CONVERTER/COMPRESSOR BUILDING, SWMU 089
MONITORING WELL 21 AREA
INTERIM MEASURE WORK PLAN
KENNEDY SPACE CENTER, FLORIDA

Prepared for:

National Aeronautics and Space Administration
Kennedy Space Center, Florida

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Revision 1

Prepared by:

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NASA/John F. Kennedy Space Center
Attn: SI-E2/Mr. Chris Adkison
Logistics Facility Building K6-1547, Room 2820B
Kennedy Space Center, FL 32899

Subject: Interim Measure Work Plan (Revision 1)
Monitoring Well 21 Area
Converter/Compressor Building (SWMU 089)
Kennedy Space Center, Florida

Dear Mr. Adkison:

On behalf of the National Aeronautics and Space Administration (NASA), Tetra Tech, Inc. (Tetra Tech) has prepared this Interim Measure Work Plan (IMWP) to detail the interim measure (IM) design for the Monitoring Well 21 (MW21) Area within the Converter/Compressor Building (CCB) site, where residual high concentrations of volatile organic compounds (VOCs) were identified in 2020-2021. CCB has been designated Solid Waste Management Unit (SWMU) 089 under Kennedy Space Center's (KSC) Resource Conservation and Recovery Act (RCRA) Corrective Action Program. This IMWP was prepared by Tetra Tech, Inc., under Indefinite Delivery Indefinite Quantity Contract 80KSC019D0011.

1.0 INTRODUCTION

This document details the approach and design for the IM to remediate groundwater within the MW21 Area where VOC concentrations exceed Florida Department of Environmental Protection (FDEP) Natural Attenuation Default Concentrations (NADCs). The IM includes in-situ bioremediation via injection of emulsified vegetable oil (EVO) and emulsified zero-valent iron (EZVI). This IMWP builds on the design from the Remedial Alternatives Evaluation (RAE) presented in September 2022 to the KSC Remediation Team (KSCRT) taking into consideration any site-specific or contractor-specific considerations.

This IMWP is divided into the following sections, tables, and attachments:

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2.0 SITE BACKGROUND

CCB is part of the Fluid Servicing Road Area (FSRA) grouping of remediation sites, which also includes the Area South of K7-516 (516S), Components Cleaning Facility (CCF), and Propellants Support Building Area (PSBA). CCB encompasses approximately 15 acres bordered by wooded areas to the north and east, open land including the Crawlerway to the south, and CCF to the west. CCB includes one main building (K7-468) east of Fluid Servicing Road and south of the railroad tracks. Several secondary support buildings are located within the area including Buildings K7-367, K7-415, K7-416, and K7-417 located north of the railroad tracks that support the Propellants North Facility. A site map of CCB and the surround area is provided as Figure 1.

Building K7-468 was constructed between 1963 and 1965, and the Petroleum, Oil, and Lubricant (POL) Flammables Storehouse (K7-417) was constructed in 1967. CCB is still operational and converts liquid helium received in tankers to a low-pressure helium gas that is pumped to high-pressure compressors and stored in pipelines and customer storage batteries. The site also controls and maintains high-pressure gaseous nitrogen that is supplied through an underground pipeline to various customers at KSC and Cape Canaveral Space Force Station. During the 1980s, the on-site storage tank previously used to supply nitrogen was removed and replaced

with a pipeline connecting to an off-site facility. In 1993, the Ammonia Boiler Refurbishment/Test Building (K7-367) was constructed, and in 2005, the Cylinder Test and Fill Facility (K7-415) and retention pond were constructed. No record of spills was identified for the CCB area. Most recently in 2021, the two liquid helium storage containers were relocated from the west side of K7-468 to the northern portion of the site on top of the railroad tracks.

2.1 SITE CHARACTERISTICS

MW21 is located between the northwest corner of Building K7-468 and the railroad tracks as shown on Figure 1. It is currently sampled annually as part of the performance monitoring program associated with the previous air sparging (AS) IM at the site. The Hot Spot (HS) plume (concentrations exceeding 10x NADCs) surrounding MW21 extends from the railroad tracks to approximately 60 feet (ft) southwest toward Fluid Servicing Road. The plume footprint overlays an area that contains aboveground infrastructure associated with operations at CCB. Site obstructions include liquid helium storage containers, piping, building infrastructure, and the railroad tracks. The liquid helium storage tanks were recently relocated from the west side of K7-468 to the top of the railroad tracks where a minimal portion of the plume extends. The Conex boxes that were on the western side of the plume were relocated offsite, which allows access to that area; however, due to ongoing construction at the site, this portion may be occupied in the future.

CCB also contains underground utilities and high-pressure lines. Other pertinent infrastructure includes equipment for the AS system from the former Hot Spot 1 through 5 IM. The former AS equipment is located north of the railroad tracks near K7-367. The sub-slab depressurization system (SSDS) remains onsite and available. The electrical power is available including the transformer and breaker panel. As a conservative measure, the SSDS is recommended to be operated for two years as part of the injection IM to extract any subsurface vapors that may be generated during the biodegradation process.

MW21 has a 10 ft screen with an interval from 10 to 20 ft below land surface (bls). The geology for the MW21 area was investigated in June 2020 by collecting a soil core at DPT419 located within the treatment area. The subsurface lithology characterized in descending order from bls consists of the following:

- 1.5 to 5 ft bls: Fine to very fine sand; little to some silt; little organics
- 5 to 7.25 ft bls: Very fine sand; little to some silt and organics
- 7.25 to 8.5 ft bls: Fine to very fine sand; little silt
- 8.5 to 9 ft bls: Very fine sand, silt, and organics; dense/firm; moderately cemented
- 9 to 10 ft bls: Very fine sand and silt; little organics; no cementation

- 10 to 20 ft bls: Very fine sand and silt; little to some organics

The groundwater flow direction in the MW21 Area is generally to the north/northeast. The depth to groundwater is approximately 5 ft bls. The geochemical data recorded at MW21 from January to July 2020 was evaluated. pH ranged from 3.80 to 4.23 standard units (SU) with an average of 4.05 SU. Conductivity ranged from 308 to 853 microsiemens per centimeter (µS/cm) with an average of 588 µS/cm. Dissolved oxygen (DO) concentrations ranged from 0.27 to 1.83 milligrams per liter (mg/L) with an average of 1.04 mg/L. Oxidation-reduction potential (ORP) ranged from 73 to 256 millivolts (mV) with an average of 155 mV. When evaluating the geochemical data between 2017 and 2019, the data is comparable. The pH ranged from 3.52 to 3.85 SU with average of 3.76 SU. Conductivity ranged from 617 to 1,069 µS/cm with an average 823 µS/cm. DO ranged from 0.21 to 0.75 mg/L with an average 0.40 mg/L. ORP ranged from 36.9 to 188 mV with an average 129 mV.

2.2 SITE HISTORY

An AS IM operated from April 2014 (expanded in May 2016) until December 2020 to treat five HSs that were delineated during previous site characterization efforts. The footprint of the AS IM is shown on Figure 1. The objective of the AS IM was to reduce concentrations of VOCs in groundwater at HSs 1 through 5 to levels that support transition to a long-term monitoring (LTM) phase. In February 2019, a decision was made during the KSCRT meeting to discontinue active AS treatment at CCB because the IM objective of reducing VOC concentrations below their respective NADCs was met. The Team agreed that NASA would continue operating the AS system until the system trailers could be moved and utilized at another site. The system operated until it was permanently shut down on December 1, 2020.

In June 2020, a groundwater investigation was conducted using direct push technology (DPT) in the area around MW21. The investigation was prompted by a NADC exceedance of 400 micrograms per liter (µg/L) trichloroethene (TCE) during the December 2019 annual event. The AS treatment zone around this well, which was shut off in 2016, was turned back on in February 2020. In June 2020, 97 discrete depth groundwater samples were collected from 13 DPT boring locations around MW21. All locations were sampled from 12 to 16 ft bls in discrete 1-ft intervals except DPT416, which was sampled from 6 to 30 ft bls. Discrete samples were also collected at 20 ft bls at all locations, and a vertical profile boring at DPT419 was collected for lithology purposes. Results of the DPT investigation confirmed that VOCs were present in the area around MW21 at concentrations greater than the Groundwater Cleanup Target Levels (GCTLs) and/or NADCs. The maximum TCE result of 5,900 µg/L was collected from DPT419 at 14 ft bls. Further investigation to the southwest of MW21 was delayed due to site obstructions preventing access. The obstructions were later removed, and the investigation continued in March 2021. The sampling consisted of 95 discrete depth groundwater samples at 10 boring locations. All

locations had discrete 1-ft intervals collected at sample depths varying based on delineation. Discrete samples were also collected at 20 ft bls. Results of this investigation showed additional significant contamination in the southwest area. DPT430 is the location with the highest contamination with a maximum TCE concentration at 85,100 µg/L at 10 ft bls. The delineated MW21 area CVOC plume is shown on Figure 2.

A Site Characterization were prepared for the MW21 Area and presented during the September 2022 KSCRT meeting. Based on results of the Site Characterization, consensus was reached that the CCB MW21 Area is adequately characterized for IM implementation (2209-M02, 2209-D02) and to proceed with the RAE (2209-M02, 2209-D03). It was also decided that the IM objective is to reduce contaminants of concern (COC) concentrations to less than NADCs in the MW21 Area via an IM to support transition to LTM (2209-M02, 2209-D04).

3.0 INTERIM MEASURE OBJECTIVE

The overall Corrective Action Objective (CAO) for the site is to reduce concentrations of TCE cis-1,2-dichloroethene (cDCE), trans-1,2-dichloroethene (tDCE), and vinyl chloride (VC) to less than State of Florida GCTLs. The IM objective for the CCB MW21 Area IM is to reduce groundwater concentrations for the COCs to less than NADCs within the MW21 Area to support transition to LTM with the rest of the site.

4.0 INTERIM MEASURE DESIGN

The treatment footprint for the IM is defined where TCE concentrations are greater than the NADC (300 µg/L), which encompasses approximately 839 square feet with depths between 8 and 16 ft bls. The design for this IM was based on the technology selected during the RAE conducted for the MW21 Area and presented during the September 2022 KSCRT meeting

Based on results of the RAE, consensus was reached for in-situ bioremediation with zero valent iron (ZVI) in the source zone (SZ; concentration greater than 100-times NADC) area as the selected alternative, with EVO/EZVI injection conducted in the MW21 Area to treat the high-concentration plume (HCP; concentration greater than NADC), HS, and SZ (2209-M02, 2209-D05). The Team also reached consensus to prepare an Advance Data Package (ADP) and Implementation Work Plan for the IM and present to the KSCRT with both documents being submitted to FDEP (2209-M02, 2209-D06). This IMWP was prepared prior to the Implementation Work Plan (IWP) to document the recommended design; the IWP will be the next step in the documentation process to further detail plans for IM implementation (see Section 8). Meeting Minutes associated with the Site Characterization and RAE are provided in Attachment A.

The accompanying ADP for this IMWP is provided in Attachment B. The following subsections describe the IM design as the next step for remediation in the MW21 Area.

4.1 TECHNOLOGY DESCRIPTION

The two technologies that will be implemented as part of the IM are bioremediation using EVO and abiotic reductive dechlorination using EZVI. The EVO will target areas of chlorinated VOC (CVOC) concentrations within the HCP and HS while EZVI will target the SZ where TCE concentrations are indicative of dense non-aqueous phase liquid (DNAPL) (concentrations greater than 11,000 µg/L).

The in-situ bioremediation technology consists of injecting electron donor substrate into the subsurface to promote microbial breakdown of CVOCs. The breakdown occurs primarily by reductive dechlorination, a reaction where the chlorine atom is replaced by a hydrogen atom in a chlorinated organic compound which acts as the electron acceptor. This process can occur naturally with the presence of reductive dechlorinators, which are microorganisms that are capable of reductive dechlorination. Only dissolved contaminants can be degraded through reductive dechlorination; although, DNAPL mass and sorbed contaminants can still be reduced by continued dissolution during treatment. The EVO injections for this IM are designed based on the use of Provectus ERD-CH4, which is a vegetable oil (VO)/carbon substrate mixture containing 60-percent fermentable carbon that contains slow, moderate, and fast releasing substrates like glycerin, soluble lactic acid, ethyl lactate, and dissolved fatty acids and an antimethanogenic reagent.

EZVI will be used to aggressively target the SZ and potential DNAPL in the subsurface. EZVI is made of food-grade surfactant, biodegradable VO, water, and ZVI particles. The emulsified portion contains the ZVI in water surrounded by an oil/liquid membrane which is miscible with DNAPL. ZVI promotes abiotic degradation of CVOCs, and the VO and surfactant act as electron donors to promote anaerobic biodegradation processes. The EZVI injections for this IM are designed based on the use of Provectus EZVI-CH4, which is an EZVI formulation containing 10-percent zero-valent iron, an antimethanogenic reagent, water, and VO.

ERD-CH4 and EZVI-CH4 are accepted for remediation via in-situ injections in Florida. Acceptance letters for both remediation products are provided in Attachment C.

4.2 TREATMENT LAYOUT AND CONFIGURATION

The IM treatment layout consists of nine injection locations of EVO at approximately 10-foot radius of influence (ROI) and three injections locations of EZVI at approximately 6-foot ROI, based on vendor recommendation and similar projects completed at KSC. The design incorporates overlap to provide treatment coverage in the highest contaminated areas. The injection method will be direct push using a DPT rig. The overall injection depths range from 7 to 17 ft bls. The EVO treatment range is from 7 ft to bottom depths from 12 to 17 ft bls, while the EZVI treatment ranges from 7 to 13 ft bls. The 7 ft bls top depth is designed to be 2 ft below the water table to prevent substrates from reaching the top of the water table. Injections are

planned to be implemented using 2 ft intervals (also known as lifts). Injections will take place using a bottom-up approach to 2 ft below the water table.

Injection locations, which are shown on Figure 3, are approximate and expected to be adjusted based on site conditions and infrastructure at the time of implementation. Due to ongoing construction at the site, coordination will occur with the facility manager to ensure the IM is implemented at the most optimal time and injection locations are as close as possible to the design. The injection details including the injection ranges, intervals, and volumes are provided in Table 1 and further discussed below.

EVO Injection Details

The EVO injection consists of nine injection locations to cover the HCP, HS, and SZ areas. Of note, an injection location was placed on the north side of the liquid helium storage containers to maximize treatment for the HCP area underneath the containers. Provectus ERD-CH4 is the proposed remediation product to be used for EVO injections. Based on vendor recommendations, the target pore space for EVO is 0.8%. Attachment D provides the design calculations for the volume of substrate and water needed for each 2 ft lift. Table 1 also provides the volume of substrate, water, and microbial consortium needed per lift, per location, and total volume for the IM. The EVO injections will occur in 2 ft injection lifts with each interval receiving 18 gallons of substrate. The total volume of water per lift is approximately 123 gallons. Additionally, 0.26 gallons of a microbial consortium will be injected at each lift. The amount of injectate (141 gallons per lift) was determined by using a rule-of-thumb of 10% total injectate pore volume. The total volume of injectate for the IM is approximately 5,368 gallons. The injectate volume is based on achieving the prescribed injection ROI while reducing the amount of contamination displaced by the injection material. The ratio of substrate-to-water is recommended by vendor to provide adequate viscosity to deliver the material into the ground while increasing substrate contact with the aquifer.

To maximize treatment effectiveness, amendments will be added to the formulation, which include pH adjustment (by adding buffering agents) and bioaugmentation (by adding microbial consortium). The adjustment of pH will be made to temporarily increase the pH within the treatment area to suitable levels to promote reductive dechlorination (ideal pH is between 6 and 7). The pH amendment dosing will be 500 mg of base chemical (sodium bicarbonate) per liter of pore volume. The dosing of pH amendment is based on experience from similar projects with comparable lithology and vendor recommendation. Approximately 225 pounds of sodium bicarbonate (baking soda) will be needed for pH adjustment for the IM. Calculations are provided in Attachment D.

The bioaugmentation product is planned to be a formulation containing a microbial consortium including *Dehalococcoides* (Dhc) to promote biotic reductive dechlorination of the CVOCs. A total volume of 37 liters (L) of KB-1® Plus is estimated to be evenly distributed across the IM

area. Sampling for Dhc communities will be conducted prior to mobilization for the implementation of the IM. Based on the results, the amount or distribution of consortium injected may be adjusted to maximize treatment effectiveness. Further sampling is planned during performance monitoring to check the Dhc levels for the appropriate levels which are generally targeted at a concentration of 1.0×10^4 cells/mL. Additionally, KB-1® Primer (sodium sulfite) will be added to the injectate solution (primarily the water) to provide anaerobic conditions for the microbial consortium and maximize the effectiveness of the bioaugmentation efforts. KB-1® Primer is distributed in 800-gram pouches. Each pouch is estimated to treat up to 250 gallons of water per vendor recommendation.

On-site mixing will be required for the required for the EVO injections. The injectate will be mixing in approximately 500-gallon batches. Based on a total injectate volume of 5,368 gallons, 11 batches will be needed. The composition of each batch is provided in the table below:

Component	Total Volume/Weight	Volume/Weight per Batch
ERD-CH4	684 gallons	62 gallons
Water	4,674 gallons	425 gallons
KB-1® Plus	37 liters	3.36 liters
KB-1® Primer	15,200 grams (19 pouches)	1,382 grams
Sodium Bicarbonate	225 pounds	20.5 pounds

Acceptance letters for the use of ERD-CH4, KB-1® Plus, and KB-1® Primer are provided in Attachment C.

EZVI Injection Details

The EZVI injections consist of three injection locations to cover the SZ area. The three locations surround DPT430, the location with the highest reported TCE concentration from the DPT events in 2020-2021. The highest TCE concentration at DPT430 was 85,100 µg/L at 10 ft bls. Provectus EZVI-CH4 is the proposed remediation product to be used for EZVI injections. Based on vendor recommendations, the target pore space for EZVI is 8%. Attachment D provides the design calculations for the volume of substrate needed for each lift. No water is planned to be added to the formulation unless needed. Table 1 provides the volume of substrate needed per lift and for each location. The EZVI injections will occur in 2 ft injection lifts with each interval receiving 41 gallons. The volume of injectate per location is 123 gallons, and the total EZVI injectate volume for the IM is 369 gallons.

The acceptance letter for the use of EZVI-CH4 is provided in Attachment C.

4.3 IM METHOD

A DPT rig will be used to deliver the injectate to the prescribed intervals and locations. Coring through existing surface cover will be required to access earthen ground for injectate delivery. The injections will be completed using 1.5-inch diameter rods with the DPT rig. Due to physical restrictions at the site, a small dolly DPT rig will be required for injection locations VO-1, VO-2, VO-3, EZVI-1, EZVI-2, and EZVI-3. The VO/carbon substrate and EZVI products will be delivered in totes since the treatment area is small enough that a larger storage tank is not needed. The totes will be stored at CCF East where there is available storage space and security fence. The VO/carbon substrate mixing will be completed in 500-gallon batches and delivered to the injection site or mixed adjacent to the injection trailer. The injection trailer will consist of a trailer-mounted pneumatic pump connecting the injectate in the tote to the DPT rig via flexible hose. The injection tool is driven to depth and then pulled back to open and expose the side discharge nozzle. The air-operated diaphragm pump on the injection trailer is used to pump liquid through the Geoprobe rods. The injection is completed by pulling upward by about 2 feet and injecting the pre-determined volume of amendment mixture.

After all the injection intervals are completed, the injection line is cleared by injecting potable water. Once the injection is completed at a location, the boring will be pressure grouted with bentonite, and ground surface will be repaired to match existing surface. Prior to the injections, MW21 will be temporarily plugged to prevent daylighting during the injections. No other monitoring wells are located within the anticipated ROI. During injections, daylighting will be monitored in the surrounding area. In addition to other ground surface outlets, manholes of storm sewers that could potentially be affected by injected material will be monitored for potential daylighting. If daylighting occurs, the injection pressure will be reduced until the daylighting stops.

4.4 SITE LAYOUT

The equipment and materials necessary for the IM include a DPT rig, injection trailer, skid steer, totes, decon pad, pumps, and appurtenances to deliver injection material. CCF will be used as long-term storage of these materials and equipment supporting the IM including the EZVI and VO/carbon substrate totes. An injection trailer and skid steer will be used to deliver material from CCF to the injection site. The injection trailer will be temporarily located in the western area adjacent to the injection area. The IM will be planned when this area is empty to optimize the site layout and ease of implementing the IM. The hose from the injection trailer will run to the DPT rig within the treatment area. The additional water for VO/carbon substrate mixing will be sourced from the hydrant located outside of the fenced entrance of CCF across and southwest from the driveway of CCB.

The investigative derived waste (IDW) anticipated to be generated during the IM will primarily be decontamination (decon) water. The IDW generated will be stored in aqueous 55-gallon

drums or other suitable large volume storage containers as volumes dictate. Containers will not be overfilled and will be staged at the normal designated area at CCF or as directed by the NASA Remediation Project Manager (RPM). The 55-gallon drums will be placed on secondary containment spill pallets. Further information for IDW storage and handling will be detailed during the implementation phase.

The injection points are located within an area of CCB with dense infrastructure. Belowground and aboveground utilities and infrastructure are a logistical concern for access issues. In addition, ongoing construction at the site will require coordination with the facility manager. Close coordination with the facility manager will be made to determine the optimal time for implementation.

4.5 SSDS OPERATION

As mentioned in Section 2.1, the existing SSDS will be operated for two years as a conservative measure to extract any subsurface vapors that may be generated during the biodegradation process. All equipment and electrical connections are still in place from when the SSDS operated during the previous AS IM. Because the system has been off since December 2020, some initial repairs have been incorporated into startup costs (see Attachment E). Routine operation and maintenance of the system will occur following startup. Operation and maintenance of the system will follow Section 8 (SSDS System Start-up, Prove-out, and O&M) of the "CCB Hot Spot Areas 1, 2, and 5 Implementation Work Plan" dated March 2013. Additional details will be provided in the forthcoming IWP prepared for this IM.

5.0 PERMITTING AND COORDINATION

IM activities are being conducted under NASA's RCRA permit for KSC; all relevant requirements will be observed. Prior to injections, pre-IM activities will be conducted to prepare for the injection IM. These activities include submittal of applications for access and badging, submittal of required permits and health and safety plan, coordination of site activities, and scheduling of utility locates and clearances. These activities will be further detailed during the implementation phase.

Applicable permits and associated authorization requirements consist of the KSC utility locate/excavation permit, KSC Environmental Checklist, and FDEP underground injection control (UIC) permitting. The following summarizes each required permit and authorizations that may be required as part of site activities:

- KSC Environmental Checklist – The KSC Environmental Checklist will be submitted to the NASA RPM prior to initiating the work. The KSC Record of Environmental Consideration (REC), based on the KSC Environmental Checklist, will be used to determine permitting requirements.

- Utility Locate/Excavation Permit – A KSC utility locate/excavation permit will be submitted for injection activities. The utility inspectors will be contacted in advance of anticipated injection activities to schedule utility clearances.
- UIC Permit – The UIC permit falls under FDEP and Florida Administrative Code (F.A.C.) and deals with the injection of fluids into the subsurface while protecting Florida's underground sources of drinking water. In accordance with 62-528.630(2)(c), F.A.C., Class V injection-type aquifer remediation wells are exempt from the permitting requirements of Rule 62-528.635, F.A.C., when authorized by an FDEP-approved Remedial Action Plan or other enforceable mechanism. Therefore, approval of this IMWP by FDEP will constitute the granting of a Class V injection well construction permit. If needed and determined at the time of approval, the FDEP UIC inventory notification form will be completed. The proposed sampling for UIC is further detailed in the performance monitoring section.

Permits not required at the time of this IMWP preparation include a site plan, well construction and abandonment permit, air permit, and stormwater permit. A site plan is not included because no permanent modifications to the site are proposed including no installation of monitoring wells. The air permit is managed under the KSC Title V FDEP Air Permit; however, injections are not expected to generate significant emissions. Furthermore, the total estimated mass of CVOCs is 3.9 pounds in the HCP/HS/SZ area, which is under the 1,000 pound per year threshold for individual hazardous air pollutant (HAP) and 2,500 pound per year total HAP. Lastly, a stormwater permit is not needed due to less than 1 acre anticipated to be disturbed. Most activities will occur on pavement minimizing the disturbance of vegetation.

6.0 SCHEDULE

Activities for injection fieldwork include site setup and delivery of injection materials, injection activities (injecting substrate into the subsurface), and demobilization. The estimated duration for injection fieldwork is one to two weeks, as detailed below:

- Site setup and material delivery = 1 to 2 days
- Injection activities = 3 to 5 days
- Demobilization = 1 to 2 days

Advance coordination with facility personnel, including personnel at K7-468, will be made to inform of the IM activities and determine an optimal time to implement fieldwork. Logistics will be a concern given the ongoing construction and modification to site infrastructure.

7.0 BASELINE AND PERFORMANCE MONITORING

Baseline and performance monitoring sampling events will be conducted for groundwater and air. The performance sampling plans for groundwater and air are provided in Tables 2 and 3, respectively. The groundwater and air sampling locations are shown on Figures 4 and 5, respectively.

Groundwater

The groundwater baseline event will be conducted to confirm contaminant concentrations and provide a basis for performance monitoring. The baseline event will consist of sampling four DPT locations (DPT-A through -D) and five monitoring well (MW15, MW16, MW21, MW118, and MW120). MW21 (screened 10 to 20 ft bls) will be sampled for VOCs, UIC parameters, Dhc, dissolved gases (methane, ethane, and ethene), and total organic carbon (TOC). Dissolved gases analysis will be used to determine if reducing conditions are present and complete dechlorination is occurring. TOC analysis will be used to determine if/how much of the injected substrate is available. MW15, MW16, MW118, and MW120 (all screened from 10-20 ft bls) will only be sampled for UIC parameters since they are located outside of the injection area. The four DPT locations will be sampled at four sample depths at each location for VOCs. The sample depths for each DPT are at midpoints 8, 12, 16, and 20 ft bls with the assumption that samples will be collected using a 4 ft direct point stainless-steel sampler. In addition, DPT-B will also be sampled at 24 ft bls to address a comment from the RAE to define the vertical extent of the plume at this location. The 8 ft bls sample depth was included to determine the shallow extent of the plume, particularly at DPT-C/DPT419, where the shallowest sample collected was 12 ft bls. Along with the MW21, DPT-A at 8 ft bls, DPT-B at 10 ft bls, DPT-C at 12 ft bls, and DPT-D at 14 ft bls will also be analyzed for Dhc, dissolved gases, and TOC. These selected intervals are targeted to sample the depths with the highest COC concentrations.

Performance monitoring samples collected will be analyzed by a fixed laboratory for VOCs using Method 8260D, dissolved gases using method RSK-175, and TOC using Method 9060a. Samples collected for UIC parameters will be analyzed for pH via field instrumentation, total recoverable petroleum hydrocarbons (TRPH) by Method FL PRO, iron, manganese, and sodium by Method 6010 or 6020, chloride by EPA Method 300, 1,4-dioxane and ethylene oxide by Method 8260D, and foaming agents (non-ionic surfactants) by SM 5540.

Significant contaminant reduction in HS/SZ (where EZVI is injected) is expected within the first two years. Significant contaminant reduction in the HCP (where EVO is injected) is expected after two-plus years. Groundwater performance monitoring is planned to be conducted for up to five years after IM implementation, as this is the projected timeframe for groundwater concentrations to reach NADCs to allow subsequent transition to LTM. This timeframe is based on other similar remediation sites at KSC where injection IMs were completed.

Groundwater performance monitoring will be conducted at the same baseline locations, including MW21 and the four DPT locations (DPT-A through -D). During the first year, MW21 will be sampled quarterly, followed by semi-annual sampling during the second and third years; the four DPT locations will be sampled annually. During the fourth and fifth year, MW21 and the four DPT locations will be sampled annually. In the event MW21 becomes clogged due to the injections, an additional DPT location (co-located with MW21) will be added to the performance monitoring plan. All samples will be analyzed for VOCs. Samples for Dhc, dissolved gases, and TOC will be analyzed annually at MW21, DPT-A at 8 ft bls, DPT-B at 10 ft bls, DPT-C at 12 ft bls, and DPT-D at 14 ft bls. MW15, MW16, MW21, MW118, and MW120 will be sampled for UIC parameters quarterly for Year 1, semi-annually for Years 2 and 3, and annually for Years 4 and 5. UIC monitoring will be discontinued once UIC parameters have met baseline or background conditions for two consecutive sampling events.

Air

Air samples will be collected during baseline and performance monitoring events. During these events, air samples will be collected at eight locations near and in Building K7-468. The samples will be collected with Summa Canisters using an 8-hour time weighted average and analyzed for VOCs by Method TO-15. Air sampling data will be compared to the Occupational Safety and Health Administration Permissible Exposure Limits and American Conference of Governmental Industrial Hygienists Threshold Values for the COCs. Air monitoring is planned to continue to Year 5 to confirm vapor intrusion is not occurring; however, air sampling will cease earlier if results justify. During the first year, air samples will be collected quarterly; during the second and third year, samples will be collected semi-annually; and during the fourth and fifth year, samples will be collected annually.

8.0 CONCLUSIONS AND PATH FORWARD

This IMWP details the IM injection design for the CCB MW21 Area to enable in-situ biotic and abiotic reductive dechlorination of VOCs using EVO to target the HCP/HS and EZVI to target the SZ. The IM objective is to reduce groundwater concentrations to below NADCs within the MW21 Area to support transition to LTM with the rest of the site. As part of the updated design from the RAE, Attachment E provides the detailed cost estimate and supporting information for this document and Attachment F provides the SiteWise evaluation (sustainability analysis) updated from the RAE design.

This IMWP was presented at the April 2023 KSCRT meeting, and consensus was reached on the IM injection design and monitoring program and to proceed with the develop an Implementation Work Plan to plan and facilitate the IM. Meeting minutes are included in Attachment A.

9.0 CLOSURE

If you have any questions regarding this submittal, please contact me at 412-921-8351 or Mark Speranza at 412-921-8916.

Sincerely,

Prepared by: Andrew M Walters
Andrew Walters, P.E.
Project Engineer

Approved by: Mark P Speranza
Mark P. Speranza, P.E.
Program Manager

This document was prepared in accordance with sound professional practices. The text, tables, and figures have been reviewed and certified by a Professional Engineer registered in the State of Florida.

Mark P. Speranza, P.E.
Professional Engineer No. PE0050304
Engineering Business License No. 2429

FIGURES

FIGURE 1 SITE MAP
SWMU 089, KENNEDY SPACE CENTER, FLORIDA

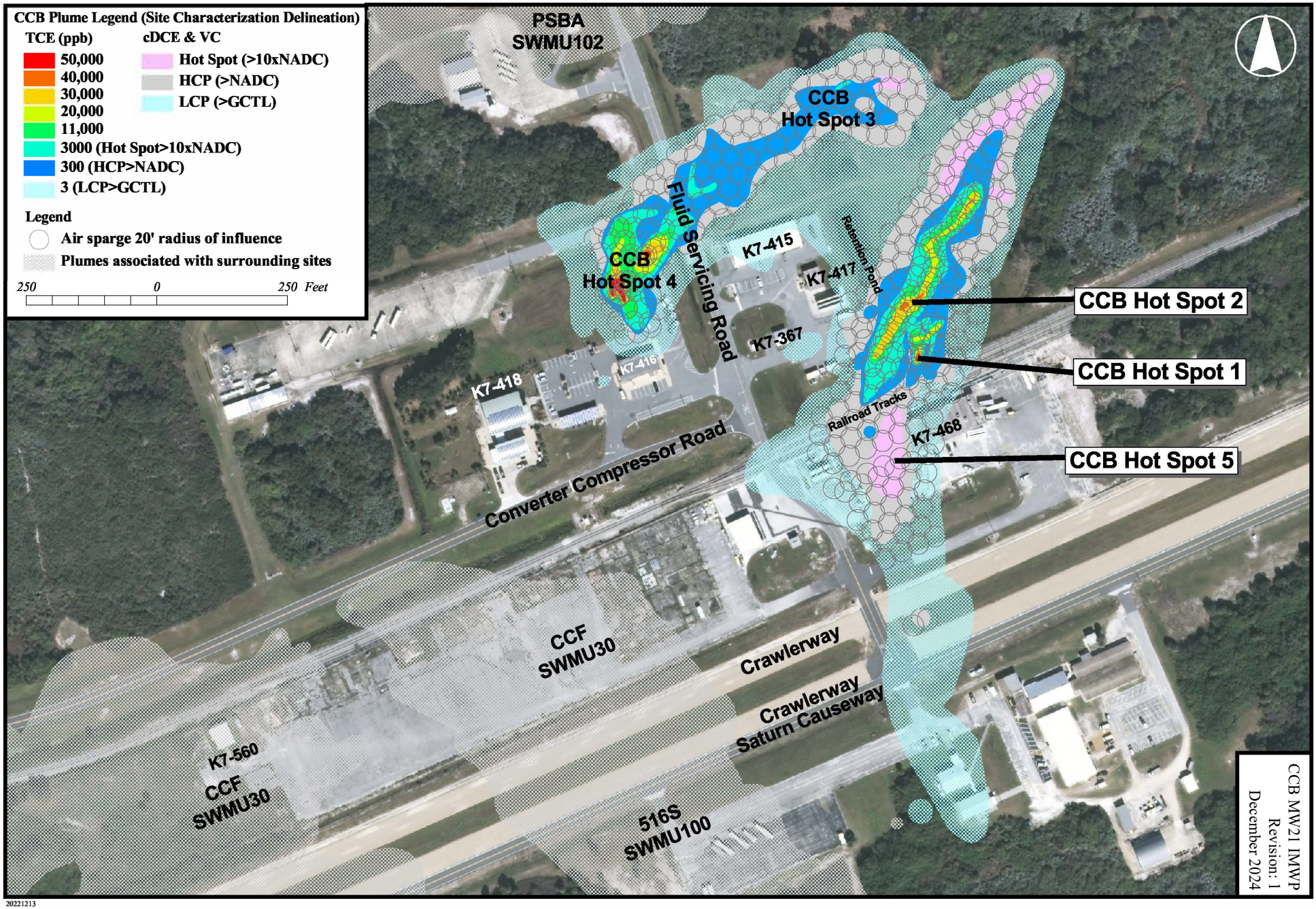

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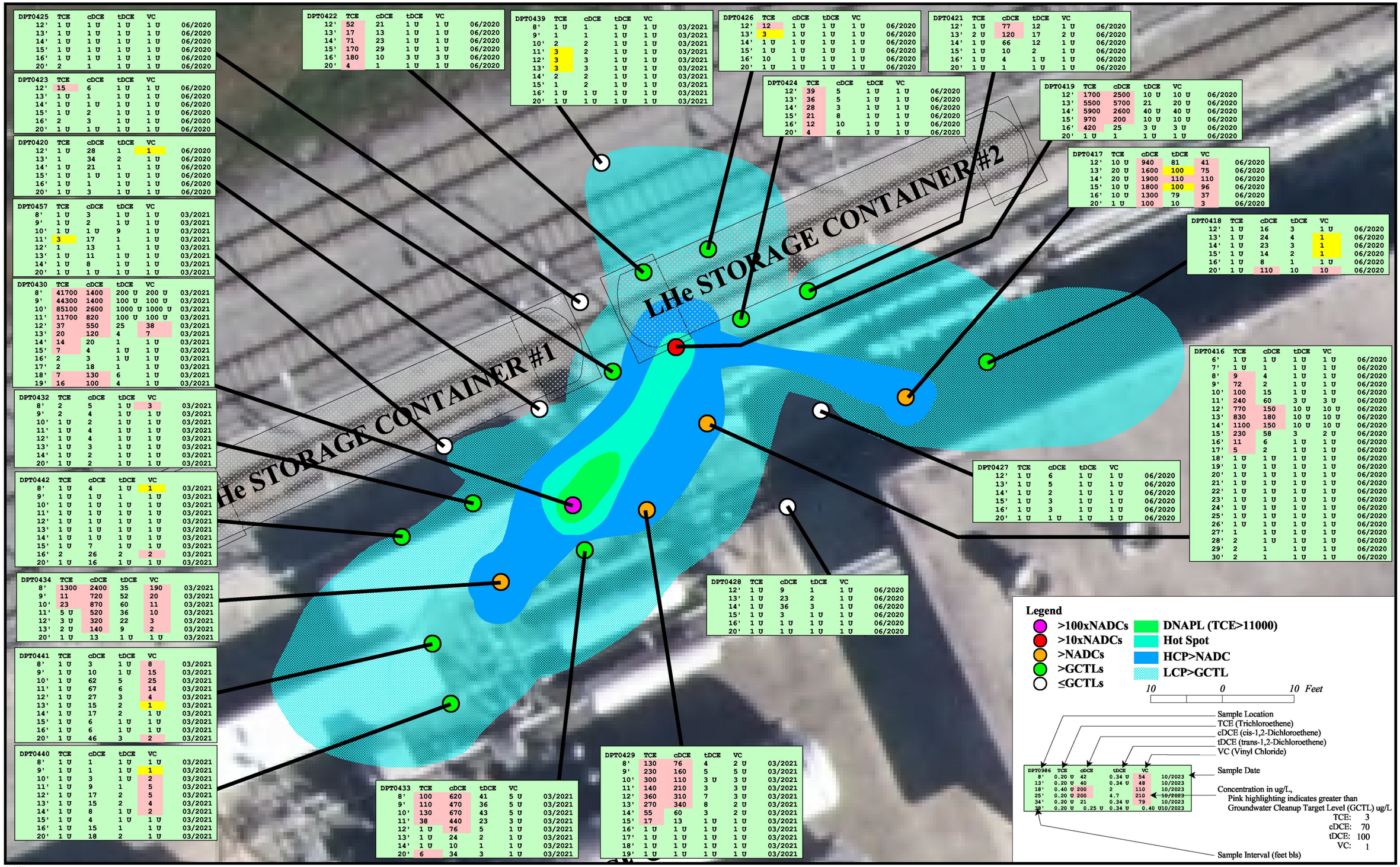
FIGURE 2 MW21 AREA GROUNDWATER RESULTS AND PLUME
SWMU 089, KENNEDY SPACE CENTER, FLORIDA

CCB MW21 IMWP
Revision: 1
December 2024



DPT0425	TCE	cDCE	tDCE	VC	
12'	1 U	1 U	1 U	1 U	06/2020
13'	1 U	1 U	1 U	1 U	06/2020
14'	1 U	1 U	1 U	1 U	06/2020
15'	1 U	1 U	1 U	1 U	06/2020
16'	1 U	1 U	1 U	1 U	06/2020
20'	2	1	1 U	1 U	06/2020

DPT0422	TCE	cDCE	tDCE	VC	
12'	52	21	1 U	1 U	06/2020
13'	17	13	1 U	1 U	06/2020
14'	71	23	1 U	1 U	06/2020
15'	170	29	1 U	1 U	06/2020
16'	180	10	3 U	3 U	06/2020
20'	4	1	1 U	1 U	06/2020

DPT0439	TCE	cDCE	tDCE	VC	
8'	1 U	1	1 U	1 U	03/2021
9'	1	1	1 U	1 U	03/2021
10'	2	2	1 U	1 U	03/2021
11'	3	2	1 U	1 U	03/2021
12'	3	3	1 U	1 U	03/2021
13'	3	3	1 U	1 U	03/2021
14'	2	2	1 U	1 U	03/2021
15'	1	2	1 U	1 U	03/2021
16'	1 U	1 U	1 U	1 U	03/2021
20'	1 U	1 U	1 U	1 U	03/2021

