact of LNAPL measured in and removed from SEE MPE wells which may have been present in the wells during SEE but above the liquid intake elevation of the eductors. In addition, please revise Section 2.1 to provide estimates of the volume of LNAPL present in the sand pack so that the volume present in the wells versus the volume present in the sand pack can be evaluated.

2. **Section 2.1, LNAPL Extent Update, Page 2-2:** Section 2.1 states, "Mobile LNAPL will continue to be removed via mechanical extraction from wells including prior to EBR injections if initial EBR extractions cause an increase in LNAPL accumulation in wells;" however, it is unclear how "if initial EBR extractions cause an increase in LNAPL accumulation in wells" is related to LNAPL removal prior to EBR injections. It should be noted that this "if" statement is not included in Appendix J (Operational Decision Matrix). Please revise Section 2.1 to clarify how "if initial EBR extractions cause an increase in LNAPL accumulation in wells" is related to LNAPL removal prior to EBR injections.

3. **Table 2-2, Total Mass Removed During SEE Operations, Page 2-4 and Appendix A, 2017 Mass Update Calculations:** Table 2-2 indicates that the total mass recovered as LNAPL is based on the volume measured in LNAPL storage tanks and an assumed LNAPL density of 6.57 pounds per gallon (lbs/gallon); however, information to support this density is not provided and/or referenced. Similarly, Appendix A does not provide a density for LNAPL despite its reference throughout the appendix. Please revise Table 2-2 and Appendix A to provide the LNAPL density used and information to support this value.

4. **Section 2.2.1, SEE Mass Removal, Page 2-4:** The text states, "Mass in the vapor stream was calculated from daily thermal accelerator influent PID [photoionization detector] readings and laboratory data. A correction factor was applied to the PID readings based on the most recent analytical data at the time of each reading. The corrected PID mass loading rate for each day was summed to calculate the total mass removed through vapor and was combined with the measured mass of recovered LNAPL to provide the total mass removed." However, the correction factors applied to the PID readings are not provided and/or referenced. Further, it is unclear how well the analytical data used corresponded to the PID reading being corrected. As such, it is unclear if the SEE mass removal estimates are representative. Please revise Section 2.2.1 to provide and/or reference the correction factors applied to the PID reading. In addition, please revise Section 2.2.1 to clarify how recent the

analytical data was to the PID reading being corrected to assess if the SEE mass removal estimates are representative.

5. **Section 2.3, Pre-EBR COC Extent Estimate, Page 2-17:** The text states, "Although no direct treatment of the LPZ [Low Permeability Zone] is planned, the sulfate injection in the UWBZ [Upper Water Bearing Zone] above and the LSZ [Lower Saturated Zone] below is expected to contribute to biological treatment in this zone;" however, information to substantiate this statement is not provided and/or referenced. As a result, it is unclear if any biological treatment of the LPZ will occur. Similarly, it is unclear if LNAPL and BTEX-N will desorb from the LPZ, as this typically occurs in finer grained soils during and after subsurface injections. Please revise Section 2.3 to provide information to substantiate that sulfate injection in the UWBZ above and the LSZ below the LPZ will contribute to biological treatment in the LPZ. Alternatively, please revise Addendum #2 to propose the installation of several pairs of wells screened above and below the LPZ to substantiate and confirm that sulfate injection in the UWBZ above and the LSZ below the LPZ contribute to biological treatment in the LPZ.

6. **Section 2.5, Background Groundwater Geochemical Analyses, Page 2-18:** The text states that sampling and analysis for nitrate and sulfate in select former SEE wells and select perimeter monitoring wells has been completed and will be presented with corresponding quarterly performance reports; however, it is unclear how this information affects the EBR design presented in Addendum #2. Specifically, pre-TEA sulfate concentrations trend graphs are needed. If the sulfate concentrations are stable, then EBR is unlikely to be successful without bioaugmentation. Please revise Addendum #2 to discuss the sampling and analysis for nitrate and sulfate in select former SEE wells and select perimeter monitoring wells. In addition, please ensure that pre-TEA sulfate concentrations trend graphs are provided and/or referenced.

7. **Section 3.1, TEA Evaluation and Selection, Page 3-1:** Section 3.1 evaluates the two primary TEAs considered (oxygen and sulfate); however, Section 2.5 (Background Groundwater Geochemical Analyses) indicates that iron is a potential TEA. Please revise Section 3.1 to discuss all potential TEAs in the event the EBR approach requires adjustment as the project progresses.

