BROOKHAVEN NATIONAL LABORATORY

Phase 2 Work Plan for the Characterization of Per- and Polyfluoroalkyl Substances (PFAS) in Known or Suspected Firefighting Foam Release Areas

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1.0 Background

Per- and Polyfluoroalkyl Substances (PFAS) are emerging contaminants of concern in soil and groundwater. In 2017, the BNL potable water supply wells were sampled for PFAS compounds for the first time. The samples were collected by the Suffolk County Department of Health Services under the Third Unregulated Contaminant Monitoring Rule (UCMR3) program. PFAS were detected in samples collected from BNL potable supply wells 6, 10 and 11 in March and August 2017 (**Appendix A**). The maximum combined concentrations of PFAS compounds perfluorooctane sulfonate (PFOS) and perfluorooctanoic acid (PFOA) was 24.26 ng/L in an August 2017 sample from supply well 10 (**Table A.1**). The EPA Lifetime Health Advisory Level (HAL) for combined PFOS and PFOA concentrations is 70 ng/L. Similar PFOS and PFOA concentrations were detected in potable well samples collected by BNL in January 2018 (**Table A.2**). Following confirmation of PFAS contamination in the supply wells, BNL began to investigate the use of PFAS containing chemicals at the Laboratory, and to develop plans to characterize PFAS contamination in the Upper Glacial aquifer within the source water contribution areas of the supply wells. A Work Plan was prepared for the characterization effort after BNL identified several areas of the site where firefighting foam had been released to the environment (BNL 2018).

2.0 Phase 1 Characterization

In May 2018, BNL installed seven temporary Geoprobe wells to characterize the distribution of PFAS within the 2-year (travel time) source water contributing areas of the BNL supply wells (**Figure 1**). The primary goal of the effort was to determine whether PFAS concentrations in the source water contributing areas are at a high enough level to potentially affect future supply well operations (i.e., where combined PFOS/PFOA concentrations could potentially exceed the 70 ng/L HAL). During the preparation of the first Work Plan, BNL identified three areas located within the 2-year contributing areas of the supply wells where firefighting foam was known or suspected to have been released to soil: 1) near Building 924; 2) the former Bubble Chamber experiment area; and 3) the BNL firehouse. PFAS were detected in all seven temporary wells. The monitoring results indicate that the three foam release areas are active sources of PFAS contamination. The locations of the source areas and the seven temporary wells are shown on **Figure 1**, and the analytical data are presented in **Appendix B**. A summary of the monitoring results is provided in **Section 2.1** and **Section 2.2**, below.

2.1 Phase 1 Monitoring Results - Eastern Supply Well Field (Supply Wells 10 and 11)

Four wells (GP-05, GP-07, GP-08 and GP-11) were installed to evaluate the distribution of PFAS contamination within the eastern supply well field. The monitoring results indicate:

- PFOS/PFOA concentrations were similar to those detected in supply wells 10 and 11, with a maximum combined concentration of 17.7 ng/L in GP-11 (**Table 1**). Well GP-11 was installed approximately 100 feet southwest of supply well 10.

- Several PFAS not analyzed under the current supply well monitoring program were also detected in the Geoprobe wells. For example, PFBA was detected at concentrations up to 175 ng/L in GP-08. A summary of the maximum PFAS concentrations detected in the eastern well field is provided in **Table 3**.
- The likely sources of the PFAS detected in potable supply wells 10 and 11 are the foam releases that occurred near Building 924 in 1970 and at the former Bubble Chamber experiment area in 1973 and 1980.

Table 1. Maximum combined PFOS and PFOA concentrations in eastern supply well field Geoprobe wells

GP Well	Maximum Combined PFOS/PFOA (ng/L)
GP-05	8.6
GP-07	7.5
GP-08	6.2
GP-11	17.7

2.2 Phase 1 Monitoring Results - Western Supply Well Field (Supply Wells 4, 6 and 7)

Three wells (GP-01, GP-02, and GP-04) were installed to evaluate the distribution of PFAS contamination in the western supply well field. The monitoring results indicate:

- PFOS/PFOA at concentrations above the 70 ng/L HAL are present in groundwater downgradient of the BNL firehouse (GP-02 and GP-04), with a maximum combined concentration of 3,124 ng/L in GP-02 (**Table 2**). The maximum combined concentration in GP-04 was 139 ng/L.
- The maximum combined concentration in GP-01, installed approximately 1,600 feet downgradient of the firehouse, was 124 ng/L.
- Several other PFAS were also detected. For example, in GP-02 PFHxS was detected at concentrations up to 3,710 ng/L, and PFBS, PFPeA, PFPeS and PFOSA were detected at concentrations above 100 ng/L. A summary of the maximum PFAS concentrations detected in the western supply well field is provided in **Table 4**.
- The likely source of the PFAS detected in supply well 6 are foam releases that occurred at the current firehouse during 1986 to 2008.

Table 2. Maximum combined PFOS and PFOA concentrations in western supply well field Geoprobe wells

GP Well	Maximum Combined PFOS/PFOA (ng/L)
GP-01	124
GP-02	3,124
GP-04	139

2.3 Potential Changes to Supply Well Operations

Based on the Phase 1 characterization results, BNL is evaluating whether to adjust its supply well operations by:

a. Taking proactive measures to repair and return to service the carbon filters currently available at Wells 10 and 11, even though PFOS/PFOA concentrations in the supply wells are currently below the 70 ng/L HAL. Well 11 will be given top priority with the intention of having the filters operational by the end of 2018;
b. Repairing currently inactive supply Well 12 and its carbon filters;
c. Restricting/suspending future use of Well 4. This well is currently infrequently used due to its poor yield caused by iron fouling of the well screen;
d. Identifying a location for a possible replacement supply well; and,
e. Verifying the effectiveness of activated carbon to remove the various PFAS detected in the supply well contributing areas (needed for issues a and b above). A report will be prepared by a consulting professional engineer.

3.0 Phase 2 Scope of Work

Following the development of the Phase 1 Work Plan, BNL confirmed via document review and interviews with long-term current and former employees that firefighting foam had been used at five additional areas, bringing the total to eight known or suspected foam storage or release sites (**Figure 2**). Available information on the eight areas are described below and summarized in **Table 5**. The available records do not provide information on firefighting foam formulations or the amount of foam that was released or stored in these areas.

The objective of the Phase 2 monitoring effort is to characterize potential PFAS contamination in the groundwater immediately downgradient of the foam release areas. For this effort, BNL will install twenty-eight (28) temporary Geoprobe wells. **Figures 3 through 10** show the locations of the planned Phase 2 Geoprobe wells, and **Tables 8 through 14** outline the proposed sample depths for each Geoprobe well. The samples will be submitted to General Engineering Laboratories (GEL) for analysis by Method 537 for 21 PFAS compounds (**Table 6**).

The scope of Phase 2 characterization effort at each known or suspected foam release area is described below.

3.1 Former Bubble Chamber Experiment and Blockhouse Area

History: Due to the use of flammable scintillation fluid at the former Bubble Chamber experiment (former Building 960), BNL installed a high-expansion foam fire suppression system in the building that housed the experiment. In April 1973, BNL conducted a test of the suppression system which resulted in the release of a large volume of high-expansion foam outside of the building (**Figure 11**). There are no records on the formulation or volume of foam concentrate that was used. Available photographs show that the area surrounding the Bubble Chamber building was unpaved. Three months later, in July 1973, the fire suppression system accidentally released foam inside the Bubble Chamber building. The foam spread out of the building and onto the ground outside. The foam was washed down with water. In 1980, the foam suppression system was tested prior to its decommissioning, and the foam released during the test was directed outside. The former Bubble Chamber building was subsequently demolished.

Although storm drains are currently located in the area that was occupied by the Bubble Chamber building, it is unclear what the drainage configuration was for this area in the 1970s and 1980s.

A second high-expansion foam fire suppression system was installed in a nearby building referred to as the "Blockhouse" (Former Building 965), where approximately 30,000 gallons of scintillation fluid for the Bubble Chamber experiment was stored. There are no records that the suppression system was ever activated or that foam from this system was released to the environment. The system was decommissioned in 1990, and the building was subsequently demolished. BNL is currently searching archived records to determine the exact location of the Blockhouse.

Based upon the monitoring results for temporary wells GP-07 and GP-08, the foam releases that occurred in the former Bubble Chamber area continue to impact groundwater quality (see **Tables B.5 and B.6**).

Phase 2 Scope: Because the closest temporary wells installed during Phase 1 were located approximately 800 feet downgradient of the former Bubble Chamber area, additional characterization is required closer to the foam release site. During Phase 2, two Geoprobe wells (GP-12 and GP-13) will be installed as close as possible to the foam release area (**Figure 3**). Four additional Geoprobe wells (GP-14, GP-15, GP-16, and GP-17) will be installed along the east side of the AGS-RHIC beam line, at distance of approximately 100 to 300 feet downgradient of the foam release area. Sample collection depths are defined in **Table 8**.

3.2 Building 924 Area

History: In September 1970, high-expansion foam was released into a work trailer (**Figure 12**). This was apparently conducted to test potential fire suppression systems that could be used for the Bubble Chamber building. Although the trailer was positioned on pavement, one side of the trailer was adjacent to a soil/vegetated area. Available photographic records show that some of the foam spread into the vegetated area. There are no storm drains in the immediate area of the former trailer location, and it is likely that the foam was rinsed off the pavement and into the nearby vegetated area after the test. Although details on the foam formulation are not available, photos show that a five-gallon container of foam concentrate was used.

Phase 2 Scope: No additional characterization is recommended as part of the Phase 2 effort. The detection of PFAS close to the water table in Phase 1 well GP-05 confirmed that PFAS from the 1970 foam test continue to leach into the aquifer, but with PFOS/PFOA concentrations below the 70 ng/L HAL (**Figure 4**; **Table B.4**). Additional characterization work may be conducted at a later date.

3.3 Area East of Building 902

History: In September 1970, a second high-expansion foam test was conducted as part of the development effort for a fire suppression system needed for the Bubble Chamber building. Photographic records show that a large volume of high-expansion foam was released from an experiment building onto a partially paved area located east of Building 902 (**Figure 13**). The experiment building was subsequently demolished, and the area was backfilled with 5 to 10 feet of soil. There are no records on the formulation or volume of foam concentrate that was used. Because there are no storm water drains in the release area, it is likely that the foam was rinsed onto the surrounding soil area after the test.

Phase 2 Scope: Two Geoprobe wells (GP-18 and GP-19) will be installed approximately 75 feet downgradient of the 1970 foam release area (**Figure 5**). Sample collection depths are defined in **Table 9**.

3.4 Current Firehouse

History: The current firehouse has been in continuous use since 1986. Based upon discussions with current and former employees, firefighters routinely practiced with foam in the paved area along the north side of the firehouse, and in the adjacent grass and wooded areas. Water released on the paved area is conveyed to several dry wells (**Figure 6**). A fire extinguisher training area was located to the northwest of the firehouse. It is not known whether foam had been used in this area. As part of routine maintenance of firetruck foam systems, foam was periodically discharged on the pavement along the north side of the firehouse or into the adjacent grass and wooded areas. The last known training event at the firehouse where Class B foam was used, was in 2008. There are no available records on the foam formulations used over this period or the amount of foam that was released. The current inventory of Class B foam consists of approximately 95 gallons of Ansulite 3x3 Low Viscosity Foam concentrate that was purchased in 2010. Although this foam concentrate contains newer formulations of fluorinated surfactants, is should not include PFOS or PFOA.

As part of the May 2018 characterization effort, temporary monitoring wells GP-02 and GP-04 were installed close to the firehouse (**Figure 6**). High levels of PFAS were detected in both wells, with a maximum PFOA/PFOS concentration of 3,124 ng/L in well GP-02 (**Table B.2** and **Table B.3**). PFAO/PFOS levels up to 124 ng/L were detected in temporary well GP-01, installed approximately 1,600 feet downgradient of the firehouse (**Table B.1**). It is the likely that the foam releases at the firehouse are the primary source of the PFAS detected in supply well 6.

Phase 2 Scope: Due to the detection of PFOS/PFAS in Phase 1 wells GP-02 and GP-04 at levels above the 70 ng/L HAL, along with elevated levels of several other PFAS compounds, five additional temporary wells (GP-35 through GP-39) will be installed as part of the Phase 2 effort to better characterize this source area (**Figure 6**). Sample collection depths are defined in **Table 10**.

3.5 Former Firehouse

History: The former firehouse was in continuous operation from 1947 through 1985. Photographic records indicate that firefighting foam was used at the facility as early as 1966. Based upon discussions with current and former employees, firefighters routinely practiced with foam in a training area that was located immediately west of the firehouse (**Figure 7**). The training area was an open grass/dirt field (**Figure 14**). A second, infrequently used training area was located east of the firehouse. In this unpaved area, firefighters would periodically practice extinguishing car fires using foam. Furthermore, as part of routine maintenance of firetruck foam systems, foam was periodically discharge on the pavement in front of the firehouse. There are no available records on the foam formulations used over this period or the amount of foam that was released. The former Firehouse was demolished in ~1985-1986, and the surrounding area was regraded and seeded. Most of the training area that was located to the west of the firehouse is presently occupied by the former National Synchrotron Light Source building that was constructed in the 1980s. It is unknown whether excavation activities resulted in the removal of potentially PFAS contaminated soils from the construction area. Although there are presently

storm drains in the area where the former firehouse building was located, it is unclear what the surface drainage pattern was for the area during active firehouse operations in the 1960s through 1980s. Former BNL water supply well 1 was located east of the former firehouse and was in active use until September 1986.

