SITE CLOSEOUT REPORT (REV 2)

U.S. DEPARTMENT OF ENERGY

HIGH FLUX BEAM REACTOR STACK (BLDG 705) DECOMMISSIONING AND DEMOLITION (D&D) BROOKHAVEN NATIONAL LABORATORY UPTON, NY CERCLIS NUMBER NY 789008975

March 2022

Prepared for:

U.S. ARMY CORPS OF ENGINEERS, BALTIMORE DISTRICT
District 2 Hopkins Plaza
Baltimore, MD 21201

Prepared by:

Olgoonik FPM JV, LLC
181 Kenwood Avenue
Oneida, NY 13421

SITE CLOSEOUT REPORT (REV 2)

U.S DEPARTMENT OF ENERGY

HIGH FLUX BEAM REACTOR STACK (BLDG 705)
DECOMMISSIONING AND DEMOLITION (D&D)
BROOKHAVEN NATIONAL LABORATORY
UPTON, NY

Contract Number: W912DW19D1025
Task Order: W912DR20F0139
Reviewed and Approved by:

Gaby Atik, PE, PMP
Program Manager
Olgoonik-FPM JV, LLC

Daniel Ours, PG, PMP
Project Manager
Olgoonik-FPM JV, LLC

Olgoonik-FPM JV, LLC (OFJV) prepared this report under the direction of the U.S. Army Corps of Engineers (USACE) and the United States Department of Energy (DOE). This document should be used only with the approval of USACE and DOE. This report is based, in part, on information provided in other documents and is subject to the limitations and qualifications presented in the referenced documents.

March 2022

TABLE OF CONTENTS

SECTION **PAGE**

LIST OF FIGURES

FIGURE

LIST OF TABLES

TABLE

LIST OF APPENDICES

LIST OF ABBREVIATIONS AND ACRONYMS

ABC	Articulated Bulk Container
AC	Alternating Current
ACM	Asbestos-containing Material
AHA	Activity Hazard Analysis
AOC	Area of Concern
APP	Accident Prevention Plan
ALARA	As Low As Reasonably Achievable
ARAR	Applicable or Relevant and Appropriate Requirement
BER	Brookhaven Executive Roundtable
BGRR	Brookhaven Graphite Research Reactor
BSA	Brookhaven Science Associates
BSS	Building Seismic Stations
BHSO	Brookhaven Site Office
BNL	Brookhaven National Laboratory
CAC	Community Advisory Council
CAMP	Community Air Monitoring Plan
CENAB	USACE Baltimore District
CELRH	USACE Huntington District
CENAN	USACE New York District
CERCLA	Comprehensive Environmental Response, Compensation and Liability Act
Co	Cobalt
Cs	Cesium
CFR	Code of Federal Regulations
CHMM	Certified Hazardous Material Manager
Ci	curies
CIH	Certified Industrial Hygienist
cm	centimeter
COC	Constituent of Concern
CO	Contracting Officer
COD	Certificate of Disposal
COR	Contracting Officer's Representative

CP	Competent Person
CPG	Certified Professional Geologist
cy	cubic yards
DCGL	Duplicate Concentration Guidance Level
DCGL	derived concentration guidance level
DOE	U.S. Department of Energy
DOELAP	DOE Laboratory Accreditation Program
dpm/cm^2	Disintegrations per minute per cubic centimeter
DQCR	Daily Quality Control Report
DQO	Data Quality Objective
DFOW	Definable Feature of Work
DOE	United States Department of Energy
DOE-EM	United States Department of Energy, Office of Environmental Management
DOE-SC	United States Department of Energy, Office of Science
DOT	Department of Transportation
EM	Engineering Manual
ERS	Environmental Rail Solutions
Eu	Europium
FAA	Federal Aviation Administration
FS	Feasibility Study
FSP	Field Sampling Plan
FSS	Final Status Survey
FSSP	Final Status Survey Plan
FSSR	Final Status Survey Report
GEI	GEI Consultants, Inc.
H-3	Tritium
HAZWOPER	Hazardous Waste Operations and Emergency Response
HEPA	high-efficiency particulate air
HFBR	High Flux Beam Reactor
HVAC	heating, ventilation, and air conditioning
ID	Identification
IMC	Intermodal Container

IVS	Independent Verification Survey
LBP	Lead-based Paint
LIRR	Long Island Railroad
LLRW	Low-level Radioactive Waste
LOTO	Lockout/Tagout
MARSSIM	Multi-Agency Radiation Survey and Site Investigation Manual
mph	miles per hour
Ni	Nickel
NHPA	National Historic Preservation Act
NPDES	National Pollutant Discharge Elimination System
NY&A	New York and Atlantic Railroad
NYSDEC	New York State Department of Environmental Conservation
NYSDOH	New York State Department of Health
NYCRR	New York Codes, Rules and Regulations
OHSMS	Occupational Health & Safety Management System
OFJV	Olgoonik-FPM JV, LLC
ORISE	Oak Ridge Institute for Science and Education
OSHA	Occupationnel Safety and Health Administration
PCBs	polychlorinated biphenyls
PCi/g	picocuries per gram
PDF	portable document format
PM10	Particulate matter 10 micrometers or less in diameter
POC	Point of Contact
PPE	Personnel Protective Equipment
PE	Professional Engineer
PG	Professional Geologist
PDT	Project Delivery Team
PM	Project Manager
PMP	Project Management Plan or Project Management Professional
PPV	Peak Particle Velocity
Pu	Plutonium
QASP	Quality Assurance Surveillance Plan

QC	Quality Control
QCM	Quality Control Manager
Ra	Radium
RESRAD	Residual Radioactivity Computer Code
RCT	Radiological Control Technician
RFP	Request for Proposal
RI	Remedial Investigation
RPP	Radiation Protection Plan
RMA	Rad Management Area
RMS	Resident Management System
ROD	Record of Decision
RSO	Radiation Safety Officer
SOW	Scope of Work
SPDES	State Pollutant Discharge Elimination System
Sr	Strontium
SSHO	Site Safety and Health Officer
SSHP	Site-Specific Health & Safety Plan
TO	Task Order
UFP/QAPP	Uniform Federal Policy/Quality Assurance Project Plan
USACE	United States Army Corps of Engineers
USEPA	United States Environmental Protection Agency
VRM	Vehicle Radiation Monitor
WBS	Work Breakdown Schedule
WMP	Waste Management Plan

1.0 INTRODUCTION

1.1 Purpose

The purpose of this Site Closeout Report is to document the completed actions associated with the decommissioning and demolition (D&D) of the High Flux Beam Reactor (HFBR) Stack (Building 705) at the Brookhaven National Laboratory (BNL). This Site Closeout Report also documents the results of the Final Status Survey (FSS) for the HFBR Stack. This work is referred to herein as the "HFBR Stack D&D Project."

The HFBR is designated as Area of Concern (AOC) 31 at Brookhaven National Laboratory (BNL). The HFBR Stack D&D Project is part of the actions described as near-term decontamination and dismantlement in the *Record of Decision – Area of Concern 31, High Flux Beam Reactor* (BNL, February 2009) (HFBR ROD). The funding agent for the project was the United States Army Corps of Engineers (USACE) Great Lakes and Ohio River Division, Huntington District (CELRH) through appropriated funding from the Department of Energy, Office of Environmental Management (DOE-EM). USACE North Atlantic Division Baltimore District (CENAB) provided technical support and USACE North Atlantic Division New York District (CENAN) provided management support. Work associated with the HFBR Stack D&D Project was performed by Olgoonik-FPM JV (OFJV), the USACE Contractor, in accordance with the HFBR ROD and the following approved Work Plans:

- Final Project Management Plan (OFJV, May 2020a)
- Final Structures and Soil Characterization Work Plan (OFJV, May 2020b)
- Final Excavation Plan (OFJV, June 2020c)
- Final Contingency Plan (OFJV, July 2020d)
- Final Waste Management Plan (Rev 0) (OFJV, July 2020e)
- Final Waste Management Plan (Rev 1) (OFJV, Oct 2020f)
- Final COVID-19 Management Plan (OFJV, July 2020g)
- Final Uniform Federal Policy/Quality Assurance Project Plan (UFP-QAPP) (OFJV, August 2020h)
- Final Accident Prevention Plan/Site Safety and Health Plan (with APP) (OFJV, August 2020i)
- Final Community Air Monitoring Plan (OFJV, August 2020j)
- Final Demolition Work Plan (with Vibration Monitoring Plan) (OFJV, August 2020k)
- Final Field Sampling Plan (OFJV, August 2020l)
- Final Radiation Protection Program (OFJV, August 2020m)
- Final Radiation Control Manual (OFJV, August 2020n)

- Final As Low As Reasonably Achievable (ALARA) Program (OFJV, August 2020o)
- Final Safety Crosswalk (OFJV, August 2020p)

The scope of work for the HFBR Stack D&D Project included the following:

- Removal of exterior coating/paint from the exterior Stack surface.
- Removal of the HFBR Stack down to grade level, including structures located internal and external to the Stack (i.e., ducts, ladders, platforms, electrical cable and conduit, and lights).
- Removal of the Stack Pedestal down to a point that any of the remaining structure is shown to be within cleanup criteria; a portion of the Pedestal is allowed to remain as long as it is at or below grade and meets cleanup criteria.
- Removal of the Silencer and Below Grade Duct structure and fill material that was placed in the Silencer and Below Grade Duct during the baffle removal project in August 2011.
- Removal of the Silencer Drain Sump.
- Removal of the HFBR Stack Stormwater Collection Tank. (Brookhaven Science Associates [BSA] collected and disposed of the rainwater collected from the Stack drains until OFJV mobilized and took control of the site in August 2020. After site mobilization, OFJV became responsible for collection and disposal of collected water.)
- Removal of the HFBR Stack drain lines to the HFBR Stack Stormwater Collection Tank.
- Removal of junction boxes and electrical cable & conduit located at ground level and leading to the Stack and the Stack Stormwater Collection Tank.
- Removal of all soil that exceeded contamination criteria and backfilling with clean soil.
- Containerization and transportation of all demolition waste to an off-site disposal site.

1.2 Site Description and Operational History

BNL is owned by the U.S. Department of Energy, Office of Science (DOE-SC), one of the 17 DOE national laboratories. BNL advances fundamental research in nuclear and particle physics to gain a deeper understanding of matter, energy, space, and time; applies photon sciences and nano-materials research to solve energy challenges of critical importance to the Nation; provides capabilities in computational science and data management for large-scale research and experimental endeavors; and performs cross-disciplinary research on computation, sustainable energy, national security, and the Earth's climate and ecosystems. BNL is located in Suffolk County on Long Island, about 65 miles east of midtown Manhattan (**Figure 1-1**).

Approximately 1.4 million people reside in Suffolk County and approximately 450,000 reside in Brookhaven Township, within which BNL is situated. BNL has operated since 1947 as a research facility for national science and technology programs and is expected to continue this mission for the foreseeable future.

The BNL site covers almost 5,320 acres, much of which is wooded. It is an irregular polygon, and each side is approximately 2.5 miles long. The developed portion of the BNL Site includes the principal facilities, which are located near the center of the BNL Site on relatively high ground.

The developed portion is approximately 1,820 acres, 500 acres of which were originally developed for Army use. Large, specialized research facilities occupy 200 acres and another 400 acres are occupied by roads, parking lots and connecting areas. Five-hundred and twenty (520) acres are occupied by outlying facilities including the Sewage Treatment Plant, ecology field, housing facilities and fire breaks and the remaining 200 acres are occupied by the Long Island Solar Farm. On November 9, 2000, ten percent of the site (530 acres) was permanently set aside for the purposes of conservation and ecological research and identified as the Upton Ecological and Research Reserve.

The HFBR was erected at BNL in the early 1960s. The HFBR operated from 1965 to 1996 and was used solely for scientific research, providing neutrons for chemistry, materials science, biology, and physics experiments. The "HFBR Stack" was originally constructed in the late 1940s with the Brookhaven Graphite Research Reactor (BGRR). The BGRR was an air cooled, graphite moderated reactor. The 320-foot Stack was initially constructed to provide an elevated exhaust of the BGRR primary and secondary cooling air. Subsequently, additional building exhausts were connected to the Stack. They included multiple exhausts streams from Buildings 801, 815, 830, 901 and the HFBR confinement building (Building 750). All of the exhaust connections from other buildings were removed during the decommissioning activities that concluded in 2011. The BGRR was defueled in 1969 and subsequently decommissioned.

The terrain is gently rolling, with elevations varying between 40 to 120 feet above mean sea level. The land lies on the western rim of the shallow Peconic River watershed, with a tributary of the Peconic River rising in marshy areas in the northern section of the tract. The sole-source aquifer beneath BNL comprises three water-bearing units: the upper glacial deposits, the Magothy Formation, and the Lloyd Sand Member of the Raritan Formation. These units are hydraulically connected and make up a single zone of saturation with varying physical properties extending from a depth of 5 to 1,500 feet below the land surface. These three water-bearing units are designated as a "sole source aquifer" by the U.S. Environmental Protection Agency (EPA) and serve as the primary source of drinking water for Nassau and Suffolk counties. The Stack is part of the HFBR complex, which is centrally located within the BNL Site at the corner of Cornell Avenue and Renaissance Street. A detailed description of the Stack is provided in Section 1.2.1 below and additional information is provided in the drawings and reference documents.

1.2.1 Building 705 Stack Description

Building 705 was a reinforced concrete Stack located within the HFBR Complex (see **Figures 1-2 and 1-3**). The overall height of the Stack was 320 feet above grade with an interior base diameter of 26 feet 7 inches and an interior top diameter of 18 feet 5 inches. The Stack had a tapered cone shape and the wall thickness varied from 14 inches at the base to 7 inches at the top. **Figure 1-4** shows the Stack details. The main components of the Building 705 Stack are identified below.

1.2.1.1 Stack Cone

The cone portion of the Stack was 298 feet 6 inches in length and rested atop a reinforced concrete base.

1.2.1.2 Exterior Stack Features

The Stack had three separate outside steel platforms at varying heights that were used for inspection and maintenance purposes. The platforms were accessed via an enclosed steel ladder that ran from the top of the pedestal to the upper platform.

The Stack had an exterior coating comprised of alternating bands of red and white paint – this paint was known to contain lead and asbestos (nonfriable); and an exterior flashing beacon assembly for air navigation protection. The Stack also has a lightning protection system consisting of eight evenly spaced 4-foot tall copper air terminals that projected above the top of the Stack and an associated grounding system.

1.2.1.3 Stack Base

The base was octagonal in shape, 21 feet 6 inches tall, and had an interior diameter of 26 feet and an exterior width of 30 feet 6 inches. The base supported the Stack cone and also framed in the exhaust entry from a silencer on the west side of the Stack (see description of silencer below).

1.2.1.4 Stack Acoustical Reflector

The 6-inch-thick acoustical reflector, located at the bottom of the Stack within the base, was constructed of reinforced concrete. The reflector was in alignment with the silencer inlet and was angled at 45 degrees. The acoustical reflector was supported with sand fill material.

1.2.1.5 Interior Ducts

A 42-inch diameter, 3/8-inch thick steel duct entered the Stack base from the north side roughly 2.5 feet above the top of the pedestal. After entering the Stack, the 42-inch duct made a 90-degree vertical bend and ran straight up along the centerline of the Stack. The 42-inch duct terminated roughly even with the top of the Stack base.

A 14-inch diameter, 10-gauge, 347 stainless steel acid flume duct penetrated the Stack base from the north side roughly 6 feet above the pedestal. Inside the Stack, the 14-inch duct made four bends, traveled up the interior wall of the Stack, and terminated at the top of the Stack cone. The top of the duct was capped in 1999.

1.2.1.6 Pedestal

The Stack sat on a large reinforced concrete foundation (i.e., pedestal), most of which is located below grade but the top of which is at grade (elevation 124′-0″). The pedestal is a series of four octagonal slabs of reinforced concrete that supported the Stack. Each concrete slab is two-feet thick, and each slab is four feet smaller than the slab beneath resulting in a “layer-cake” appearance. The bottom slab has a width of 54 feet, the second slab has a width of 50 feet, the third slab has a width of 46 feet, and the top of the pedestal has a width of 42 feet. The exposed surface of the pedestal at ground level is 1,670 square feet (155 square meters). The west side of the pedestal includes a ramp starting 3.75 inches below the surface of the pedestal extending across the top slab and part of the second slab to support the silencer duct where it connects with the bottom of the Stack.

1.2.1.7 Stack Stormwater Collection System

A series of three drains existed beneath the Stack to collect precipitation that entered the Stack (**Figure 1-5**). These drains transected the pedestal and were composed of 3-inch stainless steel pipe. All three drain lines started at or slightly above the pedestal surface on the south and east sides of the Stack, descend through the top two concrete slabs, and exited the northwest side of the pedestal approximately 3 feet 10 inches below ground surface (bgs) and connected with the stormwater collection system. The first drain line was a trough drain spanning the area where the silencer duct connected to the base of the Stack along the west side of the pedestal. The second drain line started outside the Stack on the southeast side, connected with a 3-foot diameter by 2-foot deep drain in the center of the pedestal inside the Stack, and continued to the northwest side of the pedestal. The third drain line started on the east side of the pedestal outside the Stack and continued beneath the Stack to the northwest side of the pedestal and was installed to drain water collecting between the Stack wall and a proposed brick liner that was never actually installed.

The drains exited the north side of the Stack below grade and were tied together to a 4-in common line that discharged into a 550-gallon underground storage tank located northeast of Building 705 installed in April 2010. The tank was covered by a 6-foot by 10-foot reinforced concrete pad.

1.2.1.8 Silencer

The silencer was an acoustic filter that was installed at the eastern end of the Below Ground Duct connecting the former Fan House (Building 704) and the west side of the Stack (Building 705). The remining section of the silencer at the beginning of the HFBR Stack D&D Project was a small subsurface structure connected to the west side of the pedestal (**Figure 1-4**). During previous remediation activities associated with the HFBR the baffles and above grade portions of the silencer were removed and the subsurface areas filled with clean fill. The silencer was 12 feet wide, 51 feet long, and 16.5 feet tall, and portions of the structure extended to the bottom of the previously removed Below Ground Duct approximately 18 feet bgs. There was a small sump located outside the northwest corner of the silencer connected to a drain from the silencer that was removed as part of the silencer excavation.

1.2.2 Remaining HFBR Outside Areas

The HFBR Outside Areas include all grounds around the HFBR, Building 750, as defined by the HFBR Complex Boundary (**Figure 1-3**). Final status surveys have been completed for former buildings and soils in the areas surrounding Building 705 and are summarized in the following closeout reports:

- BNL, 2011a, Final Closeout Report, High Flux Beam Reactor Underground Utilities

Removal Area of Concern 31, prepared by Brookhaven Science Associates for the U.S. Department of Energy, August 2011.

- BNL, 2011b, Final Closeout Report, High Flux Beam Reactor Fan Houses (Building 704 and Building 802) Decontamination and Dismantlement (D&D), prepared by Brookhaven Science Associates for the U.S. Department of Energy, November 2011.
- BNL, 2012, Final Closeout Report, High Flux Beam Reactor Removal of the Stack Silencer Baffles and Final Status Survey for Remaining HFBR Outside Areas, Area of Concern 31, prepared by Brookhaven Science Associates for the U.S. Department of Energy, May 2012.

The remaining HFBR Outside Area to receive a FSS for the HBBR Stack D&D project includes surface soil that was potentially radiologically impacted by project activities, such as demolition and excavation of contaminated materials.

1.3 Regulatory and Enforcement History

In 1980, the BNL Site was placed on New York State's Department of Environmental Conservation (NYSDEC) list of Inactive Hazardous Waste Sites. On December 21, 1989, the BNL Site was included on the United States Environmental Protection Agency (EPA) National Priorities List because of soil and groundwater contamination that resulted from BNL's past operations. Subsequently, EPA, NYSDEC, and the U.S. Department of Energy (DOE) entered into a Federal Facilities Agreement (herein referred to as the Interagency Agreement; [IAG]) that became effective in May 1992 (Administrative Docket Number: II-CERCLA-FFA-00201) to coordinate the cleanup.

The IAG identified AOCs that were grouped into Operable Units (OUs) to be evaluated for response actions. The IAG required a Remedial Investigation (RI)/Feasibility Study (FS) for OU I, pursuant to 42 United States Code (USC) 9601 et seq., to meet Comprehensive Environmental Response, Compensation and Liability Act (CERCLA) requirements. OU I consists of areas of soil contamination at the BNL site where waste was historically managed or disposed.

Upon completion and review of the results of the RI/FS for OU I, the *Record of Decision – Operable Unit I and Radiologically Contaminated Soils (Including Areas of Concern 6, 8, 10, 16, 17, and 18)* (OU I ROD), was signed in August 1999. The OU I ROD specified the excavation and off-site disposal of radiologically and chemically contaminated soils. In April 2009, the HFBR ROD (AOC 31) was finalized. The HFBR ROD specified the removal of ancillary buildings and underground utilities, Fan Houses, and Stack as well as the removal of contaminated soil within the HFBR complex utilizing the dose-based cleanup goal and methodology specified in the OU I ROD.

1.4 Previous Characterization and Cleanup Criteria for Stack Structures and Soils

DOE and BNL have completed numerous studies and executed several projects as part the Proposed Remedial Action Plan (PRAP) completed in 2008 and the subsequent ROD in 2009

(BSA, 2008 and 2009). The 2009 ROD encompassed all components of the HFBR complex. The HFBR Stack (Building 705) was the last outstanding action item in order to meet the fulfillment of near-term activities of the selected remedy. Studies/Actions conducted to-date include but are not limited to the following:

- P.W. Grosser 2005a, High Flux Beam Reactor & Balance of Plant Supplemental Characterization Summary, prepared by PW Grosser Consulting, June 2005.
- P.W. Grosser, 2005b, High Flux Beam Reactor and Balance of Plant Structures Preliminary Assessment/Site Inspection Report (PA/SI), prepared by PW Grosser Consulting, January 2005.
- P.W. Grosser, 2005c, Brookhaven National Laboratory Building 705 Stack Resolution of End-State, prepared by PW Grosser Consulting, February 2005.
- Final Record of Decision for Area of Concern 31- High Flux Beam Reactor, April 2009
- Final Remedial Design/Remedial Action Work Plan for the Decontamination and Dismantlement (D&D) of Building 705 (the Stack) and Associated Structures and Utilities, August 2010
- Final Closeout Report High Flux Beam Reactor Underground Utilities Removal Area of Concern 31, August 2011
- Final Closeout Report, High Flux Beam Reactor Fan Houses (Building 704 and Building 802), Decontamination and Dismantlement (D&D), Area of Concern 31, November 2011
- Final Closeout Report, High Flux Beam Reactor Removal of the Stack Silencer Baffles and Final Status Survey for Remaining HFBR Outside Areas, Area of Concern 31, May 2012
- U.S. Army Corps of Engineers Brookhaven National Laboratory High Flux Beam Reactor Complex Building 705- Stack Demolition Analysis of Alternatives, December 2017
- Surveillance and Maintenance Manual for the HFBR Grounds & Stack, Brookhaven National Laboratory, NY, September 2018
- Report of Background and Drop Test Vibration Study Results, Demolition of Brookhaven National Laboratory HFBR Stack (Building 705), August 2019
- Updated Remedial Design/Remedial Action Work Plan for the Decontamination and Dismantlement (D&D) of Building 705 (the Stack) and Associated Structures and Utilities, October 2019

The contaminants of concern identified in the ROD and any additional contaminants of concern are discussed in the following sections.