DPT0426	TCE	cDCE	tDCE	VC	
12'	12	1 U	1 U	1 U	06/2020
13'	3	1 U	1 U	1 U	06/2020
14'	1 U	1 U	1 U	1 U	06/2020
15'	1 U	1 U	1 U	1 U	06/2020
16'	10	1 U	1 U	1 U	06/2020
20'	1 U	1 U	1 U	1 U	06/2020

DPT0421	TCE	cDCE	tDCE	VC	
12'	1 U	77	12	1 U	06/2020
13'	2 U	120	17	2 U	06/2020
14'	1 U	66	12	1 U	06/2020
15'	1 U	10	2	1 U	06/2020
16'	1 U	4	1 U	1 U	06/2020
20'	1 U	1	1 U	1 U	06/2020

DPT0423	TCE	cDCE	tDCE	VC	
12'	15	6	1 U	1 U	06/2020
13'	1 U	1	1 U	1 U	06/2020
14'	1 U	1 U	1 U	1 U	06/2020
15'	1 U	2	1 U	1 U	06/2020
16'	2	3	1 U	1 U	06/2020
20'	1 U	1 U	1 U	1 U	06/2020

DPT0424	TCE	cDCE	tDCE	VC	
12'	39	5	1 U	1 U	06/2020
13'	36	5	1 U	1 U	06/2020
14'	28	3	1 U	1 U	06/2020
15'	21	8	1 U	1 U	06/2020
16'	12	10	1 U	1 U	06/2020
20'	4	6	1 U	1 U	06/2020

DPT0419	TCE	cDCE	tDCE	VC	
12'	1700	2500	10 U	10 U	06/2020
13'	5500	5700	21	20 U	06/2020
14'	5900	2600	40 U	40 U	06/2020
15'	970	200	10 U	10 U	06/2020
16'	420	25	3 U	3 U	06/2020
20'	1 U	1	1 U	1 U	06/2020

DPT0420	TCE	cDCE	tDCE	VC	
12'	1 U	28	1	1	06/2020
13'	1	34	2	1 U	06/2020
14'	1 U	21	1	1 U	06/2020
15'	1 U	1 U	1 U	1 U	06/2020
16'	1 U	1	1 U	1 U	06/2020
20'	1 U	3	1 U	1 U	06/2020

DPT0417	TCE	cDCE	tDCE	VC	
12'	10 U	940	81	41	06/2020
13'	20 U	1600	100	75	06/2020
14'	20 U	1900	110	110	06/2020
15'	10 U	1800	100	96	06/2020
16'	10 U	1300	79	37	06/2020
20'	1 U	100	10	3	06/2020

DPT0457	TCE	cDCE	tDCE	VC	
8'	1 U	3	1 U	1 U	03/2021
9'	1 U	2	1 U	1 U	03/2021
10'	1 U	1 U	9	1 U	03/2021
11'	3	17	1	1 U	03/2021
12'	1	13	1	1 U	03/2021
13'	1 U	11	1 U	1 U	03/2021
14'	1 U	8	1 U	1 U	03/2021
20'	1 U	1 U	1 U	1 U	03/2021

DPT0418	TCE	cDCE	tDCE	VC	
12'	1 U	16	3	1 U	06/2020
13'	1 U	24	4	1	06/2020
14'	1 U	23	3	1	06/2020
15'	1 U	14	2	1	06/2020
16'	1 U	8	1	1 U	06/2020
20'	1 U	110	10	10	06/2020

DPT0430	TCE	cDCE	tDCE	VC	
8'	41700	1400	200 U	200 U	03/2021
9'	44300	1400	100 U	100 U	03/2021
10'	85100	2600	1000 U	1000 U	03/2021
11'	11700	820	100 U	100 U	03/2021
12'	37	550	25	38	03/2021
13'	20	120	4	7	03/2021
14'	14	20	1	1 U	03/2021
15'	7	4	1 U	1 U	03/2021
16'	2	3	1 U	1 U	03/2021
17'	2	18	1	1 U	03/2021
18'	7	130	6	1 U	03/2021
19'	16	100	4	1 U	03/2021

DPT0416	TCE	cDCE	tDCE	VC	
6'	1 U	1 U	1 U	1 U	06/2020
7'	1 U	1	1 U	1 U	06/2020
8'	9	4	1 U	1 U	06/2020
9'	72	2	1 U	1 U	06/2020
10'	100	15	1 U	1 U	06/2020
11'	240	60	3 U	3 U	06/2020
12'	770	150	10 U	10 U	06/2020
13'	830	180	10 U	10 U	06/2020
14'	1100	150	10 U	10 U	06/2020
15'	230	58	3	2 U	06/2020
16'	11	6	1 U	1 U	06/2020
17'	5	2	1 U	1 U	06/2020
18'	1 U	1 U	1 U	1 U	06/2020
19'	1 U	1 U	1 U	1 U	06/2020
20'	1 U	1 U	1 U	1 U	06/2020
21'	1 U	1 U	1 U	1 U	06/2020
22'	1 U	1 U	1 U	1 U	06/2020
23'	1 U	1 U	1 U	1 U	06/2020
24'	1 U	1 U	1 U	1 U	06/2020
25'	1 U	1 U	1 U	1 U	06/2020
26'	1 U	1 U	1 U	1 U	06/2020
27'	1	1 U	1 U	1 U	06/2020
28'	2	1 U	1 U	1 U	06/2020
29'	2	1	1 U	1 U	06/2020
30'	2	1	1 U	1 U	06/2020

DPT0427	TCE	cDCE	tDCE	VC	
12'	1 U	6	1 U	1 U	06/2020
13'	1 U	5	1 U	1 U	06/2020
14'	1 U	2	1 U	1 U	06/2020
15'	1 U	3	1 U	1 U	06/2020
16'	1 U	3	1 U	1 U	06/2020
20'	1 U	1 U	1 U	1 U	06/2020

DPT0432	TCE	cDCE	tDCE	VC	
8'	2	5	1 U	3	03/2021
9'	2	4	1 U	1 U	03/2021
10'	1 U	2	1 U	1 U	03/2021
11'	1 U	4	1 U	1 U	03/2021
12'	1 U	4	1 U	1 U	03/2021
13'	1 U	3	1 U	1 U	03/2021
14'	1 U	2	1 U	1 U	03/2021
20'	1 U	2	1 U	1 U	03/2021

DPT0442	TCE	cDCE	tDCE	VC	
8'	1 U	4	1 U	1	03/2021
9'	1 U	1 U	1	1 U	03/2021
10'	1 U	1 U	1 U	1 U	03/2021
11'	1 U	1 U	1 U	1 U	03/2021
12'	1 U	1 U	1 U	1 U	03/2021
13'	1 U	1 U	1 U	1 U	03/2021
14'	1 U	1 U	1 U	1 U	03/2021
15'	1 U	7	1 U	1 U	03/2021
16'	2	26	2	2	03/2021
20'	1 U	16	1 U	1 U	03/2021

DPT0428	TCE	cDCE	tDCE	VC	
12'	1 U	9	1	1 U	06/2020
13'	1 U	23	2	1 U	06/2020
14'	1 U	36	3	1 U	06/2020
15'	1 U	3	1 U	1 U	06/2020
16'	1 U	1 U	1 U	1 U	06/2020
20'	1 U	1 U	1 U	1 U	06/2020

DPT0434	TCE	cDCE	tDCE	VC	
8'	1300	2400	35	190	03/2021
9'	11	720	52	20	03/2021
10'	23	870	60	11	03/2021
11'	5 U	520	36	10	03/2021
12'	3 U	320	22	3	03/2021
13'	2 U	140	9	2	03/2021
20'	1 U	13	1 U	1 U	03/2021

DPT0441	TCE	cDCE	tDCE	VC	
8'	1 U	3	1 U	8	03/2021
9'	1 U	10	1 U	15	03/2021
10'	1 U	62	5	25	03/2021
11'	1 U	67	6	14	03/2021
12'	1 U	27	3	4	03/2021
13'	1 U	15	2	1	03/2021
14'	1 U	17	2	1 U	03/2021
15'	1 U	6	1 U	1 U	03/2021
16'	1 U	6	1 U	1 U	03/2021
20'	1 U	46	3	2	03/2021

DPT0429	TCE	cDCE	tDCE	VC	
8'	130	76	4	2 U	03/2021
9'	230	160	5	5 U	03/2021
10'	300	110	3 U	3 U	03/2021
11'	140	210	3	3 U	03/2021
12'	360	310	7	3 U	03/2021
13'	270	340	8	2 U	03/2021
14'	55	60	3	2 U	03/2021
15'	17	13	1 U	1 U	03/2021
16'	1 U	1 U	1 U	1 U	03/2021
17'	1 U	1 U	1 U	1 U	03/2021
18'	1 U	1 U	1 U	1 U	03/2021
19'	1 U	1 U	1 U	1 U	03/2021

DPT0433	TCE	cDCE	tDCE	VC	
8'	100	620	41	5 U	03/2021
9'	110	470	36	5 U	03/2021
10'	130	670	43	5 U	03/2021
11'	38	440	23	3 U	03/2021
12'	1 U	76	5	1 U	03/2021
13'	1 U	24	2	1 U	03/2021
14'	1 U	10	1	1 U	03/2021
20'	6	34	3	1 U	03/2021

DPT0440	TCE	cDCE	tDCE	VC	
8'	1 U	1	1 U	1 U	03/2021
9'	1 U	1	1 U	1	03/2021
10'	1 U	3	1 U	2	03/2021
11'	1 U	9	1	5	03/2021
12'	1 U	17	2	5	03/2021
13'	1 U	15	2	4	03/2021
14'	1 U	8	1 U	2	03/2021
15'	1 U	4	1 U	1 U	03/2021
16'	1 U	15	1	1 U	03/2021
20'	1 U	18	2	1 U	03/2021

DPT0986	TCE	cDCE	tDCE	VC	
8'	0.20 U	42	0.34 U	54	10/2023
13'	0.20 U	40	0.34 U	48	10/2023
18'	0.40 U	200	2	110	10/2023
25'	0.20 U	200	4.7	210	10/2023
34'	0.20 U	21	0.34 U	79	10/2023
38'	0.20 U	0.25 U	0.34 U	0.40	U10/2023

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FIGURE 3 INJECTION POINT LAYOUT
SWMU 089, KENNEDY SPACE CENTER, FLORIDA

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FIGURE 4 GROUNDWATER PERFORMANCE MONITORING NETWORK
SWMU 089, KENNEDY SPACE CENTER, FLORIDA

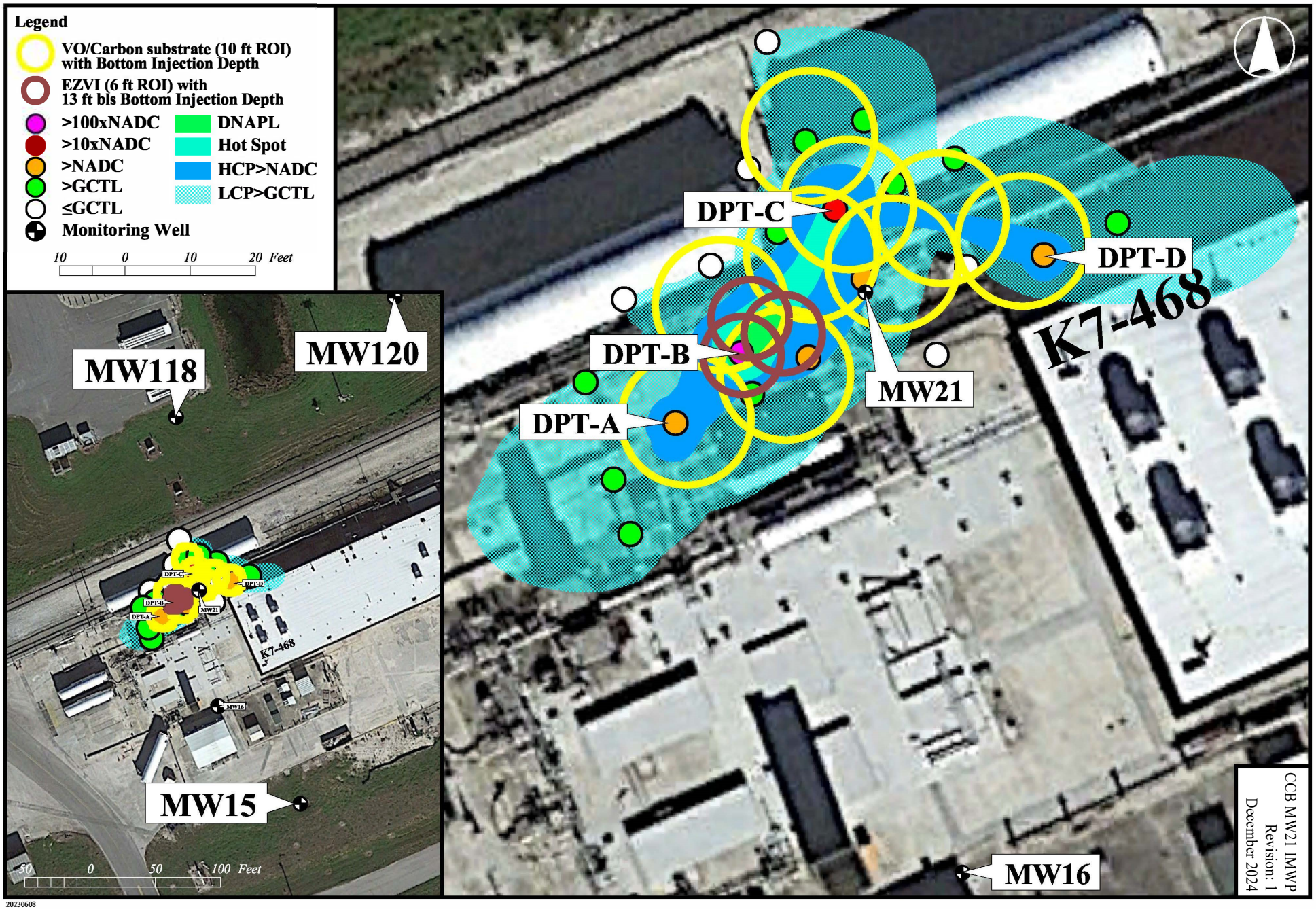
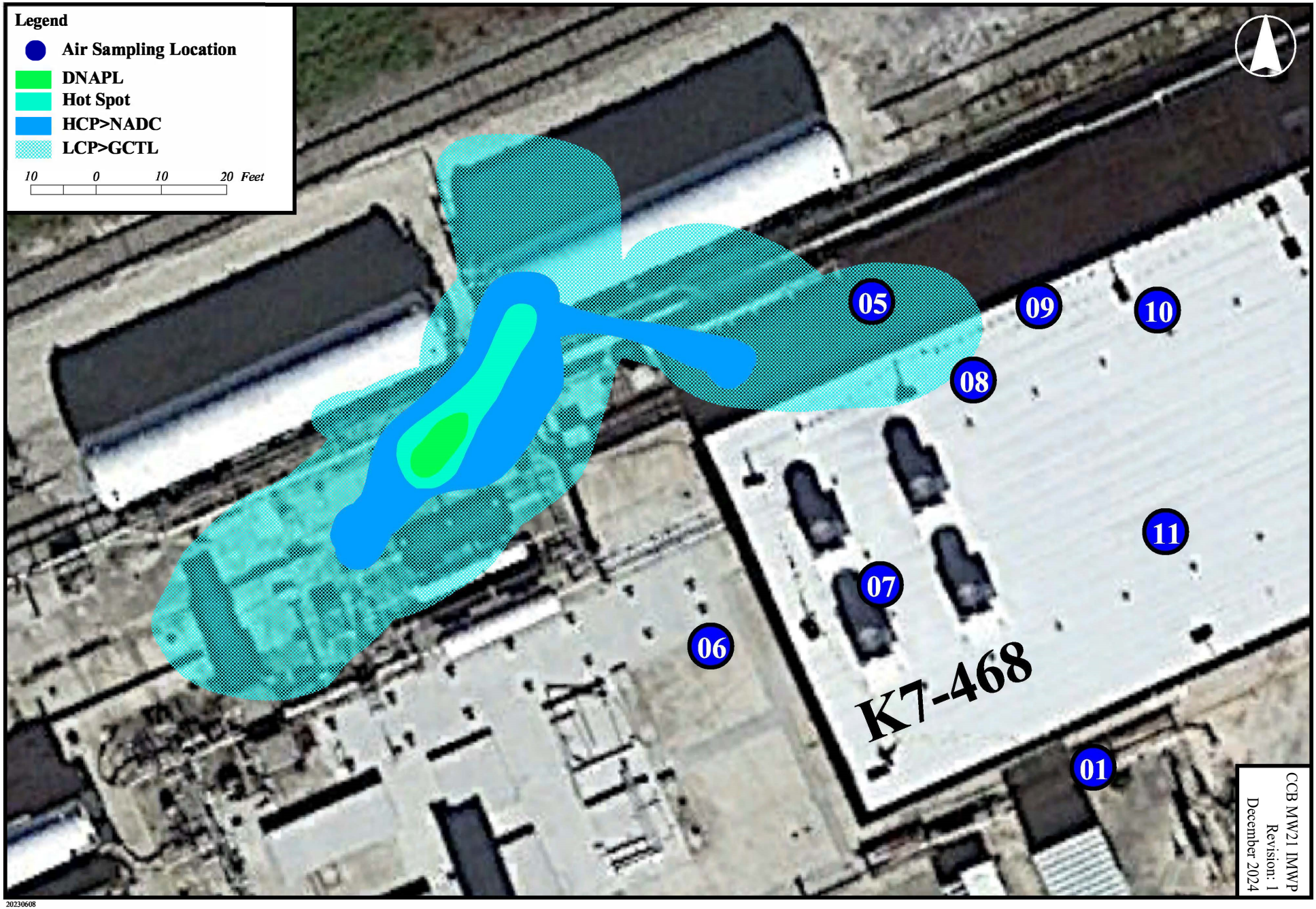


FIGURE 5 AIR MONITORING NETWORK
SWMU 089, KENNEDY SPACE CENTER, FLORIDA



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TABLES

Table 1. Injection Plan Summary

				Per Lift				Per Location			
Injection Location	**Injection Range (ft bls)**	**Injection Lifts**	**Injection Lift Depths**	**Substrate Volume/Lift (gal)**	**Additional Water Volume/Lift (gal)**	**KB-1® Plus Volume/Lift (gal)**	**Total Injectate Volume/Lift (gal)**	**Substrate Volume/Location (gal)**	**Additional Water Volume/Location (gal)**	**KB-1® Plus Volume/Location (gal)**	**Total Injectate Volume/Location (gal)**
Emusified Zero Valent Iron (EZVI)											
EZVI-1	7 - 13	3	9, 11, 13	41	--	--	41	123	--	--	123
EZVI-2	7 - 13	3	9, 11, 13	41	--	--	41	123	--	--	123
EZVI-3	7 - 13	3	9, 11, 13	41	--	--	41	123	--	--	123
				Total	**--**	**--**	**--**	**369**	**--**	**--**	**369**
Emulsified Vegetable Oil (EVO)											
VO-1	7 - 12	3	8, 10, 12	18	123	0.26	141.3	54	369	0.8	424
VO-2	7 - 14	4	8, 10, 12, 14	18	123	0.26	141.3	72	492	1.0	565
VO-3	7 - 13	3	9, 11, 13	18	123	0.26	141.3	54	369	0.8	424
VO-4	7 - 14	4	8, 10, 12, 14	18	123	0.26	141.3	72	492	1.0	565
VO-5	7 - 17	5	9, 11, 13, 15, 17	18	123	0.26	141.3	90	615	1.3	706
VO-6	7 - 14	4	8, 10, 12, 14	18	123	0.26	141.3	72	492	1.0	565
VO-7	7 - 17	5	9, 11, 13, 15, 17	18	123	0.26	141.3	90	615	1.3	706
VO-8	7 - 17	5	9, 11, 13, 15, 17	18	123	0.26	141.3	90	615	1.3	706
VO-9	7 - 17	5	9, 11, 13, 15, 17	18	123	0.26	141.3	90	615	1.3	706
				Total	**--**		**--**	**684**	**4,674**	**9.8**	**5,368**

Subtrate and injectate volumes are approximated based on the pore space volume calculation and vendor recommendations

Substrates represent formulations of EVO of 60% fermentable carbon and EZVI of 10% ZVI

The equivalent weight for total gallons of VO/carbon substarte is approximately 5,675 pounds (assuming a product density of 8.3 pounds per gallon)

Injections will be made using 2-ft injection intervals using bottom-up approach up to 2-ft below water table

Injections lift depths at 8 ft will have an extra foot over the top depth at that location

bls = below land surface
ft = feet
gal = gallon
VO = vegetable oil
ZVI = zero valent iron

Table 2. Groundwater Performance Monitoring Plan

Location ID	Screen Interval (ft bls)	Sample Depth (ft bls)	Analyses	Frequency					
				Baseline	Year 1	Year 2	Year 3	Year 4	Year 5
Monitoring Well Locations									
MW15[1]	10 - 20	15	UIC	Once	Quarterly	Semi-Annual	Semi-Annual	Annual	Annual
MW16[1]	10 - 20	15	UIC						
MW21	10 - 20	15	VOCs, Dhc, UIC, Dissolved Gases, TOC						
MW118	10 - 20	15	UIC						
MW120[1]	10 - 20	15	UIC						
DPT Locations									
DPT-A	--	8, 12, 16, 20	VOCs, Dhc[2], Dissolved Gases[2], TOC[2]	Once	Annual	Annual	Annual	Annual	Annual
DPT-B	--	8, 12, 16, 20, 24[1]	VOCs, Dhc[2], Dissolved Gases[2], TOC[2]						
DPT-C	--	8, 12, 16, 20	VOCs, Dhc[2], Dissolved Gases[2], TOC[2]						
DPT-D	--	8, 12, 16, 20	VOCs, Dhc[2], Dissolved Gases[2], TOC[2]						

DPT samples are assumed to be taken from a 4 ft screen; sample depth refers to the middle of the screen interval

UIC Parameters include TRPH, iron, managanese, sodium, chloride, 1,4-dioxane, ethylene oxide, and non-ionic surfactants.

[1] DPT-B 24 ft bls interval is only to be sampled during baseline sampling to confirm vertical extent of the HCP.

[2] Dhc, MEE, and TOC will only be collected at DPT-A 8 ft bls, DPT-B 10 ft bls, DPT-C 12 ft bls, DPT-D 14 ft bls (highest contaminated interval at each DPT location)

bls = below land surface
Dhc = Dehalococcoides
DPT = direct push technology
ft = feet
gal = gallon
MW = monitoring well
TOC = total organic carbon
TRPH = total recoverable petroleum hydrocarbons
VOC = Volatile Organic Compounds

Table 3. Air Performance Monitoring Plan

Location ID	Description	Frequency					
		Baseline	Year 1	Year 2	Year 3	Year 4	Year 5
Air Monitoring Locations							
1	South side of K7-468	Once	Quarterly	Semi-Annual	Semi-Annual	Annual	Annual
5	North side of K7-468						
6	West side of K7-468						
7	Inside K7-468						
8	Inside K7-468						
9	Inside K7-468						
10	Inside K7-468						
11	Inside K7-468						

Location IDs refer to the numbered locations shown in the IMWP ADP.

Samples will be collected using a 8-hr time-weighted average summa cannister and analyzed for VOCs by TO-15.

Air sampling results will be evaluate to Occupational Safety and Health Administration permissible exposure limits and American Conference of Governmental Industrial Hygienists Threshold Limit Values for the contaminants of concern.

ATTACHMENTS

ATTACHMENT A
MEETING MINUTES

Meeting Minutes Summary Report

Meeting Start Date:	Meeting ID:	Minute ID:	Presenter:	PRL / SWMU:
04/05/2023	226	4	Walters	CONVERTOR/COMPRESSOR BUILDING (SWMU 089)

Topic:

CCB SWMU #089 - MW21 Area Groundwater Interim Measure Work Plan

Discussion:

Historical background provided for the site. Rail cars were used to transport during the Shuttle program. These rails are no longer in service and no rail cars are stored on location.

The contamination at the MW21 Area is remaining from the air sparge IM conducted at Hot Spots 1 through 5 between 2014 and 2020. The objective for the previous IM was achieved which reduced concentrations to below NADC except for the MW21 Area. A follow-up Site Characterization for the MW21 Area was conducted in 2020 and 2021 to delineate contamination greater than NADCs. The Remedial Alternatives Evaluation (RAE) was conducted afterwards to select a treatment alternative. Consensus was reached to select in situ bioremediation using emulsified vegetable oil (EVO) in the High Concentration Plume and Hot Spot area and abiotic reductive dechlorination using emulsified zero valent iron (EZVI) in Source Zone area as the remedial alternative.

Interim Measure Design
The EVO injections consist of nine injection locations at approximately 10 feet radius of influence (ROI). The approximate volume of EVO injectate needed for the IM is 5,358 gallons, which includes 684 gallons of the vegetable oil/carbon substrate. Amendments will be made to the formulation including pH adjustment (sodium bicarbonate) and bioaugmentation (by adding microbial consortium), with dosing determined from baseline sampling results. The EZVI injection consist of three injection locations at approximately 6 feet radius of influence (ROI). The three locations surround DPT430, the location with the highest reported trichloroethene (TCE) concentration. The volume of injectate per injection location is 123 gallons, and the total injectate volume for the site is 369 gallons.
The former Components Cleaning Facility (CCF) site will be used as long-term storage of these materials and equipment. An injection trailer and skid steer will be used to deliver material from CCF to the injection site. The total implementation time from mobilization to demobilization is approximately one to two weeks.
Baseline and performance monitoring sampling events will be conducted for groundwater and air. The groundwater baseline event will be conducted to provide a basis for performance monitoring. Depending on the location and depth, samples will be analyzed for VOCs, Underground Injection Control (UIC) parameters (total recoverable petroleum hydrocarbons, sodium, iron, and total dissolved solids [TDS]), and/or Dehalococcoides (Dhc). The baseline event will consist of sampling four DPT locations (DPT-A through -D) and two monitoring wells (MW16 and MW21). During Years 1, 2, and 3, MW0021 will be sampled for VOCs on a semi-annual basis. During Years 4 and 5, MW0021 will be sampled for VOCs annually. MW0016, which is south of the treatment area, will be sampled on an annual basis for UIC parameters only. Its results will be representative of site background. The four DPT locations will be sampled annually during all five years at four depth intervals each. Air samples will be collected during baseline and performance monitoring events. During these events, air samples will be collected at eight locations near and in Building K7-468. Air monitoring is planned to continue to Year 5 to confirm vapor intrusion is not occurring. However, air sampling will cease earlier if results justify.

FDEP is good with the workplan. For the permanent monitoring wells, they understand the access issues but inquired if dolly rigs are able to install permanent wells? Tetra Tech provided the reason for the direct push technology (DPT) over monitoring wells at this time is because they are monitoring multiple intervals using DPT. Monitoring wells are one long string and bio-fouling is a potential here, rendering a monitoring well not useful.

NASA referenced the General Service Administration (GSA) site chlorinated volatile organic compounds (CVOC) plume where they used DPT for the initial performance monitoring, although it may be less feasible at this location. At the GSA southwest hot spot, DPT was used for monitoring until NASA saw that the biotic and abiotic reduction had slowed significantly. Then they installed permanent wells at that location. Data from the permanent wells were then used to obtain No Further Action on groundwater monitoring, etc. To the feasible extent DPT is interim for performance monitoring with permanent monitoring wells installed at a later time. NASA stated they could add in wells to this location, but still desire to keep the DPT performance monitoring (PM). With DPT, they have the ability to see what is going on to evaluate the effectiveness of the remedy. Installing wells after performing rounds of DPT allows NASA to place wells in areas to complement long-term monitoring at the site. NASA is prepared to discuss this further with FDEP.
FDEP requested that the specific injection chemical to be used (trade name) be provided in writing. That is necessary to confirm that the product has an existing approval for injection by the State. NASA is in contact with multiple vendors on this and will verify the exact product trade name proposed for use. FDEP stated that any injection chemical proposed for use will need to be provided by its trade name. If the chemical is not currently accepted for use in the state of Florida, it will need to be evaluated for site specific use or for use throughout the state.

FDEP offered another general statement: baseline sampling is not the same as background data. One well is not sufficient to provide background data at a site, although it can provide a background reference. Background wells should be outside of the contaminated area. The proposed background well MW0016 is within the HS5 area. Tetra Tech added that they tried to take the well closest to this area within the same screening interval to use as a reference. There are not many other existing wells in this area, but they will look at the background data and include a recommendation. Tetra Tech noted that Hot Spot 5 is the area in reference today. There are 228 air sparge wells in the overall area; Hot Spot 5 is part of that overall larger area that has already been evaluated.

FDEP inquired if the aquifer beneath this installation has been evaluated for sodium and TDS? Tetra Tech stated they would need to go back and look at the data. Action item was added to look for this information (sodium and TDS) and submit to FDEP for their information (2304-A02).

FDEP noted there looks like there is some contamination below the deepest injection depth (referencing Slide 19) and asked if that lower interval will be monitored at a later time? Tetra Tech clarified that there are 44 wells across the site. Air sparging in this area has shown clean for years now in the 40-50ft interval. The DPT will reach down to this depth and for now we would use DPT on a semi-annual basis and after a couple of rounds determine where to install the permanent well locations based on confirmed data. FDEP inquired how deep would the DPT be at DPT429 location? Slide 19 and Slide 20 were reference and Tetra Tech offered that they would sample down to 20 ft.

NASA stated the Team typically obtains consensus at these meetings for contracting. Since we cannot obtain consensus at this time, is this something we can do between now and June? FDEP responded that they should have their answers turned around fairly soon after taking a look at the injection product information and the background on MW0021. Tetra Tech will provide FDEP the trade names of the proposed chemicals to be used at the site via email as soon as possible (2304-A03). As an example, FDEP shared that the approval for use of Provect IR is not applicable to the use of Provect IR60. The approval letter is not interchangeable nor does it apply to the usage of all Provect IR chemicals. NASA added that the Mobile Launch Platform/Vehicle Assembly Building (SWMU #056) is proposing to use a similar chemical.

Goal:

The goal of this Interim Measures Work Plan (IMWP) Advance Data Package (ADP) is to present a design for an injection IM to remediate groundwater within the Convertor Compressor Building (CCB) Monitoring Well 21 (MW21) Area where volatile organic compounds (VOCs) concentrations exceed Natural Attenuation Default Concentrations (NADC).

Decision:11	Team consensus was reached on the Interim Measure Work Plan (IMWP) design for in situ reductive dechlorination injection treatment of the high concentration plume (HCP)/ Hot Spot (HS) / Source Zone (SZ) at the MW21 Area and to proceed with the develop of an Implementation Work Plan to plan and facilitate the Interim Measure (2304-D11).

Meeting Minutes Summary Report

Meeting Start Date:	Meeting ID:	Minute ID:	Presenter:	PRL / SWMU:
09/13/2022	223	2	Jonnet, Mark	CONVERTOR/COMPRESSOR BUILDING (SWMU 089)

Topic:

Converter Compressor Building (CCB) Monitoring Well 21 Area Remedial Alternatives Evaluation

Discussion:

The contamination at the MW21 Area is remaining from the air sparge interim measure (IM) conducted at Hot Spots 1 through 5 between 2014 and 2020. The objective for the previous IM was achieved, which reduced concentrations to below Natural Attenuation Default Criteria (NADC) except for the MW21 Area. A follow-up Site Characterization for the MW21 Area was conducted in 2020 and 2021, to delineate the remaining high concentration plume (HCP) contamination (concentrations greater than NADC). The RAE was conducted afterwards to select a treatment alternative for a follow-on IM. The corrective action objective for the RAE is to reduce chlorinated volatile organic compounds (CVOC) concentrations in the MW21 area via an IM to support transition to monitored natural attenuation (MNA). The ADP includes the results for the Site Characterization and RAE. A supplemental package was provided with the ADP which contains a summary of the alternatives, direct push technology (DPT) analytical results table, and associated appendices.

Site Characterization
The Site Characterization included two DPT sampling events to delineate concentrations to NADC levels within the MW21 area to support conducting a RAE. In June 2020, a groundwater investigation was conducted using DPT in the area around MW21. Results of the DPT investigation confirmed that one or more CVOCs were present in the area around MW21 at concentrations greater than the groundwater cleanup target levels (GCTLs) and/or NADCs. The maximum trichloroethylene (TCE) result of 5,900 µg/L was collected from DPT419 at 14 ft bls. Further investigation to the southwest of MW21 was delayed due to site obstructions preventing access. The obstructions were later removed, and the investigation continued in March 2021. The sampling in March 2021 consisted of 95 discrete depth groundwater samples at 10 boring locations. Results of this investigation showed additional significant contamination in the southwest area. DPT430 is the location with the highest contamination with a maximum TCE concentration at 85,100 µg/L at 10 ft bls. The total area of CVOC impact around MW21 ranged from 8 to 16 ft bls with a total HCP footprint of 839 square feet. The plume consists predominantly of TCE with a localized source zone (SZ) (based on a TCE concentration of 85,100 µg/L) at DPT430 with a footprint of 50 square feet. Freon-113 was not detected in any of the samples collected during the June 2020 and March 2021 events. The overall results of the site show the MW21 Area is adequately characterized to proceed with the RAE and for IM implementation. A technology screening was conducted as part of the Site Characterization process and identified technologies implementable at the CCB MW21 Area.

Remedial Alternatives Evaluation
The alternatives evaluated under the RAE are listed below and a summary is provided for each alternative. A cost comparison and environmental footprint analysis were conducted to support the evaluation. Cost estimates were used to compare the capital costs, active treatment costs, and lifecycle costs of the three alternatives. The environmental footprint analysis considered life-cycle quantitative metrics for global warming potential through greenhouse gas emissions criteria air pollutant emissions through nitrogen oxides (NOx), sulfur oxide (SOx) and particulate matter 10 microns or smaller (PM10) emissions, energy consumption, water usage, and worker safety.

Alternative G1: Air Sparging
The remedial technology for Alternative G1 is air sparging (AS). The AS well network would consist of four AS wells with a top-of-screen depth of 25 ft bls to target the HCP. Spacing of the AS wells is based on a radius of influence (ROI) of 20 feet. The wells would be set lower than the targeted contamination to achieve the 20-ft ROI. A NASA-owned compressor trailer would be utilized which was recently installed nearby to support the Component Cleaning Facility East IM. Performance monitoring includes air and groundwater sampling. Air sampling will consist of 17 locations during baseline then approximately 12 sample locations for each event afterwards. The existing sub-slab depressurization system (SSDS) at the CCB (K7-0468) would be operated so that indoor air CVOC concentrations are below exposure limits. The AS system is anticipated to operate for a total of 2.5 years. Based on the previous IM, operation of the AS system will only occur during off-shift hours based on a 12-hour pulse cycle. The AS system is planned to operate on this cycle during the first year of operation and then transition into a 24-hour cycle for the second and third year based on air monitoring results anticipated to be below target levels as observed during the previous IM. If the second and third year had to continue operating on a 12-hr cycle then the total time for the AS system to operate would extend to approximately 3.7 years. The emission calculations for this design show that total emission mass of CVOCs is less than the Hazardous Air Pollutant limits. Groundwater performance monitoring sampling will consist of sampling from MW21 and DPT430. A treatment duration range of 2.5 to 5 years was determined based on the shortest expected time to reach NADC to the 5-year conservative time to reach NADC. The lifecycle cost for cleanup to NADC for a 2.5, 4, and 5-year duration is $441,000, $525,000, and $575,000, respectively.

Alternative G2: In Situ Bioremediation
The remedial technology for Alternative G2 is in-situ bioremediation. This alternative design would consist of two injection events of electron donor substrate to facilitate treatment by anaerobic biodegradation. The first injection event would consist of seven injection locations across the HCP area with a 10-foot ROI. The injection material would consist of an electron donor (e.g., vegetable oil), sodium bicarbonate for pH adjustment, and microbial culture if deemed necessary. A second injection event is included as a contingency polishing step. A total of two injection locations is planned for the second injection event using vegetable oil as the electron donor substrate during the second injection event. Performance monitoring includes air and groundwater sampling. Air sampling would consist of 17 locations during baseline then

approximately 12 sample locations for each event afterwards. As a precaution for the exposure safety of the occupants in Building K7-468, the SSDS would be operated for two years after the first injection event and one year after the second injection event to conservatively extract any subsurface vapors. Groundwater performance monitoring sampling would consist of sampling from MW21 and DPT430. A treatment duration range of 3 to 5 years was determined based on the shortest expected time to reach NADC to the 5-year conservative time to reach NADC. The lifecycle cost for cleanup to NADC for a 3, 4, and 5-year duration is $483,000, $670,000, and $734,000, respectively.

Alternative G3: In Situ Bioremediation and Emulsified Zero Valent Iron (EZVI) in the Source Zone
The remedial technology for Alternative G3 is in-situ bioremediation with EZVI in the SZ. The alternative design consists of one injection event of electron donor substrate and EZVI to facilitate treatment by abiotic and anaerobic degradation. The injection event would consist of seven injection locations of electron donor substrate across the HCP area and three injection locations of EZVI within the source area. The electron donor substrate is anticipated to have a 10-foot ROI and the EZVI is anticipated to have a 6-foot ROI. The injection material for the electron donor locations consists of an electron donor (e.g., vegetable oil), sodium bicarbonate for pH adjustment, and microbial cultures if deemed necessary. Performance monitoring includes air and groundwater sampling. Air sampling will consist of 17 locations during baseline then approximately 12 sample locations for each event afterwards. As a precaution for the exposure safety of the occupants in Building K7-468, the SSDS would be operated for two years following the injection event to conservatively extract any subsurface vapors. Groundwater performance monitoring sampling would consist of sampling from MW21 and DPT430. A treatment duration range of 3 to 5 years was determined based on the shortest expected time to reach NADC to the 5-year conservative time to reach NADC. The lifecycle cost for cleanup to NADC for a 3, 4, and 5-year duration is $496,000, $557,000, and $612,000, respectively.

Conclusions and Recommendations
Based on the results of the RAE, the recommended alternative is Alternative G3, to conduct an IM consisting of in-situ bioremediation using emulsified vegetable oil and EZVI in the source area. This alternative was chosen due to several reasons. The facility infrastructure and future construction at the site is problematic for air sparge system installation. Alternative 3 costs are comparable to Alternative 1, especially if cleanup to NADC occurs in three years, then the area would transition into long term monitoring sooner than anticipated. In addition, the air sparge system could potentially operate on a 12-hour cycle for the entire duration which would extend costs to a 4 or 5-year duration. Comparing Alternatives 2 and 3, using EZVI would more aggressively target the source area minimizing the potential for second injections and avoiding unforeseen future costs. Alternative 3 would minimize the impact surrounding Building K7-468 infrastructure. Lastly, injections using ZVI and vegetable oil have been successful at KSC.

Goal:

This Advance Data Package (ADP) includes the results of the MW21 Area Remedial Alternatives Evaluation (RAE) at the Convertor Compressor Building (CCB), Solid Waste Management Unit #089. The RAE is being conducted in support of the ongoing treatment at CCB to meet the overall corrective action objective for the site.

