State of Rhode Island
Department of Environmental Management

RIDEM

Statewide PFAS Source Investigation Report

November 2023

Submit public comments by December 1, 2023 at https://dem.ri.gov/olrsmm

List of Acronyms and Abbreviations

AASF	Army Aviation Support Facility
AC	Activated Carbon
AFFF	Aqueous Film Forming Foam
AOC	Areas of Concern
ARARs	Applicable or Relevant and Appropriate Requirements
ARFF	Aircraft Rescue and Firefighting
AR-FFFP	Alcohol Resistant Film Forming Fluoroprotein
AR-FP	Alcohol Resistant Fluoroprotein Foam
ATSDR	Agency for Toxic Substances and Disease Registry
AWQCs	Ambient Water Quality Criteria
BCT BRAC	Cleanup Team
BOD	Biochemical Oxygen Demand
BRAC	Base Realignment and Closure
CD	Consent Degree
CDC	Center for Disease Control and Prevention
CED	Construction Equipment Department
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
CNALF	Charlestown Navy Auxiliary Landing Field
COC	Contaminants of Concern
COD	Chemical Oxygen Demand
CSMs	Conceptual Site Models
CVOCs	Chlorinated Volatile Organic Compounds
DACF	Department of Agriculture, Conservation, and Forestry
DEM	Department of Environmental Management
DERP	Department of Defense Environmental Restoration Program
DNAC	Decontaminating Agent Non-Corrosive

DLA	Defense Logistics Agency
DOD	Department of Defense
DOE	Department of Energy
EDTA	Ethylene Diamine Tetracetic Acid
ESDs	Explanations of Significant Differences
ESI	Expanded Site Inspection
ESTCP	Environmental Security Technology Certification Program
FDA	Food and Drug Administration
FFA	Federal Facilities Agreement
FFFP	Film Forming Fluoroprotein Foam
FTA	Firefighting Training Area
FUDS	Formerly Used Defense Sites
FYR	Five Year Report
GIS	Geographic Information Systems
HAL	Hazard Advisory Level
HCS	Hydraulic Containment System
HHRA	Human Health Risk Assessment
HRS	Hazard Ranking System
HTRW	Hazardous Toxic and Radioactive Waste
IARC	International Agency for Research on Cancer
ICs	Institutional Controls
ICLs	Interim Cleanup Levels
ISCO	In-Situ Chemical Oxidation
LFG	Landfill Gas
LHA	Lifetime Health Advisory
LNAPL	Light Non-Aqueous Phase Liquids
LTM	Long Term Monitoring
MCLs	Maximum Contaminant Level

MEDEP	Maine Department of Environmental Protection
MOM	Management of Migration
MRS	Munitions Response Site
MSCA	Multi-Site Cooperative Agreement
MTBE	Methyl Tert-Butyl Ether
MWRA	Massachusetts Water Resource Authority
NAICS	North American Industry Classification System
NARF	Naval Air Rework Facility
NAS	Naval Air Station
NAVSTA	Naval Station Newport
NBC	Narragansett Bay Commission
NCBC	Naval Construction Battalion Center
ND	Not Detected
NDDA	National Defense Authorization Act
NET	Northeast Trench
NETC	Newport Education and Training Center
NFA	No Further Action
NPL	National Priorities List
NTP	National Toxicology Program
NUSC	Naval Undersea Systems Center
NUWC	Naval Undersea Warfare Center
NWT	Northwest Trench
OC&I	Office of Compliance and Inspection
OLRSMM	Office of Land Revitalization and Sustainable Materials Management
OSD	Office of the Secretary of Defense
OUs	Operable Units
PA	Preliminary Assessment
PAHs	Polycyclic Aromatic Hydrocarbons

PCBs	Polychlorinated Biphenyls
PCE	Tetrachloroethene
PCSM	Post Closure Site Monitoring
PCSM	Site Monitoring Plan Requirements
PFAS	Per and Polyfluoroalkyl Substances
PFBS	Perfluorobutane Sulfonic Acid
PFCAs	Perfluoroinated Carboxylic Acids
PFDA	Perfluorodecanoic Acid
PFHpA	Perfluoroheptanoic Acid
PFHxS	Perfluorohexane Sulfonic Acid
PFNA	Perfluorononanoic Acid
PFOA	Perfluorooctanoic Acid
PFOS	Perfluorooctane Sulfonic Acid
POET	Point-of-Entry
ppb	Parts per billion
ppm	Parts per million
ppt	Parts per trillion
PRP	Potential Responsible Party
PT	Post-Treatment Samples
PWSs	Public Water Systems
QA/QC	Quantitative Assurance/Quality Control
RAB	Restoration Advisory Board
RAOs	Remedial Action Objectives
RCRA	Resource Conservation and Recovery Act
RI	Remedial Investigation
RI/FS	Remedial Investigation/Feasibility Study
RIDEM	Rhode Island Department of Environmental Management
RIDOH	Rhode Island Department of Health

RIRRC	Rhode Island Resource Recovery Corporation
RISWMC	Rhode Island Solid Waste Management Corporation
ROD	Record of Decision
RSLs	Regional Screening Levels
SAP	Sampling and Analysis Plan
SD	Site Discovery
SERDP	Strategic Environmental Research and Development Program
SI	Site Inspection
SIC	Standard Industrial Classification
SIP	Site Inspection Prioritization
SR	Site Reassessment
SVE	Soil Vapor Extraction
SVOCs	Semi Volatile Organic Compounds
TCE	Trichloroethylene
TMDL	Total Maximum Daily Load
TRI	Toxic Release Inventory
TSCA	Toxic Substances Control Act
UCMR3	Third Unregulated Contaminant Monitoring Rule
USACE	U.S Army Corps of Engineers
USEPA	United States Environmental Protection Agency
USFWS	U.S Fish and Wildlife Service
UT	Untreated Samples
UV/OX	Ultraviolet/Oxidation
VOCs	Volatile Organic Compounds
WWTF	Wastewater Treatment Facility

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1 Executive Summary

Per and Polyfluoroalkyl Substances (PFAS) are a group of organic compounds, which due to the presence of fluorine, have non-reactive, chemical, pressure, and thermal stability properties. They are also resistant to the typical environmental biological, chemical and physical degradation processes, thus dubbing them with the accolade of “forever chemicals” in the popular press. The aforementioned attributes allow the compounds to retain their chemical design properties, which along with their versatility, makes PFAS compounds attractive for use in a wide range of industrial, commercial, and domestic products. These applications include use in aerospace, automotive, aviation, construction, cosmetics, electronics, energy production, firefighting, food packaging, medical, metal plating, munitions, plastics, semiconductor, textiles, etc. Unfortunately, there is a growing body of scientific and epidemiological evidence suggesting that exposure to a number of these compounds is deleterious to human health and/or the environment. This has led to the development of some of the most stringent regulatory standards and guidelines applied to any organic contaminant.

Growing understanding and public concern about PFAS contamination has prompted both federal and state legislative and regulatory actions. On the federal level, the U.S. Environmental Protection Agency (USEPA) is pursuing a PFAS Strategic Roadmap (2021) that outlines actions related to research, regulation, and remediation of PFAS. In 2022, the Rhode Island General Assembly approved House Bill 7233 Substitute A and Senate Bill 2298 Substitute A, *An Act Relating to Waters and Navigation – PFAS in Drinking Water, Groundwater and Surface Waters* (Rhode Island General Laws Chapter 46-32), which was signed into law by Governor McKee. This law authorized the Rhode Island Department of Health (RIDOH) to take actions to establish a maximum contaminant limit for PFAS in drinking water and established an interim drinking water standard for certain public water supply systems. It also established PFAS as a hazardous substance under Rhode Island General Law and required the Rhode Island Department of Environmental Management (RIDEM) to establish groundwater standards and surface water quality action levels. In addition, the law directed RIDEM to develop a plan to complete a statewide investigation of potential sources of PFAS contamination.

This report documents existing information on PFAS contamination in Rhode Island and outlines a plan of recommended actions for further source investigation. To develop the plan, RIDEM drew upon available information on PFAS in the Rhode Island environment, including drinking water sources, as well as research to identify the general industrial, commercial products and uses of PFAS. RIDEM used this understanding to identify sites where PFAS were potentially used. This work involved collaboration with RIDOH and Brown University, the latter of which has developed a statewide PFAS risk assessment map. This report also documents information and activities concerning locations with known PFAS contamination. Prior to the passage of the aforementioned legislation, the State had made significant progress towards identifying potential PFAS impacts and investigating sources throughout the State. In response to the 2016 EPA Lifetime Health Advisory (LHA), RIDOH initiated a statewide surveillance monitoring study the following year in collaboration with RIDEM and Brown University, which targeted high risk public water systems to assess the presence of PFAS in Rhode Island drinking water. The findings of this study led to RIDEM promulgation of a GAA and GA ambient Groundwater Quality Standard equivalent to the 2016 EPA LHA in 2017.This study was followed by additional RIDOH sampling in 2019. Of the 87 water systems sampled during both efforts, 44% were found to have detection of one or more PFAS and 15% were found with levels above the 20 parts per trillion (ppt) limit for a sum of select PFAS compounds. RIDOH implemented additional sampling and as October 2023 had identified 12 water systems using groundwater wells with PFAS levels above the interim MCL of 20 ppt. As findings emerged, RIDEM initiated numerous follow-up investigations in and around impacted water supplies sources.

Information collected under the RIDEM Superfund Pre-Remedial Program was also considered. Private wells were sampled around public water supply wells, where PFAS were detected, particularly those associated with schools, to identify potential impacts and to delineate the nature and extent of impacts to groundwater.

This report also details the investigations of PFAS sources and releases throughout Rhode Island prior to this recent legislation and identifies areas where additional investigation is warranted and the associated implementation challenges. The various methodologies to initiating these investigations and for prioritizing sites based on risks to drinking water resources and other receptors are also discussed in detail.

The United States Department of Defense has been very proactive in identifying PFAS impacts at active and former installations. RIDEM's Department of Defense Program in the OLRSMM has been involved in the investigation of hundreds of PFAS impacted DOD sites around the state. Naval Station Newport, which is also a Superfund site, has extensive PFAS contamination due to the former fuel terminal which operated for the majority of the 20th century. The Former Quonset Naval Air Station and Charlestown Auxiliary Landing Field (CNALF) also have been found to be significant sources of PFAS due to fire training and emergency response actions. The latter is a Formerly Used Defense Site (FUDS), which the Army Corps is responsible for the investigation and remediation. The PFAS releases at CNALF have impacted several public water systems at Ninigret Park as well as private wells outside of the site boundaries.

The OLRSMM promulgated rules in 2021 requiring closed landfills with approved monitoring plans to test for PFAS. Results of this sampling have demonstrated that nearly all landfills serve as a source of PFAS contamination. These rules only applied to approximately half of the over seventy landfills throughout Rhode Island. Nonetheless, landfills located in less developed areas of the state where public water is not available warrant further investigation.

The OLRSMM has also investigated sites around the state where biosolids have been land applied as fertilizer and/or soil amendment. These sites have resulted in widespread groundwater contamination in other states, most notably Maine. Preliminary results of this study have not identified significant impacts from biosolids at this time, but additional sampling is warranted.

Other significant sources of PFAS identified are fire stations and textile finishing operations. The majority of textile finishing operations are located adjacent to rivers due to the high- water demand associated with these operations. Therefore, impacts from textile finishing operations are likely significant to receiving water bodies and wildlife. Fire stations, which number 160 across the state, are necessarily widespread and pose a similar threat as closed landfills in rural areas without access to centralized public water system.

In summary, the potential sources of PFAS contamination in Rhode Island's environment are many and widespread. Preventing and mitigating PFAS contamination will require significant efforts in pollution control and site remediation over time. A significant amount of work to identify locations of PFAS contamination has occurred and prompted actions to limit public exposure via drinking water, as well as work toward site remediation. As the science related to PFAS continues to evolve and research yields a greater understanding of impacts to human health and the environment, state programs addressing PFAS will need to adapt. The ecological impacts of PFAS are currently not well understood. Federal rulemaking related to PFAS is being followed closely and will result in future updates to state rules for drinking water, water quality, and other environmental media. Coupled with the experience being gained in RI and other states, improved science is likely to spur new actions to address various PFAS sources.

Based on the work to date regarding PFAS contamination in RI, the facilities or locations of significant RIDEM management focus over next several years will continue to be:

- Industrial Sites including textile manufacturing
- Superfund Sites
- Department of Defense Sites
- Landfills and dumps (formerly licensed and unlicensed)
- Fire Stations and Training Facilities (including airports)
- Wastewater Treatment Facilities (WWTFs) including discharges & biosolids

The RIDEM plan for further investigation of PFAS sources involves the following next steps and actions:

1. Reduce the priority data gap related to PFAS exposure:
    a. Build state capacity for the sampling of private wells around known or suspected sites with PFAS contamination.
    b. Secure funds to conduct further testing of biosolids generated by RI WWTFs and in and around locations where biosolid products have been land applied in RI.
    c. Design and carry out monitoring of RI surface waters with a focus on rivers that receive wastewater discharges. RIDEM has received FY23 EPA funding to initiate this work.
    d. Secure funding to initiate testing of fish tissue for PFAS.

2. Continue to evaluate reports of PFAS contamination that may be voluntarily submitted via site remediation programs. Prioritize follow-up actions as needed.

3. Continue and expand pre-remedial investigations in OLRSSM programs to confirm and characterize the extent of PFAS contamination at prioritized sites.

4. Collaborate with researchers collecting PFAS data in RI to support source identification.
5. Implement the Surface Water Quality Action Level rule. Evaluate reported data and assess locations to determine if a PFAS source or source area can be identified.
6. Review authorizations for Underground Injection Control and prioritize for further assessment relative to potential PFAS releases.
7. Continue to collaborate within and outside RI on initiatives to address PFAS including but not limited to interagency workgroups (RIDEM-RIDOH), regional workgroups (e.g., NEWMOA, NEIWPCC, etc.), and the URI STEEP Program.

2 Introduction

Per and Polyfluoroalkyl Substances (PFAS) are a group of organic compounds in which the typical carbon/hydrogen backbone of the molecule is replaced with a carbon/fluorene back bone. Per (Latin for through, throughout, entirely, etc.), applies to organic compounds in which all of the carbon hydrogen bonds are replaced with carbon fluorene bonds. Poly (Latin for multiple) applies to compounds in which multiple, but not all the carbon hydrogen bonds, are replaced by carbon fluorene bonds. Due to the high electronegativity of fluorine, the carbon-fluorine bond is the strongest covalent bond in organic chemistry. Further, the adjacent carbon to carbon bond strengths are also enhanced by the existence of fluorine. These bond strengths result in incredibly high thermal and pressure stability (i.e., the chemical structure is able to withstand high temperatures or pressures and still perform as designed). These compounds are also non-reactive and have high chemical stabilities. That is, when PFAS are exposed to various classes of chemicals, such as, corrosives, (acids and bases) oxidizers, reducers, etc., the compounds exhibit low reactivity compared to traditional carbon hydrogen compounds, thus allowing them to function as design under chemical exposures that would have compromised the distinct function of traditional chemical hydrogen compounds. PFAS compounds are also not susceptible to the typical environmental biological, chemical or physical degradation processes (i.e., biodegradation, atmospheric photooxidation, direct photolysis, hydrolysis, oxidation, and reduction processes, etc.). As such, while compounds created with carbon hydrogen bonds will be subject to degradation processes and lose their chemical properties, compounds created with carbon fluorene bonds are able to withstand degradation processes and retain their chemical design properties. This immunity to degradation processes and the resulting long persistence in the environment, has resulted in the popular press describing them as, “forever chemicals.”

It should be noted the abovementioned chemicals thermal and degradation stability is related to the degree of fluorination, with highly fluorinated compounds exhibiting greater degrees of these attributes. In addition to the carbon fluorine backbone, PFAS compounds have different functional groups, such as, carboxyl, sulfonates, etc. These functional groups, along with the length of the molecule and degree of fluorination, affect the chemical design properties, thus increasing the versatility of the compounds.

PFAS prolific use in a variety of industrial and consumer products and processes has resulted in widespread contamination of a variety of environmental media. Human exposure mechanisms include industrial, commercial, and domestic production and/or product use, as well as exposure via releases to water, soil, air, and food. In toxicokinetic studies both long and short chain PFAS were found to be rapidly absorbed by the body. Once absorbed, they are distributed to all tissues of the body via plasma, where PFAS bind to serum albumin and other plasma proteins. They are found in all organs with the highest concentrations in the liver and kidneys. They are also able to pass though the placenta into fetus. The same chemical characteristic of the carbon fluorine backbone of PFAS contaminants which make them chemically stable and resistant to environmental degradation, also makes them resistant to chemical modification by the body. For example, for the most part, they are not bio transformed or metabolized, leaving excretion as the primary mechanism for removal from the body. Accordingly, similar to their persistence in the environment, certain PFAS such as, PFOS, PFOA, PFNA, and PFHxS have been found to be persistent in the human body with lengthy half-life's (2-7 years). This has led to measurable levels of these PFAS in the blood of nearly the entire population in developed countries, with health effects reported globally. Illustrative of the wide variety of PFAS compounds and their chemical properties, other PFAS compounds, such as, PFHxA, PFBS, PFBA are easily excreted and have a half-life of days.

There is a growing base of toxicological and epidemiological evidence available to support health assessments for a small number of PFAS. The vast majority of PFAS compounds have not been studied. PFOA and PFOS have been studied for a longer period of time, and as a result, have large evidence bases to support human health assessments. This is why they were the first PFAS to have Drinking Water Health Assessments. Subsequently, studies have been completed on a limited number of other PFAS contaminants to support assessment, which has resulted in additional standards being proposed. The USEPA has identified over fourteen thousand different PFAS compounds. In recognition of the impracticability of performing health assessments on each compound, the USEPA has been evaluating alternative approaches. The USEPA and National Toxicology Program (NTP) are testing one hundred and fifty (150) PFAS using rapid high throughput testing to more broadly inform hazard assessments of PFAS. This list includes PFAS from seventy-five (75) different subclasses and may help regulators construct a grouped approach to managing PFAS.

Authoritative bodies that have reviewed available health effects evidence include the USEPA, the Agency for Toxic Substances and Disease Registry (ATSDR), the NTP, the C8 Science Panel, the International Agency for Research on Cancer (IARC), the European Food Safety Authority, various organizations in the European Union and other countries, as well as a host of academic and other research entities. Below are adverse health effects associated with PFAS exposure.

Reproductive Effects:

- Decreased fertility increased high blood pressure or pre-eclampsia in pregnant females. Low sperm count and mobility in males.

- Increased miscarriage risk

Developmental Effects:

- Delays and/or developmental effects in children, including low birth weight, accelerated puberty, bone variations, behavioral changes, and delayed mammary gland development.

Tumor Induction:

- Increased risk of certain cancers, including prostate, kidney, and testicular cancers

Immunotoxicity:

- Reduced ability of the body's immune system to fight infections.
- Decreased antibody response to vaccines.

Hepatic and metabolic toxicity:

- Increased cholesterol levels
- Increase risk of obesity
- Liver damage
- Changes in liver enzymes

Endocrine Disruption:

- Increase risk of thyroid disease

Other:

- Lipid and insulin dysregulation
- Interference with the body's natural hormones.
- Increased risk of asthma
- Inflammatory bowel disease (Ulcerative Colitis)

(ATSDR 2021; CT Dept of Health; EU 2019; MA DEP 2019; Nat Lib of Medicine; Minnesota Pollution Control Agency 2023; National Toxicology Program 2023; NJ DEP; Science Advisory Board; USEPA 2023; USEPA; Washington Dept of Ecology 2022)

As noted, human health evaluations have been conducted for a limited number of PFAS contaminants. In general, for the compounds studied, they have been found to present a greater human health risk than other classes of contaminants, such as inorganic (metals) or nonfluorinated organic compounds. This is exemplified by comparing the USEPA Drinking Water Standard of typical inorganic and nonfluorinated organic compounds to that proposed for PFAS compounds. Inorganic and organic contaminants have standards expressed in concentration units of parts per billion (ppb). For example, the USEPA Drinking Water Standard for inorganic contaminants range from 2000 ppb for barium to 2 ppb for mercury. The corresponding standards for the vast majority of non-fluorinated organic compounds range from

10,000 ppb for xylene to 2 ppb for vinyl chloride, with a few compounds having lower standards, such as, 0.5 ppb for Polychlorinated Biphenyls (PCBs), 0.05 ppb for ethylene dibromide, and 0.00003 ppb for dioxin. PFAS contaminants have proposed standards expressed in concentration units of parts per trillion (ppt). Proposed USEPA drinking water standards for PFAS contaminants is 4 parts per trillion for PFOA and PFOS respectively and a cumulative hazard index of 1 for four other PFAS contaminants. This is more clearly illustrated if the typical units used for other non PFAS contaminants are all expressed in typical units for PFAS, i.e., parts per trillion.

Table 1: USEPA Drinking Water Standards for inorganic and nonfluorinated organic contaminants versus per- and polyfluorinated substances

Contaminant	**Units**
Inorganic (metals)	**Parts per Trillion (ppt)**
Barium	2,000,000
Mercury	2000
Non-Fluorinated Organic Compounds	
Xylene	10,000,000
Vinyl Chloride	2000
PCBs	500
Ethylene Dibromide	50
Dioxin	0.03
Per- and Polyfluorinated Substances[a]	
PFOA	4
PFOS	4
[a] USEPA Draft MCL	

Ecological effects have not been a well-studied factor from the result of PFAS contamination. A number of PFAS compounds are known to bioaccumulate with higher concentrations being observed in the higher trophic levels. This bioaccumulation is also a human health concern. Acute and chronic toxicity, that is, concentrations that result in death of test species after a short term or long-term exposure, vary considerably depending upon the test species and the particular PFAS. The same has been observed for growth and reproductive tests. There have also been studies on other ecological endpoints. A number of states and countries, as well as, the European

Union have developed a wide range of ecological benchmarks for PFAS (benchmarks are concentrations above which an adverse ecological affect is expected). The concentration values for these benchmarks range from parts per trillion, to parts per billion and parts per million, depending upon the media and the target designed to be protected.

In recognition of the adverse human health and ecological affects associated with PFAS, the Rhode Island Department of Environmental Management Office of Land Revitalization and Sustainable Materials Management has been working on a project to identify and investigate potential PFAS source areas. The first step in this process entailed an extensive research effort to identify general industrial, commercial products and uses of PFAS. This information was used along with comprehensive research of current and Rhode Island specific, historical documents, reports, files, and data bases, in various repositories to ascertain Rhode Island locations where PFAS may have been used in various applications. This step involved several different sections of DEM and other entities, such as, Brown University researchers. Waste streams associated with this application were also identified as this represents another mode for a release to the environment.

2.1 PFAS General Industrial, Commercial and Domestic Use

The first PFAS compound was accidently invented during an experiment on freon chemicals on April 6, 1938, by Roy Plunkett, a 27-year-old research scientist working at the DuPont's Jackson Laboratory in Deepwater, New Jersey. The chemist had accidently invented the polymer polytetrafluorethylene, while performing an experiment on freon. This new compound had a very low coefficient of friction (i.e., was slippery) and had very low adherence properties. After ten years of additional research the material was marketed by DuPont as Teflon (Dupont had to find a way to get a substance, which is very slippery and does not adhere to other materials and other materials do not stick to it, to stick to a surface).

This initial discovery of a PFAS compound led to rapid development of other compounds starting in the 1940s. Their antidegradation properties and their thermal, pressure, and chemical stabilities, as well as their versatility, made these compounds attractive for use in a wide variety of applications. They can be designed to have oil, water, stain, soil repellency, friction reduction, thermal stability, improve structural stability, serve as elastomer, lower surface tension, serve as vapor barrier, serve as heat conductor, impart dielectric properties, impart reduction in reactivity of materials, etc. The United States Environmental Protection Agency Distributed Structure-Searchable Toxicity Data Base lists 14,735 PFAS compounds (last updated August 2022).

The superior properties of the PFAS compounds as well as their versatility has resulted in the substitution of these compounds over traditional carbon hydrogen backbone compounds in a wide range of industrial, commercial, domestic applications.

PFAS compounds can be designed to have an amphiphilic structure (hydrophobic tail with hydrophilic head) which allows them to behave as surfactants. Since the carbon fluorine bonds have lower polarizability compared to the carbon hydrogen bond, PFAS compounds have a stronger affinity for interfaces than traditional hydrocarbon surfactants. These strong surface-active properties and propensity toward self-assembly into films, as well as, enhanced chemical, thermal, and degradation stabilities of the carbon fluorine backbone, is what makes PFAS an extremely effective, and superior surfactant. This one attribute has resulted in PFAS being substituted for traditional compounds in a wide variety of applications with these design properties, such as:

- Water/grease/dirt repellent in textiles and other materials
  - PFAS reduces the surface tension on the material so that liquids and oils bead up rather than spreading out and soaking through the material. Dirt adhesion is also prevented due to the PFAS coating. This has led to its industrial/commercial use in clothing, upholstery, leather goods, etc., as well as coatings on other materials, such as, tent polymers, solar panels, etc. Common domestic applications include textile treatments such as, but not limited to:
    - Scotchgard
    - Crypton
    - Green Shield
    - Nano-Tex
- Food packaging, fast food wrappers,
  - PFAS is used in paper/paperboard food packaging: as grease-proofing agents in fast-food wrappers, microwave popcorn bags, take-out paperboard containers, and pet food bags to prevent oil and grease from foods from leaking through the packaging/wrapping. PFAS superior properties means less protective coating can be applied compared to traditional coatings and the thickness of the paper material can also be reduced.
- Firefighting Foams
  - PFAS ability to quickly and effectively put out fires has resulted in its extensive use in synthetic foams, such as aqueous film-forming foam (AFFF) as well as protein foams (see section on firefighting foams, *2.2.1*).

The identification of products which contain PFAS is hindered by trade and patent rights in which proprietary claims protect against the identification of the PFAS composition of the product. Currently, since PFAS are not federally designated hazardous waste, substances, or materials, there are no waste reporting requirements under the Federal Resource Conservation and Recovery Act (RCRA). RCRA is a law designed to identify and track hazardous waste generation and disposal (note: the USEPA has initiated the process to regulate four PFAS compounds under RCRA). Nor were they identified as hazardous air pollutants under Clean Air Act regulations or considered hazardous waste under the Comprehensive Environmental

Compensation and Liability Act, also known as Superfund, (CERCLA). CERCLA is a law designed to identify and remediate past hazardous waste releases (note: the USEPA has initiated the process to regulate two PFAS compounds under CERCLA).

In certain cases, forensic chemical analysis and reverse engineering has been employed to identify certain PFAS components. Historical research has revealed that the number of products identified as containing PFAS is increasing as rising efforts have been undertaken by various entities in this endeavor, and as a result of certain Federal government actions. For example, the USEPA Toxic Release Inventory (TRI), which deals with the release of contaminants by facilities covered by the program, first required reporting of certain PFAS compounds in 2020. This authority was granted to the USEPA under the 2020 National Defense Authorization Act (NDDA). Under NDDA section 7321(e), the USEPA must review confidential business information claims before adding a PFAS to the TRI list. That is, the USEPA must make a determination that the reporting of a particular PFAS will not compromise trade or proprietary claims. In 2020, approximately 800,000 pounds of PFAS wastes were reported by large quantity generators subject to the Act. This value increased to approximately 1.3 million pounds of waste in 2021, This increase was largely due to the addition of one PFAS compound, Perfluorooctyl Iodide. In 2021, one hundred and seventy-six (176) PFAS contaminants had reporting requirements, and additional compounds were added. This trend continued in 2022 when the USEPA announced that nine (9) PFAS compounds will be added to the list in 2023, to increase the total number of PFAS reporting compounds to one hundred and eighty-nine (189).

A comprehensive list of PFAS containing products and uses in consumer, industrial, and commercial settings can be found in Appendix A. This list is the result of intensive research efforts and is a compilation of information obtained from US Federal Sources (USEPA, ATSDR, TSCA, DOD, DOE, FDA, CDC, etc.).

It should be noted that currently the statutory definition for PFAS under the *Industrial Property Remediation and Reuse Act* (RIGL 23-19.14-3) is limited to six compounds. Numerous products containing PFAS do not either employ these six compounds and/or do not have these compounds in significant concentrations compared to other PFAS components. As such, there is currently no regulatory authority under the aforementioned statute to compel the investigation and/or remediation of PFAS releases not associated with these six compounds. Thus, potential PFAS releases associated with sources identified in this table might only be addressed via a voluntary action by the responsible entity. A broad statutory definition of PFAS similar to that employed by other states would address this issue.

2.2 History of Firefighting Foams

The first firefighting foam was developed in 1902 by Russian engineer and chemist Aleksandr Loran. Loran, who was employed in the oil and gas industry, was trying to find a substance to combat petroleum-based fires for which water was totally ineffective and would exacerbate the situation. Loran's solution was the first firefighting foam which was able to extinguish oil and other flammable liquids-based fires by blanketing and smothering them (i.e., depriving them of oxygen).

In the 1960s, scientists at the US Naval Research Lab and researchers at the Minnesota Mining and Manufacturing Company, (the company known today as 3M) collaborated on the development of a more effective firefighting foam. The military had developed a specification for a product that could blanket (and thus block oxygen from) the fuel spill, suppress the fuel vapors, and prevent the evaporation and subsequent reignition of the spilled fuels. The result of the research was a new foam solution called aqueous film-forming foam (AFFF), which was patented by the U.S. Navy and 3M in 1966.

This research revealed that the use of synthetic chemicals Perfluorooctanoic acid (PFOA) and Perfluorooctanesulfonic acid (PFOS), and other members of the PFAS chemical family, would more effectively suppress fuel-based fires. AFFF is a combination of these PFAS compounds, representing three to six percent by weight of the total mass of AFFF, with the rest of the AFFF being composed of non PFAS surfactants (such as, sodium alkyl sulfate, alkyl glucoside, alkyl amidobetaine, etc.), solvents (such as, 2-butoxyethanol, 2-(2-butoxyethoxy)ethanol, 1,2-ethanediol, triethanolamine, etc.) solubilizers, and stabilizers. AFFF has the following properties:

- The fluorochemical based surfactant reduces the surface tension of water allowing the foam to form an aqueous film on the surface of the hydrocarbon fuel.

- Once applied across petroleum-based liquid, it forms a film on the liquid’s surface that deprives it of oxygen. The aqueous film that the foam forms is very fluid, and it can spread out in front of the foam blanket. In certain circumstances it is possible to notice the fire being extinguished by the "invisible" film before there is complete foam blanket coverage over the surface of the fuel. This attribute of AFFF provides near-instant fire suppression and translates into unequaled speed in fire control and knockdown when used on a typical hydrocarbon spill fire.

- The foam’s functionality creates a vapor barrier, which eliminates fuel evaporation and thus prevents re-ignition.

- AFFF was far more effective than the protein foams in use in the 1960s. Further, smaller volumes of AFFF would be required to extinguish a fire, compared to protein-based foams, and the fire would be extinguished more quickly. This translated into the ability to use smaller firefighting equipment and piping networks on ships.

- AFFF can be premixed, while protein-based foams cannot, increasing its versatility. An example of its versatility is that it can be dropped from helicopters.

- AFFF is more adaptable to different equipment in that it does not require the use of specialized aerating nozzles and larger diameter hoses as is required by protein foams.

- AFFF also had a longer shelf life, (at that time estimated to be a minimum eight years), than the protein-based foams, (shelf life of three years), currently in use at that time.

The widespread use of AFFF was accelerated in part by a catastrophic fire on the US Aircraft Carrier USS Forrestal on July 29, 1967, then being deployed for Vietnam War combat operations in the Gulf of Tonkin. The fire was triggered by the accidental launch of a rocket that exploded an A-4's external fuel tank and caused subsequent explosions. The blaze killed 134 sailors and injured 161—the Navy's most disastrous carrier fire since World War II. The Forrestal disaster drove the Navy to conduct a top-to-bottom overhaul of its firefighting protocols, including the development of military firefighting foam specifications requiring specific percentages of PFAS. The Navy also mandated widespread deployment of PFAS containing foams as a fire suppressant on board ships and carriers and at naval bases and air stations. AFFF was required on all U.S. Navy vessels by the late 1960s. By the 1970s, the Department of Defense began use of AFFF at other military facilities, (Air Force, Army, etc.).

In the late 1960s, in response to the Department of Defense actions, the protein based firefighting foam companies filed a lawsuit with the US General Accounting Office against the military mandates. The Protein Foam Companies noted that AFFF foams were considerably more expensive than protein foams (eleven times the cost) and that there was only a single source provider (i.e., 3M). Both of these facts were in violation of the government procurement process. The General Accounting Office cited the numerous advantages of AFFF and ruled against the Protein Foam manufactures. Subsequently, there was adaptation of AFFF by the military in the US and in other countries, as well as widespread use at civilian airports, civilian fuel terminals, municipal fire stations, etc. This widespread use along with the superior characteristics of PFAS compounds prompted the protein-based foam manufactures to produce PFAS containing protein foams in the 1970s. Ultimately, this led to the development of a variety of protein foams that contain PFAS compounds, such as fluoroprotein foam, film-forming fluoroprotein form (FFFP), alcohol-resistant fluoroprotein foam (AR-FP) and alcohol resistant film forming fluoroprotein (AR-FFFP).

In the 1960s, non PFAS Protein Foams contained natural proteins as the foaming agents, and as such, protein foams are biodegradable, unlike AFFF (which it is now known that the PFAS component is not biodegradable). In the late 1960s, during AFFF development, the Navy determined that AFFF was considered environmentally safe. Furthermore, the Navy thought that AFFF was biodegradable.

In the 1970s, Naval scientists had environmental concerns about AFFF. In 1974, the U.S. Navy's Research Center produced a report and noted concerns over releasing "a large raft of snow-white AFFF floating" into harbors, as was then the practice. Although the precise dangers posed by the foam were unclear and 3M had assured the Navy that the foam would have no adverse effect on the environment, according to the report the authors noted that "practically anything undrinkable by humans is unfit to discharge over the side into the sea" and suggested using instead foam made of glycerin and water.

In July of 1976, the United States Naval Research Lab produced a report entitled DTNSRDC Standard Static Marine Bioassay Procedure for Shipboard Chemicals. This Naval study was designed to ascertain the environmental impacts of the Ansul brand of AFFF. The study included:

Bioassay Lethal Concentration 50 Test (LC 50 Test) which is a procedure designed to determine the concentration of a chemical in water that would produce the acute effect of fifty percent of the organism dying within three to four days. It is important to note this an acute test and is not as sensitive to certain environmental impacts employing chronic or sub chronic tests.

Test species employed:

- *Fundulus sp.* (Killifish)
- *Artemia salina* (brine Shrimp)
- *Pseudomonas nigrifaviens* (Bacteria Species)
- *Thalasseri pseddonana* (Bacteria Species)

Biochemical Oxygen Demand

Provides an assessment of the amount of oxygen that would be consumed during the biological degradation of waste, also provides impacts of waste on the oxygen content of water.

Chemical Oxygen Demand

Provides an assessment of the amount of oxygen that would be consumed during the chemical oxidation of waste, also provides impacts of waste on the oxygen content of water.

The study concluded that the Ansul brand had a relatively low level of toxicity and BOD (Biochemical Oxygen Demand) and COD (Chemical Oxygen Demand) results indicated that the material is highly biodegradable.

In October 1976 a proposal produced by the Naval Research Laboratory Washington DC entitled R&D Final Report on DOD-AGFSR-76-10 (MIRP FY 7615-76-05064) Environmental Impact Properties of AFFF Materials, supported the study of experimental AFFF formulations that would exhibit reduced impact to the environment, while retaining acceptable firefighting properties. The proposal called for studying the various components of AFFF with the aim at determining if certain components could be modified to address both environmental and firefighting concerns. The proposal study was not implemented by the Navy. If the study had been carried out, it might have revealed that the PFAS portion of the AFFF was not biologically or chemically degradable, and that the previously observed degradation was associated with the non-fluorinated surfactants, solvents, stabilizers, and solubilizers.

The report noted that, “improvements are desired in the environmental area,” and the Naval scientists proposed changes to Navy practice, including additional testing for toxicity. The Navy did not take up all of the suggestions, and in 1976, Navy scientists proposed exploring alternatives to AFFF, citing environmental concerns.

In 1978, the DOD produced a revised Military Specification for Aqueous Film-Forming Foams (MIL-F-24585B 25 May 1978 Purchasing Agent AFFF Liquid Concentrate 6 Percent for fresh and sea water) which superseded previous specs. This revised spec includes standards for environmental impacts, specifically, toxicity (acute test LC 50), COD, BOD, and biodegradability.

A 1981 study conducted by the Air Force found AFFF harmful to female rats and their pups, including low birth weights.

In 1981, the DOD produced another revised Military Specification for Aqueous Film Forming Foams (MIL-F-24585B 12 March 1981 Purchasing Agent AFFF Liquid Concentrate 6 Percent for fresh and sea water), which superseded previous specs and included revised standards for environmental impact specifically, toxicity (acute test LC 50), COD, BOD, and biodegradability.

There were other subsequent studies which raised concerns about AFFF, and in 2000, 3M, the Navy’s partner in creating AFFF, announced it would stop making PFOS, the company’s patented surfactant, and ultimately, the foam.

Following the announcement of the phaseout, the Department of Defense held a meeting at the Naval Research Laboratory to discuss AFFF environmental issues within the Department of Defense.

In 2016, the Department of Defense halted land-based use of AFFF in training, testing, and maintenance, while also issuing directive ordering of proper removal and disposal procedures of PFOS-based AFFF.

2.2.1 Production and Use

Initially 3M was the sole producer of AFFF, afterwards a number of companies started producing military spec AFFF.

Table 2: Comprehensive list of Type 6 Aqueous Film Forming Foam (AFFF) formulations from their manufacturers, along with the first date on the Qualified Products List (QPL) and date removed.

Type	Product Name	Manufacturer	First Date on QPL	Date Removed from QPL
6	FC-196 Light Water	3M	1970_05_15	1971_10_04
6	FC-199 Light Water	3M	1971_10_04	1972_05_05
6	FC-200 Light Water	3M	1972_02_03	1974_05_09
6	Aer-O-Water 6	National Foam	1973_10_24	1978_01_16
6	FC-206 Light Water	3M → Minnesota Mining & Mfg Co	1974_05_09	1978_01_16
6	FC-200 Light Water	3M → Minnesota Mining &	1974_08_08	1977_03_11

		Mfg Co		
3M changed their company name to Minnesota Mining & Mfg Co. on 27 November 1974				
6	Ansul AFFF	Ansul	1976_06_03	1978_01_16
6	AFC-2	Ansul	1978_01_16	1982_05_04
6	FC-780	3M	1978_01_16	1979_05_17
6	FC-780B	3M	1979_05_17	1982_05_04
6	AFC-3	Ansul	1979_05_17	1982_05_04
6	AFC-5	Ansul	1982_05_04	1982_09_04
6	FC-206C	3M	1982_05_04	1990_02_20
6	Aer-o-water 6MD	National Foam System, Inc.	1982_05_04	1989_03_22
6	Ansulite 6% AFFF/AFC-5	Ansul	1982_09_04	1990_02_20
6	6% AFFF Type FC-206CE	3M	1984_02_08	1990_02_20
6	Aer-o-water 6MD	CHUBB National Foam, Inc.	1989_03_22	1990_02_20
AFFF manufactured before February 20, 1990, is not acceptable for current use. Revision D of Mil-F-24385 was. instated on this date which included more stringent fire performance requirements.				
6	6% AFFF Type FC-206CE	3M	1990_12_18	2002_04_24
6	Aer-o-water 6MD	CHUBB National Foam, Inc.	1990_12_18	1997_04_29
6	Ansulite 6% AFFF/AFC-5	Ansul	1990_12_18	2010_08_10
6	FC-206C	3M	1990_12_18	2002_04_24
6	FC-206CF	3M	1991_08_22	2007_01_03
6	Aer-o-water 6-EM	CHUBB National Foam, Inc.	1992_05_21	1997_04_29
6	Aer-o-water 6MD	National Foam, Inc.	1997_04_29	1998_09_30
6	Aer-o-water 6-EM	National Foam, Inc.	1997_04_29	2004_01_02
6	Chemguard 6% AFFF P/NC-601MS	Chemguard	2002_04_24	2014_12_02
6	Aer-o-water 6-EM	Kidde	2004_01_02	2015_12_21
6	Ansulite 6% AFFF/AFC-5	Ansul/Tyco	2010_08_10	2014_11_18
6	Fireade 2000-MIL6 AFFF	Fire Service Plus	2011_05_04	2018_01_22
6	AnsuliteAFC-6MS 6% AFFF	Tyco/Ansul	2015_12_15	ACTIVE
6	Chemguard C606-MS 6% AFFF	Tyco/Chemguard	2015_12_15	ACTIVE
6	Arctic 6% MIL-SPEC AFFF	Amerex/Solberg	2016_03_30	ACTIVE
6	Aer-O-Water 6EM-C6 AFFF	National Foam	2016_05_04	ACTIVE
6	Tridol-C6 M6 AFFF	National Foam	2016_05_04	ACTIVE
6	Phos-Chek 6% Milspec AFFF	ICL	2018_01_08	ACTIVE
6	Fireade MILSPEC 6	Fire Service Plus	2018_01_22	ACTIVE

Table 3: Comprehensive list of Type 3 Aqueous Film Forming Foam (AFFF) formulations from their manufacturers, along with the first date on the Qualified Products List (QPL) and date removed.

Type	Product Name	Manufacturer	First Date on QPL	Date Removed from QPL
3	AFC_5A	Ansul	1982_05_04	1982_09_04
3	FC_203C	3M	1982_05_04	1990_02_20
3	Aer-O-Water 3	National Foam System, Inc.	1982_05_04	1989_03_22
3	Ansulite 3% AFFF/AFC-5A	Ansul	1982_09_04	1990_02_20
3	3% AFFF Type 203CE	3M	1984_02_08	1990_02_20
3	Aer-O-Water 3	CHUBB National Foam, Inc.	1989_03_22	1990_02_20
AFFF manufactured before February 20, 1990 is not acceptable for current use. Revision D of Mil-F-24385 was instated on this date which included more stringent fire performance requirements.				
3	3% AFFF Type 203CE	3M	1990_12_18	2002_04_24
3	Aer-O-Water 3	CHUBB National Foam, Inc.	1990_12_18	1997_04_29
3	Ansulite 3% AFFF/AFC-5A	Ansul	1990_12_18	2010_08_10
3	FC_203C	3M	1990_12_18	2002_04_24
3	FC_203CF	3M	1991_08_22	2010_08_10
3	Aer-O-Water 3-EM	CHUBB National Foam, Inc.	1992_05_21	1997_04_29
3	Tridol M 3%	Angus Fire	1994_04_21	2010_08_10
3	Aer-O-Water 3	National Foam, Inc.	1997_04_29	1998_09_30
3	Aer-O-Water 3-EM	National Foam, Inc.	1997_04_29	2004_01_02
3	Chemguard 3% AFFF C-301MS	Chemguard	1998_10_30	2017_02_08
3	Buckeye 3% BFC-3MS AFFF	Buckeye	2004_01_02	2015_09_22
3	Aer-O-Water 3-EM	Kidde/National	2004_01_02	2015_12_21
3	Ansulite 3% AFFF/AFC-5A	Ansul/Tyco	2010_08_10	2014_10_23
3	Tridol M 3%	Kidde/National/Angus	2010_08_10	2015_12_21
3	Phos-Chek 3% AFFF MS	ICL Performance Products	2015_11_10	ACTIVE
3	Ansulite AFC-3MS 3% AFFF	Tyco/Ansul	2015_12_15	ACTIVE
3	Chemguard C306-MS 3% AFFF	Tyco/Chemguard	2015_12_15	ACTIVE
3	Arctic 3% MIL-SPEC AFFF	Amerex/Solberg	2016_03_30	ACTIVE
3	Aer-O-Water 3EM-C6 AFFF	National Foam	2016_05_04	ACTIVE
3	Tridol-C6 M3 AFFF	National Foam	2016_05_04	ACTIVE
3	Fomtec AFFF 3%M "SWE"	Dafo Fomtec AB	2017_05_12	ACTIVE
3	Fomtec AFFF 3%M "USA"	Dafo Fomtec AB	2017_05_12	ACTIVE
3	Fireade MILSPEC 3	Fire Service Plus	2018_01_22	ACTIVE

The Ciba Geigy plant in Rhode Island was one of the facilities which produced PFAS for AFFF. In 1977 Ciba-Geigy Corp., with Ansul Co. and Able Fire and Safety Equipment, Inc. as plaintiffs, took action against a lawsuit filed by 3M for allegedly illegally producing AFFF main ingredients in the Cranston Rhode Island production facility. These defendants sought a declaration that their making, using, and selling a certain Firefighting foam, (Ansul AFFF), and its component ingredients, do not infringe patents owned by defendants because said patents are invalid, void, and unenforceable. Plaintiffs sought a preliminary injunction against 3M to halt pending patent litigation, in the Rhode Island Superior Court.

It should be noted that at that time action was taken by the USEPA and the State of Rhode Island against Ciba Geigy for the companies’ environmental practices and the pollution of the Pawtucket River and the bay. Ciba Geigy was also being sued by environmental groups over this issue.

There are different manufacturing processes to produce AFFF, as well as the various PFAS containing protein foams. This has resulted in difference in both the specific PFAS components present in the foam, as well as the number of different PFAS components present. As an illustration of the latter, certain AFFF contains hundreds of different PFAS, while other contain dozens of different PFAS components. PFAS formulation produced by the same manufacturer could change over time. Specifically, the forensic analysis of 3M AFFF produced in 1989 has a different formulation from the forensic analysis of 3M AFFF produced in 1993.

Similar to forensic investigations of other PFAS containing products, results of forensic analysis of firefighting foams varied depending upon the analytical procedures employed. As an illustration, a number of forensic studies conducted by the Department of Defense Strategic Environmental Research and Development Program (SERDP) and the Environmental Security Technology Certification Program (ESTCP) were limited to twenty-four (24) individual PFAS. In contrast, a 2017 collaborate forensic analysis conducted by six universities in the United States and Canada of ten AFFF formulations used by the military (five 3M products and five products produced by the telomer process) was far more comprehensive. This study identified forty previously unidentified classes of PFAS (a class is a group of individual compounds that have similar features), plus additional homologues (similar chemical structure) for seventeen (17) previously reported classes for a total of two hundred and forty (240) individual compounds (novel or newly discovered and previously reported).

The researchers also conducted a forensic analysis of AFFF impacted groundwater and the researchers determined that fourteen of these new PFAS classes would only be associated with AFFF contaminated groundwater. These classes include:

- O-U-PFAA
- N-HOEAmP-FASAHOPS
- N-SHOPAmPFASAHOPS
- N-AHOB-FASAPS
- N-SPAmPFASAA
- N-SHOPAmPFASAA
- N-CMAmPFASAA
- N-CEAmP-EtFASA
- N-dHOBAmP-FASA
- N-AmCP-FASA
- HO-N;2FTS
- N:2FTSO2PA

AFFF and various protein foams containing PFAS are used in a variety of industries where hazardous flammable liquids are present such as:

- Chemical Plants

- Flammable Liquid Storage and Processing Facilities
- Merchant Operations (Oil Tankers)
- Oil Refineries, Terminals, and Bulk Storage Facilities
- Aviation Operation (Fuel Storage Facilities, Hangers, Aircraft Rescue and Firefighter Training Area)
- Fire Departments Firefighting Training Facilities
- Military Facilities

The amount of AFFF stored at these industries is significant. In 2004 it was estimated that there was approximately 4.6 million gallons of AFFF concentrate (non-dilute AFFF) in the US.

The estimate volumes were as follows:

Use Sector	Gallons of PFOS-based AFFF
Military & Other Federal	2,100,000
Civil Aviation (ARFF)	130,000
Oil Refineries	950,000
Other Petro-Chem	1,000,000
Civil Aviation (Hangars)	190,000
Fire Departments (non-aviation)	120,000
Misc/Merchant Ship/Offshore	150,000
Total:	4,640,000 gallons

It should be noted that the above is limited to PFOS containing AFFF. It does not represent the total amount of AFFF in use, i.e., it does not include AFFF with telomer-based fluorosurfactants. Telomer-based fluorosurfactants do not contain or break down into PFOS. As an illustration, the DOD had 0.77 million gallons of non PFOS AFFF in 2004.

The study focused on the type of AFFF originally created by 3M/Navy. At the time of the study, PFOS was the subject of human health and environmental concerns. 3M had discontinued production of PFOS in AFFF in 2002 and the study was focused on the amount of PFOS containing AFFF was still in the US. The study was based upon a limited survey of various entities and assumed an 8 percent reduction rate in the amount of PFOS containing foam since 3M stopped production in 2000.

A different study estimated that 9150 tons of PFOS AFFF was released worldwide during the 1970-2002 time period.

Obtaining accurate data on the amount of AFFF in use by different entities has been hampered by a number of issues including the reluctance of entities to report the amount of AFFF in their possession. More specifically, the aforementioned 2004 report notes that there were 120,000 gallons of AFFF foam in US fire stations. On April 21, 2023, the State of North Carolina reported having 120,246 gallons of AFFF concentrate and in 2020 the State of Michigan reported having 51,400 gallons of AFFF (note: approximately one half of the fire stations in the state participated in the survey). As of April 2022, the State of Connecticut took back 35,000 gallons of AFFF concentrate.

Releases associated with these locations include use of foam in emergency situations, disposal of dated foam, release associated with compromised systems and use in required fire system testing.

Releases associated with the fire system testing can be significant. Insurance and/or regulatory/policy requirements require live testing of static fire suppression systems, mobile firefighting equipment and/or practice exercises using foam. The volumes of foam associated with these actions varies. A static system designed to protect tanks at a fuel terminal may entail an extensive piping network with thousands of feet of piping and multiple pump houses and associated tanks. After the system is tested, the piping network, tanks, and pumps have to be drained of AFFF, typically by drain spigots at the pumps, tanks, and at low points in various sections of the piping network. Common practice that was employed involved direct discharge of the AFFF to the ground surface.

In 1999 the USEPA produced a report to ascertain the amount of PFAS released on US Navy and Coast Guard ships combined, associated with required testing of equipment. The USEPA estimated that Naval/Coast Guard ships annually discharged approximately 4,924,000 gallons of AFFF aqueous solution (volume is based upon a calculated use of 366,000 pounds of AFFF and represents both the AFFF/water solution used in the test, and washed down water to remove foam, which as a result, contains AFFF).

3 Statewide Public Water Supply Testing

3.1 Third Unregulated Contaminant Monitoring Rule

Public water systems (PWS) in Rhode Island were first sampled for PFAS as part of the Third Unregulated Contaminant Monitoring Rule (UCMR 3). The UCMR 3 required testing of all PWSs serving more than 10,000 people, as well as a subset of smaller PWSs between January 2013 and December 2015. Six (6) PFAS were included as part of the UCMR 3 testing, these include PFOS, PFOA, PFNA, PFHxS, PFHpA, and PFBS. In Rhode Island, only two (2) of the public water systems in the Town of Cumberland and the Town of Westerly were found to contain PFAS above the method report limit (20 ppt) at that time.

3.2 2017 Statewide Surveillance Monitoring Study

In 2017, in response to the 2016USEPA Lifetime Health Advisory (LHA) for PFOA and PFOS (i.e., 70 ppt or ng/L for the sum of PFOA and PFOS), The Rhode Island Department of Health (RIDOH) initiated a sampling study of public water systems not previously covered under UCMR 3 testing (i.e., less than 10,000 people served), licensed bottlers, and licensed childcare facilities.

Source Identification and Prioritization

RIDOH partnered with RIDEM and the Brown University Superfund Research Program to prioritize PWSs for sampling based on their proximity to known or suspected sources of PFAS.

RIDEM/RIDOH

Potential PFAS sources identified and considered as part of the 2017 Surveillance Monitoring Study included:

- Airports
- Fire Training Areas
- EPCRA Tier II
  - High Priority (those that submitted forms for storage of at least 10,000 lbs. of PFAS)
- Industrial facilities with North American Industry Classification System (NAICS) codes 325211 plastics material and resin manufacturing, 332812 metal coating and engraving except jewelry and silverware, and Standard Industrial Classification (SIC) code 28210213 polytetrafluoroethylene resins and Teflon manufacturing.
  - High Priority Industrial Facility (company website explicitly describes use of PFC compounds or products known to be made with PFC compounds (Teflon, Gortex, Kevlar) in production operations conducted at specific facility)

  - Medium Priority Industrial Facilities (company website describes production operations that may use PFC compounds, but does not explicitly reference use of PFC compounds at specific facility)
  - Low Priority Industrial Facility (company website describes production operations that may use PFC compounds, but there was not enough information to confirm that such production operations occurred at specific facility)
  - Lowest Priority Industrial Facility (company website did not include any information to suggest that the company was currently using PFC compounds)
- Saint Gobain Plastics (High priority – performance plastics and high-performance glass facilities, Medium priority – all other facilities)
- Petroleum Terminals (Tank Farms)
- CERCLIS and CERCLIS NPL Sites
- Industrial Wastewater Lagoons
- Department of Defense Sites
- Electroplating Facilities
- Emergency Response Incidents with documented deployment of AFFF
- Industrial Facilities with other NASICS/SIC codes (see Table 4)

Table 4: List of industrial facilities with other North American Industry Classification System (NAICS) and Standard Industrial Classification (SIC) codes

SIC CODE	Manufacturer	NAICS Code
2221	Broadwoven Fabric Mills, Manmade Fiber and Silk	313210
2262	Finishers of Broadwoven Fabrics of Manmade Fiber and Silk	313310
2273	Carpets and Rugs	314110
2295	Coated Fabrics, Not Rubberized	313320
2297	Non-woven Fabrics	313230
2299	Textile goods, Not Elsewhere Classified	313110
2385	Waterproof Outerwear	314999
2392	House furnishing, Except Curtains and Draperies	314999
2621	Paper Mills	322121
2656	Sanitary Food Containers, Except Folding	322219
2671	Packaging Paper and Plastics Film, Coated and Laminated	322220

2672	Coated and Laminated Paper, Not Elsewhere Classified	322220
2673	Plastics, Foil, and Coated Paper Bags	322220
2752	Commercial Printing, Lithographic	323111
2796	Platemaking and Related Services	323120
2824	Manmade Organic Fibers, Except Cellulosic	325220
2842	Specialty Cleaning, Polishing, and Sanitation Preparations	325612
2844	Perfumes, Cosmetics, and other Toilet Preparations	325611
2851	Paints, Varnishes, Lacquers, Enamels, and Allied Products	325510
2869	Industrial Organic Chemicals, Not Elsewhere Classified	325193
2899	Chemicals and Chemical Preparations, Not Elsewhere Classified	325199
2911	Petroleum Refining	324110
2992	Lubricating Oils and Greases	324191
3081	Unsupported Plastics Film and Sheet	326113
3082	Unsupported Plastics Profile Shapes	326121
3083	Laminated Plastics Plate, Sheet, and Profile Shapes	326130
3089	Plastics Products, Not Elsewhere Classified	326121
3471	Electroplating, Plating, Polishing, Anodizing, and Coloring	332813
3497	Metal Foil and Leaf	332999
3589	Service Industry Machinery, Not Elsewhere Classified	333318
3841	Surgical and Medical Instruments and Apparatus	333249
3861	Photographic Equipment and Supplies	333316
5169	Chemicals and Allied Products, Not Elsewhere Classified	424690
5719	Miscellaneous Home Furnishings Stores	442291
7217	Carpet and Upholstery Cleaning	561740

Brown University

The Brown University Superfund Research Program developed their own risk-based, geospatial analysis of potential PFAS impacts to aquifers in Rhode Island. This approach was detailed in *Evaluation and Management Strategies for Per- and Polyfluoroalkyl Substances (PFASs) in Drinking Water Aquifers: Perspectives from Impacted U.S. Northeast Communities* by Guelfo et al (available at: https://ehp.niehs.nih.gov/doi/10.1289/EHP2727). The output from this work was used in conjunction with the map developed by State to target PWSs for sampling and analysis.

