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RECEIVED
By Terri.Drake at 6:49 am, Feb 13, 2023

February 10, 2023

Mr. Brian Begley
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Kentucky Department for Environmental Protection
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Frankfort, Kentucky 40601

PPPO-02-10023078-23C

Mr. Victor Weeks
Federal Facility Agreement Manager
U.S. Environmental Protection Agency, Region 4
61 Forsyth Street
Atlanta, Georgia 30303

Dear Mr. Begley and Mr. Weeks:

TRANSMITTAL OF THE INTERIM REMEDIAL ACTION COMPLETION REPORT WITH POSTCONSTRUCTION REPORT ELEMENTS FOR SWMU 211-A FOR VOLATILE ORGANIC COMPOUND SOURCES TO THE SOUTHWEST GROUNDWATER PLUME AT THE PADUCAH GASEOUS DIFFUSION PLANT, PADUCAH, KENTUCKY, DOE/LX/07-2483&D1

Please find enclosed the *Interim Remedial Action Completion Report with Postconstruction Report Elements for SWMU 211-A for Volatile Organic Compound Sources to the Southwest Groundwater Plume at the Paducah Gaseous Diffusion Plant, Paducah, Kentucky*, DOE/LX/07-2483&D1. In accordance with Section XX.G and Appendix F of the Federal Facility Agreement (FFA), the U.S. Environmental Protection Agency and the Kentucky Department for Environmental Protection have a 90-day review and comment period. If the FFA parties have no substantive comments, then the U.S. Department of Energy requests a letter of concurrence.

If you have any questions or require additional information, please contact Richard Bonczek at (859) 321-7127.

Sincerely,

TRACEY DUNCAN
Digitally signed by TRACEY DUNCAN
Date: 2023.02.07 14:41:18 -06'00'

Tracey Duncan
Federal Facility Agreement Manager
Portsmouth/Paducah Project Office

Enclosures:
1. Certification Page
2. *Interim Remedial Action Completion Report with Postconstruction Report Elements for SWMU 211-A for Volatile Organic Compound Sources to the Southwest Groundwater Plume at the Paducah Gaseous Diffusion Plant, Paducah, Kentucky*, (DOE/LX/07-2483&D1)

Administrative Record File—SWP-PD

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CERTIFICATION

Document Identification: ***Interim Remedial Action Completion Report with Postconstruction Report Elements for SWMU 211-A for Volatile Organic Compound Sources to the Southwest Groundwater Plume at the Paducah Gaseous Diffusion Plant, Paducah, Kentucky,* DOE/LX/07-2483&D1, January 2023**

I certify under penalty of law that this document and all attachments were prepared under my direction or supervision according to a system designed to assure that qualified personnel properly gather and evaluate the information submitted. Based on my inquiry of the person or persons who manage the system, or those persons directly responsible for gathering the information, the information submitted is, to the best of my knowledge and belief, true, accurate, and complete. I am aware that there are significant penalties for submitting false information, including the possibility of fine and imprisonment for knowing violations.

Four Rivers Nuclear Partnership, LLC

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Myrna E. Redfield, Program Manager — Date Signed
Four Rivers Nuclear Partnership, LLC

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U.S. Department of Energy

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April Ladd, Acting Paducah Site Lead — Date Signed
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U.S. Department of Energy

DOE/LX/07-2483&D1
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Interim Remedial Action Completion Report with Postconstruction Report Elements for SWMU 211-A for Volatile Organic Compound Sources to the Southwest Groundwater Plume at the Paducah Gaseous Diffusion Plant, Paducah, Kentucky

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Interim Remedial Action Completion Report with Postconstruction Report Elements for SWMU 211-A for Volatile Organic Compound Sources to the Southwest Groundwater Plume at the Paducah Gaseous Diffusion Plant, Paducah, Kentucky

Date Issued—January 2023

U.S. DEPARTMENT OF ENERGY
Office of Environmental Management

Prepared by
FOUR RIVERS NUCLEAR PARTNERSHIP, LLC,
managing the
Deactivation and Remediation Project at the
Paducah Gaseous Diffusion Plant
under Contract DE-EM0004895

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ACRONYMS

bgs	below ground surface
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
CFR	*Code of Federal Regulations*
DHC	*Dehalococcoides ethenogenes*
DOE	U.S. Department of Energy
DPT	direct-push technology
EISB	enhanced *in situ* bioremediation
EPA	U.S. Environmental Protection Agency
EVO	emulsified vegetable oil
FFA	Federal Facility Agreement
FRNP	Four Rivers Nuclear Partnership, LLC
IW	injection well
KDEP	Kentucky Department for Environmental Protection
KDOW	Kentucky Division of Water
KPDES	Kentucky Pollutant Discharge Elimination System
LUC	land use control
M&W	M&W Drilling, Inc.
MCL	maximum contaminant level
MW	monitoring well
mZVI	microscale zero-valent iron
OS	oxygen scavenger
PGDP	Paducah Gaseous Diffusion Plant
psi	pounds per square inch
PVC	polyvinyl chloride
PW	performance monitoring well
RA	remedial action
RACR	remedial action completion report
RAO	remedial action objective
RAWP	remedial action work plan
RDR	remedial design report
RG	remedial goal
RGA	Regional Gravel Aquifer
ROD	Record of Decision
ROI	radius of influence
SI	site investigation
SWMU	solid waste management unit
TZD	treatment zone depth
UCRS	Upper Continental Recharge System
VOC	volatile organic compound

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EXECUTIVE SUMMARY

The Paducah Gaseous Diffusion Plant (PGDP) is an inactive uranium enrichment facility owned by the U.S. Department of Energy (DOE) and formerly operated by the United States Enrichment Corporation until 2014. PGDP was placed on the National Priorities List in 1994. DOE, the U.S. Environmental Protection Agency, and the Kentucky Natural Resources and Environmental Protection Cabinet (which has since been renamed the Kentucky Energy and Environment Cabinet) entered into a Federal Facility Agreement (FFA) in 1998 (EPA 1998). This interim remedial action completion report (RACR) has been prepared to document the completion of the selected remedial action (RA), enhanced *in situ b*ioremediation (EISB) with interim land use controls (LUCs), and Upper Continental Recharge System and Regional Gravel Aquifer (RGA) groundwater sampling at Solid Waste Management Unit (SWMU) 211-A. The RA was chosen in accordance with the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA). The response action selected was one of two potential actions for SWMU 211-A, as documented in the *Record of Decision for Solid Waste Management Units 1, 211-A, 211-B, and Part of 102 Volatile Organic Compound Sources for the Southwest Groundwater Plume at the Paducah Gaseous Diffusion Plant, Paducah, Kentucky*, DOE/LX/07-0365&D2/R1 (ROD) (DOE 2012). The RA implemented for SWMU 211-A was agreed upon after the final RAs presentation to the FFA parties on May 23, 2018 (DOE 2018).

The SWMU 211-A area has been investigated several times in support of remedy selection and development of the RA, including the Waste Area Grouping 27 remedial investigation (DOE 1999); Southwest Plume site investigation (DOE 2007); SWMU 211-A and SWMU 211-B remedial design support investigation (DOE 2013); and SWMU 211-A and SWMU 211-B addendum to the final characterization report (DOE 2016).

This interim RACR addresses the completion of EISB by Direct-Push Technology Jet Injection fracturing of 325 treatments zones at 33 subsurface locations, with the placement of 221,674 lb of sand and 445,334 lb of microscale zero-valent iron and the injection of an estimated 154,436 gal of emulsified vegetable oil and 215 L of *Dehalococcoides ethenogenes* bacteria which meet or exceed the required amounts identified in the remedial design report. Contaminants being treated as part of the RA included trichloroethene (TCE) and other volatile organic compounds (VOCs). The RA treated the high TCE concentration in soils which are present at the C-720 sites and constitute principal threat waste, and will biologically remediate the TCE sources and other VOCs. After the active bioremediation, residual VOC mass (estimated at 5%) may continue to leach to groundwater in the RGA. Remediation goals are expected to be attained within 39 years. In addition, 18 performance monitoring wells (PWs) and 9 long-term monitoring wells (MWs) were installed to measure the continued effectiveness of the RA.

The SWMU 211-A RA also includes interim LUCs that consist of the Paducah Site Trenching, Excavation, and Penetration Permit Program and the placement of warning signs to provide notice and warning of environmental contamination.

Activities that will continue after the submittal of this interim RACR include the following:

- Sampling of associated long-term MWs and PWs to determine the continued effectiveness of the remedy in support of CERCLA Five-Year Review development; and
- Continuing the implementation and annual inspection and maintenance of interim LUCs of SWMU 211-A, which are reported in an FFA semiannual report.

The following are the remedial action objectives (RAOs) for this RA, as contained in the ROD (DOE 2012).

1. Treat and/or remove the principal threat waste consistent with the National Contingency Plan.

2a. Prevent exposure to VOC contamination in the source areas that will cause an unacceptable risk to the excavation workers (< 10 ft).

2b. Prevent exposure to non-VOC contamination and residual VOC contamination through interim LUCs within the Southwest Plume source areas (i.e., SWMU 1,[1] SWMU 211-A, and SWMU 211-B[2]), pending remedy selection as part of the Soils Operable Unit and the Groundwater Operable Unit.

3. Reduce VOC migration from contaminated subsurface soils in the treatment areas at the Oil Landfarm and the C-720 Northeast and Southeast Sites so that contaminants migrating from the treatment areas do not result in the exceedance of maximum contaminant levels in the underlying RGA groundwater.

The EISB RA was completed, consistent with the remedial design report, the remedial action work plan (RAWP) (DOE 2021a), and associated discussions with the FFA parties (RAO No. 1).

The interim LUCs are in place and are operational (RAO No. 2a and 2b). Long-term MWs and PWs have been installed, as required by the RAWP. The purpose of the groundwater sampling will be to ascertain when RAO No. 3 of this action is attained.

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[1] DOE has implemented remedial activities for SWMU 1 (DOE 2017); SWMU 1 is not discussed further in this report.
[2] SWMU 211-B has separate documentation and schedule under the Site Management Plan and is not discussed further in this report (DOE 2022a).

1. INTRODUCTION

This *Interim Remedial Action Completion Report with Postconstruction Report Elements for SWMU 211-A for Volatile Organic Compound Sources to the Southwest Groundwater Plume at the Paducah Gaseous Diffusion Plant, Paducah, Kentucky*, DOE/LX/07-2483&D1 (RACR), has been prepared to document the completion of the selected remedial action (RA), enhanced *in situ* bioremediation (EISB) with interim land use controls (LUCs), and the Upper Continental Recharge System (UCRS) and Regional Gravel Aquifer (RGA) groundwater sampling at Solid Waste Management Unit (SWMU) 211-A. The response action selected was one of two potential actions for SWMU 211-A, as documented in the *Record of Decision for Solid Waste Management Units 1, 211-A, 211-B, and Part of 102 Volatile Organic Compound Sources for the Southwest Groundwater Plume at the Paducah Gaseous Diffusion Plant, Paducah, Kentucky*, DOE/LX/07-0365&D2/R1 (ROD) (DOE 2012). As required by the ROD, Federal Facility Agreement (FFA) parties selected the remedy to be implemented following a final characterization period from late 2012 to 2018, which resulted in several sampling collections. The RA implemented for SWMU 211-A was agreed upon after the final RAs presentation to the FFA parties on May 23, 2018 (DOE 2018). The presentation from the May 23, 2018, meeting can be reviewed at the Paducah Gaseous Diffusion Plant (PGDP) Environmental Information Center (Accession Number ENV 1.A-01526).

The interim LUCs that were included in the signed ROD are in place and operating. Interim LUCs will be maintained until the concentrations of hazardous substances in the soil and groundwater are at such levels to allow for unrestricted use and unlimited exposure. The interim LUCs are implemented through the use of the Paducah Site Trenching, Excavation, and Penetration Permit Program and the posting of warning signs.

The Southwest Plume was identified during the Waste Area Grouping 27 remedial investigation in 1998 (DOE 1999). The U.S. Department of Energy (DOE) conducted a site investigation (SI) of the Southwest Plume and selected four potential source areas for RAs from the *Site Investigation Report for the Southwest Groundwater Plume at the Paducah Gaseous Diffusion Plant, Paducah, Kentucky*, DOE/OR/07-2180&D2/R1 (DOE 2007). Of the four areas investigated, the SI identified SWMU 211-A as one probable contributor to trichloroethene (TCE) groundwater contamination in the Southwest Plume.

The EISB RA consisted of implementing EISB through hydraulic fracturing of the UCRS with a mixture of microscale zero-valent iron (mZVI) and sand followed by the injection of emulsified vegetable oil (EVO) and bioaugmentation with *Dehalococcoides ethenogenes* (DHC) bacteria culture through installed injection wells (IWs). Performance monitoring wells (PWs) were installed within the treatment area to provide an indication of the efficacy and continuity of the RA. In addition, long-term monitoring wells (MWs) were installed to determine the continued effectiveness of the UCRS RA on reducing volatile organic compound (VOC) contaminants from the UCRS to the RGA in the SWMU 211-A area. Contaminants treated as part of the RA included TCE and other VOCs.

The RA will result in hazardous substances, pollutants, or contaminants remaining on-site above the remediation goal level for TCE at 0.075 mg/kg for the C-720 Building sites, which will not allow for unlimited use and unrestricted exposure. After the active bioremediation, residual VOC mass (estimated at 5%) may continue to leach to groundwater in the RGA. Remediation goals are expected to be attained within 39 years. Because the selected RA will result in hazardous substances remaining on-site in excess of levels allowed for unlimited use and unrestricted exposure, a statutory review under the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) Section 121(c) will be conducted every five years until the levels of contaminants of concern allow for unlimited use and unrestricted exposures of the soil and groundwater (DOE 2012). The five-year reviews will be conducted to ensure that the remedy is or will be protective of human health and the environment. If the results of a five-year review reveals that remedy integrity is compromised and the protection of human health and the environment is insufficient, the potential benefits of implementing additional RAs then will be evaluated by the FFA parties. The statutory reviews will be conducted in accordance with CERCLA Section 121(c), the National Contingency Plan in 40 *CFR* § 300.430(f)(5)(iii)(C), and U.S. Environmental Protection Agency (EPA) guidance. These reviews, although required by CERCLA, are not considered components of the selected remedies.

1.1 GENERAL DESCRIPTION OF SITE

1.1.1 Site Location

PGDP is located approximately 10 miles west of Paducah, Kentucky, and 3.5 miles south of the Ohio River in the western part of McCracken County (Figure 1.1). The Paducah Site is situated on approximately 3,556 acres divided as follows: approximately 1,450 acres are utilized for site operations, approximately 133 acres are in acquired easements, and the remaining 1,973 acres are licensed to the Commonwealth of Kentucky as part of the West Kentucky Wildlife Management Area.

1.1.2 Description

SWMU 211-A is located in the south-central portion of PGDP. More specifically, the treatment area lies northeast of the C-720 Building. The location of SWMU 211-A is shown in Figure 1.2. The C-720 Building consists of several repair and machine shops, an instrument shop, equipment and material storage areas, and other support operations.

1.1.3 Early Environmental Actions

DOE conducted an SI in 2004 to address uncertainties associated with potential source areas to the Southwest Plume that remained after previous investigations. Results of the SI were reported in the *Site Investigation Report for the Southwest Groundwater Plume at the Paducah Gaseous Diffusion Plant, Paducah, Kentucky,* DOE/OR/07-2180&D2/R1 (DOE 2007). The *Revised Focused Feasibility Study for Solid Waste Management Units 1, 211A, and 211B Volatile Organic Compound Sources for the Southwest Groundwater Plume at the Paducah Gaseous Diffusion Plant, Paducah, Kentucky,* DOE/LX/07-0362&D2 (DOE 2011), is based on the SI (DOE 2007) and previous investigations. The ROD for this RA was signed in 2012 (DOE 2012).

A remedial design support investigation (i.e., final characterization report) was performed in 2012 to gather supplemental data necessary for the design and implementation of the EISB RA selected for SWMU 211-A. Data collected from 42 soil borings during the remedial design support investigation allowed for a more refined delineation of the size and shape of the overall treatment area for this RA. The completion of this analysis was documented in the *Final Characterization Report for Solid Waste Management Units 211-A and 211-B Volatile Organic Compound Sources for the Southwest Groundwater Plume at the Paducah Gaseous Diffusion Plant, Paducah, Kentucky*, DOE/LX/07-1288&D2 (DOE 2013). TCE soil levels and the RA treatment area are shown in Figure 1.3.

Additional characterization of SWMU 211-A also was performed in 2015 before the FFA parties decided to proceed with implementing the RA. The results of this additional characterization fieldwork were compiled and documented in the *Addendum to the Final Characterization Report for Solid Waste Management Units 211-A and 211-B Volatile Organic Compound Sources for the Southwest Groundwater Plume at the Paducah Gaseous Diffusion Plant, Paducah, Kentucky,* DOE/LX/07-1288&D2/A1/R1 (DOE 2016).

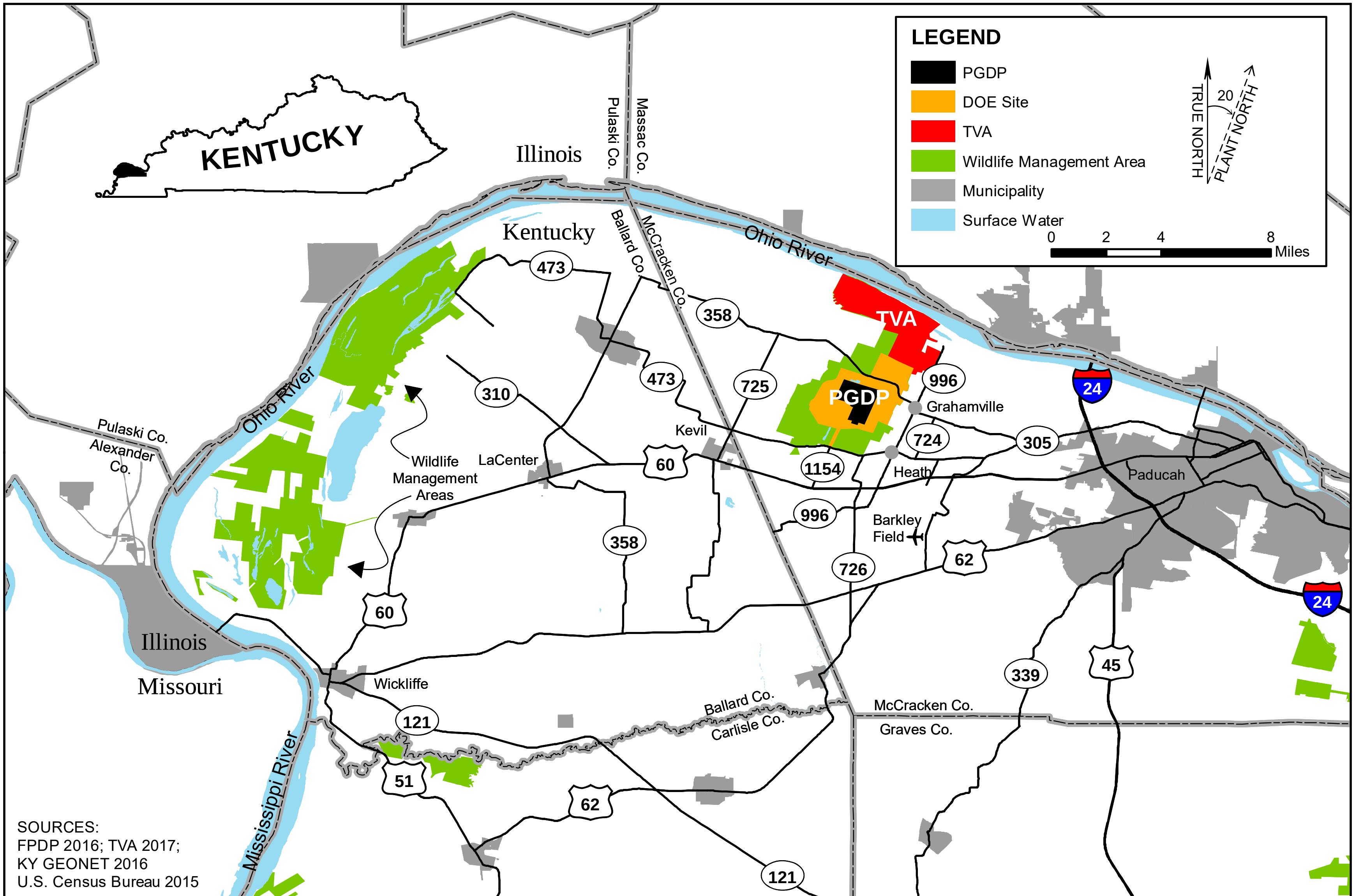

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Figure 1.1. Paducah Site Vicinity Map

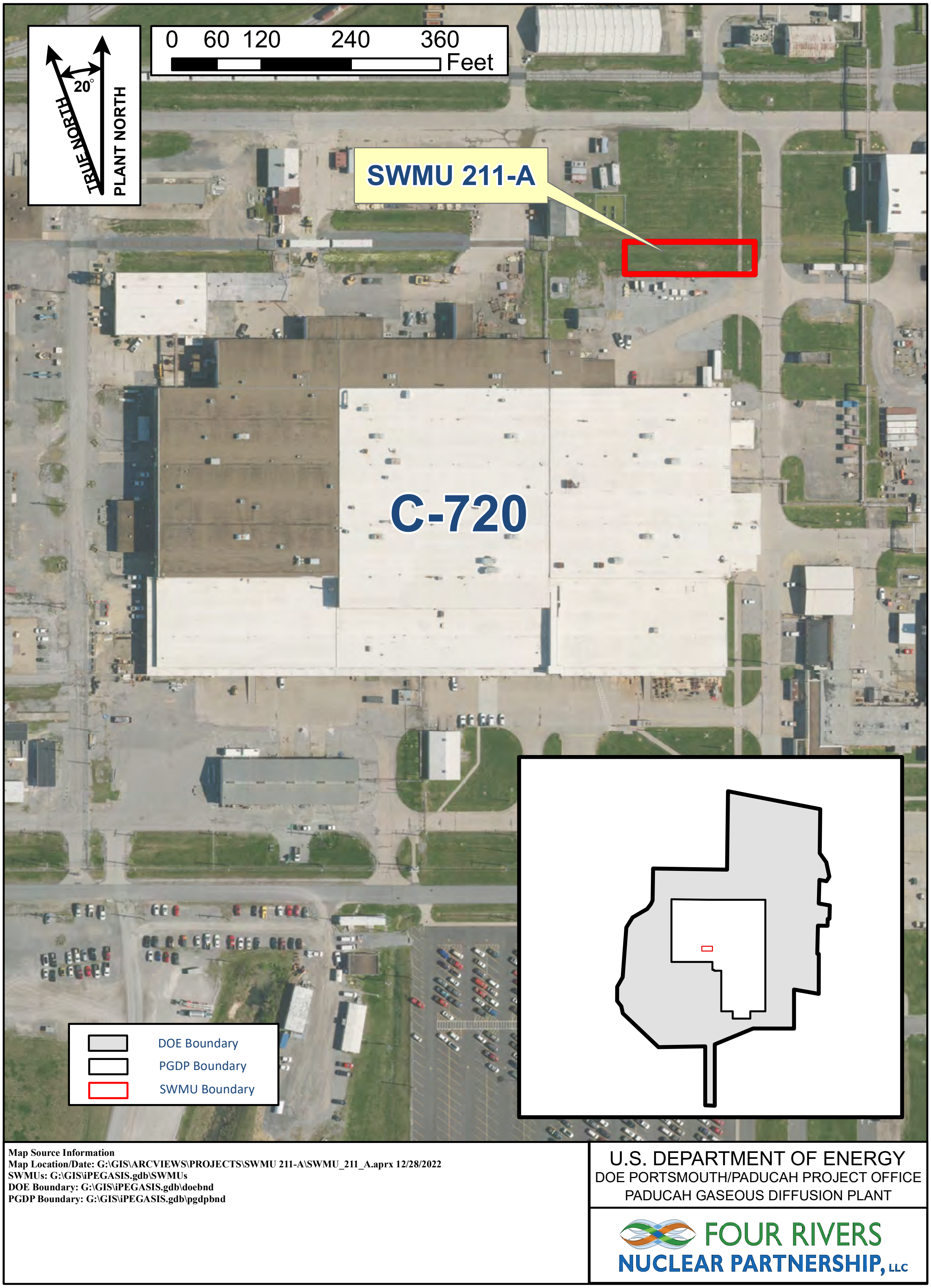
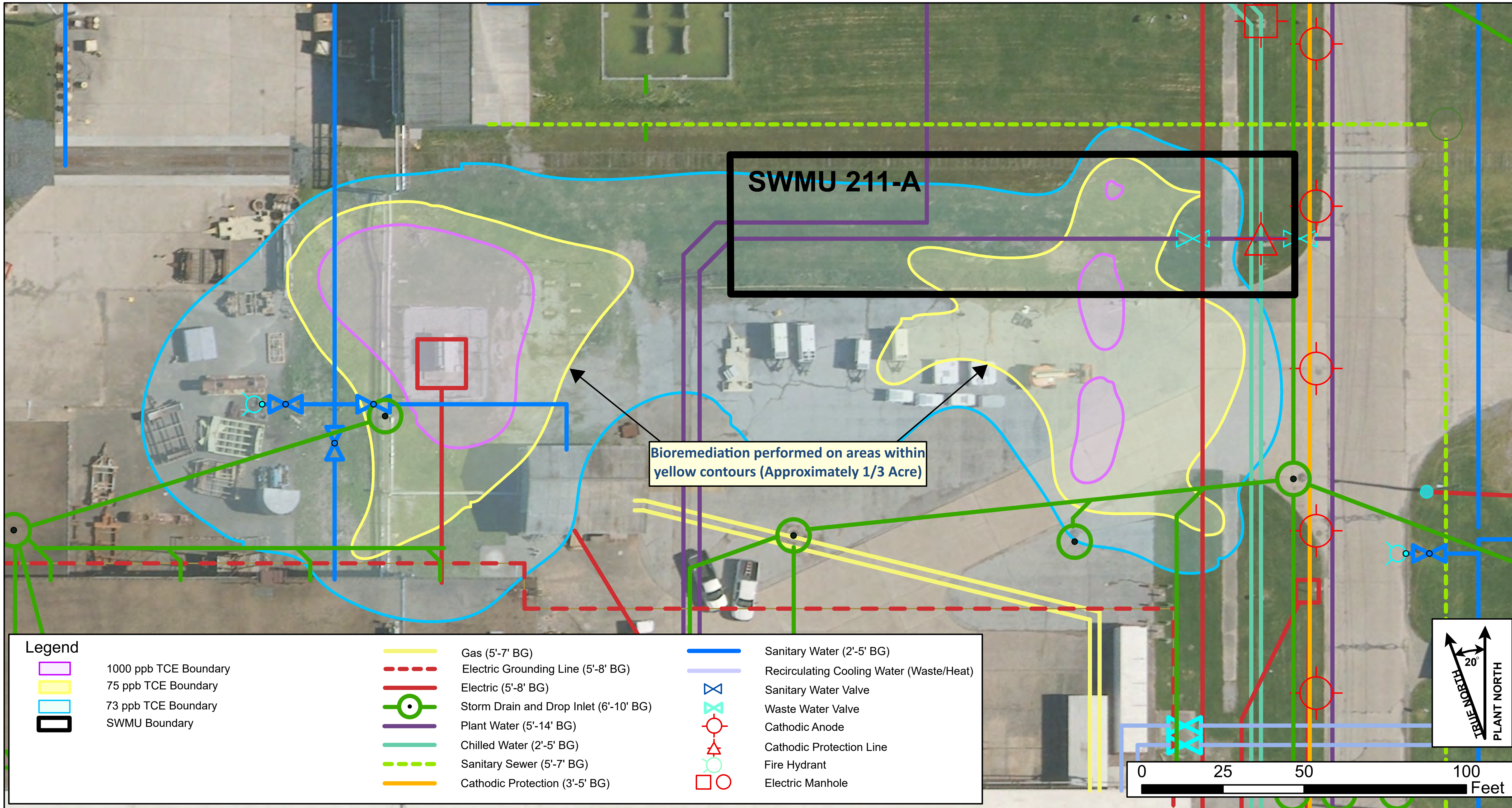


Figure 1.2. C-720 Site Location



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DOE PORTSMOUTH/PADUCAH PROJECT OFFICE
PADUCAH GASEOUS DIFFUSION PLANT

FOUR RIVERS NUCLEAR PARTNERSHIP, LLC

Figure 1.3. SWMU 211-A Area to be Treated

1.2 GENERAL DESCRIPTION OF THE REMEDY

The RA for SWMU 211-A included the design and implementation of EISB with interim LUCs. EISB consisted of jet injection hydraulic fracturing with Direct-Push Technology (DPT), and bioamendment and bioaugmentation injection. Following completion of bioaugmentation injection, a network of PWs was installed to monitor the continued effectiveness of the EISB. In addition, long-term MWs were installed to assess progress toward achieving cleanup goals, as specified in the ROD (DOE 2012). RA construction drawings are provided in Appendix A.

1.2.1 Components of the Remedy

The EISB with interim LUCs and groundwater monitoring remedy was determined after the final RAs presentation to the FFA parties on May 23, 2018 (DOE 2018). The presentation from the May 23, 2018, meeting can be reviewed at the PGDP Environmental Information Center (Accession Number ENV 1.A-01526).

Interim LUCs that include warning signs to provide notice of environmental contamination have been placed at SWMU 211-A. The warning signs state the following:

WARNING: CONTAMINATED AREA
Hazardous Substances in Soil and Groundwater
Authorized Access Only
Contact: [Insert Phone Number]

SWMU 211-A continues to require use of the Paducah Site Trenching, Excavation and, Penetration Permit program for any subsurface intrusive activities.

The EISB remedy was designed and documented in the *Certified for Construction Remedial Design Report for SWMU 211-A for Volatile Organic Compound Sources to the Southwest Groundwater Plume at the Paducah Gaseous Diffusion Plant, Paducah, Kentucky*, DOE/LX/07-2435&D2 (RDR) (DOE 2019). Additional information concerning the implementation of the EISB RA was also documented in the *Remedial Action Work Plan for SWMU 211-A Enhanced In Situ Bioremediation for Volatile Organic Compound Sources to the Southwest Groundwater Plume at the Paducah Gaseous Diffusion Plant, Paducah, Kentucky*, DOE/LX/07-2443&D2/R2 (RAWP) (DOE 2021a).

The EISB RA included the following ten major components.

1. Procurement of subcontractors
2. Site preparation
3. Mobilization and setup
4. Baseline groundwater sampling
5. DPT Jet Injection fracturing
6. IW, long-term MW, and PW installations
7. EISB bioamendment (i.e., EVO) injections
8. EISB bioaugmentation (i.e., DHC) injections
9. Performance monitoring
10. Long-term monitoring

Procurement of Subcontractors. The implementation of the RA, except for components 1, 2, 9, and 10, required the procurement of a specialty contractor to perform well installations and EISB. Arcadis in Highland Ranch, Colorado, was selected as the primary subcontractor to perform these remedial activities.

In addition, Arcadis procured M&W Drilling, Inc. (M&W); FRx, Inc.; and Chase Environmental Group as sub-tier subcontractors to assist in the performance of remedial activities.

Site Preparation. The site preparation subtask was performed in early March 2022. It included clearing the treatment area of equipment (e.g., vehicles, guardrails, parking blocks), which would reduce the movement and alignment of drilling and remedial equipment during field activities. Following the removal of equipment, the disturbed area was backfilled with clean-fill and leveled. In 2020, MW511, MW512, and MW513 were abandoned (FRNP 2020). Records of the well abandonment were sent to the Kentucky Department for Environmental Protection (KDEP) and are maintained on its website.

Mobilization and Setup. The mobilization and setup task involved sequencing the delivery of equipment for well installation and EISB treatment activities, and other supporting equipment to the SWMU 211-A EISB field area. This task also included set up of the equipment prior to initiation of EISB activities. Mobilization and setup included the following:

- Delivery and inspection of drilling equipment, which included a Geoprobe® sonic drilling rig, Geoprobe® DPT drilling rig, support equipment, and drill/tool racks.

- Delivery and inspection of hydraulic fracturing equipment, which included a proprietary mZVI/sand mixer and high pressure water delivery system, telehandler, skid steer, electric generators, hoses, and other associated equipment.

- Delivery and inspection of EISB equipment, which included an injection system, mixing tanks, water pumps, and other support equipment.

- Delivery and inspection of the data collection and monitoring systems, which included a digital sampling system, multiparameter, handheld digital water quality meter (i.e., YSI ProDSS); flow meters; mixing equipment load cells; and pressure gauges.

- Civil surveying of the area in order to locate the drilling locations for well placements, utilities, and other interfering infrastructures.

Baseline Groundwater Sampling. This subtask utilized DPT drilling methods to collect baseline discrete groundwater samples and parameters prior to EISB implementation inside the treatment area. Groundwater samples were collected at future PW locations by using a discrete groundwater sampling tool. Due to the method of collection, these samples were qualified as informational use only during data assessment. The temporary borings were abandoned with an approximate mixture of Portland cement and 5% bentonite to resist channeling from injection pressures. In addition, baseline groundwater samples were collected from pre-existing and newly installed long-term MWs outside the perimeter of the treatment area.

DPT Jet Injection Fracturing. This subtask utilized DPT drilling methods to produce horizontal fractures at pre-planned depths, with an estimated radius of 15 ft. The fractures were injected with a mixture of guar gum, sand, mZVI, and an enzyme breaker. The sand and mZVI proppant helped expand targeted fractures and acted as support, holding the factures open after injection activities ceased, which enhanced permeability to facilitate subsequent delivery of amendments. Shortly after proppant injection concludes, the guar gum biodegrades, with the assistance of the enzyme breaker. In addition, the mZVI will continue to degrade TCE and its degradation products via abiotic processes.

IW, Long-term MW, and PW Installations. This subtask involved the installation of a cluster of IWs following hydraulic fracturing. Each cluster of 2 to 3 IWs was installed within approximately 5 ft of each DPT Jet Injection location. The well and screen locations were offset and stacked, respectively, consistent with the RDR. The IWs were also developed similarly to MWs. A total of 85 IWs were installed in 33 general locations. After use, the IWs were finished with either stick up protective casings or flush-mount vaults to allow for future reuse of the wells, if needed.

Long-term MWs were installed outside the perimeter of the treatment area. The nine newly installed MWs, in combination with an existing MW, will be sampled periodically to ascertain the long-term effects of the bioremediation on the RGA groundwater and the progress toward attaining the remedial action objectives (RAOs). The MWs are either screened in the upper or middle RGA. MWs were installed and developed according to contractor procedures and Kentucky Division of Water (KDOW) regulations.

PWs were installed in three well clusters inside the perimeter of the treatment area to monitor the continued effectiveness of the bioremediation process. Each PW cluster has one well for screening in the middle UCRS, the lower UCRS, and the upper RGA. PWs were installed and developed according to contractor procedures and KDOW regulations. PWs are CERCLA wells associated with the RA and will be plugged once the RA is complete or converted to long-term MW status (in part or in whole), as agreed to by the FFA parties.

EISB Bioamendment Injection. This subtask involved the injection of EVO in conditioned water [dissolved oxygen (DO) reduced] through each IW into the UCRS to support the bioremediation process of reductive dechlorination of TCE and its degradation products to ethene. The conditioning agent used was Newman Zone OS™ (RNAS Remediation Products) to reduce DO for anaerobic bioremediation. The emulsion allowed the bioamendment to be injected further into the UCRS to allow treatment of a larger radius up to 15 ft. As indicated in the RDR, the injection pressure utilized was variable between 15 pounds per square inch (psi) and 40 psi depending on the well's capability to receive bioamendment, but did not exceed 60 psi. If an IW did not receive bioamendments, additional pressure up to the 60 psi limit was used. Consistent with the RDR, if injection rates did not exceed 0.5 gallons per minute and volumes could not be injected efficiently, the bioamendments were injected in associated IWs with deeper screen depths or in adjacent IWs that were available. An estimated total of 154,436 gal of EVO solution was injected into the treatment area, which exceeded the RDR target of 130,000 gal.

EISB Bioaugmentation Injection. This subtask involved the injection of DHC bacteria into the treatment area. DHC bacteria can facilitate the dechlorination of TCE completely to ethene. Testing of the SWMU 211-A subsurface prior to remedial activities did not identify the presence of DHC bacteria. A total of 215 L of EOS Remediation SDC-9 bacteria cultures was injected into the treatment area, consistent with the RDR.

Performance Monitoring. This subtask involved performance monitoring of the RA using PW clusters located within the treatment area. Monitoring began before the material injections to provide baseline parameters. The purpose of this monitoring is to provide an indication of the efficacy and continuity of the RA. The data will also be utilized to determine if additional bioamendment volumes, bioaugmentation volumes, or other types of activities are needed to insure biological activity continues in the subsurface as needed.