Decision:2	The Team reached consensus that the CCB MW21 Area is adequately characterized for IM implementation (2209-D02).
Decision:3	On the basis of approval of delineation, the Team formally reached consensus to proceed with the Remedial Alternatives Evaluation with retained technologies listed on Slide 32 (2209-D03).
Decision:4	The Team reached consensus that the Corrective Action Objective is to reduce the COC concentrations to below NADC in the MW21 Area via an interim measure to support transition to MNA (2209-D04).
Decision:5	The Team reached consensus that in situ Bioremediation and ZVI in source area as the selected alternative for MW21 area at CCB. A VO/EZVI injection IM will be conducted at the MW21 Area to treat the HCP/HS/SZ to support transition to MNA (2209-D05).
Decision:6	The Team reached consensus to prepare an ADP and Implementation Work Plan for the IM and present to the KSCRT. Both documents will be submitted to FDEP (2209-D06).

ATTACHMENT B

CCB MW21 AREA IMWP ADP

Converter Compressor Building (CCB), SWMU 089 – MW21 Area
Interim Measures Work Plan
Presented April 2023, Revised May 2024

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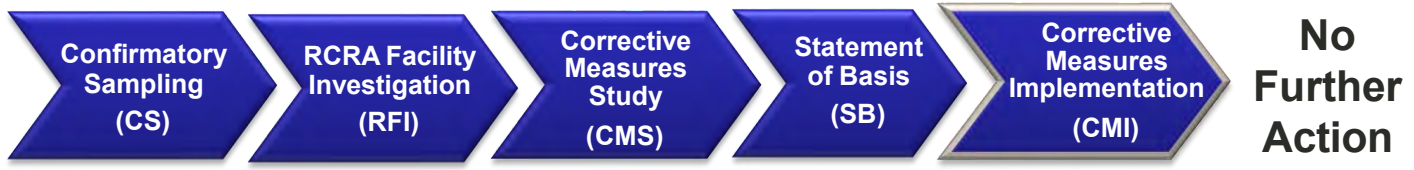
Objectives

- Background and previous interim measures (IM)
  - Background and remedial history
  - Previous air sparge IM
- Summary of the Site Characterization and Remedial Alternatives Evaluation (RAE) for the Monitoring Well 21 (MW21) Area
  - Present selected alternative and path forward to a Work Plan
- Present IM Work Plan for MW21 Area
  - Objective and Overview
  - Design and Layout
  - Performance Monitoring Plan
  - Exit Strategy
- Path forward and test consensus

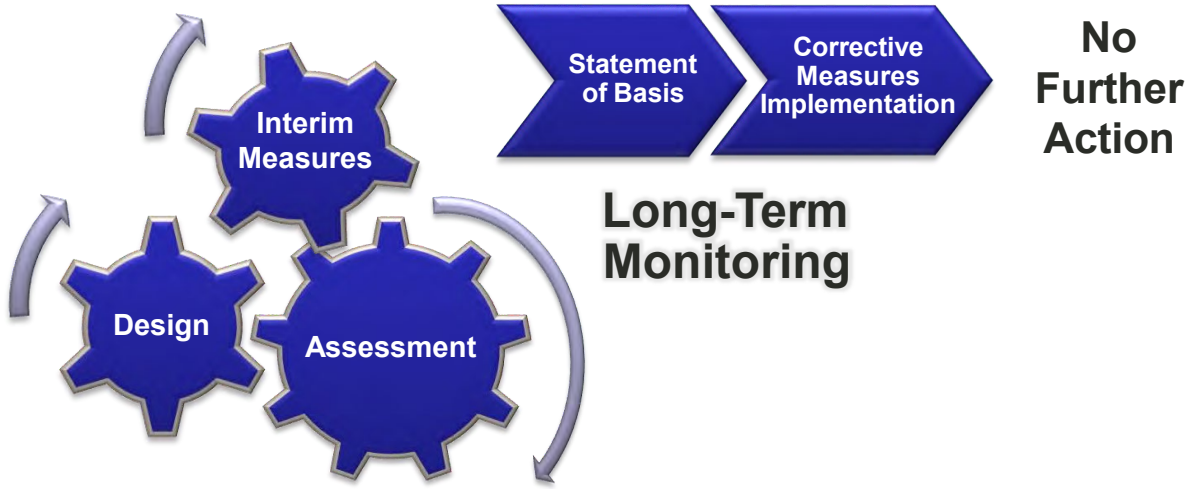
Where we are in the RCRA Process?

- Site is in RCRA Facility Investigation for volatile organic compounds (VOCs) in groundwater from a traditional RCRA stand-point
- Adaptive site management is being utilized through on-going assessment, design, and IMs
- Common terminology:
  - Source Zone - area where dense nonaqueous phase liquid (DNAPL) is suspected
  - Hot Spot - area where concentrations of VOCs are 10 times greater than Natural Attenuation Default Concentrations (NADCs)
  - High Concentration Plume - area where concentrations of VOCs are greater than NADCs
  - Low Concentration Plume - area where concentrations of VOCs are greater than Groundwater Cleanup Target Levels (GCTLs)

Traditional Linear Approach to RCRA Corrective Actions



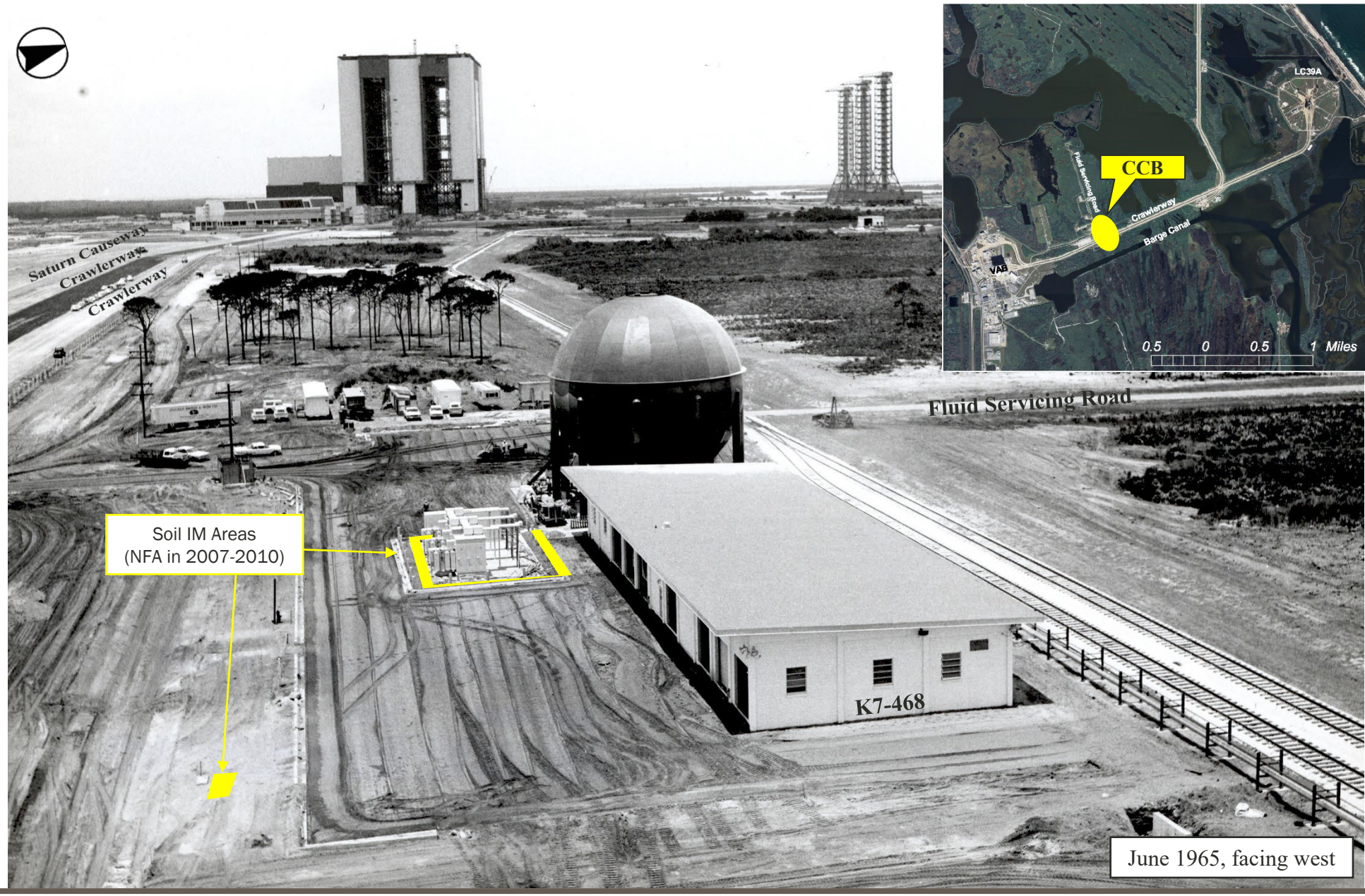
KSC Approach to RCRA Corrective Actions (Engineering Evaluation Process)



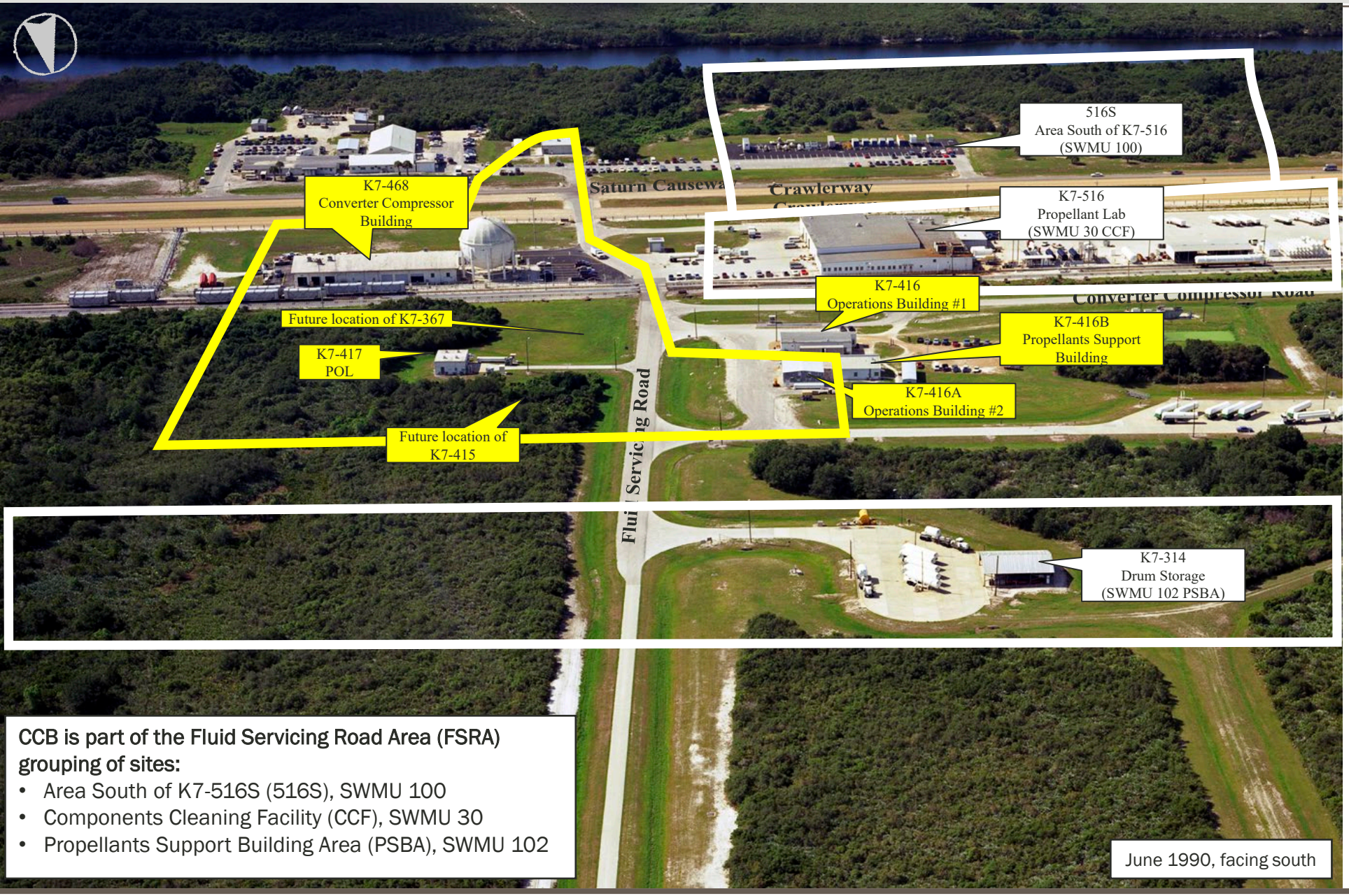
Background

K7-468

- Constructed in 1965, the CCB converts liquid helium from outside contractors (tankers) to a low-pressure helium gas which is pumped to the high-pressure gas compressors and stored in railcars, pipeline, and customer storage batteries.
- Control and maintain high pressure gaseous nitrogen (GN_2) that is supplied from an outside contractor via underground pipeline. The GN_2 pressure is reduced and flow is controlled to a variety of customers.
- Soil IM conducted in October 2009 at the Transformer Bank and Transformer Pad (LOC 1A and 1B) for polycyclic hydrocarbons (PAHs) and polychlorinated biphenyls (PCBs)



Background



CCB is part of the Fluid Servicing Road Area (FSRA) grouping of sites:

- Area South of K7-516S (516S), SWMU 100
- Components Cleaning Facility (CCF), SWMU 30
- Propellants Support Building Area (PSBA), SWMU 102

Construction History

- 1963-65: Construction of CCB (K7-468)
- 1967: Construction of Petroleum Oil Locker (POL) Flammables Storehouse (K7-417) / Operations Building (K7-416)
- 1980s: The nitrogen aboveground storage tank (AST) was removed and replaced with a nitrogen pipeline to an off-site facility, electrical reactors were also removed
- 1993: Construction of Ammonia Boiler Refurbishment / Test Building (K7-367)
- 2005: Construction of Cylinder Test and Fill Facility (K7-415) and retention pond
- The source of plume is associated with historical operations within the FSRA

Site History

2003: SWMU Assessment identified potential impacts from historical operations.

2005: Confirmation Sampling Report with RCRA Facility Investigation (RFI) Work Plan completed for soil and groundwater contamination.

2006 - 2009: RFI identified Trichloroethene (TCE) Hot Spots (HSs). CCB area expanded based on K7-417 SWMU Assessment including surrounding area (K7-417, K7-367, and K7-415).

2010: Soil IMs removed 65 yd^3, and no further action (NFA) for soil approved by FDEP. Groundwater remained only media of concern. Land Use Control Implementation Plan active for groundwater (published 2012).

2010: Site Characterization completed (LCP).

2011: Remedial Alternatives Evaluation selected air sparging (AS) as remedial technology.

2014: Full-scale operations began at Hot Spots (HSs) 1, 2, and 5. Air monitoring performed from Dec-2013 to Nov-2014.

2015: AS initiated at two sparge wells adjacent to MW0013.

2016: Full-scale operations began at HSs 3 and 4. Air monitoring from Mar-2016 to Dec-2016

2017: Reduced monitoring frequency from quarterly to semi-annual, annual, or biennial

2018: One of the AS trailers (System #1) was moved to Launch Complex 34.

2019: KSC Remediation Team (KSCRT) consensus to discontinue active AS. NASA elected to continue sparging operations until the compressor was needed for POL (SWMU 067) with continued performance monitoring.

2020: Systems #2 (sub-slab depressurization system {SSDS]) and #3 (sparge trailer) permanently shut off December 1, 2020,and the sparge trailer moved to POL.

2021: Post-IM monitoring network optimized. DPT delineation was conducted to define boundaries of LCP and install monitoring wells where needed. In December 2019, result for MW21 sample was >NADC; additional investigation was conducted in MW21 area.

2022: Site Characterization/Remedial Alternatives Evaluation completed for MW21 Area and selected In Situ Bioremediation and EZVI in Source Zone

Reporting History

Reporting	HS1	HS2	HS3	HS4	HS5
Site Characterization (LCP)	Oct 2010				
Site Characterization (HCP)	Aug 2011				
Site Characterization (SZ)	Oct 2011		Nov 2014	Nov 2013	-
Remedial Alternatives Evaluation	Dec 2011		-	Dec 2014	-
Interim Measure Work Plan	Jun 2012		-	Mar 2014	-
RFI/CMI Progress Report	Nov 2012				
Construction Completion	May 2014		Apr 2016		May 2014
Operations, Maintenance, and Monitoring	Aug 2015		-		Aug 2015
Operations, Maintenance, and Monitoring	Sep 2016		-		Sep 2016
Operations, Maintenance, and Monitoring	Apr 2016 - June 2017				
Operations, Maintenance, and Monitoring	June 2017 - April 2019				
Operations, Maintenance, and Monitoring	April 2019 - Dec 2020				
Performance Monitoring Report	Jan 2021 - Dec 2021				
Remedial Alternatives Evaluation	September 2022				
Interim Measures Work Plan	Current				

Fluid Servicing Road Area Groundwater Flow

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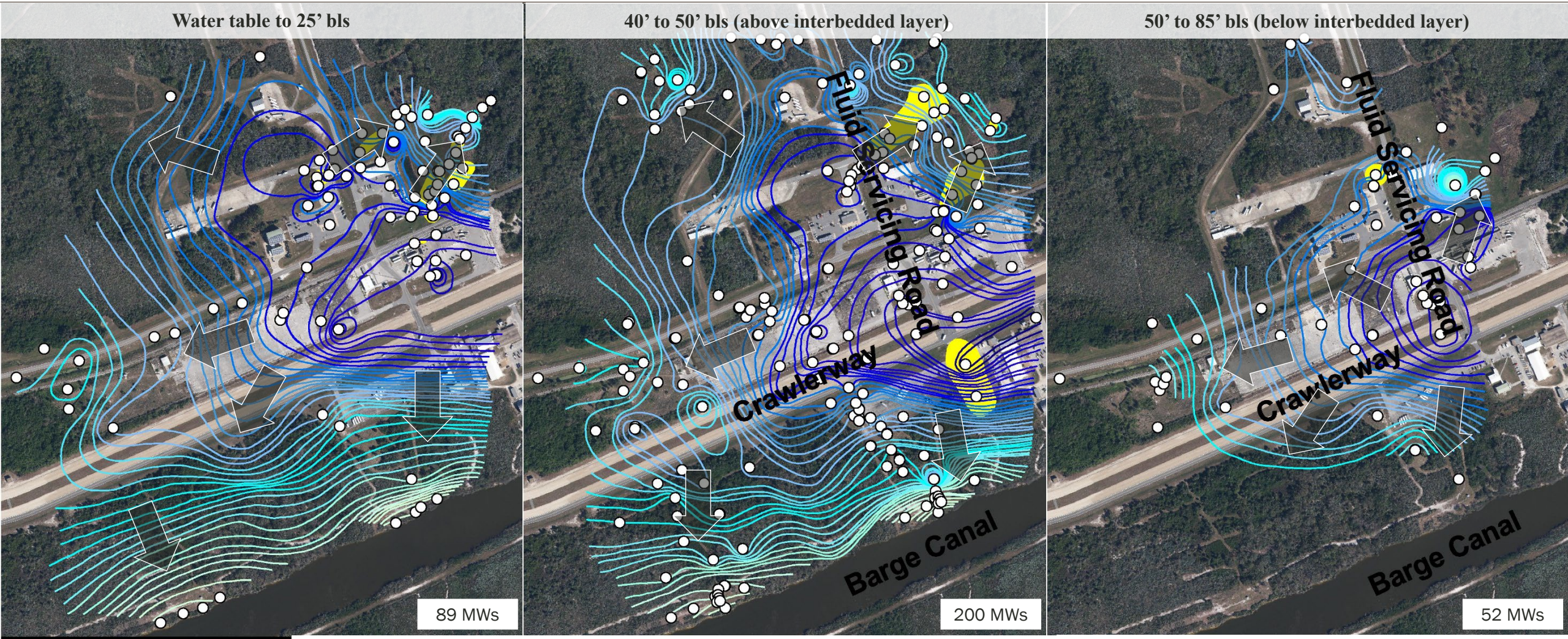


Note: CCB LCP footprints shown in yellow based on December 2021 LTM results

Water levels shown from 341 locations from June 20, 2019; IMs were inactive during field event

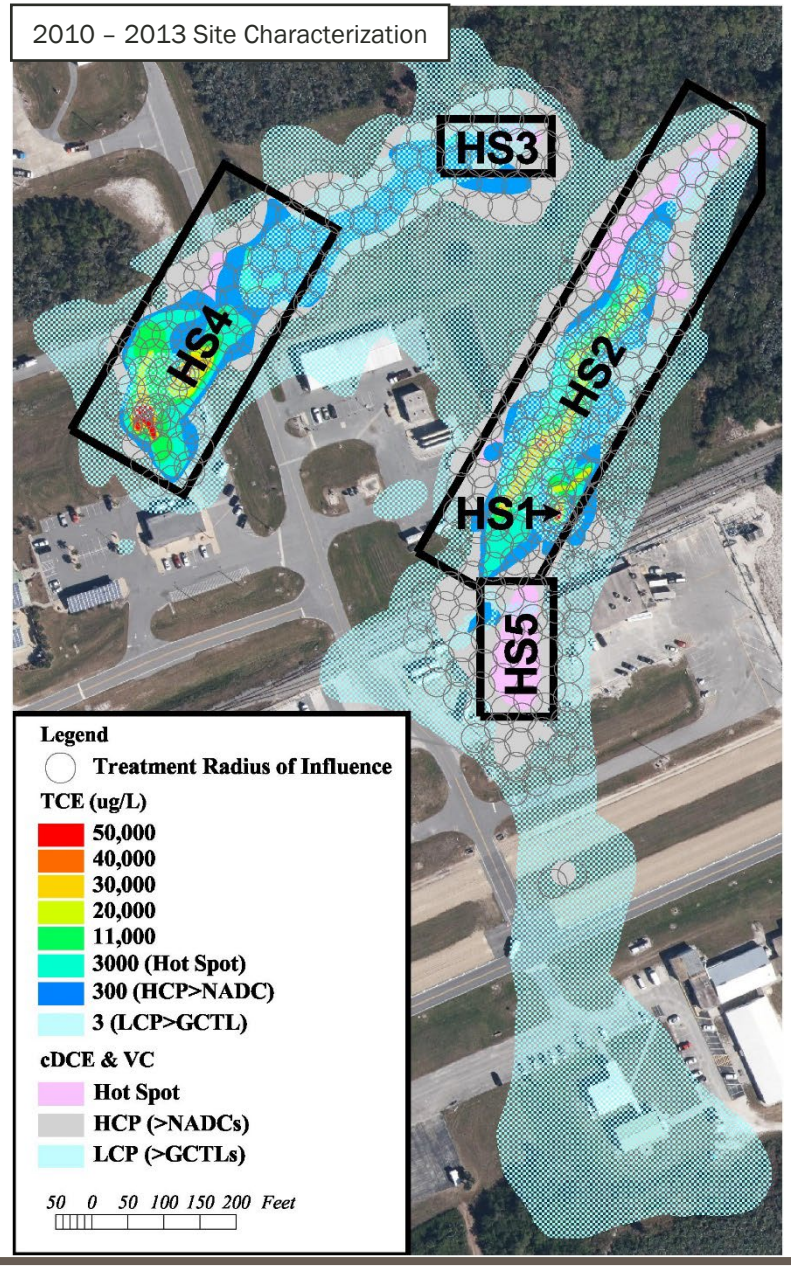
Groundwater contoured in three zones:

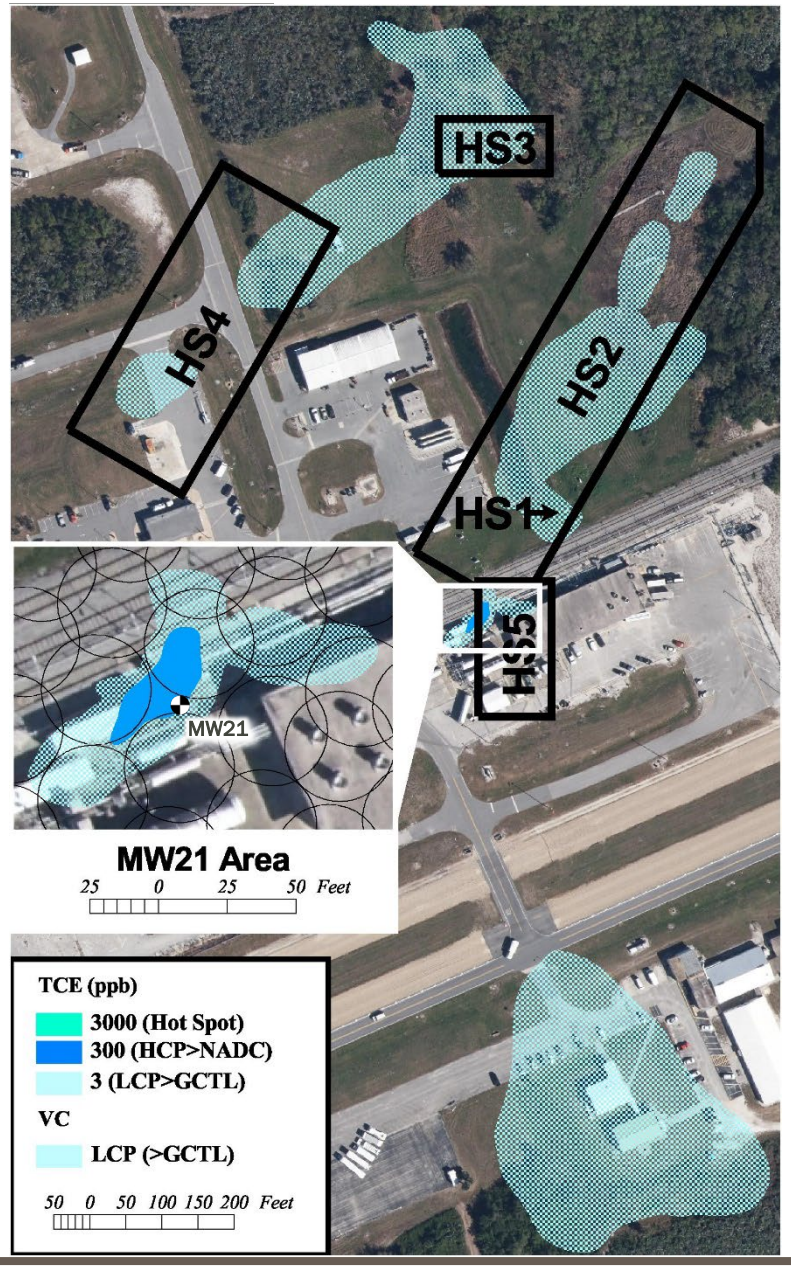
1) Water table to 25' bls
2) Above interbedded layer includes wells with screened interval between 40' to 50' bls
3) Below interbedded layer includes wells with screened interval between 50' to 85' bls

Observations:

- All zones have groundwater divide in the area of the Crawlerway.
  - Southern groundwater flow south of the Crawlerway
  - Northeastern and northwestern flow north of the Crawlerway.

Site History: Past and Current Plume





2021 – Post AS IM

- Excluding the MW21 area
  - IM objective was achieved; Concentrations <NADCs
  - Maximum concentrations by VOC in µg/L

VOC	December 2021	Site Characterization
TCE	290	191,000
cDCE	250	24,000
VC	40	3,400

  - Plume footprints

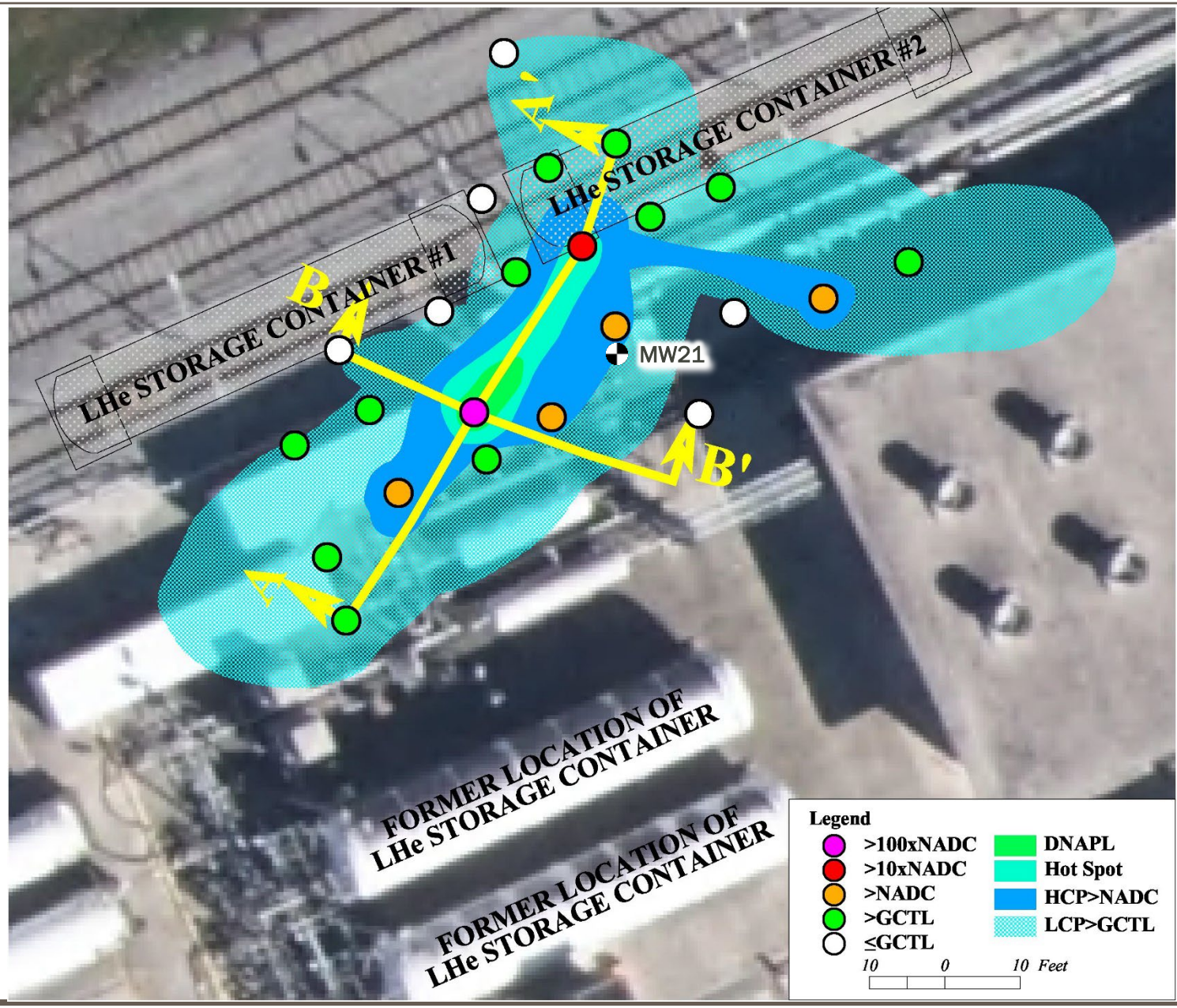
Plume	December 2021	Site Characterization (acres)
LCP	5.2 acres	12.5
HCP	664 ft^2	5.8
Hot Spot	199 ft^2	2.0
Source	50 ft^2	0.6

MW21 area has HCP, Hot Spot, and Source from March '21 DPTs

  - MW21 Area Inset
    - MW21 screened 10 to 20 ft bls
    - AS Radius of Influence shown
    - Sparging depth approximately 50 ft bls
    - Ineffective to treat shallow contamination

MW21 Area Site Characterization Overview

- A supplemental assessment was conducted under a Site Characterization to delineate the HCP that is present in the MW21 Area
  - Two DPT events in June 2020 and March 2021
  - Collected 192 groundwater samples at 23 locations ranging from 6 to 20 ft bls
  - VOC exceedances of GCTL, NADC, 10xNADC, 100xNADC
    - Freon-113 was not detected in any samples
- Results of Site Characterization showed:
  - Total VOCs HCP footprint is 839 ft^2 with impacts from 8 to 16 ft bls
  - TCE Hot Spot area is 199 ft^2
  - Localized TCE source zone of 50 ft^2 at DPT430
  - Total VOC mass exceeding NADCs estimated to be 3.9 pounds
- Consensus was reached for the Site Characterization during September 2022 KSCRT meeting:
  - The CCB MW21 Area is adequately characterized for IM implementation (2209-M02, 2209-D02)
  - Proceed with the Remedial Alternatives Evaluation with retained technologies (2209-M02, 2209-D03)
  - The Corrective Action Objective is to reduce the COC concentrations to below NADC in the MW21 Area via an interim measure to support transition to MNA (2209-M02, 2209-D04)



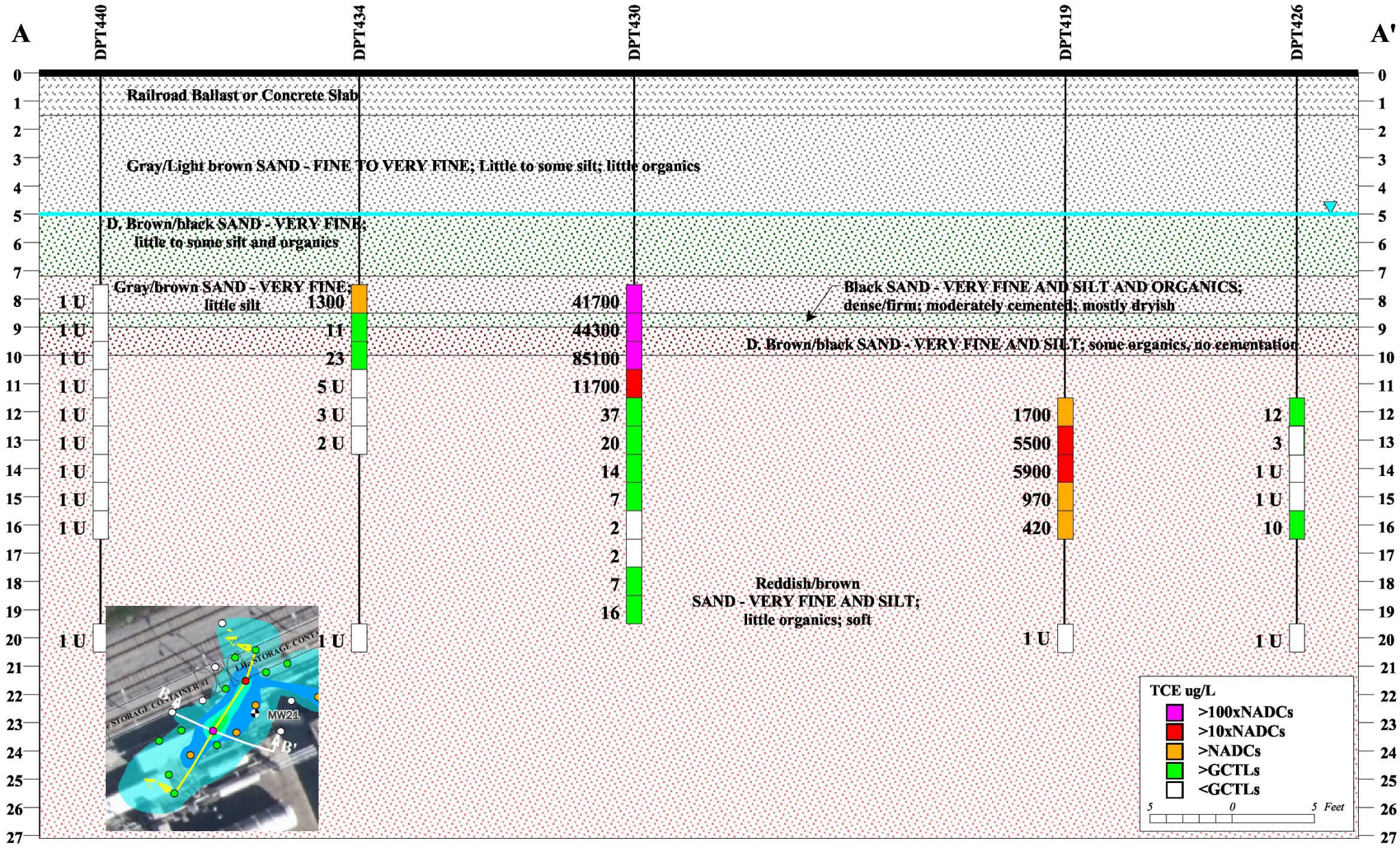
MW21 Area Lithology

Depth	Description	Photo
1.5’ to 5.0’	Gray/ light brown SAND - FINE TO VERY FINE; little to some silt; little organics	No Photo
5.0’ to 7.25’	Dark brown/black SAND – VERY FINE; little to some silt and organics	
7.25’ – 8.50’	Gray/brown SAND FINE TO VERY FINE; little silt	
8.5’ – 9.0’	Dark brown/black SAND – VERY FINE, SILT, AND ORGANICS. Dense/firm. Moderately cemented	
9.0’ – 10.0’	Dark brown/black SAND - VERY FINE AND SILT; little organics. No cementation	
10.0’ – 20.0’	Reddish brown SAND-VERY FINE AND SILT; little to some organics	

- Lithology based on soil core collected at DPT419 within MW21 treatment area
- Target contamination depth is 5 to 20 ft bls (Source zone is between 8 to 11 ft bls)
- Depth to groundwater is approximately 5 ft bls

