FINAL
ENGINEERING EVALUATION AND COST ANALYSIS NON-TIME-CRITICAL REMOVAL ACTION FOR TREATMENT OF PFAS-IMPACTED WATER IN MANCHESTER MUNICIPAL SUPPLY WELL #4 NEAR JOINT BASE MCGUIRE-DIX-LAKEHURST, NEW JERSEY

Contract Number: W9128F-21-D-0047
Delivery Order W9128F22F0290

Prepared for:

U.S. Air Force
Civil Engineer Center

U.S. Army Corps of Engineers
Omaha District

Prepared by:

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July 2025

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Final
Engineering Evaluation and Cost Analysis
Non-Time-Critical Removal Action for Treatment of PFAS-Impacted Water in Manchester Township Municipal Supply Well #4 Near Joint Base McGuire-Dix-Lakehurst, New Jersey

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Executive Summary

The United States Air Force (USAF) will conduct a non-time-critical removal action (NTCRA) to address per- and polyfluorinated alkyl substances (PFAS) contamination in the drinking water at Joint Base McGuire-Dix-Lakehurst (JBMDL), New Jersey; specifically, this NTCRA will reduce or eliminate PFAS contamination detected in the Manchester Township Municipal Drinking Water Supply Well #4, which is part of the Public Water System (PWS; NJ1518005), located downgradient (southeast) from the Lakehurst portion of JBMDL. This NTCRA will be performed in accordance with, and satisfies the requirements of, the Comprehensive Environmental Response, Compensation and Liability Act (CERCLA), Title 42 United States Code (U.S.C.) §9604, 9620; Section 2701 of the Defense Environmental Restoration Program (DERP), 10 USC § 2701; Section 300.415 of the National Oil and Hazardous Substances Pollution Contingency Plan (NCP), 40 Code of Federal Regulations (CFR) § 300.415; Executive Order (EO) 12580, as amended; and U.S. Environmental Protection Agency (EPA), DoD, and USAF guidance. The NTCRA will be implemented in accordance with the NCP as presented in 40 CFR §300.415(a) and 40 CFR §300.415(b).

PFAS are a class of synthetic fluorinated chemicals used in industrial and consumer products, including defense-related applications. In 1970, DoD components, including the USAF, began using aqueous film-forming foam (AFFF) firefighting agents containing PFAS, to extinguish petroleum fires. On April 26, 2024, EPA published a final National Primary Drinking Water Regulation establishing nationwide drinking water standards for six PFAS under the Safe Drinking Water Act. EPA's drinking water rule includes enforceable MCLs for perfluorooctane sulfonate (PFOS) (4 ppt), perfluorooctanoic acid (PFOA) (4 ppt), hexafluoropropylene oxide dimer acid [HPFO-DA] (10 ppt), perfluorononanoic acid [PFNA] (10 ppt), and perfluorohexane sulfonic acid [PFHxS] (10 ppt) as contaminants with individuals MCLs and PFAS mixtures containing at least two or more of PFHxS, PFNA, HFPO-DA, and perfluorobutanesulfonic acid using a Hazard Index MCL to account for the combined and co-occurring levels of these PFAS in drinking water. This rule applies to public drinking water systems. PFOS concentrations have been detected in quarterly sampling of Well #4 conducted by Manchester Township since 2021. In March 2023, PFOS was detected in Manchester's municipal drinking water supply Well #4 at a concentration of 16 parts per trillion (ppt), which exceeded the federal MCL for PFOS of 4 ppt. Since the installation of the temporary system in May of 2023, all PFAS concentrations have been nondetect.

This EE/CA identifies and evaluates proposed alternatives for completing the NTCRA. The EE/CA identifies removal action objectives (RAOs); identifies and evaluates potential alternatives for conducting the removal action; and recommends the best-suited removal action alternative. This removal action will provide a permanent solution to protect human health from exposure to PFAS above the EPA MCLs. The RAO of the NTCRA is to eliminate the imminent and substantial danger to human health posed by PFAS-contaminated drinking water from the Manchester Township Municipal Drinking Water Supply Well #4. The following alternatives for achieving the RAO were evaluated:

- Alternative 1 - No action. With this alternative, no action would be taken to address PFAS contamination in Well #4. This alternative was evaluated to provide a baseline against which to compare the other alternatives.
- Alternative 2 - IX Permanent System Installation.
- Alternative 3 - GAC Permanent System Installation.

The three removal action alternatives were evaluated with respect to effectiveness, implementability, and cost. Alternative 1, no action, is included to provide a baseline against which to compare the other alternatives, has the lowest degree of effectiveness and implementability. Alternatives 2 and 3 would require ongoing operation and maintenance (O&M) of the treatment system equipment, long-term monitoring for PFAS and annual media change-outs and disposal based on system design criteria. The changeout frequency for both media is accounted in a yearly basis, but the IX resin media is anticipated to need almost twice the number of bed volumes prior to breakthrough. Alternative 3 would require a connection to the sewer system for managing the backwashing effluent. Therefore, Alternative 3 has a higher capital cost than Alternative 2 but has lower long-term O&M costs. The overall cost for Alternative 2 is less than Alternative 3. Resin has proven to have longer capacity than GAC and is effective for treating both short- and long-chain PFAS compared to the cheaper to replace GAC option. Overall, Alternative 2 is preferred since it is protective of human health and the environment and provides the best combination of primary balancing attributes that comply with the EPA MCLs and has the lowest costs that meet the RAO.

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LIST OF ACRONYMS AND ABBREVIATIONS

ng/L	nanograms per liter
AFFF	aqueous film-forming foam
AFCEC	Air Force Civil Engineer Center
ARAR	Applicable or relevant and appropriate requirements
CAS	Chemical Abstracts Service
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
CFR	Code of Federal Regulations
DAF	Department of the Air Force
DERP	Defense Environmental Restoration Program
DoD	U.S. Department of Defense
DoDI	U.S. Department of Defense Instruction
EE/CA	engineering evaluation and cost analysis
EO	Executive Order
EPA	U.S. Environmental Protection Agency
ESA	Environmental Services Agreement
FTA	fire training area
GAC	granular activated carbon
gpm	gallons per minute
HA	Health Advisory
HGL	HydroGeoLogic, Inc.
HFPO-DA	hexafluoropropylene oxide dimer acid
IX	ion exchange
JBMDL	Joint Base McGuire-Dix-Lakehurst
NATTC	Naval Air Technical Training Center
NCP	National Contingency Plan
NJDEP	New Jersey Department of Environmental Protection
NJMCL	New Jersey Maximum Contaminant Level
NPL	National Priorities List
No.	number
NTCRA	non-time-critical removal action
O&M	operation and maintenance
OSWER	Office of Solid Waste and Emergency Response

PA	Preliminary Assessment
PFAS	per- and polyfluoroalkyl substances
PFHxS	perfluorohexanesulfonic acid
PFNA	perfluorononanoic acid
PFOA	perfluorooctanoic acid
PFOS	perfluorooctane sulfonate (also known as perfluorooctanesulfonic acid, Chemical Abstracts Service No. 1763-23-1)
ppt	parts per trillion
PWS	Public Water System
RAO	removal action objective
RCRA	Resource Conservation and Recovery Act
RPM	Potomac-Raritan-Magothy
SI	Site Inspection
TBC	To-Be-Considered
TCRA	time-critical removal action
USAF	U.S. Air Force
USC	U.S. Code

FINAL
ENGINEERING EVALUATION AND COST ANALYSIS
NON-TIME-CRITICAL REMOVAL ACTION TREATMENT OF PFAS-IMPACTED WATER IN MANCHESTER TOWNSHIP MUNICIPAL SUPPLY WELL #4 NEAR JOINT BASE MCGUIRE-DIX-LAKEHURST, NEW JERSEY

1.0 INTRODUCTION

1.1 PURPOSE AND OBJECTIVE

The U.S. Air Force (USAF) will conduct a non-time-critical removal action (NTCRA) to address historical releases by USAF of compounds into the environment that are a potential cause of concentrations of perfluorooctanoic acid (PFOA, Chemical Abstracts Service [CAS] Number [No.] 335-67-1) and/or perfluorooctane sulfonic acid (also known as perfluorooctane sulfonate [PFOS], CAS No. 1763-23-1) detected in the Manchester Township Municipal Drinking Water Supply Well #4, which is part of the Public Water System (PWS; NJ1518005), located downgradient (southeast) from the Lakehurst portion of Joint Base MacGuire-Dix-Lakehurst (JBMDL), New Jersey.

This engineering evaluation and cost analysis (EE/CA) was prepared in accordance with the *Guidance on Conducting Non-Time-Critical Removal Actions Under Comprehensive Environmental Response, Compensation, and Liability Act* (CERCLA) (U.S. Environmental Protection Agency (EPA, 1993) and identifies and evaluates the proposed alternatives for completing the NTCRA to protect human health from exposure to these contaminants in drinking water at Well #4. Per this guidance, the EE/CA defines the removal action objective (RAO), identifies and evaluates potential alternatives for conducting the removal action, and recommends the best-suited removal action alternative.

The USAF has the authority to undertake this removal action pursuant to Sections 104 and 120 of the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA), 42 U.S. Code (USC) §§ 9604, 9620; Section 2701 of the Defense Environmental Restoration Program (DERP), 10 USC § 2701; Section 300.415 of the National Oil and Hazardous Substances Pollution Contingency Plan (NCP), 40 Code of Federal Regulations (CFR) § 300.415; Executive Order (EO) 12580, as amended; and EPA, DoD, and USAF guidance. The NTCRA will be implemented in accordance with the NCP as presented in 40 CFR §300.415(a) and 40 CFR §300.415(b).

The removal action will provide a permanent solution to protect human health from exposure to per- and polyfluoroalkyl substances (PFAS) in drinking water from Well #4 in accordance with federal and state standards. The March 2023 PFOS concentration at Well #4 of 16 nanograms per liter (ng/L) exceeded the New Jersey Maximum Contaminant Level (NJMCL) of 13 ng/L but was lower than 70 ng/L for PFOS and PFOA (individually or combined) that was used by DoD as a trigger level at the time. PFAS concentrations in Well #4 also exceeded the nationwide drinking water standards for PFAS (4 ng/L) included in the final National Primary Drinking Water Regulation, published by EPA in April 2024.

1.2 REPORT ORGANIZATION

This EE/CA is organized in the following sections:

- Section 2.0 provides site characterization information, including site description and background; previous and ongoing removal actions; source, nature, and extent of contamination; analytical data; and a streamlined risk evaluation.
- Section 3.0 defines the RAOs for the proposed removal action.
- Section 4.0 presents the identification and analysis of removal action alternatives.
- Section 5.0 provides a comparative analysis of removal action alternatives.
- Section 6.0 identifies the recommended removal action alternative.
- Section 7.0 provides references used in support of this report.
- Appendix A presents the cost estimate for each alternative.

2.0 SITE CHARACTERIZATION

2.1 SITE DESCRIPTION AND BACKGROUND

JBMDL is a tri-service, joint-installation partnership complex that resulted from the October 1, 2009, merger of McGuire Air Force Base (operations beginning 1941), Naval Air Engineering Station Lakehurst (operations beginning 1916) and the Fort Dix Army Base (operations beginning 1917). JBMDL covers approximately 42,000 contiguous acres within the Burlington and Ocean Counties, New Jersey (Figure 1).

The majority of the 3,562-acre McGuire Area is an airfield with two active runways. The Dix Area is a permanent Class 1 Army installation with an area of approximately 30,784 acres. The Lakehurst Area encompasses 7,430 acres and is used by the U.S. Navy for research, maintenance, firefighter training, testing, and disposal activities. This combined installation complex is surrounded by 58,000 acres of state and federally managed land to protect against encroachment (Aerostar, 2016). JBMDL is a National Priorities List (NPL) site and encompasses a large and complex cleanup program that addresses over 150 separate sites under multiple federal facilities' agreements.

In 1970, DoD components, including the USAF, began using aqueous film-forming foam (AFFF) firefighting agents containing PFAS, to extinguish petroleum fires. Lakehurst was listed on the NPL in 1984. All Lakehurst area sites are NPL and managed under a Federal Facilities Agreement in accordance with CERCLA (Naval Air Engineering Center, 1989). Specifically, Site 16 (Area C) – Naval Air Technical Training Center (NATTC) Fire School is listed in the FFA; Site 16 was changed to AT016 (NATTC Firefighting Training Area) when JBMDL was formed. AT016, located in the southeastern part of JBMDL, is the source of the off-base PFAS contamination, thus the reason for the NTCRA and this EE/CA (HGL, 2023). For the remainder of this document, AT016 will be referenced as AFFF Area 18.

