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AIR FORCE CIVIL ENGINEER CENTER
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SUBJECT: Critical Process Analysis (CPA) at Stewart Air National Guard Base (ANGB), Stormwater Infrastructure

The enclosed CPA Phase 1 Technical Memorandum for Stewart ANGB Stormwater Infrastructure provides an independent assessment of site conditions and recommended approaches to provide the technical basis for and recommendations to address per- and polyfluoroalkyl substances (PFAS) contamination migration via stormwater infrastructure at Stewart ANGB. A technical team of environmental remediation experts and specialists from the AFCEC Restoration Technical Support Branch (AFCEC/CZTE) and Noblis conducted the assessment during 13–15 January 2024.

During the evaluation, the CPA Team considered the following:

1. Conceptual Site Model Overview
2. Recommendations for Stormwater Sewer Rehabilitation
3. Data Gap Investigation
4. Groundwater Response Action at Southern Boundary

In summary, the CPA Team evaluated response actions for the existing stormwater sewer network and groundwater at the base's southern boundary where highest PFAS concentrations in groundwater are encountered. These actions are intended to prevent releases of contaminated sediment and surface water to Recreation Pond and groundwater discharge to the pond and nearby Silver Stream. The CPA Team recommended rehabilitation efforts for the stormwater sewer network, and recommended a groundwater response action at the southern base boundary to contain the highest PFAS-impacted groundwater and reduce off-base migration.

Refer to the Phase 1 Report Summary and Recommendations in Section 7.0 for more information.

The CPA Team is available to discuss the findings provided in the Phase 1 Report, support you with delivery of information to stakeholders, and provide other follow-up technical support. For tracking purposes, AFCEC/CZTE will contact you in approximately 6 months to 1 year to gather information regarding outcomes from the CPA effort. Please contact me (kent.glover@us.af.mil) or Mr. Kurt Lee (kurt.lee.3@us.af.mil) if you have any questions or require follow-up support.

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CRITICAL PROCESS ANALYSIS

AFTER ACTION REPORT

STEWART AIR NATIONAL GUARD BASE

STORMWATER INFRASTRUCTURE

PHASE 1 REPORT

MEETING DATE: 13–15 JANUARY 2024

Revised Final

11 July 2024

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Acronyms and Abbreviations

6:2 FTS	6:2 fluorotelomer sulfonic acid
AAR	After Action Report
ANGB	Air National Guard Base
AFCEC	Air Force Civil Engineer Center
AER	anion exchange resin
AFFF	aqueous film forming foam
ASD(EIE)	Assistant Secretary of Defense Energy, Installations, and Environment
bgs	below ground surface
CCTV	closed-circuit television
CFR	Code of Federal Regulations
CIPP	Cured-in-Place Pipe
CPA	Critical Process Analysis
CZTE	Environmental Restoration Technical Support Branch
DGI	Data Gap Investigation
DOD	Department of Defense
EBCT	Empty bed contact time
ERPIMS	Environmental Resources Program Information Management System
ESI	Expanded Site Investigation
EW	extraction well
ft	feet/foot
ft/day	feet per day
F_{oc}	fraction organic carbon
GAC	granular activated carbon
gpm	gallons per minute
HALT	Hydrothermal Alkaline Treatment
HDPE	high-density polyethylene
ISWTS	Interim Surface Water Treatment System
mg/kg	milligram per kilogram
MW	monitor well
ng/kg	nanograms per kilogram
ng/L	nanograms per liter
NYSDEC	New York State Department of Environmental Conservation
O&G	oil and grease
ORP	oxidation-reduction potential
PCB	polychlorinated biphenyl
PDI	pre-design investigation
PFAS	per- and poly-fluoroalkyl substances
PFOA	perfluorooctanoic acid
PFOS	perfluorooctanesulfonic acid
PFHxA	perfluorohexanoic acid
PFHxS	perfluorohexane sulfonic acid
PID	photoionization detector
PLC	programable logic controller
POI	pilot optimization investigation
PVC	polyvinyl chloride
RAB	Restoration Advisory Board
RCRA	Resource Conservation and Recovery Act
RI	Remedial Investigation
RSL	regional screening level
RSSCT	rapid small scale column test
SAFF®20	surface-active foam fractionation
SCWO	Supercritical Water Oxidation
SI	Site Investigation
SIA	Stewart International Airport
SL	screening level
SPDES	State Pollutant Discharge Elimination System
SVOC	semivolatile organic compound
TCLP	Toxicity Characteristic Leaching Procedure
TDS	total dissolved solids
TOC	total organic carbon
TPH-DRO	total petroleum hydrocarbon – Diesel range organics
TPH-GRO	total petroleum hydrocarbon – Gasoline range organics
TS	treatability study
TSS	total suspended solids
UFP-QAPP	Uniform Federal Policy-Quality Assurance Project Plan
USAF	United States Air Force
USEPA	United States Environmental Protection Agency
VOC	volatile organic compound

1.0 Overview and Objectives

A Critical Process Analysis (CPA) is an independent technical evaluation conducted by the Air Force Civil Engineer Center (AFCEC) Environmental Restoration Technical Support Branch (CZTE) designed to evaluate United States Air Force (USAF) remediation activities at high-cost, -complexity, and/or -risk sites, and determine if implemented approaches are likely to meet site objectives. This CPA brought environmental remediation experts together to provide the technical basis for and recommendations to address per- and poly-fluoroalkyl substances (PFAS) contamination migration via stormwater infrastructure at Stewart Air National Guard Base (ANGB). The CPA After Action Report (AAR) documents the need for interim response actions, if appropriate, and recommended technical activities (based on currently available data) to support the Air Force in conducting programming and contracting actions to carry out proposed activities.

The CPA consists of two phases. Phase 1 is this AAR, which provides the rationale and a brief description of the conceptual approached to mitigate off-Installation public health impacts (e.g., drinking water supply) originating from on-Installation sources of PFAS contamination. Following concurrence that the proposed conceptual approaches are needed, and if requested by AFCEC/CZTE, Phase 2 of the CPA is initiated and consists of detailed technical activities and specifications of the approaches described in the Phase 1 to facilitate program and acquisition planning. The Phase 2 report is provided as a separate document. Note the scope of the technical activities described in the Phase 1 report may be modified based on data collected by concurrent and/or subsequent investigations performed by the Air Force. These include new information gained from existing ongoing investigation activities, pre-design investigations (PDIs) discussed in the Phase 1 report supporting selection and design of the technical activities.

The CPA Team reviewed available documents, and analyzed data extracted from documents and from the Environmental Resources Program Information Management System (ERPIMS) database. Based on the Air Force's priority addressing PFAS migration to off-Installation private drinking wells, the CPA Team organized this Phase 1 report and evaluated the areas of concern in accordance with a need for response action and/or future investigation.

2.0 Background

Stewart ANGB is located in Newburgh, New York. Site Investigation (SI; Wood 2018) and Expanded Site Investigation (ESI; Wood 2020) reports for PFAS have been finalized and confirmed the presence of PFAS in surface water and groundwater at multiple locations across the base (Figure 1). Sixteen locations were evaluated, and the results documented in the Final Expanded Site Inspection Report. There were widespread exceedances of PFAS screening levels in stormwater and groundwater samples. Starting from the north and proceeding south along both stormwater and groundwater flow pathways source areas of interest include: aqueous film forming foam (AFFF) Area 1 – Current Fire Station, AFFF Area 2 – Nozzle Testing Area, AFFF Area 3 – Former Fire Station, AFFF Area 11 – Apron, AFFF Areas 4 - 6 – Hangars 100, 101, and 102, and AFFF Area 15 – Retention Basins. PFAS have also been detected in groundwater off-base and in Lake Washington (Figure 1) which was a municipal drinking water supply. The municipality stopped using the lake due to the concentrations of PFAS detected and uncertainties about whether concentrations would increase.

Stewart ANGB has proactively implemented treatment of surface water, however, the extent of PFAS at the base and the continued release of PFAS from both the industrial ponds and Recreation Pond have highlighted the need for additional measures to ensure the base is able to comply with anticipated state and United States Environmental Protection Agency (USEPA) standards.

This CPA focused on understanding the primary transport pathways of PFAS at the base and developed recommended remedy approaches. The analysis and recommendations are presented in the following sections.

3.0 Conceptual Site Model Overview

3.1 Geology and Hydrogeology

Geologic deposits at Stewart ANGB consist of unconsolidated alluvium, weathered shale bedrock, and unweathered shale bedrock. Grading and fill activities necessary for establishing infrastructure have altered the surface and shallow subsurface zones. It is possible that historic drainage features were buried and through these activities may have been filled with more permeable fill material than the native glacial till. The unconsolidated native alluvium consists of well-graded glacial till. These deposits are predominantly dense and clayey; they are comprised of sand, silty sand, gravel, cobbles, and boulders. Although some descriptions suggest the materials are continuous across Stewart ANGB, the CPA Team anticipates local variabilities that could contribute to groundwater preferential flow paths. The shale bedrock is dense and is expected to serve as a barrier to downward groundwater movement. The exception to this is the upper weathered portion of the shale which, in addition to weathering, includes fractures. There are existing monitoring wells (e.g., MW-109) which have documented a fractured upper portion of the shale bedrock.

The till and alluvial deposits appear to be 40 to 50 feet (ft) thick, though the thickness downstream of Recreation Pond is expected to be less as the land surface slopes downward in that area. Weathered bedrock is potentially a groundwater transport zone of interest as well as the overlying till and alluvial deposits where they intersect Stewart ANGB infrastructure. The expectation is that weathering and fractures within this zone may cause higher transmissivity than the overlying clayey glacial till and the lower competent bedrock. The majority of investigations performed to date have been focused on either understanding the overall distribution of PFAS or monitoring and management of legacy sites like Site 3-the Former Base Landfill. Preferential pathways are likely present, such as the fractured zones of the weathered bedrock and sandy backfill around the stormwater sewer network. As was noted in the *Final Expanded Site Inspection Report for PFAS* (Wood, 2020), the groundwater to surface water pathway is the most likely mass transport pathway at Stewart ANGB. The degree of groundwater to surface water discharge has not yet been evaluated. As a result, there is not yet enough information to understand potential contaminant transport pathways in either the alluvium or the weathered bedrock. The groundwater to surface water pathway should be evaluated in the future. It seems likely that sand lenses in the alluvium or fracture zones within the weathered bedrock could be a significant factor in terms of flow direction and velocity.

Hydraulic conductivity testing has not yet been performed on wells installed during the SI, ESI, or ongoing Remedial Investigation (RI), but tests are expected to be performed at some point over the next year as investigation efforts move forward. There is a limited amount of historic data that was located and used for the CPA Team's analysis of potential flow pathways. Work reported in the 1997 RI for a pesticide burial site included evaluations of hydraulic conductivity tests performed on wells within the alluvium and the weathered bedrock. The area is located just west of Site 3 – the Former Base Landfill and northeast of the industrial ponds, which makes the hydraulic conductivity data relevant to the southern portion of the base. The overburden was estimated to have a geometric mean hydraulic conductivity of 0.35 feet per day (ft/d) while the weathered bedrock hydraulic conductivity was estimated to have a geometric mean hydraulic conductivity of 0.22 ft/d (Aneptek 1997).

A synoptic groundwater event performed in 2021 as part of the annual long-term monitoring for Site 3 (Former Base Landfill) estimated the local hydraulic gradient as 0.14 ft/ft in the alluvium and 0.06 ft/ft in the weathered bedrock (Wood 2022). Groundwater flow direction was evaluated as part of the ESI. Overall, groundwater within the western and central portion of Stewart ANGB converges on the south corner near Recreation Pond while in the eastern portion of the base groundwater flows to the east (Figure 2) (Wood 2020). The depth to groundwater ranges from 3.5 to 39 ft below ground surface (bgs) (Wood 2020).

Hydraulic conductivity, hydraulic gradient, and formation porosity are used to estimate groundwater seepage (flow) velocity. Assuming a porosity of 0.25 for the alluvium and 0.3 for the weathered bedrock for Stewart ANGB this yields groundwater velocities of 0.19 ft/day (alluvium) and 0.05 ft/day (weathered bedrock). Building 105 (Former Fire Station) (Figure 1) is located approximately 800 ft from the northeastern edge of Recreation Pond. Assuming a stable gradient over multiple years, groundwater from the former fire station would be expected to take 11 years to reach Recreation Pond with a flow pathway within the glacial till and upper portion of the weathered bedrock. The current fire station and the nozzle test area (Figure 1) are located over 3,000 ft from the northeastern edge of Recreation Pond. Groundwater from these areas would be expected to take 43 years to reach Recreation Pond if the flow pathway is within the glacial till and upper portion of the weathered bedrock. These transport times do suggest that the groundwater pathway has a role in PFAS migration, particularly for the hangar areas and former fire station. The information used for this evaluation is preliminary. Hydraulic testing that may be performed as part of the ongoing RI will provide the best understanding of groundwater pathways and flow velocities.

3.2 Hydrology

Surface water runoff is managed by a robust network of open drainages and subsurface conduits (Figure 3). These features drain to the southeast and the majority discharge through one of three outfalls, Outfall A, Outfall 002, and Outfall 003, into Recreation Pond. Outfall A mainly drains the far northern area of Stewart ANGB as well as the current fire station and part of the runway area along the path to Recreation Pond. Outfall 002 drains the Nozzle Testing Area, the apron, and most of the hangar area. Outfall 003 drains the eastern portion of Stewart ANGB. A fourth outfall, 17K, also discharges to Recreation Pond, however the majority of its drainage area is from areas north of Stewart ANGB. The majority of the Stewart ANGB area consists of impermeable surfaces and there are no surface water retention basins with the exception of the two located at the installation boundary that manage industrial runoff from the industrial/hangar area. In addition to Stewart ANGB, off-base areas from Route 17K and the Stewart

International Airport (SIA) also drain into Recreation Pond. A state construction project is under way and is expected to divert drainage from the upstream section of Route 17K. This will leave only Stewart ANGB connections to Route 17K active in the future. Storm sewer connections that appear to be from SIA are known to exist, but have not yet been fully evaluated (Wood 2020).

A partial survey of the storm sewer conduits was completed and reported in the final ESI for PFAS (Wood 2020). Findings of interest include identification of areas where groundwater is infiltrating the storm sewer conduits. Additional survey efforts have been performed as part of ongoing investigation efforts. The preliminary findings and closed-circuit television (CCTV) video logs were provided to the CPA Team for further evaluation. As with the earlier survey, more areas where the storm sewer conduits are either visibly compromised or were actively allowing groundwater infiltration were identified. The CPA Team reviewed a number of the October 2022 CCTV video logs to gauge the degree of groundwater infiltration that was taking place. In addition to the sections that were identified, the CPA Team found several areas with groundwater infiltration, generally at joints in the conduit, which had not yet been identified on figures. Two representative photos of previously unidentified joints with groundwater intrusion are included on Figure 4. Some of these compromised conduits are within areas with high concentrations of PFAS.

3.3 PFAS Distribution and Migration Pathways

Groundwater and surface water sampling performed during the SI and ESI have identified the presence of PFAS across all areas tested to date. An RI is currently under way and Mobilization 1 data that was available during the CPA event was incorporated into the CPA Team analysis.

3.3.1 PFAS Distribution

A majority of the RI samples exceed screening levels in both groundwater and surface/stormwater across the base (Figures 5 and 6). A limited amount of sediment sampling has been performed and locations are concentrated at the industrial ponds and within and around Recreation Pond. Total PFOS and PFOA concentrations in sediment tended to be above 1,000 nanogram per kilogram (ng/kg) and two from the industrial ponds were over 100,000 ng/kg. There are few sediment samples from any other area, however nearly all similarly had concentrations of total perfluorooctanesulfonic acid (PFOS) and perfluorooctanoic acid (PFOA) above 1,000 ng/kg. It is noteworthy that sediment sampling within the storm sewer network can be challenging because, based on review of video logs, most of the sediment remaining in the storm sewer conduits is coarse grained, gravelly, and sometimes chunks of concrete. These coarse-grained materials can cause problems for sediment sampling, for example, by physically blocking sample collection.