1.4.1 Radionuclides of Concern and Cleanup Criteria

The primary radiological contaminants of concern for the soil within the remaining HFBR Outside Areas were specified in the HFBR ROD (BSA, 2009) and are the same as those for OU I radiologically contaminated soils specified in the OU I ROD: cesium (Cs)-137, radium (Ra)-226, and strontium (Sr)-90. The cleanup goals for specific radionuclides were calculated using the Residual Radioactivity Computer Code (RESRAD), Version 6.5 (Argonne National Laboratory, 2001), considering a residential scenario. The dose limit used was 15 millirem per year (mrem/yr) above background (Office of Solid Waste and Emergency Response Directive 9200.4-1, EPA, 1997), residential land use after 50 years of institutional control by the DOE, and industrial land use with no decay time (Year 0). In addition, the New York State Department of Environmental Conservation (NYSDEC) cleanup guideline of 10 mrem/yr, from DER-38 (NYSDEC, 2013), was adopted as an As Low as Reasonably Achievable (ALARA) goal. The primary radiological isotope present at the site was Cs-137; its cleanup goal, as established in the OU I ROD and specified in the HFBR ROD, is 23 picocuries per gram (pCi/g). The OU I ROD also lists soil cleanup levels for Strontium-90 (Sr-90) (15 pCi/g) and Radium-226 (Ra-226) (5 pCi/g).

Additional radionuclides that were not addressed in the OU I ROD were also considered. In April 2001 a single sample described as “dirt from the stack” was collected and analyzed by gamma spectroscopy. The material inside the Stack identified Cs-137 and Ra-226, as well as cobalt-60 (Co-60) and americium-241 (Am-241) which were added to the list of radioactive contaminants of concern. Water samples collected from the Stack stormwater collection system have reported tritium (H-3) levels in excess of ambient water quality standards, so tritium was added to the list of radioactive contaminants of concern. Radiological characterization of the ducts associated with Building 704 and Building 802 indicated that they were contaminated above the surface contamination values specified in the BNL Radiological Controls Manual, with an isotopic content of Co-60, nickel-63 (Ni-63), and cesium Cs-137, so Ni-63 was included as a radioactive contaminant of concern. The Building 705 Stack-Resolution of End-Sate Report (PWGC, 2005c) states fuel failures at the Brookhaven Graphite Research Reactor resulted in releases of uranium oxides that would have adhered to the interior surfaces of the Stack; therefore, uranium-235 (U-235) and uranium-238 (U-238) were included as radioactive contaminants of concern. Based on the known presence of Am-241 inside the Stack and the likely presence of uranium oxides from fuel failures, plutonium-238 (Pu-238), plutonium-239 (Pu-239), and plutonium-240 (Pu-240) were added to the list of radionuclides of concern. Europium-152 (Eu-152) and europium-154 (Eu-154) are fission products produced in nuclear reactors, similar to Cs-137 and Sr-90, and have been identified as radioactive contaminants of concern for previous HFBR FSSs and are included as radioactive contaminants of concern. Europium-155 (Eu-155) and sodium-22 (Na-22) were identified during the historical data reviews and included as radionuclides of concern.

Additional radionuclides included in analyses from previous FSSs were not included as radioactive contaminants of concern for HFBR Stack D&D Project. Radionuclides with short half-lives that have decayed to insignificant concentrations include beryllium-7 (Be-7), cesium-134 (Ce-134), cobalt-57 (Co-57), manganese-54 (Mg-54), and zinc-65 (Zn-65).

C-14 was identified intermittently during a review of available laboratory sample results for structural demolition wastes from the upstream silencer remediation and was detected in characterization samples collected prior to the start of Stack demolition.

Table 1-1 lists the additional radionuclides of concern and their cleanup values. The soil cleanup levels were developed using the RESRAD computer program and are based on residential use at 50 years in the future, with columns presenting values representative of the 15 millirem per year dose cleanup criterion and the 10 millirem per year ALARA dose cleanup goal. The development of the soil cleanup levels is described in the FSP (OFJV, August 2020l).

1.4.2 Chemicals of Concern and Cleanup Criteria

The ROD (BSA, 2009) identified lead and mercury as contaminants of concern. Lead has a residential cleanup goal of 400 milligrams per kilogram (mg/kg) and was developed using the EPA Soil Screening Guidance (EPA, 1996). Mercury has a cleanup goal of 1.84 mg/kg developed using the Soil Screening Guidance and is protective of groundwater and residential use. The UFP-QAPP cites NYSDEC Part 375 soil cleanup objectives for mercury that are more stringent than the cleanup goal based the EPA guidance. The NYSDEC Part 375 Project Action Limit for mercury is 0.81 mg/kg for on-site soils based on Restricted Residential criteria, and 0.18 mg/kg for imported backfill based on Unrestricted criteria.

The Final Closeout Report, High Flux Beam Reactor, Removal of the Stack Silencer Baffles and Final Status Survey for Remaining HFBR Outside Areas (BSA, 2012) included copper, nickel, and zinc as chemicals of concern for the soils surrounding the Stack. None of the soil samples collected as part of the FSS for outside areas in the vicinity of the Stack reported copper, nickel, or zinc concentrations soil exceeding the established cleanup goals. Based on the results of the closeout report, these metals were not included as chemicals of concern in the FSS.

1.5 Previous Remedial Actions

Prior remediation activities (e.g., HFBR Stabilization Project, Underground Utilities Removal Project, Fan Houses Demolition Project, and Silencer Baffle Removal Project) associated with the HFBR Complex were completed before this HFBR Stack D&D Project and are documented in separate closeout reports.

Table 1-1 – Radionuclides of Concern

ROC	Half-Life	Decay Mode and Principal Emissions	Residential Cleanup Value (pCi/g)	ALARA Cleanup Goal (pCi/g)	Comments
Tritium	12.3 yr	0.018 MeV β	See Comment	See Comment	If tritium (H-3) is detected in soil samples above the critical level a RESRAD evaluation will be conducted using the H-3 soil concentration. This analysis will include an evaluation of groundwater pathways to ensure that the projected groundwater pathway annual dose to the receptor is less than 4 mrem.
Carbon-14	5700 yr	0.156 MeV β	See Comment	See Comment	C-14 identified in available sample results from upstream systems and detected in stack concrete during pre-demo characterization sampling, If C-14 is detected in soil samples above the critical level a RESRAD evaluation will be conducted using the C-14 soil concentration.
Cobalt-60	5.27 yr	0.32 MeV β; 1.17, 1.33 MeV γ	1,260	840	RESRAD Model based on 15 millirem (mrem)/yr residential
Europium-152	13.54 yr	0.7-1.47 MeV β; 0.12-1.41 MeV γ a	51	34	RESRAD Model based on 15 mrem/yr residential
Europium-154	8.8 yr	0.29 MeV β 1.2 MeV γ	180	120	RESRAD Model based on 15 mrem/yr residential
Nickel-63	101.1 yr	0.06 MeV β	See Comment	See Comment	If Ni-63 is detected in soil samples above the critical level a RESRAD evaluation will be conducted using the Ni-63 soil concentration.
Strontium-90	28.78 yr	0.55, 2.28 MeV β	15	10	OU I ROD (BSA, 2009)
Cesium-137	30.07 yr	0.51 MeV β; 0.66 MeV γ	23	15	OU I ROD (BSA, 2009)
Radium-226	1600 yr	4.60, 4.78 MeV α 0.186 MeV γ	5	3.3	OU I ROD (BSA, 2009)
Uranium-234	2.455E05 yr	4.72, 4.77 MeV α	See Comment	See Comment	If the average concentration from systematic samples exceeds the U-234 Reference Area mean (at the upper 95% confidence level) a RESRAD evaluation will be conducted using the U-234 soil concentration.
Uranium-235	7.04E08 yr	4.39, 4.36 MeV α; 0.18, 0.14 MeV γ	4.6	270	RESRAD Model based on 4 mrem/yr groundwater consumption
Uranium-238	4.47E09 yr	4.19, 4.14 MeV α; 0.049 MeV γ	4.7	270	RESRAD Model based on 4 mrem/yr groundwater consumption
Plutonium-238	87.7 yr	5.46, 5.50 MeV α	57	38	RESRAD Model based on 15 mrem/yr residential
Plutonium-239	2.41E04 yr	5.14, 5.16 MeV α 0.129 MeV γ	35	23	RESRAD Model based on 15 mrem/yr residential

Plutonium-240	6.54E03 yr	5.12, 5.17 MeV γ	35	23	RESRAD Model based on 15 mrem/yr residential
Americium-241	4.32E+02 yr	5.44, 5.48 MeV α 0.059 MeV γ	34	22	RESRAD Model based on 15 mrem/yr residential
Sodium-22	2.6 yr	Electron capture; 1.27 MeV γ	See Comment	See Comment	If Na-22 is detected in soil samples above the critical level a RESRAD evaluation will be conducted using the Na-22 soil concentration.
Europium-155	4.76 yr	0.252 MeV β; 0.087, 0.105 MeV γ	See Comment	See Comment	If Eu-155 is detected in soil samples above the critical level a RESRAD evaluation will be conducted using the Eu-155 soil concentration.

2.0 OPERABLE UNIT I (OU-I) BACKGROUND

2.1 BNL Operable Units

As part of the initial remedial efforts at BNL, thirty AOCs were identified and grouped into seven OUs. The seven OUs were subsequently reduced to six OUs as a result of combining OU II and OU VII. In February 2009, AOC 31, comprising the HFBR, was established. Since then, three new AOCs were identified, AOC 32 (Building 452 Freon-11 Plume) and AOCs 33 and 34 for PFOS/PFOA and 1,4-dioxane as well as a new OU VIII.

This report documents completion of the included scope for Stack D&D (**Section 1.1**) associated with the HFBR Stack, which is designated as AOC 31. As described in **Section 1.4**, the cleanup goals established in the OU I ROD were used for the HFBR Stack D&D FSS.

2.2 Design Criteria

Technical procedures and design criteria for the HFBR Stack D&D Project were established in the HFBR ROD and in the project-specific Work Plans (**Section 1.1**). The ROD design included:

- A plan and process for ensuring the total exposure from all radioisotopes does not exceed 15 mrem/yr above background following the 50-year period for institutional control for the site;
- Methods to reduce waste volumes that require offsite disposal; and
- An approach for sampling to confirm that cleanup goals have been achieved for the HFBR Stack D&D Project.

2.3 Community Relation Activities

2.3.1 BNL Community Relations

The BNL Community Involvement Plan was published April 15, 1999. It is supplemented by project-specific plans. In the case of the HFBR, a Communications Plan for the Regulatory Decision-Making Process for Decommissioning the High Flux Beam Reactor was developed. In accordance with these two plans and CERCLA Sections 113 (k)(2)(B)(i-v) and 117, the Community Relations Program focuses on informing and involving the public in the decision-making process to ensure that the views of the internal and external stakeholder communities are considered. A variety of activities are used to provide information and to seek public participation, including distribution of materials to a stakeholders' mailing list; holding community meetings, information sessions, tours, and workshops; and preparing and distributing fact sheets. The Administrative Record, which documents the basis for removal and remedial actions, was established and is maintained at the libraries listed below:

Brookhaven National Laboratory
Research Library, Bldg. 477A
Upton, NY 11973
631-344-3483 or 631-344-3489

Stony Brook University
Melville Library
Special Collections and University Archives
Room E-2320
Stony Brook, NY 11794
631-632-7119

U.S. EPA - Region II
Records Room
290 Broadway, 18th Floor
New York, New York 10007
212-637-4308

2.3.2 Community Involvement

The community involvement activities conducted for the remedy selection process for the HFBR included a formal public review of the HFBR Proposed Remedial Action Plan (PRAP). The public comment period began January 10, 2008, and ended March 17, 2008. Two information sessions and a public meeting were held during the public comment period. Public comments received indicated that there was considerable community support for DOE's preferred remedial alternative identified in the PRAP (Alternative C, Phased Decontamination and Dismantlement with Near-Term Control Rod Blades Removal). DOE's responses to public comments and concerns are included in the HFBR ROD Responsiveness Summary.

The planning and execution of the Project was discussed at several Brookhaven Executive Roundtable (BER) meetings that were conducted on:

- October 19, 2019
- December 16, 2020
- June 23, 2021
- October 27, 2021.

The implementation of the HFBR Complex Projects was also discussed with the BNL Community Advisory Council (CAC) on the following dates:

- April 15, 2009
- November 12, 2009
- November 4, 2010

- September 10, 2019

In addition, the HFBR Stack D&D Project was discussed with the BNL CAC by virtual teleconferences on

- May 14, 2020
- September 10, 2020
- October 8, 2020
- November 12, 2020
- March 11, 2021
- April 8, 2021
- September 19, 2021
- November 10, 2021

Minutes from these meetings are available on the BNL Community Relations website, located at: http://www.bnl.gov/community/cac/meetings.asp.

3.0 DEMOLITION AND DECOMMISSIONING ACTIVITIES

3.1 Chronology of Events

Table 3-1 lists a chronology of the main remedial events associated with the HFBR Stack D&D Project:

Table 3-1. Chronology of Events

Date	Remedial Event
April 2009	HFBR ROD Finalized
February 2019	Interagency Agreement between DOE and USACE signed
October 2019	Updated Remedial Design/Remedial Action Work Plan for the Decontamination and Dismantlement (D&D) of Building 705 (the Stack) and Associated Structures and Utilities
May 2020	Final Project Management Plan
May 2020	Final Structures and Soil Characterization Work Plan
June 2020	Final Excavation Plan
July 2020	Final Contingency Plan
July 2020	Final Waste Management Plan (Rev 0)
July 2020	Final COVID-19 Management Plan
August 2020	Final UFP-QAPP
August 2020	Final Accident Prevention Plan/Site Safety and Health Plan
August 2020	Final Community Air Monitoring Plan
August 2020	Final Demolition Work Plan (with Vibration Monitoring Plan)
August 2020	Final Field Sampling Plan
August 2020	Final Radiation Protection Program
August 2020	Final Radiation Control Manual
August 2020	Final As Low As Reasonably Achievable (ALARA) Program
August 2020	Final Safety Crosswalk
October 2020	Final Waste Management Plan (Rev 1)
August 2020	Mobilized and set up for exterior coating abatement and structure removal

August 2020 - November 2020	Stack exterior coating abatement and structure removal
November 2020	Mobilized and set up for demolition
November 2020 – February 2021	Stack demolition to grade
February 2021	Mobilized to site to begin soil excavation and subgrade structure removal
February 2021 – August 2021	Soil excavation and subgrade structure removal
August 2021 - September 2021	Final Status Survey
August 2021 - September 2021	Oak Ridge Institute for Science and Education (ORISE) Verification
September 2021	Backfill and site restoration
October 2021	Demobilization
December 2021 – January 2022	Abatement wastewater disposal

3.2 Pre-mobilization Characterization Sampling

Historical sampling summarized in prior reports identified the radiological and non-radiological contaminants present, but the historical data was insufficient to fully determine the controls needed to perform the Stack D&D work or prepare a complete waste profile for disposal of building materials, such as the Stack concrete, the acoustical reflector, 42-inch duct, 14-inch duct, steel frame system, steel liners, steel cap and the silencer. Additional sampling was conducted for the Stack D&D Project to develop controls for the work and to support waste characterization activities for proper disposal. The characterization results also provided information essential to completing final work plans for approval, including the UFP-QAPP, FSP, Waste Management Plan (WMP), Radiation Protection Plan (RPP), and health and safety documents.

Characterization results for non-radiological COCs are summarized on **Table 3-2**. Radiological analysis results for Stack concrete samples are presented in **Table 3-3**. Laboratory analytical reports are presented in **Appendix A-1**.

3.2.1 Exterior Coating Samples

The pre-mobilization exterior coating samples included the ground level samples of the ladder and silencer walls. One sample was collected from the exterior of each of two silencer walls (midway along the south and north walls and approximately 3-4 feet above the ground), and two ladder samples were collected from the ladder rungs (one at 0-4 feet and one at 6-10 feet above the ground) on June 15, 2020. Each sample was collected by scraping and collecting the coating materials from the exterior of the silencer walls and ladder rungs within the interval identified and the samples were analyzed for lead and asbestos content. In addition, polychlorinated biphenyls (PCB) content and Toxicity Characteristics Leaching Procedure analysis for lead were also performed on one of the two samples collected from each component.

Asbestos and lead were detected in both silencer wall samples, which indicated the silencer coating material would need to be removed from the exterior of the silencer walls prior to commencing demolition using the same abatement methods to be used for the Stack exterior. Because asbestos and lead were detected in one of the two ladder structure samples, the lower ladder rungs would require spot abatement on the cut lines prior to demolition, because the abatement equipment being used on the Stack and silencer would not adequately remove the ladder coating materials on these smaller surfaces.

3.2.2 Surface Soil Samples

Surface soil samples (0 – 6 inches) from eight locations within 10 feet of the Stack base were analyzed for lead and asbestos. Results for lead were compared to the 6NYCRR Part 375 Residential Use Soil Cleanup Objective (SCO) of 400 mg/kg as outlined in the Structures and Soil Characterization Plan (SSCP) and no exceedances were detected. All the surface soil samples tested negative for asbestos.

Table 3-2 – Pre-Mobilization Characterization Sampling Results

	JUNE 2020 EXTERIOR COATING SAMPLES					AUGUST 2020 EXTERIOR COATING SAMPLES					
Sample location	PC-001-061520 Silencer Wall (South)	PC-002-061520 Silencer Wall (North)	PC-003-061520 Ladder Structure (Top 4'-10')	PC-004-061520 Ladder Structure (Bottom 1-4')	PC-201-061520	PC-005-081020 Platform-Support bracket at ladder (101')	PC-006-081020 Platform - Conduit (101')	PC-007-081020 Platform - Ladder (101')	PC-008-081020 Platform - handrail 180° from ladder (101')	PC-009-081020 Platform-Support bracket at ladder (309')	Guidance Level
Lead (Pb) in mg/kg	400 D B J1 Q	290 D B Q	3,200 B D	14,000 B D	210 D B Q	31,000 Q B D	30,000 Q B D	33,000 Q B D	100,000 Q B D	84,000 Q B D	
Asbestos (%)	**1.3 CH**	0.9 CH	<0.02 CH	**1.7 CH**	**3.6 CH**	0.08 TR	0.14 AN 0.42 CH	**1.2 AN 1.2 CH**	0.50 AN 0.50 CH	0.34 AN 0.34 CH (A) **11 CH** (B)	>1[1]
TCLP Lead in mg/l	0.55 D J1	NA	0.52 D	NA	0.53 D	NA	**5.2**	NA	NA	NA	5 [2]
PCBs in ug/kg											
PCBs, Total	28 U	NA	9.2 U	NA	9.2 U	NA	260 J	NA	NA	NA	50,000 [3]
Aroclor 1016	27 U M J1	NA	8.9 U M	NA	8.9 U M	NA	44 U M	NA	NA	NA	
Aroclor 1221	27 U M	NA	8.9 U M	NA	8.9 U M	NA	44 U M	NA	NA	NA	
Aroclor 1232	27 U M	NA	8.9 U M	NA	8.9 U M	NA	44 U M	NA	NA	NA	
Aroclor 1242	27 U M	NA	8.9 U M	NA	8.9 U M	NA	44 U M	NA	NA	NA	
Aroclor 1248	27 U M	NA	8.9 U M	NA	8.9 U M	NA	44 U M	NA	NA	NA	
Aroclor 1254	28 U M	NA	9.2 U M	NA	9.2 U M	NA	260 J D	NA	NA	NA	
Aroclor 1260	28 U M J1	NA	9.2 U M	NA	9.2 U M	NA	46 U M	NA	NA	NA	
Aroclor 1262	28 U M	NA	9.2 U M	NA	9.2 U M	NA	46 U M	NA	NA	NA	
Aroclor 1268	28 U M	NA	9.2 U M	NA	9.2 U M	NA	46 U M	NA	NA	NA	

	AUGUST 2020 EXTERIOR COATING SAMPLES									
Sample location	PC-010-081020 Platform - Ladder (309')	PC-011-081020 Platform - Conduit (309')	PC-012-081020 Platform - handrail 180° from ladder (309')	PC-013-081020 Platform - Handrail (209')	PC-014-081020 Platform - Ladder (209')	PC-015-081020 Platform - Conduit (209')	PC-016-081020 Cap at ladder	PC-017-081020 Platform-Support bracket at ladder (209')	PC-211-081020 Platform - Conduit (309')	Guidance Level
Lead (Pb) in mg/kg	37,000 Q B D	110,000 Q B D	83,000 Q B D	120,000 Q B D	24,000 Q B D	35,000 Q J1 B D	190 Q B D	41,000 Q B D	110,000 Q B D	
Asbestos (%)	0.32 AN 0.96 CH	0.1 AN 0.3 CH	0.39 AN 0.13 CH	0.16 AN 0.48 CH	**1.2 AN 3.6 CH**	0.24 AN 0.24 CH	**6.5 AN 19 CH** (A) **14 CH** (B)	0.49 AN **1.5 CH** (A) ND (B)	0.08 AN 0.08 CH	>1[1]
TCLP Lead in mg/l	NA	**8.9**	NA	NA	NA	**6.5 J1**	0.48 J	3.3	**5.4**	5 [2]
PCBs in ug/kg										
PCBs, Total	NA	300 J	NA	NA	NA	940	1,800	7,200	890	50,000 [3]
Aroclor 1016	NA	84 U M	NA	NA	NA	20 U M	44 U M	44 U M	95 U M	
Aroclor 1221	NA	84 UM	NA	NA	NA	20 U M	44 U M	44 U M	95 U M	
Aroclor 1232	NA	84 U M	NA	NA	NA	20 U M	44 U M	44 U M	95 U M	
Aroclor 1242	NA	84 U M	NA	NA	NA	20 U M	44 U M	44 U M	95 U M	
Aroclor 1248	NA	84 U M	NA	NA	NA	20 U M	44 U M	44 U M	95 U M	
Aroclor 1254	NA	300 J D M	NA	NA	NA	940	1,800 D M	7,200 D	890 D M	
Aroclor 1260	NA	87 U M	NA	NA	NA	20 U M	46 U M	46 U M	99 U M	
Aroclor 1262	NA	87 U M	NA	NA	NA	20 U M	46 U M	46 U M	99 U M	
Aroclor 1268	NA	87 U M	NA	NA	NA	20 UM	46 UM	46 UM	99 U M	

	SURFACE SOIL SAMPLES									
Sample location	PSS-001-061520	PSS-002-061520	PSS-003-061520	PSS-004-061520	PSS-005-061520	PSS-006-061520	PSS-007-061520	PSS-008-061520	PSS-203-061520	Guidance Level
Lead (Pb) in mg/kg	11 D B	10 D B	19 D B	45 D B	42 D B	78 D B	330 D B	370 D B	18 D B	400 [4]
Asbestos	ND	ND	ND	ND	ND	ND	ND	ND	ND	

Notes:

1 = 29 CFR 1926.1101 - OSHA Safety and Health Regulations for Construction Asbestos

2 = 40 CFR 261.24 - Toxicity Characteristic Table 1 - Maximum Concentration of Contaminants for the Toxicity Characteristic

3 = 40 CFR 761.62 - Disposal of PCB bulk product waste

4 = 6 NYCRR Part 375 Residential Use Soil Clean-up Objective

CH = Chrysotile

AN = Anthophyllite

TR = Tremolite
< = asbestos was identified in the sample, but the concentration is less than the method quantitation limit NA = Not Analyzed
D = The reported value is from a dilution
B = Blank concentration: The analyte was detected above one-half the reporting limit in an associated blank
J1 = Estimated: The quantitation is an estimation due to discrepancies in meeting certain analyte-specific quality control criteria Q = One or more quality control criteria failed
U = Undetected at the Limit of Detection M = Manual integrated compound
ND = Not detected

3.2.3 Stack Concrete Samples

Available historical data were used to provide relative concentrations on detected radionuclides. Most data were associated with concrete and debris from samples collected inside the Stack and from samples collected during the removal of the silencer baffles. Samples of concrete and debris from the Stack and silencer were considered representative of the relative concentrations of radionuclides generated during demolition and removal of the Stack. These relative concentrations were used to develop scaling factors relative to Cs-137 to provide estimated concentrations for characterization samples where radionuclides of concern were not detected or not measured.

Thirty-six cores were collected from nine locations by BSA in support of the Stack D&D Project in July 2020 and were analyzed for radionuclides of concern. Four cores were collected from the exterior surfaces of the Stack, and five cores were collected from the interior surfaces of the Stack and pedestal. All cores were collected from the surface to a depth of one inch. **Table 3-3** summarizes the results of the concrete core analyses.