2.2 PREVIOUS AND ONGOING ACTIONS

Previous PFAS actions conducted on- and off-base to date include the following:

- In 2014, a Preliminary Assessment (PA) was conducted at JBMDL in accordance with CERCLA and NCP §300.420 with the goal of identifying locations of potential releases of legacy AFFF containing PFAS into the environment (HGL, 2015). The results of the PA indicated known or potential releases of AFFF to Fire Training Areas (FTAs), crash sites, non-FTAs (hangars), fire stations, and other AFFF spills and AFFF releases.
- In 2016, a Site Inspection (SI) of 34 potential PFAS release sites, consolidated into 21 AFFF areas, was commenced to determine the presence or absence of PFAS in soil, groundwater, surface water, and sediment in the areas (Aerostar SES, 2019). Groundwater monitoring for PFAS at JBMDL was limited to the shallow Kirkwood- Cohansey aquifer. The combined concentrations of PFOA and PFOS were detected in groundwater at concentrations greater than 70 ppt at all of the 21 AFFF areas. Potential receptor pathways with immediate impacts to human health were identified. The findings of a 2014 screening level USAF-wide investigation of AFFF releases at four sites at McGuire were also included in the 2019 SI Report.

- In 2016, a PFAS Groundwater Sampling and Mitigation Program was developed based on the results of the SI to accomplish the following: confirm potential off-base migration of PFAS in groundwater at concentrations exceeding 70 ppt at the base boundary; identify initial off-base areas with drinking water receptors with privately owned potable wells based on groundwater flow direction; conduct door-to-door reconnaissance of the off-base areas for potentially impacted drinking water receptors; offer PFAS sampling to properties with a drinking water well, if present; and provide mitigation to properties where results exceed 70 ppt. The sampling results identified off-base migration of PFAS at five off-base areas: one area associated with McGuire (AFFF Area 4 and AFFF Areas 5 through 9), one area associated with Dix (AFFF Area 14), and three areas associated with Lakehurst (AFFF Areas 16, 17, and 18).
- As of March 2021, drinking water from 195 properties had been sampled in the vicinity of JBMDL. A routine monitoring program was initiated at individual properties where PFAS was detected (as authorized by the property owner). In addition, where PFAS was detected above 70 ppt, the USAF provided drinking water mitigation that included bottled water as an immediate, short-term solution and the installation of filtration systems (e.g., granular activated carbon (GAC) or reverse osmosis) and associated routine maintenance and performance monitoring (BERS-Weston Services JVA LLC, 2022 and CAPE, 2020).
- As of September 2022, the USAF completed the response actions to connect all impacted properties in Manchester Township that were previously mitigated through short-term solutions to Manchester Township municipal water as a more permanent long-term solution (HGL, 2023).
- In December 2022, the USAF expanded its off-base PFAS investigation and collected limited surface water and groundwater samples throughout Manchester Township. PFOS was detected as high as 190 ng/L in monitoring wells and 260 ng/L in surface water. The maximum concentrations were collocated approximately 1 mile off base east of JBMDL-Lakehurst. Well #4 is located approximately 1 mile east of JBMDL-Lakehurst within this area of off-base detected PFOS impacts (HGL, 2023).

Current PFAS actions include the following activities:

- A PFAS Remedial Investigation started in 2020 at 21 PFAS sites at JBMDL to characterize the nature and extent of PFAS contamination resulting from former fire training and maintenance activities affecting soil, groundwater, surface water, and sediment on- and off-base. A draft Remedial Investigation Report is expected to be completed in early 2025.
- In 2022, an Expanded Site Inspection was conducted that included the installation and sampling of 18 off-base groundwater monitoring wells as well as surface water sampling. The data were used to update conceptual site models for off-base areas impacted by PFAS. The results of this investigation are being evaluated and will be provided in the Expanded Site Inspection Report, which will be available in the online Air Force Civil Engineer Center (AFCEC) Administrative Record upon finalization (HGL, 2023).
- The USAF agreed in May 2023 to provide wellhead treatment for the Manchester Well #4 since greater than 70 ppt for PFOS were detected in upgradient wells in March 2023. The other eight municipal water supply wells, which are part of the Eastern Service Area of Manchester Township, do not require mitigation measures at this moment due to the depth

of these wells (i.e., screened below surficial aquifer) or are not hydraulically connected to a USAF PFAS release or not solely attributed to a USAF release. Monitoring these eight wells for PFAS is conducted by the Manchester Township.

- An Environmental Services Agreement (ESA) between the USAF and the Manchester Township, signed in June 2023, obtained the services of Manchester Township to control human exposure to PFAS contamination in Manchester Township Municipal Supply Well #4 at levels above the federal MCL for PFOS and to assist USAF in carrying out its responsibilities under CERCLA and the Defense Environmental Restoration Program (AFCEC, 2023).
- Given the upgradient PFAS concentrations, a Time-Critical Removal Action (TCRA) Memorandum was published in May 2023 indicating that the USAF expects this municipal supply well to exceed 70 ppt for PFOS in the future. This will result in drinking water exceeding 70 ppt for PFOS and necessitate the installation of a temporary system (USAF, 2023).
- The temporary PFAS removal treatment system at Well #4 is installed over a leveling pad foundation and includes three vessels with ion-exchange (IX) resin and a skid with six bag filter housings. The treatment system has a total capacity of 450 gallons per minute (gpm) and was in operation from May 2023 until October 2023, which is the normal operational period for this well to cover seasonal demand (USAF, 2023).
- In 2024, the ESA was amended to obtain a longer-term, temporary water treatment system at Well #4 with a capacity of 500 gpm and utilizing GAC instead of IX. The change in filtration media was made to meet the state permit requirements of weatherproofing and security. The GAC effectively treated PFAS to non-detect concentrations from May to October 2024.

2.3 SOURCE, NATURE, AND EXTENT OF CONTAMINATION

Since the initiation of the 2016 PFAS Groundwater Sampling and Migration Plan, off-site migration of the PFAS has been confirmed in five off-base areas surrounding JBMDL. Private drinking water receptors have been identified in each of the off-base areas; routine monitoring continues at a semi-annual or annual frequency for off-base properties that had PFAS detected in their potable drinking water well but at concentrations below 70 ppt; and mitigation solutions have been implemented and continue to be monitored and maintained at PFAS-impacted properties with PFAS concentrations detected above 70 ppt in their potable drinking water wells.

Legacy AFFF contains long-chain fluorosurfactants, having eight or more fluorinated chained-carbon atoms (referred to as C8), while the new AFFF formula contains shorter chain molecules with six or less fluorinated chained-carbon atoms (referred to as C6). JBMDL has removed all C8 AFFF in its hangar systems, fire response vehicles, and stockpiled inventory, and replaced it with C6 AFFF as of 2019. Groundwater monitoring for PFAS conducted during SIs at JBMDL was limited to the shallow Kirkwood-Cohansey aquifer. In most cases, PFOS was detected in higher concentrations than other PFAS analytes. Maximum PFOS concentrations detected were as follows: 260,000 ng/L in groundwater (Area 5 McGuire Active Fire Training Area); 9,300 micrograms per kilogram (μg/kg) in soil (AFFF Area 18 Lakehurst); 750 J μg/kg in sediment (AFFF Area 18 Lakehurst); and 8,200 J ng/L in surface water (Area 6 McGuire former FTA FT-013).

The source of the PFAS contamination to the off-base Municipal Supply Well #4 included in this EE/CA is attributed to AFFF Area 18 historical release(s) in the JBMDL Lakehurst area. AFFF Area 18 is the former NATTC, served as an FTA from 1970 through 1986, and is located in the eastern portion of Lakehurst. Fire training activities were performed daily to monthly in two separate fire pits. It is assumed, based upon the operational period and lack of information about containment in JBMDL records, that the fire pits were unlined. Approximately 7,680 to 11,520 gallons of AFFF were used during the 16 years that the FTA was in operation, impacting the shallow surficial aquifer.

Although the nature and extent has not been fully delineated, base boundary sampling confirmed shallow aquifer groundwater impacts of PFAS exceeding 70 ppt. Shallow groundwater at AFFF Area 18 area flows to the east/southeast based on the topography (Tehama, 2020). AFFF Area 18 is situated approximately 1,200 ft from the closest section of the JBMDL boundary. Residential and commercial properties are located in the area beyond the JBMDL boundary, where shallow groundwater is used for drinking water. The maximum total PFOA/PFOS concentration detected at Area 18 was 18,100 ng/L, which is greater than 70 ppt. Also, perfluorononanoic acid concentrations in groundwater ranged up to 130 ng/L within the base boundary, which is above the federal MCL. The formerly mitigated off-base properties and Manchester Municipal Supply Well #4 are in close proximity to the base boundary with drinking water wells screened within the shallow surficial aquifer.

2.4 ANALYTICAL DATA

As described above, various PFAS investigations have been completed at JBMDL starting in 2016. The analytical results for completed and published investigations discussed in Section 2.2 are available on the Administrative Record website at https://ar.cce.af.mil/. Analytical data for the ongoing investigations and monitoring events will be published in the Administrative Record upon completion of the associated reports.

PFOS concentrations have been detected in quarterly sampling of Well #4 conducted by Manchester Township since 2021. In March 2023, PFOS was detected in Manchester's municipal drinking water supply Well #4 at a concentration of 16 parts per trillion (ppt), which exceeded the federal MCL for PFOS of 4 ppt. Since the installation of the temporary system in May of 2023, all PFAS concentrations have been non-detect in the effluent samples. Table 1 and Figure 2 present the PFOS, PFOA, and perfluorononanoic acid (PFNA) analytical results from Well #4 from December 2020 to October 2024. The analytical results presented in Table 1 and Figure 2 characterize the effluent sample collected from Well #4. The effluent samples from Well #4 have been collected post PFAS treatment since June 2023.

The only available pre-treated PFAS analytical results from Well #4 since March 2023 are from the sampling event conducted in October 2024. The pre-treated influent PFOS concentration at Well #4 in October 2024 was 8.22 ppt, which is less than the March 2023 PFOS concentration of 16 ppt. It should be noted that PFOA (10.1 ppt) exceeded the enforceable MCLs in the untreated influent sample at Well #4 in October 2024, but was nondetect after the GAC treatment system in October 2024, as shown in Table 1.

2.5 STREAMLINED RISK EVALUATION

On April 26, 2024, EPA published a final National Primary Drinking Water Regulation establishing nationwide drinking water standards for six PFAS under the Safe Drinking Water Act. EPA's drinking water rule includes enforceable MCLs for PFOS (4 ppt), PFOA (4 ppt), hexafluoropropylene oxide dimer acid [HPFO-DA] (10 ppt), PFNA (10 ppt), and PFHxS (10 ppt) as contaminants with individuals MCLs and PFAS mixtures containing at least two or more of PFHxS, PFNA, HFPO-DA, and perfluorobutanesulfonic acid using a Hazard Index MCL to account for the combined and co-occurring levels of these PFAS in drinking water. This rule applies to public drinking water systems. These are promulgated, chemical-specific applicable or relevant and appropriate requirements (ARARs) for PFOS or PFOA. In accordance with the September 3, 2024 Assistant Secretary of Defense (Sustainment) Memorandum, *Prioritization of Department of Defense Cleanup Actions to Implement the Federal Drinking Water Standards for Per-and Polyfluoroalkyl Substances Under the Defense Environmental Restoration Program* (DoD, 2024), DoD will initiate CERCLA removal actions to address public drinking water systems above the MCLs impacted by certain PFAS from DoD activities and coordinate with regulators to meet the PFAS MCLs as soon as possible but not later than April 2029. MCLs were calculated to protect human health from exposure to certain PFAS in drinking water. In this calculation, toxicity values developed by EPA were used to estimate health-protective concentrations. These toxicity values qualify as Tier 3 values under EPA's Office of Solid Waste and Emergency Response (OSWER) Directive 9285.7-53. In accordance with DoD Instruction (DoDI) 4715.18, Tier 3 toxicity values may be used as a basis for determining the extent of the risk and for taking any necessary response action.

Prior to EPA's rulemaking to establish MCLs for certain PFAS, the USAF identified the existence of an imminent and substantial danger to human health due to the presence of PFOS concentrations above the NJMCL outside the JBMDL boundary. The USAF agreed to complete a TCRA in May 2023 at Manchester Municipal Supply Well #4 and other drinking water wells downgradient of JBMDL with identified exceedances of the NJMCL of 13 ng/L of PFOS to mitigate exposure of off-base receptors to drinking water due to AFFF Area 18 historical release(s), which is located hydraulically upgradient of Well #4 (Figure 2).The TCRA allowed the installation of a temporary system at Manchester Municipal Supply Well #4 to treat drinking water. The well is only operational from May to October every year to meet seasonal demand.

Normally under NCP and EPA's guidance, an unacceptable human health risk is present when cumulative human health cancer risk exceeds 1×10^{-4} or the non-cancer hazard index exceeds 1. It should be noted that excess lifetime cancer risk of less than 1×10^{-4} is not acceptable by default; site-specific considerations may lead risk managers to determine that cancer risk between the risk management range of 1×10^{-6} and 1×10^{-4} is still unacceptable. However, the Air Force, as the lead authority to this action, considers the risk between 1×10^{-6} and 1×10^{-4} to be acceptable. As described above, the EPA MCLs were calculated by EPA to be protective of human health under a drinking water scenario. Well #4 has PFAS concentrations which are above the EPA MCLs and also exceed the NJMCL. Therefore, if PFOS and/or PFOA concentrations (individually or combined) in a potable water supply (such as Well #4 which is used for drinking water) are greater than the EPA MCLs, there are reasonable grounds to suggest that an unacceptable risk, threat, and danger to human health is present.