The installation has a good lateral distribution of soil sampling locations and monitoring wells that is useful in determining the primary areas for further investigations. The highest PFAS concentrations in groundwater and soil are in proximity to the hangars and the industrial ponds. For groundwater, four monitoring wells have had total PFOS and PFOA concentrations in excess of 10,000 nanograms per liter (ng/L) (Figure 5). There are three locations downgradient from the industrial ponds and one location is outside of a hangar. A number of monitoring wells upgradient of Recreation Pond and in the vicinity of the southern installation boundary have total PFOS and PFOA concentrations in the range of 1,000 to 10,000 ng/L.

For Stewart ANGB, understanding the distribution of PFAS in soil is an important factor in understanding the potential for soil to act as an ongoing source of PFAS to stormwater and groundwater (Figure 6). As anticipated, based on reported releases and area usage, the highest concentrations of PFOS and PFOA in soils (> 100,000 ng/kg) were found at the new fire station, outside of Hangar 102, and adjacent to or downhill from the two retention basins which receive runoff from the industrial area. Results from surface water and stormwater sample locations along the drainages across Stewart ANGB were largely consistent across the base. Basewide results range from 70 ng/L to less than 1,000 ng/L. The one exception to this is downhill from the two retention basins where surface water sample results exceeded 1,000 ng/L. Overflow of water from the retention basins has occurred several times because the ponds were never intended to manage all peak rainfall events. These events have resulted in a unique distribution of PFAS in soil, surface water, and groundwater.

Ultimately, the distribution of PFAS in soils informs remedy operation timelines by providing insight into the longevity of the source that could continue to feed the plume. Shallow groundwater in contact with the soil or rainfall infiltrating through contaminated soil will continue to contribute PFAS mass to both stormwater and groundwater.

An understanding of PFAS concentrations in surface water over time and under different conditions can provide insight into the source(s) of PFAS in surface water. As reported in the *Final Expanded Site Inspection Report* (Wood 2020), PFAS concentrations in Outfall A and Outfall 002 decreased during periods when rainfall increased the volume of surface water runoff whereas PFAS concentrations in Outfall 003 increased with wet weather flows. CCTV footage along with storm sewer pipe and groundwater elevation data shows that significant portions of the Outfall A and Outfall 002 storm sewer network are below the groundwater table, while those of Outfall 003 are mostly above. Additionally, flows were observed in the storm sewer pipes understood to be below the groundwater table under dry weather conditions. These findings together with the PFAS results from stormwater samples taken in both dry and wet weather events from Outfall A and Outfall 002 are indicative of groundwater infiltration being a major contributor to the flows. Lower concentrations during rainfall events result in dilution of the PFAS contributed by groundwater and yield correspondingly lower concentrations in samples. In contrast, results from Outfall 003 had higher concentrations of PFAS during rainfall events. This suggests runoff from areas within the Outfall 003 drainage system is contributing PFAS. Sediment and soil material may well act as ongoing sources. There are also multiple segments along the Outfall 003 drainage network that show infiltration of groundwater. Understanding surface water runoff sources and groundwater infiltration sources will be an important part of establishing the final remedy or remedies. This is particularly important because it is possible that surface runoff and soil carried during storm events could represent an ongoing source that will not be addressed by repairing the stormwater sewer piping. The 17K stormwater sewer system may also warrant further evaluation after the areas to the north are diverted. Once the northern areas are diverted, the only sources of water will be from system leaks and the central industrial area of Stewart ANGB. This means that along with lower flow, it is possible that there will be higher PFAS concentrations in the water discharged to Recreation Pond.

The new monitoring well data provided by the ESI and Phase 1 of the RI is continuing to improve the understanding of the nature and extent of PFAS in groundwater. However, at this point, there are a limited number of wells screened deeper than 35 ft bgs across Stewart ANGB that have been installed and sampled for PFAS. In the long-term, understanding the vertical distribution of PFAS will be necessary to ensure appropriate remedy selection and implementation. Historical documents indicate that the transport pathway of concern is groundwater to surface water. While it may be the primary groundwater pathway of concern, based on data from deeper monitoring wells across the base it does not appear to be the only pathway. Below is a summary and discussion of select data from deeper wells.

- Near the Spray Nozzle Test Area and the current Fire Training Area, the concentrations in the deeper wells tend to be lower than the water-table monitoring wells.
- Within the hangar area, there are some wells screened at or below 35 ft bgs which have higher concentrations of PFAS than the corresponding shallower wells. Specific examples and discussion of significance are included for wells near Recreation Pond (below).
- Near Recreation Pond, deeper groundwater, screened in the lower portion of the weathered bedrock, has also been impacted (Figure 7). Total PFOS and PFOA concentrations along a drainage just northwest of Recreation Pond provide perspective on potential variability in transport pathways.
    - SDPGW04 had 9 ng/L total PFOS and PFOA at 58 ft bgs while the shallower interval, at the same location, 45 ft bgs, had 1,000 ng/L total PFOS and PFOA. This confirms the understanding that the weathering and fracture network decreases with depth, however, it also confirms that high concentrations of PFOS and PFOA are present well below the surface of the water table.
    - Both SDPGW04 (1,000 ng/L total PFOS/PFOA) and SDPGW05 (920 ng/L total PFOS/PFOA) are located close enough to underground infrastructure that it is possible that groundwater flow has been enhanced by the nearby infrastructure, however elevations are well below the level that fill material should be able to influence. The locations may represent natural flow pathways
    - CP01GW01 (628 ng/L total PFOS/PFOA representative of 44 ft bls) is over 100 ft away from subsurface infrastructure and has a comparable, though lower, concentration of PFAS.

  In terms of the upgradient pathway that led to these locations, there may be a combination of groundwater flow pathways present. An understanding of depth of occurrence and vertical gradients will become important when considering potential off-base impacts and prioritization for groundwater interception technologies. The majority of data collected to date is from shallow sampling locations, it is important that remedy decisions and future data collection efforts adequately address the deeper groundwater interval too.

3.3.2 PFAS Migration Pathways

As discussed in Section 3.1, groundwater migration through both the unconsolidated material and the weathered bedrock is approximately 0.2 ft/day. Based on timing of operations at Stewart ANGB within the hangars and the industrial ponds, there has been enough time for the groundwater from both areas to reach Recreation Pond. It is also possible, based on the depositional environment, that more transmissive layers may be present below the pond, which then drain to Lake Washington.

The timing of groundwater flow from operations in upgradient source areas is not easy to assess. If the pathway is within the alluvium, aquifer test data suggest that it would take nearly 50 years for groundwater to reach Recreation Pond. However, the network of storm sewers and the associated fill that would have been used at the time the network was built provides potential preferential pathways for groundwater to flow. The net effect of the associated fill is expected to be similar to a French drain. There is no data yet to assess this possible preferential pathway.

Because of the comparatively slow velocity of transport, groundwater is not expected to be the main mass transport pathway. However, water moving within the storm sewer system is of immediate concern. Water can flow through the storm sewer system largely unimpeded and discharge to Recreation Pond. Once in the pond, movement of surface water to groundwater and soils becomes a concern for PFAS distribution and migration. As discussed previously, the source of water in the storm sewer network is a combination of surface water runoff and groundwater infiltration. The surface water flow study performed in 2019 and reported in the Final ESI report (Wood 2020) highlights the significance of the groundwater infiltration pathway into the storm sewer system. Concentrations of PFOS within Outfall 002 dropped during periods of rainfall and increased during dry periods. This suggests that the surface runoff into the storm sewer diluted the portion contributed by groundwater. Outfalls that behave similarly, like Outfall A and Outfall 002, represent opportunities for remedy implementation that will be discussed in Section 4.0. In the future, additional data gathering will be beneficial for long term remedy implementation. In comparison to Outfall A and Outfall 002, PFOS concentrations at Outfall 003 increased during wet weather flows, which is indicative of runoff infiltration into compromised pipes being a primary source of PFAS mass discharge in the storm sewer network of Outfall 003. While some portion of Outfall 003 storm sewer network is below the groundwater table and therefore subject to groundwater infiltration, most of it is above the groundwater table and receives flow from runoff.

3.3.3 PFAS Fraction Evaluation

The relative fractions of PFAS present in soils, sediment, surface water, and groundwater can provide insights into the migration pathways present at Stewart ANGB. This type of evaluation is qualitative, not quantitative. Further, it is intended to differentiate between AFFF source areas and may highlight flow pathways to downgradient or downstream areas.

There are many variables that affect the fractions of PFAS present in a given sample. Examples of variables include the brand of AFFF, the batch of AFFF, the age of the release, and whether or not the release was for testing or for actually suppressing a fire. Certain forms of PFAS preferentially partition to soils and this can be a factor in skewing groundwater sample results if the sample has a high degree of suspended solids. Even with these qualifications, some noteworthy findings are possible and can contribute to the overall conceptual site model and understanding of transport pathways. Figure 8 provides the surface water fractionization data for 10 common PFAS in samples across the base. Figure 9 provides the groundwater fractionization data for 10 common PFAS in samples across the base.

With the exception of the storm sewer PFAS profiles within the hangar areas and east, the PFAS profiles in the northwest corner (spray test area and new fire station), along Outfall A, and Outfall 003 are all similar to each other and to surface water results from Recreation Pond. The similarity is more clearly seen by averaging the selected PFAS concentrations from sample locations within a given area (Figure 10). PFOS is the dominant compound followed by 6:2 fluorotelomer sulfonic acid (6:2 FTS), perfluorohexanoic acid (PFHxA), and perfluorohexane sulfonic acid (PFHxS). Several other PFAS are present to lesser degrees and, as with the dominant three forms of PFAS, they are largely consistent within the stormwater data set.

One interesting observation is that PFOS in surface water in Recreation Pond represents nearly 50% of the PFAS present. The PFOS proportion is not that high in any surface water contributing pathway. Although it is possible that suspended solids may skew the PFOS high in Recreation Pond, it seems unlikely since flow that would result in high turbidity should also increase the levels of PFAS present in the other storm sewer pathways. A review of groundwater data for the same areas used for the surface water assessment was also performed. The area around the industrial ponds is the only one that had an average PFOS fraction greater than 50%. This indicates that groundwater flow and surface water runoff from the industrial ponds are likely contributing to the PFAS profile in Recreation Pond.

Future evaluations of PFAS fractions may provide more transport pathway insights, particularly as understanding of the plume evolves. At this point, there is enough data to determine that groundwater infiltration into the storm sewer system is a significant contributor to PFAS mass in Recreation Pond. There are several data gaps in the understanding of PFAS transport pathways. Additionally, local source areas (industrial ponds and hangars) represent a groundwater pathway for PFAS to reach Recreation Pond and potentially migrate beneath the pond and along drainage areas further off-installation. Focused data collection of the following will be necessary in the future to ensure appropriate remedy selections are made:

- The nature of preferential pathways associated with transmissive fill soils around stormwater sewer infrastructure,
- weathered bedrock, and
- groundwater to surface water as well as surface water to groundwater behavior in proximity to surface water features.

4.0 Recommendations for Stormwater Sewer Rehabilitation

Overall, groundwater PFAS concentrations tend to be higher than those observed in stormwater in the various catch basins that were sampled as well as the outfalls. The unknown component is sediment fines in the defective storm sewer lines which may be a continuing source of PFAS to groundwater. Sediment contamination in these lines remains to be investigated. Thus, the net benefit of storm sewer rehabilitation on groundwater PFAS concentrations remains to be seen. The anticipated benefit of stormwater sewer rehabilitation is expected to be more significant in the overall mass discharge and infiltration volume to the pond. The CPA Team considered two options for rehabilitating defective stormwater sewer piping based on available video inspections. The CPA Team contacted contractors that specialize in trenchless storm sewer rehabilitation. One of the more common trenchless methods for rehabilitation is Cured-in-Place Pipe (CIPP). CIPP differs from conventional slip-lining and is in general more cost-effective in pipes up to 54 inches in diameter. Conventional slip-lining of damaged pipe uses a separate carrier pipe (e.g., high-density polyethylene [HDPE] pipe or polyvinyl chloride [PVC] pipe) that is grouted and sealed in place. To install the carrier pipe, conventional slip-lining involves limited excavation, additional waste management, and potential disruption to daily site operations. In contrast, CIPP can be implemented without excavation and is less disruptive to site operations. It uses a resin-impregnated tube that is inserted or pulled into the damaged pipe and subsequently cured in place to form a pipe within a pipe. This is a fully structural solution that can be used to line pipe sizes from 6- to 96-inch diameter with an anticipated lifespan of 50 to 75 years. The majority of defective pipe subject to rehabilitation is in the range of 8–54 inches in diameter. It is cost effective to use the CIPP method for this range of pipe diameters. Although some reduction in original pipe capacity is to be expected by both conventional and CIPP methods, overall flow within restored pipe is improved due to reduced roughness of defective lines. Overall, the reduction of pipe capacity from CIPP is lesser than conventional carrier pipe slip-lining.

The CIPP method is applicable to both gravity and pressure pipe conditions. Different types of resin (polyester, vinyl ester, epoxy, etc.) and installation/curing methods can be used (e.g., hot water, steam). The resin-impregnated tube can also be coated with polyurethane or polypropylene to provide additional strength and chemical resistance.

Because of the cost-effectiveness over conventional methods, the CPA Team recommends proceeding with the CIPP method for storm sewer rehabilitation for pipes draining to Outfalls A, 002, and 003. The following discussion outlines steps involved in the CIPP method:

1) Initial cleaning (jetting),
2) Bypass pumping to isolate pipe sections to be rehabilitated,
3) CCTV inspection,
4) CIPP liner selection/design,
5) pre-lining rinsing and CCTV inspection,
6) liner installation, and
7) post-lining CCTV inspection to ensure proper installation and flow through the finished, rehabilitated pipe.

Based on discussions with a storm sewer rehabilitation contractor specializing in the CIPP method, to select proper liner for design and obtain a reliable cost estimate for the project, the CPA Team recommends that pipes identified for rehabilitation in drainage areas of Outfalls A, 002, and 003 be cleaned and inspected using CCTV. Outfall 17K sampling showed PFAS concentrations lower than the screening levels (SLs) of 40 ng/L (SL) and <10 ng/L (New York State Department of Environmental Conservation [NYSDEC] SL) during three wet weather sampling events. In addition, there is construction work related to 17K that was mentioned during CPA which may affect storm routing and discharge at this outfall. For these reasons, Outfall 17K was excluded from recommendations. In addition, invert elevations of Outfall 003 lines are reportedly mostly above the water table, but video inspections performed under dry weather conditions show water infiltrating through various defective pipe segments. Since Outfall 003 had the highest PFAS mass discharge to the pond, portions of defective piping draining to the pond are recommended for rehabilitation.

The proposed approach will help to refine the estimated 6,200 ft of pipe that require rehabilitation as depicted in the Restoration Advisory Board (RAB) presentation (Stewart ANGB 2024) and estimated based on CPA Team review of CCTV logs. This recommendation stems from the CPA Team's evaluation of available CCTV logs, discussed in Section 3.2, which indicate additional deficiencies in the pipe network (Figure 4) than those previously identified. These deficiencies should be further evaluated following storm sewer cleaning and inspection.

As part of the initial storm sewer cleaning, much of the sediment and debris within the storm sewer network to be rehabilitated will be jetted in various pipe sections with a high-pressure jet and waste material will be removed at downstream manhole sumps or, if needed, a plug will be used to contain the waste material prior to removal. Cleanup will be conducted under dry weather conditions. Bypass pumping will be conducted using trash pumps to remove water in pipe segments to be rehabilitated. This water will be containerized in frac tanks, tested, treated, and confirmed clean for disposal into a nearby sanitary sewer. Following initial cleaning, a CCTV inspection will be performed to help select and design the storm sewer liner to be used for the project. An additional pipe rinsing step will be conducted followed by CCTV inspection. A work plan and cost estimate will then be prepared for the lining process and subsequent inspection and flow testing needed to confirm the rehabilitated pipe network performs according to design specifications.

Note that storm sewer cleaning activities will require contaminated water treatment, testing, disposal of treated water, as well as testing and disposal of solids as described above. Access to an uncontaminated water source for storm sewer cleaning will be necessary and coordinated with Stewart ANGB. Following treatment and disposal activities, surfaces that may have been damaged (e.g., grassy areas) will be restored to match the existing grade.