Long-Term Monitoring. This subtask provides for periodic sampling of upgradient and downgradient MWs in the upper and middle RGA. The purpose of this monitoring is to determine the continued effectiveness of the UCRS RA on reducing the migration of TCE and other VOC contaminants from the UCRS to the RGA.

The RDR and the RAWP provide additional detail concerning the composition and scheduling of these components of the SWMU 211-A EISB project.

1.2.2 Contaminants Treated

The C-720 Building consists of several repair and machine shops, and other support operations. The Waste Area Group 27 RI identified areas of TCE contamination in or near the C-720 Building. SWMU 211-A is the paved and unpaved area northeast of the C-720 Building where contamination was found underneath.

The actual source of the TCE contamination found in SWMU 211-A is unknown; however TCE is believed to have been released from the C-720 Building to the southwest during routine equipment cleaning and rinsing performed in the area. Solvents were used to clean parts, and the excess solvent may have been discharged on the ground. Additionally, spills and leaks from the cleaning process may have contaminated surface soils in the area. Solvents may have migrated as dissolved contamination, rainfall percolating through the soils and migrating to deeper soils and the shallower groundwater, or dense nonaqueous-phase liquid migrating to adjacent and underlying soils. After the ROD was signed in 2012, SWMU 211-A underwent a final characterization, which resulted in the determination that the area of contamination was larger than previously mapped. At the conclusion of the final characterization, the treatment area (which required the application of the bioremedial activities) was expanded from approximately 1,150 ft^2 to approximately 13,000 ft^2.

The selected RA for SWMU 211-A achieves the RAOs by removing TCE and other VOCs in the subsurface soils using EISB. The following are RAOs for this action, as contained in the ROD (DOE 2012).

1. Treat and/or remove the principal threat waste consistent with the National Contingency Plan.

2a. Prevent exposure to VOC contamination in the source areas that will cause an unacceptable risk to the excavation workers (< 10 ft).

2b. Prevent exposure to non-VOC contamination and residual VOC contamination through interim LUCs within the Southwest Plume source areas (i.e., SWMU 1,[3] SWMU 211-A, and SWMU 211-B[4]), pending remedy selection as part of the Soils Operable Unit and the Groundwater Operable Unit.

3. Reduce VOC migration from contaminated subsurface soils in the treatment areas at the Oil Landfarm and the C-720 Northeast and Southeast Sites so that contaminants migrating from the treatment areas do not result in the exceedance of maximum contaminant levels (MCLs) in the underlying RGA groundwater.

The selected RA for SWMU 211-A achieves RAOs by treating TCE and other VOCs in the subsurface soils using EISB. The treatment zone of the bioremediation targeted the groundwater and soils directly below and within the area of SWMU 211-A, from depths of 20 to 64 ft below ground surface (bgs), as identified in the RDR. The RA treated the high TCE concentration in soils which are present at the C-720 sites and constitute principal threat waste, and will biologically remediate the TCE sources and other VOCs. After the active bioremediation, residual VOC mass (estimated at 5%) may continue to leach to groundwater in the RGA. Remediation goals are expected to be attained within 39 years. Groundwater remedial goals (RGs) for UCRS soil, as shown in Table 1.1, are VOC concentrations in subsurface soils in the treatment area that would not result in an exceedance of the MCLs in the RGA; therefore, the groundwater RGs would meet RAO No. 3, with no other controls necessary for SWMU 211-A. The cleanup levels were calculated for

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[3] DOE has implemented RAs for SWMU 1 (DOE 2017); SWMU 1 is not discussed further in this report.
[4] SWMU 211-B has separate documentation and schedule under the Site Management Plan and is not discussed further in this report (DOE 2022a).

TCE half-lives in UCRS soils (ranging from 5 to 50 years) to assess the effects of high to low rates of degradation on overall remedy time frames (50 years essentially represents no observable degradation).

Table 1.1. UCRS Soil Cleanup Levels for VOCs for Groundwater Protection at the C-720 Source Areas

VOC	Half-life (yr)	Primary MCL (mg/L)	UCRS Soil Cleanup RG (mg/kg)
TCE	50	5.00E-03	7.50E-02
1,1-dichloroethene	infinite	7.00E-03	1.37E-01
cis-1,2-dichloroethene	infinite	7.00E-02	6.19E-01
trans-1,2-dichloroethene	infinite	1.00E-01	5.29E+00
Vinyl chloride	infinite	2.00E-03	5.70E-01

Notes:

1. Modified from ROD Tables 17 and 19 for UCRS soil cleanup levels for VOCs for the protection of groundwater (DOE 2012).
2. Analyses show that attaining the cleanup goals for the protection of groundwater would yield residual risks (i.e., risks after the cleanup goals are attained) to the worker near the lower end of the EPA acceptable risk range under default rates of exposure. Similarly, residual hazard levels also would be below 1 under default rates of exposure. The cleanup goals that are protective of the groundwater also will protect the worker. The groundwater protection cleanup levels provided were calculated for TCE in UCRS soils with a 50 year half-life to incorporate the effects of degradation on overall remedy time frames (50 years essentially represents no observable degradation). Other VOCs were assumed not to be degraded (DOE 2012).

Long-term MWs have been installed to provide groundwater samples for examining trends in the RGA as biodegradation of VOCs continue in the UCRS. These trends will be used to determine the continued effectiveness of the remedy to meet RAO No. 3. A schedule for groundwater sampling is provided in the RDR.

1.2.3 Field Changes

The RDR and the RAWP provided base information concerning the approach, process, locations, etc. to be used in implementing the EISB project in the field. The information in these documents were implemented as closely as was feasible. Due to a number of circumstances [presence of underground and/or overhead utilities, buildings and associated entrances or access pathways (e.g., sidewalks, driveways), material availability, field conditions, and equipment issues], it became necessary to adjust materials, locations, etc. during actual implementation. Table 1.2 provides a listing of the field deviations that were captured during implementation and the information concerning those deviations. Any field deviations that were design changes to the RA were conveyed and discussed with the FFA parties in a timely fashion, as needed.

Table 1.2. Field Deviations

Item #	Description	Date	Design Reference from RDR	Deviation	Design Change
1	Field adjustment of performance well locations PW007, PW008, PW009	3/31/2022	Figure 12	Interference with existing utility steam line. Moved the three-well nest approximately 5 ft plant north to escape utility.	No. Location adjustment was allowed based on Section 5.4 of the RDR.
2	Field adjustment of performance well locations PW001, PW002, PW003	4/4/2022	Figure 12	Interference with a sharp depression and unstable soils. Moved the nest approximately 5 ft south.	No. Location adjustment was allowed based on Section 5.4 of the RDR.
3	Discrete groundwater sample locations PW002, PW003, PW018	4/5/2022	Appendix A, Operations, Maintenance, and Environmental Monitoring Plan	Unable to collect discrete groundwater samples for DHC bacteria analysis due to insufficient water. Sample locations PW004 and PW017 were substituted for collection.	No. Locations are still spatially distributed within the treatment area based on Appendix A of the RDR.
4	Field adjustment of IW cluster IW-18	4/11/2022	Figure 12	IW-18 location got 3.5-inch drill string stuck at 28 ft bgs. Moved the IW-18 location approximately 2 ft south and redrilled.	No. Location adjustment was allowed based on Section 5.4 of the RDR.
5	DPT Jet Injection tool diameter	4/12/2022	Section 4.4.2.1	The 3.5-inch diameter tooling got stuck when drilling IW-18 location and passing through 20 to 30 ft bgs. Changed out 3.5-inch tooling to 2.25-inch tooling to allow for easier driving. The fundamental operations of jet injections did not change, but the mechanics of the operation were slightly more complex.	No. The change in tooling is not a fundamental design change. The actual bioremediation approach remains consistent; only the implementing equipment differs.
6	Field adjustment of long-term wells MW582 and MW586	4/26/2022	Figure 12	Minor adjustment to well location due to utilities and infrastructure. The well cluster MW582 and MW586 was moved approximately 10 ft plant east to avoid overhead lines and subsurface storm/sanitary sewers.	No. Location adjustment was allowed based on Section 5.4 of the RDR.

Table 1.2. Field Deviations (Continued)

Item #	Description	Date	Design Reference from RDR	Deviation	Design Change
7	Drop tube used for EVO injection to control frothing/aeration of anaerobic materials	5/2/2022	Figure 16	A drop tube was to be used to assist in controlling the frothing/aeration that may occur from vertically falling within the IW bore. The bioamendment solutions are anaerobic. Note: On July 12, 2022, after further consideration and the belief that the UCRS formation has a lower conductivity such that a drop tube was not necessary to prevent aeration of the injectant, Four Rivers Nuclear Partnership, LLC, (FRNP) cancelled the use of the drop tubes for amendment injections.	No. The change to bioamendment delivery is not a fundamental change to the remedial design.
8	Adjustment of long-term MW top of filter pack	5/2/2022	Appendix C, Monitoring Well Engineering Drawings; Commonwealth of Kentucky MW regulations	The top of filter pack sand for all long-term MWs installed after May 2, 2022 will have sand to a depth of 60 ft bgs.	No. Not a design change. Well construction flexibility of the top of sand pack is allowed by the RDR and the Commonwealth of Kentucky MW regulations.
9	Field adjustment of long-term wells MW579 and MW580	5/3/2022	Figure 12	Well locations were relocated approximately 7 ft southeast due to utilities and a building wall.	No. Location adjustment was allowed based on Section 5.4 of the RDR.
10	Field adjustment of long-term wells MW575 and MW576	5/5/2022	Figure 12	Well locations were relocated approximately 20 ft plant north due to utilities and garage door and man door access area.	No. Location adjustment was allowed based on Section 5.4 of the RDR.
11	Field adjustment of IW-31 treatment zone depth (TZD) at 34 to 36 ft bgs	5/5/2022	Table 5, Sections 4.3.1 and 4.4.3	TZD moved from 34 to 36 ft bgs due to formation refusal to notch.	No. Depth adjustment was allowed based on Sections 4.3.1 and 4.4.3 of the RDR.

Table 1.2. Field Deviations (Continued)

Item #	Description	Date	Design Reference from RDR	Deviation	Design Change
12	Field adjustment of IW-31 TZD at 54 to 55 ft bgs	5/11/2022	Table 5, Sections 4.3.1 and 4.4.3	TZD moved from 54 to 55 ft bgs due to formation fracture refusal.	No. Depth adjustment was allowed based on Sections 4.3.1 and 4.4.3 of the RDR.
13	Field adjustment of grout to be placed in the annular space of SWMU 211-A IWs	5/16/2022	Appendix C, Monitoring Well Engineering Drawings	The RDR does not specifically address IW annular space to be filled. Generally, the annular space would be filled with 30% high solids bentonite grout; however, the bentonite grout does not rigidly setup and will likely become a weak location during injection of EVO. The annular space will be filled with a Portland cement and 3% bentonite mixture to control subsurface injections.	No. Not referenced in remedial design.
14	Field adjustment of long-term well cluster MW577 and MW578	5/16/2022	Figure 12	Wells were relocated approximately 5 ft northeast due to original well locations being in a swale that ponds water.	No. Location adjustment was allowed based on Section 5.4 of the RDR.
15	Field adjustment of IW-28 TZD at 54 to 55 ft bgs	5/16/2022	Table 5, Sections 4.3.1 and 4.4.3	TZD moved from 54 to 55 ft bgs due to formation resistance to notching.	No. Depth adjustment was allowed based on Sections 4.3.1 and 4.4.3 of the RDR.
16	Field adjustment of IW-30 TZD at 34 to 35 ft bgs	5/16/2022	Table 5, Sections 4.3.1 and 4.4.3	TZD moved from 34 to 35 ft bgs due to fracture refusal.	No. Depth adjustment was allowed based on Sections 4.3.1 and 4.4.3 of the RDR.
17	Field adjustment of injection cluster IW-15	5/17/2022	Figure 9	Injection locations were relocated approximately 5 ft north due to original locations surveyed being under an east-west aboveground pipeline.	No. Location adjustment was allowed based on Section 5.4 of the RDR.
18	Field adjustment of injection cluster IW-12	5/17/2022	Figure 9	Injection locations were relocated approximately 5 ft east due to original location surveyed being up against an electrical transformer fence enclosure.	No. Location adjustment was allowed based on Section 5.4 of the RDR.

Table 1.2. Field Deviations (Continued)

Item #	Description	Date	Design Reference from RDR	Deviation	Design Change
19	Field adjustment of injection cluster IW-09	5/17/2022	Figure 9	Injection locations were relocated approximately 5 ft northeast due to the original location surveyed being up against an electrical transformer fence enclosure.	No. Location adjustment was allowed based on Section 5.4 of the RDR.
20	Field adjustment of injection cluster IW-11	5/17/2022	Figure 9	Injection locations were relocated approximately 5 ft southeast due to the original location surveyed being near sanitary water line and transformer enclosure to the north.	No. Location adjustment was allowed based on Section 5.4 of the RDR.
21	Field adjustment of IW-28 TZD at 57 to 58 ft bgs	5/18/2022	Table 5, Sections 4.3.1 and 4.4.3	TZD moved from 57 to 58 ft bgs due to refusal of formation resistance to notching.	No. Depth adjustment was allowed based on Sections 4.3.1 and 4.4.3 of the RDR.
22	Field adjustment of IW-28 TZD at 60 to 61 ft bgs	5/18/2022	Table 5, Sections 4.3.1 and 4.4.3	TZD moved from 60 to 61 ft bgs due to refusal of formation resistance to notching.	No. Depth adjustment was allowed based on Sections 4.3.1 and 4.4.3 of the RDR.
23	Field adjustment of IW-30 TZD at 58 to 59 ft bgs	5/18/2022	Table 5, Sections 4.3.1 and 4.4.3	TZD moved from 58 to 59 ft bgs due to fracture refusal.	No. Depth adjustment was allowed based on Sections 4.3.1 and 4.4.3 of the RDR.
24	Field adjustment of IW-28 TZD at 63 to 64 ft bgs	5/19/2022	Table 5, Sections 4.3.1 and 4.4.3	TZD moved from 63 to 64 ft bgs due to refusal of formation resistance to notching.	No. Depth adjustment was allowed based on Sections 4.3.1 and 4.4.3 of the RDR.
25	Field adjustment of IW-26 TZD at 34 to 35 ft bgs	5/23/2022	Table 5, Sections 4.3.1 and 4.4.3	TZD moved from 34 to 35 ft bgs due to formation resistance to notching.	No. Depth adjustment was allowed based on Sections 4.3.1 and 4.4.3 of the RDR.
26	Field adjustment of IW-26 TZD at 38 to 39 ft bgs	5/23/2022	Table 5, Sections 4.3.1 and 4.4.3	TZD moved from 38 to 39 ft bgs due to formation resistance to notching.	No. Depth adjustment was allowed based on Sections 4.3.1 and 4.4.3 of the RDR.

Table 1.2. Field Deviations (Continued)

Item #	Description	Date	Design Reference from RDR	Deviation	Design Change
27	Hoganas mZVI supply market name changed	5/24/2022	RDR did not reference a mZVI tradename	Hoganas Environment Solutions, LLC, provided the zero-valent iron for the project's implementation. The project initially used iron with the market name Clean ER-200™ Release Agent. Hoganas Environment Solutions, LLC, began supplying mZVI with the market name AT500™.	No. Mr. Louis LeBrun's, Hoganas Environmental Solutions, LLC, President, e-mail dated May 25, 2022, provided verification that Clean ER-200™ and AT500™ are identical materials, except for the trademark name. AT500™ is packaged for the manufacturing and welding markets.
28	Field adjustment of IW-10 TZD at 34 to 35 ft bgs	6/2/2022	Table 5, Sections 4.3.1 and 4.4.3	TZD moved from 34 to 35 ft bgs due to formation resistance to notching.	No. Depth adjustment was allowed based on Sections 4.3.1 and 4.4.3 of the RDR.
29	Field adjustment of IW-10 TZD at 38 to 39 ft bgs	6/6/2022	Table 5, Sections 4.3.1 and 4.4.3	TZD moved from 38 to 39 ft bgs due to formation resistance to notching.	No. Depth adjustment was allowed based on Sections 4.3.1 and 4.4.3 of the RDR.
30	Field adjustment of IW-11 TZD at 45 to 46 ft bgs	6/8/2022	Table 5, Sections 4.3.1 and 4.4.3	TZD moved from 45 to 46 ft bgs due to formation resistance to notching.	No. Depth adjustment was allowed based on Sections 4.3.1 and 4.4.3 of the RDR.
31	Field adjustment of IW-10 TZD at 54 to 55 ft bgs	6/9/2022	Table 5, Sections 4.3.1 and 4.4.3	TZD moved from 54 to 55 ft bgs due to refusal to inject.	No. Depth adjustment was allowed based on Sections 4.3.1 and 4.4.3 of the RDR.
32	Field adjustment of IW-11 TZD at 56 to 57 ft bgs	6/14/2022	Table 5, Sections 4.3.1 and 4.4.3	TZD moved from 56 to 57 ft bgs due to refusal to inject.	No. Depth adjustment was allowed based on Sections 4.3.1 and 4.4.3 of the RDR.
33	Field adjustment of IW-07 TZD at 30 to 31 ft bgs	6/14/2022	Table 5, Sections 4.3.1 and 4.4.3	TZD moved from 30 to 31 ft bgs due to refusal to inject.	No. Depth adjustment was allowed based on Sections 4.3.1 and 4.4.3 of the RDR.
34	Field adjustment of IW-15 TZD at 33 to 34 ft bgs	6/14/2022	Table 5, Sections 4.3.1 and 4.4.3	TZD moved from 33 to 34 ft bgs due to refusal to inject.	No. Depth adjustment was allowed based on Sections 4.3.1 and 4.4.3 of the RDR.

Table 1.2. Field Deviations (Continued)

Item #	Description	Date	Design Reference from RDR	Deviation	Design Change
35	Field adjustment of IW-07 TZD at 36 to 38 ft bgs	6/15/2022	Table 5, Sections 4.3.1 and 4.4.3	TZD moved from 36 to 38 ft bgs due to refusal to inject.	No. Depth adjustment was allowed based on Sections 4.3.1 and 4.4.3 of the RDR.
36	Field adjustment of IW-03 TZD at 58 to 59 ft bgs	6/16/2022	Table 5, Sections 4.3.1 and 4.4.3	TZD moved from 58 to 59 ft bgs due to refusal to inject.	No. Depth adjustment was allowed based on Sections 4.3.1 and 4.4.3 of the RDR.
37	Field adjustment of IW cluster IW-01	6/29/2022	Figure 9	IW-01 well cluster (as surveyed from the design) placed the wells in a depression. Moved wells approximately 15 ft southwest. Moved IW-05 location approximately 5 ft south due to close proximity to IW-01.	Yes. Approved by FFA parties on June 29, 2022, during weekly groundwater conference call.
38	Confirmation of bioamendment and bioaugmentation products	7/7/2022	General	Arcadis proposed utilizing EOS Pro-60, Newman OS™, and EOS SDC-9 for the EVO, water deoxygenator, and bioaugmentation bacteria, respectively.	No. Geosyntec Consultants, the design engineer of record, approved the use of all three compounds for the EISB project in an e-mail dated July 7, 2022.
39	Field adjustment of IW-05 TZD at 57 to 58 ft bgs	7/13/2022	Table 5, Section 4.3.1	TZD moved from 57 to 58 ft bgs due to refusal to notch formation.	No. Depth adjustment was allowed based on Sections 4.3.1 and 4.4.3 of the RDR.

2. CHRONOLOGY OF EVENTS

The following provides a summary of the chronology of events associated with the RA, beginning with the signing of the ROD and then leading to the development of this interim RACR.

March 20, 2012—ROD signed for SWMUs 1, 211-A, 211-B, and Part of 102.

December 10, 2013—Submitted *Final Characterization Report for Solid Waste Management Units 211-A and 211-B Volatile Organic Compound Sources for the Southwest Groundwater Plume at the Paducah Gaseous Diffusion Plant, Paducah, Kentucky*, DOE/LX/07-1288&D2 (DOE 2013).

December 11, 2015—Submitted *Addendum to the Final Characterization Report for Solid Waste Management Units 211-A and 211-B Volatile Organic Compound Sources for the Southwest Groundwater Plume at the Paducah Gaseous Diffusion Plant, Paducah, Kentucky,* DOE/LX/07-1288&D2/A1 (DOE 2015).

April 25, 2016—Submitted *Addendum to the Final Characterization Report for Solid Waste Management Units 211-A and 211-B Volatile Organic Compound Sources for the Southwest Groundwater Plume at the Paducah Gaseous Diffusion Plant, Paducah, Kentucky*, DOE/LX/07-1288&D2/A1/R1 (DOE 2016).

May 23, 2018—The EISB that included interim LUCs and groundwater monitoring was selected and documented after a presentation to the FFA parties.

December 19, 2019—Submitted *Certified for Construction Remedial Design Report for SWMU 211-A for Volatile Organic Compound Sources to the Southwest Groundwater Plume at the Paducah Gaseous Diffusion Plant, Paducah, Kentucky*, DOE/LX/07-2435&D2 (DOE 2019).

September 7, 2021—Approval received for *Memorandum of Agreement for Resolution of Informal Dispute Concerning U.S. Environmental Protection Agency Conditional Concurrence on the Remedial Action Work Plan for SWMU 211-A Enhanced In Situ Bioremediation for Volatile Organic Compound Sources to the Southwest Groundwater Plume at the Paducah Gaseous Diffusion Plant, Paducah, Kentucky*, *DOE/LX/07-2443&D2* (DOE 2021b).

December 16, 2021—Submitted *Remedial Action Work Plan for SWMU 211-A Enhanced In Situ Bioremediation for Volatile Organic Compound Sources to the Southwest Groundwater Plume at the Paducah Gaseous Diffusion Plant, Paducah, Kentucky*, DOE/LX/07-2443&D2/R2 (DOE 2021a).

March 8, 2022—Worksite preparation activities commenced.

March 10, 2022—Completed worksite preparation activities.

March 16, 2022—Submitted notification of RA field start for SWMU 211-A EISB (DOE 2022b).

March 24, 2022—Drilling operations commenced and began collecting baseline discrete groundwater samples from future PW locations.

April 5, 2022—Completed the collection of baseline discrete groundwater samples.

April 7, 2022—Began the setup of the hydraulic fracturing equipment.

April 11, 2022—Commenced hydraulic fracturing in the eastern wellfield.

April 27, 2022—Began installation of long-term MWs.

May 16, 2022—Began well development of the installed long-term MWs.

May 18, 2022—Completed the installation of long-term MWs. Began the installation of IWs in the eastern wellfield.

May 26, 2022—Completed hydraulic fracturing in the eastern wellfield.

May 26, 2022—Commenced hydraulic fracturing in the western wellfield.

May 31, 2022—Completed well development of the installed long-term MWs.

June 21, 2022—Began the installation of bollards and well pads for the newly installed long-term MWs.

June 21, 2022—Began well development of the installed IWs in the eastern wellfield.

June 23, 2022—Completed installation of bollards and well pads for the newly installed long-term MWs.

July 6, 2022—Began and completed the collection of groundwater samples from the long-term MWs.

July 13, 2022—Completed hydraulic fracturing in the western wellfield. Began demobilization of the fracturing equipment.

July 13, 2022—Began the mobilization of bioamendment and bioaugmentation bacteria injection equipment.

July 22, 2022—Completed the assembly of bioamendment injection and bioaugmentation equipment; conducted leak testing.

July 23, 2022—Began injection of bioamendments and bioaugmentation in IWs in the eastern wellfield.

August 4, 2022—Suspended bioamendment and bioaugmentation injections due to a release at Kentucky Pollutant Discharge Elimination System (KPDES) Outfall 008. Approximately 42,000 gal of water which contained a portion of EVO solution were removed and placed into a holding lagoon near the outfall. The EVO solution was suspected of entering a nearby damaged storm sewer line during the injection process.

August 8, 2022—Conducted an injection control measure meeting; resumed bioamendment and bioaugmentation injections, with the exception of five IWs near the suspect storm sewer line (IW-29A, IW-29B, IW-30A, IW-30B, and IW-31A).

August 17, 2022—Completed installation of IWs in the western wellfield.

August 20, 2022—Began injecting bioamendments and bioaugmentation in the western wellfield.

August 24, 2022—Completed the development of the IWs.

September 9, 2022—Began installation of well pads and bollards at IWs.

September 13, 2022—42,000 gal of water containing a portion of EVO solution was pumped from holding lagoon into 16,000 gal frac tanks.

September 14, 2022—Completed bioamendment and bioaugmentation injections in the western wellfield.

September 19, 2022—Began installation of PWs in the eastern wellfield.

September 19, 2022—Continued bioamendment and bioaugmentation injections in the eastern wellfield, including the five IWs near the storm sewer line.

September 21, 2022—Completed bioamendment and bioaugmentation injections.

September 22, 2022—Began demobilization of the bioamendment and bioaugmentation injection equipment.

September 22, 2022—Began well development of installed PWs.

September 23, 2022—Began the installation of well pads and bollards at PWs.

September 24, 2022—Completed the installation of PWs in the eastern wellfield.

September 26, 2022—Began installation of PWs in the western wellfield.

September 29, 2022—Completed the release of the estimated 42,000 gal of water that contained a fraction of EVO solution from the frac tanks, which was discharged out of KPDES Outfall 008.

September 30, 2022—Completed the installation of PWs in the western wellfield.

October 3, 2022—Began demobilization of the drilling equipment.

October 4, 2022—Completed the installation of well pads at the IWs.

October 6, 2022—Completed the installation of well pads and bollards at the PWs.

October 10, 2022—Completed well development of PWs.

October 26, 2022—Completed the placement of large concrete stones around the IWs.

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3. PERFORMANCE STANDARDS AND CONSTRUCTION QUALITY CONTROL

3.1 STANDARDS

FRNP was responsible for the overall management of EISB activities, including quality assurance, quality control, radiological protection, and industrial health and safety activities. FRNP confirmed that the selected subcontractors were capable of meeting applicable quality requirements, as detailed in the RAWP and the RDR.

3.2 RESULTS OF FIELD SAMPLING

The results of field sampling for baseline groundwater parameters are summarized in Section 4.2.1. Post-injection sampling is scheduled to begin approximately one month after completion of the field activities for the RA, in December 2022, as contained in the RDR. Long-term monitoring data will be utilized to support the evaluation of the SWMU 211-A RA in the CERCLA Five-Year Reviews required for this remedy.

3.3 LOCATION AND FREQUENCY OF TESTS

During RA implementation, active data collection and review were performed by the project team to confirm that injection volume requirements were achieved for each of the IWs. As EISB is remediation that occurs over a period of time, other than baseline sampling (which is discussed in Section 3.3.1), no analytical testing was performed during the injection of the bioamendments and bioaugmentation.

3.3.1 Baseline Groundwater Sampling

Baseline sampling was conducted prior to EISB implementation to assess groundwater characteristics in the UCRS and upper RGA in the areas that would contain the PW network. Prior to EISB intrusive activities, baseline discrete samples were obtained, when feasible, utilizing Geoprobe® direct-push drilling techniques for collecting discrete groundwater samples from specific depths at future PW locations (PW001 through PW018). The samples were obtained from the depths consistent with the RDR. Of the 18 future PW locations, only 11 provided sufficient groundwater for sample analysis. The other seven locations were deficient in water. Performance well baseline samples are provided in Table 3.1.

Table 3.1 Baseline Groundwater Monitoring (Pre-EISB Injection)

Location	Drilling Complete	Discrete Groundwater Sample Collection Depth (ft bgs)	Discrete Groundwater Sampling Date	Plugging and Abandonment Date
PW001	4/5/2022	65*	4/5/2022	4/6/2022
PW002	4/4/2022	57	Insufficient Water	4/6/2022
PW003	4/4/2022	47	Insufficient Water	4/6/2022
PW004	3/30/2022	62*	4/5/2022	4/6/2022
PW005	3/30/2022	57	3/31/2022	4/4/2022
PW006	3/30/2022	47	Insufficient Water	4/4/2022

Table 3.1. Baseline Groundwater Monitoring (Pre-EISB Injection) (Continued)

Location	Drilling Complete	Discrete Groundwater Sample Collection Depth (ft bgs)	Discrete Groundwater Sampling Date	Plugging and Abandonment Date
PW007	3/31/2022	67	4/4/2022	4/7/2022
PW008	3/31/2022	57	4/4/2022	4/4/2022
PW009	3/31/2022	47	4/4/2022	4/4/2022
PW010	3/23/2022	67	3/24/2022	3/29/2022
PW011	3/24/2022	57	3/28/2022	3/29/2022
PW012	3/24/2022	47	Insufficient Water	3/29/2022
PW013	3/24/2022	67	3/24/2022	3/28/2022
PW014	3/28/2022	57	Insufficient Water	3/29/2022
PW015	3/24/2022	47	Insufficient Water	3/28/2022
PW016	3/29/2022	67	3/30/2022	3/31/2022
PW017	3/29/2022	57	3/30/2022	3/31/2022
PW018	3/29/2022	47	Insufficient Water	3/31/2022

*DPT drill met refusal.

Baseline samples also were collected from 10 long-term MWs (9 newly installed and 1 existing) outside the perimeter of the treatment area early in the project and before bioamendment injections were initiated. Samples were collected using low-flow methods after parameter stabilization. The following long-term MWs were selected for baseline sampling in accordance with the RDR: MW203, MW575, MW576, MW577, MW578, MW579, MW580, MW581, MW582, and MW586.

Samples were collected in accordance with contractor procedures by using a dedicated bladder pump and by purging the well prior to sample collection. If possible, the samples were collected using low-flow methods after parameter stabilization.[5]

Both PW and long-term MW baseline samples were analyzed by a laboratory in accordance with the RAWP for five VOCs by EPA Method 8260D: TCE, *cis*-1,2-dichloroethene, *trans*-1,2-dichloroethene, 1,1-dichloroethene, and vinyl chloride. Additionally, PW samples were analyzed for total organic carbon (TOC). Samples for DHC bacteria were also collected in a subset of the PW samples, including two locations in the middle UCRS and one in the lower UCRS.

Due to the lack of water in several of the sampling locations, samples for DHC bacteria were collected from alternate locations. A description of these field changes is provided in Section 1.2.3.

The complete baseline sampling and analysis plan is provided in the Operations, Maintenance, and Environmental Monitoring Plan, which is located in Appendix A of the RDR. A summary of the baseline groundwater sampling data is provided in Section 4.2.1.

3.4 BASIS FOR DETERMINATION THAT STANDARDS WERE MET

EISB is a remedial technology that will continue to biologically remediate TCE and other VOCs once the desired subsurface conditions are sufficiently attained. Injections of mZVI, EVO, and bacterial

[5] Because of the low yield within the UCRS, parameter stabilization may not have been feasible at certain points within the UCRS. If parameter stabilization was not feasible due to slow recharge, the sampler and drill rods were purged dry. The apparatus was then left in place until it had recharged (e.g., 24 hours). The sample was then collected from the water that refilled the sampling apparatus.

bioaugmentation are used to attain subsurface conditions. The standards and RAOs for the SWMU 211-A RA are only expected to be obtained after a period of bioremediation is performed (see Section 1.2.2). The follow-up long-term and performance monitoring results and identified contaminant trends will be included in the CERCLA Five-Year Reviews until the levels of contaminants of concern allow for unlimited use and unrestricted exposure of the soil and groundwater.

Employees from both FRNP and Arcadis were in the field during EISB remedial implementation activities to verify that all design criteria were met for the SWMU 211-A treatment area. The Arcadis field crew consisted of an Arcadis site superintendent and field crew members, who combined to perform and observe the implementation of remedial activities as they occurred, and also provided oversight of Arcadis subcontractors. In addition, an FRNP site superintendent and support staff observed and documented the implementation of remedial activities.

3.4.1 DPT Jet Injection Fracturing

DPT Jet Injection fracturing was implemented by FRx, Inc., technicians who were supervised by the Arcadis site superintendent. FRx, Inc., technicians combined the appropriate amount of proppant sand and mZVI, as specified in the RDR. Guar gum was then mixed into the batch for each injection location and specified TZD. During injection, the crew controlled water blaster pressure and average slurry injection pressures. The Arcadis site superintendent observed DPT Jet Injection fracturing operations to ensure they were completed in accordance with the RDR. Appendix B provides the quantities of mZVI and sand (lb) used per injection location, as well as injection pressures (psi). Data from actual injection fracturing were recorded in the field using a laptop and Microsoft Excel. FRx, Inc., technicians recorded weights of mZVI and sand using a digital load cell scale. Guar gum amounts to be mixed with the sand and mZVI were measured by taking before and after readings on the graduated storage tank. In total, the DPT Jet Injection fracturing used the following amounts of materials by placing the materials in the subsurface.

- Zero-valent Iron—445,334 lb
- Proppant sand—221,674 lb
- Guar gum gel—66,240 gal

Consistent with the requirements of the RDR, 325 treatment zones were injected in 33 locations. The completion of each treatment zone is summarized in Section 4.2.2.

3.4.2 EISB Bioamendment and Bioaugmentation Injection

Bioaugmentation and bioamendment activities were implemented by Arcadis technicians and supervised by the Arcadis site superintendent. Arcadis technicians utilized the design quantities of EVO solution for each IW. Because 60% concentrate of EVO stock solution was utilized, the mixing and injection system was setup to deliver 13.4% EVO solution for injection into the subsurface that would result in a 2% concentration in each DPT Jet Injection zone. The anoxic injection water was pumped and the EVO stock solution was metered in by dosing pumps. Water parameters were collected from mixed anoxic water using a multi-parameter meter prior to injection. The Arcadis site superintendent observed all EISB operations to ensure they were completed in accordance with the RDR.

Data from EISB injection activities were recorded on field forms. Arcadis field staff recorded daily anoxic water usage (gal) via a flow totalizer located on the effluent portion of the water storage frac tank. In addition, total EVO stock usage (gal) was recorded using dose pumps located on the EVO storage tanks. The dose pumps fed EVO stock solution into the bioamendment injection system combining it with the anoxic water. The sum of the EVO stock usage (gal) and total anoxic water (gal) was recorded as the total

EVO solution volume (gal). In addition, the bioaugmentation consortium (i.e., DHC) was premeasured in a graduated cylinder prior to injection.

Total flow of the EVO solution was split into separate manifolds for each injection. At each injection wellhead, a flow totalizer was installed to measure the flowrate of EVO solution for each individual IW. During bioamendment injection operations, a discrepancy was noted in the individual IW totalizer flow volumes when compared to the daily overall total amount of anoxic water and stock EVO usage measured. This discrepancy was due to mechanical issues because the totalizers interacted with the EVO solution that contained a buildup of solids, which were generated in both the EVO stock product and EVO solution. The generation of solids and IW totalizer issues are discussed further in Section 4.5. Due to the discrepencies encountered with the individual IW totalizers, Arcadis staff proportionally allocated EVO solution volumes (gal) based on the difference between the overall daily EVO solution used and the sum of the individual injection wellhead volumes. Appendix C provides estimated quantities of the daily EVO solution volumes injected into each IW.

In total, during bioamendment and bioaugmentation injections, the following materials were injected into the subsurface.

- Estimated EVO solution volume—154,436 gal
- SDC-9 DHC bacterial consortium—215 L

Consistent with the requirements of the RDR, 85 IWs were injected with the EVO solution volume over the required 130,000 gal, and with the required 215 L of DHC bacteria. The estimated total EVO injection volumes and DHC bacterial (i.e., SDC-9) volumes are summarized in Section 4.2.3.

4. CONSTRUCTION ACTIVITIES

4.1 NARRATIVE DESCRIPTION

The construction phase of implementing the RA was initiated in March 2022, with the completion of the internal field review and management approval to initiate fieldwork. This section describes the work performed to implement the RA.

4.1.1 Site Preparation

Site preparation was performed from March 8, 2022, to March 10, 2022. Activities included clearing the treatment area of equipment such as vehicles, guardrails, parking blocks, and tank saddles. The removal of equipment was necessary to facilitate safe movement of remedial equipment and personnel. All nearby utilities were located and potential subsurface anomalies were identified and documented in an excavation/penetration permit. Clean fill was used to fill in potholes and other low spots in the treatment area. In addition, safety barricades were installed inside the work area. Photographs of the work area taken prior to the start of field activities and during site preparation are presented in Figures 4.1 through 4.3.

Mobilization of drilling and hydraulic fracturing equipment took place in mid-March 2022. Additional equipment for bioamendment and bioaugmentation injections and other support activities was brought on-site, as needed, for that phase of the project.