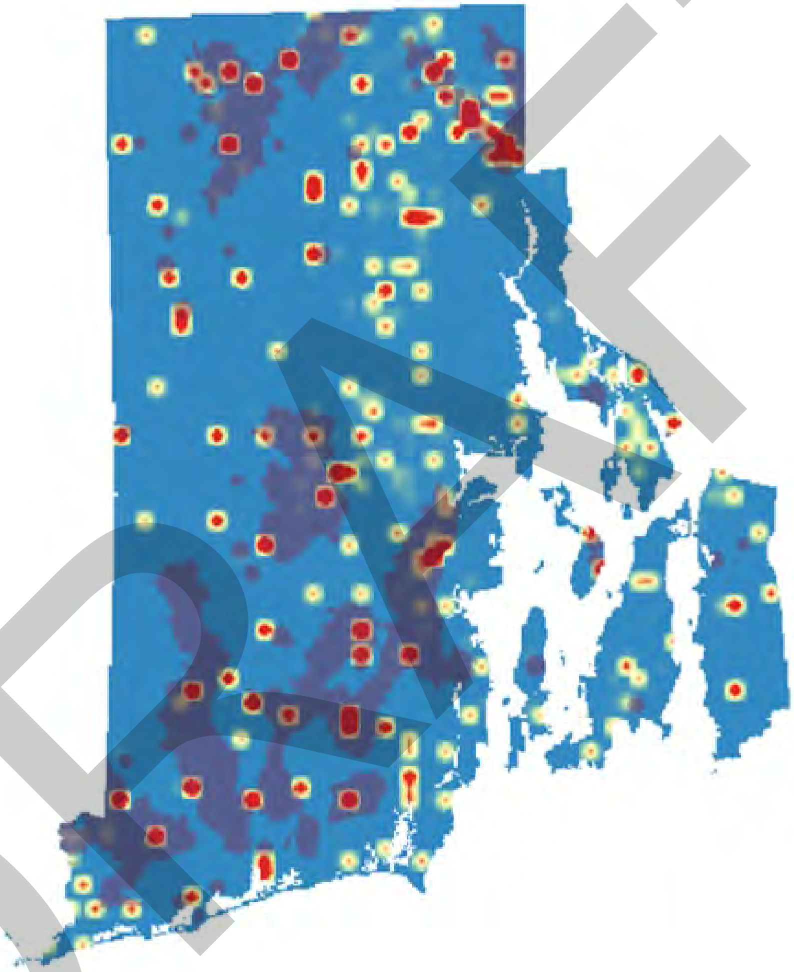


Figure 1: Geospatial analysis of potential PFAS impacts to aquifers in Rhode Island created by the Brown University Superfund Research Program

Sampling and Analysis

Graduate and Post-Doc students from Brown University collected the samples from the selected PWSs. The samples were analyzed at the Rhode Island Department of Health Laboratory for nine PFAS. At the time, the laboratory was able to achieve an MDL of 4 ppt. The 2017 study targeted approximately 40 total and the results are summarized below:

- < MRL: 26 water systems
- Detected < 35 ng/L (ppt): 8 water systems.
    - 4 - 24 ppt (Average and Median = 13 ppt)
- 35 – 70 ppt: 1 water system
    - Raw 43.2 ppt, Treated 11.0 ppt.
- >70 ppt: Oakland Water Association, Inc.

3.3 2019 Statewide Surveillance Monitoring Study

A follow-up Statewide Surveillance Monitoring Study was implemented by RIDOH in 2019, taking into account some of the lessons learned from the previous study and including a broader suite of analytes and lower detections limits. Five additional PFAS were included as part of this study, bringing the total number of PFAS analyzed for to fourteen (14).

Fire stations were not included as part of the methodology for identifying potentially impacted PWSs during the 2017. This was primarily due to the thought that fire stations themselves would present a lower likelihood of release as opposed to fire training areas, airports, and other locations where intentional discharge of AFFF would be anticipated. Furthermore, including fire stations would have greatly expanded the scope of potentially impacted PWSs. After the 2017 study results and the impacts to the Oakland Water Association which the OLRSMM was able to attribute to the Oakland-Mapleville Fire Department, it was decided that PWSs within ½-mile of a fire station would be sampled as part of the 2019 study.

After the conclusion of the 2019 Surveillance Monitoring Study, the drinking water of approximately 87% of Rhode Islanders had been sampled, including 97% of Rhode Islanders who get their drinking water from public water systems, 100% of municipal water systems that serve populations more than 10,000, 49% of community water systems, 100% of schools that have their own public wells, and 5 licensed childcare facilities served by private wells.

The results of both studies are summarized below:

- Of the 87 water systems sampled (including the 5 childcare facilities that use private wells), 38 (44% of sampled water systems) had a detection of at least one PFAS.
- One public water system (1% of sampled water systems), Oakland Association in Burrillville, had levels of PFOA and PFOS that were higher than theUSEPA LHA of 70 ppt.
- Two public water systems (2% of sampled water systems) had levels of PFOA and PFOS between 36 and 70 ppt.
- Thirteen public water systems (15% of sampled water systems) had PFAS levels higher than 20 ppt for the combined sum of PFOA, PFOS, PFHxS, PFHpA, and PFNA.
- RIDOH found detections of PFAS in wells serving schools in eight communities, with a range of 4 to 30 ppt for total PFOS and PFOA.

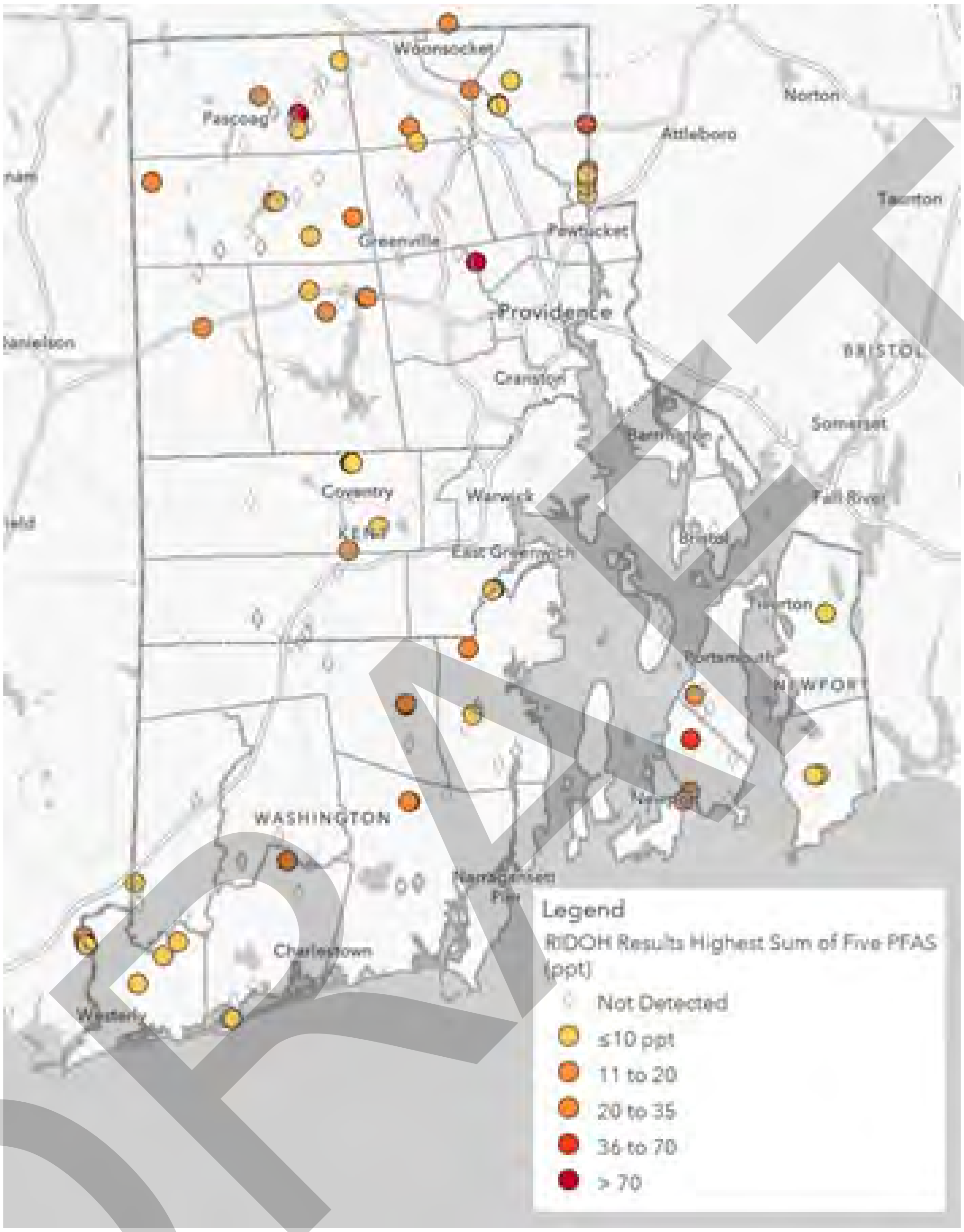


Figure 2: Location results with the highest sum of five PFAS from the Statewide Surveillance Monitoring Study implemented by RIDOH in 2019

3.4 Oakland Water Association Source Investigation

As previously noted, the only PWS to exceed the 2016 USEPA LHA for PFAS during the 2017 Statewide Surveillance Monitoring Study was the Oakland Water Association, in Burrillville. The Oakland Water Association served consisted of 35 connections, many of them multifamily dwellings, and serving approximately 175 residents. The preliminary sample collected from the Oakland Water Association was collected on August 24, 2017. The results of this sample were reported on September 14th and the sum of PFOA and PFOS was 88 ppt. Per protocol developed by RIDOH, a confirmatory sample was collected immediately. The confirmatory sample was collected on September 19th and the results were reported on September 22nd. This time the sum of PFOA and PFOS were just below the USEPA LHA at 69 ppt. One additional sample was collected on September 26th and the results were reported on September 29th. In this final sample, the sum of PFOA and PFOS were 114 ppt.

The village of Oakland is located at the confluence of the Clear River and Branch River. The physical geography effectively means that the village is hydraulically isolated from the surrounding area. The potential PFAS "source" responsible for the Oakland Water Association being included in the initial surveillance monitoring study was actually a municipal wastewater lagoon located approximately three-quarters of a mile to the south in Mapleville. There are also two closed municipal landfills approximately three-quarters of a mile to the west located along the Branch River. However, the unique geography of the village pointed to a more localized source. An initial assessment of the area after the reported exceedance noted that the Oakland-Mapleville Fire Station was located less than 100 yards away from the impact public water supply well. This fact, coupled with the relative proportion of perfluorinated sulfonic acids, particularly PFHxS and PFOS, which are typically indicative of an AFFF release, led RIDEM to suspect the fire station as the likely source of contamination.

Figure 3: Location map of the Oakland Water Association in the village of Oakland. The dark blue dot in the center of the map is the location of public supply well(s) that served the PWS. The PWS served the eastern portion of the village, primarily those houses located along Victory Highway.

Both RIDOH and RIDEM had prepared extensively for the possibility of PFAS exceeding the USEPA LHA in a PWS during the study. RIDOH immediately initiated communication with the affected community and a public meeting was held on October 3rd at the Burrillville Police Department. RIDEM was tasked with the source investigation and also the investigation of private wells in close proximity to the impacted public water supply well located at 1264 Victory Highway in the Village of Oakland in the Town of Burrillville. Following the public meeting, RIDEM immediately provided bottled water to all residents on the Oakland Water Association and all residents on private wells within one-quarter mile of the impacted well. There were nearly 60 private wells located within the one-quarter mile radius, primarily located in the western portion of the village, with few exceptions. With the assistance of a technical assistance contractor, Weston & Sampson, RIDEM sampled nearly all of the private wells in the village over the next three days following the public meeting.

OLRSMM staff and Burrillville Police assist in the delivery and distribution of bottled water to reseidents on October 4th.

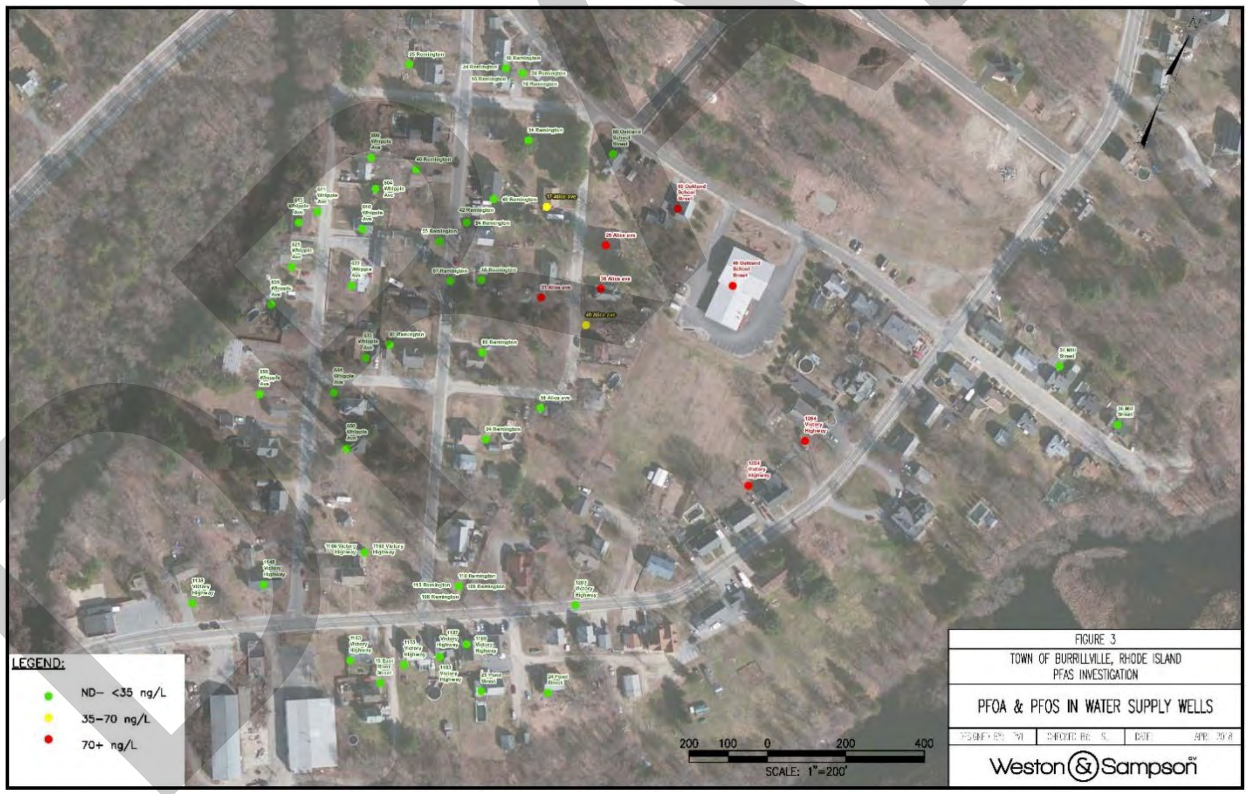


Figure 4: Map showing the results of the private well sampling in Oakland. Note the Oakland-Mapleville Fire Department is the large building in the center of the map (Weston & Sampson, 2018).

The results of RIDEM’s private well sampling effort are shown in the Figure above. The highest levels of PFAS were detected in the vicinity of the Oakland-Mapleville Fire Department. Concentrations were detected as high as 218 ppt for the sum of PFOA/PFOS in the initial round of sampling. All residences served by the Oakland Water Association and all private wells exceeding the USEPA LHA were provided with water dispenser and set up to receive regular deliveries of bottled water until an alternative source water source was available.

Numerous 5-gallon containers of various AFFF concentrate were observed stacked on either side of the main bay of the fire station upon initial inspection. Note the trench drain at the end of the garage bay in the first photograph.

At this time, RIDEM had no established standards for PFAS and no authority to regulate PFAS. No PFAS were, and still are not, listed as a hazardous substance under Federal law and the definition of a hazardous substance in State statute is directly tied to the Federal definition. Fortunately, the *Groundwater Quality Rules* allowed for the Director to adopt an interim Class GAA and Class GA Groundwater Quality Standard for “a substance with no maximum contaminant level.” As a result, on October 18, 2017, the Director, Janet Coit officially adopted an interim Groundwater Quality Standard for PFOA and PFOS equivalent to the 2016 USEPA LHA. This gave RIDEM the authority to require the restoration of groundwater classifed as GAA and/or GA impacted by PFAS, including the village of Oakland.

With the assistance of Weston & Sampson, the OLRSMM developed a plan to investigate the entire village to definitively determine the source of the PFAS contamiantion and to characterize the nature and extent of the release. The investigation consisted of the advancement of soil borings, collection of discrete groundwater samples, and the installation of permanent groundwater monitoring wells throughout the village. The investigation was completed over the course of the next few months into 2018. The results of this investigation demonstrated that the Oakland-Mapleville Fire Department located at 60 Oakland School Street was the source of the PFAS contamination in the village as initially suspected. The highest concentrations of PFAS in goundwater were found on the fire station property. It was found that shallow (overburden) groundwater generally flowed in a southeasterly direction towards the Branch River. Subsequent investigations determined that the overburden groudnwater plume is discharging into the former mill pond in the Branch River. It was apparent that high-density of public and private wells in the village had also drawn the contamination into the bedrock aquifer.

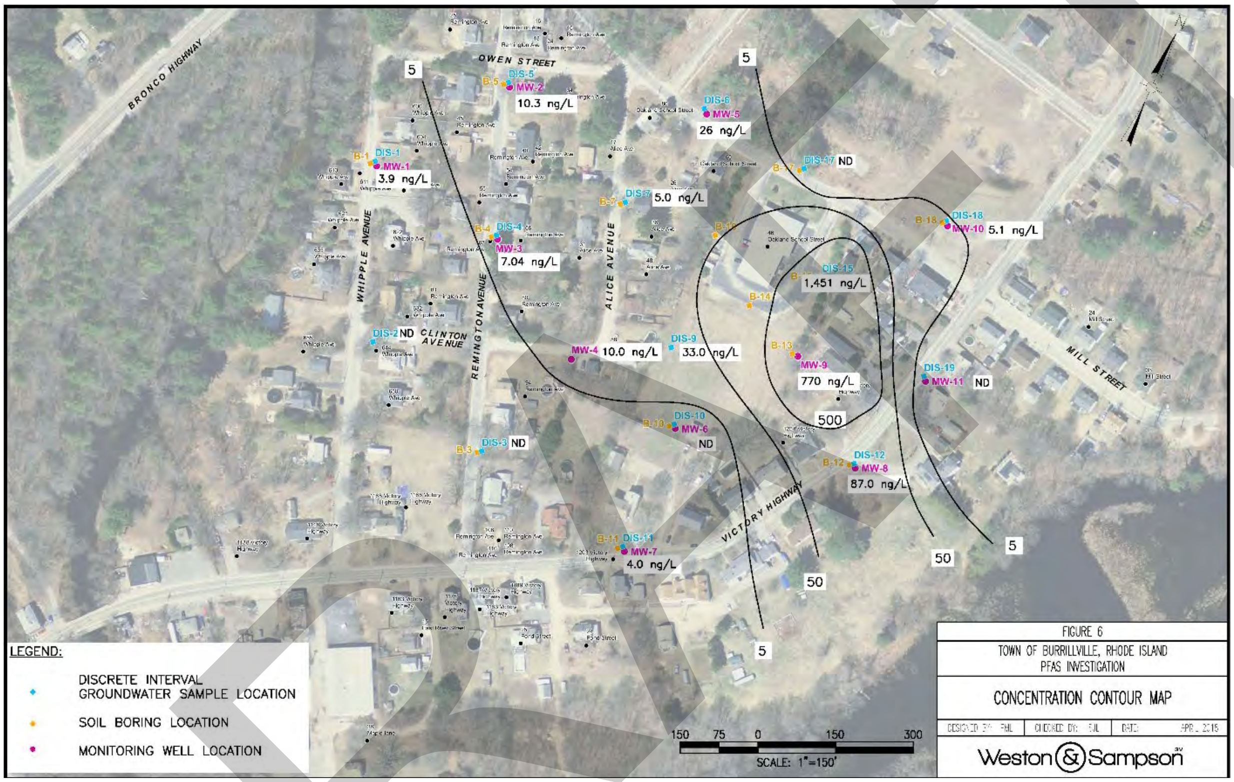


Figure 5: Figure showing the results of the PFAS Source Investigation in Oakland. The concentrations of PFAS (PFOA and PFOS) detected in groundwater and the concentration gradients are shown on this Figure(Weston & Sampson, 2018).

The conceptual site model for the release of PFAS in Oakland likely involved a combination of the following: leaking and/or spillage of AFFF concentrate containers stored at the fire station, incidental releases of contaminated water from apparatus stored in the garage after use of AFFF in response incidents, and/or incidental releases from washing and/or rinsing of fire apparatus in the fire station parking lot. Trench drains located at either end of the garage bays at the openings were improperly tied into the stormwater system serving the roof downspouts and parking lot area. This connection is not allowed due to the potential of hazardous substances and/or petroleum leaking from fire apparatus stored in the garage bays to infiltrate directly into the subsurface. When the facility was constructed circa 2001, RIDEM approved the construction of an approximately 200-foot-long underground injection control (UIC) system (i.e., an infiltration galley) to infiltrate stormwater falling on impervious surfaces on the property. The infiltration galley consisted of a series of five (5) perforated pipes enclosed in approximately four (4) feet of crushed stone. The bottom depth of the structure was approximately six (6) below grade. Two catch basins were also located in the parking lot and tied directly into this UIC.

The infiltration galley was located on the western side of the fire station property underneath the parking lot. Subsurface investigation conducted by Weston & Sampson on behalf of RIDEM determined that bedrock in this particular area of village was particularly shallow, as shallow as seven (7) below grade immediately adjacent to the infiltration galley. Therefore, any discharge from this infiltration galley would have had a conduit directly into the underlying bedrock.

Following this PFAS source investigation, the OLRSMM issued a Letter of Responsibility requiring the Oakland-Mapleville Fire Department to initiate groundwater remediation in accordance with the *Groundwater Quality Rules*. This included taking over the provision of bottled water to all affected residences and to further investigate and monitor the impacts to groundwater and surface water from the PFAS release.

RIDOH worked with the Rhode Island Infrastructure Bank (RIIB) and the Harrisville Water Department on a water line extension in the village of Oakland to serve all of the affected residences, including both private wells owners and those residences formerly tied into the Oakland Water Association. Fortunately. the Harrisville Water District had a service line that ran directly in front of the fire station on Oakland School Street and served a new subdivision to the north. The over $2 million dollar project was made possible in large part due to a principal forgiveness loan from RIIB to the Harrisville Water district. The water line extension was completed in late 2019 and the majority of residences in the village, save for a few served by private wells, opted to connect. RIDOH had previously explored treatment options for the Oakland Water Association, which would have been very costly and not provided a solution to the private well owners in the village. There was also concern that if the public supply well was no longer withdrawing groundwater that the private wells to the west would begin drawing significantly more contamination, potentially increasing the number of private wells exceeding the USEPA LHA.

RIDEM learned a significant amount from managing the response to the Oakland Water Association PFAS contamination. The prioritization of identifying impacts to drinking water resources over first characterizing the nature and extent of the release was a departure from the standard approach to site assessment, but it has since become integral to RIDEM's approach to PFAS contamination. This is largely due to the recognition that remediation of PFAS impacts in a drinking water aquifer are often impractical from both a technical and economical perspective. Therefore, prioritizing point-of-use treatment of impacted drinking water is paramount. RIDEM has subsequently required the responsible party in this case continue monitoring drinking water resources (i.e., private wells still in use) and to provide an alternative drinking water source (e.g., connection to the new water line, bottled water, etc.) in the event that these drinking water resources exceed current and/or future standards for PFAS. This overall approach is consistent with the principles of risk management outlined in the *Remediation Regulations*.

The cost of the initial response actions and subsequent source investigation cost RIDEM upwards of $250,000, not including staff time. The availability of an unimpacted municipal water supply from the neighboring village of Harrisville, greatly mitigated what could have been an extremely costly and perpetual treatment of the entire village of Oakland's drinking water resources. A hypothetical case study is discussed later, which demonstrates what the cost would have been to treat the impacted drinking water in perpetuity. In short, it very quickly would have exceeded the cost of the water line extension.

3.5 2022-2023 Mandatory Sampling

The PFAS legislation passed in June 2022 (RI HB 7223A/ RI S2298) required that on or before July 1, 2023, all public water systems, with the exception of transient, non-community water systems, conduct monitoring for the presence of PFAS in drinking water. This requirement was more comprehensive than the previous Statewide Surveillance Monitoring studies. The Table 5 below summarizes the exceedances of the Interim Drinking Water Standard.

Table 5: PFAS results for PWSs subject to the mandatory sampling requirement.

Water System	**City/Town**	**PFAS Level (ppt)**
Exceeds 70 parts per trillion (ppt)		
Bruins Plastics	Glendale (Burrillville)	129
Exeter Job Corps[a]	Exeter	198[b] / 40
Ladd Center	Exeter	314[b] / 30
Exceeds 20 parts per trillion (ppt)		
West Glocester Elementary School	Glocester	44
Captain Isaac Paine School	Foster	42
North Smithfield Jr-Sr High School	North Smithfield	31
Carousel Industries	Exeter	55
Wrights Farm	Burrillville	22
Coventry Air National Guard	Coventry	84[b] / 18
Wood River Health Services	Hope Valley (Hopkinton)	28
University of Rhode Island (URI)	South Kingstown	43[b] / 39
Quonset Business Park	North Kingstown	21

[a] The Exeter Job Corps is supplied water from the Ladd Center's water system.
[b] This well was turned off after sample was taken and is no longer in use. The second highest result is also shown.

Public water systems who exceeded 70 ppt for the sum of the PFAS6 were issued “Do Not Drink the Water” warnings by RIDOH. Although some new PWSs that exceeded the interim drinking water standard were expected, it should be noted that some PWSs that previously did not exceed this standard during the Statewide Surveillance Monitoring Studies, did exceed this time around, namely the Ladd Center in Exeter.

3.6 Hypothetical Case Study

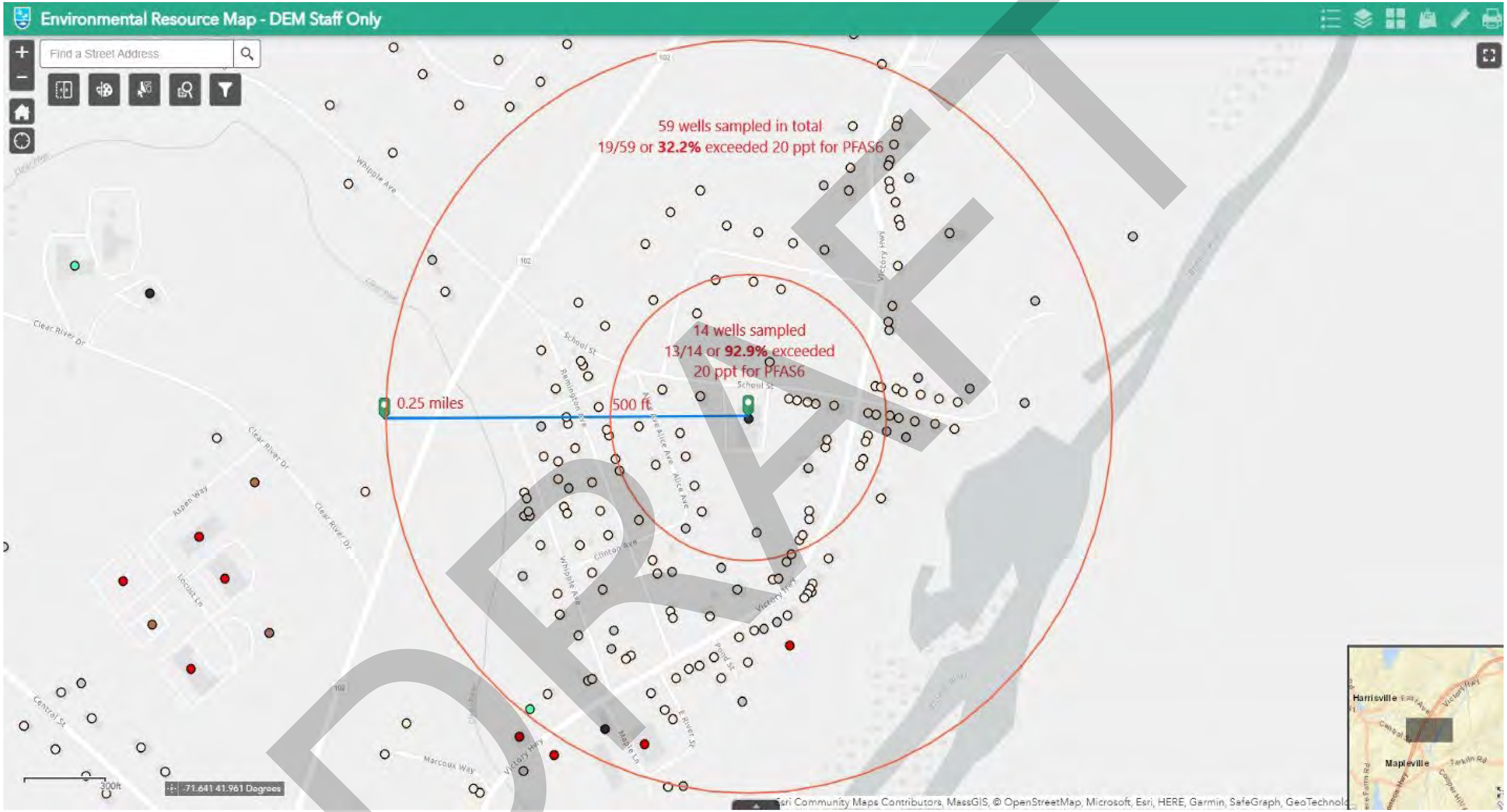
POET System Cost Estimates

Point-of-Entry, or POET systems, are water treatment systems that are installed to treat water as it enters a home. A preliminary cost estimate was developed by researching different POET systems around the country that treat PFAS in residential areas. It was determined that a system filtration module with two media vessels, sampling ports and a meter cost around $20,000 for a 50 gal/hour system, and around $15,000 for a 30 gal/hour system.

In order to determine how many homes located near a contaminated PWS supply well that may potentially need POET systems installed, OLRSMM identified the percentage of PFAS6 exceedances around the Oakland-Mapleville Fire Department where PFAS was sampled in 2017 and 2018.

Within 500 feet of the fire department, 92.9% of wells exceeded 20 ppt for PFAS6. Within 0.25 miles of the fire department, 32.2% of wells exceeded 20 ppt for PFAS6.

If an uncontaminated municipal water source were not available, it would have cost anywhere from $285,000 to $380,000 for initial capital costs, and approximately $100,000 in annual operation and maintenance of the POET systems in perpetuity.



59 wells sampled in total
19/59 or **32.2%** exceeded 20 ppt for PFAS6

14 wells sampled
13/14 or **92.9%** exceeded
20 ppt for PFAS6

Figure 6: Exceedances within 500 ft and 0.25 miles of the Oakland-Mapleville Fire Department

4 Pre-Remedial Program

4.1 What is the Pre-Remedial Program?

Each year the Rhode Island Department of Environmental Management, Office of Land Revitalization and Sustainable Materials Management enters into a Multi-Site Cooperative Agreement with the United States Environmental Protection Agency to conduct work under the Pre-Remedial Program. The Pre-Remedial Program is the initial step in the Comprehensive Environmental Response, Compensation and Liability Act of 1980 process for listing a site on the National Priorities List (NPL). This program is currently the only avenue by which a possible hazardous waste site can undergo a comprehensive investigation by an independent authority.

The Superfund Pre-Remedial program provides management assistance for assessments performed by EPA's contractor, management of the State abandoned site program and conducts investigations for sites listed on CERCLA. Assessments conducted by EPA's contractor or by RIDEM are submitted to USEPA for review and approval and include Site Discovery (SD), Preliminary Assessments (PA), Site Inspection (SI), Site Reassessments (SR) and Expanded Site Inspections (ESI).

A Pre-Remedial Site Discovery also called a Pre-CERCLA Screen consists of a form generated by USEPA to determine the initial status of the site. The purpose of this step is to assist site assessors in determining if a release or potential release has occurred and if the site is eligible for further CERCLA consideration.

A Preliminary Assessment consists of reviewing all existing information regarding a site which includes site reconnaissance, file/previous report reviews, collecting information on all targets, and preparing the PA site characteristics form. The goal of a PA is to differentiate sites that pose no threat from sites that warrant further action under CERCLA. Most PAs do not include sampling and therefore are low in cost.

A Site Inspection is typically the first investigation to collect and analyze environmental samples. The SI consists of reviewing all available information, performing field work, and evaluating all the available data. The SI data and information supports the site evaluation and Hazard Ranking System (HRS) Scoring. At this stage a HRS Quickscore is performed. The HRS Quickscore is an USEPA tool to provide an initial site score prior to an HRS package. In both the Quickscore and the HRS package score, a number of 28.5 is necessary for listing on the NPL. Currently PFAS is not listed in the toxicity database used for HRS Quickscore and therefore cannot contribute to scoring.

A Site Reassessment is completed if new information becomes available regarding a previously evaluated site.

An Expanded Site Inspection is conducted if any additional information or data is needed for a the HRS package. If a significant amount of time has passed since the SI was completed, an ESI can be done in order to provide the most recent and accurate data.

4.2 How does PFAS fit in?

Currently, PFAS is not listed as a hazardous substance under EPA's IRIS and therefore cannot be a part of the HRS scoring but USEPA can use PFAS as an additional contaminant of concern (COC) when assessing the site in the Pre-Remedial Program. Due to its status as an emerging contaminant, PFAS has been an important contaminant to be evaluated. An agreement was made between RIDEM and USEPA that Pre-Remedial funds can be used to perform PA/SI activities on sites that PFAS is the primary concern.

4.3 Pre-Remedial PFAS Sites

In 2017 and 2019 RIDOH along with RIDEM and Brown University Superfund Research Program conducted a PFAS sampling study of water systems that are located near the types of facilities that may use or have in the past used PFAS. The results of the study identified public water systems that were both above and below the, at the time, USEPA Health Advisory of 70ppt for the sum of PFOA and PFOS. The locations that were above 70 ppt were identified and addressed under a different avenue. Wells reporting PFOA and PFOS below the health advisory but above the reporting limit were added to the working list of Pre-Remedial sites to evaluate. A total of 29 locations had PFAS detections between non-detect and 70 ppt.

OLRSMM Pre-Remedial staff created a prioritization criteria for including sites from the list of 29 into the MSCA with USEPA. The criteria included but was not limited to:

- Private wells located within ¼ mile of the site of the detection
- Sensitive receptors at the site (i.e., schools and childcare facilities)
- Eliminated community water systems and federal facilities (DO NOT qualify for inspection under the Pre-Remedial program)

Of the 29 sites with detections, the Pre-Remedial Program has included and targeted 10 sites initially to be evaluated under the Pre-Remedial Program. Of the 10 sites, RIDEM OLRSMM has conducted Pre-Remedial activities at 6 to date. Find below a list of the Pre-Remedial sites and the associated detections of combined PFOA and PFOS in 2017/2019:

- Narganst Drive Area/Ladd Center (Former): Ladd Center Water System, 24 ppt
- Trimtown Rd/ Rockland Rd Area: Scituate Middle School and High School, 24 ppt
- Carolina Back Rd/ Old Shannock Rd Area: Charlestown Elementary School, 12 ppt
- Providence Pike/Farnum Pike Area: North Smithfield Junior/Senior High School, 30 ppt

- Sea Breeze Ave Area: Quanochataug East Beach Water Association, 14 ppt
- 100 Reynolds Rd Area: West Glocester Elementary School, 25ppt

In addition to the PFAS study sites, the OLRSMM Pre-Remedial Program received a site referral from the State voluntary clean-up program for evaluation of the Bradford Printing and Finishing complex. The Town of Westerly provided a Phase II report to the OLRSMM identifying numerous contaminants of concern including the highest groundwater detections of PFAS in the entire state.

4.4 Details on Previous Sites in Chronological Order of Pre-Remedial Activity

4.4.1 Narganst Ave Area/Ladd Center (Former)

The Joseph H. Ladd Center was a former school and caring facility for people with intellectual and developmental disabilities. The school has been since removed but the water system has remained. The water system is managed by Quonset Air National Guard and used by the Exeter Job Corp. There are 4 private wells in use within a quarter of a mile of the impacted well. The Rhode Island Fire Training Academy uses land nearby for training exercises.

In April 2018, RIDEM OLRSMM performed a Site Discovery on the site and completed the Pre-CERCLA Screening form. The conclusion of the form was that the site could move forward with additional CERCLA work in the form of a PA/SI. Due to the location, and limited number of private wells, USEPA and OLRSMM determined that moving forward with a PA/SI was not warranted at the time.

Figure 7: Pre-CERCLA Screening Map-LADD Center

4.4.2 Trimtown Rd/ Rockland Rd Area

The Trimtown Rd/ Rockland Rd Area site consists of a quarter mile radius around the Trimtown Rd and Rockland Rd intersection with an extension of a quarter mile towards Manning Field in Scituate, RI. The initial sample was taken at the Scituate Middle and High School. RIDEM OLRSMM completed a Pre-CERCLA Screen in May 2018 with a recommendation to complete a PA/SI. An Abbreviated PA was completed in September 2018. The SI was completed in August 2019.

Sixteen private drinking water wells and 3 monitoring wells within the site footprint were sampled as part of the SI. One monitoring well surrounding the North Scituate Town Dump was reported above the 70 ppt health advisory. No private drinking water wells laid within a quarter mile down gradient of the elevated well.

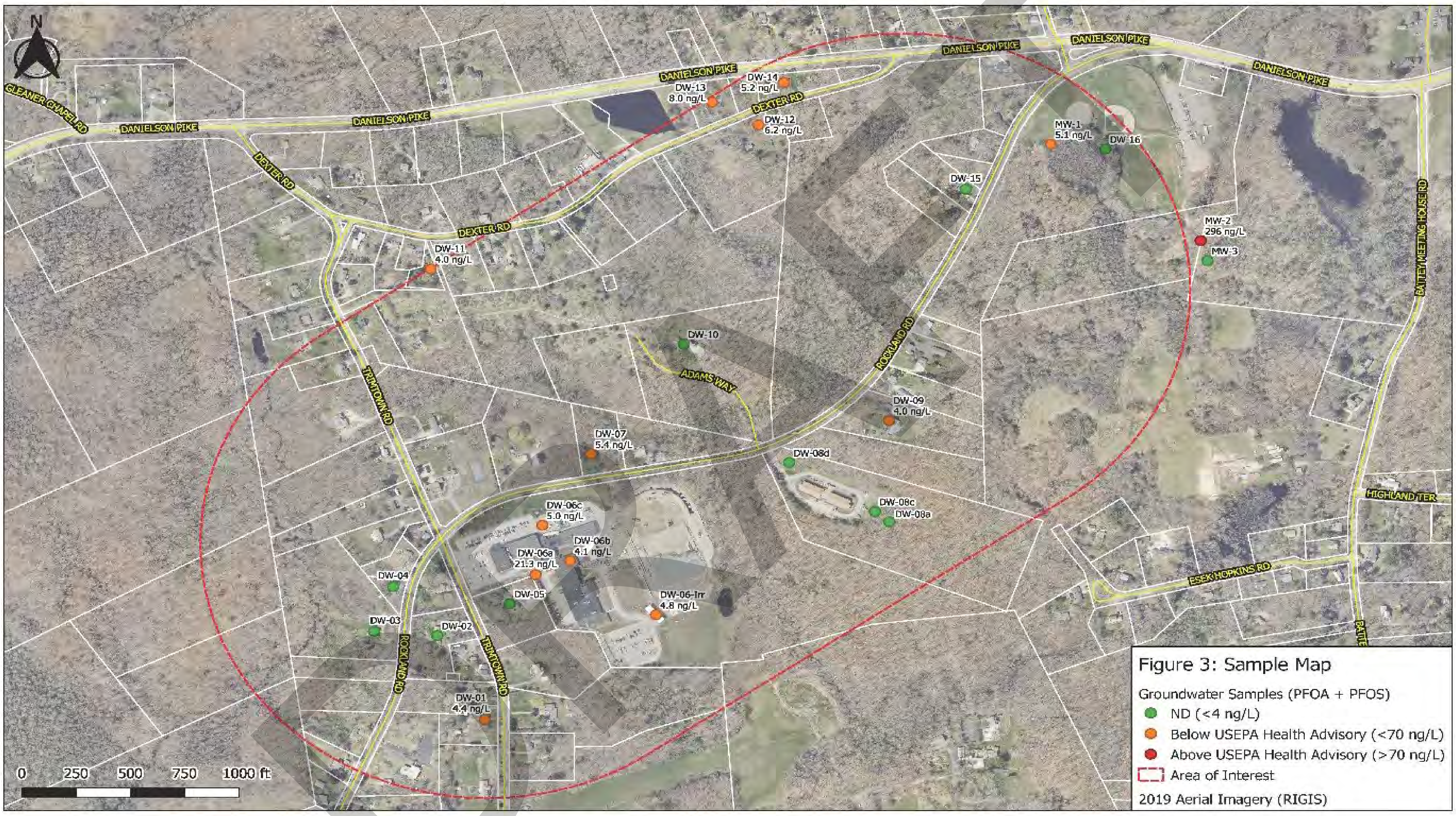


Figure 8: Site Inspection Results Map- Trimtown Road/Rockland Road Area

4.4.3 Carolina Back Rd/ Old Shannock Rd Area

The Carolina Back Rd/ Old Shannock Rd Area consists of a quarter mile radius around the Carolina Back Rd and Old Shannock Rd intersection in Charlestown, RI. The initial sample was taken at the Charlestown Elementary School. RIDEM OLRSMM completed a Pre-CERCA Screen in May 2018 with a recommendation to complete a PA/SI. An Abbreviated PA was completed in October 2018. The SI was completed in September 2020.

Twenty-two private drinking water wells within the site footprint were sampled as part of the SI. No samples were above the 70 ppt health advisory.

Figure 9: Site Inspection Results Map- Carolina Back Road/Old Shannock Road Area

4.4.4 Bradford Printing and Finishing

The Bradford Printing and Finishing site consists of 4 Areas of Concern (AOC) in the village of Bradford in the town of Westerly, RI. All AOCs are associated with the Former Bradford Printing and Finishing textile mill processing and wastewater treatment system. In 2018 the Town of Westerly contracted Wood Environmental to perform a Phase I and Limited Phase II environmental assessment of the Former Bradford Printing and Finishing facility. The town notified the State Voluntary Clean Up program. The former owner, Bradford Dye Association, had gone bankrupt and the property was in court appointed receivership.

Upon receipt of the Phase I and Limited Phase II RIDEM OLRSMM conducted a Pre-CERCLA Screen on the site in September 2018. Due to the high levels of PFAS detected in the Phase II sampling, RIDEM OLRSMM put together a PA/SI Work Plan to sample private drinking water wells within a quarter mile of the site. This sampling event took place in October 2018. Twelve private drinking water wells were sampled across the Pawcatuck River from the site. No wells were above the 70 ppt health advisory.

A PA/SI Work Plan Addendum was prepared in March 2019 to address the remaining contamination on the site. A Preliminary Assessment was completed in January 2020. The SI was completed in April 2020. PFAS levels were detected in the groundwater at some of the highest levels in the state, well above the health advisory of 70 ppt. The site contains many other contaminants of concern and has since been referred to the USEPA to complete an HRS package to list the site on the NPL.

Additional information and map on Bradford Printing and Finishing can be found in the Rhode Island Textile Mills section.

4.4.5 Providence Pike/ Farnum Pike Area

The Providence Pike/ Farnum Pike Area consists of a quarter mile radius around the Providence Pike and Farnum Pike intersection in North Smithfield, RI. The initial sample was taken at the North Smithfield Junior/Senior High School. RIDEM OLRSMM completed a Pre-CERCLA Screen in December 2019 with the recommendation to complete a PA/SI. An Abbreviated PA was completed in June 2021. The SI was completed in September 2022 with a finalized report in September 2023.

Seven locations with a total of 10 private drinking water wells within the site footprint were sampled as part of the SI. Due to the COVID-19 pandemic, response was low. No samples were above the 70 ppt health advisory. Since the samples were taken, the RI interim drinking water standard has been lowered to the interim drinking water MCL of 20ppt for the PFAS6. No private drinking water wells were above the 20 ppt standard.

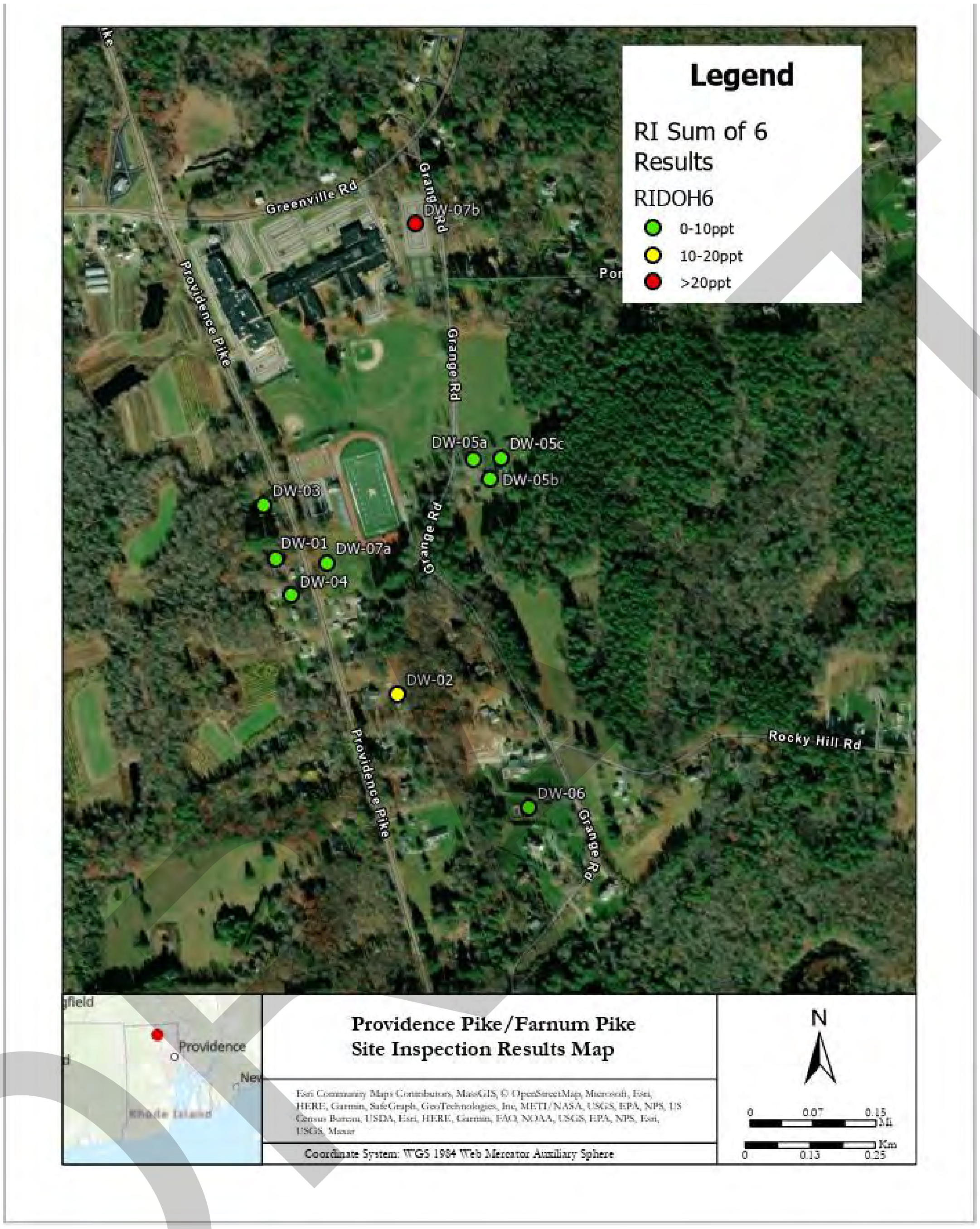


Figure 10: Site Inspection Results Map- Providence Pike/Farnum Pike Area

4.4.6 Sea Breeze Ave Area

The Sea Breeze Ave Area consists of a quarter mile radius around the Quonochontaug East Beach Water Association well in Charlestown, RI. The initial sample was taken from the Quonochontaug East Beach Water Association Well. RIDEM OLRSMM completed a Pre-

CERCLA Screen in March 2022 with the conclusion that the only private drinking water wells were located up-gradient of the site and that a PA/SI is not warranted.

4.4.7 100 Reynolds Rd Area

The 100 Reynolds Rd Area consists of a half mile radius around 100 Reynolds Rd in Glocester, RI. The initial sample was taken at the West Glocester Elementary School. RIDEM OLRSMM completed a Pre-CERCLA Screen in January 2020. An Abbreviated Preliminary Assessment was completed in June 2023. The SI is scheduled for completion in Fall 2023.

As of the time of this report, 10 private drinking water wells within the footprint of the site were sampled as part of the SI. No private drinking water wells were above the interim drinking water MCL of 20 ppt for the PFAS6.

4.5 Current and Future Plan and Sites

RIDEM OLRSMM enters into a Multi-Site Cooperative Agreement with the USEPA each fiscal year from June to the following July. The grant period lasts 5 years with a 2-year extension. The OLRSMM Pre-Remedial Program will continue to use these limited funds for non-immediate PFAS source investigations from sites referred by the RIDOH and the RIDEM Voluntary Clean Up Program. The following PFAS sites are currently listed on the MSCA for Pre-Remedial consideration, based upon current funding:

- Cooks Landfill
- East Providence Fire Training Area
- High Street Area
- Hemlock Road Area
- Mount Pleasant Road Area
- Pine Ledge Road Area
- Other non-time critical sites

4.5.1 Cooks Landfill

Cooks Landfill was used as a private disposal area for soil and industrial waste prior to its closure in 1961. Even though the site was closed in 1961, no precautions were taken to eliminate further dumping on the site therefore PFAS cannot be eliminated at a contaminant of concern.

In 1985, a total of 127 drums of liquid contamination, 59 5-gallon cans of flammable material, 20 bags contaminated wastes, 35 empty drums, and 7 cubic yards of asbestos containing material were removed as part of an USEPA removal action. No soil or groundwater samples were taken at that time. The recommendations of the Removal Action were to perform a Site Inspection Prioritization (SIP). The SIP was completed in 1995 and confirmed the presence of metals, pesticides, volatile organic compounds (VOCs), and polycyclic aromatic hydrocarbons (PAHs). The Remedial Site Assessment Decision determined that further work was warranted under CERCLA.

In 2014 RIDEM Office of Compliance and Inspection received a complaint of a dark black, semi solid substance on the site by a resident. OC&I completed their own Site Re-Inspection with sampling. SVOCs, PAHs, and metals were found above Upper Contaminant Levels. With the information collected from the SIP and OC&I's Re-Inspection, OLRSMM initiated a Pre-Remedial Site Re-Inspection to further evaluate the site under CERCLA. A work plan was completed in September 2022 and work is scheduled to be complete in Fall 2023. Both the unknown nature of the contamination dumped after closure in 1961 as well as the proximity to the East Providence Fire Training Area, PFAS is a COC at the site and will be evaluated.

4.5.2 East Providence Fire Training Area

The former East Providence Fire Department Training Area is located on the Hunt's Mill Picnic and Recreational Area in Rumford on the border with Seekonk, MA. The training area itself is immediately adjacent to the Ten Mile River. This site was in operation since at least the early 1960's based on a review of historical aerial imagery. The remains of a fuel tanker used to train firefighters at putting out petroleum fires is still located at the site today with informational placards denoting the use of "foam" to extinguish "pots of oil and gas." The OLRSMM Pre-Remedial Program plans to conduct a Pre-CERCLA Screen at the site.

4.5.3 High Street Area

The High Street Area consists of a quarter mile radius around the intersection of High Street and Wellstown Road in Ashaway, RI. The initial sample was taken at the Trinity Lutheran Church Pre-School with a level of 4 ppt for combined PFOA and PFOS in 2017. The OLRSMM Pre-Remedial Program plans to conduct a Pre-CERCLA Screen at the site.

4.5.4 Hemlock Road Area

The Hemlock Road Area consists of a quarter mile radius around the intersection of Hemlock Road and Park View Drive in Chepachet, RI. The initial sample was taken as part of The Village on Chopmist Hill's drinking water system. PFOA and PFOS were detected at a combined 4.1 ppt. The OLRSMM Pre-Remedial Program plans to conduct a Pre-CERCLA Screen at the site.

4.5.5 Mount Pleasant Road Area

The Mount Pleasant Road Area consists of a quarter mile radius 600ft west of the Mount Pleasant Road and Fortier Ave intersection Burillville, RI. The initial sample was taken at a childcare facility on Mount Pleasant Rd with a level of 4.6 ppt for combined PFOA and PFOS in 2017. The OLRSMM Pre-Remedial Program plans to conduct a Pre-CERCLA Screen at the site.

4.5.6 Pine Ledge Road Area

The Pine Ledge Road Area consists of a quarter mile radius around 60 Pine Ledge Rd, Glocester, RI. The initial sample was taken at the Cooper Hill Office Complex Inc. with a level of 11 ppt for combined PFOA and PFOS in 2019. The OLRSMM Pre-Remedial Program plans to conduct a Pre-CERCLA Screen at the site.

4.6 Other Non-Time Critical Sites

OLRSMM Pre-Remedial staff will continue to use the prioritization criteria for including sites in the MSCA with USEPA. The criteria included but not limited to:

- Non-time critical investigations (i.e. sites with detections of PFAS but below the RIDOH drinking water MCL of 20 ppt for the sum of the PFAS6)
- Private wells located within ¼ mile of the site of the detection
- Sensitive receptors at the site (i.e. schools and childcare facilities)
- Community water systems and federal facilities DO NOT qualify for inspection under the Pre-Remedial program

5 Superfund Sites

5.1 Central Landfill

The Central Landfill Superfund Site is a 154-acre area located within the Central Landfill, an active waste disposal facility located at 65 Shun Pike in Johnston, Rhode Island. Central Landfill is the largest waste disposal facility in Rhode Island and services the majority of communities in the state.

The Site has been used as a solid waste disposal area since 1962. During the mid- to late- 1970s, large volumes of liquid industrial waste were disposed of in an unlined area within the landfill. This approximately half-acre area is referred to as the OU1 Hot Spot, and it is the primary source of contamination at the Site. Site operations have resulted in the release of volatile organic compounds, semi-volatile organic compounds, and metals to soil and groundwater.

The Site consists of two operable units (OU). OU1 includes the Hot Spot, the 121-acre Phase I landfill surrounding the Hot Spot, and the 33-acre Phase II and III landfill areas overlapping Phase I. The OU2 off-site area includes about 1,300 acres surrounding, but not including the 154-acre OU1 area.