4.1 Storm Sewer Cleaning: Waste Removal, Testing, and Disposal

Waste material collected from storm sewer cleaning will consist of sediment, various sizes of concrete chunks and other debris in the pipes. These materials were observed in previous CCTV inspections of the pipes. Stormwater is anticipated in the pipes since it was also observed in previous inspections performed under dry weather conditions. These materials will be removed from various pipe segments using a vacuum truck. Some of the oversized concrete chunks may require removal by hand. Water will be temporarily stored in frac tanks, then treated using granular activated carbon (GAC) vessels, tested, and confirmed to meet pretreatment standards for discharge to sanitary sewer (city of New Windsor). Waste solid materials will be segregated in separate lined roll-offs based on sediment PFAS results obtained during the Data Gap Investigation (DGI, Section 5 below) and containerized in lined roll-offs. Waste materials will be segregated based on PFAS concentrations compared with Assistant Secretary of Defense Energy, Installations, and Environment (ASD[EIE]) guidance (i.e., list of 8 PFAS and associated USEPA regional screening levels (RSLs) presented in ASD(EIE) August 24, 2023 guidance, as amended by 2 additional PFAS [current total in list is 10 PFAS compounds] in March 2024). Using sediment data collected during the DGI and ASD(EIE) PFAS RSLs, wastes will be placed in two separate roll-offs: the first roll-off will contain materials that have no PFAS detections and do not exhibit hazardous waste characteristics in accordance with 40CFR261; the second roll-off will contains materials that have PFAS detections and/or exhibit hazardous waste characteristics in accordance with 40CFR261. Additional roll-offs may be needed depending on volume of materials collected for each waste material category. Note that concrete chunks will be placed within the non-hazardous, non-PFAS detected waste materials. This waste segregation approach may help to reduce waste disposal costs.

Prior knowledge of the waste materials (PFAS data collected during the DGI) could be used for initial waste acceptance by the disposal facility since these materials are not anticipated to be hazardous as defined in 40 Code of Federal Regulations (CFR) Part 261. However, for a licensed facility acceptance of these wastes, one composite sediment waste sample from each roll-off container will then be collected for analysis of hazardous waste determination in accordance with 40 CFR Part 261 requirements and the selected off-site disposal facility's requirements for waste acceptance. These analyses include Toxicity Characteristic Leaching Procedure (TCLP) list in accordance with 40 CFR Part 261 (volatile organic compounds [VOCs], semivolatile organic compound [SVOCs], pesticides, herbicides, and eight Resource Conservation and Recovery Act [RCRA] metals). The samples will also be analyzed for polychlorinated biphenyls (PCBs), total petroleum hydrocarbon – Diesel range organics (TPH-DRO), total petroleum hydrocarbon – Gasoline range organics (TPH-GRO), ignitability (flashpoint), reactivity (sulfide and cyanide), and corrosivity (pH). Based on PFAS data and 40 CFR Part 261 test results, waste materials will be managed in accordance with Department of Defense (DOD), USEPA, and Air Force policy in effect at time of planning for storm sewer rehabilitation.

5.0 Data Gap Study

Stormwater Sampling: The ESI (Wood 2020) concluded that flows from Outfall A and Outfall 003 are major contributors of PFAS mass flux to the Recreation Pond followed by Outfall 002 and Outfall 17K being the lowest contributions. This discussion will focus on the top storm sewer contributors of mass to Recreation Pond.

As discussed in Section 3.3, PFAS concentrations in Outfall A and Outfall 002 samples decreased during periods when rainfall increased the volume of surface water runoff whereas PFAS concentrations in Outfall 003 samples increased with wet weather flows. CCTV footage along with storm sewer pipe and groundwater elevation data shows that significant portions of the Outfall A and Outfall 002 storm sewer network are reportedly below the groundwater table, while those of Outfall 003 are reportedly mostly above although video inspections during dry weather showed water infiltrating into various compromised pipes. Additionally, flows were observed under dry weather conditions in the storm sewer pipes understood to be below the groundwater table. These findings together with the PFAS results under dry and wet weather events stormwater samples from Outfall A and Outfall 002 are indicative of groundwater infiltration being a major contributor to the PFAS mass discharge. In contrast, based on the PFAS and video inspection results for Outfall 3 network, it has been hypothesized that runoff through PFAS-impacted surface soils and / or infiltration though PFAS impacted-soils into defective pipes are a major contributor to the PFAS mass discharge from Outfall 003. As discussed in Section 4, Outfall 17K is not being considered for an interim response action as future construction work is planned for this outfall and this outfall is likely not a major contributor of PFAS mass loading based on sampling conducted during the ESI.

As a stormwater response action, the CPA Team proposes CIPP to mitigate groundwater infiltration and curtail PFAS mass discharge into the storm sewer network associated with the outfalls and eventually to the Recreation Pond. The data gap investigation will include collection of stormwater samples from catch basins to assess the spatial extent of PFAS impacts in areas with elevated groundwater concentrations and in areas with limited data from prior investigations. Samples will be collected from catch basins along discharge areas for Outfalls A, 002, and 003. These proposed sampling locations are shown on Figure 11. The stormwater samples will be analyzed for PFAS via USEPA draft method 1633. At select locations, extra sample volume will be collected for analysis of PFAS in laboratory-filtered samples to determine PFAS mass associated with suspended solids in the stormwater.

***Sediment Sampling*:** Previous investigations have collected limited data regarding PFAS in sediments of storm sewer network. Two surficial (0–0.5 ft) sediment samples associated with drainage areas of Outfall 002 and Outfall 003 were collected during the Phase I Site Investigation (Wood, 2018). One sediment sample, 12SD02 associated with Outfall 002 storm sewer network and collected west of Building 105 (Former Fire Station) showed presence PFOS at a concentration of 0.0144 mg/kg. The other sample collected at or near Outfall 003 showed PFOS concentration of 0.02 milligram per kilogram (mg/kg). The additional sediment samples have been collected in the lagoons and Recreation Pond and they exhibit elevated PFAS concentrations. The CCTV logs from the ESI (Wood 2020) show accumulated sediments in a majority of pipe sections of storm sewer network associated with all outfalls. The fines in the accumulated sediments are likely resuspended during flow events and are eventually transported to Recreation Pond thereby contributing to the PFAS impacts.

The proposed rehabilitation of the storm sewer pipes via the CIPP method will consist of jetting/cleaning of the pipes and collection of the accumulated debris, which will require further management based on their PFAS concentrations. As part of the recommended DGI, the CPA Team recommends inspection of catch basins for sediments and stormwater (ponded or flowing) along the conduits for Outfall A, Outfall 002, and Outfall 003 where elevated PFAS concentrations in storm/surface water have been previously observed. The proposed locations are shown on Figure 11. If present, surficial sediments from the catch basin will be collected to identify PFAS impacts in fine grain solids. These sample locations will be collocated with stormwater samples grab samples. The collected sediment will be homogenized prior to filling laboratory provided containers. The samples will be analyzed for PFAS via USEPA draft method 1633, Fraction organic carbon (F_{oc}) and grain size. The PFAS analytical results will be screened against the ASD(EIE)soil/sediment screening levels (for direct contact and impact to groundwater). In the stormwater sewer rehabilitation area, the data will be used to segregate sediments for storage and disposal in hazardous or non-hazardous waste landfills based on PFAS concentrations in the solids. In the non-rehabilitation area, the data will be used to assess if sediments are a source of impacts or indicate the presence of a surface source area. Sediments deemed to be a PFAS source are recommended for removal and off-base disposal.

Soil Sampling: As discussed above, results from the ESI indicate that PFAS concentrations in the Outfall 003 discharge generally increased with increase in wet weather flows. This concentration trend along with majority of the Outfall 003 storm sewer network being above the groundwater table led to the conclusion that the primary pathway for PFAS transport in the Outfall 003 network is through surface runoff. The goal of the soil sampling as part of the DGI will be to identify PFAS impacts in shallow soils associated with the Outfall 003 drainage area as a PFAS source discharging to surface water during rainfall events. Samples are located short distances away from the sewer lines and catch basins in predominantly grassy areas and are intended to evaluate the potential for ongoing soil to surface water transport. The proposed sampling locations are shown in Figure 12. Shallow soil samples will be collected in grassy areas from 0–2 ft bgs using a hand auger. Upon retrieval at each location, two separate soil samples will be collected, one from the 0-0.5 ft interval and the other from the 1–2 ft interval. Soil in each interval will be homogenized prior to transferring the material into laboratory provided containers. The 0–0.5 ft interval sample from each location will be analyzed for PFAS via USEPA Method 1633, F_{oc} and grain size. If the 0-0.5 ft sample exhibits

PFAS impacts, then the 1–2 ft interval sample will be analyzed for the same analytical parameters. The analytical results will be compared to the ASD(EIE)soil screening levels (direct contact and impact to groundwater) to identify areas that may need a shallow interim action from reducing PFAS mass discharge to Outfall 003.

6.0 Groundwater Response Action at Southern Boundary

Groundwater migrating toward the installation southern boundary upgradient of Recreation Pond (Figure 5) consistently has PFOS and PFOA concentrations above 10 ng/L with levels in many wells ranging between 1,000 and 10,000 ng/L. Some sampling locations exceed 20,000 ng/L. Groundwater in this area is migrating off base, albeit at a relatively slow rate, and impacting Recreation Pond and downstream drinking water supply (Lake Washington).

As requested by Stewart ANGB during the CPA and discussions with AFCEC/CZTE, the Phase 1 report incorporates a pilot groundwater extraction and treatment system for the Stewart ANGB Southern Boundary Groundwater Pilot System response action. This Pilot System's objective is to contain the highest PFAS-impacted groundwater in the glacial till and reduce off-base migration. It does not address potential migration in the underlying fractured/weathered shale, nor does it contain lower PFAS concentrations that have migrated off-base. The CPA team understands that predesign data for system design and construction is currently not available. This data would include saturated zone hydrogeologic properties, extracted groundwater flow rates, concentrations of legacy contaminants (i.e., VOCs, SVOCs, metals; if any), and other water quality parameters that can affect system performance (e.g., total organic carbon [TOC], total suspended solids [TSS], total dissolved solids [TDS], cations, anions, alkalinity, and hardness). Given the uncertainties involved in the proposed pilot system, along with a desire by Stewart ANGB to expedite its implementation, the CPA Team proposes to: (1) construct and operate the pilot extraction and treatment system based on design using available data with appropriately conservative assumptions; (2) collect pre-design data during initial pilot system operation; and (3) use this new data to design, retrofit as needed, and optimize performance of the pilot extraction and treatment system.

Main risks which are introduced due to lack of this data include the following:

- Potentially incomplete hydraulic capture of PFAS plume at the southern boundary;
- Potentially over- or under-designing of the system's capacity;
- Potential iron/manganese fouling of polishing anion exchange resin (AER) vessels/GAC; and
- Potential excessive polishing media replacement due to presence of TOC and legacy contaminants.

The following sections describe the proposed pilot groundwater extraction and treatment system as well as pilot system optimization investigation.

6.1 Pilot Groundwater Extraction and Treatment System

The proposed conceptual pilot extraction and treatment system includes the following components: a groundwater extraction system (trench and associated sumps/pumps), influent conveyance piping and treated effluent discharge piping, and pilot treatment system.

6.2 Groundwater Extraction System

Given the low permeability and anticipated yield of the glacial till, the extraction system will consist of an extraction trench and two sumps/pumps that will be installed along southern boundary. This system is proposed to contain, collect, and subsequently treat (treatment described in separate section below) the highest observed PFAS concentrations (>4,000 to >23,000 ng/L) and reduce PFAS migrating off-base and mass discharge to Recreation Pond and Silver Stream. The average combined PFOS and PFOA concentration at the boundary is 16,530 ng/L (or 14,000 ng/L PFOS and 2,530 ng/L PFOA) while the estimated sum of average PFAS concentrations is 30,627 ng/L (Table 1). The difference in concentration between the sum of average PFAS and PFOS/PFOA is from the shorter chain compounds (primarily four- to seven-carbon sulfonic acids and carboxylates). A groundwater extraction trench is proposed that extends from the industrial effluent storage lagoons to the east upstream of former Landfill 3. The extraction trench is anticipated to be 2 ft wide by 30 ft deep and approximately 900-ft long to capture PFAS-impacted groundwater. A conceptual layout of the extraction trench and associated performance monitoring wells is presented in Figure 13.

Overall, the glacial till yield in the trench is anticipated to be relatively low (1-2 gallons per minute [gpm]) based on monitoring well development observations during previous investigations. This yield was estimated based on data provided in the ESI report (Wood, 2020; hydraulic conductivity of 0.35 ft/day and hydraulic gradient of 0.03 ft/ft), till saturated thickness of 25 ft, and the conceptual extent of extraction trench (900-ft long by 30-ft deep) for PFAS plume containment at the base boundary. Note that preferential flow paths in this area may exist given PFAS plume migration off-base which could result in higher than anticipated flow rates. To account for uncertainties related to formation yield, the CPA Team assumed extracted groundwater flows up to 50 gallons per minute (gpm) for purposes of scoping a pilot scale extraction and treatment system.

Construction of the trench is proposed using a one-pass trencher to avoid dewatering, excavation shoring, and reduce safety concerns and costs of conventional trench construction. Prior to excavating the trench, the one-pass trencher will be used to install two groundwater collection stainless steel sumps (20-30 ft apart) at the approximate mid-point of the trench. One sump will be used to capture water collected in the western segment of the trench and the other from the eastern segment of the trench. Two 12-inch diameter stainless-steel sumps with wire-wrapped screens (20 or 40 slot) are proposed given the length of the trench, to facilitate construction and reduce cost of trench installation. The screened sections of the sumps will extend from approximately 15 ft to 30 ft bgs depending on location and groundwater elevation. Each sump will be equipped with a clean-out (HDPE pipe) to allow for periodic maintenance. A conceptual elevation view of the two sumps is presented in Figure 14.

Following sump installation, the trench will be installed using the one-pass trencher, which will also install a slotted (20 or 40 slot) high-density polyethylene (4 to 6-inch diameter HDPE) drainage pipe at the bottom of the trench, and gravel/coarse aggregate backfill in the trench. One pass will be required to install the western segment of the trench and another pass to install the eastern segment of the trench. The bottom of the trench will be at the approximate interface between the glacial till overburden and fractured shale bedrock. However, this interface has not been demarcated by investigations to date, but the depth is estimated to be at approximately 30 ft bgs based on existing boring logs in the area and data provided in the PFAS RI Uniform Federal Policy-Quality Assurance Project Plan (UFP-QAPP) (AECOM 2022). The excavation will terminate when the trencher reaches 30 ft bgs or assumed fractured bedrock surface, whichever is encountered first.

Depth to groundwater along the alignment of the trench varies and is approximated based on shallow groundwater samples collected at MW-113 and vertical aquifer sampling (GW01, GW02, and GW04). Depth to groundwater varies approximately from 4 ft bgs to 15 ft bgs depending on location. Gravel backfill will be placed in the trench to an approximate depth of 4 ft bgs and compacted. Geotextile fabric will be placed on top of gravel and a layer of clay approximately 4-ft thick will be placed above the geotextile, compacted, and finished with topsoil to the ground surface or to match the existing grade. Clay will be used to reduce infiltration of potentially elevated PFAS concentrations and possibly other contaminants present in shallow soil near the trench. An HDPE pipe will be installed just below the frost line to convey combined groundwater flow from the two sumps to the pilot treatment system (Figure 14). Electrical conduit will be installed in the same trench as the conveyance pipe to provide power from the treatment system to the extraction sump pumps.

An estimated 2,000 bank cubic yards (900 ft by 30 ft by 2 ft converted in cubic yards) of glacial till spoils will be removed during trench excavation, temporarily staged on either side of the excavation, and direct loaded into lined roll-off boxes. Grab and composite soil samples (approximately 30 samples or one per 30 ft of trench excavation) will then be collected, sampled for PFAS and hazardous waste parameters per 40 CFR Part 261 requirements and disposal facility acceptance requirements, and managed in accordance with DOD/USEPA and Air Force policy in effect at the time of planning trench construction. The analytical suite for excavated soil disposal will include: PFAS compounds and the full TCLP list in accordance with 40 CFR Part 261 (VOCs, SVOCs, pesticides, herbicides, and eight RCRA metals). The samples will also be analyzed for PCBs, ignitability (flashpoint), reactivity (sulfide and cyanide), and corrosivity (pH).