Table 3-3 – Stack Concrete Radionuclide Concentrations

Radionuclide	Minimum	Average			Maximum
	Concentration (pCi/g)	Concentration (pCi/g)	Uncertainty (pCi/g)	Percent (%)	Concentration (pCi/g)
H-3	4.50E+00	2.68E+01	1.31E+00	5%	8.71E+01
C-14	7.12E-02	6.32E+00	4.47E-01	7%	2.85E+01
Ni-63	6.92E-03	7.75E-01	5.25E-02	7%	2.77E+00
Sr-90	1.14E+00	1.01E+01	4.35E-01	4%	3.30E+01
U-234	7.12E-04	8.21E-02	1.02E-02	12%	2.85E-01
U-235	4.08E-05	4.70E-03	1.64E-03	35%	1.63E-02
U-238	7.12E-04	5.81E-02	9.00E-03	15%	2.85E-01
Pu-238	1.72E-04	1.68E-02	4.46E-03	27%	6.90E-02
Pu-239	1.35E-02	1.20E+00	7.96E-02	7%	5.41E+00
Pu-241	1.34E-04	2.28E-02	2.14E-02	94%	7.06E-02
Am-241	2.93E-03	3.18E-01	5.87E-02	18%	1.17E+00
Na-22	3.71E-11	1.22E-07	1.90E-07	155%	6.29E-07
Co-60	1.12E-05	4.28E-03	1.30E-03	30%	1.32E-02
Zn-65	1.96E-28	1.37E-19	2.19E-19	160%	7.20E-19
Cs-137	2.09E-01	2.83E+01	1.37E+00	5%	8.37E+01
Pm-147	4.07E-09	1.30E-05	2.02E-05	155%	6.69E-05
Eu-152	1.87E-04	3.24E-02	2.93E-03	9%	1.01E-01
Eu-154	5.05E-05	1.19E-02	1.46E-03	12%	4.38E-02
Eu-155	3.90E-06	2.09E-03	4.40E-04	21%	9.56E-03
Ra-226	2.45E-02	3.68E-02	2.73E-03	7%	4.83E-02
Th-232	4.12E-02	6.34E-02	1.35E-02	21%	7.97E-02

The results of the July 2020 analyses along with historical sample data were used to develop scaling factors relative to Cs-137 for each of the radionuclides of interest and radionuclides of concern. This process and the results were presented in the Waste Management Plan - Rev 1 (OFJV, 2020f). **Table 3-4** presents the results of the radiological waste evaluation of Stack core samples.

The calculated average and maximum concentrations for individual isotopes are compared against the disposal facility, Waste Control Specialists, LLC (WCS) RCRA Cell Authorized Limits (ALs). The table also lists the DOT exempt activity concentration limits from 49 CFR 173.436 that govern placarding, and DOT reportable quantities for radionuclides from 49 CFR 172.101 Appendix A Table 2 that would identify a shipment (a hypothetical intermodal container filled with 17 tons of waste) as Class 9 hazardous waste. Using the expected average waste concentrations, the fraction of the limit for each radionuclide is listed with all well below Unity (i.e., SOF<1).

Table 3-4 – Stack Demo Debris Radiological Waste Evaluation

	WCS RCRA Authorized Limits			Class 7 Limits		Class 9 Limits		
Radionuclide	Waste Acceptance Criteria (pCi/g)	Average Activity Fraction of Limit	Maximum Activity Fraction of Limit	DOT AC Limit (pCi/g)	Fraction of Class 7 Limit	Total Activity (Ci)*	RQ 172.101 Limit (Ci)	Fraction of Class 9 Limit
H-3	2.50E+06	1.07E-05	3.48E-05	1.00E+18	2.68E-17	4.14E-04	1.00E+02	4.14E-06
C-14	5.00E+04	1.26E-04	5.71E-04	2.70E+05	2.34E-05	9.75E-05	1.00E+01	9.75E-06
Ni-63	2.19E+05	3.54E-06	1.27E-05	2.70E+06	2.87E-07	1.20E-05	1.00E+02	1.20E-07
Sr-90**	2.50E+03	4.03E-03	1.32E-02	2.70E+03	3.73E-03	1.55E-04	1.00E-01	1.55E-03
U-234	2.08E+04	3.95E-06	1.37E-05	2.70E+02	3.04E-04	1.27E-06	1.00E-01	1.27E-05
U-235	2.15E+04	2.19E-07	7.60E-07	2.70E+02	1.74E-05	7.26E-08	1.00E-01	7.26E-07
U-238	2.30E+04	2.53E-06	1.24E-05	2.70E+02	2.15E-04	8.96E-07	5.20E-02	1.72E-05
Pu-238	1.00E+03	1.68E-05	6.90E-05	2.70E+01	6.21E-04	2.59E-07	1.00E-02	2.59E-05
Pu-239	1.00E+03	1.20E-03	5.41E-03	2.70E+01	4.45E-02	1.86E-05	1.00E-02	1.86E-03
Pu-241	3.50E+04	6.52E-07	2.02E-06	2.70E+03	8.45E-06	3.52E-07	1.00E+00	3.52E-07
Am-241	1.00E+03	3.18E-04	1.17E-03	2.70E+01	1.18E-02	4.91E-06	1.00E-02	4.91E-04
Na-22	2.05E+05	5.96E-13	3.07E-12	2.70E+02	4.52E-10	1.89E-12	1.00E+01	1.89E-13
Co-60	1.74E+05	2.46E-08	7.59E-08	2.70E+02	1.59E-05	6.61E-08	1.00E+01	6.61E-09
Zn-65	7.27E+05	1.88E-25	9.90E-25	2.70E+02	5.07E-22	2.11E-24	1.00E+01	2.11E-25
Cs-137	6.25E+04	4.53E-04	1.34E-03	2.70E+02	1.05E-01	4.37E-04	1.00E+00	4.37E-04
Pm-147	7.02E+07	1.85E-13	9.53E-13	2.70E+05	4.81E-11	2.01E-10	1.00E+01	2.01E-11
Eu-152	2.08E+05	1.56E-07	4.86E-07	2.70E+02	1.20E-04	5.01E-07	1.00E+01	5.01E-08
Eu-154	2.67E+05	4.44E-08	1.64E-07	2.70E+02	4.39E-05	1.83E-07	1.00E+01	1.83E-08
Eu-155	7.94E+06	2.63E-10	1.20E-09	2.70E+03	7.74E-07	3.23E-08	1.00E+01	3.23E-09
Ra-226	2.00E+03	1.84E-05	2.42E-05	2.70E+02	1.36E-04	5.68E-07	5.30E-02	1.07E-05

Th-232	4.58E+03	1.38E-05	1.74E-05	2.70E+02	2.35E-04	9.79E-07	1.10E-02	8.90E-05
	SOF	0.6%	2.2%		17%			0.45%

*Total activity for Class 9 limits based on 17 tons of waste
** Limiting isotope for comparison to Authorized Limits

3.3 Stack Exterior Structure Removal and Coating Abatement

3.3.1 Premobilization Meeting and Initial Site Training

BNL's Contractor Vendor Orientation (CVO) training was completed in two online sessions, on June 5 and July 17, 2020. This training provided an overview of BNL's environmental, safety, security, and health policies that all on site contractors were required to follow.

A Pre-Mobilization Preparatory Meeting was held on July 22, 2020, via teleconference with project stakeholders that discussed overall project requirements, roles and responsibilities, execution strategy, and schedule of critical milestones for the HFBR Stack D&D Project.

A Pre-Abatement Preparatory Meeting was held on August 8, 2020, via teleconference that focused more specifically on the exterior structures removal and abatement phase of the project. This teleconference discussed, in further detail, specific work requirements for structures removal and abatement, along with logistics, execution approach, training and safety, and the schedule of critical abatement phase milestones.

The following sections describe the execution of the exterior structure removal and coating abatement activities. Photographs of abatement activities are included as **Appendix C.**

3.3.2 Abatement Mobilization and Work Zone Setup

3.3.2.1 Radiological Controlled Areas

Radiological controlled areas were established to support radiological demolition and remediation activities.

Site monitoring and dosimetry data are summarized in **Section 4** and included as **Appendix D**.

3.3.2.2 Water and Electric Hookups

BSA provided water and electrical service to support site operations on the Stack D&D Project. The basic connection specifications included:

Water	Toilet/sanitation and decontamination facilities	Surface connection for potable water supply from BNL hydrant
OFJV Trailers	Eastern side of stack straddling and outside the exclusion zone	100-amp panel box, single phase, hard wired
USACE Trailer	Eastern side of stack outside the exclusion zone next to site access road	60-amp panel box, single phase, hard wired

Community Air Monitoring Plan (CAMP) Monitoring Stations	4 perimeter locations at CAMP boundary	Hookup for 110v outlets at each location
OFJV Power Panel	Hookup at transformer behind Bldg 801	480v 3-phase hardwired to the primary power panel for operation of exterior coating abatement equipment and tools
3 additional power drops	Inside exclusion zone	Hookup for 110v outlets at each location
4 additional power drops	On Eastern side of stack and positioned at OFJV trailer location crossing exclusion zone (1 inside 1 outside exclusion zone). Two additional drops, at the Gate area and near the northwestern exclusion zone boundary	Hookup for 110v outlets at each location

Electric and water hookups were completed by August 24, 2020, except for the CAMP monitoring stations (see **Section 3.3.2.3**)

3.3.2.3 Community Air Monitoring Plan (CAMP) Stations

The CAMP prescribed monitoring activities to detect any potential airborne releases of constituents of concern from the work site to surrounding areas during the implementation of Stack D&D activities (OFJV, 2020 j). The CAMP specified air emissions action levels, air monitoring procedures, monitoring schedule and data collection and reporting to be performed.

The CAMP fulfilled the requirements of the New York State Department of Health (NYSDOH) Generic Community Air Monitoring Plan (GCAMP) (May 2010), and also addressed requirements of relevant ARARS identified in the HFBR ROD (February 2009).

Four monitoring locations were established based on prevailing southwest wind direction (**Figure 3-1**). CAMP monitoring was performed at the CAMP monitoring boundary for particulate matter less than 10 microns in diameter (PM_{10}), of silica, lead and asbestos, as summarized in **Table 3-5**.

Table 3-5 – Summary of CAMP Monitoring

Parameter	Method	Conducted During
PM_{10}	Real-time Particulate Monitoring	Stack Coating Abatement Stack Demolition Soil Excavation / Backfill
Asbestos	NIOSH 7400	Stack Coating Abatement
Lead	NIOSH 7303	Stack Coating Abatement

Silica	NIOSH 7500	Stack Demolition

The CAMP action levels for the project are presented in **Table 3-6**.

Table 3-6 - CAMP Boundary Monitoring Action Levels

Contaminant	***Action Level***	***Control Action***
PM_{10}	> 100 ug/m^3 above background and no visible emissions	Continue dust suppression, continue monitoring Work can only continue if there are no visual emissions and PM10 < 150 µg/m3 above background.
	> 150 ug/m^3 above background	Stop operations, revaluate work, implement additional controls Resume work if controls successful in reducing PM_{10} < 150 ug/m^3 above background and no visual emissions.
Asbestos	> 0.1 f/cc	Stop operations, revaluate work, implement additional controls
Lead	>4.5 ug /m^3	Stop operations, revaluate work, implement additional controls
Silica	> 25 ug/m^3	Stop operations, revaluate work, implement additional controls

< - *Less Than*

> - *Greater than*

CAMP station set up began the week of July 27, 2020. The CAMP stations operated on battery power from the start of field work on August 27, 2020, until BNL completed electrical hookups on October 5, 2020.

CAMP data for the project are included as **Appendix E**. The CAMP data were submitted weekly by OFJV to USACE, DOE, BNL, NYSDEC, and NYSDOH during the project.

Throughout field work, the CAMP PM-10 air particulate monitoring readings stayed consistently below action levels for the project. This CAMP program provided real time monitoring and immediate evaluation of PM-10 measurement and trends associated with Stack D&D operations. All monitoring exceedances were investigated to determine if instrument cleaning, changes in site operations, and/or or additional dust suppression were needed. Overall, there were no exceedances that could be attributed to the D&D project. Temporary and upgradient particulate sources were identified during site work that temporarily exceeded monitoring limits. Two PM-10 monitoring exceedances were identified at the South CAMP monitoring station that was placed adjacent to a chimney discharge on the roof of Building 901. The temporary monitoring exceedances on 12-22-20 and 5-14-21 were both caused by a direct wind path observed from the chimney discharge point into the particulate monitoring port of the CAMP monitor. All other temporary monitoring exceedances were observed, analyzed, and attributed to instrument issues or ambient activities unrelated to Stack D&D operations. During CAMP monitoring operations, excessive moisture in the weatherproof instrument case caused anomalous monitoring exceedances not associated with observed site work. These impacted instruments were evaluated and then cleaned with the use of cleaning kits or filter exchange. Frozen or wet instrument cases and sample tubing was addressed with compressed air and heated dryers. Instrument replacement was immediate for units that failed calibration or showed continued instability.

It is noted that BNL conducted its own air monitoring program for both radiological and non-radiological parameters independent of the Stack D&D Project and unrelated to CAMP requirements. BNL monitoring occurred at various locations outside of the work exclusion zone and the CAMP boundary but generally within close proximity of the Stack D&D monitoring locations. BNL's objective was to collect daily air quality data outside the work exclusion zone but within the CAMP boundary, and also beyond the CAMP boundary. The independent BNL air monitoring program was undertaken by BNL as part of its community involvement interests to inform BNL workers and neighboring communities. The results of BNL monitoring program are included as **Appendix F**.

3.3.2.4 FAA Notification and Temporary Lighting

BSA notified the Federal Aviation Administration (FAA) on August 10, 2020, that aviation lighting on the Stack would be deactivated and temporary lighting would be installed prior to abatement. Temporary lighting was installed on August 25, 2020, and the existing Stack lights were deactivated on August 28, 2020.

3.3.3 Stack Exterior Structure Removal

External Stack structures were removed prior to abatement, including three (3) platforms, a ladder system, and other various appurtenances including conduit piping. Steel components were cut by removing the paint at each cut line with a needle gun then using cutting torches to perform each cut; the cut sections were then lowered into a dumpster. The dumpsters were covered and staged on site. During Stack demolition activities outlined below, the removed steel material was loaded into IMCs along with concrete debris from the Stack demolition process for disposal.

3.3.4 Stack Exterior Coating Abatement

The exterior coating of the Stack was removed and collected using a BlazerVac™ high pressure closed loop vacuum recovery system. The BlazerVac system's closed loop technology minimized exposure to hazardous materials while maximizing efficiency as coatings are removed and contained in one process, eliminating multiple handlings of the waste streams. The coating and water were piped through a 5-micron filtration system and contained on site, for later laboratory analysis characterization to determine proper disposal (see **Section 5**).

Coating abatement began on August 27, 2020, beginning at the east side of the Stack base (ground level). The abatement was carried out from bottom to top of Stack, first on the east side and then on the west side, in approximate 100-foot increments. When the top of each increment was reached, work platforms and rigging were repositioned, and abatement resumed upward.

The abatement for the eastern portion of the Stack to the 309-foot level was completed on October 1, 2020. Abatement of the western portion of the Stack began at the base on October 6, 2020 and was completed to the 309-foot level on October 29, 2020.

The work platform was reconfigured at the 309-foot level to girdle the full Stack circumference on October 8, 2020, and abatement of the final eleven feet (309 feet to 320 feet above grade) on both the east and west sides began on October 9, 2020.

Throughout the abatement process, radiological screening was done approximately every ten feet vertically on coating scrapings to identify possible or potential exposures to radioactivity that may be present on the outside of the Stack. As the work passed 317 feet above grade, direct measurements of contamination exceeded RPP contamination control limits. The maximum recorded measurement readings for alpha was 105 dpm/100cm2; beta-gamma was 13,206 dpm/100cm2; average readings were 51 dpm alpha and 4,325 dpm beta-gamma. Work was paused and the adequacy of contaminations controls was re-assessed for future work at and above grade elevation 317 feet.

A modified approach was submitted to USACE to remove the steel cap that covered the top rim of the Stack in accordance with RPP requirements on November 10, 2020, which included:

- increased radiological controls and monitoring consistent with higher-risk Stack demolition,
- applying a fixative to the top cap and Stack exterior above grade elevation 317 feet,
- abatement of proposed demo saw cut lines with a needle gun and HEPA vacuum while wearing appropriate PPE, and
- cutting and removing cap using appropriate PPE and a torch or grinder.

USACE provided a notice to proceed with cap removal on November 12, 2020. The Stack cap fixative was applied on November 13 to 14, 2020 and the top of the Stack cap was abated on November 15, 2020 and was removed and dropped into the Stack on November 16, 2020 using the process noted above.

3.4 Stack Demolition to Grade

3.4.1 Pre-Demolition Meeting

A Pre-Demolition Preparatory Meeting was held with the project team via teleconference on October 27, 2020, that discussed work requirements, logistics, execution approach, and schedule of critical demolition phase milestones.

The following sections describe the execution of demolition activities.

3.4.2 Demolition Mobilization

3.4.2.1 Crane and Mantis Mobilization

A separate preparatory teleconference meeting was held with the project team on November 5, 2020, to discuss the mobilization of the crane for lifting the Mantis to the top of the Stack. The crane arrived on site on November 17, 2020 and was deployed in accordance with a Critical Lift Plan (OFJV, 2021q), which received final USACE signatures and approval after inspection of the crane upon its arrival on site.

The Mantis was installed at the top of the HFBR Stack on November 18, 2020, and the crane was demobilized on November 19, 2020. BSA notified the FAA before the raising and the lowering of the crane.

3.4.2.2 Equipment Delivery and Setup

Other demolition equipment was delivered to the site and set up from November 6 to November 12, 2020. Key equipment elements are described below:

- **Temporary ladders.** Ladders were installed at the exterior of the Stack for the duration of the concrete demolition procedures as a suitable egress from the Stack. Stack ladders were a means of a secondary egress only and their use was minimal as suspended scaffolds were installed at the beginning of the project. The temporary ladders were removed as the scaffold descended. All of the platforms were inspected prior to use.
- **K bracket scaffold.** The Stack demolition procedure with the Mantis was completed using a double-deck access platform installed at the top of the Stack. The K bracket system was installed from November 19 to December 2, 2020. The system was secured to the Stack with multiple 1 in. diameter cables installed around the circumference of the Stack approximately 5 ft. from the top of the concrete wall. The top deck was the access point from which the Mantis demolition machine is operated. The platform top deck was sealed to the Stack with a rubber seal installed around the complete circumference of the Stack. The seal controlled debris chips falling on the deck as the wall was demolished. The chips were contained on the deck of the platform and continually collected and placed with demolition debris. The K bracket system design was presented in Appendix S of the Demolition Plan (OFJV, 2020k).

- **Power and Utilities.** Power and utilities to the K bracket were installed on December 1 and 2, 2020.
- **Seismic monitors.** Appendix T of the Demolition Plan (OFJV, 2020k) was a Vibration Monitoring Plan that described the arrangement and operation of a vibration monitoring system. Vibration readings were collected continuously to address the potential impacts of vibrations transmitted to specific Brookhaven facilities from demolition activities. A total of (11) monitors were installed at (11) locations around the base of the Stack (**Figure 3-3**). Vibration monitor locations included three (3) Ground Seismic Stations (GSS) positioned within 230 feet of the Stack perimeter, and Building Seismic Stations (BSS) located further away from the Stack adjacent to the closest BNL buildings to the Stack where sensitive laboratory equipment was housed. Further details of the vibration monitoring program, including vibration threshold levels for the project, pre-demolition background measurements, and measurements recorded during D&D work are discussed in **Section 3.7**.
- **Heavy Equipment.** Aside from the Mantis, the general equipment inventory utilized for the Project included excavators with various attachments for digging, cutting and hammering; a roll off truck for transporting containers between the Stack site and rail yard area; ABC rail cars; 20-yard IMCs for debris; light plants; cranes for loading and unloading contains in the rail area; and a rail car tug to position cars at the rail yard during loading and unloading operations.
- **Dust Suppression System**. Following the installation and inspection of platforms, a dust suppression system was installed. Dust was controlled in accordance with Appendix P(2)-1053, Dust Suppression, of the approved Demolition Work Plan. The system was comprised of two levels of water misting at the interior of the Stack at roughly 50 and 100 feet above grade. Each misting level consisted of four water misting heads directing water to the interior of the Stack and connected to water supply lines installed on the outside of the Stack. One misting head was also installed on the arm of the Mantis to provide direct misting at the point of contact during demolition. Additional water suppression was administered during Stack base demolition conducted at ground level by hand-held water sprayers on the platform and at the base of the Stack. Water generated from dust suppression misting operations was collected in the existing Stack drain tank system (**Section 3.5.4**).

3.4.2.3 Haul roads

BSA completed improvements and repairs to the haul road from October 19 to 23, 2020. The BNL haul road route is shown on **Figure 3-2**.

3.4.2.4 Rail yard

The BNL rail yard served as a receiving, loading, and staging area for the project (**Figure 3-2**). BSA completed improvements and repairs to the rail yard and the on-site portion of the rail spur from October 19 to 23, 2020. The on-site rail spur passed inspection for use by New York & Atlantic NY&A Rail Road on October 27, 2020. The off-site section of the spur, between the main Long Island Rail Road (LIRR) line and the BNL site boundary, required additional permitting between BNL and LIRR. After a permit was obtained, the off-site section of the spur was cleared of brush and debris on December 1, 2020, and passed inspection for use by NY&A on December 2, 2020.

3.4.2.5 IMC delivery

Environmental Rail Solutions (ERS) facilitated the delivery of Intermodal Containers (IMCs) to the site by rail. The rail cars were released from a rail staging area in Queens after the final inspection of the off-site rail spur and delivered to the site on December 12, 2020. The IMCs were off-loaded and inspected them for any defects or remnants of waste material. The inspections included a visual examination of the interior to confirm cleanliness, an inspection of the exterior to confirm no holes were present, and operation of all working parts to confirm the lid and doors are acceptable.

The IMCs were removed from the rail cars with a forklift and transported to a designated staging area with a rolloff truck. While in the staging area, the IMCs were lined with polyethylene liners and prepped for loading.

3.4.3 Stack Demolition

3.4.3.1 General Approach

The Stack demolition was completed using the Mantis system, per the approved Demolition Plan. After installation on the top of the Stack the Mantis was operated from the double-deck access platforms (K-Bracket Platform) installed at the top of the Stack.

The Mantis started a spiral demolition/cut at the top of the Stack that continued to the top of the Stack base approximately 30 feet above grade. As the concrete was removed from the area above the scaffold, the scaffold was re-positioned down in approximately 5- to 6-foot increments to continue the concrete removal process. The concrete was cut into panels and guided to the inside of the Stack. The Stack itself acted as a debris chute containing the concrete panels and the small debris. Small debris was cleaned from the scaffold on a continuous basis.

Internal structures were demolished as the Mantis moved down the Stack. The interior 14-inch diameter flue was demolished using an oxy-acetylene torch set-up. Sections of the flue were deposited into the Stack and removed at grade for disposal in accordance with the Waste Management Plan. A 5/8” safety cable was installed around the circumference of the Stack at each platform prior to removal.

Once the Mantis reached the top of the octagonal Stack base at approximately 30 feet above grade, it was removed by crane from the remaining Stack and the remainder of the concrete Stack was demolished utilizing an excavator with demolition hammer attachment.

3.4.3.2 Demolition Work Sequence

- **Silencer Demolition and Debris Opening**. Demolition of the remaining above-ground silencer structure was completed November 9-16, 2020. The silencer breach was opened to the Stack on November 16 to provide a means to remove concrete Stack debris from the bottom of the Stack every one or two days as the demolition progressed. The debris opening was secured with a debris shield that consisted of an engineered steel barrier, in two halves, that was removed when debris needed to be removed and replaced for resumption of demolition activities.

  It had been planned for silencer debris to be direct loaded into IMCs. However, permitting delays to clear the off-site portion of the rail spur to the site (see **Section 3.4.2.4**) had delayed the delivery of IMCs. To avoid delays to the demolition schedule approval was obtained from USACE to temporarily stockpile the silencer wall debris, using the same stockpile approach specified by the approved Final Excavation Plan.