8. **Section 3.1.2, Sulfate, Page 3-2:** Based on Section 3.1.2, sulfate is a TEA that is utilized under anaerobic conditions; however, information to substantiate that conditions at the site in each hydrostratigraphic zone are anaerobic is not provided and/or referenced. As a result, it is unclear if sulfate is an appropriate TEA. Please revise Section 3.1.2 to provide and/or reference information to substantiate that conditions at the site including each hydrostratigraphic zone are anaerobic.

9. **Section 3.1.2, Sulfate, Page 3-2:** The text states, "Aquifer-borne microbial consortia have shown to be adaptive to changing conditions such as the change in available TEA;" however, information to substantiate this statement is not referenced. Please revise Section 3.1.2 to include a reference to substantiate this statement.

10. **Section 3.1.3, TEA Selection, Page 3-2:** The third bullet of Section 3.1.3 states, "influent upgradient background sulfate can supplement sulfate amendments to promote petroleum hydrocarbon degradation during and after EBR without having to change the established bacterial populations or redox conditions;" however, information to substantiate this statement is not provided and/or referenced. It should be noted that Section 2.5 (Extraction Phase) of Appendix D (Enhanced Bioremediation Field Test Report) indicates that historical groundwater monitoring upgradient of site contamination has shown background sulfate concentrations generally range from 250 to 300 milligrams per liter (mg/L); however, this information is based on data obtained during a treatability study conducted prior to 1998 and SEE. As such, it is unclear if the presence of upgradient background sulfate remains. Please revise Section 3.1.3 to provide information to substantiate that influent upgradient background sulfate can supplement sulfate amendments to promote petroleum hydrocarbon degradation during and after EBR without having to change the established bacterial populations or redox conditions.

11. **Section 3.2.1, Groundwater Extraction and Treatment, Page 3-4 and Figure 3-1, EBR System Process Flow Diagram:** Section 3.2.1 indicates that water pumped by the equalization pump will pass through primary and standby bag filters to a gravity separator and that the gravity separator may be bypassed if deemed unnecessary based on composition of the influent water; however, Figure 3-1 (EBR System Process Flow Diagram) does not include an equalization pump or gravity separator. Please revise Section 3.2.1 and Figure 3-1 to resolve these discrepancies.

12. **Section 4.1.2, Installation of Extraction and Injection Wells, Page 4-2:** The text states, "Additional well locations could be added in future phases based on field observations during Phase 1 activities and results of the 2016 additional characterization conducted for FVM [field variance memorandum] #4;" however, this implies that the results of the 2016 additional characterization conducted for FVM #4 were not included in Addendum #2. Please revise Addendum #2 to address this discrepancy.

13. **Section 4.1.2, Installation of Extraction and Injection Wells, Page 4-3:** Section 4.1.2 states, "Observed evidence of COC-impacted soil resulted in additional testing or sampling in several instances;" however, details regarding this additional testing or sampling are not provided and/or referenced. Please revise Section 4.1.2 to include and/or reference details related to this additional testing or sampling.

14. **Section 4.2.6, Conceptual EBR Contingency Planning, Page 4-13:** The Limited VOC Reduction subsection does not acknowledge that SRB may not be present. Given that the EBR field test was only conducted in the LSZ, it is unknown if SRB are present in the CZ or UWBZ. Further, it is unclear if species capable of degrading naphthalene or other VOCs are present or are present in sufficient quantities to degrade naphthalene or other VOCs, as information to substantiate this information in the third bullet is not provided and/or referenced. Please revise Section 4.2.6 to provide information to substantiate that SRB is present in the CZ and UWBZ. In addition, please revise Section 4.2.6 to provide information to substantiate that species capable of degrading naphthalene or other VOCs are present or are present in sufficient quantities to degrade naphthalene or other VOCs.

15. **Section 4.2.6, Conceptual EBR Contingency Planning, Page 4-14:** The Limited VOC Reduction subsection indicates that a chemical addition (e.g., biocide) may be utilized to redevelop injection and/or extraction wells affected by biofouling; however, the text does not discuss the need to extract sufficient water after well development to remove all of the chemical addition to ensure SRB are not affected. Please revise Section 4.2.6 to discuss the need to extract sufficient water after well development to remove all of the chemical addition to ensure SRB are not affected.

16. **Section 5.1.2, Soil Characterization for LNAPL (Completed in 2016), Page 5-9:** The text states, "Results of LNAPL characterization will be used to make adjustments to screened intervals, well layout, and the TEA injection/extraction strategy;" however, it is unclear why these adjustments would not be incorporated into Addendum #2 given the soil characterization for LNAPL was completed in 2016. Please revise Section 5.1.2 to resolve this discrepancy.