RIRRC (formerly known as the Rhode Island Solid Waste Management Corporation [RISWMC]) has owned and operated the Central Landfill since 1980. In addition to the landfill and related facilities, RIRRC also owns other surrounding parcels that bring its total holdings to about 1,300 acres. The total holdings include a large tract of undeveloped land to the west, a buffer zone of undeveloped land along Central Avenue to the north, and undeveloped buffers between the landfill and Apple Tree Lane (to the northeast) and Old Pocasset Road (to the east). Other holdings include undeveloped and developed parcels to the east of the landfill, including an undeveloped strip of land along the north shore of the Upper Simmons Reservoir and several properties with buildings on Shun Pike opposite the landfill entrance.

Beyond the RIRRC-owned land, the Site is surrounded by rural and suburban residential development, commercial/industrial properties, and undeveloped land. The nearest residential properties are north of the Site, along and to the north of Central Avenue, and northeast of the Site, on Apple Tree Lane and Old Pocasset Road. Commercial and industrial development exists to the east of the landfill. Properties along the south side of Shun Pike and Green Hill Road, to the south of OU1, include closed landfills and commercial/industrial facilities, with occasional residences farther west on Shun Pike.

Surface waters immediately downgradient of the Site are Cedar Swamp Brook, which discharges to the Upper Simmons Reservoir and then the Lower Simmons Reservoir. Within a 1-mile radius of the Site are Oak Swamp Reservoir, Almy Reservoir and a number of smaller ponds and brooks, including Duck Pond, Madison Pond, Betty Pond, Brandy Brook, Pine Swamp, and unnamed wetland areas west and northwest of the Site.

The Site is underlain by glacial till (shallow overburden aquifer), which in turn is underlain by fractured granitic bedrock (deep bedrock aquifer). Both aquifers are contaminated. Bedrock groundwater is the major potential pathway for contaminated groundwater to travel from the OU1 landfill to off-site areas (OU2). Site groundwater discharges to the Upper Simmons Reservoir, located about 1,200 feet southeast of the landfill. A small portion of the flow beneath the landfill also flows to the Almy Reservoir, located about 2,400 feet north. Cedar Swamp Brook west of the landfill, Sedimentation Pond 2 (Pond 2) and Sedimentation Pond 3 (Pond 3) are also groundwater discharge points. The state classified groundwater under the landfill and areas immediately surrounding the landfill as a current or potential source of drinking water. Between 1986 and 1990, RIRRC, in conjunction with RIDEM and the town of Johnston, eliminated exposure to contaminated groundwater by connecting neighboring properties to the public drinking water supply. In 2003, the town of Johnston adopted an ordinance that prohibits the use of groundwater wells and prohibits the building inspector from issuing permits for the construction of groundwater wells in OU1 and the OU2 areas recommended for institutional controls.

Waste manifests on file at RIDEM indicate that site owners accepted and disposed of industrial wastes at the OU1 Hot Spot from December 1976 to May 1979. Neither federal nor state hazardous waste regulations were in effect at this time. In December 1979, RIDEM advised the site owner that the Site must comply with the newly adopted hazardous waste facility rules and regulations to maintain its status as an existing but inactive hazardous waste management facility. After the Site was purchased and transferred to RIRRC, RIDEM determined that the Site was and is a hazardous waste management facility. In February 1981, RIDEM ordered RIRRC to close the hazardous waste disposal area. RIRRC closed it in July 1982. However, the closure did not address all areas of hazardous waste disposal. After violations of the Fresh Water Wetlands Act related to excavation and stream diversion of Cedar Swamp Brook and placement of fill in and within 100 feet of Cedar Swamp Brook and its associated wetlands, RIDEM did not renew the license for the facility.

In 1984, after RIDEM issued additional notices of solid waste violations, USEPA determined that the landfill may have presented and may continue to present a substantial hazard to human health and the environment. In the 1980s, about 32 acres of the Site were capped with a state-approved Resource Conservation and Recovery Act (RCRA) Subtitle D landfill cap. USEPA added the Site to the Superfund program's National Priorities List in June 1986. Also in 1986, RIRRC, in conjunction with RIDEM and the Town of Johnston, initiated a project to provide public drinking water to area residents. The project was completed in 1990. RIRRC purchased residentially zoned property within 1,000 feet of the licensed landfill area and offered residents within the next 1,000 feet the option of selling their properties to RIRRC. This property acquisition was mandated by the Rhode Island General Assembly.

USEPA issued an Administrative Order to RIRRC in 1987, pursuant to RCRA, requiring that RIRRC perform the Site's remedial investigation and feasibility study (RI/FS). The Site's 1993 OU1 RI included a human health risk assessment (HHRA). The OU1 HHRA concluded that there were no complete exposure pathways for human receptors to contaminants in soil, groundwater, surface water and sediment under site conditions at that time. However, under future hypothetical use of groundwater, the OU1 HHRA concluded that the risks at the Site are almost solely attributable to ingestion and dermal contact with groundwater beyond the toe of the landfill but within the RIRRC-owned property.

USEPA selected the Site's remedy in decision documents for the OU1, as summarized below.

OU1 (Source Control)
USEPA selected source control as the remedy for OU1 in the Site's June 1994 ROD (Record of Decision). The ROD included the following remedial action objectives (RAOs):

- Minimize the effects of landfill contaminants on groundwater quality. Specifically, reduce to a minimum the amount of precipitation allowed to leak through the waste column and infiltrate to the groundwater.
- Eliminate potential future risks to human health through direct contact with landfill contaminants by maintaining a physical barrier.
- Minimize migration of contaminants in groundwater so that groundwater is not injurious to the aquatic ecological system of receiving water bodies (Upper Simmons Reservoir, Cedar Swamp Brook and Almy Reservoir).
- Minimize risks to human health associated with potential future consumption of and direct contact with groundwater.
- Comply with state and federal applicable or relevant and appropriate requirements (ARARs).
- Minimize potential impacts of implementing the selected source control alternative on adjacent surface waters and wetlands.

The final OU1 remedy components included a combination of capping, hydraulic containment, and treatment of groundwater in the Hot Spot area of the landfill, and additional components revised by the Site's 2005 and 2013 Explanations of Significant Differences (ESDs). They include:

- Construction of a multi-layer RCRA Subtitle C cap over the existing 121-acre Phase I landfill area and incorporation of the existing 33 acres of the RIDEM-approved cap on the side slopes.
- Construction of a hydraulic containment system (HCS) for groundwater in the Hot Spot area of the landfill with discharge of the groundwater to either on-site surface water or the Cranston Rhode Island wastewater treatment plant.
- Relocation of the HCS after completion of Phase VI of the landfill expansion, about 1,500 feet downgradient (i.e., south) of its current location, to capture the eastern part of the OU1 groundwater plume prior to its discharge to Pond 2 south of the Compliance Boundary (the edge of the waste management area).
- Continued capture of the western part of the plume by the stone underdrain underneath Phase V of the landfill and treatment, if necessary, prior to discharge into Cedar Swamp Brook to achieve surface water performance standards for the remedy.
- Evaluation of whether effluent from the constructed industrial wastewater pipeline connected to the Narragansett Bay Commission (NBC) Fields Point wastewater treatment

facility in Providence, Rhode Island, is protective of human health and the environment prior to its discharge to the NBC Fields Point facility.

- Implementation of deed restrictions on groundwater use and land development for property owned by RIRRC.
- Implementation of a long-term sampling and analysis program for groundwater, surface water and air.
- Detailed evaluation of the existing landfill gas (LFG) collection and combustion system.
- Installation of a chain-link fence to prevent access.

As part of the long-term monitoring, PFAS sampling was conducted on the on-site wells and the results concluded that PFAS was found at concentrations above regulatory standards.

5.2 Rose Hill

The Rose Hill Regional Landfill Superfund Site (the Site) is located within the town of South Kingstown, Rhode Island, in the village of Peace Dale within Washington County. It lies about 5 miles inland from Narragansett Bay and 2 miles north of Wakefield, Rhode Island. The Site is bordered by Rose Hill Road to the west, the Saugatucket River to the east, and residential private property to the north and south. Remedial response activities including this Remedial Investigation and Feasibility Study were conducted under a United States Environmental Protection Agency (USEPA) lead with the State of Rhode Island Department of Environmental Management (RIDEM) remaining active throughout as the support agency. The Site is located in an abandoned sand and gravel quarry and encompasses approximately 70 acres. The Site consists of three separate and inactive disposal areas or landfills, referred to herein as the Solid Waste Area (SWA), the Bulky Waste Area (BWA), and the Sewage Sludge Area (SSA). An active transfer station, south of the disposal areas, is also located on the Site. Two primary surface water bodies flow through the Site: Saugatucket River and Mitchell Brook. An unnamed brook, west of the Site, flows into the Saugatucket River and an unnamed tributary, in the northern portion of the Site, flows into Mitchell Brook. The Saugatucket River is classified by the State of Rhode Island as a Class B water body that is designated for fish and wildlife habitat and secondary recreation activities. The river is impaired and not supporting both aquatic life and recreation. Wetland and flood plain habitats are also found adjacent to the disposal areas and are subject to runoff and contamination from the disposal areas. An open excavated area approximately 400 feet north of the disposal areas is currently used for target and skeet shooting. Approximately 200 feet west of the disposal areas, sand and gravel operators excavate sand, gravel, and loam for resale to the public. Groundwater is used within a 3-mile radius of the Site for the following purposes: private residential supplies (no alternate supply available) and municipal public water supply. Residents in South Kingstown obtain water from both public and private wells. Private wells within a 3-mile radius of the Site consist of overburden or bedrock wells. Three supply wells for the University of Rhode Island are located 2.7 miles northwest of the Site.

Prior to 1941, the Site was used for agriculture. Sand and gravel excavation operations were conducted at the Site from at least 1948 through 1963. The Rose Hill Site began operation as a landfill in 1967 in the area previously used for sand and gravel excavation. The landfill was operated by the Town of South Kingstown under a state permit from RIDEM which was renewable annually. For approximately 16 years, it received domestic and industrial wastes from residents and industries in South Kingstown and Narragansett. In October 1983, the landfill reached its state-permitted maximum capacity and active land filling operations ceased. For the past fifty years, the Site owner has conducted organized small game hunts, the boarding, breeding, training, and showing of hunting dogs, skeet and target shooting, and stocking and periodic release of small game birds throughout the Site.

Landfills in the three disposal areas (the Solid Waste, Bulky Waste, and Sewage Sludge Areas), began operations in 1967, 1978, and 1977, respectively. The Solid Waste Area landfill was closed in 1982 and the Bulky Waste and Sewage Sludge Area landfills were closed in 1983. During 1983, a transfer station for municipal refuse was located south of the Bulky Waste Area. The transfer station is currently active. At the station, refuse is unloaded from collection trucks and transferred to vehicles that transport it off site to the Johnston landfill.

Waste handling procedures for the Rose Hill Regional Landfill were set by state regulations and town ordinance. The waste handling practices conducted at the landfill consisted of the disposal of municipal refuse and industrial refuse including the disposal of industrial wastes. Through its investigation, USEPA has acquired some information regarding the disposal and approximate location of these industrial wastes, but the exact quantity and location(s) of hazardous substances disposed of on the Site throughout the landfill's operation are predominantly unknown. Information regarding the total volume of solid waste placed in the landfill is available through studies conducted for the Town of South Kingstown by C.E. Maguire.

In 1967, when activity at the landfill officially commenced, a court order prohibited the disposal of combustibles at Rose Hill. In 1978, the order was amended to allow the disposal of combustibles in the Bulky Waste Area. In 1979, the State of Rhode Island ordered cities and towns to establish facilities for the collection of waste oil. It is reported that a waste oil collection facility at the Rose Hill Site was established during this time.

The sand and gravel pit was filled in with refuse material starting in the southern portion and progressing north. By 1988, waste materials were present throughout the pit, and all remnants of the original sand and gravel pit were gone. Several possible leachate seeps (rust-colored staining as evidenced in November 5th, 1988 photography) are observed in the northern, eastern and southern portions of the disposal area. The thickness of solid waste deposited throughout the landfill prior to 1977 is unknown. However, it was estimated that from 1977 to 1982 between 10 and 14 feet of solid waste were deposited.

In 1985, the Town of South Kingstown provided a municipal water line extension to adjacent residences located on Rose Hill Road and those dwellings abutting the immediate northern portion of the Site.

On October 4, 1989, the Site qualified for a final listing on the NPL.

The Remedial Investigation (RI) and Feasibility Study (FS), conducted by USEPA, began in 1990 with field work commencing in the Spring of 1991.

The first operable unit remedy consists of the following components: Consolidate the Bulky Waste Area landfill onto the Solid Waste Area landfill; collect and manage leachate and waters collected from runoff and de-watering operations during the excavation and consolidation of the Bulky Waste Area; apply a protective cover (hazardous waste cap) to the Solid Waste Area landfill; assess, collect and treat landfill gases via an enclosed flare; inspect and monitor the integrity and performance of the cap over time; monitor groundwater, surface water, leachate emergence, and landfill gas emissions over the duration of the remedial action; implement deed restrictions (in form of easements and covenants) on groundwater and land use and prevent access onto the portions of the Site where remediation activities warrant this restriction; provide data to assess the need for taking any further response actions after the cap is in place and functional; operation and maintenance of the remedy; and plan for and conduct statutory five-year reviews to ensure protectiveness. Site monitoring will furnish data to assess the effectiveness of the source control remedy and assist the State with TMDL (Total Maximum Daily Load) predictions for Site-related contaminant concentrations affecting local water bodies, should it be determined that a TMDL is necessary to bring the waterbodies back into compliance with water quality standards. The Sewage Sludge Area meets minimal State requirements for sewage sludge landfill closure and poses no significant health threat as closed. The source control remedy includes continued monitoring of this area.

5.3 Landfill Resource and Recovery (L&RR) Superfund Site

The Site was initially used as a sand and gravel pit, which reportedly began accepting municipal wastes for disposal around 1927 and continued until 1969 when the facility became a solid waste disposal area. In 1974, the Site was sold to L&RR, the current owner, and operations expanded to include acceptance of commercial, domestic, industrial waste and hazardous waste. For a limited period during the site operation, hazardous waste manifest was required by the RIDEM. Based upon this data, the USEPA estimates for a two-year time period around this manifest reporting requirement, the site accepted more than two million gallons of hazardous chemicals including solvents, plating waste, asbestos, oils, and dyes. Specific waste known to be dumped at the site included: waste oil containing metals, asbestos, calcium fluoride sludge with lead, scrap paints containing VOCs and alcohols, chemical compounds containing VOCs, batteries containing mercury, metal hydroxide sludge containing copper and nickel, lime sludge containing iron and copper, paint sludge containing VOCs, waste sludge containing hydroxide, calcium and zinc sludge, HPR 106 containing butyl acetate and xylene, filtrate waste containing methanol and organic byproducts, tank rinse containing sodium hydroxide and organic byproducts, rinse water containing ammonia and ethylene diamine tetracetic acid (EDTA), sodium oxylate sludge containing metals, organic latex and organic latex wash containing copper, nickel, chromium, silver and VOCs, waste oil and solvents containing VOCs, water soluble dye and fibers containing acids and VOCs, solvents and alcohol containing acetone, toluene, methyl ethyl ketone, isopropanol, isobutyl acetate and cyclohexanone, waste coating material containing methyl ethyl ketone, isobutyl acetate, cyclohexanone and ethylene vinyl acetate, waste oil containing arsenic, cadmium, chromium, mercury, lead, selenium and silver, organic latex waste containing styrene and ammonia, waste solvents containing 1,1,1-trichloroethane, grinding swarf containing selenium, mercury and arsenic, fine wire tank waste water containing metals, and adhesives and solvents containing methylene chloride, ketones and esters.

It should be noted that PFAS is not included in the above list because at that time it was not considered a hazardous substance or waste, and therefore, there were no tracking or reporting requirements.

In November 1977, L&RR, Inc., submitted plans for installing seven monitoring wells to the Rhode Island Department of Health. These wells were installed to comply with State regulations pertaining to hazardous waste disposal. In September 1979, Rhode Island Department of Environmental Management ordered L&RR, Inc., to cease accepting hazardous waste. In December 1979, per RIDEM requirements the hazardous waste area, as defined by L&RR, Inc., was covered with a synthetic cover. Additional landfilling of commercial and domestic waste over and around the covered area continued until 1985. Landfill closure began in 1985 pursuant to a 1983 Court Order and Consent Order and Agreement ("the 1983 Court Order") between RIDEM and L&RR, Inc.

In 1986, under the direction of RIDEM, the owners of the landfill covered a majority of the landfill with a 20-mil PVC geomembrane and soil. A system of 18 gas vents was also installed.

USEPA initiated the Remedial Investigation/Feasibility Study process under CERCLA Superfund Program in May 1986. The RI/FS and remedy selection process was concluded in September 1988 with issuance of the Record of Decision (ROD). Under this ROD the USEPA continued a number of the remedial actions initiated by the State, including the following: improving side slopes, installation of a synthetic cover on the northeast area, increasing soil cover thickness to 24 inches and completing the vegetative cover, upgrading the surface water runoff system, installation of a perimeter fence, and establishing institutional controls. Collecting and treating the landfill gas. This includes utilizing a thermal destruction technology to reduce the release of volatile organic compounds to the ambient air.

Following landfill closure, annual environmental monitoring has been conducted in accordance with the post closure Site Monitoring (PCSM) Plan requirements, including collection of groundwater and surface water samples to evaluate water quality. Several VOCs and arsenic have been historically detected above MCLs or health risk-based levels at the CW-5 and MW-102 groundwater monitoring well nests on the northeastern-eastern side of the landfill. In 2013, to support institutional control efforts, RIDEM ORLSMM requested that field investigations be conducted on Lot 23 adjacent to the site. The initial approach involved use of the Waterloo Advanced Profiling System (Waterloo) to obtain overburden vertical profiling data at three locations (WL-1, WL-2, and WL-3) downgradient from either well CW-5 or MW-102. The results of this groundwater profiling confirmed the presence of a limited subset of VOCs, including 1,4-dioxane, and metals in the overburden aquifer at elevated concentrations, which in some cases were above MCLs.

As a result of these detections, a second phase of investigation was initiated in March and April 2014 to further evaluate groundwater and surface water hydraulics and bedrock aquifer conditions. Groundwater-surface water interactions were evaluated using a network of piezometers installed in Trout Brook Pond. Data from four of the five piezometers (PZ-1, PZ-3, PZ-4, and PZ-5) supported downward groundwater flow and discharge of surface water to groundwater, and data from and the piezometer installed furthest in the wetland complex (PZ-2) indicated upward groundwater flow and discharge of groundwater to surface water, consistent with historic observations.

Bedrock assessment occurred using one borehole (BH14-1) east of the landfill on Lot 23, followed by geophysical logging to identify potential water-bearing zones. The geophysical results identified two possible transmissive fracture zones in the borehole, and a packer system was subsequently used to isolate these zones and collect groundwater samples during two mobilizations. Multiple VOCs, including 1,4-dioxane, and metals were detected in groundwater samples from these events. Concentrations of tetrachloroethene (PCE) and trichloroethylene (TCE) were detected above MCLs. In 2015, a residential drinking water sampling program was implemented to evaluate current drinking water conditions based on the bedrock groundwater results referenced above. Samples from residential wells at 1305, 1309, 1313, 1317, 1325-, 1363-, 1375-, and 1431-Pound Hill Road were analyzed for VOCs and 1,4-dioxane. In 2017, sampling was expanded to include 1301 Pound Hill Road. Sampling continues to occur on a semi-annual basis at all nine residential well locations. Results from the residential sampling have consistently shown no detections of 1,4-dioxane or other Site-related VOCs (such as TCE), and occasional detections of non-Site related VOCs (i.e., chloroform, methyl tertiary-butyl ether (MTBE) and naphthalene). Naphthalene was detected only once at 1309 Pound Hill Road in 2017; MTBE was detected only at 1375 Pound Hill Road in 2014-2015. Chloroform has consistently been detected at 1431 Pound Hill Road during most rounds in 2014-2018; it is believed that its presence is attributed to disinfection of the well by the owner.

In January 2016, the SDs performed a surficial geophysical survey using electrical resistivity profiling methods in order to assess the extent of spatial overburden groundwater impacts within a broader area east of the landfill and to also identify prevailing bedrock fracture zones for further evaluation as part of the bedrock drilling program. Resistivity surveys are commonly used near landfills and suspected waste areas, where low resistivity zones correlate with zones of higher dissolved ion concentrations that result from leachate migration. The resistivity survey was conducted along four generally north-south trending survey lines and four generally east-west trending survey lines. Detailed interpretations of subsurface features obtained from the resistivity profiles were used to modify the originally proposed hydrogeological investigation locations based on indicators of potential water-bearing bedrock zones. As a result of the 2013 and 2014 sampling data, implementation of RI/FS activities began in May 2016 with a wetland survey and wetland and ecological sampling activities. The focus of the RI/FS investigation is to define the nature and extent of VOCs and other contaminant impacts in groundwater and surface water, as well as pore water and sediment in the wetlands. The RI/FS was completed in 2020. Various metals, volatile organic compounds including 1,4 dioxane and PFAS was found in groundwater above regulatory standards.

The remedial action elected for the site includes in situ treatment and sequestration, institutional controls, and monitoring. The in-situ groundwater treatment strategy includes two technologies that would be used together in a two-stage reactive treatment zone to address Site COCs. The two technologies include: (i) ISCO with potassium persulfate, a slow-release form of chemical oxidant, to address CVOCs, 1,4-dioxane, and some PFAS (notably perfluorinated carboxylic acids (PFCAs); and (ii) sequestration/stabilization with injectable activated carbon for PFAS that are not susceptible to ISCO, primarily PFSAs associated with the sulfonic acid/sulfonate sub-group. Metals are not specifically addressed by these technologies; however, metals are expected to become less mobile in the subsurface as groundwater shifts towards prevailing oxidizing conditions following persulfate injections.

The above two step remedial approach is novel. The requestioning agent development was a joint effort with Brown University researchers, the responsible parties and the USEPA/RIDEM. The effectiveness of the requestioning agent was evaluated using bench scale studies at Brown University. Based upon this research, the requestioning agent was approved for use in the remedial action.

This remedial action includes the following components:

- Treatability/Pilot Testing: Treatability testing is underway and will be completed to determine the effectiveness of the innovative technologies to treat Site-specific conditions. Treatability testing provides information to design the pilot test and the full-scale remedy. Pilot testing will be performed to provide additional information for implementation (such as, injection volumes, radius of influence, field-scale solubility/longevity of the reagents, and the Site-specific method(s) for injection).

- Pre-Design Investigations: Pre-design investigations will likely include steps to refine the extent of horizontal and vertical impacts in the vicinity of the proposed footprint of the two-stage reactive zone, understand contrasts in overburden permeabilities, and identify target treatment zones.

- In-situ Chemical Oxidation (ISCO) Treatment Zone: This alternative uses a combination of potassium persulfate and sodium persulfate injections as the first step to treat the contaminant mass and non-target oxidant demand, respectively. An iron activator may also be used to facilitate the oxidative processes.

- ISCO Injections: In addition to the ISCO treatment zone, the remedy includes targeted ISCO injections in areas downgradient of the ISCO treatment zone, in areas of elevated 1,4-dioxane concentrations.

- Activated Carbon (AC) Injections: The remedy includes a second step consisting of an activated carbon barrier extending approximately 5 to 60 feet below ground surface and 750 feet across.

- Performance monitoring will be conducted to evaluate whether the treatment of VOCs has resulted in conditions which will reduce the mobility and associated concentrations of metals in groundwater. If the system does not perform as designed, there is a contingency remedy of standard pumping of contaminated groundwater and treating the water ex-situ (in a above ground treatment system).

Other components of the remedial action include:

- Wetland Restoration: In-situ treatment zones may need to be constructed within a wetland or floodplain because groundwater impacts extend below the wetlands adjacent to Trout Brook. The remedy will be designed to minimize wetland and floodplain impacts. Wetlands that are disturbed as part of construction will be restored and impacts to any floodplain are expected to be temporary.

- Monitoring: Monitoring includes groundwater and surface water monitoring. The monitoring program includes the current OU1 Post Closure Site Monitoring (PCSM) program, monitoring of wells installed as part of OU2 Remedial Investigation activities, and monitoring of new wells intended to enhance the Site-wide network to evaluate if contaminant concentrations are decreasing by natural processes. Surface water monitoring is included in the PCSM and LTM programs. Monitoring of residential drinking water wells is also included in this alternative. Remedy performance monitoring will also include the installation and sampling of additional performance monitoring wells upgradient of the ISCO injections, between the two stages, and downgradient of the AC zone to monitor remedy performance.

- Institutional Controls: Institutional controls (ICs) would be implemented to restrict groundwater use in all areas necessary to control exposure. ICs may also be necessary for the protection of the selected remedy including limitations on uses and activities that interfere with or disturb components of the remedy. ICs are also necessary to require a vapor intrusion assessment and/or a vapor barrier for new building construction in areas where Site related groundwater contamination is present.

The estimated timeframe for cleanup for groundwater hydraulically upgradient of the treatment zones ranges from 55 to 119 years. For the downgradient aquifer zones located beyond the two treatment zones, cleanup levels are expected to be achieved between 8- and 19-years following implementation of the remedy. The estimated present worth cost associated with this remedial action is $11,700,000.

5.4 Western Sand and Gravel Superfund Site

The Western Sand & Gravel site is located primarily in Burrillville, and partially in North Smithfield, Providence County, Rhode Island. The site was a sand and gravel quarry operation from 1953 until 1975. From 1975 to April 1979, a portion of the Site was used for the disposal of liquid wastes including chemicals and septic waste. Contents of tank trucks were dumped directly into twelve open lagoons and pits. Unpermitted wastes were disposed of at the Site and over time, some of the wastes penetrated the soil and contaminated the groundwater. During a one-year interval from May 1978 to April 1979, Hazardous Waste Manifests indicated that approximately 470,000 gallons of liquid waste was disposed of at the site.

In 1979, hazardous wastes were no longer accepted at the Site, and in March 1980, the U.S Environmental Protection Agency conducted a removal action at the Site during which approximately 60,000 gallons of VOC-contaminated liquids were pumped from lagoons. RIDEM conducted a study of the site and determined that site groundwater and nearby residential wells were contaminated. RIDEM also evaluated a variety of treatment options and selected a free product removal system for waste floating on top of the water table and an air striper, activated carbon system to treat contaminated groundwater.

In September 1983, USEPA added the Site to the Comprehensive Environmental Response, Compensation, and Liability Act National Priorities List. From 1982 to 1989, the Rhode Island Department of Environmental Management operated a groundwater recirculation system to control the spread of groundwater contamination and to remove Light Non-Aqueous Phase Liquids (LNAPL). Records indicate that from 1982-1984 approximately 1,000 gallons of LNAPL (which contained PCBs) was extracted from the site. The RIDEM planned air stripper/activated carbon system to treat contaminated groundwater was not installed as the USEPA took over as the regulatory lead at the site.

USEPA has issued three Records of Decision (ROD) for this Site. Under the first ROD (1984), water filters were installed on private wells until a permanent water supply system was constructed to serve the affected area (approximately 56 parcels) in 1992. The second ROD (1985) addressed contaminated soils at the Site. A Resource Conservation and Recovery Act (RCRA) Subtitle C cap (the cap) was installed over a two-acre soil disposal area in 1987. An area of approximately six acres was graded (including the area occupied by the cap), and it was fenced and posted with warning signs. Post-closure monitoring and inspections of this fenced Site area are ongoing.

USEPA issued the third ROD in 1991 to address groundwater contamination. The groundwater remedy selected for the Site consists of 1) natural attenuation until Interim Cleanup Levels (ICLs) have been met, 2) Site monitoring, and 3) Institutional Controls (ICs). In addition, the 1991 ROD includes a contingency remedy for active remediation, which takes effect in the event that natural attenuation does not occur at the predicted rate, or if one or more of three other scenarios, as laid out in the 1992 Consent Decree (CD), occur. RIDEM wanted the groundwater to be actively treated with the aforementioned pump and treat system, and therefore, did not concur with this ROD and its proposed remedy of natural attenuation.

The Site was purchased in 2001 by Supreme Mid-Atlantic; the company built a truck body assembly plant on the upgradient portion of the Site in 2003-2004. During construction-related blasting activities two nearby residents reported turbidity problems in their wells. Elevated levels of lead, above MCLs, were found in one of the residential wells. An investigation was conducted of alleged disposal pits on a portion of the site close to these residents. The disposal pits were not found, and the concentration of all contaminants were below MCLs in a subsequent sampling round of the nearby residents.

Contaminate levels in groundwater monitoring wells have fluctuated with significant sharp increased being observed and apparent plume directions changes occurring. The reasons for these are unknown. Emerging contaminant such as 1,4 dioxane and PFAS have been found in site monitoring wells above regulatory criteria. Additional studies are planned to determine the nature and the extent of the PFAS contamination.

5.5 Picillo Pig Farm Superfund Site

The Site is located on Piggy Lane in the Town of Coventry, Rhode Island. It is about 20 miles southwest of Providence, Rhode Island, and near the intersection of State Highway 102 and Perry Hill Road (Figure 1). The Site is the location of former pig farm that was used as an illegal hazardous waste disposal area in the late 1970's. The Site includes a 10-acre former disposal area and about 35 acres of surrounding woodland and wetland areas, defined by the extent of the groundwater and surface water impacts.

Drums containing hazardous waste and bulk liquid waste were illegally disposed within a portion of the Picillo Farm over an unknown period of time. A series of trenches - the northeast trench, northwest trench, west trench, south trench, and two slit trenches, were used for this activity. The waste included a wide variety of industrial, commercial and laboratory waste such as, solvents, pesticides, paint sludges, resins, till bottoms, etc. In September of 1977, a sodium aluminum hydride explosion and fire brought the site to the attention of the regulatory authorities.

Subsequently, from 1977-1982, a number of investigations and remedial activities have been conducted at the site by the RIDEM. RIDEM hired a series of environmental contractors to remove drums and contaminated soils from the site. Intact drum removals under RIDEM oversight included 2,314 drums in the northeast trench 4,400 drums in the northwest trench and 3,300 drums in the south and west trench.

Contaminated soils from the site were relocated and underwent biological treatment via landfarming using a variety of microbes. This action was successful for certain contaminants; however, it was found to be lacking for others. About 6,500 cubic yards of PCB and phenol-contaminated soil remained stockpiled on site within the footprint of the former disposal area. Soils were temporarily capped, and offsite disposal of contaminated soils were deemed necessary. RIDEM also determined that a pump and treat system would be needed to remediate contaminated groundwater at the site and had initiated the design of the system.

In 1983 the site was added to the National Priorities List and the United States Environmental Protection Agency took over the regulatory lead role at the site.

In 1985 the USEPA signed a Record of Decision for Operable Unit 1 (OU 1) (remedial agreement between the USEPA and the responsibility parties that disposed of material at the site). The OU1 remedy, as amended, addressed three contaminated soil piles that remained on site after the removal action in the early 1980s. A primary objective of the OU1 remedy was to prevent the infiltration of soil contaminants into the underlying groundwater. The OU1 remedy included the following major components: Disposal of 3,500 cubic yards of primarily PCB-contaminated soils and disposal of 3,000 cubic yards of primarily phenol-contaminated soils off site in a Toxic Substances Control Act or Resource Conservation and Recovery Act landfill. Implementation of site closure activities included filling, grading, and revegetating the disturbed areas, installing a run-on/run-off control system, installing a fence, mowing the area inside the fence, and providing for future maintenance, as needed.

The 1985 ROD noted that any future actions for groundwater and surface water, if needed, would be addressed in a future ROD. USEPA subsequently established OU2 to address remaining contamination at the Site.

In 1988, USEPA began the remedial investigation and feasibility study to address contamination that remained on site after the OU1 actions. The remedial investigation determined that contaminated groundwater was discharging to a wetland about 1,200 feet northwest of the former waste disposal areas. Groundwater and surface water were contaminated by various halogenated and aromatic VOCs, SVOCs and metals. On-site soil contaminated with VOCs and SVOCs was a continuing source of contamination to groundwater.

Based upon this investigation the USEPA selected the remedy for OU2 in the Site’s September 1993 ROD. It addressed all remaining contamination at the Site and included source control and management of migration (MOM) components. The 1993 ROD identified the following remedial action objectives:

- Restore contaminated groundwater to drinking water standards, and to a level that is protective of human health and the environment, as soon as practicable.
- Restore contaminated surface water to drinking water standards and ambient water quality criteria (AWQCs), and to a level that is protective of human health and the environment, as soon as practicable.
- Prevent or mitigate the continued release of hazardous substances to the groundwater and surface water from the soils by reducing the concentration of contaminants in the soil. To ultimately achieve the concentration in groundwater and surface water to not exceed drinking water standards or AWQCs and will not pose a risk to human health and the environment.
- Prevent or mitigate releases of contaminants to the Unnamed Swamp.
- Reduce contaminant exposure of wildlife through bioaccumulation in the food chain and direct contact with contaminated surface water, sediments, and surface soils.
- Minimize impact on wetlands due to operation of the remedial alternative.

The 1993 ROD selected the following major source control and MOM remedy components:

- Source Control In-situ soil vapor extraction (SVE) to remove VOCs and SVOCs. This remedy component included the installation of ninety-five (95) extraction wells, lowering the water table and treatment of the extracted groundwater, treatment of extracted vapors and placement of a temporary cap over the treatment area to enhance recovery. During remedial design, the originally required thermal treatment component of the in-situ SVE system was found not necessary. It should be noted that during the installation of the extraction wells, epoxy waste was discovered which warranted removal. Approximately two hundred and fifty (250) tons of waste was removed. Subsequently, after the installation of the SVE system, an additional two thousand three hundred (2300) tons of waste were removed.

- Excavation and off-site disposal of 1,350 cubic yards of surface soil contaminated with PCBs (primarily in the area of the former PCB soil stockpile).

- Institutional controls to restrict access around the areas of active soil remediation until cleanup levels are met.

- A soil monitoring program to demonstrate compliance with soil cleanup levels and performance monitoring to evaluate the effectiveness of the SVE system.

- MOM Extraction of contaminated groundwater from the overburden and shallow bedrock aquifers in the source and concentrated regions of the plume (referred to as the Concentrated Plume) and monitored natural attenuation of the dilute region of the plume (referred to as the Dilute Plume).

- Treatment of extracted groundwater using ultraviolet/oxidation (UV/OX) and carbon adsorption or air stripping and carbon adsorption; reinjection of the treated water into the aquifer or discharge of the treated water to surface water.

- Implementation of an environmental monitoring program to evaluate the extent of contamination over time, to demonstrate compliance with groundwater and surface water cleanup levels and the need to adjust or modify operating parameters of the system.

In 2000, the USEPA installed the pump and treat system designed to address contaminated groundwater at the site and a soil vapor extraction system (SVE) to address subsurface soils.

In-situ soil vapor extraction is designed to remove VOCs and SVOCs. This remedy component included lowering the water table and treatment of the extracted groundwater, treatment of extracted vapors and placement of a temporary cap over the treatment area to enhance recovery. During remedial design, the originally required thermal treatment component of the in-situ SVE system was found not necessary.

Efforts to completely dewater the till unit and weathered bedrock target dewatering elevations were not successful near MW-85 in the NWT. While effective for the shallow overburden, dewatering and SVE were demonstrated to be ineffective for treating residual contamination in the glacial till. With USEPA and RIDEM approval, the SVE system was shut down in September 2006. The dewatering operations in the NET and NWT were shut down in October 2006. During its nearly five years of operation, the SVE system is estimated to have removed over 40,000 pounds of VOCs and SVOCs. Significant decreases in groundwater VOC concentrations were observed over most of the Site as a result of the source remedy operations.

The groundwater treatment system is designed to extract contaminated groundwater from the overburden and shallow bedrock aquifers in the source and concentrated regions of the plume (referred to as the Concentrated Plume) and monitored natural attenuation of the dilute region of the plume (referred to as the Dilute Plume). Treatment of extracted groundwater using ultraviolet/oxidation (UV/OX) and carbon adsorption or air stripping and carbon adsorption; reinjection of the treated water into the aquifer or discharge of the treated water to surface water. Implementation of an environmental monitoring program to evaluate the extent of contamination over time, to demonstrate compliance with groundwater and surface water cleanup levels and the need to adjust or modify operating parameters of the system.

The SVE system was taken offline in 2006. The pump and treat system is still active.

Subsequently, studies have revealed the presence of contaminated groundwater in areas not expected, such as the MW 28 area.

Despite continued operation of the MOM remedy, elevated concentrations of VOCs persisted near MW-85 (overburden well) in the NWT and near MW-28 (shallow bedrock well) northeast of the NET. In 2016, EPA’s contractor performed an optimization review of the Site’s remedy. The review made recommendations to optimize the remedial response and to improve cost effectiveness and progress toward remedial goals. The recommendations focused on the two remaining residual areas of significant contamination near MW-85 and MW-28 northeast of the NET. The review recommended more characterization in the MW-28 area and a pilot study for in-situ chemical oxidation (ISCO). It also identified two possible source treatment options for the MW-85 NWT area where residual contaminant mass remains primarily in the saturated glacial till. It recommended addressing the MW-85 NWT area after the MW-28 area. Monitoring recommendations included the addition of 1,4-dioxane to routine groundwater monitoring (it was first identified at the Site in 2016), statistical trend analysis of total VOCs and priority COCs, and annual estimates of reduction in mass flux from each of the source areas. The review also recommended modifying the treatment system to treat 1,4-dioxane.

In 2017, the PRP Group conducted several phases of investigation in the NET/MW-28 area. Results found that the NET is not an ongoing source of groundwater degradation in the MW-28 area; elevated VOC concentrations were not detected in soil. These activities and results are presented in the Draft MW-28 Area Assessment Report, submitted to USEPA in August 2018. Revised conclusions to the MW-28 Area Assessment Report were submitted to USEPA in April 2019. A comprehensive review of all data collected from the MW-28 area suggested the bedrock VOC plume is a detached, dissolved plume that is localized in extent. In 2019, EPA’s contractor performed a follow up to the optimization review and prepared an optimization memorandum

(2019 Optimization Memo) to recommend more steps to determine if there are other possible sources contributing to the groundwater contamination in the MW-28 area. They included inspections of the MW28 area, test pitting activities and installation of monitoring wells east of MW-28 and near the Unnamed Swamp. The PRP Group completed the inspections and test pitting activities shortly thereafter. The results of the subsurface (test pit) investigation did not find a potential source of impacts to soil or groundwater. The PRP Group summarized the results in a January 2020 memorandum to USEPA and RIDEM. The PRP Group prepared the Draft MW-28 Area Groundwater Monitoring and ISCO Work Plan in October 2020 to address more recommendations from the 2016 optimization review and the 2019 Optimization Memo. In November and December 2020, the PRP Group installed two monitoring well couplets (MW-117U/BRS and MW-118U/BRS) and four ISCO injection wells (IW-1 through IW-4) and conducted more groundwater sampling and hydraulic testing. Elevated concentrations of VOCs and 1,4-dioxane were detected in bedrock well MW-117BRS, located hydraulically upgradient of MW-28, which resulted in a delay of the planned ISCO injection work to investigate the area near MW-117BRS.

In summer 2021, the PRP Group installed and sampled three more monitoring well couplets (MW-119U/BRS, MW-120U/BRS and MW-121U/BRS) east and southeast of MW-28 (Figure C-2, Appendix C). Detected concentrations from the newly installed wells were considerably less than those at MW-117BRS; as a result, the proposed location for the ISCO pilot study was revised from MW-28 to MW-117BRS, which is considered the most upgradient portion of the bedrock plume that warrants remediation. The PRP Group submitted a Revised Draft 2022 MW-28 Area ISCO Work Plan to USEPA and RIDEM in June 2022. It proposed changing the focus of the pilot study from the area immediately around MW-28 to the MW117BRS area. The first round of ISCO injections took place in summer 2022. The overall effectiveness of an ISCO remedy for COCs in bedrock groundwater will be assessed following the interpretation of results from both process and performance monitoring. Data from the pilot study were not yet available for review for inclusion in this FYR Report. Groundwater extraction and treatment is ongoing.

In response to a recommendation in the 2018 FYR Report, groundwater was sampled for per- and polyfluoroalkyl substances (PFAS) beginning in 2018. In spring 2019, the PRP Group added a UV/OX unit to the groundwater treatment train to treat 1,4-dioxane in groundwater; the system became fully operational in June 2019. The PRP Group continues to monitor groundwater concentrations in the Concentrated Plume (defined by total VOC concentrations above 1,000 micrograms per liter [µg/L]) and the Dilute Plume (defined by total VOCs below 1,000 µg/L) semiannually. Data suggests that natural attenuation is occurring, and COC concentrations are declining in the Dilute Plume, and the Concentrated Plume is hydraulically contained. More information on recent site data is included in the Data Review section of this FYR Report.

Residential wells near the site are routinely tested and site related contaminants are not present. Note, not all nearby residents have agreed to have their wells tested.

Emerging contaminates, such as 1,4 dioxane and PFAS has been found in site groundwater above regulatory criteria. The existing groundwater treatment system has been remediating these contaminants, although breakthrough (failure of the system to treat the contaminants) has occurred. Necessary actions were taken to address this. Additional investigations are planned to ascertain the nature and extent of the PFAS contamination.

5.6 Other Superfund Sites

PFAS sampling is anticipated at other Superfund Sites in Rhode Island in the future. For sites where the remedial action has already occurred, it is anticipated that sampling for PFAS will be incorporated as an ARAR as part of the Five-Year Review Process. For sites where remedial action has yet to take place or is ongoing, it is also anticipated that PFAS will ultimately be included in long-term monitoring plan.

One example of the latter is for the Peterson Puritan Superfund Site, Operable Unit 2, which is located in the Towns of Cumberland and Lincoln. This site consists of a series of hazardous waste landfills and disposal areas in and along the Blackstone River. The remedy for the site primary involves excavating buried waste and contaminated soils in the floodplain and consolidating it into two landfills which will be encapsulated with a RCRA Subtitle C or equivalent cap. Due to the site location on the Blackstone River and the underlying GAA aquifer, PFAS sampling will ultimately be incorporated as part of the Environmental Monitoring Plan post construction.

6 Department of Defense (DOD) Sites

6.1 Background

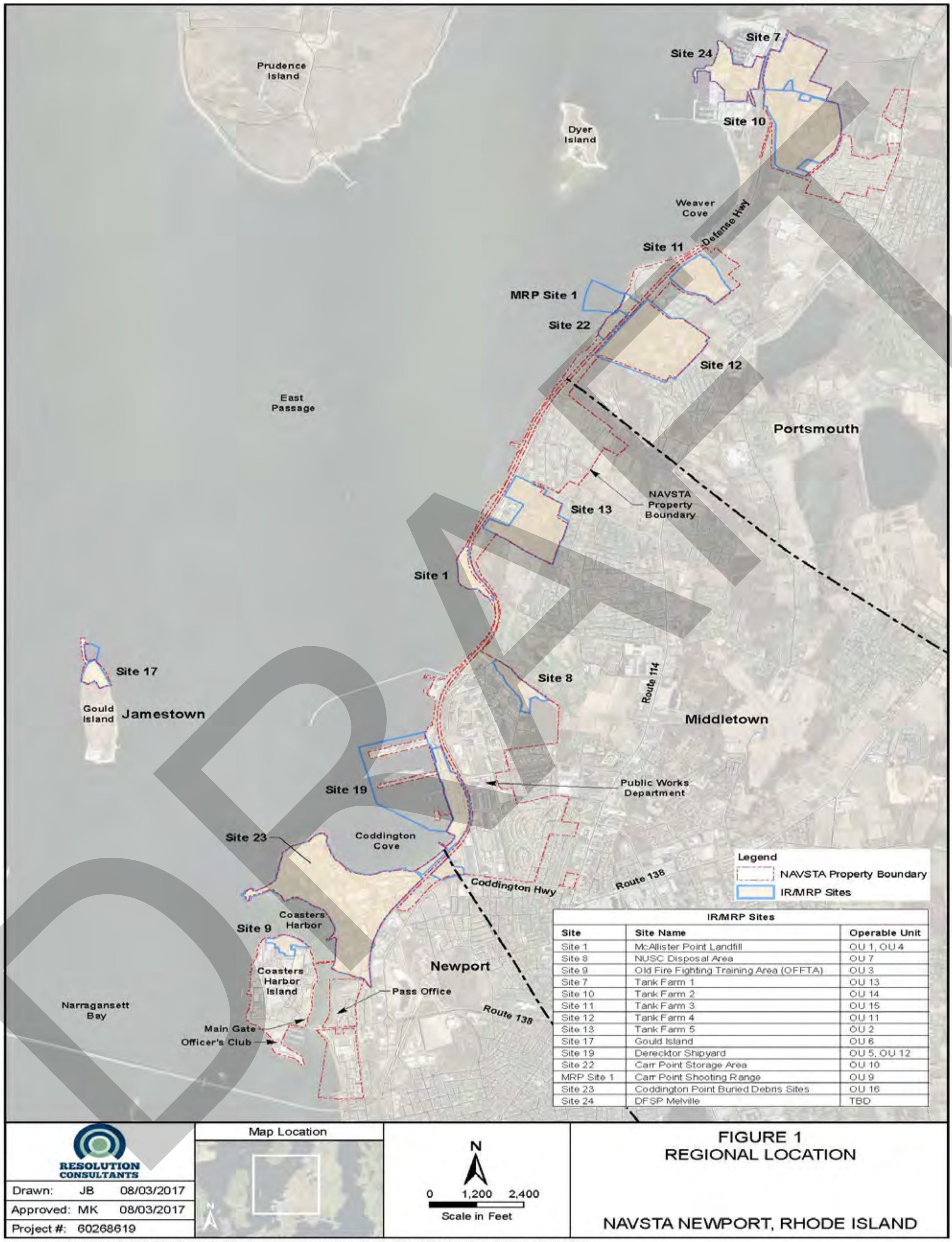
The United States Department of Defense's (DOD) usage of PFAS for military operations began as early as the 1930s (Resolution Consultants, 2018). PFAS was a major component of a range of military operations, mainly being used in aqueous film-forming foam (AFFF) and electroplating activities. AFFF was commonly used for firefighting training activities, thus is a main source of PFAS in the environment at historic DOD sites nationwide and in the State of Rhode Island. The Newport Naval Station, for example, formerly housed multiple tank farms, which required foam fire suppression systems that used AFFF. PFAS was used by the DOD as bath mist suppressants during electroplating activities. PFAS acts as a surfactant, which lowered the surface tension on the conductive metal surface during electroplating. This mist suppression prevented the formation of carcinogenic air borne aerosols that get released during the electroplating process. PFAS can also be found in landfills and waste disposal areas at DOD, as fluorinated compounds are known to be present in adhesives, rubbers, paints, and plastics.

In the mid-1960s, the Navy developed AFFF to be used for Class B fires (highly flammable or combustible liquid fires, including gas tankers and refineries). AFFFs are water-based (60-90%) and frequently contain hydrocarbon-based surfactants such as sodium alkyl sulfate, and fluorosurfactants, such as fluorotelomers, PFOA, and/or PFOS. Traditional AFFFs, including PFOA and PFOS based foams, were manufactured using fluorinated surfactants with carbon chain lengths between C6 and C12. Fluorinated surfactants with chain lengths longer than C8 can breakdown in water to PFOA, and in contrast fluorinated surfactants with chain lengths of C6 or less do not breakdown to PFOA (USEPA, 2014; FFFC, 2014). In response to the United States Environmental Protection Agency 2010/2015 PFOA Stewardship Program initiated in 2006, manufacturers of firefighting foams have switched production to C6 and fluorine-free firefighting foams (USEPA, 2014).

6.2 Newport Naval Education and Training Center (NETC) (Basewide PA/SI)

Naval Station Newport (NAVSTA), formerly known as Naval Education and Training Center (NETC), has been used and operated on by the United States Navy since the Civil War era. The Newport Naval Education & Training Center is the largest, both in land area and number of operable units, and one of the most complex Superfund sites in the State. The site encompasses the entirety of Naval Station Newport, both past and present, along the western coast of Aquidneck Island. In the World War II era, NAVSTA Newport was mainly used as a refueling depot as it is home to one of the largest DOD-operated fuel terminals on the East Coast, consisting of a series of 2.5-million-gallon capacity underground storage tanks with extensive fire suppression systems. Due to the nature of the historical Naval operations at NETC, exploratory investigations into potential environmental concerns began in the 1980s.

In 1992, the United States Navy, United States Environmental Protection Agency and Department signed a Federal Facilities Agreement (FFA), a legally binding document amongst the parties developed to enable the Navy to meet the provisions of CERCLA and applicable state law for environmental investigations and remediations at NETC. The FFA describes roles and responsibilities, outlines the work to be performed and sets schedules/deadlines, among other requirements. Today, the NETC Superfund site consists of approximately 1,000 acres of land on the western portion of Aquidneck Island with over 20 different sites and Operable Units, each presenting their own environmental challenges and concerns. Portions of NETC site are also located on the current active Navy base, NAVSTA Newport. As PFAS toxicity information and knowledge of wide-range DOD usage evolved, the Navy began conducting CERCLA investigations site-wide at NETC into the potential impacts from PFAS with regulatory oversight from the USEPA and RIDEM starting in the 2010s. The figure below is a regional location map of the NETC Superfund site, outlining the areas of the different sites and Operable Units along the west coast of Aquidneck Island.



IR/MRP Sites

Site	Site Name	Operable Unit
Site 1	McAllister Point Landfill	OU 1, OU 4
Site 8	NUSC Disposal Area	OU 7
Site 9	Old Fire Fighting Training Area (OFFTA)	OU 3
Site 7	Tank Farm 1	OU 13
Site 10	Tank Farm 2	OU 14
Site 11	Tank Farm 3	OU 15
Site 12	Tank Farm 4	OU 11
Site 13	Tank Farm 5	OU 2
Site 17	Gould Island	OU 6
Site 19	Derecktor Shipyard	OU 5, OU 12
Site 22	Carr Point Storage Area	OU 10
MRP Site 1	Carr Point Shooting Range	OU 9
Site 23	Coddington Point Buried Debris Sites	OU 16
Site 24	DFSP Melville	TBD

Drawn:	JB	08/03/2017
Approved:	MK	08/03/2017
Project #:	60268619	

FIGURE 1
REGIONAL LOCATION

NAVSTA NEWPORT, RHODE ISLAND

Path: P:\Govt\Projects\NavyCLEAN AECOM-EnSafe JV\Newport\GIS\Projects\Sitewide\Regional_Location\MXD\Fig_1_Regional_Location.mxd

Figure 11: Regional map location of NAVSTA Newport, Rhode Island (Resolution Consultants, 2018)

A Preliminary Assessment (PA) was the first step into the CERCLA PFAS investigation at NETC and was conducted installation wide for all areas within the current property boundaries. The purpose of the PA was to identify potential PFAS release areas at NETC. No environmental sampling occurred as part of this PA. Potential PFAS release areas were identified by gathering and collecting as much information as possible through a variety of research mechanisms. Literature review was conducted from 2015-2017 through the Navy Administrative Record to evaluate potential areas on existing NETC sites where AFFF containing PFAS or PFAS constituents may have been used and/or disposed. Interviews were also conducted with former and current NAVSTA Newport employees who had knowledge of potential current and historical PFAS use at NETC. The interviews provided critical information from those with first-hand knowledge to help identify exact locations of where AFFF was stored, where firefighting training activities may have occurred, and where PFAS-containing waste may have been disposed of, among other things. A review through historical photographs, engineering plans, condition maps, waste inventories and more occurred as part of the research in the PA (Resolution Consultants, 2018).

The PA focused on PFAS-containing firefighting foam, electroplating bath mist suppressants, and areas historically receiving waste streams potentially containing PFAS as the sources into the environment at NETC. Common source areas identified during this PA include firefighting training areas, fire suppression systems, landfills, oil-water-separators, and electroplating facilities. Site-specific conceptual site models (CSMs) are described for each area of potential PFAS use in the PA. In total, the PA for PFAS at NETC evaluates the potential source areas at fourteen (14) different sites at NAVSTA Newport, as seen in Table 6 below.

Table 6: Potential source areas at 14 different sites at NAVSTA Newport identified in the PFAS PA for NETC

BASE AREA	POTENTIAL PFAS RELEASE AREA
McAllister Landfill	General Area
Tank Farm 1	Fire Pump/Foam System Valve House No. 1
	Foam Pump House No. 2 (Building 49)
	Foam Pump Tank House (Building 23)
	Hose House (Buildings 224 and 225)
Coasters Harbor Island	Fire Station No. 1 (Building 55)
Tank Farm 2	Foamite Equipment and Powder House (Building 105)
	Hose House (Building 218)
	Foamite Equipment and Powder House (Building 104)
	Fire Station No. 4 (Building 48)
	Fire Training Area

Tank Farm 3	Pumping House - Foam System (Building 108)
Tank Farm 4	Pump House - Foam System (Building 109)
	Equipment House - Foamite (Building 110)
	Hose House (Building 217)
Tank Farm 5	Extinguisher House (Building 216)
	Equipment House - Foamite (Building 112)
	Pump House - Foam System (Building 113)
	Tanks 53 and 56
	Firefighting Training Academy (Buildings 1275, 1276 and 1277)
Gould Island	General Area
Derecktor Shipyard	Pipe Shop (Building 6)
	S42 Paint Disposal Area (Building 42)
	Steam Plant ASTs Fire Suppression System
	Fire Station (Building 10)
	Fire Training Area (Buildings 13, 15 and 47)
	Fire Training Area (Former Navy Housing Area)
Carr Point	Storage Area and Fire Supression System
	Fire House (Building 187)
DFSP Melville	Truck Fueling Rack Area (Buildings 1159, 1179 and 67)
	Drum and Can Loading Facility (Building 266)
	Fire Hose House (Building 39)
	Fire Pump/Foam System Valve House (Building 1282/Building S12)
	Pump House - Foamite (Building 96)
	Fire Pumper Shed (Building 95)
	Booster Fuel Pump House (Building S22) and Issue Valve House
	Fuel Pump, Filter, Seperator Building (Building C35)
	Net Storehouse/General Warehouse (Building S42)

	Pump House - Foam and Hose Reel House (Buildings 102 and 103)
	Pumphouse (Building 231)
	Hose House (Buildings 215 and 235)
	Garage - Fire Pumper (Building 107)
	North and South Fueling Pier
	North and South Booster Pump House (Buildings 58 and 59)
	Surge Pool
	Tanks 1, 2, 3 & 5
	Fire House (Building 205)
Midway	General Area
NUWC	Building 116A and 1170
	Paint Can Disposal Area
	Fire Station (Building 133)
Coddington Point	Fire Stations (Buildings 305, 1105, and 1505)
	Fire Department Headquarters (Building 1931)
	Fire Training Area (Coddington Point Area)

The main objective of the PFAS PA was to make a recommendation for either further assessment in the form of a Site Inspection (SI), or no further action (NFA) on a site based off the potential use of PFAS. In general, if a site was determined to have known or potential historical usage, storage, or disposal of AFFF containing PFAS or PFAS constituents identified in the PA, it was recommended for further assessment in the SI. The PFAS PA for NETC in its entirety, which contains a table summarizing the findings and recommendation for each site investigated as part of this PA, as well as more information as it relates to PFAS usage at NETC can be found at this link: https://administrative-records.navfac.navy.mil/Public_Documents/MID_ATLANTIC/NEWPORT_NS/N62661_003861_REDACTED.pdf.