  Silencer material stored on two layers of reinforced heavy-duty poly material and covered with two layers of reinforced heavy-duty poly material and a heavy-duty tarp and sandbagged. Additional barrier protection was placed to protect against debris and contaminant migration. The stockpile was routinely inspected until the IMCs arrived on December 12, 2020, for offloading.

- **Stack Cone Demolition**. Demolition began at the top of the Stack cone on December 3, 2020 and reached the top of the Stack base approximately 30 feet above grade on January 30, 2021.

- **Mantis Demobilization**. The work platforms assisting the Mantis were removed February 1-3, 2021. The initial Mantis decontamination was performed on February 5, 2021 by pressure washing it in place from a manlift. A crane was then utilized to remove the Mantis off the Stack and place next to the Stack for additional cleaning. Additional pressure washing on the Mantis occurred on February 6 and again February 8-9 following a snowstorm. The Mantis was cleared by RadCon and demobilized from the site on February 11, 2021. Radiological screening release data are provided in **Appendix D**.

- **Stack Base Demolition**. After the Mantis was removed, demolition work transitioned to a ground-based approach on February 11, 2021. Demolition continued from outside the Stack using an excavator with a hammer attachment with a laborer providing dust suppression with a hose and reached grade level on February 22, 2021.

  By the time the demolition of the Stack base began, 66 IMCs had been fully loaded and staged at the rail yard awaiting to be loaded to for rail transport. Additional empty IMCs were to be delivered to the site when the train arrived to pick up the filled IMCs. However, there was a delay in rail service such that there were not enough empty IMCs available to direct load Stack base debris. To avoid work delays, USACE approved the creation of a stockpile of remaining concrete debris from the base of the Stack. The Stack base debris was placed on top of the former silencer footprint, which is an area that would be excavated as part of the soil excavation and subsurface structures removal. During Stack base demolition activities, the Stack tank and drain system remained in place to capture any wastewater until the above ground demolition was completed and the debris stockpile was constructed. The position of the stockpile within the silencer footprint allowed for adequate space around the perimeter of the Stack base to maneuver equipment to complete above grade demolition activities, and to subsequently remove the Stack tank, piping, and associated soil. The positioning of the stockpile also provided the following controls:

- The proposed stockpile was within an existing radiological-controlled area. Access control, signage, and radiological postings was maintained.
- The silencer soils were already planned for excavation with FSS and ORISE confirmation of the excavation surface following soil removal. The project scope included contaminated soil excavation from this area and ensured that any impacts from the stockpile to the underlying soil were remediated.
- No plastic cover or underlayer was used so that stormwater runoff stayed within the area planned for remediation. This ensured that stormwater remained within the silencer area and was managed as part of the excavation of silencer soils with FSS/ORISE verification.
- Straw wattles surrounded the stockpile to control stormwater runoff.

3.5 Removal and Remediation of Underground Structures and Soil

3.5.1 Pre-Excavation Meeting

A Pre-Excavation Preparatory Meeting with the project team was held via teleconference on February 4, 2021, that discussed work requirements, logistics, execution approach, and schedule of critical excavation phase milestones.

3.5.2 Overview of Approach

All removed structures were considered contaminated and disposed as Low-level Radioactive Waste (LLRW) at WCS. Soils surrounding those structures were treated as follows:

- Soils above the structures were designated *non-impacted*.
  - Non-impacted overburden soils were removed and placed in windrows and gamma walkover surveys were performed to screen for unexpected levels of residual

radioactivity.

  - Overburden soil with elevated levels of residual radioactivity based on gamma walkover screening was placed in soft sided 10-ton capacity super sacks and shipped to WCS for disposal.
  - Overburden soil that passed gamma walkover screening was sampled and analyzed for radiological and non-radiological contaminants of concern. One composite soil sample was collected from each 500 cubic yard lot of overburden soil.
  - If the analytical data indicated the soil met cleanup criteria for the contaminants of concern specified in the UFP-QAPP (OFJV, 2020h), it was reused as backfill after the structures and adjacent underlying soil were removed.

- Soils immediately adjacent to and underlying the structures, as well as surface soil within the Stack demolition work footprint that could have been contaminated by the demolition process, were designated as *impacted*.
  - Impacted soil was excavated and placed in super sacks and disposed offsite at WCS.

After removing the structures and excavating impacted soils, another walkover survey was conducted at the bottom of the excavation, and biased soil samples were collected from areas and locations with high readings or "hot spots". Excavation activities were continued as necessary based on the sample results until soil cleanup criteria specified by the FSP (OFJV, 2020l) were achieved.

Laboratory analytical results for soil samples collected per above are provided in **Appendix A-4**. Validation Reports for the sample analyses that supported the final survey are included as **Appendix B**. The following sections describe the execution of excavation activities and subsurface structure removal.

3.5.3 Utility Markouts and Setup

BNL was notified of the need for an updated utility locates and mark out on February 12, 2021, and the site was set up for excavation activities from February 23-26, 2021. BNL completed the utility mark out by March 1, 2021, after snow cover had melted and meltwater had dissipated.

3.5.4 Stack Stormwater Collection System

The Stack stormwater collection system included the Stack drain tank and associated piping from the tank to the pedestal (**Figure 1-5**). BNL transferred responsibility to OFJV for operating and maintaining the Stack drain system when Project field work began in August 2020 and maintained control of the system until it was removed as part of the Project. The Stack drain tank and 35 feet of associated piping leading to the Stack pedestal was excavated and removed on March 5, 2021.

The top of the tank and piping were exposed, an overflow alarm and concrete slab attached to the top of the tank were removed, and the tank was pulled from the surrounding pea gravel. A visual examination of the tank, piping, and piping connections to the tank verified the tank and piping was in excellent condition with no indication of holes or damage. Excavated overburden soil and soil adjacent to the tank and piping showed no visible evidence of leaks or spills. A radiation survey of the removed tank and piping was completed on March 8, 2021, which detected no radiation levels of concern on the tank and piping.

The tank was originally estimated to be approximately 10 feet below grade but was found at a significantly greater depth of approximately 14-16 feet below grade. The associated tank piping was also located at a greater depth – 8 feet below grade – than had been originally estimated (~ 6 feet). Pea gravel was also discovered adjacent to the tank beginning at approximately 8 feet below grade and extending to approximately 16 feet below grade. After the tank was removed, the combined effect of the greater than expected depth, the instability of the native loose sand and gravel soils, and the presence of pea gravel around the tank created sidewall instability that required immediate action to stabilize. Excavation activities were paused to arrange for the installation of a trench box before attempting to remove pea gravel. Concurrence was sought from USACE and BSA to use overburden soil that had been removed from above the tank and piping as backfill to temporarily stabilize the excavation. Although this soil had not undergone screening prior to being returned to the excavation, USACE, BSA, and OFJV recognized that:

- field observations indicated the tank and piping were found in excellent condition with no evidence of leaks, and the radiation screening did not detect evidence of radiological contamination on the tank and piping;
- soil that had been removed from above the buried tank and piping (previously described in Section 3.5.2 as *"non-impacted"* because it was above the structures and therefore radiological contamination related to the tank and piping system was not expected) would be returned to the excavation physically separated from the underlying soil and pea gravel by demarcation fabric;
- due to the unanticipated increase in depth to the tank and piping, a trench box was necessary to ensure that the backfilled soil could be removed, as soon as possible, and the tank excavation could be completed to the required depth to remove all impacted soil and pea gravel;
- all soils temporarily returned to the excavation as backfill would be screened when removed again after the trench box was installed;
- as the soils were re-excavated, they would be examined and screened to ensure that any comingling of impacted and non-impacted soils were recognized and identified as impacted per the Excavation Plan and FSP;
- by this screening process the presence of pea gravel in re-excavated soil would be identified and treated accordingly as impacted soil; and

- the Final Status Survey could be completed on a slightly larger survey unit with additional sample collection, but otherwise without deviating from the approved FSP, to confirm that cleanup goals were met.

With USACE and BSA concurrence, a layer of demarcation fabric was placed at the bottom of the excavation (i.e., on top of the pea gravel and at the elevation of the associated piping), and the excavation was backfilled as a stability safeguard with overburden soil that had been removed from above the tank and piping.

A 12'x12' three-sided trench box was installed in the tank excavation area on April 1, 2021, to complete the soil excavation. Overburden soil that had been temporarily placed back into the tank excavation was re-excavated. All material above the demarcation fabric was visually screened to remove all soils containing pea gravel that previously surrounded the tank. Material above the demarcation fabric without pea gravel was designated per the UFP-QAPP (OFJV, 2020h) as non-impacted, stockpiled, and verified as such through screening in accordance with the Excavation Plan (OFJV, 2020c) and UFP-QAPP (OFJV, 2020h). Any material containing pea gravel was designated as impacted in accordance with the Excavation Plan (OFJV, 2020c) and UFP-QAPP (OFJV, 2020h), bagged, and transported to WCS for disposal.

Once the level of the demarcation fabric was reached, all pea gravel and soils surrounding the tank were removed and bagged until all of the pea gravel was removed and "native" soils were encountered. The trench box installed to slightly below depth of the bottom of the former tank supported excavation of pea gravel and soil surrounding the former tank fully encompassing the 10'x6' area identified in the FSP (OFJV, 2020l). The open side of the dig box faced the piping run toward the former Stack drain. Pea gravel removed from the area immediately surrounding the tank (i.e., inside the 12'x12' dig box) was bagged in supersacks for transport to WCS.

The bottom of the tank and piping excavation was screened using a gamma walkover survey to determine if residual radioactivity is present. Excavated non-impacted overburden soil was stockpiled and screened in accordance with the Excavation Plan. Underlying soils that contained visible pea gravel, as well as soils identified as radiologically impacted during gamma walkover screening, were placed in sacks for transport to WCS for disposal. Excavation continued until the gamma walkover survey results supported a decision the area is ready for final status survey.

The piping excavation extended to the west side of the pedestal to remove the remaining piping. The piping was removed, visually inspected, and screened for residual radioactivity prior to being packaged for transport to WCS for disposal. The soil beneath the piping along the entire length of the trench was screened for residual radioactivity using a gamma walkover survey. All soil removed based on this screening was identified as impacted soil and bagged for transport to WCS. Soil remaining in the completed excavation underwent FSS (OFJV, 2020l).

A small area adjacent to the pedestal was excavated to remove the pipe connections to the pedestal. The drain lines within the pedestal were flushed with water to remove any loose sediments that may have entered the drains during demolition and removal activities.

The drains were stainless steel and steeply pitched, which maintained smooth inner surfaces with only a small amount of debris buildup to make them amenable to flushing. After the drains were flushed the ends of the drain were sealed to prevent any additional material from entering the pipes in accordance with the FSP (OFJV, 2020l). All water generated during flushing was collected and processed as described in the UFP-QAPP and the Waste Management Plan (OFJV, 2020d). The overall process involved periodically transferring the wastewater as needed from the Stack drain tank into totes, and adding a solidification agent so that the waste could be disposed as solids along with other demolition wastes at WCS.

3.5.5 Subgrade Silencer

The subgrade portion of the silencer and approximately 10 ft of attached horizontal plenum to the west were removed from March 13 to 31, 2021. Prior to removing the silencer and plenum, overburden soils surrounding the silencer were excavated and laid out in 10-foot-wide sections on plastic sheeting with a thickness of less than 1 foot and walk-over surveys were performed in accordance with the UFP-QAPP to determine if the soil was radiologically impacted. Impacted soil was loaded into soil bags for off-facility disposal at WCS. Non-impacted soils were stockpiled on sheeting and covered for further sampling and potential re-use as backfill material. Sidewall grades were maintained at a maximum 1.5 to 1 slope for stability as the structure was exposed.

The sump and associated drain line were encountered during removal of surrounding soils. Soils within 5 feet of the sump were put into soil sacks for off-site disposal at WCS and the sump and piping were removed and radiologically scanned. Scanning results indicated the presence of radiological impacts at the bottom 2 feet of the sump, but no radiological impacts were detected in any of the associated piping. The sump and associated piping were placed into IMCs for off-site disposal at WCS.

After soil removal had exposed the entire silencer structure and floor, a 10-foot Tyvek barrier was placed on the ground surrounding the silencer to contain concrete material as the silencer was removed. The silencer was removed using an excavator equipped with a hammer and debris was loaded into IMCs for disposal. A minimum of two feet of soil underlying the silencer floor was excavated and placed into soil bags for disposal. Dust suppression during the removal process was provided by multiple sprinkler systems along with hand-held sprayers directed by personnel.

On March 30, 2021, a concrete footer system was identified under the silencer below the connection of the silencer and plenum and further west (**Figure 3-4**). The footer structures consisted of a 14-ft by 6-ft by 5-ft deep footer below the connection of the silencer and plenum – identified as Footer A – and a 28-ft by 7-ft by 5-ft deep footer located approximately 7 feet west of Footer A – identified as Footer B. The two footers were connected by two 18-inch wide by roughly 7-feet long by 3-feet deep reinforced concrete beams.

Initial radiological screening indicated elevated readings for Footer A. Footer A and the beams connecting it to Footer B were demolished from April 15 to 27, 2021. Trench boxes were used to extend the excavation deeper and remove impacted soil below the removed Footer A and braces. Screening of soil, Footer B, and remaining braces attached to Footer B indicated no further radiological impacts.

A core sample of Footer B concrete was collected on June 18, 2021, to verify that leaving it in place was consistent with project cleanup goals. Cs-137 and Sr-90 were not detected in the concrete sample. Ra-226 was detected, but at 13% of the ALARA cleanup goal and 9% of the ROD cleanup goal. The only other detected radionuclide identified above background that isn't naturally occurring was Ni-63 (activation product), which is not identified in the ROD and has no cleanup goal. Footer B and adjoining section of braces were left in place based on laboratory confirmation that contamination related to the silencer did not extend up to/beyond Footer B. No further surveys of Footer B (or area to the west beyond Footer B) were necessary to meet the scoped cleanup objectives of the HFBR Stack Project.

3.5.6 Pedestal Remediation

An Edco 5-head Crete Crusher scabbler connected to an Edco Vortex 200cfm HEPA vacuum was utilized from April 13 to 29, 2021 to remove one-half inch of concrete from the surface of the pedestal. A Matabo hand-operated concrete planer was utilized to remove concrete from the surface of the sloped portion of the pedestal that connected to the silencer. Scabbling was initially performed within an 8 ft by 10 ft containment room, but was adjusted to encapsulate only the scabbling tool to reduce worker exposure to dust (see **Section 4.1**). This adjustment remained in compliance with the RPP (OFJV, 2020m).

Initial beta readings prior to any scabbling indicated maximum beta levels of approximately 400,000 dpm/cm^2 on the pedestal surface. Following removal of one-half inch of concrete, radiological surface screening of the scabbled surface still indicated radiological readings between 8,000 and 260,000 dpm/cm2, above the target criteria of 1,000 dpm/cm^2. An additional 1.5 inches of concrete was scabbled from the highest impacted surfaces and follow up screening indicated the surface still showed radiological impacts well above acceptable levels. Four concrete cores were collected from various hotspots on the pedestal from 4 to 12 inches below the scabbled surface and provided evidence of radiological impacts extending to at least 6 inches below the surface. Because scabbling was not an efficient way to remove impacted concrete at greater depths, along with dust control concerns (see **Section 4.1**), scabbling was discontinued on May 7, 2021, and alternative pedestal remediation methods were evaluated. OFJV recommended a wire cut option, which was accepted by USACE on May 20, 2021.

Wire cutting of the pedestal began on June 16, 2021. The wire cut system utilized concrete wet saws for vertical cuts, wire cutting wet saws for horizontal cuts, pulleys and mounts, wire cutter motor, and water collection equipment. Pulleys were mounted on the pedestal to position the wire saw on horizontal cuts.

A gutter system was installed surrounding the pedestal to recover cooling water. The water was solidified in IBC totes and transported to WCS for disposal as radiologically impacted waste. The cut pieces of concrete were containerized in IMCs and also transported to WCS.

After the top one foot of concrete was cut from the western portion of the pedestal, a small crack was observed on the cut surface below the removed one-foot slab. Radiological screening of the cut surface indicated at least portions of the crack were radiologically impacted. After wire cutting had removed the top one foot of concrete from the entire pedestal a more complete radiological survey could be performed, which showed areas with elevated radiation measurements. A rectangular trench was cut along the 12-foot length of the crack, approximately 6 inches wide and 15 inches deep, to allow better radiological screening access. Upon completion of the rectangular trench and removal of the dust suppression slurry generated during the wire cutting operation, additional radiological surface scans were completed on the pedestal which indicated radiological impacts in a small area on the west side of the pedestal as well as along the pedestal steps that ramped down to the former silencer area to the west. The west side of the pedestal where residual contamination was found was removed along with the impacted concrete of the pedestal steps.

Following this work, on July 24, 2021, it was determined by radiological survey that fixed radiological contamination on the concrete pedestal surface had been removed, and remaining radiological impacts were associated with the pedestal drainpipes that remained in the concrete (see **Section 3.5.7**).

3.5.7 Pedestal Drainpipes

The Stack water collection system (holding tank, drain pipes - see **Section 3.5.4**) was removed in February 2021, leaving three drainpipes exiting the northwest side of the pedestal. Drain A is located on the west side of the pedestal and collected water from a trench drain located at the interface where the silencer connected with the Stack. Drain B is in the middle of the pedestal with a drainpipe running from southeast to northwest, including a sump in the center of the pedestal. Drain C is located on the east side of the pedestal and was designed to drain any liquids collecting between the planned double wall of the Stack. Since the exterior portion of the double wall was not completed, Drain C was outside the Stack.

Water potentially containing radioactive material, either dissolved or as suspended particulates, would enter the drains and flow to the exterior drain tank. Because the pipes are constructed of stainless steel and are pitched toward the drain tank, radioactive contamination inside the pipes, including debris from demolition of the Stack and Silencer, was expected to be removable activity.

The planned FSS activities in the FSP included measurements of removable radioactivity at the exposed ends of the pipes.

After the Stack water collection system was removed (Section 3.5.4), smear samples collected from inside the three pipes reported less than 5 dpm/100 cm^2 alpha and less than 125 dpm/100 cm^2 beta, less than the removable activity release limits of 20 dpm/100 cm^2 alpha and 200 dpm/100 cm^2 beta listed in the FSP. The drain lines were capped after the water collection system was removed to prevent the potential spread of contamination as subsequent remediation activities were completed.

The decision to cut and remove approximately 12 inches of concrete from the pedestal surface resulted to cuts in the three drainpipes, which provided access to the pipes. In particular, Drain B was cut on an angle providing access to approximately one foot of the interior surface of the pipe.

A survey of removable activity on the inside surface of Drain B on July 13, 2021, confirmed there was no removable alpha activity, but the removable beta activity was reported at 556 dpm/100 cm^2. Drain A and Drain C were blocked with debris and no measurements were performed.

After concrete cutting was completed, the surface of the pedestal was cleaned and the debris was removed from Drain A and Drain C. Alpha activity for all three drains was below the release criteria with a maximum of 37 dpm/100 cm^2 total surface activity for Drain B and a maximum of 6.5 dpm/100 cm^2 removable surface activity for Drain B. However, total beta surface activity for Drain A exceeded 10,000 dpm/100 cm^2, and exceeded 200,000 dpm/100 cm^2 for Drain B.

The drains were flushed to remove loose surface contamination and the total surface activity was reduced to less than 5,000 dpm/100 cm^2 for Drain A and less than 50,000 dpm/100 cm^2 for Drain B. More aggressive remediation using muriatic acid and scrubbing to remove visible black stains from the inside surface of Drain B further reduced the total surface activity in Drain B to less than 2,500 dpm/100 cm^2. All cleaning solutions and debris generated during remediation were collected, solidified, and transported to WCS for disposal.

A remedial action support survey performed on August 5, 2021, showed a maximum removable alpha activity of 13 dpm/100 cm^2 for Drain B, and no detectable removable beta activity for all three drainpipes. The three drainpipes were grouted on September 13, 2021.

3.6 Additional Radiologically Impacted Areas

The soil surrounding the Stack was previously surveyed and released (**see Section 1.2**). As with all soil excavation activities, overburden soils removed to provide access to subsurface contamination were handled as reusable overburden if analytical results confirmed they met cleanup criteria for site COCs (**see Section 3.5.2**) based on analytical results and gamma walkover survey, as specified in the UFP-QAPP (OFJV, 2020h), and did not require FSS.

Site soils that became impacted as a result of demolition and remediation (including material storage and waste package filling areas) were identified by RadCon, posted according to the RPP, surveyed and remediated during remedial support efforts, and remaining in-place soils were included in the FSS.

3.7 Vibration Monitoring Results

Eleven (11) vibration monitoring devices were installed the week of October 26, 2020. In accordance with the Scope of Work and the approved Vibration Monitoring Plan (Demolition Plan Appendix T), three (3) Ground Seismic Stations (GSSs) were installed within the Stack work zone, approximately 230 feet from the Stack pedestal, to provide real-time data for alerts to BNL, BHSO, USACE, and OFJV. The three GSSs were positioned on three radial lines between the Stack pedestal and Buildings 912, 480, and 901A, respectively, as shown on **Figure 3-3**.

Eight (8) Building Seismic Stations (BSSs) were set up in accordance with the SOW adjacent to the following nearby buildings outside the Stack work zone (**Figure 3-3**):

- Building 912 – AGS Exp. Area
- Building 480 – Condensed Matter Physics & Materials Science Department
- Building 901A – Tandem Van de Graaff
- Building 703 – NSLS-II Research Labs
- Building 555 – Chemistry Department
- Building 734 – Interdisciplinary Science Building
- Building 735 – Center for Functional Nanomaterials (CFN)
- Building 740 – National Synchrotron Light Source II

Vibrations were monitored by recording peak particle velocity along three orthogonal axes at each seismograph location, as well as the frequency of the motion. The seismographs were programmed to perform continuous monitoring in histogram combination-mode, which created a waveform during the histogram recording if a vibration exceeded the threshold level. In the event that the threshold level was exceeded, the seismographs were programmed to transmit all data immediately to appropriate project personnel following the recording of the exceedance.

The BSSs provided data that was cross-checked against GSS data alerts to determine if any onsite GSS events had produced vibrations above established building-specific thresholds near any particular BSS. The Vibration Monitoring Plan identified response actions based on decision rules to manage such events. **Tables 3-7 and 3-8** below contain vibration thresholds for the GSS and BSS stations, respectively:

Table 3-7 – Vibration Limits for Ground Seismic Station (GSS)

	Threshold Level	Initial Upset	Maximum Upset
Vibration (PPV) Limit	0.050 in/sec	0.100 in/sec	0.300 in/sec

Table 3-8 – Vibration Limits for Ground Motion of Outside BNL Buildings (BSS)

Building Seismic Station (BSS)	Vibration (PPV) Limit (in/sec)
480 – Condensed Matter Physics & Science	0.017
555 – Chemistry	0.010
703 – NSLS-II Research	0.170
734 – Interdisciplinary Science Bldg I	0.013
735 – CFN	0.006
740 – National Synchrotron Light Source	0.008
901A – Tandem Van de Graaff	0.003
912 – AGS Exp. Area	0.052

The above vibration limits were established based on previous field studies, as presented in the Report of Background and Drop Test Vibration Study Results, Demolition of Brookhaven National Laboratory HFBR Stack (Building 705), August 2019.

Once email notifications were received for an exceedance of a vibration criterion, the following actions were taken:

If the **Table 3-7** Threshold Level was reached at a GSS:

- The readings collected at the nearest BSS were evaluated relative to the limits defined in **Table 3-8**.
- The project team investigated the cause of the exceedance and determined if mitigation measures were needed.
- If mitigation was necessary, OFJV provided a response plan to USACE for approval and implementation.

If the **Table 3-7** Initial Upset was reached at a GSS:

- Vibration generating demolition activities were stopped.

- The readings collected at the nearest BSS were evaluated relative to the limits defined in **Table 3-8**.
- The project team investigated and determined the cause of the exceedance. The construction activity deemed responsible for the exceedance was stopped.
- The project team determined if mitigation measures were needed and implemented those measures prior to restarting this work.
- Vibration generating demolition activities resumed upon approval from the USACE.