Equipment brought on-site beginning in March 2022 included the following:

- Sonic drilling rig with support trailer and associated tooling
- Direct-push drilling rig with associated tooling
- Subsurface discrete groundwater sampling device
- Drilling supplies, including bentonite pellets, sand, bentonite grout, Portland cement, tremie, well casings, well screens, and well stabilizers
- DPT Jet Injection tooling, solids hopper and feeder, telehandler, and generators

4.1.2 Baseline Water Sampling

After initial mobilization, baseline groundwater sampling began on March 24, 2022. Discrete groundwater samples were collected from future PW locations using a direct-push drilling rig. Sampling of discrete groundwater samples was completed on April 5, 2022. Additional baseline samples were collected after the installation and development of long-term MWs on July 6, 2022. The project tentatively plans on collecting the first round of post-EISB groundwater samples from the PWs and long-term MWs in December 2022. Further discussion of baseline groundwater sampling is provided in Section 3.3.1 and summarized in Section 4.2.1.

4.1.3 DPT Jet Injection Fracturing

DPT Jet Injection fracturing commenced on April 11, 2022, in the eastern wellfield of SWMU 211-A. A total of 16 locations (IW-17 through IW-32) were drilled and fractured in the eastern wellfield. Following

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Figure 4.1. Site Prior to Fieldwork Looking Southwest

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Figure 4.2. Site Preparation Looking Northeast

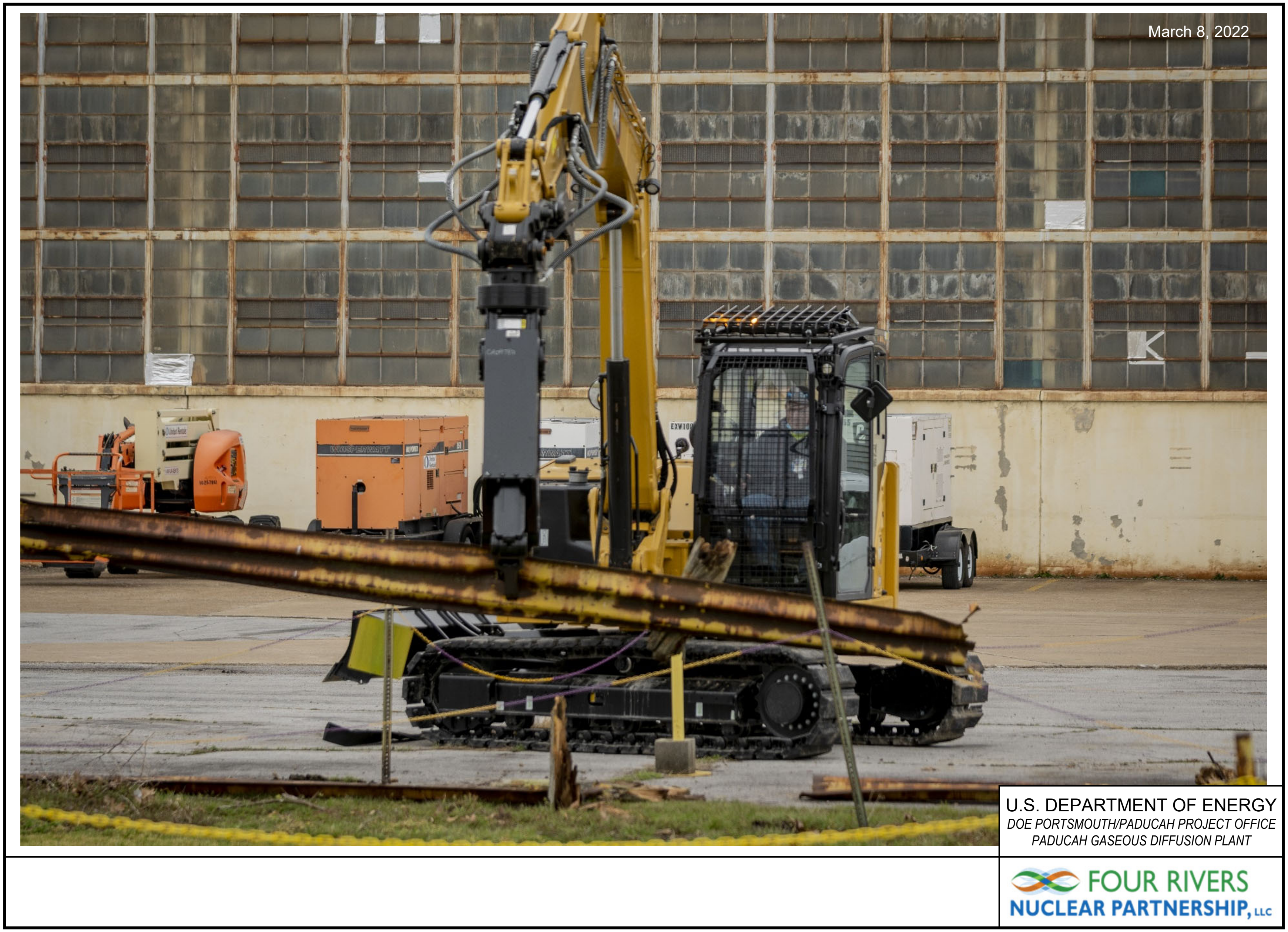


Figure 4.3. Site Preparation Looking South

completion of fracturing in the eastern wellfield on May 25, 2022, work commenced in the western wellfield the following day. A total of 17 locations (IW-01 through IW-16 and IW-33) were drilled and fractured in the western wellfield, with work being completed on July 13, 2022. IW-01 was relocated from its designed location due to ponding water and an inclined ground surface which prevented drill rig access. Due to the shift in the treatment zone of IW-01, the location of IW-05 was also offset to ensure proper coverage of the RA treatment area. Other locations were also moved (< 5 ft) to avoid utilities and other infrastructure as well as to allow DPT Jet Injection drilling equipment to access injection well locations.

DPT Jet Injection fracturing included (1) advancing injection tooling to the desired fracture depth; (2) using high-pressure jetting to inscribe a horizontal disc shape (also referred to as a kerf/notch) into the wall of the borehole to focus injection stresses; (3) injecting a viscous slurry containing cross-linked guar gum and proppant (i.e., sand/mZVI) to initiate the formation of a hydraulic fracture; and (4) continued injection of the viscous slurry to propagate the hydraulic fracture. The fractures created are expected to be relatively thin at less than ½ inch immediately at the boring and to have a radius of influence (ROI) of approximately 15 ft from the injection boring. A conceptual cross-section depicting the mZVI fractures is presented in Figure 4.4.

The slurry injected was composed of a mixture of sand and mZVI, in accordance with the RDR in a cross-linked hydrated guar gum (guar gel) slurry. The hydrated guar gum is made by mixing guar gum and water. Prior to injection, sand and mZVI in individual 2,000 to 2,200 lb supersacks, respectively, were loaded into a hopper by a telehandler. The sand and mZVI were then mixed with hydrated guar gum cross-linked using borax. Guar gel formed when borax was added, which created a viscous sand-mZVI slurry that suspended sand and mZVI, thus promoting the delivery of bioamendments with limited disaggregation of the sand-mZVI slurry within the aquifer matrix. An enzymatic breaker was also added to the sand-mZVI slurry prior to injection at the concentrations recommended by the manufacturer. The enzymatic breaker assisted in breaking down the guar gel after injection and enhanced the permeability of the sand-mZVI slurry-formed lenses.

Each of the individual injection locations was unique with designated fracturing depths and prescribed amounts of sand-mZVI slurry to be injected in accordance with the RDR. The following general steps were performed for a single depth-discrete injection.

- A DPT drill rig was used to advance 2.25-inch DPT drill rods equipped with specialized injection tooling into the subsurface to the first (i.e., shallowest) target injection depth. Injections were performed using a top-down approach to prevent an open borehole below the injection tooling from forming, and acting as a preferential pathway for remediation amendments to short-circuit into deeper zones.

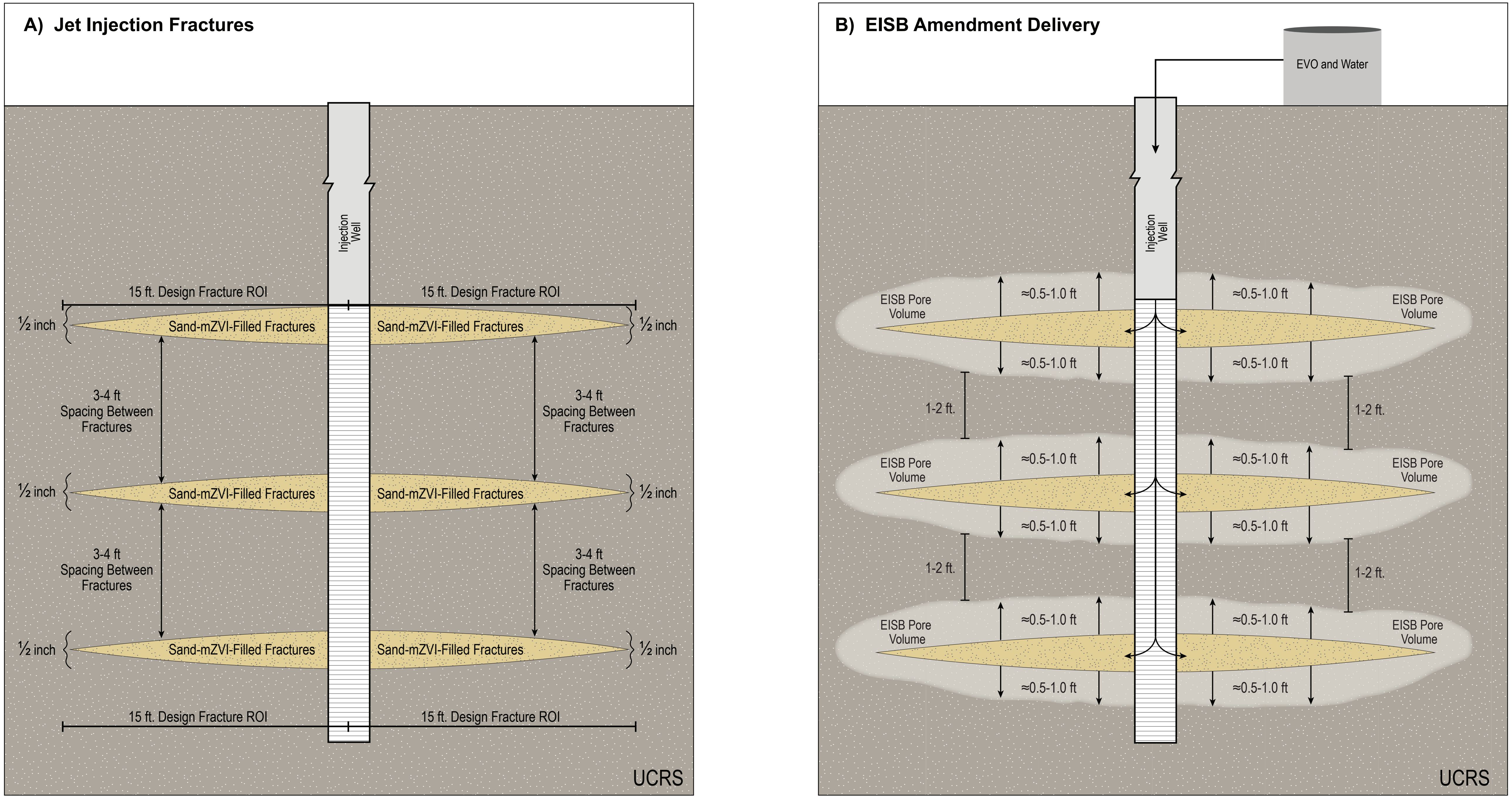
- After the injection tooling was advanced to depth, higher pressure water jetting was used to erode a horizontal disc shape (kerf/notch) in the formation surrounding the injection tooling by rotating the injection tooling.

- The sand-mZVI slurry was mixed prior to the start of the injection at each depth interval.

- After the water jetting step was completed, the sand-mZVI slurry was injected under sufficient pressures to create sand-mZVI slurry-filled horizontal fractures with a target ROI of 15 ft.

- After the target volume of slurry had been injected, the subsurface pressures in the IWs were allowed to recede, and the tooling was advanced to the next injection interval.

A process flow diagram of the DPT Jet Injection process is provided in Figure 4.5, and photographs of the field setup are provided in Figures 4.6 through 4.8. Locations of DPT injections with estimated ROIs are located in Figure 4.9. Total volumes of sand-mZVI slurry are summarized in Section 4.2.2, and field changes are summarized in Section 1.2.3. A complete summary of DPT Jet Injection data is provided in Appendix B.



Not to scale

Not to scale

<u>Acronyms</u>

EISB = Enhance *In Situ* Bioremediation

ROI = Radius of influence

UCRS = Upper Continental Recharge System

mZVI = microscale Zero-Valent Iron

EVO = Emulsified Vegetable Oil

Conceptual Cross Section Depicting Sand-mZVI Fractures and EISB Injections

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Figure **4.4**

November 2022

Figure 4.4. Conceptual Cross Section Depicting Sand-mZVI Fractures and EISB Injections

Source: Adapted from DOE 2019

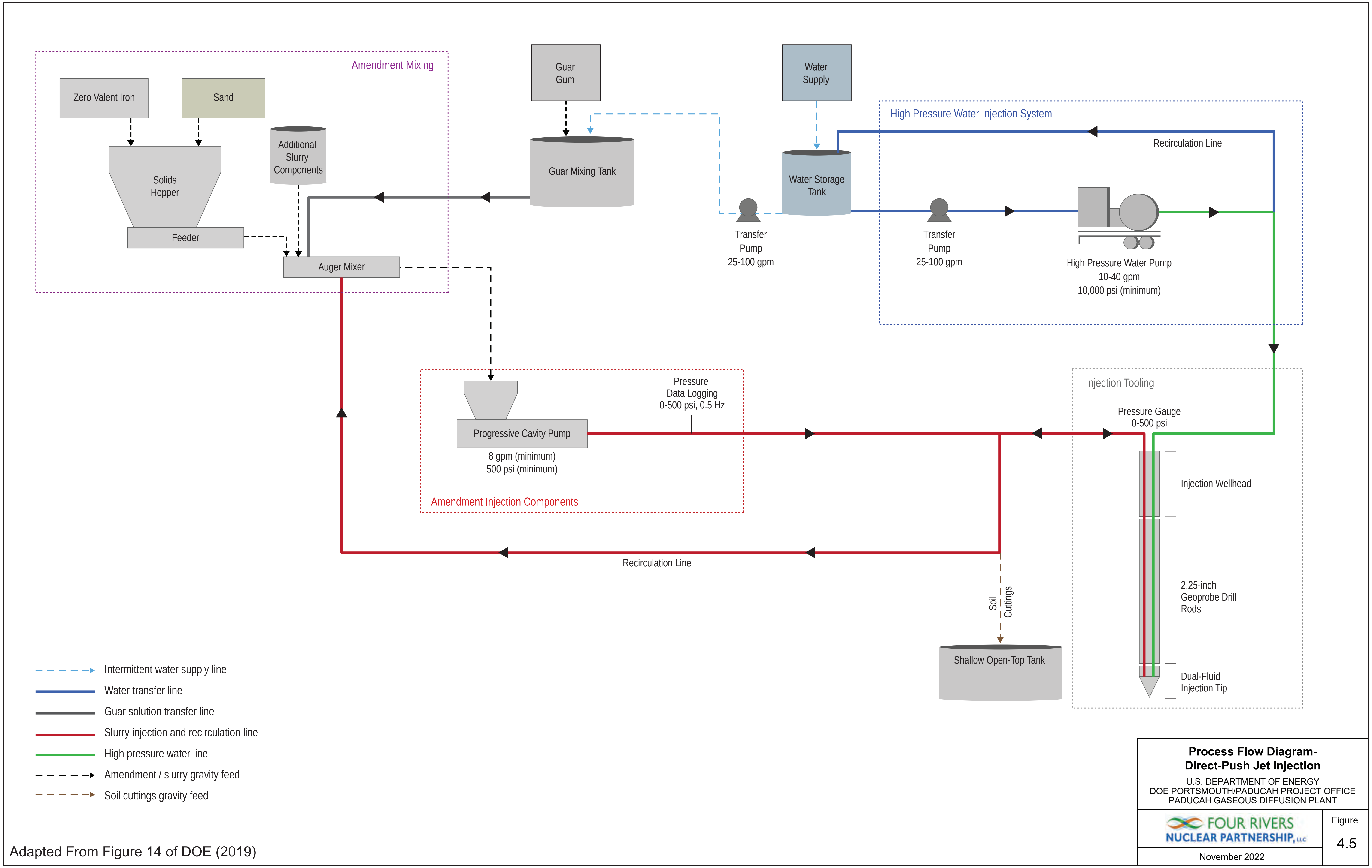
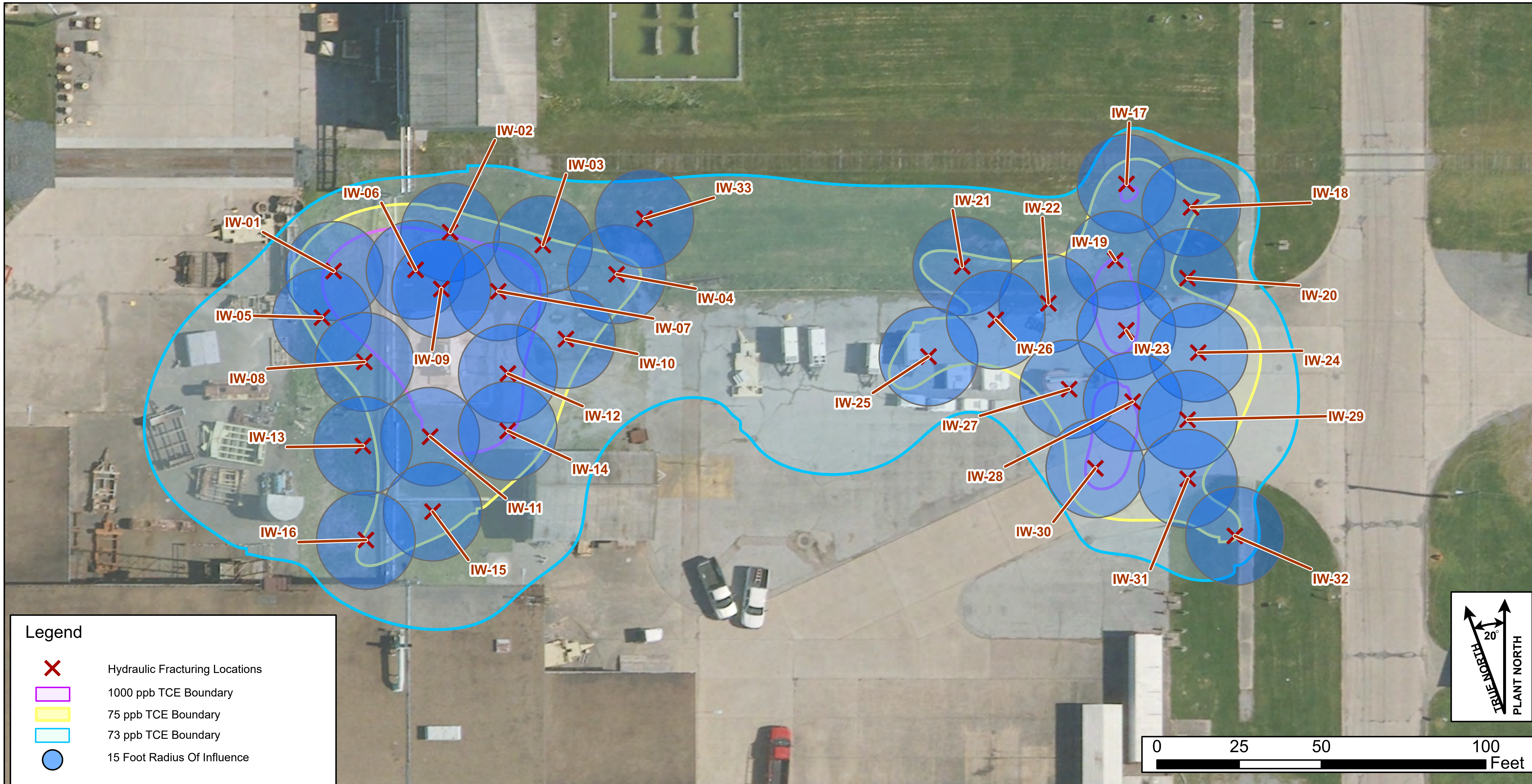


Figure 4.5. Process Flow Diagram—Direct-Push Jet Injection

Figure 4.6. DPT Jet Injection Equipment

Figure 4.7. Hydraulic Fracturing

Figure 4.8. FRx, Inc., Technician Loading Hopper with Sand and mZVI



Map Source Information
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Figure 4.9. SWMU 211-A DPT Jet Injection Hydraulic Fracturing As-Built Locations

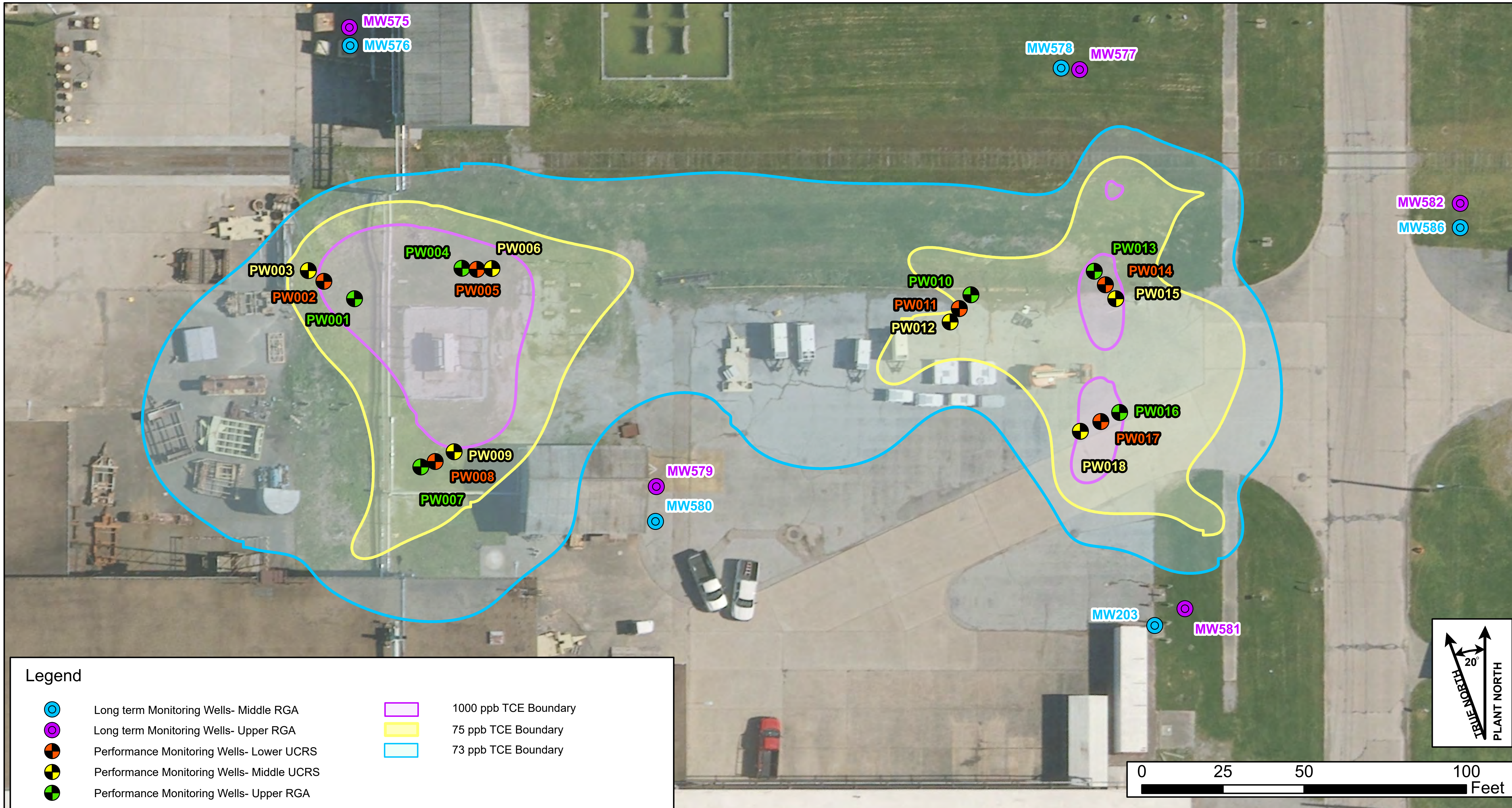
4.1.4 Injection Well and Long-Term Monitoring Well Installation

Concurrent with DPT Jet Fracturing, long-term MWs were installed beginning in late April 2022 and were completed in May 2022. The drilling of the long-term MWs was sequenced as feasible to keep the DPT Jet Injection activities approximately 100 ft apart for safety reasons. A total of nine new MWs were installed. Six MWs, oriented as couplets, were installed downgradient or crossgradient of SWMU 211-A. Each couplet had one well screened in the upper RGA and one screened in the middle RGA. Three additional MWs were also installed upgradient of SWMU 211-A, with two wells being a couplet screened in the upper RGA and middle RGA, and one well screened solely in the upper RGA. MWs were constructed of 4-inch polyvinyl chloride (PVC) Schedule 40 pipe with a 5-ft PVC screen and dedicated bladder pump. Wells were installed in accordance with the RDR and KDOW regulations. The new long-term MWs and existing MW203 were sampled to acquire baseline parameters and will be sampled periodically in accordance with the Operations, Maintenance, and Environmental Monitoring Plan in Appendix A of the RDR. A summary of the newly installed wells is provided in Table 4.1. Locations are shown in Figure 4.10, and as-built drawings are provided in Appendix A.

Table 4.1. Installed Long-Term Monitoring Wells

Well ID	Screened Zone	Well Diameter (in)	Screened Interval (ft bgs)	Total Depth (ft bgs)	Monitoring Position with Respect to SWMU 211-A (gradient)
MW575	RGA (Upper)	4	65–70	71.5	Downgradient
MW576	RGA (Middle)	4	70–75	76.5	Downgradient
MW577	RGA (Upper)	4	65–70	71.5	Downgradient
MW578	RGA (Middle)	4	70–75	76.5	Downgradient
MW579	RGA (Upper)	4	65–70	71.5	Upgradient
MW580	RGA (Middle)	4	70–75	76.5	Upgradient
MW581	RGA (Upper)	4	65–70	71.5	Upgradient
MW582	RGA (Upper)	4	65–70	71.5	Crossgradient
MW586	RGA (Middle)	4	70–75	76.5	Crossgradient

Note:
MWs constructed with a 1.5-ft sump below the screened interval.



Map Source Information
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Figure 4.10. SWMU 211-A Long-Term and Performance Monitoring Well Locations

From May 2022 to August 2022, after the completion of DPT Jet Injection fracturing emplacement at a location, a cluster of 2 to 3 IWs (nested/offset) were generally installed within 5 ft of each DPT Jet Injection location. IWs were constructed of 2-inch PVC Schedule 40 riser with a 5-ft joint of 2-inch Schedule 40 PVC well screen and were offset, stacked, and installed in accordance with the RDR. A summary of the IWs is provided in Table 4.2. Locations of completed IWs are shown in Figure 4.11, and as-built drawings are provided in Appendix A. Photographs of both IW and long-term MW installations are provided in Figures 4.12 and 4.13. Following the completion of all injections, the injection wells were covered with either a stick up protective casing or a flush-mount vault to allow the wells to remain in-place for potential use in the future. The well cluster was also surrounded by large concrete stones for protection in the future.

Table 4.2. Installed Injection Wells

Injection Location	Well ID	Well Diameter (in)	Screened Interval (ft bgs)	Total Depth (ft bgs)
IW-01	IW-01A	2	25–40	41.5
	IW-01B	2	41–51	52.5
	IW-01C	2	53–63	64.5
IW-02	IW-02A	2	23–38	39.5
	IW-02B	2	39–49	50.5
	IW-02C	2	51–61	62.5
IW-03	IW-03A	2	25–40	41.5
	IW-03B	2	41–51	52.5
	IW-03C	2	53–63	64.5
IW-04	IW-04A	2	24–34	35.5
	IW-04B	2	35–50	51.5
	IW-04C	2	51–61	62.5
IW-05	IW-05A	2	18–33	34.5
	IW-05B	2	34–49	50.5
	IW-05C	2	50–65	66.5
IW-06	IW-06A	2	21–36	37.5
	IW-06B	2	37–52	53.5
	IW-06C	2	53–63	64.5
IW-07	IW-07A	2	22–37	38.5
	IW-07B	2	38–53	54.5
	IW-07C	2	54–64	65.5
IW-08	IW-08A	2	23–38	39.5
	IW-08B	2	39–54	55.5
	IW-08C	2	55–65	66.5
IW-09	IW-09A	2	22–37	38.5
	IW-09B	2	38–53	54.5
	IW-09C	2	54–64	65.5
IW-10	IW-10A	2	25–40	41.5
	IW-10B	2	41–51	52.5
	IW-10C	2	53–63	64.5
IW-11	IW-11A	2	27–37	38.5
	IW-11B	2	38–53	54.5
	IW-11C	2	54–64	65.5
IW-12	IW-12A	2	27–42	43.5
	IW-12B	2	43–53	54.5
	IW-12C	2	54–64	65.5
IW-13	IW-13A	2	33–48	49.5
	IW-13B	2	49–64	65.5

Table 4.2 Installed Injection Wells (Continued)

Injection Location	Well ID	Well Diameter (in)	Screened Interval (ft bgs)	Total Depth (ft bgs)
IW-14	IW-14A	2	33–48	49.5
	IW-14B	2	49–64	65.5
IW-15	IW-15A	2	31–46	47.5
	IW-15B	2	47–62	63.5
IW-16	IW-16A	2	39–54	55.5
IW-17	IW-17A	2	34–49	50.5
	IW-17B	2	50–60	61.5
IW-18	IW-18A	2	32–47	48.5
	IW-18B	2	48–63	64.5
IW-19	IW-19A	2	30–45	46.5
	IW-19B	2	46–56	57.5
	IW-19C	2	57–62	63.5
IW-20	IW-20A	2	30–45	46.5
	IW-20B	2	46–61	62.5
IW-21	IW-21A	2	38–48	49.5
IW-21	IW-21B	2	50–60	61.5
IW-22	IW-22A	2	25–35	36.5
	IW-22B	2	36–51	52.5
	IW-22C	2	52–62	63.5
IW-23	IW-23A	2	17–32	33.5
	IW-23B	2	33–48	49.5
	IW-23C	2	49–64	65.5
IW-24	IW-24A	2	26–36	37.5
	IW-24B	2	37–52	53.5
	IW-24C	2	53–63	64.5
IW-25	IW-25A	2	41–51	52.5
	IW-25B	2	52–62	63.5
IW-26	IW-26A	2	32–47	48.5
	IW-26B	2	48–63	64.5
IW-27	IW-27A	2	26–41	42.5
	IW-27B	2	42–52	53.5
	IW-27C	2	54–64	65.5
IW-28	IW-28A	2	22–37	38.5
	IW-28B	2	38–53	54.5
	IW-28C	2	54–64	65.5
IW-29	IW-29A	2	28–38	39.5
	IW-29B	2	39–54	55.5
	IW-29C	2	55–65	66.5
IW-30	IW-30A	2	25–35	36.5
	IW-30B	2	36–51	52.5
	IW-30C	2	52–62	63.5
IW-31	IW-31A	2	32–47	48.5
	IW-31B	2	48–63	64.5
IW-32	IW-32A	2	44–54	55.5
IW-33	IW-33A	2	26–36	37.5
	IW-33B	2	37–52	53.5
	IW-33C	2	53–63	64.5

Note:
MWs constructed with a 1.5-ft sump below the screened interval.

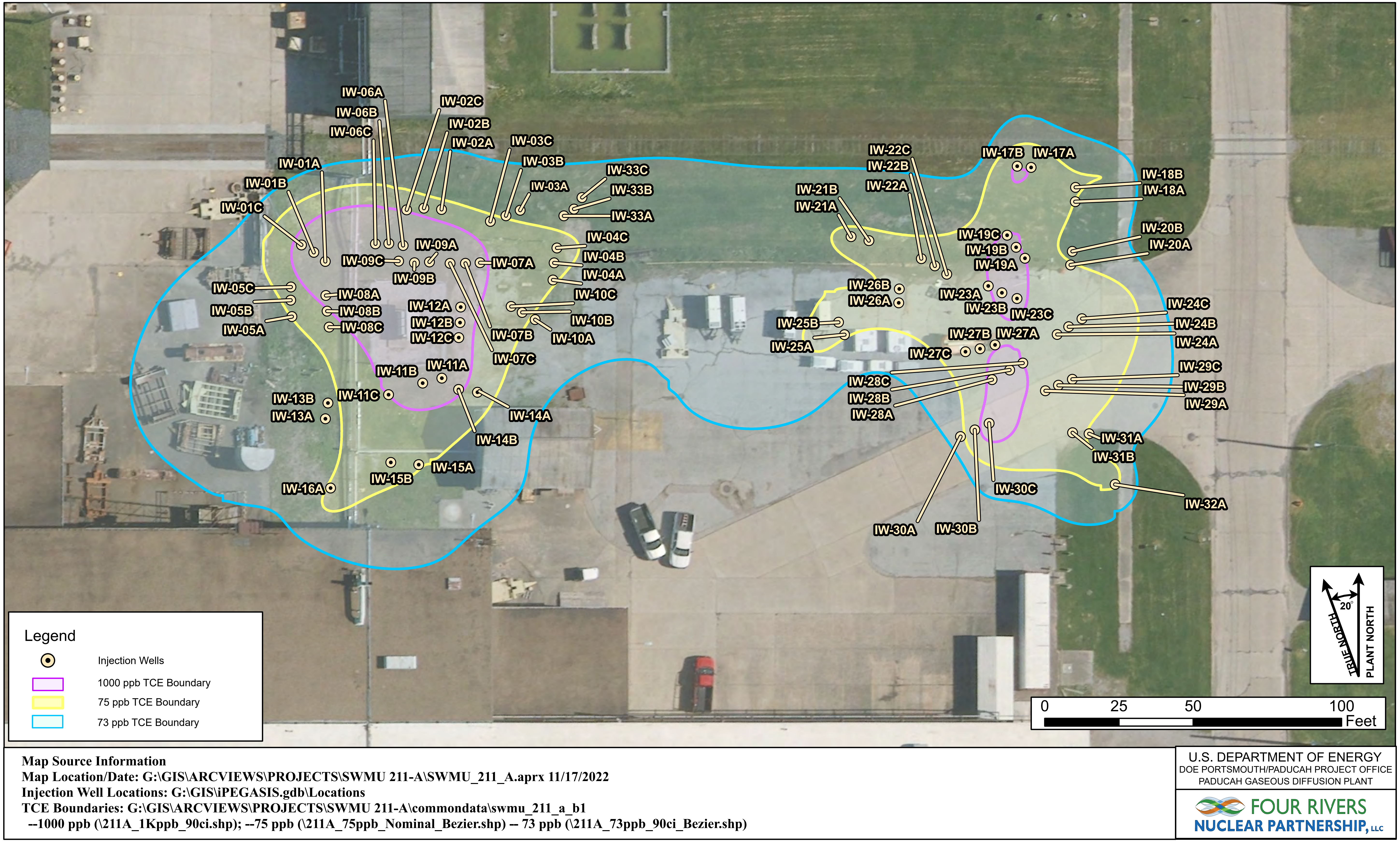

Figure 4.11. SWMU 211-A Injection Well Locations

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Figure 4.12. Long-Term Monitoring Well Installation

Figure 4.13. Injection Well Installation

4.1.5 EISB Bioamendment and Bioaugmentation Injection

EISB bioamendment and bioaugmentation injection was conducted from July 23, 2022, to September 21, 2022. EISB injections consisted of the following four stages: the first stage was the injection of EVO mixed with anoxic water; the second stage was the injection of a bacterial consortium containing DHC bacteria after approximately 50% of the EVO solution was injected; the third stage was a second injection of EVO mixed with water; and the final stage was a 100-gal flush of anoxic water.