An electrical, submersible pump will be installed at the bottom of each sump to pump water collected in the trench to an equalization tank, then transferred to the treatment system using a transfer pump. The water will be sampled in accordance with pretreatment requirements before final discharge to a sanitary sewer. The equalization tank will be insulated and/or heat traced for cold weather conditions. For planning purposes, capacity of the equalization tank is assumed to be 5,000 gallons.

Submersible pumps will be equipped with variable frequency drives to adjust to varying water volumes collected from the trench. Each sump pump will be capable of delivering up to 50 gpm and lifting water from an approximate depth of 25 ft bgs to the conveyance HDPE pipe (approximately 4 ft bgs) and subsequently to the equalization tank. This approach will allow flexibility for concurrent pump operation in the two sumps and independent pump operation for each segment of the extraction trench when sump and/or pump maintenance is required. The HDPE discharge pipe from each sump will be manifolded into one influent conveyance pipe to the treatment system. At an approximate combined flow rate of 40-50 gpm to the treatment system, the trench could be dewatered (estimated volume of approximately 81,000 gallons) in approximately 1.1-1.4 days. Groundwater could be extracted at 50 gpm, if needed, for somewhat faster trench dewatering until equalization tank capacity is reached.

6.3 Influent Conveyance and Treated Effluent Discharge

Groundwater from the extraction trench will be conveyed to the equalization tank. Stored groundwater will then be pumped to the pilot treatment system for removing PFAS prior to effluent discharge. The CPA

Team identified three options for discharge based on discussions during the CPA and subsequent evaluation to help identify feasible and cost-effective options. Three options were identified which are shown in attached figures (Option 1 in Figure 15, Option 2 in Figure 16, and Option 3 in Figure 17). These options assume the treatment system equipment location would be to the north or south of the Recreation Pond. Effluent discharge for Options 1 and 2 would be above the weir of Outfall 10 near the Interim Storm Water Treatment System (ISWTS). Option 3 assumes the treatment system equipment would be located to the northeast of the industrial wastewater lagoons and treated effluent discharge would be to the sanitary sewer (Figure 17). The Option 3 effluent discharge location is approximated since a sanitary sewer utility map was not available when the CPA took place (Figure 17). Estimated influent conveyance and effluent discharge piping length for each option are as follows: Option 1: influent approximately 360 ft, effluent approximately 780 ft; Option 2: influent approximately 960 ft, effluent approximately 160 ft; Option 3: influent approximately 250 ft, effluent approximately 90 ft. Total piping length for Options 1 and 2 is similar (approximately 1,140 and 1,120 ft, respectively). Total piping length for Option 3 to sanitary sewer is approximately 340 ft. Influent conveyance and effluent discharge piping for each option will be installed in a 1-ft wide by 4-ft deep trench.

6.4 Pilot Treatment System

A pilot treatment system consisting of surface-active foam fractionation (SAFF®20) unit with prefiltration (100 to 200-micron bag filters) for solids removal packaged in an 8-ft wide by 40-ft long by 9.5-ft high insulated Conex box (Figure 18). This unit has an approximate capacity of 40 gpm. Influent conveyance piping to the unit will be reduced to a 3-inch diameter HDPE pipe. Effluent from the SAFF®20 unit will be further filtered to reduce finer particulates prior to polishing using two in-series treatment vessels containing sorbent media. Based on discussions with the SAFF®20 unit vendor, a second equalization tank and transfer pump was added to provide a relatively constant supply of water to the two polishing sorbent media vessels. One AER vessel 2 ft in diameter containing 5 ft of media (Empty Bed Contact Time [EBCT]=3 minutes) will be connected in series with one GAC vessel 4 ft in diameter containing 4 ft of media (EBCT=9.4 minutes). Bag filters and polishing AER and GAC vessels will be packaged in an 8-ft wide by 20-ft long by 9.5-ft high insulated Conex box. Treated effluent from polishing units will be discharged in accordance with the preferred discharge option described above. SAFF®20 process concentration factors vary over a wide range (1,000x-10,000x). For planning purposes, assuming a concentration factor of 5,000x and a flow rate of 40 gpm, the estimated volume of foamate generated over a 1-year pilot system operation would be approximately 4,200 gallons. Foamate would be collected from the SAFF®20 unit and periodically destroyed on- or off-installation, depending on treatment equipment availability, in accordance with current Office of the Secretary of Defense and USEPA guidance. Destructive technology selection and frequency of foamate removal/treatment will be determined based on data collected during pilot system operation as well as data collected during parallel laboratory treatability studies (TSs) which are briefly described below.

For planning purposes, it is assumed installation of a transformer will be required and 3-Phase, 460 Volt electrical service will be available near the location of the preferred option for staging the pilot treatment system. Electrical conduit will be installed in the same trench as the influent conveyance HDPE piping. A programable logic controller (PLC) with level controls and a power disconnect will be installed to control operation of extraction trench sump pumps, influent transfer pump to the SAFF®20 system, and polishing treatment vessels. Pilot system operation and maintenance will be conducted for 1 year and include monitoring of system flow rates, pressures, influent and effluent PFAS, legacy VOCs, SVOCs, and metal contaminants, as well as other constituents, as needed, based on substantive requirements of NYSDEC State Pollutant Discharge Elimination System (SPDES) requirements. This data will be used for system performance and discharge monitoring purposes. In addition, if SAFF®20 unit effluent exceeds applicable discharge criteria, a sample of this unit's effluent will be collected for baseline characterization and laboratory bench-scale TSs. In that case, laboratory TS data will be used to evaluate potential pretreatment system requirements (e.g., TOC, iron, and manganese removal). After pilot system operation has been completed, it is assumed that AER and GAC media, approximately 690 pounds and 1,700 pounds, respectively, will be disposed of off-base at a licensed facility based on DOD/USEPA and Air Force policy in effect when planning for pilot system operation and decommissioning. The actual amount of AER and GAC that would require disposal for continued system operation will be determined based on data collected during system operation and data collected during the TS.

6.5 Pilot System Optimization Investigation

A pilot optimization investigation (POI) will be conducted during initial pilot system operation. The POI will accomplish the following:

- better determine the highest PFAS concentrations along the southern base boundary;
- collect necessary geologic/geotechnical data;
- assess potential preferential flow pathways through aquifer testing (slug tests) to determine hydraulic conductivity;
- evaluate pretreatment technology requirements and media usage rates with a bench-scale TS.

Pump tests are proposed as optional activities at two locations (CPA-EW01 and CPA-EW02 and associated CPA-MWs along the extraction trench alignment) in the event pump tests are deemed feasible based on POI activities described in this section. If pump tests are performed, one of the monitoring well clusters (CPA-MW04S/I) will also be optional. If pump tests are not performed, the operation of the extraction trench will be used to assess the zone of pumping influence. In any event, formation testing is proposed at monitoring wells (CPA-MWs and MW-113) using slug tests to evaluate formation hydraulic conductivity at various locations and depths along the trench and potential flow contributions to the extraction trench. Proposed MWs will be clustered, where applicable, with existing MWs (i.e., one existing in glacial till, MW-113) for monitoring aquifer response during the tests. Proposed MWs will also be used for evaluating extraction trench performance during the pilot test.

During the POI, the proposed CPA-MWs discussed below (Figure 13) will be sampled for analysis of PFAS, VOCs, SVOCs, and eight RCRA metals, and water quality parameters previously listed (Section 6.0). Proposed MWs are designated as CPA-MW##S/I to indicate the well ID and upper/lower portion of the glacial till to be monitored. Shallow MWs will generally be screened from approximately 5 to 15 ft bgs and intermediate MWs will be screened from 20 to 30 ft bgs. Note that there is a lack of legacy VOC, SVOC, and RCRA metals data as well as water quality parameters (data gap is discussed below) based on data available in ERPIMS. Sampling and analysis for legacy contaminants and water quality parameters are proposed to provide data needed to fill these data gaps.

The general approach for the POI is described below and additional information will be provided in the technical specifications in the Phase 2 report.

- *Installation of two (2) extraction wells (EWs) and one (1) monitor well (MW) cluster (optional)*: The borings and wells discussed in this bullet are optional. These wells would be constructed following installation of other proposed monitoring wells and slug testing to assess whether pump testing is feasible along the trench. If pump tests are deemed feasible, two soil borings will be drilled for installing two extraction wells (CPA-EW01 and CPA-EW02). The EWs will be installed to an approximate depth of 30 ft bgs and will be screened from approximately 5 to 30 ft bgs. The EWs will be constructed with 4-inch diameter Schedule 40 PVC casing and 0.01-inch wire wrapped, Schedule 40 PVC screen. In addition, two soil borings will be drilled for installing an equal number of MWs (CPA-MW04S/I). The MWs will be constructed with 2-inch diameter Schedule 40 PVC casing and 0.01-inch wire wrapped PVC screen. The MW cluster will be used for the aquifer tests as well as for performance monitoring of the response action pilot system. Soil borings will be installed using a rotasonic rig. Borings for the EWs and intermediate MWs will be installed to 30 ft bgs or to refusal whichever is encountered first.
- *Installation of six MW clusters and a single MW:* These MWs are proposed to better define the distribution of highest PFAS levels along the base boundary, collect formation hydraulic conductivity data, and for pilot system performance monitoring. Thirteen soil borings will be drilled for installing an equal number of MWs (CPA-MW01S/I through CPA-MW04S/I, CPA-MW06S/I, and CPA-MW05I, and CPA-MW07S/I). Note that one of these clusters (CPA-MW04S/I) is optional as described above. Proposed MWs will be constructed as described above for the optional MWs. A single MW (CPA-MW05I) will be paired with existing shallow well MW-113.
- *Soil sample collection for analysis of PFAS, VOCs, SVOCs, and RCRA metals:* Given the proximity of PFAS source areas (e.g., industrial wastewater lagoons, and other areas) and contaminated runoff at the southern base boundary, soil sample collection in the vadose zone will be performed during drilling for analysis of the above parameters. Soil cores collected during drilling will be logged, screened with a photoionization detector (PID), and observed for evidence of visual/olfactory contaminant impacts. Three soil samples will be collected from each boring: near the surface, above the field-interpreted water table (approximately 4-15 ft bgs), and at the depth where impacts may be observed in the field or at the highest PID reading.
- *Soil sample collection for geotechnical parameters and grain size analysis:* Four soil samples will be collected at each of the six MW cluster locations for these analyses. Samples will be collected from the deeper soil borings (i.e., CPA-MW##I designated wells) drilled at each MW cluster location. One sample will be collected from the vadose zone and three samples will be collected from the saturated zone. This data will be used for extraction trench design, MW well design, and other evaluations regarding PFAS plume containment, fate, and transport. Samples will be analyzed for the following parameters: grain size distribution, clay content, soil classification, particle size distribution, soil bulk density, moisture content, porosity, cation exchange capacity, and fraction of organic carbon.
- *Groundwater sample collection from 14 (existing and proposed) MWs:* Groundwater samples will be collected to better define distribution of PFAS and legacy contaminants, if any, in the glacial till as well as characterize water quality parameters. Samples will be analyzed for PFAS, VOCs, SVOCs,

total and dissolved RCRA (eight) metals, and water quality parameters (anions [nitrate, sulfate, bicarbonate, chloride, fluoride], cations [total and dissolved calcium, magnesium, iron, and manganese], TOC, TSS, TDS, Oil and Grease (O&G), alkalinity, and hardness). Additionally, wells will be gauged using an oil/water interface probe and field parameters (pH, oxidation-reduction potential [ORP], temperature, specific conductance, and turbidity) will be measured at each of the above well locations. Well development and purge water generated in preparation for sampling will be treated onsite using GAC vessels and then discharged to the sanitary sewer. Treated water will be sampled for the analytical parameters on a quick turnaround time.

- *Slug testing at 14 MWs:* Rising and falling head slug tests will be performed at the 13 proposed MWs and one existing well (MW-113). Transducers will be placed in each MW to collect data related to formation response to introduction and withdrawal of slugs from the MWs during the tests. Data from slug tests will be analyzed to evaluate formation hydraulic conductivity at various locations and depths along the extraction trench.
- *Pump testing at CPA-EW01 and CPA-EW02 (optional):* Pressure transducers will be installed in the EWs and the proposed MWs (CPA-MW03S/I, CPA-MW04S/I, and CPA-MW-5S/I) and data used for evaluating aquifer properties and capture zone. Variable rate pump tests and a constant rate pump test will be performed at EWs assuming the formation recharges and yields groundwater for testing. Tests will be conducted over a two-week period to allow time for the formation to equilibrate between tests. The expected volume of water to be produced during the pump tests will be evaluated following MW installation, development, and slug testing. If feasible, following the constant rate test, water levels will be monitored until water levels return to approximately 80% of the baseline static water elevations. Water produced during these tests will be stored onsite in a frac tank; sampled for PFAS, VOCs, SVOCs, and RCRA metals on a quick turnaround time (48–72 hours); treated onsite using GAC (size of vessels to be determined); and then stored onsite for testing prior to discharge to a nearby sanitary sewer. Duration of pump testing-related activities, if performed, is approximately two months. Additional information regarding aquifer testing will be provided in the Phase 2 report technical specifications. If pump tests are not performed, development water will be containerized in 55-gallon steel drums, sampled, and managed in accordance with DOD/USEPA and Air Force policy in effect when planning for field work is performed.
- *Zone of pumping influence of extraction trench:* If pump tests are deemed infeasible, the zone of pumping influence will be evaluated during operation of the pilot system. Seventeen (17) pressure transducers will be installed in the two (2) stainless steel slotted sumps, 13 proposed MWs, and two (2) existing wells (MW-113 and MW-113BR). A transducer in the latter well will be used to assess potential response in fractured bedrock due to pumping in the glacial till. Transducer data collected over a period of six (6) months will be evaluated to assess extraction system influence over a range of flows recorded during system operation based on rate of formation recharge to the trench.
- *Groundwater sample collection for laboratory TS (jar, batch, and rapid small scale column tests [RSSCTs]).* Four 55-gallon drums of groundwater (or two drums from each sump discharge) will be collected from the extraction system and sent to the SAFF®20 system vendor for TS testing. Samples will be tested for ability to generate foam with or without addition of surfactants at various air flow rates and times of aeration. Since groundwater along the southern base boundary

contains both long-chain (i.e., PFOS/PFOA) and short-chain PFAS (four to seven carbon sulfonates and carboxylates), testing of additives to enhance SAFF®20 performance for removing short-chain PFAS will also be performed. SAFF®20 TS testing will also include potential for and amount of VOC production in the off-gas, if applicable, and amount of waste produced from the SAFF®20 technology (assumed to be approximately 4,200 gallons of foamate for purposes of this report).

- In addition, one sample will be collected from each of the drums for baseline characterization and analyzed for PFAS, VOCs, SVOCs, RCRA metals, and water quality parameters described above for groundwater analysis. If analytical data indicate that SAFF®20 effluent will likely exceed the ASD(EIE)guidance RSLs and/or NYSDEC SPDES criteria, RSSCTs will be performed to assess PFAS breakthrough and media (e.g., AER and GAC) usage rates. Pretreatment process requirements (i.e., to remove TOC, free chlorine, iron/manganese, and anions/cations), will be tested, as appropriate. Pretreatment TS tests will evaluate chemical dosages and reaction times for effective removal of each of these parameters. Details for the proposed scope of pretreatment bench-scale TS will be provided in the Phase 2 report technical specifications. Substantive discharge requirements (i.e., pretreatment requirements) will be evaluated for discharge to sanitary sewer if discharge Option 3 is selected by SANG or to the ISWTS weir if discharge Options 1 or 2 are selected. This evaluation will assess whether any additional parameters should be included in the analyte list (e.g., 5-day Biochemical Oxygen Demand, Chemical Oxygen Demand, glycols, and others), if necessary.

7.0 Summary and Recommendations

In accordance with the Stewart ANGB request and discussions with AFCEC/CZTE, the CPA Team evaluated response actions for the existing stormwater sewer network and groundwater at the base's southern boundary where highest PFAS concentrations in groundwater are encountered. These actions are intended to prevent releases of contaminated sediment and surface water to Recreation Pond and groundwater discharge to the pond and nearby Silver Stream.