17. **Section 5.3, Extraction Well Sampling, Page 5-10 and Table 5-1, EBR Monitoring, Sampling and Analysis Methods and Frequencies, Pages 5-4 to 5-5:** Based on Table 5-1 (EBR Monitoring, Sampling, and Analysis Methods and Frequencies), pH and temperature monitoring will stop following shutoff of the extraction well; however, this implies that pH and temperature will be monitored prior to shutoff of the extraction; however, these parameters are not listed as monitoring/analysis that will be conducted. In addition, Section 5.3 does not discuss pH or temperature monitoring. Please revise Section 5.3 and Table 5-1 to discuss conducting the pH and temperature monitoring proposed for the extraction wells.

18. **Table 5-1, EBR Monitoring, Sampling and Analysis Methods and Frequencies, Pages 5-1 to 5-8:** Based on Table 5-1, additional information is not provided in Appendix I (QAPP/SAP Worksheets) on LNAPL paraffin, isoparaffin, aromatic, naphthalene, and olefin (PIANO) sampling; however, it is unclear why additional information on PIANO sampling is not included in Appendix I. It should be noted that PIANO sampling is included in Tables 17.1 (EBR Sampling Summary Table) and 18.3 (Re-Baseline and Annual LNAPL Sampling) of Appendix I and therefore should be discussed in this appendix. Please revise Appendix I to include additional details regarding PIANO sampling.

19. **Table 5-1, EBR Monitoring, Sampling and Analysis Methods and Frequencies, Pages 5-4 to 5-5:** Table 5-1 indicates that monthly monitoring (i.e., sulfate field screening and sulfate) will occur at the 20 extraction wells locations listed in Table 4-1 (Proposed Injection and Extraction Wells and Screened Intervals) once extraction is turned off; however, it is unclear if the other extraction wells listed in Table 5-1 (ST012-CZ18, -CZ19, -CZ21, -UWBZ26, -UWBZ28/LSZ51, -LSZ28, and -LSZ38) will also be turned off and if the monthly monitoring occurring during extraction will continue. It should also be noted that Table 5-1 indicates that biweekly monitoring will occur during the first month and then transition to monthly thereafter. Please revise Table 5-1 to clarify if extraction at the other extraction wells listed in Table 5-1 (ST012-CZ18, -CZ19, -CZ21, -UWBZ26, -UWBZ28/LSZ51, -LSZ28, and -LSZ38) will also be turned off and if the monthly monitoring occurring during extraction will continue. In addition

20. **Section 5.3, Extraction Well Sampling, Page 5-10:** Section 5.3 indicates that extraction wells are predicted to have a short timeframe (less than two months) to TEA breakthrough and will be monitored on a weekly basis using sulfate field test kits; however, the basis for concluding that breakthrough will occur in two months is not provided. For example, there is no site-specific hydraulic parameter data for the CZ wells to substantiate that TEA breakthrough will occur in a short timeframe. Please revise Addendum #2 to discuss the distance between the wells in each pair, the hydraulic parameters used to calculate the breakthrough time, supporting calculations, supporting groundwater results, etc.

21. **Section 5.4, Groundwater Monitoring Well Sampling, Page 5-12:** The text states that, "The Bio-traps should not be deployed until sulfate concentrations reach the test well locations at concentrations significant enough to support zero-order sulfate reduction;" however, the concentration required to reach zero-order sulfate reduction is not specified. Please revise Section 5.4 to provide the concentration required to reach zero-order sulfate reduction.

22. **Figure 3-4, EBR Injection, Extraction and Monitoring Well Locations – LSZ:** Based on Figure 3-4, only fifteen injection wells and ten extraction wells are proposed for the LSZ; however, it does not appear that the injection well locations account for the groundwater flow direction. In addition, it appears that there are no suitably located extraction wells to facilitate sulfate distribution. For example, the purpose of extraction well ST012-LSZ2 is unclear as there are no nearby injection wells upgradient. The four injection wells in this area appear to be located crossgradient and are located 150 to 265 feet from this extraction well. Please revise Figure 3-4 to account for the groundwater flow direction. In addition, please clarify how the extraction wells are suitably located to facilitate sulfate distribution.

23. **Figure 7-1, Proposed Project Schedule:** Figure 7-1 lacks sufficient detail. For example, injection well and injection solution sampling, extraction well sampling, groundwater monitoring well sampling, process water sampling, and EBR reporting are not included on the figure. Please revise Figure 7-1 to include all critical path items.