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3.0 IDENTIFICATION OF REMOVAL ACTION OBJECTIVES

This section identifies the statutory framework of removal actions and determines the removal scope based on the RAOs.

3.1 STATUTORY FRAMEWORK

This response action is performed pursuant to CERCLA and the NCP under the authority delegated by the Office of the President of the United States through EO 12580 as redelegated. This Executive Order, as implemented through DoDI 4715.07 and DoD Manual 4715.20 as amended, provides USAF with authorization to conduct removal actions. The DERP provides funding to USAF for removal actions conducted under CERCLA (DERP, 2012). As shown in **Table 1**, sampling results from Manchester Supply Well #4 demonstrated the presence of PFOS above the EPA MCL of 4 ng/L and NJMCL of 13 ng/L, as a result of historical releases of AFFF at Area 18 of JBMDL. In addition to the PFOS results at Well #4, PFOA results also exceed the EPA MCLs established in April 2024. Based on these results, USAF has determined that an imminent and substantial threat to human health exists (see Section 2.5). Therefore, a removal action is authorized under CERCLA to address PFAS in drinking water from this production well.

The EPA has categorized removal actions in three ways (emergency, time-critical, and non-time-critical) based on the type of situation, the urgency and threat of the release or potential release, and the subsequent period in which the action must be initiated. As discussed in Section 2, a TCRA was completed in June 2023 with the installation of a portable ion-exchange (IX) treatment system to treat water from Manchester municipal supply well #4 that operates at a capacity of 450 gallons per minute. Manchester Township operated Well #4 in 2023 under an emergency permit obtained from the NJDEP; the permit was approved for a maximum of 1-year. The IX filtration system was effective at treating the PFAS to non-detect levels through the duration of the season and permit. To address other rules and requirements not specific to PFAS treatment, the system was modified in 2024 to include two 10-foot diameter vessels with GAC. The GAC filtration system was effective at treating the PFAS to non-detect levels through the duration of the season. This modification was not due to the IX not being able to achieve compliance with federal or state MCLs.

This removal action is non-time-critical because the potable GAC treatment system has a temporary permit approval until May 31, 2027, and the planning period from the time this removal action was determined to be necessary to the time when the removal action will be initiated is greater than 6 months. This EE/CA provides an analysis of three removal alternatives for PFAS at Manchester Municipal Well #4, including no further action, and recommends a removal action alternative. This EE/CA has been prepared pursuant to Section 300.415(b)(4)(i) of the NCP and its mandated public comment period provide an opportunity for public input regarding the cleanup process.

Removal actions are usually interim measures that, to the extent practicable, must contribute to the efficient performance of any anticipated, long-term remedial action. The GAC treatment system is a temporary solution that was considered as an interim measure. One other example of a removal action listed in 40 CFR 300.415(e) is provision of an alternate water supply, such as bottled water, until a permanent remedy can be implemented. USAF is the lead federal agency for a removal action to address PFAS contamination in off-base drinking water supply wells that the USAF determines is attributable to its activities and poses an imminent and substantial danger to public health or welfare since PFAS concentrations exceed federal and state MCLs. As such, the USAF has final approval authority, with state and EPA concurrence, over the recommended alternative and all public participation activities. This EE/CA complies with the requirements of CERCLA, DERP, the NCP, and EO 12580.

3.2 DETERMINATION OF REMOVAL ACTION SCOPE AND STATUTORY LIMITS ON REMOVAL ACTIONS

The scope of this removal action is to eliminate exposure to PFAS in drinking water at concentrations greater than the federal and state MCLs at Manchester Municipal Supply Well #4, which is located downgradient of AFFF Release Area 18 at JBMDL (**Figure 2**). USAF's intent is to select long-term removal actions that eliminate risk and reduce disruption to the water suppliers and residents while also minimizing cost and contributing to efficient performance of any long-term remedial action selected by USAF with respect to the PFAS release.

The RAO specifies what the proposed removal action is expected to accomplish. In other words, it defines the goals for the removal action. As such, RAOs are site-specific and are influenced by the nature and extent of chemical contamination, current and potentially threatened resources, and the potential for human and environmental exposure. Based on the NCP requirements and the newly established federal standards, the following RAO was developed for the NTCRA at Well #4:

- Eliminate human exposure via ingestion of drinking water contaminated with PFAS at concentrations above the EPA established MCLs for PFOA = 4 ppt; PFOS = 4 ppt; perfluorohexane sulfonic acid = 10 ppt; hexafluoropropylene oxide dimer acid = 10 ppt; and perfluorononanoic acid = 10 ppt or a Hazard Index of 1 for a mixture of at least two or more of PFHxS, PFNA, HFPO-DA, and perfluorobutanesulfonic acid. These concentrations are lower than those established by the state.

3.3 DETERMINATION OF REMOVAL SCHEDULE

The removal schedule calls for completing the EE/CA by March 2026, publishing a NTCRA Memorandum, and completing an ESA to fund the design and construction prior to implementing the selected alternative. The permit for the existing system expires in May 2027 and it is anticipated to cover the needs of the township without any media changeout until 2027. The current ESA covers the yearly operation of the temporary GAC system from May to October until 2025. The ESA with the Manchester Township will need to be extended until 2027. There is sufficient time until 2027 to complete the initial scoping, prepare proposals, award, and develop all the required work plans and designs to implement the selected permanent remedy. Once the permanent remedy is implemented, the estimated duration of the removal action is 6 months from May to October of every year. A detailed schedule has not been developed at this time.

3.4 APPLICABLE OR RELEVANT AND APPROPRIATE REQUIREMENTS

ARARs are federal and state human health and environmental requirements used to define the appropriate extent of site cleanup, identify sensitive land areas or land uses, develop response alternatives, and direct site cleanup. ARARs analysis remains a part of the removal decision process since the NCP requires that in removals, ARARS be met to the extent practicable. .

Potential ARARs and To-Be-Considered (TBC) requirements identified for this removal action are presented in Table 2. Proposed removal action alternatives are evaluated with respect to compliance with ARARs. The identification of ARARs is an iterative process, and the final determination of ARARs will be made in the Action Memorandum, which will be submitted after public review of this EE/CA as part of the selection process for this response action (40 CFR 300.415[n]). The Action Memorandum is the primary Decision Document for NTCRAs and provides a concise, written record of the decision to select an appropriate removal action. It substantiates the need for a removal action, identifies the proposed action, and explains the rationale for the removal action.

3.5 PLANNED REMEDIAL ACTIVITIES

Currently, specific remedial activities for PFAS in groundwater are not planned because investigation of the off-Base contamination is ongoing. Until there is a more complete understanding of the nature and extent of PFAS contamination, as well as risks to human health and the environment via other exposure routes, potential remedial activities for these contaminants cannot be identified. Regardless, because the potential removal action alternatives will not substantially alter the groundwater flow and chemical conditions, the alternatives considered for this NTCRA will not interfere with or hinder any future groundwater remedial action for the entire aquifer zone.

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4.0 IDENTIFICATION AND ANALYSIS OF REMOVAL ACTION ALTERNATIVES

Removal action alternatives are identified and developed with the overall goals of protecting human health and the environment and achieving the RAO in a cost-effective manner. The EE/CA identifies the removal action alternatives and analyzes the effectiveness, implementability, and cost of various alternatives that may satisfy the RAO. Descriptions for each of these evaluation criteria are as follows:

- **Effectiveness:** An alternative's effectiveness is its ability to meet the objective within the scope of the removal action. This criterion considers protection of public health, the community, the workers during implementation, and the environment. The following factors also are considered:
  - Long-term effectiveness and permanence, the extent and effectiveness of controls that may be required to manage the risk posed by treatment residuals and/or untreated wastes;
  - Reduction of toxicity, mobility, or volume through treatment; and
  - Short-term effectiveness, which addresses the effects of the alternative during implementation before the RAO has been met.
- **Implementability:** This criterion evaluates the technical and administrative feasibility of each alternative and the availability of the services and materials needed to implement the alternative. This criterion also considers state and community acceptance. The acceptance of an alternative would be evaluated during the public comment period and preparation of the NTCRA Memorandum that announces which alternative the USAF decides to implement. The final version of this EE/CA would be made available for a 30-day public comment period, and all comments received would be summarized and addressed in the responsiveness summary section of the Action Memorandum.
  - Technical feasibility: The ability of the technology to implement the remedy and the technology's reliability. Technical feasibility is evaluated from construction through operation and maintenance (O&M) of the removal action. This factor also evaluates whether an alternative would contribute to the anticipated performance of any remedial activity.
  - Administrative feasibility: This factor evaluates those activities needed to coordinate with other offices and agencies, the need for off-site permits, adherence to applicable non-environmental laws, and concerns of other regulatory agencies.
  - Availability of services and materials: This factor considers whether the requisite personnel, equipment, and materials would be available during the removal action schedule; the adequacy of off-site treatment capacity if the alternative includes off-site removal and treatment of waste; and whether the technology has been sufficiently developed for full-scale application.
- **Cost:** The direct and indirect capital and O&M costs that are estimated for each alternative. Costs are calculated on a present worth basis for any removal action lasting longer than 12 months. Ranges or approximations of relative capital, O&M, and periodic costs are used

rather than detailed estimates and are representative of actual costs within +50 percent or -30 percent. Annual costs and periodic costs are estimated over a 30-year performance period. Alternatives that provide effectiveness and implementability like those of other alternatives, but at a greater cost, can be eliminated (40 CFR § 300.430(e)(7)(iii)) (EPA, 1988).

4.1 REMOVAL ACTION SCREENING

There were removal actions initially considered for evaluation such as installing a new deeper well, covering the capacity provided by Well #4 with a surface water supply system, or using a municipal water interconnection with an adjacent township/borough. These actions are not included in any of the alternatives presented in Section 4.2; the rationale for eliminating them from further consideration is discussed below:

1. The installation of a deeper well to the Upper Potomac-Raritan-Magothy (RPM) aquifer was screened out due to the rejection of the New Jersey Department of Environmental Protection (NJDEP) Bureau of Water Allocation and Well Permitting to install additional wells within the Township's Eastern Service Area where Well #4 is located. The rationale for not allowing an increase in the annual allocation in the Upper RPM is documented in a letter dated October 25, 2019, and addressed to the Water Utility Department of the Manchester Township (NJDEP, 2019).

   As stated in the letter, Manchester Township is located within portions of Areas of Critical Water Concern and is precluded by law (N.J.A.C. 7:19-8.3[j]) from providing additional allocation from the affected aquifers and would not approve a diversion that would cause additional drawdown with these Areas. The letter listed the only options that Manchester Township has for additional water supply, and these are as follows:

   a) Providing treatment for the contaminated Cohansey wells, such as Well #4 and the temporary system;
   b) Connecting the Eastern and Western service areas;
   c) Installing wells in the far western portion of the Township at the Mt. Laurel-Wenonah aquifer;
   d) Attempting to locate uncontaminated wells within the Cohansey aquifer; and
   e) Purchasing water through the Toms River interconnection.

   Option (a) is considered as a valid alternative and discussed in detail in the following sections. Options (b) and (c) were discussed with the Manchester Township Water Utility and are considered only feasible if the need for additional capacity for both Western and Eastern Service Areas is not met with the existing drinking water production wells. Option (d) is not technically feasible based on the current understanding of the extent of PFAS-contaminated water in the Cohansey aquifer. The rationale for eliminating option (e) is provided below.

2. The installation of a system near a surface water body in the Eastern Service Area of Manchester Township has two technical factors that led to its elimination as an alternative. Based on available analytical results, off-base surface water concentrations of PFOS are higher than the off-base groundwater results from wells such as Well #4 (USAF, 2023). In

addition, the seasonal demand between May and October of 450 gpm is not likely attainable from any local surface water bodies.

3. An interconnection with associated distribution lines with the adjacent Borough of Lakehurst, Jackson Township, or Toms River Township was discussed with the Manchester Township representatives during a visit at the treatment facility TP002009 on October 16, 2024. An interconnection vault with the Borough of Lakehurst has already been constructed and the water mains are extended to either side of the vault, but additional appurtenant equipment is needed to complete the connection. Even if this interconnection is completed, Lakehurst would not be able to provide enough water to match the yield of Well #4. A grant to expand Lakehurst's public water system is pending but an increase on Lakehurst's capacity to provide drinking water to Manchester Township through the interconnection will take years. Manchester Township has an interconnection with Toms River Township to purchase water in an emergency at a high cost. Regardless the cost, Toms River Township would not commit to providing long-term drinking water to Manchester Township. Finally, there is no interconnect with Jackson Township and in addition, the agreement between the two townships would only be for emergency use only. Therefore, none of the surrounding borough/townships can offer a long-term solution.