Below is Figure 12 outlining the areas evaluated as part of the PFAS PA for NETC.

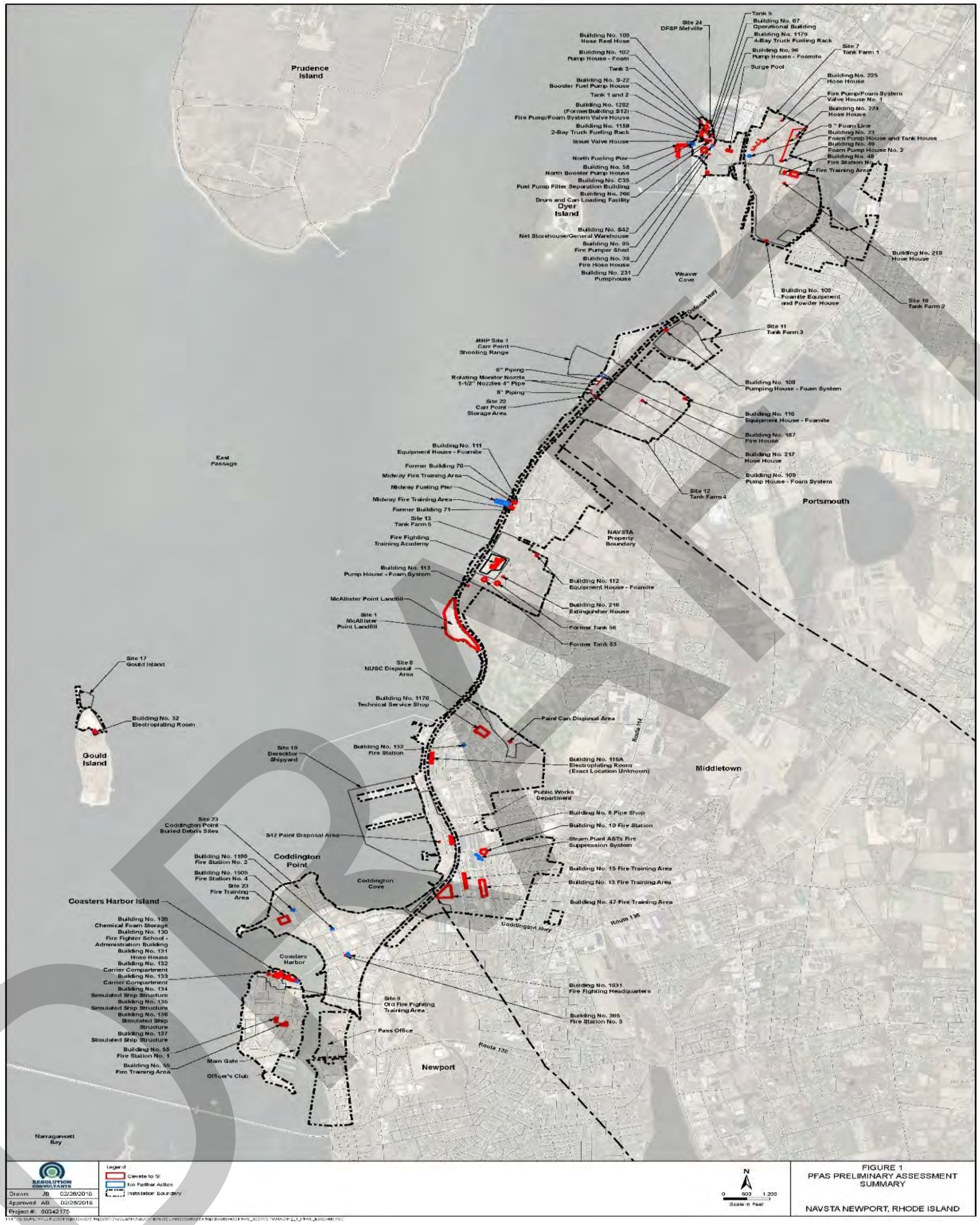


Figure 12: Areas evaluated as part of the PFAS PA for NETC (Resolution Consultants, 2018)

The PFAS PA for NETC was finalized in March of 2018. The next step in the process was to begin scoping a Sampling and Analysis Plan (SAP) to support investigations into any sites that were identified in the PA requiring further evaluation in the form of a Site Inspection (SI). Collecting environmental data for the sites is a critical aspect of an SI, as no samples are collected in the PA. Alongside the USEPA and Navy, RIDEM helped develop CSMs for each site to determine the appropriate locations for sampling potential PFAS sources at NETC. Fate and transport of PFAS in the environment was considered as direct discharge into the surface was the most probable release mechanism identified. PFAS mobilizes through soil to groundwater via advection. As water solubility for PFAS is high, local groundwater is an ideal environmental medium to sample for investigating PFAS impacts. Groundwater was the only environmental media that was sampled as part of the first round of sampling during the SI. Groundwater monitoring wells were installed in strategic locations relative to PFAS source areas and the groundwater contours at each area to ensure samples were taken downgradient of sources. Construction workers, future residents, trespassers, and occupational workers were considered as potential receptors to PFAS contaminated media as part of the SAP (Tetra Tech, 2020). The overall goal of the Phase I PFAS SI, and the supplemental SAP, was to determine if PFAS is in the groundwater, and if so, at what concentrations.

The SAP was finalized in 2020, and fieldwork commenced that year in support of the SI for PFAS at NETC. Fieldwork included site visits, mobilization/utility clearance, monitoring well installation, well development, well surveying, groundwater level monitoring and groundwater sampling. Forty-nine (49) new monitoring wells were installed site wide at NETC as part of this SAP. Existing monitoring wells were also included in the sampling network at multiple sites. Quality control measures were utilized during sampling and are described in the SAP. For management of investigation-derived waste, 55-gallon drums were used. For the samples that were collected as part of this event, “all PFAS analyses were conducted in accordance with Department of Defense/Department of Energy Quality Systems Manual for Environmental Laboratories, Version 5.3, using liquid chromatography with tandem mass spectrometry (LC/MS/MS), per Appendix B Table B- 15 (2019)” (Tetra Tech, 2020). This includes a suite of 14 total PFAS that were analyzed. The regulatory approved Final SAP in its entirety can be found https://administrative-records.navfac.navy.mil/Public_Documents/MID_ATLANTIC/NEWPORT_NS/N62661_004445_REDACTED.pdf.

It is important to note that some sites at NETC that are included in the SI report had been sampled for PFAS constituents from 2015-2019 as part of site-specific investigations. These sites included Site 1 McAllister Point Landfill, Site 7 Tank Farm 1, Site 12 Tank Farm 4, Site 13 Tank Farm 5, Site 22 Carr Point Storage Area, Site 8 NUCS Disposal Area, Site 19 Derecktor Shipyard, and Site 17 Gould Island. Of the forty potential PFAS release areas that are reported in the SI report, seventeen (17) of them were investigated as part of modified long-term monitoring programs or site-specific investigations not solely focused on PFAS. The remaining twenty-three (23) PFAS sources identified in the PA were investigated and sampled in summer of 2020 in accordance with the 2020 SAP generated by Tetra Tech. However, all data collected is reported and discussed in the PFAS SI, regardless of when the data was collected.

Following completion of fieldwork, getting sample results back and analyzing the data, the Navy submitted a Draft PFAS SI at NETC to the USEPA and Department for review and comments in May 2021. The Draft PFAS SI reports the sample concentrations observed from groundwater monitoring wells sampled as part of this investigation and makes recommendations for each site based upon data and migration pathways/exposure routes. Loaded with tables, figures and appendices, the May 2021 Draft PFAS SI report is 3,126 pages in bulk. The Department was tasked with reviewing all the data to ensure the conclusions and recommendations being made are consistent in ensuring safety for human health and the environment and are in accordance with the most up to date PFAS regulatory standards. In November 2021, the Department completed its review of the PFAS SI report and provided the Navy with a comment letter that included over one-hundred thirty (130) comments, requests, and recommendations. Comments ranged from disagreements on data evaluations, site recommendations, groundwater migration pathways, and potential source areas, among other things.

In the time it took the Navy to review and respond to both RIDEM and USEPA comments on the Draft PFAS SI report, the USEPA published new Regional Screening Levels (RSL) for PFAS constituents, lowering the previous values and introducing standards for three new PFAS. This was announced in May 2022 by the USEPA. The previous project screening levels were 40 ng/L (ppt) for both PFOA and PFOS, and 600 ng/L (ppt) for PFBS. These were the values that were employed to compare with the sample concentrations reported in the May 2021 Draft PFAS SI for NETC, and thus used to make recommendations on a site-by-site basis for whether further PFAS investigation is warranted. As a result of the change in regulations and lower RSLs, new recommendations had to be made for sites that now exceeded the current standards. A comparison to new standards for HFPO-DA, PFHxS and PFNA was also required due to the updated PFAS RSLs. As of this writing, the PFAS Regional Screening Levels in groundwater being used for the PFAS SI is as follows:

Table 7: USEPA Regional Screening Levels for PFAS

PFAS COMPOUND	RSL (ppt)
PFOS	4
PFOA	6
PFBS	600
HFPO-DA	6
PFHxS	39
PFNA	5.9

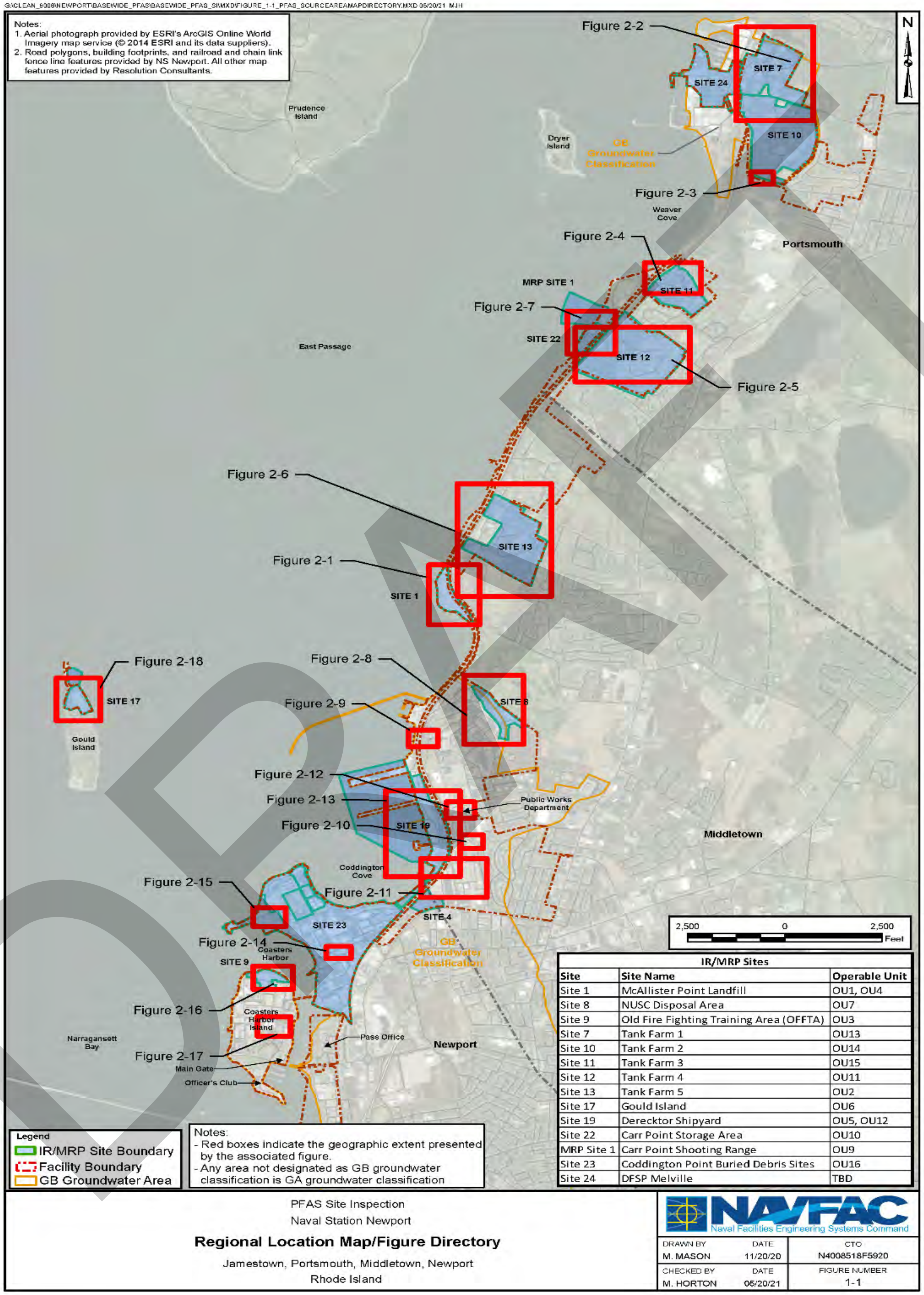
In January 2023, the Navy submitted a Revised Draft PFAS SI for NETC, as well as response to agency comments to RIDEM and USEPA. The major changes made to the revised draft report included updating recommendations, changing of PFAS RSLs, and amending the report to satisfy agency comments. RIDEM had to ensure all our one-hundred thirty (130) plus comments on the first draft had been resolved, and the revised report adequately represents that. This required a comprehensive review of the revised report and all the Navy's response to Department comments.

The January 2023 Revised PFAS SI for NETC contains a substantial amount of information regarding PFAS at Naval Station Newport. It includes a summary of the PA findings with a facility history for each site included in the report and the potential uses of PFAS at each site. The Revised SI also describes the field investigation work that has been performed from 2015-2020 to aid the SI. Groundwater flow and analytical results are also presented for each site. Numerous tables and figures are exploited to display sample concentrations and their respective locations. Based off the sampling data, migration pathways and potential receptors for each site, a determination is then made by the Navy for a future course of action. It is the USEPA and Department's responsibility to ensure recommendations for each site are appropriate, contemporary with Federal and State regulations. The forty sites that are reported and discussed in the Revised PFAS SI for NETC are shown in the table and figure below.

Table 8: PFAS source area that are reported and discussed in the Revised PFAS SI for NETC

BASE AREA	POTENTIAL PFAS RELEASE AREA
Site 1	McAllister Point Landfill
Site 7 - Tank Farm 1	Foam Pump House No. 2 (Building 49)
	Hose House (Former Building 224)
	Hose House Former Building 225)
	Foam System Valve House No. 1
Site 10 - Tank Farm 2	Foamite Equipment and Powder House (Building 105)
	Hose House (Building 218)
	Fire Station No. 4 (Building 48)
	Firefighting Training Area
Site 11 - Tank Farm 3	Pumping House - Foam System (Former Building 108)
Site 12 - Tank Farm 4	Pump House - Foam System (Former Building 109)
	Equipment House - Foamite (Building 110)
	Hose House (Former Building 217)
Site 13 - Tank Farm 5	Pump House - Foam System (Building 113)
	Firefighting Training Academy (Building 1275)
	Firefighting Training Academy (Building 1276)

	Firefighting Training Academy (Building 1277)
	Firefighting Training Academy Concrete Sump
	Equipment House - Foamite (Building 112)
	Extinguisher House (Building 216)
	Tanks 53 and 56
Site 17 - Gould Island	Torpedo Overhaul Shop (Building 32)
Site 19 - Derecktor Shipyard	Pipe Shop (Building 6)
	S42 Paint Disposal Area (Building 42)
Naval Undersea Warfare Center (NUWC)	Technical Service Shop (Building 1170)
	Former Building 116A
	Site 8 - Naval Undersea Systems Center (NUSC) Disposal Area
Carr Point	Storage Area and Fire Suppression System
Coddington Cove Area	Fire Station (Building 1373)
	Fire Station (Former Building 10)
	Former Firefighting Training Area (Building 13)
	Former Firefighting Training Area (Building 15)
	Former Firefighting Training Area (Building 47)
Site 23 - Coddington Point	Coddington Point Former Firefighting Training Area
	Fire Station (Building 305)
Coasters Harbor Island	Chemical Foam Storage (Former Building 126)
	Carrier Compartment (Former Buildings 132 & 133)
	Simulated Ship Structures (Former Buildings 134, 135, 136, & 137)
	Hose House (Former Building 131)
	Fire Station No. 1 and Firefighting Training Area (Building 55)



Notes:
1. Aerial photograph provided by ESRI's ArcGIS Online World Imagery map service (© 2014 ESRI and its data suppliers).
2. Road polygons, building footprints, and railroad and chain link fence line features provided by NS Newport. All other map features provided by Resolution Consultants.

IR/MRP Sites

Site	Site Name	Operable Unit
Site 1	McAllister Point Landfill	OU1, OU4
Site 8	NUSC Disposal Area	OU7
Site 9	Old Fire Fighting Training Area (OFFTA)	OU3
Site 7	Tank Farm 1	OU13
Site 10	Tank Farm 2	OU14
Site 11	Tank Farm 3	OU15
Site 12	Tank Farm 4	OU11
Site 13	Tank Farm 5	OU2
Site 17	Gould Island	OU6
Site 19	Derecktor Shipyard	OU5, OU12
Site 22	Carr Point Storage Area	OU10
MRP Site 1	Carr Point Shooting Range	OU9
Site 23	Coddington Point Buried Debris Sites	OU16
Site 24	DFSP Melville	TBD

Legend
- 🟩 IR/MRP Site Boundary
- 🟥 Facility Boundary
- 🟧 GB Groundwater Area

Notes:
- Red boxes indicate the geographic extent presented by the associated figure.
- Any area not designated as GB groundwater classification is GA groundwater classification

PFAS Site Inspection
Naval Station Newport

Regional Location Map/Figure Directory

Jamestown, Portsmouth, Middletown, Newport
Rhode Island

DRAWN BY	DATE	CTO
M. MASON	11/20/20	N4008518F5920
CHECKED BY	DATE	FIGURE NUMBER
M. HORTON	05/20/21	1-1

Figure 13: NETC PFAS SI Investigation Areas (Tetra Tech)

As each site investigated as part of the PFAS SI at NETC has a unique operational history that vary in use, storage, and disposal of PFAS, the groundwater sample results varied significantly. Overall, two-hundred eight (208) monitoring wells were sampled and are reported in the Revised PFAS SI, and ninety-one (91) wells exceeded the RSL for at least one of the six PFAS compounds. Site 1 McAllister Point Landfill had PFAS exceedances sitewide with a maximum PFOA concentration observed at 495 ng/L. Site 7 Tank Farm 1 had PFAS exceedances observed at four out of five release areas described in the report, as well as in areas not near an identified potential PFAS release area. Site 10 Tank Farm 2 had PFAS exceedances downgradient of a former fire station and former firefighting training area, with PFOS concentrations as high as 772.9 ng/L. Only one well was sampled at Site 11 Tank Farm 3, and it did not exceed RSLs. Site 12 Tank Farm 4 had PFAS exceedances observed in wells located in areas not near an identified potential PFAS release area. Site 13 Tank Farm 5 had PFAS exceedances in wells downgradient of an extinguisher house and a firefighting training academy. Site 22 Carr Point had PFAS exceedances in three of fifteen wells sampled. At Naval Undersea Warfare Center (NUWC), PFAS exceedances were observed at Site 8 Naval Undersea Systems Center (NUSC) Disposal Area. The Coddington Cove area had PFAS exceedances downgradient of all identified source areas investigated. Site 19 Derecktor Shipyard had PFAS exceedances downgradient of a pipe shop as well as a paint disposal area. Site 23 Coddington Point had PFAS exceedances for PFOS and PFOA in all wells sampled at the former firefighting training area. Site 9 OFFTA had PFAS exceedances for PFOS and PFOA at high levels in all wells sampled, with the maximum PFOS concentration at 1,079 ng/L. Coasters Harbor Island had PFAS exceedances at a former fire station and firefighting training area with a maximum PFOS concentration of 163.87 ng/L. Site 17 Gould Island also had PFAS exceedances observed. A table outlining the number of wells sampled and exceedances observed at each potential source area is shown below.

Table 9: Number of wells sampled and exceedances to PFAS RSLs as part of the PFAS SI fieldwork for NETC

SITE	POTENTIAL PFAS RELEASE AREA	# OF WELLS SAMPLED	# OF WELLS WITH PFAS EXCEEDANCE TO RSLs
Site 1	McAllister Point Landfill	9	8
Site 7 - Tank Farm 1	Foam System Valve House No. 1	9	9
Site 7 - Tank Farm 1	Foam Pump House No. 2 (Building 49)	2	2
Site 7 - Tank Farm 1	Hose House (Former Building 224)	2	0

Site 7 - Tank Farm 1	Hose House (Former Building 225)	6	2
Site 7 - Tank Farm 1	No Identified Potential PFAS Release Area	23	9
Site 10 - Tank Farm 2	Foamite Equipment and Powder House (Building 105)	1	0
Site 10 - Tank Farm 2	Hose House (Building 218)	2	0
Site 10 - Tank Farm 2	Fire Station No. 4 (Building 48) and Firefighting Training Area	6	6
Site 11 - Tank Farm 3	Pumping House - Foam System (Former Building 108)	1	0
Site 12 - Tank Farm 4	Pump House - Foam System (Former Building 109)	2	0
Site 12 - Tank Farm 4	Equipment House - Foamite (Building 110)	3	0
Site 12 - Tank Farm 4	Hose House (Former Building 217)	2	0
Site 12 - Tank Farm 4	No Identified Potential PFAS Release Area	16	3
Site 13 - Tank Farm 5	Equipment House - Foamite (Building 112)	2	0
Site 13 - Tank Farm 5	Pump House - Foam System (Building 113)	1	0

Site 13 - Tank Farm 5	Extinguisher House (Building 216)	3	2
Site 13 - Tank Farm 5	Tanks 53 and 56	2	0
Site 13 - Tank Farm 5	Firefighting Training Academy (Building 1275, 1276, and 1277)	5	5
Site 13 - Tank Farm 5	No Identified Potential PFAS Release Area	7	0
Site 22 - Carr Point	Storage Area and Fire Suppression System	15	3
Naval Undersea Warfare Center (NUWC)	Site 8 - Naval Undersea Systems Center (NUSC) Disposal Area	24	5
Naval Undersea Warfare Center (NUWC)	Technical Service Shop (Building 1170)	3	0
Naval Undersea Warfare Center (NUWC)	Former Building 116A	3	0
Coddington Cove Area	Fire Station (Former Building 10)	2	1
Coddington Cove Area	Former Firefighting Training Area (Building 13)	4	2
Coddington Cove Area	Former Firefighting Training Area (Building 15)	4	3
Coddington Cove Area	Former Firefighting Training Area (Building 47)	4	3
Coddington Cove Area	Fire Station (Building 1373)	3	3

Site 19 - Derecktor Shipyard	Pipe Shop (Building 6)	8	3
Site 19 - Derecktor Shipyard	S42 Paint Disposal Area (Building 42)	2	2
Site 23 - Coddington Point	Fire Station (Building 305)	3	0
Site 23 - Coddington Point	Coddington Point Former Firefighting Training Area	4	4
Coasters Harbor Island	Site 9 – OFFTA (Building 126 and Buildings 131 through 137)	4	4
Coasters Harbor Island	Fire Station No. 1 and Firefighting Training Area (Building 55)	6	4
Site 17 - Gould Island	Torpedo Overhaul Shop (Building 32)	12	6
Site 17 - Gould Island	No Identified Potential PFAS Release Area	3	2

For some results reported in the Revised PFAS SI for NETC, the laboratory detection limits at the time of analysis were greater than the current risk-based screening level. These sites include Site 12 Tank Farm 4 and Site 13 Tank Farm 5. This is because the sampling data for these sites were collected in 2017 and PFAS analytical methods at that time could not detect concentrations as low as 4 ng/L. RIDEM will require the Navy to conduct an additional round of sampling for these sites, employing a laboratory detection limit lower than the current RSLs to make a proper determination for the site.

Currently, the Navy, USEPA and Department are in the process of evaluating the PFAS data collected to come to consensus on a path forward for each site. This will all be summarized in a Final PFAS SI for NETC once the three parties can come to agreement on the proper course of action for each site. In general, and to be consistent with CERCLA guidance, RIDEM encourages further investigations into any site that had PFAS exceedances observed. Decisions need to be made on a site-by-site basis for those without exceedances, factoring in number of wells sampled, sample concentrations and groundwater migration to make an appropriate determination. For example, for sites with only one monitoring well in the network, a discussion needs to be had as to whether one well is enough to adequately characterize the site. As PFAS toxicity information is constantly evolving, it is important that data is being compared to the most up-to-date regulatory standards to properly determine a course of action for each site.

The forty sites reported and discussed in the Revised Draft PFAS SI are being recommended one of three options: data gaps SI, move to Remedial Investigation, or no action at this time. Sites being recommended for a data gaps SI are sites where the parties feel more data is required to make a confident decision as to whether the site moves to RI. Sites recommended for RI are areas where the team has conclusive data to state PFAS is present in potentially unacceptable concentrations to human health and the environment. Remedial Investigations for these areas are required to determine the full nature and extent of PFAS contamination. Sites that are recommended for no action at this time have conclusive data to show PFAS is not present at any concentrations that could be potentially unacceptable for human health and the environment. This is compared to standards that are constantly evolving and lowering. It is critical that the team is adherent to the latest State and Federal regulations as it relates to PFAS toxicity information. Thus, sites that are potentially to be concluded as “no action at this time” may require action in the future if PFAS standards continue to shrink.

The current goal for finalization of the report is by the end of 2023. Upon regulatory approval of the document from the USEPA and RIDEM, the SI will be available to the public on the NAVFAC administrative record. Following completion of the PFAS SI, scoping for future data gaps SI and Remedial Investigations may occur based on the determinations for sites made by the Navy and agreed to by the USEPA and Department. RIDEM will play a crucial role in the scoping for these future investigations by participating in scoping sessions, conducting field inspections, recommending sample locations, and ensuring proper analytical methods of samples, among other things.

6.3 Site specific investigations – Site 24 RIs, Tank Farm 1 DLA

6.3.1 Tank Farm 1 and Melville Specific PFAS Investigations

The FFA for NETC, outlining the Navy’s remedial responsibilities from historical operations at Naval Station Newport, was signed in 1992 and was the initiation of the cleanup process at multiple Operable Units. As these Operable Units all differ in site history and environmental contamination of concern, they are all at different stages of the CERCLA process. With the emergence of PFAS as a contaminant of concern nationwide at DOD Superfund sites in the recent years, investigation into potential impacts at NETC was required. For certain NETC Operable Units in or nearing the Record of Decision CERCLA phase, the emergence and presence of elevated PFAS concentrations has altered the course of remedial action. Two of these sites include Tank Farm 1 and Melville Defense Fuel Support Point.

Tank Farm 1 is a complicated site due to its historical operation and ownership. The site is located in Portsmouth, RI. The Navy began ownership of the Tank Farm 1 property in the 1920s and constructed the tanks themselves in the 1940s. Naval tank construction at the site consisted of two 2.56-million-gallon partial aboveground storage tanks and six 1.12- million-gallon capacity underground storage tanks. Associated tank support utilities (including transformer vaults), roadways, subsurface cable networks and piping systems were also constructed and utilized by the Navy. The tank farm also consisted of a series of fire suppression systems. The Navy operated on Tank Farm 1 until 1974, when the property was leased to the Defense Logistics Agency (DLA) for usage as a fuel storage area and distribution facility. DLA terminated their activities at Tank Farm 1 in 1998. As actions on Tank Farm 1 property from both the Navy and DLA have resulted in environmental contamination, both parties are liable for the remediation of the site. The Navy's preferred CERCLA method of remediation prior to knowledge of PFAS impacts at the site was a dig and haul. This was proposed to consist of removal and proper disposal of non-PFAS contaminated environmental media. In concert with the Navy's remedial approach, DLA proposed a demolition of all remaining infrastructure on-site, including but not limited to tanks, transformers, buildings, cables, pipes, etc.

Once it was discovered that Tank Farm 1 was contaminated with PFAS among other contaminants of concern, the preferred dig and haul remedial alternative required re-evaluation. The presence of PFAS in waste adversely affects both disposal location and cost. There are not many facilities that will accept PFAS-containing waste, making this remedial approach more expensive. An alternative remedial action that involved baking the excavated soils in large on-site ovens to off gas non-PFAS contaminates was attempted as a result. This alternative approach, though, had limited success due to the extreme temperatures required to burn off PFAS. Thus, a site-wide Remedial Investigation conducted by the Navy under CERCLA is now required for the entire Tank Farm 1 property to understand the full nature and extent of all the contamination at the site. The RI SAP for Tank Farm 1, which is currently being scoped by the Navy, USEPA and OLRSMM, includes site-wide sampling of groundwater for PFAS as well as PFAS soil sampling at suspected source areas, among other non-PFAS source areas being investigated. Additional installation of monitoring wells is being proposed by the Navy on-site to strengthen the current well network, as well as installation of piezometers in the Melville Pond area to evaluate the groundwater-surface water connection. OLRSMM is also recommending the Navy sample additional environmental media as part of the RI SAP for the site.

DLA's soil remediation and closure activities for the remaining tanks and associated infrastructure is planned to be conducted in accordance with RIDEM UST and remediation regulations. Proper coordination between the two parties' cleanups is essential to ensure appropriate remediation of all contamination known on-site. The goal is for the Navy to complete their investigation and subsequential remediation prior to DLA's initiation of demolition work to ensure contamination is not spread throughout the site during tank closure activities.

Preliminary data collected by the Navy at Tank Farm 1 show elevated concentrations of PFAS constituents' site-wide in the groundwater. This data is reported in the January 2023 Draft PFAS SI for NETC. Soil has been sampled for PFAS in the area of Tanks 11 and 12 at the site. To date, site-wide impacts of PFAS in soil has yet to be investigated, though it is proposed as part of the site-wide RI SAP. OLRSMM has conducted two rounds of surface water sampling downgradient of the Tank Farm 1 site, which is further discussed in Section 6.3.2 of this report. The tank farm is composed of fire suppression systems, foam pump houses, foam valve houses, etc., which are the likely sources of PFAS into the environment on the site. The figure below shows site wide PFAS concentrations at Tank Farm 1 and the northern end of Tank Farm 2, as well as identified source areas from the January 2023 Revised Draft PFAS SI for NETC. Please note the results shown in the figure below are presented in the units of ng/L.

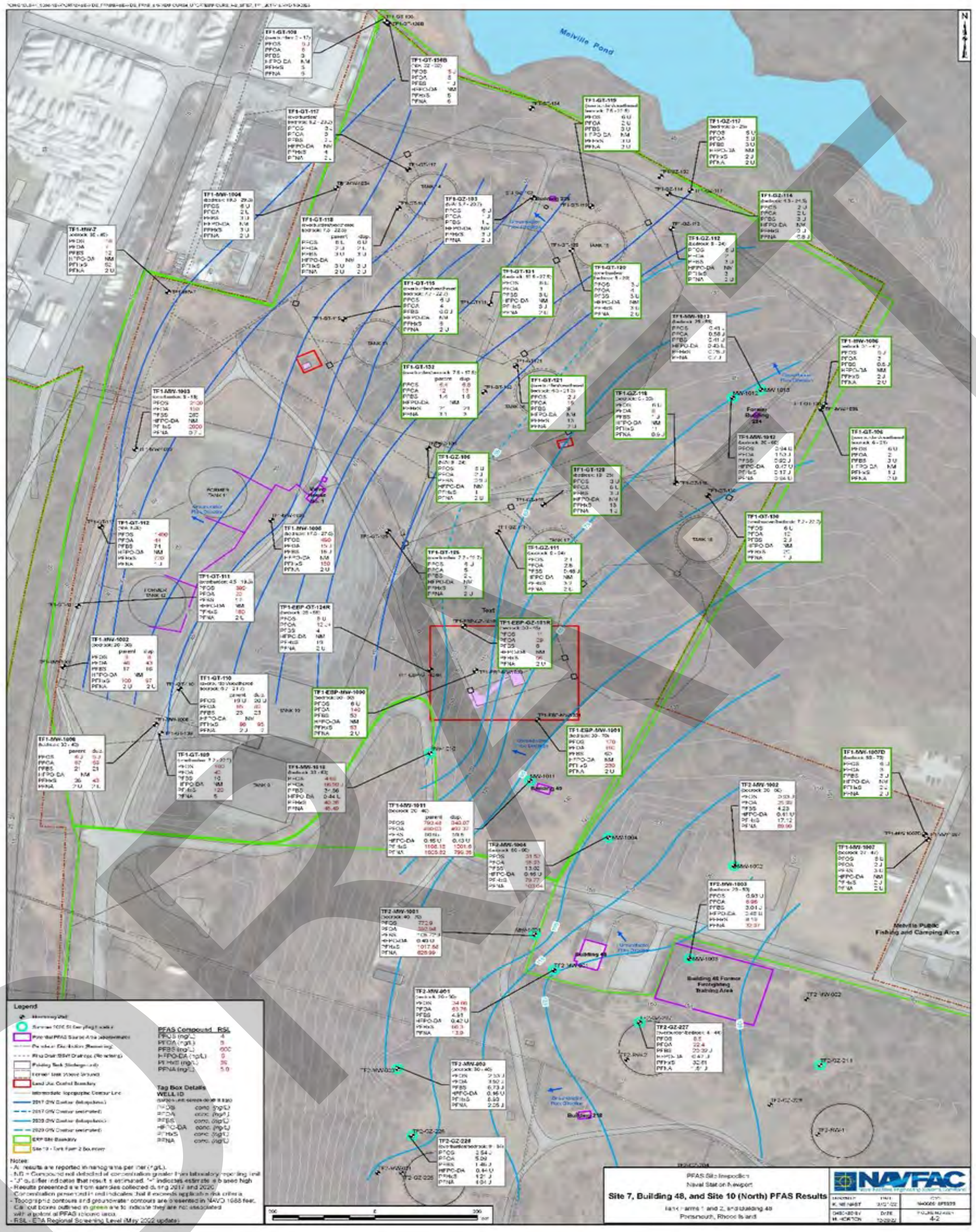


Figure 14: Site wide PFAS groundwater concentrations at Tank Farm 1 and the northern end of Tank Farm 2 (Tetra Tech)

At the Melville Defense Fuel Support Point (DFSP) complex, a large portion of the site was found to be contaminated with petroleum products both in the groundwater and the soil. Melville DSFP is also located in Portsmouth, RI, just west of the Tank Farm 1 site. The selected and approved remedial action to address this contamination was the air sparging method. This is an established and proven remedial action which consists of pumping air into the groundwater to volatilize the petroleum products in both the groundwater and the soil. The resulting volatilized petroleum in the air is then captured via a concurrent vacuum. Unfortunately, this remedial action would have introduced large volumes of air into the subsurface, chemically altering precursor PFAS compounds into the more toxic longer chain PFAS compounds such as PFOA and PFOS. Once the potential for PFAS contamination became known, this once-approved remedial action could not be implemented and instead a phytoremediation approach is being considered. An expanded site-wide Remedial Investigation to understand the full nature and extent of all the contamination at the site is currently being scoped by the US EPA and OLRSMM. This site-wide RI for Melville DFSP will include the collection of additional groundwater, soil, sediment, and other environmental media samples for analysis of PFAS and other contaminants of concern.

The 2018 PA for PFAS at NETC identified multiple PFAS sources at Melville DFSP that were historically used by the Navy for fire suppression and foam storage/usage (Resolution, 2018). Surface and subsurface soil, groundwater, pore water, sediment and infrastructure samples were collected due to the findings of the PA site wide for PFAS analysis at Melville DFSP. This was done by the Navy with regulatory oversight from the USEPA and OLRSMM during a 2018 event to support the on-going RI for Melville DFSP. Results showed elevated PFAS concentrations site-wide at Melville DFSP. OLRSMM is currently evaluating the available PFAS data to assist in scoping future CERCLA investigations, which includes investigations into additional contamination from constituents other than PFAS. This includes but is not limited to proposing sample locations and frequencies based on source areas, migration pathways and exposure scenarios to ensure the site is properly characterized and PFAS contamination is fully understood. Figures 15-17 showing PFAS sampling results in soil and groundwater at Melville DFSP can be seen below.

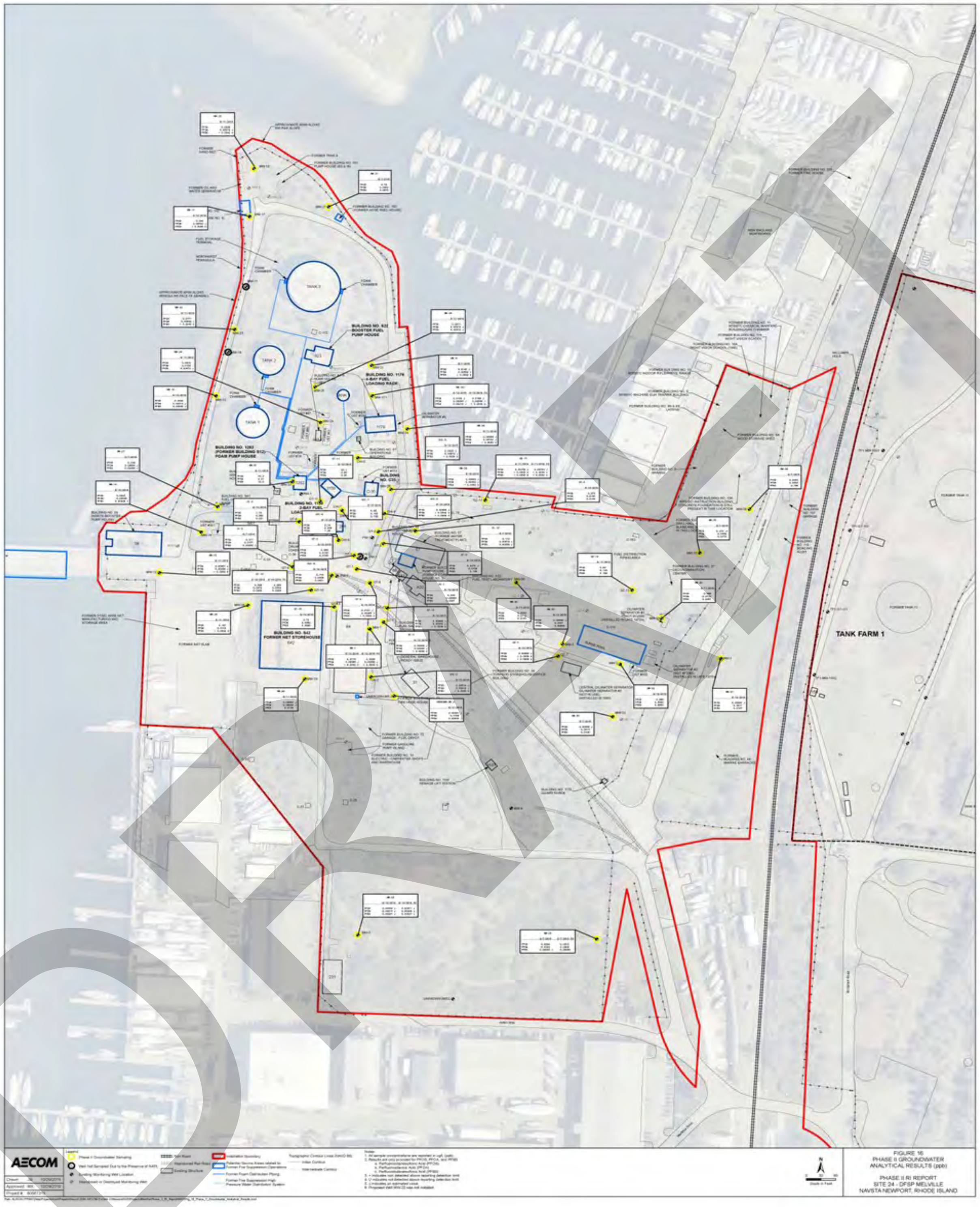


Figure 15: Phase II PFAS groundwater analytical results (ppt) for Melville DFSP (AECOM, 2019)

Figure 16: Phase II PFAS soil analytical results for Melville DFSP (AECOM, 2019)

Figure 17: Phase II PFAS soil analytical results (ppt) for Melville DFSP (AECOM, 2019)

6.3.2 RIDEM OLRSMM Surface Water Sampling

As part of the Superfund Cleanup process at Federal Facilities, such as NETC, a Restoration Advisory Board (RAB) may be convened as a public forum to exchange information and partnership among citizens, the installation, and the regulatory agencies (USEPA and RIDEM). The RAB for NETC was founded over 25 years ago and still is chaired and attended by some of the founding members from the local community. One of the primary community concerns of late has been the presence of PFAS. Local residents and RAB members had raised concerns of runoff from Site 7 Tank Farm 1 in Portsmouth impacting nearby areas including the Lower Melville Ponds and the East Passage of Narragansett Bay after initial PFAS SI data showed concerning levels of PFAS at Tank Farm 1. While neighboring properties do not use groundwater as a potable water source, RAB members have conveyed it is used for lawn sprinkling systems and irrigation on crops, providing an exposure pathway for downgradient properties of the Superfund site.

As of this writing, the Navy has yet to sample runoff and nearby surface water bodies at Tank Farm 1. Due to the community concerns, RIDEM took initiative to conduct sampling around Tank Farm 1 using monies which had previously been allocated for PFAS sampling. This was done to address the community concerns in a timely fashion and provide valuable information for the ongoing remedial investigation at Tank Farm 1. Sampling was completed by OLRSMM representatives at twelve locations around Tank Farms 1 and 2 in September of 2021. The samples were collected at surface water bodies located directly off-site and likely downgradient of the Tank Farm 1 Operable Unit to assess potential off-site impacts of PFAS. These surface water bodies sampled included ponds, discharge points, wetlands and more. Potential for human exposure was considered when selecting locations for sampling during this event. The OLRSMM staff were aided by representatives from the USEPA, Navy, as well as a RAB member on the sampling event.

Proper QA/QC (Quality Assurance/ Quality Control) procedures were adhered to during this Department-led PFAS surface water sampling event. Three field blanks were taken, and all came back as non-detect for PFAS. A field duplicate was taken at one location. Non-PFAS containing sampling equipment was utilized including gloves and sampling containers. Samples were taken at the top of the water column by simply submerging the sample container by hand (with a PFAS-free glove on) into the surface water body deep enough until water could begin to flow in through the opening at the top. Bottles were filled and dumped twice per location before capturing the sample. Samples were labeled following collection and then placed in a cooler on ice. Sample nomenclature was decided in the field based on the sample locations. The time of collection was recorded for each sample taken and a picture of the sample location was captured. Sample locations biased towards areas that were downgradient of NETC, where no PFAS data had previously been collected, in nearby ponds and surface water bodies, and areas of interest dictated by the community, USEPA, Navy or OLRSMM. Sample locations were chosen in the field. Surface water samples were collected at areas off-site to the north and east of Tank Farm 1, and to the west of Tank Farm 2. Samples were delivered same day of collection to Alpha

Analytical, a water quality testing laboratory located in Mansfield, MA. Surface water samples were analyzed at Alpha Analytical for 24 PFAS**.**

Photograph captured by OLRSMM staff during sample collection.

Compound	Sample ID/Concentration, ng/L (ppt)											
	WH	WH 2	WH 2 DUP	RR Outfall	RR North	RR South	TG Pond	Camp	Pond Inlet	Pond Outlet	Pond Wetlands	RR Bridge
PFBA	14	13.7	13.5	21.5	14.2	20.5	4.34	4.57	4.85	3.59	8.74	3.52
PFPeA	42	40.1	40	53.2	42.7	49.8	13.3	11.4	11.6	9.23	8.8	8.18
PFBS	6.9	6.71	6.69	36.9	7.68	31.8	3.59	3.98	4.13	2.89	2.96	4.02
PFHxA	39	37.2	35.8	96.8	38.6	87.4	10.6	9.55	9.87	7.49	6.85	7.18
PFPeS	4.9	4.63	4.39	38.8	5.24	35.9	ND	ND	ND	ND	ND	ND
PFHpA	16	16.1	16	26.2	16.8	26	4.98	4.63	4.95	3.89	4.99	3.61
PFHxS	35	35.8	37.3	314	37.5	328	4.48	4.48	5.47	4.24	4.33	3.33
PFOA	25	27.1	28	58.3	27	59.6	8.77	9.78	9.41	7.09	13.2	7.54
6:2FTS	ND	ND	ND	ND	ND	ND	2.76	ND	ND	ND	15.1	ND
PFHpS	ND	ND	ND	21.2	ND	15.9	ND	ND	ND	ND	ND	ND
PFNA	ND	ND	ND	4.37	ND	4.95	16.7	13	16	7.16	12.9	6.32
PFOS	5.8	9.21	11.3	640	12	466	14.9	17.5	54.6	9.32	11.1	9.85
PFDA	ND	ND	ND	ND	ND	ND	ND	ND	5.54	ND	ND	ND
PFUnA	ND	ND	ND	ND	ND	ND	ND	ND	19.2	ND	ND	ND
PFOA/PFOS	31	36	39	698	39	526	24	27	64	16	24	17
MA/VT (6)	82	88	93	1043	93	885	50	49	96	32	47	31
Total	189	191	193	1311	202	1126	84	73	146	55	89	54

Figure 18: Photograph of sample locations around Tank Farm 1 and Tank Farm 2. Note MA/VT (6) shown on the table is equivalent to PFAS6

Analytical results from the September 2021 Department-led sampling event show detections of PFAS off-site of the Tank Farm 1 area. Currently, there are no promulgated Rhode Island regulatory standards for PFAS in surface water, although standards are in the process of being finalized. Comparisons to results of this sampling event were made to PFAS6. The PFAS6 are the six PFAS constituents currently being regulated federally. Table 10 below summarizes the results. Please note that “ND” means the constituent was not detected during analysis.

Table 10: Tank Farm 1 outfalls & Melville Pond PFAS surface water sampling results Fall 2021

Compound	**Sample ID/Concentration, ng/L (ppt) for Fall 2021 Round**											
	WH	**WH 2**	**WH 2 DUP**	**RR Outfall**	**RR North**	**RR South**	**TG Pond**	**Camp**	**Pond Inlet**	**Pond Outlet**	**Pond Wetlands**	**RR Bridge**
PFBA	14	13.7	13.5	21.5	14.2	20.5	4.34	4.57	4.85	3.59	8.74	3.52
PFPeA	42	40.1	40	53.2	42.7	49.8	13.3	11.4	11.6	9.23	8.8	8.18
PFBS	6.9	6.71	6.69	36.9	7.68	31.8	3.59	3.98	4.13	2.89	2.96	4.02
4:2FTS	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
PFHxA	39	37.2	35.8	96.8	38.6	87.4	10.6	9.55	9.87	7.49	6.85	7.18
PFPeS	4.9	4.63	4.39	38.8	5.24	35.9	ND	ND	ND	ND	ND	ND
PFHpA	16	16.1	16	26.2	16.8	26	4.98	4.63	4.95	3.89	4.99	3.61
PFHxS	35	35.8	37.3	314	37.5	328	4.48	4.48	5.47	4.24	4.33	3.33
PFOA	25	27.1	28	58.3	27	59.6	8.77	9.78	9.41	7.09	13.2	7.54
6:2FTS	ND	ND	ND	ND	ND	ND	2.76	ND	ND	ND	15.1	ND
PFHpS	ND	ND	ND	21.2	ND	15.9	ND	ND	ND	ND	ND	ND
PFNA	ND	ND	ND	4.37	ND	4.95	16.7	13	16	7.16	12.9	6.32
PFOS	5.8	9.21	11.3	640	12	466	14.9	17.5	54.6	9.32	11.1	9.85
PFDA	ND	ND	ND	ND	ND	ND	ND	ND	5.54	ND	ND	ND
8:2FTS	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
PFNS	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
NMeFOSAA	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
PFUnA	ND	ND	ND	ND	ND	ND	ND	ND	19.2	ND	ND	ND
PFDS	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
FOSA	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
NEtFOSAA	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
PFDoA	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
PFTrDA	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
PFTA	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
PFOA/PFOS	31	36	39	698	39	526	24	27	64	16	24	17
PFAS6	82	88	93	1043	93	885	50	49	96	32	47	31
Total	189	191	193	1311	202	1126	84	79	146	55	89	54

Results from the September 2021 PFAS surface water sampling event were alarming. PFOS was observed as high as 640 and 466 ng/L at two locations along the railroad tracks west of Tank Farm 1. At the same two locations, PFOA was recorded at 59.6 and 58.3 ng/L. The highest total PFAS concentration observed was 1,311 ng/L, which is a sum of the concentrations of all the PFAS compounds analyzed. Concentrations seemed to be the highest at ponded surface water located along the railroad tracks. There are a number of outfalls from Tank Farm 1 that directly discharge groundwater from Tank Farm 1 off-site to the railroad area. Concerning concentrations of PFAS were also observed in Melville Pond, an area of specific concern from the RAB members. Results have been shared with the Navy, USEPA, and the RAB for their informational purposes.

As a result of the elevated levels of PFAS observed in September 2021, the OLRSMM conducted a follow-up PFAS surface water sampling event in May of 2022 to better understand potential migration pathways. The focus of the second sampling event was to further understand the potential PFAS migration to the south of Tank Farm 1 and area sampled in the previous event. Conducting the following event in May was also crucial for understanding potential seasonal differences in PFAS concentrations. Samples were taken at ten locations as part of the May 2022 event and a duplicate was taken at one location. Four locations were areas sampled in September 2021, and the other six locations are more southern and had not been previously sampled by OLRSMM. The May 2022 round of PFAS surface water sampling was conducted and attended only by OLRSMM representatives. The same sampling and QA/QC procedures employed in the September 2021 sampling event were utilized in May 2022.

Samples taken as part of the May 2022 event were mainly along the railroad tracks that border Tank Farms 1 and 2 to the east. The four areas resampled in the second event were in the ponded water along the railroad tracks directly east of Tank Farm 1 and located near discharge points from the site. The other six remaining sample locations included a beach outfall, an outfall from a pipe connected to Tank Farm 2, a pond and standing water along the railroad track. These six locations were all located south of the four resampled locations. Figure 19 depicts sample locations. The samples on Figure 19 with a white shade and a green outline are new locations sampled as part of the May 2022 round, while the four samples with a green shade and a red outline are locations that were resampled as part of this event. Sample locations from the first sampling event are also displayed on Figure 19.

Photographs captured by OLRSMM staff during Spring 2022 sample collection.

Figure 19: Sampling location for the Spring 2022 sampling event

PFAS again were detected during this second round of sampling at even higher concentrations than the first. A table with the sample results is below. The italicized columns represent areas that were resampled as part of this event.

Table 11: PFAS sampling Spring 2022. The italicized columns represent areas that were resampled as part of this event.

Compound	**Sample ID/Concentration, ng/L (ppt) for Spring 2022 Round**										
	RR North	***Williams Hole***	***TF1 Outfall (RR Outfall)***	***TF1 Outfall Dup***	***RR Overpass (RR South)***	**RR Storage**	**RR Pond**	**RR Oil Sheen**	**RR Culvert Entrance**	**TF2 Outfall**	**Beach Outfall**
PFBA	*14.4*	*14.8*	*27.2*	*26.9*	*24.2*	21.2	ND	19.7	19.7	2.77	2.96
PFPeA	*44.3*	*45.4*	*58.5*	*57.7*	*53.6*	46.5	2.42	42.7	42.9	3.73	3.24
PFBS	*7.01*	*7.06*	*73.7*	*74*	*55.6*	44.8	2.37	38.6	39	4.28	4.3
4:2FTS	*ND*	*ND*	*ND*	*ND*	*ND*	ND	ND	ND	ND	ND	ND
PFHxA	*38.6*	*39.6*	*191*	*190*	*151*	121	2.94	110	109	3.34	3.08
PFPeS	*4.78*	*4.57*	*103*	*101*	*74.2*	56.5	1.88	51.8	49.7	ND	ND
PFHpA	*17.1*	*17.4*	*31.5*	*31.7*	*31.6*	28.8	ND	26.2	26.2	ND	ND
PFHxS	*40.9*	*41.7*	*753*	*721*	*609*	518	22.2	474	470	ND	1.98
PFOA	*28.3*	*29.2*	*77.4*	*78.1*	*75.6*	69.1	4.72	62	62.4	4.48	4.75
6:2FTS	*ND*	*ND*	*ND*	*ND*	*ND*	ND	ND	ND	ND	ND	ND
PFHpS	*ND*	*ND*	*66.2*	*63.5*	*38*	31.2	ND	26.9	28.7	ND	ND
PFNA	*ND*	*ND*	*3.66*	*3.64*	*5.62*	5.29	ND	4.33	5.67	ND	ND
PFOS	*12.4*	*16.2*	*1450*	*1400*	*833*	783	35.6	662	799	3.33	2.99
PFDA	*ND*	*ND*	*ND*	*ND*	*ND*	ND	ND	ND	ND	ND	ND
8:2FTS	*ND*	*ND*	*ND*	*ND*	*ND*	ND	ND	ND	ND	ND	ND
PFNS	*ND*	*ND*	*ND*	*ND*	*ND*	ND	ND	ND	ND	ND	ND
NMeFOSAA	*ND*	*ND*	*ND*	*ND*	*ND*	ND	ND	ND	ND	ND	ND
PFUnA	*ND*	*ND*	*ND*	*ND*	*ND*	ND	ND	ND	ND	ND	ND
PFDS	*ND*	*ND*	*ND*	*ND*	*ND*	ND	ND	ND	ND	ND	ND
FOSA	*ND*	*ND*	*ND*	*ND*	*ND*	ND	ND	ND	ND	ND	ND
NEtFOSAA	*ND*	*ND*	*ND*	*ND*	*ND*	ND	ND	ND	ND	ND	ND
PFDoA	*ND*	*ND*	*ND*	*ND*	*ND*	ND	ND	ND	ND	ND	ND
PFTrDA	*ND*	*ND*	*ND*	*ND*	*ND*	ND	ND	ND	ND	ND	ND
PFTA	*ND*	*ND*	*ND*	*ND*	*ND*	ND	ND	ND	ND	ND	ND
PFOA/PFOS	*41*	*45*	*1527*	*1478*	*909*	852	40	724	861	8	8
MA/VT (6)	*99*	*105*	*2316*	*2234*	*1555*	1404	63	1229	1363	8	10
Total	*208*	*216*	*2835*	*2748*	*1951*	1725	72	1518	1652	22	23

A total of 11 samples were taken at ten locations with one duplicate. Total PFAS concentrations observed in this sampled event were upwards of 2,835 ng/L and were above 1,000 ng/L in 6 samples. PFOS was analyzed at 1,450 ng/L at one location and 1,400 ng/L in the duplicate sample taken at the same location. Similar to the first round of sampling, PFAS concentrations were highest in the surface water along the railroad tracks, with the most extreme concentrations observed in the areas resampled during the second event. PFOA/PFOS sums were observed at combined concentrations as high as 1,527 ng/L in one of the resampled locations. Samples taken further south along the railroad tracks followed pattern with troubling PFOA/PFOS concentrations observed at 852, 724 and 861 ng/L at three different respective locations. This seems to indicate that PFAS are migrating south from potential NETC impacts based on results observed in the September 2021 and May 2022 sampling events. The most southern sample taken along the railroad tracks (TF2 Outfall), though, did not observe any elevated PFAS concentrations. A sample taken on the beach at a flowing outfall (Beach Outfall) also did not have elevated PFAS levels, demonstrating that PFAS isn't flowing into the Narragansett Bay at that particular beach outfall. More sampling needs to be conducted to adequately determine potential PFAS impacts in the East Passage of Narragansett Bay from historical NETC operations.