If the **Table 3-7** Maximum Upset Level was reached at a GSS:

- Vibration generating demolition was stopped.
- The readings collected at the nearest BSS were evaluated relative to the limits defined in **Table 3-8**.
- The project team investigated and determined the cause of the exceedance. The demolition activity deemed responsible for the exceedance was stopped.
- The project team determined if mitigation measures were needed and implemented those measures prior to restarting this work.
- If a revised demolition approach was needed, it must be approved by the USACE prior to resuming vibration generating construction activities.

The vibration sensors were activated on October 30, 2020, the week prior to the beginning of demolition activities, to test the system and collect pre-demolition "background" data. The pre-demolition data indicated that designated thresholds were routinely exceeded by background events, unrelated to Stack demolition (since the demolition has not yet started), at several monitoring locations. It was likely that ongoing construction between Buildings 735 and 901 was being recorded by the vibration monitors. GEI, who provided and maintained the monitors, provided a summary of preliminary findings of pre-demolition data that indicated:

- There seemed to be a correlation between recorded ground vibrations and construction activities unrelated to the Stack demolition project.
- There was evidence of vibrations from vehicles unrelated to the demolition project driving over potholes on nearby roads.
- There was evidence of wind and winter storm effects.
- The most regular vibration exceedances occurred for buildings farther away from the Stack, including 734, 735, and 740. But GEI noted that the thresholds at these buildings are extremely low.
- There were no vibration exceedances at monitors located closest to the Stack base.

In general, the vibration monitoring program did not measure any events caused by Stack demolition activities that had a negative impact on the surrounding BNL facilities. There were several recorded events that exceeded thresholds at the GSS locations, but none produced any vibrations above the BSS thresholds. Over the course of the demolition project there were multiple recorded events above thresholds at the near-building BSS stations. Most of these near-building events occurred when no demolition work was being conducted. None of the near-building events that occurred during demolition work could be correlated with a concurrent trigger event at any of the GSS stations, which indicated the near-building BSS events were not related to site work.

Most of the near-building BSS events appeared to correlate with truck traffic and transmitted by utilities under roads. The remaining events could be related to weather or other construction activities occurring at BNL.

The vibration monitoring network was deactivated and removed from the site on August 2, 2021, following the completion of site excavation structure removal activities.

3.8 Final Status Survey

The Field Sampling Plan (FSP) described the radiological & non-radiological parameters Final Status Survey (FSS) Report requirements for activities related to the HFBR Stack D&D project. The FSP focused on demonstrating radiological/non-radiological parameter compliance and served as the final status survey (FSS) plan as defined in the Multi-Agency Radiation Survey and Site Investigation Manual (MARSSIM, EPA, 2000).

The primary objectives of the FSS were to:

- Identify survey unit boundaries,
- Classify survey units,
- Demonstrate the potential dose is below the ROD requirement for each survey unit, and
- Demonstrate the potential dose from small areas of elevated activity is below the ROD requirement for each survey unit.

This FSP covered areas within the HFBR related property that were not addressed by prior FSPs associated with the Fan Houses Project, the HFBR Underground Utilities Project, the HFBR Stabilization Project, and removal of the HFBR Stack Silencer Baffles. The areas included in the HFBR Stack D&D project include the pedestal that served as the foundation for the Stack, the subsurface soil beneath the remaining portions of the silencer, the subsurface soil beneath the collection tank and pipes associated with the Stack stormwater drainage system, and surface soils in all outdoor areas posted as a “Contamination Area” or “Soil Contamination Area” as defined in the project Radiation Protection Program (RPP, OFJV, 2020m).

The FSS was conducted following the collection and laboratory analysis of post-remediation confirmation samples from the designated Survey Units (SUs): SU-7A, the pedestal (**Section**

3.5.5); SU-7B, the silencer excavation (**Section 3.5.4**); SU-7C, the Stack stormwater collection system (**Section 3.5.3**); and SU-7D, the surrounding work area. The Survey Units are shown on **Figure 3-5**.

A total of 257 samples were collected as part of final status survey activities. Two hundred eight samples were collected from the SUs:

- 174 soil samples were collected from SU 7B, SU 7C, and SU 7D.
- 7 concrete samples were collected from SU 7A.
- 4 asphalt samples were collected from SU 7D.

The general approach for soil sample collection was to collect from 3 depth intervals at each sample location (0-6 inches, 6-12 inches, 18-24 inches), per the FSP.

Twenty-two reference background area samples (16 soil and 6 concrete) were also collected. The reference background areas were selected from non-impacted areas at BNL to provide data representative of background. Locations of the soil reference background area and the concrete reference background area are described in the FSS Report (Appendix G). The soil reference background area is located along a fire road southeast of the HFBR. The concrete reference background area is located on an outdoor loading ramp attached to Building 610.

There were 27 field duplicates (all soil).

SU samples were collected following the completion of walkover surveys of the SUs. The sample locations relative to the survey results are shown on **Figures 3-6 through 3-11**. The confirmation sample analytical reports are included in **Appendix A-7** and validation results in **Appendix B**. A tabulated summary of FSS analytical results and a detailed discussion of the FSS evaluation process and findings are presented in **Appendix G**.

The maximum projected dose to a resident (non-farmer) after 50 years of institutional controls is 5.5 mrem/yr for the area of elevated activity on the concrete pedestal. The maximum projected dose to an industrial worker with no decay time (Year 0) is 9.3 mrem/yr for the elevated reading on the concrete pedestal. The maximum dose from the water ingestion pathway is 0.26 mrem/yr for an industrial worker on the concrete pedestal. The results of the dose assessment are below the limits established in the HFBR ROD, including the dose objective of 15 mrem/yr and the New York State Department of Environmental Conservation (NYSDEC) cleanup guideline of 10 mrem/yr adopted as an As Low As Reasonably Achievable (ALARA) goal.

For non-radiological constituents, the FSS samples indicated lead was below the residential cleanup value for all samples collected. There were two mercury detections out of a total of 199 FSS samples analyzed for mercury that were above the residential cleanup value. An evaluation of the mercury data using USEPA ProUCL software (Version 5.1) calculated the 95% upper confidence limit (UCL) of the mean value as the exposure point concentration for mercury. Based on the ProUCL evaluation, the exposure point concentration for mercury (0.028 mg/kg) is well below the residential cleanup value (0.81 mg/kg). The ProUCL results are provided in **Appendix G**, and summarized on **Table 3-9**.

Table 3-9. Summary ProUCL Evaluation Results for Mercury FSS Samples

Soil Results					
Analyte	**Frequency Detected**	**Maximum Detected Concentration**	**Exposure Point Concentration (Calculated 95% UCL of the Mean)**	**Residential Cleanup Value**	**Above Residential Cleanup Value (Yes or No)**
Mercury (mg/kg)	87/199	0.89	0.028	0.81	**No**

Notes:

For the EPC calculations, non-detections were assigned a value of the limit of detection. The values are summarized in Appendix G under the general statistics sections of the ProUCL summary sheets.

3.9 ORISE Verification Survey

ORISE conducted an independent verification of the FSS results under contract with DOE. The purpose of the ORISE verification survey was to provide independent verification data for DOE's evaluation of the FSS results, by generating radiological data for DOE's assessment and evaluation of the accuracy and adequacy of the FSS design, implementation, and results for demonstrating compliance with release criteria. The results of the ORISE Verification Survey are included as **Appendix H**.

The FSS Report (**Appendix G**) discusses ORISE findings, and provides dose calculations that take ORISE results into account to demonstrates exposure limits are met.

3.10 Placement of Backfill Material and Site Restoration

Site restoration began on September 7, 2021, with the removal of the trench boxes from the silencer excavation, followed by backfilling the silencer and drain tank excavation areas. Previously excavated and stockpiled soil determined to be suitable for re-use as backfill, based on screening and analysis, was placed in the excavation first and compacted in one-foot lifts. Approximately 1,800 cy of excavated soil was reused for this purpose. As indicated in the UFP-QAPP, on-site overburden material to be potentially reused as backfill was analyzed for radionuclides Cs-137, Sr-90, Ra-226; and Pb, Hg, and asbestos. Walkover surveys were completed with sodium-iodide gamma detectors on freshly excavated soil as a first screening step. Soil that gamma screening showed was contaminated was removed from the screening area and placed in sacks for off-site disposal. Soil that gamma screening indicated was not contaminated was taken to a pre-screened area on the western side of the site and staged on and covered by poly sheeting to avoid cross contamination. The stockpiled soil was then sampled for laboratory analysis for ROD primary radionuclides Cs-137, Sr-90, and Ra-226, as well as Pb, Hg, and asbestos to verify it met site cleanup criteria identified in the UFP-QAPP (OFJV, 2020h). Analytical results for on-site soil that was reused as backfill are provided in **Appendix A-4**. Analytical results are summarized on **Table 3-10**.

Table 3-10. Analytical Summary for On-Site Soil Samples for Backfill

			Sample ID	BF-03-041321		BF-04-042121		BF-05-051021		BF-06-051021		BF-07-061621	
			Lab Sample ID	160-41698-1		160-41798-1		160-42005-1		160-42005-2		160-42457-1	
			Collection Date	4/13/2021		4/21/2021		5/10/2021		5/10/2021		6/16/2021	
Analyte	Residential Cleanup Value	ALARA Cleanup Goal	Unit	Result	Qual	Result	Qual	Result	Qual	Result	Qual	Result	Qual
Radionuclide Method 905 (GFPC)													
Strontium-90	15	10	pCi/g	0.0987	U	-0.107	U	**0.480**		**0.116**	U	0.0164	U
Radionuclide Method GA-01-R Gamma Emitters (GS)													
Actininum-228			pCi/g	**0.577**		**0.364**		**0.407**		**0.484**			
Americium-241	34	22	pCi/g	0.055	U			0.00944	U	0.0572	U	0.0415	U
Bismuth-212			pCi/g			0.014	U						
Bismuth-214			pCi/g	**0.213**		**0.324**		**0.386**		**0.264**		**0.236**	
Cesium-137	23	15	pCi/g	**0.361**		**0.221**		**0.0262**	U	**0.0949**		0.0047	U
Cobalt-60	1,260	840	pCi/g	0.0206	U			0.0133	U	0.00978	U	0.015	U
Lead-212			pCi/g			**0.28**		0.430		0.500		**0.286**	
Lead-214			pCi/g			**0.394**				0.338		**0.292**	
Potassium-40			pCi/g	**4.31**		**4.25**		**3.49**		**3.57**		**3.51**	
Radium-226	5	3.3	pCi/g	**0.213**		**0.324**		**0.386**		**0.264**		**0.236**	
Europium-152	51	34	pCi/g	0.0566	U			0.0685	U	0.089	U	0.0868	U
Europium-154	180	120	pCi/g	0.0196	U			0.0704	U	0.0501	U	**0.0696**	
Europium-155			pCi/g	0	U			0.0522	U	0.005577	U	0.0656	U
Method 6020B (ICP/MS)													
Lead	400		mg/kg	**7.8**		**7.3**	D	**8.2**		**7.6**		**5.4**	
Method 7471B (CVAA)													
Mercury	0.81		mg/kg	**0.036**				**0.12**		**0.13**		**0.041**	H J
Method 198.1 (Asbestos)													
Asbestos					ND		ND		ND		ND		ND

Notes:
Qual – Data Qualifier
ND – Not Detected
U – Undetected at limit of detection
D – The reported value is from a dilution
H – Sample was prepped or analyzed beyond the specified holding time but still determined usable by validation
J – Estimated value

The analytical results indicate the excavated soil reused as backfill met the established cleanup criteria for the project. It is noted that one of the samples did not include a mercury analysis due to a laboratory error. However, the highest mercury concentration detected for the 4 other samples (0.13 mg/kg) was less than 20% of the residential use criteria for mercury, demonstrating compliance with the cleanup objectives. Another sample had mercury analysis completed out of the holding time. The mercury result for this sample was flagged estimated (J) but determined to be usable.

Imported backfill that met 6 NYCRR Part 375 Unrestricted Use Soil Cleanup Objectives was placed above the re-used backfill, and similarly compacted. Imported backfill material was delivered to the site by West Hampton Properties of Deer Park NY. This backfill was derived from its native location as virgin material and consisted primarily of homogenous sand. West Hampton provided an analytical report of soil from their facility to demonstrate it met 6 NYCRR Part 375 requirements for Unrestricted Use (**Appendix A-5**). OFJV collected additional soil samples to provide characterization for per- and polyfluoroalkyl substances (PFAS), and also to further characterize for Part 375 parameters. West Hampton created four 500- to 750-cy stockpiles for OFJV from the borrow location, and OFJV collected one sample from each stockpile and created a composite sample for analysis for PFAS, volatile organic compounds (VOCs), semi-volatile organic compounds (SVOCs), metals, pesticides, herbicides, PCBs, and total cyanide. The backfill was analyzed to demonstrate it met 6 NYCRR Part 375 requirements for Unrestricted Use, per Table 375-6.8(a) Unrestricted Use Soil Cleanup Objectives. Analytical results for imported backfill are provided in **Appendix A-5**.

Approximately 2,400 cy of soil was imported for backfilling and restoration. Approximately 1 foot of imported fill was placed over the top of the pedestal, and variable thickness ranging from 5 to 10 feet was placed in the excavation over the reused onsite backfill.

Trucks delivering imported backfill to the site were screened at BNL's Vehicle Radiation Monitor (VRM) before being brought on site. The Thermo Scientific SGS-II VRM system is typically used to radiologically screen outgoing material/trash from the BNL facility, as a best-management practice "go/no-go" quality check. Although the VRM system was used on the Stack D&D Project to ensure incoming soils did not introduce radiological contamination to the Stack site, it is noted that the system is not designed to provide a direct measurement method for release under 10CFR835 or DOE O.458.1 requirements. The VRM system was designed for BSA management practices/requirements but was neither designed nor initially intended for application on the Stack project.

When the VRM system boots up, it begins a background collection session prior to deeming itself 'ready for use'. Background data is also collected and updated during periods with no vehicle in the array of four detectors. Alarm thresholds are set by software algorithms in the 'no vehicle' stage, using the difference between the current measurement value and the learned background. The average background at the monitor is usually between 800-1000 CPS, per detector.

Once a vehicle enters, the vehicle will self-shield a significant portion of background, so the alarm thresholds lower to increase the sensitivity of the detection system. When a vehicle passes through the monitor without an alarm, a 'clean' ticket/receipt is generated. If a vehicle alarms the system, a buzzer and light alert the driver and an 'alarm' ticket/receipt is printed. The signage directs the driver to call for assistance. An 'acknowledge alarm' button must be selected to return the system to use after another background check/update.

The "shielding factor", the variable size and shape of different vehicles passing through, and vehicles parked nearby or driving by in close proximity to the system can all contribute to false alarms.

A few of the trucks that passed through the VRM from September 10 to 17, 2021 triggered the alarm, which prompted the BNL Radiation Control Technician to conduct scanning of the planar surfaces of those trucks. In addition to scanning the truck surfaces, the BNL technician also recorded background radiation levels (microR/hr) between the VRM detectors and each vehicle's license plate number. The follow-up surveys indicated normal background dose rate levels. It was determined that the alarms were most likely due to the sensitivity of the portal monitor and its response to the low-level NORM (U/Th/Ra) that is "normal" in regional backfill. Radiation screening results for the imported fill are provided in **Appendix A-5**, along with a BNL Radiation Control Management System document that describes the application of the VRM system. Overall, the radiation surveys for incoming backfill trucks indicated radiation levels were well below 2x normal background levels.

Approximately one foot of soil cover was placed over the remediated pedestal. Surrounding areas were graded to create a uniform surface, and the area was Hydroseeded from September 30 to October 5, 2021. A final topographic survey was completed for the restored area (**Appendix J**).

A walkover survey of the railyard was conducted before any activities occurred to identify potential contamination hazards to OFJV personnel. Throughout the work, there were no open, damaged, leaking, or externally contaminated packages brought from the Stack radiologically controlled area to the rail yard for load-out. No surveys were required to down-post the temporary Radioactive Materials Area that was established solely to control the staging of waste packages otherwise ready for load-out. The haul road and rail yard area were inspected with BNL personnel and were determined to be properly restored.

4.0 FINAL INSPECTION AND CERTIFICATIONS

As described in **Sections 3.8 and 3.9**, the results of both the FSS performed by OFJV and the IVS performed by ORISE demonstrate that remaining residual radioactivity meets applicable release criteria based on independent evaluation of field measurements and sample results data collected using MARSSIM methods and, the results of a post-remedial dose assessment, as defined in the FSP/UFP-QAPP.

Industrial safety and radiological safety precautions were followed through the entire duration of the Project. In addition to prescribed PPE and engineering controls, personnel monitoring was implemented. Project dosimetry data are provided in **Appendix D**.

Work was performed under written and approved work plans and supporting procedures; additional details and outcomes are discussed in the following two sections:

4.1 Industrial Hygiene/Safety Oversight & Monitoring

Industrial Hygiene (IH)/Safety oversight and monitoring was conducted by an on-site OFJV Site Safety & Health Officer (SSHO) in accordance with the Project APP/SSHP. Occupational air monitoring was conducted for non-radiological parameters (e.g., lead, asbestos, and silica dust) during specific work activities. Onsite personnel sampling was compared to the American Conference of Governmental Industrial Hygienists (ACGIH) Threshold Limit values (TLV). There were no lost-work day cases associated with the Project.

For asbestos and lead, 100% of results were below limits established in the Project SSHP. There were occasional measurements of silica on personal monitors above the TLV/PEL in April, June, and July 2021. Personal respirable silica samples collected on April 13 and 14, 2021, during Stack pedestal scabbling activities, indicated one worker had an 8-hour time weighted average exposure to respirable crystalline silica of 45.9 ug/m^3 on April 13 and 1,094.0 ug/m^3 on April 14, which exceeded the American Conference of Governmental Industrial Hygienists (ACGIH) 8-hour threshold limit value of 25 ug/m3 for respirable crystalline silica. The worker was wearing a 3M silicone face piece, half mask respirator with P-100 cartridges while performing the work on both days. The half mask respirator has a protection factor of 10 that provided protection to exposure up to 250 ug/m^3 of respirable crystalline silica, which means that the worker's exposure to respirable silica on April 14 was slightly above four times the level of protection provided by the half-mask respirator. The radiological monitoring of the laborer on both days was below any radiological limits listed in OFJV's Radiological Protection Program and ALARA approach (see below).

OFJV modified the scabbling controls to mitigate future exposures by replacing a larger movable enclosure that had housed the scabbler tool and the worker operating it with a smaller 3-foot by 3-foot secondary containment that housed only the scabbling tool. As noted in **Section 3.5.6**, scabbling was suspended on May 7, 2021, due to overall ineffectiveness and replaced with a wire cut method that produced more efficient concrete cuts and significantly reduced dust emissions. The SSHO also provided oversight and routine internal reporting of non-radiological air emissions monitoring for total suspended particulates (TSP) at the PM-10 threshold, conducted at four locations along the Project work site boundary in accordance with the Community Air Monitoring Program (CAMP). All recorded non-radiological emissions results were below the CAMP limits for TSP (150 µg/m^3) and are presented as charts and data tables in **Appendix E.**

Data summary tables for personnel silica monitoring are provided in **Appendix D**. As indicated on the tables, other recordable events for silica exposure above ACGIH TLV limits occurred on April 22, 23, 26, and 27; June 16, 17, and 18; and July 1, 2021.

After the wire cut method was implemented on June 16, 2021, there was no visible dust observed during the cutting process. The cause for the recordable silica events after June 16 was investigated. The vertical concrete saw cutting is a wet method and created a concrete cutting slurry that was found in droplets on the sampling cartridges and pumps. Since minimal dust is generated by the wet cutting process, it was determined that the detections of the samplers most likely represented particulates that became airborne from water droplets deposited on the workers' samplers and Tyvek after the water dried up. The cutting method was evaluated, and new cutting approaches were added in addition to additional communication for workers to stay away from slurry discharge areas. The highest silica reading for wire cutting events was 177 ug/m^3 (June 30, 2021), which is below the exposure protection value of the half mask respirator (250 ug/m^3).

To confirm that the Stack D&D Project's dust suppression and emission control measures were effective, BNL performed periphery air monitoring surrounding the construction site where stack debris size reduction and handling activities generated the greatest potential for particulates. More detail on BNL's monitoring program for this project and associated results are included as Appendix F and summarized, as follows:

BNL's Industrial Hygiene Department conducted non-radiological sampling during abatement and demolition activities executed by the Stack D&D Project. Sampling was conducted at and beyond the perimeter of the CAMP, for lead and asbestos during abatement as well as silica and nuisance dusts during demolition. All results were below OSHA regulatory limits as well as ACGIH limits.

4.2 Radiological Oversight & Monitoring

Radiological safety and oversight was provided by a Radiological Controls Manager/Certified Health Physicist supported by an on-site Radiological Control Supervisor and up to three Radiological Control Technicians (RCTs). Project radiation oversight was also provided by a USACE Baltimore District Certified Health Physicist. Work was conducted under the OFJV Project Radiation Protection Plan comprised of the following OFJV documents:

- Final Radiation Protection Program (RPP-B705); US DOE HFBR Stack (Bldg 705) Demolition and Decommissioning (July 2020)
- Final As Low As Reasonably Achievable (ALARA) Program (ALARA-B705); US DOE HFBR Stack (Bldg 705) Demolition and Decommissioning (July 2020)
- Final Radiological Controls Manual (RCM-B705); US DOE HFBR Stack (Bldg 705) Demolition and Decommissioning (July 2020)

All radiological work was performed in accordance with the RPP and supporting procedures/permits. A total of nine (9) radiological work permits (RWPs) were issued by the RadCon Manager during the overall Project for activities when supplemental engineering/administrative controls/personal protective clothing were warranted, as a precaution, to maintain contamination control or to maintain overall doses ALARA and within established goals.

Pre-work evaluation of air emissions modeling performed by BNL and characterization data collected prior to and during the initial phases of the Project by BNL and OFJV indicated that thresholds for *individual* worker internal/external dose monitoring from 10 CFR 835.402 were not likely to be exceeded. Therefore, the approved RPP did not include initial or ongoing requirements for individual monitoring, recording, and reporting of internal or external doses unless subsequent routine area/activity monitoring identified an increased dose potential during the Project's execution.

As additional ALARA measures, work was planned to limit worker proximity to any radioactive debris during demolition, handling, and packaging and engineering controls were employed to minimize the generation of airborne radioactivity. The results of radiological monitoring to support Project activities are summarized as follows:

- Prior to demolition, during characterization data gap surveys, elevated dose rates were noted inside the base of the Stack; the maximum observed surface contact reading was 1.3 mrem/hr. The maximum observed whole-body dose rate inside the Stack Base was 0.2 mrem/hr.
- The OFJV pre-planned remote demolition, dust control, and debris handling strategies were effectively used to limit actual worker dose potential. The maximum observed dose rates in worker-accessible areas during demolition, excavation, pedestal decontamination, and handling of associated wastes was 0.100 mrem/h (on contact) and 0.050 mrem/hr (at 30cm distance).
- Disc swipe measurements were routinely collected within and at the boundaries of radiologically controlled areas by Project RCTs in Project work areas to ensure radiological postings were adequate and verify adequacy of contamination/engineering controls. No swipe measurements for removable surface contamination in worker accessible

radiologically controlled areas exceeded the "Contamination Area" posting limits established in the RPP (i.e., 20 dpm/100cm^2 alpha, 1,000 dpm/100cm^2 beta-gamma).