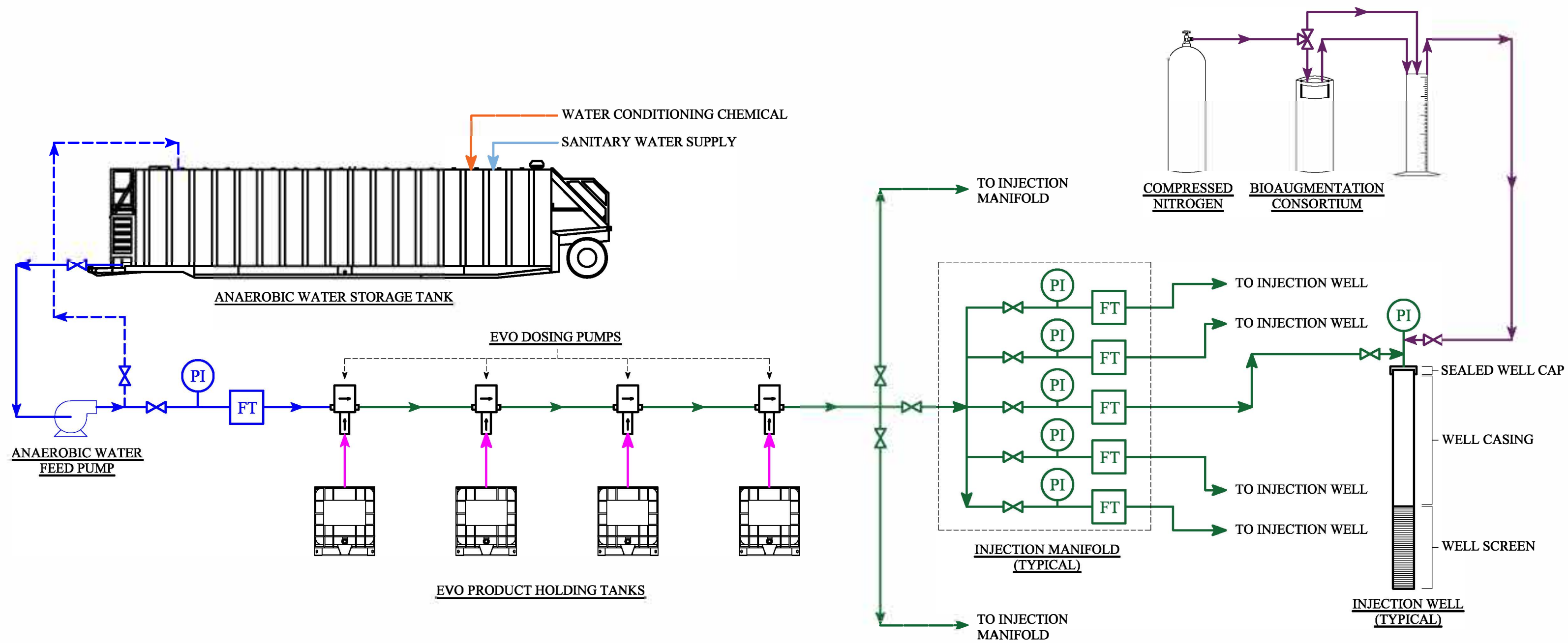
Prior to injection, anoxic water was prepared in a 21,000-gal stock frac tank, using potable water treated with RNAS Newman Zone OS™ (RNAS Remediation Products) OS (oxygen scavenger) to remove oxygen to prepare negative oxidation-reduction potential anoxic water. EVO (i.e., EOS PRO 60) was mixed with the anoxic water to create an approximate 13.4% EVO solution.

The EVO solution was then injected into each IW utilizing a temporary aboveground piping network. Injections began by plumbing the EVO injection system to the wellheads through an injection manifold system. Each of the IW headers was fitted with a pressure gauge and a flow meter to document the required EVO solution that was added to each of the IWs. The EVO solution was injected via either gravity feed or by using a transfer pump. During the early stages of bioamendment injection activity, discrepancies between the overall EVO solution volume and the totalizer readings at individual injection wellheads were noted due to mechanical issues. The individual well totalizers were recording less volume than what was prepared and actually injected. Arcadis field staff proportionally allocated the EVO solution volumes (gal) based on the difference between the overall daily EVO solution used and the sum of the individual injection wellhead totalizer volumes.

After approximately one-half of the design volume of EVO solution was injected into a given IW, bioaugmentation was performed using the DHC bacterial consortium (i.e., SDC-9). Prior to bioaugmentation, the geochemistry of the anoxic water and/or the EVO solution was assessed using a digital sampling system, multiparameter, handheld digital water quality meter (i.e., YSI ProDSS) to confirm that it was compatible with the DHC bacteria, in accordance with specifications listed in the RDR. The bioaugmentation injection vessel was connected to the aboveground injection piping, and the system was purged with nitrogen gas to displace oxygen from the well column and maintain inert gas in the well above the water table. The DHC bioaugmentation consortium was premeasured in a graduated cylinder, then transferred and metered directly into each IW using compressed gas.

After bioaugmentation was completed, the remaining volume of EVO solution was injected into each IW to distribute the DHC bacterial consortium into the formation. A flush of 100 gal of anoxic water was then performed to clear the EVO solution out of the well screen and the sand pack to reduce the potential for biofouling of the well screen.

A flow diagram of the EISB process is provided in Figure 4.14, with a conceptual EISB amendment delivery cross-section in Figure 4.4. Summaries of the estimated EVO solution volumes and DHC bacterial consortium amounts are summarized in Section 4.2.3. Photographs of bioamendment and bioaugmentation injection field setup are provided in Figures 4.15 through 4.18.



LEGEND

- PUMP
- PI - PRESSURE INDICATOR
- FT - FLOW TOTALIZER
- ISOLATION VALVE
- 3-WAY VALVE
- GRADUATED CYLINDER

ACRONYMS & PIPING

EISB - ENHANCED *IN SITU* BIOREMEDIATION

EVO - EMULSIFIED VEGETABLE OIL

- ANAEROBIC WATER (PRIMARY)
- ANAEROBIC WATER (SECONDARY)
- WATER CONDITIONING CHEMICAL
- SANITARY WATER
- EVO PRODUCT
- EISB AMENDMENT
- BIOAUGMENTATION

NOTES:

1. PRODUCT INFORMATION ON CHEMICALS UTILIZED FOR SWMU 211-A EISB PROJECT:
   - EMULSIFIED VEGETABLE OIL - EOS PRO 60
   - WATER CONDITIONING CHEMICAL - RNAS NEWMAN ZONE® OS AND KB-1® PRIMER
   - BIOAUGMENTATION CONSORTIUM - RNAS SDC-9™

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Figure 4.14. SWMU 211-A EISB Bioamendment and Bioaugmentation Injection System Process Flow Diagram

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Figure 4.15. Anoxic Water Frac Tank and EVO 60 Storage Tanks with Dose Pumps

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Figure 4.16. View of Injection Well Field Setup

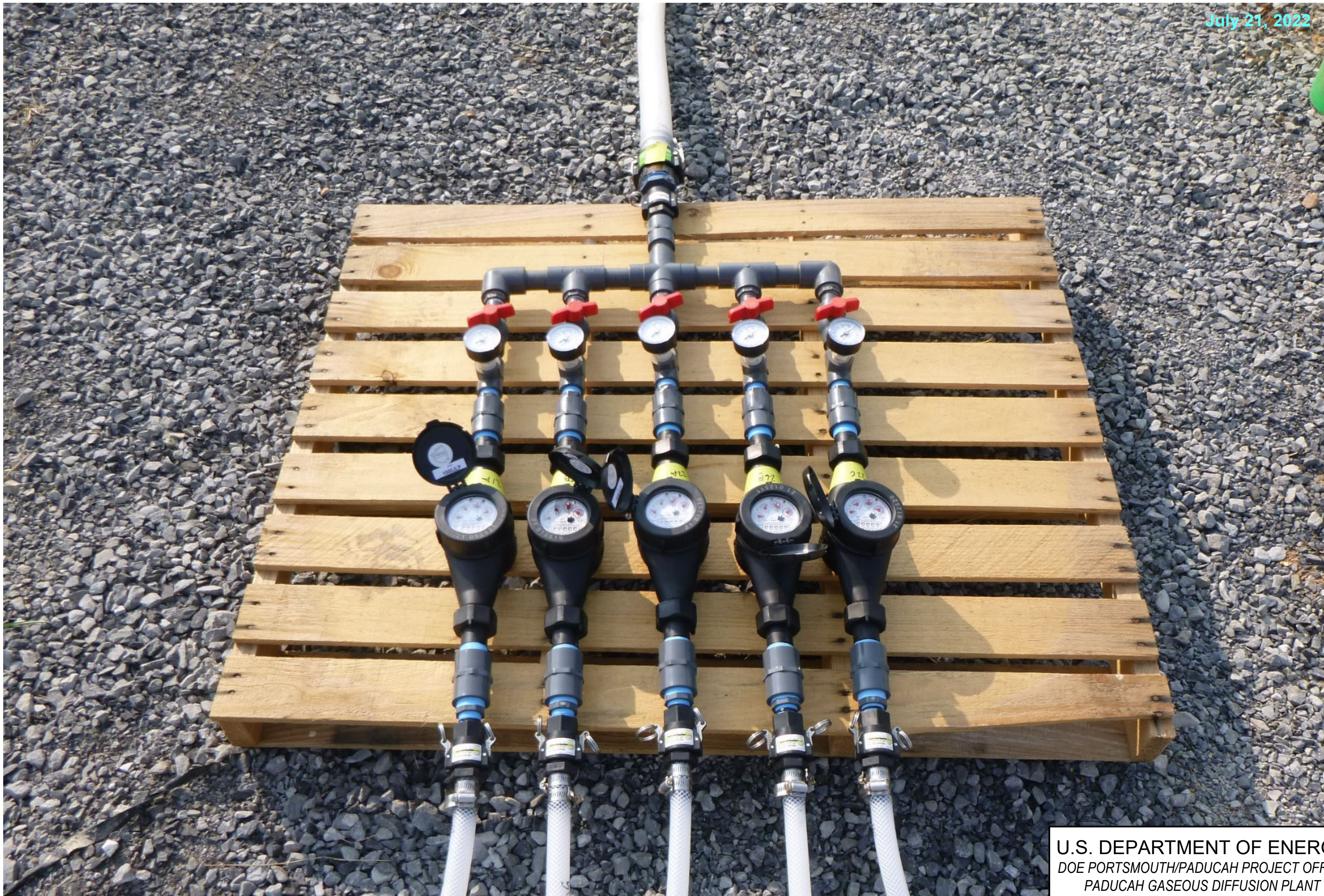

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Figure 4.17. Injection Well Totalizers

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Figure 4.18. Typical Injection Well Header

PW installations were conducted after the completion of the EISB injections between September 9, 2022, and September 30, 2022. Eighteen performance wells were installed [arranged as six (nested) triplets of wells] within the treatment area. PWs were installed to track the continued effectiveness of the EISB RA in the UCRS and upper RGA. Each well was constructed of 4-inch diameter PVC with 5-ft PVC screens and installed with a dedicated bladder pump. PWs were installed in accordance with the RDR and the RAWP. Locations of PWs are shown in Figure 4.10, and are summarized in Table 4.3. A photograph of PW sample pump installation is shown in Figure 4.19.

Table 4.3. Installed Performance Monitoring Wells

Well ID	Screen Location	Well Diameter (inches)	Screened Interval (ft bgs)	Total Depth (ft bgs)
PW001	RGA (Upper)	4	65–70	71.5
PW002	UCRS (Lower)	4	55–60	61.5
PW003	UCRS (Middle)	4	45–50	51.5
PW004	RGA (Upper)	4	65–70	71.5
PW005	UCRS (Lower)	4	55–60	61.5
PW006	UCRS (Middle)	4	45–50	51.5
PW007	RGA (Upper)	4	65–70	71.5
PW008	UCRS (Lower)	4	55–60	61.5
PW009	UCRS (Middle)	4	45–50	51.5
PW010	RGA (Upper)	4	65–70	71.5
PW011	UCRS (Lower)	4	55–60	61.5
PW012	UCRS (Middle)	4	45–50	51.5
PW013	RGA (Upper)	4	65–70	71.5
PW014	UCRS (Lower)	4	55–60	61.5
PW015	UCRS (Middle)	4	45–50	51.5
PW016	RGA (Upper)	4	65–70	71.5
PW017	UCRS (Lower)	4	55–60	61.5
PW018	UCRS (Middle)	4	45–50	51.5

Note:
MWs constructed with a 1.5-ft sump below the screened interval.

4.2 TABULAR SUMMARIES

4.2.1 Baseline Groundwater Sampling

Baseline groundwater samples were collected from the treatment area prior to EISB activities to assess groundwater characteristics in the UCRS and upper RGA. Samples were collected from future PW locations (PW001 through PW018) using temporary sample points. In addition, samples were collected from newly installed and existing long-term MWs (MW203, MW575, MW576, MW577, MW578, MW579, MW580, MW581, MW582, and MW586). A description of groundwater sampling activities is provided in Section 3.3.1, with field changes summarized in Section 1.2.3.

Samples were analyzed, in accordance with the RAWP, for five VOCs: TCE, *cis*-1,2-dichloroethene, *trans*-1,2-dichloroethene, 1,1-dichloroethene, and vinyl chloride. Samples from future PW locations were also analyzed for TOCs and a subset of PW samples were analyzed for the presence of DHC bacteria.

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Figure 4.19. Performance Monitoring Well Sampling Pump Installation

Samples collected from future PW locations, using a discrete groundwater sampler, were assessed as informational use only due to the method of collection. A summary of samples from long-term MWs is provided in Table 4.4 and a complete analytical report of all groundwater samples collected is located in Appendix D.

4.2.2 DPT Jet Injection Hydraulic Fracturing

The RDR included a total of 33 locations for hydraulic fracturing, with a total of 325 stacked fractures. Each injection location consisted of a number of DPT Jet Injection fracture zones, based on the screening interval of the corresponding IW that was installed following fracturing activities. Table 4.5 summarizes the total amounts of amendments used for hydraulic fracturing at each location.

4.2.3 EISB Bioamendment and Bioaugmentation Injections

A total of 85 IWs screened at different depths were treated during EISB injections. During bioaugmentation injection, nine injection zones in the upper and middle UCRS were unable to be treated due to daylighting. The allotted volume of DHC bacteria for these shallow zones was injected in either the zone above or the zone below. Even though these shallow zones were unable to be directly injected with treatment, groundwater flows downward through the UCRS. As such, the dissolved VOCs from these untreated shallow zones will migrate through underlying EISB treatment zones and will be remediated.

Summaries of the total estimated volume of bioamendments and volume of bioaugmentation are provided in Tables 4.6 and 4.7. Changes to design amounts are discussed in Section 1.2.3.

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Table 4.4. Baseline VOC Groundwater Data in Long-Term Monitoring Wells

Location ID		MW203	MW575	MW575	MW576	MW577	MW578	MW579	MW580	MW581	MW582	MW586
Sample ID		**211AMW2030122**	**211AMW5750122**	**211AMW5750122D**	**211AMW5760122**	**211AMW5770122**	**211AMW5780122**	**211AMW5790122**	**211AMW5800122**	**211AMW5810122**	**211AMW5820122**	**211AMW5860122**
Parameter	**Units**	**7/6/2022**	**7/6/2022**	**7/6/2022**	**7/6/2022**	**7/6/2022**	**7/6/2022**	**7/6/2022**	**7/6/2022**	**7/6/2022**	**7/6/2022**	**7/6/2022**
1,1-dichloroethene	µg/L	3.34	1,530	1,500	3,530	15.8	34.3	5.89	5.5	0.39 J	22.6	75.4
cis-1,2-dichloroethene	µg/L	9.76	39.1	40.1	83.3	1.41	14	3.88	4.58	3.95	14.6	39.5
trans-1,2-dichloroethene	µg/L	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U	0.43 J
TCE	µg/L	38.9 Y1	1,060 Y1	1,100 Y1	3,760 Y1	138 Y1	80.8 Y1	22.3 Y1	14.7 Y1	14.9 Y1	76 Y1	900 Y1
Vinyl chloride	µg/L	1 U	2.55	2.66	7.04	1 U	1 U	1 U	1 U	1 U	1 U	1 U

µg/L = micrograms per liter
U = Analyte analyzed for, but not detected at or below, the lowest concentration reported.
J = Indicates an estimated value.
Y1 = Matrix spike/matrix spike duplicate recovery outside acceptance criteria.

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Table 4.5. DPT Jet Injection Summary

DPT Jet Injection Location	Injection Depth (ft bgs)	Date	Guar Gel (gal)	mZVI (lb)	Sand (lb)
IW-01	26	6/28/2022	120	1,102	550
IW-01	30	7/6/2022	150	1,102	550
IW-01	34	7/6/2022	250	1,102	550
IW-01	38	7/7/2022	150	1,102	550
IW-01	42	7/7/2022	175	1,102	550
IW-01	46	7/11/2022	145	1,102	550
IW-01	50	7/11/2022	150	1,102	550
IW-01	54	7/12/2022	160	1,102	550
IW-01	58	7/12/2022	170	1,102	550
IW-01	62	7/13/2022	160	1,102	550
IW-01 Totals			**1,630**	**11,020**	**5,500**
IW-02	24	6/21/2022	150	1,102	550
IW-02	28	6/22/2022	150	1,102	550
IW-02	32	6/22/2022	120	1,102	550
IW-02	36	6/23/2022	175	1,102	550
IW-02	40	6/27/2022	140	1,102	550
IW-02	44	6/27/2022	150	1,102	550
IW-02	48	6/27/2022	140	1,102	550
IW-02	52	6/27/2022	150	1,102	550
IW-02	56	6/27/2022	175	1,102	550
IW-02	60	6/28/2022	150	1,102	550
IW-02 Totals			**1,500**	**11,020**	**5,500**
IW-03	26	6/1/2022	170	1,102	550
IW-03	30	6/2/2022	140	1,102	550
IW-03	35	6/7/2022	120	1,102	550
IW-03	38	6/7/2022	120	1,102	550
IW-03	42	6/8/2022	120	1,102	550
IW-03	46	6/8/2022	120	1,102	550
IW-03	50	6/9/2022	140	1,102	550
IW-03	54	6/13/2022	175	1,102	550
IW-03	59	6/16/2022	120	1,102	550
IW-03	62	6/21/2022	200	1,102	550
IW-03	39	6/30/2022	175	1,102	550
IW-03 Totals			**1,600**	**12,122**	**6,050**
IW-04	28	6/1/2022	100	850	250
IW-04	32	6/6/2022	200	1,350	850
IW-04	36	6/15/2022	145	1,102	550
IW-04	40	6/15/2022	140	1,102	550
IW-04	44	6/16/2022	150	1,102	550
IW-04	48	6/21/2022	200	1,102	550
IW-04	52	6/22/2022	175	1,102	550
IW-04	56	6/22/2022	150	1,102	550
IW-04	60	6/23/2022	175	1,102	550
IW-04 Totals			**1,435**	**9,914**	**4,950**

Table 4.5. DPT Jet Injection Summary (Continued)

DPT Jet Injection Location	Injection Depth (ft bgs)	Date	Guar Gel (gal)	mZVI (lb)	Sand (lb)
IW-05	21	6/29/2022	280	1,650	825
IW-05	24	6/30/2022	180	1,650	825
IW-05	27	6/30/2022	220	1,650	825
IW-05	30	6/30/2022	200	1,650	825
IW-05	33	7/6/2022	250	1,650	825
IW-05	36	7/6/2022	280	1,650	825
IW-05	39	7/7/2022	240	1,650	825
IW-05	42	7/7/2022	200	1,650	825
IW-05	45	7/11/2022	250	1,650	825
IW-05	48	7/11/2022	220	1,650	825
IW-05	51	7/12/2022	250	1,650	825
IW-05	54	7/12/2022	200	1,650	825
IW-05	58	7/13/2022	280	1,650	825
IW-05	60	7/13/2022	250	2,202	875
IW-05	63	7/13/2022	300	2,202	875
IW-05 Totals			**3,600**	**25,854**	**12,475**
IW-06	23	6/22/2022	180	1,650	825
IW-06	26	6/23/2022	200	1,650	825
IW-06	29	6/27/2022	200	1,650	825
IW-06	32	6/27/2022	220	1,650	825
IW-06	35	6/27/2022	225	1,650	825
IW-06	38	6/28/2022	275	1,650	825
IW-06	41	6/28/2022	150	1,650	825
IW-06	44	6/28/2022	220	1,650	825
IW-06	47	6/28/2022	175	1,650	825
IW-06	50	6/29/2022	250	1,650	825
IW-06	53	6/29/2022	175	1,650	825
IW-06	56	6/29/2022	200	1,650	825
IW-06	59	6/29/2022	300	1,650	825
IW-06	62	6/30/2022	370	1,650	825
IW-06 Totals			**3,140**	**23,100**	**11,550**
IW-07	24	6/8/2022	250	1,650	825
IW-07	27	6/9/2022	180	1,650	825
IW-07	31	6/14/2022	175	1,650	825
IW-07	33	6/15/2022	180	1,650	825
IW-07	36	6/15/2022	200	1,650	825
IW-07	39	6/16/2022	190	1,650	825
IW-07	42	6/21/2022	250	1,650	825
IW-07	45	6/21/2022	275	1,650	825
IW-07	48	6/22/2022	220	1,650	825
IW-07	51	6/22/2022	200	1,650	825
IW-07	54	6/23/2022	280	1,650	825
IW-07	57	6/23/2022	250	1,650	825
IW-07	60	6/27/2022	200	1,650	825
IW-07	63	6/27/2022	200	1,650	825
IW-07 Totals			**3,050**	**23,100**	**11,550**

Table 4.5. DPT Jet Injection Summary (Continued)

DPT Jet Injection Location	Injection Depth (ft bgs)	Date	Guar Gel (gal)	mZVI (lb)	Sand (lb)
IW-08	25	6/29/2022	220	1,650	825
IW-08	28	6/30/2022	200	1,650	825
IW-08	31	6/30/2022	225	1,650	825
IW-08	34	7/6/2022	300	1,650	825
IW-08	37	7/6/2022	220	1,650	825
IW-08	40	7/7/2022	220	1,650	825
IW-08	43	7/11/2022	400	1,650	825
IW-08	46	7/11/2022	200	1,650	825
IW-08	49	7/12/2022	220	1,650	825
IW-08	52	7/12/2022	200	1,650	825
IW-08	55	7/12/2022	260	1,650	825
IW-08	58	7/12/2022	240	1,650	825
IW-08	61	7/13/2022	300	1,650	825
IW-08	64	7/13/2022	280	1,650	825
IW-08 Totals			**3,485**	**23,100**	**11,550**
IW-09	24	6/21/2022	220	1,650	825
IW-09	27	6/21/2022	250	1,650	825
IW-09	30	6/22/2022	200	1,650	825
IW-09	33	6/27/2022	220	1,650	825
IW-09	36	6/27/2022	210	1,650	825
IW-09	39	6/27/2022	180	1,650	825
IW-09	42	6/27/2022	200	1,650	825
IW-09	45	6/28/2022	200	1,650	825
IW-09	48	6/28/2022	200	1,650	825
IW-09	51	6/28/2022	200	1,650	825
IW-09	54	6/28/2022	280	1,650	825
IW-09	57	6/29/2022	200	1,650	825
IW-09	60	6/29/2022	175	1,650	825
IW-09	63	6/30/2022	220	1,650	825
IW-09 Totals			**2,955**	**23,100**	**11,550**
IW-10	26	6/1/2022	125	1,102	550
IW-10	30	6/1/2022	150	1,102	550
IW-10	35	6/2/2022	180	1,102	550
IW-10	38	6/6/2022	150	1,102	550
IW-10	42	6/7/2022	130	1,102	550
IW-10	46	6/7/2022	120	1,102	550
IW-10	50	6/8/2022	125	1,102	550
IW-10	55	6/9/2022	275	1,102	550
IW-10	58	6/13/2022	200	1,102	550
IW-10	62	6/14/2022	130	1,102	550
IW-10 Totals			**1,585**	**11,020**	**5,500**
IW-11	30	6/2/2022	200	1,650	825
IW-11	33	6/2/2022	200	1,650	825
IW-11	36	6/7/2022	150	1,650	825
IW-11	39	6/7/2022	200	1,650	825
IW-11	42	6/7/2022	200	1,650	825
IW-11	45	6/8/2022	175	1,650	825
IW-11	48	6/9/2022	165	1,650	825

Table 4.5. DPT Jet Injection Summary (Continued)

DPT Jet Injection Location	Injection Depth (ft bgs)	Date	Guar Gel (gal)	mZVI (lb)	Sand (lb)
IW-11	51	6/9/2022	220	1,650	825
IW-11	54	6/13/2022	150	1,650	825
IW-11	57	6/13/2022	210	1,650	825
IW-11	60	6/13/2022	240	1,650	825
IW-11	63	6/15/2022	225	1,650	825
IW-11 Totals			**2,335**	**19,800**	**9,900**
IW-12	29	6/2/2022	180	1,650	825
IW-12	32	6/2/2022	120	1,650	825
IW-12	35	6/6/2022	200	1,650	825
IW-12	38	6/7/2022	170	1,650	825
IW-12	41	6/7/2022	200	1,650	825
IW-12	44	6/7/2022	150	1,650	825
IW-12	47	6/8/2022	180	1,650	825
IW-12	50	6/9/2022	180	1,650	825
IW-12	53	6/9/2022	200	1,650	825
IW-12	57	6/14/2022	210	1,650	825
IW-12	59	6/14/2022	200	1,650	825
IW-12	62	6/15/2022	190	1,650	825
IW-12 Totals			**2,180**	**19,800**	**9,900**
IW-13	35	6/29/2022	175	1,102	550
IW-13	43	6/30/2022	125	1,102	550
IW-13	47	7/6/2022	220	1,650	825
IW-13	51	7/6/2022	170	1,102	550
IW-13	55	7/7/2022	175	1,102	550
IW-13	59	7/11/2022	200	1,102	550
IW-13	63	7/12/2022	150	1,102	550
IW-13 Totals			**1,215**	**8,262**	**4,125**
IW-14	35	6/2/2022	180	1,102	550
IW-14	39	6/2/2022	120	1,102	550
IW-14	43	6/6/2022	150	1,102	550
IW-14	47	6/7/2022	120	1,102	550
IW-14	51	6/7/2022	120	1,102	550
IW-14	55	6/8/2022	150	1,102	550
IW-14	59	6/9/2022	125	1,102	550
IW-14	63	6/13/2022	150	1,102	550
IW-14 Totals			**1,115**	**8,816**	**4,400**
IW-15	34	6/14/2022	145	1,102	550
IW-15	37	6/15/2022	140	1,102	550
IW-15	41	6/16/2022	125	1,102	550
IW-15	45	6/22/2022	150	1,102	550
IW-15	49	6/22/2022	150	1,102	550
IW-15	53	6/23/2022	150	1,102	550
IW-15	57	6/23/2022	175	1,102	550
IW-15	61	6/23/2022	175	1,102	550
IW-15 Totals			**1,210**	**8,816**	**4,400**

Table 4.5. DPT Jet Injection Summary (Continued)

DPT Jet Injection Location	Injection Depth (ft bgs)	Date	Guar Gel (gal)	mZVI (lb)	Sand (lb)
IW-16	40	6/29/2022	150	1,102	550
IW-16	44	7/7/2022	180	1,102	550
IW-16	48	7/11/2022	150	1,102	550
IW-16	52	7/11/2022	170	1,102	550
IW-16 Totals			**650**	**4,408**	**2,200**
IW-17	35	4/13/2022	350	1,650	725
IW-17	38	4/19/2022	400	1,650	825
IW-17	41	4/20/2022	290	1,450	225
IW-17	44	4/25/2022	280	1,650	825
IW-17	47	4/25/2022	280	1,650	825
IW-17	50	4/26/2022	280	1,650	825
IW-17	53	4/26/2022	200	1,650	825
IW-17	56	4/27/2022	190	1,650	825
IW-17	59	4/28/2022	300	1,650	825
IW-17 Totals			**2,570**	**14,650**	**6,725**
IW-18	34	4/12/2022	475	1,102	550
IW-18	38	4/13/2022	300	1,102	400
IW-18	42	4/19/2022	320	1,102	550
IW-18	46	4/19/2022	210	1,102	750
IW-18	50	4/20/2022	210	1,150	550
IW-18	54	4/21/2022	190	1,102	450
IW-18	58	4/21/2022	190	1,102	400
IW-18	62	4/25/2022	200	1,102	525
IW-18 Totals			**2,095**	**8,864**	**4,175**
IW-19	31	4/25/2022	200	1,102	525
IW-19	34	4/26/2022	50	600	150
IW-19	37	5/2/2022	220	1,650	825
IW-19	40	5/3/2022	280	1,650	825
IW-19	43	5/4/2022	290	1,650	825
IW-19	46	5/4/2022	250	1,650	825
IW-19	49	5/9/2022	300	1,650	825
IW-19	52	5/10/2022	260	2,250	1,025
IW-19	55	5/11/2022	280	2,250	1,025
IW-19	58	5/19/2022	300	2,675	1,400
IW-19	61	5/23/2022	450	2,675	1,400
IW-19 Totals			**2,880**	**19,802**	**9,650**
IW-20	32	4/13/2022	390	1,102	550
IW-20	36	4/13/2022	200	1,102	500
IW-20	40	4/19/2022	320	1,102	600
IW-20	44	4/20/2022	210	1,202	600
IW-20	48	4/20/2022	220	1,102	550
IW-20	52	4/21/2022	180	1,102	550
IW-20	56	4/21/2022	190	1,102	550
IW-20	60	4/21/2022	190	1,102	550
IW-20 Totals			**1,900**	**8,916**	**4,450**
IW-21	39	4/27/2022	150	1,102	550
IW-21	43	4/28/2022	200	1,102	550
IW-21	47	5/2/2022	120	1,002	250
IW-21 Totals			**470**	**3,206**	**1,350**

Table 4.5. DPT Jet Injection Summary (Continued)

DPT Jet Injection Location	Injection Depth (ft bgs)	Date	Guar Gel (gal)	mZVI (lb)	Sand (lb)
IW-21B	57	5/5/2022	30	200	100
IW-21B Totals			**30**	**200**	**100**
IW-22	29	5/2/2022	220	1,102	550
IW-22	33	5/3/2022	400	1,102	550
IW-22	37	5/4/2022	280	1,102	650
IW-22	41	5/9/2022	200	1,102	550
IW-22	45	5/10/2022	150	1,102	550
IW-22	49	5/10/2022	175	1,102	550
IW-22	53	5/11/2022	290	1,102	550
IW-22	57	5/19/2022	220	1,102	550
IW-22	61	5/19/2022	150	1,102	550
IW-22 Totals			**2,085**	**9,918**	**5,050**
IW-23	20	4/25/2022	40	400	100
IW-23	23	4/26/2022	200	1,650	825
IW-23	26	4/26/2022	100	800	400
IW-23	29	5/2/2022	250	1,650	825
IW-23	32	5/3/2022	300	1,650	875
IW-23	35	5/4/2022	250	1,750	825
IW-23	38	5/5/2022	390	1,850	1,050
IW-23	41	5/9/2022	290	1,850	825
IW-23	44	5/10/2022	240	1,650	825
IW-23	47	5/16/2022	280	1,850	1,025
IW-23	50	5/19/2022	220	1,600	960
IW-23	53	5/19/2022	200	1,600	960
IW-23	56	5/23/2022	300	1,600	960
IW-23	59	5/23/2022	140	1,600	960
IW-23	62	5/24/2022	250	1,600	960
IW-23 Totals			**3,450**	**23,100**	**12,375**
IW-24	30	4/19/2022	340	1,102	550
IW-24	34	4/19/2022	160	1,102	600
IW-24	38	4/20/2022	300	1,102	550
IW-24	42	4/20/2022	210	1,102	550
IW-24	46	4/21/2022	210	1,102	550
IW-24	50	4/21/2022	190	1,102	550
IW-24	54	4/21/2022	200	1,102	650
IW-24	58	4/21/2022	170	1,102	550
IW-24	62	4/25/2022	200	1,102	525
IW-24 Totals			**1,980**	**9,918**	**5,075**
IW-25	45	5/23/2022	150	1,102	550
IW-25	49	5/23/2022	160	1,102	550
IW-25	53	5/23/2022	150	1,102	550
IW-25	53	5/24/2022	100	567	325
IW-25	57	5/24/2022	190	967	675
IW-25	61	5/25/2022	50	400	200
IW-25 Totals			**800**	**5,240**	**2,850**
IW-26	35	5/23/2022	150	1,102	550
IW-26	39	5/23/2022	150	1,102	550
IW-26	42	5/24/2022	150	1,102	550

Table 4.5. DPT Jet Injection Summary (Continued)

DPT Jet Injection Location	Injection Depth (ft bgs)	Date	Guar Gel (gal)	mZVI (lb)	Sand (lb)
IW-26	46	5/24/2022	120	1,102	550
IW-26	50	5/24/2022	200	1,667	875
IW-26	54	5/25/2022	220	2,238	1,137
IW-26	58	5/25/2022	170	2,038	737
IW-26	58	5/25/2022	100	200	400
IW-26	62	5/26/2022	400	1,939	900
IW-26 Totals			**1,660**	**12,490**	**6,249**
IW-27	27	4/27/2022	140	1,102	550
IW-27	31	4/28/2022	135	1,102	550
IW-27	38	5/2/2022	180	1,102	550
IW-27	40	5/3/2022	250	1,102	550
IW-27	43	5/3/2022	225	1,102	550
IW-27	47	5/4/2022	250	1,102	550
IW-27	52	5/5/2022	200	1,102	550
IW-27	55	5/9/2022	200	1,102	550
IW-27	59	5/9/2022	140	1,102	550
IW-27	63	5/10/2022	190	1,102	550
IW-27 Totals			**1,910**	**11,020**	**5,500**
IW-28	24	4/27/2022	375	1,650	825
IW-28	27	4/28/2022	200	1,650	825
IW-28	30	5/2/2022	120	1,550	400
IW-28	33	5/3/2022	380	1,650	825
IW-28	36	5/3/2022	290	1,650	825
IW-28	39	5/9/2022	290	1,650	825
IW-28	42	5/9/2022	250	1,650	825
IW-28	45	5/10/2022	220	1,650	825
IW-28	48	5/10/2022	275	1,650	825
IW-28	51	5/12/2022	275	1,650	825
IW-28	55	5/16/2022	270	1,650	825
IW-28	57	5/18/2022	180	1,650	825
IW-28	60	5/18/2022	160	1,650	825
IW-28	63	5/19/2022	325	1,650	825
IW-28 Totals			**3,610**	**23,000**	**11,125**
IW-29	32	5/11/2022	170	1,102	550
IW-29	36	5/12/2022	160	1,102	550
IW-29	40	5/16/2022	190	1,102	550
IW-29	44	5/16/2022	200	1,102	550
IW-29	48	5/17/2022	150	1,102	550
IW-29	52	5/17/2022	150	1,102	550
IW-29	56	5/17/2022	120	1,102	550
IW-29	60	5/18/2022	130	1,102	550
IW-29	64	5/18/2022	250	1,102	550
IW-29 Totals			**1,520**	**9,918**	**4,950**
IW-30	28	5/11/2022	190	1,650	825
IW-30	31	5/12/2022	220	1,650	825
IW-30	35	5/16/2022	270	1,650	825
IW-30	37	5/16/2022	250	1,650	825
IW-30	40	5/17/2022	250	1,650	825

Table 4.5. DPT Jet Injection Summary (Continued)

DPT Jet Injection Location	Injection Depth (ft bgs)	Date	Guar Gel (gal)	mZVI (lb)	Sand (lb)
IW-30	43	5/17/2022	240	1,650	825
IW-30	46	5/17/2022	270	1,650	825
IW-30	49	5/17/2022	200	1,650	825
IW-30	52	5/17/2022	250	1,650	825
IW-30	55	5/17/2022	250	1,650	825
IW-30	59	5/18/2022	180	1,650	825
IW-30	61	5/19/2022	280	1,650	825
IW-30 Totals			**2,850**	**19,800**	**9,900**
IW-31	36	5/5/2022	150	1,102	550
IW-31	38	5/9/2022	280	1,102	550
IW-31	42	5/9/2022	275	1,102	550
IW-31	46	5/10/2022	200	1,102	550
IW-31	50	5/10/2022	180	1,102	550
IW-31	55	5/11/2022	250	1,102	550
IW-31	58	5/11/2022	190	1,102	550
IW-31	62	5/12/2022	180	1,102	550
IW-31 Totals			**1,705**	**8,816**	**4,400**
IW-32	45	5/4/2022	280	1,102	550
IW-32	49	5/4/2022	260	1,102	550
IW-32	53	5/5/2022	200	1,102	550
IW-32 Totals			**740**	**3,306**	**1,650**
IW-33	30	6/1/2022	170	1,102	550
IW-33	34	6/1/2022	120	1,102	150
IW-33	38	6/6/2022	200	1,102	1,000
IW-33	42	6/14/2022	130	1,102	550
IW-33	46	6/15/2022	120	1,102	550
IW-33	50	6/16/2022	115	1,102	550
IW-33	54	6/21/2022	120	1,102	550
IW-33	58	6/21/2022	175	1,102	550
IW-33	62	6/22/2022	150	1,102	550
IW-33 Totals			**1,300**	**9,918**	**5,000**
Totals			**66,240**	**445,334**	**221,674**