Overall, it was observed that at locations sampled in both the Fall 2021 and Spring 2022 round of surface water PFAS sampling, higher concentrations were reported in the second event. This shows the potential effect of seasonable variability on the PFAS concentrations in the environment in the area downgradient of Tank Farm 1. The four locations resampled during the second event were Williams Hole, Tank Farm 1 Outfall, Railroad North, and Railroad South. The sample locations with the largest differences observed between Fall 2021 and Spring 2022 were at the Tank Farm 1 Outfall and Railroad South. The Tank Farm 1 Outfall also had a duplicate sample in that location during the May 2022 sampling round. Comparisons between concentrations observed in 2021 and 2022 at those four locations for the sum of PFOA/PFOS, the PFAS6, and the total sum of all the PFAS analyzed can be seen in the bar charts below.

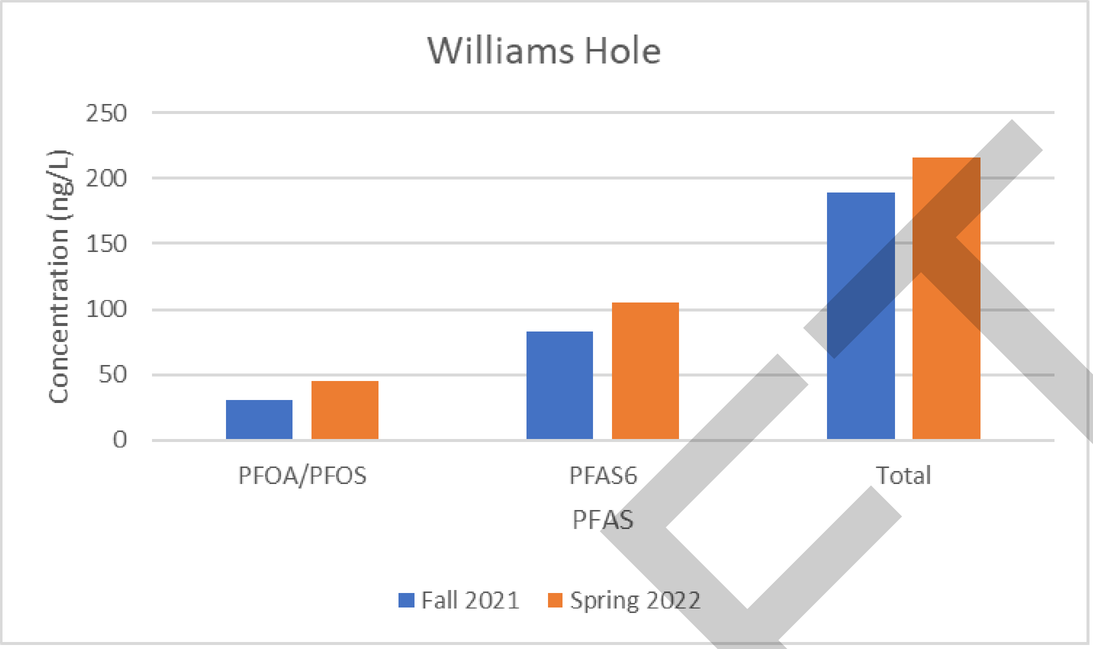


Figure 20: Bar graph depicting the sum of PFOA/PFOS, the PFAS6, and the total sum of all the PFAS analyzed at Williams Hole

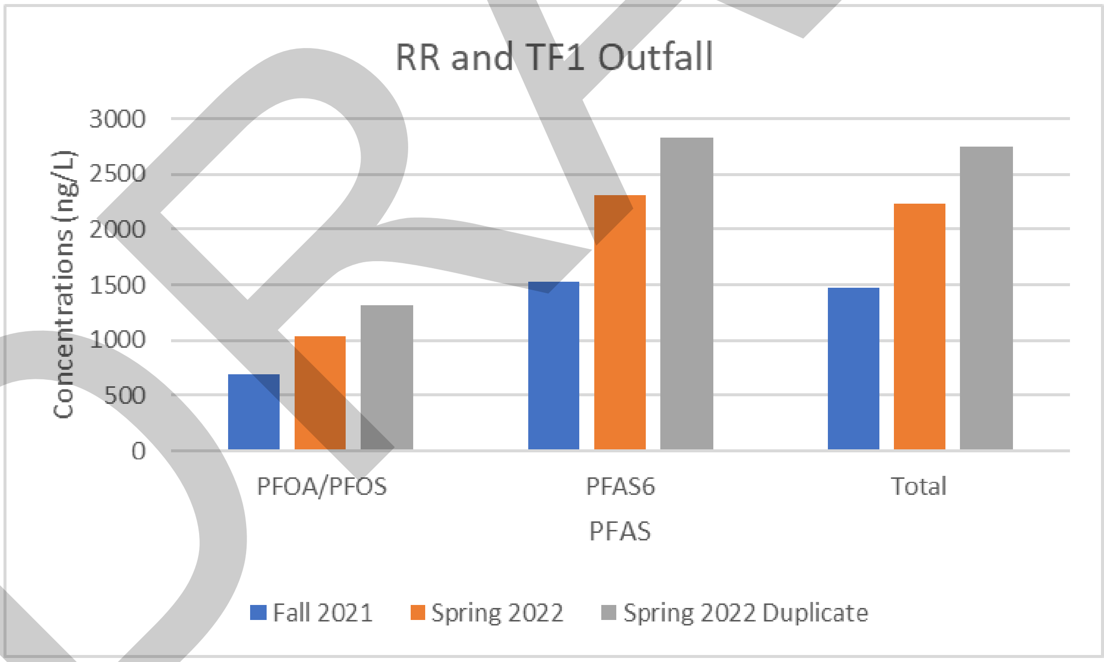


Figure 21: Bar graph depicting the sum of PFOA/PFOS, the PFAS6, and the total sum of all the PFAS analyzed at Railroad North and South and Tank Farm 1 Outfall

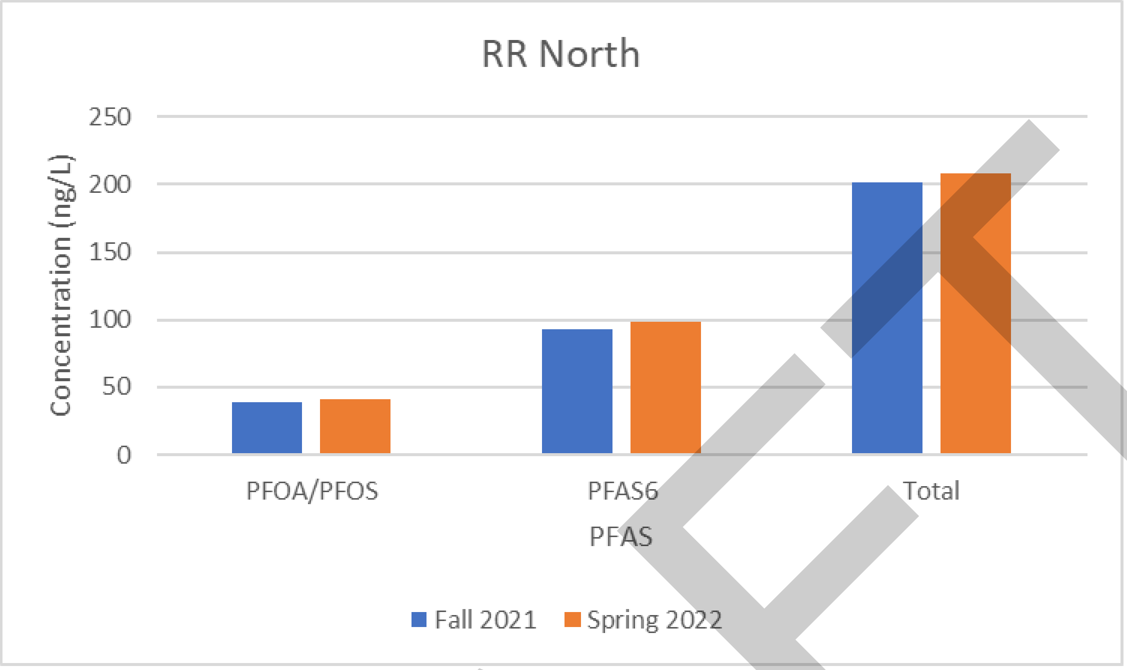


Figure 22: Bar graph depicting the sum of PFOA/PFOS, the PFAS6, and the total sum of all the PFAS analyzed at Railroad North

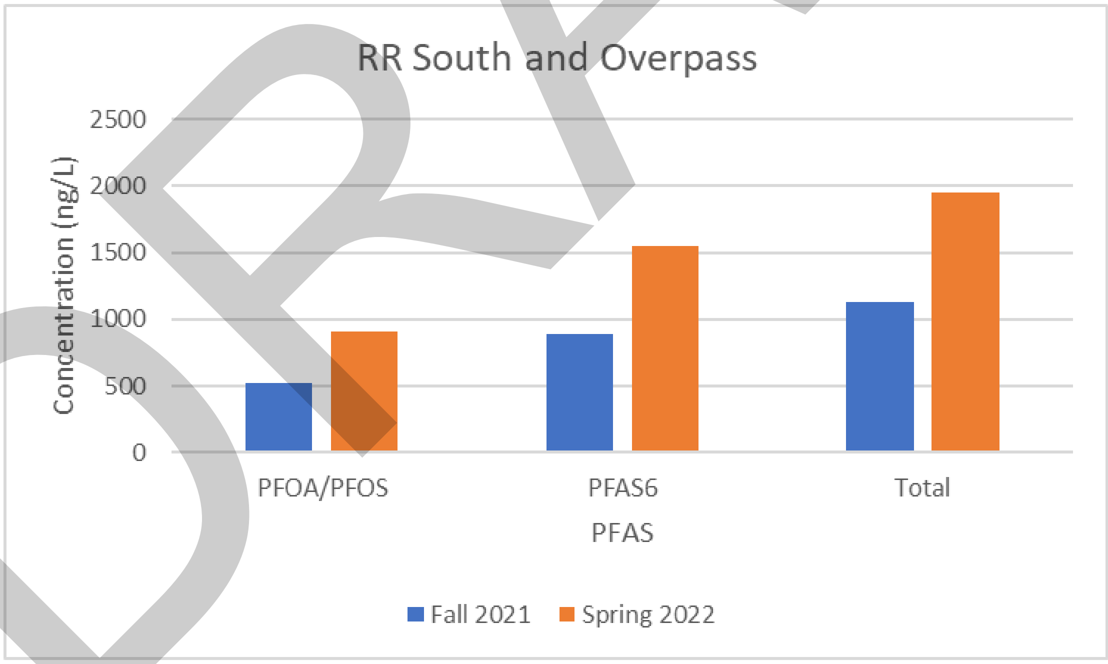


Figure 23: Bar graph depicting the sum of PFOA/PFOS, the PFAS6, and the total sum of all the PFAS analyzed at Railroad South and Overpass

Williams Hole overall showed high PFAS concentrations in Spring 2022 compared to Fall 2021, though not by much. The Railroad/Tank Farm 1 Outfall showed substantially higher concentrations in the Spring round, nearly doubling the total PFAS concentration in that area. The RR North location showed very similar concentrations within parts per trillion (ppt) of each other from the two rounds of sampling. The Railroad South/ Overpass location also showed considerable increase in PFAS concentrations in the Spring 2022 round of sampling with total PFAS concentration jumping from 1,156 to 1,951 ng/L.

The information collected as part of the OLRSMM-led September 2021 and May 2022 sampling events is critical in terms of understanding the nearby off-site impacts of PFAS. PFAS concentrations and chemistry is currently being analyzed to understand sources, impacts, and fate and transport of PFAS impacts off-site of the NETC Superfund site. The OLRSMM also found it imperative to address the communities concerns in a timely manner by conducting this sampling to gather necessary PFAS data. The OLRSMM is using the information gathered from these sampling events to coordinate with both the Army Corps and Navy on the suspected sources of these impacts from former foam infrastructure, including foam pump houses, above and below ground foam piping, and foam equipment storage buildings. It will also be used to guide future investigations and remediations, led by the respective DOD responsible party with regulatory oversight by the USEPA and the OLRSMM. The OLRSMM will conduct additional rounds of sampling in the future as necessary to add to the information already collected and gain a better understanding of the PFAS impacts in the area downgradient and off-site of Tank Farm 1.

6.4 Naval Construction Battalion Center (NCBC) Davisville

6.4.1 Site History

The former U.S. Naval Construction Battalion Center (NCBC) Davisville is located in North Kingstown, Rhode Island. A significant portion of the NCBC Davisville facility is located adjacent to Narragansett Bay. In 1939, Quonset Point was acquired by the Navy to establish a Naval Air Station (NAS). By 1951, operations at NAS Quonset Point had expanded and became the NCBC Headquarters. The NCBC loaded ships and trained men for both the Korean and Vietnam Wars. In the late 1960s, the base was home to around 8,500 military personnel. The base shipped over 450,000 tons of equipment over the course of the conflict. Through the 1970s and 1980s, activity gradually tapered off as the military's strategic focus shifted to the Pacific Ocean. Operations and waste disposal practices at the site resulted in widespread soil and groundwater contamination. Operations also contaminated surface water in nearby Allen Harbor.

Figure 24: Aerial image of the former NCBC Davisville located in North Kingstown, Rhode Island

NCBC Davisville was composed of three areas: the Main Center, the West Davisville storage area, and Camp Fogarty, a training facility located approximately 4 miles west of the Main Center. In December 1993, Camp Fogarty was transferred to the U.S. Department of the Army and subsequently assigned to the Rhode Island National Guard. Adjoining the southern boundary of the Main Center was the NAS Quonset Point, which was decommissioned and transferred to the Rhode Island Port Authority (currently named the Rhode Island Economic Development Corporation) and others between 1975 and 1980.

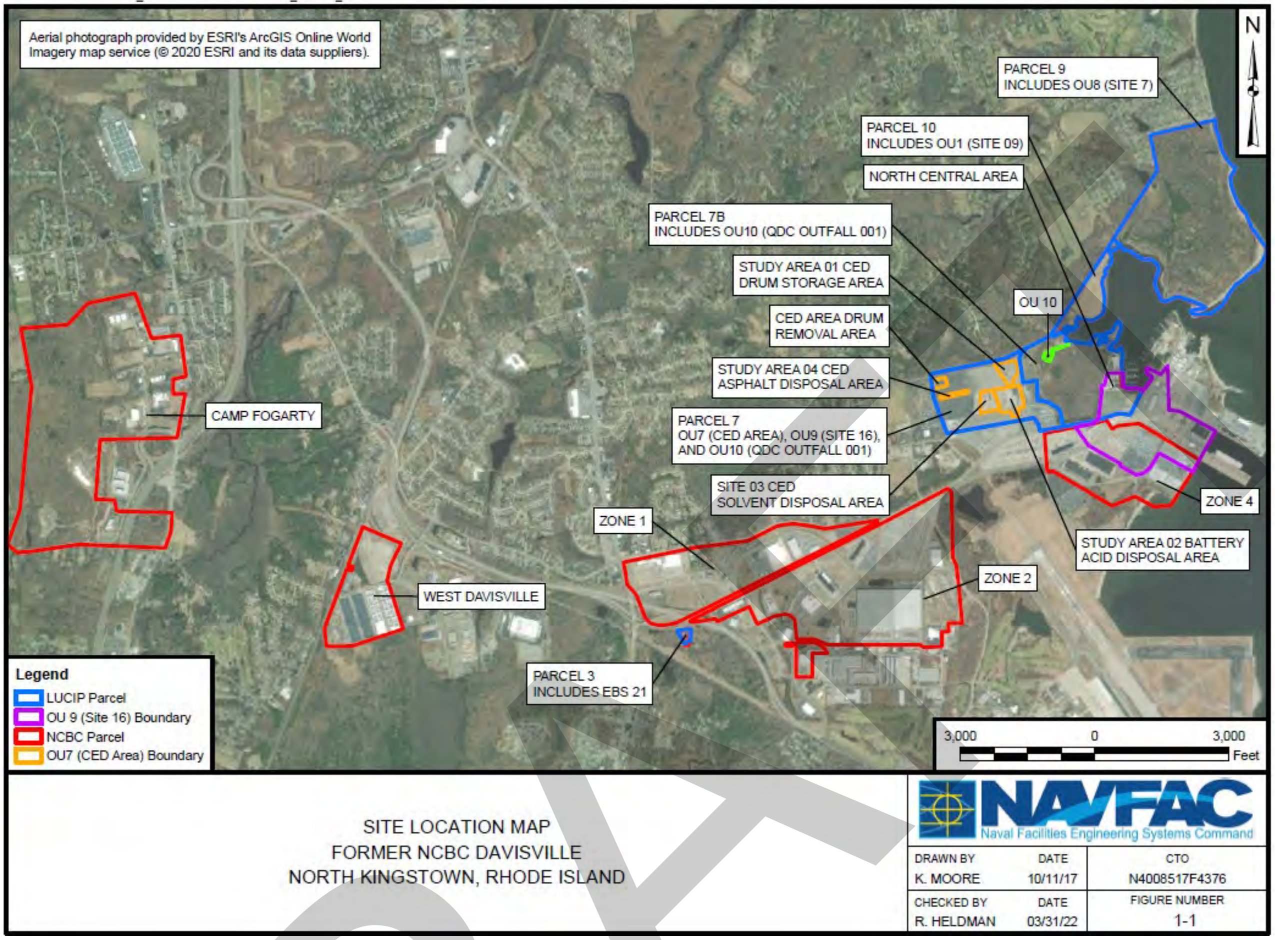


Figure 25: Site location map of Former NCBC Davisville (Resolution Consultants, 2016)

In November 1989, NCBC Davisville was added to the National Priorities List (NPL) for evaluation under the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) program, commonly known as Superfund. Of the 24 suspected areas of contamination initially identified, 16 warranted investigations under CERCLA. In 1991, the Department of Defense announced that NCBC Davisville was closing under the Base Realignment and Closure Act (BRAC). NCBC Davisville was officially closed on April 1, 1994.

Heavy metals identified onsite included lead, cadmium, silver, mercury, and chromium, which were found in the sediments and on the shoreline of Allen Harbor. Other contaminants in Allen Harbor include chlorinated volatile organic compounds, polycyclic aromatic hydrocarbons, solvents, and PCBs. Soil contamination includes organic solvents, PCBs, sewage sludge, contaminated fuel oil, and halogens. Groundwater is shallow, 2 to 4 feet in some areas, and the soil is permeable, conditions that facilitate the movement of contaminants into the groundwater and toward Narragansett Bay. A number of salt marshes that could be affected by contamination from the site have been identified in the Allen Harbor, Calf Pasture Point, and Narragansett Bay areas.

6.4.2 Operable Units (OUs)

There are nine OUs at NCBC Davisville, which are areas where a specific remedial action is required. The following table lists all the OUs, as well as the associated decision document issued by the USEPA and the cleanup technologies selected (USEPA).

Table 12: List of all the OUs, as well as the associated decision document issued by the USEPA and the cleanup technologies selected

OU ID	Site Name	Decision Document	Cleanup Technologies Selected
01	Allen Harbor Landfill	Record of Decision (September 29, 1997)	Cap (engineered cap) Cap (exsitu) Institutional Controls Monitoring Wetlands Replacement
01	Allen Harbor Landfill	Explanation of Significant Differences (July 21, 1999)	Disposal (offsite) Excavation
02	Sites 12, 14	Record of Decision (September 23, 1993)	Demolition Disposal (offsite) Excavation Incineration (offsite)
02	Sites 12, 14	Explanation of Significant Differences (September 30, 1998)	Excavation
03	Sites 5 & 8 Soils	Record of Decision (September 18, 1995)	No Action
04	Sites 6, 11 & 13	Record of Decision (September 30, 1998)	No Action No Further Action
05	Sites 10 And 8 Groundwater	Record of Decision (June 30, 1998)	No Further Action
06	Site 14 - Building 38	No decision document	
07	CED Solvent Disposal Area	Record of Decision (March 25, 2021)	Institutional Controls
08	Calf Pasture Point - Site 7	Record of Decision (September 30, 1999)	Institutional Controls Monitoring

OU ID	Site Name	Decision Document	Cleanup Technologies Selected
08	Calf Pasture Point - Site 7	Explanation of Significant Differences (January 5, 2000)	ESD - Nonfundamental Change (other)
09	Site 16 - Creosote & Firefighting Training Area	Record of Decision (June 11, 2014)	Chemical Oxidation (insitu) Cover (soil) Disposal (offsite) Excavation Institutional Controls Monitored Natural Attenuation Monitoring (soil) Treatment (other, not otherwise specified, offsite)
09	Site 16 - Creosote & Firefighting Training Area	Explanation of Significant Differences (September 28, 2021)	ESD/Amd - ARAR(s) Change ESD/Amd - Cleanup/Performance Standard Change ESD/Amd - ICs - Implement or Change ESD/Amd - RAO(s) Change Institutional Controls
10	QDC Outfall 001	No decision document	

6.4.3 Potential Sources of PFAS

Perfluorinated compounds may be attributed to firefighting activities where AFFF was potentially used onsite. Electroplating is another industrial activity where perfluorinated compounds were used and have been detected in environmental media. The addition of polyfluorinated surfactants (PFOS and derivatives) to chromic acid baths lowers the surface tension by forming a thin foamy layer on the surface of the chrome bath. In 1994, USEPA issued regulations to limit air emissions of chromium from electroplating and anodizing tank operations (USEPA, 2004), which required that hard plating operations have a fume hood and scrubbers to capture chrome off gassing from the plating bath surface (USEPA, 2004).

The Navy submitted a Final Technical Memorandum: Evaluation of Potential Sources of Perfluorinated Compounds dated December 6, 2016, which was requested by the USEPA. The objective of the memorandum was to identify potential uses of PFOS and PFOA at NCBC and to assess if any areas represent potential releases to the environment and should be considered for further assessment. The report identified the potential sources of perfluorinated compounds as firefighting, fire suppression systems, electroplating, landfills, and disposal areas.

Firefighting activities were identified at Site 11 and Site 16. Site 11 consists of an open, grassy area measuring approximately 200 feet by 300 feet at the intersection of Moscrip Avenue and Middletown Street. Firefighting training activities were conducted at Site 11 between the mid-1940s and 1955 (TRC, 1994c). Firefighting training exercises consisted of igniting waste oils and extinguishing fire. These activities ceased in 1955 prior to the introduction of AFFF for firefighting. Therefore, the Navy concluded that it is very unlikely that AFFF was used at Site 11; and therefore, it is unlikely PFOA/PFOS were released to the environment at Site 11.

Site 16 is pictured in Figure 26 below. bounded on the west by Thompson Road and to the south by railroad tracks; the site also extends north to Allen Harbor and east to Narragansett Bay. A firefighting training area (FTA) was reportedly located in an asphalt-paved area located within the north-central area of Site 16. At the Site 16 FTA, structures were reportedly constructed, doused with flammable materials, set on fire, and extinguished as part of the Firefighting training exercises during the late 1960s. Although these firefighting training activities took place after the Navy developed AFFF in the mid-1960s, the likelihood of AFFF being used at the Site 16 is low since the exercises involved extinguishing structures set on fire and not extinguishing Class B (i.e., highly flammable or combustible liquid) fires.

In addition, groundwater sampling for PFOA and PFOS was conducted at four groundwater monitoring wells at Site 16 in November 2011 (see Section 3.0). Groundwater sampling was conducted in November 2011, where two shallow wells and two intermediate wells were sampled within the immediate vicinity of the Firefighting training area. PFOS was detected in the shallow well at 0.8 ng/L, and PFOA was detected in three wells at 0.13, 0.51 and 0.21 ng/L.

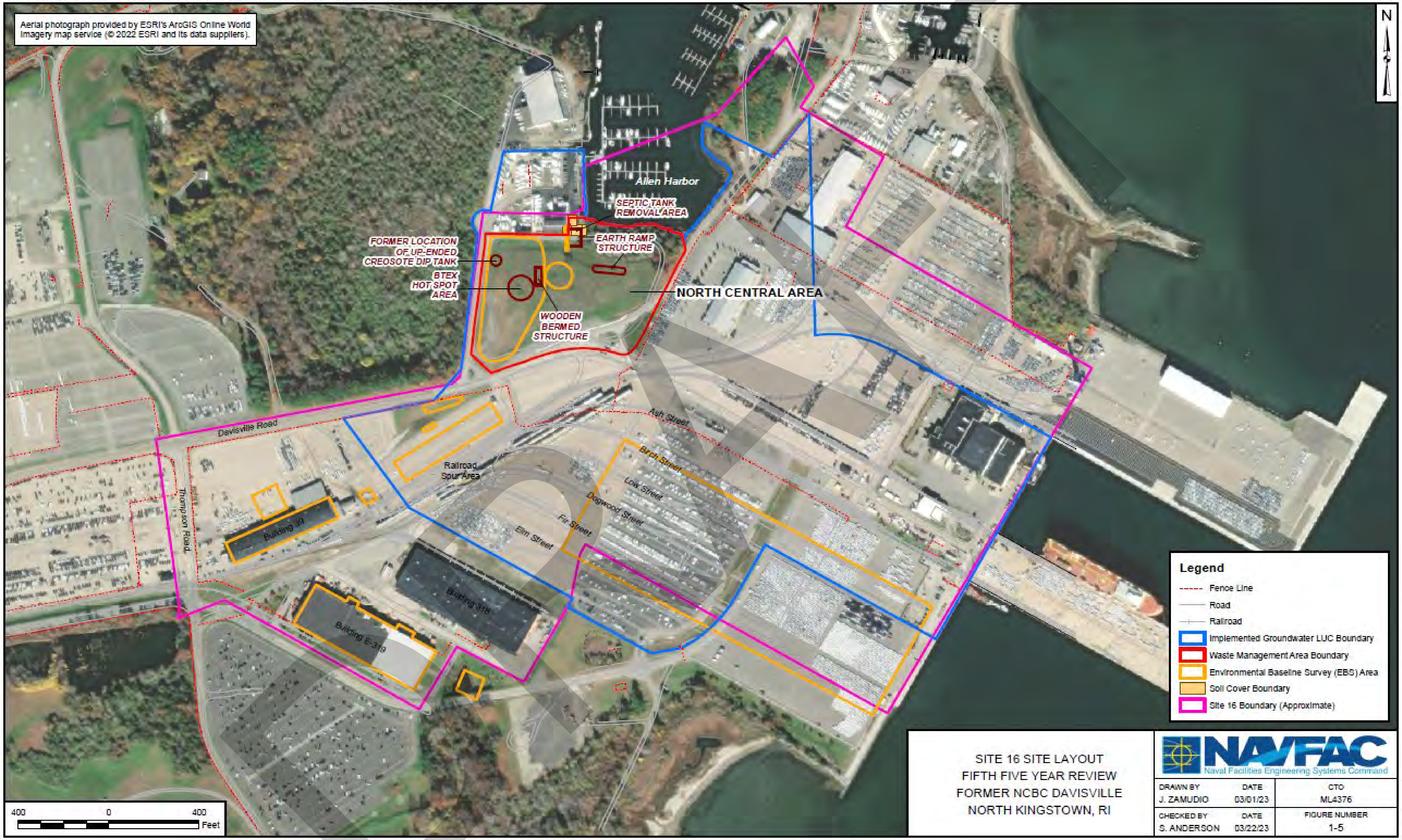


Figure 26: Site 16 layout for former NCBC Davisville (Tetra Tech 2023)

Firefighting foams are used for fire suppression systems. Examples of fire suppression systems include in hangers, refineries, bulk oil storage terminals, and dry docks. No evidence of AFFF fire suppression systems was identified during this review. Therefore, the Navy concluded that there is very limited potential for PFOA/PFOS releases to the environment associated with fire suppression systems.

Evidence of electroplating activities was not identified during this review. Therefore, the Navy concluded that there is very limited potential for PFOA/PFOS releases to the environment associated with electroplating. Former NCBC Davisville contains one on-site landfill, the Site 09 Allen Harbor Landfill (OU 1) seen in Figure 27 below. This landfill covers approximately 13.5 acres on the western side of Allen Harbor and was used between 1946 and 1972. Reportedly, municipal, and industrial waste disposed of at the site included construction debris, rubble, preservatives, acetone, turpentine, paint thinners, degreasers, PCBs, asbestos, ash, sewage sludge, and waste fuel oil. Much of the waste was burned and covered (TRC, 1994a). In addition, the NCBC Davisville Initial Assessment Study (IAS) indicates that Site 09 also received some chromic acid waste from plating operations at former Naval Air Station (NAS) Quonset Point and plating waste from former Naval Air Rework Facility (NARF) Quonset Point. Limited information exists regarding landfill operation procedures and the types and amounts of waste received. Since the landfill operated until 1972 and there is limited information regarding the types of waste received, especially that from former NAS Quonset Point and NARF Quonset Point, the possibility exists that waste containing perfluorinated compounds was disposed of in Allen Harbor Landfill.

Following the publication of the Final Technical Memorandum, groundwater sampling was conducted April 2018 at 10 monitoring wells and three seeps for laboratory analysis of 14 PFAS, where PFOS was detected in six monitoring wells from 0.79 ng/L to 15 ng/L and PFOA was detected in all 10 monitoring wells from 2.3 ng/L to 970 ng/L. No additional PFAS were detected in monitoring well samples at concentrations exceeding PALs, and no other monitoring well locations had combined PFOA/PFOS exceeding the USEPA HA. Additionally, no PFAS were detected in seep samples at concentrations exceeding PALs.

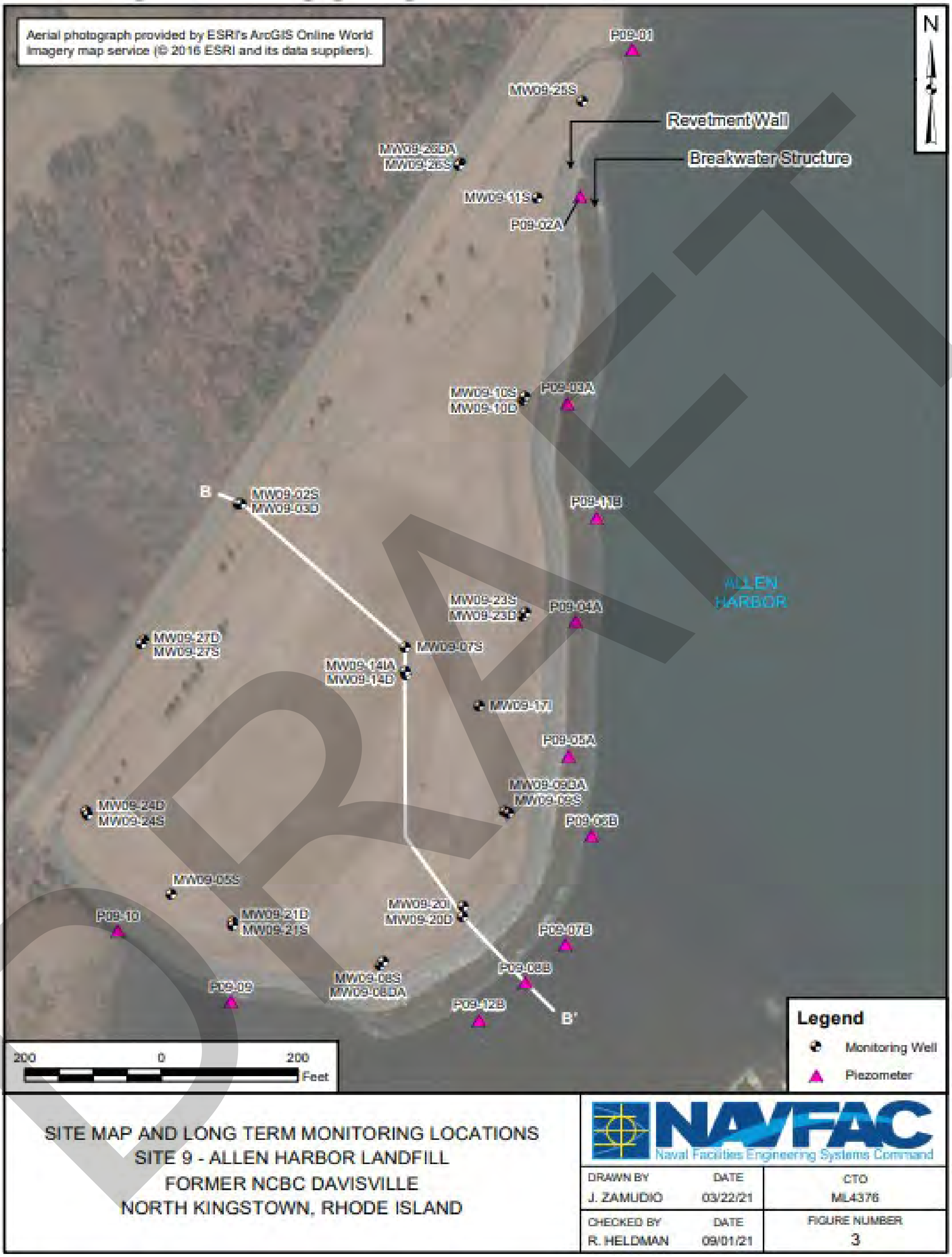


Figure 27: Site 09 Allen Harbor Landfill (OU 1) (Tetra Tech, 2023)

Multiple locations were used as disposal areas at former NCBC Davisville. OU 7 contains Building 224 (Site 02) that was used as a Construction Equipment Department (CED) Battery Shop from approximately 1955 to 1980. Approximately 60 gallons of battery acid (primarily dilute sulfuric acid and small amounts of lead) per month (totaling approximately 18,000 gallons of acid and 0.75 pounds of lead) were poured down the drain at the southwest corner of Building 224, which discharged into a dry well and a suspected leaching field. Paint thinners and unidentified solvents were reportedly being disposed of at a location west of Sayers Street and Building 224 (Site 03) between 1955 and the late 1970s. It is estimated that approximately 3,000 gallons of solvents were disposed of at a rate of about 10 gallons per month. Part of the site was also used to store heavy equipment.

Site 06 is a quarter of an acre area between Building No. 67 and Warehouse No. 38 associated with OU 4 that was used for the disposal of waste chlorinated hydrocarbon solvents between 1970 and 1972. Approximately a dozen 5-gallon cans of liquid waste were drained in this area about once every three weeks (totaling approximately 1,750 gallons).

Calf Pasture Point (Site 07), associated with OU 8, contained three former magazine bunkers that were used to store munitions. Reportedly, there were three disposal activities in this area. The first incident was between 1960 and 1974 when around twenty 5-gallon cans of calcium hypochlorite were disposed of in a ditch alongside a bunker. Navy personnel removed and disposed of multiple cans containing this material between 1978 and 1982. The second incident was in 1973 when thirty to forty 35-gallon cardboard drums of a chloride compound (possibly ferric chloride) were stored and buried at the site. The third incident was between 1968 and 1974 when an estimated 2,500 3-gallon cans of Decontaminating Agent Non-Corrosive (DNAC) solution were buried in the area.

The Site 10 Camp Fogarty Disposal Area associated with OU 5 is approximately six to seven acres in size. Approximately 50,000 cubic feet of waste (rifle and weapon cleaning oils and preservatives and municipal-type garbage) was disposed of just west of the rifle ranges at Camp Fogarty. Reported waste included rusty, empty paint cans, 55-gallon drums, and miscellaneous metal parts. The Navy reportedly removed and relocated thousands of cans of rifle bore oil. Construction debris was also present at three depressions at this site.

Buildings W-3, W-4, and T-1 at Site 13 associated with OU 4 were used for vehicle overhaul and repair activities. Vehicles were in fields (on the ground surface) to the north and west and drums of oils, thinners, and solvents were stored adjacent to the buildings. Reportedly, approximately 300 gallons of waste oils per month spread on the field northwest of the buildings.

The Navy’s conclusion for the disposal areas was that none of the wastes released in the disposal areas listed above were from sources that have the potential to contain perfluorinated compounds. Therefore, there is very limited potential for PFOA or PFOS releases to the environment at these disposal areas.

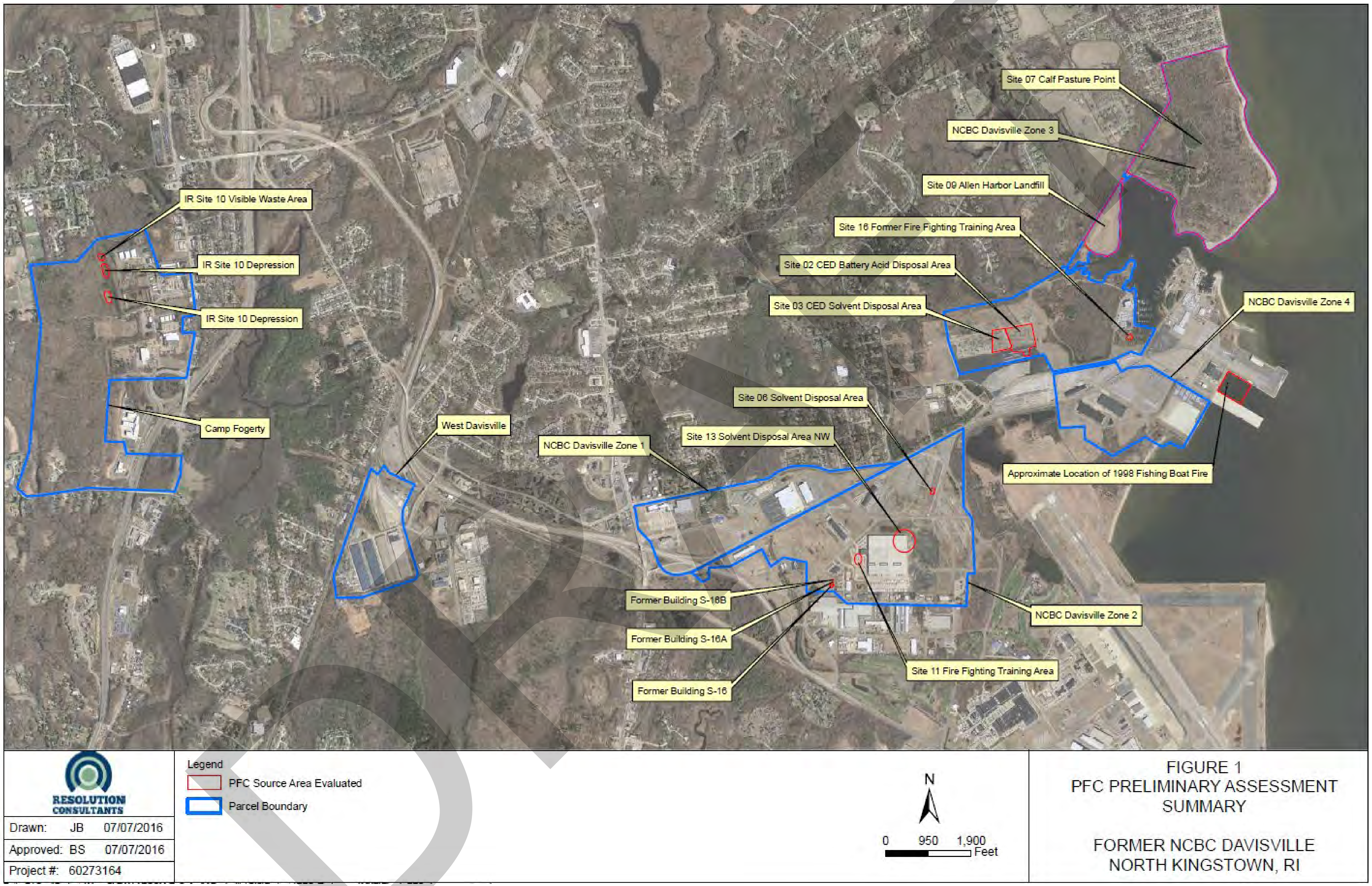


Figure 28: PFC Preliminary Assessment Summary (Resolution Consultants, 2016)

6.4.4 Potential Future PFAS Investigation

On July 14, 2022, the USEPA sent a letter to the Navy summarizing their positions on PFAS and requesting its incorporation into NCBC's Fifth Five Year Review Document. USEPA also requested a review of No Further Action sites and PFAS sampling at current Long-Term Monitoring (LTM). No Further Action with respect to PFAS sampling at Site 11 (OU 4) was concurred by RIDEM on November 28, 2016, and USEPA on July 20, 2016, after completion of the Draft Final Evaluation of Potential Sources of Perfluorinated Compounds with the Final document submitted on December 6, 2016. However, this determination could be revised in the future if there are revisions of federal or state PFAS standards.

The USEPA and RIDEM requested the analysis of shellfish at Site 9 for PFAS to evaluate potential migration from the landfill to Allen Harbor. Although the Navy generally concurs with the request, PFAS sampling has not occurred due to the lack of an approved DOD PFAS sampling method for tissue samples and uncertainty in use of the resultant data. Consistent with CERCLA and in accordance with DOD policy Investigating Per- and Polyfluoroalkyl Substances within the Department of Defense Cleanup Program dated July 6, 2022, the Navy will perform this work in conjunction with the 2023 LTM sampling event. During the July 21, 2022, Base Realignment and Closure (BRAC) cleanup Team (BCT) Teleconference, and the Navy, USEPA, and RIDEM agreed to this timeline to allow time for preparation of a Sampling and Analysis Plan. Ongoing discussions are conducted during monthly BCT calls in preparation of this work to address any short-term exposure and risk from PFAS at Site 9. The Navy, USEPA and RIDEM will continue to collaborate to determine the best course of action for future sampling efforts.

6.5 Quonset Army National Guard

The US Navy is not the only Department of Defense agency cleaning up PFAS contamination in the State of Rhode Island with regulatory oversight from RIDEM. Quonset Point, located in North Kingstown, has a rich history of military operations dating back to 1939 with multiple DOD entities operating on the land. Following the Navy's closure of NAS Quonset Point in 1973, ownership of the land was transferred to the State of Rhode Island and then simultaneously a portion of the land was leased to the U.S. Air Force for the Rhode Island Air National Guard (RIANG). The U.S. Air Force then licensed a portion of their leased land to the Rhode Island Army National Guard (RIARNG) in 1981 for a period of 50 years. Due to historical military operations from the RIARNG at Quonset Point, RIARNG is currently in the process of investigating potential PFAS impacts on the facilities used.

The Army National Guard (ARNG) G9 is performing Preliminary Assessments (PAs) and Site Inspections (SIs) at ARNG facilities nationwide based on the current or potential historical use of per- and polyfluoroalkyl substances (PFAS), which includes the Quonset Point Army Aviation Support Facility (AASF) located in North Kingstown, Rhode Island. The Quonset Point AASF is an active Rhode Island ARNG (RIARNG) support facility that encompasses approximately 27.9 acres of land in Quonset, RI. The Quonset Point AASF consists of an office/training building, two hangars, various support buildings, and a helicopter landing apron. This property falls under the jurisdiction of the U.S. Army.

The PA for Quonset Point AASF identified two potential PFAS release areas via record searches and interviews with personnel on-site (EA, 2023). The first potential PFAS release area that was identified was the fire suppression system for the North and South aircraft hangars (AOI 1). The existing AFFF fire suppression system at Quonset Point AASF is stored in a maintenance room located in the South Hangar and services both the North and South hangars. It is equipped with a 700-gallon tank of Chemguard 3 percent (%) AFFF C-301MS. Interviews with RIARNG personnel and contractors as part of the PA testing of the fire suppression system has occurred on a semi-annual basis since construction completion in 2010. The initial testing was accomplished by connecting a by-pass line to the end of the header line and releasing the test foam directly onto the concrete in the courtyard area between the two hangars. Interviews conducted during the PA state that dish soap was used in lieu of AFFF during this initial test, though there is no documentation to confirm such. Semi-annual testing of the fire suppression system consists of opening the header to collect the AFFF in a 55-gallon drum, and then vacuuming the AFFF from the drum into a tank for off-site disposal. RIARNG state the only potential for AFFF release intro the environment as a result of the testing would be from accidental drips the vacuum hoses and header lines following completion of the tests and no other releases have been documented within the past 20 years.

The second potential PFAS release area identified in the PA for Quonset Point AASF was a former industrial plating building located on the Facility (AOI 2). Industrial usage at the building from private owners began in 1973 and lasted until the property was acquired by RIARNG in 2008. Prior to 1973 the property was used for aviation equipment assembly and maintenance by the US Navy until it was transferred to the State of Rhode Island and subsequently leased to private owners in 1973. The former plating building has been historically listed as Noble Industries and Annex Industries. While no information has been found to suggest PFAS was used as a surfactant at the former plating facility, it has been confirmed that the facility was generators of wastewater and sludges from electroplating activities. The building was demolished in 2009 according to an aerial photograph review, and only the concrete pad still exits. Due to the potential for PFAS to have been used during historical electroplating activities, the facility was proposed for sampling in the form of a CERCLA SI with regulatory oversight from RIDEM OLRSMM. A figure depicting the location of the two PFAS areas of interest identified by the Quonset Point AASF PA, as well as surrounding property features can be seen below.

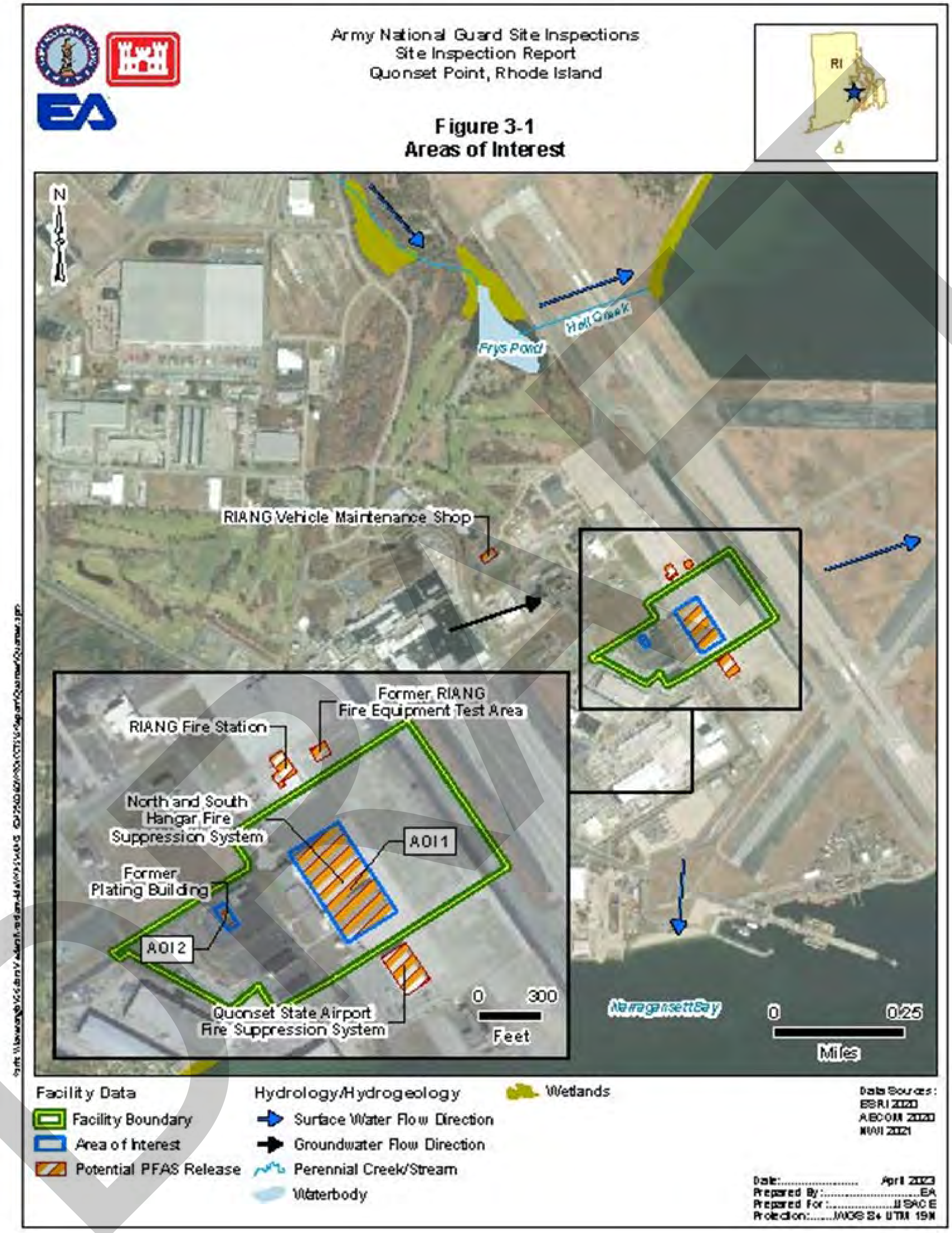


Figure 29: Location of the two PFAS areas of interest identified by the Quonset Point AASF PA (EA, 2023)

The objective of the SI for Quonset Point AASF was to identify whether there has been a release of PFAS into the environment at the two AOIs identified in the PA. This was accomplished in the SI via the collection and analysis of soil and groundwater PFAS samples at and in the vicinity of each AOI. SI field activities occurred from July 27 to July 30 of 2021 (EA, 2023). A total of 33 surface and subsurface soil samples, 13 groundwater samples and 13 quality assurance/ quality control (QA/QC) samples were collected as part of the SI fieldwork and analyzed for a subset of 24 compounds via Liquid Chromatography Tandem Mass Spectrometry (LC/MS/MS) compliant with QSM 5.3 Table B-15 to fulfill the project DQOs. Field activities consisted of hand auger coring and surface soil sample collection, DPT boring and soil sample collection, temporary monitoring well installation, grab groundwater sample collection, surveying, and site restoration. All fieldwork was conducted in accordance with the OLRSMM approved UFP-QAPP Addendum.

In July 2022, the DOD issued a memorandum describing the policy for retaining facilities in the CERCLA process based on risk-based screening levels for PFAS in soil and groundwater. The ARNG program under which this SI was performed follows this DOD policy. The memorandum states that AOIs should proceed to a Remedial Investigation (RI) under CERCLA should sampled media exceed the Office of the Secretary of Defense's (OSD) established screening levels. The table below displays the OSD established screening levels for both soil and groundwater, as presented in the July 2022 memorandum, that was utilized for this SI to compare data collected to and make CERCLA determinations at the site.

Table 13: OSD established PFAS screening levels for soil and groundwater from the July 2022 memorandum

Analyte	Residential 0 to 2 ft bgs (Soil) (µg/kg)	Industrial/Commercial Composite Worker 2 to 15 ft bgs (Soil) (µg/kg)	Tap Water (Groundwater) (ng/L)
PFOA	19	250	6
PFOS	13	160	4
PFBS	1,900	25,000	601
PFHxS	130	1,600	39
PFNA	19	250	6

It is important to note that HFPO-DA, commonly referred to as GenX, is also presented in the 2022 OSD memorandum as a PFAS chemical of concern but was not analyzed as part of this ARNG SI. The SI gives the following rationale for the exclusion of HFPO-DA analysis as part of this SI: "Based on the conceptual site model (CSM) developed during the PA and revised based on SI findings, the presence of HFPO-DA is not anticipated at the facility because HFPO-DA is generally not a component of military specification (MILSPEC) aqueous film forming foam (AFFF) and based on its history including distribution limitations that restricted use of GenX, it is generally not a component of other products the military used. In addition, it is unlikely that GenX would be an individual chemical of concern in the absence of other PFAS." RIDEM, as part of the review of the SAP, has requested that HFPO-DA be analyzed as part of any future PFAS investigations at the site.

At AOI 1, the northern and southern hangars, soil was sampled at five boring locations. Due to the thick pavement and shallow water-table, surface soil samples could only be collected from two of the five soil borings. PFOS (1.1 J+ μg/kg) and PFOA (0.19 J μg/kg) were detected in one of the two surface soil samples collected at AOI 1 at concentrations below the screening levels. All other PFAS constituents were non-detect in the surface soil results.

A total of eight subsurface samples were collected at AOI 1, five shallow subsurface and three deep subsurface samples. All subsurface samples were collected at depths less than 15 ft bgs. PFOS was detected in three of the eight subsurface samples at a maximum concentration of 6.2 J+ μg/kg, PFOA was detected in five of the eight subsurface samples 0.45 J μg/kg, and PFHxS was detected in only one subsurface sample at a concentration of 0.92 μg/kg. PFBS and PFNA were not detected in any subsurface samples at AOI 1. All subsurface detections at AOI 1 were below the screening levels.

Groundwater samples from AOI 1 were collected at five temporary monitoring well locations associated with a potential PFAS release area. PFOS was detected at all five monitoring well locations above the screening level with the maximum concentration being observed at a concentration of 1,300 ng/L. PFOA was also detected at all five monitoring well locations above the screening level with a maximum concentration of 180 ng/L. PFHxS was detected in all five samples, but only exceeded the screening level in four of the five locations. The maximum concentration of PFHxS at AOI 1 was observed at 160 ng/L. PFBS and PFNA results were lall lower than the screening levels in groundwater at AOI 1.

At AOI 2, the former industrial plating building, soil was sampled at four boring locations. PFOS (11 μg/kg) and PFHXS (0.23 J μg/kg) were detected in one of the four surface soil locations at AOI 2. Both detections were below the screening level. All other PFAS constituents analyzed for came back non-detect in the surface soil samples collected at AOI 2.

A total of eight subsurface samples were collected from the four boring locations. Two subsurface were collected in each boring at different intervals. PFOS was detected in three of the eight subsurface samples at a maximum concentration of 10 μg/kg, less than the screening level of 160 μg/kg. PFOA was detected in two of the eight subsurface samples at a maximum concentration of 0.45 J μg/kg, also less than the screening level. PFHxS was detected at concentrations less than the screening level in two of the eight subsurface samples, with a maximum concentration of 0.53 J μg/kg. PFBS and PFNA were not detected in any of the subsurface samples collected at AOI 2.

Groundwater samples from AOI 2 were collected at four temporary monitoring well locations associated with a potential PFAS release area. PFOS was detected at all four monitoring well locations above the screening level with a maximum concentration observed at 4,000 ng/L. PFOA was detected and exceeded the screening level at all four monitoring well locations as well, with a maximum concentration of 220 ng/L. PFHxS was detected in all four monitoring well locations and exceeded the screening level in three out of the four locations. The highest PFHxS concentration observed was 770 ng/L. PFBS and PFNA were detected in all four monitoring wells but had concentrations all below the screening levels.

The RIARNG also made the decision as part of the PFAS SI for AASF Quonset Point to sample the facility boundary to assess impacts from potential PFAS source areas off-site. To the north of the facility boundary is the Rhode Island Air National Guard (RIANG) Fire Station and the Former RIANG Fire Equipment Test Area. To the south of the facility boundary is the Quonset State Airport Fire Suppression System. As these areas may be sources of PFAS into the environment, sampling along the boundary of the facility was conducted to assess potential impacts from these nearby sources. No exceedances to screening levels were observed in any of the boundary surface/ subsurface samples collected. Exceedances to screening levels in the groundwater were observed for the analytes PFOS, PFOA and PFHxS in all four groundwater boundary samples collected. PFBS and PFNA did not exceed their respective screening levels in any of the groundwater boundary samples collected. The figures below show the detections of PFAS chemicals in the groundwater collected as part of this RI.