4.2 REMOVAL ACTION ALTERNATIVES

PFAS remediation technologies are focused on removing, destroying, or immobilizing PFAS from groundwater. Common methods include GAC, IX resin, and high-pressure membrane systems like nanofiltrations and reversed osmosis. Since GAC and IX have both been tested at Well #4 individually under normal operational conditions for at least an entire season (May to October), the alternatives below are constructed on the basis of site experience, site data, and applicable literature information. Therefore, no alternatives were constructed with the potential implementation of a high-pressure membrane system or the combined implementation of GAC and IX since each technology was individually effective in meeting the goals. The removal action alternatives are listed below.

- **Alternative 1, No Further Action:** With this alternative, no USAF action would be taken to address PFOS contamination in Manchester Municipal Supply Well #4, which would result in exposure to PFOS levels exceeding the NJMCL and EPA MCL. This alternative provides a baseline against which the other removal action alternatives can be evaluated.
- **Alternative 2, IX Permanent System Installation:** A permanent system with IX at the treatment facility TP002009 will consist six carbon steel, epoxy-coated vessels filled with IX resin (Purolite PFA694E ion-exchange resin, 60 cubic feet per vessel), two skid-mounted 6-filter housings with 10-micron #2 bag filters, and appurtenant equipment and fittings. Three of the six vessels will be working in parallel. The other three vessels will operate in parallel and in a lead-lag configuration with the first three vessels. This configuration conforms with N.J.A.C. 7:10-11. Annual O&M would include monthly influent and effluent sampling events (May to October), periodic system maintenance, and changeout of the IX resin (three vessels) every six years. To eliminate the need of winterization, the existing treatment facility will be expanded to house the IX vessels and the filter housings.

- **Alternative 3, GAC Permanent System Installation:** A permanent system with GAC at the treatment facility TP002009 will consist of two vessels, containing 20,000 pounds of GAC combined, connected in series in a lead/lag configuration. Two skid-mounted 6-filter housings with 10-micron #2 bag filters will remove contaminants and extend the life of the carbon media. This configuration conforms with N.J.A.C. 7:10-11 and also satisfies the NJDEP mandated empty bed contact time of 20 minutes. Annual O&M would include monthly influent and effluent sampling events (May to October), periodic system maintenance, and changeout of the GAC (lead vessel) every three years. To meet state requirements, a sewer connection should be extended to handle the backwashing effluent. Winterization of the GAC vessels is feasible without expanding the existing facility or providing a pre-engineered structure, but this alternative includes the expansion of the existing facility to house the GAC vessels and the filter housings to provide a fair comparison with Alternative 2.

The selected removal alternative would need to be operated until replaced by or incorporated into a remedy for PFAS contamination from JBMDL in the groundwater. At this time, it is not known how long it would take to fully investigate and develop a remedy for the PFAS contamination from JBMDL. For the purposes of this EE/CA, it is assumed each alternative would be operated for 30 years, if necessary. Each alternative is described and evaluated below.

4.2.1 Alternative 1 – No Further Action

Alternative 1 consists of no action. As required by the NCP, when developing removal alternatives, the “no action” response is evaluated to provide a comparative baseline against which other alternatives can be assessed. Under this alternative, no action would be conducted to address impacted groundwater at Well #4, and no controls would be implemented to control or monitor potential receptor exposures to PFAS. The contaminated groundwater would be left in place without the implementation of extraction, treatment, or other mitigation measures to reduce the potential for exposure to site contaminants. The existing rented GAC treatment system would not be used beyond 2027 and will be demobilized. Because no removal action would be implemented, site conditions would be unchanged and long-term risks due to exposure to PFAS in drinking water at the properties serviced by Well #4 would remain the same. There would be no costs associated with this alternative as no action would be taken, and the temporary GAC treatment system would not be used in the forthcoming years. The No Further Action alternative would not meet the RAO and would not be protective of human health.

4.2.2 Alternative 2 – IX Permanent System Installation

Alternative 2 consists of modifying the existing treatment facility TP002009 to house six vessels, each with 60 cubic feet of Purolite PFA694E ion-exchange resin, and a skid with six bag filter housings. Each filter vessel will be constructed of carbon steel and will be epoxy coated inside and painted outside. Vessels will be equipped with internals including inlet distributor and underdrain and exterior face piping manifold. Each of the six vessels will contain 60 cubic feet of IX resin (e.g., Purolite PFA694E). Each vessel will be rated for 150 pounds per square inch and capable of operating at approximately 150 gpm each. The lead unit with the three vessels working in parallel will provide a 2.5-minute empty bed contact time. The lag unit with the other three vessels working in parallel will provide similar bed contact time. No backwashing is required for the IX resin.

O&M over a 30-year performance period for the IX permanent system would include monthly sampling events within the anticipated operational period (May to October) and maintenance. It is assumed that the IX resin from three vessels (180 cubic feet) would be replaced every six years over the 30-year performance period based on available research regarding breakthrough of IX resin (Conner et al., 2021; Woodward et al., 2017). A routine maintenance activity included in the O&M costs is the periodic (once a month) run of water through the system during the months outside the operation period. This will maintain the hydration of the resin and avoid unnecessary replacement or rehydration of the resin every year.

4.2.2.1 Effectiveness

This alternative would achieve the RAO and be protective of human health because the IX treatment system was effective in removing PFAS from the drinking water to below the NJMCL values throughout the time it was in operation in 2023 (Table 1). Long-term protectiveness would be achieved if the IX resin media are replaced in a timely manner. Routine sampling of the treated water would ensure proper timing with respect to replacement of the IX resin. It is recommended to sample between the lead and lag units at the beginning, middle, and end of operational period (May to October) in addition to the routine monthly influent and effluent sampling to establish a breakthrough curve. All samples should be analyzed, at minimum, for all PFAS with MCLs in addition to basic water quality parameters (e.g., anions, cations, and total organic carbon).

IX is a well-established technology with respect to removing PFAS from drinking water. This technology is being used at large scale (for example, in municipal water treatment facilities) and small scale (for example, in individual homes) to provide long-term effective treatment of PFAS. The treatment technology contains solid materials to which PFAS adsorb (stick), thus IX resin can reduce the mobility and volume of PFAS in the water that flows through the IX system. The treatment unit does not directly affect PFAS toxicity, but by removing these compounds from drinking water, the potential for exposure is eliminated. Because the IX system would treat only the water that is pumped through it, this alternative would have no effect on the mobility, toxicity, and volume (excluding that which is extracted by the well) of PFAS in the groundwater flowing past the well.

Environmental impacts are primarily associated with transportation and disposal of the spent IX resin as well as the energy use associated with the treatment system. Waste generated during IX system installation and treatment facility modification may include liquid wastewater from the installation of vessels, piping, and related appurtenances and solid materials including piping, valves, vessels, water softeners (if any), and any other related plumbing and masonry system equipment. Waste generated during O&M activities may include liquids and single-use IX resins loaded with PFAS. DoD's interim guidance on destruction or disposal of materials containing PFAS identifies three disposal options for PFAS-contaminated resin: 1) hazardous waste landfills with environmental permits; 2) solid waste landfills with environmental permits that have composite liners, and gas and leachate collection and treatment systems; and 3) hazardous waste incinerators with environmental permits (DoD, 2023a). However, following the issuance of the interim guidance the DoD provided a follow-on memorandum (DoD, 2023b) that placed an indefinite prohibition on resuming incineration of PFAS containing materials. Therefore, the disposal methods for resin and other waste (e.g., liquids) that contains PFAS would be subject to profile analytical results to determine their disposal to a RCRA Subtitle C (hazardous waste landfills with environmental permits) or Subtitle D (non-hazardous waste landfills with environmental permits) landfill.

Any waste materials and liquids generated during the IX system installation and treatment facility modification and operation would be sampled, characterized, and disposed of at an appropriate facility (RCRA Subtitle C or Subtitle D facility). Waste liquids and filter media contaminated with PFAS must be disposed of in a responsible manner. RCRA Subtitle C or Subtitle D facilities are available to accept waste generated during the IX system installation and treatment facility modification and operation to make certain that the risk posed by treatment residuals and/or untreated wastes are responsibly managed to ensure long-term effectiveness and permanence for the protection of public health, the community, and the environment.

The primary short-term risks posed by this alternative are potential accidents from the use of equipment and transportation vehicles required to implement the remedy. The potential for exposure to impacted groundwater during remedy implementation is minimal and does not present short-term risks to on-site workers. It is documented that IX can have an adverse effect on treated water chemistry by increasing corrosivity. This effect is not long-term but could require post-treatment corrosion control or alterations to existing corrosion controls. The treatment facility has a lime slurry feed system for pH and hardness adjustment, as well as polyphosphate injection for iron and manganese sequestration. Regardless, Manchester Township should semiannually sample and analyze for metals and organic matter to ensure significant pretreatment measures are needed or the lifespan of the media is not influenced. Following project planning activities (e.g., initial scoping, proposals, awards, work plans, designs, permits) the period to achieve the RAO for Alternative 2 is approximately 6 months before the Township can start using Well #4. This schedule includes construction, inspection, system startup, sampling, and data validation.

4.2.2.2 Implementability

Installation of the IX system and treatment facility modification would be easily implemented with readily available material, services, and labor. Implementation is technically feasible: components are well-established, available, and can be completed with conventional equipment. The system installation period may take approximately 6 months, including building modification, installation, inspection, system startup, sampling, and data validation before Manchester Township could start using the system. IX resin equipment installation does not require specialized equipment. Required equipment includes, but is not limited to, media vessels, valves, a flow meter, a particulate filter, pressure gauges, sample taps, and other ancillary appurtenances.

Additional administration requirements would include coordinating with the local permitting agencies for extending the treatment facility. The final design package would require 6 months to complete. There is enough space to install the six IX vessels and all the equipment needed to operate the IX permanent system between the treatment plant facility and the underground chlorine contact tank. Manchester Township would be responsible for authorizing the permits and conducting interim and/or follow-up inspections until the system is operational. Licensed civil engineers, electricians and plumbers would be readily available to perform the required modifications to the treatment facility and install the permanent IX treatment system.

4.2.2.3 Cost

The costs for Alternative 2 include the modification of the treatment facility TP0020009 in which Manchester Municipal Supply Well #4 is the sole production well and the installation of the permanent IX treatment system. The capital costs for Alternative 2 include preparation of a Response Action Plan, a Memo, bid package, O&M Manual, permit fees, and NJDEP permit installation design ($89,400), water quality sampling and a preconstruction site visit ($8,600), system fabrication and treatment facility modifications ($651,500), and sampling ($8,300) that would occur every month between May and October. Assuming general and administrative fees (less labor), and contingency costs at 8 percent, 5 percent, and 30 percent, respectively, the total capital cost under this alternative is approximately $1,080,000 (Table 3).

For the purposes of this EE/CA, it is assumed that TP002009 is still only needed to meet seasonal demand; therefore, an alternative water source would not be provided for the Eastern Service Area of Manchester Township. Continued O&M costs associated with the IX system would be the responsibility of the USAF. The O&M costs consist of monthly sampling events and inspections as well as transportation and disposal of IX resin in the lead unit every six years. The total O&M costs, including an annual report, biweekly bag filter changeout, sampling of the influent and effluent (and in between the lead/lag units three times during the operational period) over the first year would be $100,000 for the IX permanent system. The O&M costs are estimated over a 30-year performance period and the total discounted O&M costs over that time, including administration and contingency costs, would be $2,879,000 (Table 3). Appendix A provides a detailed breakdown of the costs for this Alternative. Table 3 also includes the total present cost for this Alternative ($3,959,000).

4.2.3 Alternative 3 – GAC Permanent System Installation

Similar to Alternative 2, this option consists of modifying treatment facility TP002009 to house two GAC vessels connected in series, one after the other, in lead/lag configuration. Each vessel will provide 10 minutes of empty bed contact time at the design flow rate of 500 gpm. This configuration conforms with the mandated empty bed contact time of 20 minutes per N.J.A.C. 7:10-11 et. Seq. The bag filtration system will include two (2) skid mounted filter housings each sized for 500 gpm. Each filter housing will be 24” in diameter and hold six (6) standard 10-micron #2 bag filters. The treatment system will also include an instrumentation system that consists of pressure gauges for each vessel. Even though the GAC is not used as a filtration medium, backwashing will be available at a minimum rate of 12 gpm per square foot of medium surface area. Therefore, a sewer connection will be provided to handle the backwashing effluent. O&M over a 30-year performance period for the GAC permanent system would include monthly sampling events within the anticipated operational period (May to October) and maintenance. It is recommended to sample between the lead and lag units at the beginning, middle, and end of operational period (May to October) in addition to the routine monthly influent and effluent sampling to establish a breakthrough curve. All samples should be analyzed, at minimum, for all PFAS with MCLs in addition to basic water quality parameters (e.g., anions, cations, and total organic carbon). It is assumed that the GAC from one vessel (10,000 pounds) would be replaced every three years over the 30-year performance period based on available research regarding GAC breakthrough (Conner et al., 2021; Woodward et al., 2017).