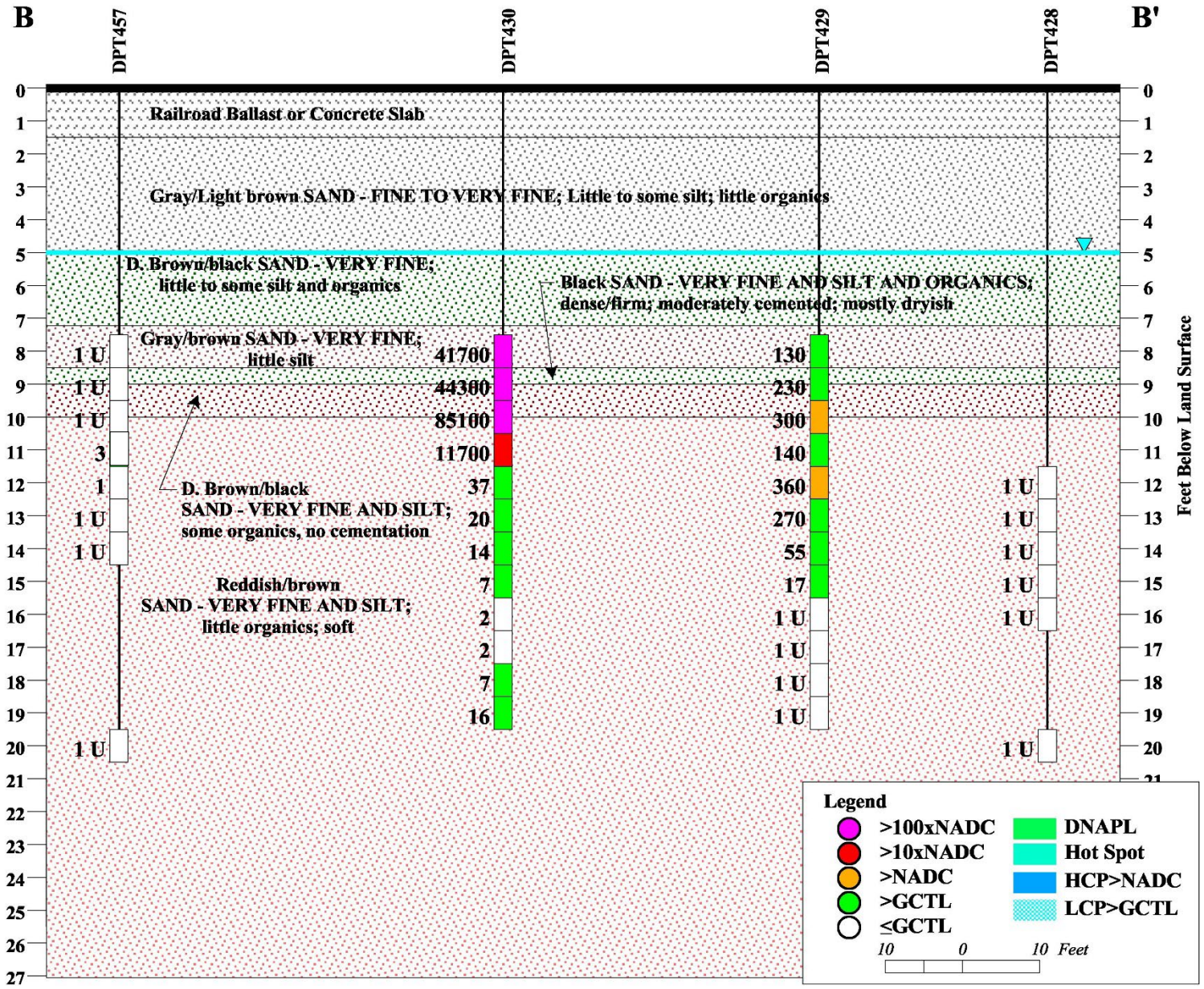
Cross Section A-A'

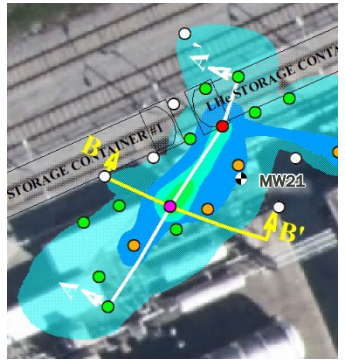
- TCE impacts for A - A' extend to 16 ft bls at DPT419 at >NADC concentrations
- Plume is shallower on southern side with TCE impacts extend to ~12 ft bls at DPT430 at >10x NADC concentrations
- On northern side, plume is deeper with TCE impacts extend to ~16 ft bls at DPT419 at >NADC



Cross Section B-B'

- TCE impacts for B - B' extend to ~13 ft bls at DPT429 at >NADC concentrations
- No TCE impacts >NADC at DPT457 and DPT428 on western and eastern side
- DPT430 (shared with A – A') has highest TCE concentrations to ~12 ft bls





MW21 Area Remedial Alternatives Evaluation Overview

- A RAE was conducted to evaluate the technologies retained during the Site Characterization
- During the RAE it was noted that several factors favored Alternative 3 including:
  - Facility infrastructure and future construction
  - Comparable costs
  - EZVI will more aggressively target the source area
  - Minimizes impact surrounding Building K7-468 infrastructure
  - Bioremediation injections have been successful at KSC
- Consensus was reached for the RAE during the September 2022 KSCRT meeting:
  - In Situ Bioremediation and EZVI in source area (Alternative #3) as the selected alternative for MW21 area at CCB.
    - A VO/EZVI injection IM will be conducted at the MW21 Area to treat the HCP/HS/SZ to support transition to MNA (2209-M02, 2209-D05)
  - The Team reached consensus to prepare an ADP and Implementation Work Plan for the IM and present to the KSCRT. Both documents will be submitted to FDEP (2209-M02, 2209-D06)

Alternative 1 *Air Sparge*	• Air sparge with utilization of existing infrastructure • Operation of SSDS
Alternative 2 *In Situ Bio without EZVI*	• In situ bioremediation by injection without EZVI • Operation of the SSDS • Bioaugmentation if necessary
Alternative 3 *In Situ Bio with EZVI*	• In situ bioremediation by injection with EZVI • Operation of SSDS • Bioaugmentation if necessary

Retained technologies evaluated during the RAE

Interim Measures Work Plan Outline

Overview

- IM Objective is to reduce groundwater concentrations to below NADC within the MW21 area to support transition to LTM with rest of site
  - Constituents of concern are TCE, cDCE, VC
  - IM will target the HCP, HS, SZ
- Build on the design presented in the RAE taking into consideration any site-specific or contractor-specific considerations that might impact the IM
- Establish an exit strategy and transition into LTM with rest of site

Supplemental Attachments

- Summary Write-up
- Tables
  - Table 1: Summary of Injection Plan
  - Table 2: Groundwater Performance Monitoring Plan
  - Table 3: Air Performance Monitoring Plan
- Attachments
  - Attachment A: KSCRT Meeting Minutes
  - Attachment B: CCB MW21 IMWP ADP
  - Attachment C: Remediation Product Use Acceptance Letters P
  - Attachment D: Design Calculations
  - Attachment E: Design Cost Estimate and Supporting Information
  - Attachment F: Sitewise Analysis

Technology Description

- IM consists of one injection event to promote in situ biotic and abiotic reductive dechlorination processes
  - Injection substrates include **emulsified zero valent iron (EZVI)** and **emulsified vegetable oil (EVO)**
  - Reductive dechlorination processes involve replacing chlorine atoms through biotic and/or abiotic processes with hydrogen forming more reduced dechlorination products
  - Additional injection materials include sodium bicarbonate (pH buffer), KB-1 Plus (microbial culture), and KB-1 Primer (promote anaerobic conditions) as an amendment based on site conditions and baseline sampling

EZVI in Source Area

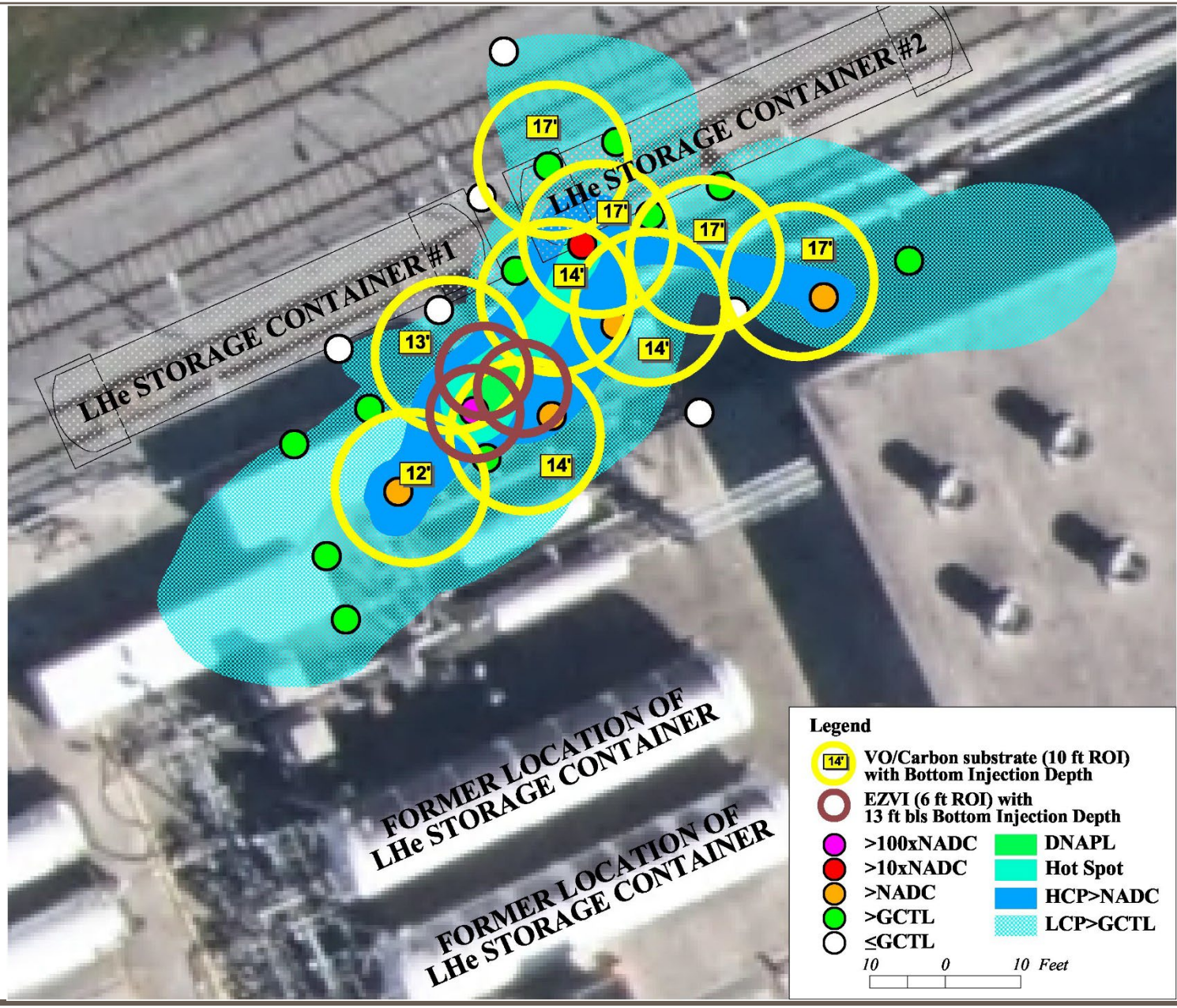
- EZVI works in situ as a "water-in-oil" emulsification
- The DNAPL is sequestered, dissolved into the "interior" aqueous phase, and undergoes reductive dehalogenation through abiotic and biotic processes
- Proposed EZVI product is Provectus EZVI-CH4
  - Formulation includes zero-valent iron (ZVI), food-grade vegetable oil (VO), water, and antimethanogenic reagent
  - Formulation per NASA patent, EZVI composed of 10% ZVI in product

EVO in HCP/HS

- EVO provides readily available carbon substrate to enhance the reductive dechlorination process
- Proposed EVO product is Provectus ERD-CH4 :
  - VO/carbon substrate mixture containing 60% fermentable carbon
  - Formulation including slow, moderate, and fast releasing substrates (e.g., glycerin, soluble lactic acid, and dissolved fatty acids), antimethanogenic reagent, and pH control
  - Requires water for on-site mixing

Treatment Layout and Configuration

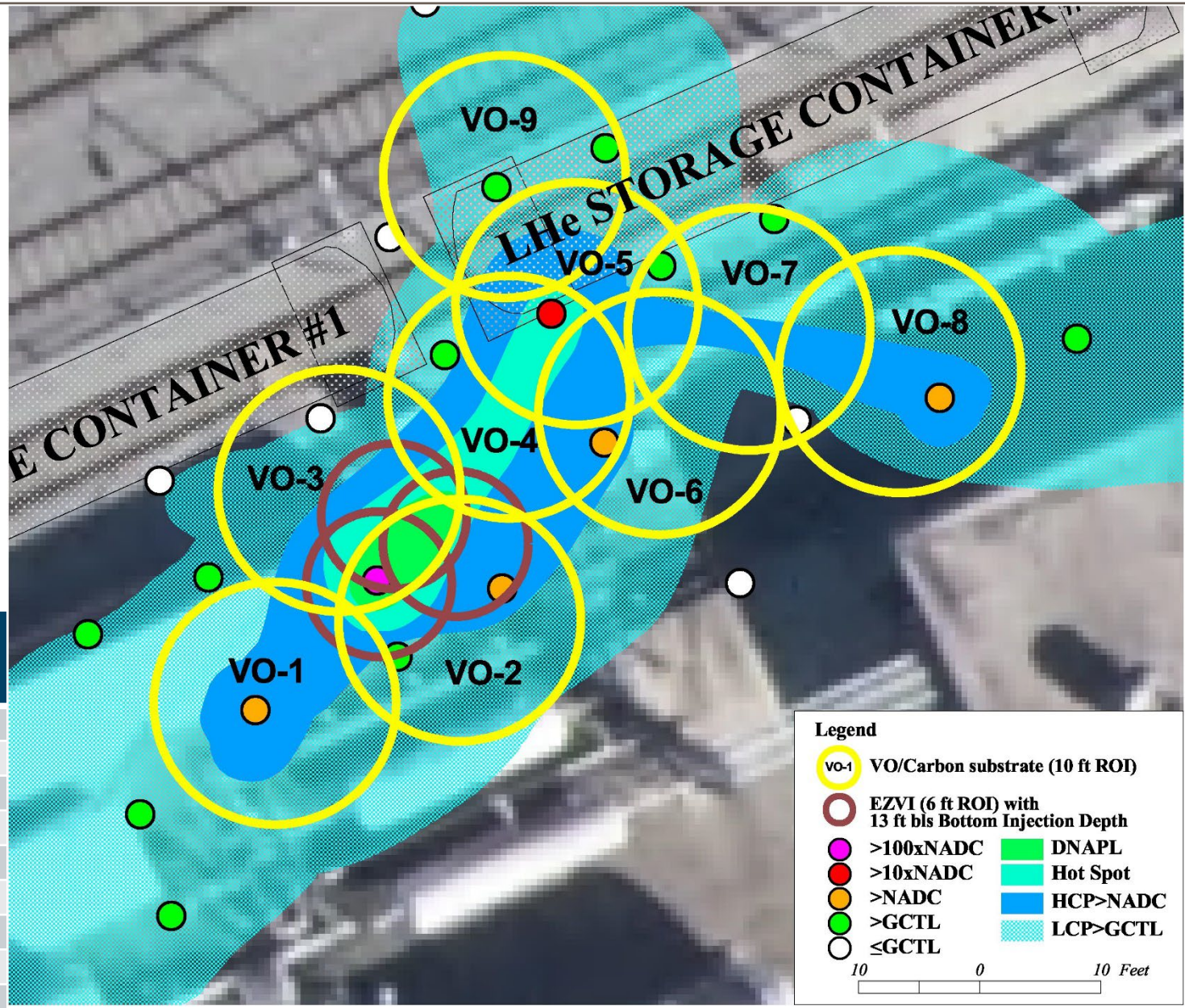
- Nine EVO injection points at approximately 10’ ROI (yellow circles)
- Three EZVI injection locations at approximately 6’ ROI (dark red circles)
- Overlap of EVO and EZVI in source area will provide enhanced coverage in highest contaminated area
- Locations are expected to be adjusted based on site conditions and infrastructure at time of implementation
- Injection method is via direct push
  - Upper injection depth is 7 ft bls with max VO treatment depths from 12 to 17 ft bls and EZVI max depth is 13 ft bls
  - 2-ft injection intervals (aka “lifts”) using bottom-up approach to 2-ft below water table



EVO Injection Details

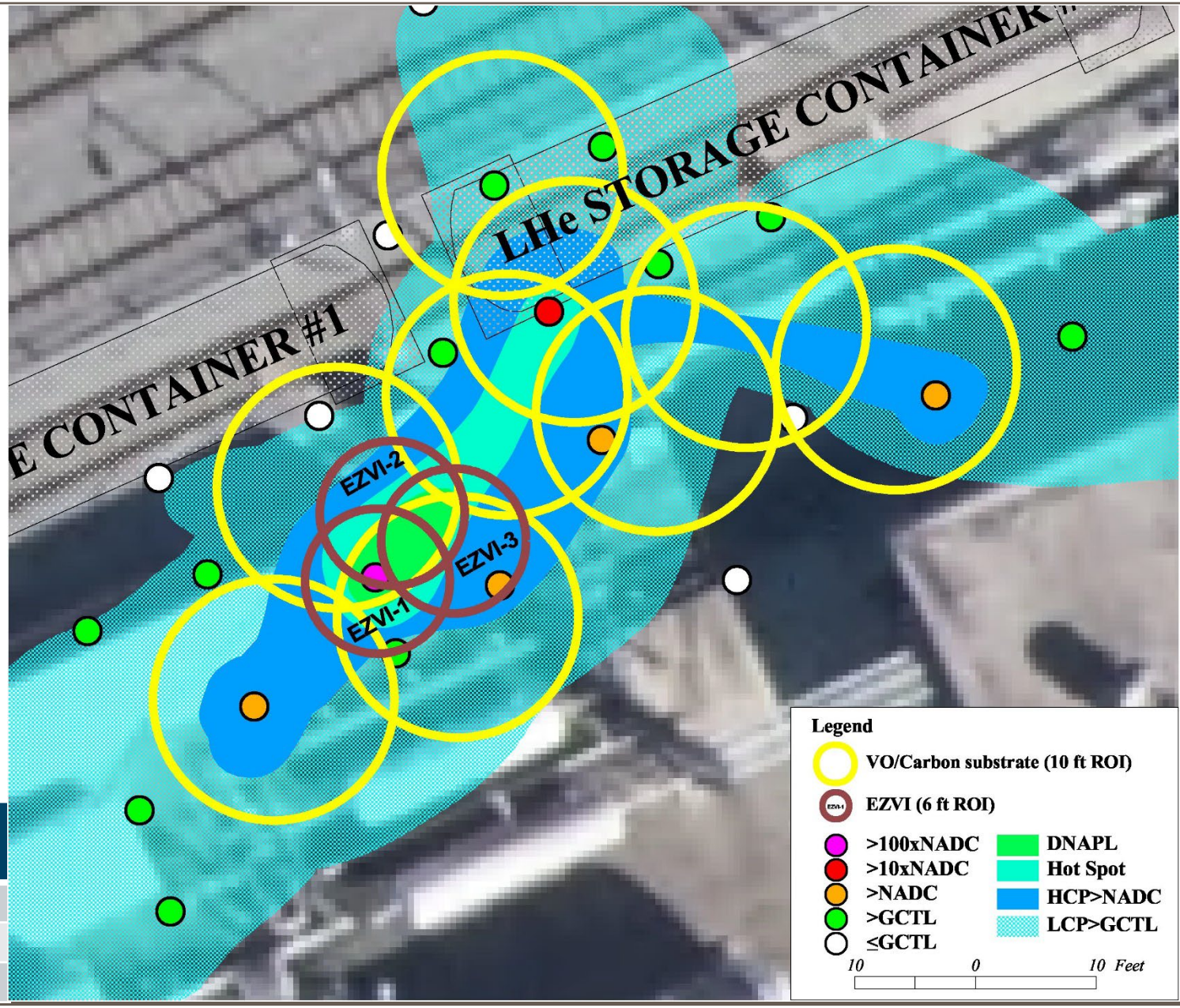
- The EVO injection range, intervals, and volumes are listed in table at bottom of slide
- Target pore space of EVO is 0.8%
  - Vendor recommendation based on 0.15 lb fermentable carbon per cubic foot
- EVO injections will occur in 2-ft injection intervals with each interval receiving 18 gallons of substrate
  - Injectate volumes include mixed water and bioaugmentation culture
- Estimated total injectate volume is 5,368 gallons (684 gallons of VO/carbon substrate mixture)
- Amendments to the formulation are based on baseline conditions and include:
  - pH adjustment using 500 mg of sodium bicarbonate per liter of pore volume based on comparable projects
  - Bioaugmentation culture KB-1 Plus (low pH)

Injection Location	Injection Range (ft bgs)	Lift Depth (ft bgs)	VO/ Lift (gal)	Injectate/ Lift (gal)	VO/ Location (gal)	Injectate/ Location (gal)
VO-1	7 – 12	8, 10, 12	18	141.3	54	424
VO-2	7 – 14	8, 10, 12, 14	18	141.3	72	565
VO-3	7 – 13	9, 11, 13	18	141.3	54	424
VO-4	7 – 14	8, 10, 12, 14	18	141.3	72	565
VO-5	7 – 17	9, 11, 13, 15, 17	18	141.3	90	706
VO-6	7 – 14	8, 10, 12, 14	18	141.3	72	565
VO-7	7 – 17	9, 11, 13, 15, 17	18	141.3	90	706
VO-8	7 – 17	9, 11, 13, 15, 17	18	141.3	90	706
VO-9	7 – 17	9, 11, 13, 15, 17	18	141.3	90	706



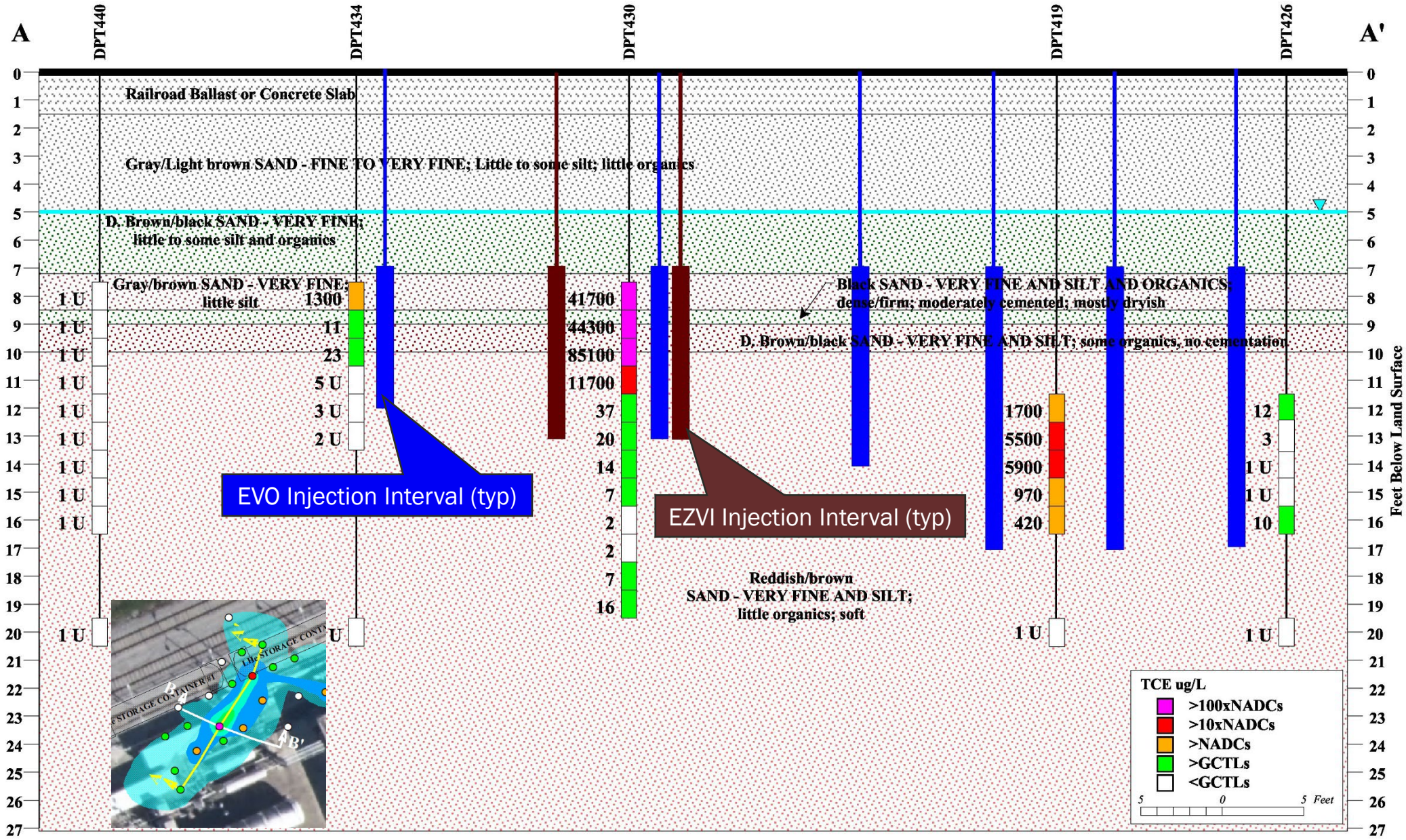
EZVI Injection Details

- The EZVI injection range, intervals, and volumes are listed in table at bottom of slide
- Target pore space is 8% as recommended by vendor
- EZVI injections will occur in 2-ft injection intervals with each interval receiving 41 gallons
- Estimated total EZVI volume is 369 gallons

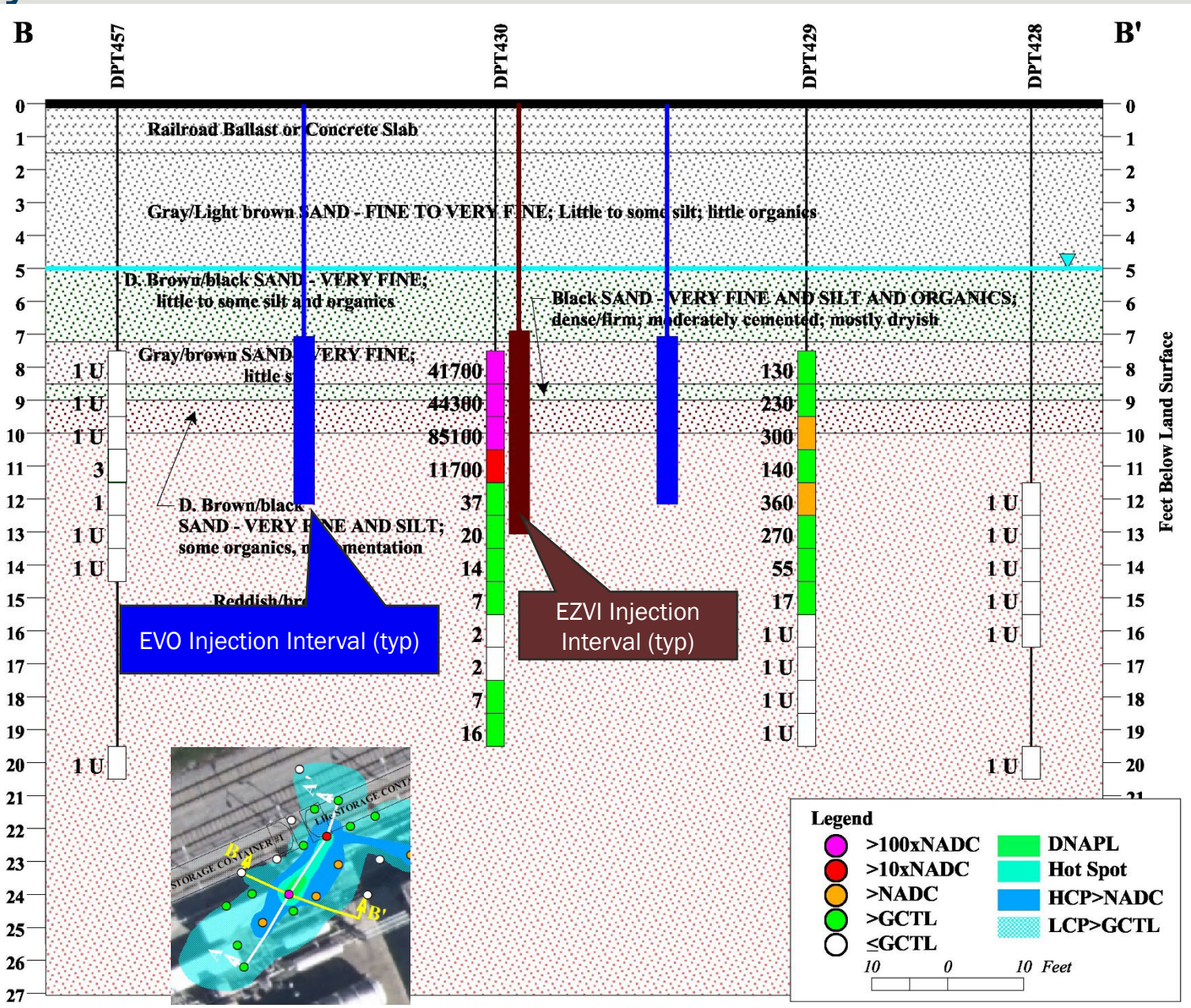


Injection Location	Injection Range (ft bgs)	Lift Depth (ft bgs)	EZVI/ Lift (gal)	EZVI/ Location (gal)
EZVI-1	7 – 13	9, 11, 13	41	123
EZVI-2	7 – 13	9, 11, 13	41	123
EZVI-3	7 – 13	9, 11, 13	41	123

Injection Layout – Cross Section A-A'



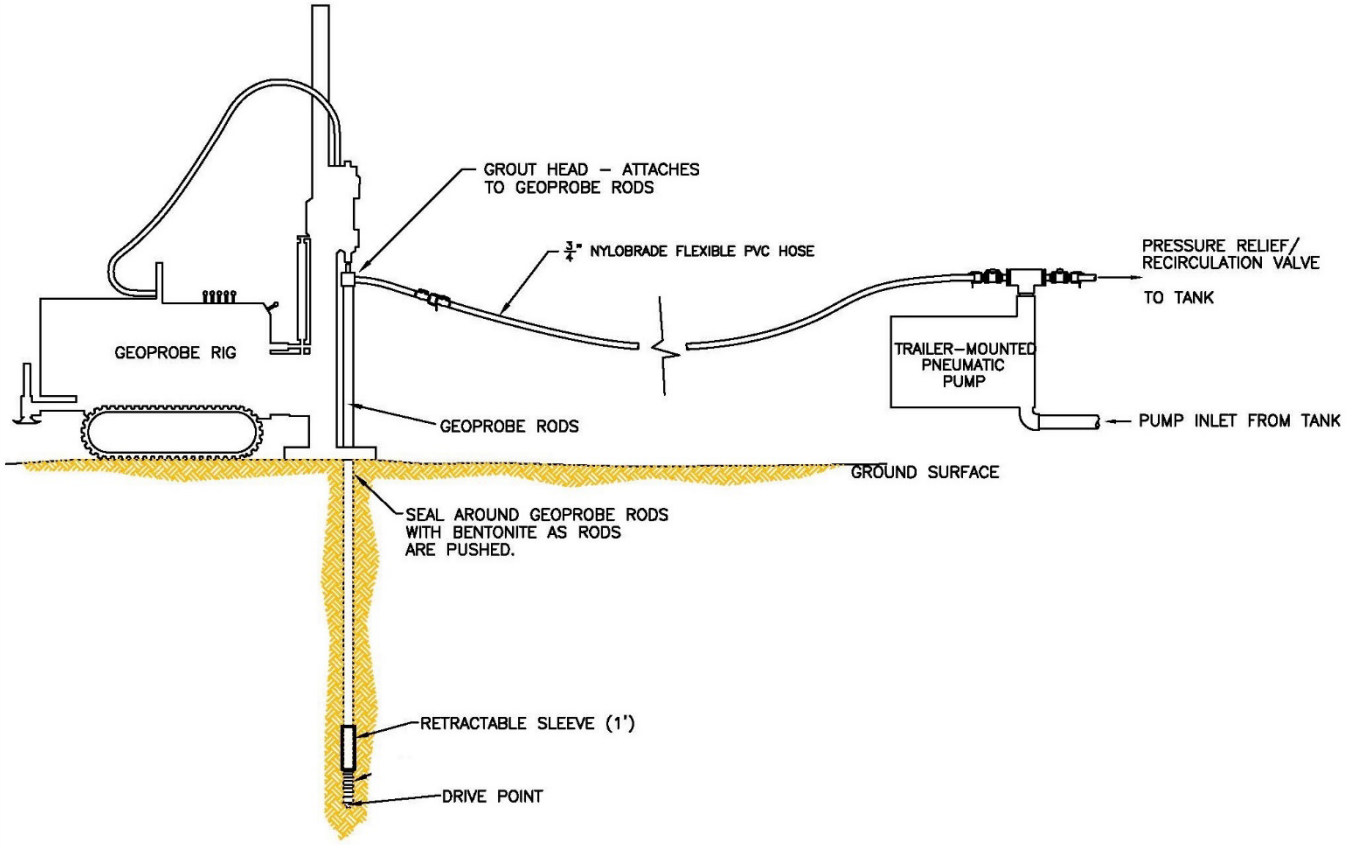
Injection Layout – Cross Section B-B'



Injection Method

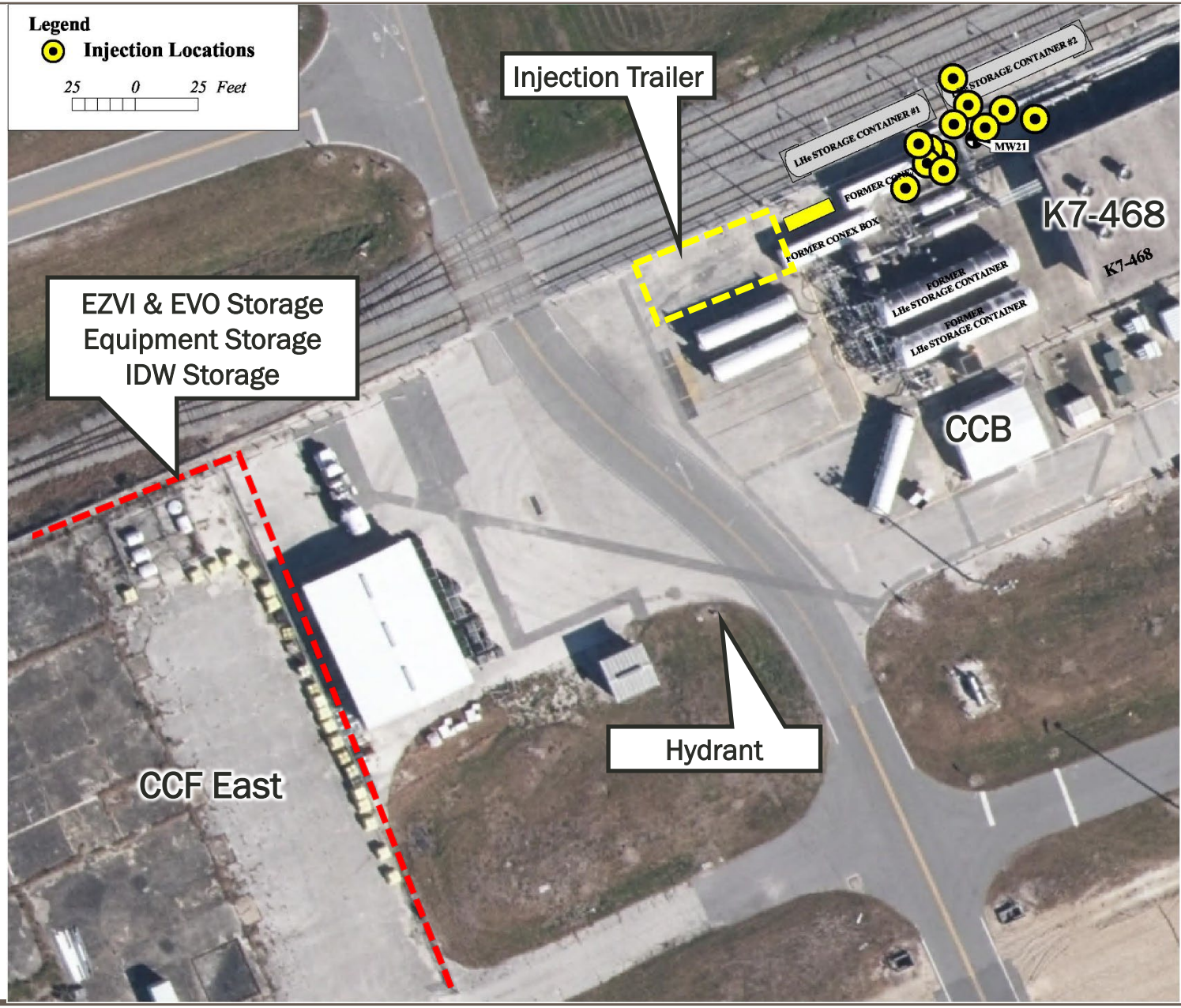
General injection method consists of:

1. Injections will be completed using a DPT rig
2. Mixing for EVO is completed in 500-gallon batches
3. The injection tool is driven to depth and then pulled back approximately 1 ft to open and expose the side discharge nozzle.
4. An air-operated diaphragm pump on an injection trailer is used to pump liquid through the geoprobe rods. The injection is completed by pulling upward by about 2 feet and injecting the pre-determined volume of amendment mixture.
5. After all the injection intervals are completed, the injection line is cleared by injecting potable water. The hole is plugged with bentonite when the injection is complete.



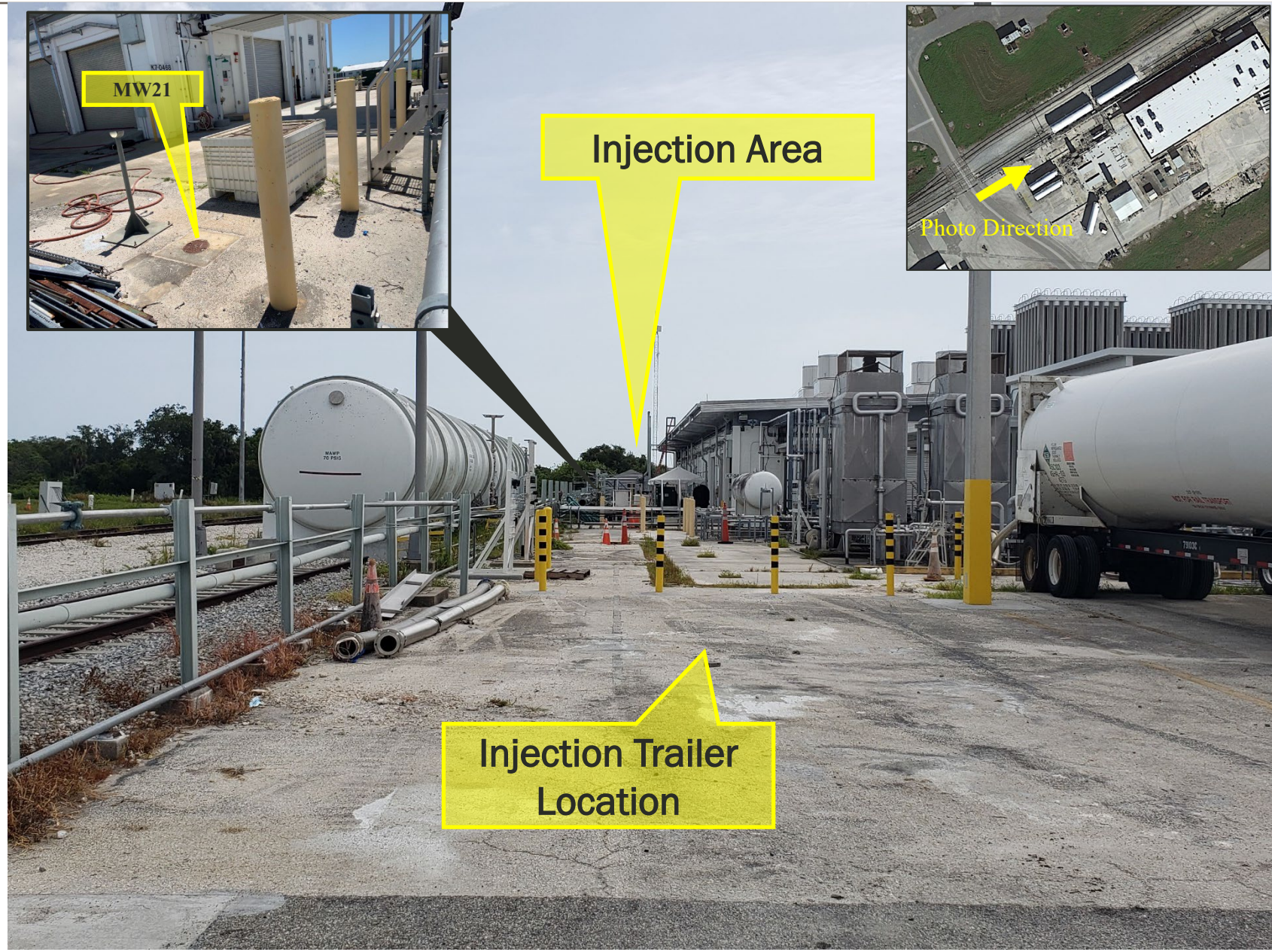
Site Layout

- Components Cleaning Facility (CCF) will be used for long term storage of materials and equipment supporting the IM including EZVI and EVO totes and IDW storage (red line)
- An injection trailer and a skid steer will be used to deliver material from CCF to the injection site
- The injection trailer will be temporarily located in the area located west of the injection area (yellow line)
  - Hoses from the injection trailer will run to the DPT rig
- Water will be sourced from the nearby hydrant
  - A backflow preventor will be installed and the hose can be temporarily disconnected when not in use
  - KB-1 Primer (sodium sulfite) will be added to reduce DO of the make-up water



Site Layout

- Belowground and aboveground utilities and infrastructure are a logistical concern and could cause potential access issues
- Close coordination with site personnel will be made to determine optimal time for implementation
- The injection trailer will be located adjacent to injection area
- Hose will be run between the two areas to deliver injectate from the totes to the DPT rig
- During injections
  - A temporary plug will be placed in MW21 to prevent daylighting from the well
  - During injections, the ground surface and outlets and manholes of storm sewers that could potentially be affected by injected material will be observed
  - If daylighting occurs, the injection pressure will be reduced until the daylighting stops.