Phase 2 Scope: Seven temporary wells will be installed immediately downgradient of the area where the former firehouse building was located and the nearby training areas (**Figure 7**). Wells GP-20, GP-21, and GP-22 will be installed downgradient of the western training area, wells GP-23 and GP-24 will be installed downgradient of the former firehouse area, and wells GP-25 and GP-26 will be installed downgradient of the eastern training area. Sample collection depths are defined in **Table 11**.

3.6 Major Petroleum Facility

History: In September 1986, low-expansion firefighting foam was used during a single day firefighting training exercise at the Major Petroleum Facility (MPF), within the containment berm of former above ground petroleum storage tank 611A (**Figure 15**). There are no records on the foam formulation or the amount that was used during the training. Although BNL's current containment berms are configured to allow for controlled releases of collected rain water to the sanitary system, a records search is required to locate information on berm drainage at the former tank area. There are no records or employee recollections of other training exercises being conducted in the MPF area.

Phase 2 Scope: Geoprobe wells GP-27 and GP-28 will be installed immediately downgradient of the former storage tank 611A area (**Figure 8**). Sample collection depths are defined in **Table 12**.

3.7 Building 526 Area

History: In the early 1970s, a high-expansion foam suppression system was installed on the roof of Building 526, apparently due to the use of flammable materials in one of the experimental areas of the building. Records indicate that the system was taken out of service in 1980. There are no records or recollections of firefighter personnel that the system was ever activated, or that foam was released to the surrounding environment during testing or servicing.

Phase 2 Scope: Although there are no documented foam releases at Building 526, Geoprobe wells GP-29 and GP-30 will be installed approximately 100 feet downgradient of the facility to verify that foam was not release to the surrounding soil during maintenance of the former fire suppression system (**Figure 9**). Sample collection depths are defined in **Table 13**.

3.8 Recreation Center Area

History: Documents show that here were at least two releases of high-expansion foam in the Recreation Center area. In 1978, foam was released to the paved area south of the Recreation Center, and in 1980 foam was released to a grass field to the northeast of the Recreation Center (**Figure 10**). In both areas, it is likely that the foam was hosed down at the end of the day. In grassy areas, the water would have infiltrated into the soil. However, in the paved area it is possible that most of the water would have entered one of the nearby stormwater drains. Stormwater from this area is conveyed by an underground pipe to a drainage area located approximately 450 feet to the northeast of the Recreation Center. Based upon recollections of several firefighters, additional foam releases may have occurred in this area during the 1970s and

1980s. Although there are no records on foam formulations or volumes used in this area, several firefighters recall that protein-based (biodegradable) foam may have been used in this area.

Phase 2 Scope: Geoprobe wells GP-31 and GP-32 will be installed approximately 50 feet downgradient of the grass field where the foam was released in 1980 (**Figure 10**). Geoprobe wells GP-33 and GP-34 will be installed approximately 50 feet downgradient of the stormwater drainage area. Sample collection depths are defined in **Table 14**.

On July 10, 2018, BNL collected soil samples in the stormwater drainage area to evaluate potential impacts from foam released to the pavement in 1978, and in the grass field where foam was released in 1980. Soil samples SS-01 and SS-02 were collected close to the end of the stormwater discharge pipe (**Figure 10**). Soil samples from locations SS-03, SS-04, SS-05, and SS-06 were collected in the grass field where foam was discharged in 1980. Sample collection depths are defined in **Table 15**. The collection of the soil samples was expedited to support a Phase II Environmental Assessment (EA) that is required for BNL's planned construction of a new laboratory support facility called "Discovery Park." (Discovery Park will consist of a new administration building, office space for research collaborations, and housing for guests.) The samples were submitted to GEL for analysis by Method 537 for 21 PFAS compounds (**Table 7**).

4.0 Sample Collection

4.1 Groundwater Samples

Installation and sampling protocols defined in BNL standard operating procedure EM-SOP-311, *Collection of Groundwater Samples Using Geoprobe Wells*, will be used for the collection of groundwater samples. A four-foot long screen will be used for Geoprobe sampling. Sample intervals for each Geoprobe well are defined in **Tables 8 through 13**. For quality assurance purposes, duplicate groundwater samples will be collected at a rate of 1 for every 10 sample intervals. One trip blank (prepared using PFAS-free water supplied by GEL) will be included with each sample shipment. To verify that cross contamination of samples is not occurring during the sampling process, field blanks (using PFAS-free water supplied by GEL) will be prepared in the field at every fifth sample location. Furthermore, to verify the effectiveness of the decontamination procedures, one equipment blank will be collected at every fifth sampling location using PFAS-free water supplied by GEL. All precautions listed in **Section 5.0** shall be followed to prevent potential cross contamination of the samples.

4.2 Soil Samples

As described in **Section 3.8**, soil samples were collected in the Recreation Center area in support of a Phase 2 Environmental Assessment required for the planned construction of "Discovery Park." Soil sampling protocols defined in BNL standard operating procedure EM-SOP-601, *Collection of Soil Samples Using Hand Tools*, were used.

Decontaminated hand augers, sample spoons and mixing bowls were used at each location and depth. Composite soil samples were collected with hand augers at intervals from 0 to 12 inches and 12 to 24 inches below land surface. For quality assurance purposes, one duplicate soil sample was collected at the grass field. Furthermore, to verify the effectiveness of the decontamination procedures for the augers and mixing bowls, one equipment blank was collected using PFAS-free water supplied by GEL. All applicable precautions listed in **Section 5.0** were followed to prevent potential cross contamination of the samples.

4.3 Sample Handing and Analyses

Groundwater samples will be analyzed for PFAS by GEL, Charleston, SC, using EPA Method 537.0 for twenty-one (21) PFAS compounds (**Table 6**). The soil samples will be also be analyzed for PFAS by GEL using EPA Method 537.0 for twenty-one (21) compounds (**Table 7**). All samples shall be sealed in individual polypropylene zip-lock bags and placed into GEL supplied coolers filled with crushed ice sealed in polypropylene zip-lock bags. The samples will be packaged and delivered to the BNL shipping and receiving building by the field sampling crew. Sample holding time is 14 days. Samples will be sent to GEL for PFAS analysis with 14-day turnaround times. A full (Category B) data package will be provided by GEL. A quality assurance summary will be prepared for the final report.

4.4 Waste Management

All reusable sampling equipment will be cleaned after use at the Field Team building. All non-reusable equipment and gloves will be disposed of as normal waste.

5.0 Decontamination and Cross Contamination Prevention Procedures

In addition to adhering to BNL standard operating procedures for the collection of groundwater and soil samples and chain-of-custody requirements for the samples, the following items/procedures shall be adhered to:

1. All Geoprobe rods will be decontaminated by first by power washing. Stainless steel check valves, and well screens shall will be cleaned with a solution of Alconox® followed by a water rinse.
    a. For soil samples, all hand augers, mixing bowls and spoons will be cleaned with a solution of Alconox® followed by a water rinse.
2. As a final rinse, the sampling equipment will be rinsed with raw, untreated <u>water obtained directly from BNL potable supply well 7</u>. (Note: During 2017, PFAS were not detected in water from well 7 during two sample rounds conducted by SCDHS.) Allow all equipment to fully air dry before use.
3. New high-density polyethylene (HDPE) tubing and a decontaminated stainless steel check valve shall be used at each sample location.
4. New nitrile gloves shall be worn between each sample interval.
5. Only clean cotton or synthetic clothes shall be worn – preferably washed more than six times, and without the use of fabric softeners. No waterproof or insecticide treated clothing, boots or rain jackets made or treated with Teflon products shall be used at the collection site. This includes all Gore-Tex® and Tyvek® products.
6. Do not apply moisturizers or hand creams to hands or face on the day of sampling. No sunblock or insect repellants. Do not bring packaged food to the work site or use aluminum foil.
7. Field notes shall be taken using a computer tablet or by using ink pens on non-water proof plain paper attached to a metal clipboard. Do not use Sharpies or markers. Transcribe field notes to Chain-of-Custody forms and official field books when back in the office after the collection process.
8. For groundwater samples use only GEL supplied 250 ml polypropylene sample bottles containing Trizma (a reagent used for buffering and removal of free chlorine).

    a. For soil samples, use only GEL supplied 250 ml polypropylene sample bottles that do not contain Trizma
9. Print labels before going into the field and apply to the sample containers.
10. Use only GEL supplied PFAS-free water for trip and equipment blanks.
11. Place each sample container in a separate polypropylene zip-lock bag.
12. For the shipping coolers, use only regular crushed ice packaged in polypropylene zip-lock plastic bags.
13. Use only GEL shipping coolers that were used to ship sample containers for this project. Tape and band the cooler shut before shipping samples to GEL.

6.0 References

BNL 2018. Work Plan for the Characterization of Per-fluorinated Compounds in Groundwater within the Source Water Contributing Areas of BNL Supply Wells. Brookhaven National Laboratory, Upton, New York. March 26, 2018.

Table 3. PFAS Detected in BNL Eastern Supply Well Field 2-Year Contributing Area

Chemical	Maximum Concentration (ng/L)	
	GP Wells (a)	Potable Wells (b)
Perfluorooctanesulfonate (PFOS)	**16.4**	**18.9**
Perfluorooctanoic acid (PFOA)	**7.2**	**6.6**
Perfluoroundecanoic acid (PFUdA)	<	NA
N-methylperfluoro-1-octanesulfonamidoacetic acid	<	NA
Perfluoropentanoic acid (PFPeA)	**7.2**	NA
Perfluoropentanesulfonate (PFPeS)	**0.9 J**	NA
N-ethylperfluoro-1-octanesulfonamidoacetic acid	<	NA
Perfluorohexanoic acid (PFHxA)	**5.6**	NA
Perfluorododecanoic acid (PFDoA)	<	NA
Perfluorodecanoic acid (PFDA)	<	NA
Perfluorodecanesulfonate (PFDS)	<	NA
Perfluorohexanesulfonate (PFHxS)	**16.8**	**9.1**
Perfluorobutyric acid (PFBA)	**175**	NA
Perfluorobutanesulfonate (PFBS)	**2.1**	**1.9**
Perfluoroheptanoic acid (PFHpA)	<	**2.6**
Perfluoroheptanesulfonate (PFHpS)	<	NA
Perfluorononanoic acid (PFNA)	**1.6 J**	**2.7**
Perfluorotetradecanoic acid (PFTeDA)	<	NA
Perfluorononanesulfonate (PFNS)	<	NA
Perfluorotridecanoic acid (PFTrDA)	<	NA
Perfluorooctanesulfonamide (PFOSA)	<	NA

(a) Phase 1 Geoprobe data from May 2018.

(b) Potable Wells 10 and 11 data from 2017 and early 2018.

<: Not detected. Typical detection limit is 0.6 ng/L.

NA: Compound not analyzed for under the potable water monitoring program.

J: Estimated concentration.

GP: Geoprobe

Table 4. PFAS Detected in BNL Western Supply Well Field 2-Year Contributing Area

Chemical	Maximum Concentration (ng/L)	
	GP Wells (a)	Potable Wells (b)
Perfluorooctanesulfonate (PFOS)	**2,980**	**24**
Perfluorooctanoic acid (PFOA)	**144**	**0.9 J**
Perfluoroundecanoic acid (PFUdA)	<	NA
N-methylperfluoro-1-octanesulfonamidoacetic acid	<	NA
Perfluoropentanoic acid (PFPeA)	**127**	NA
Perfluoropentanesulfonate (PFPeS)	**626**	NA
N-ethylperfluoro-1-octanesulfonamidoacetic acid	<	NA
Perfluorohexanoic acid (PFHxA)	**564**	NA
Perfluorododecanoic acid (PFDoA)	<	NA
Perfluorodecanoic acid (PFDA)	<	NA
Perfluorodecanesulfonate (PFDS)	<	NA
Perfluorohexanesulfonate (PFHxS)	**3,710**	**8.9**
Perfluorobutyric acid (PFBA)	**60**	NA
Perfluorobutanesulfonate (PFBS)	**223**	**<**
Perfluoroheptanoic acid (PFHpA)	**72**	**<**
Perfluoroheptanesulfonate (PFHpS)	**23**	NA
Perfluorononanoic acid (PFNA)	**40**	<
Perfluorotetradecanoic acid (PFTeDA)	<	NA
Perfluorononanesulfonate (PFNS)	**2.6**	NA
Perfluorotridecanoic acid (PFTrDA)	<	NA
Perfluorooctanesulfonamide (PFOSA)	**330**	NA

(a) Phase 1 Geoprobe data from May 2018.

(b) Potable Well 6 data from 2017 and early 2018.

<: Not detected. Typical detection limit is 0.6 ng/L.

NA: Compound not analyzed for under the potable water monitoring program.

J: Estimated concentration.

GP: Geoprobe

Table 5. Summary of Firefighting Foam Containing PFAS Used at BNL

Location	Use Date(s)	Event(s) (Note 1)
Former BNL Firehouse	1966 – 1985	The former firehouse was in continuous operation from 1947 through 1985. Possible multiple foam training exercises and equipment maintenance occurred between 1966 and 1985. Firefighting training was routinely conducted in an open area immediately west of the former firehouse. Occasional car fire training conducted in an area east of the firehouse (immediately north of former BNL supply well 1).
Building 924 AGS Trailer	1970	Testing of a high-expansion foam suppression system. Foam was released inside a work trailer located in the parking lot adjacent to Building 924.
Area East of Building 902	1970	Testing of a high-expansion foam suppression system.
Former 7' Bubble Chamber Experiment and Blockhouse	1973	Foam test of newly installed high-expansion foam suppression system. Foam was discharged outside. Three months later the high-expansion foam suppression system accidentally released foam into the Bubble Chamber building and the surrounding ground.
	1980	Bubble Chamber foam suppression system was tested prior to decommissioning. Records indicate that the foam was directed outside.
	1982-1990	High-expansion foam system was installed at the Blockhouse. There are no records that foam was released to the environment. System was decommissioned in ~1990.
Building 526	1970-1980	Foam suppression system was installed on the roof of the building possibly in early 1970s. System was taken out of service in July 1980. No records of foam being released inside the building or to the ground outside.
Recreation Center Area	1978 1980	Firefighters sprayed high-expansion foam on at least two occasions. In 1978, foam was released to paved area adjacent to the Rec Center. Foam could have entered nearby storm drains during wash down. Stormwater is conveyed to a drainage swale in the woods northeast of the Rec Center area. In 1980, foam was released in the nearby grass field. Foam is likely to have been released in these areas on other occasions.
Major Petroleum Facility	1986	BNL firefighting training session was held near former above ground storage tank 611A using low-expansion foam. No records on whether other training exercises were held at the MPF.
Current BNL Firehouse	1986-2008	Training and maintenance operations on the north side of the firehouse. Foam was routinely changed out on the northern paved area during maintenance or sprayed into the northern grass/wooded areas during training. Some rinse water would make its way into a nearby dry well. Last training with Class B foam apparently was in 2008.