4.2.3.1 Effectiveness

GAC is a well-established technology with respect to removing PFAS from drinking water. Based on the available literature, GAC is being used at a large scale (for example, in municipal water treatment facilities) and small scale (for example, in individual homes) to provide long-term, effective treatment of PFAS. GAC contains solid material to which PFAS adsorb (stick), thus it can reduce the mobility and volume of PFAS in the water that flows through the system. In 2024, the temporary GAC treatment system treating water from Well #4 was able to achieve the RAO and be protective of human health (Table 1). Although the treatment units do not directly reduce PFAS toxicity, by removing these compounds from drinking water the potential for exposure is effectively eliminated. Because the system would treat only the water that is pumped through it, this alternative would have no effect on the mobility, toxicity, and volume of PFAS in the groundwater flowing past the well.

Environmental impacts are primarily associated with transportation and disposal of the spent GAC as well as the energy use associated with the treatment system. Waste generated during GAC system installation and treatment system modification may include liquid wastewater from the installation of vessels, piping, and related appurtenances and solid materials including piping, valves, vessels, water softeners (if any), along with any other related plumbing and masonry system equipment. Waste generated during O&M activities may include liquids and single-use GAC loaded with PFAS. DoD’s interim guidance on destruction or disposal of materials containing PFAS identifies four disposal options for PFAS-contaminated GAC: 1) carbon reactivation units with environmental permits, 2) hazardous waste landfills with environmental permits, 3) solid waste landfills with environmental permits that have composite liners as well as gas and leachate collection and treatment systems, and 4) hazardous waste incinerators with environmental permits (DoD, 2023a). However, following the issuance of the interim guidance the DoD provided a follow-on memorandum (DoD, 2023b) that placed an indefinite prohibition on resuming incineration of PFAS containing materials. Based on the DoD’s interim guidance, the spent GAC would require handling and disposal in accordance with applicable requirements at carbon reactivation units with environmental permit. Disposal methods for waste (other than GAC) that contains PFAS would be subject to profile analytical results to determine their disposal to RCRA Subtitle C (hazardous waste landfills with environmental permits) or Subtitle D (non-hazardous waste landfills with environmental permits) landfill.

Any waste materials and liquids generated during the GAC system installation and treatment system modification and operation would be sampled, characterized, and disposed of at an appropriate facility (RCRA Subtitle C or Subtitle D facility). Waste liquids and filter media contaminated with PFAS must be disposed of in a responsible manner. RCRA Subtitle C or Subtitle D facilities are available to accept waste generated during the treatment system modification and operation to make certain that the risk posed by treatment residuals and/or untreated wastes are responsibly managed to ensure long-term effectiveness and permanence for the protection of public health, the community, and the environment. Based on the interim DoD guidance and EPA’s proposed PFAS National Primary Drinking Water Regulation, carbon reactivation units with environmental permits that use thermal treatment at high temperatures are currently the best option for disposal of PFAS-contaminated, spent GAC. If it is not cost effective to transport the spent GAC to carbon reactivation units, spent GAC could also be disposed of at an approved RCRA Subtitle C or Subtitle D facility.

The primary short-term risks posed by this alternative are potential accidents from the use of equipment and transportation vehicles required to implement the remedy. The potential for exposure to impacted groundwater during remedy implementation is minimal and does not present short-term risks to on-site workers. Following project planning activities, the period to achieve the RAO for Alternative 3 is approximately 6 months before the Township could start using Well #4. This schedule includes construction, inspection, system startup, sampling, and data validation.

4.2.3.2 Implementability

The installation of the GAC system and treatment facility modification is easily implemented with readily available material, services, and labor. Implementation is technically feasible, and components are well-established, available, and could be completed with conventional equipment. The system installation period may take approximately 6 months, including building modification, treatment system installation, inspection, system startup, sampling, and data validation before Manchester Township could start using the system. GAC equipment installation does not require specialized equipment. Required equipment includes, but is not limited to, media vessels, valves, a flow meter, a particulate filter, pressure gauges, sample taps, and other ancillary appurtenances.

Additional administration requirements would include coordinating with the local permitting agencies for extending the treatment facility. The final design package would require 6 months to complete. There is enough space to install the two GAC vessels, and all the equipment needed to operate the GAC permanent system between the treatment plant facility and the underground chlorine contact tank. Manchester Township would be responsible for authorizing the permits and conducting interim and/or follow-up inspections until the system is operational. Licensed civil engineers, electricians and plumbers would be readily available to perform the required modifications to the treatment facility and install the permanent GAC treatment system.

4.2.3.3 Cost

The costs for Alternative 3 include the modification of the treatment facility TP0020009 in which Manchester Municipal Supply Well #4 is the sole production well and the installation of the permanent GAC treatment system. The capital costs for Alternative 3 include preparation of a Response Action Plan, a Memo, bid package, O&M Manual, permit fees, and NJDEP permit installation design ($104,400), water quality sampling and a preconstruction site visit ($8,600), system fabrication and treatment facility modifications ($1,058,500), and sampling ($8,300) that would occur every month between May and October. Assuming general and administrative fees (less labor), and contingency costs at 8 percent, 5 percent, and 30 percent, respectively, the total capital cost under this alternative is approximately $1,685,000 (Table 3).

For the purposes of this EE/CA, it is assumed that TP002009 would only be needed to meet seasonal demand; therefore, an alternative water source would not be provided for the Eastern Service Area of Manchester Township. Continued O&M costs associated with the GAC system would be the responsibility of the USAF. The O&M costs consist of monthly sampling events and inspections as well as transportation and disposal of GAC from one vessel every three years. The total O&M costs over the first year would be $94,400 for the GAC permanent system. The O&M costs are estimated over a 30-year performance period and the total discounted O&M costs over that time, including administration and contingency costs, would be $2,721,000. (Table 3).

Appendix A provides a detailed breakdown of the costs for this Alternative. Table 3 also includes the total present cost for this Alternative ($4,406,000).

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5.0 COMPARATIVE ANALYSIS OF REMOVAL ACTION ALTERNATIVES

This section provides a comparative analysis of the removal action alternatives described and evaluated in Section 4. The alternatives are described and individually assessed against the effectiveness, implementability, and cost criteria, and a comparative analysis is conducted to evaluate the relative performance of each alternative in relation to each of the criteria. This process identifies key trade-offs that affect the remedy selection. This analysis is summarized in **Table 3**.

5.1 EFFECTIVENESS

Alternative 1, No Action, is included as a baseline for comparison purposes. Since Alternative 1 is not protective of human health, it will not be carried further for consideration. Both Alternatives 2 and 3 are technologies that effectively meet the RAO of preventing exposure of off-base residents to drinking water that contains PFAS at concentrations that, individually or in combination, exceed the EPA MCL and the NJMCL. Based on available research and associated research (Conner et al., 2021; Woodward et al., 2017) , IX resin generally outperforms GAC as it is significantly more effective at adsorbing shorter PFAS chains due to its specific ionic interactions, while GAC tends to be better at removing longer-chain PFAS molecules due to hydrophobic interactions; this means resins are typically the preferred option for treating water with high levels of short-chain PFAS.

IX resin and GAC have been widely implemented for long-term and short-term applications that provide effective protection of human health and the environment from PFAS. Alternatives 2 and 3 both require long-term monitoring and maintenance of the permanent system to maintain long-term effectiveness. Alternative 1 does not include treatment as a principal element; therefore, the ability of this alternative to reduce contaminant toxicity, mobility, or volume is lower than Alternatives 2 and 3. The potential treatment provided by operation of the permanent systems included in Alternatives 2 and 3, however, would have negligible effect on the long-term groundwater remediation. Unlike Alternatives 2 and 3, Alternative 1 would not generate PFAS-contaminated waste. Based on current bed volume treatment metrics, it is anticipated that resin (Alternative 2) would last significantly longer than GAC (Alternative 3) leading to less frequent media changeouts and production of waste.

The primary short-term risks posed by Alternatives 2 and 3 are accidents from the use of equipment and transportation vehicles required to implement the remedies. Also, further transportation and disposal are required for the IX resin and GAC that are generated by the permanent systems. The potential for exposure to impacted groundwater during implementation of both alternatives 2 and 3 is minimal and does not present short-term risks to workers. Short-term risks with the completion of a sewer connection to accommodate GAC backwashing for Alternative 3 are not a concern with Alternative 2. Following coordination with the local permitting agencies, the period to achieve the RAO for both alternatives is short. The time to complete construction, inspection, system startup, sampling, and data validation of the permanent system, either filled with an IX resin or GAC, is the same. Therefore, the short-term risk to receptors is the same between Alternative 2 and 3. The township will be able to use the temporary treatment system until the selected remedy is implemented.

Alternatives 2 and 3 would generate contaminated waste that includes single use IX resin and GAC, which would require carbon regeneration units, hazardous waste landfills, or nonhazardous waste landfills with environmental permits for disposal. Disposal of waste other than resin or GAC would require a RCRA Subtitle C or Subtitle D facility to mitigate the environmental risk posed by the treatment residuals. The need of a sewer connection to accommodate GAC backwashing for Alternative 3 adds short environmental impacts until the completion of the connection.

5.2 IMPLEMENTABILITY

Alternative 1 is not protective of human health and the environment and therefore is not implementable. Alternatives 2 and 3 would be technically feasible to implement since the equipment and personnel required to conduct the response actions are readily available. Both alternatives are proven methods for mitigating the risks associated with PFAS-impacted drinking water. PFAS-contaminated wastes (spent IX resin and GAC) would be generated under Alternatives 2 and 3; however, there are disposal facilities available to accept the materials. The preferred disposal facilities would be a RCRA Subtitle C landfill for spent resin and a carbon reactivation facility for spent GAC.

Alternatives 2 and 3 are administratively feasible to implement by coordinating with the local permitting agencies for the installation of the permanent systems. Alternative 3 would require additional administrative coordination with the local agencies for design reviews and approvals for the sewer connection.

5.3 COST

The progression of present-worth costs from least expensive to most expensive alternative is as follows:

- Alternative 1, No Action—$0
- Alternative 2, Permanent IX System Installation —$3,958,862
- Alternative 3, Permanent GAC System Installation —$4,406,297

Since no action would be implemented under Alternative 1, there are no costs associated with this alternative. Alternative 2 has a lower total cost in comparison to Alternative 3, but the cost for Alternative 3 includes the additional sewer connection and the backwash system to conform with state regulations. The changeout frequency for both media is accounted in a yearly basis, but as discussed in previous sections, the IX resin media is anticipated to need almost twice the number of bed volumes prior to breakthrough. A summary of the comparative analysis of removal action alternatives is presented in **Table 3**. The detailed breakdown of the costs for the removal action alternatives is provided in **Appendix A**.

6.0 RECOMMENDED REMOVAL ACTION ALTERNATIVE

Based on analysis of the effectiveness, implementability, and cost criteria in Section 5, determination of the recommended action and the rationale for the recommendation are presented in this section.

The USAF selected Alternative 2, IX Permanent System Installation as the Recommended Removal Action Alternative for the treatment facility TP002009. Alternative 2 satisfies the RAO by eliminating exposure to PFAS-impacted drinking water with concentrations above the federal and state MCLs. Alternative 2 also is implementable using readily available materials and supplies and utilizes standard installation and construction techniques, has long-term O&M but no long-term obligations or dependence with neighboring townships. The risk of water sources, within the Manchester Township or in neighboring townships, potentially identified as contaminated with PFAS increases the need for reliable systems capable of removing PFAS down to EPA MCLs. Resin has proven to have longer capacity than GAC and is effective for treating both short- and long-chain PFAS compared to the cheaper to replace GAC option. In addition, Alternative 2 costs less than Alternative 3 over the 30-year period.

Overall, Alternative 2 is preferred since it is protective of human health and the environment, as proven during the first year of operation, and provides the best combination of primary balancing attributes that comply with the EPA MCLs and has the lowest costs that meet the RAO.