24. **Appendix A, 2017 Mass Update Calculations:** Appendix A indicates that the vertical distribution of LNAPL in individual borings for pre-design investigation locations and historical borings (where available) were based on scoring interpretations (e.g., If there was a positive dye test within the interval, the interval was automatically scored "Likely Residual LNAPL;" however, the interpretations made for the vertical intervals are not provided and/or referenced. Please revise Appendix A to include these interpretations so that they can be reviewed and assessed.

25. **Appendix D, Enhanced Bioremediation Field Test Report, Table 2-1, Analytical Data for ST012-W11, Page 2-3 and Appendix D, Enhanced Bioremediation Field Test Report, Table 2-2, Analytical Data for ST012-W30, Page 2-4:** Tables 2-1 and 2-2 of Appendix D do not define the "U" data qualifier. Please revise Tables 2-1 and 2-2 of Appendix D to define all data qualifiers.

26. **Appendix D, Enhanced Bioremediation Field Test Report, Section 2.4, Shut-In Period, Page 2-6:** Section 2.4 indicates that following the push phase of the EBR field test, samples were collected twice per week from each monitoring well; however, Tables 2-3 (Microbial Data for ST012-W11) and 2-4 (Microbial Data for ST012-W30) only include one post-shut-in sampling data point (i.e., 9/2/2014). Please revise Appendix D to address this discrepancy.

27. **Appendix D, Enhanced Bioremediation Field Test Report, Section 2.4, Shut-In Period, Pages 2-6 to 2-7:** The text indicates that due to the unreliability of the bromide meter readings, bi-weekly sample results were compiled and trend graphs were created and updated as soon as data became available so that decisions could be made on when to conduct the pull phase. However, the bi-weekly sample results and associated trend graphs are not provided and/or referenced. In addition, the text does not discuss how this field variance impacted the shut-in period. Please revise Appendix D to provide and/or provide/reference the bi-weekly sample results and trend graphs used to make decisions on when to conduct the pull phase. In addition, please clarify how the field variance impacted the shut-in periods.

28. **Appendix D, Enhanced Bioremediation Field Test Report, Section 2.4, Shut-In Period, Page 2-7:** The text indicates that the duration of the shut-in period was dependent on how long it would take for the bromide to reach ambient conditions; however, it is unclear what concentration was considered ambient. If background was considered to be ambient conditions, then the initiation of the post-shut-in period at ST012-W30 was premature, based on bromide concentrations in Table 2-6 (Bromide and Sulfate Concentrations during Shut-In Period). Please revise Section 2.4 of Appendix D to clarify the bromide concentration that was considered ambient. If background was considered ambient, please clarify why the post-shut-in period at ST012-W30 occurred prior to bromide concentrations reaching ambient conditions.

29. **Appendix D, Enhanced Bioremediation Field Test Report, Section 2.4, Shut-In Period, Page 2-7:** Section 2.4 of Appendix D indicates that initial results for the pull-phase of ST012-W11 were used to calculate the total amount of sulfate that was extracted from the groundwater; however, these calculations are not provided and/or referenced. This is of particular concern given that the results indicated that more sulfate was extracted from the groundwater than was introduced during the push-phase of the field test – information which has been incorporated into the full-scale implementation. Please revise Appendix D to include the initial results for the pull-phase of ST012-W11, which were used to calculate the total amount of sulfate that was extracted from the groundwater.

30. **Appendix D, Enhanced Bioremediation Field Test Report, Appendix E, Microbial Kinetics Estimation:** Appendix E of Appendix D assumes that the stoichiometric relationship between sulfate and TPH is 5.25 sulfate to 1 TPH; however, information to support this relationship is not provided and/or referenced. Please revise Appendix E of Appendix D to provide information to substantiate that the stoichiometric relationship between sulfate and TPH is 5.25 sulfate to 1 TPH.

31. **Appendix I, QAPP/SAP Worksheet, UFP-QAPP Crosswalk, Pages i and iv:** The Crosswalk indicates that Worksheet #9 (Project Scoping Session Participants Sheet) is not

included in the QAPP; however, Worksheet #9 is included. Additionally, the reasoning for why Worksheet #29 is not included in the QAPP has not been provided. Please revise the Crosswalk to accurately reflect the worksheets not included in the QAPP and to provide the reason for not including any worksheets.