Note 1: No information available on actual foam formulations or amounts used. However, groundwater monitoring data from Phase 1 indicate that some of the foam used at BNL contained PFAS.

Table 6. List of PFAS to be Analyzed for in Water

General Engineering Laboratories EPA Method 537.0		Water Detection Limits	
Parameter	**CAS Number**	**MDL ng/L**	**PQL ng/L**
Perfluorooctanesulfonate (PFOS)	1763-23-1	0.66	2
Perfluoroundecanoic acid (PFUdA)	2058-94-8	0.72	2
N-methylperfluoro-1-octanesulfonamidoacetic acid	2355-31-9	1.32	4
Perfluoropentanoic acid (PFPeA)	2706-90-3	0.66	2
Perfluoropentanesulfonate (PFPeS)	2706-91-4	0.66	1.88
N-ethylperfluoro-1-octanesulfonamidoacetic acid	2991-50-6	1.32	4
Perfluorohexanoic acid (PFHxA)	307-24-4	0.66	2
Perfluorododecanoic acid (PFDoA)	307-55-1	0.66	2
Perfluorooctanoic acid (PFOA)	335-67-1	0.66	2
Perfluorodecanoic acid (PFDA)	335-76-2	0.66	2
Perfluorodecanesulfonate (PFDS)	335-77-3	0.66	1.94
Perfluorohexanesulfonate (PFHxS)	355-46-4	0.66	1.82
Perfluorobutyric acid (PFBA)	375-22-4	0.82	2
Perfluorobutanesulfonate (PFBS)	375-73-5	0.8	1.78
Perfluoroheptanoic acid (PFHpA)	375-85-9	0.66	2
Perfluoroheptanesulfonate (PFHpS)	375-92-8	0.66	1.9
Perfluorononanoic acid (PFNA)	375-95-1	0.66	2
Perfluorotetradecanoic acid (PFTeDA)	376-06-7	0.66	2
Perfluorononanesulfonate (PFNS)	68259-12-1	0.7	1.92
Perfluorotridecanoic acid (PFTrDA)	72629-94-8	0.66	2
Perfluorooctanesulfonamide (PFOSA)	754-91-6	0.66	1.86

MDL: Minumum detection limit

PQL: Practical quantitation limit

ng/L: Nanograms per liter

Table 7. List of PFAS to be Analyzed for in Soil

General Engineering Laboratories EPA Method 537.0		Soil Detection Limits	
Parameter	**CAS Number**	**MDL µg/kg**	**PQL µg/kg**
Perfluorooctanesulfonate (PFOS)	1763-23-1	0.165	0.5
Perfluoroundecanoic acid (PFUdA)	2058-94-8	0.165	0.5
N-methylperfluoro-1-octanesulfonamidoacetic acid	2355-31-9	0.19	0.5
Perfluoropentanoic acid (PFPeA)	2706-90-3	0.165	0.5
Perfluoropentanesulfonate (PFPeS)	2706-91-4	0.165	0.5
N-ethylperfluoro-1-octanesulfonamidoacetic acid	2991-50-6	0.275	1
Perfluorohexanoic acid (PFHxA)	307-24-4	0.165	0.5
Perfluorododecanoic acid (PFDoA)	307-55-1	0.165	0.5
Perfluorooctanoic acid (PFOA)	335-67-1	0.165	0.5
Perfluorodecanoic acid (PFDA)	335-76-2	0.37	1
Perfluorodecanesulfonate (PFDS)	335-77-3	0.165	0.5
Perfluorohexanesulfonate (PFHxS)	355-46-4	0.165	0.5
Perfluorobutyric acid (PFBA)	375-22-4	0.165	0.5
Perfluorobutanesulfonate (PFBS)	375-73-5	0.165	0.5
Perfluoroheptanoic acid (PFHpA)	375-85-9	0.165	0.5
Perfluoroheptanesulfonate (PFHpS)	375-92-8	0.19	0.5
Perfluorononanoic acid (PFNA)	375-95-1	0.165	0.5
Perfluorotetradecanoic acid (PFTeDA)	376-06-7	0.165	0.5
Perfluorononanesulfonate (PFNS)	68259-12-1	0.165	0.5
Perfluorotridecanoic acid (PFTrDA)	72629-94-8	0.165	0.5
Perfluorooctanesulfonamide (PFOSA)	754-91-6	0.165	0.5

MDL: Minumum detection limit

PQL: Practical quantitation limit

µg/L: Micrograms per kilogram

Table 8
Phase 2 PFAS Characterization
Geoprobe Sample Collection Intervals
Former Bubble Chamber Experiment Area

Well	**GP-12**	**GP-13**	**GP-14**	**GP-15**	**GP-16**	**GP-17**
Land Surface Elev. (Feet AMSL)	63	63	73	73	73	73
Water Table Elev. (Feet AMSL)	42	42	42	42	42	42
Depth to Water (Feet BLS)	21	21	31	31	31	31
Sample Depth (Feet BLS)						
	22-26	22-26	30-34	30-34	30-34	30-34
	26-30	26-30	34-38	34-38	34-38	34-38
	30-34	30-34	38-42	38-42	38-42	38-42
	34-38	34-38	42-46	42-46	42-46	42-46
	42-46	42-46	50-54	50-54	50-54	50-54
			58-62	58-62	58-62	58-62

BLS: In feet below land surface

AMSL: In feet above mean sea level

Table 9
Phase 2 PFAS Characterization
Geoprobe Sample Collection Intervals
Foam Release Area East of Building 902

Well	**GP-18**	**GP-19**
Land Surface Elev. (Feet AMSL)	84	84
Water Table Elev. (Feet AMSL)	40	40
Depth to Water (Feet BLS)	44	44
Sample Depth (Feet BLS)		
	42-46	42-46
	46-50	46-50
	56-54	56-54
	54-58	54-58
	58-62	58-62
	66-70	66-70

BLS: In feet below land surface

AMSL: In feet above mean sea level

Table 10
Phase 2 PFAS Characterization
Geoprobe Sample Collection Intervals
Current Firehouse Area

Well	**GP-35**	**GP-36**	**GP-37**	**GP-38**	**GP-39**
Land Surface Elev. (Feet AMSL)	93	93	93	93	93
Water Table Elev. (Feet AMSL)	45	45	45	45	45
Depth to Water (Feet BLS)	48	48	48	48	48
Sample Depth (Feet BLS)					
	50-54	50-54	50-54	50-54	50-54
	54-58	54-58	54-58	54-58	54-58
	58-62	58-62	58-62	58-62	58-62
	62-66	62-66	62-66	62-66	62-66
	66-70	66-70	66-70	66-70	66-70
		74-78	74-78	74-78	74-78
		78-82	78-82	78-82	78-82
				90-94	90-94
				110-114	110-114

BLS: In feet below land surface

AMSL: In feet above mean sea level

Table 11
Phase 2 PFAS Characterization
Geoprobe Sample Collection Intervals
Former Firehouse Area

Well	**GP-20**	**GP-21**	**GP-22**	**GP-23**	**GP-24**	**GP-25**	**GP-26**
Land Surface Elev. (Feet AMSL)	74	74	74	74	74	74	74
Water Table Elev. (Feet AMSL)	38	38	38	38	38	38	38
Depth to Water (Feet BLS)	36	36	36	36	36	36	36
Sample Depth (Feet BLS)							
	34-38	34-38	34-38	34-38	34-38	34-38	34-38
	38-42	38-42	38-42	38-42	38-42	38-42	38-42
	42-46	42-46	42-46	42-46	42-46	42-46	42-46
	46-50	46-50	46-50	46-50	46-50	46-50	46-50
	50-54	50-54	50-54	50-54	50-54	50-54	50-54
	58-62	58-62	58-62	58-62	58-62	58-62	58-62
	66-70	66-70	66-70	66-70	66-70	66-70	66-70
				74-78	74-78	74-78	74-78
				82-86	82-86	82-86	82-86

BLS: In feet below land surface

AMSL: In feet above mean sea level

Table 12
Phase 2 PFAS Characterization
Geoprobe Sample Collection Intervals
Central Steam Facility

Well	**GP-27**	**GP-28**
Land Surface Elev. (Feet AMSL)	77	77
Water Table Elev. (Feet AMSL)	39	39
Depth to Water (Feet BLS)	38	38
Sample Depth (Feet BLS)		
	38-42	38-42
	42-46	42-46
	46-50	46-50
	50-54	50-54
	58-62	58-62

BLS: In feet below land surface

AMSL: In feet above mean sea level

Table 13
Phase 2 PFAS Characterization
Geoprobe Sample Collection Intervals
Building 526 Area

Well	**GP-29**	**GP-30**
Land Surface Elev. (Feet AMSL)	78	78
Water Table Elev. (Feet AMSL)	38	38
Depth to Water (Feet BLS)	40	40
Sample Depth (Feet BLS)		
	42-46	42-46
	46-50	46-50
	50-54	50-54
	54-58	54-58
	62-66	62-66

BLS: In feet below land surface

AMSL: In feet above mean sea level

Table 14
Phase 2 PFAS Characterization
Geoprobe Sample Collection Intervals
Recreation Center Area

Well	**GP-31**	**GP-32**	**GP-33**	**GP-34**
Land Surface Elev. (Feet AMSL)	100	100	100	100
Water Table Elev. (Feet AMSL)	36	36	36	36
Depth to Water (Feet BLS)	64	64	64	64
Sample Depth (Feet BLS)				
	62-66	62-66	62-66	62-66
	66-70	66-70	66-70	66-70
	70-74	70-74	70-74	70-74
	74-78	74-78	74-78	74-78
	82-86	82-86		

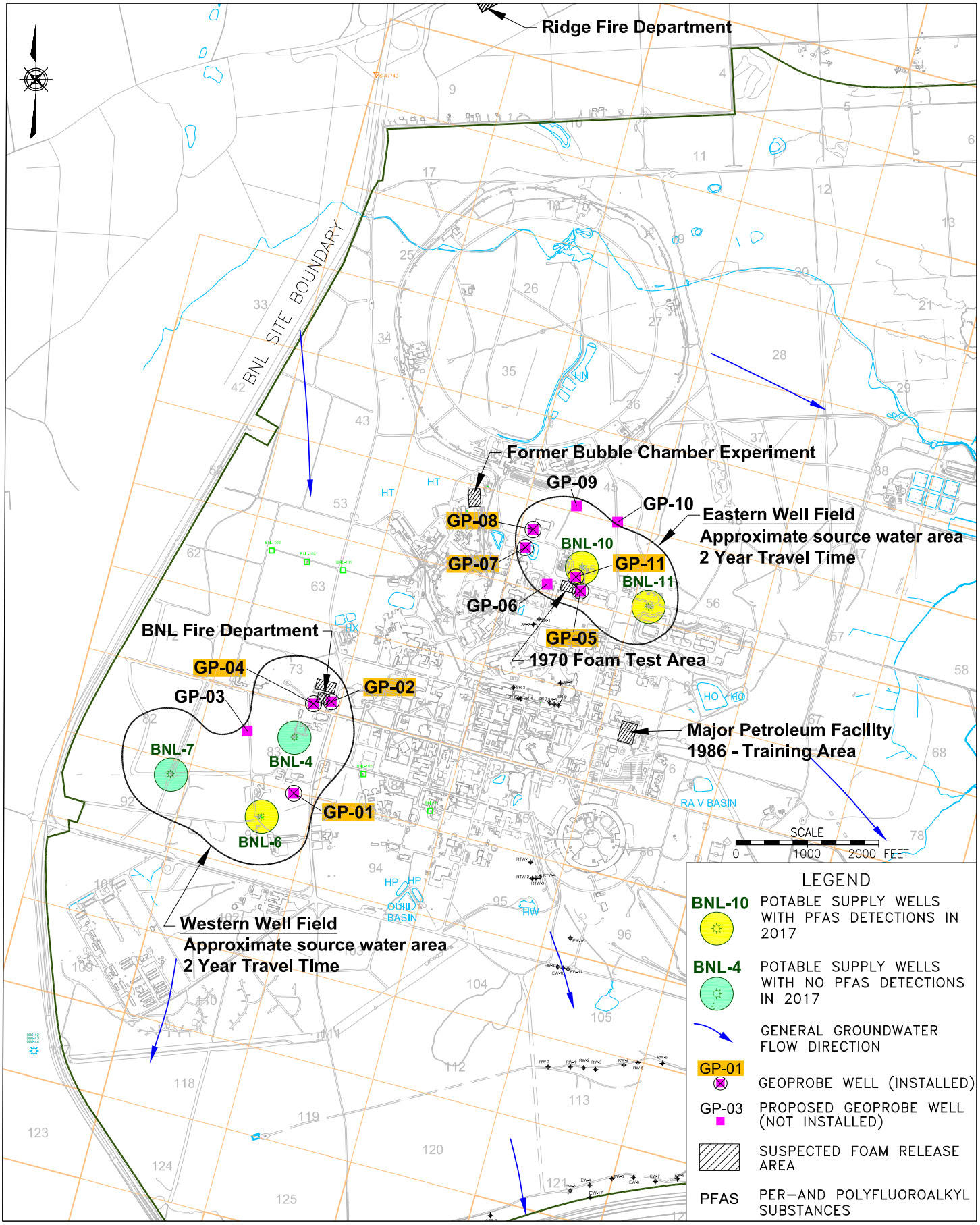
BLS: In feet below land surface

AMSL: In feet above mean sea level

Table 15
Phase 2 PFAS Characterization
Soil Sample Collection Intervals
Recreation Center Area