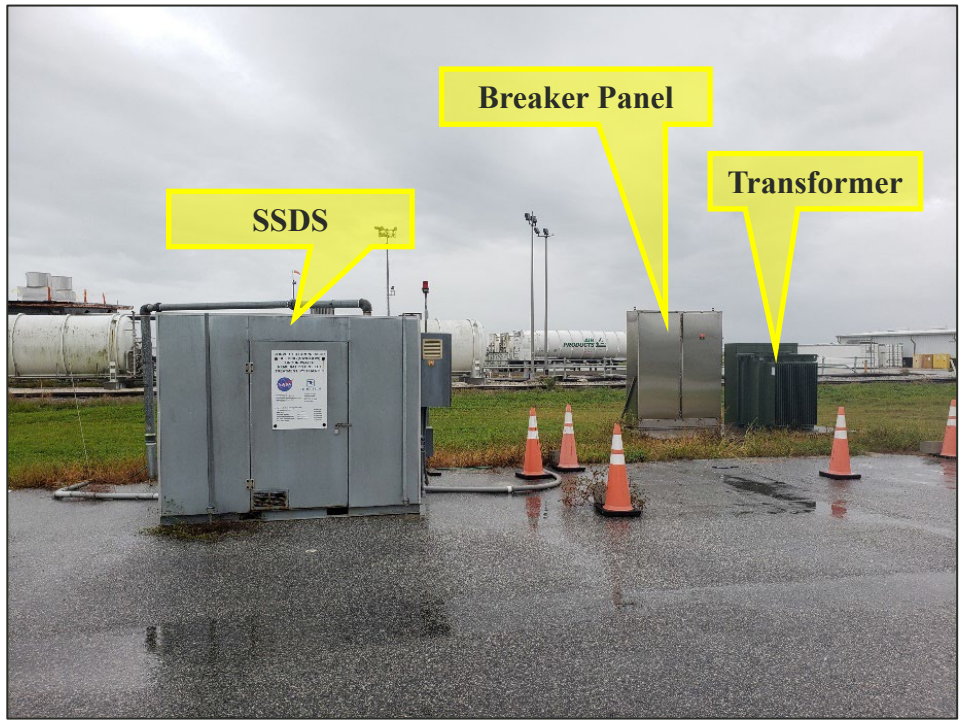
Permitting and Coordination

Permitting

- Required permitting during implementation phase
  - Excavation Permit
    - DPT underground injections will require utility locating and KSC excavation permit
  - KSC Environmental Checklist
  - Underground Injection Control (UIC) Permitting (discussed in later slides)
- Permitting not required
  - Site Plan
    - No modifications to site are planned
  - Well Construction and Abandonment Permit
    - Monitoring well construction not planned
  - Air Permit
    - Injections are not expected to generate significant emissions. All emissions will fall under KSC's Title V permit with FDEP
  - Stormwater Permit
    - Not required due to less than 1 acre disturbed during IM activities. Most activity will occur on pavement minimizing the disturbance of vegetation

SSDS Operation

- The SSDS will be operated to prevent any vapor intrusion in Building K7-468
  - System was used for previous air sparge IM that depressurized the vadose zone beneath K7-468 to prevent sparged vapors from potentially intruding into building (Exhaust is located 500’ east of K7-468)
- SSDS is planned to be operated for two years to conservatively extract any subsurface vapors
- The IM is not expected to yield a significant amount of vapors since the treatment is completed in situ and does not promote active volatilization of contaminants
  - In addition, the total VOCs estimated in the treatment area are significantly less than the Title V Permit HAP limits (3.9 pounds total in plume)
- Initial repairs are included in detailed cost estimate to account for any startup repairs



Schedule and Coordination

- Estimated duration of injection fieldwork is 1 to 2 weeks
  - Site setup and material delivery = 1 to 2 days
  - Injection activities = 3 to 5 days
  - Demobilization = 1 to 2 days
- Coordination with the site personnel including personnel at K7-468 will be made to inform of the IM activities
- Logistics will be a concern given the ongoing construction and modification to the site infrastructure
  - IM activities will be completed during an optimal time to have area access for injection trailer
- Estimated cleanup timeframe:
  - Significant contaminant reduction in SZ (where EZVI is injected) is expected within the first 2 years
  - Significant contaminant reduction in the HCP/HS (where EVO is injected) is expected after 2+ years
  - Groundwater performance monitoring planned to be conducted for up to five years after IM implementation, as this is the projected timeframe for groundwater concentrations to reach NADCs to allow subsequent transition to LTM
  - This timeframe is based on other similar remediation sites at KSC where injection IMs were completed.

UIC Permitting

- UIC permitting pertains to the injection of fluids into the subsurface while protecting Florida's underground sources of drinking water
- In accordance with 62-528.630(2)(c), F.A.C., Class V injection-type aquifer remediation wells are exempt from the permitting requirements of Rule 62-528.635, F.A.C., when authorized by an FDEP-approved Remedial Action Plan or other enforceable mechanism
- In line with a similar injection IM completed at GSRY (SWMU #010), approval by FDEP of this IMWP will constitute the granting of a Class V injection well construction permit
  - If needed and determined at time of approval, the FDEP UIC inventory notification form will be completed
- Proposed UIC parameters will be collected from five monitoring wells include total recoverable petroleum hydrocarbons (TRPH), iron, manages, sodium, chloride, 1,4-dioxane, ethylene oxide, and foaming agents (non-ionic surfactants) based on requirements stated in the acceptance letters for the proposed remediation products
- UIC monitoring will be discontinued if after two consecutive sampling events, concentrations are less than baseline sampling results or the KSC Upper Range of Background

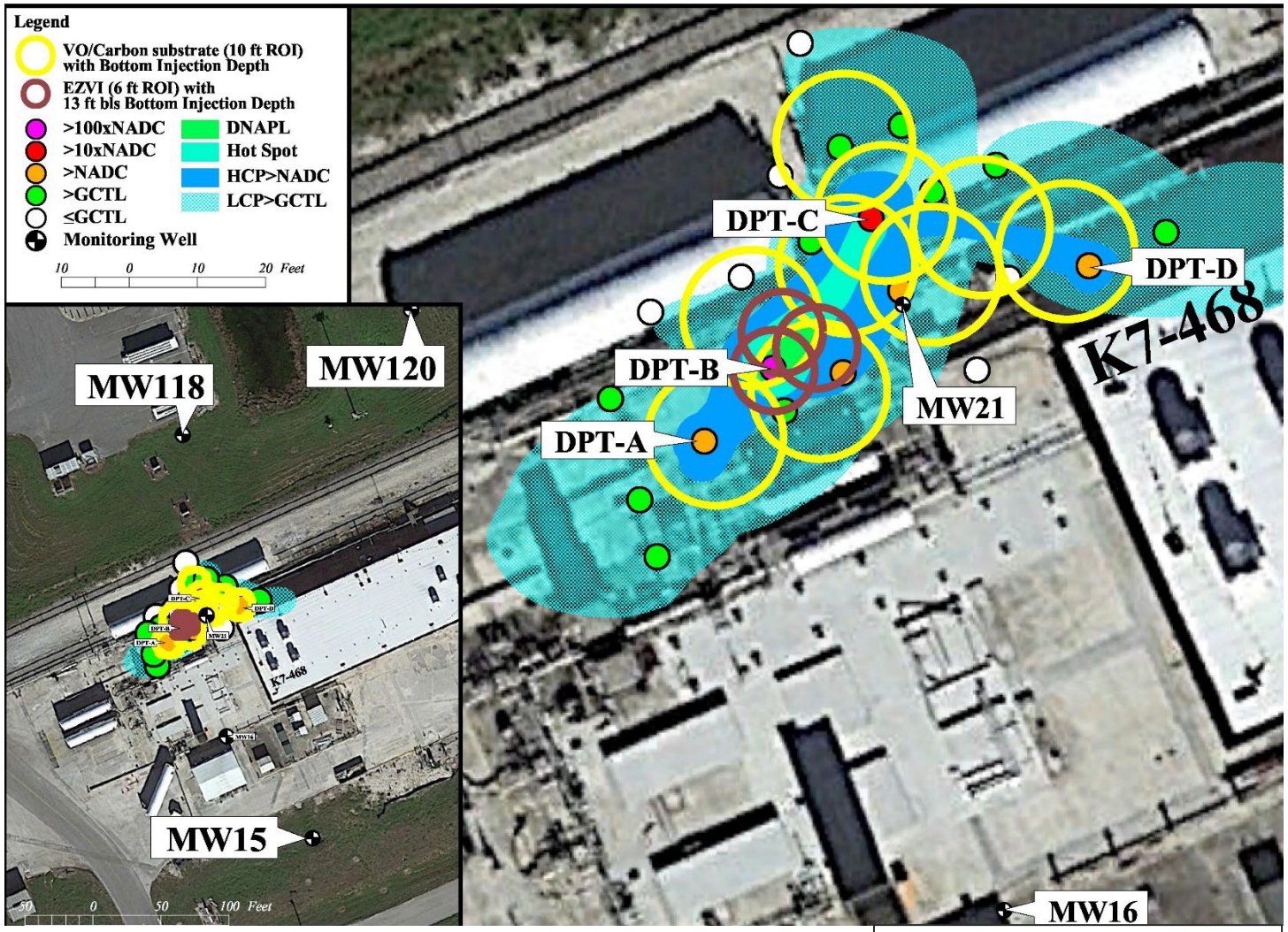
Baseline Performance Monitoring

Groundwater Baseline Event

- A groundwater baseline event will be conducted to provide a basis for performance monitoring
- The baseline event consists of:
  - Sample MW21 (screened 10-20 ft bls) for VOCs, UIC parameters, *Dehalococcoides* species (Dhc), dissolved gases (methane, ethane, and ethene), and total organic carbon (TOC)
  - Sample four DPT locations covering the HCP at 8, 12, 16, and 20 ft and 24 ft bls sample at DPT-B for VOCs
    - Depths are midpoints and collected with a 4 ft screen
  - Dhc, dissolved gases, and TOC will be analyzed at historically highest contaminated depths at each location: DPT-A (8 ft bls), DPT-B (10 ft bls), DPT-C (12 ft bls), DPT-D (14 ft bls)
  - Sample MW15, MW16, MW118, and MW120 (all screened 10-20 ft bls) for UIC parameters
- Following DPT depths were included:
  - The 24 ft bls depth was added based on RAE comments to define the vertical extent of plume at DPT430
  - The 8 ft bls depth was added to determine shallow extent of contamination (i.e., at DPT C aka DPT419)

Air Baseline Event

- An air baseline event will be conducted to document the vapor conditions before IM start
- The event will consist of 8 air sample locations nearby and in Building K7-468

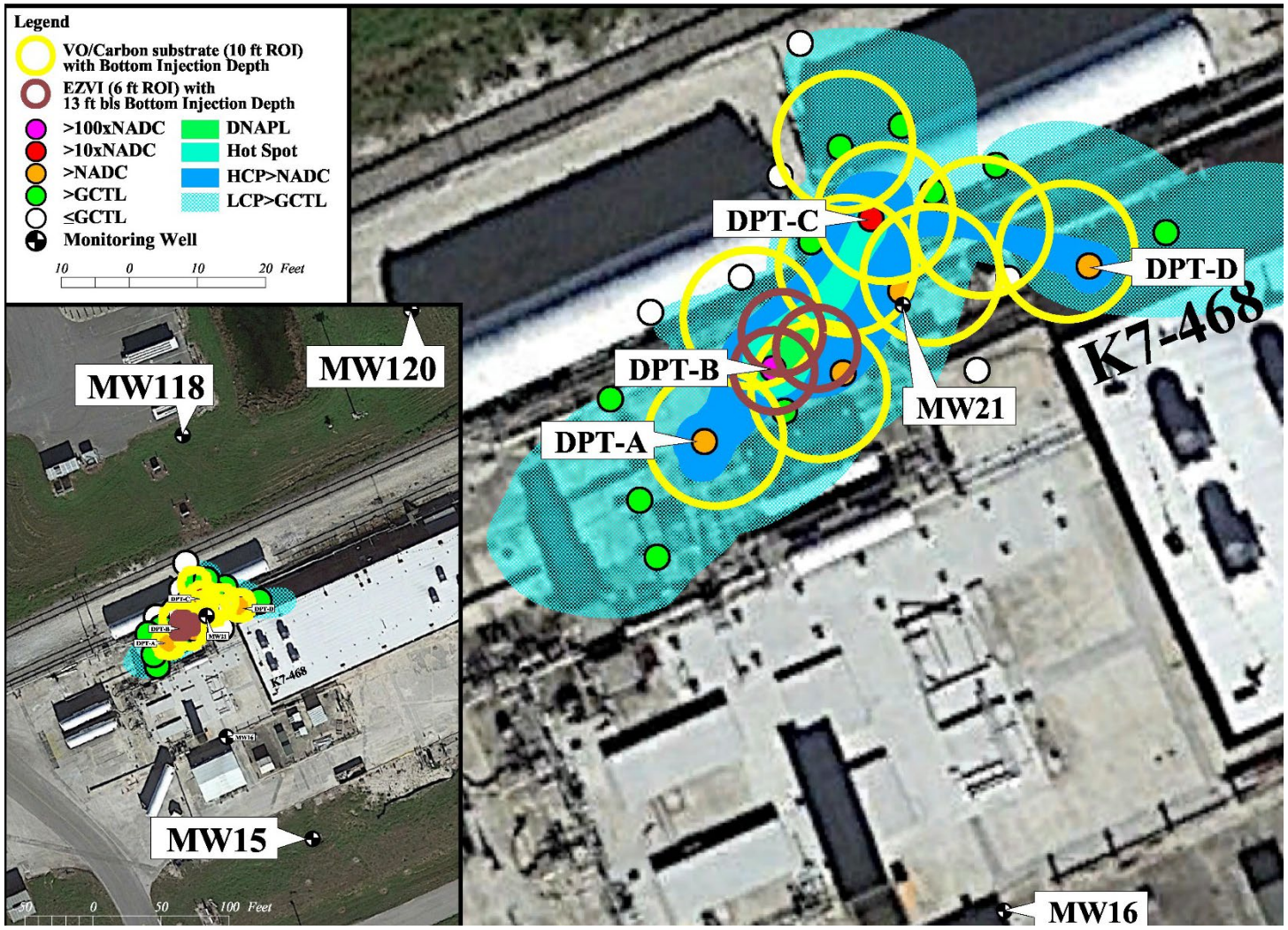


Note: DPT-C will be sampled as close as possible to previous DPT location. Physical limitation is present due to LHe Containers.

Groundwater Performance Monitoring

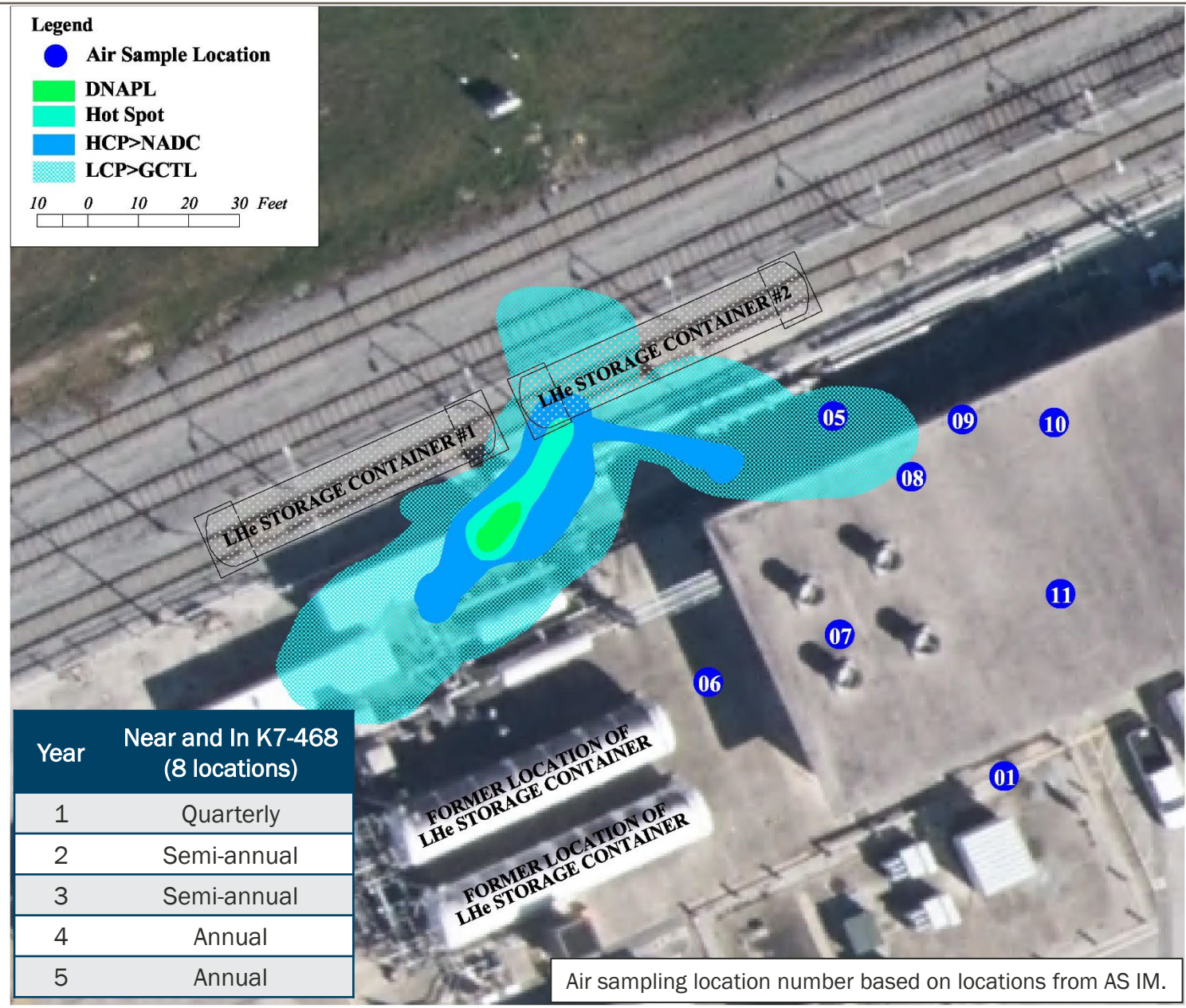
- Performance monitoring events will be conducted to evaluate IM performance
- Performance monitoring will include sampling MW21 and four DPT locations for VOCs, dissolved gases, and TOC
- The planned performance monitoring schedule is shown below
- If MW21 becomes comprised from the injections during performance monitoring, an additional DPT location (DPT-E) adjacent to MW21 will be added to the performance monitoring plan
- Specific sampling will be conducted as follows:
  - Dhc annually at MW21
  - UIC parameters at MW15, MW16, MW21, MW118, and MW120 quarterly Year 1, semi-annualy Years 2/3, and annually for Years 4/5
  - Dhc, dissolved gases, and TOC annually at historically highest contaminated depths at each DPT location: DPT-A (8 ft bls), DPT-B (10 ft bls), DPT-C (12 ft bls), DPT-D (14 ft bls)

Year	MWs	DPT Locations
1	Quarterly	Annual 4 locations (4 depths each)
2	Semi-annual	Annual 4 locations (4 depths each)
3	Semi-annual	Annual 4 locations (4 depths each)
4	Annual	Annual 4 locations (4 depths each)
5	Annual	Annual 4 locations (4 depths each)



Air Performance Monitoring

- Air monitoring events will be conducted to evaluate IM performance
- Air samples will be collected at 8 locations near and in Building K7-468
  - Locations 7 to 11 will be sampled inside the building
- Samples collected with summa canisters using 8-hr time weighted average and analyzed for VOCs (TO-15)
- Air monitoring is planned to continue to Year 5 to confirm vapor intrusion is not occurring; however, air sampling will cease if results justify

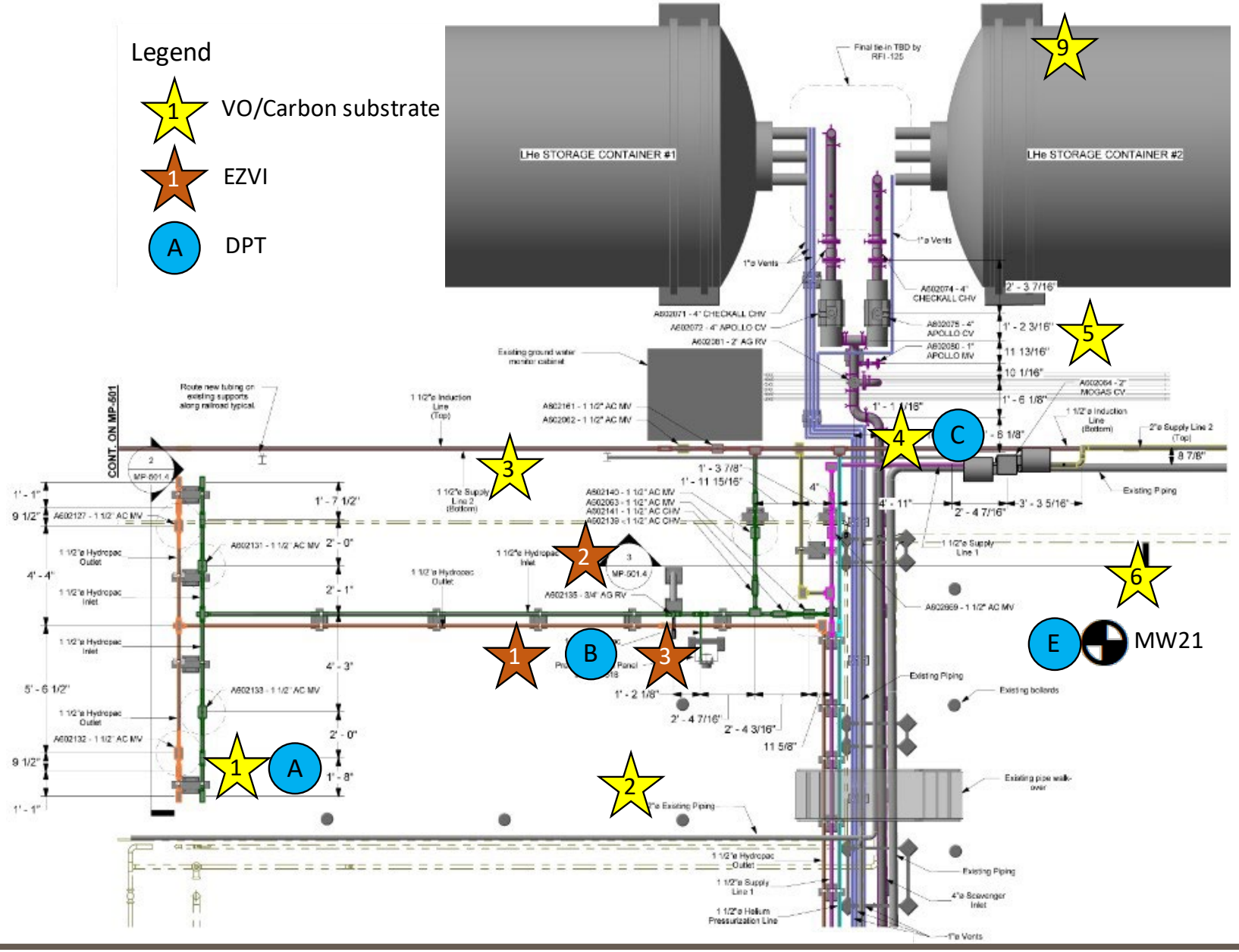


Year	Near and In K7-468 (8 locations)
1	Quarterly
2	Semi-annual
3	Semi-annual
4	Annual
5	Annual

Air sampling location number based on locations from AS IM.

Current Site Conditions

- VO-7, VO-8, and DPT-D are located beyond the extents of the image to the right
  - No access issues for these locations
- Dolly DPT rig will be used for VO-1, VO-2, VO-3, EZVI-1, EZVI-2, EZVI-3, DPT-A, and DPT-B
- DPT rig capable of angled drilling will be required for VO-4, VO-5, VO-9, and DPT-C
  - Entry points will be offset for access
- VO-6, VO-7, VO-8, DPT-D, and DPT-E can be accessed by either DPT rig



Consensus/Path Forward

- Test Consensus:
  - Accept the IMWP design for in situ reductive dechlorination injection treatment of the HCP/HS/SZ at the MW21 Area and to proceed with the develop of an Implementation Work Plan to plan and facilitate the IM

ATTACHMENT C

REMEDIATION PRODUCT USE ACCEPTANCE LETTERS

FLORIDA DEPARTMENT OF Environmental Protection

Bob Martinez Center
2600 Blair Stone Road
Tallahassee, FL 32399-2400

Ron DeSantis
Governor

Jeanette Nuñez
Lt. Governor

Shawn Hamilton
Secretary

April 29, 2024

Via Electronic Mail to Troy Lizer at troy.lizer@provectusenv.com

Troy Lizer
Technical Director
Provectus Environmental
721 Frana Clara Street
Louisville, OH 44641

Re: **EZVI/ EZVI-CH4™**
Innovative Technology Application Acceptance Letter

Dear Mr. Lizer:

The Florida Department of Environmental Protection's Division of Waste Management (Division) hereby accepts *EZVI/ EZVI-CH4™* for remediation via reductive dechlorination of highly substituted halogenated hydrocarbons (particularly, trichloroethylene [TCE] and tetrachloroethylene [PCE]) and other suitable contaminants.

The accepted use of *EZVI/ EZVI-CH4™* is subject to a minimum of 1:1 pre-injection dilution (1-part *EZVI/ EZVI-CH4™*: 1-part water [by weight] dilution prior to use).

Enclosure 1 is a voucher for a confidential disclosure of the proprietary ingredients submitted by Provectus Environmental Products. Enclosure 2 contains regulatory information. For in situ injections of *EZVI/ EZVI-CH4™,* there are underground injection control regulations that must be observed.

Since injection-type, in situ aquifer remediation is likely to be the most common application of *EZVI/ EZVI-CH4™*, the bulk of the regulatory requirements discussed herein will be directed to that topic.

For vadose zone remediation, such as soil blending, the underlying groundwater may be affected by the leaching of the *EZVI/ EZVI-CH4™* formulation. Although this remediation approach is not subject to the regulatory requirements of Chapters 62-528 and 62-520, Florida Administrative Code (F.A.C.), a regulatory advisory for Remedial Action Plan preparers and reviewers is included in Enclosure 2 for assistance with compliance with Chapters 62-780 and 62-777, F.A.C.

The Florida Department of Environmental Protection (FDEP) does not provide endorsement of specific or brand name remediation products or processes, however, it does recognize the need to determine

their acceptability from an environmental standpoint with respect to applicable rules and regulations, and the interests of public health safety. Vendors are responsible for marketing their product or process on its merits regarding performance, cost, and safety in comparison to competing alternatives in the marketplace. This acceptance letter shall not be construed as either an approval of the product or a certification of its performance.

Additionally, Department acceptance of any product or process does not imply it has been deemed applicable for any particular cleanup situation, or that it is preferred over other treatment or cleanup techniques. A site-specific evaluation of applicability should be considered for any product or process, whether conventional or innovative, and adequate site-specific design details must be provided in a Remedial Action Plan.

It is not a requirement that a remediation product or process obtain an acceptance from the Department in order to be proposed for use in a site-specific Remedial Action Plan, but the plan must contain information to show that it meets all applicable and appropriate rules and regulations. For *EZVI/ EZVI-CH4™*, a copy of this acceptance letter containing regulatory compliance advice should be included in the appendix of each site-specific Remedial Action Plan that proposes its use.

The Department reserves the right to revoke its acceptance of a product or process if any component has been falsely represented.

This acceptance letter is valid for a period of ten (10) years from the issuance date above. At the end of the ten-year period, the acceptance can be renewed subject to an updated review of the product's use and formulation. The purpose of the updated review is to determine if the use conditions and monitoring requirements for this product need to be modified.

If you have any questions, contact Elena Compton at (850) 245-8911, through Mail Station 4535 at the letterhead address, or by e-mail at Elena.Compton@FloridaDEP.gov.

Sincerely,

Elena Compton, M.S., P.E.
Professional Engineer III
District Support Program, FDEP
850-245-8911

Enclosures: (1) Voucher; (2) Regulatory Information.

FLORIDA DEPARTMENT OF Environmental Protection

Bob Martinez Center
2600 Blair Stone Road
Tallahassee, FL 32399-2400

Ron DeSantis
Governor

Jeanette Nuñez
Lt. Governor

Shawn Hamilton
Secretary

April 29, 2024

Mr. Troy Lizer
Technical Director
Provectus Environmental
721 Frana Clara Street
Louisville, OH 44641

Re: **Proprietary Ingredients:** *EZVI/ EZVI-CH4™*

Dear Mr. Lizer:

The Division of Waste Management hereby acknowledges the submittal of a confidential disclosure by Provectus Environmental Products. The disclosure provided the proprietary ingredients and their concentrations in *EZVI/ EZVI-CH4™*.

Without this voucher for the disclosures, and the advice provided by the Division in Enclosure 2 based on its review of all the ingredients, users of *EZVI/ EZVI-CH4™* would not know how to comply with the requirements of Rule 62-520.310(8)(c), Florida Administrative Code (F.A.C.), for a temporary Zone of Discharge.

For underground injection control purposes, remediation plans proposing the use of *EZVI/ EZVI-CH4™* must indicate the volume and complete chemical composition of the fluid to be injected. Since the identities of some ingredients are proprietary, it will suffice to just specify the overall volume and concentration of *EZVI/ EZVI-CH4™* and then provide a footnote indicating that the confidential disclosure dated August 21, 2023, and analytical results with supplemental information dated through March 2024, are already on file with the Division. Please note: the information for ZVI was derived from the May 13, 2021, Innovative Technology Acceptance Letter for Hogan, Cleanit SI.5/ CleanER-5. Please direct questions regarding this voucher to Elena Compton at 850-245-8911.

Sincerely,

Elena Compton, M.S., P.E.
Professional Engineer III
District Support Program, FDEP

1. Groundwater cleanup standards: The onus shall be on users of *EZVI/ EZVI-CH4™* to ensure that all applicable groundwater standards will be met at the time of project completion for the contaminants of concern being remediated, and any by-products produced as a result of chemical reactions induced or assisted by *EZVI/ EZVI-CH4™*. The following chapters of the Florida Administrative Code (F.A.C.) are cited: Chapter 62-550, F.A.C., for primary and secondary water quality standards; Chapter 62-520, F.A.C., for groundwater classes, for groundwater permitting, and for monitoring requirements; Chapter 62-528, F.A.C., for underground injection control, particularly Part V, for Class V, Group 4 aquifer remediation projects; Chapter 62-780, F.A.C., for cleanup criteria, allowance of alternative cleanup target levels and conditional closure requirements; and Chapter 62-777, F.A.C., for cleanup target levels.

2. Injection well permit: Per Rule 62-528.630(2)(c), F.A.C., the issuance of an enforceable, site-specific Remedial Action Plan Approval Order by the Department for injection-type aquifer remediation constitutes the granting of a Class V injection well construction/clearance permit.

3. Underground Injection Control (UIC): Remedial Action Plans proposing injection-type aquifer remediation shall include the information required by Rules 62-528.630(2)(c)1 through 6, F.A.C., for the purposes of the UIC program. Reviewers of those plans, upon issuance of a Department-enforceable Remedial Action Plan Approval Order, must transmit this information to the UIC program in Tallahassee by submitting a completed copy of the "UIC Notification". The notification for sites that are impacted with petroleum contaminants of concern is in the form of a memorandum currently located on the Internet at https://floridadep.gov/waste/district-business-support/documents/uic-notice-remediation-products. The notification for sites impacted with any other contaminants of concern is in the form of a memorandum currently located on the Internet at https://floridadep.gov/waste/district-business-support/documents/injection-well-proposal-form

4. General information about temporary Zones of Discharge (ZOD): For groundwater remediation, the composition of a fluid to be injected must meet the primary and secondary drinking water standards set forth in Chapter 62-550, F.A.C., and the minimum groundwater criteria of Chapter 62-520, F.A.C. [and Chapter 62-777, F.A.C.], pursuant to UIC Rule 62-528.600(2)(d), F.A.C. Aquifer remediation products that do not meet these requirements must seek relief from water quality criteria by one of two mechanisms as follows. Permission for a temporary ZOD may be obtained via Rule 62-520.310(8)(c), F.A.C. If permission for a ZOD cannot be obtained by rule, then it will be necessary to seek a variance from Department rules in accordance with Section 120.542, Florida Statutes.

   Rule 62-520.310(8)(c), F.A.C., allows for a temporary ZOD for closed-loop re-injection systems, for the prime constituents of the reagents used to remediate site contaminants, and for groundwater secondary standards. In order to obtain permission for a temporary ZOD by rule, a site-specific Remedial Action Plan must indicate: (a) the chemical ingredients of concern in the fluid to be injected that will be present in excess of groundwater standards; (b) the size of the ZOD that is needed; (c) the amount of time that the ZOD will be needed; and (d) a plan for monitoring the injected chemical ingredients of concern.

   The size of the temporary ZOD will usually be the injection well radius of influence when the treatment system is a single injection point. For a multiple point system, the ZOD can usually be expressed and illustrated as the total area covered by all the injection points, located side-by-side with overlapping radii of influence.

5. Upon expiration of the time-period granted for the ZOD by way of Rule 62-520.310(8)(c), F.A.C., the concentrations of the above referenced analytes must meet their respective groundwater standards or their site-specific background values, whichever is less stringent.

   Conditional closure is also allowable provided the closure criteria of Rule 62-780.680, F.A.C., are met and there are no exceedances of a primary standard due to impurities in the product. Note that such conditional closure may require a modification of the size or duration of the ZOD. This modification must be approved in an enforceable order of the department, such as a conditional Site Rehabilitation Completion Order.

6. Site-specific Remedial Action Plans shall describe the volume and concentration of *EZVI/ EZVI-CH4™* that will be injected.

7. Specific ZOD information for *EZVI/ EZVI-CH4™*:

   Prior to injections,
   - *EZVI/ EZVI-CH4™* must be diluted to 1:1 (1-part *EZVI/ EZVI-CH4™* :1 part-water, by weight),

   a. Please note: Chapter 62-528, F.A.C, requires that the quality of the fluid (or non-liquid substance) introduced to the sub-surface be compared to the primary and secondary drinking water standards and the minimum criteria for groundwater before it is injected (i.e., before it is diluted by the receiving groundwater). A non-compliance with dilution of *EZVI/ EZVI-CH4™* may result in a violation of this requirement.

   b. For the ZOD parameters: chlorine, iron, manganese, pH, and foaming agent (non-ionic surfactant) shall be monitored.

   c. If *EZVI/ EZVI-CH4™* is proposed to be delivered into the aquifer via injection wells, reviewers of Remedial Action Plans should check the box as shown below when filling out the UIC Notification memorandum:
   "☐ *ZOD permission by rule* 62-520.310(8)(c), F.A.C., for *reagent chemical species and/or parameter(s) in the fluid to be injected (or re-injected) that exceed secondary groundwater standards. …".

   d. If *EZVI/ EZVI-CH4™* is proposed to be delivered into the aquifer by means other than injection wells (for example, most excavations [except by large diameter augers], infiltration galleries, trenches, etc.), the UIC Notification memorandum is not required to be filed but monitoring for the UIC parameters is required.

8. Required UIC ZOD compliance for *EZVI/ EZVI-CH4™* to comply with Rule 62-520.310(8)(c), F.A.C.: pre-injection dilution to 1:1 and monitoring for chloride, iron, manganese, pH, and foaming agent (non-ionic surfactant).

9. Analytical method for surfactants: Per Chapter 62-550, F.A.C., Standard Method 5540 (SM 5540) can be used to determine the concentrations of surfactants in water samples. Method SM 5540 C is for the measurement of anionic surfactant concentrations, and method SM 5540 D is for the measurement of nonionic surfactant concentrations.

10. Quarterly monitoring should suffice in most cases. Upon expiration of the time period granted for the ZOD by way of Rule 62-520.310(8)(c), F.A.C., the concentrations of the above referenced analytes must meet their respective groundwater standards or their site-specific background values, whichever is less stringent, or appropriate controls are put in place to allow conditional closure under rule 62-780.680, F.A.C.

    a. Chloride, iron, manganese, pH, and foaming agent are secondary drinking water pollutants with the following standards: chloride = 250,000 micrograms per liter (ug/L), iron = 300 ug/L, manganese = 50 ug/L, pH = 6.5 – 8.5, and foaming agent =50 ug/L.

10. Utilization of wells: If a remediation site has sufficient monitoring wells, then the Division of Waste Management has no objection to the use of some existing monitoring wells for the injection of *EZVI/ EZVI-CH4™*. However, no "designated" monitoring well, dedicated to the tracking of remediation progress (by sampling) shall be used to apply *EZVI/ EZVI-CH4™*. Nor shall wells used for the injection of *EZVI/ EZVI-CH4™* as dedicated wells for tracking remediation progress. This will avoid a premature conclusion that the site meets cleanup goals. By making sure that designated tracking wells are not used for treatment, there will be more assurance that the treatment process has permeated the entire site and that it did not remain localized to the area immediately surrounding each injection well.

11. Baseline Sampling: Baseline sampling (prior to any injection) for the ZOD monitoring parameters (and the impurities) is not required but is strongly recommended. The baseline sampling data is very useful for evaluating when the aquifer has returned to the pre-injection conditions.