- Personnel who worked under applicable RWPs that addressed potential intake or contamination control concerns were required to "frisk" for indications of elevated activity above background using hand-held contamination survey instruments upon each doffing of protective clothing and exiting from the immediate work area. Zero (0) occurrences of clothing, skin, or facial contamination were reported.
- Materials, Tools, and Equipment used during the Project in radiologically controlled areas were also carefully cleaned, as needed and, monitored for radiological contamination prior to release from the Project work site in accordance with the RPP and associated Laboratory Authorized Limits for Surface Contamination. The exterior surfaces of the abatement wastewater tanks that were loaded within the RCA were surveyed and demonstrated to meet unrestricted release criteria for surface contamination.
- Occupational air sampling for particulate radionuclides was conducted by OFJV RadCon within the OFJV Project fence line at locations in and around intrusive work including at the top and base of the Stack during all demolition and waste handling work and, in and around soil and debris excavation and packaging areas, as follows:
    - General Area (GA) work zone particulate air sampling was conducted using rotary vane style low-volume air samples to verify general conditions, identify possible breakdowns in radiological controls, and verify radiological postings were adequate throughout the Project. Four (4) samplers were located along the perimeter of the Radiologically Controlled Area (RCA) (**Figure 4-1**) with up to four (4) additional samplers strategically placed/moved on daily basis to support radiological work on the Mantis Platform and at the Stack Base. During the course of the Project, a total of 793 GA air sample filters were collected. Based on on-site analysis results, no site worker/visitor accessing the Stack Demo Controlled Area received a cumulative intake exceeding the Project ALARA Goal (i.e., 100 mrem/year).
    - Workers performing intrusive work (i.e., potential airborne radioactivity generating activities) with the greatest internal dose potential wore lapel air samplers to measure particulate radionuclide air concentrations in the worker's breathing zone (BZ). BZ sampling was done using personal air samplers connected via a length of hose to a filter head worn by the worker on/near the shirt lapel. BZ sampling was conducted to verify pre-work dose assessments that indicated that collecting, recording, and reporting of *individual* worker doses would not be required. During the course of the Project, a total of 534 BZ air sample filters were collected. Consistent with General Area work zone sampling results, no site

worker/visitor accessing the Stack Demo Controlled Area received a cumulative intake exceeding the Project ALARA Goal (i.e., 100 mrem/year).

Prior to the start of the Stack Project BNL assessed off-site radiological consequences. This National Emission Standard for Hazardous Air Pollutants (NESHAPs) evaluation was performed in accordance with USEPA requirements (40CFR61 Subpart H) utilizing Clean Air Act Code CAP88-PC, version 4.0.1.17 modeling program. This code is the standard for determining maximum radiological exposures to off-site personnel utilizing a known radiological source term based on existing characterization data. The calculated source term fraction is the amount of radiological material at risk that has the potential to become airborne when engineering barriers and other mitigation factors are not utilized (i.e. no engineering controls are used). This gives a conservative dose-risk estimate to members of the public.

The results of this evaluation provided a conservative estimate of the effective dose equivalent of 0.003 mrem/year to a Maximally Exposed Offsite Individual (MEOSI) at 2,405 meters northwest of the stack. This estimate is well below the 10 mrem/year annual limit as specified in the 40 CFR 61, subpart H.

BNL performed additional periphery air monitoring for radiological constituents surrounding the construction site to confirm that the Stack Project's emission control measures were effective. BNL collected air samples at the site boundary from four (4) existing sampling stations that were analyzed for airborne radioactivity. More detail on BNL's monitoring program for this project and associated results are included as Appendix F and summarized, as follows:

BNL particulate radiation air monitors have been sampling at four locations near the site boundary (See **Appendix F, Figure 3**) for over 20 years. In addition to these monitoring locations, BNL established four stack demolition periphery air monitoring stations outside the project boundary (See **Appendix F, Figure 2**). Air monitoring for gross alpha, beta, and gamma results did not show any evidence that radiological activity was released into the air during stack demolition and captured by any of the monitored periphery or perimeter air samplers (See Appendix F, BSA Stack Demolition Monitoring Summary for more details). Although some background measurements in June 2021 indicated elevated thorium activity in a building north of the site (see **Section 8.12**), BSA confirmed that this was due to activities at the building and not due to the D&D project.

5.0 WASTE MANAGEMENT

The WMP Rev 1 (OFJV, 2020f) provided the management and planning tool for identifying, characterizing, and managing waste streams generated from the activities associated with HFBR Stack D&D project.

There were radionuclides absorbed on the inner surface of the Stack to a depth of up to 3/4-inch. The concentration of radionuclides detected in other project areas were too low to result in significant direct personnel radiation exposure. Based on the characterization of this material as Residual Radioactive Material, transportation to a specialized disposal facility was required. Radiologically and/or chemically contaminated soil and debris was transported on site by OFJV to the established waste staging rail spur and then by rail to WCS, in Andrews, TX in accordance with the federal, state and local regulations. The major applicable regulations for this project were:

- Toxic Substances Control Act (TSCA), 15 USC 2605
- USDOE O 435.1, Radioactive Waste Management
- USDOE M 435.1-1, Radioactive Waste Management Manual
- 10 Code of Federal Regulations (CFR) 20; Standards for Protection Against Radiation, and Transfer and Disposal and Manifests
- 49 CFR - Transportation
- 40 CFR - Protection of Environment
- USDOE O 458.1, Radiation Protection of the Public and the Environment
- USDOE O 460.lD, Hazardous Materials Packaging and Transportation Safety
- USDOE O 460.2A, Departmental Materials Transportation and Packaging Management
- USDOE M 460.2-1 A, Radioactive Material Transportation Practices Manual
- Article 12 of the Suffolk County Sanitary Code

5.1 Waste Generation

5.1.1 Stack Exterior Coatings

Low-level waste containing polychlorinated biphenyls, ACM, and lead were managed in accordance with requirements specified in TSCA, as amended, and the USDOE O 435.1, Radioactive Waste Management Manual (USDOE O 435.1-1, 2007).

Asbestos and lead-containing coatings were removed from the exterior of the Stack prior to commencing demolition. The coatings were removed using a coating abatement technology that removed and contained coatings in a single process, thereby eliminating multiple handlings of the waste streams.

5.1.2 Structures Demolition

The demolition of the Stack and its various above ground and below ground structures (exterior Stack structures, silencer, drain tank, piping, ducts) produced approximately 2,800 tons of concrete and steel debris that was placed into IMCs at the Stack work site and transported by truck to the BNL rail yard (**Table 5-1**). IMCs were staged at the rail yard until lifted and loaded to rail cars for shipment to WCS.

5.1.3 Soil Excavation

Approximately 2,139 tons of impacted soil surrounding the Stack was excavated and disposed off site (**Table 5-1**). The impacted soils were excavated and placed into soft-sided containers at the Stack work site and transported by truck to the BNL rail yard, where the sacks were staged until loaded to rail cars for shipment to WCS.

5.1.4 Generated Liquid Waste

Coating abatement on the exterior of the Stack produced wastewater. The coating and water were piped to a vacuum box lined with an asbestos approved bladder bag. During periods of the abatement, the wastewater was run through a series of filters, finally passing through a one-micron bag and then a cartridge filter. Following filtration, the water was tested and evaluated against BNL 's State Pollutant Discharge Elimination System (SPDES) permit limits.

The containerized abatement wastewater contained low-level radiological constituents that required the water and residual solids (sludge) to be disposed as LLRW at WCS. The water and solids collected by the abatement process were transferred to holding tanks within the RCA, and the tank loading area was included in the FSS. Approximately 14,400 gallons of abatement wastewater and approximately 25 cubic yards of residual solids were containerized in tanks in a designated Rad Management Area (RMA) at the Stack site under OFJV RadCon. The tanks were sealed and had secondary containment.

Samples of abatement wastewater were analyzed for chemical and radiological constituents to determine proper means for disposal. It was initially planned to filter the wastewater on site and discharge for disposal at BNL's treatment plant. Analytical results indicated the presence of radiological constituents in the wastewater that prohibited discharge to the BNL treatment plant or other POTW. Accordingly, the abatement waste was sampled for further analysis to support waste profiling and disposal at WCS as LLRW. Analytical results are summarized on **Table A-6.1** in **Appendix A-6**.

5.2 Waste Characterization

Stack D&D wastes were characterized to classify the waste streams for compliance with applicable disposal facility license, permits, and associated waste acceptance criteria. The WMP (Rev 1) (OFJV, 2020f) contained a complete analysis of available characterization data related to the radionuclide content in the two independently evaluated waste streams. Based on bounding analysis, 100% of wastes met criteria for final disposition in the WCS Low Activity (RCRA) Waste Cell using their established RS 5.0.0 Process.

The WMP also included waste profile details for WCS for the following contaminated waste streams:

- Stack Exterior Wastes
- Stack Demo Debris (Primarily Concrete and Metal)
- Soils & Solidified Wastewater

Waste profiles were developed for each waste stream identified during characterization. Generally, waste was characterized as low-level radioactive waste (LLRW), CERCLA, and Toxic Substances Control Act (TSCA) waste (asbestos-containing material [ACM]).

A separate waste profile was developed for wastewater and solids generated by asbestos abatement of the Stack. Laboratory analysis of abatement wastes indicated that it would also require disposal as LLRW. A waste profile was prepared for disposal at WCS based on the analytical results, which are summarized on Table A-6.1 in Appendix A-6, along with the laboratory analytical results.

5.3 Waste Containerization and Shipment

5.3.1 On-Site Movement of Waste Packages

Empty waste containers, including IMCs, were staged in the receiving area of the satellite rail loading spur that terminated at Brookhaven Avenue within the Lab's overall boundaries. Containers were transported to and from the Stack D&D site via the pre-designated Haul Road **(Figure 3-2)** approved by the Lab and was overseen by OFJV RadCon staff to ensure protection of personnel and maintain control of radioactive materials during on-site movements between work areas. BSA allowed OFJV to use the parking lot at Building 801 for temporary staging of empty IMCs when space in the Stack D&D Controlled Area was not available, to facilitate the loading and hauling process from the site to the rail yard. When used for staging, the Building 801 lot was roped off with signage.

Filled containers that were transferred from the Stack D&D Controlled Area to the satellite rail spur (IMCs, soft-sided soil bags, and IBC totes) were covered prior to movement. Packages were cleaned of visible dirt and surveyed for compliance with RPP contamination limits prior to on-site transfer.

The material moved to the rail spur for loading did not meet the USDOT definition of Hazardous materials (HAZMAT).

Waste packages were screened for USDOT Class 7 determination at the Stack D&D Work Area during contamination/radiation surveys conducted per 49 CFR 173 or the RPP. USDOT Class determinations were made by scaling radionuclide content based on cesium-137 gamma response during measurements using non-destructive gamma measurements collected by RadCon personnel.

The loading of waste packages to the rail cars involved mobilization of a Liebherr LTM1220-52 crane to the railyard for lifting packaged waste onto ABC rail cars and gondolas. The IMCs were rigged in accordance with the approved lift plans and placed on the appropriate rail cars. A manifest was prepared for each shipment in accordance with waste shipping requirements.

Wastewater and solids from the Stack asbestos abatement was stored on site in secure containers with secondary containment prior to off-site disposal. There were three 25-cy containers that contained water; three 25-cy containers that contained primarily concrete millings and paint chips from the exterior of the Stack, with small amounts of water; and one 20-cy roll off container that contained bagged dry abatement equipment waste and PPE. Following WCS acceptance of the waste profile for this material, it was transferred to trucks for off-site transport and disposal at WCS.

The abatement wastewater was transferred from the on-site containers to tanker trucks, and solid materials were transferred from on-site containers into super sacks that were loaded on flatbed trucks. A small portion of solid material that had trapped residual water was left in the on-site containers to eliminate the potential for water to be released during transfer. These containers were directly loaded to flatbed trucks for off-site transport.

On-site waste transfer activities were monitored by OFJV RadCon staff, who maintained radiological control measures per the *Radiation Protection Program* (OFJV, 2020m). The transfer process utilized hoses with camlock fittings and gaskets that were visually inspected and secured to prevent loosening during transfer operations. Plastic sheeting and/or absorbent pads were also secured at each connection location, and a spill tray was placed below each hose run for secondary containment. There was no release of abatement waste during transfer activities. The empty tanks and equipment were screened for release following the waste transfer, and disposable equipment that was not released was included in the containerized shipment.

On February 3, 2022, following the final waste shipment off site, OFJV RadCon notified BNL that all Project radiological control areas had been down-posted and the Project RPP was no longer in effect anywhere on site.

5.3.2 Waste Transportation and Disposal

OFJV utilized the New York & Atlantic (NY&A) Railway as the carrier for shipping wastes by rail. Shipping and disposal documentation and preparations complied with USDOT and Site disposal requirements. Based on the calculated activities the waste material for the project was not regulated for transport as HAZMAT. Transportation arrangements were made by Environmental Rail Solutions, Inc. (ERS).

The waste material was disposed at the WCS facility in Andrews, TX. The conservative bounding analysis concluded that that all waste packages met criteria under the RS 5.0.0 Process. The WCS process and disposal in their RCRA landfill has an Authorized Limit determination from USDOE Headquarters (see letter from USDOE to WCS dated January 07, 2019, Attachment 3).

Outgoing shipments were loaded and secured, compliant with USDOT load securement requirements, before leaving the designated load staging areas. Desiccant was included in the shipments to assist in the prevention of any free liquids accumulating during shipping; one half bag of desiccant was added to each debris IMC during loading.

NY&A moved the gondola cars on the LIRR system tracks from the BNL siding on the Main Line to the NY&A facility in Fresh Pond. From Fresh Pond Yard, the rail cars were transferred via the interchange track to the CSX Freight Rail operation. CSX Rail transported the rail cars over the Hellsgate Bridge on Metro North Railroad's track to WCS Andrews.

For all waste shipments by rail from the BNL Stack Project (regulated or not) notifications to local Office of Emergency Management (OEM) (New York City, Nassau, Suffolk) were made two weeks in advance as well as on the day of shipment. New York City OEM was also notified whenever a shipment left the Hellsgate Yard.

Rail transport of materials was performed in accordance with 49 CFR 174.700. The signed documents were provided to WCS via upload to the ECS "Elite Access Customer Portal" and by email and arrived at WCS prior to receipt of the rail shipment.

The liquid asbestos abatement waste was shipped by three 4,800-gallon tanker trucks to WCS. Three of the on-site containers that contained abatement solid wastes with residual trapped water were also shipped to WCS by a flatbed truck, along with solid material that was transferred into 5 cubic yard sacks. All transporters were DOE MCEP approved carriers with 381 and 364 permits to transport radioactive waste in NY and trailer tags for shipment to the WCS facility.

Waste shipment documents are provided in **Appendix I**. **Table 5-1** summarizes the waste shipments to WCS for the project.

Table 5-1 – Waste Shipment Summary

Shipment # / Date	Inventory	Tons
1 – March 6, 2021	Debris in IMCs	1,381.09
2 – May 15, 2021	Debris in IMCs	832.41
	Soil in supersacks	705.41
	Solidified water in totes	17.66
3 – June 19, 2021	Debris in IMCs	299.06

	Soil in supersacks	709.76
	Solidified water in totes	9.42
4 – August 29, 2021	Debris in IMCs	268.9
	Soil in supersacks	725.42
	Solidified water in totes	25
5 – December 2021	Abatement liquid waste (gallons)	14,385
	Abatement solid waste	39.63
	Total Tons	5,013.09
	Total Gallons	14,385

6.0 LONG TERM MANAGEMENT

The BNL Land Use Controls Management Plan (2013) and the Land Use and Institutional Controls Fact Sheet/Map will be revised by BSA's Groundwater Protection Group to reflect demolition of the HFBR stack and associated underground structures/utilities, current site conditions and post remediation surveillance and maintenance activities for the HFBR grounds. The BNL site utility drawings will also be updated. The Surveillance and Maintenance (S&M) Manual for the High Flux Beam Reactor (HFBR) Grounds & Stack (2018) will be discontinued, and this information will be added to a revised S&M Manual for the HFBR. The S&M manual update will include discussion of applicable institutional controls including access, land use, notifications and restrictions, and administrative controls such as work planning, digging permits, and government ownership. In addition to maintaining institutional controls for the area, BSA will ensure that routine inspections and maintenance are performed. There will be no changes to the institutional controls as identified in the HFBR Record of Decision (ROD) as a result of the stack demolition and removal of ancillary structures and contaminated soil. Inspection and maintenance activities as required by the HFBR Grounds and Stack S&M Manual such as stack and silencer inspections and paint chip collections will be eliminated. As noted, the Grounds & Stack S&M Manual will be discontinued. As required by the ROD, LUICs will continue to be maintained until the hazardous substances reach levels that allow unlimited use and unrestricted exposure.

7.0 PROJECT COSTS

7.1 Base Contract

The original contract award costs were:

Scope Item	Contract Cost
1. Project Management	$2,191,273
2. Work Plans	$226,913
3. Demolition and Soil Remediation	$5,379,130
4. Waste Transport	$2,551,278
5. Waste Disposal	$1,368,577
6. Closeout Report and Project Closure	$17,370
7. Performance Bond	$139,471
8. Contract modifications	$202,130.38
Total Contract Cost	**$12,076,122**

7.2 RFP for Task Order Modification (October 4, 2021)

USACE issued an RFP on October 4, 2021, that requested a cost estimate for the following additional work elements that were completed for the project but determined to be out of scope of the original SOW. OFJV provided a proposal on October 13, 2021, that provided a cost estimate for the following:

- Pre-mobilization & COVID-19
- Abatement and Demolition
- Sunday work
- Excavation & Subsurface Structure Removal
- Pedestal Remediation
- Waste Management

USACE is currently reviewing the cost estimate and intends to enter into negotiations with OFJV upon completion of its review.

8.0 CHALLENGES AND LESSONS LEARNED

8.1 COVID-19 Pandemic

Lessons Learned Statement: The original Scope of Work for the project, as presented in the RFP, established a contract completion date of March 31, 2021, with a critical milestone requirement that the above ground Stack demolition be completed by no later than September 30, 2020. The COVID-19 pandemic prompted a BNL shut down in March 2020 that delayed the start of field work. In addition, the pandemic also created risks to personnel availability due to interstate travel restrictions, and supply chain shortages emerged, in particular for PPE, which further jeopardized the September 30, 2020, milestone.

Discussion: After BNL reopened in June 2020 and OFJV mobilized to the site in July 2020, OFJV focused efforts towards streamlining and expediting work progress to regain lost schedule. However, a number of other unforeseen and uncontrollable events occurred after mobilization that slowed and/or interrupted field work and severely impaired OFJV's capacity to control and expedite work. These risk events were communicated by OFJV to the project team as they occurred, with follow up discussion during weekly teleconferences and monthly status reports. The single greatest risk event related to the weather; the abatement and demolition phases that had been designed as a 4-month summer program to be completed by September 30, 2020, could not start until August, which negatively impacted productivity and caused the bulk of the demolition phase to extend into winter months.

Schedule impacts prompted discussions between OFJV and USACE about modifying the contract milestone dates and extend the contract POP. USACE also requested a Response Action Plan from OFJV to describe how it intended to mitigate the schedule impacts (OFJV, 2021).

Lessons Learned Recommendation: The above events underscore the need for (1) rigorous communication and (2) management of the project baselines (e.g. cost, schedule and scope).

- **Communication:** Rare force majeure events, such as the COVID-19 pandemic, can trigger immediate and large-scale schedule, logistical, and cost impacts that can place contract objectives at very serious risk. Early and frequent discussion between stakeholders provided a means to identify and manage the risks and establish appropriate cost and schedule recovery strategies. OFJV communicated COVID-19 schedule and cost impacts to USACE during the initial planning months of the project, which provided USACE opportunity to inform DOE and USEPA/NYSDEC on behalf of DOE, providing the stakeholders an opportunity to review priorities and objectives.
- **Baseline Management:** COVID-19 created events noted above that impacted the project baselines for cost and schedule. However, decisions to implement response actions were driven primarily to maintain performance against the baseline schedule, with less consideration of performance in relation to cost, creating at-risk work for the contractor. It is recommended that budget contingencies be more accessible to re-baseline project costs to support response actions that carry a cost risk.

8.2 Rail Inspections

Lessons Learned Statement: BSA was contractually responsible for inspections and repairs of the rail spur and rail yard area. Rail inspections and repairs were predecessors for delivery of the IMCs, and IMC delivery was a predecessor for the Stack demolition to begin. BSA completed inspections and repairs for tracks within the BNL property line in a timely manner to support the delivery of the IMCs. However, there were sections of tracks on the rail spur, outside BNL property, that also required clearing. In order for BSA to clear the tracks and conduct any repairs on sections outside BNL property, a permit was needed from LIRR. LIRR issued a permit to BSA on 27 October 2020, but BSA attorneys determined that permit language regarding insurance certification and indemnification posed a risk to BSA. The railroad spur could not be cleared by BSA until the permit was issued.

Discussion: BSA initially discussed with LIRR to determine if LIRR could clear the tracks for repair. LIRR declined because they do not own the spur. BSA then sought direction from DOE to mitigate that risk and to meet the permit's insurance requirements. The following actions were identified as potential solutions:

- DOE would evaluate whether it could provide indemnification and certificate of insurance as required by the permit.
- OFJV would investigate if it was feasible to transport IMCs to the site by truck. This option would add cost to the project.
- BSA would determine if it could hire their own subcontractor to clear the spur as an emergency requisition.

Of the potential solutions considered, BSA's hiring of an independent subcontractor under emergency requisition was the chosen solution because it provided the best approach for mitigating risks:

- financial risks to BSA posed by the indemnification,
- critical schedule risk to source and ship IMCs to the site by truck,

BSA hired a contractor, and the track was cleared and subsequently repaired to support rail car delivery.

Lessons Learned Recommendation:

- Communication: Communication between OFJV project team and BSA: Had OFJV coordinated with BSA to start the permit application process earlier, the liability concerns in the LIRR permit would have been exposed, giving more reaction time to keep the permit process off the critical path for IMC delivery. This could have been achieved by more active communication between OFJV and BSA during the abatement phase of preparatory needs for the demolition phase.
- Project Planning Risk Analysis: The clearing of the tracks was a time-critical task that was

subject to control and influence of the LIRR, which as an independent privately-owned entity was neither a project stakeholder nor under any direct stakeholder control or influence. Recognizing such entities early in the planning process can provide an opportunity for stakeholders – in this case OFJV and BSA – to coordinate as noted above.

8.3 Track Separation and Derailment at Rail Yard

Lessons Learned Statement: On Saturday 1 May 2021, an articulating bulk container (ABC) rail car was loaded with 6 filled intermodal containers (IMCs) at the BNL the rail yard. The car was linked to several other rail cars that had been previously loaded with IMC. After loading, a track mobile machine was utilized to push the linked rail cars to a bumper at the end of the tracks approximately 400 feet away from the loading area. Upon impact with the bumper a small section of track separated and caused one wheel of the ABC car to fall off the end of the track. Aside from a portion of the chain link fence that borders the rail yard, separated track, and bent train bumper, there was no equipment or property damage, and there were no injuries to any personnel.

Discussion: The track mobile machine moved the ABC car at walking pace toward the train bumper at the end of the tracks, as had been done previously to position the rail cars within the loading area. In this case, as the ABC car was moved along the rail towards the bumper, it came to a point approximately 200’ before the bumper where the rail begins to slightly descend. Although the train brakes and track mobile breaks were applied to control the slow descent of the ABC car at a walking pace toward the bumper, the force of impact with the bumper was still sufficient to cause a small section of track to separate. Upon review of the safety control measures that were used – namely the track mobile and train brake systems – they were determined to be functioning as intended and had been previously effective at controlling and stopping the ABC cars.

A train services company (The Anderson’s Inc.) put the ABC car back on the tracks on Tuesday 3 May 2021 and inspected the track. It was observed that the seam of the rail had been secured by only two of four required bolts. A 9.5’-long section of the rail was removed and a new bump stop was installed in accordance with the manufacturer’s recommended specifications at a location approved by BSA. Installation was inspected and approved by NY&A.

Lessons Learned Recommendation:

- Reduce velocity of filled ABCs: Although the brake systems were effective at controlling ABC car to maintain the same walking pace speed that was previously used to position the cars, the added mass of the cars combined with the gentle slope of the last 200 ft of rail toward the bumper increased the force of impact. Accordingly, it was determined that the safety controls were effective but needed to reduce the speed of car movement to prevent future similar incidents.
- Reduce acceleration of filled ABCs: In addition to maintaining lower velocities, acceleration of the cars along the sloped portion of the track can be controlled by moving

cars in stepwise fashion over small incremental distances. OFJV added two pre-full stop break checks as loaded ABC cars were moved along the tracks. Each loaded ABC car was brought to a complete stop two times before stopping to link to other cars or stop for storage. This pre-stop check verified the brakes were working properly and the cars could be slowed and stopped in an acceptable manner. The planned stops offset the increased mass of the filled ABCs to keep the force of impact to a minimum.