Well	**SS-01**	**SS-02**	**SS-03**	**SS-04**	**SS-05**	**SS-06**
Sample Depth (Inches BLS)						
	0 to 12	0 to 12	0 to 12	0 to 12	0 to 12	0 to 12
	12 to 24	12 to 24	12 to 24	12 to 24	12 to 24	12 to 24

BLS: Below land surface



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BROOKHAVEN NATIONAL LABORATORY

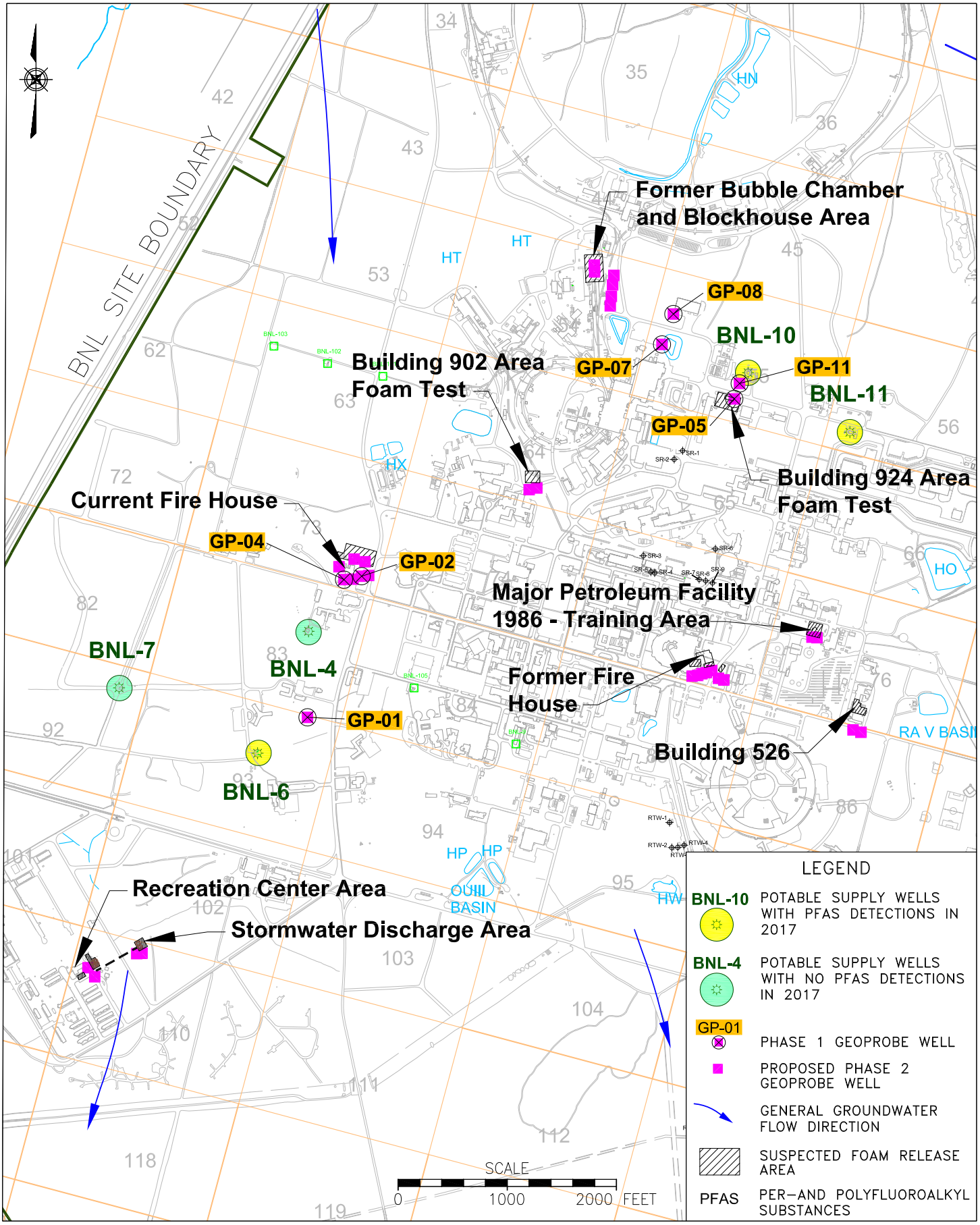
ENVIRONMENTAL PROTECTION DIVISION

TITLE: LOCATIONS OF PHASE 1 GEOPROBE WELLS

PFAS CHARACTERIZATION WORK PLAN

DWN:	VT:HZ.:	DATE:	PROJECT NO.:
AJZ	–	06/20/18	–
CHKD:	APPD:	REV.:	NOTES:
–	DEP	08/02/18	–

FIGURE NO.: 1



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BROOKHAVEN NATIONAL LABORATORY

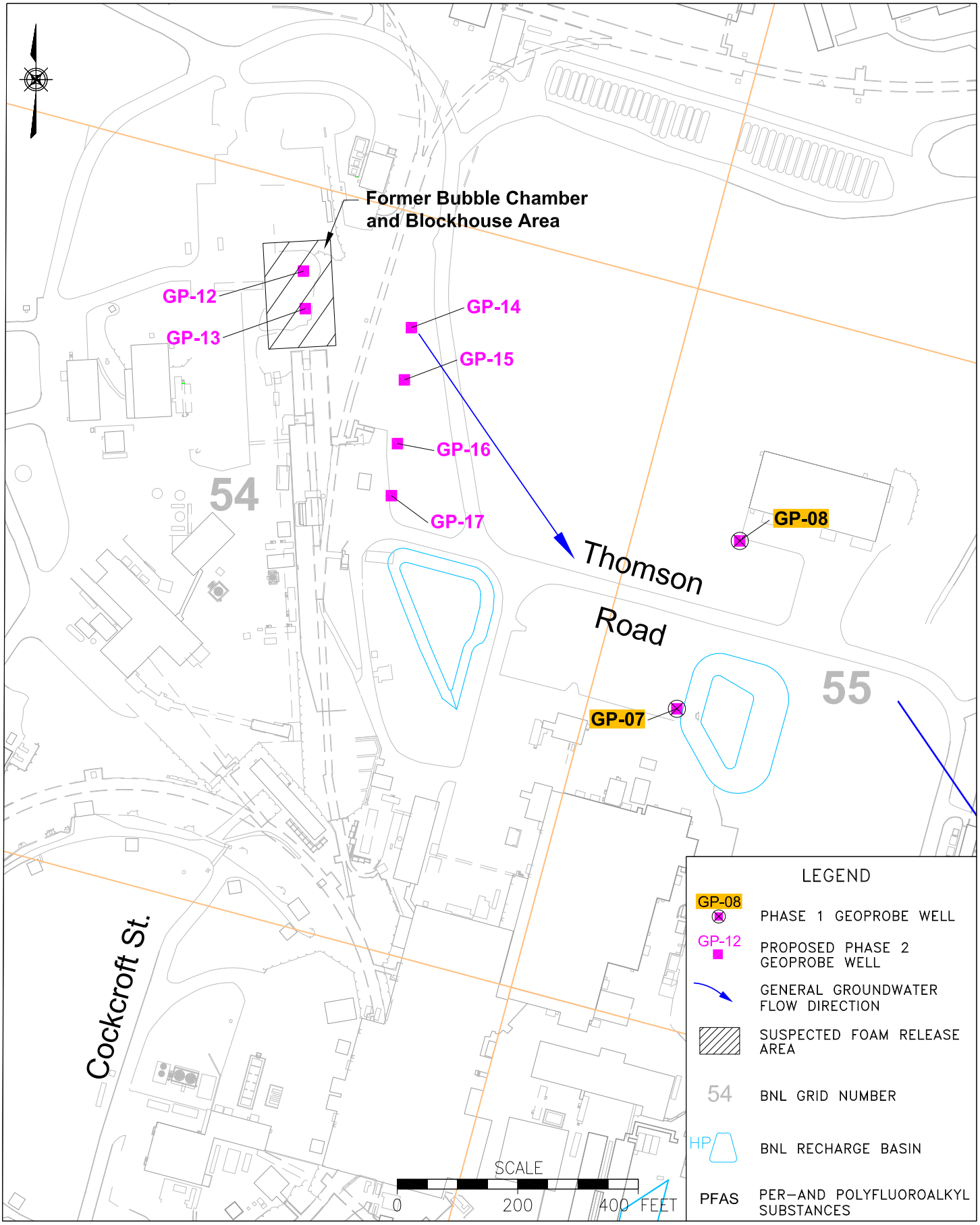
ENVIRONMENTAL PROTECTION DIVISION

TITLE: LOCATIONS OF PROPOSED PHASE 2 GEOPROBE WELLS

PFAS CHARACTERIZATION WORK PLAN

DWN:	VT:HZ.:	DATE:	PROJECT NO.:
AJZ	–	07/11/18	–
CHKD:	APPD:	REV.:	NOTES:
–	DEP	08/02/18	–

FIGURE NO.: 2



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BROOKHAVEN NATIONAL LABORATORY

ENVIRONMENTAL PROTECTION DIVISION

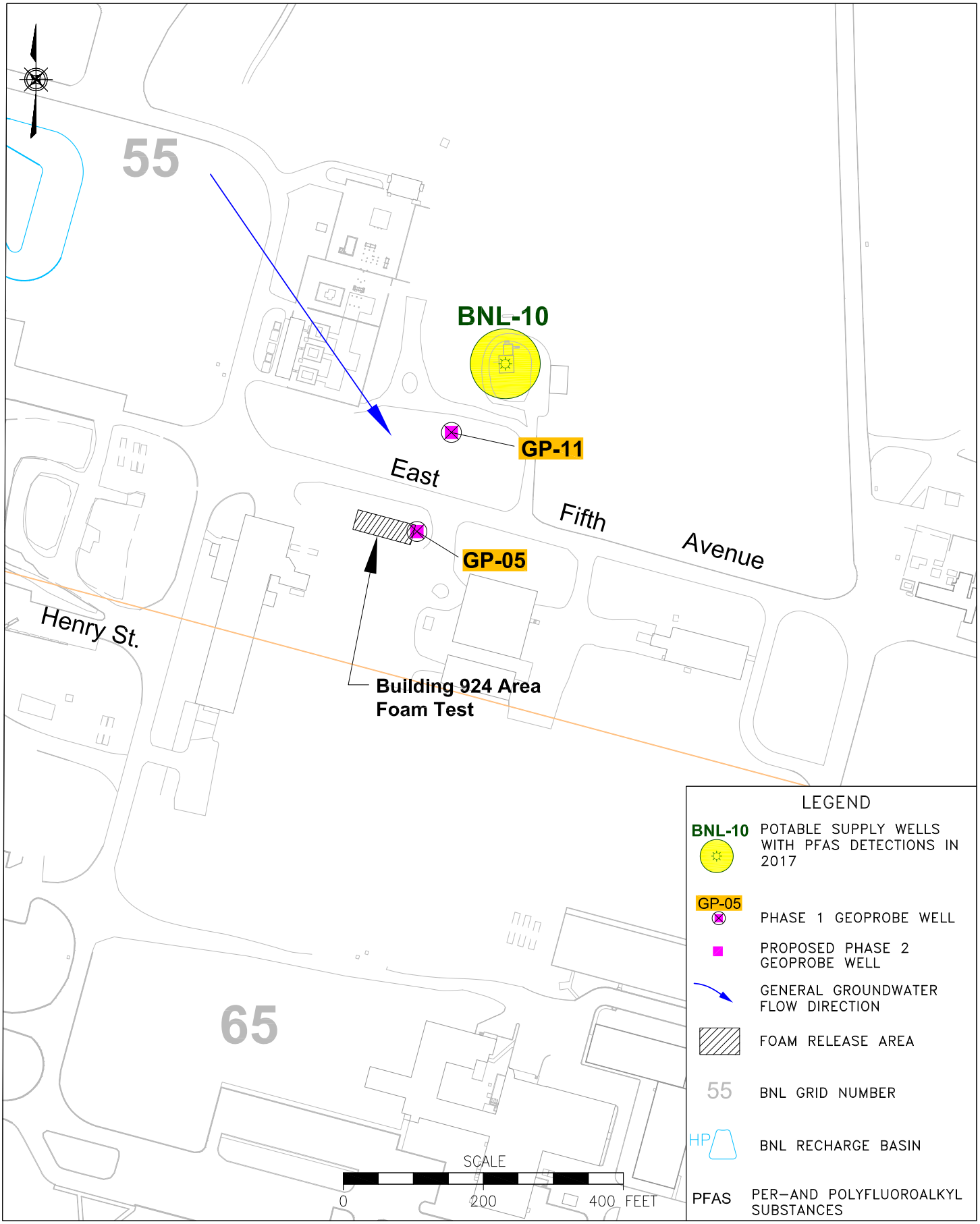
TITLE:

FORMER BUBBLE CHAMBER EXPERIMENT AND BLOCKHOUSE AREA

PFAS CHARACTERIZATION WORK PLAN

DWN:	VT:HZ.:	DATE:	PROJECT NO.:
AJZ	–	07/03/18	–
CHKD:	APPD:	REV.:	NOTES:
–	DEP	07/25/18	–

FIGURE NO.: 3



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BROOKHAVEN NATIONAL LABORATORY