With regard to the stormwater sewer network, the CPA Team identified additional locations to those that previous CCTV inspections revealed in the network where piping is defective leading to contaminated groundwater infiltration into the system under dry weather conditions. Additionally, the Team worked closely with contractors who specialize in stormwater piping rehabilitation and identified the CIPP method to be a more cost-effective method for application at the site. For proper liner selection and design and to obtain a reliable work plan and cost estimate, the Team recommends an initial cleaning and inspection of the defective network be performed which would necessitate high pressure jetting of the piping and collection of debris and contaminated stormwater. Since previous site investigations suggest that the sediments within the piping network have not been characterized for PFAS and other potential constituents, the CPA Team recommends a DGI be performed to assess PFAS presence and concentrations within impacted piping. This data is important to collect to allow segregation of wastes during sewer rehabilitation activities and to determine properly licensed off-site disposal facilities and develop cost estimates for transportation and disposal. Transportation and disposal costs are a function of the detected PFAS concentrations.

A groundwater response action is recommended at the southern base boundary to contain the highest PFAS-impacted groundwater in the glacial till and reduce off-base migration. Hydrogeological, chemical, and engineering data needed to design and construct a pilot groundwater treatment system are very limited. Typically, these types of data are obtained during a pre-design investigation prior to design and construction of a treatment system. However, because Steward ANGB wishes to begin treatment as early as possible, an alternate approach to design and construction is recommended which entails: (1) construction and operation of an initial pilot treatment system designed using available data with appropriately conservative assumptions; (2) collection of pre-design information during initial pilot system operation; and (3) using the new information to design, retrofit as needed, and optimize performance of the extraction and treatment system.

The recommended groundwater response action is containment of the highest PFAS concentrations using a collection trench given the low permeability glacial till that comprises the overburden at the site. A trench measuring approximately 900-ft long by 30-ft deep and 2-ft wide would be installed using a one-pass trencher to minimize construction costs and safety concerns during construction. The one-pass trencher would also be used to install coarse aggregate backfill, slotted HDPE piping, and two sumps for groundwater collection. Extracted groundwater would be treated on-site and discharged to either Recreation Pond or a sanitary sewer depending on the pilot treatment system location selected by Stewart ANGB. As discussed in Section 6.0, three options were identified for locating the treatment system and associated effluent discharge piping. On-site treatment and discharge to sanitary sewer, if selected, would result in the shortest effluent piping/trenching costs. Pilot treatment system flow rate and treatment processes are conceptual at this time since formation hydrogeologic properties, legacy contaminant, and water quality data are lacking. Pilot treatment system is envisioned to consist of surface-active foam fractionation (SAFF®20 pilot unit with prefiltration of suspended solids and 40-gpm capacity) followed by polishing using one AER vessel in series with a GAC vessel. This system capacity is proposed to account for potential preferential flow pathways and may under- or over-estimate actual formation yields. As described above, the CPA Team also recommends collecting the POI data, including laboratory treatability studies early on during pilot system operation to allow for pretreatment system design, and SAFF®20 unit off-gas capture and treatment should these components be deemed necessary.

8.0 References

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Aneptek. 1997. *Remedial Investigation Report, Site 2 – Pesticide Pit Burial Area, Stewart Air National Guard Base, Newburgh, New York.* September.

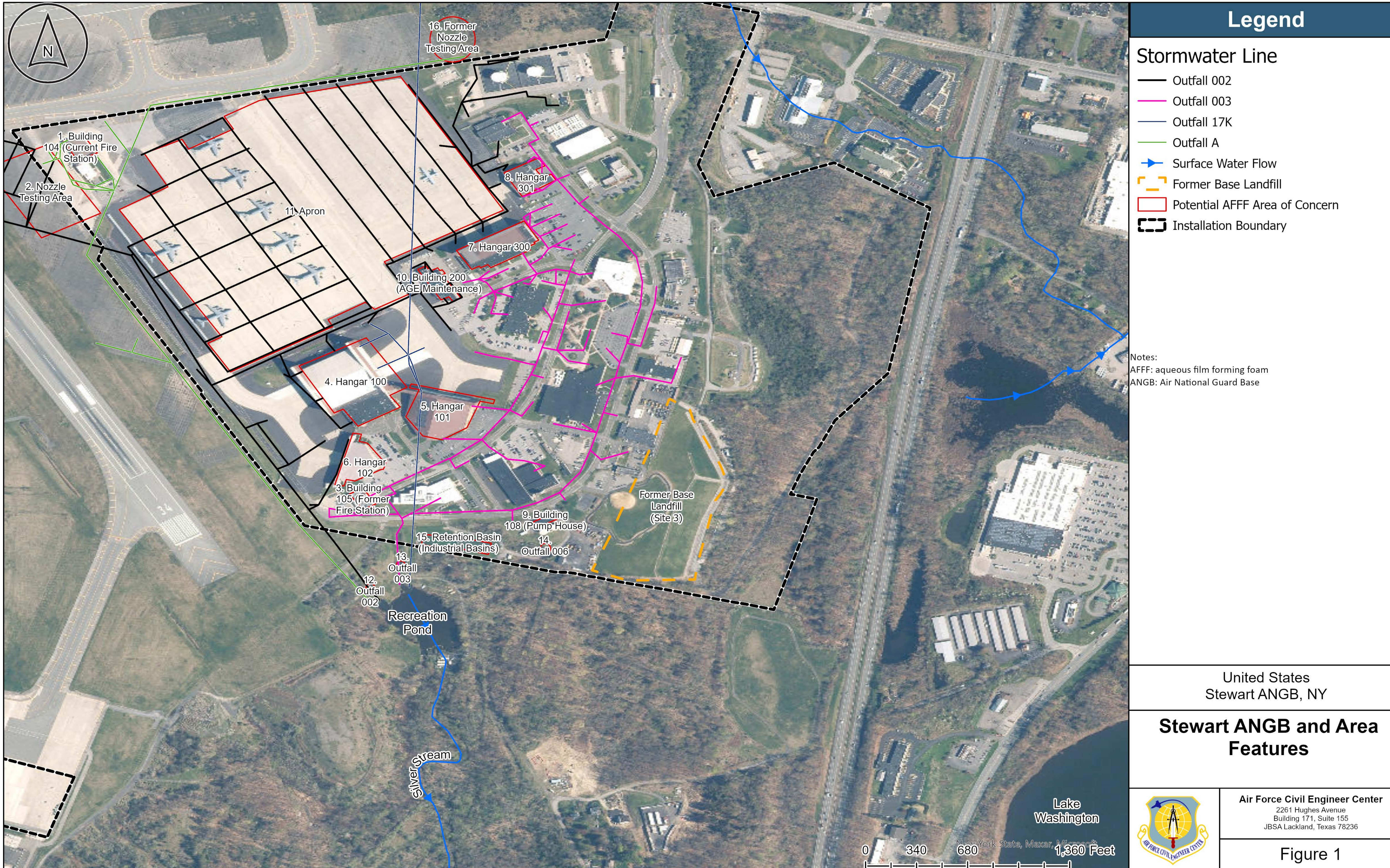
Stewart ANGB. 2024. *Restoration Advisory Board Presentation*. January 31.

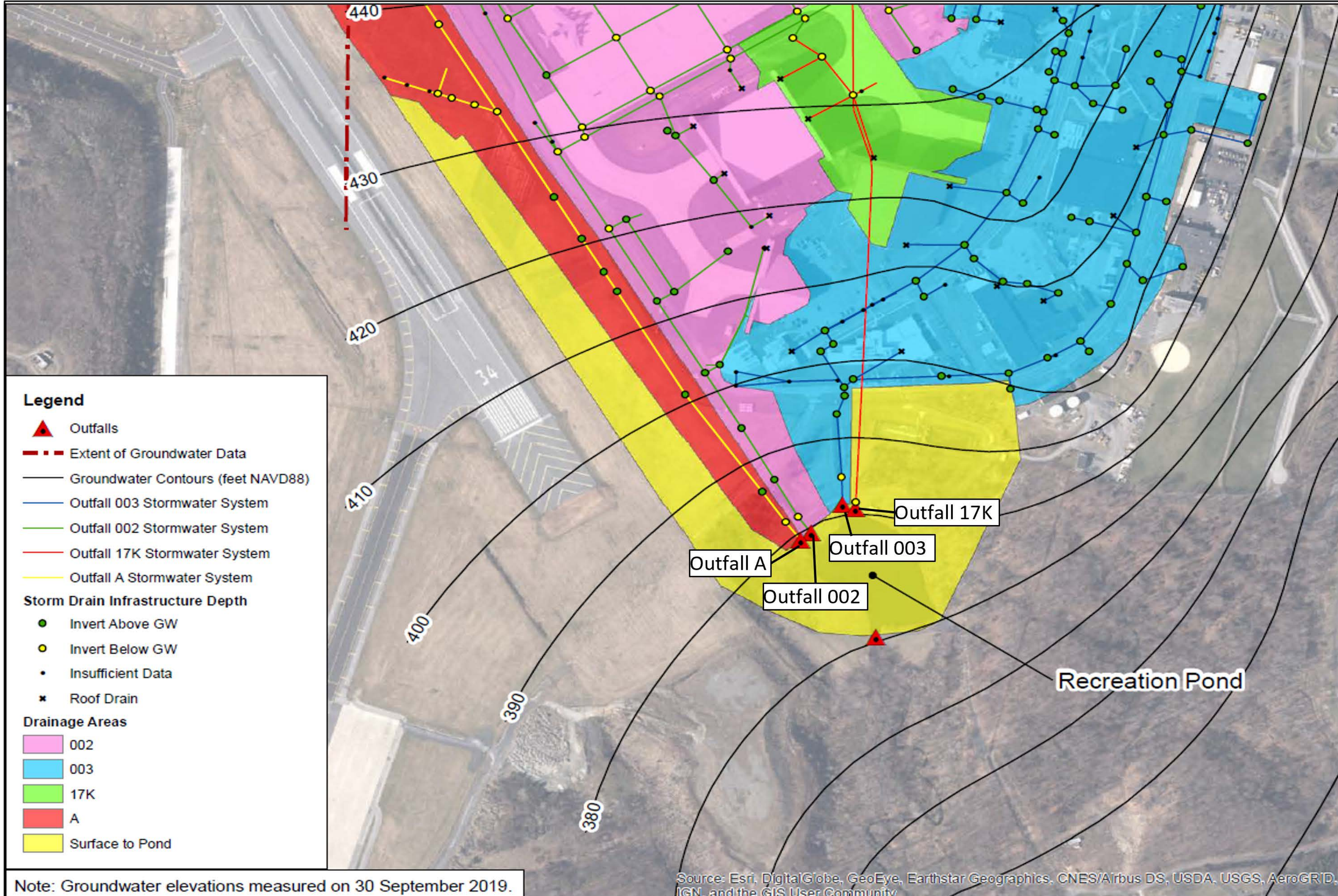
Wood. 2018. *Revised Final FY16 Phase 1 Regional Site Inspection Report For Per- And Polyfluoroalkyl Substances 105th Airlift Wing New York Air National Guard Stewart Air National Guard Base Newburgh, NY.* October.

Wood. 2020. *Final Expanded Site Inspection Report For Per- And Polyfluoroalkyl Substances 105th Airlift Wing New York Air National Guard Stewart Air National Guard Base Newburgh, NY.* September.

Wood. 2022. *Final 2021 Annual Long Term Monitoring Report, Site 3: Former Base Landfill, 105th Airlift Wing New York Air National Guard Stewart Air National Guard Base Newburgh, NY.* April.

Appendix A CPA Phase 1 Report Figures


N
16. Former Nozzle Testing Area
1. Building 104 (Current Fire Station)
2. Nozzle Testing Area
11. Apron
8. Hangar 301
7. Hangar 300
10. Building 200 (AGE Maintenance)
4. Hangar 100
5. Hangar 101
6. Hangar 102
3. Building 105 (Former Fire Station)
9. Building 108 (Pump House)
15. Retention Basin (Indistrial Basins)
14. Outfall 006
13. Outfall 003
12. Outfall 002
Former Base Landfill (Site 3)
Recreation Pond
Silver Stream
Lake Washington
0 340 680 1,360 Feet
Legend
Stormwater Line
Outfall 002
Outfall 003
Outfall 17K
Outfall A
Surface Water Flow
Former Base Landfill
Potential AFFF Area of Concern
Installation Boundary
Notes:
AFFF: aqueous film forming foam
ANGB: Air National Guard Base
United States
Stewart ANGB, NY
Stewart ANGB and Area Features
Air Force Civil Engineer Center
2261 Hughes Avenue
Building 171, Suite 155
JBSA Lackland, Texas 78236
Figure 1



Note: Groundwater elevations measured on 30 September 2019.

Legend

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Potentiometric Surface at the South Corner

wood.

271 Mill Road
Chelmsford, MA 01824

Tel. 978-692-9090
www.woodplc.com

CLIENT	PROJECT	PROJECT NO.: 291330006
STEWART AIR NATIONAL GUARD BASE	STEWART AIR NATIONAL GUARD BASE EXPANDED SITE INSPECTION FOR PER- AND POLYFLUOROALKYL SUBSTANCES NEWBURGH, NEW YORK	REVISION NO.: 1
		DATE: JUNE 2020

PROJECTION / DATUM: NY83F	PREPARED BY: DNP	TITLE	FIGURE NO.:

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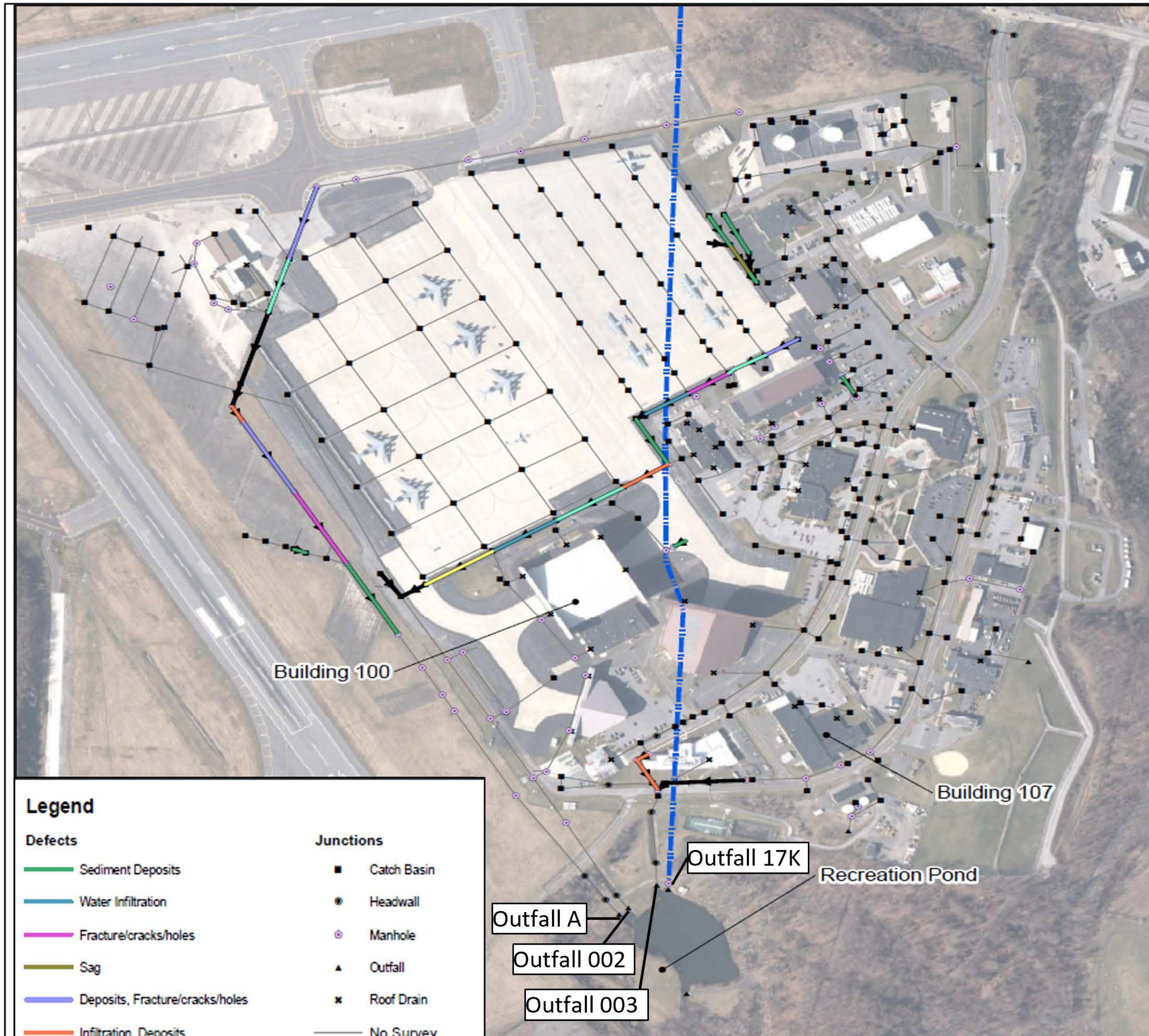
Building 171, Suite 155
JBSA Lackland, Texas 78236

Figure 2



*Because NYDOT performed the CCTV survey of 17K, Wood did not conduct an engineering analysis of the 17K CCTV investigation. Therefore, while the location of the NYDOT survey is shown, the results of the survey are not shown on this figure. The NYDOT survey results are included in the appendices.

wood.