12. Three categories of groundwater monitoring:

    a. Active remediation monitoring for a cleanup site's contaminants of concern: During the period of active remediation, groundwater shall be monitored in accordance with the requirements of the approved RAP as set forth in Section 62-780.700, F.A.C.

    b. Post Active Remediation Monitoring for a cleanup site's contaminants of concern: At least one (1) year of quarterly post remediation groundwater monitoring for the contaminants of concern shall be conducted at a minimum of two (2) wells: one located in the area of highest contamination, the other at the downgradient edge of the contamination plume, pursuant to Section 62-780.750, F.A.C.

    c. Monitoring of the UIC zone of discharge: When *EZVI/ EZVI-CH4™* is utilized, in order to comply with Rule 62-520.310(8)(c), F.A.C., the ZOD shall be monitored for chloride, iron, manganese, pH, and foaming agent, as discussed in paragraph 7b above.

13. Injection operations:

    a. Avoidance of migration: For injection-type in-situ aquifer remediation projects, injection of *EZVI/ EZVI-CH4™* shall be performed in such a way and at such a rate and volume that no migration of *EZVI/ EZVI-CH4™* (beyond the ZOD) or the contaminants of concern in the aquifer, or surface water, results, pursuant to Rule 62-528.630(3), F.A.C.

b. Underground Injection Control operating permit: Although an operating permit is not required for aquifer remediation wells pursuant to Rule 62-528.640(1)(b) and (c), F.A.C., since no movement of the contamination plume is expected to accompany the treatment process, the Department requests that the information items listed in Rule 62-528.640(1)(b), F.A.C., be considered and included in Remedial Action Plan proposals as a matter of good and thorough design practice. Briefly summarized, they are quality of water in the aquifer, quality of the injected fluid, existing and potential uses of the affected aquifer, and well construction details.

14. Abandonment of wells: Upon issuance of a Site Rehabilitation Completion Order or a declaration of "No Further Action", injection wells shall be abandoned pursuant to Rule 62-528.645, F.A.C. The Underground Injection Control Section of the Department shall be notified so that the injection wells can be removed from the inventory-tracking list.

FLORIDA DEPARTMENT OF Environmental Protection

Bob Martinez Center
2600 Blair Stone Road
Tallahassee, FL 32399-2400

Ron DeSantis
Governor

Jeanette Nuñez
Lt. Governor

Shawn Hamilton
Secretary

May 6, 2024

Via Electronic Mail to Troy Lizer at troy.lizer@provectusenv.com

Troy Lizer
Technical Director
Provectus Environmental
721 Frana Clara Street
Louisville, OH 44641

Re: **ERD-CH4™**
Innovative Technology Application Acceptance Letter

Dear Mr. Lizer:

The Florida Department of Environmental Protection's Division of Waste Management (Division) hereby accepts *ERD-CH4™* for remediation via in-situ reductive dechlorination of chlorinated hydrocarbons and other suitable contaminants.

The accepted use of *ERD-CH4™* is subject to a minimum of 1:1 pre-injection dilution (1-part *ERD-CH4™*: 1-part water [by weight] dilution prior to use).

Enclosure 1 is a voucher for a confidential disclosure of the proprietary ingredients submitted by Provectus Environmental Products. Enclosure 2 contains regulatory information. For in situ injections of *ERD-CH4™,* there are underground injection control regulations that must be observed.

Since injection-type, in situ aquifer remediation is likely to be the most common application of *ERD-CH4™*, the bulk of the regulatory requirements discussed herein will be directed to that topic.

For vadose zone remediation, such as soil blending, the underlying groundwater may be affected by the leaching of the *ERD-CH4™* formulation. Although this remediation approach is not subject to the regulatory requirements of Chapters 62-528 and 62-520, Florida Administrative Code (F.A.C.), a regulatory advisory for Remedial Action Plan preparers and reviewers is included in Enclosure 2 for assistance with compliance with Chapters 62-780 and 62-777, F.A.C.

The Florida Department of Environmental Protection (FDEP) does not provide endorsement of specific or brand name remediation products or processes, however, it does recognize the need to determine their acceptability from an environmental standpoint with respect to applicable rules and regulations, and the interests of public health safety. Vendors are responsible for marketing their product or process

on its merits regarding performance, cost, and safety in comparison to competing alternatives in the marketplace. This acceptance letter shall not be construed as either an approval of the product or a certification of its performance.

Additionally, Department acceptance of any product or process does not imply it has been deemed applicable for any particular cleanup situation, or that it is preferred over other treatment or cleanup techniques. A site-specific evaluation of applicability should be considered for any product or process, whether conventional or innovative, and adequate site-specific design details must be provided in a Remedial Action Plan.

It is not a requirement that a remediation product or process obtain an acceptance from the Department in order to be proposed for use in a site-specific Remedial Action Plan, but the plan must contain information to show that it meets all applicable and appropriate rules and regulations. For *ERD-CH4™*, a copy of this acceptance letter containing regulatory compliance advice should be included in the appendix of each site-specific Remedial Action Plan that proposes its use.

The Department reserves the right to revoke its acceptance of a product or process if any component has been falsely represented.

This acceptance letter is valid for a period of ten (10) years from the issuance date above. At the end of the ten-year period, the acceptance can be renewed subject to an updated review of the product's use and formulation. The purpose of the updated review is to determine if the use conditions and monitoring requirements for this product need to be modified.

If you have any questions, contact Elena Compton at (850) 245-8911, through Mail Station 4535 at the letterhead address, or by e-mail at Elena.Compton@FloridaDEP.gov.

Sincerely,

Elena Compton, M.S., P.E.
Professional Engineer III
District Support Program, FDEP
850-245-8911

Enclosures: (1) Voucher; (2) Regulatory Information.

FLORIDA DEPARTMENT OF Environmental Protection

Bob Martinez Center
2600 Blair Stone Road
Tallahassee, FL 32399-2400

Ron DeSantis
Governor

Jeanette Nuñez
Lt. Governor

Shawn Hamilton
Secretary

May 6, 2024

Mr. Troy Lizer
Technical Director
Provectus Environmental
721 Frana Clara Street
Louisville, OH 44641

Re: **Proprietary Ingredients:** *ERD-CH4™*

Dear Mr. Lizer:

The Division of Waste Management hereby acknowledges the submittal of a confidential disclosure by Provectus Environmental Products. The disclosure provided the proprietary ingredients and their concentrations in *ERD-CH4™*.

Without this voucher for the disclosures, and the advice provided by the Division in Enclosure 2 based on its review of all the ingredients, users of *ERD-CH4™* would not know how to comply with the requirements of Rule 62-520.310(8)(c), Florida Administrative Code (F.A.C.), for a temporary Zone of Discharge.

For underground injection control purposes, remediation plans proposing the use of *ERD-CH4™* must indicate the volume and complete chemical composition of the fluid to be injected. Since the identities of some ingredients are proprietary, it will suffice to just specify the overall volume and concentration of *ERD-CH4™* and then provide a footnote indicating that the confidential disclosure dated August 21, 2023, and analytical results with supplemental information dated through March 2024, are already on file with the Division. Please direct questions regarding this voucher to Elena Compton at 850-245-8911.

Sincerely,

Elena Compton, M.S., P.E.
Professional Engineer III
District Support Program, FDEP

1. Groundwater cleanup standards: The onus shall be on users of *ERD-CH4™* to ensure that all applicable groundwater standards will be met at the time of project completion for the contaminants of concern being remediated, and any by-products produced as a result of chemical reactions induced or assisted by *ERD-CH4™*. The following chapters of the Florida Administrative Code (F.A.C.) are cited: Chapter 62-550, F.A.C., for primary and secondary water quality standards; Chapter 62-520, F.A.C., for groundwater classes, for groundwater permitting, and for monitoring requirements; Chapter 62-528, F.A.C., for underground injection control, particularly Part V, for Class V, Group 4 aquifer remediation projects; Chapter 62-780, F.A.C., for cleanup criteria, allowance of alternative cleanup target levels and conditional closure requirements; and Chapter 62-777, F.A.C., for cleanup target levels.

2. Injection well permit: Per Rule 62-528.630(2)(c), F.A.C., the issuance of an enforceable, site-specific Remedial Action Plan Approval Order by the Department for injection-type aquifer remediation constitutes the granting of a Class V injection well construction/clearance permit.

3. Underground Injection Control (UIC): Remedial Action Plans proposing injection-type aquifer remediation shall include the information required by Rules 62-528.630(2)(c)1 through 6, F.A.C., for the purposes of the UIC program. Reviewers of those plans, upon issuance of a Department-enforceable Remedial Action Plan Approval Order, must transmit this information to the UIC program in Tallahassee by submitting a completed copy of the "UIC Notification". The notification for sites that are impacted with petroleum contaminants of concern is in the form of a memorandum currently located on the Internet at https://floridadep.gov/waste/district-business-support/documents/uic-notice-remediation-products. The notification for sites impacted with any other contaminants of concern is in the form of a memorandum currently located on the Internet at https://floridadep.gov/waste/district-business-support/documents/injection-well-proposal-form

4. General information about temporary Zones of Discharge (ZOD): For groundwater remediation, the composition of a fluid to be injected must meet the primary and secondary drinking water standards set forth in Chapter 62-550, F.A.C., and the minimum groundwater criteria of Chapter 62-520, F.A.C. [and Chapter 62-777, F.A.C.], pursuant to UIC Rule 62-528.600(2)(d), F.A.C. Aquifer remediation products that do not meet these requirements must seek relief from water quality criteria by one of two mechanisms as follows. Permission for a temporary ZOD may be obtained via Rule 62-520.310(8)(c), F.A.C. If permission for a ZOD cannot be obtained by rule, then it will be necessary to seek a variance from Department rules in accordance with Section 120.542, Florida Statutes.

   Rule 62-520.310(8)(c), F.A.C., allows for a temporary ZOD for closed-loop re-injection systems, for the prime constituents of the reagents used to remediate site contaminants, and for groundwater secondary standards. In order to obtain permission for a temporary ZOD by rule, a site-specific Remedial Action Plan must indicate: (a) the chemical ingredients of concern in the fluid to be injected that will be present in excess of groundwater standards; (b) the size of the ZOD that is needed; (c) the amount of time that the ZOD will be needed; and (d) a plan for monitoring the injected chemical ingredients of concern.

   The size of the temporary ZOD will usually be the injection well radius of influence when the treatment system is a single injection point. For a multiple point system, the ZOD can usually be expressed and illustrated as the total area covered by all the injection points, located side-by-side with overlapping radii of influence.

5. Upon expiration of the time-period granted for the ZOD by way of Rule 62-520.310(8)(c), F.A.C., the concentrations of the above referenced analytes must meet their respective groundwater standards or their site-specific background values, whichever is less stringent.

   Conditional closure is also allowable provided the closure criteria of Rule 62-780.680, F.A.C., are met and there are no exceedances of a primary standard due to impurities in the product. Note that such conditional closure may require a modification of the size or duration of the ZOD. This modification must be approved in an enforceable order of the department, such as a conditional Site Rehabilitation Completion Order.

6. Site-specific Remedial Action Plans shall describe the volume and concentration of *ERD-CH4™* that will be injected.

7. Specific ZOD information for *ERD-CH4™*:

   Prior to injections,
   - *ERD-CH4™* must be diluted to 1:1 (1-part *ERD-CH4™*:1 part-water, by weight),

   a. Please note: Chapter 62-528, F.A.C, requires that the quality of the fluid (or non-liquid substance) introduced to the sub-surface be compared to the primary and secondary drinking water standards and the minimum criteria for groundwater before it is injected (i.e., before it is diluted by the receiving groundwater). A non-compliance with dilution of *ERD-CH4™* may result in a violation of this requirement.

   b. For the ZOD parameters: iron, foaming agent (non-ionic surfactant), 1, 4- dioxane, ethylene oxide, and Total Recoverable Petroleum Hydrocarbons (TRPH) shall be monitored.

   c. If *ERD-CH4™* is proposed to be delivered into the aquifer via injection wells, reviewers of Remedial Action Plans should check the box as shown below when filling out the UIC Notification memorandum:
   "☐ *ZOD permission by rule* 62-520.310(8)(c), F.A.C., for *reagent chemical species and/or parameter(s) in the fluid to be injected (or re-injected) that exceed secondary groundwater standards. …".

   d. If *ERD-CH4™* is proposed to be delivered into the aquifer by means other than injection wells (for example, most excavations [except by large diameter augers], infiltration galleries, trenches, etc.), the UIC Notification memorandum is not required to be filed but monitoring for the UIC parameters is required.

8. Required UIC ZOD compliance for *ERD-CH4™* to comply with Rule 62-520.310(8)(c), F.A.C.: pre-injection dilution to 1:1 and monitoring for iron, foaming agent (non-ionic surfactant), 1-4 dioxane, ethylene oxide, and TRPH.

9. Analytical method for surfactants: Per Chapter 62-550, F.A.C., Standard Method 5540 (SM 5540) can be used to determine the concentrations of surfactants in water samples. Method SM 5540 C is for the measurement of anionic surfactant concentrations, and method SM 5540 D is for the measurement of nonionic surfactant concentrations.

10. Quarterly monitoring should suffice in most cases. Upon expiration of the time period granted for the ZOD by way of Rule 62-520.310(8)(c), F.A.C., the concentrations of the above referenced analytes must meet their respective groundwater standards or their site-specific background values, whichever is less stringent, or appropriate controls are put in place to allow conditional closure under rule 62-780.680, F.A.C.

    a. Iron and foaming agent are secondary drinking water pollutants with the following standards: iron = 300 micrograms per liter (ug/L) and foaming agent =50 ug/L.
    b. 1, 4- dioxane, ethylene oxide, and TRPH have minimum criteria values: 1,4- dioxane = 3.2 ug/L, ethylene oxide = 0.03 ug/, and TRPH = 5,000 ug/L.

10. Utilization of wells: If a remediation site has sufficient monitoring wells, then the Division of Waste Management has no objection to the use of some existing monitoring wells for the injection of *ERD-CH4™*. However, no "designated" monitoring well, dedicated to the tracking of remediation progress (by sampling) shall be used to apply *ERD-CH4™*. Nor shall wells be used for the injection of *ERD-CH4™* as dedicated wells for tracking remediation progress. This will avoid a premature conclusion that the site meets cleanup goals. By making sure that designated tracking wells are not used for treatment, there will be more assurance that the treatment process has permeated the entire site and that it did not remain localized to the area immediately surrounding each injection well.

11. Baseline Sampling: Baseline sampling (prior to any injection) for the ZOD monitoring parameters (and the impurities) is not required but is strongly recommended. The baseline sampling data is very useful for evaluating when the aquifer has returned to the pre-injection conditions.

12. Three categories of groundwater monitoring:

    a. Active remediation monitoring for a cleanup site's contaminants of concern: During the period of active remediation, groundwater shall be monitored in accordance with the requirements of the approved RAP as set forth in Section 62-780.700, F.A.C.

    c. Post Active Remediation Monitoring for a cleanup site's contaminants of concern: At least one (1) year of quarterly post remediation groundwater monitoring for the contaminants of concern shall be conducted at a minimum of two (2) wells: one located in the area of highest contamination, the other at the downgradient edge of the contamination plume, pursuant to Section 62-780.750, F.A.C.

    d. Monitoring of the UIC zone of discharge: When *ERD-CH4™* is utilized, in order to comply with Rule 62-520.310(8)(c), F.A.C., the ZOD shall be monitored for iron, foaming agent, 1,4- dioxane, ethylene oxide, and TRPH, as discussed in paragraph 7b above.

13. Injection operations:

    a. Avoidance of migration: For injection-type in-situ aquifer remediation projects, injection of *ERD-CH4™* shall be performed in such a way and at such a rate and volume that no migration of *ERD-CH4™* (beyond the ZOD) or the contaminants of concern in the aquifer, or surface water, results, pursuant to Rule 62-528.630(3), F.A.C.

b. Underground Injection Control operating permit: Although an operating permit is not required for aquifer remediation wells pursuant to Rule 62-528.640(1)(b) and (c), F.A.C., since no movement of the contamination plume is expected to accompany the treatment process, the Department requests that the information items listed in Rule 62-528.640(1)(b), F.A.C., be considered and included in Remedial Action Plan proposals as a matter of good and thorough design practice. Briefly summarized, they are quality of water in the aquifer, quality of the injected fluid, existing and potential uses of the affected aquifer, and well construction details.

14. Abandonment of wells: Upon issuance of a Site Rehabilitation Completion Order or a declaration of "No Further Action", injection wells shall be abandoned pursuant to Rule 62-528.645, F.A.C. The Underground Injection Control Section of the Department shall be notified so that the injection wells can be removed from the inventory-tracking list.

FLORIDA DEPARTMENT OF
Environmental Protection

Bob Martinez Center
2600 Blair Stone Road
Tallahassee, FL 32399-2400

Ron DeSantis
Governor

Jeanette Nuñez
Lt. Governor

Noah Valenstein
Secretary

May 1, 2019

Via Electronic Mail to Jeff Roberts at JRoberts@siremlab.com

Mr. Jeff Roberts, M.Sc.
Senior Manager
SiREM
130 Stone Road West
Ontario, Canada N1G 3Z2

Re: **KB-1 Plus**
The FDEP Innovative Technology Application Number: 1753

Dear Mr. Roberts:

The Florida Department of Environmental Protection's Division of Waste Management (Division) hereby accepts KB-1 Plus as an anaerobic microbial consortium for in-situ bioremediation of chlorinated solvents and other suitable contaminants in groundwater and soil.

Enclosure 1 contains regulatory information. Enclosure 2 provides calculation of an Alternative Groundwater Cleanup Target Level (AGCTL) for un-ionized ammonia.

For vadose remediation, where the underlying groundwater will not be affected by the leaching of KB-1 Plus, there are no special concerns beyond those that would normally need to be addressed in preparing a Remedial Action Plan and conducting a cleanup in accordance with Chapters 62-780 and 62-777, F.A.C. However, for in situ groundwater remediation, via direct injection of KB-1 Plus into an aquifer, there are underground injection control regulations that must be observed. Since injection-type, in situ aquifer remediation is likely to be the most common application of KB-1 Plus, the bulk of the regulatory requirements discussed herein will be directed to that topic.

While the Florida Department of Environmental Protection (FDEP) does not provide endorsement of specific or brand name remediation products or processes, it does recognize the need to determine their acceptability from an environmental standpoint with respect to applicable rules and regulations, and the interests of public health safety. Vendors, upon receipt of an acceptance, must market their product or process on its merits regarding performance, cost, and safety in comparison to competing alternatives in the marketplace. This acceptance letter shall not be construed as either an approval of the product or a certification of its performance.

Additionally, Department acceptance of any product or process does not imply it has been deemed applicable for all cleanup situations, or that it is preferred over other treatment or cleanup techniques in any particular case. A site-specific evaluation of applicability and cost-effectiveness must be

considered for any product or process, whether conventional or innovative, and adequate site-specific design details must be provided in a Remedial Action Plan.

It is not a requirement that a remediation product or process obtain an acceptance from the Department in order to be proposed for use in a site-specific Remedial Action Plan, but the plan must contain information to show that it meets all applicable and appropriate rules and regulations. For KB-1 Plus listed in this letter, a copy of this acceptance letter containing regulatory compliance advice should be included in the appendix of each site-specific Remedial Action Plan that proposes its use.

The Department reserves the right to revoke its acceptance of a product or process if it has been falsely represented.

If you have any questions, contact Elena Compton at (850) 245-8911, through Mail Station 4535 at the letterhead address, or by e-mail at Elena.Compton@dep.state.fl.us.

Sincerely,

Elena C. Compton

Elena Compton, M.S., P.E.
Professional Engineer III
PRP Team 2, FDEP
850-245-8911

Enclosures: (1) Regulatory Information; (2) Calculation of AGCTL for Ammonia

10-09-2018: FDEP e-mail
05-01-2019: FDEP e-mail
05-01-2019: Burlab # 1753

1. Groundwater cleanup standards: The onus shall be on users of KB-1 Plus to ensure that all applicable groundwater standards will be met at the time of project completion for the contaminants of concern being remediated, and any by-products produced as a result of chemical or biochemical reactions induced or assisted by KB-1 Plus listed in the subject letter. The following chapters of the Florida Administrative Code (F.A.C.) are cited: Chapter 62-550, F.A.C., for primary and secondary water quality standards; Chapter 62-520, F.A.C., for groundwater classes and standards; Chapter 62-522, F.A.C., for groundwater permitting and monitoring requirements; Chapter 62-528, F.A.C., for underground injection control, particularly Part V, for Class V, Group 4 aquifer remediation projects; Chapters 62-780, F.A.C., for cleanup criteria, allowance of alternative cleanup target levels and conditional closure requirements; and Chapter 62-777, F.A.C., for cleanup target levels.

2. Injection well permit: Per Rule 62-528.630(2)(c), F.A.C., the issuance of an enforceable, site-specific Remedial Action Plan Approval Order by the Department for injection-type aquifer remediation constitutes the granting of a Class V injection well construction/clearance permit.

3. Underground Injection Control (UIC): Remedial Action Plans proposing injection-type aquifer remediation shall include the information required by Rules 62-528.630(2)(c)1 through 6, F.A.C., for the purposes of the UIC program. Reviewers of those plans, upon issuance of a Department-enforceable Remedial Action Plan Approval Order, must transmit this information to the UIC program in Tallahassee by submitting a completed copy of the "UIC Notification". The notification is in the form of a memorandum currently located on the Internet at https://floridadep.gov/waste/petroleum-restoration/forms/uic-notification-remediation-hazardous-waste.

4. General information about temporary Zones of Discharge (ZOD): For groundwater remediation, the composition of a fluid to be injected must meet the primary and secondary drinking water standards set forth in Chapter 62-550, F.A.C., and the minimum groundwater criteria of Chapter 62-520, F.A.C. [and Chapter 62-777], pursuant to UIC Rule 62-528.600(2)(d), F.A.C. Aquifer remediation products that do not meet these requirements must seek relief from water quality criteria by one of two mechanisms as follows. Permission for a temporary ZOD may be obtained via Rule 62-520.310(8)(c), F.A.C. If permission for a ZOD cannot be obtained by rule, then it will be necessary to seek a variance from Department rules in accordance with Section 120.542, Florida Statutes.

   Rule 62-520.310(8)(c), F.A.C., allows for a temporary ZOD for closed-loop re-injection systems, for the prime constituents of the reagents used to remediate site contaminants, and for groundwater secondary standards. In order to obtain permission for a temporary ZOD by rule, a site-specific Remedial Action Plan must indicate: (a) the chemical ingredients of concern in the fluid to be injected that will be present in excess of groundwater standards; (b) the size of the ZOD that is needed; (c) the amount of time that the ZOD will be needed; and (d) a plan for monitoring the injected chemical ingredients of concern.

   The size of the temporary ZOD will usually be the injection well radius of influence when the treatment system is a single injection point. For a multiple point system, the ZOD can usually be expressed and illustrated as the total area covered by all the injection points, located side-by-side with overlapping radii of influence.

5. Upon expiration of the time-period granted for the ZOD by way of Rule 62-520.310(8)(c), F.A.C., the concentrations of the above referenced analytes must meet their respective groundwater standards or their natural-occurring background values at the specific cleanup site, whichever is less stringent.

   Conditional closure is also allowable provided the closure criteria of Rule 62-780.680, F.A.C., are met and there are no exceedances of a primary standard due to impurities in the product. Note that such conditional closure may require a modification of the size or duration of the ZOD. This modification must be approved in an enforceable order of the department, such as a conditional Site Rehabilitation Completion Order.

6. Site-specific Remedial Action Plans shall describe the volume and concentration of KB-1 Plus reagents that will be injected.

7. Specific ZOD information for KB-1 Plus:

   a. If prior to injection KB-1 Plus is diluted at least as one (1) part of KB-1 Plus to 35,000 (thirty-five thousand) parts of water, a ZOD is not required. Reviewers of Remedial Action Plans should check the box as shown below when filling out the UIC Notification memorandum:

      "☑ No ZOD needed."

   b. If prior to injection the dilution rate is less than specified in paragraph 7a above, the following required UIC ZOD compliance monitoring for to comply with Rule 62-520.310(8)(c), F.A.C.: Sodium, Nitrate, Molybdenum, Chloride, Sulfate, Iron, TDS (Total Dissolved Solids), pH, and Ammonia, reviewers of Remedial Action Plans, when filling out the UIC Notification memorandum, should check the box labeled as follows:

      "☑ ZOD permission by rule 62-520.310(8)(c), F.A.C., for *reagent chemical species and/or parameter(s) in the fluid to be injected (or re-injected) that exceed secondary groundwater standards. …".*

8. Quarterly monitoring should suffice in most cases. Upon expiration of the time period granted for the ZOD by way of Rule 62-520.310(8)(c), F.A.C., the concentrations of the above referenced analytes must meet their respective groundwater standards or their natural-occurring background values at the specific cleanup site, whichever is less stringent, or appropriate controls are put in place to allow conditional closure under rule 62-780.680, F.A.C.

   Sodium and Nitrate have primary drinking water standards of 160,000 ug/L (micrograms per liter) and 10,000 ug/L, respectively. Molybdenum is listed in Chapter 62-777, F.A.C, as a "minimum criteria systemic toxicant" and it has a Groundwater Cleanup Target Level (GCTL) of 35 ug/L. Chloride, Sulfate, Iron, TDS, and pH have the following secondary drinking water standards: Sulfate = 250,000 ug/L, TDS = 500,000 ug/L, pH = range from 6.5 to 8.5, and Iron = 300,000 ug/L. Ammonia is currently identified in Chapter 62-777, F.A.C., as a "minimum criteria systemic toxicant" and it has a Groundwater Cleanup Target Level (GCTL) of 2,800 ug/L. However, the oral reference dose upon which this number is based has been withdrawn from the U.S. Environmental Agency's (EPA) Integrated Risk Information System (IRIS) database. Therefore, the FDEP has calculated an alternative groundwater cleanup target level in accordance with Chapter 62-780, F.A.C. This Alternative Groundwater Cleanup Target Level (AGCTL) calculation is attached as Enclosure 3. The Department recommends using the referenced AGCTL for ammonia.

10. Utilization of wells: If a remediation site happens to have an abundance of monitoring wells, then the Division of Waste Management has no objection to the use of some wells for the injection of KB-1 Plus if the wells are suitable for the purpose. However, no "designated" monitoring well, dedicated to the tracking of remediation progress (by sampling) shall be used to apply KB-1 Plus product. This will avoid a premature conclusion that the entire site meets cleanup goals. By making sure that designated tracking wells are not used for treatment, there will be more assurance that the treatment process has permeated the entire site and that it did not remain localized to the area immediately surrounding each injection well.

11. Three categories of groundwater monitoring:

    a. Active remediation monitoring for a cleanup site's contaminants of concern:
    During the period of active remediation, groundwater shall be monitored in accordance with the requirements set forth in Section 62-780.700, F.A.C.

    b. Post Active Remediation Monitoring for a cleanup site's contaminants of concern:
    At least one (1) year of quarterly post remediation groundwater monitoring for the contaminants of concern shall be conducted at a minimum of two (2) wells: one located in the area of highest contamination, the other at the downgradient edge of the contamination plume, pursuant to Section 62-780.750, F.A.C.

    a. Monitoring of the UIC zone of discharge for Sodium, Nitrate, Molybdenum, Chloride, Sulfate, Iron, TDS, pH, and Ammonia, as discussed in paragraph 7b (seven b) above.

12. Injection operations:

    a. Avoidance of migration: For injection-type in-situ aquifer remediation projects, injection of KB-1 Plus shall be performed in such a way and at such a rate and volume that no migration of either the KB-1 Plus or the contaminants of concern in the aquifer or surface water results, pursuant to Rule 62-528.630(3), F.A.C.

    b. Underground Injection Control operating permit: Although an operating permit is not required for aquifer remediation wells pursuant to Rule 62-528.640(1)(b), and 62-528.640(1)(c), F.A.C., since no movement of the contamination plume is expected to accompany the treatment process, the Department requests that the information items listed in Rule 62-528.640(1)(b), F.A.C., be considered and included in Remedial Action Plan proposals as a matter of good and thorough design practice. Briefly summarized, they are: quality of water in the aquifer, quality of the injected fluid, existing and potential uses of the affected aquifer, and well construction details.

13. Abandonment of wells: Upon issuance of a Site Rehabilitation Completion Order or a declaration of "No Further Action", injection wells shall be abandoned pursuant to Section 62-528.645, F.A.C. The Underground Injection Control Section of the Department shall be notified so that the injection wells can be removed from the inventory-tracking list.

14. Open-pit application: There is no objection to the introduction of KB-1 Plus to an open excavation pit in which the groundwater has been exposed. Open-pit application is not injection, and it is not

necessary to notify the Underground Injection Control Section, but this should not be construed as carte blanche to introduce to the pit any substance at any concentration with no regard to potential toxicological effects. The Division of Waste Management therefore recommends that the groundwater in the area of the pit be monitored for the same zone of discharge parameters that would have been monitored (if any) had the application actually been an injection.

UF UNIVERSITY of FLORIDA

Center for Environment & Human Toxicology

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September 1, 2015

Brian Dougherty, PhD
Office of District and Business Support
Division of Waste Management
Florida Department of Environmental Protection
2600 Blair Stone Road
Tallahassee, FL 32399-2400

Re: Calculation of an alternative groundwater cleanup target level for un-ionized ammonia

Dear Dr. Dougherty:

At your request, we have calculated alternative groundwater cleanup target levels (AGCTL) for total ammonia based on water temperature and pH. As you know, calculation of an AGCTL necessitates consideration of exposure from oral, dermal, and inhalation pathways (Chapter 62-780, FAC). The GCTL equation promulgated in Chapter 62-777, FAC calculates a criterion for groundwater based on the oral route, but does not consider other routes of exposure. The FDEP has not specified a preferred methodology for calculating exposure for the inhalation and dermal routes from groundwater. Therefore, to aid our calculation, we utilized the USEPA regional screening level (RSL) tap water equation, which includes exposure from the inhalation and dermal routes.

We reviewed current toxicity values available for ammonia using the hierarchy of toxicity sources promulgated in Chapter 62-780, FAC. No oral reference dose (RfD_o) is currently available for ammonia. An inhalation reference concentration (RfC) of 0.1 mg/m^3 is available from the USEPA's IRIS database.[1] This value was based on a lack of decreased pulmonary function or changes in subjective symptomatology in humans (USEPA, 1991). As this effect is route specific to inhalation, an RfD_o cannot be extrapolated from the RfC. Without an oral reference dose, the toxicity from exposure by the oral and dermal routes cannot be estimated. While it is possible for ammonia to cause direct irritation of the skin due to its alkaline properties, quantitative data are lacking and it is not possible to calculate with any certainty the concentration of ammonia in groundwater that would cause irritation from direct contact (ATSDR, 2004). Therefore, the AGCTL was calculated based on inhalation exposure to ammonia volatilized from groundwater.

[1] The USEPA has recently proposed an updated RfC of 0.3 mg/m^3, but this has not been approved or posted on IRIS. The time frame for completing this update is unknown.

To calculate an AGCTL for total ammonia, it was first necessary to estimate the risk-based concentration of un-ionized ammonia that would be of concern (since this is the fraction that will volatilize). We utilized the USEPA equation for tap water for non-carcinogenic effects by the inhalation route to calculate a risk-based concentration for un-ionized ammonia (Figure 1). Calculation of an AGCTL under Chapter 62-780, FAC also requires the consideration of sensitive sub-populations. Because ammonia is a non-carcinogen, children are the appropriate receptor of concern.

Figure 1: USEPA RSL equation for inhalation exposure from tap water for a non-carcinogen

$$NH_3\left(\frac{\mu g}{L}\right) = \frac{THQ \times AT \times CF}{EF \times ED \times ET \times \left(\frac{1\,day}{24\,hours}\right) \times \left(\frac{1}{RfC}\right) \times K}$$

Parameter	Definition (units)	Default Value
NH_3	un-ionized ammonia (µg/L)	--
THQ	target hazard quotient	1
AT	child averaging time (days)	2190
CF	conversion factor (µg/mg)	1000
EF	exposure frequency (d/y)	350
ED	exposure duration (years)	6
ET	resident water exposure time (hours/day)	24
RfC	inhalation reference concentration (mg/m^3)	0.1
K	Andelman Volatilization Factor (L/m^3)	0.5

The risk-based concentration of un-ionized ammonia was calculated as:

$$NH_3\left(\frac{\mu g}{L}\right) = \frac{1 \times 2190 \times 1000}{350 \times 6 \times 24 \times \left(\frac{1\,day}{24\,hours}\right) \times \left(\frac{1}{0.1}\right) \times 0.5}$$

$$NH_3\left(\frac{\mu g}{L}\right) = 208.57\ (rounded\ to\ 210)$$

In groundwater, ammonia concentrations are reported as total ammonia. The reported value is the sum of both the un-ionized (NH_3) and ionized (NH_4^+) forms. The FDEP has a manual for the calculation of un-ionized ammonia based on total ammonia concentrations in fresh water, pH, and temperature (FDEP, 2001). The concentration of unionized ammonia can be calculated using the FDEP Unionized Ammonia Calculator v1.2 or using the equations below. Based on the methodology presented in the FDEP manual, the mole fraction of un-ionized ammonia is calculated using the following equations:

$$f = 1/(10^{(pKa-pH)} + 1)$$

$$pKa = 0.0901821 + 2729.92/T_k$$

$$T_k = °C + 273.2$$

where:
f = the mole fraction of un-ionized ammonia
T_k = temperature in degrees Kelvin
°C = temperature in degrees Celsius

The mole fraction of un-ionized ammonia is used to determine the concentration of un-ionized ammonia using the following equation:

$$Ammonia_{total} \times f \times \left(\frac{17}{14}\right) = NH_3$$

where:
$Ammonia_{total}$ = total ammonia (μg/L)
NH_3 = un-ionized ammonia (μg/L)

Table 1 (attached) lists AGCTLs for total ammonia based on a range of common pH values and temperatures for Florida groundwater. The AGCTLs listed in Table 1 do not consider organoleptic effects. The odor threshold for total ammonia in tap water is 1,500 μg/L and for taste is 35,000 μg/L (ATSDR, 2004). Based on Table 1, the risk-based concentration of total ammonia will likely exceed the odor threshold and will exceed the taste threshold at pH less than 7.0.

Because the concentration of un-ionized ammonia increases with water temperature, showering/bathing represents an acute exposure scenario where residents are exposed for short periods of time to relatively higher concentrations of un-ionized ammonia in air. We could not find any published data regarding the average temperature of water used for showering. However, 120°F (48.9°C) is considered a safe hot water temperature (Shields et al., 2013). Exposure to 48.9°C water takes 10 minutes to cause a serious burn and therefore can be used as the maximum likely shower temperature (Shields et al., 2013). Using the equations above, at water temperature of 48.9°C and a pH of 7.5 (chosen because it produces the largest fraction of un-ionized ammonia), the fraction of un-ionized ammonia available for inhalation would be 7.9%. The maximum airborne concentration of ammonia below which it is believed nearly all individuals could be exposed for up to one hour without experiencing anything other than mild, transient effects or without perceiving a defined odor is 25 ppm (AIHA, 2015). Using maximum allowable air concentration of 25 ppm for un-ionized ammonia and a water temperature of 48.9°C results in an acute AGCTL of 260,000 μg/L. Therefore, the AGCTLs in Table 1 were limited to a maximum concentration of 260,000 μg/L to protect against acute exposures.

Please let us know if you have any questions regarding the derivation of this AGCTL.

Sincerely,

Leah D. Stuchal, Ph.D.

Hannah M. Neeley, MPH

Stephen M. Roberts, Ph.D.

References:

AIHA (2015) *2015 ERPG Levels.* American Industrial Hygiene Association, Emergency Response Planning Guidelines, Falls Church, VA.

ATSDR (2004) *Toxicological Profile for Ammonia.* US Department of Health and Human Services, Public Health Service, Agency for Toxic Substances and Disease Registry.

FDEP (2001) *Calculation of Un-Ionized Ammonia in Fresh Water.* Florida Department of Environmental Protection, Chemistry Laboratory Methods Manual, Tallahassee.

Shields, WC, McDonald, E, Frattaroli, S, Zhu, J, Perry, EC, and Gielen, AC. (2013) Still too hot: Examination of water temperature and water heater characteristics 24 years after manufacturers adopt voluntary temperature setting. *J Burn Care Res.* 34(2): 281-287.

USEPA (1991) *Ammonia (CASRN 7664-41-7).* United States Environmental Protection Agency, Integrated Risk Information System, http://www.epa.gov/iris/subst/0422.htm

Table 1 – AGCTLs in μg/L (ppb) for total ammonia based on a range of common pH and temperatures for Florida groundwater

pH	20°C	21°C	22°C	23°C	24°C	25°C	26°C	27°C	28°C	29°C	30°C
5.5	260,000*	260,000*	260,000*	260,000*	260,000*	260,000*	260,000*	260,000*	260,000*	260,000*	260,000*
5.6	260,000*	260,000*	260,000*	260,000*	260,000*	260,000*	260,000*	260,000*	260,000*	260,000*	260,000*
5.7	260,000*	260,000*	260,000*	260,000*	260,000*	260,000*	260,000*	260,000*	260,000*	260,000*	260,000*
5.8	260,000*	260,000*	260,000*	260,000*	260,000*	260,000*	260,000*	260,000*	260,000*	260,000*	260,000*
5.9	260,000*	260,000*	260,000*	260,000*	260,000*	260,000*	260,000*	260,000*	260,000*	260,000*	260,000*
6.0	260,000*	260,000*	260,000*	260,000*	260,000*	260,000*	260,000*	260,000*	250,000	230,000	210,000
6.1	260,000*	260,000*	260,000*	260,000*	260,000*	240,000	230,000	210,000	200,000	180,000	170,000
6.2	260,000*	260,000*	240,000	220,000	210,000	190,000	180,000	170,000	160,000	150,000	130,000
6.3	220,000	200,000	190,000	180,000	160,000	150,000	140,000	130,000	120,000	120,000	110,000
6.4	170,000	160,000	150,000	140,000	130,000	120,000	110,000	110,000	98,000	92,000	86,000
6.5	140,000	130,000	120,000	110,000	100,000	96,000	90,000	84,000	78,000	73,000	68,000
6.6	110,000	100,000	95,000	88,000	82,000	77,000	71,000	67,000	62,000	58,000	54,000
6.7	87,000	81,000	75,000	70,000	65,000	61,000	57,000	53,000	49,000	46,000	43,000
6.8	69,000	64,000	60,000	56,000	52,000	48,000	45,000	42,000	39,000	37,000	34,000
6.9	55,000	51,000	48,000	44,000	41,000	38,000	36,000	33,000	31,000	29,000	27,000
7.0	44,000	41,000	38,000	35,000	33,000	31,000	28,000	27,000	25,000	23,000	22,000
7.1	35,000	32,000	30,000	28,000	26,000	24,000	23,000	21,000	20,000	18,000	17,000
7.2	28,000	26,000	24,000	22,000	21,000	19,000	18,000	17,000	16,000	15,000	14,000
7.3	22,000	20,000	19,000	18,000	17,000	15,000	14,000	13,000	13,000	12,000	11,000
7.4	18,000	16,000	15,000	14,000	13,000	12,000	11,000	11,000	10,000	9,300	8,700
7.5	14,000	13,000	12,000	11,000	10,000	9,800	9,200	8,500	8,000	7,500	7,000

* - acute exposure AGCTL

AGCTLs were calculated using an f value rounded to 5 significant digits and an un-ionized ammonia concentration of 210 μg/L

FLORIDA DEPARTMENT OF
Environmental Protection

Bob Martinez Center
2600 Blair Stone Road
Tallahassee, FL 32399-2400

Ron DeSantis
Governor

Jeanette Nuñez
Lt. Governor

Noah Valenstein
Secretary

November 20, 2020

Via Electronic Mail to Jeff Roberts at JRoberts@siremlab.com

Mr. Jeff Roberts, M.Sc.
Senior Manager
SiREM
130 Stone Road West
Ontario, Canada N1G 3Z2

Re: **KB-1 Primer**
The FDEP Innovative Technology Application Number: 1520

Dear Mr. Roberts:

The Florida Department of Environmental Protection's Division of Waste Management (Division) hereby accepts KB-1 Primer as a chemical reductant, used for oxygen removal from the municipal or groundwater sources that are utilized for preparation/ premixing of bioremediation amendments for anaerobic bioremediation. This water is often aerobic and may expose anaerobic bioaugmentation cultures to inhibitory concentrations of dissolved oxygen, which can impinge on the effective activity of the culture.