ENVIRONMENTAL PROTECTION DIVISION

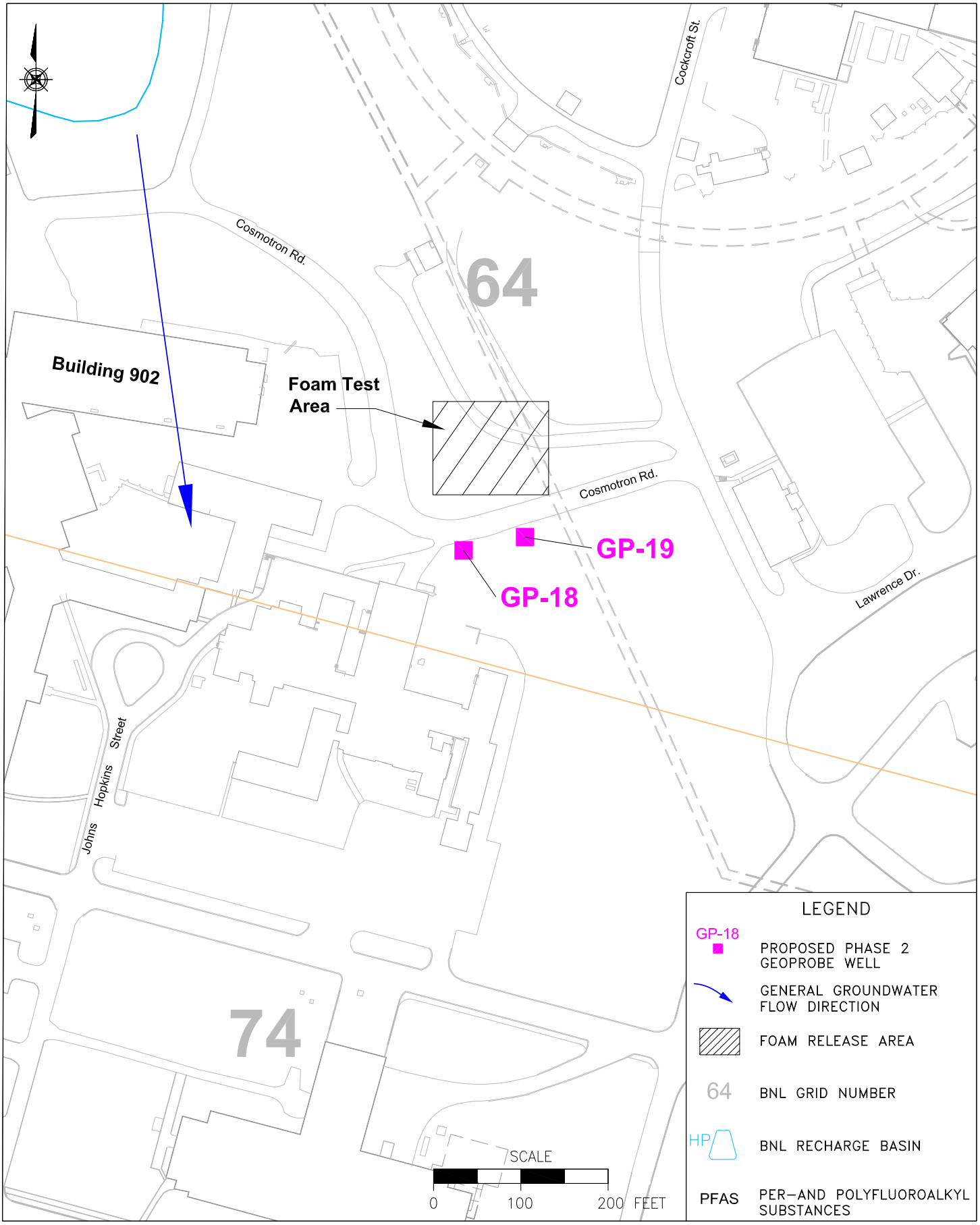
TITLE:

BUILDING 924 AREA

PFAS CHARACTERIZATION WORK PLAN

DWN:	VT: HZ.:	DATE:	PROJECT NO.:
AJZ	–	07/03/18	–
CHKD:	APPD:	REV.:	NOTES:
–	DEP	08/02/18	–

FIGURE NO.: 4



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BROOKHAVEN NATIONAL LABORATORY

ENVIRONMENTAL PROTECTION DIVISION

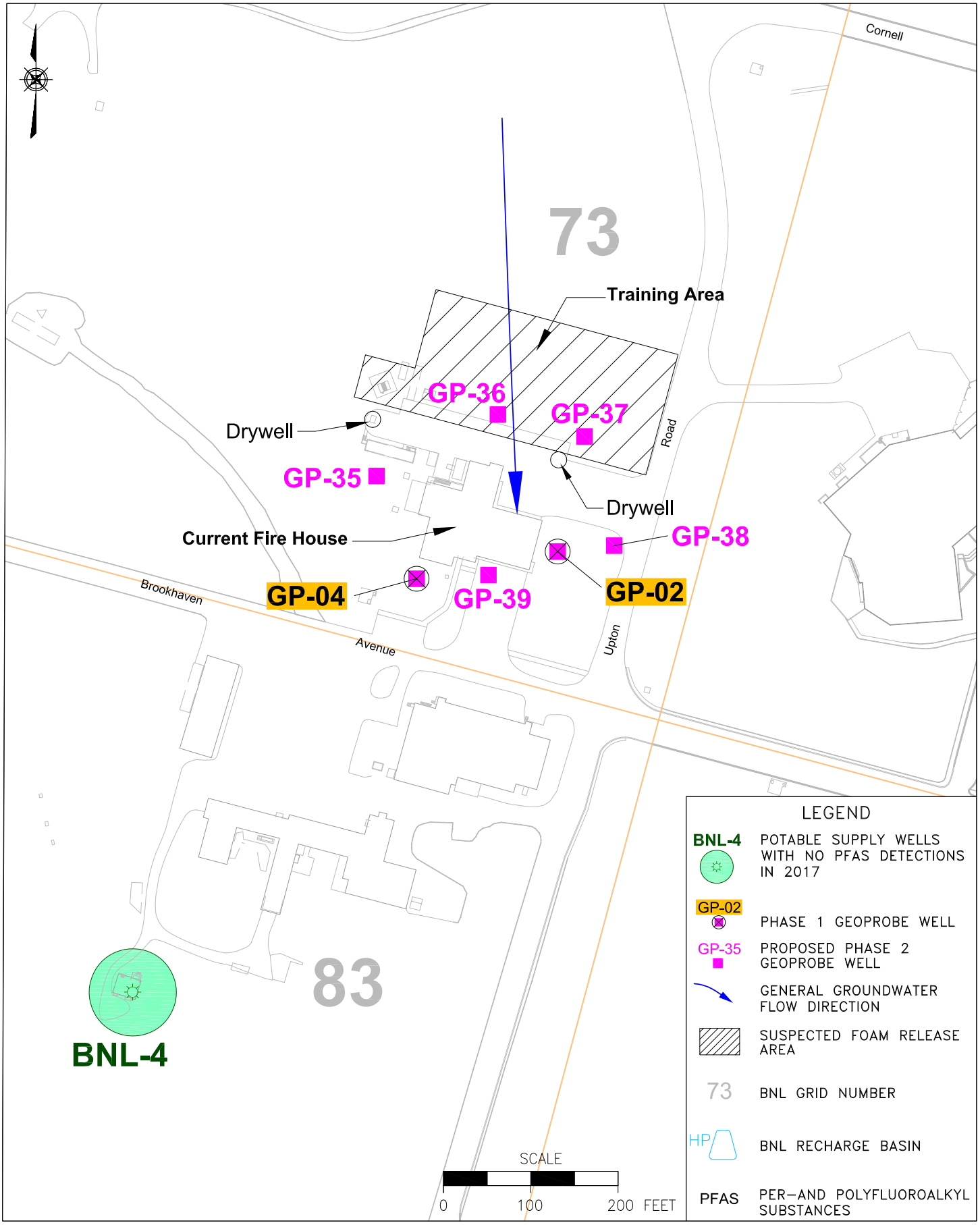
TITLE:

BUILDING 902 AREA

PFAS CHARACTERIZATION WORK PLAN

DWN:	VT: HZ.:	DATE:	PROJECT NO.:
AJZ	–	07/03/18	–
CHKD:	APPD:	REV.:	NOTES:
–	DEP	07/25/18	–

FIGURE NO.: 5



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BROOKHAVEN NATIONAL LABORATORY

ENVIRONMENTAL PROTECTION DIVISION

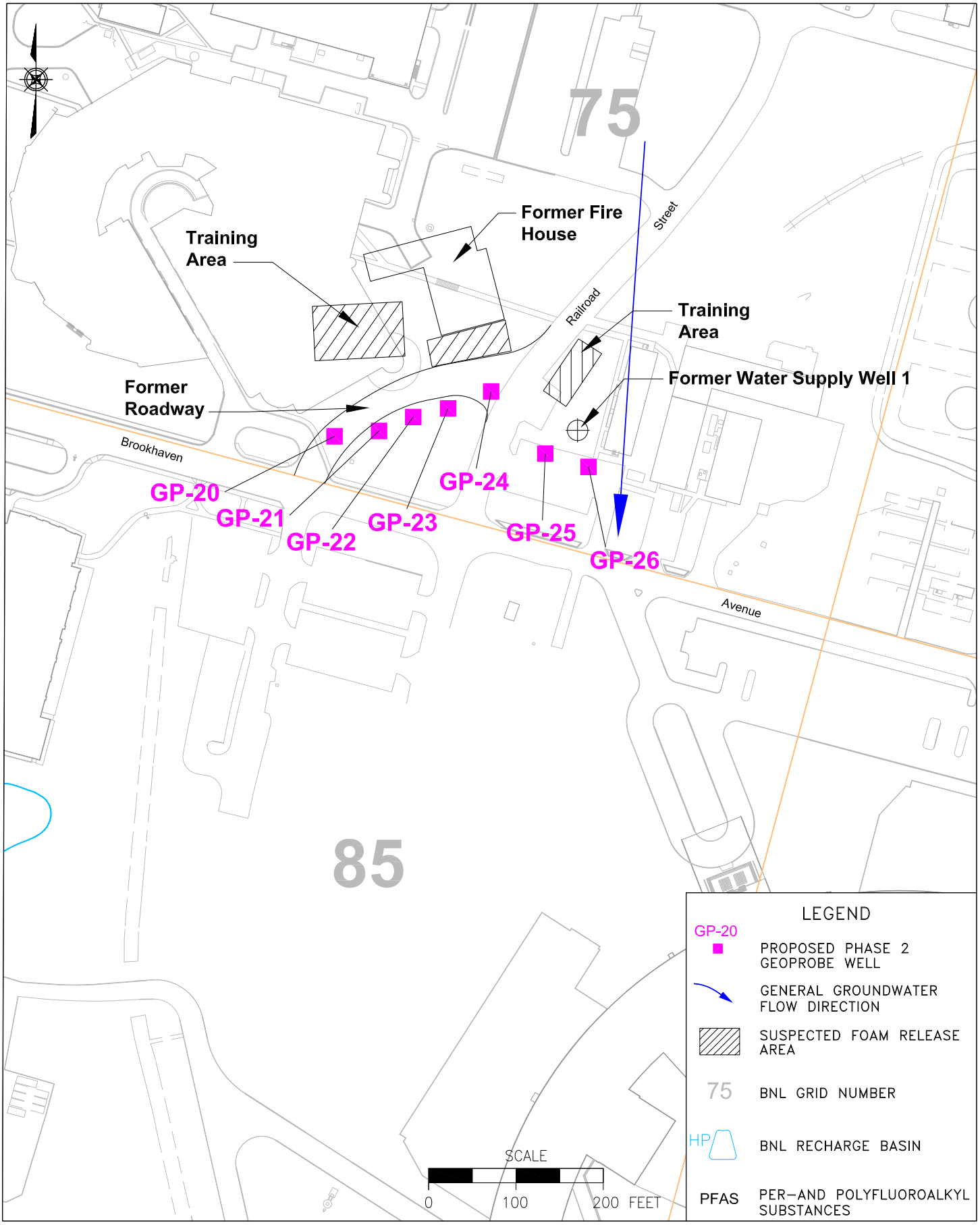
TITLE:

CURRENT FIREHOUSE AREA

PFAS CHARACTERIZATION WORK PLAN

DWN:	VT: HZ.:	DATE:	PROJECT NO.:
AJZ	–	07/11/18	–
CHKD:	APPD:	REV.:	NOTES:
–	DEP	08/02/18	–

FIGURE NO.: 6



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BROOKHAVEN NATIONAL LABORATORY