Table 4.6. Bioamendment Injection Summary

Injection Location	Well ID	Target EVO Solution Injection Volume (gal)	Total Estimated EVO Solution Injection Volume (gal)	Notes
IW-01	IW-01A	1,600	411	Slow flow rates and daylighting; remaining estimated volume (1,189 gal EVO solution) added to IW-01B.
	IW-01B	1,200	2,389	
	IW-01C	1,200	1,266	
IW-02	IW-02A	1,600	46	Slow flow rates and daylighting; remaining estimated volume (1,554 gal EVO solution) added to IW-02B and IW-02C.
	IW-02B	1,200	1,297	
	IW-02C	1,200	2,673	
IW-03	IW-03A	1,600	695	Daylighting; remaining estimated volume (905 gal EVO solution) reallocated to IW-03B and IW-03C.
	IW-03B	1,200	1,287	
	IW-03C	1,200	2,845	
IW-04	IW-04A	800	96	Daylighting; remaining estimated volume (704 gal EVO Solution) reallocated to IW-04B and IW-04C.
	IW-04B	1,600	1,924	
	IW-04C	1,200	1,743	
IW-05	IW-05A	2,000	225	Slow flow rates and daylighting; remaining estimated volume was allocated to IW-05C (844 gal EVO solution) and IW-08C (931 gal EVO solution).
	IW-05B	2,000	1,887	Daylighting; additional estimated volume (120 gal EVO solution) allocated to IW-05C.
	IW-05C	2,000	2,992	Daylighting occurred during reallocation from IW-05A to IW-05C.
IW-06	IW-06A	2,000	55	Daylighting; remaining estimated volume (1,945 gal EVO solution) reallocated to IW-06B.
	IW-06B	2,000	1,047	Daylighting; remaining estimated volume (953 gal EVO solution) from IW-06B reallocated to IW-06C.
	IW-06C	1,600	4,743	
IW-07	IW-07A	2,000	76	Daylighting; remaining estimated volume (1,924 gal EVO solution) from IW-07A reallocated to IW-07B and IW-07C.
	IW-07B	2,000	2,740	
	IW-07C	1,600	2,983	
IW-08	IW-08A	2,000	2,030	
	IW-08B	2,000	1,111	Daylighting; remaining estimated volume (889 gal EVO solution) for IW-08 cluster reallocated to IW-08C.
	IW-08C	1,600	4,105	

Table 4.6. Bioamendment Injection Summary (Continued)

Injection Location	Well ID	Target EVO Solution Injection Volume (gal)	Total Estimated EVO Solution Injection Volume (gal)	Notes
IW-09	IW-09A	2,000	1,794	Slow flow rates and daylighting; remaining estimated volume (205 gal EVO solution) reallocated to IW-09B and IW-09C.
	IW-09B	2,000	423	Daylighting; remaining estimated volume (1,577 gal EVO solution) for IW-09 cluster achieved through over injection of IW-09C.
	IW-09C	1,600	4,335	
IW-10	IW-10A	1,600	267	Daylighting; remaining estimated volume (1,334 gal EVO solution in total) reallocated to IW-10C.
	IW-10B	1,200	1,392	
	IW-10C	1,200	2,731	
IW-11	IW-11A	1,200	2,629	
	IW-11B	2,000	749	No flow observed, pump deadheaded; remaining estimated volume (1,252 gal EVO solution) reallocated to IW-11A and IW-11C.
	IW-11C	1,600	2,036	
IW-12	IW-12A	2,000	2,068	
	IW-12B	1,600	1,828	
	IW-12C	1,200	1,439	
IW-13	IW-13A	1,600	2,028	
	IW-13B	1,600	1,732	
IW-14	IW-14A	1,600	564	Daylighting; remaining estimated volume (1,036 gal EVO solution) reallocated to IW-14B.
	IW-14B	1,600	2,951	
IW-15	IW-15A	1,600	1,819	
	IW-15B	1,600	1,731	
IW-16	IW-16A	1,600	1,619	
IW-17	IW-17A	2,000	3,741	
	IW-17B	1,600	1,885	
IW-18	IW-18A	1,600	1,889	
	IW-18B	1,600	2,358	
IW-19	IW-19A	2,000	3,080	
	IW-19B	1,600	1,651	
	IW-19C	800	1,222	Additional estimated volume (100 gal EVO solution) accounted for by over injection into IW-19A.
IW-20	IW-20A	1,600	1,664	
	IW-20B	1,600	2,649	
IW-21	IW-21A	1,200	1,774	
	IW-21B	1,200	378	Slow flow rates. Additional estimated volume (822 gal EVO solution) accounted for by over injection into IW-21A.
IW-22	IW-22A	800	1,568	
	IW-22B	1,600	3,725	
	IW-22C	1,200	1,942	

Table 4.6. Bioamendment Injection Summary (Continued)

Injection Location	Well ID	Target EVO Solution Injection Volume (gal)	Total Estimated EVO Solution Injection Volume (gal)	Notes
IW-23	IW-23A	2,000	1,464	Slow flow rates and daylighting; additional estimated volume (625 gal EVO solution) accounted for by over injection into IW-23B and IW-23C.
	IW-23B	2,000	2,378	
	IW-23C	2,000	2,973	
IW-24	IW-24A	800	1,369	
	IW-24B	1,600	1,002	Slow flow rates; additional estimated volume (599 gal EVO solution) accounted for by over injection into IW-24A and IW-24C.
	IW-24C	1,200	2,312	
IW-25	IW-25A	800	1,241	
	IW-25B	1,200	2,279	
IW-26	IW-26A	1,600	2,408	
	IW-26B	1,600	2,543	
IW-27	IW-27A	1,600	1,772	
	IW-27B	1,200	1,088	Slow flow rates; remaining estimated volume (113 gal EVO solution) for IW-27B reallocated to IW-27C.
	IW-27C	1,200	3,195	
IW-28	IW-28A	2,000	250	Daylighting; remaining estimated volume (1,750 gal EVO solution) reallocated to IW-28B.
	IW-28B	2,000	3,861	
	IW-28C	1,600	2,450	
IW-29	IW-29A	800	832	Slow flow rates; remaining IW-29A/IW-29B estimated volume (1,677 gal EVO solution) reallocated IW-29C.
	IW-29B	1,600	5	Slow flow rates; remaining IW-29A/IW-29B estimated volume (1,677 gal EVO solution) reallocated IW-29C.
	IW-29C	1,200	3,429	
IW-30	IW-30A	1,200	100	Slow flow rates; remaining IW-30 cluster estimated volume (188 gal EVO solution) reallocated to IW-27C. IW-30A/IW-30B remaining estimated volume (2,299 gal EVO solution) achieved through reallocation to IW-30C.
	IW-30B	2,000	751	Slow flow rates; remaining IW-30 cluster estimated volume (188 gal EVO solution) reallocated to IW-27C. IW-30A/IW-30B remaining estimated volume (2,299 gal EVO solution) achieved through reallocation to IW-30C.
	IW-30C	1,600	3,892	
IW-31	IW-31A	1,600	14	Slow flow rates and daylighting; remaining estimated volume (1,586 gal EVO solution) achieved through reallocation to IW-31B.
	IW-31B	1,600	3,258	

Table 4.6. Bioamendment Injection Summary (Continued)

Injection Location	Well ID	Target EVO Solution Injection Volume (gal)	Total Estimated EVO Solution Injection Volume (gal)	Notes
IW-32	IW-32A	1,200	1,325	
IW-33	IW-33A	800	789	Additional estimated volume (11 gal EVO solution) accounted for by over injection into IW-33B and IW-33C.
	IW-33B	1,600	1,795	
	IW-33C	1,200	1,334	
Total		**130,000**	**154,436**	

Table 4.7. Bioaugmentation Injection Summary

Injection Location	Well ID	Target DHC Bacteria Injection Amount (L)	Total DHC Bacteria Injection Amount (L)	Notes
IW-01	IW-01A	3	0	Slow flow rates and daylighting during EVO solution injection; bioamendments reallocated to IW-01B.
	IW-01B	2	5	
	IW-01C	2	2	
IW-02	IW-02A	3	0	Slow flow rates and daylighting during EVO solution injection; bioamendments reallocated to IW-02C.
	IW-02B	2	2	
	IW-02C	2	5	
IW-03	IW-03A	3	3	
	IW-03B	2	2	
	IW-03C	2	2	
IW-04	IW-04A	2	0	Daylighting during EVO solution injection; bioamendments reallocated to IW-04C.
	IW-04B	3	3	
	IW-04C	2	4	
IW-05	IW-05A	3	0	Slow flow rates and daylighting during EVO solution injection; bioamendments reallocated to IW-05B.
	IW-05B	3	6	
	IW-05C	3	3	
IW-06	IW-06A	3	0	Daylighting during EVO solution injection; bioamendments reallocated to IW-06C.
	IW-06B	3	3	
	IW-06C	2	5	
IW-07	IW-07A	3	0	Daylighting during EVO solution injection; bioamendments reallocated to IW-07C.
	IW-07B	3	3	
	IW-07C	2	5	
IW-08	IW-08A	3	3	
	IW-08B	3	3	
	IW-08C	2	2	

Table 4.7. Bioaugmentation Injection Summary (Continued)

Injection Location	Well ID	Target DHC Bacteria Injection Amount (L)	Total DHC Bacteria Injection Amount (L)	Notes
IW-09	IW-09A	3	3	
	IW-09B	3	0	Daylighting during EVO solution injection; bioamendments reallocated to IW-09C.
	IW-09C	2	5	
IW-10	IW-10A	3	3	
	IW-10B	2	2	
	IW-10C	2	2	
IW-11	IW-11A	2	5	
	IW-11B	3	0	No flow observed, pump deadheaded during EVO solution injection; bioamendments reallocated to IW-11A.
	IW-11C	2	2	
IW-12	IW-12A	3	3	
	IW-12B	2	2	
	IW-12C	2	2	
IW-13	IW-13A	3	3	
	IW-13B	3	3	
IW-14	IW-14A	3	0	Daylighting during EVO solution injection; bioamendments reallocated to IW-14B.
	IW-14B	3	6	
IW-15	IW-15A	3	3	
	IW-15B	3	3	
IW-16	IW-16A	3	3	
IW-17	IW-17A	3	3	
	IW-17B	2	2	
IW-18	IW-18A	3	3	
	IW-18B	3	3	
IW-19	IW-19A	3	3	
	IW-19B	2	2	
	IW-19C	1	1	
IW-20	IW-20A	3	3	
	IW-20B	3	3	
IW-21	IW-21A	2	2	
	IW-21B	2	2	
IW-22	IW-22A	2	2	
	IW-22B	3	3	
	IW-22C	2	2	
IW-23	IW-23A	3	3	
	IW-23B	3	3	
	IW-23C	3	3	
IW-24	IW-24A	2	2	
	IW-24B	3	3	
	IW-24C	2	2	
IW-25	IW-25A	2	2	
	IW-25B	2	2	
IW-26	IW-26A	3	3	
	IW-26B	3	3	

Table 4.7. Bioaugmentation Injection Summary (Continued)

Injection Location	Well ID	Target DHC Bacteria Injection Amount (L)	Total DHC Bacteria Injection Amount (L)	Notes
IW-27	IW-27A	3	3	
	IW-27B	2	2	
	IW-27C	2	2	
IW-28	IW-28A	3	3	
	IW-28B	3	3	
	IW-28C	2	2	
IW-29	IW-29A	2	2	
	IW-29B	3	3	
	IW-29C	2	2	
IW-30	IW-30A	2	2	
	IW-30B	3	3	
	IW-30C	2	2	
IW-31	IW-31A	3	3	
	IW-31B	3	3	
IW-32	IW-32A	2	2	
IW-33	IW-33A	2	2	
	IW-33B	3	3	
	IW-33C	2	2	
Totals		**215**	**215**	

4.2.4 Waste Material Generated

The implementation of the EISB RA resulted in the generation of waste materials. The wastes generated included solids, wastewater, and general refuse. Solid waste included soils, personal protective equipment, hoses, plastic, pallets, broken wood, cardboard, and paper. Wastewater was generated from the installation of MWs and IWs, DPT Jet Injection hydraulic fracturing, and bioamendment injection activities. In addition, during EISB injections, a release of water containing a fraction of EVO solution was captured in an oil retention basin near Outfall 008.

Table 4.8 contains the estimated volumes of the waste materials generated in the implementation of the RA and associated supporting activities. Water captured near KPDES Outfall 008 was first placed into frac tanks; then the water was sampled; and after analytical results were reviewed, the water was released into Outfall KPDES 008. Additional information on this release is provided in Sections 4.5.2 and 4.5.3. All other waste was dispositioned in accordance with contractor procedures.

Table 4.8. SWMU 211-A Remedial Action Waste Generation

Waste Stream	Volume (ft^3)	Disposal Location
Solid Waste	6,345	C-746-U Landfill
Wastewater	13,569	C-612 Pump-and-Treat Facility and KPDES Outfall 001
Water containing a fraction of EVO solution captured near KPDES Outfall 008	5,615	KPDES Outfall 008

4.3 NAMES AND ROLES OF REMEDIAL ACTION CONTRACTORS

FRNP. Prime contractor to DOE at PGDP from July 2017 to present. FRNP served as the point of contact to DOE for implementation of this RA. FRNP also served as the main coordinator for the applicable subcontractors to perform the implementation. The coordination efforts included training, the collection of samples, analytical laboratory contracting, radiological and safety oversight, and waste management activities.

Geosyntec Consultants. Subcontractor to FRNP and remedial action designer. Geosyntec Consultants provided intermittent technical oversight.

Arcadis. Subcontractor to FRNP and general contractor for implementation of EISB remedial activities. Arcadis performed the installation of bioamendment and bioaugmentation injection equipment and performed the actual injections. Supplemental manpower used to support EISB activities, including material suppliers and equipment vendors, were sourced locally by Arcadis.

M&W. Drilling subcontractor for Arcadis. M&W performed installation of IWs, long-term MWs, and PWs. M&W supported the hydraulic fracturing with the DPT drilling services. M&W provided the Commonwealth of Kentucky-licensed driller and developed and submitted the necessary MW completion forms and well variances.

FRx, Inc. Hydraulic fracturing subcontractor for Arcadis. FRx, Inc. conducted hydraulic fracturing, with the assistance of DPT drilling services, performed Jet Injection Technology, and sourced the mZVI, proppant sand, and other associated compounds used in the process.

Chase Environmental Group. Environmental support subcontractor for Arcadis. Chase Environmental Group performed MW development on installed IWs, long-term MWs, and PWs. In addition, Chase Environmental Group procured and installed stick up protective casings, flush-mount vaults, well pads and bollards for newly installed wells; it also procured and installed submersible bladder pumps into long-term MWs and PWs.

4.4 PARTICIPATION BY STATE AND OTHER FEDERAL AGENCIES

DOE, the Kentucky Natural Resources and Environmental Protection Cabinet (which has since been renamed the Kentucky Energy and Environment Cabinet), and the EPA entered into the FFA for the PGDP in 1998 (EPA 1998). DOE is the lead agency for the implementation of the SWMU 211-A RA, and EPA and KDEP provide regulatory oversight. The ROD was signed by DOE and EPA in March 2012 (DOE 2012). KDEP concurred with the selected remedy. KDEP and EPA both provided regulatory review and approval of the RDR and the RAWP. A representative of KDEP visited the worksite to observe and document the ongoing RA.

4.5 LESSONS LEARNED/PROBLEMS ENCOUNTERED

4.5.1 When Hydraulic Fracturing Shallow, Relatively Tight Clayey Silts Have Preventive Measures in Place to Mitigate Daylighting of Proppants and EISB Amendments

During hydraulic fracturing operations associated with the SWMU 211-A EISB project, numerous injection locations experienced daylighting of sand-mZVI slurry proppants and later during EISB bioaugmentation injection operations of EVO solution.

Recommended Actions: Several Naval Facilities Engineering Command *Best Practices for Injection and Distribution of Amendments* are discussed below as preventive measures to reduce the likelihood of daylighting and mitigate its impact (NAVFAC 2013).

- Perform pre-injection assessment of site conditions by assessing locations that may serve as daylighting points, such as underground utilities, outfalls, vaults, cracks, abandoned MWs, etc.

- Reduce injection flowrate to maintain a pressure less than 60% of the maximum calculated pressure.

- Monitor pressure in each point/well as necessary.

- Perform intermittent (pulsed) injection to allow potential mounding of water to dissipate.

- Use a recirculation system to extract daylighted amendments and reinject. Note that in injection areas where radioactive components are present, recirculation should consider radioactive contaminant impacts to equipment.

- Be aware of all subsurface utility corridors and other subsurface structures that could act as preferential pathways for fluid flow. It may be necessary to reduce or eliminate injection in these areas.

4.5.2 Emulsified Vegetable Oil Enters Storm Sewer during Bioaugmentation Injection Operations

On August 4, 2022, at 0908 hours, an FRNP Facility Manager reported a white, milky plume in an oil retention basin upsteam of KPDES Outfall 008, while active injection of EVO was ongoing at the SWMU 211-A EISB project. After inspecting the milky plume and determining that the SWMU 211-A project was the likely source, SWMU 211-A EVO injection operations were paused at 0922 hours, and storm sewers in the vicinity of the EVO injections were inspected. White EVO solution was discovered present in a 16-inch lateral storm sewer line at the junction of a 24-inch storm sewer line that was immediately adjacent to injection operations. This incident resulted in the loss of four days of active EVO injection before limited injections were resumed. Operations at the five IWs located nearest to the lateral storm sewer line were suspended for approximately one and a half months while a plan of action was formalized prior to resuming injections at these locations. The plan of action required the subcontractor to resume injections, with maximum pressure not to exceed 15 psi, and to monitor nearby storm sewer lines for the visual presence of EVO. This incident resulted in a significant loss of work hours, which affected the project schedule.

Recommended Actions: When conducting remedial injection operations, controls should be in place to monitor underground utilities within the ROI of the IWs for breaches of the injectant, for the duration of active injection operations; and workers should be prepared to halt injections in the event of a breach.

4.5.3 Release of Emulsified Vegetable Oil/Surfactant Solution from SWMU 211-A EISB Project into an Oil Retention Basin

An uncontrolled release associated with the SWMU 211-A EISB project occurred on August 4, 2022, at 0908 hours, during injection operations. This uncontrolled release resulted in the capture of approximately 42,000 gal of water, which contained a fraction of EVO solution in an oil retention basin before reaching KPDES Outfall 008 (a regulatory point of compliance). Emergency Response utilized a transfer pump to move the EVO/surfactant/water solution to an adjacent oil containment basin for temporary storage; thereafter, the solution was pumped into three 17,000-gal double-walled water tanks, which were temporarily staged adjacent to the oil containment basin until analytical data could be collected and reviewed to determine the disposition of the solution. After review of the analytical data (total oil and grease levels were below federal best practicable technology effluent limits and TCE was nondetect), FRNP Environmental Compliance allowed the solution to be released back into the oil retention basin and discharged through the KPDES Outfall 008 regulatory point of compliance. This incident resulted in significant time delays to the project which contributed to delays to the project schedule. The project also incurred unanticipated costs associated with tank rentals, labor, sample analysis, waste engineering, and waste disposal.

Analysis: Routine inspections of KPDES Outfall 008 by FRNP personnel helped in the early detection of the release and averted a noncompliance issue by detecting the release before reaching the regulatory point of compliance. The FRNP Facility Manager for KPDES Outfall 008 was aware of injection operations at the SWMU 211-A EISB project and immediately informed project field management in time to pause injection activities while FRNP Environmental Compliance and SWMU 211-A EISB project personnel investigated the release and confirmed a release to storm sewer lines in close proximity to active IWs.

Recommended Actions: It is important to keep facility managers appraised of project activities that could adversely impact other PGDP operations. When conducting remedial injection operations, controls should be in place to monitor underground utilities within the ROI of the IWs for breaches of the injectant, for the duration of active injection operations; and workers should be prepared to halt injections in the event of a breach. Finally, significant time should be allotted in the project schedule to account for the risk associated with unanticipated issues that are inherently analogous with EISB-type projects.

4.5.4 Generation of Solids in EVO Stock Product and Effect on IW Flow Totalizers

The following discussion on the generation of solids in EVO stock product and the effect they have on IW flow totalizers was provided by Arcadis, the general contractor for the implementation of the SWMU 211-A EISB project. This information is presented in its entirety without modification.

> As discussed with FRNP starting on August 11, 2022, during enhanced in situ bioremediation (EISB) program implementation at SWMU 211-A, Arcadis field team identified the generation of solids in both the EVO stock product, as well as in the dilute EVO solution within stock tanks and conveyance throughout the injection wellfield. EOS Pro 60™ was the stock EVO product selected for implementation and the dilute injection solution consisted of a combination of EOS Pro 60™, hydrant water fed from the Site water treatment plant (sourced from the Ohio River), and Newman Zone OS which is a commercially available oxygen scavenger.
>
> The solids that formed in the EVO stock tanks appear to be the result of emulsion degradation. The EVO stock tank solids partially clogged the inlet of the EVO dosing pumps while pulling stock EVO into the injection solution conveyance lines at SWMU 211-A. The solids formation and associated partial clogging of the inlet screens led to EVO dosing accuracy issues at the proportional dosing pumps during the initial phase (i.e., first 3 weeks of injection) of the EISB program. The solid was identified by the field implementation team as a gelatinous yellow substance having a consistency similar to a jellyfish. The field team installed additional filtering at the inlet of the dosing pumps and began implementing a preventative operations and maintenance program to keep the filters clean. This preventative operations and maintenance program increased pump efficiency and dosing accuracy for the remainder of the injection event.
>
> Subsequently, a second solid was later observed downstream of the EVO dosing area at the IW totalizers that process dilute EVO. This second solids issue was initially identified during inspections following routine QC of daily injection volumes. The Arcadis EISB

tracking table demonstrated a growing volume discrepancy between the main anoxic water totalizer (not containing EVO) and the IW totalizers (dilute EVO solution) as reconciled daily. The field implementation team identified accumulation of the same gelatinous yellow solids found in the stock EVO pump intake screen and a black fine solid within the IW totalizer housing that was affecting totalizer capacity and accuracy. Arcadis began evaluating the root cause of the issue by discussing the observations with the EVO manufacturer (EOS Pro, sold by EOS Remediation LLC), who stated the generation of the observed solids under SWMU 211-A field conditions are not common or expected. EOS Remediation LLC is currently taking steps to recreate the solid production to better understand the root cause of the solidification of the solution. EOS Remediation LLC requested information regarding the hardness of the hydrant water (subsequently confirmed by FRNP to be 55 mg/L [as $CaCO_3$]), which can affect emulsion stability in the EOS Pro stock solution. Note that iron used in the Newman Zone OS (or other commercially available products), required to condition makeup water by removing [DO], can add over 400 mg/L (as $CaCO_3$) hardness. As such, EOS Remediation also suggested that the dosage of the oxygen scavenger (OS) could be a contributing factor for the fouling of the dilute EVO solution.

Arcadis further empirically evaluated dilute EVO product stability by mixing up small batches of injection solution with and without OS to assess visible emulsion breakdown and/or solids generation. Arcadis created dilute solutions with various makeup water sources, including: 1) hydrant water and EVO, 2) hydrant water with Newman Zone OS, 3) hydrant water, EVO, and Newman Zone OS, and [4]) bottled drinking water, EVO, and Newman OS to assess emulsion breakdown and/or solids generation under differing water chemistries.

Within one day of mixing of the various solutions, field observations were made as follows: (1) hydrant water and EVO yielded a milky coloration and no precipitation; (2) hydrant water with Newman Zone OS yielded no color change and a black sand-like iron precipitation; (3) hydrant water, EVO, and Newman Zone OS yielded a milky coloration and a black sand-like iron precipitation; and ([4]) bottled drinking water, EVO, and Newman OS yielded a milky coloration and a black sand-like iron. The jellyfish/gelatinous material was not observed to form with any of the test batches.

These observations, when taken together, suggest that the EVO solution (at the target 13.4% by volume dosage specified for the SWMU 211-A project) is unstable when combined with the conditioned (i.e., anoxic) water sourced from the hydrant onsite. The cause of emulsion degradation is not currently understood, but could be a byproduct of biological reactions and/or chemical incompatibility of the conditioned hydrant water and the EVO solution. Once the emulsion is destabilized, it leads to solids generation that were unanticipated in the design and construction of the EVO mixing and delivery system and that partially clogged mechanical equipment. In this case, the partial clogging resulted in reduced accuracy of the IW totalizers.

To address the discrepancies in readings between the injection wellhead totalizers and the more accurate reconciled volume of makeup water and stock EVO solution processed on a given day, Arcadis developed the approach below, which establishes a proportional correction factor to each well per day.

- For each day, Arcadis compared the total volume of anoxic water and stock EVO used against the cumulative volume summed from each wellhead totalizer, which establishes the volume discrepancy missed by the clogging of the IW leg totalizers for that day. Since there is no fouling at the system-wide anoxic water totalizer prior to the addition of EVO, Arcadis has a high confidence that this value is representative of the amount of injection solution volume on a given day.

- For each well, Arcadis established the proportional volume on a given day and used that to assign a percentage of each day's total volume discrepancy to that well. That volume was then added to the cumulative total recorded by the flow meters to arrive at corrected values for total volume and mass injected for progress and completion tracking.

This process was vetted with FRNP and Geosyntec during a meeting on August 16, 2022. Because we have high confidence in the totalizer tracking anoxic water usage, our ability to track EVO usage, and the ability to evaluate the proportional flow of the individual wells, this method was adequate to meet project needs and ensured that EVO and anoxic water used each day is accounted for across the IW network. This agreed upon procedure was applied for the remainder of the injection program, and injection volumes were more accurately assessed and target volume requirements in the RDR were met across the program.

The specific steps that Arcadis took to apply this process are as follows:

- The field engineer sent the field data from personal journals before leaving the site each day.

- The EISB tracking table was updated daily by office staff based on that information, prior to planning the next morning's injection work, such that accurate volumes could be considered prior to planning injections for the next day.

- Injection logs were developed for each day using the field notes.

By late August (approximately 6 weeks into the injection program), Arcadis observed less fouling of the totalizers with more frequent proactive cleaning of the tanks and injection wellhead totalizers. Since there still remained some discrepancies in totalizer readings, this process, as described above, continued through the end of the injection program. Injections were completed on [September 21, 2022], and the final EISB tracking table was sent to FRNP on [November 16, 2022], which reconciled total volumes at each well location.

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5. FINAL INSPECTION

5.1 LIST OF INSPECTION ATTENDEES

The implemented RA at SWMU 211-A was not of a nature that can be inspected to determine the efficacy of the action due to the active remediation taking place during the bioremediation process. Because a visual inspection of the SWMU 211-A RA does not provide information of the efficacy of the action in the subsurface, a final inspection was not necessary. The RA was visited multiple times by the FFA parties or their representatives.

5.2 DEFICIENCIES FOUND

No deficiencies in the RA have been identified at this time.

5.3 RESOLUTIONS OF DEFICIENCIES

This section is not applicable at this time.

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6. CERTIFICATION THAT THE REMEDY IS OPERATIONAL AND FUNCTIONAL

6.1 STATEMENT OF WORK WAS PERFORMED WITHIN DESIRED SPECIFICATIONS

Implementation of the EISB RA was performed, consistent with remedial designs, the RAWP, and agreements made among the FFA parties. An estimated total of 154,436 gal of EVO and 215 L of DHC bacteria were injected, which meets or exceeds the required amounts of 130,000 gal of EVO and 215 L of DHC identified in the RDR. Bioamendments will continue to assist in biodegrading VOCs in the treatment area for several years. The interim LUCs are in place and operational. MWs, both long-term and performance, have been installed as required by the RAWP and the RDR. The purpose of the long-term groundwater sampling is to monitor the continued effectiveness of bioremediation and to ascertain when RAO No. 3 of this action is attained. The remedy for SWMU 211-A, consistent with the requirements of Section III, "Purposes of Agreement," and Section XXX, "Five-Year Review" of the FFA (EPA 1998) will be subject to CERCLA Five-Year Reviews to evaluate and determine the continued effectiveness of the remedy.

6.2 AFFIRMATION THAT PERFORMANCE STANDARDS HAVE BEEN MET AND THE BASIS FOR DETERMINATION

The RA has been implemented successfully; the injected amendments and DHC bacteria will continue to bioremediate VOCs. The discussion of the methods utilized to determine that the RA performance standards have been met is contained in Section 3.4.

The RA, however, will result in hazardous substances, pollutants, or contaminants remaining on-site above the remediation goal level for TCE at 0.075 mg/kg for the SWMU 211-A site, which will not allow unlimited use and unrestricted exposure. Because the selected RA will result in hazardous substances remaining on-site in excess of levels that allow for unlimited use and unrestricted exposure, a statutory review under CERCLA Section 121(c) will be conducted every five years until the levels of contaminants of concern allow for unlimited use and unrestricted exposures of the soil and groundwater (DOE 2012). The five-year reviews will be conducted to ensure that the remedy is or will be protective of human health and the environment. If the results of the five-year reviews reveal that remedy integrity is compromised and the protection of human health and the environment is insufficient, the potential benefits of implementing additional RAs then will be evaluated by the FFA parties. The statutory reviews will be conducted in accordance with CERCLA Section 121(c), the National Contingency Plan in 40 *CFR* § 300.430(f)(5)(iii)(C), and EPA guidance. These reviews, although required by CERCLA, are not considered components of the selected remedies.

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7. OPERATION AND MAINTENANCE

7.1 HIGHLIGHTS OF OPERATION AND MAINTENANCE

The EISB treatment has been implemented and requires monitoring and maintenance to ensure continuing biodegradation in the UCRS. After EISB is initiated, EVO is potentially consumed by the biodegradation process. If EVO is consumed by the bacteria prior to attaining project RAOs, additional EVO injections may need to be delivered into the UCRS; therefore, IWs will be maintained until RAO No. 3 is achieved. Installed PWs and long-term MWs will be sampled for target VOCs, TOC, and geochemical parameters. The scheduling of these periodic sampling events are included in Appendix A of the RDR. Based on the levels of these parameters, analytical trends, and other lines of evidence in groundwater results (e.g., ratios of parent and degradation products, spatial and temporal variability), additional EVO injections may be necessary. EISB maintenance is discussed fully in Appendix A of the RDR.

In addition, the RA has two associated items that will be performed, consistent with the requirements of the ROD. As documented in the ROD, the estimated timeframe for attaining the groundwater protection RG within the SWMU and outside of the treatment area is expected to be approximately 39 years (DOE 2012). The following summarizes the scope of the two associated items.

- Long-term MWs have been installed, as required by the RAWP. These MWs will provide groundwater data that will be used to examine trends in the RGA as biodegradation of VOCs in the UCRS continues. The RDR contains the schedule for MW sampling after installation. MW groundwater sampling will continue until applicable RAOs are attained (Section 1.2.2). The results of PW and long-term MWs will be used to support the development of CERCLA Five-Year Reviews.

- The ROD requires that the interim LUCs be maintained until the concentrations of hazardous substances in the soil and groundwater are at such levels to allow for unrestricted use and unlimited exposure. The interim LUCs will remain in place pending final remedy selection as part of a subsequent operable unit that addresses the relevant media. The annual monitoring information will be used in preparation of the five-year reviews required for this remedy.

7.2 POTENTIAL PROBLEMS OR CONCERNS

SWMU 211-A historically has been maintained as a parking and equipment storage area, which may result in damage to wells due to moving equipment and vehicles. To mitigate damage from equipment and vehicles, concrete bollards and large concrete stones have been installed near IWs and MWs. Inspections will be conducted periodically, damage will be noted, and wells will be repaired, if needed, in accordance with CP2-ES-0024, *Monitoring Well Maintenance Implementation Plan for the Paducah Gaseous Diffusion Plant, Paducah, Kentucky*.

In addition, MWs and PWs may need to be rehabilitated periodically to remove fine particles that enter the well and settle to the bottom and/or to improve the connectivity among the well screen, filter pack, and formation. Rehabilitation activities will follow the same general process as well development performed during well installation.

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8. SUMMARY OF PROJECT COSTS

8.1 FINAL COSTS

The cost for the design and implementation of the SWMU 211-A RA was $9.94 million. This cost includes the efforts to accomplish the following tasks.

- Design the RA
- Develop the remedial design work plan
- Develop the RAWP
- Prepare the site
- Implement the EISB
- Procure materials
- Perform performance and post-treatment evaluations throughout MW installation
- Determine labor costs
- Set up project management
- Prepare the interim RACR

The information reported in this section includes the cost for the active portion of implementing this RA. The cost of injecting the bacteria into the SWMU 211-A area is included. The bacteria will continue to treat VOCs present in the treated area.

8.2 COMPARISON OF FINAL COSTS TO ORIGINAL COST ESTIMATE

The signed ROD estimated the cost of implementing the SWMU 211-A RA at $3.7 million unescalated (DOE 2012). The cost estimate indicated in the ROD is an order-of-magnitude engineering cost estimate that is expected to be within + 50% to - 30% of the actual project cost. The actual project cost, as shown in Section 8.1, is outside the range of the ROD estimate.

8.3 NEED FOR AND COST OF MODIFICATIONS

Issuance of a cost modification for implementing the remedy was necessary as the actual cost exceeded the range specified in the ROD. The exceedances of the projected cost were due to an increase in the area and volume of treated soil. Details of the differences of cost are summarized in *Explanation of Significant Differences to the Record of Decision for Solid Waste Management Units 1, 211-A, 211-B, and Part of 102 Volatile Organic Compound Sources for the Southwest Groundwater Plume at the Paducah Gaseous Diffusion Plant, Paducah, Kentucky,* DOE/LX/07-2480&D2 (DOE 2022c).

8.4 SUMMARY OF REGULATORY AGENCY OVERSIGHT COSTS

There were no DOE costs associated with regulatory agency oversight.

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9. REFERENCES

DOE (U.S. Department of Energy) 1999. *Remedial Investigation Report for Waste Area Grouping 27 at the Paducah Gaseous Diffusion Plant Paducah, Kentucky*, DOE/OR/07-1777&D2, U.S. Department of Energy, Paducah, KY, June.

DOE 2007. *Site Investigation Report for the Southwest Groundwater Plume at the Paducah Gaseous Diffusion Plant, Paducah, Kentucky*, DOE/OR/07-2180&D2/R1, U.S. Department of Energy, Paducah, KY, June.

DOE 2011. *Revised Focused Feasibility Study for Solid Waste Management Units 1, 211A, and 211B Volatile Organic Compound Sources for the Southwest Groundwater Plume at the Paducah Gaseous Diffusion Plant, Paducah, Kentucky*, DOE/LX/07-0362&D2, U.S. Department of Energy, Paducah, KY, May.

DOE 2012. *Record of Decision for Solid Waste Management Units 1, 211-A, 211-B, and Part of 102 Volatile Organic Compound Sources for the Southwest Groundwater Plume at the Paducah Gaseous Diffusion Plant, Paducah, Kentucky*, DOE/LX/07-0365&D2/R1, U.S. Department of Energy, Paducah, KY, March.

DOE 2013. *Final Characterization Report for Solid Waste Management Units 211-A and 211-B Volatile Organic Compound Sources for the Southwest Groundwater Plume at the Paducah Gaseous Diffusion Plant, Paducah, Kentucky*, DOE/LX/07-1288&D2, U.S. Department of Energy, Paducah, KY, December.

DOE 2015. *Addendum to the Final Characterization Report for Solid Waste Management Units 211-A and 211-B Volatile Organic Compound Sources for the Southwest Groundwater Plume at the Paducah Gaseous Diffusion Plant, Paducah, Kentucky*, DOE/LX/07-1288&D2/A1, U.S. Department of Energy, December.

DOE 2016. *Addendum to the Final Characterization Report for Solid Waste Management Units 211-A and 211-B Volatile Organic Compound Sources for the Southwest Groundwater Plume at the Paducah Gaseous Diffusion Plant, Paducah, Kentucky*, DOE/LX/07-1288&D2/A1/R1, U.S. Department of Energy, April.

DOE 2017. *Remedial Action Completion Report for In Situ Source Treatment by Deep Soil Mixing of the Southwest Groundwater Plume Volatile Organic Source at the C-747-C Oil Landfarm (Solid Waste Management Unit 1), at Paducah Gaseous Diffusion Plant, Paducah, Kentucky*, DOE/LX/07-2405&D2, U.S. Department of Energy, January.

DOE 2018. "SWMU 211-A and SWMU 211-B Options," WebEx Meeting, Paducah Environmental Information Center, Accession Number ENV 1.A-05126, U.S. Department of Energy, Paducah, KY, May 23.

DOE 2019. *Certified for Construction Remedial Design Report for SWMU 211-A for Volatile Organic Compound Sources to the Southwest Groundwater Plume at the Paducah Gaseous Diffusion Plant, Paducah, Kentucky*, DOE/LX/07-2435&D2, U.S. Department of Energy, Paducah, KY, December.

DOE 2021a. *Remedial Action Work Plan for SWMU 211-A Enhanced In Situ Bioremediation for Volatile Organic Compound Sources to the Southwest Groundwater Plume at the Paducah Gaseous Diffusion*

Plant, Paducah, Kentucky, DOE/LX/07-2443&D2/R2, U.S. Department of Energy, Paducah, KY, December.