271 Mill Road
Chelmsford, MA 01824

Tel. 978-692-9090
www.woodplc.com

CLIENT	STEWART AIR NATIONAL GUARD BASE
PROJECT	STEWART AIR NATIONAL GUARD BASE EXPANDED SITE INSPECTION FOR PER- AND POLYFLUOROALKYL SUBSTANCES NEWBURGH, NEW YORK
PROJECT NO.:	291330006
REVISION NO.:	1
DATE:	JUNE 2020
PROJECTION / DATUM:	NY83F
PREPARED BY:	DNP
CHECKED BY:	JDB
REVIEWED BY:	JDB
TITLE	CCTV SURVEY
FIGURE NO.:	6

0 130 260 520
Feet

Legend

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Storm Sewer Layout and Results from ESI Storm Sewer Evaluation

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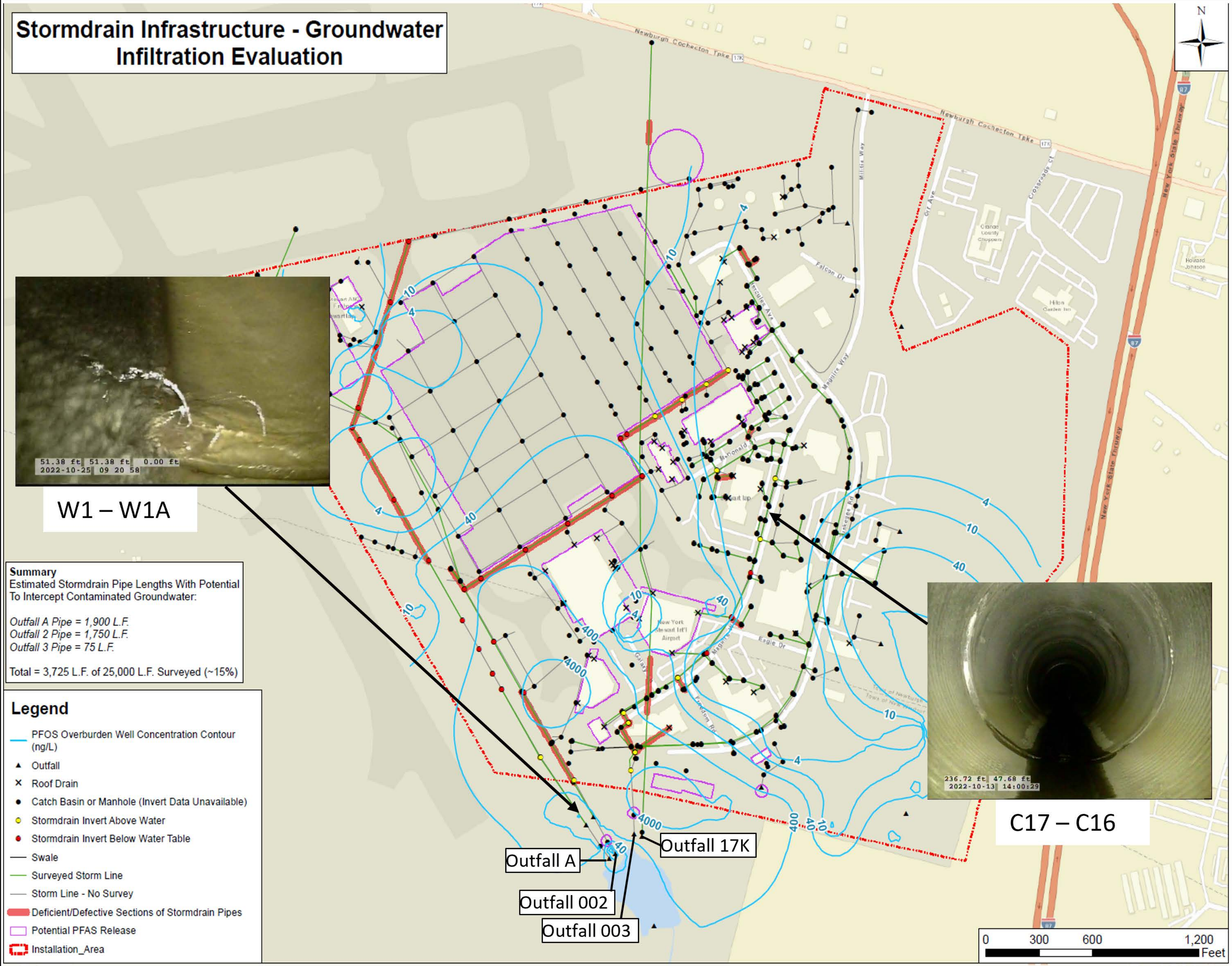
Figure 3



Legend

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Preliminary Results from Ongoing Storm Sewer Evaluation

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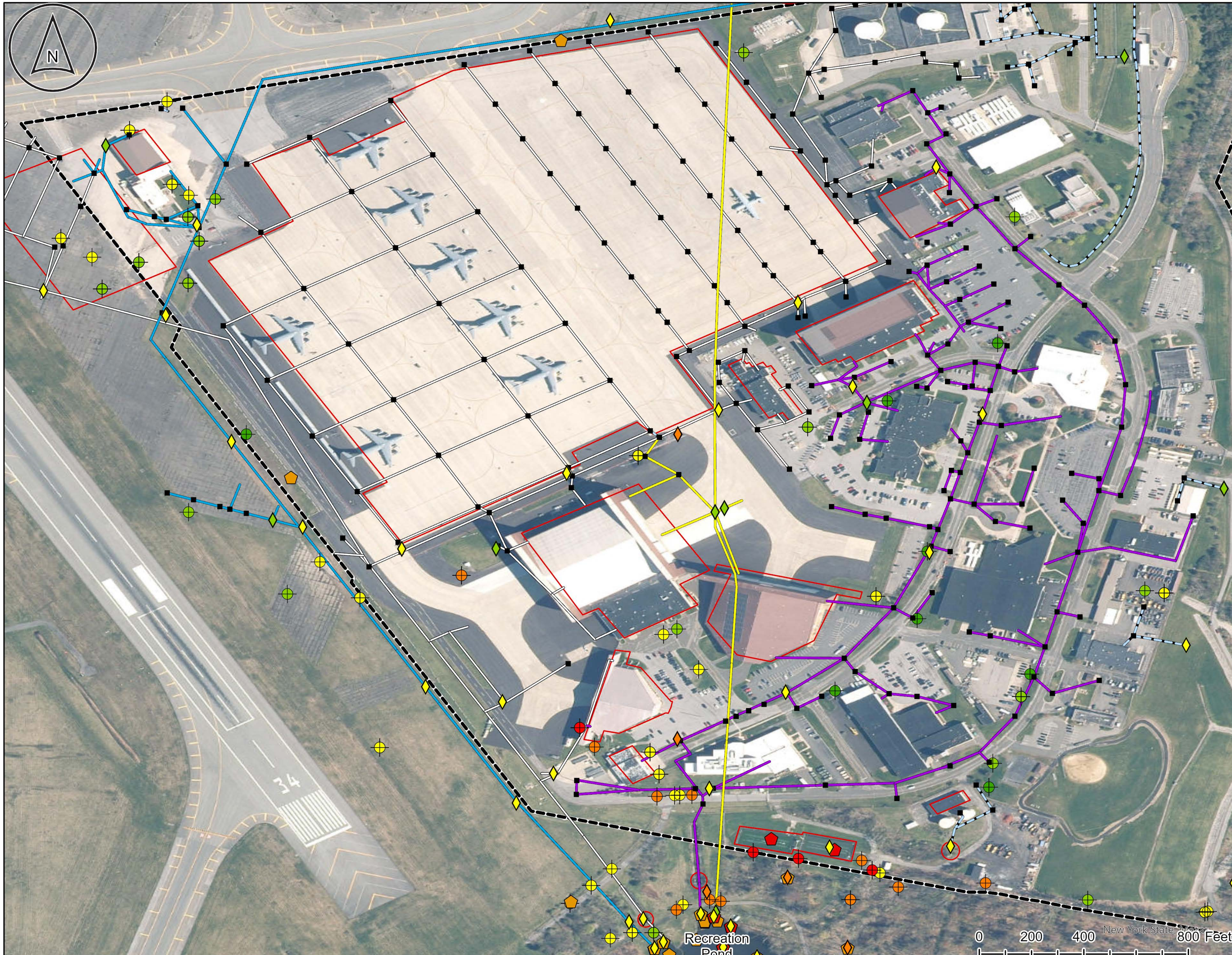
Figure 4



Legend

Groundwater

PFOA + PFOS (ng/L)

- Not Detected
- Detected - <70
- 70 - <1,000
- 1,000 - <10,000
- ≥10,000

Sediment

PFOA + PFOS (ng/kg)

- Not Detected
- Detected - <70
- 70 - <1,000
- 1,000 - <100,000
- ≥100,000

Surface Water

PFOA + PFOS (ng/L)

- Not Detected
- Detected - <70
- 70 - <1,000
- 1,000 - <10,000
- ≥10,000

Stormsewer Line

Drainage Area

- 002
- 003
- 17K
- A
- Other
- Catch Basin
- Potential AFFF Area of Concern
- Installation Boundary

Notes:

AFFF: aqueous film forming foam
ANGB: Air National Guard Base
CPA: Critical Process Analysis
ng/kg: nanograms per kilogram
ng/L: nanograms per liter
PFOA: perfluorooctanoic acid
PFOS: perfluorooctanesulfonic acid

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Groundwater, Surface Water, and Sediment Sample Results

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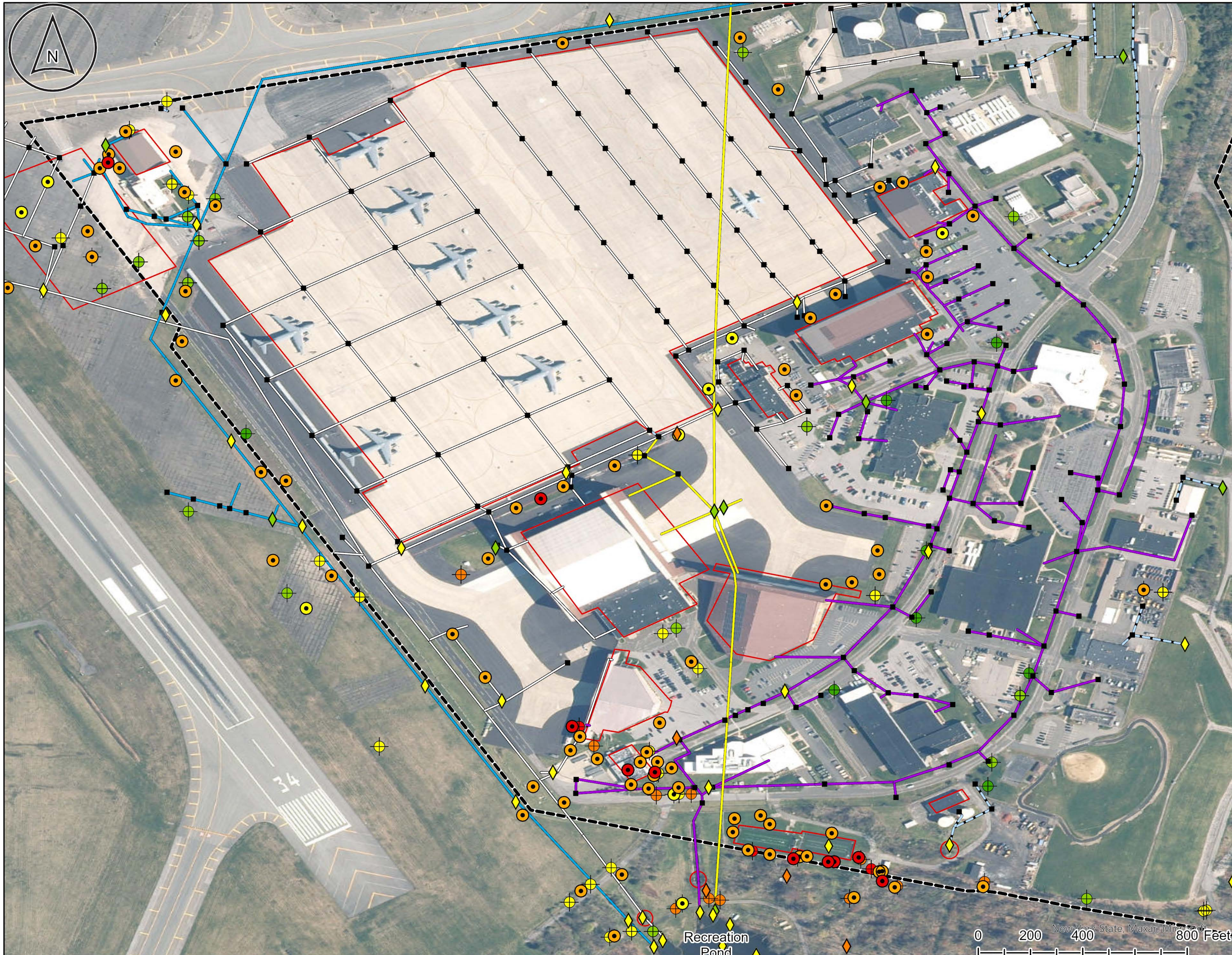
Figure 5



Legend

Groundwater
PFOA + PFOS (ng/L)
- Not Detected
- Detected - <70
- 70 - <1,000
- 1,000 - <10,000
- ≥10,000

Surface Water
PFOA + PFOS (ng/L)
- Not Detected
- Detected - <70
- 70 - <1,000
- 1,000 - <10,000
- ≥10,000

Soil
PFOA + PFOS (ng/kg)
- 70 - <1,000
- 1,000 - <100,000
- ≥100,000

Stormsewer Line
Drainage Area
- 002
- 003
- 17K
- A
- Other
- Catch Basin
- Potential AFFF Area of Concern
- Installation Boundary

Notes:
AFFF: aqueous film forming foam
ANGB: Air National Guard Base
CPA: Critical Process Analysis
ng/kg: nanograms per kilogram
ng/L: nanograms per liter
PFOA: perfluorooctanoic acid
PFOS: perfluorooctanesulfonic acid