ENVIRONMENTAL PROTECTION DIVISION

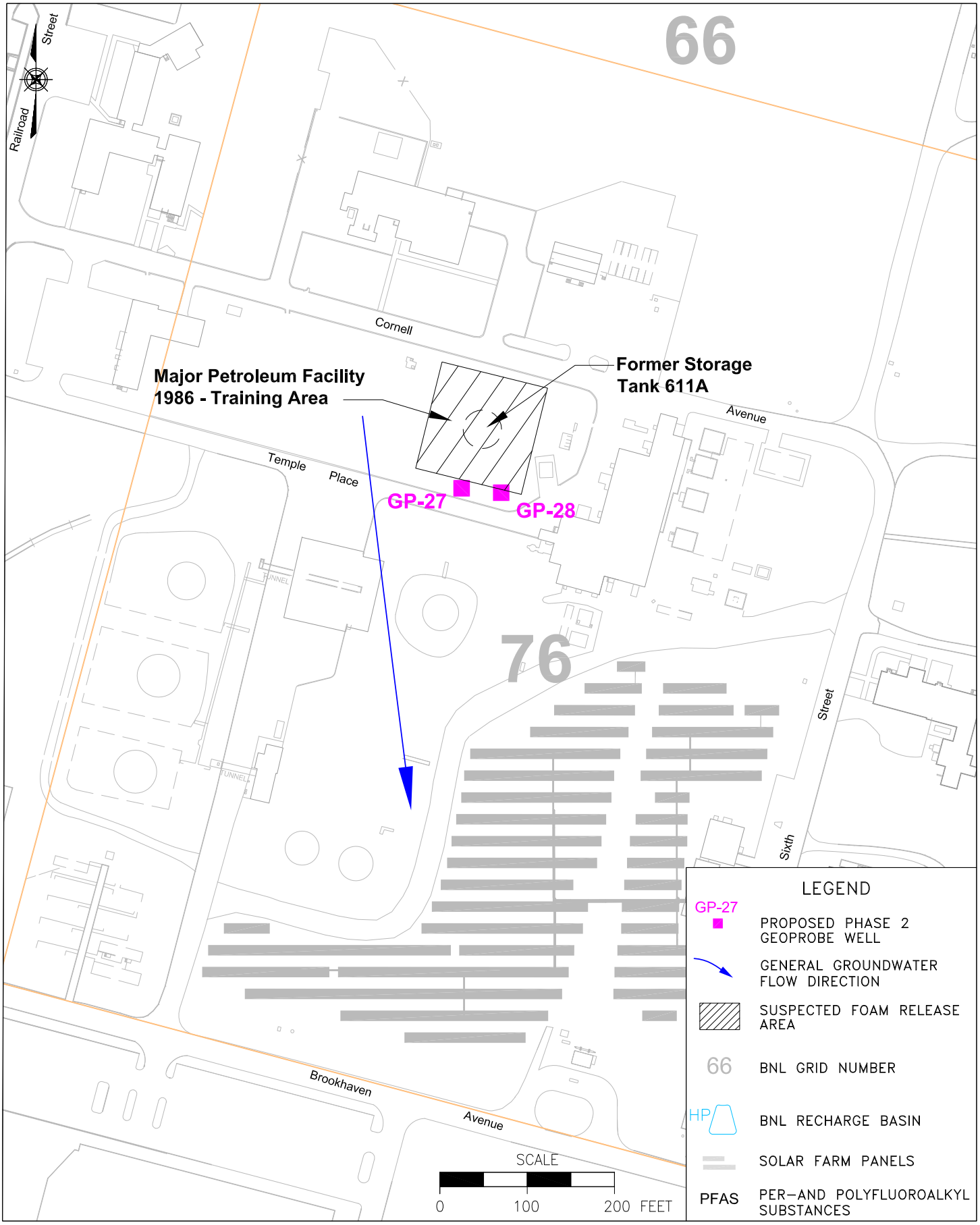
TITLE:

FORMER FIREHOUSE AREA

PFAS CHARACTERIZATION WORK PLAN

DWN:	VT: HZ.:	DATE:	PROJECT NO.:
AJZ	–	07/03/18	–
CHKD:	APPD:	REV.:	NOTES:
–	DEP	07/25/18	–

FIGURE NO.: 7



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BROOKHAVEN NATIONAL LABORATORY

ENVIRONMENTAL PROTECTION DIVISION

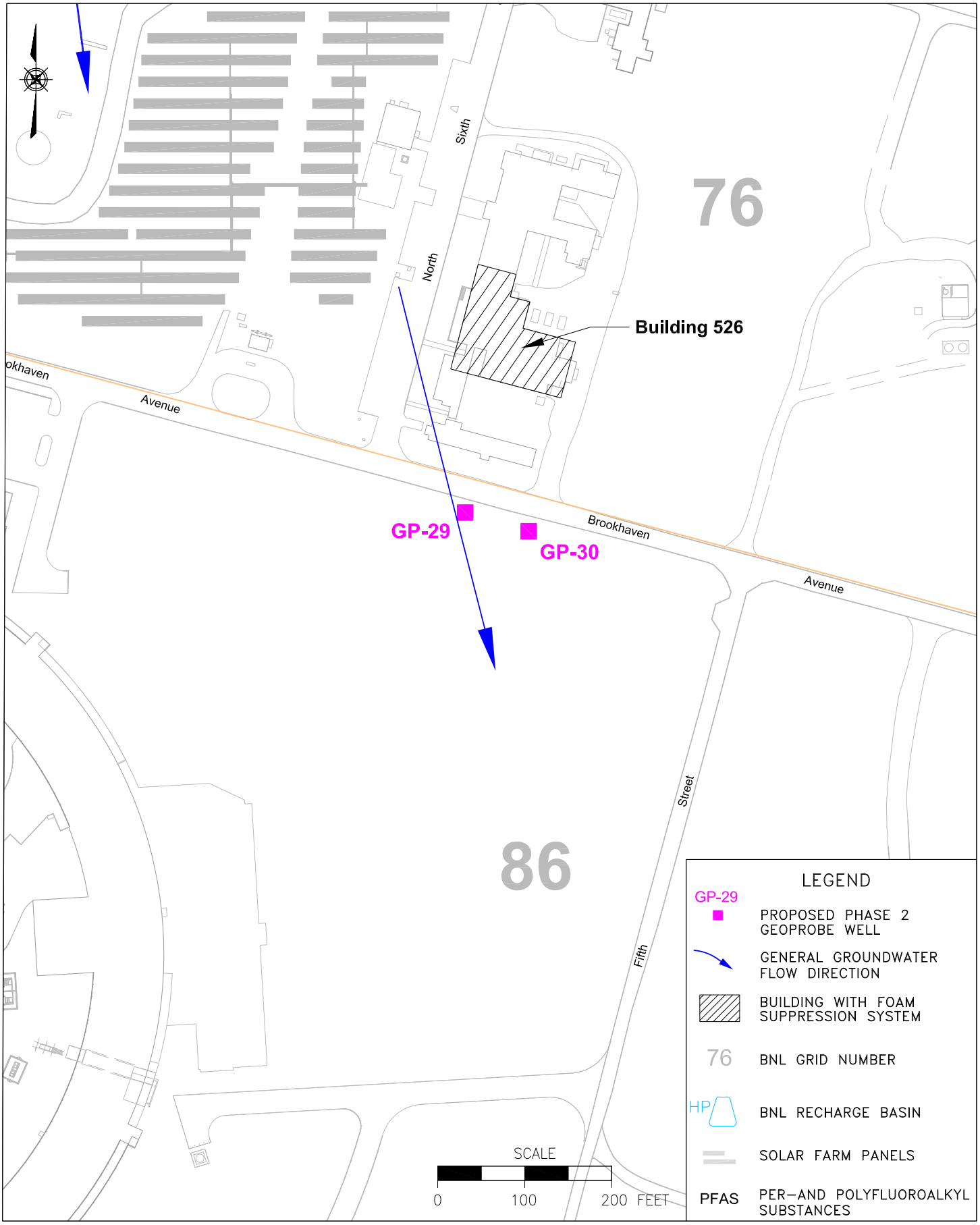
TITLE:

MAJOR PETROLEUM FACILITY AREA

PFAS CHARACTERIZATION WORK PLAN

DWN:	VT: HZ.:	DATE:	PROJECT NO.:
AJZ	–	07/03/18	–
CHKD:	APPD:	REV.:	NOTES:
–	DEP	07/25/18	–

FIGURE NO.: 8



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BROOKHAVEN NATIONAL LABORATORY

ENVIRONMENTAL PROTECTION DIVISION

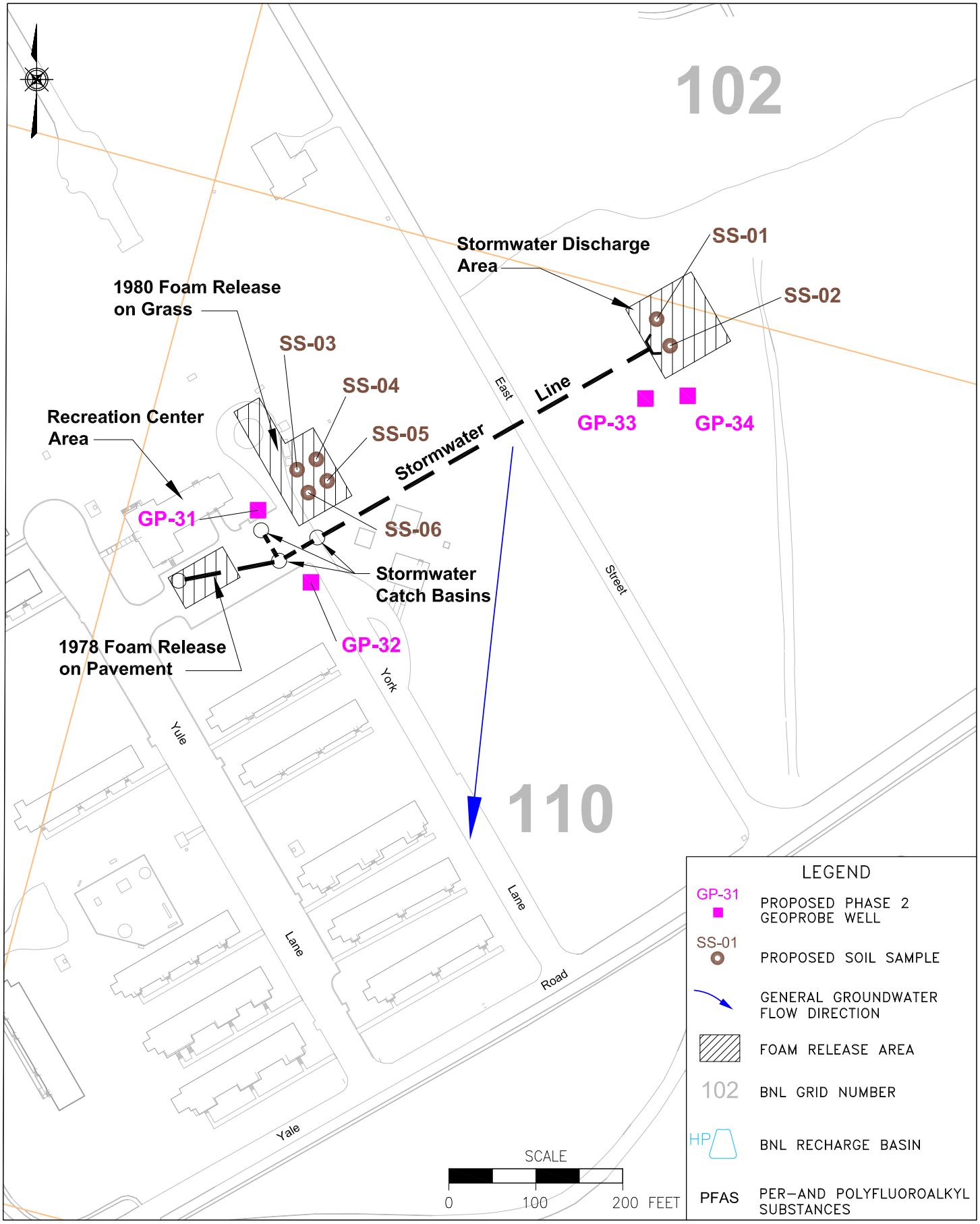
TITLE:

BUILDING 526 AREA

PFAS CHARACTERIZATION WORK PLAN

DWN:	VT:HZ.:	DATE:	PROJECT NO.:
AJZ	–	07/03/18	–
CHKD:	APPD:	REV.:	NOTES:
–	DEP	07/25/18	–

FIGURE NO.: 9



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BROOKHAVEN NATIONAL LABORATORY

ENVIRONMENTAL PROTECTION DIVISION

TITLE:

RECREATION CENTER AREA

PFAS CHARACTERIZATION WORK PLAN

DWN:	VT: HZ.:	DATE:	PROJECT NO.:
AJZ	–	07/10/18	–
CHKD:	APPD:	REV.:	NOTES:
–	DEP	07/25/18	–

FIGURE NO.: 10

Figure 11. Release of high-expansion foam at the former Bubble Chamber area. April 1973.

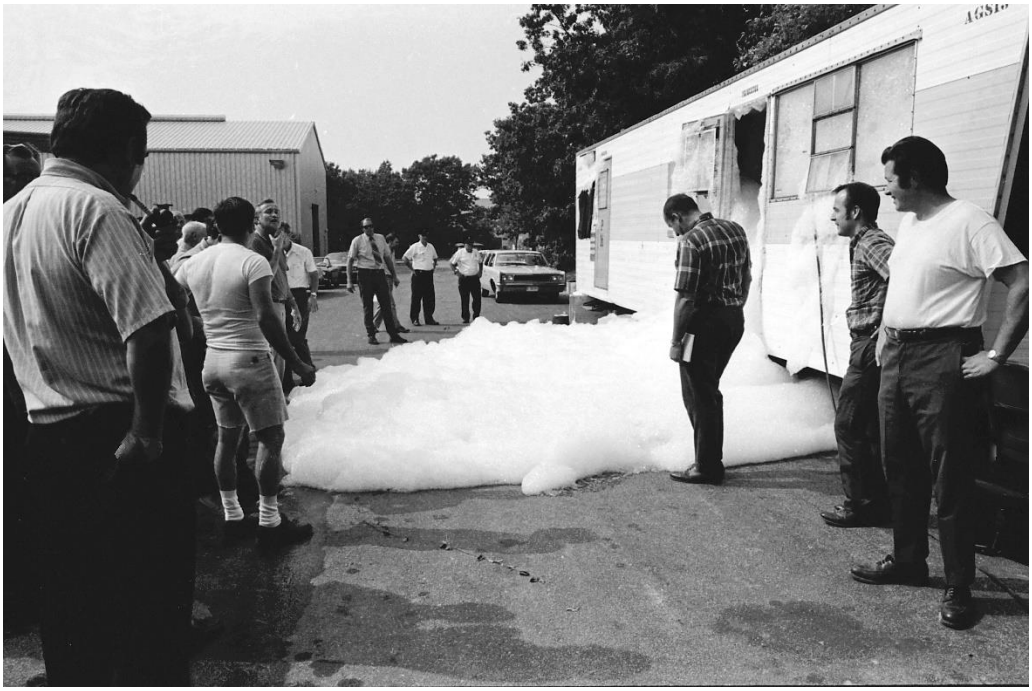

Figure 12. Release of high-expansion foam near Building 924. September 1970.