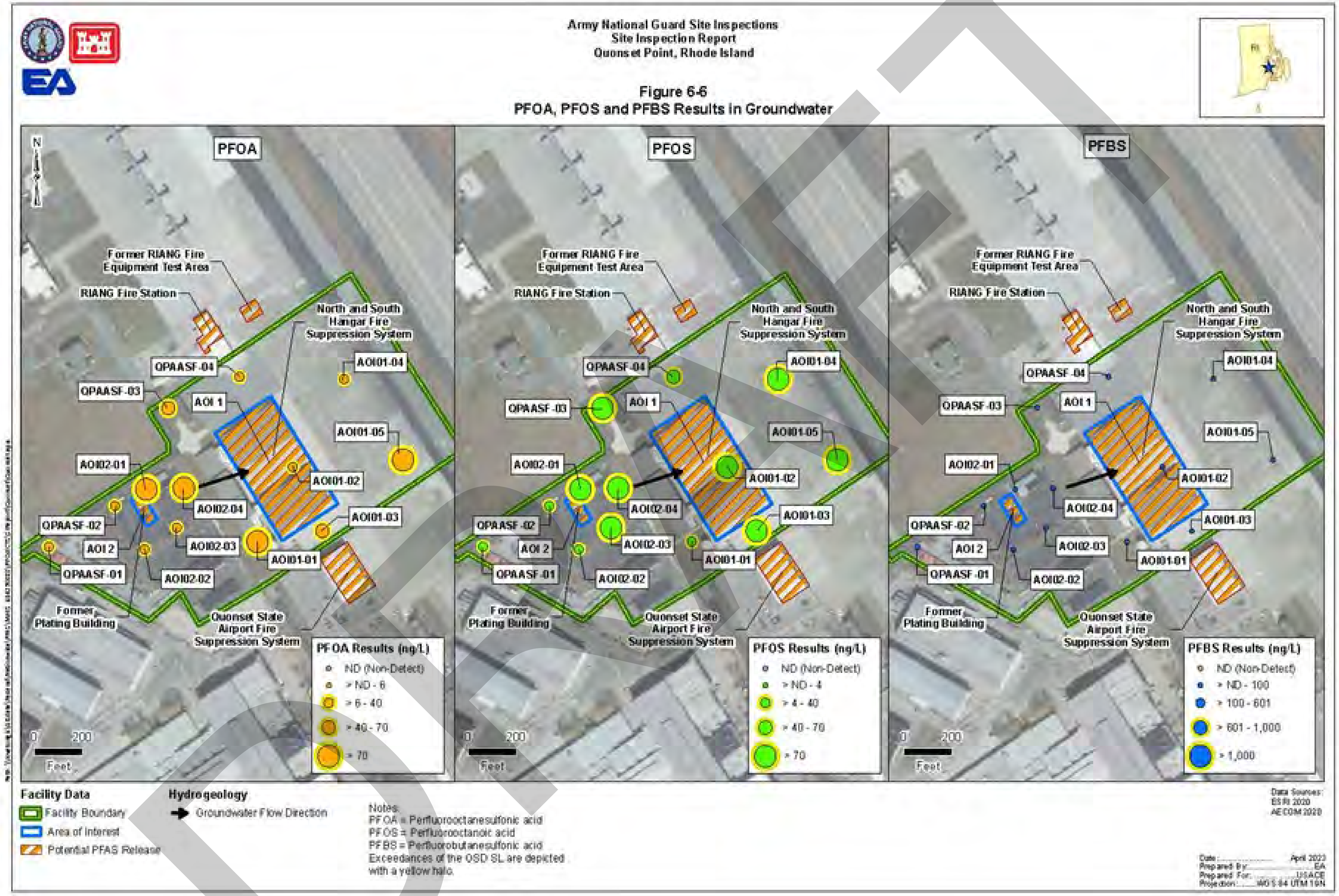


Figure 30: Detections of PFAS chemicals in the groundwater at Quonset Point (EA, 2023)

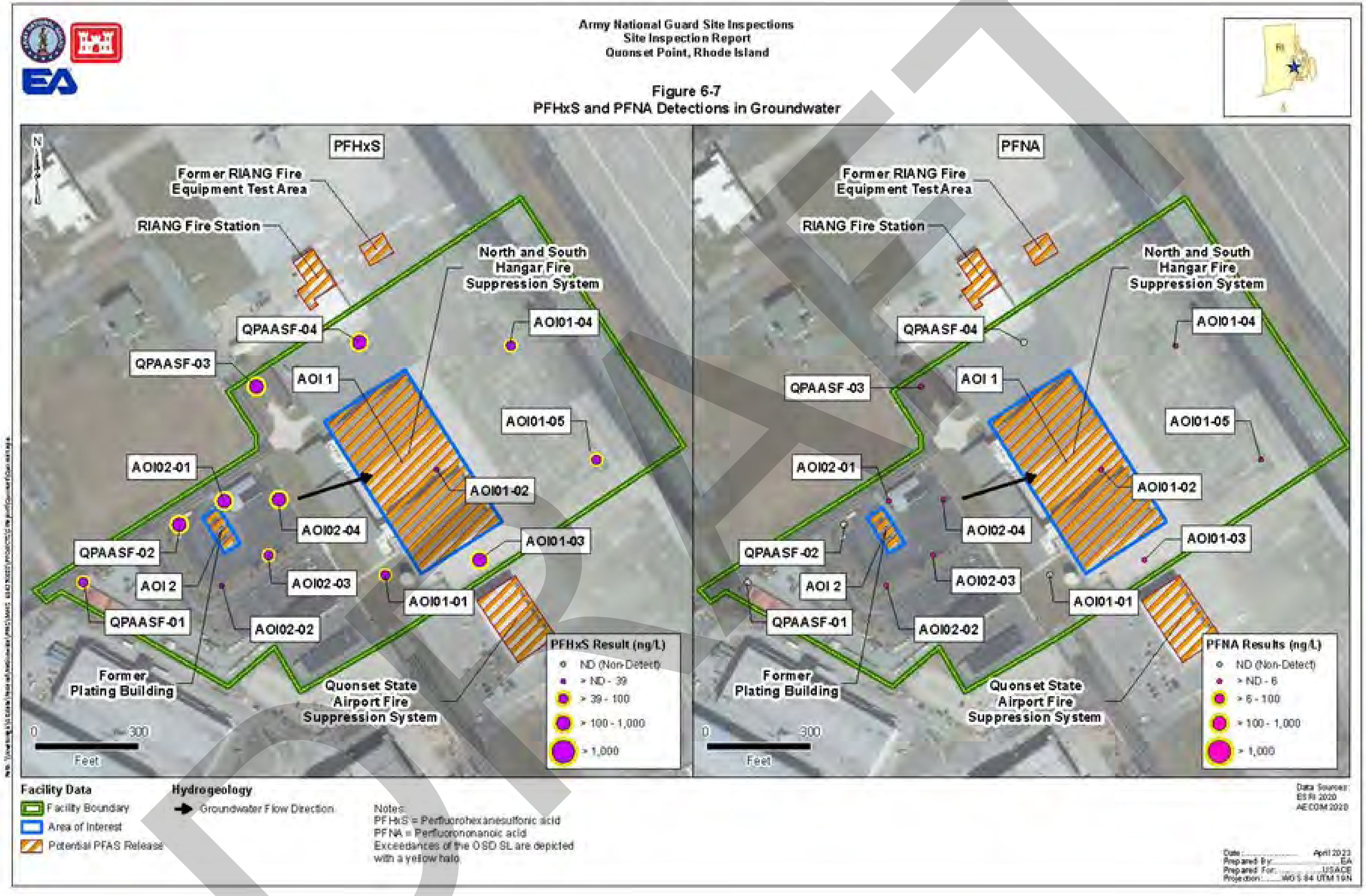

Army National Guard Site Inspections
Site Inspection Report
Quonset Point, Rhode Island

Figure 6-7
PFHxS and PFNA Detections in Groundwater

Notes:
PFHxS = Perfluorohexanesulfonic acid
PFNA = Perfluorononanoic acid
Exceedances of the OSD SL are depicted with a yellow halo

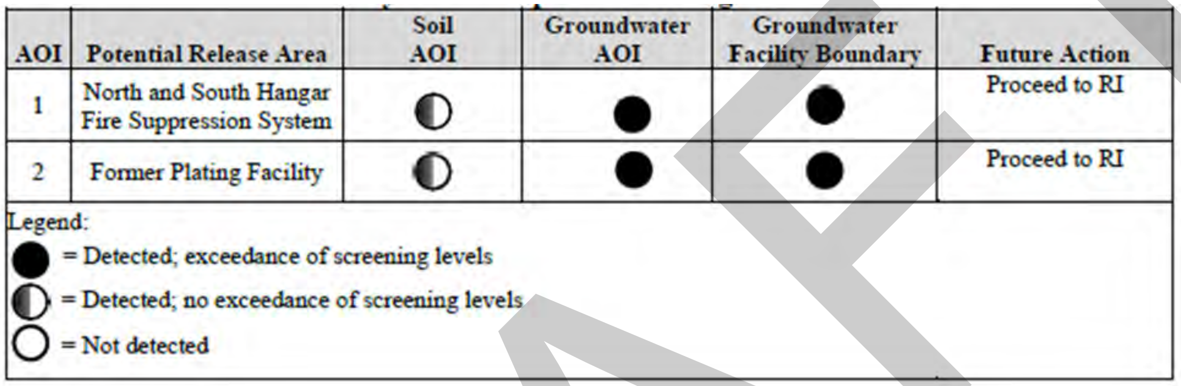
Data Sources:
ESRI 2020
AECOM 2020

Date: April 2023
Prepared By: EA
Prepared For: USACE
Projection: WGS 84 UTM 19N

Figure 31: PFHxS and PFNA detections in groundwater at Quonset Point (EA, 2023)

As set forth in the 2022 OSD PFAS memorandum, should any sample collected during the SI phase exceed the screening levels established by OSD, the AOI will proceed to the next phase under CERCLA, which is a Remedial Investigation (RI). As exceedances to screening levels in the groundwater were observed at both AOI's sampled during this SI, both AOI's are being proposed by RIARNG for further evaluation in the form of a RI. The table seen below summarizes the findings and recommendations based on this SI.

Table 14: Summary of Site Inspection findings and recommendations



AOI	Potential Release Area	Soil AOI	Groundwater AOI	Groundwater Facility Boundary	Future Action
1	North and South Hangar Fire Suppression System	◐	●	●	Proceed to RI
2	Former Plating Facility	◐	●	●	Proceed to RI

Legend:
● = Detected; exceedance of screening levels
◐ = Detected; no exceedance of screening levels
○ = Not detected

Currently, RIDEM is in the process of helping finalize the SI report to be able to move along in the CERCLA process. RIDEM supports the RIARNG's decision for further investigation at the site in the form of an RI. RIARNG does a nationwide ranking system for their contaminated systems in order to determine cleanup priorities, and due to the concentrations observed in the SI and the lack of potential human receptors at this site, this did not rank as a high priority site for RIARNG. The goal is for the RIARNG to have funding available to continue this investigation by Fiscal Year (FY) 2025. RIDEM will continue to provide regulatory oversight through the completion of the CERCLA process to ensure proper investigation and remediation of the site applicable to state and federal regulations. More information can be found on this investigation upon the conclusion and finalization of the RIARNG's PFAS SI for the site.

6.6 Charlestown Navy Auxiliary Landing Field (CNALF)

6.6.1 Site History

The Former Charlestown Naval Auxiliary Landing Field (CNALF) is a Formerly Used Defense Site (FUDS) located in Charlestown, Rhode Island. CNALF encompasses approximately 630 acres on Foster Cove and Ninigret Pond. The property was acquired between 1940 and 1942 by the United States Navy. It was used as a pilot and flight crew training facility during World War II and was later used as a support facility to Quonset Point Naval Base until the facility was closed in the early 1970s.

Figure 32: Aerial photograph of the former CNALF is a Formerly Used Defense Site (FUDS) located in Charlestown, Rhode Island

Figure 33: Aerial photograph of the site location of CNALF (Weston, 2023)

In 1982, the property was divided into northern and southern parcels that were transferred to two separate entities. The approximately 400-acre southern parcel was transferred to the U.S. Fish and Wildlife Service (USFWS) and is now Ninigret National Wildlife Refuge. This area contains over 3 miles of nature trails, opportunities for kayaking and areas to view wildlife. The approximately 230-acre northern parcel was transferred to the Town of Charlestown and is now Ninigret Park. The park contains a playground, ball fields, tennis and basketball courts, picnic areas, a freshwater swimming pond and more.

6.6.2 Areas of Concern (AOC) Descriptions

In 2017, the U.S. Army Corps of Engineers (USACE) reorganized the prior authorized U.S. DOD Environmental Restoration Program (DERP)-FUDS property Hazardous Toxic and Radioactive Waste (HTRW) Project 01 into two separate projects, Project 08 and Project 09. Figure 33 below shows the areas of concern for Project 9. The purpose of these new reorganized projects was to divide the work into individual projects to allow for more effective management and execution. Project 09 identified five areas of concern, including three landfills, which are the Charlestown Landfill, the Eastern Area Landfill, and the Ninigret Wildlife Refuge Landfill. These landfills were used for the disposal of a variety of items including military debris, aircraft, construction debris, trash, and potential munitions debris. Project 09 also includes the Burn Pit Area that was used for fire and rescue training exercises, and the Water Supply Well Area that includes the portion of the town parcel with water supply wells.

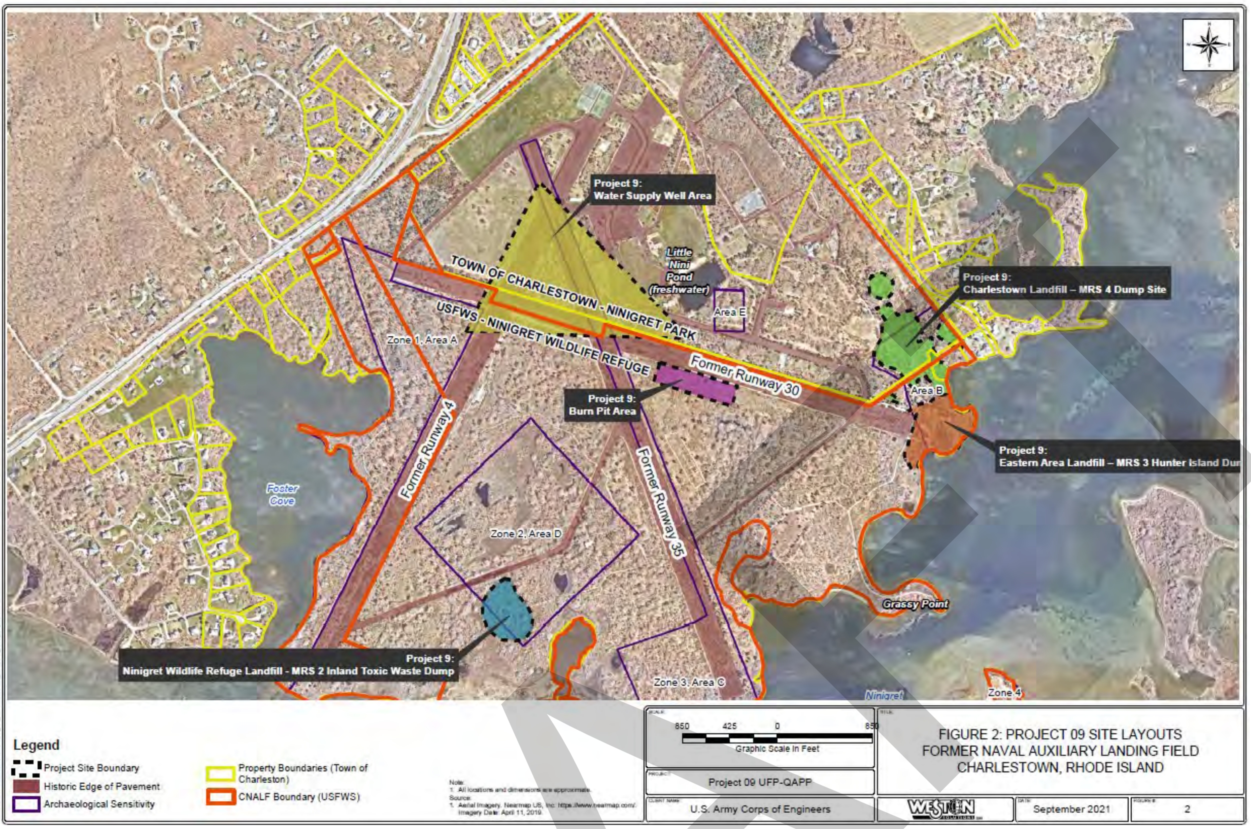


Figure 33: Project 09 Site Layout (Weston, 2023)

The Charlestown Landfill/Munitions Response Site (MRS) 4 Dump Site is located in both Ninigret Park and the Ninigret National Wildlife Refuge (pictured in Figure 34 below) on the eastern edge of CNALF. It is adjacent and east of the former sewage treatment system sand filters, and south of the sewage disposal area. The landfill is 13-acres with fill from 7 to 12 feet deep, likely extending under the water table. The overburden soil is fine to coarse sand and gravel, with glacial outwash deposits up to 30 feet thick. Groundwater flows to the southeast. Parts from nine separate aircrafts were uncovered from excavations in 1973 and 1977. The landfill contains military debris including airplane and vehicle parts, scrap metal, inert practice bombs, household debris, and crushed and intact or partially intact drums. It is also reported to contain munitions debris associated with the inert practice bombs. The northwest boundary of the landfill reportedly contains road debris, asphalt, and soil. The former sand filter area west of the landfill was used for disposal of crushed asphalt, subsoil gravel concrete, and light brush removed during construction of Ninigret Park.

The Eastern Area Landfill/MRS 3 Hunter Island Dump Site is located at the Ninigret National Wildlife Refuge at the end of runway 30 on the eastern end of CNALF. The landfill is 60-acres with fill from 3.5 to 6.5 feet deep, possibly extending under the water table over a wide area of the landfill. The landfill was formerly Hunter's Island that the Navy filled in to create a peninsula. The overburden soil is fine to coarse sand and gravel, with glacial outwash deposits over 22 feet thick. Groundwater flows to the southeast. The landfill contains aircraft parts, including airplanes used in fire training and construction debris including concrete, bricks, and metal parts. Parts from four airplanes that were once used as Firefighting hulks were partially uncovered and excavated in 1969. It is reported to contain munitions debris associated with inert practice bombs. Buried drums and containers were also reportedly observed.

The Ninigret Wildlife Refuge Landfill/MRS 2 Inland Toxic Waste Dump is located at the Ninigret National Wildlife Refuge that surrounds the former high explosive storage bunker. The landfill is 2-acres with fill from 2-4 feet deep, likely extending below the water table over a wide area of the landfill. The groundwater is shallow, and it is likely that the Navy filled in wetlands. The soil is silty sand fill overlying well-stratified fine to coarse sand, with gravel glacial outwash deposits over 30 feet thick. The landfill contains trash, small to medium caliber ammunition, airplane parts, at least one airplane hulk used for fire training, construction debris, scrap metal, appliances, tires, cans, bottles, and drums. It is also reported to contain munitions debris.

The Burn Pit Area is a 3-to-4-acre area at the Ninigret National Wildlife Refuge along the south side of runway 30. It was used for fire rescue training for the scenario of an aircraft crash from the 1950s to 1970s. Typical Firefighting practices included use of dry chemical fire extinguisher agents (Purple K), protein or light water foam, carbon dioxide, and water. The active fire training period at CNALF coincided with beginning of manufacturing of aqueous film-forming foam (AFFF), which contained PFOS and long chained PFAS. In the 1960s and 1970s, the burned-out fuselages from these operations were removed and reportedly deposited in the three landfills. Surface material encountered at 6 feet in the burn pit area includes a black, sandy silt mixture with burned metallic debris, ash, and degrading asphalt. Overburden soil in this area is composed of fill overlying well-stratified fine to coarse sand and gravel glacial outwash deposits. The overburden soil thickness is estimated to be over 30 feet thick. Groundwater was encountered at 8–10.5 feet below ground surface in the overburden at this location.

The Water Supply Area is an approximately 80-acre area that encompasses portions of the former overlapping runways, aircraft parking ramp areas and the former fire station where AFFF may have been used. It is located at the Ninigret Park property and includes Little Nini Pond, which is currently used for swimming and fishing. There are 7 active water supply wells that have various uses, including drinking water and potable use for Ninigret Park. Onsite wells include the RW-1 (Frosty Drew Nature Center), RW-2 (Charlestown Senior Center), RW-3 (Gate House), RW-4 (Beach Pavilion), RW-5 (Bike Pavilion), RW-6 (Seafood Festival Well), RW-7 (Navy Well), RW-8 (Charlestown Police Well), and RW-9 (Charlestown Rescue/EMS Well).

There are 15 offsite wells located east of the CNALF boundary on Arnolda Road, Colony Road, Hunter Harbor Road, and Dudley Lane. Wells on Hunters Harbor Road include RES-DW-4, RES-DW-6 (PT), RES-DW-7 (PT, UT), RES-DW-8 (UT), RES-DW-9 (PT, UT), RES-DW-9 (PT, Gate House), RES-DW-11 (PT, UT) and RES-DW-14 (PT,UT). The wells on Colony Road include RES-DW-3 (UT), RES-DW-5 (PT, UT), and RES-DW-13. The well on Arnolda Road is RES-DW-1 (PT, UT). The well on Dudley Lane is RES-DW-10 (UT). There are several additional wells on Hunters Harbor Road that are not active.

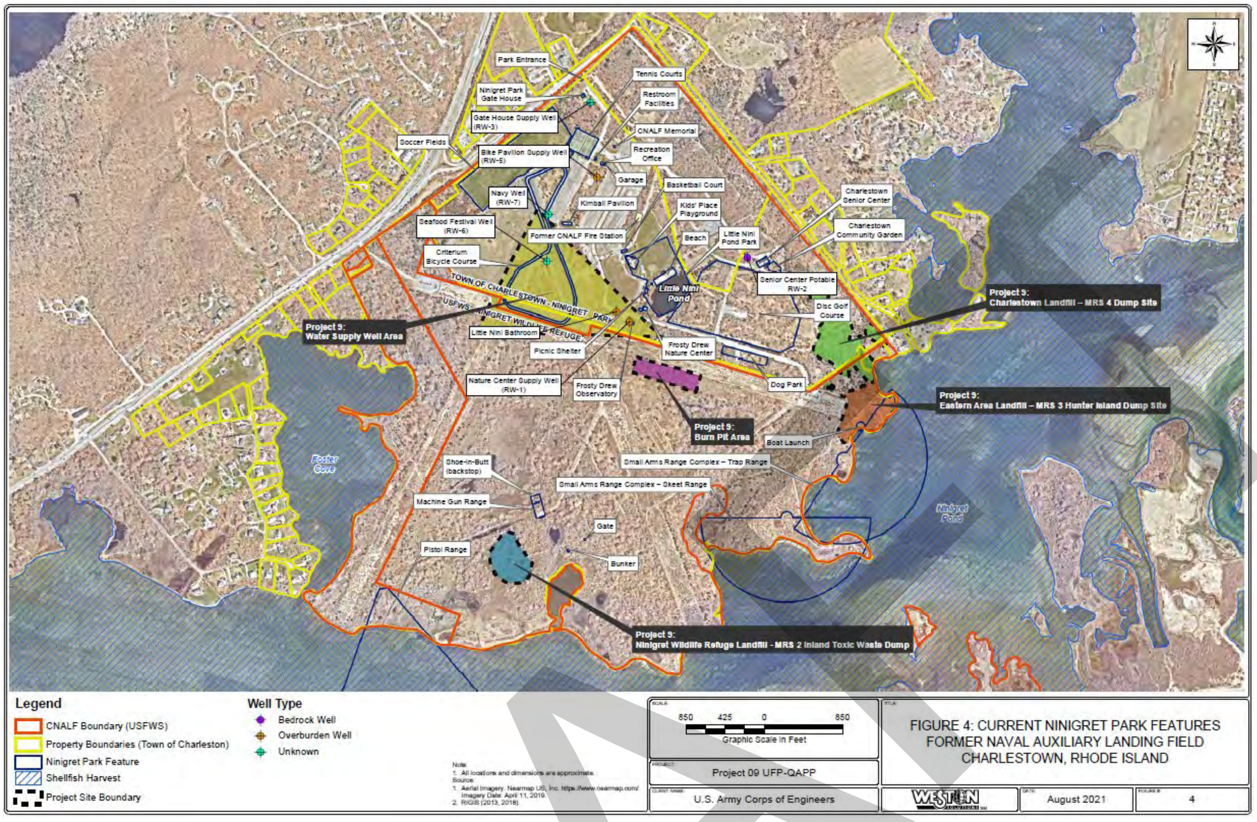


Figure 34: Map of current Ninigret Park features (Weston, 2023)

6.6.3 PFAS Sampling

Per-and Polyfluoroalkyl Substances (PFAS) have been identified at several locations throughout CNALF and are currently being investigated under Project 09. One objective of the remedial investigation (RI) for Project 09 is to determine whether onsite and offsite drinking water wells are impacted by site-related contaminants above US Environmental Protection Agency (USEPA) Regional Screening Levels (RSLs), Maximum Contaminant Levels (MCLs), or the Hazard Advisory Level (HAL) for PFAS. Based on historical information and limited analytical data, the source of PFAS at CNALF appears to be from AFFF that may have been used at the fire training station.

6.6.4 Surface and Subsurface Soil Sampling

Surface soil sampling of PFAS for the Project 09 sites includes collecting systematic random discrete surface soil investigative samples at each of the landfills, the Burn Pit Area, the Water Supply Well Area, and at background locations across the Ninigret Wildlife Refuge in areas away from the Project 09 sites that are not known or suspected of contaminant impacts other than widespread anthropogenic impacts or naturally occurring conditions. Subsurface systematic random discrete investigative PFAS samples will be collected only at the Burn Pit Area and the Water Supply Well Area.

6.6.5 Groundwater Sampling and Water Supply Well Sampling

Water samples are collected from groundwater monitoring wells at the three landfills, the Burn Pit Area, the Water Supply Well Area, seven on-site water supply wells at Ninigret Park, two existing off-site water supply wells adjacent to Ninigret Park at the Charlestown Police Department and Emergency Services buildings, and 15 off-site residential drinking water supply wells northeast of CNALF. In addition, groundwater samples may be collected from up to 12 existing on-site monitoring points in the vicinity of the Water Supply Well Area.

Tap water sampling of the onsite and off-site residential wells involves collection of untreated samples, and post-treatment samples at residences with treatment and/or filtration systems in place. The post-treatment samples will assess potential exposure to the residents and the effectiveness of the current treatment system for removing PFAS from the water. PFAS6 includes perfluorooctanoic acid (PFOA), perfluorooctane sulfonic acid (PFOS), perfluorohexane sulfonic acid (PFHxS), perfluorononanoic acid (PFNA), and perfluoroheptanoic acid (PFHpA), and perfluorodecanoic acid (PFDA).

As a result of the round 1 sampling event in spring 2021, four out of twenty-two (22) on-site wells exceeded the sum of PFAS6 standard of 20 ppt. Additionally, only one well was over half the standard at 10.3 ppt, seven wells were below 10 ppt, and ten wells were not sampled.

In the summer of 2021, round 2 of sampling took place, which determined that seven out of the twenty-two (22) wells exceeded the sum of PFAS6 of 20 ppt. Only three wells were above 10 ppt, with five wells under 10 ppt, and seven wells not sampled.

In the summer of 2022, round 3 of sampling was conducted, determining three wells exceeded the sum of 20 ppt, with six wells results testing over 10 ppt. Additionally, four wells were under 10 ppt, seven wells were not sampled, and two wells had no PFAS6 detected.

Round 4 of sampling on-site wells was completed in fall 2022, of which six wells exceeded the standard for PFAS6 of 20 ppt. Four wells were above 10 ppt and four wells were under 10 ppt. A total of three wells were not sampled in this round and five wells did not detect any PFAS6.

A total of seven on-site wells had an increase in the sum of PFAS6 detected going from round 1 in spring of 2021 to round 4 in fall of 2022.

Once again, it is important to note that the PFAS6 are made up of the following compounds: perfluorooctanoic acid (PFOA), perfluorooctane sulfonic acid (PFOS), perfluorohexane sulfonic acid (PFHxS), perfluorononanoic acid (PFNA), and perfluoroheptanoic acid (PFHpA), and perfluorodecanoic acid (PFDA).

Of the twenty-three (23) off-site wells in round 1 of Spring 2021, two wells exceeded the standard of 20 ppt and five wells were above 10 ppt. With this, four wells were below 10 ppt, ten wells did not detect any PFAS6, and two wells were not sampled.

Round 2 of sampling off-site wells took place in summer of 2021, which determined three wells were above the standard of 20 ppt and one well was detected a level above 10 ppt. A total of seven wells detected levels below 10 ppt. Seven wells did not detect any PFAS6, and two wells were not sampled.

In the summer of 2022, round 3 of sampling took place of off-site wells, determining five wells exceeded the standard of 20 ppt and four wells were above 10 ppt. Thirteen (13) wells detected levels below 10 ppt and one well was not sampled for.

It was determined that six off-site wells exceeded the standard of 20 ppt for round 4 in fall of 2022. Six wells detected levels above 10 ppt and seven wells were below 10 ppt. Two wells were not sampled, and two wells did not detect any PFAS6.

In total, ten off-site wells increased in the sum of PFAS6 each round of sampling from spring of 2021 to Fall of 2022.

Additionally, groundwater sampling onsite indicated high concentrations of PFOA to the southeast of the former fire station, with the highest result at 11,000 ppt. PFOA was also high at the southern end of the Burn Pit Area, with concentrations up to 2,910 ppt.

6.6.6 Sediment, Surface Water and Pore Water Sampling

Sediment sampling at the Project 09 sites includes linear systematic random discrete sampling in the pond east of Charlestown Landfill (East Pond), the pond south of Eastern Area Landfill (South Pond), the ponded water area downgradient of the Burn Pit Area, the wetlands surrounding Ninigret Wildlife Refuge Landfill, and portions of the shoreline of Ninigret Pond adjacent to and downgradient of the three landfills. In addition, offshore discrete sediment sampling will be conducted in Ninigret Pond adjacent to the Charlestown and Eastern Area landfill sites.

Discrete surface water and pore water samples will be collected from each site sediment. Surface water samples, except for PFAS, will be collected as discrete samples from the mid-point depth of the surface water column. For PFAS only, an interface sample will be collected by immersing an unpreserved sample bottle so that the opening of the bottle intercepts the air/water interface to collect water along the interface. Pore water samples will be collected from the upper 0.5 ft of the sediment using a push-point sampler or similar pore water extracting device.

6.6.7 Test Pit Sampling

Test pits will be advanced within the three landfills to define the vertical extent of fill and debris at each landfill and to determine their contents. Soil samples will be collected to assess potential contaminants present that may impact site groundwater, including PFAS. If a potential site-related contaminant source is identified, additional sampling would be needed to determine the extent of the source area and whether remedial action may be necessary.

The estimated number of test pits to be dug in each of the three project areas are as follows:

- Charlestown Landfill: 25 locations
- Eastern Area Landfill: 16 locations
- Ninigret Wildlife Refuge Landfill: 10 locations

RIDEM is working with USACE to ensure that significant data gaps are addressed in order to complete the RI and risk assessments regarding PFAS. According to the March 2023 Uniform Federal Policy Quality Assurance Project Plan, **i**f sample results for PFAS exceed the 70 ppt HA for combined PFOA plus PFOS concentrations, exceeding MCLs are detected and the contaminant is considered attributable to a DOD release at CNALF, an alternative drinking water source such as bottled water may be provided by USACE under a separate Work Plan. If a treatment system is determined to be necessary, design, installation and operation and maintenance monitoring of a system may be implemented under a separate Work Plan/UFP-QAPP. Adjustments will be made based on changing PFAS standards, including the 20 ppt Interim Drinking Water Standard for the PFAS6.

7 Landfills and Dumps

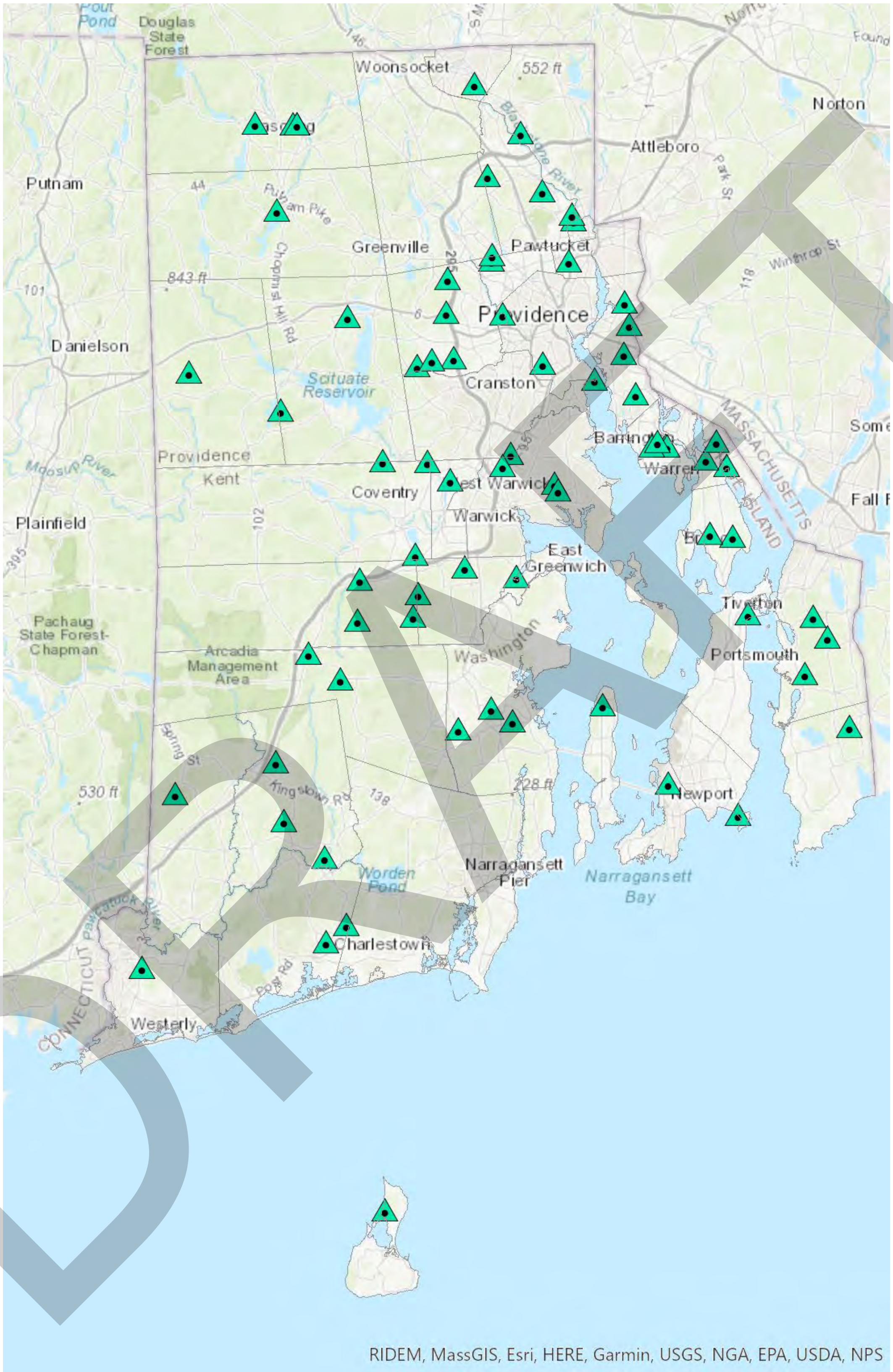
Due in large part to the prevalence of PFAS in consumer products, dumps, landfills, and other waste disposals areas, these sites are known to be significant sources of PFAS contamination. As waste containing PFAS breaks down over time and precipitation percolates through waste material deposited at these locations, PFAS are released to the environment through migration of leachate and/or groundwater.

The *Solid Waste Regulations No. 2 Solid Waste Landfills* (250-RICR-140-05-2) were amended on January 31, 2021, to require a minimum of two rounds of sampling groundwater for the full suite of PFAS in accordance with Section 2.18 (F)(1)(h) of the aforementioned regulations. This rule applied to all jurisdictional closed landfills in long-term monitoring with approved Environmental Monitoring Plans. Owners and operators were allotted 180 days from notification by the OLRSMM to initiate the required monitoring. If exceedances of the Department's GA and GAA Groundwater Quality Standard for PFAS (i.e., 70 ppt for the sum of PFOA and PFOS) were detected, owners or operators were required to revise the environmental monitoring plan to address the exceedances and any impacts.

There are over seventy formerly permitted landfills and unlicensed dumps in Rhode Island, not including Superfund sites or FUDS. Of these landfills, approximately half are subject to required PFAS sampling under the amended 250-RICR-140-05-2. The OLRSMM has received PFAS sampling results for just over thirty landfills subject to the new rule.

- Of those, all but one landfill (New Shoreham Town Landfill) exceeded the Interim Drinking Water Standard for the PFAS6 in one or more groundwater monitoring wells.
- Approximately 4 in 5 (80%) landfills sampled exceeded the GA Groundwater Quality Standard of 70 ppt for PFOA/PFOS in at least one monitoring well.
- Approximately 1 in 5 (20%) landfills sampled exceeded the GA Groundwater Quality Standard of 70 ppt for PFOA/PFOS by a factor of 10 in at least one monitoring well (i.e., greater than 700 ppt).

The results of landfill sampling for PFAS were not unexpected. Prior sampling of landfills at Superfund and other sites in Rhode Island for PFAS had yielded similar results.



RIDEM, MassGIS, Esri, HERE, Garmin, USGS, NGA, EPA, USDA, NPS

Figure 35: Location of landfills and dumps throughout Rhode Island

Although the bulk of closed landfills are concentrated in and around the urban corridor of Rhode Island, where impacts to drinking water would be limited, there are a significant number of closed landfills and dumps located in rural areas that are not served by public water. Approximately one-third of all landfills in the State have no public water service within one-quarter mile of the site.

In accordance with Section 2.18 (F)(1)(h) of the *Solid Waste Regulations No. 2*, the OLRSMM has required that owners or operators conduct an assessment of private wells and other drinking water resources in the vicinity of their sites that may be impacted.

The cost of both assessments, namely sampling of private wells, and the costs associated with installation, operation, and maintenance of the potentially required point-of-entry treatment (POET) systems at impacted homes presents a significant financial burden on owners and operators. The vast majority of landfills are owned by municipalities and the financial burden may be too great depending on the extent of impacts.

The OLRSMM has conducted its own assessment of all landfills sampled to date and developed a risk-based ranking system to identify those landfills that represent the highest risk to drinking water sources by considering the magnitude of PFAS concentrations and proximity to private/public wells.

The table below is a comprehensive list of the landfills in Rhode Island, with the exception of those associated with Superfund sites or FUDS.

Table 15: List of landfills in Rhode Island, with the exception of those associated with Superfund sites or FUDS.

Landfill Name	City/Town	Landfill Closure Program Lead	PFAS Sampling Completed	Availability of Public Water
ARKWRIGHT INC. DUMPSITE	COVENTRY	No	No	Yes
BARRINGTON LANDFILL #1	BARRINGTON	Yes	Yes	Yes
BARRINGTON LANDFILL #2	BARRINGTON	Yes	Yes	Yes
BARRINGTON LANDFILL #3	BARRINGTON	Yes	No	Yes

Landfill Name	City/Town	Landfill Closure Program Lead	PFAS Sampling Completed	Availability of Public Water
BARRINGTON LANDFILL #4	BARRINGTON	Yes	No	Yes
BEAVER RIVER DUMP	RICHMOND	No	No	No
BRISTOL LANDFILL	BRISTOL	No	Yes	Yes
BURRILLVILLE LANDFILL #1	BURRILLVILLE	Yes	Yes	Yes
BURRILLVILLE LANDFILL #2	BURRILLVILLE	No	Yes	Yes
CECE-MACERA LANDFILL	JOHNSTON	Yes	Yes	Yes
CENTRAL FALLS DUMPSITE	LINCOLN	No	No	Yes
CHARLESTOWN LANDFILL	CHARLESTOWN	No	Yes	No
COLE SCHOOLHOUSE ROAD DUMP	WARREN	No	No	Yes
COOK'S LANDFILL	EAST PROVIDENCE	No	No	Yes
COVENTRY MUNICIPAL LANDFILL	COVENTRY	Yes	Yes	Yes
CRANSTON SANITARY LANDFILL	CRANSTON	Yes	Yes	Yes
CUMBERLAND MUNICIPAL LANDFILL	CUMBERLAND	Yes	No	Yes
Division Road Town Dump	WEST GREENWICH	Yes	Yes	Yes
DUPRAW DUMP	LINCOLN	No	No	Yes
EAST GREENWICH LANDFILL	EAST GREENWICH	Yes	Yes	Yes

Landfill Name	City/Town	Landfill Closure Program Lead	PFAS Sampling Completed	Availability of Public Water
ELM TREE DUMP	LINCOLN	No	No	Yes
EXETER LANDFILL #1	EXETER	No	No	No
EXETER LANDFILL #2	EXETER	Yes	No	No
EXETER TOWN DUMP	EXETER	No	No	No
FIELDS POINT CITY DUMP	PROVIDENCE	No	No	Yes
FIRESTONE LANDFILL	TIVERTON	No	Yes	No
FORBES STREET LANDFILL	EAST PROVIDENCE	No	Yes	Yes
FOSTER TOWN LANDFILL	FOSTER	No	No	No
GLOCESTER TOWN LANDFILL	GLOCESTER	Yes	Yes	No
Gorham Textron Dump - School	PROVIDENCE	No	No	Yes
GREENWOOD AVE	EAST PROVIDENCE	Yes	No	Yes
HI-LO CIPRIANO	JOHNSTON	No	No	Yes
HOMETOWN PROPERTY	NORTH KINGSTOWN	Yes	Yes	Yes
HOPE TOWN DUMP	SCITUATE	No	No	No
HOPKINTON LANDFILL	HOPKINTON	Yes	Yes	No
JAMESTOWN LANDFILL	JAMESTOWN	Yes	Yes	No
JAMIEL PARK LANDFILL	WARREN	No	No	Yes
KENT HEIGHTS	EAST PROVIDENCE	No	No	Yes
LITTLE COMPTON TOWN DUMP	LITTLE COMPTON	Yes	No	No

Landfill Name	City/Town	Landfill Closure Program Lead	PFAS Sampling Completed	Availability of Public Water
LONSDALE NARROWS	LINCOLN	No	No	Yes
MACERA (ANTHONY) LANDFILL	JOHNSTON	Yes	Yes	Yes
MACERA (STEVE) LANDFILL	EAST GREENWICH	No	No	No
MANTON AVE LANDFILL	PROVIDENCE	No	No	Yes
NARROW LANE LANDFILL	CHARLESTOWN	No	No	No
NELSON'S GARAGE DUMPSITE	BURRILLVILLE	No	No	Yes
NEW SHOREHAM TOWN LANDFILL	NEW SHOREHAM	No	Yes	No
NEWPORT CITY DUMP	NEWPORT	No	No	Yes
NORTH KINGSTOWN LANDFILL #1	NORTH KINGSTOWN	Yes	Yes	Yes
NORTH KINGSTOWN LANDFILL #2	NORTH KINGSTOWN	Yes	Yes	Yes
NORTH PROVIDENCE LANDFILL	NORTH PROVIDENCE	Yes	Yes	Yes
NORTH SCITUATE TOWN DUMP	SCITUATE	No	Yes (Pre-Remedial)	No
PAWTUCKET INCINERATOR RESIDUE	PAWTUCKET	Yes	Yes	Yes
PERRY/WOOD STREET DUMP	BRISTOL	No	No	Yes
PINE HILL ROAD DUMP	RICHMOND	No	No	No
PONTIAC MILLS	WARWICK	No	No	Yes

Landfill Name	City/Town	Landfill Closure Program Lead	PFAS Sampling Completed	Availability of Public Water
PORTSMOUTH TOWN DUMP/ AP Enterprise	PORTSMOUTH	Yes	Yes	Yes
PRUDENCE ISLAND LANDFILL	PORTSMOUTH	No	Yes	No
RHODE ISLAND RESOURCE RECOVERY	JOHNSTON	?	Yes	Yes
RICHMOND TOWN LANDFILL	RICHMOND	Yes	Yes	No
ROCKY HILL DISPOSAL AREA	EAST GREENWICH	Yes	Yes	Yes
SACHUEST POINT LANDFILL	MIDDLETOWN	No	No	Yes
SCITUATE TOWN LANDFILL	SCITUATE	No	No	No
SMITHFIELD TOWN LANDFILL	SMITHFIELD	Yes	Yes	Yes
TIVERTON TOWN DUMP	TIVERTON	No	No	No
TIVERTON TOWN LANDFILL #2	TIVERTON	No	Yes	No
TRUK-AWAY LANDFILL	WARWICK	Yes	No	Yes
TUCKERS INDUSTRIAL DISPOSAL	JOHNSTON	No	No	No
VINAGRO (J) LANDFILL	JOHNSTON	No	No	Yes
VINAGRO L	JOHNSTON	No	No	Yes
WARREN TOWN LANDFILL	WARREN	Yes	No	No
WARWICK CITY DUMP	WARWICK	Yes	Yes	Yes

Landfill Name	City/Town	Landfill Closure Program Lead	PFAS Sampling Completed	Availability of Public Water
WEST GREENWICH TOWN LANDFILL	WEST GREENWICH	Yes	No	No
WEST WARWICK TOWN LANDFILL	WEST WARWICK	Yes	No	Yes
WESTERLY LANDFILL	WESTERLY	Yes	Yes	No
WOONSOCKET CITY DUMP	WOONSOCKET	Yes	Yes	Yes

Despite the amendment of the *Solid Waste Regulations No. 2* to include a minimum amount of PFAS sampling at closed landfills, nearly half of all landfills in Rhode Island have yet to be sampled, as many unlicensed dumps and waste disposal sites are not subject to these regulations. Based on sampling conducted to date, it may be assumed that PFAS impacts are more likely than not at all of these sites. Private well sampling around these sites is recommended to ensure that there are no off-site impacts. If funding is made available for this purpose, it is recommended that a risk based ranking system, similar to the one developed for landfills sampled to date, be developed to prioritize based on proximity of potential receptors (understanding that the magnitude of on-site exceedances may not be ascertained at some sites due to lack of existing and/or intact monitoring wells).

8 Wastewater Treatment Facilities and Biosolids/Residuals

8.1 Wastewater Treatment Facility Sampling

As permits are reissued, RIDEM is requiring PFAS sampling of influent and effluent at municipal wastewater treatment facilities, beginning in 2024. The first permits with these monitoring requirements were issued in 2023, with monitoring to begin in the first calendar quarter of 2024. There are nineteen municipal wastewater treatment facilities permitted by RIDEM. As of October 2023, three of these permits have PFAS sampling requirements.

The PFAS sampling conditions in the permits require the facility to conduct quarterly influent and effluent sampling for PFAS chemicals and annual sampling of certain industrial users (I.e., industrial users that discharge into the municipal sewer system). Facilities must use draft USEPA Method 1633 until a 40 CFR Part 136 approved test method is made available to the public. Permittees are required to report all forty PFAS compounds that are measured in draft USEPA Method 1633. The forty compounds include the PFAS6 that were specified in the 2022 Rhode Island Surface Water and Groundwater Legislation.

As indicated previously, wastewater treatment facilities are required to sample relevant industrial users that discharge into their wastewater system once per year. This requirement applies to facilities with and without pretreatment programs. In the case that there are no relevant dischargers, the facility must describe the process used to determine that there were no relevant dischargers. Sampling is not required if the user's discharge is not related to the industrial practice that would potentially contain PFAS (e.g., a sanitary-only discharge). Relevant industrial users include the following industries:

- Platers/Metal Finishers
- Paper and Packaging Manufacturers
- Tanneries and Leather/Fabric/Carpet Treaters
- Manufacturers of Parts with Polytetrafluorethylene (PTFE) or Teflon type coatings (i.e., bearings)
- Landfill Leachate
- Centralized Waste Treaters
- Contaminated Sites
- Firefighting Training Facilities
- Airports
- Any Other Known or Expected Sources of PFAS

The purpose of this monitoring and reporting requirement is to better understand potential discharges of PFAS from wastewater treatment facilities and to inform future permitting decisions, including the potential development of water quality-based effluent limits on a facility- specific basis. DEM is authorized to require this monitoring and reporting by CWA § 308(a), which states:

> "SEC. 308. (a) Whenever required to carry out the objective of this Act, including but not limited to (1) developing or assisting in the development of any effluent limitation, or other limitation, prohibition, or effluent standard, pretreatment standard, or standard of performance under this Act; (2) determining whether any person is in violation of any such effluent limitation, or other limitation, prohibition or effluent standard, pretreatment standard, or standard of performance; (3) any requirement established under this section; or (4) carrying out sections 305, 311, 402, 404 (relating to State permit programs), 405, and 504 of this Act—
>
> > (A) the Administrator shall require the owner or operator of any point source to (i) establish and maintain such records, (ii) make such reports, (iii) install, use, and maintain such monitoring equipment or methods (including where appropriate, biological monitoring methods), (iv) sample such effluents (in accordance with such methods, at such locations, at such intervals, and in such manner as the Administrator shall prescribe), and (v) provide such other information as he may reasonably require…"

8.2 RIPDES Requirements for Relevant Industrial and Stormwater Dischargers

As individual permits are reissued, RIDEM intends to require PFAS sampling at relevant industrial and stormwater dischargers with individual permits. Relevant dischargers would be those dischargers where there is a likelihood that the discharge may contain PFAS. PFAS sampling requirements for process wastewater would include quarterly influent and effluent sampling, while stormwater dischargers would require semi-annually or quarterly sampling at the outfall. Facilities must use draft USEPA Method 1633 until a 40 CFR Part 136 approved test method is made available to the public and would be required to report all forty PFAS compounds that are measured in draft USEPA Method 1633. The forty compounds include the six PFAS compounds that were specified in the 2022 Rhode Island Surface Water and Groundwater Legislation. If monitoring demonstrates that PFAS are not present (i.e., if all samples are non-detect), the permittee may request to remove the requirements for PFAS monitoring. The purpose of this monitoring and reporting requirement is to better understand potential discharges of PFAS and to inform future permitting decisions, including the potential development of water quality-based effluent limits on a facility- specific basis.

In addition to issuing individual RIPDES permits, DEM also issued general RIPDES permits. A general permit streamlines the permitting process to allow owners and operators to discharge with less delay than an individual permit while still protecting the environment. Dischargers obtain coverage after the general permit is issued, consistent with permit eligibility and authorization provisions. RIDEM does have the option of requiring an individual permit if RIDEM determines that the General Permit does not provide adequate environmental protection for a specific facility. RIDEM has several general permits that regulate entities that may discharge PFAS.

The Remediation General Permit (RGP) regulates the discharge of waters associated with the treatment of remediation wastewaters. PFAS are not included in the current RGP, but the RGP allows RIDEM to require monitoring for pollutants that are outside the scope of the RGP. Since there are no effluent limit guidelines nor Rhode Island water quality standards or action levels, RIDEM would not typically assign a limit for PFAS, but when issuing a permit, DEM would expect that an appropriate treatment technology (e.g., activated carbon, PFAS specific resin, etc.) be used to treat and remove any PFAS compounds to reduce the potential of contributing to any adverse environmental effects. RIDEM is scheduled to re-issue this permit in 2024 and anticipates including additional PFAS requirements to this permit.

The MSGP regulates stormwater from specific categories of industrial facilities which discharge stormwater directly to the waters of the State or indirectly through a separate storm sewer system via a point source conveyance. Ten major categories of industrial activities have been designated as requiring permit coverage. RIDEM is scheduled to re-issue this permit in 2024 and will evaluate the need to include PFAS monitoring requirements for relevant industries.

8.3 Biosolids/Residuals

8.3.1 Background

Sewage sludge or sludge are the residuals that result from the treatment of sewage/wastewater. Sludge is generated from various mechanical, chemical, and biological treatment processes employed at municipal wastewater treatment facilities that receive and treat domestic, commercial, and industrial wastewaters. The sludge that is produced by wastewater treatment facilities is typically dewatered to separate liquid from the solids, which produces a drier material referred to as sludge "cake" that can be disposed of via incineration, landfilling or land application.

Wastewater treatment facilities receive wastewater from a variety of sources such as residential homes and commercial/industrial facilities. PFAS compounds are used in certain industrial processes/applications and can be a significant source of PFAS that enters wastewater treatment facilities. PFAS is also found in various commercial and household products, which in addition to drinking water, can be pathways for human exposure and is a source of PFAS received by wastewater treatment facilities. Conventional wastewater treatment processes are not designed to destroy PFAS which may result in PFAS ending up in sludge and/or effluent discharge from the wastewater treatment facility. Several emerging technologies are currently being studied for PFAS destruction in sludge/biosolids prior to disposal.

Biosolids is a term for sludge that is intended for beneficial reuse via land application as fertilizer or soil amendment. Biosolids undergo treatment to sufficiently reduce disease causing pathogens. Disposal of sludge/biosolids is regulated at both federal (USEPA) and state levels. At the federal level, sludge disposal is regulated under federal regulation ***40 CFR Part 503***. In Rhode Island, the management of sludge and biosolids is governed by the *Rules and Regulations for Sewage Sludge Management* (250-RICR-150-10-3). Rhode Island's sludge management rules mirror the USEPA Part 503 regulations with additional, more stringent requirements. Biosolids are generally divided into two separate classes, "Class A" and "Class B", depending on the level of treatment and levels of pathogens and pollutants. Class A Biosolids are the highest class and meet the most stringent pathogen and pollutant limits. In Rhode Island, only Class A Biosolids are land applied – there is no land application of Class B Biosolids. USEPA is currently conducting a risk assessment for PFAS in biosolids that may result in new federal standards for allowable levels of PFAS in land applied biosolids. This risk assessment is anticipated to be completed in 2024.

In the United States, a little over half of all sludge generated is applied to agricultural land (USEPA 2020). In recent years, concerns have been raised over land application of biosolids as a potential pathway for introducing PFAS into the environment by migrating from land application sites into nearby surface waters and groundwater. Additionally, plant uptake of PFAS has been documented and there are indications that PFAS can enter the food chain (Lesmeister et al., 2021). The State of Maine has historically had one of the highest biosolids land application rates among New England states. In 2016 high levels of PFOS were discovered at a dairy farm in

Arundel, Maine, which resulted in the Maine Department of Agriculture, Conservation, and Forestry (DACF) to investigate the state's farms for PFAS contamination. Based on that investigation, it was determined that several farms in Maine, that had historically land applied highly industrially impacted biosolids and other types of residuals over many decades, had high levels of PFAS in their soils, farm products, irrigation water, and well water. As a result, in 2019 the Maine Department of Environmental Protection (MEDEP) set biosolids screening standards for PFAS in biosolids (MEDEP 2019) and in 2022, Maine became the first and only state to ban the use of biosolids for land application through legislation LD 1911. This resulted in an increased demand on the already limited regional sludge disposal infrastructure.

Approximately 90% of the sludge generated by Rhode Island wastewater treatment facilities is incinerated, while 8-9% is landfilled or disposed out-of-state. Less than 1% of sludge generated in Rhode Island is land applied. There is currently a lack of sludge disposal capacity in the New England region due to various reasons including limited number of regional incineration facilities, decreasing landfill capacity, and reduced land application options. In particular, landfills have been less willing to accept sludge due to concerns about impacts of PFAS on leachate as well as operational issues, such as odors. In addition, as indicated above, land application in the region is decreasing due to PFAS concerns. As also indicated above, most Rhode Island sludge is incinerated. These incineration facilities are located in Woonsocket and Cranston, which also accept sludge from out-of-state sources in the region. USEPA is currently studying destruction of PFAS compounds in sludge incineration facilities and PFAS concentrations in incinerator air emissions.