- Conduct more thorough rail pre-inspections: Pre-inspections of the track prior to rail car delivery by BSA did not report that the track that separated was connected to the adjacent track using two (2) bolts instead of four (4) bolts as required. Also, a visual examination of the train bumper after the incident indicated extensive corrosion that possibly diminished its ability to function as intended.
- Designated signal team meeting: OFJV began conducting short review meetings before each ABC and gondola movement. This short meeting reviewed protocols for the designated operator and signalman tasked with moving the rail cars. The movement team maintained communication during rail car movement.

8.4 Emissions Control

Lessons Learned Statement: OFJV was notified by BNL on the morning of 22 September 2020 that a BNL employee had found that their vehicle parked at Bldg 901A, south of the Stack, appeared to have white water spots on it that the employee suspected was related to paint abatement work being conducted on the nearby HFBR Stack.

A representative from OFJV subsequently visually examined all vehicles in the Bldg 901A parking lot and observed water residue spots on several vehicles. OFJV then checked wind direction data, which showed prevailing winds from the north on the previous day, thereby opening the possibility that the water spots could have originated from water droplets transported by wind from Stack abatement activities conducted on September 21, 2020.

Discussion: The paint removal process used a closed loop water injection system to minimize process emissions. However, it is possible that passing winds can pull water droplets off the stack during the cleaning process. Because the observation of water spots on cars in the parking lot emerged after work elevation exceeded 180 feet above grade, the wind capture of water droplets off the Stack seems likely to be dependent on height as well as wind speed. Moreover, changing wind direction opens the possibility that other areas around the Stack could be similarly impacted as heights are reached.

Outdoor demolition efforts of any sort have potential for small emissions, even utilizing best available technologies such as the methods being used. The OFJV team utilized a closed-loop wet method of dust mitigation and wet slurry vacuum capture. The windy environment at height created potential for some effluent to be transported away from the Stack. However, the fact that a small amount of water could be potentially emitted from the wet method process, and then potentially become airborne by wind, did not necessarily mean it was hazardous or capable of depositing appreciable contamination by particulate deposition. This is why real time PM-10 particulate monitoring was conducted at the CAMP boundary to identify offsite fugitive emissions above action levels.

In addition, BNL conducted its own sampling in other areas beyond the CAMP boundary. Camp boundary PM10 monitoring, confirmatory CAMP sampling, asbestos zone perimeter sampling, and personnel sampling for lead and asbestos showed very low levels of contaminant mass that was well below regulatory limits and very low PM-10 measurements of particulate density far below action limits in onsite screening with correlated analytical results. These real time measurements were conducted continuously each workday and provide a high level of knowledge and confidence about the nature of airborne materials at the job site.

Upon discovery of the incident, the following measures were taken:

- OFJV worked with BSA to block off impacted parking spots.
- OFJV temporarily suspended operations that included the use of water while it evaluated feasible control measures to reduce windborne transmission of water droplets. OFJV immediately undertook certain measures to improve system suction and thereby increase capture of generated water. It determined that during the work conducted on 21 September, a hose associated with one of the wall cleaning tools collapsed due to suction. This may have reduced system suction and allowed the release of some water. The hose to that particular tool was replaced and the diameter of the hose was increased from 2" to 3" with a reinforced hose to eliminate the collapse potential and allow for more volume of suction to that tool.
- OFJV inspected the affected vehicles in the Building 901A parking lot and provided the owners of impacted cars to receive a free commercial car wash.

Lessons Learned Recommendation:

- Lessons Learned from previous similar projects should be reviewed as part of the project planning process. Responses to potential events should be captured in the Project Contingency Plan prior to start of work.
- In response to this specific event, OFJV prepared a Response Plan that described actions taken by OFJV to mitigate potential off-site impacts to adjoining property from windborne transmission of water droplets generated by ongoing coating abatement activities at the HRBR Stack. Actions included:
    - Daily: The USACE-OFJV team would review the weather forecast (especially predicted wind direction and speed), and every afternoon will advise BNL on parking lots that could be affected by abatement water drift. The cars affected by the incident described above were just over 100 yards from the Stack. Depending on wind speed, wind direction, and the planned elevation for work on the Stack, OFJV will consider all parking areas that could reasonably be predicted as potentially affected by water droplet drift.

- Weekly: The USACE-OFJV team would process reimbursement requests for car washes for any cars identified as hit with water droplets from coating abatement activities.
- Adding an additional set of brushes to the cleaning tool exterior.

8.5 Unforeseen Radiological Contamination of Stack Cap

Lessons Learned Statement: As indicated in the WMP, the exterior of the Stack was not known to be radiologically impacted and was not posted or otherwise radiologically controlled by BNL. During the period of transition of Stack work area control to OFJV, the BNL RadCon Manager communicated that known radiological hazards were limited to the interior surfaces of the Stack. As a confirmation, during the data gap characterization efforts spot checks were performed on the Stack exterior at ground level with no elevated surface radioactivity identified.

Based on the available data and past radiological controls by BNL, the initial coating removal on the exterior had limited radiological controls (i.e., periodic spot-checking of worker PPE and hand tools for signs of removable contamination and pre-work verification contamination screening of coating scrapings collected as the work platform progressed up the Stack at surfaces that would otherwise be inaccessible). During coating removal, OFJV RadCon conducted field radiological surveys to verify conditions including on-site screening of coating samples for gross alpha-beta as work progressed. Based on available historical data, consultation with the BSA RadCon Manager regarding their access practices for routine maintenance, and surface contamination measurements and media sample results collected from the accessible areas of the Stack exterior during the characterization data gap effort, the primary health & safety concerns for initial coating removal on the exterior were focused on asbestos and lead. Additional radiological controls were limited to radiological safety training for coating removal personnel; periodic spot-checking of worker PPE and hand tools for any indications of elevated residual radioactivity warranting implementation of a radiological work permit with additional controls and monitoring requirements and; RadCon contamination screening of pre-removal test scrapings provided by the removal work crew as they progressed up the Stack.

On 5 November 2020 Stack coating radiological measurements were taken at above grade elevation 317 ft that exceeded initial screening limits:

- Max readings: alpha- 105dpm/100cm2 beta/gama- 13,206 dpm/100cm2
- Avg readings: alpha- 51 dpm/100cm2 beta/gama- 4,325 dpm/100cm2

In accordance with the RPP, coating removal/cap abatement activities were paused by OFJV to ensure response elements of the RPP were in place to continue.

Discussion: The surface contamination was associated with particulates adhering to the highest elevations of the Stack. When surface activity was detected at above grade elevation 317 ft, full rad controls were implemented for the remaining demo set-up work including RPP, PPE, personnel frisking and air sampling, and careful pre-decontamination of those limited contaminated surface points at the top that required cutting or drilling to remove the cap and secure demo equipment. It was further determined by OFJV RadCon that:

- There was no evidence of contamination release in connection with this discovery or the work that was completed. The coating scrapings were collected in a manner to prevent cross-contamination and were scanned with survey instruments under the assumption that all the activity is affixed in the coating. Once the coatings were collected and scanned, work was halted until contamination/airborne controls and associated monitoring could be implemented.
- The need for bioassay testing of individual workers was not triggered by this discovery. The OFJV RPP calls for bioassay if individual worker doses are expected to exceed 100 mrem and that the air samples collected to date have been well below that standard.

OFJV submitted an adjusted work approach to remove the cap in accordance with RPP requirements:

- encapsulating the cap and the coating down to 3 ft from the top of the Stack,
- abatement of proposed cut lines with a needle gun and HEPA filter while wearing appropriate PPE and a particulate radionuclide lapel air sampler, and
- cutting and removing cap using appropriate PPE, lapel air sampler, and a torch or grinder.

The cap of the Stack was abated on 15 November 2020 in accordance with adjusted removal approach that was submitted via RMS. The cap was removed on 16 November 2020. All air results were less than 2% DAC (ALARA Goal).

Lessons Learned Recommendation:

- RadCon programs need to be comprehensive and robust enough to address potential risks and contingencies. They should therefore be developed with consideration of lessons learned from previous similar projects as well as an evaluation of potential project-specific risks during the RFP process.
- The OFJV RadCon program was functioning as intended: The above detection and response demonstrates that the program worked exactly as it should. The surveys being performed to verify non-radiological conditions during the exterior coating removal work identified the hazard before they were disturbed; this prevented the cross-contamination of the BlazerVAC coating removal system/wastes. There was a slight delay as the team complied and communicated the information, but this enabled the field team to communicate and respond effectively in accordance with established protocols, thereby minimizing more significant schedule impacts and avoid safety and environmental impacts, while standing up the necessary rad controls to permit the Mantis set-up to safely resume with appropriate radiological controls consistent with other upcoming Stack demo tasks.

8.6 Vibrations

Lessons Learned Statement: Questions and concerns were raised by occupants of Building 901A about the impact of demolition vibrations on their sensitive instrumentation – Tandem Van de Graaff – and if it would be possible to install an additional vibration monitor inside the building. OFJV discussed logistics of placing an additional vibration monitor inside Building 901A, its purpose in relation to the project, and held a conference call with the building occupants to clarify their questions, concerns, and needs. OFJV provided USACE with a proposal with cost estimate to install an additional vibration monitor inside Building 901A as a contract modification since it was not a requirement of the project's vibration monitoring program. USACE was in the process of evaluating the OFJV proposal to modify the contract, but the Stack demolition phase of the project was completed before this process was completed, obviating the need for the additional monitor.

Discussion: Background vibrations were routinely recorded in the absence of any demolition activities, and routinely above the established thresholds at certain Building Seismic Stations (BSSs). In accordance with the Statement of Work (SOW) and the approved Vibration Monitoring Plan, Ground Seismic Stations (GSSs) within the Stack work zone provide actionable data for alerts to BNL, BHSO, USACE, and OFJV. Building Seismic Stations (BSSs) have also been set up in accordance with the SOW adjacent to several nearby buildings outside the Stack work zone. The BSSs provide data that can be cross-checked against GSS data alerts to determine if any onsite GSS events have produced vibrations above established building-specific thresholds near any particular BSS.

The Vibration Monitoring Plan identified response actions based on decision rules to manage vibration events related to site work. It also provided a way to discern background vibrations unrelated to site work (and therefore not actionable) for vibrations related to site work (and therefore actionable). The project stakeholders discussed the design and purpose to the vibration monitoring program in those terms and agreed that vibration data from an additional monitor inside Building 901A would provide data for information purposes only, but otherwise the decision rules established in the Vibration Monitoring Plan would still be relied upon to identify vibration events requiring evaluation or response by the project team.

Lessons Learned Recommendation:

- Early identification and engagement of stakeholders. The Tandem Van de Graaff at Building 901A was identified in the Statement of Work and project planning documents as a particularly sensitive building in relation to vibration monitoring. Project requirements and the scope of activities were clearly defined, documented, and conveyed to designated project/facility stakeholders involved in work planning, work review, and work execution. Although there was common understanding of the work requirements and stakeholder subject matter experts had been properly engaged, concerns from Tandem Van de Graaff staff were raised after planning documents had been approved and work was underway and prompted consideration of additional project requirements. Ultimately, the event had no measurable impact on the project schedule or scope, since there was no requirement to pause demolition work as the matter was considered, and the demolition phase was completed before the matter could be resolved. However, early proactive engagement would ensure that work scopes are clearly understood by all involved parties with potential influence over the work.

- Effective communication. BSA's communication program was effective at responding to technical inquiries from BNL occupants in accordance with good faith conduct of its operations practices. BSA ensured that inquiries were delivered to appropriate project points of contact and clearly understood by all parties involved.

8.7 Silencer and Stack Base Debris Stockpiles

Lessons Learned Statement: The Demolition Work Plan stated that debris would be live loaded into IMCs. However, the first delivery of IMCs to the site was delayed until early December. To proceed with demolition of silencer and acoustical reflector, OFJV needed to temporarily stockpile the demolition debris on-site.

Discussion: Demolition of the Stack silencer walls was a necessary precursor to mobilization of the crane to install the Mantis on top of the Stack. Coordinating rail shipments of IMCs to the site proved to be one of the biggest logistical challenges faced by the project team. Because of the planned method to live load debris to IMCs, the completion of time-critical demolition tasks became subject to an involved administrative process of rail permitting, inspection, and repairs; and a national operations schedule of privately-run rail systems with regional priorities that favored commuter schedules over freight deliveries.

An alternate approach was adopted to allow stockpiling of debris so the Stack silencer walls could be demolished prior to arrival of the IMCs. Concrete debris was placed on a double layer of reinforced 6 mil poly material and covered with the same poly material. Sandbags were placed on top of the covered debris in a manner to sufficiently hold the cover in place and protect from high winds. Additional protection against migration was provided by surrounding the pile with sediment migration barrier (9" straw wattle).

Upon receipt of IMCs the material was transferred to IMCs in accordance with the accepted workplan.

Lessons Learned Recommendation:

The reliance on rail transport created logistical uncertainties that should have been captured as a known unknown on the project risk register. This recognition should have prompted contingencies to be identified early in the planning process to enable alternative methods to be implemented as quickly as possible. Although proper alternatives were identified and implemented, pre-project contingency plans can avoid potential disruptions to the schedule from evaluations, discussions, and approvals.

8.8 Worker Silica Exposure

Lessons Learned Statement: There were occasional measurements of silica on personal monitors above the TLV/PEL in April, June, and July 2021, during the pedestal remediation. This required an evaluation of potential causes and an adjustment of controls to mitigate.

Discussion: When elevated silica readings were detected on personal monitors during scabbling in April 2021, OFJV modified the scabbling controls to mitigate future exposures by replacing a larger movable enclosure that had housed the scabbler tool and the worker operating it with a smaller 3-foot by 3-foot secondary containment that housed only the scabbling tool.

Wire cutting was adopted by the Project team in June 2021 as an alternative method to complete the pedestal remediation after it was determined that the original scabbling method was not effective to remove contaminated concrete discovered at depths beyond one inch. Elevated silica readings after the wire cutting process was implemented were also investigated. Since minimal dust is generated by the wet cutting process, it was determined that the detections of the samplers most likely represented particulates that became airborne from water droplets deposited on the workers' samplers and Tyvek after the water dried up. The highest silica reading for wire cutting events was 177 ug/m^3, which is below the exposure protection value of the half mask respirator (250 ug/m^3). The cutting method was evaluated, and new cutting approaches were added in addition to additional communication for workers to stay away from slurry discharge areas.

The site monitoring and management process worked for these events, as it identified the issues and communicated the need for adjustment to mitigate potential risks. Work was properly paused, the situation evaluated, relevant facts identified, and effective mitigative measures were put into place.

The modified controls adopted to mitigate silica during the scabbling process were not effective for the alternative wire cutting method that was substantially different from scabbling. The Project team did conduct an overall review of relevant SOPs, site controls, and health and safety measures for the wire cutting process, and a work plan was prepared for the approach. The cutting process was a wet method with built-in dust controls to minimize exposure to respirable silica particulates. Although the aqueous slurry it created was not respirable, it was still measurable to the personal monitors that were designed to measure dry particulates.

Lessons Learned Recommendation: When alternative methods are adopted for a project that are significantly different than the original approach, they may occasionally create a new condition that impacts controls and/or monitors, in unforeseen ways, that were not designed to measure that condition. In this case, personnel monitoring became a critical issue. To manage the introduction of new risks to the project, the wire cutting contractor provided an AHA to identify potential hazards in relation to the wire cutting methods and necessary controls to manage risks. The AHA did not identify any work elements that carried a risk that could not be properly managed by the controls in place. However, the importance of personnel monitoring, combined with experience and foresight regarding the function of personnel monitors during a wet slurry process, warranted more rigorous attention to the possibility that the wet method might trigger detections that did not represent respirable exposure.

8.9 Silencer Footers

Lessons Learned Statement: During silencer removal OFJV identified a concrete foundation footer (Footer A) approximately 2 feet below the former silencer floor and a second footer (Footer B) further west where silencer duct had connected with a previously removed duct. OFJV informed USACE, DOE, and BSA of this discovery, and it was determined that the western Footer B was a remnant of the Building 704 plenum that was previously removed and was connected by concrete bracing to Footer A below the silencer. OFJV exposed Footer A to complete a radiological screening, which indicated Footer A concrete was contaminated. The unexpected presence of contaminated concrete meant that an FSS could not be performed unless the impacted concrete was removed. The footers were not identified as structures to be removed or remediated under this project, and since they were contaminated meant that OFJV would have to enlarge the soil excavation to remove the impacted concrete in order to complete the FSS and ORISE verification. OFJV discussed with the stakeholders that the additional effort to remove impacted footer concrete and additional impacted soil surrounding it would have a schedule and cost impact to the project.

Lessons Learned Recommendation: The previous Final Closeout Report for HFBR Fan Houses (704 & 802) (BSA, 2011b) reported that the footers were close to meeting background and were left in place.

The Final Closeout Report for the Stack Silencer Baffles and Remaining HFBR Outside Areas (BSA, May 2012) indicated that the below grade fan discharge plenum was removed up to the Stack silencer during the D&D of Building 704. That report notes constraints to the FSS due to remaining underground structures and recommended a separate FSS of this area would be performed at the completion of the Stack D&D Project in 2020.

In view of the above, the footers below the silencer should have been prominently identified in the original Stack D&D Project Scope during the RFP process. Although copies of historic documents were made available to project team members during the RFP and planning process, the RFP did not specifically identify the footers as part of the Project's scope. During the RFP period for the Stack D&D Project, the Government indicated, in response to question 8258500, that the expected maximum depth of the soil excavation would be to the bottom of the silencer, approximately 16.5 feet below grade. The footers, however, extended to approximately 22 feet below grade, and produced an elevated exposure rate of radiologic measurements that impacted screening of the silencer excavation. This required that they be removed in order to complete the FSS, which created a substantially larger and deeper excavation than had been expected, with additional shoring/slope stability plans and controls.

The potential impact to the scope of the Stack D&D Project caused by the footers left in place below the target soil excavation depth warranted additional consideration as a significant Project risk during the RFP process. It is recommended that a more thorough pre-project risk evaluation be completed during the RFP process to identify events that could cause significant negative impact to schedule and cost, such that contingencies can be built into the planning process.

It is also recommended that future actions identified in Final Closeout Reports that were approved by the regulators be forwarded to projects that are expected to address those actions in the future. A more robust system should be instituted to address this in the future.

8.10 Pedestal Remediation

Lessons Learned Statement: OFJV initially utilized a scabbling method based on the stated assumptions in the RFP that approximately ½ inch of impacted concrete would be removed from the pedestal surface to achieve cleanup criteria. Initial beta readings prior to any scabbling indicted max beta levels of approximately 400,000 dpm/100cm^2. The target criteria for completion of pedestal surface remediation is 1,000 dpm/100cm^2.

Discussion: After one-half to two inches of concrete had been removed from the pedestal surface by scabbling, the beta readings of the scabbled surface were still above the 1,000 dpm/100cm2 target criteria, ranging from 800 to 22,000 dpm/100cm2. Deeper contamination in the concrete surface, coupled with observations of emerging rebar and more irregular surfaces, diminished scabbler performance and the efficiency of scabbler debris capture and containment. The effects of these conditions were observed in silica worker air monitoring data, and required changes to the tools (i.e., more powerful scabblers and needle gun systems, with greater dust control and containment).

The schedule delays to procure this more powerful and precise concrete removal equipment (6-12 weeks), the time-consuming nature of their use to achieve uncertain outcomes (as much as 4 weeks), and the cost to decontaminate and release the rental equipment itself, meant that scabbling could no longer produce a cost effective or schedule compliant outcome.

OFJV evaluated alternative options to complete the pedestal remediation along with their respective schedule and cost impacts, with USACE:

- Wire cutting pedestal surface up to 2 feet
- Demolition hammer to removed pedestal surface up to 2 feet
- Remove entire pedestal using demolition hammer

Pros and cons were evaluated, with a recommendation to implement the wire cut method. Upon USACE acceptance of the recommendation, wire and saw cutting equipment was mobilized to the Stack pedestal.

- Concrete wet saws were used for vertical cuts, wire cutting wet saws were used for horizontal cuts, with pulleys and mounts, a wire cutter motor, and water collection equipment. Pulleys were mounted at select locations on the pedestal to allow for positioning of the wire saw to perform horizontal cuts. A gutter system was installed surrounding the pedestal to recover cooling water.

- A 0.5-gallon per minute wet cutting technique was used to control dust and heat during vertical saw cutting, and a 2-gallon per minute wet cutting technique was used to control dust and heat during horizontal wire cutting. Contaminated soil/dust generated by the cutting processes was captured by the water collection gutter system surrounding the pedestal. The gutter system directed water to a collection point; the water was pumped from the collection point and transferred to IBC totes and a polymer agent was added to the totes to solidify the water for waste disposal purposes.
- This approach reduced the potential for contamination to spread and reduce worker intake exposure risks.
- This approach provided a smooth surface to perform the Final Status Survey.

Lessons Learned Recommendation: The actual condition of the pedestal – with contamination that extended more than one foot below the pedestal surface – was substantially different than the conceptual model that anticipated contamination limited to the upper ½ to 1 inch. The depth of concrete contamination was a condition that would have a significant impact on the selection of an appropriate remedial approach, and the cost, logistics, and duration of that approach. With the stack in place, conducting a proper characterization program for the pedestal, e.g., collecting characterization core samples to confirm conditions, would have been an extremely difficult undertaking, if feasible at all. The uncertainty related to contamination depth introduced a critical cost and schedule risk to the Project that should have been identified as a known unknown and warranted a more complete and thorough pre-design characterization of the pedestal prior to the selecting and implementing the remedy.

8.11 Task Order Modification

Lessons Learned Statement: As noted in **Section 7.2**, USACE issued an RFP on October 4, 2021, that requested a cost estimate for additional work elements that were completed for the project but determined to be out of scope of the original SOW.

Discussion: The project team was generally very effective at identifying and communicating project risks, mitigation measures, and risk responses. Communication included:

- Weekly OFJV and USACE calls to discuss project status (deliverables, field, etc.), issues, and schedule.
- Weekly OFJV, USACE, and DOE EM calls to discuss project updates.
- Weekly OFJV, USACE, DOE EM, BNL, and BSA calls to discuss project status (deliverables, field, etc.), issues, and schedule.
- Monthly IAG calls with regulators
- Quarterly CAC meetings

Lessons Learned Recommendation: While project communication was frequent and direct, the project team at times allowed issues that were identified early to become critical and schedule-impacting. While some impacts were unavoidable (lack of facility access to BNL due to COVID-19 or other impacts due to COVID-19), the following measures could have facilitated prioritizing issues with schedule and cost impacts early, and are provided as recommendations for future project to manage change:

- Establish a project risk register early with clear delineation of the scope/quantities associated with the contract's firm-fixed price. An early clear delineation of risk ownership would have readily identified who is responsible for implementing risk responses when risks could not be mitigated.
- Given the firm-fixed price nature of the contract, the Government may have benefited from verifying certain assumptions through additional investigation/characterization in advance of project execution. For example, an intrusive investigation may have identified the required depth of excavation or the depth of pedestal remediation. Similarly, complete characterization of the external stack conditions would have ensured that abatement waste was appropriately planned for.
- Given the complexity of the project and the timeline associated with planning for and implementing the acquisition strategy, additional time for project execution would have benefited all stakeholders.
- Recognizing that COVID-19 stretched the workload of Contracting, early and regular engagement by Contracting with the project team may have allowed more efficient resolution of contractual issues when identified.
- When delays result in abatement or demolition work being conducted during winter months, the project team should consider delaying such work to favorable weather conditions due to the significant reduction in productivity.

8.12 Background Radiation Sources

Lessons Learned Statement: OFJV encountered unexpected detectable variability in outdoor background gamma radiation levels at the Stack work area that originated from intermittent Laboratory experiments with thorium-based accelerator targets.