Enclosure 1 contains regulatory information.

While the Florida Department of Environmental Protection (FDEP) does not provide endorsement of specific or brand name remediation products or processes, it does recognize the need to determine their acceptability from an environmental standpoint with respect to applicable rules and regulations, and the interests of public health safety. Vendors, upon receipt of an acceptance, must market their product or process on its merits regarding performance, cost, and safety in comparison to competing alternatives in the marketplace. This acceptance letter shall not be construed as either an approval of the product or a certification of its performance.

Additionally, Department acceptance of any product or process does not imply it has been deemed applicable for all cleanup situations, or that it is preferred over other treatment or cleanup techniques in any particular case. A site-specific evaluation of applicability and cost-effectiveness must be considered for any product or process, whether conventional or innovative, and adequate site-specific design details must be provided in a Remedial Action Plan.

It is not a requirement that a remediation product or process obtain an acceptance from the Department in order to be proposed for use in a site-specific Remedial Action Plan, but the plan must contain information to show that it meets all applicable and appropriate rules and regulations. For KB-1 Primer

listed in this letter, a copy of this acceptance letter containing regulatory compliance advice should be included in the appendix of each site-specific Remedial Action Plan that proposes its use.

The Department reserves the right to revoke its acceptance of a product or process if it has been falsely represented.

If you have any questions, contact Elena Compton at (850) 245-8911, through Mail Station 4535 at the letterhead address, or by e-mail at Elena.Compton@dep.state.fl.us.

Sincerely,

Elena C. Compton

Elena Compton, M.S., P.E.
Professional Engineer III
District and Business Support ProgramFDEP
850-245-8911

Enclosures: (1) Regulatory Information

Burlab # 1520

1. Groundwater cleanup standards: The onus shall be on users of KB-1 Primer to ensure that all applicable groundwater standards will be met at the time of project completion for the contaminants of concern being remediated, and any by-products produced as a result of chemical or biochemical reactions induced or assisted by KB-1 Primer listed in the subject letter. The following chapters of the Florida Administrative Code (F.A.C.) are cited: Chapter 62-550, F.A.C., for primary and secondary water quality standards; Chapter 62-520, F.A.C., for groundwater classes, for groundwater permitting, and for monitoring requirements; Chapter 62-528, F.A.C., for underground injection control, particularly Part V, for Class V, Group 4 aquifer remediation projects; Chapters 62-780, F.A.C., for cleanup criteria, allowance of alternative cleanup target levels and conditional closure requirements; and Chapter 62-777, F.A.C., for cleanup target levels.

2. Injection well permit: Per Rule 62-528.630(2)(c), F.A.C., the issuance of an enforceable, site-specific Remedial Action Plan Approval Order by the Department for injection-type aquifer remediation constitutes the granting of a Class V injection well construction/clearance permit.

3. Underground Injection Control (UIC): Remedial Action Plans proposing injection-type aquifer remediation shall include the information required by Rules 62-528.630(2)(c)1 through 6, F.A.C., for the purposes of the UIC program. Reviewers of those plans, upon issuance of a Department-enforceable Remedial Action Plan Approval Order, must transmit this information to the UIC program in Tallahassee by submitting a completed copy of the "UIC Notification". The notification is in the form of a memorandum currently located on the Internet at https://floridadep.gov/waste/petroleum-restoration/forms/uic-notification-remediation-hazardous-waste.

4. General information about temporary Zones of Discharge (ZOD): For groundwater remediation, the composition of a fluid to be injected must meet the primary and secondary drinking water standards set forth in Chapter 62-550, F.A.C., and the minimum groundwater criteria of Chapter 62-520, F.A.C. [and Chapter 62-777], pursuant to UIC Rule 62-528.600(2)(d), F.A.C. Aquifer remediation products that do not meet these requirements must seek relief from water quality criteria by one of two mechanisms as follows. Permission for a temporary ZOD may be obtained via Rule 62-520.310(8)(c), F.A.C. If permission for a ZOD cannot be obtained by rule, then it will be necessary to seek a variance from Department rules in accordance with Section 120.542, Florida Statutes.

   Rule 62-520.310(8)(c), F.A.C., allows for a temporary ZOD for closed-loop re-injection systems, for the prime constituents of the reagents used to remediate site contaminants, and for groundwater secondary standards. In order to obtain permission for a temporary ZOD by rule, a site-specific Remedial Action Plan must indicate: (a) the chemical ingredients of concern in the fluid to be injected that will be present in excess of groundwater standards; (b) the size of the ZOD that is needed; (c) the amount of time that the ZOD will be needed; and (d) a plan for monitoring the injected chemical ingredients of concern.

   The size of the temporary ZOD will usually be the injection well radius of influence when the treatment system is a single injection point. For a multiple point system, the ZOD can usually be expressed and illustrated as the total area covered by all the injection points, located side-by-side with overlapping radii of influence.

5. Upon expiration of the time-period granted for the ZOD by way of Rule 62-520.310(8)(c), F.A.C., the concentrations of the above referenced analytes must meet their respective groundwater standards or their natural-occurring background values at the specific cleanup site, whichever is less stringent.

   Conditional closure is also allowable provided the closure criteria of Rule 62-780.680, F.A.C., are met and there are no exceedances of a primary standard due to impurities in the product. Note that such conditional closure may require a modification of the size or duration of the ZOD. This modification must be approved in an enforceable order of the department, such as a conditional Site Rehabilitation Completion Order.

6. Site-specific Remedial Action Plans shall describe the volume and concentration of KB-1 Primer reagents that will be injected.

7. Specific ZOD information for KB-1 Primer:

   a. Prior to injection, KB-1 Primer must be diluted to at least 0.08% concentration.

      Note: In order to completely dissolve the KB-1 Primer, SiREM recommends conducting dilutions in two (2) steps. First, create a slurry of one 800 gram pouch of KB-1 Primer in 20 liters (~5.3 gallons) of water. Then, pour this slurry into the preparatory tank with 250 gallons of water and mix it gently to facilitate complete dissolution. The reaction time to meet the ORP and DO requirements is typically 1 to 2 hours and is not temperature specific

   b. For the ZOD parameters: sodium shall be monitored. Reviewers of Remedial Action Plans should check the box as shown below when filling out the UIC Notification memorandum:
      "☑ *ZOD permission by rule* 62-520.310(8)(c), F.A.C., for *reagent chemical species and/or parameter(s) in the fluid to be injected (or re-injected) that exceed secondary groundwater standards. …".

8. Required UIC ZOD compliance monitoring for KB-1 Primer to comply with Rule 62-520.319(8)(c), F.A.C.: the receiving groundwater must be monitored for sodium.

9. Quarterly monitoring should suffice in most cases. Upon expiration of the time period granted for the ZOD by way of Rule 62-520.310(8)(c), F.A.C., the concentrations of the above referenced analytes must meet their respective groundwater standards or their natural-occurring background values at the specific cleanup site, whichever is less stringent, or appropriate controls are put in place to allow conditional closure under rule 62-780.680, F.A.C.

   Sodium has primary drinking water standard of 160,000 ug/L (micrograms per liter).

10. Utilization of wells: If a remediation site happens to have an abundance of monitoring wells, then the Division of Waste Management has no objection to the use of some wells for the injection of KB-1 Primer if the wells are suitable for the purpose. However, no "designated" monitoring well, dedicated to the tracking of remediation progress (by sampling) shall be used to apply KB-1 Primer product. This will avoid a premature conclusion that the entire site meets cleanup goals. By making sure that designated tracking wells are not used for treatment, there will be more assurance that the

treatment process has permeated the entire site and that it did not remain localized to the area immediately surrounding each injection well.

11. Three categories of groundwater monitoring:

    a. Active remediation monitoring for a cleanup site's contaminants of concern:
    During the period of active remediation, groundwater shall be monitored in accordance with the requirements set forth in Section 62-780.700, F.A.C.

    b. Post Active Remediation Monitoring for a cleanup site's contaminants of concern:
    At least one (1) year of quarterly post remediation groundwater monitoring for the contaminants of concern shall be conducted at a minimum of two (2) wells: one located in the area of highest contamination, the other at the downgradient edge of the contamination plume, pursuant to Section 62-780.750, F.A.C.

    c. Monitoring of the UIC zone of discharge for sodium, as discussed in paragraph 7b (seven b) above.

12. Injection operations:

    a. Avoidance of migration: For injection-type in-situ aquifer remediation projects, injection of KB-1 Primer shall be performed in such a way and at such a rate and volume that no migration of either the KB-1 Primer or the contaminants of concern in the aquifer or surface water results, pursuant to Rule 62-528.630(3), F.A.C.

    b. Underground Injection Control operating permit: Although an operating permit is not required for aquifer remediation wells pursuant to Rule 62-528.640(1)(b), and 62-528.640(1)(c), F.A.C., since no movement of the contamination plume is expected to accompany the treatment process, the Department requests that the information items listed in Rule 62-528.640(1)(b), F.A.C., be considered and included in Remedial Action Plan proposals as a matter of good and thorough design practice. Briefly summarized, they are: quality of water in the aquifer, quality of the injected fluid, existing and potential uses of the affected aquifer, and well construction details.

13. Abandonment of wells: Upon issuance of a Site Rehabilitation Completion Order or a declaration of "No Further Action", injection wells shall be abandoned pursuant to Section 62-528.645, F.A.C. The Underground Injection Control Section of the Department shall be notified so that the injection wells can be removed from the inventory-tracking list.

14. Open-pit application: There is no objection to the introduction of KB-1 Primer to an open excavation pit in which the groundwater has been exposed. Open-pit application is not injection, and it is not necessary to notify the Underground Injection Control Section, but this should not be construed as allowing any substance at any concentration with no regard to potential groundwater contamination or toxicological effects. The Division of Waste Management therefore requires that the groundwater in the area of the pit be monitored for the same zone of discharge parameters that would have been monitored (if any) had the application actually been an injection.

ATTACHMENT D

DESIGN CALCULATIONS

Purpose: Estimate the substrate volume needed per 2-ft injection lift based on target pore volume percentages of vegetable oil (VO) and emulsified zero valent iron (EZVI).

Assumptions:

- For calculations and work plan purposes, the substrate volumes were calculated based on vendor formulations from Provectus. For VO injections, ERD-CH4 is used consisting of 60% fermentable carbon and for EZVI, EZVI-CH4 is used made up of 10% ZVI.
- The target pore space volume for VO is 0.8% and for EZVI 8% based on vendor recommendations and available literature.
- For VO/L, the total injectate volume (substrate plus additional water) is calculated with a rule-of-thumb of 10% of pore space volume.
- For EZVI, no additional water is required.

VO/L Injection

Injection Area
Radius of influence = 10 ft

10 ft x 10 ft x π = **315 ft^2**

Pore Space Volume
Lift thickness = 2 ft
Porosity = 30%
38 lifts in treatment design

315 ft^2 x 2 ft x 7.48 gal/ft^3 x 0.30 porosity = **1,413 gallons per lift**
1,413 gal/lift x 38 lifts = **53,694 gallons total pore space**

Substrate Pore Space Volume
The target pore space volume is 0.8% VO
60% of ERD-CH4 is fermentable carbon (FC)/vegetable oil (VO)
Density of vegetable oil = 0.92

1,413 gal x 0.8% = 11.5 gallons of VO per lift

11.5 gal x 8.34 lb/gal x 0.92 = 88 lb VO

88 lb VO / 60% = 147 lb of ERD-CH_4

147 lb ERD-CH_4 x gal/8.3 lb = **18 gal of ERD-CH_4 per lift**

18 gal ERD-CH_4/lift x 38 lifts = **684 total gallons of ERD-CH_4**

684 gal ERD-CH_4 x 8.3 lb/gal = **5,675 lb of ERD-CH_4**

Water Volume Required
Target injectate volume is 10% of pore space volume

1,413 gal x 10% = **141 gallons total injectate per lift**

53,694 gal x 10% = **approximately 5,358 gallons total injectate over treatment area**

141 gal injectate - 18 gal ERD-CH4 = **123 gallons of water per lift**
123 gal water/lift x 38 lifts = **4,674 gallons of water over treatment area**

EZVI Injection

Injection Area
Radius of influence = 6 ft
3 injection locations

6 ft x 6 ft x π = 115 ft^2

Pore Space Volume
Lift interval = 2 ft
Porosity = 30%
9 total lifts

115 ft^2 x 2 ft x 7.48 gal/ft^3 x 0.30 porosity = **516 gallons water per lift**
516 gallons x 9 lifts = **4,644 gallons total pore space**

Pore Space Percentage
The target pore space volume is 8% EZVI

516 gal x 0.08 = **41 gallons of EZVI-CH4 per lift**
41 gal EZVI-CH4/lift x 9 lifts = **369 gallons of total EZVI-CH4**

pH Amendent Injection
Amendment loading (based on comparable projects) = 500 mg sodium bicarbonate per L of pore volume.

1,413 gal x 500 mg/L x 3.785 L/gal x lb/453,592 mg = **5.9 pounds per lift**
5.9 lb/lift x 38 lifts = 224 lb = **roughly 225 lb of pH amendment**

ATTACHMENT E

DESIGN COST ESTIMATE AND SUPPORTING INFORMATION

NASA KENNEDY SPACE CENTER, FLORIDA
SWMU 089: CCB - MW21
Interim Measures Work Plan
In Situ Bioremediation, including ZVI
Capital Cost

Item	Quantity	Unit	Unit Cost				Extended Cost				
			Subcontract	Material	Labor	Equipment	Subcontract	Material	Labor	Equipment	Subtotal
1 PROJECT PLANNING											
1.1 Prepare Documents & Plans including Permits	350	hr			$42.00		$0	$0	$14,700	$0	$14,700
1.2 Prepare Air and Groundwater Monitoring Plan	80	hr			$42.00		$0	$0	$3,360	$0	$3,360
1.3 Completion Report	225	hr			$42.00		$0	$0	$9,450	$0	$9,450
2 MOBILIZATION AND DEMOBILIZATION											
2.1 Site Support Facilities (trailers, phone, electric, etc.)	0	ea		$1,000.00		$3,500.00	$0	$0	$0	$0	$0
2.2 Equipment Mobilization/Demobilization	0	ea			$183.00	$518.00	$0	$0	$0	$0	$0
2.3 Drill Rig/Inj. Eq. Mobilization/Demobilization	1	ea	$8,500.00				$8,500	$0	$0	$0	$8,500
3 FIELD SUPPORT											
3.1 Site Support Facilities (trailers, phone, electric, etc.)	1	mo		$220.00	$370.00		$0	$220	$370	$0	$590
3.2 Construction Survey Support	1	day	$1,125.00				$1,125	$0	$0	$0	$1,125
3.3 Site Superintendent	10	day			$760.00		$0	$0	$7,600	$0	$7,600
3.4 Site Health & Safety and QA/QC	3	day			$700.00		$0	$0	$2,100	$0	$2,100
4 DECONTAMINATION											
4.1 Decontamination Services	1	mo		$1,220.00	$2,245.00	$1,550.00	$0	$1,220	$2,245	$1,550	$5,015
4.2 Equipment Laydown and Decon Pad	1	ls		$4,500.00	$3,000.00	$725.00	$0	$4,500	$3,000	$725	$8,225
4.3 Decon Water	500	gal		$0.20			$0	$100	$0	$0	$100
4.4 Decon Water Storage Tank, 1,600 gallon	1	mo				$782.00	$0	$0	$0	$782	$782
4.5 Clean Water Storage Tank. 1,500 gallon	1	mo				$703.00	$0	$0	$0	$703	$703
4.6 IDW Disposal: non-hazardous	1	drum	$135.00				$135	$0	$0	$0	$135
4.7 IDW Disposal: hazardous	0	drum	$250.00				$0	$0	$0	$0	$0
5 BIOREMEDIATION INJECTION											
5.1 VO/carbon substrate	5,675	lb		$2.20			$0	$12,485	$0	$0	$12,485
5.2 Sodium bicarbonate	200	lb		$1.00			$0	$200	$0	$0	$200
5.3 Microbial culture (KB-1)	37	L	$260.00				$9,620	$0	$0	$0	$9,620
5.4 Primer for ~4,000 gallons of water (KB-1 Primer)	20	ea	$80.00				$1,600	$0	$0	$0	$1,600
5.5 EZVI	370	gal		$26.00			$0	$9,620	$0	$0	$9,620
5.6 Injection Equipment and crew	5	day	$4,400.00		$430.00	$1,160.00	$22,000	$0	$2,150	$5,800	$29,950
5.7 Delivery/Freight	1	ls	$1,650.00				$1,650	$0	$0	$0	$1,650
5.8 Water Storage	1	mo	$5,000.00				$5,000	$0	$0	$0	$5,000
5.9 Additional mob cost (angled drill equipment)	1	ea				$1,500.00	$0	$0	$0	$1,500	$1,500
6 SSDS SYSTEM REACTIVATION											
6.1 Extraction Blower (Trailer, existing)	1	ea			$430.00		$0	$0	$430	$0	$430
6.2 Inspection of SSDS (two people)	2	day			$430.00		$0	$0	$860	$0	$860
6.3 Piping repairs (two people, 2 days)	4	day		$200.00	$430.00		$0	$800	$1,720	$0	$2,520
6.4 Extraction well repairs (two people, 2 days)	4	day		$200.00	$430.00		$0	$800	$1,720	$0	$2,520
6.6 Electric Power Supply	0	ea	$5,000.00				$0	$0	$0	$0	$0
6.7 System Startup Labor (1 people, 5 days)	5	day			$800.00		$0	$0	$4,000	$0	$4,000

NASA KENNEDY SPACE CENTER, FLORIDA
SWMU 089: CCB - MW21
Interim Measures Work Plan
In Situ Bioremediation, including ZVI
Capital Cost

Item	Quantity	Unit	Unit Cost Subcontract	Unit Cost Material	Unit Cost Labor	Unit Cost Equipment	Extended Cost Subcontract	Extended Cost Material	Extended Cost Labor	Extended Cost Equipment	Subtotal
7 SITEWIDE BASELINE SAMPLING											
7.1 MW: Analysis VOC analytes	1	ea	$125.00				$125	$0	$0	$0	$125
7.2 MW: Analysis UIC analytes	5	ea	$300.00				$1,500	$0	$0	$0	$1,500
7.3 MW: Analysis Dhc analytes	1	ea	$355.00				$355	$0	$0	$0	$355
7.4 MW: Analysis Dissolved gas analytes	1	ea	$320.00				$320	$0	$0	$0	$320
7.5 MW: Analysis TOC analytes	1	ea	$100.00				$100	$0	$0	$0	$100
7.6 MW: Equipment	1	days				$500.00	$0	$0	$0	$500	$500
7.7 MW: Sampling Labor	1	days			$430.00		$0	$0	$430	$0	$430
7.8 DPT: Daily Rate	3	day	$2,100.00		$1,000.00		$6,300	$0	$3,000	$0	$9,300
7.9 DPT: Mob/Demob (1 event)	1	ea	$3,500.00				$3,500	$0	$0	$0	$3,500
7.10 DPT: Analysis VOC analytes	17	ea	$125.00				$2,125	$0	$0	$0	$2,125
7.11 DPT: Analysis Dhc analytes	4	ea	$355.00				$1,420	$0	$0	$0	$1,420
7.12 DPT: Analysis Dissolved gas analytes	4	ea	$320.00				$1,280	$0	$0	$0	$1,280
7.13 DPT: Analysis TOC analytes	4	ea	$100.00				$400	$0	$0	$0	$400
7.14 Air: Analysis VOCs (8 locations)	8	ea	$200.00				$1,600	$0	$0	$0	$1,600
7.15 Air: Sampling Labor	1	days			$430.00		$0	$0	$430	$0	$430
Subtotal							$68,655	$29,945	$57,565	$11,560	$167,725
Overhead on Labor Cost @ 36%									$20,723		$20,723
G & A on Labor, Material, Equipment, & Sub Cost @ 12%							$8,239	$3,593	$6,908	$1,387	$20,127
Tax on Materials and Equipment Cost @ 6%								$1,797		$694	$2,490
Total Direct Cost							$76,894	$35,335	$85,196	$13,641	$211,066
Indirects on Total Direct Cost @ 5%											$10,553
Profit on Total Direct Cost @ 10%											$21,107
Total Field Cost											$242,726
Contingency on Total Field Costs @ 10%											$24,273
Engineering on Total Field Cost @ 5%											$12,136
TOTAL CAPITAL COST											**$279,134**

NASA KENNEDY SPACE CENTER, FLORIDA
SWMU 089: CCB - MW21
Interim Measures Work Plan
In Situ Bioremediation, including ZVI
Annual Cost (Year 1)

	Item	Quantity	Unit	Unit Cost Subcontract	Unit Cost Material	Unit Cost Labor	Unit Cost Equipment	Extended Cost Subcontract	Extended Cost Material	Extended Cost Labor	Extended Cost Equipment	Subtotal
1	**PERFORMANCE MONITORING**											
1.1	MW: Analysis VOC analytes (semi-annual)	2	ea	$125.00				$250	$0	$0	$0	$250
1.2	MW: Analysis UIC analytes (semi- annual)	10	ea	$300.00				$3,000	$0	$0	$0	$3,000
1.3	MW: Analysis Dhc analytes (annual)	1	ea	$355.00				$355	$0	$0	$0	$355
1.4	MW: Analysis Dissolved Gases (semi-annual)	2	ea	$320.00				$640	$0	$0	$0	$640
1.5	MW: Analysis TOC analytes (semi-annual)	2	ea	$100.00				$200	$0	$0	$0	$200
1.6	MW: Equipment (semi-annual)	2	days				$500.00	$0	$0	$0	$1,000	$1,000
1.7	MW: Sampling Labor (semi-annual)	2	days			$430.00		$0	$0	$860	$0	$860
1.8	DPT: Daily Rate (annual)	3	day	$2,100.00		$1,000.00		$6,300	$0	$3,000	$0	$9,300
1.9	DPT: Mob/Demob (1 event)	1	ea	$3,500.00				$3,500	$0	$0	$0	$3,500
1.10	DPT: Analysis VOC analytes (annual)	16	ea	$125.00				$2,000	$0	$0	$0	$2,000
1.11	DPT: Analysis Dhc analytes (annual)	4	ea	$355.00				$1,420	$0	$0	$0	$1,420
1.12	DPT: Analysis Dissolved Gases (annual)	4	ea	$320.00				$1,280	$0	$0	$0	$1,280
1.13	DPT: Analysis TOC analytes (annual)	4	ea	$100.00				$400	$0	$0	$0	$400
1.14	Air: Analysis VOCs (8 locations, quarterly)	32	ea	$200.00				$6,400	$0	$0	$0	$6,400
1.15	Air: Sampling Labor	4	days			$430.00		$0	$0	$1,720	$0	$1,720
2	**EQUIPMENT OPERATION AND MAINTENANCE**											
2.1	Site Visits Labor (technician) (SSDS) (monthly)	12	visits			$430.00		$0	$0	$5,160	$0	$5,160
2.2	Equipment Maintenance and Repair Replacement	1	ea		$500.00			$0	$500	$0	$0	$500
2.3	SSDS Electrical (assumed 7.5 HP, 24/7/365)	48,992	kWH	$0.08				$3,919	$0	$0	$0	$3,919
3	**REPORTING**											
3.1	Step 4C Engineering Evaluation ADP	1	ea			$10,000.00		$0	$0	$10,000	$0	$10,000
3.2	Annual OM&M/MNA Report	1	ea			$13,000.00		$0	$0	$13,000	$0	$13,000
	Subtotal							$29,664	$500	$33,740	$1,000	$64,904
	Overhead on Labor Cost @ 36%									$12,146		$12,146
	G & A on Labor, Material, Equipment, & Sub Cost @ 12%							$3,560	$60	$4,049	$120	$7,789
	Tax on Materials and Equipment Cost @ 6%								$30		$60	$90
	Total Direct Cost							$33,224	$590	$49,935	$1,180	$84,929
	Indirects on Total Direct Cost @ 5%											$4,246
	Profit on Total Direct Cost @ 10%											$8,493
	Total Field Cost											$97,669
	Contingency on Total Field Costs @ 10%											$9,767
	Engineering on Total Field Cost @ 5%											$4,883
	TOTAL ANNUAL COST											**$112,319**

NASA KENNEDY SPACE CENTER, FLORIDA
SWMU 089: CCB - MW21
Interim Measures Work Plan
In Situ Bioremediation, including ZVI
Annual Cost (Year 2)

	Item	Quantity	Unit	Unit Cost Subcontract	Unit Cost Material	Unit Cost Labor	Unit Cost Equipment	Extended Cost Subcontract	Extended Cost Material	Extended Cost Labor	Extended Cost Equipment	Subtotal
1	**PERFORMANCE MONITORING**											
1.1	MW: Analysis VOC analytes (semi-annual)	2	ea	$125.00				$250	$0	$0	$0	$250
1.2	MW: Analysis UIC analytes (semi- annual)	10	ea	$300.00				$3,000	$0	$0	$0	$3,000
1.3	MW: Analysis Dhc analytes (annual)	1	ea	$355.00				$355	$0	$0	$0	$355
1.4	MW: Analysis Dissolved Gases (semi-annual)	2	ea	$320.00				$640	$0	$0	$0	$640
1.5	MW: Analysis TOC analytes (semi-annual)	2	ea	$100.00				$200	$0	$0	$0	$200
1.6	MW: Equipment (semi-annual)	2	days				$500.00	$0	$0	$0	$1,000	$1,000
1.7	MW: Sampling Labor (semi-annual)	2	days			$430.00		$0	$0	$860	$0	$860
1.8	DPT: Daily Rate (annual)	3	day	$2,100.00		$1,000.00		$6,300	$0	$3,000	$0	$9,300
1.9	DPT: Mob/Demob (1 event)	1	ea	$3,500.00				$3,500	$0	$0	$0	$3,500
1.10	DPT: Analysis VOC analytes (annual)	16	ea	$125.00				$2,000	$0	$0	$0	$2,000
1.11	DPT: Analysis Dhc analytes (annual)	4	ea	$355.00				$1,420	$0	$0	$0	$1,420
1.12	DPT: Analysis Dissolved Gases (annual)	4	ea	$320.00				$1,280	$0	$0	$0	$1,280
1.13	DPT: Analysis TOC analytes (annual)	4	ea	$100.00				$400	$0	$0	$0	$400
1.14	Air: Analysis VOCs (8 locations, quarterly)	32	ea	$200.00				$6,400	$0	$0	$0	$6,400
1.15	Air: Sampling Labor	4	days			$430.00		$0	$0	$1,720	$0	$1,720
2	**EQUIPMENT OPERATION AND MAINTENANCE**											
2.1	Site Visits Labor (technician) (SSDS) (monthly)	12	visits			$430.00		$0	$0	$5,160	$0	$5,160
2.2	Equipment Maintenance and Repair Replacement	1	ea		$500.00			$0	$500	$0	$0	$500
2.3	SSDS Electrical (assumed 7.5 HP, 24/7/365)	48,992	kWH	$0.08				$3,919	$0	$0	$0	$3,919
3	**REPORTING**											
3.1	Step 4C Engineering Evaluation ADP	1	ea			$10,000.00		$0	$0	$10,000	$0	$10,000
3.2	Annual OM&M/MNA Report	1	ea			$13,000.00		$0	$0	$13,000	$0	$13,000
	Subtotal							$29,664	$500	$33,740	$1,000	$64,904
	Overhead on Labor Cost @ 36%									$12,146		$12,146
	G & A on Labor, Material, Equipment, & Sub Cost @ 12%							$3,560	$60	$4,049	$120	$7,789
	Tax on Materials and Equipment Cost @ 6%								$30		$60	$90
	Total Direct Cost							$33,224	$590	$49,935	$1,180	$84,929
	Indirects on Total Direct Cost @ 5%											$4,246
	Profit on Total Direct Cost @ 10%											$8,493
	Total Field Cost											$97,669
	Contingency on Total Field Costs @ 10%											$9,767
	Engineering on Total Field Cost @ 5%											$4,883
	TOTAL ANNUAL COST											**$112,319**

NASA KENNEDY SPACE CENTER, FLORIDA
SWMU 089: CCB - MW21
Interim Measures Work Plan
In Situ Bioremediation, including ZVI
Annual Cost (Year 3)

	Item	Quantity	Unit	Unit Cost Subcontract	Unit Cost Material	Unit Cost Labor	Unit Cost Equipment	Extended Cost Subcontract	Extended Cost Material	Extended Cost Labor	Extended Cost Equipment	Subtotal
1	**PERFORMANCE MONITORING**											
1.1	MW: Analysis VOC analytes (semi-annual)	2	ea	$125.00				$250	$0	$0	$0	$250
1.2	MW: Analysis UIC analytes (semi- annual)	10	ea	$300.00				$3,000	$0	$0	$0	$3,000
1.3	MW: Analysis Dhc analytes (annual)	1	ea	$355.00				$355	$0	$0	$0	$355
1.4	MW: Analysis Dissolved Gases (semi-annual)	2	ea	$320.00				$640	$0	$0	$0	$640
1.5	MW: Analysis TOC analytes (semi-annual)	2	ea	$100.00				$200	$0	$0	$0	$200
1.6	MW: Equipment (semi-annual)	2	days				$500.00	$0	$0	$0	$1,000	$1,000
1.7	MW: Sampling Labor (semi-annual)	2	days			$430.00		$0	$0	$860	$0	$860
1.8	DPT: Daily Rate (annual)	3	day	$2,100.00		$1,000.00		$6,300	$0	$3,000	$0	$9,300
1.9	DPT: Mob/Demob (1 event)	1	ea	$3,500.00				$3,500	$0	$0	$0	$3,500
1.10	DPT: Analysis VOC analytes (annual)	16	ea	$125.00				$2,000	$0	$0	$0	$2,000
1.11	DPT: Analysis Dhc analytes (annual)	4	ea	$355.00				$1,420	$0	$0	$0	$1,420
1.12	DPT: Analysis Dissolved Gases (annual)	4	ea	$320.00				$1,280	$0	$0	$0	$1,280
1.13	DPT: Analysis TOC analytes (annual)	4	ea	$100.00				$400	$0	$0	$0	$400
1.14	Air: Analysis VOCs (8 locations, quarterly)	32	ea	$200.00				$6,400	$0	$0	$0	$6,400
1.15	Air: Sampling Labor	4	days			$430.00		$0	$0	$1,720	$0	$1,720
2	**EQUIPMENT OPERATION AND MAINTENANCE**											
2.1	Site Visits Labor (technician) (SSDS) (monthly)	0	visits			$430.00		$0	$0	$0	$0	$0
2.2	Equipment Maintenance and Repair Replacement	0	ea		$500.00			$0	$0	$0	$0	$0
2.3	SSDS Electrical (assumed 7.5 HP, 24/7/365)	0	kWH	$0.08				$0	$0	$0	$0	$0
3	**REPORTING**											
3.1	Step 4C Engineering Evaluation ADP	1	ea			$10,000.00		$0	$0	$10,000	$0	$10,000
3.2	Annual OM&M/MNA Report	1	ea			$13,000.00		$0	$0	$13,000	$0	$13,000
	Subtotal							$25,745	$0	$28,580	$1,000	$55,325
	Overhead on Labor Cost @ 36%									$10,289		$10,289
	G & A on Labor, Material, Equipment, & Sub Cost @ 12%							$3,089	$0	$3,430	$120	$6,639
	Tax on Materials and Equipment Cost @ 6%								$0		$60	$60
	Total Direct Cost							$28,834	$0	$42,298	$1,180	$72,313
	Indirects on Total Direct Cost @ 5%											$3,616
	Profit on Total Direct Cost @ 10%											$7,231
	Total Field Cost											$83,160
	Contingency on Total Field Costs @ 10%											$8,316
	Engineering on Total Field Cost @ 5%											$4,158
	TOTAL ANNUAL COST											**$95,634**

NASA KENNEDY SPACE CENTER, FLORIDA
SWMU 089: CCB - MW21
Interim Measures Work Plan
In Situ Bioremediation, including ZVI
Annual Cost (Year 4)

	Item	Quantity	Unit	Unit Cost Subcontract	Unit Cost Material	Unit Cost Labor	Unit Cost Equipment	Extended Cost Subcontract	Extended Cost Material	Extended Cost Labor	Extended Cost Equipment	Subtotal
1	**PERFORMANCE MONITORING**											
1.1	MW: Analysis VOC analytes (annual)	1	ea	$125.00				$125	$0	$0	$0	$125
1.2	MW: Analysis UIC analytes (annual)	5	ea	$300.00				$1,500	$0	$0	$0	$1,500
1.3	MW: Analysis Dhc analytes (annual)	1	ea	$355.00				$355	$0	$0	$0	$355
1.4	MW: Analysis Dissolved Gases (annual)	1	ea	$320.00				$320	$0	$0	$0	$320
1.5	MW: Analysis TOC analytes (annual)	1	ea	$100.00				$100	$0	$0	$0	$100
1.6	MW: Equipment (annual)	1	days				$500.00	$0	$0	$0	$500	$500
1.7	MW: Sampling Labor (annual)	1	days			$430.00		$0	$0	$430	$0	$430
1.8	DPT: Daily Rate (annual)	3	day	$2,100.00		$1,000.00		$6,300	$0	$3,000	$0	$9,300
1.9	DPT: Mob/Demob (1 event)	1	ea	$3,500.00				$3,500	$0	$0	$0	$3,500
1.10	DPT: Analysis VOC analytes (annual)	16	ea	$125.00				$2,000	$0	$0	$0	$2,000
1.11	DPT: Analysis Dhc analytes (annual)	4	ea	$355.00				$1,420	$0	$0	$0	$1,420
1.12	DPT: Analysis Dissolved Gases (annual)	4	ea	$320.00				$1,280	$0	$0	$0	$1,280
1.13	DPT: Analysis TOC analytes (annual)	4	ea	$100.00				$400	$0	$0	$0	$400
1.14	Air: Analysis VOCs (8 locations, annual)	8	ea	$200.00				$1,600	$0	$0	$0	$1,600
1.15	Air: Sampling Labor (annual)	1	days			$430.00		$0	$0	$430	$0	$430
2	**EQUIPMENT OPERATION AND MAINTENANCE**											
2.1	Site Visits Labor (technician) (SSDS) (monthly)	0	visits			$430.00		$0	$0	$0	$0	$0
2.2	Equipment Maintenance and Repair Replacement	0	ea		$500.00			$0	$0	$0	$0	$0
2.3	SSDS Electrical (assumed 7.5 HP, 24/7/365)	0	kWH	$0.08				$0	$0	$0	$0	$0
3	**REPORTING**											
3.1	Step 4C Engineering Evaluation ADP	1	ea			$10,000.00		$0	$0	$10,000	$0	$10,000
3.2	Annual OM&M/MNA Report	1	ea			$13,000.00		$0	$0	$13,000	$0	$13,000
	Subtotal							$18,900	$0	$26,860	$500	$46,260
	Overhead on Labor Cost @ 36%									$9,670		$9,670
	G & A on Labor, Material, Equipment, & Sub Cost @ 12%							$2,268	$0	$3,223	$60	$5,551
	Tax on Materials and Equipment Cost @ 6%								$0		$30	$30
	Total Direct Cost							$21,168	$0	$39,753	$590	$61,511
	Indirects on Total Direct Cost @ 5%											$3,076
	Profit on Total Direct Cost @ 10%											$6,151
	Total Field Cost											$70,737
	Contingency on Total Field Costs @ 10%											$7,074
	Engineering on Total Field Cost @ 5%											$3,537
	TOTAL ANNUAL COST											**$81,348**

NASA KENNEDY SPACE CENTER, FLORIDA
SWMU 089: CCB - MW21
Interim Measures Work Plan
In Situ Bioremediation, including ZVI
Annual Cost (Year 5)

	Item	Quantity	Unit	Unit Cost Subcontract	Unit Cost Material	Unit Cost Labor	Unit Cost Equipment	Extended Cost Subcontract	Extended Cost Material	Extended Cost Labor	Extended Cost Equipment	Subtotal
1	**PERFORMANCE MONITORING**											
1.1	MW: Analysis VOC analytes (annual)	1	ea	$125.00				$125	$0	$0	$0	$125
1.2	MW: Analysis UIC analytes (annual)	5	ea	$300.00				$1,500	$0	$0	$0	$1,500
1.3	MW: Analysis Dhc analytes (annual)	1	ea	$355.00				$355	$0	$0	$0	$355
1.4	MW: Analysis Dissolved Gases (annual)	1	ea	$320.00				$320	$0	$0	$0	$320
1.5	MW: Analysis TOC analytes (annual)	1	ea	$100.00				$100	$0	$0	$0	$100
1.6	MW: Equipment (annual)	1	days				$500.00	$0	$0	$0	$500	$500
1.7	MW: Sampling Labor (annual)	1	days			$430.00		$0	$0	$430	$0	$430
1.8	DPT: Daily Rate (annual)	3	day	$2,100.00		$1,000.00		$6,300	$0	$3,000	$0	$9,300
1.9	DPT: Mob/Demob (1 event)	1	ea	$3,500.00				$3,500	$0	$0	$0	$3,500
1.10	DPT: Analysis VOC analytes (annual)	16	ea	$125.00				$2,000	$0	$0	$0	$2,000
1.11	DPT: Analysis Dhc analytes (annual)	4	ea	$355.00				$1,420	$0	$0	$0	$1,420
1.12	DPT: Analysis Dissolved Gases (annual)	4	ea	$320.00				$1,280	$0	$0	$0	$1,280
1.13	DPT: Analysis TOC analytes (annual)	4	ea	$100.00				$400	$0	$0	$0	$400
1.14	Air: Analysis VOCs (8 locations, annual)	8	ea	$200.00				$1,600	$0	$0	$0	$1,600
1.15	Air: Sampling Labor (annual)	1	days			$430.00		$0	$0	$430	$0	$430
2	**EQUIPMENT OPERATION AND MAINTENANCE**											
2.1	Site Visits Labor (technician) (SSDS) (monthly)	0	visits			$430.00		$0	$0	$0	$0	$0
2.2	Equipment Maintenance and Repair Replacement	0	ea		$500.00			$0	$0	$0	$0	$0
2.3	SSDS Electrical (assumed 7.5 HP, 24/7/365)	0	kWH	$0.08				$0	$0	$0	$0	$0
3	**REPORTING**											
3.1	Step 4C Engineering Evaluation ADP	1	ea			$10,000.00		$0	$0	$10,000	$0	$10,000
3.2	Annual OM&M/MNA Report	1	ea			$13,000.00		$0	$0	$13,000	$0	$13,000
	Subtotal							$18,900	$0	$26,860	$500	$46,260
	Overhead on Labor Cost @ 36%									$9,670		$9,670
	G & A on Labor, Material, Equipment, & Sub Cost @ 12%							$2,268	$0	$3,223	$60	$5,551
	Tax on Materials and Equipment Cost @ 6%								$0		$30	$30
	Total Direct Cost							$21,168	$0	$39,753	$590	$61,511
	Indirects on Total Direct Cost @ 5%											$3,076
	Profit on Total Direct Cost @ 10%											$6,151
	Total Field Cost											$70,737
	Contingency on Total Field Costs @ 10%											$7,074
	Engineering on Total Field Cost @ 5%											$3,537
	TOTAL ANNUAL COST											**$81,348**

ATTACHMENT F
SITEWISE ANALYSIS

Environmental Footprint Evaluation
NASA KSC CCB MW21 Area IMWP
Kennedy Space Center
Orlando, Florida
February 2023

OBJECTIVE

This Environmental Footprint Evaluation of the selected remedial alternative is provided as an appendix to the Interim Measures Work Plan (IMWP) for NASA KSC CCB MW21 Area located at the Kennedy Space Center in Merritt Island, FL. The purpose of the footprint evaluation is to assess the environmental impacts of the selected remedial alternative using the metrics of greenhouse gas (GHG) and criteria pollutant emissions, energy use, water consumption, and worker safety, and compare with the environmental footprint of the remedy as presented in the RAE to show any factors included to decrease the footprint. The results of this footprint evaluation are intended to provide details of the environmental impacts throughout the remedy life-cycle for each of the proposed alternatives.