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Soil Sampling Results

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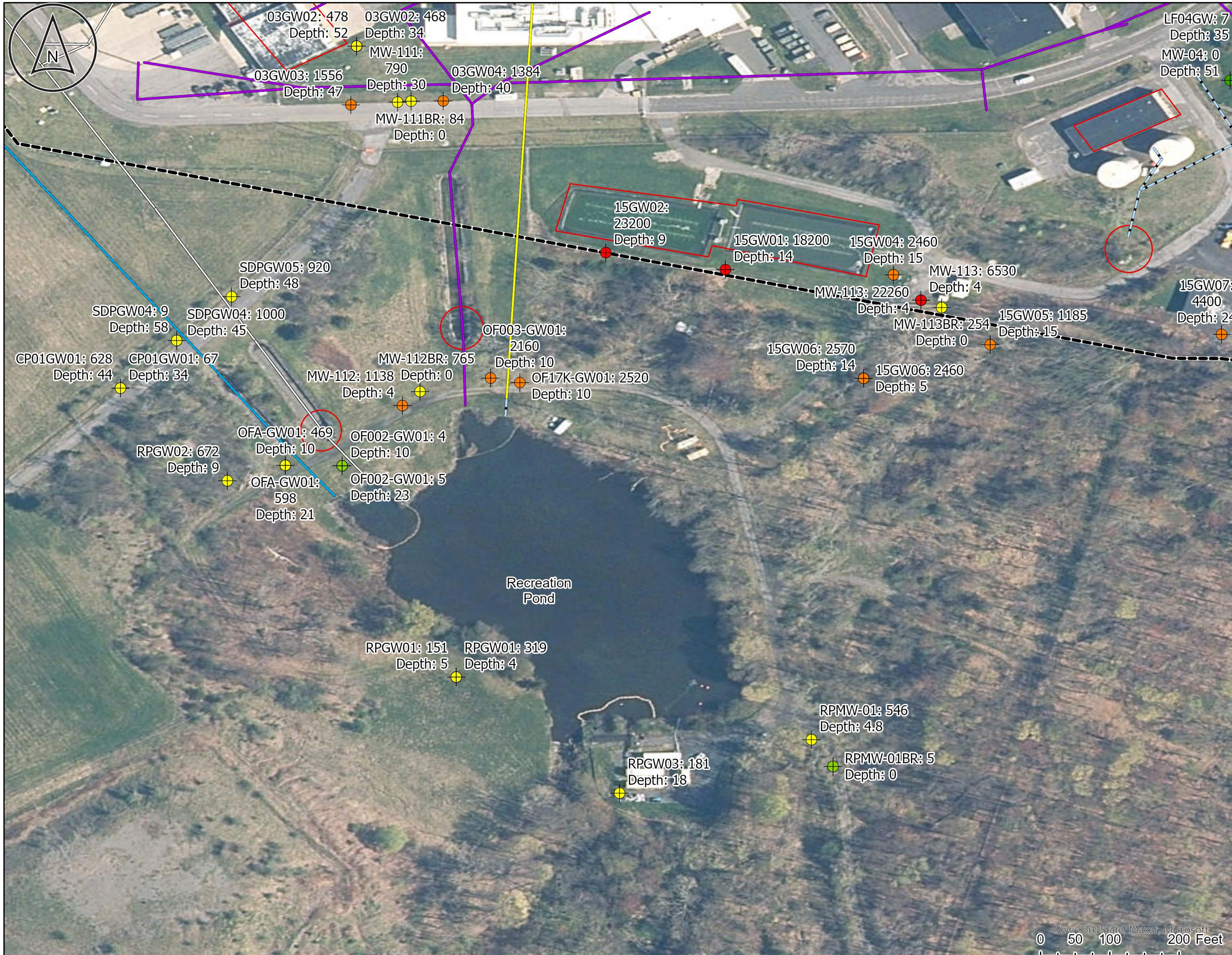
Figure 6



Legend

Groundwater

PFOA + PFOS (ng/L)

- Not Detected
- Detected - <70
- 70 - <1,000
- 1,000 - <10,000
- ≥10,000

Stormsewer Line

Drainage Area

- 002
- 003
- 17K
- A
- Other

- Potential AFFF Area of Concern
- Installation Boundary

Notes:
AFFF: aqueous film forming foam
ANGB: Air National Guard Base
CPA: Critical Process Analysis
ng/L: nanograms per liter
PFOA: perfluorooctanoic acid
PFOS: perfluorooctanesulfonic acid

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PFAS Concentrations in Groundwater at Recreation Pond

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Figure 7

Legend

Surface Water Fractionation*

- 6:2-fluorotelomersulfonic acid
- 8:2-fluorotelomersulfonic acid
- perfluorobutanoic acid (PFBA)
- perfluorobutanesulfonic acid (PFBS)
- perfluoroheptanoic acid (PFHpA)
- perfluorohexanoic acid (PFHxA)
- perfluorohexanesulfonic acid (PFHxS)
- perfluorononanoic acid (PFNA)
- perfluorooctanoic acid (PFOA)
- perfluorooctane sulfonate (PFOS)

Stormsewer Line

Drainage Area

- 002
- 003
- 17K
- A
- Other
- Potential AFFF Area of Concern
- Installation Boundary

Notes:
AFFF: aqueous film forming foam
ANGB: Air National Guard Base
ng/L: nanograms per liter
PFAS: per- and polyfluoroalkyl substances

Groundwater Fractionation:
6:2FTS: 1*H*, 1*H*, 2*H*, 2*H*-perfluorooctane sulfonic acid
8:2FTS: 1*H*, 1*H*, 2*H*, 2*H*-perfluorodecane sulfonic acid
HFPO-DA: hexafluoropropylene oxide dimer acid or GenX
PFBA: perfluorobutanoic acid
PFBS: perfluorobutanesulfonic acid
PFHPA: perfluoroheptanoic acid
PFHxA: perfluorohexanoic acid
PFHxS: perfluorohexanesulfonic acid
PFNA: perfluorononanoic acid
PFOA: perfluorooctanoic acid
PFOS: perfluorooctanesulfonic acid
*Locations where the total concentration of PFAS constituents was less than 60 ng/L were excluded.

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Surface Water Fractionation Profile

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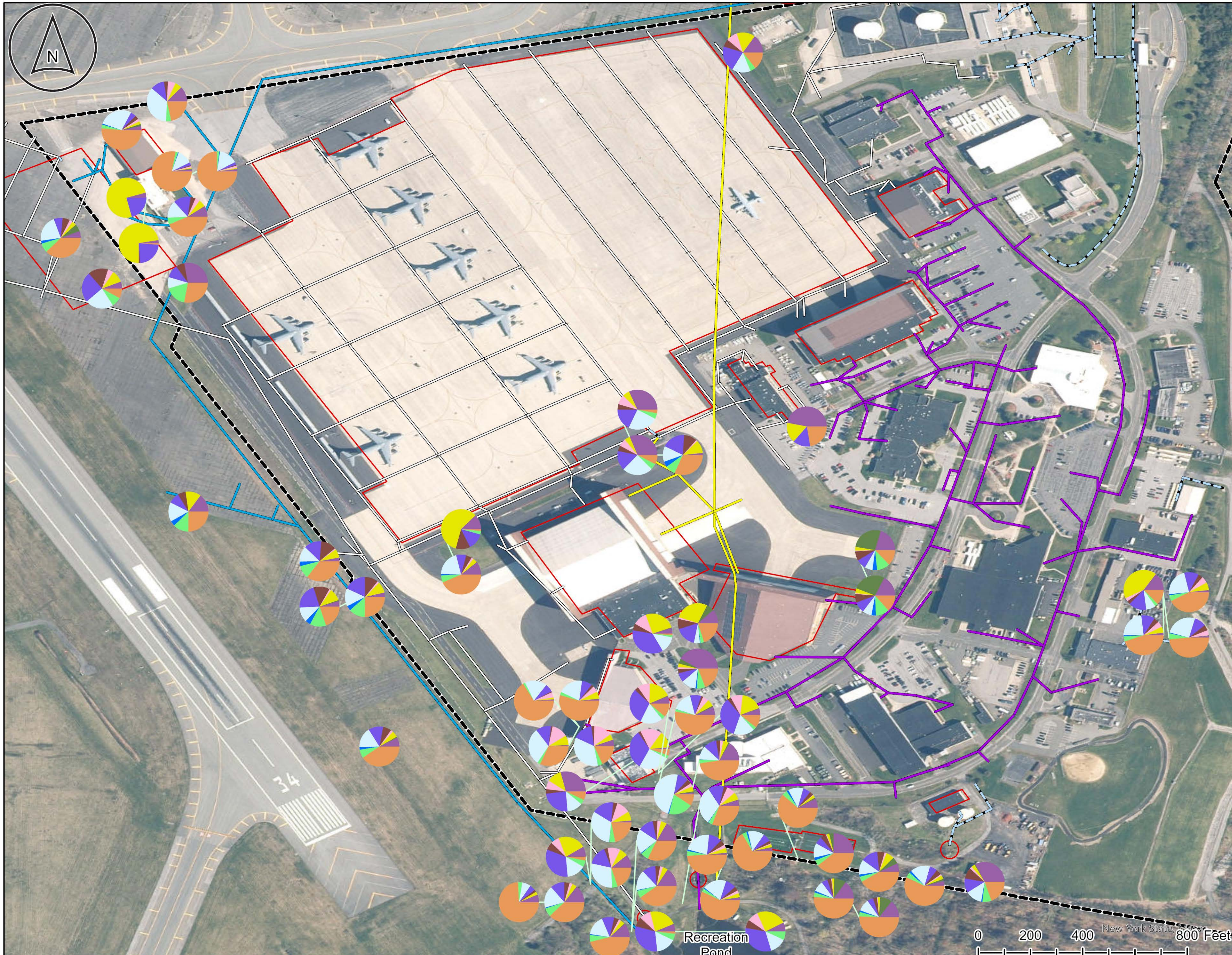
Figure 8



Legend

Groundwater Fractionation *

- 6:2-fluorotelomersulfonic acid
- 8:2-fluorotelomersulfonic acid
- perfluorobutanoic acid (PFBA)
- perfluorobutanesulfonic acid (PFBS)
- perfluoroheptanoic acid (PFHpA)
- perfluorohexanoic acid (PFHxA)
- perfluorohexanesulfonic acid (PFHxS)
- perfluorononanoic acid (PFNA)
- perfluorooctanoic acid (PFOA)
- perfluorooctane sulfonate (PFOS)

Stormsewer Line

Drainage Area

- 002
- 003
- 17K
- A
- Other
- Potential AFFF Area of Concern
- Installation Boundary

Notes:
AFFF: aqueous film forming foam
ANGB: Air National Guard Base
ng/L: nanograms per liter
PFAS: per- and polyfluoroalkyl substances

Groundwater Fractionation:
6:2FTS: 1*H*, 1*H*, 2*H*, 2*H*-perfluorooctane sulfonic acid
8:2FTS: 1*H*, 1*H*, 2*H*, 2*H*-perfluorodecane sulfonic acid
HFPO-DA: hexafluoropropylene oxide dimer acid or GenX
PFBA: perfluorobutanoic acid
PFBS: perfluorobutanesulfonic acid
PFHPA: perfluoroheptanoic acid
PFHxA: perfluorohexanoic acid
PFHxS: perfluorohexanesulfonic acid
PFNA: perfluorononanoic acid
PFOA: perfluorooctanoic acid
PFOS: perfluorooctanesulfonic acid
*Locations where the total concentration of PFAS constituents was less than 60 ng/L were excluded.

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Groundwater Fractionation Profile

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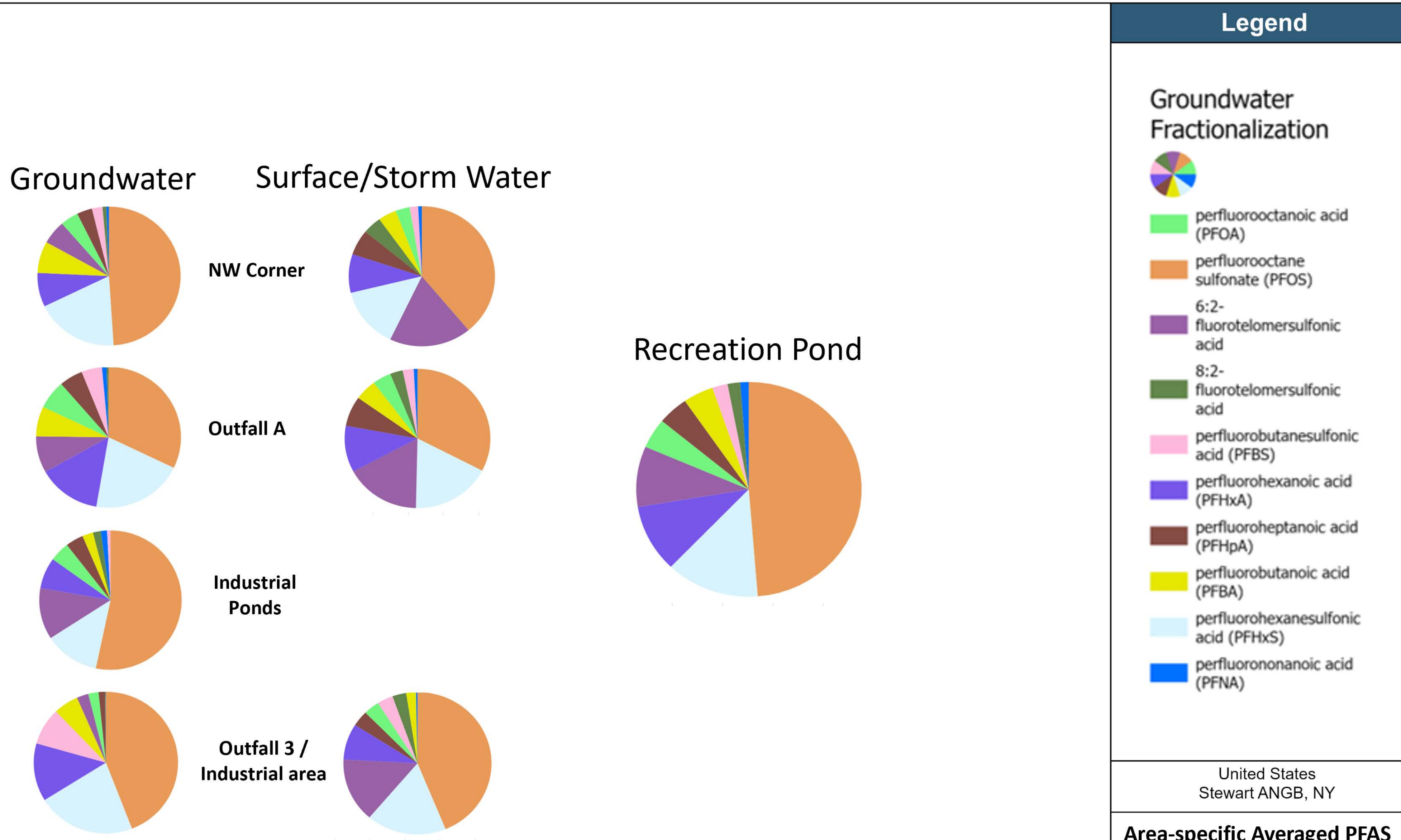
Figure 9



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Area-specific Averaged PFAS Fraction

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Figure 10

Legend

Groundwater

PFOA + PFOS (ng/L)

- Not Detected
- Detected - <70
- 70 - <1,000
- 1,000 - <10,000
- ≥10,000

Surface Water

PFOA + PFOS (ng/L)

- Not Detected
- Detected - <70
- 70 - <1,000
- 1,000 - <10,000
- ≥10,000

Stormsewer Line

Drainage Area

- 002
- 003
- 17K
- A
- Other
- Catch Basin
- Potential AFFF Area of Concern
- Installation Boundary

Sediment

PFOA + PFOS (ng/kg)

- Not Detected
- Detected - <70
- 70 - <1,000
- 1,000 - <100,000
- ≥100,000
- CPA Colocated Surface Water and Sediment

Notes:
AFFF: aqueous film forming foam
ANGB: Air National Guard Base
CPA: Critical Process Analysis
ng/kg: nanograms per kilogram
ng/L: nanograms per liter
PFOA: perfluorooctanoic acid
PFOS: perfluorooctanesulfonic acid

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Proposed Surface Water Sediment Sampling - Storm Sewer Network Investigation

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Figure 11

Legend

SI, ESI, and RI Mobilization 1 Surface Water
PFOA + PFOS (ng/L)
- Not Detected
- Detected - <70
- 70 - <1,000
- 1,000 - <10,000
- ≥10,000

Sediment
PFOA + PFOS (ng/kg)
- Not Detected
- Detected - <70
- 70 - <1,000
- 1,000 - <100,000
- ≥100,000

Stormsewer Line
Drainage Area
- 002
- 003
- 17K
- A
- Other

- Catch Basin
- RI Dependent CPA Soil Boring
- Potential AFFF Area of Concern
- Installation Boundary

Notes:
AFFF: aqueous film forming foam
ANGB: Air National Guard Base
CPA: Critical Process Analysis
ng/kg: nanograms per kilogram
ng/L: nanograms per liter
PFOA: perfluorooctanoic acid
PFOS: perfluorooctanesulfonic acid

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RI Dependent Soil Sampling - Storm Sewer Network Investigation

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Figure 12

Legend

Groundwater

PFOA + PFOS (ng/L)

- Not Detected
- Detected - <70
- 70 - <1,000
- 1,000 - <10,000
- ≥10,000
- CPA Extraction Well (optional)
- CPA Monitoring Well*
- Groundwater Recovery System
- Potential AFFF Area of Concern
- Installation Boundary

Notes:

ANGB: Air National Guard Base
AFFF: aqueous film forming foam
CPA: Critical Process Analysis
ng/L: nanograms per liter
PFOA: perfluorooctanoic acid
PFOS: perfluorooctanesulfonic acid

*Monitoring well cluster CPA-MW04S/I is recommend only in conjunction with extraction well CPA-EW01.