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TABLES

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Table 1
Well #4 PFAS Drinking Water Sample Results

	Parameter	**PFOS** (ng/L)	**PFOA** (ng/L)	**PFNA** (ng/L)	**HPFO-DA (ng/l)**	**PFHxS (ng/l)**	**Hazard Index**
	EPA MCLs	4	4	10	10	10	1
	NJMCLs	13	14	13	NA	NA	NA
Drinking Water Wells	**Sample Date**						
Well #4	12/7/2020	**8.1**	3.9	<2	NA	NA	NA
	3/4/2021	<2	<2	<2	NA	NA	NA
	6/2/2021	<2	<2	<2	NA	NA	NA
	9/30/2021	**11**	**9.3**	<2	NA	NA	NA
	12/7/2021	**10**	**10**	<2	NA	NA	NA
	3/17/2022	**11**	**10**	<2	NA	NA	NA
	6/2/2022	**12**	**11**	<2	NA	NA	NA
	9/1/2022	<2	<2	<2	NA	NA	NA
	10/20/2022	**13**	**9.8**	<2	NA	NA	NA
	3/14/2023	***16***	**11**	<2	NA	NA	NA
	6/29/2023*	<2	<2	<2	NA	NA	NA
	7/26/2023*	<2	<2	<2	NA	NA	NA
	9/12/2023*	<2	<2	<2	NA	NA	NA
	10/4/2023*	<2	<2	<2	NA	NA	NA
	6/18/2024*	<0.919	<0.919	<0.919	NA	NA	NA
	8/27/2024*	<1.84	<1.84	<1.84	NA	NA	NA
	9/24/2024*	<1.84	<1.84	<1.84	NA	NA	NA
	10/17/2024	**8.22**	**10.1**	<1.79	<1.79	**10.6**	**1.18**
	10/17/2024*	<1.76	<1.76	<1.76	NA	NA	NA

Bold = result exceeds the EPA MCL
HPFO-DA = hexafluoropropylene oxide dimer acid
Hazard Index = Estimated for a mixture of at least two or more of PFHxS, PFNA, HFPO-DA, and perfluorobutanesulfonic acid to account for the combined and cooccurring levels of these PFAS in drinking water
Italics = result exceeds the NJMCL
NA = not available
ng/L= nanograms per liter analogous to parts per trillion
PFOA = perfluorooctanoic acid
PFOS = perfluorooctane sulfonate (also known as perfluorooctanesulfonic acid)
PFNA = perfluorononanoic acid
PFHxS = perfluorohexane sulfonic acid
* Effluent sample collected post-treatment of PFAS

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Table 2
Identification of Potential ARARs and TBCs

Federal or State Statute, Regulation, or Guidance	Requirement	Type of ARAR	Actions to be Taken to Attain Requirement
National Primary Drinking Water Regulation under the Safe Drinking Water Act: 40 CFR Parts 141 and 142, federal- regulated MCL for six PFAS.	MCLs are enforceable standards for public drinking water supply systems	Applicable	Any public water distribution system will need to meet the substantive requirements of this regulation; otherwise, a treatment system will need to be installed to meet the federal MCLs.
NJ Administrative Code 7:10-11.14(d) & 7:10-11.15(h) (Safe Drinking Water Act) for regulatory approval of filtration systems.	Manchester Township will identify the construction and permit requirements under the State Safe Drinking Water Act for filtration systems.	Applicable	CERCLA 121(e)(1) states that no Federal, State, and local permits are required for remedial actions taken pursuant to Federal action under section 106 of CERCLA. However, the Air Force will meet (or waive) the substantive provisions of permitting regulations that are ARARs. Manchester Township, as a permitted entity, has agreed to provide design drawings and specifications to the state for permit approval prior to construction or modification of existing system.

Table 2 (Continued)
Identification of Potential ARARs and TBCs

Federal or State Statute, Regulation, or Guidance	Requirement	To-Be-Considered	Actions to be Taken to Attain Requirement
Code of Manchester Township, NJ Part II, General Legislation, Chapter 133 Construction Codes	Identifies the construction requirements for Manchester Township, NJ.	Applicable	Manchester Township will prepare a request for quote to treatment system suppliers that meet their requirement. Construction activities will comply with required construction codes.

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Table 3
Summary of Comparative Analysis of Removal Action Alternatives

CERCLA Evaluation Criteria	Remedial Alternatives		
	Alternative 1	Alternative 2	Alternative 3
	No Action	IX Permanent System Installation	GAC Permanent System Installation
Effectiveness			
Protective of Human Health and Environment	No	Yes	Yes
Complies with Applicable or Relevant and Appropriate Requirements	No	Yes	Yes
Effective and Permanent	No	Medium	Medium
Reduces Toxicity, Mobility, or Volume through Treatment	None (No Treatment)	Minimal (Incidental Treatment)	Minimal (Incidental Treatment)
Short-Term Effectiveness	Low	Medium	Medium
Implementable			
Technically Feasible	Yes	Yes	Yes
Administratively Feasible	No	Yes	Yes
Costs[1]			
Capital	$0	$1,080,000	$1,685,000
O&M (discounted)	$0	$2,879,000	$2,721,000
Present Worth (Capital + discounted O&M)	$0	$3,959,000	$4,406,000

[1]Costs rounded to nearest thousand-dollar value.

CERCLA = Comprehensive Environmental Response, Compensation, and Liability Act
O&M = Operation and Maintenance

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FIGURES

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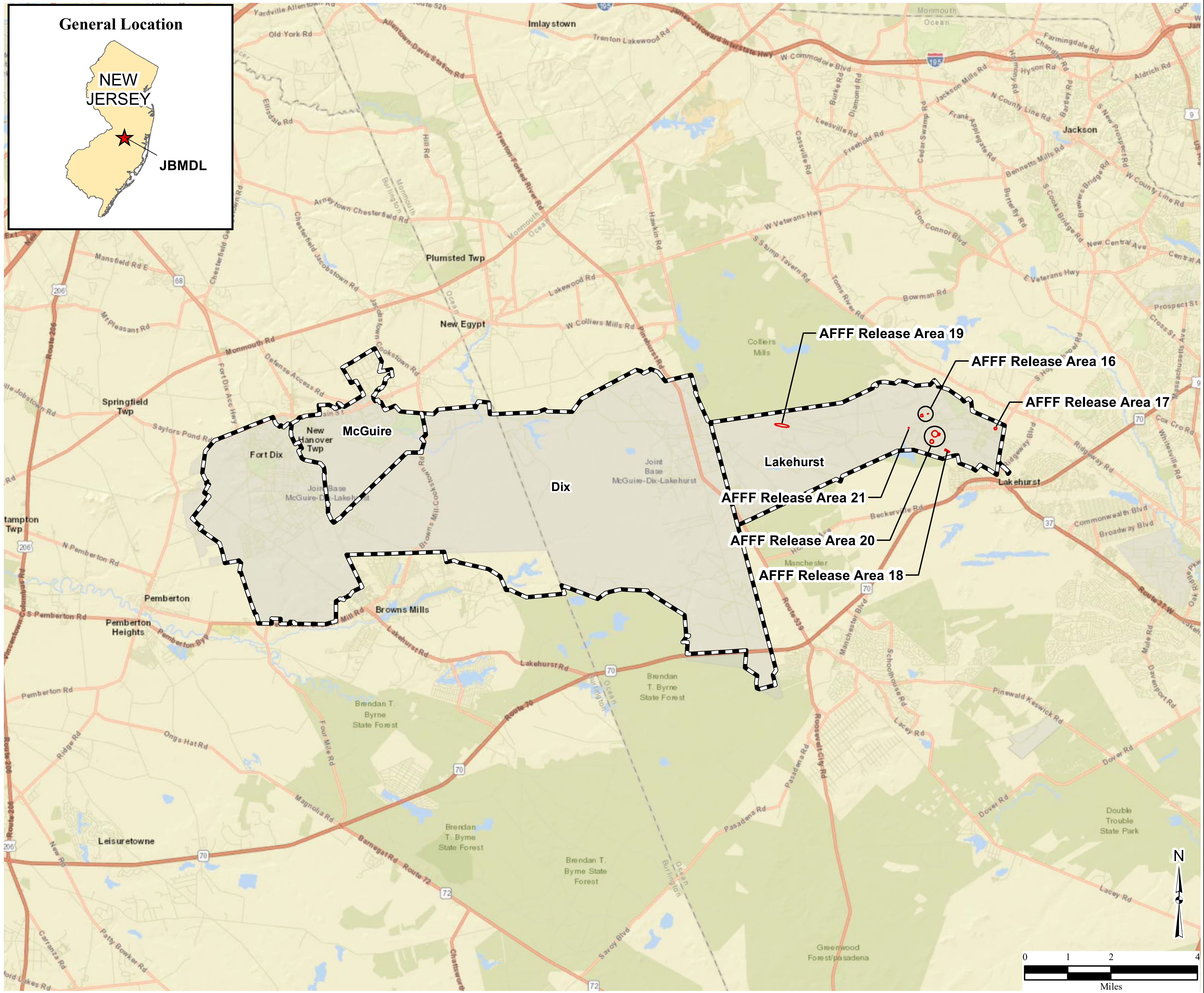
EE/CA NTCRA of PFOS- and PFOA- Impacted Water in Manchester Municipal Well #4, JBMDL, New Jersey

Figure 1
Site Location



Legend

SI AFFF Area

JBMDL Installation Boundary

Notes:
AFFF=aqueous film-forming foam
EE/CA=Engineering Evaluation and Cost Analysis
JBMDL=Joint Base McGuire-Dix-Lakehurst
NTCRA=non-time critical removal action
PFOS=perfluorooctane sulfonic acid
PFOA=perfluorooctanoic acid
SI=Site Inspection
UFP-QAPP=Uniform Federal Policy for Quality Assurance Project Plan

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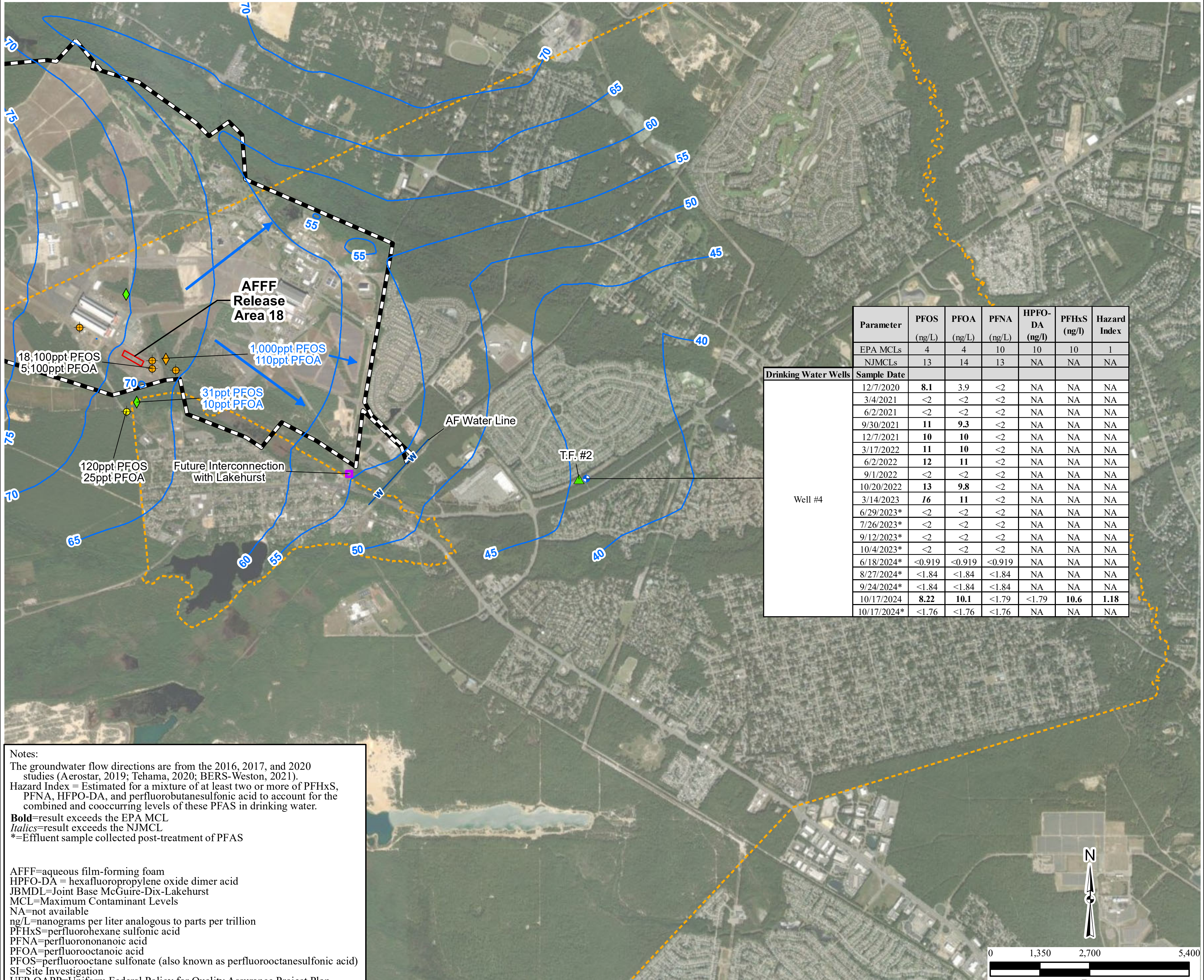
11/22/2023 JG
Source: HGL, ESRI
ArcGIS Online Streets Basemap

Figure 2
Site Inspection Results



Parameter	PFOS (ng/L)	PFOA (ng/L)	PFNA (ng/L)	HPFO-DA (ng/l)	PFHxS (ng/l)	Hazard Index
EPA MCLs	4	4	10	10	10	1
NJMCLs	13	14	13	NA	NA	NA