The Bristol Wastewater Treatment Facility is the only current generator of biosolids, producing less than 1% of the sludge generated in Rhode Island. The Bristol facility utilizes a composting process that produces Class A Biosolids that can be used as a soil amendment or fertilizer. The majority of the compost is marketed out-of-state and is used in turf markets and landscaping in Massachusetts (NBDP 2018). Bristol also gives their product to Bristol residents and local landscapers. The vast majority of Class A Biosolids beneficially used in Rhode Island come from out-of-state sources and are typically applied to the same sites. The largest source of Class A Biosolids is from the Massachusetts Water Resource Authority (MWRA) sludge pelletization (heat-drying) facility in Quincy, Massachusetts is marketed under the brand name Bay State Fertilizer. An additional out-of-state Class A Biosolids product is Milorganite which is sold in packages at home and garden stores as a pelletized biosolids product. Milorganite is produced in Wisconsin and is sold throughout the United States as a fertilizer and soil amendment.

8.4 Methodology

All bulk distributors of Class A Biosolids are required to keep records of the end user or other distributors that receive more than 25 cubic yards per day in accordance with Section 3.12(B)(2)(c) of 250-RICR-150-10-3. Records were obtained for period from January 1, 2014, through July 15, 2020, from Casella Organics, who is responsible for distributing Bay State

Fertilizer for MWRA. The records reported the total weight (in tons) of pelletized fertilizer delivered to individual users in the State.

There were approximately 30 individual recipients identified over the timeframe in question. The total amount of biosolids received ranged from under 20 tons to over 1,100 tons per recipient. The primary recipients can best be grouped into three separate categories:

1. Agriculture – most notably dairy/livestock
2. Sod/turf
3. Soil blending

RIDEM developed an approach to prioritize the land application sites based on their likelihood to impact drinking water sources. The first of the considerations for risk ranking was the nature of the application. This considered the three aforementioned categories and how the specific use of biosolids would impact the site in the long-term. Agriculture was identified as carrying the highest risk of leaching to groundwater, due to the fact that biosolids are applied directly to farmland on a regular basis. As noted earlier, some of the largest quantities of biosolids were related to dairy and/or livestock farms. Many of these farms produce most, if not all, of the hay and/or silage required themselves on owned or leased fields adjacent to the farm. The regular, seasonal application of biosolids means a strong potential for PFAS from these biosolids to accumulate over time.

The other two categories considered, sod/turf farming and soil blending, are less likely to result in accumulation of PFAS in site soils over time. For sod/turf operations, which are prevalent in Washington County, the biosolids applied to grow sod/turf are likely to be removed when the sod/turf is cut and harvested. Similarly, soil blending operations utilizing biosolids as a soil amendment to increase organic matter and nutrient content are ultimately selling the amended soils, even if they are stored and stockpiled on site for a duration. When considering these categories, sod/turf was identified as carrying the higher risk for leaching due to the irrigation requirements for growing sod/turf, whereas no excess water would be expected to be added in a soil blending operation, with the exception of occasional dust control measures.

The next consideration for risk ranking was estimated loading rates. This required additional research to ascertain the acreage over which the biosolids would be land applied. This included use of land evidence records to ascertain ownership of land (e.g., farmland) and GIS to further refine the extent of land application by directly measuring cleared or farmed acreage using ortho-imagery.

The final consideration was proximity of these land application sites to both public and private drinking water sources. RIDEM considered an approximate one-quarter mile radius from all suspect areas of land application associated with a specific site. This was largely accomplished through the use of GIS. The sites in question were compared to GIS data layers for public water system supply wells. There were several public water supply wells within or immediately adjacent to these land application sites which were previously sampled as part of RIDOH Statewide Surveillance Monitoring studies. When available, this data was helpful in prioritizing sites (e.g., if a public water supply well in the middle of farmland where land application of biosolids had occurred shows no impact, then it is less likely that private wells on the periphery would have impacts). Public water system distribution networks were considered to determine whether private wells were likely to be present. When the availability of public water could not be definitely determined (e.g., incomplete or out-of-date distribution maps) site reconnaissance was performed to determine the availability of public water and the presence/absence of private drinking water wells.

Based upon these considerations, RIDEM initially targeted three agricultural land application sites for further study. Outreach was conducted to private well owners within a one-quarter mile radius via mail. RIDEM utilized USEPA Multipurpose Grant monies set aside specifically for PFAS sampling of private wells to conduct the analysis at no cost to homeowners. However, the response rate was less than 10%.

8.4.1 Study Area 1:

Figure 36: Livestock Farm

Four respondents, including one property with a dug well for irrigation immediately adjacent to farmed field. No exceedances of the Interim Drinking Water Standard for the PFAS6.

8.4.2 Study Area 2:

Figure 37: Dairy Farm

Two respondents on either side of the land application site in question. Both properties were located topographically upgradient. No exceedances of the Interim Drinking Water Standard for the PFAS6.

8.4.3 Study Area 3:

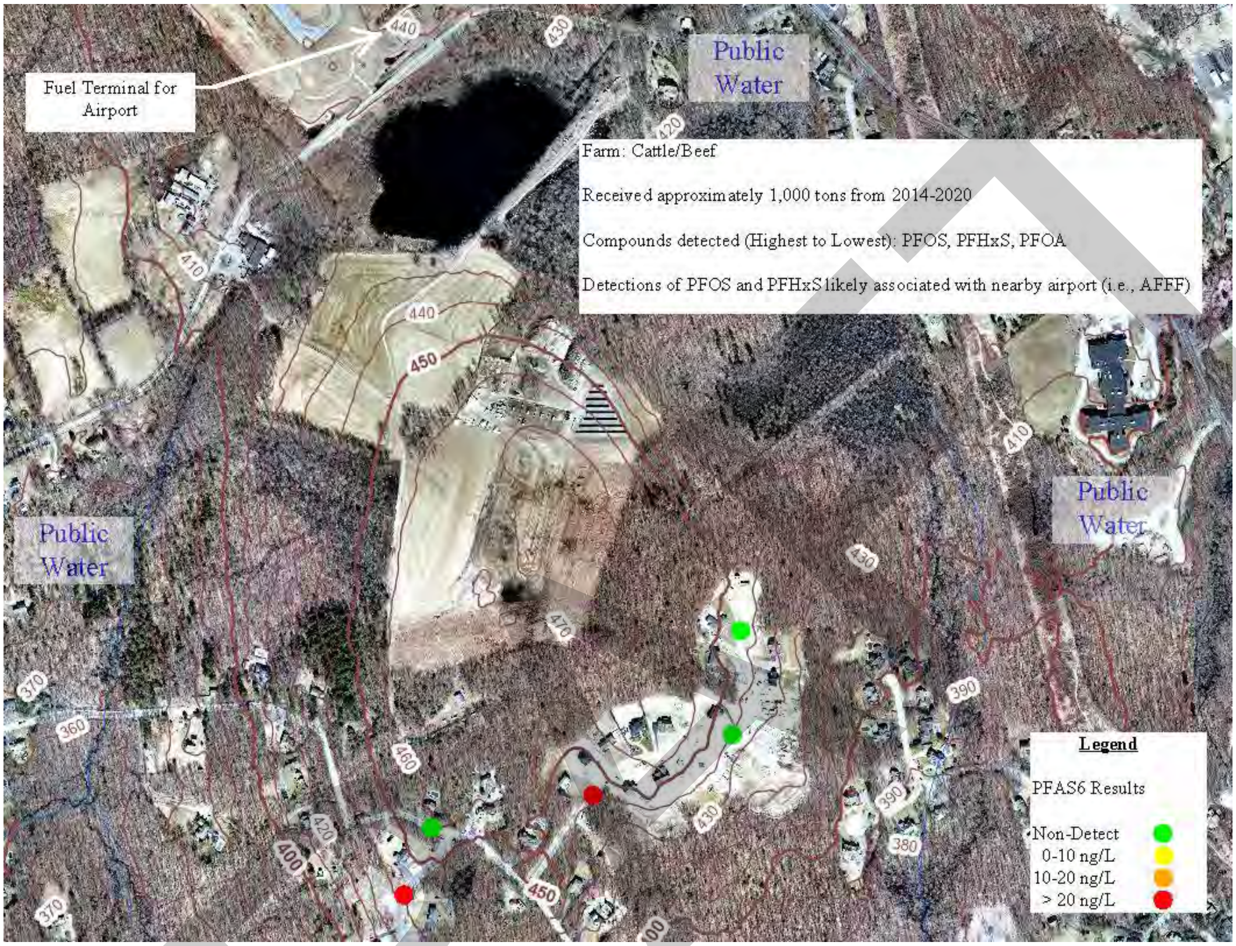


Figure 38: Livestock Farm

Five respondents from surrounding area not serviced by a public water system. Two exceedances of the Interim Drinking Water Standard for the PFAS6. Primary PFAS detected were PFOS and PFHxS. The signature appears consistent with a release of AFFF at a nearby airport. The fuel terminal serving the airport is in the same sub-watershed as the properties sampled.

8.4.4 Turf Grass Case Study with Chariho High School

Although RIDEM did not target turf farms as part of the private well sampling effort around biosolid land application sites, data from the RIDOH Statewide Surveillance Monitoring Study of public water systems did provide some information on potential impacts to drinking water resources from turf farms. Chariho Regional Middle School and Chariho Regional High School are surrounded by one of the larger turf farms in Washington County, which did receive a significant amount of pelletized fertilizer in the period evaluated. There are three wells total that serve the school complex. These wells are relatively shallow for supply wells, ranging from 70 to

135 feet below grade. PFAS were not detected in either of the two wells serving the Middle School and only one PFAS, PFBS, which is not part of the Interim Drinking Water Standard, was detected in the shallower well serving the High School at 5 ppt. Given the very close proximity of these wells to the turf farm and the absence of PFAS detected, it would appear to support the Department's hypothesis that the transient nature of biosolids in turf farming (i.e., the limited potential for accumulation in site soils) does not result in a higher risk of leaching to groundwater as compared to traditional agricultural land application sites.

Figure 39: Chariho Regional Middle School/High School surrounded by turf farms (supply wells indicated in blue)

Based on RIDEM's limited, targeted sampling of private wells and analysis of other sampling results from public water systems or surface water sampling, there currently does not appear to be significant PFAS impacts or significant threat to drinking water resources associated with land applied biosolids. Additional sampling and analysis of private wells and soils would be necessary to further investigate potential impacts. If future funding is made available, additional sampling should be prioritized around sod/turf farms and soil blending operations to verify the potential for these sites to impact ground and surface waters.

9 Rhode Island Textile Mills

9.1 Introduction

Rhode Island has a large textile manufacturing footprint both historically and currently. PFAS has been used in textile manufacturing for many decades due to their hydrophobic and oleophobic nature. These characteristics make the garments highly water and oil repellant, benefitting medical uniforms, waterproof apparel, etc. Firefighting uniforms also benefit from PFAS coating not just from water proofing but due to the extremely high temperature necessary to break it down. PFAS has also been used in textiles associated with rugs, carpets, furniture, etc. for the same reasons. Sampling of PFAS at active/inactive textile operations for PFAS to date has generally been the result of environmental site assessments conducted by private entities and/or requests by the OLRSMM for existing jurisdictional sites in the remediation process.

9.2 Bradford Printing and Finishing

Bradford Printing and Finishing has been used for mill activities since the early 18th century. Early operations utilized the waterpower provided by the Pawcatuck River, supporting at various times a sawmill, gristmill, and by the early 19th century, textile mills. Textile operations continued through much of the 19th century, and near the turn of the century the operations shifted to dyeing and finishing of fabrics. In 1910 the site was bought by Bradford Dyers Association, who then undertook a massive expansion of the millworks. The site was used as a textile finishing and dying plant from 1911 through 2012 when Bradford Printing & Finishing LLC, the owner at the time, declared bankruptcy. The property rights were then given to the Town and the court-appointed Special Master as the legal representative of the property. In June 2019 an agreement for sale was made with Rockingham Estate, LLC. The parcel was subdivided into 4 sections. Section A and C are the main mill buildings and full ownership belongs to Rockingham Estate, LLC. Section D is the lagoons and wastewater system which remains with the Special Master at this time. Section B, the wetlands to the west of the mill parcel, are owned by Rockingham Estate, LLC, but prohibited from development.

Since 1911, the site has consisted of a large mill complex with storage warehouses and several outbuildings. The site buildings/structures/areas consist of the following: 1) main mill building complex, 2) warehouse/chemical storage building, 3) a lagoon-based wastewater treatment system, 4) former water supply well network and pump house and 5) vehicle parking and vehicle storage building.

The Main Mill Building Complex consists of numerous additions and interconnected sections, approximately forty-five (45) in total. Specific purposes of the building included color mixing room, print shop, motor storage, machine shop, finishing plant, pigment room, dye house, bleaching room, carpenter shop, blower house, etc. Much of the machinery for dyeing and finishing has been removed from the complex. Dozens of 55-gallon drums and 330-gallon totes were noted throughout the interior of the buildings prior to Rockingham Estates' purchase. They contained dyes, waste oil, and other chemicals. At least one drum was labeled as containing Fluorochemical Oil and Water Repellant. Most drums were found in the southeast portion of the complex. These drums were removed and properly disposed of by Rockingham Estates, LLC.

The Warehouse/Chemical Storage Building is on the northeast corner of the site and is referred to as the "Old Mill" building. The building was being used for storage of household and miscellaneous items such as paints, water sealer, and stains.

The Wastewater Treatment System is located generally northwest of the mill complex. The principal components consist of four lagoons, a clarifier, and a discharge gallery into the Pawcatuck River. Originally wastewater from the facility was discharged directly to the Pawcatuck River. Later, the waste stream was directed to a series of waste stabilization ponds located on the Grills Preserve. They were constructed due to the results of an environmental assessment performed by the State of Rhode Island. These ponds and channels were designed in the 1950s by a group of engineers from the University of Rhode Island to control the pollution by allowing it to dissipate before discharging into the Pawcatuck River. In the 1970s the current wastewater treatment system was erected, and the ponds were only used when there was significant overflow. The previous owner of the site noted the process handled industrial wastewater, facility sewage, and stormwater that were carried from the mill complex to the equalization basin and from there pumped into the aerobic digestion basin. After the aerobic digestion basin, water was transferred into the aeration basin. Water would then be pumped from the aeration basin into a clarifier tank. From there, the treated wastewater would then exit the clarifier tank and be discharged into the Pawcatuck River. Historically, sewage from houses on Bowling Lane located immediately south of the facility was processed through the treatment system. The treatment process was slightly different according to information in the 1995 "Wastewater Treatment System Upgrade" design drawings prepared by Hydroscience. Based on review of the process flow diagram, wastewater flowed from the equalization basin to the aeration basin, and from there to the clarifier. From the clarifier, nearly all of the sludge was returned to the aeration lagoon while "clean" effluent was discharged to a diffuser in the Pawcatuck River. A very small percentage of the sludge may have been diverted through the aerobic digester lagoon prior to being pumped to the aeration lagoon. At the time of the Wood Phase II assessment, all lagoons except the aerobic digester lagoon contained water. The aerobic digester lagoon was filled with several feet of sludge, same for a small pool of water near the outlet pipe.

The former water supply network is located on the northeast portion of the site across the Pawcatuck River which included a water supply pump house and a well field. Initially the well field consisted of 7 point-driven wells served by a vertical pump and fed under the Pawcatuck River to the facility. The field was not meeting demand and Bradford Printing & Finishing connected to Westerly Water to add capacity. In 1994, the 7 point wells failed and were disconnected from the system. A new 8-inch steel cased well located just northwest off the pumphouse was installed to replace the 7 point well system. The 2010 flood in the area compromised the piping under the river and the well has presumably been abandoned since, although not in accordance with the proper procedures.

The vehicle parking areas are all completely paved and surround the southern and eastern sides. One building is located in the parking area and was used for limousine storage.

On behalf of the Town of Westerly, in 2018, Wood completed a Phase I and Phase II Environmental Site Assessment of the former Bradford Printing & Finishing facility. The investigation included the following:

- Ground penetrating radar study to clear intrusive subsurface sampling locations and identify potential buried utilities and structures (including underground storage tanks);
- Subsurface soil gas screening investigation for volatile organic compounds;
- Advancement of 18 soil borings and installation of seven groundwater monitoring wells;
- Collection and analysis of groundwater samples from 18 locations
- Collection and analysis of six (6) surface water samples and eight (8) sediment samples;
- Collection and analysis of 10 soil samples;
- Test pit/exposure of UST to confirm presence and size;
- Synoptic water level round; and
- Survey of all exploration locations

In 2019 and 2020, as discussed above under the Pre-Remedial Program, OLRSMM completed a Preliminary Assessment and Site Inspection due to the high levels of PFAS detected in the Phase II sampling.

RIDEM OLRSMM put together a PA/SI Work Plan to sample private drinking water wells within a quarter mile of the site. This sampling event took place in October 2018. Twelve (12) private drinking water wells were sampled across the Pawcatuck River from the site. No wells were above the 70 ppt health advisory or the current RIDOH Interim Standard of 20 ppt for the sum of PFAS6.

RIDEM OLRSMM then put together an SI Work Plan for the sampling at the 4 AOCs identified at the site. AOC 1 consisted of the Main Mill Buildings. AOC 2 consisted of the wastewater lagoons and the Grills Preserve waste stabilization ponds. AOC 3 consisted of a waste disposal area with visible drum carcasses. AOC 4 consisted of a waste disposal area along one of the Grills Preserve pathways containing burned debris and various other buried debris.

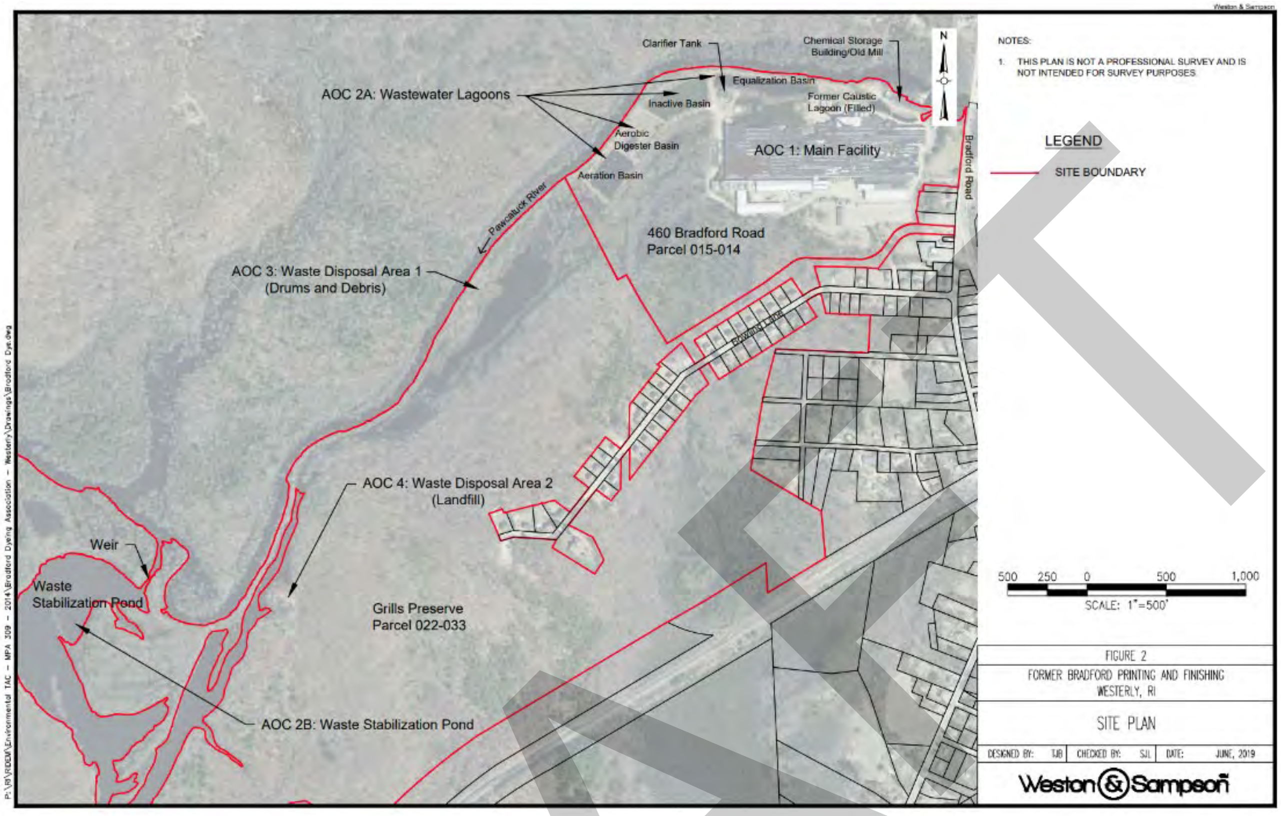


Figure 40: Location of Bradford Printing and Finishing in Westerly, Rhode Island (Weston & Sampson, 2019)

PFAS levels were detected in the groundwater at some of the highest levels in the state, well above the health advisory of 70 ppt. The site contains many other contaminants of concern and has since been referred to the USEPA to complete an HRS package to list the site on the NPL.

9.3 Charbert

The Former Charbert, Inc. (Charbert) textile mill is nestled in the land between the Wood and Pawcatuck Rivers, just before their confluence. This area has been the site of various textile operations since the mid-1800's and the Wood River was dammed to form Alton Pond, which originally provided the waterpower for the mill operation. Charbert, Inc. purchased the mill in 1962 and primarily manufactured elasticized knit fabrics for use in bathing suits, athletic wear, and other applications. The main mill building, and associated outbuildings are located in the northern portion of the property along Church Street (Route 91). The former wastewater lagoons were located in the southern portion of the property.

In July 1976, Charbert received approval to construct Lagoons 1 through 3. These lagoons were designed to infiltrate wastewater into the underlying soil (i.e., no direct discharge to surface water), effectively operating as large sand filters. This approval allowed for periodic removal of the surface layer of organic material collected in the lagoons to improve infiltration. These “scrapings” were stockpiled on the property.

Charbert constructed Lagoon 4 between April 1981 and April 1985 without approval from RIDEM. Inspections by RIDEM in 1998 revealed that wastewater was leaching into the Pawcatuck River from Lagoon 4. At the time, Charbert claimed Lagoon 4 was only used when maintenance was being performed on Lagoons 1 through 3.

Figure 41: Annotated aerial photograph of the Former Charbert, Inc. facility located in the Village of Alton (Richmond), RI circa 2008. The location of the mill and associated wastewater lagoons are marked on the map. Note that Lagoon 4 is empty as this photo was taken just prior to its closure.

The stockpiled lagoon “scrapings” came under DEM jurisdiction in 1987 with the promulgation of the solid waste regulations. Sampling was conducted in the early 2000’s to characterize the stockpiles and determine if they were suitable for reuse in the closure of the lagoons. Samples were analyzed for a comprehensive suite of analytes and only low levels of metals and VOCs were detected, all below the Residential Direct Exposure Criteria and Leachability Criteria. Charbert requested permission to reuse 2,000 cubic yards of stockpiled materials for the closure of Lagoon 4 and the remaining 5,600 cubic yards for the closure of Lagoons 1 through 3.

Charbert advised RIDEM in November 2007 of its intention to close the facility and proceed with the closure of the lagoons and restoration of the riverbank wetland as required by a prior

Consent Agreement. RIDEM concurred and the lagoons were closed over the course of a few years.

The majority of environmental remediation at the former Charbert property has been focused on releases of chlorinated solvents from operations that impacted on-site and off-site drinking water wells. However, in March, 2020, the OLRSMM requested testing for PFAS at the former Charbert property sampled for PFAS. An initial round of PFAS sampling using the existing monitoring well network identified exceedances of the Department's GA Groundwater Quality Standard (70 ppt for the sum of PFOA and PFOS) in the former lagoon area.

New monitoring wells were installed within the footprints of the former lagoons. These monitoring were sampled for PFAS and were found to contain PFAS over 1,000 ppt. The primary PFAS detected were PFCAs, including PFHxA, PFHpA, and PFOA. Monitoring well GZ-102, installed in the footprint of Lagoon 2, had concentrations of PFHxA, PFHpA, and PFOA, at 2,600, 1,400, and 5,500 ppt, respectively during the initial sampling round in August, 2020.

Additional investigations for PFAS at Charbert involved sampling of surface water, downgradient private well sampling, and soil sampling of the former lagoons. Six soil borings advanced through the former lagoons in March 2021, and samples were collected at various depth intervals (e.g., fill material above the sludge layer, the sludge layer, and the water table). Samples were analyzed for total PFAS and also analyzed for SPLP to determine leaching potential. The highest concentrations of PFAS were detected in the fill above the sludge layer. Similar to results in groundwater, PFAAs were the most prevalent compounds. Notably, longer chain PFCAs (e.g., PFDA, PFUnA, PFDODA, etc) were more prevalent in soils, which is not unexpected given their greater affinity for adsorption to soils. 8:2 fluorotelomer sulfonic acid (8:2 FTS) was detected at the highest levels in soil (upwards of 12 µg/kg). 8:2 FTS is known breakdown to form PFAAs, including the those most prevalent in site groundwater (PFHxA, PFHpA, and PFOA). It is possible that 8:2 FTS, along with other fluorotelomers which are not currently able to be quantified are responsible for the persistent contamination at Charbert. The distribution of PFAS in soils in the former wastewater lagoons (i.e., higher in the fill material) also suggests that the stockpiled "scrapings" used as backfill may be a significant source of PFAS contamination. This is not unexpected given that these "scrapings" would have consisted of sediment high in organic matter to which PFAS would preferentially adsorb.

As regulatory for PFAS in soil, including director exposure and leachability criteria, are promulgated, it is anticipated that further remedial action may be warranted at sites like Charbert. In this particular case, there appears to be a significant quantity of PFAS retained in the former lagoon sediment/sludge that poses an ongoing threat to groundwater and surface water.

9.4 Others

In 2021, the OLRSMM collaborated with Matthew Dunn of the URI STEEP (Sources, Transport, Exposure & Effects of PFAS) Program on the validation of tube passive samplers for detecting PFAS in groundwater and surface waters. The research involved deploying these samplers for a duration of one month to determine a time-weighted average of PFAS concentrations at various locations along the entire length of the Pawcatuck River from its headwaters at Worden Pond, South Kingstown, to the mouth of the river in Westerly and Long Island Sound. Discrete samples were collected at the deployment locations and the data were used to determine the overall mass flux of individual PFAS from various sources and the overall mass flux to the Atlantic Ocean. The Pawcatuck River was selected due to its extensive history of textile finishing operations. OLRSMM staff worked with URI to select sample locations downstream of both active and legacy textile finishing operations. Samples were also collected from the former wastewater stabilization ponds at Bradford Dye and the former tail race associated with Griswold Textile Print, Inc., both in Westerly. The results of the sampling demonstrated distinct signatures of PFAS from active (shorter chain) and legacy (longer chain) textile operations. The results of the study can be accessed at https://digitalcommons.uri.edu/oa_diss/1569/.

RIDEM Engineering Interns Lindsay Guertin (UNH) and Julia Muise (UMass) assist Matthew Dunn (URI STEEP) deploying samplers in Braford, RI, upstream of the former Bradford Dye Facility.

This collaboration with URI provided valuable data for understanding the impacts of these facilities on the Pawcatuck River. This data was utilized in the promulgation of the Surface Water Action Limit and may be used in the future to help identify potential releases and responsible parties along the Pawcatuck River.

10 Fire Stations and Fire Training Areas

Fire stations have been demonstrated to be a significant source of PFAS contamination. As discussed previously, a release from a single fire station in Rhode Island which has been in operation for less than two decades impacted the water resources of the entire Village of Oakland in Burrillville and necessitated the extension of a water line to service several hundred residents and with a cost over $1.7 million. The adverse impacts of PFAS have only come to light in recent years and past firefighting practices and procedures understandably did not treat AFFF as a potentially harmful product. As such, either through purposeful releases of AFFF (e.g., training, firefighting response, etc.) or through incidental release from apparatus and equipment (e.g., leaking containers, hoses, and tanks, washing equipment, etc.) fire stations are seldom free from PFAS impacts if AFFF was stored and/or used at the particular station.

There are approximately 160 fire stations throughout the state, many of which are not in areas supported by public water service and are the highest risks to those areas not served by a centralized public water supply. The figure below shows the geographic distribution of fire stations in Rhode Island.

Fire stations associated with airports and/or military installations are frequently associated with releases of PFAS. Fire stations at Charlestown Naval Auxiliary Landing Field (CNALF), Naval Station Newport, and the Quonset Air National Guard Base/Quonset State Airport all have significant releases associated them. The investigations at CNALF are ongoing, however, the release associated with the fire station appears to be at least partly, if not primarily responsible, for the contamination of on-site public water system wells at Ninigret Park.

Underground Injection Control (UIC) systems at fire stations have proven to be a significant concern when it comes to PFAs releases. Permitted and/or unpermitted UICs serving trench drains in station garages are of particular concern. As was the case with the Oakland-Mapleville Fire Department, it appears that these trench drains, which were tied into an underground infiltration gallery used to treat stormwater, intercepted leaks from apparatus and AFFF concentrate containers stored in the garage. Over the past several years, the OWR has reached out to several fire stations regarding closing out UICs for standard UIC compliance purposes, but also in association with the PFAS issue. The inclusion of the PFAS/PFOS topic has stalled the process somewhat as there were no standards nor regulations to provide guidance or targets for any potential remedial efforts. With the upcoming proposed RI Groundwater Regulations for PFAS/PFOS, the UIC Program will be able to restart the closure process at these facilities. Unsurprisingly, impacts to soil and groundwater have been identified at some of these locations. As many of these facilities are volunteer or incorporated outside of municipal ownership, the biggest likely obstacle to a successful effort to close and remediate any site sources from past use at these sites will be financial. The Burrillville site mentioned above is a fair example of how quickly those costs can grow. There will need to be a substantial financial commitment to assist these facilities if we hope to have success. If just 25% of these stations have previous releases that create a similar scenario, it could easily take $100 million to address.

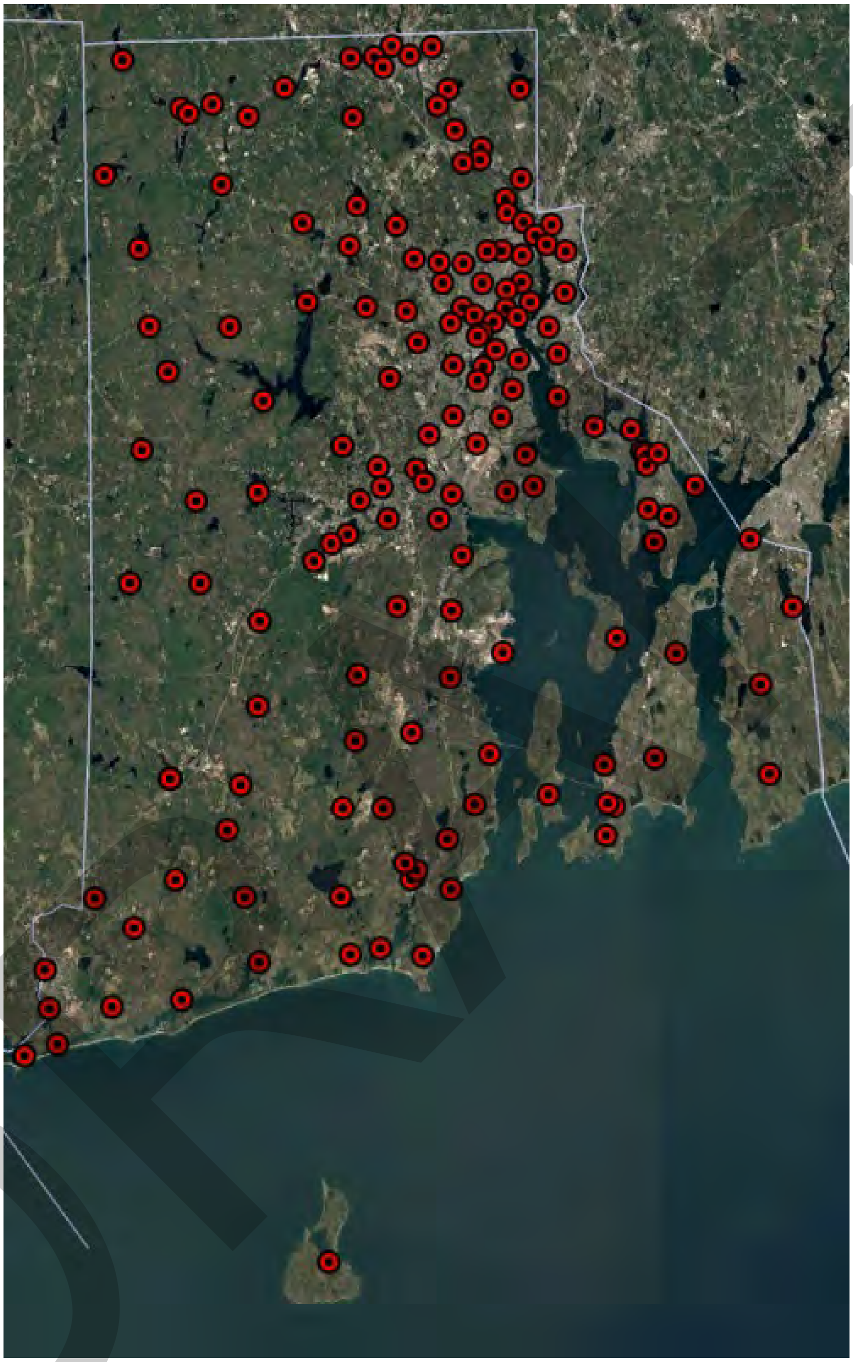


Figure 42: Location of fire stations in Rhode Island

Sampling of private wells in the vicinity of fire stations should also be prioritized if funding is made available. Based upon the limited sampling of fire stations in Rhode Island and the high incidence of associated releases and impacts, fire stations should rank higher than most other potential sources from a risk perspective.

11 PFAS Regulations and Impacts to Source Investigation

11.1 PFAS in RI Soils

The PFAS legislation passed in June 2022 (RI HB 7223A/ RI S2298) added the PFAS6 to the definition of a hazardous substance under the *Industrial Property Remediation and Reuse Act* (RIGL 23-19.14-3). This effectively allowed for the adoption of standards of PFAS in other environmental media, namely soil, via the *Rules and Regulations for the Investigation and Remediation of Hazardous Material Releases* (250-RICR140-30-1).

11.1.1 Background Study

PFAS are an entirely man-made class of chemicals that otherwise would not be present in the natural environment. Due to their extreme stability from the strength of the carbon-fluorine bonds, PFAS that are released into the environment are highly recalcitrant. These characteristics make it possible for PFAS to travel long distances through the environment, including via aerial deposition. In the decades since the discovery and initial manufacture of PFAS, PFAS have become distributed throughout the globe, albeit at low levels. The OLRSMM determined it would be appropriate to conduct a Statewide Background Study of PFAS in shallow soils to inform the development of soil standards for the PFAS6, particularly given that leachability criteria were likely to be less than 1 µg/kg (ppb) in soil. Furthermore, other States, including those in the region who have conducted their own anthropogenic background studies, have potential localized sources that may have impacted ambient concentrations of PFAS. For example, Bennington, VT and Merrimack, NH, have documented aerial deposition from manufacturing facilities which could quite possibly result in higher ambient concentrations of PFAS than what may be present in Rhode Island.

The term “Background” is defined in the *Remediation Regulations* as “*the ambient concentrations of Hazardous Substances present in the environment that have not been influenced by human activities, or the ambient concentrations of Hazardous Substances consistently present in the environment in the vicinity of the Contaminated-Site which are the result of human activities unrelated to Releases at the Contaminated-Site*.” In the case of PFAS, the latter half of the definition “*the ambient concentrations of Hazardous Substances consistently present in the environment in the vicinity of the Contaminated-Site which are the result of human activities unrelated to Releases at the Contaminated-Site*,” is the most appropriate definition. Determining a background threshold value (BTV) for PFAS is crucial in distinguishing site specific releases of PFAS from ambient anthropogenic background and making the determination as to whether a release of hazardous materials containing PFAS has occurred.

Sample locations were carefully selected on State-owned properties using available historic aerial imagery to target locations that showed no disturbance since the 1940s. A representative distribution of sample locations throughout the state were selected in areas where groundwater was classified as GA or GAA. The distribution attempted to select a representative number of samples from each county based on land area. Samples were not taken in wetland areas. Each exact location was chosen on a site-specific basis based on in-field observations and site conditions. Overall, samples were collected at 50 locations that met the criteria.

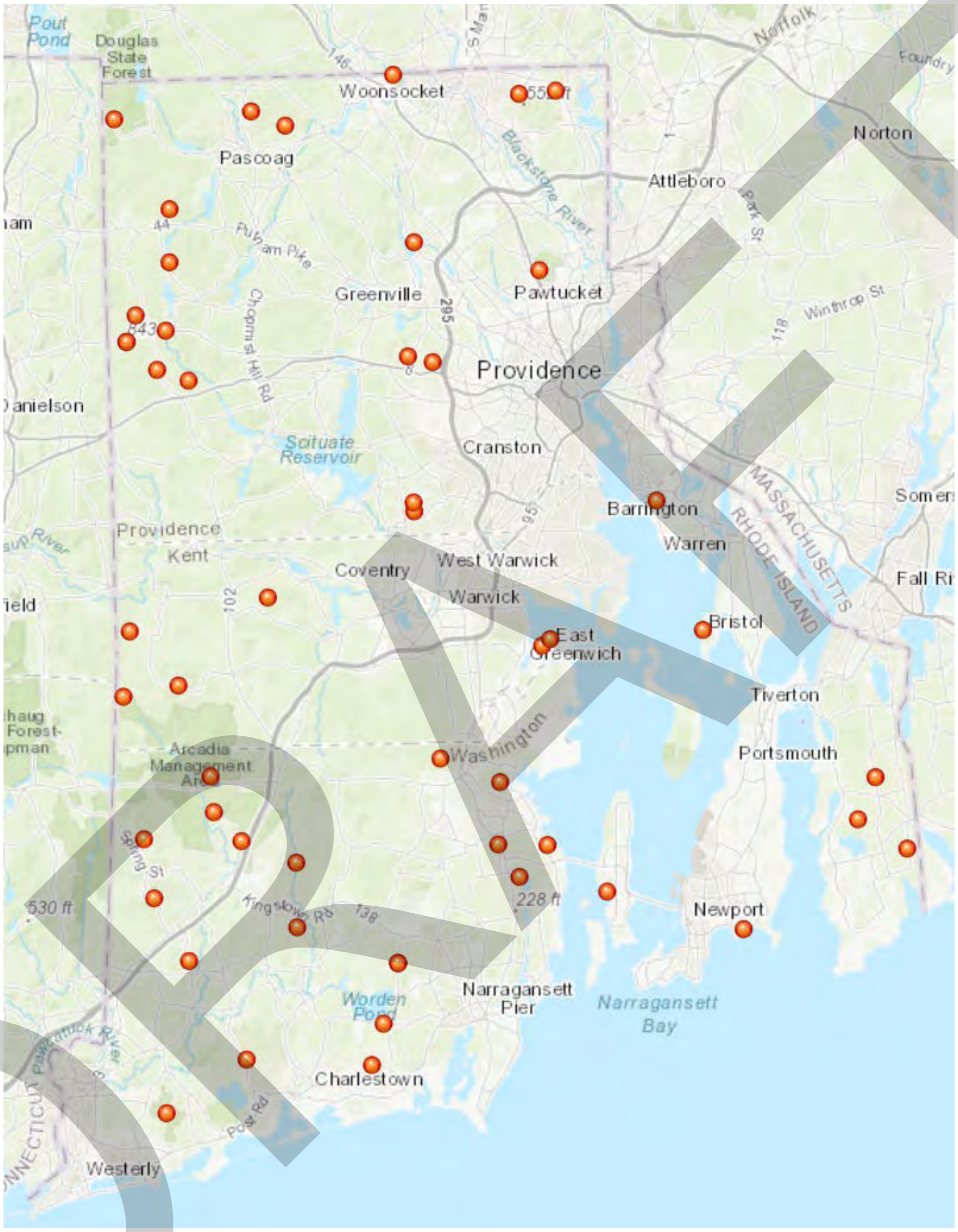


Figure 43: Sample locations for Statewide PFAS Background Study

Sampling methodology was developed by the team in accordance with currently accepted PFAS sampling methodology. The location was cleared of leaf litter and other debris. A 2 ¾ inch stainless steel hand auger was used to collect soil from the 0 to 24-inch interval below ground surface. This depth interval was chosen as it represents the minimum depth to which Direct Exposure Criteria are applied per the *Remediation Regulations*. The soils were collected in a stainless steel mixing bowl and homogenized, removing any rocks, roots, and other debris before taking a discrete grab sample. One (1) duplicate sample was collected per 20 samples (3 total for 50 samples), one (1) field blank was collected for each sampling event, and one (1) equipment blank was collected for each piece of equipment per 20 samples (3 blanks for each piece of equipment for 50 samples). Decontamination procedures involved rinsing the auger bucket, mixing bowl, and scoop (all stainless steel) after each sample with certified PFAS-free water and Alconox®. Location characteristics were recorded on data sheets and a GPS location was recorded to the working ArcGIS map. OLRSMM staff collected the samples beginning in November 2022 through the end of the year. Samples were analyzed for 24 individual PFAS by Alpha Analytical.

OLRSMM staff logging a soil sample collected at High Rocks Gorge in North Smithfield.

The results of the Statewide Background Study of PFAS in soils are summarized in Table 16 below: Not included in the Table are the results for PFBA, PFPeA, PFHxA, and PFUnA, which were detected in 100%, 88%, 78% and 18% of samples, respectively. No other individual PFAS were detected in more than one sample. One sample was statistically determined to be an outlier and was removed from the subsequent analyses. This sample location was responsible for several PFCAs maximum detections.

Table 16: Results Summary of PFAS6 for Statewide Background Study of PFAS in Soil.

Compound	% Detection[a]	Mean (ng/kg)	Median (ng/kg)	Maximum (ng/kg)
PFHpA	92	113	105	312[b] / 187
PFOA	100	376	347	1,735 [b] / 701
PFNA	52	127	121	209
PFDA	14	112	99	149
PFHxS	0	–	–	–
PFOS	100	406	354	899

[a] Detection above the Method Detection Limit (MDL)

[b] Associated with outlier sample location that was not included in subsequent analyses, next highest value is shown.

The relative total concentrations of PFAS6 in each of the background sample locations is shown in Figure 44 below. The maximum detection was a sample collected at Jerimoth Hill, coincidentally the highest point in RI. This sample was determined to be an outlier and removed from subsequent analyses. There were no notable patterns in relative PFAS distribution observed.

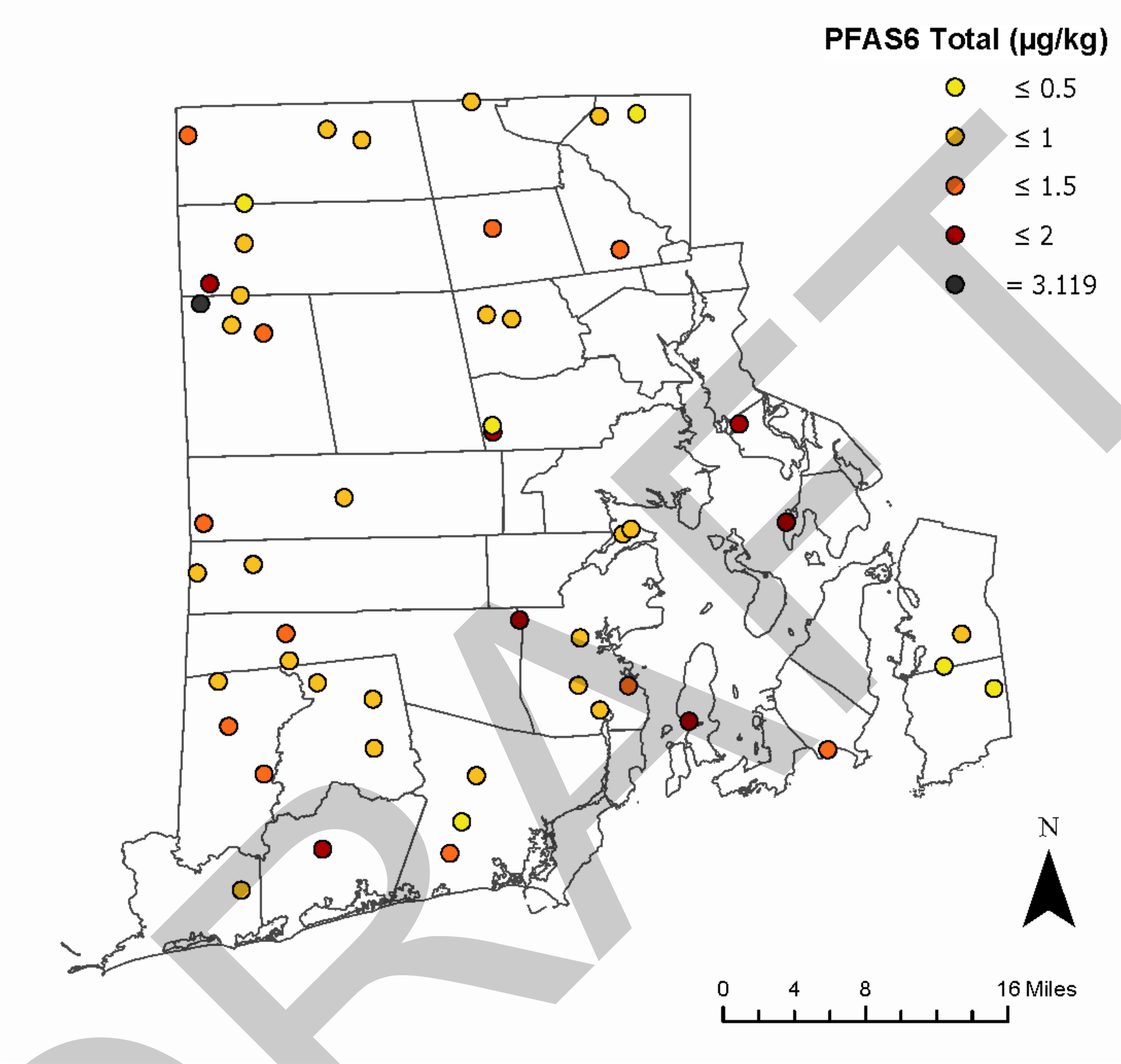


Figure 44: Map showing the relative total concentrations of PFAS6 detected in soils. Note the change in units from the previous table, units are in µg/kg or ppb.

Background threshold values (BTVs) were calculated using ProUCL Version 5.2, a comprehensive statistical software package for analysis of environmental data sets made available by the USEPA, and the associated guidance on calculating BTVs. As noted earlier, one sample was identified as an outlier using statistical tests included in this software. The 95%-95% Upper Tolerance Limit (UTL) was selected as the BTV, with the exception of PFHxS, which did not have enough detections to perform a statistical analysis. In the case of PFHxS, the maximum method detection limit (MDL) was used, since PFHxS was not detected at any sample location. As discussed earlier, these BTVs are representative of ambient anthropogenic background and will serve as the lower limit of future soil standards. The calculated BTVs for the PFAS6 are shown in Table 17 below:

Table 17: Background Threshold Values for the PFAS6.

Compound	UTL 95-95 (µg/kg)
PFHpA	0.178
PFOA	0.639
PFNA	0.172
PFDA	0.110
PFHxS	0.087[a]
PFOS	0.842
[a] Maximum MDL used.	

The development of a regulatory standard for the PFAS6 in soil is an integral part of future source identification. Source area delineation is a pivotal part of identifying the most appropriate remedial alternatives. With the promulgation of these soil standards, more sites throughout Rhode Island will be identified, as an exceedance of these standards will constitute a reportable condition under the *Remediation Regulations*.

11.1.2 Direct Exposure Criteria and Leachability Criteria

As part of a forthcoming revision of the *Rules and Regulations for the Investigation and Remediation of Hazardous Material Releases* (250-RICR140-30-1), the OLRSMM is developing soil standards for the PFAS6 for promulgation. These standards were developed consistent with past practices and utilizing current physical, chemical, and toxicological properties of the PFAS under consideration. More specifically, the new criteria will include Residential Direct Exposure Criteria, Industrial/Commercial Direct Exposure Criteria, and GA Leachability Criteria for each of the individual PFAS6. The OLRSMM contracted with GZA GeoEnvironmental, Inc., to derive GA Leachability Criteria using the SESOIL and AT123D Models consistent with the derivation of existing leachability criteria. In instances where the derived leachability criteria for an individual PFAS is below the BTV determined by RIDEM, the leachability criteria will default to the BTV. This is not anticipated to be an issue for Direct Exposure Criteria, which are orders of magnitude higher than the associated GA Leachability Criteria.

11.2 PFAS in RI Surface Water

Very limited baseline sampling of surface water has occurred in Rhode Island. The surface water sampling that has occurred has been primarily associated with the investigation of a known source sites as described earlier in this report. Without a baseline characterization sampling, the extent, presence, and magnitude of PFAS in Rhode Island rivers/streams, lakes, and estuaries is unknown. RIDEM's Office of Water Resources' (OWR) request to direct federal Clean Water Act funds awarded to the Department to conduct baseline PFAS sampling in surface waters was recently approved. The study is expected to be initiated in 2024. Other New England states have conducted similar studies, and this study will be an important step to help resource managers prioritize and better quantify the extent of PFAS in Rhode Island. Based on other states' experience and the contents of this report, it is expected that PFAS will be detected in Rhode Island surface waters.

The 2022 passage of the "PFAS in Drinking Water, Groundwater and Surface Waters Act" directed DEM to establish a surface water quality action level for at a minimum the 6 PFAS identified in the Act. The development of the surface water quality action level focused on providing information to RIDEM on elevated surface water that should be further investigated under other regulatory authority to identify potential site clean-ups that were not known.

Additionally, consumption of contaminated fish and shellfish is a potential PFAS exposure pathway for humans. At least ten states have developed fish and/or shellfish consumption guidance or advisories to limit dietary exposure from consumption of fish and shellfish from waterbodies having elevated PFAS concentration (Environmental Council of the States, 2023). To date, a limited study of freshwater fish associated with a known site contamination and a baseline study of 18 marine species in Narragansett Bay have been completed by researchers and federal partners in Rhode Island.

Several of the RI sites having elevated PFAS levels, namely Newport Naval Education and Training Center (NETC), Naval Construction Battalion Center (NCBC) Davisville, and Charlestown Navy Auxiliary Landing Field (CNALF), are adjacent to commercially important shellfish growing waters. The waters of Narragansett Bay adjacent to NETC in Newport and adjacent to NCBC in Davisville are classified as prohibited to shellfish harvest which limits potential PFAS exposure to humans through shellfish consumption. However, the waters of Ninigret Pond adjacent to Charlestown Navy Auxiliary Landing Field (CNALF) are open to wild shellfish harvest and are also the site of at least 12 oyster aquaculture operations. While limited studies have indicated that shellfish harvested in the United States have low PFAS concentrations (Ruffle et al., 2020; Young et al., 2022; Hedgespeth et al., 2023), oysters can bioaccumulate PFAS at tissue concentrations that are 50- to 100-times greater than the exposure concentrations (Aquilina-Becker et al., 2020). Because of this potential dietary exposure pathway, quantification of PFAS contaminant levels in Ninigret Pond shellfish, both wild harvest and aquaculture raised, should be a priority for future research and monitoring efforts.

Further efforts will be needed to fully characterize ambient surface water PFAS concentrations and fish/shellfish tissue PFAS concentrations to address human health and ecological risk.

11.3 PFAS in RI Groundwater

US EPA released a Drinking Water Health Advisory for PFAS in 2016. The advisory level was set at 70 ppt for the sum of PFOA and PFOS. In response, the R.I. Groundwater Quality Rules (250-RICR-150-05-3) were amended to add an interim groundwater standard for PFAS of 70 ppt for the sum of the two compounds. Section 3.11(A)(2) of the regulation sets interim standards for groundwaters classified as GAA and GA for substances that do not have a federal drinking water MCL established. Specifically, section 3.11(A)(2) (c-e) in the current (2018) rule sets the interim standard for PFOA, PFOS, and a sum total of both PFOA and PFOS.

The 2022 passage of the "PFAS in Drinking Water, Groundwater and Surface Waters Act" directed DEM to establish a groundwater quality standard for the sum of six PFAS compounds specified in the Act. The same legislation establishes an interim drinking water standard at 20 ppt for same six PFAS compounds. RIDEM has authority under the state's groundwater protection statute (R.I. Gen. Laws § 46-13.1) to set groundwater quality standards. For groundwaters classified GAA and GA, meaning they are suitable for drinking water use without treatment, RIDEM interprets current state laws and policy as requiring consistency between the proposed groundwater quality interim standard and the interim drinking water MCL for PFAS which is also specified in R.I. Gen. Laws § 46-32-5. Therefore, the groundwater quality standard for the six PFAS compounds is established at 20 ppt.

Proposed amendments to the Groundwater Quality Rules will replace the current 70 ppt interim PFAS standard found in section 3.11(A)(2) (c-e) in the current (2018) rule. The original language will be replaced with a new subsection (c) establishing an interim standard for the sum of six PFAS compounds as specified in R.I. Gen. Laws § 46-32-5 at less than or equal to 20 ppt. Public notice for these amendments was issued on October 4, 2023

11.4 Federal PFAS Regulations

The United States Environmental Protection Agency is spearheading the federal approach to addressing PFAS. In 2021, USEPA announced the 2021-2024 PFAS Strategic Roadmap to set timelines for plans to take actions and set policies for protection of human health and the environment. USEPA’s approach to PFAS includes three key directives: Research, Restrict, and Remediate. Research includes investing in research and development to increase understanding of PFAS exposures and toxicities, health effects, and intervention techniques. Restrict pursues an approach to minimizing potential release into the environment. Remediate broadens and accelerates the cleanup efforts of PFAS contamination. Since 2021, USEPA has made regulatory progress in all three key directives.

The USEPA initiated the Fifth Unregulated Contaminant Monitoring Rule (UCMR 5) to sample for data on 29 PFAS compounds between 2023 and 2025. The initial monitoring results have been released in August 2023 and more are forthcoming as results are processed.

The toxicity assessment for PFBS has been updated and a Final Human Health Toxicity Assessment was published for HFPO-DA.

The National PFAS Testing Strategy was announced, requiring Toxic Substances Control Act authorities to require PFAS manufacturers to provide their PFAS information.

Clean Water Act actions have also been occurring. Draft Aquatic Life Criteria for PFOA and PFOS have been proposed and put out for public comment. USEPA has begun to use their Clean Wate Act authority for minimizing PFAS discharge under the National Pollutant Discharge Elimination System. In December 2022, USEPA issued a memo to provide guidance to states for how to use NPDES to reduce PFAS pollution.

USEPA has been working on multiple analytical methods for PFAS analysis. Draft USEPA Method 1621 has been published for absorbable organic fluorine. Draft USEPA Method 1633 is going through multi-lab validation for analysis of PFAS in aqueous, solid, biosolids, and tissue samples. Currently USEPA Method 533, Method 537, and Method 537.1 are used for drinking water.