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Proposed Monitoring, Pump Test Wells and Conceptual Extraction Trench

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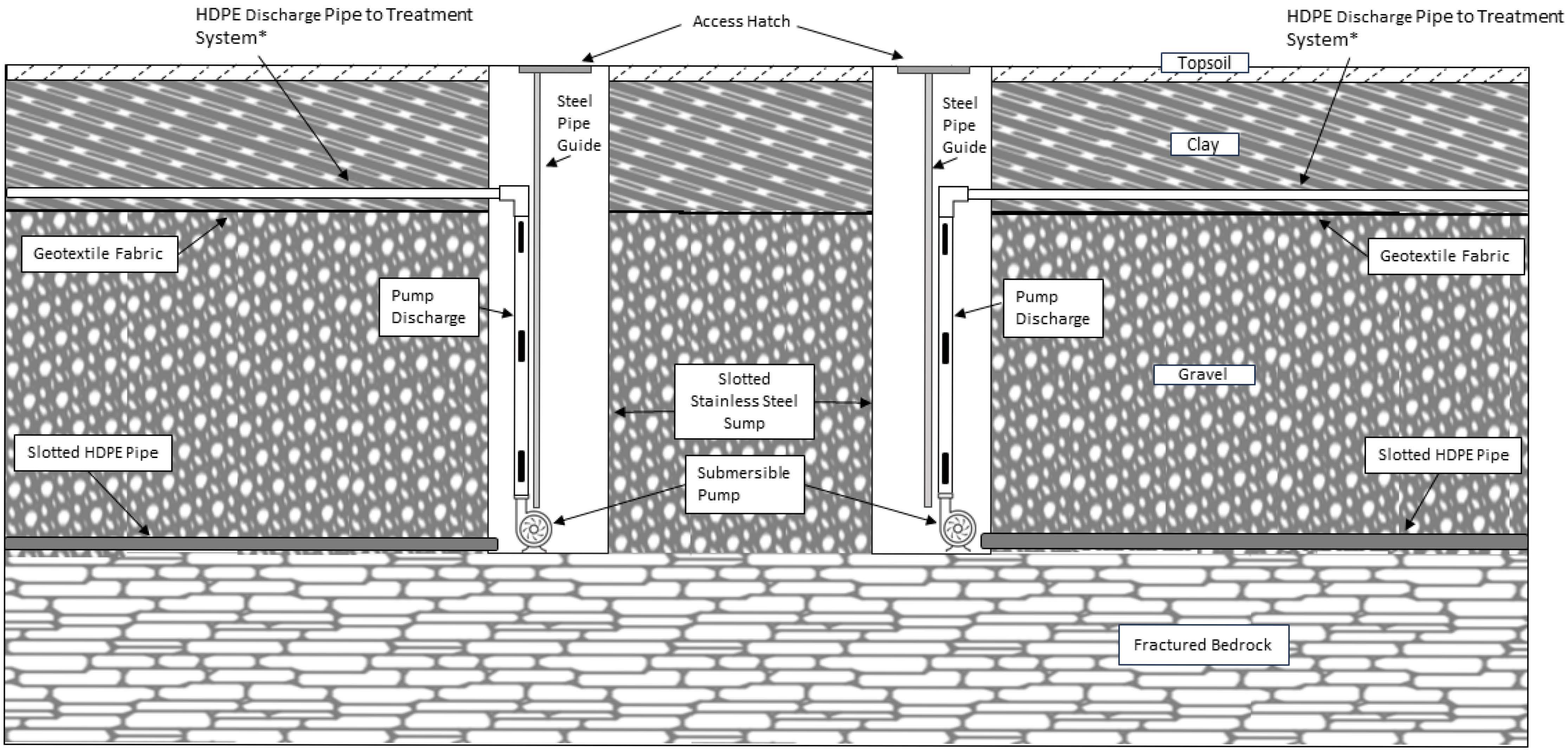
Figure 13



Conceptual Extraction Trench Elevation View

Figure 14

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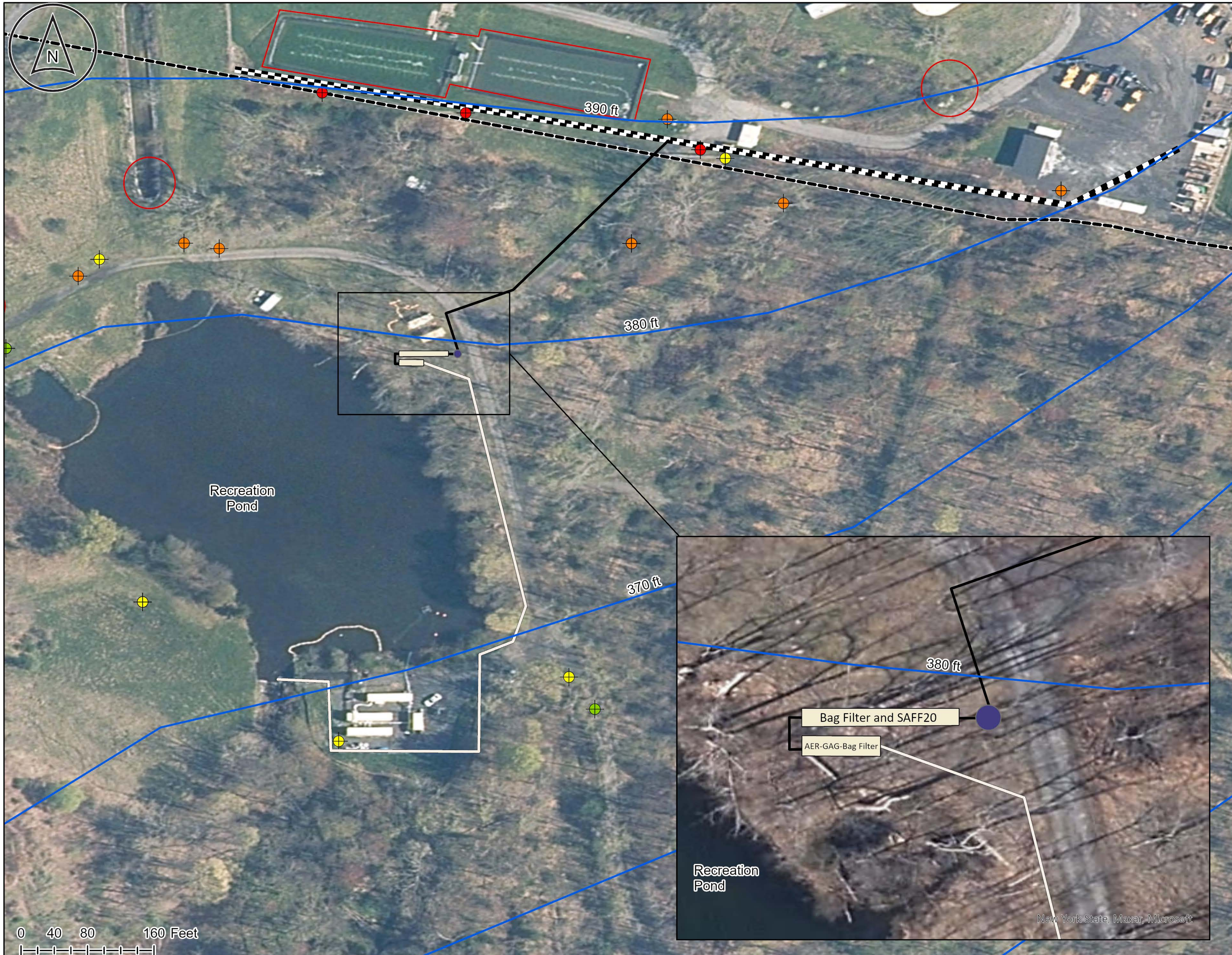
Legend

Notes:
ANGB: Air National Guard Base
HDPE: High Density Polyethylene

*HDPE discharge pipe from each sump will be manifolded into one influent conveyance pipe to treatment system



Legend

Groundwater

PFOA + PFOS (ng/L)

- Not Detected
- Detected - <70
- 70 - <1,000
- 1,000 - <10,000
- ≥10,000
- Groundwater Recovery System
- Storage Tank Option 1
- Effluent Discharge Option 1
- Groundwater Conveyance Pipe Option 1
- Treatment Facility Option 1
- Groundwater Contours (Wood 09.2024)
- Potential AFFF Area of Concern
- Installation Boundary

Notes:
AFFF: aqueous film forming foam
ANGB: Air National Guard Base
ng/L: nanograms per liter
PFOA: perfluorooctanoic acid
PFOS: perfluorooctanesulfonic acid

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Treatment Facility Location Option 1

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Figure 15


N
390 ft
380 ft
370 ft
Recreation Pond
0 40 80 160 Feet
Recreation Pond
370 ft
Bag Filter and SAFF20
AER-GAG-Bag Filter
New York State, Maxar, Microsoft
Legend
Groundwater
PFOA + PFOS (ng/L)
Not Detected
Detected - <70
70 - <1,000
1,000 - <10,000
≥10,000
Groundwater Recovery System
Treatment Facility Option 2
Groundwater Conveyance Pipe Option 2
Storage Tank Option 2
Effluent Discharge Option 2
Current Treatment Facility
Groundwater Contours (Wood 09.2024)
Potential AFFF Area of Concern
Installation Boundary
Notes:
AFFF: aqueous film forming foam
ANGB: Air National Guard Base
CPA: Critical Process Analysis
ng/L: nanograms per liter
PFOA: perfluorooctanoic acid
PFOS: perfluorooctanesulfonic acid
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Treatment Facility Location Option 2
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JBSA Lackland, Texas 78236
Figure 16

Legend

Groundwater

PFOA + PFOS (ng/L)

- Not Detected
- Detected - <70
- 70 - <1,000
- 1,000 - <10,000
- ≥10,000
- Groundwater Recovery System
- Treatment Facility Option 3
- Effluent Discharge Option 3
- Groundwater Conveyance Pipe Option 3
- Storage Tank Option 3
- Sanitary Sewer
- Groundwater Contours (Wood 09.2024)
- Potential AFFF Area of Concern
- Installation Boundary

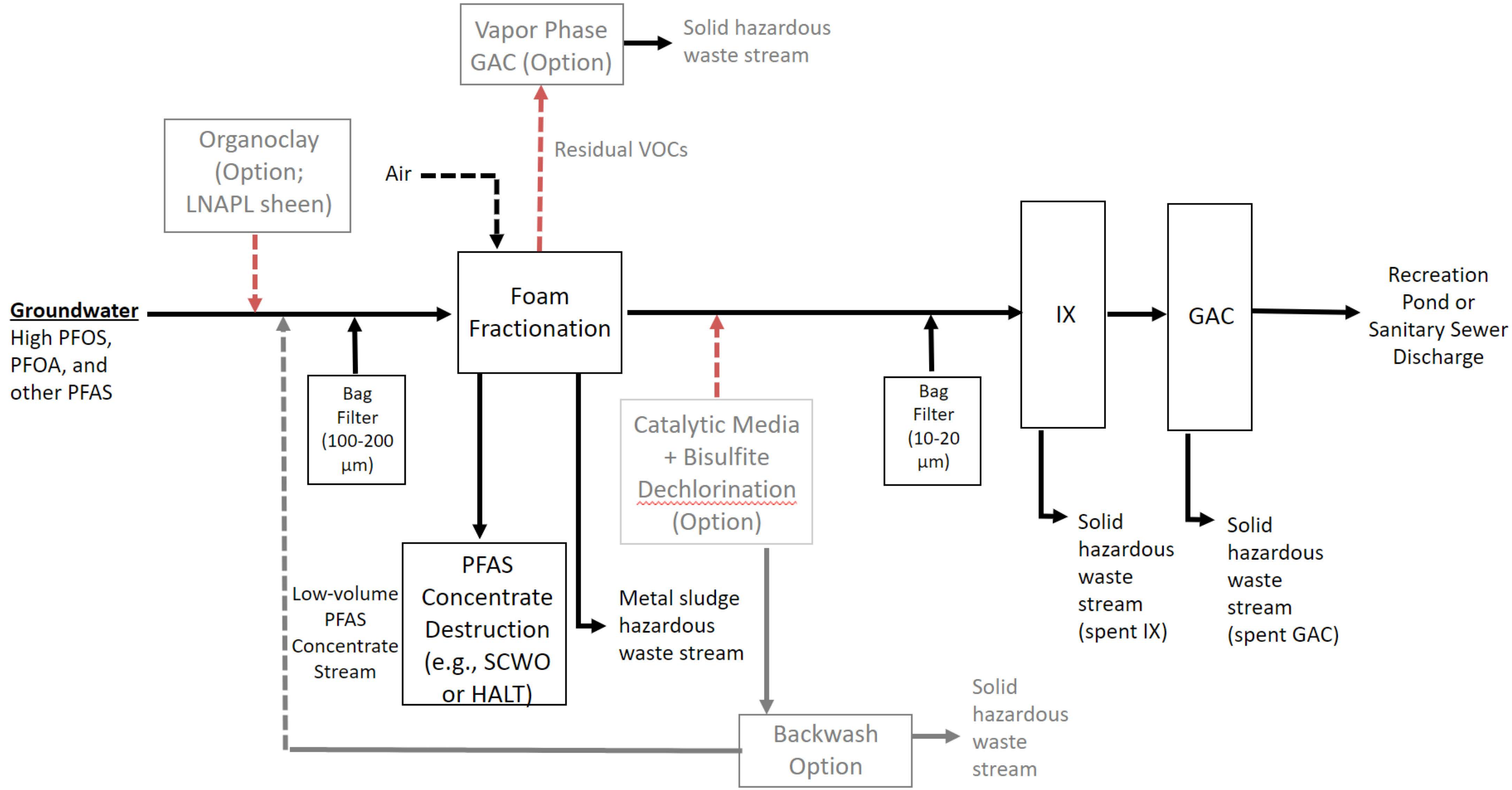
Notes:
AFFF: aqueous film forming foam
ANGB: Air National Guard Base
CPA: Critical Process Analysis
ng/L: nanograms per liter
PFOA: perfluorooctanoic acid
PFOS: perfluorooctanesulfonic acid

United States
Stewart ANGB, NY

Treatment Facility Location Option 3

Air Force Civil Engineer Center
2261 Hughes Avenue
Building 171, Suite 155
JBSA Lackland, Texas 78236

Figure 17



CPA Proposed Treatment Train Configuration for Stewart ANGB

Figure 18

United States
Stewart ANGB, NY

Air Force Civil Engineer Center
2261 Hughes Avenue
Building 171, Suite 155
JBSA Lackland, Texas 78236

Legend

- Main Path
- Main Path Input or Output
- Optional Path
- Optional Path Residual
- Residual Input or Output

Notes:
µm: micrometer
ANGB: Air National Guard Base
GAC: granular activated carbon
HALT: Hydrothermal Alkaline Treatment
IX: ion exchange
LNAPL: light, non-aqueous phase liquid
PFAS: per- and polyfluoroalkyl substances
PFOA: perfluorooctanoic acid
PFOS: perfluorooctanesulfonic acid
SCWO: supercritical water oxidation
VOC: volatile organic compound