Drinking Water Wells	Sample Date	PFOS (ng/L)	PFOA (ng/L)	PFNA (ng/L)	HPFO-DA (ng/l)	PFHxS (ng/l)	Hazard Index
Well #4	12/7/2020	**8.1**	3.9	<2	NA	NA	NA
	3/4/2021	<2	<2	<2	NA	NA	NA
	6/2/2021	<2	<2	<2	NA	NA	NA
	9/30/2021	**11**	**9.3**	<2	NA	NA	NA
	12/7/2021	**10**	**10**	<2	NA	NA	NA
	3/17/2022	**11**	**10**	<2	NA	NA	NA
	6/2/2022	**12**	**11**	<2	NA	NA	NA
	9/1/2022	<2	<2	<2	NA	NA	NA
	10/20/2022	**13**	**9.8**	<2	NA	NA	NA
	3/14/2023	***16***	**11**	<2	NA	NA	NA
	6/29/2023*	<2	<2	<2	NA	NA	NA
	7/26/2023*	<2	<2	<2	NA	NA	NA
	9/12/2023*	<2	<2	<2	NA	NA	NA
	10/4/2023*	<2	<2	<2	NA	NA	NA
	6/18/2024*	<0.919	<0.919	<0.919	NA	NA	NA
	8/27/2024*	<1.84	<1.84	<1.84	NA	NA	NA
	9/24/2024*	<1.84	<1.84	<1.84	NA	NA	NA
	10/17/2024	**8.22**	**10.1**	<1.79	<1.79	**10.6**	**1.18**
	10/17/2024*	<1.76	<1.76	<1.76	NA	NA	NA

Notes:
The groundwater flow directions are from the 2016, 2017, and 2020 studies (Aerostar, 2019; Tehama, 2020; BERS-Weston, 2021).
Hazard Index = Estimated for a mixture of at least two or more of PFHxS, PFNA, HFPO-DA, and perfluorobutanesulfonic acid to account for the combined and cooccurring levels of these PFAS in drinking water.
Bold=result exceeds the EPA MCL
Italics=result exceeds the NJMCL
*=Effluent sample collected post-treatment of PFAS

AFFF=aqueous film-forming foam
HPFO-DA = hexafluoropropylene oxide dimer acid
JBMDL=Joint Base McGuire-Dix-Lakehurst
MCL=Maximum Contaminant Levels
NA=not available
ng/L=nanograms per liter analogous to parts per trillion
PFHxS=perfluorohexane sulfonic acid
PFNA=perfluorononanoic acid
PFOA=perfluorooctanoic acid
PFOS=perfluorooctane sulfonate (also known as perfluorooctanesulfonic acid)
SI=Site Investigation
UFP-QAPP=Uniform Federal Policy for Quality Assurance Project Plan

Legend

- Treatment Facility
- Well

Groundwater PFOS+PFOA (ppt):
- Not Detected
- Detected Below MCL
- 4 ppt - 1,000 ppt
- 1,000 ppt - 100,000 ppt
- >100,000 ppt

Surface Water PFOS+PFOA:
- Not Detected
- Detected Below MCL
- 4 ppt - 1,000 ppt
- 1,000 ppt - 100,000 ppt
- >100,000 ppt

- Groundwater Potentiometric Contours
- Groundwater Flow Direction
- AF Water Line
- SI AFFF Area
- JBMDL Installation Boundary
- Manchester Township Boundary

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4/18/2025 JG
Source: HGL, ESRI
ArcGIS Online Imagery

APPENDIX A

COST ESTIMATES

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Table A-1
Alternative 2: IX Permanent System Installation
Cost Summary

ITEM	UNIT	UNIT COST	QUANTITY	TOTAL
CAPITAL COSTS				
Installation of IX resin system				
Planning	Lump Sum	$89,374	1	$89,374
Water Quality Sampling/Preconstruction Site Visit	Lump Sum	$8,612	1	$8,612
Treatment Facility Modification and IX System Fabrication	Lump Sum	$651,534	1	$651,534
Monthly System Sampling	Lump Sum	$8,337	1	$8,337
	SUBTOTAL			**$757,857**
	GENERAL AND ADMINISTRATIVE @ 8%			$60,629
	FEE (LESS LABOR) @ 5%			$33,958
	CONTINGENCY @ 30%			$227,357
	TOTAL CAPITAL COSTS			**$1,079,801**
ANNUAL O&M COSTS				
Annual O&M at treatment facility TP002009 (PFAS treatment only)				
Annual Operation and Maintenance (May to October)	Lump Sum	$99,852	30	$2,995,551
	SUBTOTAL (30 Years)			**$2,995,551**
	GENERAL AND ADMINISTRATIVE @ 8%			$239,644
	FEE (LESS LABOR) @ 5%			$159,610
	CONTINGENCY @ 30%			$898,665
	TOTAL ANNUAL O&M COSTS (30 Years)			**$4,293,470**
	O&M PRESENT WORTH (2.8%)			**$2,879,061**
TOTAL ALTERNATIVE COST (Capital + O&M Present Worth)				**$3,958,862**

Assumptions:These costs are for comparison purposes only and have an accuracy of +50% or -30%.

Table A-2
Alternative 2: IX Permanent System Installation
Cost Estimate

			Subtask 2.1		Subtask 2.2		Subtask 2.3		Subtask 2.4		Subtask 2.5		Total	
			Planning		Water Quality Sampling/ Preconstruction Site Visit		Treatment Facility Modification and IX System Fabrication		Monthly System Sampling		Annual Operation and Maintenance (May to October)			
		Project Rate	**Hours/Qty**	**Dollars**	**Hours/Qty**	**Dollars**	**Hours/Qty**	**Dollars**	**Hours/Qty**	**Dollars**	**Hours/Qty**	**Dollars**	**Hours/Qty**	**Dollars**
LABOR CATEGORY (HOME SITE)														
Project Manager		$165.00	40	$6,600	2	$330					48	$7,920	90	$14,850
Installation Lead		$135.00	40	$5,400	2						48	$6,480	90	$11,880
Process Engineer		$114.78	80	$9,182									80	$9,182
Junior Engineer		$71.12	120	$8,534							48	$3,414	168	$11,948
Health and Safety Officer		$150.35	40	$6,014	1	$150							41	$6,164
Quality Manager		$150.35	40	$6,014	1	$150					48	$7,217	89	$13,381
Administrative Assistant		$47.38	40	$1,895							48	$2,274	88	$4,169
Procurement Specialist		$85.00	40	$3,400	8	$680					48	$4,080	96	$8,160
Project Chemist		$135.00	40	$5,400							48	$6,480	88	$11,880
TOTAL HOME SITE LABOR			**480**	**$52,440**		**$1,311**		**$0**		**$0**		**$37,865**	**480**	**$91,616**
LABOR CATEGORY (FIELD SITE)														
Construction Manager		$110.68					348	$38,517					348	$38,517
Site Safety and Health Officer		$63.19	40	$2,528				$0					40	$2,528
Field Engineer		$100.54	40	$4,022	18	$1,810	348	$34,988					406	$40,819
Junior Geologist		$47.57			18	$856			60	$2,854	108	$5,138		
TOTAL FIELD SITE LABOR			**80**	**$6,549**	**50**	**$2,666**	**696**	**$73,505**	**60**	**$2,854**	**444**	**$5,138**	**1,330**	**$90,712**
TOTAL LABOR			**560**	**$58,989**	**50**	**$3,977**	**696**	**$73,505**	**60**	**$2,854**	**444**	**$43,002**	**1,810**	**$182,327**
OTHER DIRECT COSTS:	**Unit of Measure**	**Rate**	**Quantity**	**Dollars**	**Quantity**	**Dollars**	**Quantity**	**Dollars**	**Quantity**	**Dollars**	**Quantity**	**Dollars**	**Quantity**	**Dollars**
Sample Shipments	each	$75			1	$75			6	$450			7	$525
Installation Technical Memo with As-builts (HGL Labor)	each	$17,500					1	$17,500					1	$17,500
Annual Report (HGL Labor)	each	$30,000									1	$30,000	1	$30,000
Permits	each	$30,000	1.00	$30,000										
EQUIPMENT AND MATERIALS (INSTALLATION)														
IX Vessel System Pre-Engineered Building (30x30x15')	sq.ft	$150					900	$135,000					900	$135,000
(6) 60 cuft IX vessels (48x72")	each	$20,000					6	$120,000					6	$120,000
IX Resin	cu.ft	$380					360	$136,800						
Supporting equipment	each	$25,000					1	$25,000					1	$25,000
Pipes and Appurtenances	each	$15,000					1	$15,000					1	$15,000
System Parts	each	$10,000					1	$10,000					1	$10,000
Controls Equipment	each	$10,000					1	$10,000					1	$10,000
Concrete Pad	each	$25,000					1	$25,000					1	$25,000
Forklift/Crane Rental	each	$5,000					1	$5,000					1	$5,000
Sales tax	6.63%						1	$31,919					1	$31,919
Equipment Shipping Fees	each	$15,000.00					1	$15,000					1	$15,000
Materials Shipping Fees	each	$5,000.00					1	$5,000					1	$5,000
Supplier Preconstruction Visit	lump sum	$3,200.00			1	$3,200							1	$3,200

Table A-2
Alternative 2: IX Permanent System Installation
Cost Estimate

			Subtask 2.1 Planning		Subtask 2.2 Water Quality Sampling/ Preconstruction Site Visit		Subtask 2.3 Treatment Facility Modification and IX System Fabrication		Subtask 2.4 Monthly System Sampling		Subtask 2.5 Annual Operation and Maintenance (May to October)		Total	
EQUIPMENT AND MATERIALS (O&M)														
IX Media Replacement	each	$68,400									0.17	$11,400	0	$11,400
Particulate Filter	each	$25.00									12	$300	12	$300
GAC replacement	each	$40,000											0	$0
Misc. parts	each	$2,500									1	$2,500	1	$2,500
Sampling Supply	each	$45.00							6	$270	4	$180	10	$450
Sales tax	6.63%									$18		$953		$971
Shipping Fees	each	$300.00									1	$300	1	$300
TOTAL OTHER DIRECT COSTS				**$30,000**		**$3,275**		**$551,219**		**$738**		**$45,633**		**$630,865**
TRAVEL														
Vehicle Rental	day	$325.00	**1**	$325	1	$325	6	$1,950	1	$325	12	$3,900	21	$6,825
Fuel/Tolls	tank	$60.00	**1**	$60	1	$30	6	$360	1	$60	12	$720	21	$1,230
TOTAL TRAVEL				**$385**		**$355**		**$2,310**		**$385**		**$4,620**		**$8,055**
SUBCONTRACTORS:														
Mechanical Subcontractor	lump sum	$10,000					1	$10,000					1	$10,000
Electrical Subcontractor	lump sum	$10,000					1	$10,000					1	$10,000
Utility Locate Subcontractor	lump sum	$2,000					1	$2,000					1	$2,000
Surveyor Subcontractor	lump sum	$2,500					1	$2,500						$2,500
Laboratory for PFAS Analysis	each	$200.00			2	$400			16	$3,200	16	$3,200	34	$6,800
Laboratory for Bacterial Analysis	each	$45.00			1	$45			4	$180			5	$225
Laboratory for Water Quality Analysis	each	$250.00			2	$500			2	$500			4	$1,000
Data Validation - PFAS	each	$30.00			2	$60			16	$480	16	$480	34	$1,020
IDW Analysis/Waste Profile	each	$2,500									0.17	$417	0	$417
IX or GAC Media Transportation	drum	$7,500									0.17	$1,250	0	$1,250
IX or GAC Media Disposal	drum	$7,500									0.17	$1,250	0	$1,250
TOTAL SUBCONTRACTORS				**0**		**1,005**		**24,500**		**4,360**		**6,597**		**$36,462**
SUBTOTAL COSTS				**$89,374**		**$8,612**		**$651,534**		**$8,337**		**$99,852**		**$857,709**

Table A-3
Alternative 2: IX Permanent System Installation
Basis of Estimate

2.1 Planning

Labor hours for planning includes preparation of Response Action Plan, a Memo, and permanent system installation drawings and bid package, subcontractor and equipment procurement, and coordination with local permitting agencies and inspections. Submittals also include an O&M Manual and Design Package.

2.2 Water Quality Testing/Pre-Construction Site Visit

Water quality testing one 10-hour day.
Water quality testing includes one sample plus field duplicate for PFAS and water quality analysis and one sample for bacteria analysis.
Pre-construction site visit includes a total of two 8-hour days, including 8-hours for travel and preparation and 10-hr day for the Site Visit for the Field Engineer and the Junior Geologist to confirm site conditions, coordinate with the subcontractors, and collect the samples.

2.3 Treatment Facility Modification and IX System Fabrication

Fabrication of the system will include 6 IX vessels (48x72"), filter housing, accessories, piping, valves, fittings, and all appurtenant equipment.
Pre-engineered building and associated pad is assumed to be 30x30x15'. Any mechanical, electrical, or plumbing work (labor and materials) inside the IX system is included in this line item.
Any mechanical, electrical, or plumbing work outside the IX system for the final connections with the existing treatment facility is included in separate lines and includes labor and materials.
Field labor includes the Construction Manager and Field Engineer to oversee subcontractors and installation of the system (40 hours per month for 6 months).
Vehicle and fuel costs for Construction Manager and Field Engineer are included in this subtask for one trip per month for 6 months.
Each trip is 10 hours workday + 8 hours for travel and preparation.
No office labor hours included. Technical memorandum with as-built drawings is included.