DOE 2021b. *Memorandum of Agreement for Resolution of Informal Dispute Concerning U.S. Environmental Protection Agency Conditional Concurrence on the Remedial Action Work Plan for SWMU 211-A Enhanced In Situ Bioremediation for Volatile Organic Compound Sources to the Southwest Groundwater Plume at the Paducah Gaseous Diffusion Plant, Paducah, Kentucky, DOE/LX/07-2443&D2,* U.S. Department of Energy, Paducah, KY, September.

DOE 2022a. *Site Management Plan Paducah Gaseous Diffusion Plant, Paducah, Kentucky*, *Annual Revision—FY 2023*, DOE/LX/07-2482&D2, U.S. Department of Energy, Paducah, KY, December.

DOE 2022b. Letter from T. Duncan, U.S. Department of Energy, to B. Begley, Kentucky Department for Environmental Protection, and V. Weeks, U.S. Environmental Protection Agency, "Notification of Remedial Action Field Start for Solid Waste Management Unit 211-A Enhanced *In Situ* Bioremediation for Volatile Organic Compound Sources to the Southwest Groundwater Plume at the Paducah Gaseous Diffusion Plant, Paducah, Kentucky," PPPO-02-10020691-22, March 16.

DOE 2022c. *Explanation of Significant Differences to the Record of Decision for Solid Waste Management Units 1, 211-A, 211-B, and Part of 102 Volatile Organic Compound Sources for the Southwest Groundwater Plume at the Paducah Gaseous Diffusion Plant, Paducah, Kentucky*, DOE/LX/07-2480&D2, U.S. Department of Energy, Paducah, KY, November.

EPA (U.S. Environmental Protection Agency) 1998. *Federal Facility Agreement for the Paducah Gaseous Diffusion Plant*, U.S. Environmental Protection Agency, Atlanta, GA, February.

FRNP (Four Rivers Nuclear Partnership) 2020. Letter from M. Redfield, Four Rivers Nuclear Partnership, LLC, to M. Fultz, U.S. Department of Energy, "Four Rivers Nuclear Partnership, LLC—Notification of Abandonment of Piezometers and Wells Completion," FRNP-21-4338, October 28.

NAVFAC (Naval Facilities Engineering Command) 2013. *Best Practices for Injection and Distribution of Amendments*, TR-NAVFAC-EXWC-EV-1303, Battelle Memorial Institute and NAVFAC Alternative Restoration Technology Team, Port Hueneme, CA, March.

APPENDIX A

CONSTRUCTION DRAWINGS

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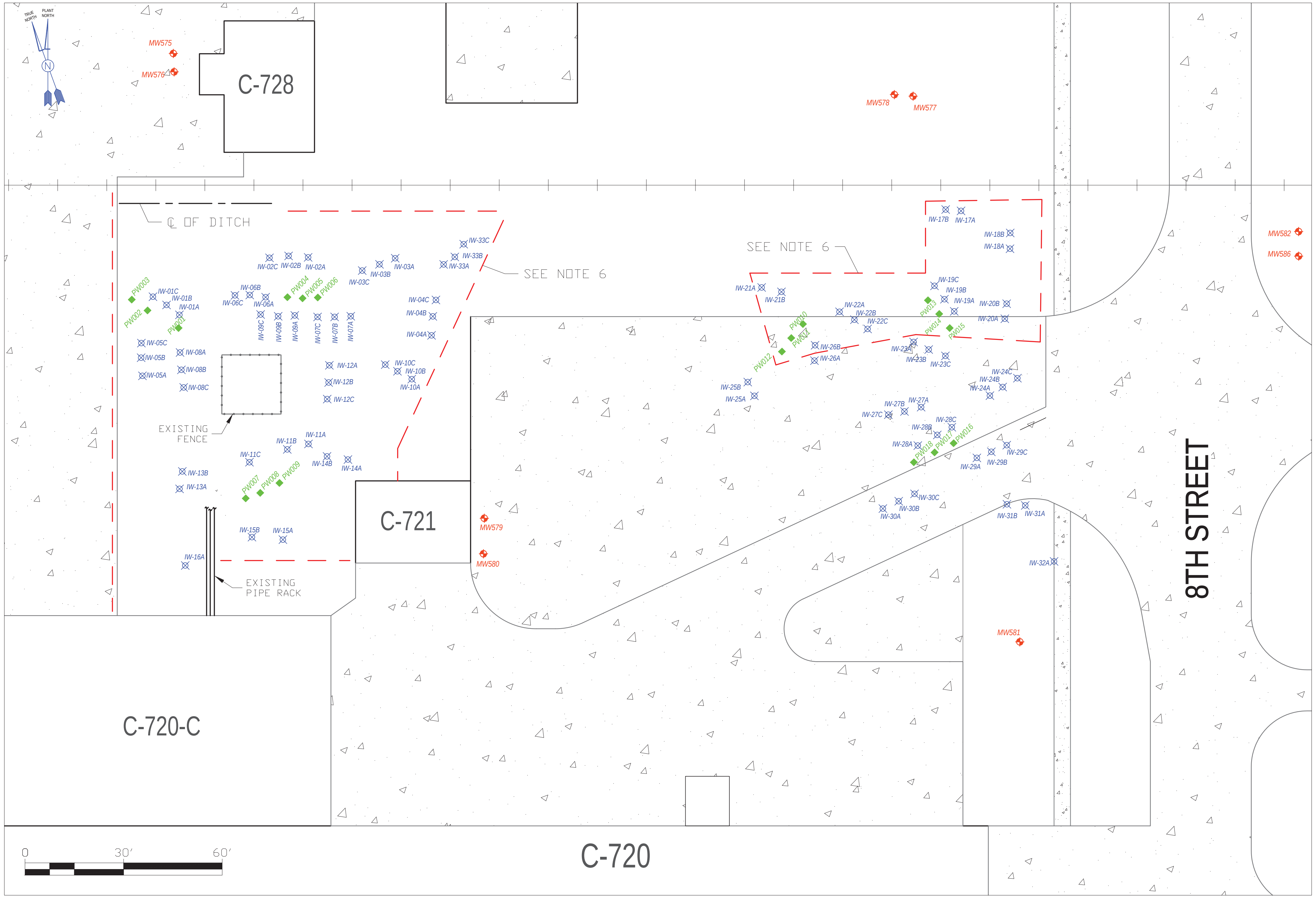
KTW



WELL NETWORK SITE PLAN

GENERAL NOTES:

1. LOCATIONS SHOWN ON THIS DRAWING ARE TO PROVIDE GENERAL LOCATION OF MONITORING WELLS, PERFORMANCE WELLS, AND CENTRAL LOCATION OF INJECTION WELL NETWORK. REFERENCE SWMU 211-A REMEDIAL DESIGN REPORT AND REMEDIAL ACTION WORK PLAN FOR SPECIFIC LOCATIONS. FIELD ADJUST LOCATIONS, AS NEEDED, WITH PRIOR APPROVAL FROM THE CONTRACTOR.
2. REFERENCE DRAWINGS C7DCWELLSA002 AND C7DCWELLSA003 FOR CONSTRUCTION DETAILS ASSOCIATED WITH MONITORING WELL AND PERFORMANCE WELL INSTALLATION.
3. REFERENCE DRAWING C5D-FA5510-A02 FOR CONSTRUCTION DETAILS ASSOCIATED WITH INJECTION WELL INSTALLATION.
4. NOT USED.
5. REFERENCE REMEDIAL DESIGN REPORT AND REMEDIAL ACTION WORK PLAN FOR SPECIFIC SCREEN DEPTHS AND LENGTHS FOR EACH WELL.
6. IN-LIEU OF PROTECTIVE BOLLARDS INSTALLED FOR INDIVIDUAL WELLS, PROJECT MAY ELECT TO INSTALL CONCRETE BARRIERS AROUND GROUPS OF WELLS. BARRIERS SHALL BE SPACED APPROXIMATELY 3 FEET (EDGE TO EDGE). STATE VARIANCE REQUIRED FOR THIS INSTALLATION.

LEGEND

- IW-xx - INJECTION WELL
- MWxxx - MONITORING WELL
- PWxxx - PERFORMANCE WELL
- CONCRETE BARRIERS

NOTE:
THE WELL LOCATIONS SHOWN ON REVISION 1 OF THIS DRAWING ARE INDICATING AS BUILT COORDINATE LOCATIONS.

SECTION NUMBER OR DETAIL LETTER
DRAWING ON WHICH SECTION OR DETAIL IS TAKEN
DRAWING ON WHICH SECTION OR DETAIL IS SHOWN
SECTION AND DETAIL KEY

TOLERANCES UNLESS OTHERWISE SPECIFIED
FRACTIONS ± 1/16"
XX DECIMALS
XXX DECIMALS
ANGLES
BREAK SHARP EDGES MAX.
FINISH

"NO REPRESENTATION OR WARRANTY, EXPRESSED OR IMPLIED, IS MADE THAT THE USE OR DISCLOSURE OF ANY INFORMATION, APPARATUS, METHOD OR PROCESS DISCLOSED IN THESE DRAWINGS MAY NOT INFRINGE PRIVATE RIGHTS OF OTHERS. NO LIABILITY IS ASSUMED WITH RESPECT TO THE USE OF, OR FOR DAMAGES RESULTING FROM THE USE ANY INFORMATION, APPARATUS, METHOD OR PROCESS DISCLOSED IN THESE DRAWINGS.

THIS DRAWING PRODUCED ON AUTOCAD DO NOT REVISE MANUALLY

REV. NO.	ISSUE / REVISION DESCRIPTION	DATE	DRW	CHKR	RE	TR	APPD
1	AS BUILT ENTIRE DRAWING, INCORPORATED ESO FA5510, ECN-2023-0001, ECN-2022-0006	11/2/22	KTW	DJH	DJH	X	TAW
0A2	CERTIFIED FOR CONSTRUCTION FOR ESO FA5510, ECN-2023-0001	X	X	X	X	X	X
0A1	CERTIFIED FOR CONSTRUCTION FOR ESO FA5510, ECN-2022-0006	5/2/22	KW	DH	HD	X	TW
0	CERTIFIED FOR CONSTRUCTION FOR ESO FA5510	12/8/21	DJH	CTD	DJH	N/A	TAW

REVISION OR ISSUE APPROVALS

DRAWING APPROVALS		DATE
DRW	J.WAEHLER	10/5/2022
CHKR	D.HATTON	10/5/2022
RE	D.HATTON	10/5/2022
TR	N/A	N/A
APPD	T.STEPHENS	10/5/2022

FOUR RIVERS NUCLEAR PARTNERSHIP, LLC
DOE PRIME CONTRACT # DE-EM0004895

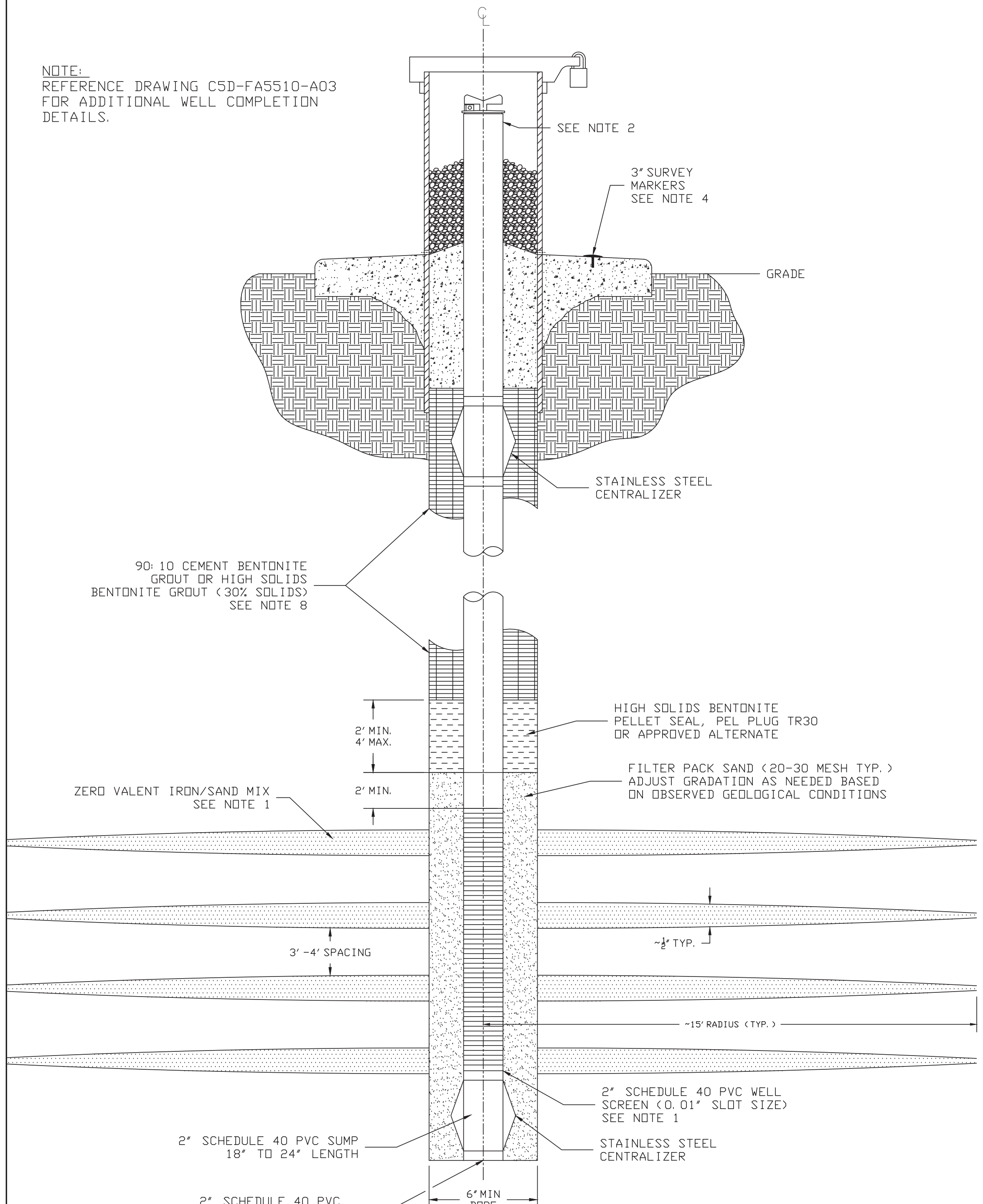
ESO FA5510
SWMU 211-A REMEDIATION PROJECT
SITE PLAN

NON-ESSENTIAL

SCALE	PLANT	BLDG	FL	SHEET	CLASS
AS NOTED	PGDP	AREA	N/A		U

ID	DRAWING NO.	REV
FA5510	C5D-FA5510-A01	1

NOTE:
REFERENCE DRAWING C5D-FA5510-A03 FOR ADDITIONAL WELL COMPLETION DETAILS.

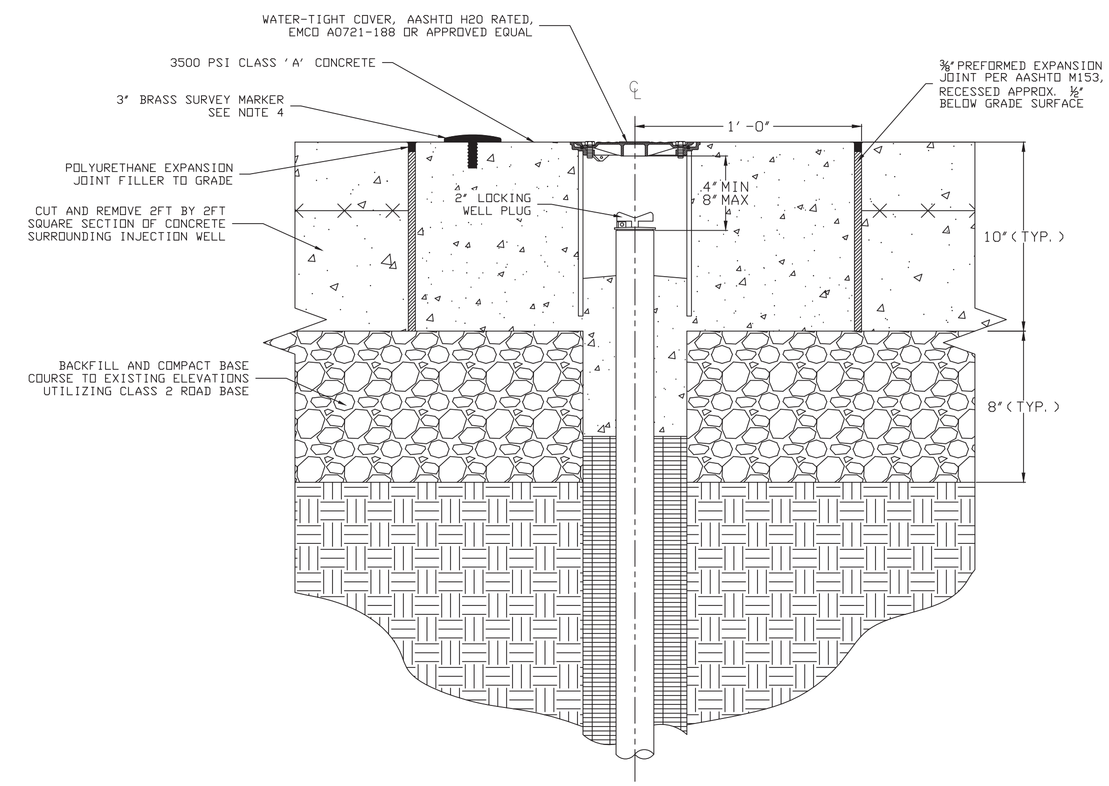


INJECTION WELL INSTALLATION DETAIL

SCALE: NONE

GENERAL NOTES:

1. INJECTION WELLS SHALL BE INSTALLED IN ACCORDANCE WITH THE REMEDIAL DESIGN REPORT FOR SWMU 211-A. REFERENCE DOCUMENT FOR LOCATIONS, NUMBER OF WELLS, SCREENED INTERVALS, INJECTION INTERVALS, AND INJECTED MATERIAL QUANTITIES. BORINGS UTILIZED TO FACILITATE FRACTURE INSTALLATION SHALL BE BACKFILLED, AS NEEDED, IN ACCORDANCE WITH 401 KAR 6:350.
2. SUBCONTRACTOR RESPONSIBLE FOR TIE-IN TO INJECTION WELL CASING TO SUPPORT BIOAMENDMENT INJECTION.
3. ALL CONCRETE SHALL BE CLASS 'A' IN ACCORDANCE WITH KENTUCKY TRANSPORTATION CABINET STANDARD SPECIFICATION SECTION 601.
4. SUBCONTRACTOR SHALL STAMP WELL NUMBER (1/2" MIN. LETTERING) INTO BRASS SURVEY MARKERS. ADDITIONAL SURVEY DATA (COORDINATES/ELEVATION) AND MARKERS MAY BE ADDED AT PROJECTS DISCRETION.
5. NOT USED.
6. NOT USED.
7. EACH PROTECTIVE WELL CASING SHALL BE LABELED WITH 3" BLACK LETTERING. LABELING SHALL INCLUDE INJECTION WELL ID NUMBER AS INDICATED IN TABLE 7 OF THE REMEDIAL DESIGN REPORT.
8. UTILIZE 30% SOLIDS BENTONITE GROUT OR 90:10 CEMENT BENTONITE GROUT AS DIRECTED BY FIELD GEOLOGIST.
9. SURFACE COMPLETIONS SHALL BE INSTALLED IN ACCORDANCE WITH 401 KAR 6:350, MONITORING WELL CONSTRUCTION PRACTICES AND STANDARDS. ANY VARIANCE MUST BE REVIEW AND APPROVED BY THE CONTRACTOR PRIOR TO FIELD IMPLEMENTATION.
10. NOT USED.
11. FLUSH MOUNT COMPLETIONS MAY BE APPROVED, BY THE PROJECT, IN-LIEU OF ABOVE-GROUND COMPLETIONS IN AREAS WHERE ABOVE-GROUND COMPLETIONS ARE NOT PRACTICAL OR POSE A THREAT TO WELL INTEGRITY.



FLUSH MOUNT SURFACE COMPLETION

SCALE: NONE

SECTION AND DETAIL KEY: SECTION NUMBER OR DETAIL LETTER; DRAWING ON WHICH SECTION OR DETAIL IS TAKEN; DRAWING ON WHICH SECTION OR DETAIL IS SHOWN

TOLERANCES UNLESS OTHERWISE SPECIFIED
FRACTIONS
XX DECIMALS
XXX DECIMALS
ANGLES
BREAK SHARP EDGES MAX.
FINISH

REV. NO.	ISSUE / REVISION DESCRIPTION	DATE	DRW	CHKR	RE	TR	APPD
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0A1	CERTIFIED FOR CONSTRUCTION FOR ESO FA5510, ECN-2022-0006	X	X	X	X	X	X
0	CERTIFIED FOR CONSTRUCTION FOR ESO FA5510	12/8/21	DJH	CTD	DJH	N/A	TAW

REVISION OR ISSUE APPROVALS

DRAWING APPROVALS		DATE
DRW	K.WELSH	4/21/2022
CHKR	D.HATTON	5/2/2022
RE	D.HATTON	5/2/2022
TR	N/A	N/A
APPD	T.WALKER	5/2/2022

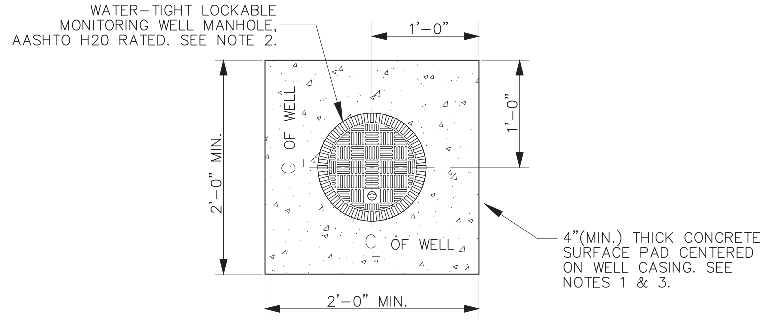
FOUR RIVERS NUCLEAR PARTNERSHIP, LLC
DOE PRIME CONTRACT # DE-EM0004895

ESO FA5510
SWMU 211-A REMEDIATION PROJECT
INJECTION WELL TYPICAL DETAILS

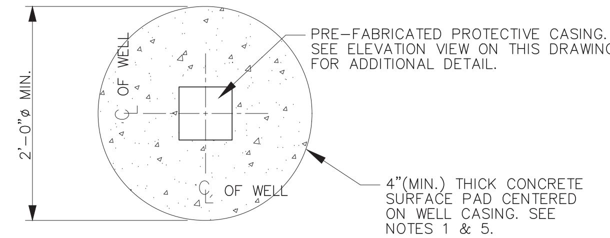
NON-ESSENTIAL

SCALE	PLANT	BLDG	FL	SHEET	CLASS
NONE	PGDP	AREA	N/A		U

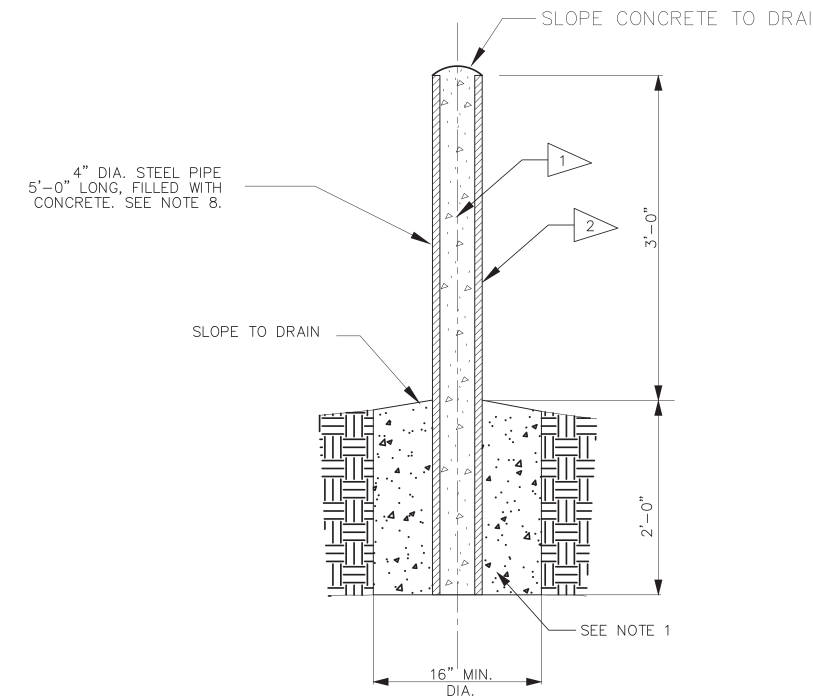
ID	DRAWING NO.	REV
FA5510	C5D-FA5510-A02	1



FLUSH MOUNTED MONITORING/PERFORMANCE WELL PAD DETAIL (SEE NOTE 5)



WELL PAD DETAIL FOR SURFACE COMPLETED WELLS (SEE NOTE 5)

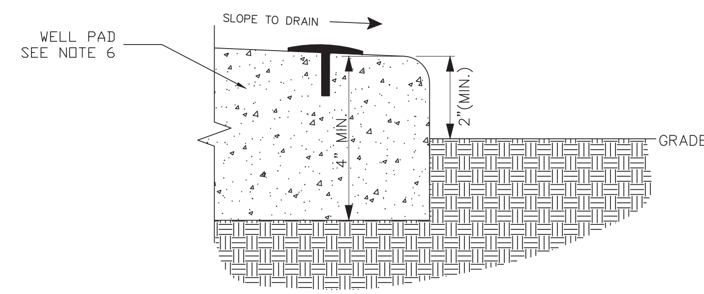


PERFORMANCE/INJECTION WELL TYPICAL BOLLARD DETAIL (SEE NOTE 5)

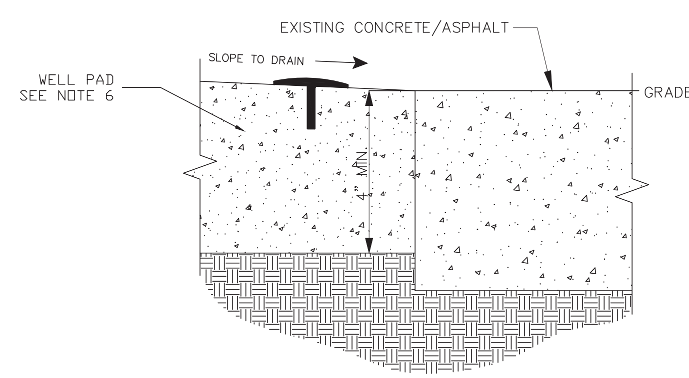
GENERAL NOTES:

1. CONCRETE SHALL BE CLASS "A" IN ACCORDANCE WITH KENTUCKY TRANSPORTATION CABINET STANDARD SPECIFICATION SECTION 601. ADMIXTURES REQUESTED BY THE PROJECT SHALL BE REVIEWED AND APPROVED BY ENGINEERING ON A CASE BY CASE BASIS.
2. NOMINAL SIZE OF THE PROTECTIVE MANHOLE COVERS SHALL BE A MINIMUM OF 8" FOR INJECTION WELLS AND A MINIMUM OF 12" FOR PERFORMANCE/MONITORING WELLS.
3. REFERENCE SECTION VIEW FOR WELL PADS INSTALLED IN IMPROVED AREAS (THIS DRAWING) FOR ADDITIONAL DETAIL. WELL PADS WITHIN THE TRAVEL PATH BETWEEN C-720-C AND 8TH STREET, AS SHOWN ON DRAWING C5D-FA5510-A01, SHALL INSTALLED IN ACCORDANCE WITH C5D-FA5510-A02.
4. PRE-FABRICATED PROTECTIVE WELL CASING SHALL BE PAINTED STEEL OR ALUMINUM CONSTRUCTION. MAINTAIN A MINIMUM ANNULAR SPACE OF 2" BETWEEN THE INSIDE DIAMETER OF THE OUTER PROTECTIVE CASING AND THE OUTSIDE DIAMETER OF THE WELL CASING. ALTERNATE MATERIALS AND SIZES TO BE APPROVED BY THE CONTRACTOR PRIOR TO INSTALLATION.
5. WITH THE EXCEPTION OF THE BOLLARD DETAILS PROVIDED ON THIS DRAWING, LONG-TERM MONITORING WELL SURFACE COMPLETIONS ARE TO BE INSTALLED IN ACCORDANCE WITH DRAWING C7DCWELLSA002.
6. REFERENCE DRAWING C7DCWELLSA003 FOR BRASS MONUMENT REQUIREMENTS ON MONITORING/PERFORMANCE WELLS AND DRAWING C5D-FA5510-A02 FOR BRASS MONUMENT REQUIREMENTS ON INJECTION WELLS.
7. EACH PROTECTIVE WELL CASING SHALL BE LABELED WITH 3" LETTERING. LABELING SHALL INCLUDE WELL ID NUMBER AS PROVIDED BY THE PROJECT.
8. BOLLARDS SHALL BE PRIMED WITH TNEMEC SERIES 37H @ 3-5 MILS AND FINISHED WITH TNEMEC SERIES 1028 ENDURATONE, SAFETY YELLOW @ 2-3 MILS, OR APPROVED ALTERNATE. PREPARE METAL SURFACE IN ACCORDANCE WITH MANUFACTURER'S RECOMMENDATIONS PRIOR TO APPLYING PRIMER.

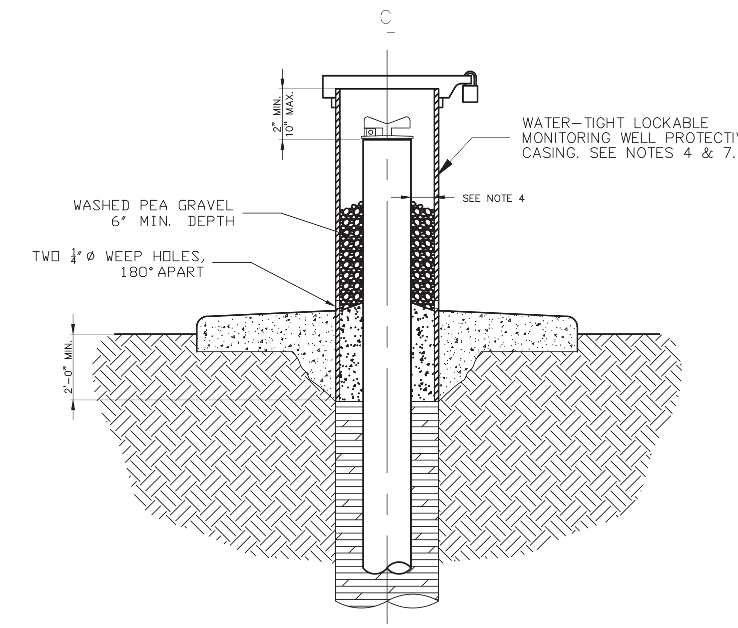
REFERENCE DRAWINGS	DRAWING NO.
GROUND WATER MONITORING WELLS TYPICAL WELL DETAILS	C7DCWELLSA002
GROUND WATER MONITORING WELLS INSTALLATION DETAILS	C7DCWELLSA003
SWMU 211-A REMEDIATION PROJECT SITE PLAN	C5D-FA5510-A01
SWMU 211-A REMEDIATION PROJECT INJECTION WELL TYPICAL DETAILS	C5D-FA5510-A02



SECTION VIEW OF WELL PADS INSTALLED IN UNIMPROVED AREAS



SECTION VIEW OF WELL PADS INSTALLED IN IMPROVED AREAS (SEE NOTE 3)



ELEVATION VIEW OF SURFACE COMPLETED WELLS

FOUR RIVERS NUCLEAR PARTNERSHIP, LLC
DOE PRIME CONTRACT # DE-EM0004895

ESO FA5510
SWMU 211-A REMEDIATION PROJECT
WELL SURFACE COMPLETION DETAILS

NON-ESSENTIAL

SCALE	PLANT	BLDG	FL	SHEET	CLASS
NONE	PGDP	AREA	N/A	1 OF 1	U

ID	DRAWING NO.	REV
FA5510	C5D-FA5510-A03	1

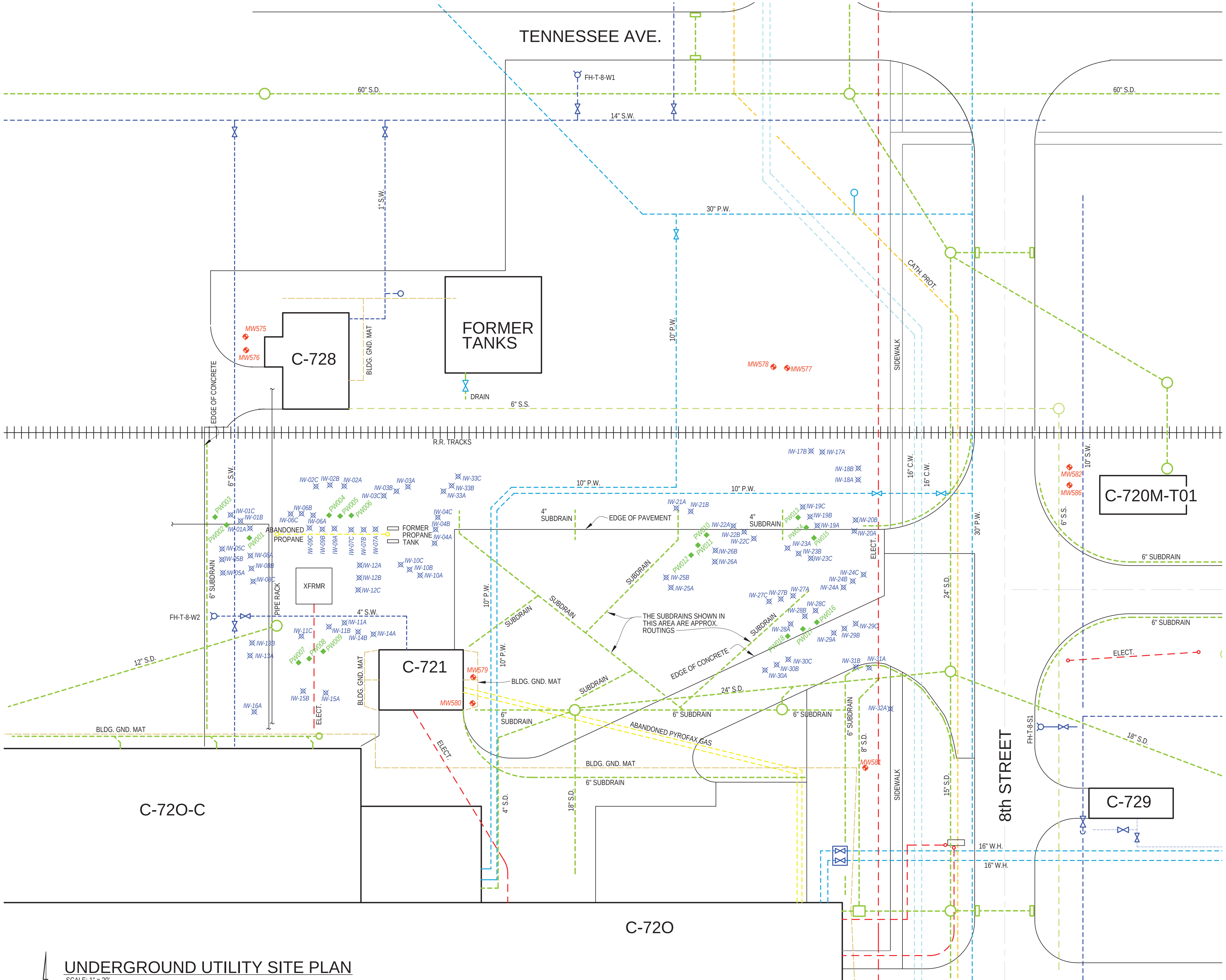
DRAWING APPROVALS		DATE
DRW	K.WELSH	4/21/2022
CHKR	D.HATTON	5/2/2022
RE	D.HATTON	5/2/2022
TR	N/A	N/A
APPD	T.WALKER	5/2/2022

REV. NO.	ISSUE / REVISION DESCRIPTION	DATE	DRW	CHKR	RE	TR	APPD
1	AS BUILT ENTIRE DRAWING, INCORPORATED ESO FA5510, ECN-2022-0006	11/2/22	KTW	DJH	DJH	X	TAW
0	CERTIFIED FOR CONSTRUCTION FOR ESO FA5510, ECN-2022-0006	X	X	X	X	X	X

REVISION OR ISSUE APPROVALS

SECTION AND DETAIL KEY: SECTION NUMBER OR DETAIL LETTER; DRAWING ON WHICH SECTION OR DETAIL IS TAKEN; DRAWING ON WHICH SECTION OR DETAIL IS SHOWN

TOLERANCES UNLESS OTHERWISE SPECIFIED
FRACTIONS
XX DECIMALS
XXX DECIMALS
ANGLES
BREAK SHARP EDGES MAX.
FINISH



UNDERGROUND UTILITY SITE PLAN

SCALE: 1" = 20'

GRAPHIC SCALE

0 10' 25' 50' 100'

GENERAL NOTES

1. LOCATIONS SHOWN ON THIS DRAWING ARE TO PROVIDE A GENERAL LOCATION OF MONITORING WELLS, PERFORMANCE WELLS, AND CENTRAL LOCATIONS OF INJECTION WELL NETWORK. REFERENCE SWMU 211-A REMEDIAL DESIGN REPORT AND REMEDIAL ACTION WORK PLAN FOR SPECIFIC LOCATIONS.FIELD ADJUST LOCATIONS AS NEEDED WITH PRIOR APPROVAL FROM THE CONTRACTOR.
2. WORK THIS DRAWING WITH C5D-FA5510-A01.
3. SEE DRAWING C5D-FA5510-A01 FOR ADDITIONAL GENERAL NOTES.