EVALUATION TOOLS

This evaluation was performed using a hybrid model of the Navy's SiteWise™ tool supplemented with a Tetra Tech developed model as appropriate for some site-specific items.

SiteWise™ is a life-cycle footprint assessment tool developed jointly by the U.S. Navy, U.S. Army Corps of Engineers (USACE), and Battelle. SiteWise™ assesses the environmental footprint of a remedial alternative/technology using a consistent set of metrics. The assessment is conducted using a building block approach, where each remedial alternative is first broken down into modules that follow the phases for most remedial actions, including remedial investigation (RI), remedial action construction (RA-C), remedial action operation (RA-O), and long-term monitoring (LTM). Once broken down by remedial phase, the footprint of each phase is calculated. The phase-specific footprints are then combined to estimate the overall footprint of the remedial alternative. This building block approach reduces redundancy in the footprint assessment and facilitates the identification of specific impact drivers that contribute to the environmental footprint. The inputs that need to be considered include (1) production of material required by the activity; (2) transportation of the required materials to the site, transportation of personnel; (3) all site activities to be performed; and (4) management of the waste produced by the activity.

GSRx builds off of SiteWise™ and allows for a flexible, detailed analysis, particularly for materials and equipment use. GSRx was used to account for materials and activities not readily input into SiteWise™ and where equipment usage assumptions built into SiteWise™ were not consistent with site-specific requirements.

ENVIRONMENTAL FOOTPRINT EVALUATION FRAMEWORK AND LIMITATIONS

The environmental footprint evaluation performed for the CCB MW21 RAE considered life-cycle quantitative metrics for global warming potential (through greenhouse gas emissions), criteria air pollutant emissions (through NO_X, SO_X and PM_{10} emissions), energy consumption, water usage, and worker safety.

Life cycle impacts were calculated for energy consumption, emissions of GHG (carbon dioxide [CO_2], methane [CH_4], and nitrous oxide [N_2O]) and criteria pollutants (nitrogen oxides [NO_x], sulfur oxides [SO_x] and particulate matter [PM_{10}]), water usage, and energy consumption, and worker safety.

Life cycle inventory inputs in SiteWise™ were divided into four categories – 1) materials production; 2) transportation of personnel, materials and equipment; 3) equipment use and miscellaneous; and 4) residual handling and disposal. Cost estimates from the RAE and design calculations were used as a basis for inventory quantities and related assumptions. Emission factors, energy consumption, and water usage data were correlated to material quantities, equipment, transportation distances, and installation time frames in order to calculate life-cycle emissions, energy consumption, water usage, and worker safety. Default SiteWise™ emission, energy usage, water consumption, and worker fatality and accident risk factors were utilized.

Although GSRx was used to minimize limitations resulting within SiteWise™, elimination of all limitations was not possible while using a hybrid model of SiteWise™ and GSRx. For example, several materials and construction equipment inventoried were input into GSRx and these impacts were incorporated into SiteWise™ within the “Equipment Use and Miscellaneous” sector. This sector in SiteWise™ does not differentiate into the specific equipment usage or material consumption items that are input in GSRx, but rather are considered miscellaneous items. However, impact drivers for items input in GSRx can be identified and evaluated directly within the respective GSRx evaluation and output summary sheets. In addition, worker safety results in general do not include worker safety related to equipment usage that was input within GSRx because GSRx was not developed to evaluate worker safety.

EVALUATION RESULT

Table D-1 shows the results of the SiteWise evaluation compared to the results of the evaluation of the alterative which was conducted as part of the Remedial Alternative Evaluation (RAE). Overall, changes made to the remedial alternative between the RAE and the IMWP resulted in a decreased environmental footprint compared to what was proposed in the RAE. The total amount of GHG emitted was similar, but decreased by approximately 11 metric tons of CO2e, or approximately 11-percent. The total energy usage of the remedy as designed in this IMWP is approximately 155 MMBTU less than the energy usage of the alternative in the RAE, or about 9-percent decrease. Emissions of NOx, SOx, and PM10 all decreased with the design of the alternative for this IMWP, with next decreases of approximately 35-percent, 18-percent,

and 6-percent, respectively. Risk of fatality and risk of injury increased with the changes made between the RAE and the IWMP.

Contributing factors to these changes included an increase in the number of injection points from 7 to 9, and an increase in the number of DPT samples to be collected, both of which increased the usage of the DPT rig, which led to slight increases in CO2e, NOx, and energy consumption, and led to more significant increases in risk of injury and fatality when compared to the remedy as presented in the RAE. The number of air samples to be collected decreased from what was proposed in the RAE, which resulted in a net decrease of CO2e and component emissions due to the decrease in lab work and time spent in sample collection over the years of the project. Also, the remedy as designed in this IMWP, requires a lesser volume of EZVI, the production of which is a major contributor to the CO2e, NOx, and energy consumption for the remedy.

The full result of the SiteWise evaluation broken down by remedy component is attached, along with the GSRx.

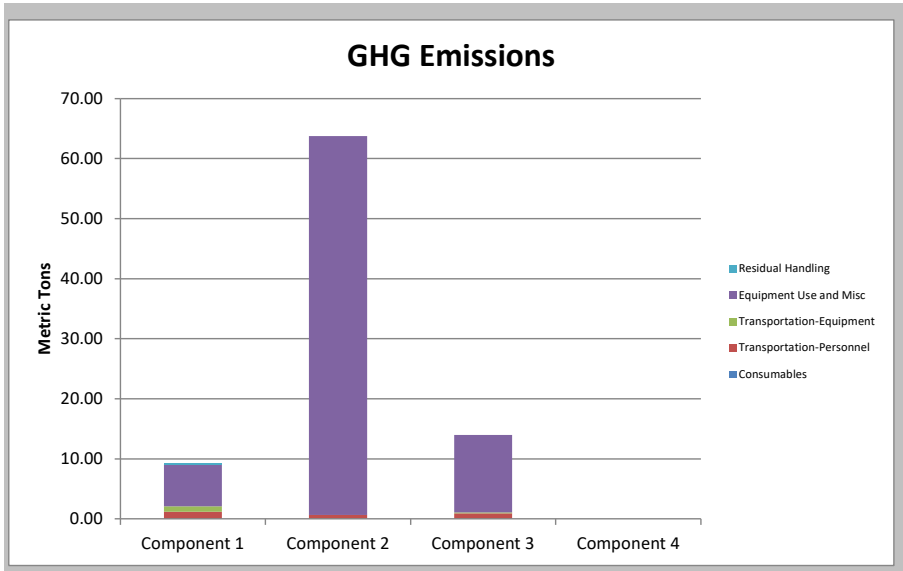
Table D-1
Environmental Footprint Evaluation Results, RAE vs IWMP
NASA KSC CCB MW21 Area
Merritt Island, Florida

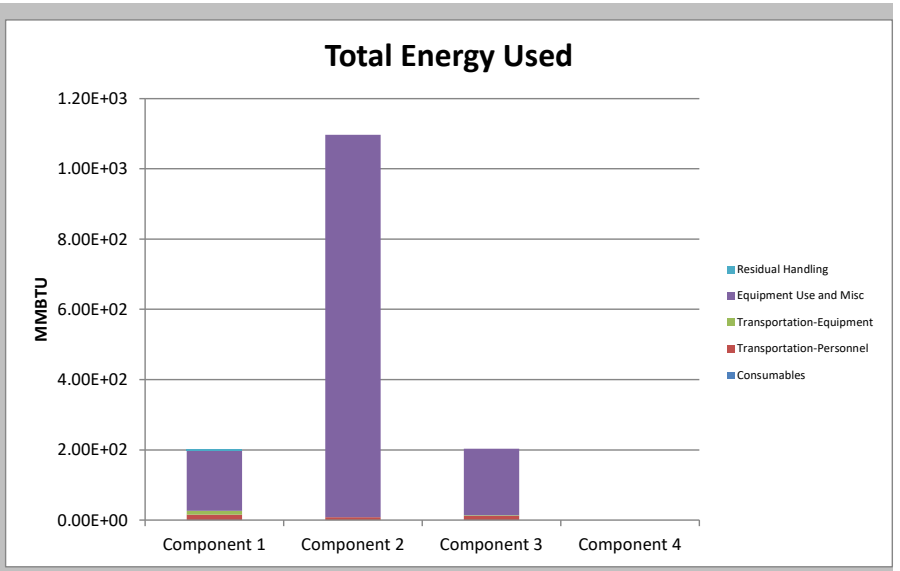
Alternative	Activities	GHG Emissions	Total Energy Used	Water Impacts	NO_X Emissions	SO_X Emissions	PM_{10} Emissions	Accident Risk Fatality	Accident Risk Injury
		metric ton CO_2e	MMBTU	gallons	metric ton	metric ton	metric ton		
Alt 3 From RAE	Materials Production	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	NA	NA
	Transportation-Personnel	2.70E+00	3.23E+01	0.00E+00	1.12E-03	3.53E-05	1.61E-04	5.73E-05	4.61E-03
	Transportation-Equipment	1.26E+00	1.72E+01	0.00E+00	4.05E-04	1.65E-05	3.28E-05	7.02E-06	5.65E-04
	Equipment Use and Misc	9.37E+01	1.60E+03	5.80E+04	2.29E+00	2.10E-01	6.69E-02	2.89E-05	8.73E-03
	Residual Handling	2.79E-01	3.82E+00	0.00E+00	8.98E-05	3.66E-06	7.28E-06	1.56E-06	1.26E-04
	Total	**9.79E+01**	**1.66E+03**	**5.80E+04**	**2.29E+00**	**2.11E-01**	**6.71E-02**	**9.49E-05**	**1.40E-02**
Selected Alt in IMWP	Materials Production	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	NA	NA
	Transportation-Personnel	2.81E+00	3.55E+01	0.00E+00	1.17E-03	3.68E-05	1.68E-04	6.05E-05	4.87E-03
	Transportation-Equipment	1.01E+00	1.38E+01	0.00E+00	3.25E-04	1.33E-05	2.64E-05	5.46E-06	4.39E-04
	Equipment Use and Misc	8.30E+01	1.45E+03	5.79E+04	1.49E+00	1.72E-01	6.30E-02	2.89E-05	8.73E-03
	Residual Handling	2.79E-01	3.82E+00	0.00E+00	8.98E-05	3.66E-06	7.28E-06	1.56E-06	1.26E-04
	Total	**8.71E+01**	**1.50E+03**	**5.79E+04**	**1.49E+00**	**1.72E-01**	**6.32E-02**	**9.64E-05**	**1.42E-02**

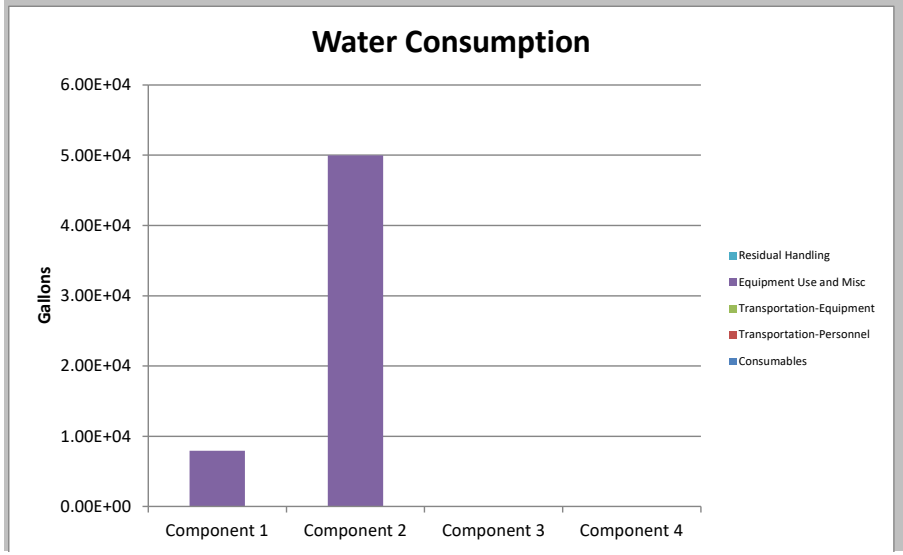
Sustainable Remediation - Environmental Footprint Summary
IWMP

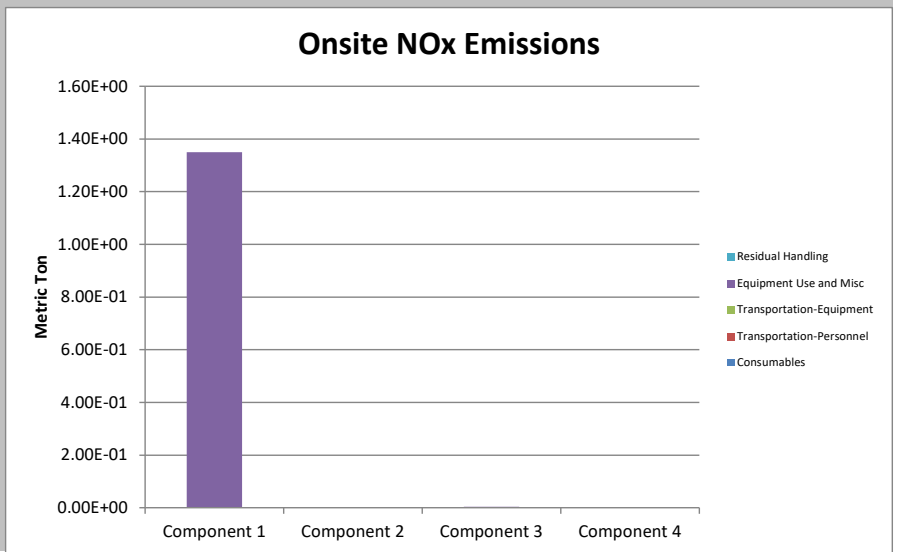
Phase	Activities	GHG Emissions	Total Energy Used	Water Consumption	Electricity Usage	Onsite NOx Emissions	Onsite SOx Emissions	Onsite PM10 Emissions	Total NOx Emissions
		metric ton	MMBTU	gallons	MWH	metric ton	metric ton	metric ton	metric ton
Component 1	Consumables	0.00	0.0E+00	NA	NA	NA	NA	NA	0.0E+00
	Transportation-Personnel	1.21	1.5E+01	NA	NA	NA	NA	NA	5.0E-04
	Transportation-Equipment	0.85	1.2E+01	NA	NA	NA	NA	NA	2.8E-04
	Equipment Use and Misc	6.98	1.7E+02	8.0E+03	2.7E-01	1.3E+00	3.9E-03	8.2E-04	1.4E+00
	Residual Handling	0.28	3.8E+00	NA	NA	0.0E+00	0.0E+00	0.0E+00	9.0E-05
	Sub-Total	9.33	2.03E+02	7.96E+03	2.68E-01	1.35E+00	3.88E-03	8.23E-04	1.36E+00
Component 2	Consumables	0.00	0.0E+00	NA	NA	NA	NA	NA	0.0E+00
	Transportation-Personnel	0.66	8.3E+00	NA	NA	NA	NA	NA	2.7E-04
	Transportation-Equipment	0.00	0.0E+00	NA	NA	NA	NA	NA	0.0E+00
	Equipment Use and Misc	63.10	1.1E+03	5.0E+04	9.8E+01	0.0E+00	0.0E+00	0.0E+00	6.7E-02
	Residual Handling	0.00	0.0E+00	NA	NA	0.0E+00	0.0E+00	0.0E+00	0.0E+00
	Sub-Total	63.76	1.10E+03	5.00E+04	9.80E+01	0.00E+00	0.00E+00	0.00E+00	6.68E-02
Component 3	Consumables	0.00	0.0E+00	NA	NA	NA	NA	NA	0.0E+00
	Transportation-Personnel	0.94	1.2E+01	NA	NA	NA	NA	NA	3.9E-04
	Transportation-Equipment	0.15	2.1E+00	NA	NA	NA	NA	NA	5.0E-05
	Equipment Use and Misc	12.90	1.9E+02	0.0E+00	0.0E+00	4.0E-03	8.1E-05	4.0E-04	6.4E-02
	Residual Handling	0.00	0.0E+00	NA	NA	0.0E+00	0.0E+00	0.0E+00	0.0E+00
	Sub-Total	13.99	2.03E+02	0.00E+00	0.00E+00	4.04E-03	8.08E-05	4.02E-04	6.45E-02
Component 4	Consumables	0.00	0.0E+00	NA	NA	NA	NA	NA	0.0E+00
	Transportation-Personnel	0.00	0.0E+00	NA	NA	NA	NA	NA	0.0E+00
	Transportation-Equipment	0.00	0.0E+00	NA	NA	NA	NA	NA	0.0E+00
	Equipment Use and Misc	0.00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
	Residual Handling	0.00	0.0E+00	NA	NA	0.0E+00	0.0E+00	0.0E+00	0.0E+00
	Sub-Total	0.00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Total		**8.7E+01**	**1.5E+03**	**5.8E+04**	**9.8E+01**	**1.4E+00**	**4.0E-03**	**1.2E-03**	**1.5E+00**

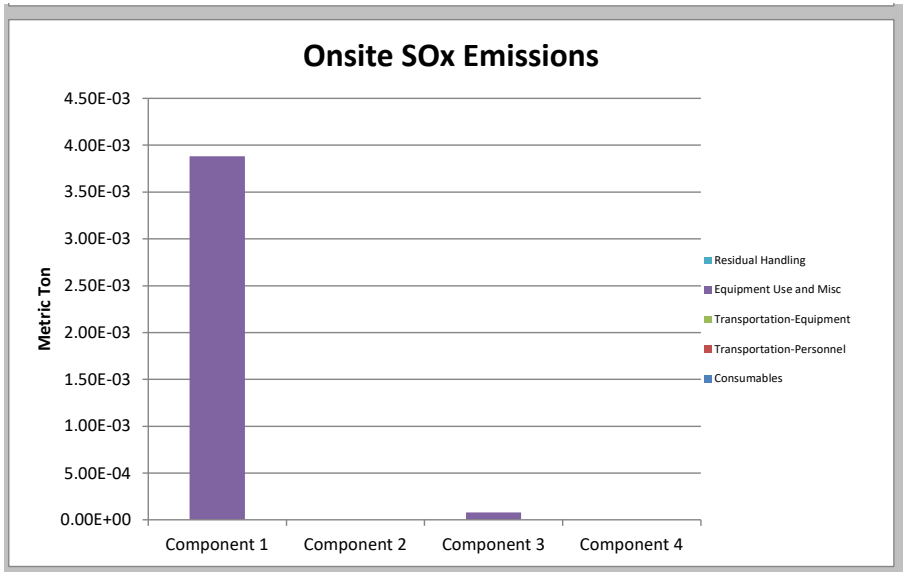
Remedial Alternative Phase	Non-Hazardous Waste Landfill Space	Hazardous Waste Landfill Space	Topsoil Consumption	Costing	Lost Hours - Injury	Percent electricity from renewable sources	Total Cost with Footprint Reduction
	tons	tons	cubic yards	$		%	
Component 1	0.0E+00	0.0E+00	0.0E+00	0	7.8E-02	2.3%	
Component 2	0.0E+00	0.0E+00	0.0E+00	0	1.0E-02	2.3%	
Component 3	0.0E+00	0.0E+00	0.0E+00	0	2.5E-02	0.0%	**$0**
Component 4	0.0E+00	0.0E+00	0.0E+00	0	0.0E+00	0.0%	
Total	**0.0E+00**	**0.0E+00**	**0.0E+00**	**$0**	**1.1E-01**	**1.1%**	

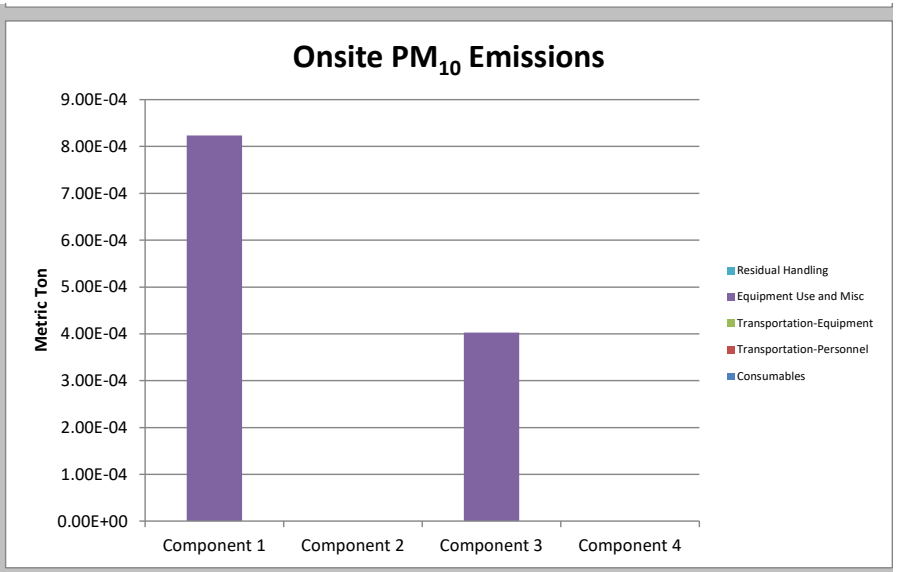

GHG Emissions
Metric Tons
70.00
60.00
50.00
40.00
30.00
20.00
10.00
0.00
Component 1
Component 2
Component 3
Component 4
Residual Handling
Equipment Use and Misc
Transportation-Equipment
Transportation-Personnel
Consumables

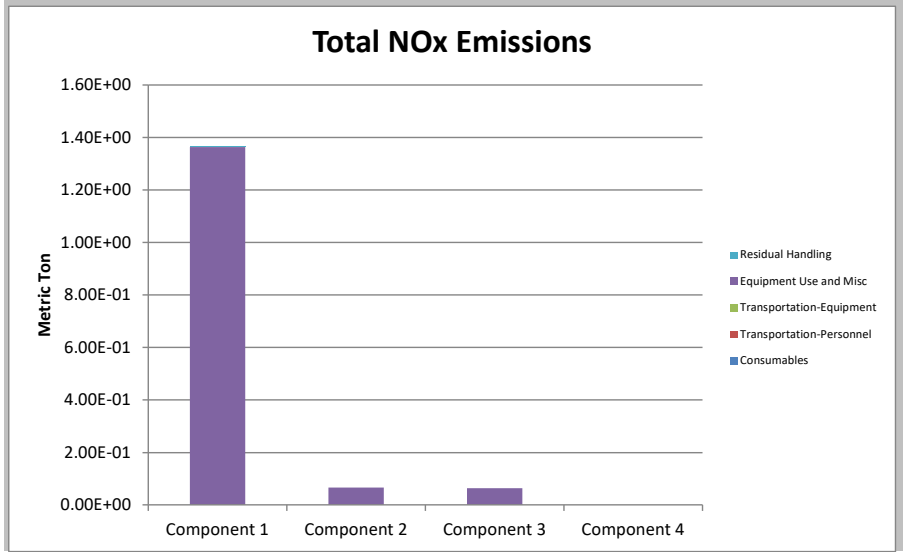

Total Energy Used
MMBTU
1.20E+03
1.00E+03
8.00E+02
6.00E+02
4.00E+02
2.00E+02
0.00E+00
Component 1
Component 2
Component 3
Component 4
Residual Handling
Equipment Use and Misc
Transportation-Equipment
Transportation-Personnel
Consumables

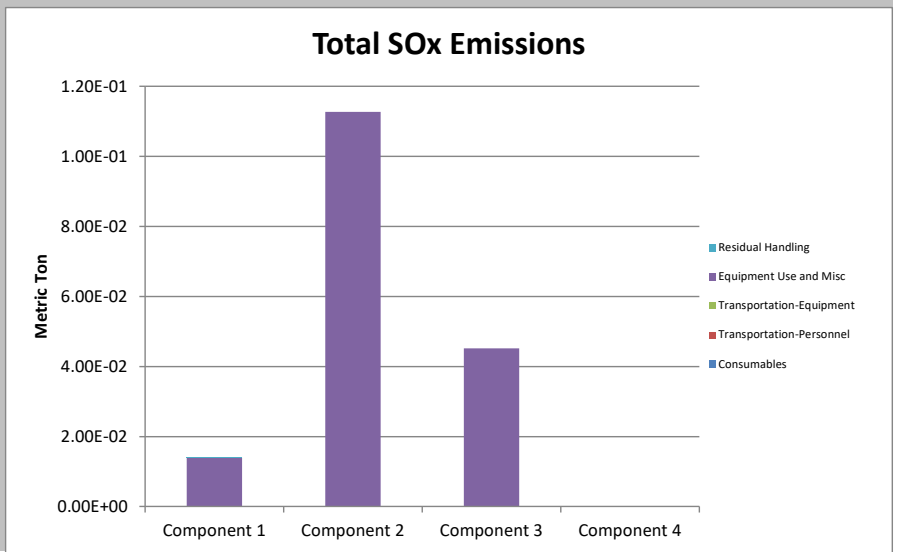

Water Consumption
Gallons
6.00E+04
5.00E+04
4.00E+04
3.00E+04
2.00E+04
1.00E+04
0.00E+00
Component 1
Component 2
Component 3
Component 4
Residual Handling
Equipment Use and Misc
Transportation-Equipment
Transportation-Personnel
Consumables

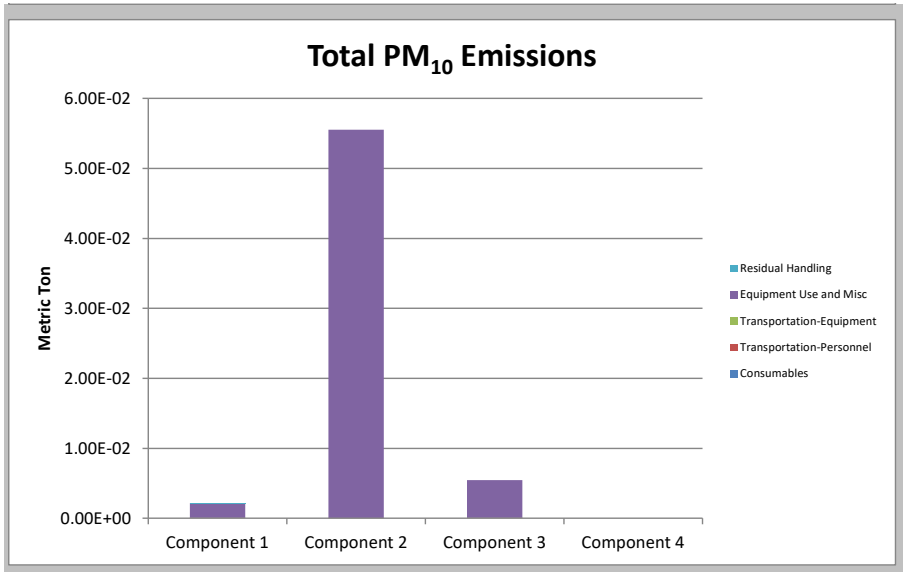

Onsite NOx Emissions
Metric Ton
1.60E+00
1.40E+00
1.20E+00
1.00E+00
8.00E-01
6.00E-01
4.00E-01
2.00E-01
0.00E+00
Component 1
Component 2
Component 3
Component 4
Residual Handling
Equipment Use and Misc
Transportation-Equipment
Transportation-Personnel
Consumables

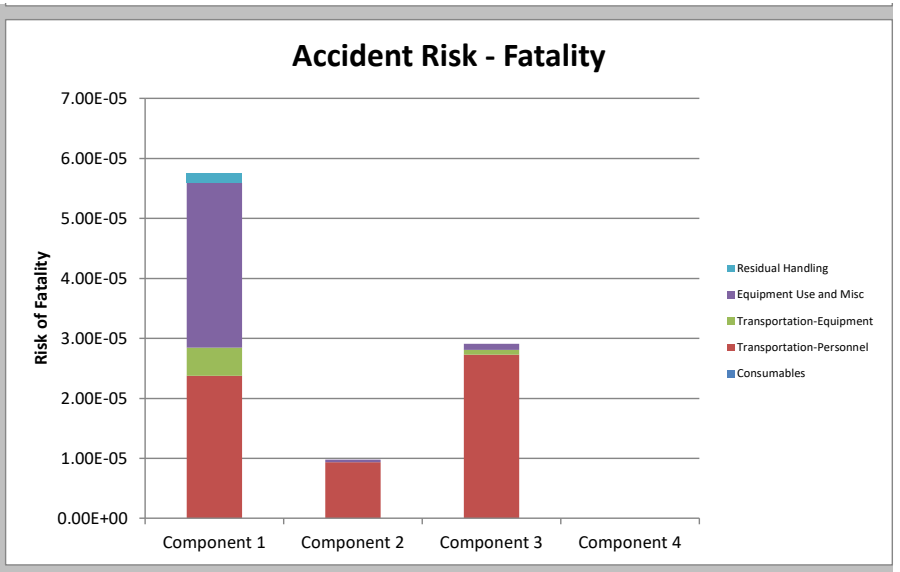

Onsite SOx Emissions
Metric Ton
4.50E-03
4.00E-03
3.50E-03
3.00E-03
2.50E-03
2.00E-03
1.50E-03
1.00E-03
5.00E-04
0.00E+00
Component 1
Component 2
Component 3
Component 4
Residual Handling
Equipment Use and Misc
Transportation-Equipment
Transportation-Personnel
Consumables

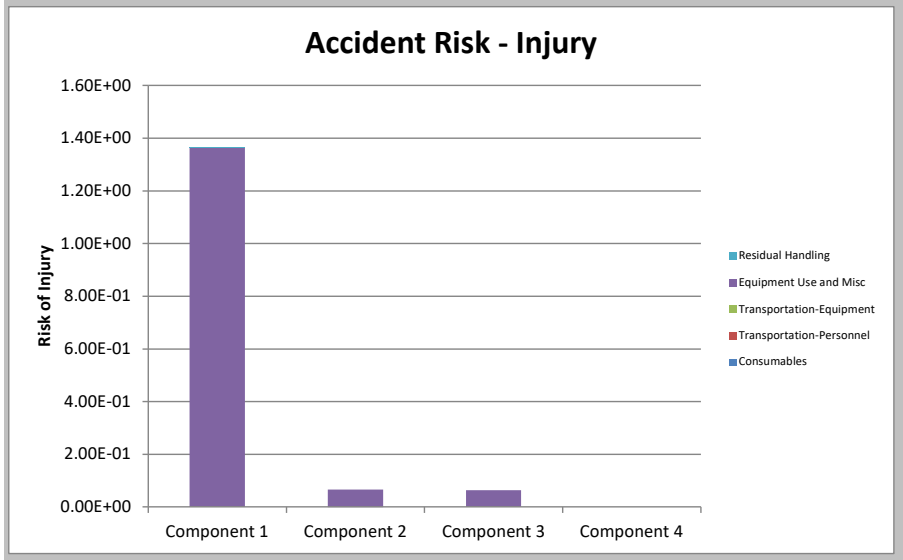

Onsite PM10 Emissions
Metric Ton
9.00E-04
8.00E-04
7.00E-04
6.00E-04
5.00E-04
4.00E-04
3.00E-04
2.00E-04
1.00E-04
0.00E+00
Component 1
Component 2
Component 3
Component 4
Residual Handling
Equipment Use and Misc
Transportation-Equipment
Transportation-Personnel
Consumables

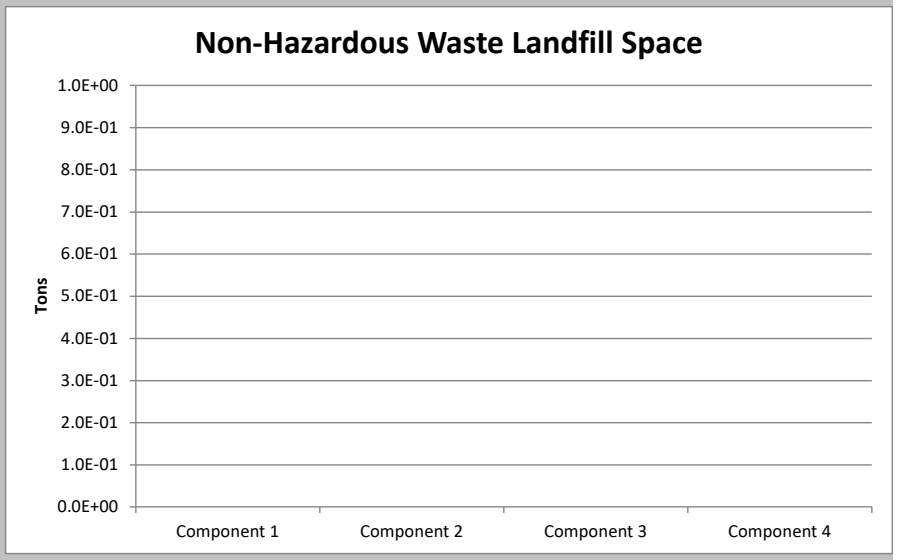

Total NOx Emissions
Metric Ton
1.60E+00
1.40E+00
1.20E+00
1.00E+00
8.00E-01
6.00E-01
4.00E-01
2.00E-01
0.00E+00
Component 1
Component 2
Component 3
Component 4
Residual Handling
Equipment Use and Misc
Transportation-Equipment
Transportation-Personnel
Consumables


Total SOx Emissions
Metric Ton
1.20E-01
1.00E-01
8.00E-02
6.00E-02
4.00E-02
2.00E-02
0.00E+00
Component 1
Component 2
Component 3
Component 4
Residual Handling
Equipment Use and Misc
Transportation-Equipment
Transportation-Personnel
Consumables


Total PM10 Emissions
Metric Ton
6.00E-02
5.00E-02
4.00E-02
3.00E-02
2.00E-02
1.00E-02
0.00E+00
Component 1
Component 2
Component 3
Component 4
Residual Handling
Equipment Use and Misc
Transportation-Equipment
Transportation-Personnel
Consumables


Accident Risk - Fatality
Risk of Fatality
7.00E-05
6.00E-05
5.00E-05
4.00E-05
3.00E-05
2.00E-05
1.00E-05
0.00E+00
Component 1
Component 2
Component 3
Component 4
Residual Handling
Equipment Use and Misc
Transportation-Equipment
Transportation-Personnel
Consumables


Accident Risk - Injury
Risk of Injury
1.60E+00
1.40E+00
1.20E+00
1.00E+00
8.00E-01
6.00E-01
4.00E-01
2.00E-01
0.00E+00
Component 1
Component 2
Component 3
Component 4
Residual Handling
Equipment Use and Misc
Transportation-Equipment
Transportation-Personnel
Consumables


Non-Hazardous Waste Landfill Space
Tons
1.0E+00
9.0E-01
8.0E-01
7.0E-01
6.0E-01
5.0E-01
4.0E-01
3.0E-01
2.0E-01
1.0E-01
0.0E+00
Component 1
Component 2
Component 3
Component 4

	Technology Module / Phase	Module Components	Comments / Assumptions	Quantity	(Units)	Greenhouse Gas Emissions				Criteria Pollutant Emission			Energy Consumption	Water Consumption
						CO_2e	CO_2	N_20	CH_4	NO_x	SO_x	PM_{10}		
Stage	**Materials**								**Tonnes**				**MWhr**	**gal x 1000**
RAC	Decon Pad - Liner	HDPE	450	450	lbs	1.00	0.53	0.001	0.00	0.000	0.002	0.000	5.89	0.16
RAC	ED	Electron Donor		5,675	lbs	0.87	0.85	0.000	0.00	0.000	0.000	0.000	6.08	0.58
RAC	Decon Pad - Frame	Low Impact Material	Wood	300	lbs	0.07	0.07	0.000	0.00	0.000	0.000	0.000	1.84	0.00
RAC	Sodium Bicarbonate	Sodium Hypochlorite	Assuming no CO2 emissions as it consumes Co2 to produce	200	lbs	0.00	0.00	0.000	0.00	0.000	0.000	0.000	2.89	0.35
RAC	Microbial Culture	Medium Impact Material		81	lbs	0.04	0.04	0.000	0.00	0.000	0.000	0.000	1.50	0.00
RAC	ZVI			3086	lbs	1.75	1.75	0.000	0.00	1.345	0.001	0.000	17.11	1.12
	Subtotal					**3.73**	**3.23**	**0.001**	**0.00**	**1.345**	**0.004**	**0.000**	**35.30**	**2.22**
	Construction Equipment								**Tonnes**				**MWhr**	**gal x 1000**
RAC		Drill Rig, DPT (diesel)		24	hrs	0.38	0.38	0.00	0.00	0.004	0.000	0.000	2.93	
LTM		Drill Rig, DPT (diesel)		24	hrs	0.38	0.38	0.00	0.00	0.004	0.000	0.000	2.93	
	Subtotal					**0.38**	**0.38**	**0.000**	**0.00**	**0.004**	**0.000**	**0.000**	**2.93**	**0**
				Total		**4**	**4**	**0.00**	**0.01**	**1.35**	**0.00**	**0.00**	**38**	**2**

Alternative 1
Values Input into SiteWise as "Other"

Module	Greenhouse Gas Emissions				Criteria Pollutant Emission			Energy Consumption	Water Consumption
	CO_2e	CO_2	N_20 (CO_2e)	CH_4 (CO_2e)	NO_x	SO_x	PM_{10}		
	Tonnes							**MMBTU**	**gal**
RI	-	-	-	-	-	-	-	-	-
RAC	4.110351	3.609622	0.392349	0.108381	1.349164	0.003881	0.000823	130.438096	2,222.801187
RAO	-	-	-	-	-	-	-	-	-
LTM	0.384652	0.375427	-	0.009225	0.004040	0.000081	0.000402	10.007586	-

Note: 1 MWhr = 3412141.4799 BTU, 1MMTBU = 10^6 BTU