Table A-3
Alternative 2: IX Permanent System Installation
Basis of Estimate

2.4 Monthly System Sampling

Field labor hours for Junior Geologist includes a total of six 10-hour days, including sampling for PFAS, water quality, and bacteria sampling to meet local, state and federal requirements.
Subtask includes system inspection and PFAS (6 samples plus QC samples) and chloride/sulfate and BacT (2 samples) sample collection.
QC samples for PFAS analysis include field duplicate, trip blank, matrix spike, and matrix spike duplicate. No QC samples are required for chloride/sulfate and BacT analysis.
Subtask workday is 10 hours.

2.5 Annual Operation and Maintenance

Field labor hours for Junior Geologist includes changeout of only three vessels every six years. Biweekly filter changeout is assumed.
Changeout of resin, transportation to RCRA Subtitle C landfill, and disposal is included. Changeout cost is estimated in a yearly basis to assist with the calculations of the present value.
Annual report will document all analytical results, O&M activities, and waste tickets.
The duration of O&M is 30 Years.

Table A-4
Alternative 3: GAC Permanent System Installation
Cost Summary

ITEM	UNIT	UNIT COST	QUANTITY	TOTAL
CAPITAL COSTS				
Installation of GAC system				
Planning	Lump Sum	$104,374	1	$104,374
Water Quality Sampling/Preconstruction Site Visit	Lump Sum	$8,612	1	$8,612
Treatment Facility Modification and GAC System Fabrication	Lump Sum	$1,058,465	1	$1,058,465
Monthly System Sampling	Lump Sum	$8,337	1	$8,337
	SUBTOTAL			**$1,179,788**
	GENERAL AND ADMINISTRATIVE @ 8%			$94,383
	FEE (LESS LABOR) @ 5%			$56,742
	CONTINGENCY @ 30%			$353,936
	TOTAL CAPITAL COSTS			**$1,684,850**
ANNUAL O&M COSTS				
Annual O&M at treatment facility TP002009 (PFAS treatment only)				
Annual Operation and Maintenance (May to October)	Lump Sum	$94,388	30	$2,831,643
	SUBTOTAL (30 Years)			**$2,831,643**
	GENERAL AND ADMINISTRATIVE @ 8%			$226,531
	FEE (LESS LABOR) @ 5%			$150,759
	CONTINGENCY @ 30%			$849,493
	TOTAL ANNUAL O&M COSTS (30 Years)			**$4,058,426**
	O&M PRESENT WORTH (2.8%)			**$2,721,448**
TOTAL ALTERNATIVE COST (Capital + O&M Present Worth)				**$4,406,297**

Assumptions:These costs are for comparison purposes only and have an accuracy of +50% or -30%.

Table A-5
Alternative 3: GAC Permanent System Installation
Cost Estimate

			Subtask 3.1		**Subtask 3.2**		**Subtask 3.3**		**Subtask 3.4**		**Subtask 3.5**		**Total**	
			Planning		**Water Quality Sampling/ Preconstruction Site Visit**		**Treatment Facility Modification and GAC System Fabrication**		**Monthly System Sampling**		**Annual Operation and Maintenance (May to October)**			
		Project Rate	**Hours/Qty**	**Dollars**	**Hours/Qty**	**Dollars**	**Hours/Qty**	**Dollars**	**Hours/Qty**	**Dollars**	**Hours/Qty**	**Dollars**	**Hours/Qty**	**Dollars**
LABOR CATEGORY (HOME SITE)														
Project Manager		$165.00	40	$6,600	2	$330					48	$7,920	90	$14,850
Installation Lead		$135.00	40	$5,400	2						48	$6,480	90	$11,880
Process Engineer		$114.78	80	$9,182									80	$9,182
Junior Engineer		$71.12	120	$8,534							48	$3,414	168	$11,948
Health and Safety Officer		$150.35	40	$6,014	1	$150							41	$6,164
Quality Manager		$150.35	40	$6,014	1	$150					48	$7,217	89	$13,381
Administrative Assistant		$47.38	40	$1,895							48	$2,274	88	$4,169
Procurement Specialist		$85.00	40	$3,400	8	$680					48	$4,080	96	$8,160
Project Chemist		$135.00	40	$5,400							48	$6,480	88	$11,880
TOTAL HOME SITE LABOR			**480**	**$52,440**		**$1,311**		**$0**		**$0**		**$37,865**	**480**	**$91,616**
LABOR CATEGORY (FIELD SITE)														
Construction Manager		$110.68					348	$38,517					348	$38,517
Site Safety and Health Officer		$63.19	40	$2,528				$0					40	$2,528
Field Engineer		$100.54	40	$4,022	18	$1,810	348	$34,988					406	$40,819
Junior Geologist		$47.57			18	$856			60	$2,854	108	$5,138		
TOTAL FIELD SITE LABOR			**80**	**$6,549**	**50**	**$2,666**	**696**	**$73,505**	**60**	**$2,854**	**444**	**$5,138**	**1,330**	**$90,712**
TOTAL LABOR			**560**	**$58,989**	**50**	**$3,977**	**696**	**$73,505**	**60**	**$2,854**	**444**	**$43,002**	**1,810**	**$182,327**
OTHER DIRECT COSTS:	**Unit of Measure**	**Rate**	**Quantity**	**Dollars**	**Quantity**	**Dollars**	**Quantity**	**Dollars**	**Quantity**	**Dollars**	**Quantity**	**Dollars**	**Quantity**	**Dollars**
Sample Shipments	each	$75			1	$75			6	$450			7	$525
Installation Technical Memo with As-builts (HGL Labor)	each	$17,500					1	$17,500					1	$17,500
Annual Report (HGL Labor)	each	$15,000									1	$30,000	1	$30,000
Permits	each	$45,000	1.00	$45,000										
EQUIPMENT AND MATERIALS (INSTALLATION)														
GAC Vessel System Pre-Engineered Building (40X40X20')	sq.ft	$175					1,600	$280,000					1,600	$280,000
(2) Model 10 (10x12')	each	$175,000					2	$350,000					2	$350,000
GAC media (bituminous)	lbs	$2					20,000	$40,000						
Backwash supply and receiving tanks and pads	each	$35,000					2	$70,000						
Supporting equipment	each	$35,000					1	$35,000					1	$35,000
Pipes and Appurtenances	each	$15,000					1	$15,000					1	$15,000
System Parts	each	$10,000					1	$10,000					1	$10,000
Controls Equipment	each	$10,000					1	$10,000					1	$10,000
Concrete Pad	each	$25,000					1	$25,000					1	$25,000
Forklift/Crane Rental	each	$5,000					1	$5,000					1	$5,000
Sales tax	6.63%						1	$55,650					1	$55,650
Equipment Shipping Fees	each	$15,000.00					1	$15,000					1	$15,000
Materials Shipping Fees	each	$5,000.00					1	$5,000					1	$5,000
Supplier Preconstruction Visit	lump sum	$3,200.00			1	$3,200							1	$3,200

Table A-5
Alternative 3: GAC Permanent System Installation
Cost Estimate

			Subtask 3.1		Subtask 3.2		Subtask 3.3		Subtask 3.4		Subtask 3.5		Total	
			Planning		Water Quality Sampling/ Preconstruction Site Visit		Treatment Facility Modification and GAC System Fabrication		Monthly System Sampling		Annual Operation and Maintenance (May to October)			
EQUIPMENT AND MATERIALS (O&M)														
IX Media Replacement	each	$68,400											0	$0
Particulate Filter	each	$25.00									12	$300	12	$300
GAC replacement	each	$20,000									0.33	$6,667	0	$6,667
Misc. parts	each	$2,500									1	$2,500	1	$2,500
Sampling Supply	each	$45.00							6	$270	4	$180	10	$450
Sales tax	6.63%									$18		$639		$657
Shipping Fees	each	$300.00									1	$300	1	$300
TOTAL OTHER DIRECT COSTS				**$45,000**		**$3,275**		**$933,150**		**$738**		**$40,586**		**$1,022,749**
TRAVEL														
Vehicle Rental	day	$325.00	**1**	$325	1	$325	6	$1,950	1	$325	12	$3,900	21	$6,825
Fuel/Tolls	tank	$60.00	**1**	$60	1	$30	6	$360	1	$60	12	$720	21	$1,230
TOTAL TRAVEL				**$385**		**$355**		**$2,310**		**$385**		**$4,620**		**$8,055**
SUBCONTRACTORS:														
CB&I														$0
Court Reporter														$0
Mechanical Subcontractor	lump sum	$10,000					1	$10,000					1	$10,000
Electrical Subcontractor	lump sum	$10,000					1	$10,000					1	$10,000
Utility Locate Subcontractor	lump sum	$2,000					1	$2,000					1	$2,000
Surveyor Subcontractor	lump sum	$2,500					1	$2,500						$2,500
Plumbing/Excavation Subcontractor	lump sum	$25,000					1	$25,000						
Laboratory for PFAS Analysis	each	$200.00			2	$400			16	$3,200	16	$3,200	34	$6,800
Laboratory for Bacterial Analysis	each	$45.00			1	$45			4	$180			5	$225
Laboratory for Water Quality Analysis	each	$250.00			2	$500			2	$500			4	$1,000
Data Validation - PFAS	each	$30.00			2	$60			16	$480	16	$480	34	$1,020
IDW Analysis/Waste Profile	each	$2,500									0.33	$833	0	$833
IX or GAC Media Transportation	drum	$2,500									0.33	$833	0	$833
IX or GAC Media Disposal	drum	$2,500									0.33	$833	0	$833
TOTAL SUBCONTRACTORS				**0**		**1,005**		**49,500**		**4,360**		**6,180**		**$61,045**
SUBTOTAL COSTS				**$104,374**		**$8,612**		**$1,058,465**		**$8,337**		**$94,388**		**$1,274,176**

Table A-6
Alternative 3: GAC Permanent System Installation
Basis of Estimate

3.1 Planning

Labor hours for planning includes preparation of Response Action Plan, a Memo, and permanent system installation drawings and bid package, subcontractor and equipment procurement, and coordination with local permitting agencies and inspections. Submittals also include an O&M Manual and Design Package.

3.2 Water Quality Testing/Pre-Construction Site Visit

Water quality testing one 10-hour day.
Water quality testing includes one sample plus field duplicate for PFAS and water quality analysis and one sample for bacteria analysis.
Pre-construction site visit includes a total of two 8-hour days, including 8-hours for travel and preparation and 10-hr day for the Site Visit for the Field Engineer and the Junior Geologist to confirm site conditions, coordinate with the subcontractors, and collect the samples.

3.3 Treatment Facility Modification and GAC System Fabrication

Fabrication of the system will include 2 GAC vessels (10X12"), filter housing, accessories, piping, valves, fittings, and all appurtenant equipment.
Pre-engineered building and associated pad is assumed to be 40x40x20'. Any mechanical, electrical, or plumbing work (labor and materials) inside the GAC system is included in this line item.
Any mechanical, electrical, or plumbing work outside the GAC system for the final connections with the existing treatment facility is included in separate lines and includes labor and materials.
To satisfy state requirements, two 10,000 gallon tanks and a pump are part of the backwashing system. The tanks will be set in separate pads outside the system while the pump will be housed inside the GAC system.
A sewer connection line will be trenched to deal with the backwashing effluent. Permits and design are included in 2.1. A plumbing and excavating contractor is included.
Field labor includes the Construction Manager and Field Engineer to oversee subcontractors and installation of the system (40 hours per month for 6 months).
Vehicle and fuel costs for Construction Manager and Field Engineer are included in this subtask for one trip per month for 6 months.
Each trip is 10 hours workday + 8 hours for travel and preparation.
No office labor hours included. Technical memorandum with as-built drawings is included.

Table A-6
Alternative 3: GAC Permanent System Installation
Basis of Estimate

3.4 Monthly System Sampling

Field labor hours for Junior Geologist includes a total of six 10-hour days, including sampling for PFAS, water quality, and bacteria sampling to meet local, state and federal requirements.
Subtask includes system inspection and PFAS (6 samples plus QC samples) and chloride/sulfate and BacT (2 samples) sample collection.
QC samples for PFAS analysis include field duplicate, trip blank, matrix spike, and matrix spike duplicate. No QC samples are required for chloride/sulfate and BacT analysis.
Subtask workday is 10 hours.

3.5 Annual Operation and Maintenance

Field labor hours for Junior Geologist includes changeout of one GAC vessel every three years. Biweekly filter changeout is assumed.
Changeout of GAC, transportation to a regeneration facility or disposal is included. Changeout cost is estimated in a yearly basis to assist with the calculations of the present value.
Annual report will document all analytical results, O&M activities, and waste tickets.
The duration of O&M is 30 Years.