Figure 13. Release of high-expansion foam in area east of Building 902. September 1970.

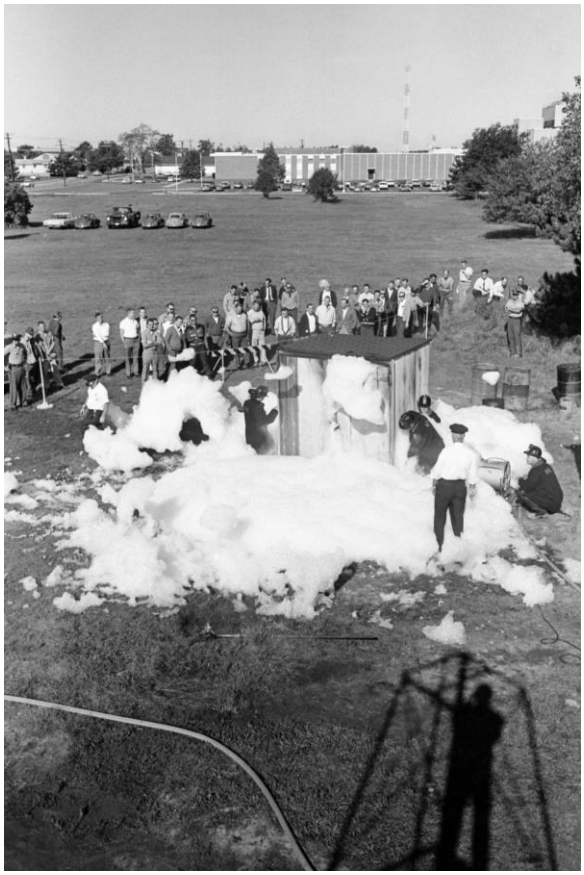

Figure 14. Training with high-expansion foam at the former firehouse. September 1966.

Figure 15. Training with low-expansion foam at the Major Petroleum Facility. September 1986.

Appendix A

BNL Potable Wells

PFAS Analytical Results

Table A1. Suffolk County Department of Health Services (SCDHS) Perfluorinated Compound (PFC) Data From BNL Potable Wells Samples Collected 3/22/17 and 8/17/17

Parameter	Detection Limit ng/L	Well 4 3/22/17 Sample Result ng/L	Well 6 3/22/17 Sample Result ng/L	Well 7 3/22/17 Sample Result ng/L	Well 10 3/22/17 Sample Result ng/L	Well 11 3/22/17 Sample Result ng/L	WTP Tap 3/22/17 Sample Result ng/L
Perfluorooctanesulfonate (PFOS)	<1.91	ND	23.0/24.0*	ND	12.3	12.0	ND
Perfluorooctanoic acid (PFOA)	<2	ND	ND/ND*	ND	6.28	3.07	ND
Perfluorohexanesulfonate (PFHxS)	<1.89	ND	8.93/8.68*	ND	5.40	8.75	ND
Perfluorobutanesulfonate (PFBS)	<1.77	ND	ND/ND*	ND	ND	ND	ND
Perfluoroheptanoic acid (PFHpA)	<2	ND	ND/ND*	ND	ND	ND	ND
Perfluorononanoic acid (PFNA)	<2	ND	ND/ND*	ND	ND	ND	ND
Combined PFOA/PFOS	**NA**	**ND**	**23.0/24.0***	**ND**	**18.58**	**15.07**	**ND**

Parameter	Detection Limit ng/L	Well 4 8/17/17 Sample Result ng/L	Well 6 8/17/17 Sample Result ng/L	Well 7 8/17/17 Sample Result ng/L	Well 10 8/17/17 Sample Result ng/L	Well 11 8/17/17 Sample Result ng/L	WTP Tap 8/17/17 Sample Result ng/L
Perfluorooctanesulfonate (PFOS)	<1.91	ND	14.2	ND	17.6	15.8	2.39/2.26*
Perfluorooctanoic acid (PFOA)	<2	ND	ND	ND	6.66	3.42	ND/ND*
Perfluorohexanesulfonate (PFHxS)	<1.89	ND	4.08	ND	7.10	7.97	ND/ND*
Perfluorobutanesulfonate (PFBS)	<1.77	ND	ND	ND	1.88	1.8	ND/ND*
Perfluoroheptanoic acid (PFHpA)	<2	ND	ND	ND	2.56	ND	ND/ND*
Perfluorononanoic acid (PFNA)	<2	ND	ND	ND	2.67	ND	ND/ND*
Combined PFOA/PFOS	**NA**	**ND**	**14.2**	**ND**	**24.26**	**19.22**	2.39/2.26*

* original sample/duplicate sample
ND = Not detected
NA = Not applicable
Analyses were performed by NYSDOH Wadsworth Center (Biggs Lab) in Albany

Table A.2. Perfluorinated Compound (PFC) Data From BNL Potable Wells
Samples Collected 1/30/18

Parameter	Detection Limit ng/L	Well 4 1/30/18 Sample Result ng/L	Well 6 1/30/18 Sample Result ng/L	Well 7 1/30/18 Sample Result ng/L	Well 10 1/30/18 Sample Result ng/L	Well 11 1/30/18 Sample Result ng/L	WTP Tap 1/30/18 Sample Result ng/L
Perfluorooctanesulfonate (PFOS)	0.62	1.01 J	14.6	0.88 J	16.8/18.9*	16.1	2.14
Perfluorooctanoic acid (PFOA)	0.62	0.69 J	0.90 J	0.87 J	5.08/5.96*	2.86	0.63 J
Perfluorohexanesulfonate (PFHxS)	0.62	ND	6.59	ND	9.10/9.11*	7.86	0.94 J
Perfluorobutanesulfonate (PFBS)	0.62	ND	0.69 J	ND	1.46 J/1.81*	1.05 J	ND
Perfluoroheptanoic acid (PFHpA)	0.62	ND	ND	ND	1.94 J/2.07*	0.77 J	ND
Perfluorononanoic acid (PFNA)	0.62	ND	ND	ND	1.91 J/2.27*	0.67 J	ND
Combined PFOA/PFOS	**NA**	**1.7**	**15.5**	**1.7**	**21.88/24.86***	**18.96**	**2.77**

* original sample/duplicate sample
ND = Not detected
NA = Not applicable
J = Estimated concentration
Analyses were performed by General Engineering Laboratories

Appendix B

Phase 1 Geoprobe Wells

PFAS Analytical Results

Table B.1
Brookhaven National Laboratory
Phase 1 Geoprobe Results
PFAS Concentrations in Nano Grams per Liter (ng/L)
Geoprobe: PFC-GP-01
Installed May 24, 2018

Chemical	Perfluorooctanesulfonate (PFOS)	Perfluoroundecanoic acid (PFUdA)	N-methylperfluoro-1-octanesulfonamidoacetic acid	Perfluoropentanoic acid (PFPeA)	Perfluoropentanesulfonate (PFPeS)	N-ethylperfluoro-1-octanesulfonamidoacetic acid	Perfluorohexanoic acid (PFHxA)	Perfluorododecanoic acid (PFDoA)	Perfluorooctanoic acid (PFOA)	Perfluorodecanoic acid (PFDA)	Perfluorodecanesulfonate (PFDS)	Perfluorohexanesulfonate (PFHxS)	Perfluorobutyric acid (PFBA)	Perfluorobutanesulfonate (PFBS)	Perfluoroheptanoic acid (PFHpA)	Perfluoroheptanesulfonate (PFHpS)	Perfluorononanoic acid (PFNA)	Perfluorotetradecanoic acid (PFTeDA)	Perfluorononanesulfonate (PFNS)	Perfluorotridecanoic acid (PFTrDA)	Perfluorooctanesulfonamide (PFOSA)	PFOA/PFOS (Combined)
BLS																						
74-78	**120**	<	<	4.4	3.4	<	6.7	<	3.7	<	<	43	1.8J	2.3	<	2.8	40	<	<	<	<	**124**
86-90	52	<	<	2.5	2.6	<	6.2	<	2.7	<	<	26	1.2J	1.5J	1.3J	1.2J	33	<	<	<	<	55
98-102	40	<	<	3.1	3.9	<	5.5	<	9.2	<	<	26	1.2J	3	1.7J	0.9J	22	<	<	<	<	49
110-114	56	<	<	13	17	<	19	<	5.7	<	<	91	4	12	3.6	2.1	<	<	<	<	<	62
130-134	38	<	<	0.9J	2.6	<	4.4	<	3.9	<	<	19	1.1J	2.3	0.7J	0.9J	<	<	<	<	<	42
EB	<	<	<	<	<	<	<	<	<	<	<	<	<	<	<	<	<	<	<	<	<	<
TB	<	<	<	<	<	<	<	<	<	<	<	<	<	<	<	<	<	<	<	<	<	<

BLS: Sample depth in feet below ground surface.
Depth to Water Table at time of sampling = 48 ft.
<: Not detected. Typical detection limit is 0.6 ng/L.
D: Blind duplicate
J: Estimated concentration

EB: Equipment blank = HDPE discharge tubing
FB: Field blank
TB: Trip blank

BNL COC# 39812

Table B.2
Brookhaven National Laboratory
Phase 1 Geoprobe Results
PFAS Concentrations in Nano Grams per Liter (ng/L)
Geoprobe: PFC-GP-02
Installed May 21, 2018

Chemical	Perfluorooctanesulfonate (PFOS)	Perfluoroundecanoic acid (PFUdA)	N-methylperfluoro-1-octanesulfonamidoacetic acid	Perfluoropentanoic acid (PFPeA)	Perfluoropentanesulfonate (PFPeS)	N-ethylperfluoro-1-octanesulfonamidoacetic acid	Perfluorohexanoic acid (PFHxA)	Perfluorododecanoic acid (PFDoA)	Perfluorooctanoic acid (PFOA)	Perfluorodecanoic acid (PFDA)	Perfluorodecanesulfonate (PFDS)	Perfluorohexanesulfonate (PFHxS)	Perfluorobutyric acid (PFBA)	Perfluorobutanesulfonate (PFBS)	Perfluoroheptanoic acid (PFHpA)	Perfluoroheptanesulfonate (PFHpS)	Perfluorononanoic acid (PFNA)	Perfluorotetradecanoic acid (PFTeDA)	Perfluorononanesulfonate (PFNS)	Perfluorotridecanoic acid (PFTrDA)	Perfluorooctanesulfonamide (PFOSA)	PFOA/PFOS (Combined)
BLS																						
50-54	**2980**	<	<	127J	626	<	564	<	**144J**	<	<	3710	60	223	72	23	<	<	2.6	<	330	**3124**
54-58	**272**	<	<	17	13	<	32	<	14	<	<	137	5.8	12	5.1	7.9	<	<	<	<	5.8	**286**
66-70	**162**	<	<	7.9	7.7	<	18	<	11	<	<	74	3.4	5.4	2.6	4.3	1.5J	<	<	<	1.4J	**173**
66-70**D**	**170**	<	<	7.4	6.4	<	17.7	<	9.4	<	<	78.1	3.2	6.4	2.5	4.9	2	<	<	<	1.5J	**180**
78-82	**313**	<	<	23	17	<	32	<	12	<	<	122	6.3	16	5.8	4.5	2.1	<	<	<	0.8J	**325**
90-94	**231**	<	<	15	11	<	25	<	9.2	<	<	91	5.4	11	4.1	3.7	1.8J	<	<	<	<	**240**
110-114	48.6	<	<	1.3J	2.9	<	2.8	<	2.5	<	<	24	1.2J	2.1	<	0.8J	1.6J	<	<	<	<	51
130-134	9.8	<	<	<	<	<	1.8J	<	1.8J	<	<	4.1	<	<	<	<	<	<	<	<	<	12
TB	<	<	<	<	<	<	<	<	<	<	<	<	<	<	<	<	<	<	<	<	<	<

BLS: Sample depth in feet below ground surface.
Depth to Water Table at time of sampling = 48 ft.
<: Not detected. Typical detection limit is 0.6 ng/L
D: Blind duplicate
J: Estimated concentration

EB: Equipment blank
FB: Field blank
TB: Trip blank

BNL COC# 39805

Table B.3
Brookhaven National Laboratory
Phase 1 Geoprobe Results
PFAS Concentrations in Nano Grams per Liter (ng/L)
Geoprobe: PFC-GP-04
Installed May 22-23, 2018