In May 2022, USEPA added six PFAS compounds to a list of risk-based screening levels for federal site cleanups, Regional Screening Levels (RSLs), due to Agency for Toxic Substances and Disease Registry (ATSDR) updates. The compounds include PFBS, PFBA, PFHxS, PFHxA, PFNA, and HFPO-DA. RSLs for PFOA and PFOS were also updated.

In June 2022, USEPA released four drinking water health advisories for PFAS. Two of the new health advisories were revisions to the PFOA and PFOS Lifetime Health Advisories, 0.004ppt and 0.02ppt respectively. In addition, Lifetime Health Advisories for PFBS and HFPO-DA were finalized at 2,000ppt and 10 ppt respectively.

In August 2022, USEPA proposed the designation of PFOA and PFOS as hazardous substances under CERCLA.

In January 2023, USEPA announced a plan for determining revised Effluent Limitation Guidelines and pretreatment standards for reducing PFAS in landfill leachate as well as ongoing study of discharges from textile manufacturers and POTW influent.

In February 2023, $2 billion in Bipartisan Infrastructure Law Funding was allocated to emerging contaminants in drinking water and funding will be made available to small or disadvantaged communities through state grants. RIDOH has been allocated funds and is preparing proper use and dissemination.

In March 2023, USEPA proposed a National Primary Drinking Water Regulation for six PFAS compounds. The proposal includes individual MCLs of 4.0 ppt for PFOA and 4.0 ppt for PFOS and a Hazard Index of 1 for the PFNA, PFHxS, PFBS, and HFPO-DA MCL. At the time of this report, these MCLs are currently in Draft status and are scheduled to be finalized by the end of 2023.

In June 2023, USEPA proposed framework under TSCA to ensure that extensive evaluation of PFAS chemicals will occur before they are allowed to enter into commerce.

Across USEPA offices, science and regulations regarding PFAS will continue to evolve. USEPA will continue to follow and expand upon their PFAS Roadmap.

12 Conclusion

Rhode Island has been working diligently since the establishment of the 2016 USEPA Lifetime Health Advisory to identify potential PFAS impacts and investigate sources. As detailed in this report, RIDOH has conducted statewide surveys of public water systems. RIDEM has followed-up with many of the impacted PWSs and sampled private wells to better characterize the nature and extents of the impacts. With PFAS drinking water standards becoming more stringent, there is likely to be more impacted PWSs that warrant further assessment.

RIDEM's OLRSMM has worked with the USEPA and the Department of Defense to investigate PFAS sources at Superfund sites, DOD sites, and FUDS throughout the State. These investigations are extensive and will continue for the foreseeable future.

The OLRSMM has implemented PFAS sampling at closed landfills and demonstrated that landfills are a reliable source of PFAS contamination. As outlined in this report, data gaps exist for landfills that are not subject to existing legislation and will need to be assessed by other means.

RIDEM has also implemented sampling of biosolid land application sites. Although the preliminary assessment appears to show that these sites may not pose as significant a threat in Rhode Island, as compared to what other states have found, more assessment may be warranted.

Investigations of other potential PFAS sources, such as airports, fire stations and fire training areas, and textile finishing operations are ongoing. As identified in this report, some of these sources pose a high risk to private well owners throughout the State. It is anticipated that more of these sources will come under the purview of RIDEM as regulations are promulgated requiring reporting of PFAS in various environmental media.

RIDEM has made significant progress towards identifying potential PFAS sources in Rhode Island and through collaboration with other State and outside agencies. RIDEM has a firm handle on the known potential sources of PFAS specific to Rhode Island and has worked to developed risk-based ranking to prioritize investigation of potential impacts to drinking water resources and other potential receptors in the future. High priority source investigations include fire stations, fire training areas, and landfills. Department of Defense sites are similarly of high priority; however, the Army Corps, US Navy, and other DOD entities have already initiated investigation (and response actions) at many sites throughout Rhode Island.

All PFAS source investigations and related studies conducted to date have been accomplished through federally funded programs, such as the Pre-Remedial Program, federal grants, namely USEPA Multipurpose Grants, or carried out directly by responsible parties under the direction and oversight of the OLRSMM. These investigations, with a few exceptions, were not viewed as emergency response actions as the 2016 USEPA Lifetime Health Advisory (LHA) of 70 ng/L or ppt for the sum of PFOA and PFOS was the determining threshold. In light of the changing regulatory environment surrounding PFAS, particularly more stringent drinking water standards including the proposed USEPA Maximum Contaminant Levels (MCLs), the scope of potential PFAS impacts and sources in Rhode Island is anticipated to greatly expand. These facts coupled with the high costs for treating and remediating PFAS impacts may result in challenges in both conducting source investigations and, more so, addressing impacts. Significant federal funding has been made available to assist public water systems with providing treatment for PFAS. However, no funding is available for remediating impacts to private wells.

With the expanded and more frequent PFAS sampling for public water systems required under Rhode Island House Bill 7233 Substitute A and Senate Bill 2298 Substitute A, *An Act Relating to Waters and Navigation – PFAS in Drinking Water, Groundwater and Surface Waters*, newly identified impacted public water supply wells have already been identified, several of which received “Do Not Drink” orders from RIDOH due to elevated concentrations of PFAS greater than 70 ppt.

The aforementioned legislation also importantly added the PFAS6 to the definition of a hazardous substance under the *Industrial Property Remediation and Reuse Act* (RIGL 23-19.14-3). The planned revisions of the *Rules and Regulations for the Investigation and Remediation of Hazardous Material Releases* (250-RICR140-30-1) will incorporate PFAS soil and groundwater standards and require exceedances of these standards be a reportable release. This will help to ensure that PFAS are considered at brownfields and other contaminated sites and help to identify other potential sources and impacts.

Implementing source investigations themselves at high priority sites is also a challenge from both a regulatory and economic perspective. Most RIDEM regulations, namely the *Rules and Regulations for the Investigation and Remediation of Hazardous Materials Releases* (250-RICR-140-30-1), are “reactive” in nature. In other words, RIDEM does not have the authority to investigate suspect hazardous material releases sites (e.g., fire stations), unless there is existing evidence of a release. The voluntary nature of these regulations would preclude RIDEM from implementing many of these source investigations at certain sites themselves. This is why the OLRSMM has relied on voluntary private well sampling to initiate source investigations. This approach has proven to be effective in implementing such investigations as it provides immediate information as to whether or not impacts to drinking water resources are present.

Once evidence of a release is established, the OLRSMM may then identify potential responsible parties to further investigate their individual contributions.

Another significant challenge in relying upon responsible parties, as defined in statute (i.e., property owners and/or operators), to conduct source investigations under Department oversight, is that many of the potential responsible parties associated with high priority PFAS sources are municipalities and/or non-profit organizations, such as volunteer fire departments, who do not possess the resources to conduct such an investigation, let alone to provide treatment or remediate impacted resources. Ongoing class-lawsuits against PFAS manufacturers may provide some relief when it comes to these types of situations, but the timeframe for this is uncertain.

An important piece of the overall strategy for addressing PFAS contamination that is not discussed in detail in this report involves eliminating PFAS from consumer products and other applications, which will help eliminate PFAS from the waste stream and to reduce the potential for PFAS releases to the environment. Recent legislation aimed phasing out legacy AFFF and transitioning to PFAS free alternatives and for removing PFAS from food packaging will help to achieve this goal.

In summary, there are numerous regulatory, legal, and economic challenges associated with the investigation of PFAS sources in Rhode Island. Resource limitations are one of the most significant hurdles for implementing such investigations, particularly for private well owners when no viable responsible party exists. RIDEM has developed methodologies and policies for implementing PFAS source investigations, which are aimed at maximizing the utility of any available funding by targeting areas at the highest risk for potential impacts.

13 References

Agency for Toxic Substances and Disease Registry (ATSDR). (2021). Toxicological profile for Perfluoroalkyls. May 2021. chromeextension://efaidnbmnnnibpcajpcglclefindmkaj/https://www.atsdr.cdc.gov/toxprofiles/tp200.pdf

Aquilina-Becker, A. et al., 2020. Uptake and biological effects of perfluorooctane sulfonate exposure in the adults Eastern Oyster (Crassostrea virginica). Arch. Environ. Contam.. 79(3): 333-342.

Consumed Seafood Products from U.S. Markets. J Agricultural and Food Chemistry 70:13545-13553,

Davisville Naval Construction Battalion Center | Superfund Site Profile | Superfund Site Information | US EPA. cumulis.epa.gov/supercpad/cursites/csitinfo.cfm?id=0101430.

EA Engineering, Science, and Technology, Inc., PBC. *Draft Final Site Inspection Report Quonset Point Army Aviation Support Facility North Kingstown, Rhode Island*. Army National Guard G9, Oct. 2023

ECOS, 2023. Processes and considerations for setting State PFAS standards. 84 pages. Available at: https://www.ecos.org/documents/ecos-paper-processes-and-considerations-for-setting-state-pfas-standards-2023-update/ .

“Emerging Chemical Risks in Europe - ‘PFAS.’” *European Environment Agency*, 12 Dec. 2019, www.eea.europa.eu/publications/emerging-chemical-risks-in-europe.

Fenton, Suzanne E, et al. “Per- and Polyfluoroalkyl Substance Toxicity and Human Health Review: Current State of Knowledge and Strategies for Informing Future Research.” *Environmental Toxicology and Chemistry*, U.S. National Library of Medicine, 7 Dec. 2020, www.ncbi.nlm.nih.gov/pmc/articles/PMC7906952/.

Hedgespeth, ML, et al. 2023. Ecological characteristics impact PFAS concentrations in a U.S. North Atlantic food web. Science of the Total Environment 880: article 163302.

Massachusetts Department of Environmental Protection. “Per- and Polyfluoroalkyl Substances (PFAS): An Updated Subgroup Approach to Groundwater and Drinking Water Values.” *Mass.Gov*, MassDEP (Department of Environmental Protection), 26 Dec. 2019, www.mass.gov/info-details/per-and-polyfluoroalkyl-substances-pfas.

National Toxicology Program. NTP Technical Report on the Toxicology and Carcinogenesis Studies of Perfluorooctanoic Acid (CASRN 335-67-1) Administered in Feed to Sprague Dawley (Hsd:Sprague Dawley® SD®) Rats (Revised): Technical Report 598 [Internet]. Research Triangle Park (NC): National Toxicology Program; 2023 Feb. Available from:

https://www.ncbi.nlm.nih.gov/books/NBK560147/ doi: 10.22427/NTP-TR-598

"NJDEP: Division of Science and Research: IGWQC Technical Support and PQL Documents." *Division of Science and Research*, 5 June 2023, dep.nj.gov/dsr/igwqc-technical-support-documents/.

"Our Current Understanding of the Human Health and Environmental Risks ..." *Environmental Protection Agency*, 7 June 2023, www.epa.gov/pfas/our-current-understanding-human-health-and-environmental-risks-pfas.

"Per- and Polyfluoroalkyl Substances (PFAS)." *CT.Gov*, Department of Public Health, portal.ct.gov/DPH/Environmental-Health/PFAS/PFAS#healthInfo.

Per- and Polyfluoroalkyl Substances Chemical Action Plan - Washington, Hazardous Waste and Toxic Reduction Prgram- Washington State Department of Ecology, Sept. 2022, apps.ecology.wa.gov/publications/documents/2104048.pdf.

"Per- and Polyfluoroalkyl Substances (PFAS) | US EPA- Proposed PFAS National Primary Drinking Water Regulation." *Environmental Protection Agency*, 14 Mar. 2023, www.epa.gov/sdwa/and-polyfluoroalkyl-substances-pfas.

Preimesberger, Angela. "Water Quality Standards: Human Health Protective Water Quality Criteria ..." *Water Quality Standards*, Minnesota Pollution Control Agency, Jan. 2023, www.pca.state.mn.us/sites/default/files/wq-s6-63a.pdf.

Resolution Consultants. (2018). *PRELIMINARY ASSESSMENT PER- and POLYFLUOROALKYL SUBSTANCES (PFAS) NAVSTA Newport, Rhode Island*. Department of Navy. https://administrative-records.navfac.navy.mil/Public_Documents/MID_ATLANTIC/NEWPORT_NS/N62661_003861_REDACTED.pdf

Resolution Consultants, December 2016. *Evaluation of Potential Sources of Perfluorinated Compounds Former Naval Construction Battalion Center Davisville*

"Review of EPA's Analyses to Support EPA's National Primary Drinking Water Rulemaking for PFAS." *Environmental Protection Agency*, Science Advisory Board, 22 Aug. 2022, sab.epa.gov/ords/sab/f?p=100%3A18%3A10311539418988%3A%3A%3A18%3AP18_ID%3A2601#report.

Rhode Island Department of Environmental Management. *Abbreviated Preliminary Assessment- 100 Reynolds Rad Area*. RIDEM, Sept. 2023.

Rhode Island Department of Environmental Management. *Bradford Printing and Finishing Site Inspection Report*. RIDEM, Apr. 2020.

Rhode Island Department of Environmental Management. *Pre-CERCLA Screening Checklist/Decision Form- Narganst Drive Area/ Ladd Center (Former)*. RIDEM, 20 Apr.

2018.

Rhode Island Department of Environmental Management. *Pre-CERCLA Screening Checklist/Decision Form- Sea Breeze Avenue Area*. RIDEM, 29 June 2022.

Rhode Island Department of Environmental Management. *Site Inspection Report- Carolina Back Road/ Old Shannock Road Area*. RIDEM, Sept. 2020.

Rhode Island Department of Environmental Management. *Site Inspection Report- Trimtown Road/Rockland Road Area*. RIDEM, Aug. 2019.

Rhode Island Department of Environmental Management. *Site Inspection Report- Providence Pike/Farnum Pike Area*. RIDEM, Sept. 2023.

Rhode Island Department of Environmental Management. *Site Reassessment Work Plan for Groundwater, Soil, Surface Water and Sediment Sampling- Cooks Landfill*. RIDEM, Sept. 2022.

Ruffle, B et al., 2020. Perfluoroalkyl substances in US market basket fish and shellfish. Environ. Res. 190: article 109932.

Tetra Tech, March 2023. Final Fifth Five-Year Review Report, Naval Construction Battalion Center Davisville

Tetra Tech. (2020). *Final Sampling and Analysis Plan (Field Sampling Plan and Quality Assurance Project Plan) for Naval Station Newport Environmental Restoration Program Basewide Per- and Polyfluoroalkyl Substances Phase 1 Site Inspection*. Department of Navy. https://administrative-records.navfac.navy.mil/Public_Documents/MID_ATLANTIC/NEWPORT_NS/N62661_004445_REDACTED.pdf

US EPA. “Key EPA Actions to Address PFAS.” *Www.epa.gov*, 13 Mar. 2018, www.epa.gov/pfas/key-epa-actions-address-pfas.

Weston. Final Uniform Federal Policy Quality Assurance Project Plan Remedial Investigation – Project 09 Former Charlestown Naval Auxiliary Landing Field, Mar. 2023.

Weston & Sampson, *PFAS Source Investigation Report, Oakland Association Water District, Burrillville, Rhode Island*, Apr. 2018.

Wood Environmental & Infrastructure Solutions, Inc. *Phase II Environmental Site Assessment Report- Bradford Printing & Finishing, LLC*. Wood Environmental & Infrastructure Solutions, Inc., 20 Sept. 2018.

Young, W. 2022. Analysis of Per- and Poly(fluoroalkyl) Substances (PFASs) in Highly

Appendix A

The following table represents an intensive research effort of PFAS containing products and uses in consumer, industrial and commercial settings. This table is a compilation of information obtained from US Federal sources (USEPA, ATSDR, TSCA, DOD, DOE, FDA, CDC, etc.) as well as corresponding entities in other countries, information reported by various states, industrial sources, academic sources, and credited organizations composed of federal, state, private, and academic members. When possible, the function of the PFAS component is listed as this and will provide valuable information concerning other products and uses, yet to be identified, which may contain PFAS.

While the table does note certain PFAS compounds or PFAS classes for certain products and uses, it does not list all specific PFAS compounds and classes associated with a specific product. This was not included due to a number of factors including:

- The list of specific PFAS for a particular application can be extensive.
- PFAS containing products may have different PFAS compounds depending upon the formulation employed by the particular manufacture. There were eleven different manufacturers of Aqueous Film Forming Foams (AFFF) firefighting foams. Forensic analysis has revealed that certain AFFF formulations contained dozens of different PFAS compounds while others contain hundreds of different PFAS compounds.
- The spectrum of PFAS chemicals which underwent analysis varied depending upon the particular forensic analysis being performed, and as such, any reported PFAS contaminant observed may not be representative of all of the PFAS contaminants present, nor may it represent the major PFAS component. As an illustration, in the forensic analysis of certain products, the total concentration of PFAS identified using the current standard analysis of approximately forty PFAS compounds revealed that these compounds only represented a few percent of the total PFAS present based upon total organic fluorine analysis.

- Finally, for a number of products, forensic analysis was not conducted and the presence of PFAS was determined by manufacturing information, which reference PFAS as a component of the product. Typically, this reference is general in nature, and due to proprietary protection does not provide the exact PFAS makeup.

Application Category/Subcategory	Function of PFAS	PFAS Properties
Aerospace/Aviation - *Industrial, Commercial*		
- Phosphate ester-based brake and hydraulic fluids	Corrosion protection Hydraulic fluid additives made from PFSA salts to prevent evaporation, fires, and corrosion	Altering the electrical potential at the metal surface
- Gyroscopes	Flotation fluids in gyroscopes	
- Wire and cable	High-temperature endurance, fire resistance, and high-stress crack resistance	Non-flammable polymers, stable
- Turbine-engine	Use as lubricant	Corrosion resistant, stable, non-reactive, operate at a wide temperature range
- Turbine-engine	Use as elastomeric seals	Operate at a wide temperature range
- Thermal control and radiator surfaces	Reject waste heat	Survival over a wide operating temperature range, low solar absorbance, high thermal emittance, and freedom from contamination by outgassing
- Coating	Protect underlying polymers from atomic oxygen attack	Non-reactive, very stable
- Propellant system	Elastomers compatible to aggressive fuels and oxidizers	Non-reactive, very stable
- Jet engine/satellite instrumentation	Use as lubricant	Long-term retention of viscosity, low volatility in vacuum and their fluidity at extremely low temperatures
Mechanical components made of fluoropolymers (such as PTFE and PFA tubing, piping, seals, gaskets, and insulators)	High-temperature endurance, fire resistance, and high-stress crack resistance	Nonflammable, non-degradable structural components
Automotive - *Industrial, Commercial, Domestic*		
- Car body	Weather resistance paint, no-wax brilliant topcoat	Low surface tension

Application Category/Subcategory	Function of PFAS	PFAS Properties
- Automotive waxes	Aid spreading, improve the resistance of the polish to water and oil	Lower the surface tension of the wax, oleophobic
- Windshield wiper fluid	Prevent icing of the wind shield	
- Car body	Light, stable	Beneficial weight-to-surface ratio, stable
- Engine and steering system	Polymeric PFAS are used as sealants and bearings	Operate at a wide temperature range, non-reactive
- Engine oil coolers	Heat transfer fluid	Good heat conductivity
- Cylinder head coatings and hoses	Increase the fuel efficiency	
- Cylinder head coatings and hoses	Reduce the fugitive gasoline vapor emissions	Low surface tension
- Electronics	Cables and wires	High-temperature endurance, fire resistance
- Fuel lines, steel hydraulic brake tubes	Corrosion protection	Non-reactive, stable
- Interior	Dirt repellent in carpets and seats	Low surface tension, oleophobic
- Brake pad additives		
Biotechnology *(Industrial, Commercial)*		
- Cell cultivation	Supply of oxygen and other gases to microbial cells	Great capacity to dissolve gases
- Ultrafiltration and microporous membranes	Prevent bacterial growth	
Building and construction **-** *Commercial, Domestic*		
Architectural membranes either as *a component* of or as a *coating* on Air Emission filters, caulks, doors, sealants, shutters, siding, windows roofing, roof fabric, roofs, fabrics, *metal, stone,*	Resistance to weathering, dirt repellent, light, increase strength.	Oleophobic and hydrophobic, low surface tension, beneficial weight-to-surface ratio
Glass (specialty) tall buildings, overhead/roof glass, etc.	Transparent to both UV and visible light and/or block UV light, resistant to weathering, dirt repellent	Oleophobic and hydrophobic, low surface tension

Application Category/Subcategory	Function of PFAS	PFAS Properties
- Cement additive	Reduce the shrinkage of cement is more weather resistant	Concrete wear content can be reduced while still allowing the cement to be fluid. Cement is more flowable. Used as a surfactant.
Cable and wire Production and Use Industrial, Commercial, Domestic		
Cable and wire insulation and wire material (gaskets hoses)	High-temperature endurance, fire resistance, and high-stress crack resistance	Superior non-flammable polymers, chemical resistance, thermal resistance
Chemical Production *Industrial**,** Commercial*		
- Fluoropolymer processing aid	Emulsify the monomers, increase the rate of polymerization, stabilize fluoropolymers	Fluorinated part is able to dissolve monomers, non-fluorinated part is able to dissolve in water
- Production of chlorine and caustic soda (with asbestos diaphragms cells)	Binder for the asbestos-fiber-based diaphragms	
- Production of chlorine and caustic soda (with fluorinated membranes)	Stable membrane in strong oxidizing conditions and at high temperatures	Stable, non-reactive
- Processing aids in the extrusion of high- and liner low-density polyethylene film	Eliminate melt fracture and other flow-induced imperfections	Low surface tension
- Tantalum, molybdenum, and niobium processing	Cutting or drawing oil	Non-reactive, stable
- Chemical reactions	Inert reaction media (especially for gaseous reactants)	Non-reactive, stable
- Polymer curing	Medium for crosslinking of resins, elastomers, and adhesives	
- Ionic liquids	Raw materials for ionic liquids	
- Solvents	Dissolve other substances	Bipolar character of some of the PFAS

Application Category/Subcategory	**Function of PFAS**	**PFAS Properties**
PFAS	Emulsion polymerization processing aids for fluoropolymers, copolymers and of side chain fluorinated polymers and production of fluorotelomers and flour elastomers	Necessary component
Cleaning Product*s Industrial, Commercial, Domestic*		
Cleaning compositions for hard surfaces, found in cleaners for Alkaline cleaners, Blades and bits, Cams and pulley, Car Body, Concrete, Conveyer Belts, Counter Tops, Floors, Glass, Metal surfaces on planes, Power tools, Rollers (industrial)Winches, Wood.	Enhance wettability	Lower the surface tension of the cleaning product
- Carpet and upholstery cleaners	Provide stain resistance and repel soil	Low surface tension, oleophobic
- Cleaning compositions for adhesives		
- Dry cleaning fluids	Stabilizer, improve the removal of hydrophilic soil. Less aggressive towards fabrics compared to chlorinated counter parts. Dries faster. Initially considered less of a human health risk than chlorinated counterparts.	Hydrophobic and oleophobic, low surface tension Ranges from hydrofluoric ethers to a wide range of PFAS compounds contain different functional groups.
- Cleaning of reverse osmosis membranes	Remove calcium sulphate	
Coatings, paints, and varnishes *Industrial, Commercial, Domestic*		
- Paints	Emulsifier for the binder, dispersant for the pigments, wetting agent	Hydrophobic and oleophobic, low surface tension
- Paints	Enhance the protective properties of anticorrosive paints	Non-reactive

Application Category/Subcategory	Function of PFAS	PFAS Properties
- Paints	Antifouling on ships	
- Paints and coatings	Anti-crater, improved surface appearance, better flow and levelling, reduced foaming, decreased block, open-time extension, oil- and water repellency, dirt pickup resistance	Low surface tension, oleophobic
- Paints and coatings	Dispersing Agent, Increases penetration,	Hydrophobic and oleophobic, low surface tension
- Paints and coatings	Antistatic, Anti Fouling,	
- Paints and coatings	Corrosion resistant, resistant to atmospheric agents (UV Light, etc.) and Air Pollution	
- Paints and coatings	Chemical Resistant Corrosives (acid/bases Oxidants, Reducers, etc. Heat and High Pressure	Chemical Stability
- Paints and coatings	Form second coat on a first coat	Low surface tension
- Coatings	Antistick and anticorrosive coatings	Low surface tension, non-reactive
- Coatings	Highly durable and weatherable	Stable, non-reactive
Paints and Coating Materials which contain PFAS include		
Automobile Finishes, Caulks		
Cellulose, Cement, Ceramics		
Chemical Processing Equipment		
Ducts, Impellors, Pipes, Reactor		
Impellors, Pipes, Reactors		
Clear Coat.		
Cook Ware (Industrial Commercial, Domestic),		
Dryer Drums (Commercial)		
Fishing Rods and Reels		
Floor Waxes		
Glass Coating Architectural		
Glass Coating (Automobile		
Windshield, Headlights		
Glass Coating Mirrors		

Application Category/Subcategory	Function of PFAS	PFAS Properties
Glass Coatings Lenses		
Guns. Gouts,		
Plastics and Elastomers		
Polishes, Resins Sealers		
Stains, Vanishes, Waxes, Wood		
Electroplating (Metal Plating including electroless plating) Industrial, Commercial		
Electroless plating	Disperses the pitch fluoride in the plating solution	Low surface tension
- Chrome plating	Wetting Agent, mist suppression prevents the evaporation of chromium(vi) vapor and surfactants	Lower the surface tension of the electrolyte solution, very stable in strongly acidic and oxidizing conditions
- Nickel plating	Non-foaming surfactant. Mist suppression.	Low surface tension
- Nickel plating	Increase the strength of the nickel electroplate by eliminating pinholes, cracks, and peeling	Low surface tension
- Copper plating	Prevent haze by regulating foam and improving stability, Mist suppression surfactant	Low surface tension
- Tin plating	Help to produce a plate of uniform thickness. Mist suppression surfactant.	Low surface tension
- Alkaline zinc and zinc alloy plating	Mist Suppression	
- Deposition of fluoropolymer particles onto steel	Supported by fluorinated surfactants. Mist suppression	Cationic and amphoteric fluorinated surfactants impart a positive charge to fluoropolymer particles which facilitates the electroplating of the fluoropolymer
Electronic Sector Production and Use *Industrial, Commercial*		

Application Category/Subcategory	**Function of PFAS**	**PFAS Properties**
- Testing of electronic devices and equipment	Inert fluids for electronics testing	Non-reactive
- Heat transfer fluids	Cooling of electrical equipment	Good heat conductivity
- Solvent systems and cleaning	Form the basis of cleaning solutions	Non-flammable, low surface tension
- Carrier fluid/lubricant deposition	Dissolve and deposit lubricants on a range of substrates during the manufacturing of hard disk drives	
- Etching of piezoelectric ceramic filters	Etching solution	Acidic
Fluoropolymers (such as PVDF and PTFE) used in	Wide range of reasons for application	Wide range of functions.
insulators, solder sleeves, printed circuit boards,		
cell phones, computers, speakers, and transducers		
- Multilayer circuit board	Bonding ply composition	Low dielectric constant, low dissipation factor
Electronic Industry - Electronical devices		
- Printed circuit boards	Use fiber-reinforced fluoropolymer layer	Low dielectric constant
- Capacitors	Separation of high voltage components (dielectric fluid)	High dielectric breakdown strength, non-flammable
- Acoustical equipment	Provide an electrical signal in response to mechanical or thermal signals	Piezoelectric and pyroelectric properties
- Liquid crystal displays (LCDs)	Provide the liquid crystal with a dipole moment	Dipoles
- Liquid crystal displays (LCDs)	Polymeric PFAS provide moisture sensitive coating for displays	Hydrophobic
- Light management films in flat panel display	Reduced static electricity build-up and dust attraction during fabrication	Low dielectric constant
Electronic Devices found to contain PFAS		
Communication Facilities Cables and Wires, Cell Phones		

Application Category/Subcategory	Function of PFAS	PFAS Properties
Circuit Boards, Coaxial Cabe Insulation, Computer Cables		
Digital Cameras, Disk Drives,		
Electronic Wires Insulation, Floppy Disk, Low Frequency Plenum Cables, Magnetic Recording Devices, Magnetic Tape, Optical Fibers, Printers		
Radar Systems, Satellite Communications, Scanners		
Electronic Industry - Semiconductor industry		
- Photoresist (itself)	Photoresist matrix, changes solubility when exposed to light	
- Photoresist (photosensitizer)	Increase the photosensitivity of the photoresist	
- Photoresist (photo-acid generator)	Generate strong acids by light irradiation	Able to generate strong acids
- Photoresist (quencher)	Controlling the diffusion of the acid to unexposed region	
- Antireflective coating	Provide low reflectivity	Low refractive index
- Developer	Facilitate the control of the development process	
- Rinsing solution	Rinsing the photoresist to remove the developer	Low surface tension
- Etching	Wetting agent	Low surface tension
- Etching	Reduce the reflection of the etching solution	Low refractive index
- Etching	Etching agent in dry etching	Strong acids
- Cleaning of silicon wafers	Etch cleaning	Strong acids
- Cleaning of integrated circuit modules	Remove cured epoxy resins	
- Cleaning vapor deposition chamber	Remove dielectric film build up	Generation of reactive oxygen species
- Wafer thinning	Non-stick coating composition on carrier wafer	Low surface tension
- Vacuum pumps	Working fluid	Stable, non-reactive
- Technical equipment in contact with process chemical or reactive plasma	Polymeric PFAS are used in inert modes, pipes, and elastomers	Stable, non-reactive

Application Category/Subcategory	**Function of PFAS**	**PFAS Properties**
Energy sector		
Dielectric Fluids, Dielectric Gases	Perfluorinated ethers and other PFAS	Superior in breakdown strength, dielectric strength, power factor, corona formation resistant under high pressure and temperature, heat exchange
Dielectric uses include		
Capacitors		
Circuit Breakers		
Insulated Lines Gas/Liquid		
Transformers		
Switch Gear		
- Solar collectors and photovoltaic cells	High vapor barrier, high transparency, great weatherability and dirt repellency	Oleophobic and hydrophobic, low surface tension
- Photovoltaic cells	Adhesives with PFAS hold mesh cathode in place	Lower the surface tension of the adhesive
- Wind mill blades	Coating	High weatherability
- Coal-based power plants	Polymeric PFAS filter remove fly ash from the hot smoky discharge	Stable, non-reactive
- Coal-based power plants	Separation of carbon dioxide in flue gases	Lower the surface tension of the aqueous solution
Alkaline Magnesium Batteries	Cathode treated with PFA	
Fuel Cells	Cell membranes poly (perfluoro sulfonic acid) ionomer membranes tetrafluoroethylene backbone perfluorinated vinyl ethers	Increase thermal, mechanical, and electrochemical stability
- Lithium batteries	Binder for electrodes (PVDF)	Almost no reactivity with the electrodes and electrolyte
- Lithium batteries	Prevent thermal runaway reaction	Good heat absorption of first layer and good heat conductivity of second layer

Application Category/Subcategory	Function of PFAS	PFAS Properties
- Lithium batteries	Improve the oxygen transport of lithium–air batteries	Great capacity to dissolve gases
- Lithium batteries	Electrolyte solvents for lithium–sulfur batteries fluorine-substituted ethers, amides, esters, carbonates, phosphate esters, and phosphates. Also, perfluoro nitrile compounds Fluorinated Graphite for nonaqueous electrolyte batteries	Bipolar character of some of the PFAS Avoids electrolyte loss increased battery safety
Lead Storage Batteries and Edison Storage Batteries	PFSA additive to electrolyte	Lower surface tension, allows for rapid and complete wetting out and penetration by electrolytes
- Ion exchange membrane in vanadium redox batteries	Polymeric PFAS are used as membranes	Resistance to acidic environments and highly oxidizing species
- Zinc batteries	Prevent formation of dendrites, hydrogen evolution and electrode corrosion due to adsorption onto the electrode surface	Low surface tension, non-reactive, replaces mercury initial consider safer human health alternative
- Alkaline manganese batteries	MnO_2 cathodes containing carbon black are treated with a fluorinated surfactant	
- Polymer electrolyte fuel cells	Polymeric PFAS are used as membranes poly (perfluoro sulfonic acid	Ion conductance
- Power transformers	Cooling liquid/ dielectric properties	Good heat conductivity
- Conversion of heat to mechanical energy	Heat transfer fluids	Good heat conductivity
Energy Sector - Nuclear industry		
- Lubricants for valves and ultracentrifuge bearings in UF6 enrichment plants	PFAS are used as the lubricants	Stable to aggressive gases
Energy Sector - Oil & gas industry		
- Drilling fluid	Foaming agent	Low surface tension

Application Category/Subcategory	**Function of PFAS**	**PFAS Properties**
- Drilling – insulating material for cable and wire	Polymeric PFAS are used as insulating material	Withstand high temperatures
- Chemical driven oil production	Increase the effective permeability of the formation	Low surface tension
- Chemical driven oil production	Foaming agent for fracturing subterranean formations	Low surface tension
- Chemical driven oil production	Heavy crude oil well polymer blocking remover	
- Chemical driven gas production	Change low-permeability sandstone gas reservoir from strong hydrophilic to weak hydrophilic	Hydrophobic and oleophobic properties
- Chemical driven gas production	Eliminate reservoir capillary forces, dissolve partial solid, dis-assemble clogging, increase efficiency of displacing water with gas	Lower surface tension of the material
- Oil and gas transport	Lining of the pipes is made out of polymeric PFAS	Non-reactive (corrosion resistant)
- Oil and gas transport	Reduce the viscosity of crude oil for pumping from the borehole through crude oil-in-water emulsions	Hydrophobic and oleophobic properties
- Oil and gas storage	Aqueous layer with PFAS prevents evaporation loss	Lower the surface tension of the aqueous solution
- Oil and gas storage	Floating layer of cereal treated with PFAs prevents evaporation loss	Low surface tension
- Oil containment (injection a chemical barrier into water)	Prevents spreading of oils or gasoline on water	
- Oil and fuel filtration	Polymeric PFAS are used as membranes	Non-reactive (corrosion resistant)
Firefighting Foam Production and Use *Industrial, Commercial*		
- Fluoroprotein (FP) foams	Fuel repellents	Low surface tension
- Film-forming fluoroprotein (FFFP) foam	Film formers, foam stabilizers	Lower the surface tension of water
- Alcohol-resistant film forming fluoroprotein (AR-FFFP) foam	Film formers, foam stabilizers	Lower the surface tension of water

Application Category/Subcategory	**Function of PFAS**	**PFAS Properties**
- Aqueous film-forming foams (AFFF)	1965-1975 Perfluorinated carboxylic acids by electrochemical fluorination. 1970-2002 Perfluorooctanesulfonyl fluoride (POSF)-based AFFF 1975-2004 fluorotelomer-based AFFF	Lower the surface tension of water
- Alcohol-resistant aqueous film forming foam (AR-AFFF)	Foam stabilizers	Low surface tension
Firefighting Equipment and Personnel Safety Gear	Fluoropolymers and PFCA, PFSAs, etc. used as water, oil and stain repellents, vapor suppression for flammable liquids	Thermal stability, chemical resistant
Dry Fire Extinguishing Agents	Powder is non wettable by hydrocarbons	
Road Dust Suppression	Out of date AFFF used to suppress dust on dirt roads	Consider environmental safer than oil or other products
Firefighting Foam sources include		
Airports, Department of Defense Facilities, Electric Power Generation (Coal, Petroleum, Gas), Fire Stations, Fire Training, Fire Incidents, Flammable Chemical Storage,		
Mineral, Oil and Gas Extraction Coal Mining, Petroleum Production (Exploration Storage and Refining), Production of Aluminum, Batterie, Bitumen, Brewing and Distilling, Coal Works, Dangerous Goods, Explosives, Paint, Polishes, Adhesives, Transportation, Ferries, Tunnels		
Flame retardants Production and Use *Industrial, Commercial*		
- Polycarbonate resin	Flame retardants	Non-flammable

Application Category/Subcategory	**Function of PFAS**	**PFAS Properties**
- Other plastic	Flame retardants	Non-flammable
Floor Covering Production and Use *Industrial, Commercial, Domestic*		
Floor covering including carpets and floor polish	Improve wetting and levelling	Low surface tension
- Soil-release finishes for carpets	Provide water and oil repellence, stain resistance and soil release	Low surface tension, hydrophobic and oleophobic
- Resilient linoleum		
- Laminated floor covering		
- Floor polish	Improve levelling and wetting	Low surface tension
Food production *Industrial, Commercial, Domestic*		
- Wineries and dairies	Final filtration before bottling with polymeric PFAS	Resist degradation
Machinery and equipment	coatings both high and low temperature ranging from industrial food processing machinery to domestic cook ware	Superior thermal properties, stick resistant, anticorrosion Low surface tension, non-reactive, Polymeric PFAS form moisture barrier film
Packaging, wrappers	Polymeric PFAS, fluorotelomer based alcohols, phosphate ester salts of PASF, etc. form moisture oil/grease/nonstick barrier film	Superior thermal stability, water, oil, grease does not stick resistivity
Glass Production Treatment Industrial*, Commercial, Domestic*		
- Surface treatment	Make glass surfaces hydrophobic and oleophobic	Hydrophobic and oleophobic
- Surface treatment	Prevents misting of glass	Hydrophobic
- Surface treatment	Dirt-repellent	Low surface tension
- Surface treatment	Fire-or weather resistant	Non-flammable, stable
- Etching and polishing	Increase the speed of etching, improve wetting	Low surface tension
- Drying as production step in glass finishing	Solvents in solvent displacement drying	Low surface tension

Application Category/Subcategory	**Function of PFAS**	**PFAS Properties**
Leather Industrial, Commercial, Domestic		
- Manufacturing of genuine leather	Improve the efficiency of hydrating, pickling, degreasing, and tanning	
- Repellent treatment (genuine leather)	Provide water and oil repellence, stain resistance and soil release	Hydrophobic and oleophobic, low surface tension
- Manufacturing of synthetic leather	Polymer melt additives that impart oil and water repellency to the finished fibers	Hydrophobic and oleophobic
- Shoe brighteners	Improve the levelling of shoe brighteners	Low surface tension
- Impregnation spray	Provide water and oil repellence, stain resistance and soil release	Low surface tension
Lubricants Industrial, Commercial, Domestic		
Lubricants and greases	Form a thick oil layer and reduced wear	Non-reactive, non-flammable, operate also at high temperatures, do not form sludge or varnish
Metal Products Manufacture (Industrial)		
- Manufacture of basic metals	Inhibit the formation of acid mist during the electrowinning of copper	Lower the surface tension of the aqueous solution
- Manufacture of fabricated metal products		
- Pickling of steel wires	Acid-pickling promoter	
- Treatment of coating of metal surfaces	Promote the flow of metal coatings, prevent cracks in the coating during drying	Lower the surface tension of the coating
- Treatment of coating of metal surfaces	Corrosion inhibitor on steel	Non-reactive
- Etching of aluminum in alkali baths	Improving the efficient life of the alkali baths	
- Phosphating process for aluminum	Fluoride-containing phosphating solutions help to	

Application Category/Subcategory	Function of PFAS	PFAS Properties
	dissolve the oxide layer of the aluminum	
- Cleaning of metal surfaces	Disperse scum, speed runoff of acid when metal is removed from the bath, increase the bath life	
- Water removal from processed parts	Solvent displacement	Low surface tension
Mining Sector Industrial		
- Ore leaching in copper and gold mines	Increase wetting of the sulfuric acid or cyanide that leaches the ore	Low surface tension
- Ore leaching in copper and gold mines	Acid mist suppressing agents	Low surface tension
- Ore floating	Create stable aqueous foams to separate the metal salts from soil	Low surface tension
- Separation of uranium contained in sodium carbonate and/or sodium bicarbonate solutions by nitrogen floatation	Improve the separation	
- Concentration of vanadium compounds	Destruction of the mineral structure, increases the specific surface area and pore channel thus facilitating vanadium leaching	Acidity
Medical Sector *Industrial, Commercial*		
- Electronic devices that rely on high frequency signals (defibrillators, pacemakers, cardiac resynchronization therapy (CRT), positron-emission tomography (PET) and magnetic resonance imaging (MRI) devices)	High dielectric insulators	High dielectric breakdown strength
- Video endoscope	Use in charge-coupled device color filters	
- Microbubble-based ultrasound contrast agents	Fluorinated gas inner core, which provides osmotic stabilization and contributes to interfacial tension reduction	Low solubility in aqueous media (dissolve more slowly)

Application Category/Subcategory	Function of PFAS	PFAS Properties
- X-ray imaging	Contrast enhancement agents	Radio-opaque
- Magnetic resonance imaging	Contrast agent	Lack of a 19F endogenous background signal *in vivo* and high magnetic resonance sensitivity of 19F atoms
- Proton and 19F NMR imaging	Contrast agents	Lack of fluorine in organs and tissue
- Computed tomography and sonography	Contrast agents	Lack of fluorine in organs and tissue
- Radio-opaque materials	Polymeric PFAS has been used	Radio-opaque
- Surgical drapes and gowns	Improve water-, oil- and dirt-resistance	Hydrophobic and oleophobic, low surface tension
- X-ray films	Wetting agents, emulsion additives, stabilizers, and antistatic agent	Low surface tension, low dielectric constant
- Dispersant	Facilitate the dispersion of cell aggregates	Low surface tension
- Contact lenses	Raw material	
- Retinal detachment surgery and proliferative vitreoretinal	Endotamponade gases	High specific gravity, low surface tension, and low viscosity
- Retinal detachment surgery and proliferative vitreoretinal	Intraoperative tool during vitreoretinal surgery	High specific gravity, low surface tension, and low viscosity
- Eye drops	Delivery agent	Unique combination of polarity and amphiphility
- Filters, tubing, O-rings, seals, and gaskets in dialysis machines	Made out of polymeric PFAS	Low surface tension
- Dialysis membranes	Made out of polymeric PFAS	Low surface tension
- Catheter, stents, and needles	Provide low-friction and clot-resistant coatings	Low surface tension
- Surgical patches and vascular catheter	Use of polymeric PFAS	
- Blood transfer and artificial blood	Oxygen carrier	Great capacity to dissolve gases
- Organ perfusion	Oxygen carrier	Great capacity to dissolve gases

Application Category/Subcategory	**Function of PFAS**	**PFAS Properties**
- Percutaneous transluminal coronary angioplasty	Oxygen carrier	Great capacity to dissolve gases
- Toothpaste	Enhances fluorapatite formation and inhibits caries	Low surface tension
- Dental floss	Allows the narrow ribbon to slip easily between close-pressed teeth	Low surface tension
- UV-hardened dental restorative materials	Improve the wetting of the set materials	Low surface tension
- Ventilation of respiratory airway		
- Anesthesia	Polymeric PFAS is used to dry or humidify breath	Hydrophobic
- Artificial heart pump	Blood compatible and durable	Non-reactive, stable
- Wound care	Cleaning burn residues	Dissolve hydrocarbon
Contact Lens	Wetting agent	Low surface tension
Bags, Blood contact surfaces		
Breast prostheses and any other device which can act to replace soft tissue		
Cannulae, Catheters, Containers,		
Device surface coatings		
Drainage tubes, Endoprostheses		
Fabric liners, Gaskets, Grafts, Guidewires, Hernia patches, Hypo tubes, Inhaler propellant,		
Joint replacement or repair		
Joint spacers, Lenses, Mandrels, Needles, Needles cannulas, Oral capsules, Oral tablets		
Pericardial patches, Ports, Seals, Shunts, Space-filling, or augmentation devices		
Synthetic lattices in forming a scaffold, Synthetic spinal disks		
Transdermal patches, Tubes, Vascular grafts, Wood surfaces or clean room, Wound Care		

Application Category/Subcategory	**Function of PFAS**	**PFAS Properties**
Medical - Pharmaceutical industry		
- Reaction vessels, stirrers, and other components	Use of polymeric PFAS instead of stainless steel	
- Ultrapure water systems	Polymeric PFAS are used as filter	Low surface tension
- Packaging	Polymeric PFAS form moisture barrier film	Hydrophobic
- Manufacture of "microporous" particles	Processing aid	
Munitions Industrial, Commercial, Domestic Military		
Ammunition, Guns, Propellants	PTFE, fluoropolymers, Viton, PFCAs, PCTFE other PFAS Fluoropolymers improve lubrication (ex-immunization lubricant contained a 20 percent (%) fluorocarbon telomer dispersion in 1,1,2-trichloro-1,2,2-trifluoroethane.), antidegradation of metals in weapons, tungsten iron fluoropolymers replace lead, fluoropolymer use in flare, warhead, incendiaries, etc. PFCAs and others used in energetics, ignition pyrolite, coating of reactive metal powders, combustion modification, fillers, and binders.	Lubrication, antidegradation, replacement of lead, modification of combustion and other processes, reduce the likelihood of an unplanned explosion due to shock; enable long-term storage without degradation of the polymer
Energetics	Magnesium, Telflo (PTFE Viton ((vinylidene fluoride, hexafluoropropylene Copolymer known at MTV)	Favorable properties for energetic use. Increased density and volatility, lowers melting point omcreaes impact
Oxidizers	Fluorinated Oxidizers replace Metal Oxidizers	Favorable properties, higher heat formation of, high vapor pressure, generation of more gases

Application Category/Subcategory	Function of PFAS	PFAS Properties
Coatings	coat reactive metal powder to protect pyrophoric compositions	
Binders (explosvie0	Fluorinated Polymers are cued as binders for explosives	Provide better mechanical properties and thermal stability
Bullets	Fluoropolymer iron tungsten used as a replacement for lead	Nontoxic
Other Munitions which contain PFAS include		
Agent Defeat Warheads (neutralize biological and chemical warfare agents)		
Aircraft Counter Measure Flare		
Buller/Shells Tracers		
Document Destruction		
Gas generators igniter pyrolite		
Ignition pellets		
Incendiaries		
Mine disposal torches		
Propellant charges igniter pyrolite		
Propellants		
Rocket motors igniter pyrolite		
Shot for shotguns		
Smoke grenades		
Target augmentation flares		
Tracking flares		
Underwater cutting torches		
Underwater explosives		
Underwater flares		

Application Category/Subcategory	Function of PFAS	PFAS Properties
Paper and Packaging Production and Use *Industrial, Commercial, Domestic*		
Packaging, wrappers	Polymeric PFAS, fluotelomer based alcohols, phosphate ester salts of PASF, etc. form moisture oil/grease/nonstick barrier film to paper, paperboard molded paper product, antireflective coatings,	Superior thermal stability, water, oil, grease does not stick, resistivity
- Manufacturing of paper	Release agent for paper-coating compositions	Low surface tension
Food Packing Containing PFAS include		
Anticorrosion liner		
Baking paper		
Butter wrappers		
Carbonless forms		
Coated raw paper		
Folding cartons		
Food plates, bowls, etc.		
General liner and flute		
Kraft paper		
Masking papers		
Microwave popcorn bag susceptors		

Application Category/Subcategory	**Function of PFAS**	**PFAS Properties**
Neutral liner		
Paper combined with metal		
Pet food bags		
Pizza boxes		
Raw paper for plaster board		
Take out food containers		
Food warp, including fast food wraps		
Wallpaper		
Wood containing paper		
Personal Care Products Production and Use *Industrial, Commercial, Domestic*		
- Cosmetics	Emulsifiers, lubricants, or oleophobic agents	Hydrophobic, low surface tension
- Cosmetics	Make creams *etc.* penetrate the skin more easily	
- Cosmetics	Make the skin brighter	
- Cosmetics	Make the skin absorb more oxygen	Great capacity to dissolve gases
- Cosmetics	Make the makeup more durable and weather resistant	Hydrophobic and oleophobic, stable, non-reactive
- Cosmetics	Effect Product consistency and texture	
- Cosmetics	Produce long lasting effects	Chemical stability
- Cosmetics	Improve oil and water resistance	Hydrophobic and oleophobic, stable, non-reactive
Contact Lens	Wetting agent	Low surface tension
- Dental floss	Allows the narrow ribbon to slip easily between close-pressed teeth	Low surface tension
- Hair-conditioning formulations	Enhance wet combing and render hair oleophobic	
Razors	Polymeric PFAS coatings	
Toothpaste, Dental Cream, Tooth Powders	Enhances fluorapatite formation and inhibits cavities, enhance design attributes	Low surface tension

Application Category/Subcategory	**Function of PFAS**	**PFAS Properties**
Other Personnel Products include:		
Acne Treatment, Blush, Brow (eyeliner, eyeshadow, mascara)		
Blush, Foundation, Hair Conditioner, Hair Creams		
Hair Shampoos, Hand Sanitizer, Lip Stick, Lip Balms, Lotions. Nail Polish, Shaving Creams, Sin Screens, Waxes		
Pesticides Production and Use *Industrial, Commercial, Domestic*		
- Insecticide against the common housefly and carmine mite	Suffocation of the insect by the adsorbed fluorinated surfactant	
- Insecticide against ants and cockroaches		
- Formulation additives	Anti-foaming agent	Low surface tension
- Formulation additives	Dispersant, facilitate the spreading of plant protection agents on insects and plant leaves	Low surface tension
- Formulation additives	Dispersant, increase uptake by insects and plants	Low surface tension
- Formulation additive	Wetting agent for leaves	Low surface tension
Photographic Sector Industrial *Commercial, Domestic*		
- Processing solutions	Antifoaming agent	Lower the surface tension of the solution
- Processing solutions	Prevent formation of air bubbles in the solution	Lower the surface tension of the solution
- Photographic materials, such as films and papers	Wetting agents, emulsion additives, stabilizers, and antistatic agent	Low surface tension, low dielectric constant
- Photographic materials, such as films and papers	Prevent spot formation and control edge uniformity in multilayer coatings	Low surface tension
- Paper and plates	Anti-reflective agents	Low refractive index

Application Category/Subcategory	**Function of PFAS**	**PFAS Properties**
*P**ipes, pumps, fittings, and liners production and use*** *Industrial, Commercial*		
- Pipes, pipe plugs, seal glands, pump parts, fasteners, fittings, and liners	Polymeric PFAS are used for these applications	Stable, non-reactive, low surface tension, hydrophobic and oleophobic
- Working fluid for pumps in the electronics industry	Stable to reactive gases and aluminum chloride	Extremely stable, non-reactive
***Plastic and Rubber Productio**n* *Industrial, Commercial*		
- Separation of mode and mode material	Mode release agent	Hydrophobic and oleophobic properties
- Separation of mode and mode material	Reduce imperfections in the mode surface	Low surface tension
- Foam blowing	Foam blowing agent	Low surface tension
- Polyol foams	Foam regulator	10.5.3.1.1.1.1 lower the surface tension of the foam
- Polymer processing aid	Increase processing efficiency and quality of polymeric compounds	Lower the surface tension of the polymeric products
- Etching of plastic	Wetting agent	Low surface tension
- Production of rubber	Antilocking agent	Low surface tension
- Fluor elastomer formulation	Additive in curatives	
- Plastic	Polymeric PFAS micro powder as additive	
- Thermoplastic	Plasticizer	
- Bonding of rubber to steel	Allow adhesiveness bonding	Low surface tension
- Rubber and plastic	Antistatic agent	Low dielectric constant
- Resin	Improve weatherability and elasticity	Non-reactive, stable
- Polycarbonate resins	Flame retardant for polycarbonate resins	Non-flammable
PFAS found in plastic, Resins and Rubber include		

Application Category/Subcategory	Function of PFAS	PFAS Properties
Aerospace equipment, Agricultural chemical containers, Architectural coatings, Architectural fabrics, Caustic potash electrolyze membranes, Caustic soda electrolyze membranes		
Chemical containers,		
Chemical handling parts		
Chemical plant equipment		
Chlor-alkali cell membranes		
Citrus product containers		
Cleaning chemical containers, household, medical, and industrial		
Cords, Corrosive liners Electrical cable insulation and jacketing		
Electronic chemical containers		
Emission control apparatus membranes		
Expansion joints/bellows, Fishing Line, Flavor, fragrance, and essential oil containers, Food processing equipment,		
Fuel cell membranes, Gaskets, Geotextiles, High Purity Piping		
Hydrocarbon containers and tanks		
Instrument strings, Linings (ex. vessels, valve, pipes), Medical processing equipment, Oil, and gas drilling equipment		
Oil and gas drilling equipment		
Paper and pulp industry components		
Pesticide containers,		
Pharmaceutical processing components		
Photography chemical containers		

Application Category/Subcategory	Function of PFAS	PFAS Properties
Polish containers, Racquet strings, Ropes, Seals, Semiconductor piping		
Sewing thread,		
Stone and tile care product containers		
Sutures. Tubing, Water Electrolyte Membranes, Was Containers,		
Printing (inks) production and use *Industrial, Commercial, Domestic*		
- Toner and printer ink	Enhance ink flow and levelling, improve wetting, aid pigment dispersion	Low surface tension
- Toner and printer ink	Impart water resistance to water-based inks	Hydrophobic
- Ink-yet recording heads	Make them ink repellent	Low surface tension
- Recording and printing paper		
- Lithographic printing plates		
Refrigerant Systems Production and Use *Industrial, Commercial, Domestic*		
- Refrigerant fluid system	Heat transfer fluid	Good heat conductivity
- Refrigerant compressor	Lubricants	Non-flammable
Sealants and Adhesives Production and Use *Industrial, Commercial, Domestic*		
- Sealants	Can be made out of polymeric PFAS	Operate at a wide temperature range, non-reactive, stable
- Silicone rubber seals	Prevents soiling	Low surface tension, hydrophobic and oleophobic
- Adhesives	Improve levelling, spreading, and the penetration of the adhesive into the pore structure of the substrates	Low surface tension

Application Category/Subcategory	**Function of PFAS**	**PFAS Properties**
Textile Production, and Use *Industrial, Commercial, Domestic*		
- Dyeing and bleaching of textiles	Wetting agent	Low surface tension
- Dyeing process using Sulphur dyes	Antifoaming agent	Low surface tension
- Dye transfer material	Release agent	Low surface tension
- Textile treatment baths	Antifoaming agent	Low surface tension
- Fiber finishes	Emulsifying agent	Hydrophobic and oleophobic properties
- Breathable membranes	Polymeric PFAS are used as membranes	High permeability to water vapor, but resist passage of liquid water
- Long-lasting durable water repellent finish	Provide water and oil repellence, stain resistance and soil release	Lower surface tension of the fabric, hydrophobic and oleophobic properties
Aftermarket apparel, carper, upholstery, etc. protection	Provide water and oil repellence, stain resistance and soil release	Low surface tension, hydrophobic and oleophobic
PFAS found in textiles include		
Automobile interior parts		
Awning textiles, Carpets, Clothing apparel general		
Clothing apparel worker stain		
and oil resistant, Firefighting protection clothing and gear		
Gloves, Jackets, Medical garments, Outdoor Textiles, Sails, Shoes, Tents, Umbrellas, Upholstery		
Watchmaking industry Production *Industrial*		
- Lubricants	Form an oil layer and reduced wear	Non-reactive (do not oxidize, resistant to corrosion)
- Drying as production step after aqueous cleaning	Solvents in solvent displacement drying	Low surface tension

Application Category/Subcategory	**Function of PFAS**	**PFAS Properties**
Wood industry Production and Use *Industrial, Commercial*		
- Drum filtration during bleaching	The used coarse fabric is made out of polymeric PFAS	Stable
- Coating for wood substrate	Clear coating is made out of polymeric PFAS	Stable, non-reactive
- Wood particleboard	Part of adhesive resin	Low surface tension
Other use areas		
Aerosol propellant	Aerosol propellant	Non-flammable, stable, non-reactive
Air conditioning	Working fluid	Non-flammable, stable, non-reactive
Antifoaming agent	Prevent foaming	Low surface tension