32. **Appendix I, QAPP/SAP Worksheet, Worksheet #5, Project Organizational Chart, Page 2:** The organization chart does not show the independence of the quality assurance (QA) function (as indicated by the line of authority). Please revise the organization chart to show that the QA role is independent of all other project tasks.

33. **Appendix I, QAPP/SAP Worksheet, Worksheet #6, Communication Pathways, Pages 1 to 3:** This worksheet does not include EPA in any communication pathway. Additionally, the communication procedures do not specify the form of communication for the notifications, nor does it always specify the timeframe for notifications. Please revise this worksheet to specify that the EPA will be notified when significant corrective actions or changes to the QAPP occur in the field. Please also revise this worksheet to include the form of communication and timeframe for notification for all communication drivers.

34. **Appendix I, QAPP/SAP Worksheet, Worksheet #11, Project Quality Objectives/Systematic Planning Process Statements, Page 2:** Step 3 (Decision Inputs) includes a list of worksheets where specific information can be found. However, several of the worksheets listed are not provided in the QAPP (Worksheets #14, #27, #34-37). Additionally, Step 3 indicates that QA management support is described in Worksheet #38, but Worksheet #38 is not included in the QAPP or identified in the QAPP Crosswalk, nor is it part of the UFP QAPP Manual. Please revise this worksheet to specify where project-specific and data management, validation criteria, and QA management support requirements can be found.

35. **Appendix I, QAPP/SAP Worksheet, Worksheet #11, Project Quality Objectives/Systematic Planning Process Statements, Pages 1 to 3**: The information in this worksheet is insufficiently detailed. For example, the analytic approach should provide decision statements (i.e., "if…, then,,," statements) for how the project data will be used. As a second example, the screening levels that will be used for making each project decision have not been defined. As a third example, Step 6 should examine consequences of making incorrect decisions from the test, and place acceptable limits on the likelihood of making decision errors. Please revise Worksheet #11 to provide additional detail following EPA's Guidance on Systematic Planning Using the Data Quality Objectives Process (QA/G-4).

36. **Appendix I, QAPP/SAP Worksheet, Worksheet #15, Reference Limits and Evaluation, Pages 1 to 7**: This worksheet provides target reporting limits (RLs) and approximate method detection limits (MDLs); however, the laboratory specific RLs and MDLs should be provided in the QAPP to ensure project action levels (PALs) can be met. Additionally, the PAL for several analytes is listed as "NA," and therefore, it is unclear how these results will be evaluated. Please revise the QAPP to provide the laboratory specific RLs and MDLs, and to discuss how results with no PAL will be evaluated.

37. **Appendix I, QAPP/SAP Worksheet, Worksheet #17, Sampling Design and Rationale, Table 17.1, ERB Sampling Summary Table:** As requested in the checklist, analyses to evaluate the benzene content in LNAPL should be included in Table 17.1. Please revise Table 17.1 to include benzene analysis of LNAPL.

38. **Appendix I, QAPP/SAP Worksheet, Worksheet #17, Sampling Design and Rationale, Table 17.1, ERB Sampling Summary Table:** Table 17.1 only proposes the PIANO suite for LNAPL, but this is insufficient to evaluate the content of COCs in the LNAPL at the start of ERB. Please revise Table 17.1 to include full VOC and SVOC analytical suites for liquid LNAPL as requested in the checklist.

39. **Appendix I, QAPP/SAP Worksheet, Worksheet #17, Sampling Design and Rationale, Table 17.1, ERB Sampling Summary Table:** As requested in the checklist, additional analytes should be proposed; including phosphorus, ferrous iron, total iron, hydrogen sulfide, methane, alkalinity, and arsenic. While the Annual Groundwater monitoring section of Worksheet #17 references the Groundwater Monitoring Work Plan (AMEC 2013b), text should be included that commits to collecting field data for temperature, pH, oxygen-reduction potential, and dissolved oxygen. Please revise Table 17.1 to include additional these analytes and revise Worksheet #17 to include a discussion to committing to the collection field data.

40. **Appendix I, QAPP/SAP Worksheet, Worksheet #18, Sampling Locations and Methods/SOP Requirements Table, Pages 1 to 32**: The tables in this worksheet identify the sampling locations where field duplicate samples should be collected, but it is unclear when MS and matrix spike duplicate (MSD) samples should be collected. Please revise the QAPP to include this information.

41. **Appendix I, QAPP/SAP Worksheet, Worksheet #19, Analytical SOP Requirement Table, Page 1:** This worksheet does not indicate the type of container to be used for the collection of each analytical parameter or the minimum sample volume required. Please revise the QAPP to include this information.