Chemical	Perfluorooctanesulfonate (PFOS)	Perfluoroundecanoic acid (PFUdA)	N-methylperfluoro-1-octanesulfonamidoacetic acid	Perfluoropentanoic acid (PFPeA)	Perfluoropentanesulfonate (PFPeS)	N-ethylperfluoro-1-octanesulfonamidoacetic acid	Perfluorohexanoic acid (PFHxA)	Perfluorododecanoic acid (PFDoA)	Perfluorooctanoic acid (PFOA)	Perfluorodecanoic acid (PFDA)	Perfluorodecanesulfonate (PFDS)	Perfluorohexanesulfonate (PFHxS)	Perfluorobutyric acid (PFBA)	Perfluorobutanesulfonate (PFBS)	Perfluoroheptanoic acid (PFHpA)	Perfluoroheptanesulfonate (PFHpS)	Perfluorononanoic acid (PFNA)	Perfluorotetradecanoic acid (PFTeDA)	Perfluorononanesulfonate (PFNS)	Perfluorotridecanoic acid (PFTrDA)	Perfluorooctanesulfonamide (PFOSA)	PFOA/PFOS (Combined)
BLS																						
50-54	**72**	<	<	2.2	9.1	<	10	<	2.3	<	<	46	<	4.1	0.8J	0.7J	0.6J	<	<	<	<	**74**
54-58	**136**	<	<	2.2	11	<	11	<	2.6	<	<	58	<	6.1	<	0.9J	<	<	<	<	<	**139**
66-70	2.2	<	<	<	<	<	0.8J	<	<	<	<	1.3J	<	<	<	<	<	<	<	<	<	2.2
78-82	1.4J	<	<	<	<	<	0.6J	<	<	<	<	<	<	<	<	<	<	<	<	<	<	1.4
90-94	1.4J	<	<	<	<	<	<	<	<	<	<	<	<	<	<	<	<	<	<	<	<	1.4
110-114	1.4J	<	<	<	<	<	<	<	<	<	<	<	<	<	<	<	<	<	<	<	<	1.4
130-134	1.2J	<	<	<	<	<	<	<	<	<	<	<	<	<	<	<	<	<	<	<	<	1.2
TB	<	<	<	<	<	<	<	<	<	<	<	<	<	<	<	<	<	<	<	<	<	<

BLS: Sample depth in feet below ground surface.
Depth to Water Table at time of sampling = 48 ft.
<: Not detected. Typical detection limit is 0.6 ng/L.
D: Blind duplicate
J: Estimated concentration

EB: Equipment blank
FB: Field blank
TB: Trip blank

BNL COC# 39809

Table B.4
Brookhaven National Laboratory
Phase 1 Geoprobe Results
PFAS Concentrations in Nano Grams per Liter (ng/L)
Geoprobe: PFC-GP-05
Installed May 14, 2018

Chemical	Perfluorooctanesulfonate (PFOS)	Perfluoroundecanoic acid (PFUdA)	N-methylperfluoro-1-octanesulfonamidoacetic acid	Perfluoropentanoic acid (PFPeA)	Perfluoropentanesulfonate (PFPeS)	N-ethylperfluoro-1-octanesulfonamidoacetic acid	Perfluorohexanoic acid (PFHxA)	Perfluorododecanoic acid (PFDoA)	Perfluorooctanoic acid (PFOA)	Perfluorodecanoic acid (PFDA)	Perfluorodecanesulfonate (PFDS)	Perfluorohexanesulfonate (PFHxS)	Perfluorobutyric acid (PFBA)	Perfluorobutanesulfonate (PFBS)	Perfluoroheptanoic acid (PFHpA)	Perfluoroheptanesulfonate (PFHpS)	Perfluorononanoic acid (PFNA)	Perfluorotetradecanoic acid (PFTeDA)	Perfluorononanesulfonate (PFNS)	Perfluorotridecanoic acid (PFTrDA)	Perfluorooctanesulfonamide (PFOSA)	PFOA/PFOS (Combined)
BLS																						
46-50	0.7 J	<	<	1.9	<	<	3.8	<	6	<	<	1.4 J	4.8	<	1.8	<	1.2 J	<	<	<	<	**6.7**
46-50**D**	1.4 J	<	<	2.1	<	<	4.2	<	7.2	<	<	1.4 J	5.4	<	2.1	<	1.6 J	<	<	<	<	**8.6**
58-62	1.6 J	<	<	7.2	<	<	5.6	<	3.1	<	<	3.4 J	10.4	<	1.4 J	<	1.5	<	<	<	<	**4.7**
70-74	1.4 J	<	<	1.8 J	<	<	2.1	<	1.8 J	<	<	0.7 J	26.1	<	0.6 J	<	0.6 J	<	<	<	<	**3.2**
90-94	2.1	<	<		<	<	1.4 J	<	2.2	<	<	1.1 J	4.7	<	0.7 J	<	0.7 J	<	<	<	<	**4.3**
110-114	2.8	<	<	1.2 J	<	<	4.1	<	4.9	<	<	1.0 J	19.9	<	1.8 J	<	0.9 J	<	<	<	<	**7.7**
130-134	1.8 J	<	<	0.9 J	<	<	2.8	<	2.3	<	<	0.9 J	3.2	<	0.9 J	<	0.6 J	<	<	<	<	**4.1**
EB	<	<	<	<	<	<	<	<	<	<	<	<	<	<	<	<	<	<	<	<	<	<
FB	<	<	<	<	<	<	<	<	<	<	<	<	<	<	<	<	<	<	<	<	<	<
TB	<	<	<	<	<	<	<	<	<	<	<	<	<	<	<	<	<	<	<	<	<	<

BLS: Sample depth in feet below ground surface.
Depth to Water Table at time of sampling = 45 ft.
<: Not detected. Typical detection limit is 0.6 ng/L.
D: Blind duplicate
J: Estimated concentration

EB: Equipment blank = Screen and sheath.
FB: Filed blank
TB: Trip blank

BNL COC# 39789

Table B.5
Brookhaven National Laboratory
Phase 1 Geoprobe Results
PFAS Concentrations in Nano Grams per Liter (ng/L)
Geoprobe: PFC-GP-07
Installed May 16-17, 2018

Chemical	Perfluorooctanesulfonate (PFOS)	Perfluoroundecanoic acid (PFUdA)	N-methylperfluoro-1-octanesulfonamidoacetic acid	Perfluoropentanoic acid (PFPeA)	Perfluoropentanesulfonate (PFPeS)	N-ethylperfluoro-1-octanesulfonamidoacetic acid	Perfluorohexanoic acid (PFHxA)	Perfluorododecanoic acid (PFDoA)	Perfluorooctanoic acid (PFOA)	Perfluorodecanoic acid (PFDA)	Perfluorodecanesulfonate (PFDS)	Perfluorohexanesulfonate (PFHxS)	Perfluorobutyric acid (PFBA)	Perfluorobutanesulfonate (PFBS)	Perfluoroheptanoic acid (PFHpA)	Perfluoroheptanesulfonate (PFHpS)	Perfluorononanoic acid (PFNA)	Perfluorotetradecanoic acid (PFTeDA)	Perfluorononanesulfonate (PFNS)	Perfluorotridecanoic acid (PFTrDA)	Perfluorooctanesulfonamide (PFOSA)	PFOA/PFOS (Combined)
BLS																						
34-38	2.8	0.8J	<	<	<	<	0.7J	<	4.7	<	<	<	20.5	<	1.2J	<	1.4J	<	<	<	<	**7.5**
46-50	1.6J	1.8J	<	0.8J	<	<	1.5J	<	3.2	<	<	<	22.4	<	1.8J	<	0.9J	<	<	<	<	**4.8**
58-62	2.2	1.0J	<	0.8J	<	<	1.5J	<	4.8	<	<	<	17.1	<	1.9J	<	0.7J	<	<	<	<	**7.0**
70-74	2.3	<	<	<	<	<	0.7J	<	2.9	<	<	<	3.1	<	0.6J	<	0.7J	<	<	<	<	**5.2**
90-94	2.4	<	<	<	<	<	1.2J	<	2.9	<	<	0.6J	5.3	<	0.8J	<	1.1J	<	<	<	<	**5.3**
110-114	<	<	<	<	<	<	<	<	<	<	<	<	<	<	<	<	<	<	<	<	<	<
130-134	<	<	<	<	<	<	<	<	<	<	<	<	<	<	<	<	<	<	<	<	<	<
TB	<	<	<	<	<	<	<	<	<	<	<	<	<	<	<	<	<	<	<	<	<	<

BLS: Sample depth in feet below ground surface.
Depth to Water Table at time of sampling = 34 ft.
<: Not detected. Typical detection limit is 0.6 ng/L.
D: Blind duplicate
J: Estimated concentration

EB: Equipment blank
FB: Field blank
TB: Trip blank

BNL COC# 39801

Table B.6
Brookhaven National Laboratory
Phase Geoprobe Results
PFAS Concentrations in Nano Grams per Liter (ng/L)
Geoprobe: PFC-GP-08
Installed May 17-18, 2018

Chemical	Perfluorooctanesulfonate (PFOS)	Perfluoroundecanoic acid (PFUdA)	N-methylperfluoro-1-octanesulfonamidoacetic acid	Perfluoropentanoic acid (PFPeA)	Perfluoropentanesulfonate (PFPeS)	N-ethylperfluoro-1-octanesulfonamidoacetic acid	Perfluorohexanoic acid (PFHxA)	Perfluorododecanoic acid (PFDoA)	Perfluorooctanoic acid (PFOA)	Perfluorodecanoic acid (PFDA)	Perfluorodecanesulfonate (PFDS)	Perfluorohexanesulfonate (PFHxS)	Perfluorobutyric acid (PFBA)	Perfluorobutanesulfonate (PFBS)	Perfluoroheptanoic acid (PFHpA)	Perfluoroheptanesulfonate (PFHpS)	Perfluorononanoic acid (PFNA)	Perfluorotetradecanoic acid (PFTeDA)	Perfluorononanesulfonate (PFNS)	Perfluorotridecanoic acid (PFTrDA)	Perfluorooctanesulfonamide (PFOSA)	PFOA/PFOS (Combined)
BLS																						
46-50	1.5J	<	<	1.7J	<	<	1.5J	<	2.8	<	<	<	175	<	0.9J	<	<	<	<	<	<	4.3
58-62	2.8	<	<	3.2	<	<	3.2	<	3.4	<	<	0.8J	153	<	2.4	<	0.9J	<	<	<	<	6.2
70-74	0.9J	<	<	<	<	<	<	<	0.8J	<	<	<	2.1	<	<	<	<	<	<	<	<	1.7
70-74**D**	1.1J	<	<	<	<	<	<	<	0.8J	<	<	0.6J	2.2	<	<	<	<	<	<	<	<	1.9
90-94	1.1J	<	<	<	<	<	<	<	2.2	<	<	<	1.5J	<	<	<	<	<	<	<	<	3.3
110-114	5.4	<	<	<	<	<	<	<	1.2J	<	<	1.7J	1.4J	<	<	<	<	<	<	<	<	6.6
130-134	<	<	<	<	<	<	<	<	<	<	<	<	<	<	<	<	<	<	<	<	<	<
TB	<	<	<	<	<	<	<	<	<	<	<	<	<	<	<	<	<	<	<	<	<	<
FB	<	<	<	<	<	<	<	<	<	<	<	<	<	<	<	<	<	<	<	<	<	<

BLS: Sample depth in feet below ground surface.
Depth to Water Table at time of sampling = 43 ft.
<: Not detected. Typical detection limit is 0.6 ng/L.
D: Blind duplicate
J: Estimated concentration

EB: Equipment blank
FB: Field blank
TB: Trip blank

BNL COC# 39803

Table B.7
Phase 1 Geoprobe Results
PFAS Concentrations in Nano Grams per Liter (ng/L)
Geoprobe: PFC-GP-11
Installed May 15, 2018

Chemical	Perfluorooctanesulfonate (PFOS)	Perfluoroundecanoic acid (PFUdA)	N-methylperfluoro-1-octanesulfonamidoacetic acid	Perfluoropentanoic acid (PFPeA)	Perfluoropentanesulfonate (PFPeS)	N-ethylperfluoro-1-octanesulfonamidoacetic acid	Perfluorohexanoic acid (PFHxA)	Perfluorododecanoic acid (PFDoA)	Perfluorooctanoic acid (PFOA)	Perfluorodecanoic acid (PFDA)	Perfluorodecanesulfonate (PFDS)	Perfluorohexanesulfonate (PFHxS)	Perfluorobutyric acid (PFBA)	Perfluorobutanesulfonate (PFBS)	Perfluoroheptanoic acid (PFHpA)	Perfluoroheptanesulfonate (PFHpS)	Perfluorononanoic acid (PFNA)	Perfluorotetradecanoic acid (PFTeDA)	Perfluorononanesulfonate (PFNS)	Perfluorotridecanoic acid (PFTrDA)	Perfluorooctanesulfonamide (PFOSA)	PFOA/PFOS (Combined)
BLS																						
46-50	0.8J	<	<	<	<	<	1.2J	<	1.6J	<	<	16.8	10.5	1.1J	<	<	<	<	<	<	<	**2.3**
58-62	16.3	<	<	<	<	<	0.9J	<	1.4J	<	<	3.1	3.5	<	<	<	<	<	<	<	<	**17.7**
58-62**D**	16.4	<	<	<	<	<	0.9J	<	1.1J	<	<	3.2	3.5	<	<	<	<	<	<	<	<	**17.5**
70-74	3.6	<	<	<	<	<	<	<	0.8J	<	<	1.2J	2.2	<	<	<	<	<	<	<	<	**4.4**
90-94	<	<	<	0.7J	<	<	<	<	1.2J	<	<	<	8.9	<	<	<	<	<	<	<	<	**1.2**
110-114	12	<	<	1.9	0.9J	<	2.6	<	3.8	<	<	6.9	63	2.1	2.1	<	1.3J	<	<	<	<	**15.8**
130-134	6.1	<	<	0.8J	<	<	1.5J	<	1.5J	<	<	3.9	1.4J	<	<	<	<	<	<	<	<	**7.6**
TB	<	<	<	<	<	<	<	<	<	<	<	<	<	<	<	<	<	<	<	<	<	<

BLS: Sample depth in feet below ground surface.
Depth to Water Table at time of sampling = 45 ft.
<: Not detected. Typical detection limit is 0.6 ng/L
D: Blind duplicate
J: Estimated concentration

EB: Equipment blank
FB: Field blank
TB: Trip blank

BNL COC# 39795