LEGEND

IW-xxx	INJECTION WELL CENTROID
MWxxx	MONITORING WELL
PWxxx	PERFORMANCE WELL
S.W.	SANITARY WATER
S.D.	STORM DRAIN
S.S.	SANITARY SEWER
P.W.	PLANT WATER
C.W.	CHILLED WATER
W.H.	WASTE HEAT WATER
ELECT.	ELECTRICAL DUCT
CATH. PROT.	CATHODIC PROTECTION

REFERENCE DRAWINGS

C5E-6121	SANITARY WATER
C5E-6221	PLANT WATER AND WASTE HEAT
C5E-6321	STORM DRAINS
C5E-6421	SANITARY SEWER
C5E-6521	ELECTRICAL AND GROUNDING
C5E-6821	CHILLED WATER
C5E-6921	PROPANE AND PYROFAX
C5E-7121	CATHODIC PROTECTION
A6-124-C	STORM DRAIN SUBDRAINS
E-14051	SITE UNDERGROUND PIPING PLAN
E-14053	SITE UNDERGROUND PIPING PLAN
E16-1-E	C-721 GROUNDING PLAN
D-PA-P4442	STORM DRAIN SUBDRAINS

NOTE:
THE WELL LOCATIONS SHOWN ON REVISION 1 OF THIS DRAWING ARE INDICATING AS BUILT COORDINATE LOCATIONS.

SECTION NUMBER OR DETAIL LETTER — DRAWING ON WHICH SECTION OR DETAIL IS TAKEN — DRAWING ON WHICH SECTION OR DETAIL IS SHOWN

SECTION AND DETAIL KEY

TOLERANCES UNLESS OTHERWISE SPECIFIED
FRACTIONS
XX DECIMALS
XXX DECIMALS
ANGLES
BREAK SHARP EDGES MAX.
FINISH

THIS DRAWING PRODUCED ON AUTOCAD DO NOT REVISE MANUALLY

REV. NO.	ISSUE / REVISION DESCRIPTION	DATE	DRW	CHKR	RE	TR	APPD
1	AS BUILT ENTIRE DRAWING, INCORPORATED ESO FA5510 AND ECN-2022-0005	11/2/22	KTW	DJH	DJH	X	TAW
0	CERTIFIED FOR CONSTRUCTION FOR ESO FA5510 AND ECN-2022-0005	X	X	X	X	X	X

REVISION OR ISSUE APPROVALS

DRAWING APPROVALS		DATE
DRW	K.WELSH	3/16/2022
CHKR	D.HATTON	3/16/2022
RE	D.HATTON	3/16/2022
TR	N/A	N/A
APPD	T.WALKER	3/16/2022

FOUR RIVERS NUCLEAR PARTNERSHIP, LLC

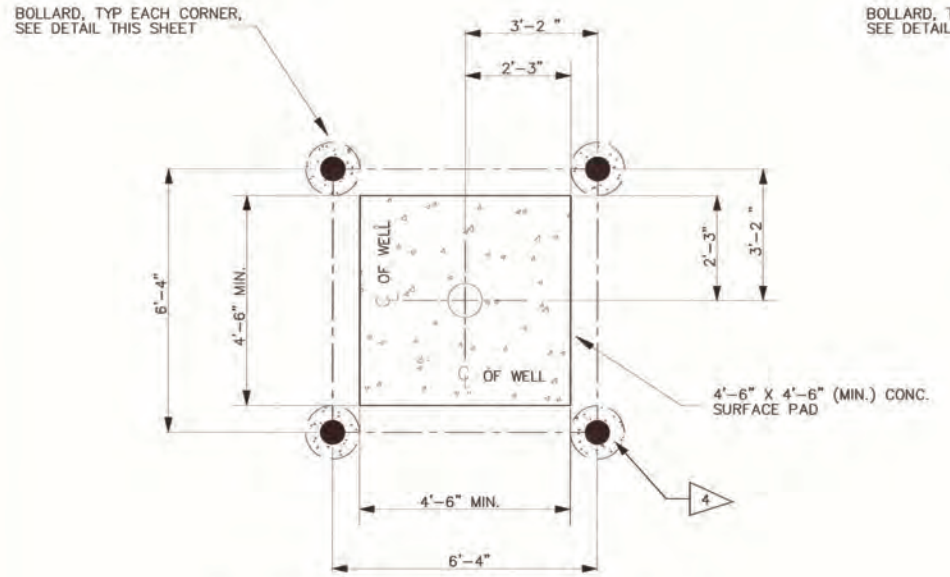
DOE PRIME CONTRACT # DE-EM0004895

SWMU 211-A REMEDIATION PROJECT UNDERGROUND UTILITY SITE PLAN

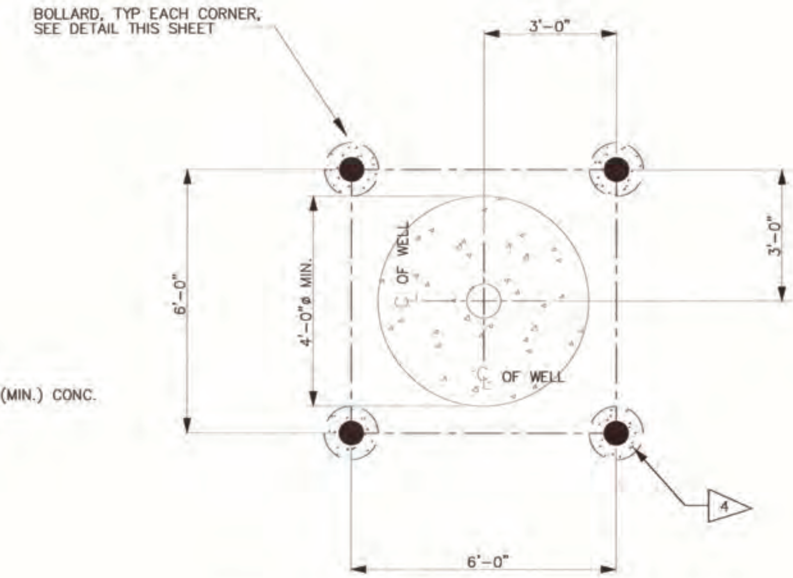
NON-ESSENTIAL

SCALE	PLANT	BLDG	FL	SHEET	CLASS
1" = 20'	PGDP	AREA	X	1 OF 1	U

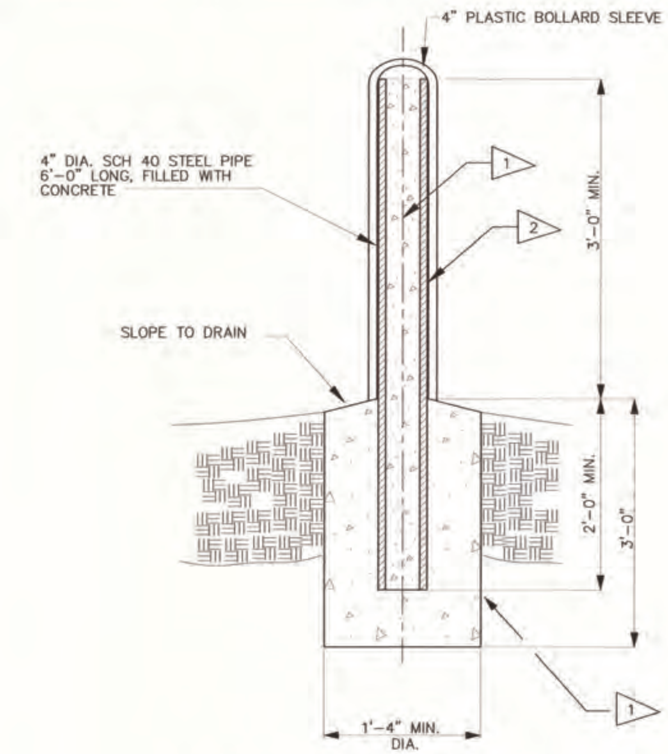
ID	DRAWING NO.	REV
FA5510	C5D-FA5510-A04	1



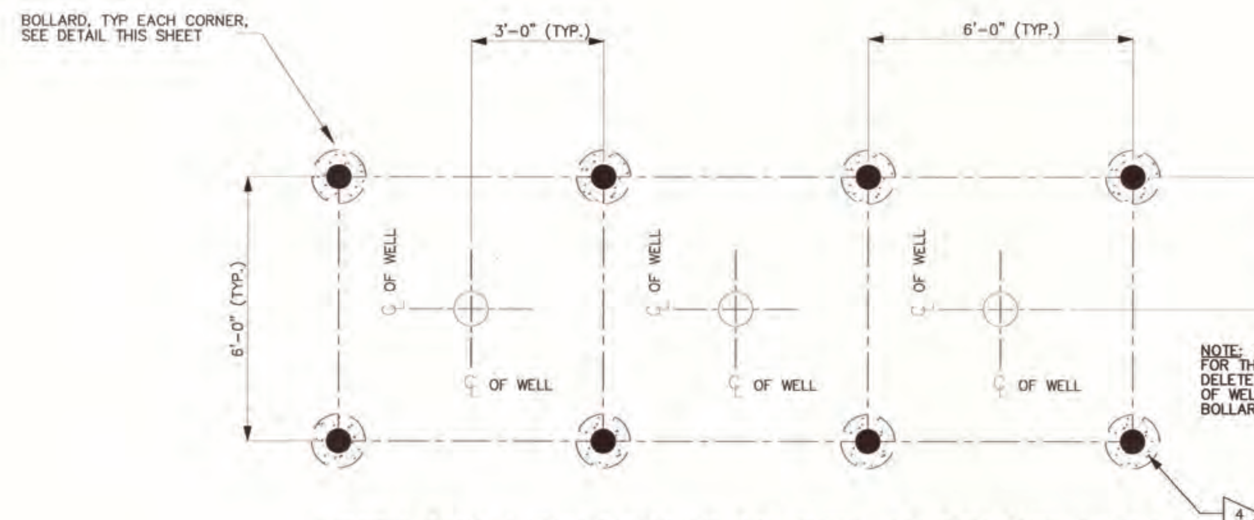
SQUARE CONCRETE PAD AND BOLLARD LOCATION PLAN



CIRCULAR CONCRETE PAD AND BOLLARD LOCATION PLAN



TYPICAL BOLLARD DETAIL



NOTE: BOLLARD LOCATION PLAN SHOWN FOR THREE ADJOINING WELLS. ADD OR DELETE BOLLARDS BASED ON NUMBER OF WELLS INSTALLED. MAINTAIN FOUR BOLLARDS AROUND EACH WELL.

BOLLARD LOCATION PLAN FOR ADJOINING WELLS

GENERAL NOTES:

1. CONCRETE FOR BOLLARDS SHALL BE CLASS "A" IN ACCORDANCE WITH KENTUCKY TRANSPORTATION CABINET STANDARD SPECIFICATION SECTION 601. ADMIXTURES REQUESTED BY THE PROJECT SHALL BE REVIEWED AND APPROVED BY ENGINEERING ON A CASE BY CASE BASIS.
2. BOLLARD SHALL BE CLEANED ACCORDING TO SSPC-SP6 AND PRIMED WITH TNEMEC SERIES 37H @ 3-5 MILS OR CONTRACTOR ACCEPTED EQUAL. AFTER PRIMING IS COMPLETE INSTALL PLASTIC BOLLARD POST SLEEVE (⅛" THICK MINIMUM) PER MANUFACTURER'S INSTRUCTIONS. TRIM EXCESS LENGTH AS REQUIRED TO MATCH HEIGHT OF CONCRETE BOLLARD. BOLLARD SLEEVES SHALL BE A HIGHLY VISIBLE COLOR.
3. SURFACE COMPLETIONS SHALL BE INSTALLED IN ACCORDANCE WITH 401 KAR 6:350, MONITORING WELL CONSTRUCTION PRACTICES AND STANDARDS. ANY VARIANCES FROM STATE REGULATIONS MUST BE REVIEWED AND APPROVED BY THE CONTRACTOR PRIOR SUBMITTAL FOR STATE APPROVAL.
4. FIELD ADJUST BOLLARD SPACING, AS NEEDED, WITH APPROVAL FROM THE CONTRACTOR.

REFERENCE DRAWINGS	DRAWING NO.
GROUND WATER PIEZOMETER WELLS INSTALLATION DETAILS	C5E-FA1950-A12
GROUND WATER MONITORING WELLS INSTALLATION DETAILS	C7DCWELLSA003

THIS DRAWING PRODUCED ON AUTOCAD
DO NOT REVISE MANUALLY

LPE

STATE OF KENTUCKY
KAREN A. SIZEMORE
21059
LICENSED PROFESSIONAL ENGINEER
02-15-2022
DATE
PROFESSIONAL SEAL

SECTION NUMBER OR DETAIL LETTER
DRAWING ON WHICH SECTION OR DETAIL IS TAKEN
DRAWING ON WHICH SECTION OR DETAIL IS SHOWN
SECTION AND DETAIL KEY

TOLERANCES UNLESS OTHERWISE SPECIFIED
FRACTIONS
XX DECIMALS
XXX DECIMALS
ANGLES
BREAK SHARP EDGES MAX.
FINISH

"NO REPRESENTATION OR WARRANTY, EXPRESSED OR IMPLIED, IS MADE THAT THE USE OR DISCLOSURE OF ANY INFORMATION, APPARATUS, METHOD OR PROCESS DISCLOSED IN THESE DRAWINGS MAY NOT INFRINGE PRIVATE RIGHTS OF OTHERS. NO LIABILITY IS ASSUMED WITH RESPECT TO THE USE OF, OR FOR DAMAGES RESULTING FROM THE USE, ANY INFORMATION, APPARATUS, METHOD OR PROCESS DISCLOSED IN THESE DRAWINGS. THE DRAWINGS ARE BEING MADE FOR INFORMATION TO BIDDER AND ARE NOT TO BE USED FOR OTHER PURPOSES, AND ARE TO BE RETURNED UPON REQUEST OF THE FORWARDING CONTRACTOR."

REV. NO.	ISSUE / REVISION DESCRIPTION	DATE	DRW	CHKR	RE	TR	APPD
4	AS-BUILT ENTIRE DRAWING INC. ESO FA5410	3/14/22	JDW	DJH	DJH	N/A	TAW
3	CERTIFIED FOR CONSTRUCTION FOR ESO FA5410	9/26/19	DJH	CTD	DJH	N/A	TS
2	CERTIFIED FOR CONSTRUCTION FOR FCT-CCA-FA5120-002	8/23/18	DJH	CTD	DJH	N/A	TS
0	AS-BUILT ENTIRE DRAWING FOR ESO FA1950, INC. ECN-2016-0059	9/25/17	KTW	TAW	TAW	N/A	KAS
FA2	CERTIFIED FOR CONSTRUCTION FOR ECN-2016-0059	9/8/16	DJH	TAW	TAW	N/A	KAS
FA1	CERTIFIED FOR CONSTRUCTION FOR ESO FA1950	3/2/16	DJH	GWD	GWD	N/A	KAS
1	GENERAL REVISIONS	6/28/13	KTW	PAC	KRD	N/A	PAC

REVISION OR ISSUE APPROVALS

DRAWING APPROVALS		DATE
DRW	D. HATTON	9/8/16
CHKR	T.A.WALKER	9/8/16
RE	T.A.WALKER	9/8/16
TR	N/A	
APPD	K.SIZEMORE	9/8/16

FOUR RIVERS NUCLEAR PARTNERSHIP, LLC
DOE PRIME CONTRACT # DE-EM0004895

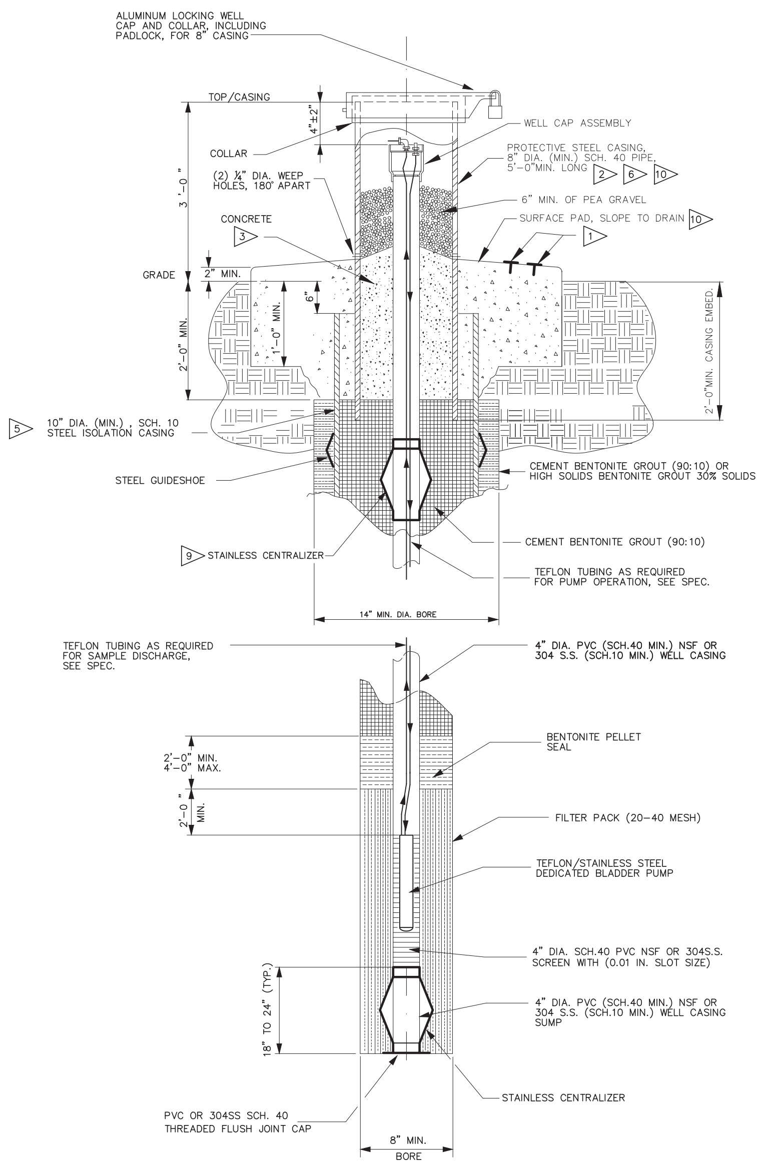
FLUOR. PADUCAH DEACTIVATION PROJECT
DOE Prime Contract #DE-DT0007774

GROUND WATER MONITORING WELLS TYPICAL WELL DETAILS

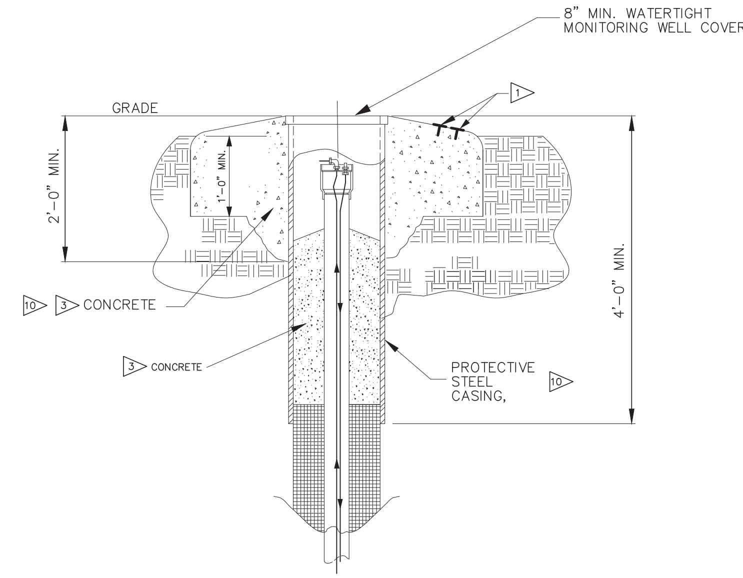
NON-ESSENTIAL

SCALE	PLANT	BLDG	FL	SHEET	CLASS
NONE	PGDP	N/A	N/A		U

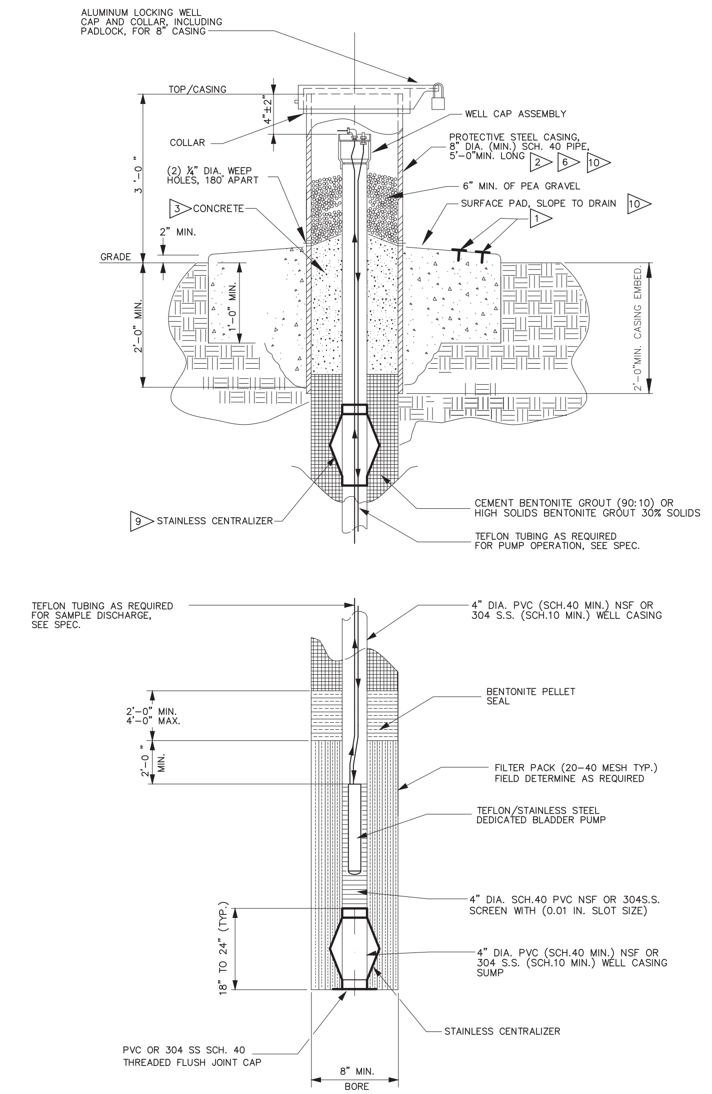
ID FA5410 | DWG NO. C7DCWELLSA002 | REV 4



MONITORING WELL WITH ISOLATION CASING



FLUSH MOUNT SURFACE PAD ARRANGEMENT



MONITORING WELL WITHOUT ISOLATION CASING

GENERAL NOTES:

1. INSTALL TWO BRASS PLATE MONUMENTS. SUB-CONTRACTOR SHALL STAMP WELL NUMBER, COORDINATES, ELEVATIONS, AND ASSEMBLED KENTUCKY GROUNDWATER DATABASE REGISTRATION NUMBER (MIN. OF ½" SIZE LETTERS) IN BRASS PLATE. BRASS PLATE SHALL BE DOMED SURVEY MARKER 3" DIA.
2. PROTECTIVE CASING SHALL BE CLEANED ACCORDING TO SSPC-SP6 AND PRIMED WITH TNEMEC SERIES 37H @ 3-5 MILS AND FINISHED WITH TNEMEC SERIES 1028 SAFETY YELLOW @ 2-3 MILS, OR CONTRACTOR ACCEPTED EQUAL.
3. CONCRETE FOR PAD AND PROTECTIVE WELL CASING SHALL BE CLASS "A" IN ACCORDANCE WITH KDH STANDARD SPECIFICATION SECTION 601
4. MATERIAL OF CONSTRUCTION (PVC OR 304SS) TO BE SPECIFIED BY THE PROJECT.
5. ISOLATION CASING TO BE INSTALLED IN CONFINING LAYER ABOVE RGA.
6. EACH PROTECTIVE CASING SHALL BE LABELED WITH BLACK LETTERS. LABEL SHALL INCLUDE THE "MW" PREFIX AND THE NUMBER ASSIGNED BY THE CONTRACTOR. LETTERS SHALL BE A MINIMUM OF 3 INCHES HIGH.
7. 304 STAINLESS STEEL SCREENS SHALL BE 4" SCHEDULE 40 JOHNSON SCREENS, 60 WIRE OR ENGINEERING APPROVED EQUIVALENT.
8. UTILIZE 30% SOLIDS BENTONITE GROUT OR CEMENT BENTONITE GROUT 90:10 AS ANNULAR SEAL IN THE UCRS (AS REQURIED BY PROJECT SPECIFICATIONS) AND UTILIZE 30% SOLIDS BENTONITE GROUT IN MCNAIRY FORMATION. REFERENCE PROJECT SPECIFICATIONS FOR ADDITIONAL INFORMATION ON GROUT MIXTURE.
9. SECOND CENTRALIZER REQUIRED FOR ALL MONITORING WELLS WITH A TOTAL DEPTH GREATER THAN OR EQUAL TO 50 FT BGS. BASE OF THE CENTRALIZER SHALL BE PLACED AT THE BASE OF THE UCRS
10. REFERENCE DRAWING C5D-FA5510-A03 FOR SURFACE COMPLETIONS SPECIFIC TO THE SOLID WASTE MANAGEMENT UNIT 211-A BIOREMEDIATION PROJECT.

REFERENCE DRAWINGS	DRAWING NO.
GROUND WATER MONITORING WELLS TYPICAL WELL DETAILS	C7DCWELLSA002
SWMU 211-A REMEDIATION PROJECT WELL SURFACE COMPLETION DETAILS	C5D-FA5510-A03

REV. 3A1	
DRW. K.WELSH	5/3/2022
CHKR. D.HATTON	5/3/2022
R.E. D.HATTON	5/3/2022
T.R. N/A	N/A
APPD. T.WALKER	5/3/2022
DRAWING APPROVALS	DATE

THIS DRAWING PRODUCED ON AUTOCAD
DO NOT REVISE MANUALLY

FOUR RIVERS NUCLEAR PARTNERSHIP, LLC
DOE PRIME CONTRACT # DE-EM0004895

LPE

KAREN A. SIZEMORE 21069 STATE OF KENTUCKY LICENSED PROFESSIONAL ENGINEER

KAREN SIZEMORE (Affiliate) Digitally signed by KAREN SIZEMORE (Affiliate) Date: 2022.11.02 15:33:27 -05'00'

DATE
PROFESSIONAL SEAL

SECTION AND DETAIL KEY: SECTION NUMBER OR DETAIL LETTER; DRAWING ON WHICH SECTION OR DETAIL IS TAKEN; DRAWING ON WHICH SECTION OR DETAIL IS SHOWN

TOLERANCES UNLESS OTHERWISE SPECIFIED
FRACTIONS ± 1/16"
XX DECIMALS
XXX DECIMALS
ANGLES
BREAK SHARP EDGES MAX.
FINISH

REV. NO.	ISSUE / REVISION DESCRIPTION	DATE	DRW	CHKR	RE	TR	APPD
4	AS BUILT ENTIRE DRAWING, INCORPORATED ESO FA5510, ECN-2022-0006	11/2/22	KTW	DJH	DJH	X	TAW
3A1	CERTIFIED FOR CONSTRUCTION FOR ESO FA5510, ECN-2022-0006	X	X	X	X	X	X
3	AS-BUILT ENTIRE DRAWING FOR ESO FA5410	3/14/22	JW	DJH	DJH	N/A	TAW
2A1	CERTIFIED FOR CONSTRUCTION FOR ECN-2020-0001	3/2/20	KTW	DJH	DJH	N/A	TDS
2	CERTIFIED FOR CONSTRUCTION FOR ECN-2019-0026	10/23/19	DJH	DA	DJH	N/A	TDS
1	CERTIFIED FOR CONSTRUCTION FOR ESO FA5410	9/26/19	DJH	CTD	DJH	N/A	TDS
0	AS-BUILD ENTIRE DRAWING FOR ESO FA1950	9/25/17	KTW	TAW	TAW	N/A	KAS
FA1	CERTIFIED FOR CONSTRUCTION FOR ESO FA1950	X	X	X	X	X	X

REVISION OR ISSUE APPROVALS

DRAWING APPROVALS	DATE
DRW D.HATTON	3/2/16
CHKR G.DUNCAN	3/2/16
RE G.DUNCAN	3/2/16
TR N/A	
APPD K.SIZEMORE	3/2/16

FLUOR.
PADUCAH DEACTIVATION PROJECT
DOE Prime Contract #DE-DT0007774

GROUND WATER MONITORING WELLS INSTALLATION DETAILS

NON-ESSENTIAL

SCALE	PLANT	BLDG	FL	SHEET	CLASS
NONE	PGDP	N/A	N/A		U

ID FA5410 | C7DCWELLSA003 | REV 4

C7DCWELLSA003

APPENDIX B

DPT JET INJECTION DATA

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DPT Jet Injection Log

Project Name: SWMU 211-A Bioremediation Remedial Action
Project Number: PO-0010222
Field Personnel: Doug Knight, Spencer Halstrom, Justin Burroughs, Dean Varner, Eric Flanegan
Date: 4/12/22-7/13/22
Weather: Variable, clear skies/cool to hot/humid with thunderstorms

Location ID	Injection Depth (ft bgs)	Date	Time Injection Started	Time Injection Completed	Guar Gel (Gal)	ZVI (lbs)	Sand (lbs)	Water Blaster Injection Pressure (PSI)	Average Slurry Injection Pressure (PSI)	Notes
IW-18	34	4/12/2022	14:25	15:01	475	1,102	550	4,400	150	
IW-20	32	4/13/2022	7:55	8:21	390	1,102	550	4,400	100	
IW-17	35	4/13/2022	9:08	9:33	350	1,650	725	4,400	100	
IW-18	38	4/13/2022	11:33	11:51	300	1,102	400	4,400	80	
IW-20	36	4/13/2022	12:58	13:18	200	1,102	500	4,400	100	
IW-24	30	4/19/2022	8:08	8:41	340	1,102	550	4,400	125	
IW-17	38	4/19/2022	9:54	10:29	400	1,650	825	4,400	100	
IW-18	42	4/19/2022	12:24	12:47	320	1,102	550	4,400	130	
IW-20	40	4/19/2022	13:22	13:44	320	1,102	600	4,400	140	
IW-24	34	4/19/2022	14:20	14:42	160	1,102	600	4,400	150	
IW-18	46	4/19/2022	15:01	15:24	210	1,102	750	4,400	150	
IW-17	41	4/20/2022	8:06	8:29	290	1,450	225	4,400	100	Hydraulic Connection 26 Ft South West from Old 8 Inch Boring
IW-20	44	4/20/2022	9:14	9:36	210	1,202	600	4,400	100	
IW-18	50	4/20/2022	10:09	10:30	210	1,150	550	4,400	70	
IW-24	38	4/20/2022	12:46	13:12	300	1,102	550	4,400	100	
IW-20	48	4/20/2022	13:37	13:56	220	1,102	550	4,400	100	
IW-24	42	4/20/2022	14:59	15:17	210	1,102	550	4,400	80	
IW-24	46	4/21/2022	7:45	8:06	210	1,102	550	4,400	100	
IW-20	52	4/21/2022	8:25	8:45	180	1,102	550	4,400	110	
IW-18	54	4/21/2022	9:15	9:32	190	1,102	450	4,400	150	
IW-24	50	4/21/2022	10:04	10:23	190	1,102	550	4,400	100	
IW-20	56	4/21/2022	10:38	10:56	190	1,102	550	4,400	120	
IW-18	58	4/21/2022	13:08	13:25	190	1,102	400	4,400	90	Hydraulic Connection 45 Ft West from Old 8 Inch Boring
IW-24	54	4/21/2022	13:40	13:59	200	1,102	650	4,400	150	
IW-20	60	4/21/2022	14:21	14:39	190	1,102	550	4,400	130	
IW-24	58	4/21/2022	15:04	15:24	170	1,102	550	4,400	100	
IW-17	44	4/25/2022	9:28	9:50	280	1,650	825	4,400	90	
IW-24	62	4/25/2022	10:30	10:46	200	1,102	525	4,400	140	
IW-18	62	4/25/2022	12:42	13:01	200	1,102	525	4,400	200	
IW-17	47	4/25/2022	13:45	14:04	280	1,650	825	4,400	120	
IW-23	20	4/25/2022	14:40	14:50	40	400	100	4,400	130	Daylight 2 Ft North West 5 Gallons from Old Borehole
IW-19	31	4/25/2022	15:17	15:31	200	1,102	525	4,400	150	Hydraulic Connection 11 Ft South West through Old Borehole
IW-17	50	4/26/2022	7:51	8:13	280	1,650	825	4,400	175	
IW-23	23	4/26/2022	9:00	9:23	200	1,650	825	4,400	100	
IW-19	34	4/26/2022	10:11	13:19	50	600	150	4,400	200	Daylight South West 5 Ft 5 Gallons Underneath Gravel and Tarp
IW-17	53	4/26/2022	13:44	14:01	200	1,650	825	4,400	120	
IW-23	26	4/26/2022	14:40	15:01	100	800	400	4,400	180	Surfacing through unknown feature 18 Ft North West from Underneath Gravel and Tarp 200 pounds ZVI
IW-21	39	4/27/2022	8:30	8:44	150	1,102	550	4,400	125	
IW-17	56	4/27/2022	9:19	9:35	190	1,650	825	4,400	150	
IW-27	27	4/27/2022	10:12	10:24	140	1,102	550	4,400	170	
IW-28	24	4/27/2022	13:30	14:06	375	1,650	825	4,400	100	
IW-17	59	4/28/2022	9:52	10:43	300	1,650	825	4,400	120	
IW-21	43	4/28/2022	12:16	12:36	200	1,102	550	4,400	150	
IW-27	31	4/28/2022	12:55	13:07	135	1,102	550	4,400	150	
IW-28	27	4/28/2022	13:39	13:50	200	1,650	825	4,400	100	Hydraulic Connection to IW -23 and Daylight 36 Ft North 5 Gallons (Chase)
IW-28	30	5/2/2022	7:40	8:05	120	1,550	400	4,400	130	Daylight 2 FT North East from underneath Asphalt
IW-22	29	5/2/2022	9:14	9:30	220	1,102	550	4,400	150	
IW-21	47	5/2/2022	10:41	11:02	120	1,002	250	4,400	110	Daylight 15 Ft West 15 Gallons Slurry
IW-23	29	5/2/2022	13:24	13:44	250	1,650	825	4,400	100	
IW-27	38	5/2/2022	14:14	14:28	180	1,102	550	4,400	175	
IW-19	37	5/2/2022	14:53	15:13	220	1,650	825	4,400	120	
IW-22	33	5/3/2022	7:20	7:48	400	1,102	550	4,400	200	
IW-28	33	5/3/2022	8:35	9:04	380	1,650	825	4,400	185	
IW-23	32	5/3/2022	9:41	10:04	300	1,650	875	4,400	120	
IW-27	40	5/3/2022	10:53	11:08	250	1,102	550	4,400	190	
IW-19	40	5/3/2022	13:14	13:35	280	1,650	825	4,400	125	
IW-28	36	5/3/2022	14:02	14:23	290	1,650	825	4,400	150	
IW-27	43	5/3/2022	15:36	15:50	225	1,102	550	4,400	150	

DPT Jet Injection Log

Project Name: SWMU 211-A Bioremediation Remedial Action
Project Number: PO-0010222
Field Personnel: Doug Knight, Spencer Halstrom, Justin Burroughs, Dean Varner, Eric Flanegan
Date: 4/12/22-7/13/22
Weather: Variable, clear skies/cool to hot/humid with thunderstorms

Location ID	Injection Depth (ft bgs)	Date	Time Injection Started	Time Injection Completed	Guar Gel (Gal)	ZVI (lbs)	Sand (lbs)	Water Blaster Injection Pressure (PSI)	Average Slurry Injection Pressure (PSI)	Notes
IW-22	37	5/4/2022	7:21	7:42	280	1,102	650	4,400	130	
IW-19	43	5/4/2022	8:46	9:14	290	1,650	825	4,400	140	
IW-23	35	5/4/2022	10:04	10:26	250	1,750	825	4,400	150	
IW-32	45	5/4/2022	10:40	11:10	280	1,102	550	4,400	200	
IW-19	46	5/4/2022	13:34	13:58	250	1,650	825	4,400	125	
IW-32	49	5/4/2022	14:27	14:49	260	1,102	550	4,400	200	
IW-27	47	5/4/2022	15:39	15:54	250	1,102	550	4,400	175	
IW-23	38	5/5/2022	7:30	8:00	390	1,850	1,050	4,400	190	
IW-31	36	5/5/2022	8:17	8:34	150	1,102	550	4,400	140	
IW-32	53	5/5/2022	9:05	9:23	200	1,102	550	4,400	160	
IW-21B	57	5/5/2022	9:48	9:56	30	200	100	4,400	135	Daylight 3 Ft North West 5 Gallons Slurry
IW-27	52	5/5/2022	12:30	12:47	200	1,102	550	4,400	150	
IW-22	41	5/9/2022	7:40	7:51	200	1,102	550	4,400	110	
IW-31	38	5/9/2022	8:18	8:35	280	1,102	550	4,400	120	
IW-23	41	5/9/2022	9:03	9:26	290	1,850	825	4,400	90	
IW-28	39	5/9/2022	9:53	10:14	290	1,650	825	4,400	100	
IW-27	55	5/9/2022	10:40	10:55	200	1,102	550	4,400	105	
IW-31	42	5/9/2022	12:47	13:10	275	1,102	550	4,400	100	
IW-19	49	5/9/2022	13:28	13:50	300	1,650	825	4,400	130	
IW-28	42	5/9/2022	14:52	15:13	250	1,650	825	4,400	125	
IW-27	59	5/9/2022	15:30	15:47	140	1,102	550	4,400	150	
IW-31	46	5/10/2022	7:33	7:50	200	1,102	550	4,400	140	
IW-27	63	5/10/2022	8:10	8:27	190	1,102	550	4,400	150	
IW-22	45	5/10/2022	8:41	8:55	150	1,102	550	4,400	120	
IW-23	44	5/10/2022	9:12	9:33	240	1,650	825	4,400	110	
IW-28	45	5/10/2022	10:00	10:20	220	1,650	825	4,400	10	
IW-31	50	5/10/2022	14:40	15:05	180	1,102	550	4,400	130	
IW-22	49	5/10/2022	13:04	13:20	175	1,102	550	5,000	175	
IW-28	48	5/10/2022	13:45	14:06	275	1,650	825	5,000	150	
IW-19	52	5/10/2022	15:20	15:39	260	2,250	1,025	5,000	150	
IW-22	53	5/11/2022	8:20	8:52	290	1,102	550	5,000	175	
IW-31	55	5/11/2022	9:22	9:43	250	1,102	550	5,000	150	
IW-19	55	5/11/2022	10:15	10:41	280	2,250	1,025	5,000	120	
IW-29	32	5/11/2022	13:35	13:58	170	1,102	550	5,000	200	
IW-30	28	5/11/2022	14:32	14:54	190	1,650	825	5,000	80	
IW-31	58	5/11/2022	15:25	15:45	190	1,102	550	5,000	150	
IW-31	62	5/12/2022	11:58	12:20	180	1,102	550	5,000	120	
IW-29	36	5/12/2022	12:46	13:02	160	1,102	550	5,000	100	
IW-30	31	5/12/2022	13:50	14:17	220	1,650	825	5,000	100	
IW-28	51	5/12/2022	15:00	15:20	275	1,650	825	5,000	100	
IW-29	40	5/16/2022	8:37	8:58	190	1,102	550	5,000	120	
IW-30	35	5/16/2022	10:38	11:25	270	1,650	825	5,000	200	
IW-28	55	5/16/2022	13:10	13:44	270	1,650	825	5,000	100	
IW-29	44	5/16/2022	13:52	14:02	200	1,102	550	5,000	100	
IW-30	37	5/16/2022	14:25	14:49	250	1,650	825	5,000	120	
IW-23	47	5/16/2022	15:13	15:38	280	1,850	1,025	5,000	130	
IW-30	40	5/17/2022	7:19	7:51	250	1,650	825	5,000	130	
IW-30	43	5/17/2022	8:15	8:40	240	1,650	825	5,000	100	
IW-29	48	5/17/2022	8:51	9:06	150	1,102	550	5,000	100	
IW-30	46	5/17/2022	9:50	10:10	270	1,650	825	5,000	90	
IW-29	52	5/17/2022	10:44	10:57	150	1,102	550	5,000	130	
IW-30	49	5/17/2022	12:36	12:56	200	1,650	825	5,000	100	
IW-29	56	5/17/2022	13:24	13:39	120	1,102	550	5,000	100	
IW-30	52	5/17/2022	13:56	14:13	250	1,650	825	5,000	100	
IW-30	55	5/17/2022	14:43	15:53	250	1,650	825	5,000	120	
IW-28	57	5/18/2022	9:57	10:19	180	1,650	825	5,000	150	
IW-29	60	5/18/2022	12:25	12:36	130	1,102	550	5,000	130	
IW-28	60	5/18/2022	12:51	13:18	160	1,650	825	5,000	110	

DPT Jet Injection Log

Project Name: SWMU 211-A Bioremediation Remedial Action
Project Number: PO-0010222
Field Personnel: Doug Knight, Spencer Halstrom, Justin Burroughs, Dean Varner, Eric Flanegan
Date: 4/12/22-7/13/22
Weather: Variable, clear skies/cool to hot/humid with thunderstorms

Location ID	Injection Depth (ft bgs)	Date	Time Injection Started	Time Injection Completed	Guar Gel (Gal)	ZVI (lbs)	Sand (lbs)	Water Blaster Injection Pressure (PSI)	Average Slurry Injection Pressure (PSI)	Notes
IW-30	59	5/18/2022	13:56	14:15	180	1,650	825	5,000	150	
IW-29	64	5/18/2022	14:58	15:38	250	1,102	550	5,000	150	
IW-30	61	5/19/2022	7:17	7:45	280	1,650	825	5,000	130	
IW-22	57	5/19/2022	8:04	8:25	220	1,102	550	5,000	150	
IW-28	63	5/19/2022	8:58	9:52	325	1,650	825	5,000	200	
IW-23	50	5/19/2022	10:15	10:49	220	1,600	960	5,000	120	
IW-19	58	5/19/2022	13:02	13:28	300	2,675	1,400	5,000	120	
IW-23	53	5/19/2022	13:59	14:15	200	1,600	960	5,000	100	
IW-22	61	5/19/2022	14:30	14:48	150	1,102	550	5,000	120	Hydraulic Connection to IW -19
IW-19	61	5/23/2022	7:46	8:21	450	2,675	1,400	5,000	120	
IW-23	56	5/23/2022	9:19	9:43	300	1,600	960	5,000	100	
IW-26	35	5/23/2022	10:08	10:22	150	1,102	550	5,000	90	
IW-25	45	5/23/2022	10:43	10:56	150	1,102	550	5,000	100	
IW-25	49	5/23/2022	13:52	14:02	160	1,102	550	5,000	100	
IW-23	59	5/23/2022	14:41	14:53	140	1,600	960	5,000	150	
IW-26	39	5/23/2022	15:12	15:22	150	1,102	550	5,000	110	
IW-25	53	5/23/2022	15:42	15:54	150	1,102	550	5,000	110	
IW-25	53	5/24/2022	7:25	7:30	100	567	325	5,000	120	
IW-23	62	5/24/2022	8:07	8:29	250	1,600	960	5,000	120	Hydraulic Connection to IW-28
IW-26	42	5/24/2022	9:10	9:22	150	1,102	550	5,000	110	
IW-26	46	5/24/2022	12:58	13:08	120	1,102	550	5,000	120	
IW-25	57	5/24/2022	13:20	13:41	190	967	675	5,000	100	Daylight 18 Ft North West 100 lbs Slurry
IW-26	50	5/24/2022	15:13	15:36	200	1,667	875	5,000	150	
IW-26	54	5/25/2022	9:48	10:06	220	2,238	1,137	5,000	150	
IW-25	61	5/25/2022	10:40	10:47	50	400	200	5,000	150	Daylight 18 Ft North West 5 lbs Slurry
IW-26	58	5/25/2022	12:52	13:19	170	2,038	737	5,000	150	Daylight 36 Ft West 50 lbs Slurry
IW-26	58	5/25/2022	14:00	14:15	100	200	400	5,000	150	
IW-26	62	5/26/2022	7:05	7:46	400	1,939	900	5,000	180	
IW-33	30	6/1/2022	7:49	7:59	170	1,102	550	5,000	100	
IW-4	28	6/1/2022	8:15	8:29	100	850	250	5,000	100	Daylight 10 Ft North East Through Old 8 Inch Borehole
IW-10	26	6/1/2022	8:55	9:05	125	1,102	550	5,000	75	
IW-3	26	6/1/2022	9:44	10:10	170	1,102	550	5,000	150	
IW-33	34	6/1/2022	10:50	11:05	120	1,102	150	5,000	150	Daylight 12 Ft South East Thorugh Old 8 Inch Borehole
IW-10	30	6/1/2022	13:21	13:35	150	1,102	550	5,000	75	
IW-3	30	6/2/2022	6:59	7:10	140	1,102	550	5,000	80	Daylight 18 Ft West (Chase)
IW-14	35	6/2/2022	8:23	8:36	180	1,102	550	5,000	100	
IW-12	29	6/2/2022	10:40	10:57	180	1,650	825	5,000	140	
IW-11	30	6/2/2022	12:47	13:07	200	1,650	825	5,000	120	
IW-10	35	6/2/2022	13:25	13:36	180	1,102	550	5,000	100	
IW-12	32	6/2/2022	13:51	14:07	120	1,650	825	5,000	150	
IW-14	39	6/2/2022	14:43	15:04	120	1,102	550	5,000	100	
IW-11	33	6/2/2022	15:35	16:06	200	1,650	825	5,000	150	
IW-33	38	6/6/2022	7:52	8:07	200	1,102	1,000	5,000	80	Daylight 7 Ft North West and 13 Ft South West (Chase)
IW-4	32	6/6/2022	9:25	9:43	200	1,350	850	5,000	180	Daylight 7 Ft North East Through Old 8 Inch Borehole (5 Gallons)
IW-10	38	6/6/2022	9:58	10:10	150	1,102	550	5,000	150	
IW-12	35	6/6/2022	10:46	11:03	200	1,650	825	5,000	180	
IW-14	43	6/6/2022	14:51	15:12	150	1,102	550	5,000	125	
IW-11	36	6/7/2022	6:50	7:04	150	1,650	825	5,000	100	
IW-12	38	6/7/2022	7:32	7:44	170	1,650	825	5,000	125	
IW-3	35	6/7/2022	7:59	8:13	120	1,102	550	5,000	100	
IW-10	42	6/7/2022	8:27	8:41	130	1,102	550	5,000	150	
IW-14	47	6/7/2022	9:07	9:18	120	1,102	550	5,000	100	
IW-11	39	6/7/2022	9:36	9:50	200	1,650	825	5,000	110	Hydraulic Connection to MW 579
IW-12	41	6/7/2022	10:45	11:00	200	1,650	825	5,000	125	Hydraulic Connection to IW-3
IW-14	51	6/7/2022	12:54	13:05	120	1,102	550	5,000	150	
IW-12	44	6/7/2022	13:17	13:32	150	1,650	825	5,000	150	
IW-10	46	6/7/2022	14:13	14:20	120	1,102	550	5,000	130	
IW-3	38	6/7/2022	14:39	14:48	120	1,102	550	5,000	120	

DPT Jet Injection Log

Project Name: SWMU 211-A Bioremediation Remedial Action
Project Number: PO-0010222
Field Personnel: Doug Knight, Spencer Halstrom, Justin Burroughs, Dean Varner, Eric Flanegan
Date: 4/12/22-7/13/22
Weather: Variable, clear skies/cool to hot/humid with thunderstorms

Location ID	Injection Depth (ft bgs)	Date	Time Injection Started	Time Injection Completed	Guar Gel (Gal)	ZVI (lbs)	Sand (lbs)	Water Blaster Injection Pressure (PSI)	Average Slurry Injection Pressure (PSI)	Notes
IW-11	42	6/7/2022	15:55	16:13	200	1,650	825	5,000	100	
IW-14	55	6/8/2022	7:13	7:26	150	1,102	550	5,000	180	
IW-11	45	6/8/2022	7:42	7:57	175	1,650	825	5,000	150	
IW-12	47	6/8/2022	8:21	8:36	180	1,650	825	5,000	120	
IW-10	50	6/8/2022	8:53	9:04	125	1,102	550	5,000	150	
IW-3	42	6/8/2022	10:09	10:17	120	1,102	550	5,000	100	
IW-7	24	6/8/2022	10:36	11:14	250	1,650	825	5,000	120	
IW-3	46	6/8/2022	14:47	14:57	120	1,102	550	5,000	100	Hydraulic Connection to IW-10
IW-7	27	6/9/2022	7:26	7:44	180	1,650	825	5,000	140	
IW-12	50	6/9/2022	8:18	8:37	180	1,650	825	5,000	100	
IW-14	59	6/9/2022	8:49	9:03	125	1,102	550	5,000	125	
IW-11	48	6/9/2022	9:32	9:47	165	1,650	825	5,000	125	
IW-10	55	6/9/2022	10:07	10:44	275	1,102	550	5,000	200	
IW-3	50	6/9/2022	13:29	13:42	140	1,102	550	5,000	100	
IW-12	53	6/9/2022	14:26	14:45	200	1,650	825	5,000	100	
IW-11	51	6/9/2022	15:23	15:41	220	1,650	825	5,000	100	
IW-14	63	6/13/2022	7:34	7:49	150	1,102	550	5,000	100	
IW-11	54	6/13/2022	8:09	8:28	150	1,650	825	5,000	100	
IW-11	57	6/13/2022	10:35	10:59	210	1,650	825	5,000	175	
IW-10	58	6/13/2022	13:23	13:43	200	1,102	550	5,000	125	
IW-3	54	6/13/2022	14:13	14:29	175	1,102	550	5,000	150	Daylight 18 Ft East (Chase)
IW-11	60	6/13/2022	15:15	15:40	240	1,650	825	5,000	150	Hydraulic Connection to IW-14
IW-15	34	6/14/2022	7:49	8:07	145	1,102	550	5,000	100	
IW-7	31	6/14/2022	9:35	9:53	175	1,650	825	5,000	75	
IW-12	57	6/14/2022	10:11	10:30	210	1,650	825	5,000	100	
IW-33	42	6/14/2022	12:42	12:56	130	1,102	550	5,000	100	
IW-10	62	6/14/2022	13:25	13:37	130	1,102	550	5,000	100	
IW-12	59	6/14/2022	14:41	15:01	200	1,650	825	5,000	100	
IW-4	36	6/15/2022	8:09	8:21	145	1,102	550	5,000	50	
IW-7	33	6/15/2022	8:46	9:01	180	1,650	825	5,000	100	
IW-12	62	6/15/2022	9:42	9:59	190	1,650	825	5,000	125	Hydraulic Connection to IW -10
IW-15	37	6/15/2022	10:30	10:42	140	1,102	550	5,000	75	
IW-33	46	6/15/2022	12:50	13:01	120	1,102	550	5,000	100	
IW-7	36	6/15/2022	13:24	13:42	200	1,650	825	5,000	100	
IW-4	40	6/15/2022	14:19	14:30	140	1,102	550	5,000	75	Daylight 10 Ft North East Through Old 8 Inch Borehole (Chase)
IW-11	63	6/15/2022	15:03	15:20	225	1,650	825	5,000	150	
IW-7	39	6/16/2022	7:41	7:59	190	1,650	825	5,000	75	
IW-33	50	6/16/2022	8:18	8:29	115	1,102	550	5,000	75	
IW-3	59	6/16/2022	8:58	9:08	120	1,102	550	5,000	150	
IW-15	41	6/16/2022	9:33	9:44	125	1,102	550	5,000	100	
IW-4	44	6/16/2022	10:05	10:16	150	1,102	550	5,000	100	
IW-33	54	6/21/2022	7:24	7:35	120	1,102	550	5,000	130	
IW-9	24	6/21/2022	8:03	8:35	220	1,650	825	5,000	100	
IW-7	42	6/21/2022	9:00	9:18	250	1,650	825	5,000	150	
IW-3	62	6/21/2022	10:08	10:29	200	1,102	550	5,000	180	Hydraulic Connection to IW-33
IW-4	48	6/21/2022	11:59	12:17	200	1,102	550	5,000	200	
IW-2	24	6/21/2022	12:38	12:54	150	1,102	550	5,000	120	
IW-33	58	6/21/2022	13:22	13:39	175	1,102	550	5,000	100	Hydraulic Connection to IW-3
IW-9	27	6/21/2022	14:45	15:06	250	1,650	825	5,000	150	
IW-7	45	6/21/2022	15:25	15:43	275	1,650	825	5,000	120	
IW-2	28	6/22/2022	7:53	8:06	150	1,102	550	5,000	120	
IW-33	62	6/22/2022	8:19	8:31	150	1,102	550	5,000	180	
IW-7	48	6/22/2022	0:03	9:23	220	1,650	825	5,000	120	
IW-9	30	6/22/2022	9:38	9:54	200	1,650	825	5,000	100	
IW-4	52	6/22/2022	10:11	10:22	175	1,102	550	5,000	150	
IW-15	45	6/22/2022	10:40	10:52	150	1,102	550	5,000	100	
IW-2	32	6/22/2022	13:00	13:12	120	1,102	550	5,000	100	
IW-4	56	6/22/2022	13:23	13:42	150	1,102	550	5,000	100	

DPT Jet Injection Log

Project Name: SWMU 211-A Bioremediation Remedial Action
Project Number: PO-0010222
Field Personnel: Doug Knight, Spencer Halstrom, Justin Burroughs, Dean Varner, Eric Flanegan
Date: 4/12/22-7/13/22
Weather: Variable, clear skies/cool to hot/humid with thunderstorms

Location ID	Injection Depth (ft bgs)	Date	Time Injection Started	Time Injection Completed	Guar Gel (Gal)	ZVI (lbs)	Sand (lbs)	Water Blaster Injection Pressure (PSI)	Average Slurry Injection Pressure (PSI)	Notes
IW-15	49	6/22/2022	14:09	14:20	150	1,102	550	5,000	120	
IW-6	23	6/22/2022	14:45	15:01	180	1,650	825	5,000	125	
IW-7	51	6/22/2022	15:14	15:30	200	1,650	825	5,000	150	
IW-15	53	6/23/2022	7:08	7:19	150	1,102	550	5,000	100	
IW-6	26	6/23/2022	7:40	7:52	200	1,650	825	5,000	100	
IW-7	54	6/23/2022	8:12	8:27	280	1,650	825	5,000	200	
IW-4	60	6/23/2022	8:57	9:10	175	1,102	550	5,000	200	
IW-15	57	6/23/2022	9:22	9:31	175	1,102	550	5,000	150	
IW-2	36	6/23/2022	9:43	9:53	175	1,102	550	5,000	150	
IW-15	61	6/23/2022	10:12	10:23	175	1,102	550	5,000	150	
IW-7	57	6/23/2022	10:56	11:15	250	1,650	825	5,000	180	
IW-9	33	6/27/2022	7:00	7:19	220	1,650	825	5,000	120	
IW-2	40	6/27/2022	7:30	7:40	140	1,102	550	5,000	100	
IW-6	29	6/27/2022	7:58	8:11	200	1,650	825	5,000	100	
IW-7	60	6/27/2022	8:20	8:32	200	1,650	825	5,000	150	
IW-2	44	6/27/2022	9:14	9:23	150	1,102	550	5,000	130	
IW-2	48	6/27/2022	9:58	10:09	140	1,102	550	5,000	110	
IW-9	36	6/27/2022	10:19	10:31	210	1,650	825	5,000	120	
IW-6	32	6/27/2022	11:03	11:15	220	1,650	825	5,000	125	
IW-7	63	6/27/2022	13:00	13:20	200	1,650	825	5,000	180	
IW-9	39	6/27/2022	13:33	13:46	180	1,650	825	5,000	120	
IW-2	52	6/27/2022	13:54	14:04	150	1,102	550	5,000	100	
IW-6	35	6/27/2022	14:40	14:56	225	1,650	825	5,000	100	
IW-9	42	6/27/2022	15:21	15:35	200	1,650	825	5,000	100	
IW-2	56	6/27/2022	15:42	15:53	175	1,102	550	5,000	120	
IW-9	45	6/28/2022	7:30	7:47	200	1,650	825	5,000	150	
IW-6	38	6/28/2022	8:51	9:04	275	1,650	825	5,000	150	
IW-2	60	6/28/2022	9:20	9:31	150	1,102	550	5,000	200	
IW-6	41	6/28/2022	10:03	10:22	150	1,650	825	5,000	200	
IW-9	48	6/28/2022	10:33	10:46	200	1,650	825	5,000	150	
IW-6	44	6/28/2022	12:17	12:31	220	1,650	825	5,000	130	
IW-9	51	6/28/2022	12:57	13:14	200	1,650	825	5,000	200	
IW-1	26	6/28/2022	13:33	13:42	120	1,102	550	5,000	100	
IW-6	47	6/28/2022	14:33	14:47	175	1,650	825	5,000	100	
IW-9	54	6/28/2022	15:09	16:02	280	1,650	825	5,000	250	
IW-6	50	6/29/2022	6:51	7:10	250	1,650	825	5,000	100	
IW-13	35	6/29/2022	7:35	8:06	175	1,102	550	5,000	150	
IW-9	57	6/29/2022	8:40	9:11	200	1,650	825	5,000	175	
IW-6	53	6/29/2022	9:28	9:43	175	1,650	825	5,000	125	
IW-16	40	6/29/2022	9:52	10:08	150	1,102	550	5,000	80	
IW-6	56	6/29/2022	11:29	11:45	200	1,650	825	5,000	180	
IW-9	60	6/29/2022	12:06	12:28	175	1,650	825	5,000	100	
IW-8	25	6/29/2022	12:48	13:15	220	1,650	825	5,000	100	
IW-6	59	6/29/2022	13:45	14:35	300	1,650	825	5,000	220	
IW-5	21	6/29/2022	14:51	15:15	280	1,650	825	5,000	180	
IW-6	62	6/30/2022	6:57	7:33	370	1,650	825	5,000	280	
IW-9	63	6/30/2022	7:56	8:21	220	1,650	825	5,000	200	
IW-5	24	6/30/2022	9:11	9:29	180	1,650	825	5,000	50	
IW-3	39	6/30/2022	9:40	9:52	175	1,102	550	5,000	125	
IW-8	28	6/30/2022	10:13	10:26	200	1,650	825	5,000	75	
IW-5	27	6/30/2022	11:11	11:26	220	1,650	825	5,000	80	
IW-8	31	6/30/2022	11:49	12:28	225	1,650	825	5,000	150	
IW-13	43	6/30/2022	12:57	13:08	125	1,102	550	5,000	100	
IW-5	30	6/30/2022	13:15	13:31	200	1,650	825	5,000	50	
IW-1	30	7/6/2022	7:15	7:27	150	1,102	550	5,000	100	
IW-5	33	7/6/2022	7:41	8:30	250	1,650	825	5,000	250	
IW-8	34	7/6/2022	9:00	9:39	300	1,650	825	5,000	200	
IW-13	47	7/6/2022	10:25	10:40	220	1,650	825	5,000	120	

DPT Jet Injection Log

Project Name: SWMU 211-A Bioremediation Remedial Action
Project Number: PO-0010222
Field Personnel: Doug Knight, Spencer Halstrom, Justin Burroughs, Dean Varner, Eric Flanegan
Date: 4/12/22-7/13/22
Weather: Variable, clear skies/cool to hot/humid with thunderstorms

Location ID	Injection Depth (ft bgs)	Date	Time Injection Started	Time Injection Completed	Guar Gel (Gal)	ZVI (lbs)	Sand (lbs)	Water Blaster Injection Pressure (PSI)	Average Slurry Injection Pressure (PSI)	Notes
IW-1	34	7/6/2022	11:39	12:20	250	1,102	550	5,000	175	
IW-5	36	7/6/2022	13:00	13:28	280	1,650	825	5,000	125	
IW-13	51	7/6/2022	14:13	14:27	170	1,102	550	5,000	150	
IW-8	37	7/6/2022	15:09	15:31	220	1,650	825	5,000	150	
IW-1	38	7/7/2022	7:33	7:47	150	1,102	550	5,000	100	
IW-5	39	7/7/2022	9:00	9:19	240	1,650	825	5,000	100	
IW-13	55	7/7/2022	10:04	10:25	175	1,102	550	5,000	180	
IW-8	40	7/7/2022	10:53	11:17	220	1,650	825	5,000	150	
IW-1	42	7/7/2022	12:20	12:49	175	1,102	550	5,000	120	
IW-5	42	7/7/2022	13:25	13:49	200	1,650	825	5,000	150	
IW-16	44	7/7/2022	13:50	14:30	180	1,102	550	5,000	150	
IW-8	43	7/11/2022	7:37	8:14	400	1,650	825	5,000	100	
IW-1	46	7/11/2022	8:44	9:03	145	1,102	550	5,000	100	
IW-5	45	7/11/2022	9:34	10:08	250	1,650	825	5,000	100	
IW-16	48	7/11/2022	10:57	11:25	150	1,102	550	5,000	100	
IW-5	48	7/11/2022	12:55	13:14	220	1,650	825	5,000	100	
IW-1	50	7/11/2022	13:42	13:57	150	1,102	550	5,000	100	
IW-8	46	7/11/2022	14:13	14:28	200	1,650	825	5,000	100	
IW-13	59	7/11/2022	14:57	15:11	200	1,102	550	5,000	120	
IW-16	52	7/11/2022	15:36	15:50	170	1,102	550	5,000	100	
IW-1	54	7/12/2022	7:10	7:24	160	1,102	550	5,000	120	
IW-5	51	7/12/2022	7:50	8:08	250	1,650	825	5,000	150	
IW-8	49	7/12/2022	8:25	8:39	220	1,650	825	5,000	100	
IW-13	63	7/12/2022	9:07	9:19	150	1,102	550	5,000	150	
IW-5	54	7/12/2022	10:02	10:18	200	1,650	825	5,000	120	
IW-8	52	7/12/2022	10:48	11:07	200	1,650	825	5,000	100	
IW-1	58	7/12/2022	12:38	12:54	170	1,102	550	5,000	150	
IW-8	55	7/12/2022	13:13	13:28	260	1,650	825	5,000	150	
IW-8	58	7/12/2022	14:58	15:13	240	1,650	825	5,000	110	
IW-5	58	7/13/2022	6:48	7:09	280	1,650	825	5,000	170	
IW-1	62	7/13/2022	7:29	7:42	160	1,102	550	5,000	150	
IW-8	61	7/13/2022	8:02	8:28	300	1,650	825	5,000	200	Hydraulic Connection to IW-13
IW-8	64	7/13/2022	9:57	10:20	280	1,650	825	5,000	150	
IW-5	60	7/13/2022	10:38	10:56	250	2,202	875	5,000	110	
IW-5	63	7/13/2022	12:50	13:13	300	2,202	875	5,000	150	
				Totals	66,240	445,334	221,674			

APPENDIX C

BIOAMENDMENT INJECTION DATA

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Daily Bioamendment Injection Summary

Injection Well ID	Total EVO Solution Injection Volume (gal)	Date of Bioamendment Injection																																	
		7/23/20221	7/25/2022	7/26/2022	7/27/2022	7/28/2022	8/1/2022	8/2/2022	8/3/2022	8/4/2022	8/9/2022	8/10/2022	8/11/2022	8/15/2022	8/16/2022	8/17/2022	8/18/2022	8/19/2022	8/20/2022	8/22/2022	8/23/2022	8/24/2022	8/25/2022	8/29/2022	8/30/2022	8/31/2022	9/7/2022	9/8/2022	9/9/2022	9/10/2022	9/12/2022	9/13/2022	9/14/2022	9/19/2022	9/20/2022
		EVO Solution Injection Volume (gal)	EVO Solution Injection Volume (gal)	EVO Solution Injection Volume (gal)	EVO Solution Injection Volume (gal)	EVO Solution Injection Volume (gal)	EVO Solution Injection Volume (gal)	EVO Solution Injection Volume (gal)	EVO Solution Injection Volume (gal)	EVO Solution Injection Volume (gal)	EVO Solution Injection Volume (gal)	EVO Solution Injection Volume (gal)	EVO Solution Injection Volume (gal)	EVO Solution Injection Volume (gal)	EVO Solution Injection Volume (gal)	EVO Solution Injection Volume (gal)	EVO Solution Injection Volume (gal)	EVO Solution Injection Volume (gal)	EVO Solution Injection Volume (gal)	EVO Solution Injection Volume (gal)	EVO Solution Injection Volume (gal)	EVO Solution Injection Volume (gal)	EVO Solution Injection Volume (gal)	EVO Solution Injection Volume (gal)	EVO Solution Injection Volume (gal)	EVO Solution Injection Volume (gal)	EVO Solution Injection Volume (gal)	EVO Solution Injection Volume (gal)	EVO Solution Injection Volume (gal)	EVO Solution Injection Volume (gal)	EVO Solution Injection Volume (gal)	EVO Solution Injection Volume (gal)	EVO Solution Injection Volume (gal)	EVO Solution Injection Volume (gal)	EVO Solution Injection Volume (gal)
IW-22C	1,942	47	105	147	166	338	437	--	98	146	458	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
IW-26B	2,543	199	578	360	199	78	363	362	396	8	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
IW-22A	1,568	114	172	223	270	789	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
IW-25B	2,279	325	332	224	285	29	617	467	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
IW-21A	1,774	83	9	12	51	100	109	164	245	101	352	548	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
IW-23A	1,464	67	253	112	68	0	0	73	82	68	83	--	--	211	108	110	101	128	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
IW-23C	2,973	364	734	606	635	329	0	305	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
IW-24A	1,369	122	122	168	103	38	271	107	131	111	196	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
IW-27A	1,772	113	172	204	323	104	422	2	92	67	174	67	--	20	12	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
IW-27C	3,195	466	181	438	517	0	18	198	--	--	--	--	--	--	--	--	166	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	1211
IW-19C	1,222	520	33	371	88	0	12	198	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
IW-17A	3,741	185	386	313	297	475	696	510	664	215	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
IW-18B	2,358	388	505	389	585	182	30	279	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
IW-20B	2,649	119	172	163	149	80	628	218	69	144	347	560	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
IW-24C	2,312	69	93	189	170	282	679	180	188	146	316	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
IW-19A	3,080	90	84	103	162	129	794	170	85	208	516	739	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
IW-29C	3,429	--	--	--	--	--	--	--	263	280	496	563	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	308	1519
IW-25A	1,241	--	--	--	--	--	--	--	465	186	381	209	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
IW-28B	3,861	--	--	--	--	--	--	--	215	209	423	497	752	151	171	259	377	320	--	--	--	--	--	--	--	--	--	--	--	425	--	--	--	62	--
IW-30B	751	--	--	--	--	--	--	--	620	104	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	27	--
IW-29A	832	--	--	--	--	--	--	--	408	318	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	106
IW-18A	1,889	--	--	--	--	--	--	--	266	81	223	296	445	124	353	101	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
IW-17B	1,885	--	--	--	--	--	--	--	--	76	323	673	813	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
IW-26A	2,408	--	--	--	--	--	--	--	--	42	437	703	951	275	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
IW-01A	411	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	32	115	78	78	73	35	--	--	--	--	--	--	--	--	--
IW-01B	2,389	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	378	413	519	329	--	533	217	--	--
IW-01C	1,266	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	352	627	287	--	--	--	--	--	--	--	--	--	--	--	--	--	--
IW-02A	46	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	46	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
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IW-03B	1,287	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	75	606	270	336	--	--	--	--	--	--	--	--	--	--	--	--	--
IW-03C	2,845	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	1314	205	--	1167	159	--	--	--	--	--	--	--
IW-04A	96	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	51	45	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
IW-04B	1,924	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	153	639	523	512	--	--	--	--	97	--	--	--	--	--	--	--
IW-04C	1,743	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	309	955	--	--	--	--	--	--	--	--	345	107	--	27	--	--	--
IW-05A	225	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	130	80	15	--	--	--	--	--	--	--	--	--
IW-05B	1,887	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	255	259	193	302	--	656	222	--	--
IW-05C	2,992	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	1169	1356	--	371	96	--	--
IW-06A	55	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	55	--	--	--	--	--	--	--
IW-06B	1,047	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	58	215	206	114	114	171	96	38	--	35	--	--	--	--	--	--	--
IW-06C	4,743	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	1278	1790	880	635	--	160	--	--	--
IW-07A	76	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	76	--	--	--	--	--	--	--	--	--	--	--
IW-07B	2,740	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	45	619	714	75	703	--	--	--	312	272	--	--	--	--	--	--	--
IW-07C	2,983	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	106	963	725	--	--	--	--	591	437	94	--	42	25	--	--
IW-08A	2,030	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	119	831	403	297	80	151	90	8	51	--	--	--	--	--	--	--	--
IW-08B	1,111	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	20	158	217	360	238	5	113	--	--	--	--	--	--	--	--
IW-08C	4,105	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	145	751	637	--	102	86	--	--	1431	404	--	--	--	--	549	--	--
IW-09A	1,794	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	309	523	325	283	152	105	27	70	--	--	--	--	--	--	--	--
IW-09B	423	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	282	27	114	--	--	--	--	--	--	--	--
IW-09C	4,335	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	301	731	580	--	220	--	--	--	892	1611	--	--	--	--	--	--	--
IW-10A	267	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	58	168	--	--	--	--	--	--	24	17	--	--	--	--	--	--	--
IW-10B	1,392	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	228	511	263	160	54	--	--	90	86	--	--	--	--	--	--	--
IW-10C	2,731	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	911	90	511	736	386	67	--	--	30	--	--
IW-11A	2,629	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	238	344	252	97	379	521	615	143	--	32	8	--	--
IW-11B	749	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	283	169	259	38	--	--	--	--	--	--	--
IW-11C	2,036	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	99	685	338	588	--	--	--	--	--	79	247	--	--	--	--	--	--
IW-12A	2,068	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	97	961	36	275	606	93	--	--	--	--	--	--	--	--	--	--	--
IW-12B	1,828	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	539	628	166	401	94	--	--	--	--	--	--	--
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IW-13A	2,028	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	89	70	31	286	430	1122	--	--	--	--	--	--
IW-13B	1,732	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	274	860	497	101	--	--	--	--
IW-14A	564	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	180	117	53	214	--	--	--	--	--	--	--	--
IW-14B	2,951	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	86	490	492	229	523	146	--	--	59	556	206	125	--	39	--	--	--
IW-15A	1,819	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	62	175	163	126	142	218	166	75	392	300	--	--	--	--	--	--	--
IW-15B	1,731	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	467	869	266	129	--	--	--	--
IW-16A	1,619	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	746	625	--	248	--	--	--
IW-19B	1,651	--	--	--	--	--	--	--	--	--	--	--	--	151	273	249	471	422	85	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
IW-20A	1,664	--	--	--	--	--	--	--	--	--	--	--	--	187	315	340	534	288	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
IW-21B	378	--	--	--	--	--	--	--	--	--	--	--	--	50	61	43	107	117	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
IW-22B	3,725	--	--	--	--	--	--	--	--	--	286	1257	2182	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
IW-23B	2,378	--	--	--	--	--	--	--	--	--	400	769	1209	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
IW-24B	1,002	--	--	--	--	--	--	--	--	--	--	--	--	320	364	122	103	93	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
IW-27B	1,088	--	--	--	--	--	--	--	--	--	208	292	533	31	8	16	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
IW-28A	250	--	--	--	--	--	--	--	--	--	--	--	--	134	6	45	--	65	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
IW-28C	2,450	--	--	--	--	--	--	--	--	--	852	1153	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	445	--	--	--	--	--
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IW-30C	3,892	--	--	--	--	--	--	--	--	--	--	--	--	343	475	455	235	196	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	367	1821
IW-31A	14	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	14	--
IW-31B	3,258	--	--	--	--	--	--	--	--	--	--	--	--	435	407	356	431	414	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	248	967
IW-32A	1,325	--	--	--	--	--	--	--	--	--	--	--	--	318	514	248	100	145	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
IW-33A	789	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	469	320	--	--	--	--	--	--	--	--	--	--	--	--	--	--
IW-33B	1,795	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	60	265	229	525	325	38	232	121	--	--	--	--	--	--	--
IW-33C	1,334	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	264	1070	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--

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