Discussion: OFJV detected slightly elevated gamma radiation levels (a few microrem per hour above normal background) during some of the field work that it suspected may have been caused by other research/operations on-site. OFJV reached out BSA RadCon who investigated and identified sources from neighboring building operations. These were not occupational hazard levels but did require consideration when screening soils and other items using gamma sensitive instruments. By sharing test schedules to OFJV, BNL RadCon helped OFJV to better plan for the increase in gamma background from NSLS-II experiments with thorium targets. BSA provided communication to OFJV on subsequent test runs with thorium targets during the remainder of the work. The detections were due to building activities, were temporary in nature, and not related to the D&D project.

Lessons Learned Recommendation: The project was properly managed, with air monitors and controls in place to ensure that project-related activities did not negatively impact surrounding areas, and communication procedures to report any issues. Determinations on the effectiveness of those measures relies upon the data that are collected by the monitoring stations. Because of the importance of the data integrity to make such determinations, it is recommended that projects of this nature also take into account the potential for non-project related "background" activities to impact the project monitoring stations during the RFP and planning processes. When working on active facilities with research that can create variable background conditions in surrounding areas, those conditions should be considered by EM and their remediation contractors during the planning and initial partnering meetings with the Site Office and their Lab/Facility reps.

9.0 REFERENCES

Argonne National Laboratory, 2001. User's Manual for RESRAD Version 6. July.

BSA, 2008. The Proposed Remedial Action Plan for the High Flux Beam Reactor at Brookhaven National Laboratory. January.

BSA, 2009. Final Record of Decision for Area of Concern 31 High Flux Beam Reactor. February.

BSA, 2010. Final Remedial Design/Remedial Action Work Plan for the Decontamination and Dismantlement (D&D) of Building 705 (the Stack) and Associated Structures and Utilities, August.

BSA, 2011a. Final Closeout Report High Flux Beam Reactor Underground Utilities Removal Area of Concern 31, August.

BSA, 2011b. Final Closeout Report, High Flux Beam Reactor Fan Houses (Building 704 and Building 802), Decontamination and Dismantlement (D&D), Area of Concern 31, November.

BSA, 2012. Final Closeout Report, High Flux Beam Reactor Removal of the Stack Silencer Baffles and Final Status Survey for Remaining HFBR Outside Areas, Area of Concern 31, May.

BSA, 2018. Surveillance and Maintenance Manual for the HFBR Grounds & Stack, Brookhaven National Laboratory, NY, September.

BSA, 2019. Updated Remedial Design/Remedial Action Work Plan for the Decontamination and Dismantlement (D&D) of Building 705 (the Stack) and Associated Structures and Utilities, October.

MPR, 2019. Report of Background and Drop Test Vibration Study Results, Demolition of Brookhaven National Laboratory HFBR Stack (Building 705), August.

New York State Department of Environmental Conservation, 2013. Cleanup Guidelines for Soils Contaminated with Radioactive Materials. Division of Environmental Remediation, DER-38. April.

OFJV, 2020a. Final Project Management Plan High Flux Beam Reactor Stack (Bldg 705), Area of Concern 31, Brookhaven National Laboratory. May.

OFJV, 2020b. Final Structures and Soil Characterization Plan High Flux Beam Reactor Stack (Bldg 705), Area of Concern 31, Brookhaven National Laboratory. May.

OFJV, 2020c. Final Excavation Plan High Flux Beam Reactor Stack (Bldg 705), Area of Concern 31, Brookhaven National Laboratory. June.

OFJV, 2020d. Final Contingency Plan High Flux Beam Reactor Stack (Bldg 705), Area of Concern 31, Brookhaven National Laboratory. July.

OFJV, 2020e. Final Waste Management Plan (Rev 0) High Flux Beam Reactor Stack (Bldg 705), Area of Concern 31, Brookhaven National Laboratory. July.

OFJV, 2020f. Final Waste Management Plan (Rev 1) High Flux Beam Reactor Stack (Bldg 705), Area of Concern 31, Brookhaven National Laboratory. October.

OFJV, 2020g. Final COVID-19 Management Plan High Flux Beam Reactor Stack (Bldg 705), Area of Concern 31, Brookhaven National Laboratory. July.

OFJV, 2020h. Final Uniform Federal Policy/Quality Assurance Project Plan (UFP-QAPP) High Flux Beam Reactor Stack (Bldg 705), Area of Concern 31, Brookhaven National Laboratory. August.

OFJV, 2020i. Final Accident Prevention Plan/Site Safety and Health Plan (with APP) High Flux Beam Reactor Stack (Bldg 705), Area of Concern 31, Brookhaven National Laboratory. August.

OFJV, 2020j. Final Community Air Monitoring Plan High Flux Beam Reactor Stack (Bldg 705), Area of Concern 31, Brookhaven National Laboratory. August.

OFJV, 2020k. Final Demolition Plan High Flux Beam Reactor Stack (Bldg 705), Area of Concern 31, Brookhaven National Laboratory. August.

OFJV, 2020l. Final Field Sampling Plan High Flux Beam Reactor Stack (Bldg 705), Area of Concern 31, Brookhaven National Laboratory. August.

OFJV, 2020m. Final Radiation Protection Program High Flux Beam Reactor Stack (Bldg 705), Area of Concern 31, Brookhaven National Laboratory. August.

OFJV, 2020n. Final Radiation Control Manual High Flux Beam Reactor Stack (Bldg 705), Area of Concern 31, Brookhaven National Laboratory. August.

OFJV, 2020o. Final As Low As Reasonably Achievable (ALARA) High Flux Beam Reactor Stack (Bldg 705), Area of Concern 31, Brookhaven National Laboratory. August.

OFJV, 2020p. Final Safety Crosswalk High Flux Beam Reactor Stack (Bldg 705), Area of Concern 31, Brookhaven National Laboratory. August.

OFJV, 2020q. Critical Lift Plan High Flux Beam Reactor Stack (Bldg 705), Area of Concern 31, Brookhaven National Laboratory. November.

OFJV, 2021. Response Action Plan (Rev 1) Plan High Flux Beam Reactor Stack (Bldg 705), Area of Concern 31, Brookhaven National Laboratory. January.

P.W. Grosser 2005a, High Flux Beam Reactor & Balance of Plant Supplemental Characterization Summary, prepared by PW Grosser Consulting, June.

P.W. Grosser, 2005b, High Flux Beam Reactor and Balance of Plant Structures Preliminary Assessment/Site Inspection Report (PA/SI), prepared by PW Grosser Consulting, January.

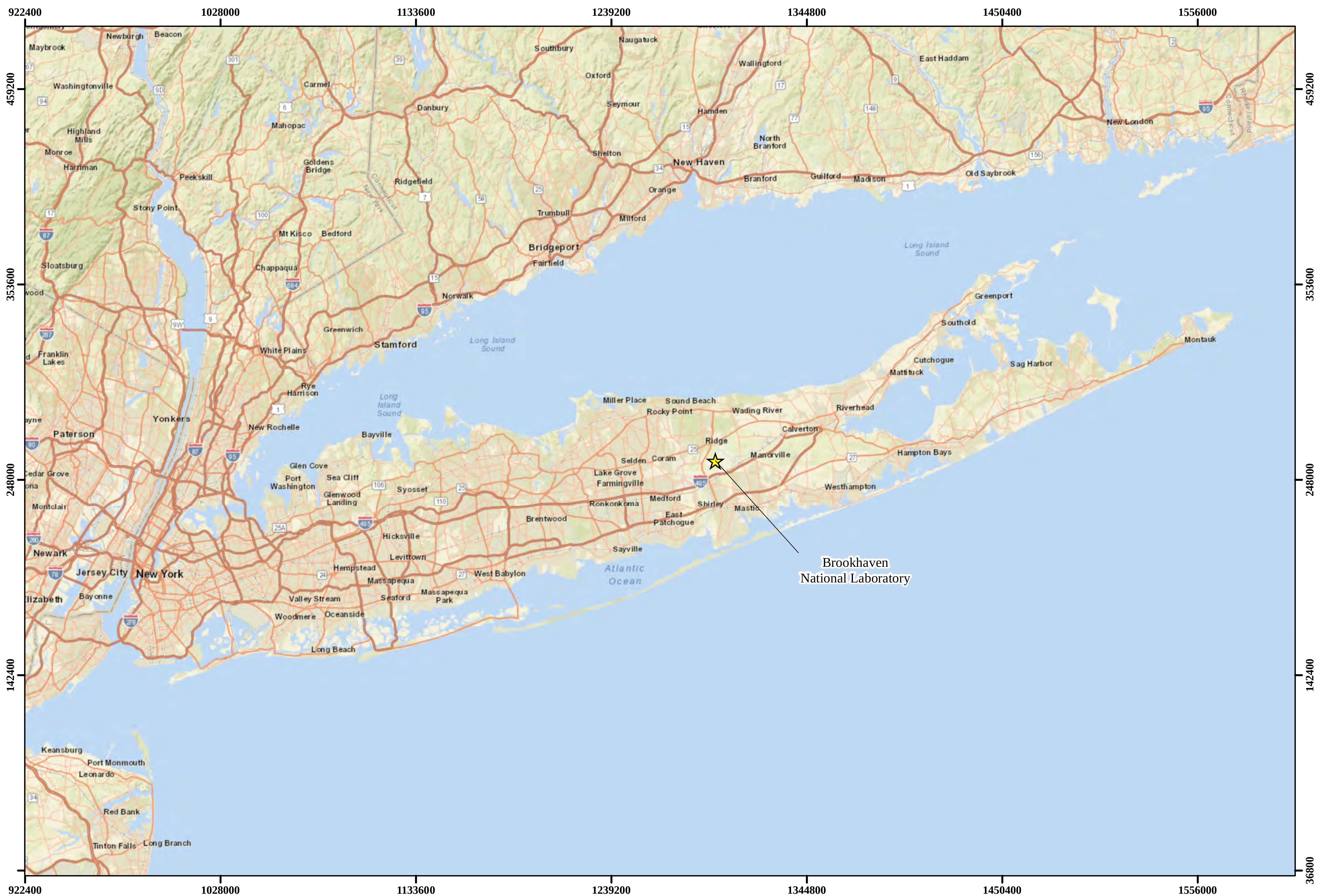
P.W. Grosser, 2005c, Brookhaven National Laboratory Building 705 Stack Resolution of End-State, prepared by PW Grosser Consulting, February.

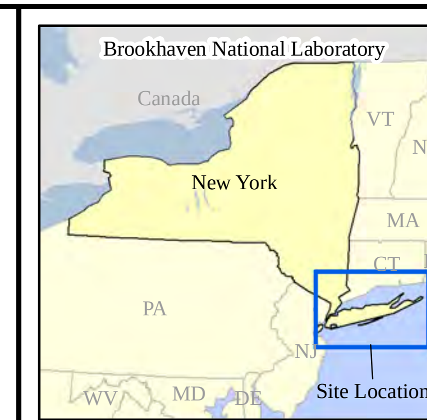
U.S. Army Corps of Engineers, 2017. Brookhaven National Laboratory High Flux Beam Reactor Complex Building 705- Stack Demolition Analysis of Alternatives, December.

U.S. Environmental Protection Agency, Office of Solid Waste and Emergency Response 1996. Soil Screening Guidance, 9355.4-23. July.

U.S. Environmental Protection Agency, Research and Development 2015. ProUCL Version 5.1, 600/R-07/041. October.

FIGURES





Key Features

☆ Site Location

Brookhaven National Laboratory
High Flux Beam Reactor Stack, Bldg. 705
Decommissioning & Demolition

USACE
Baltimore District

FIGURE 1-1

Brookhaven
National Laboratory
Site Location

Notes:
1. Revision Date: 4/5/2021

Coordinate System:
NAD 1983 StatePlane New York Long Island FIPS 3104 Feet
Projection: Lambert Conformal Conic
Datum: North American 1983
Units: Foot US
Service Layer Credits: Sources: Esri, HERE, Garmin, USGS, Intermap, INCREMENT P, NRCan, Esri Japan, METI, Esri China (Hong Kong), Esri Korea, Esri (Thailand), NGCC, (c) OpenStreetMap contributors, and the GIS User Community

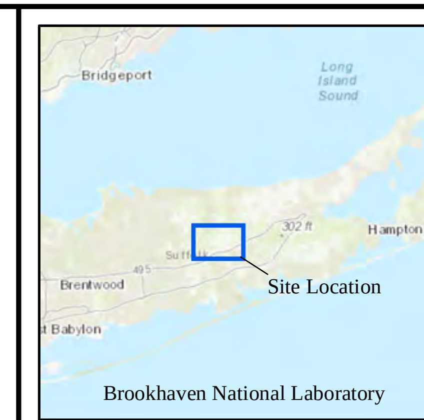
0 3.75 7.5 15 Kilometers
0 2.5 5 10 Miles

N
W E
S

Olgoonik FPM JV, LLC
Cabrera Services
International Chimney Corporation

2021

Path: Y:\GIS_Projects\Brookhaven\Projects\Site_Closeout_Report\Fig1_1_Site_Location.mxd



Key Features

- High Flux Beam Reactor (HFBR) Complex
- BNL Boundary

Brookhaven National Laboratory
High Flux Beam Reactor Stack, Bldg. 705
Decommissioning & Demolition

USACE
Baltimore District

FIGURE 1-2

High Flux Beam Reactor Complex Location at BNL

Olgoonik FPM JV, LLC

Cabrera Services — International Chimney Corporation

2021

Notes:
1. Revision Date: 5/11/2021

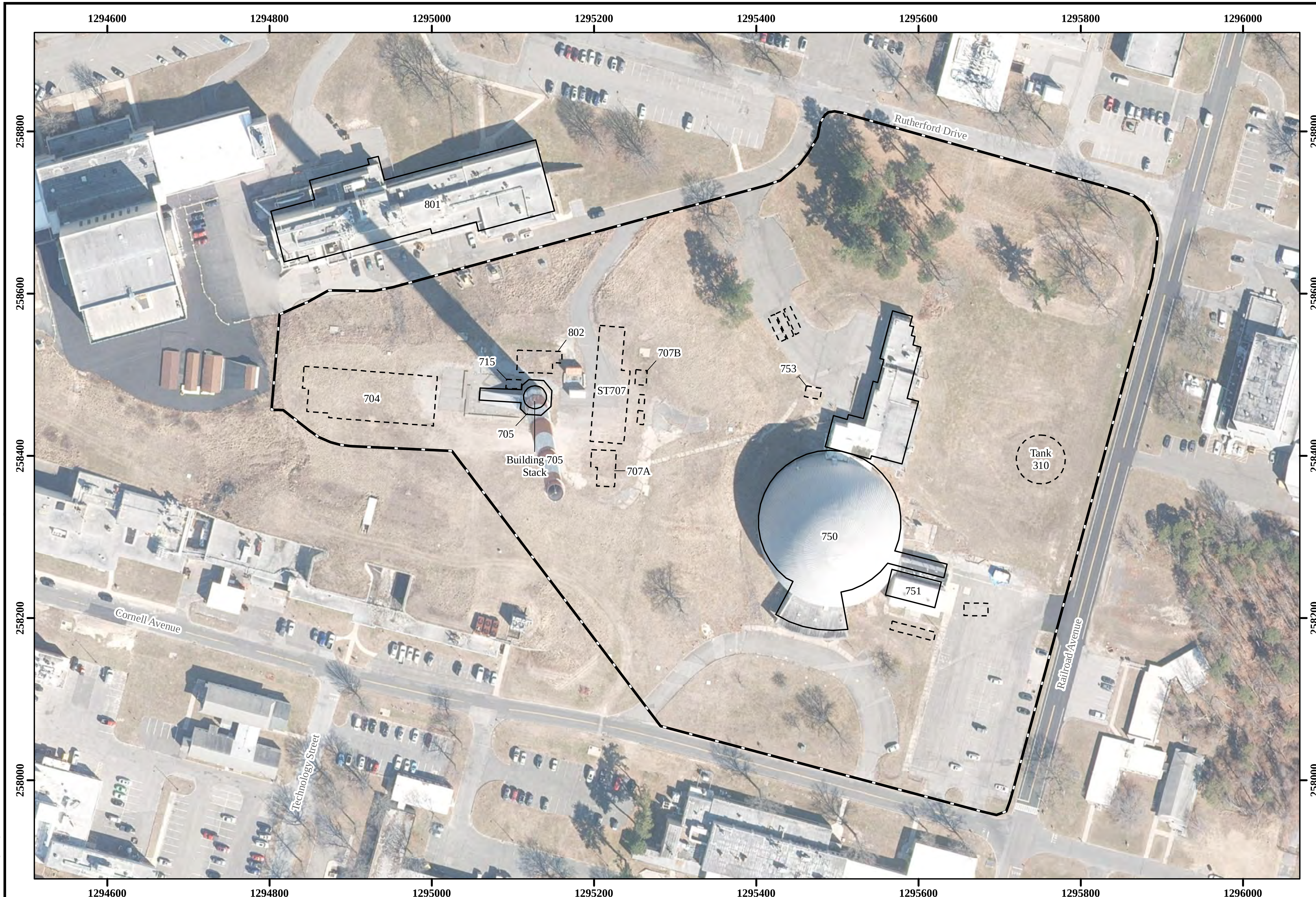
Coordinate System: NAD 1983 StatePlane New York Long Island FIPS 3104 Feet
Projection: Lambert Conformal Conic
Datum: North American 1983
Units: Foot US
Service Layer Credits: Source: Esri, Maxar, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community
Sources: Esri, HERE, Garmin, Intermap, increment P Corp., GEBCO, USGS, FAO, NPS,

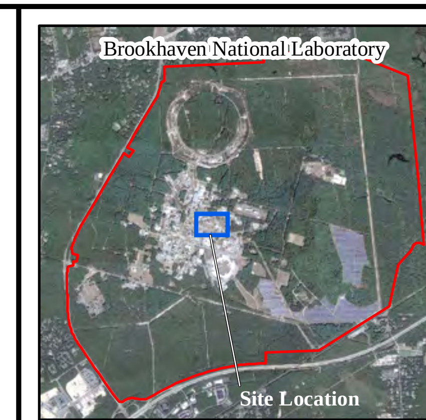
0 500 1,000 Meters

0 2,500 5,000 Feet

N E S W

Path: Y:\GIS_Projects\Brookhaven\Projects\Site_Closeout_Report\Fig1_2_FBR_Loc.mxd





Key Features

- Existing Building
- Former Building/Infrastructure
- HFBR Complex Boundary

Brookhaven National Laboratory
High Flux Beam Reactor Stack, Bldg. 705
Decommissioning & Demolition

USACE
Baltimore District

FIGURE 1-3

High Flux Beam Reactor
Site Plan

Notes:
1. Revision Date: 5/11/2021

Coordinate System:
NAD 1983 StatePlane New York Long Island FIPS 3104 Feet
Projection: Lambert Conformal Conic
Datum: North American 1983
Units: Foot US
Service Layer Credits: Source: Esri, Maxar, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community
Basemap Date: February 26, 2016

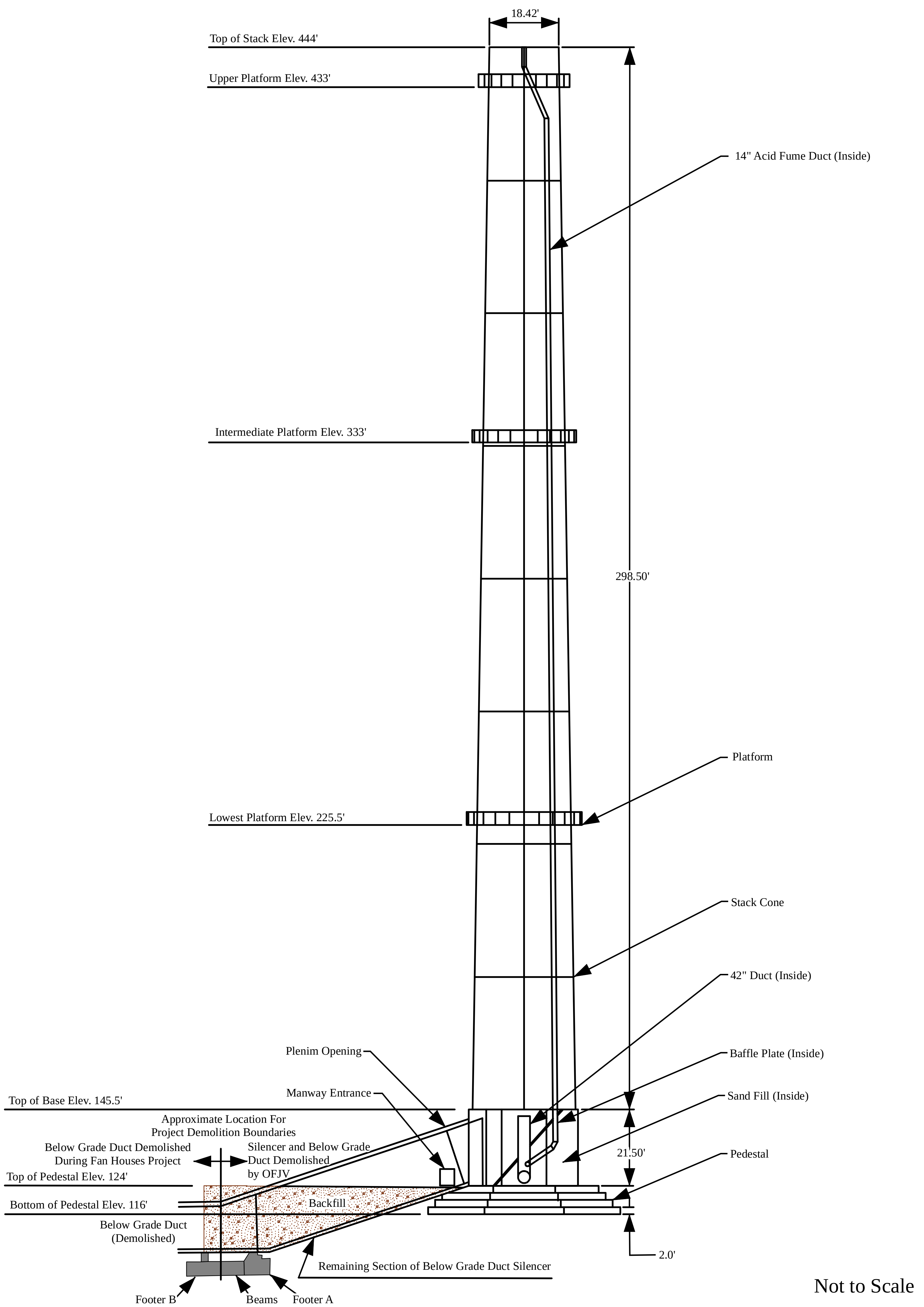
0 9 18 36 Meters
0 30 60 120 Feet

N
W E
S

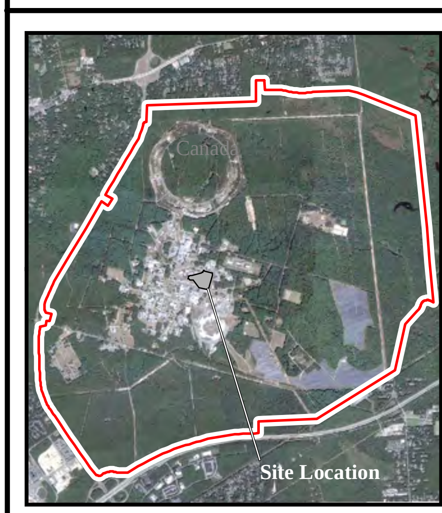
Olgoonik FPM JV, LLC
CABRERA SERVICES
INTERNATIONAL CHIMNEY CORPORATION

2021

Path: Y:\GIS_Projects\Brookhaven\Projects\Site_Closeout_Report\Fig1_3_FBR_Site_Plan.mxd



Not to Scale



Source: Remedial Design/Remedial Action Work Plan for the D&D of Building 705, BSA, October 2019.

Coordinate System:
NAD 1983 StatePlane New York Long Island FIPS 3104 Feet
Projection: Lambert Conformal Conic
Datum: North American 1983
Units: Foot US
Service Layer Credits: No credits for this map.

N W E S

Revision Date: 2/8/2022

Path: Y:\GIS_Projects\Brookhaven\Projects\Site_Closeout_Report\Fig1_4_B705_Stack_Details.mxd

Brookhaven National Laboratory
High Flux Beam Reactor Stack, Bldg. 705
Decommissioning & Demolition

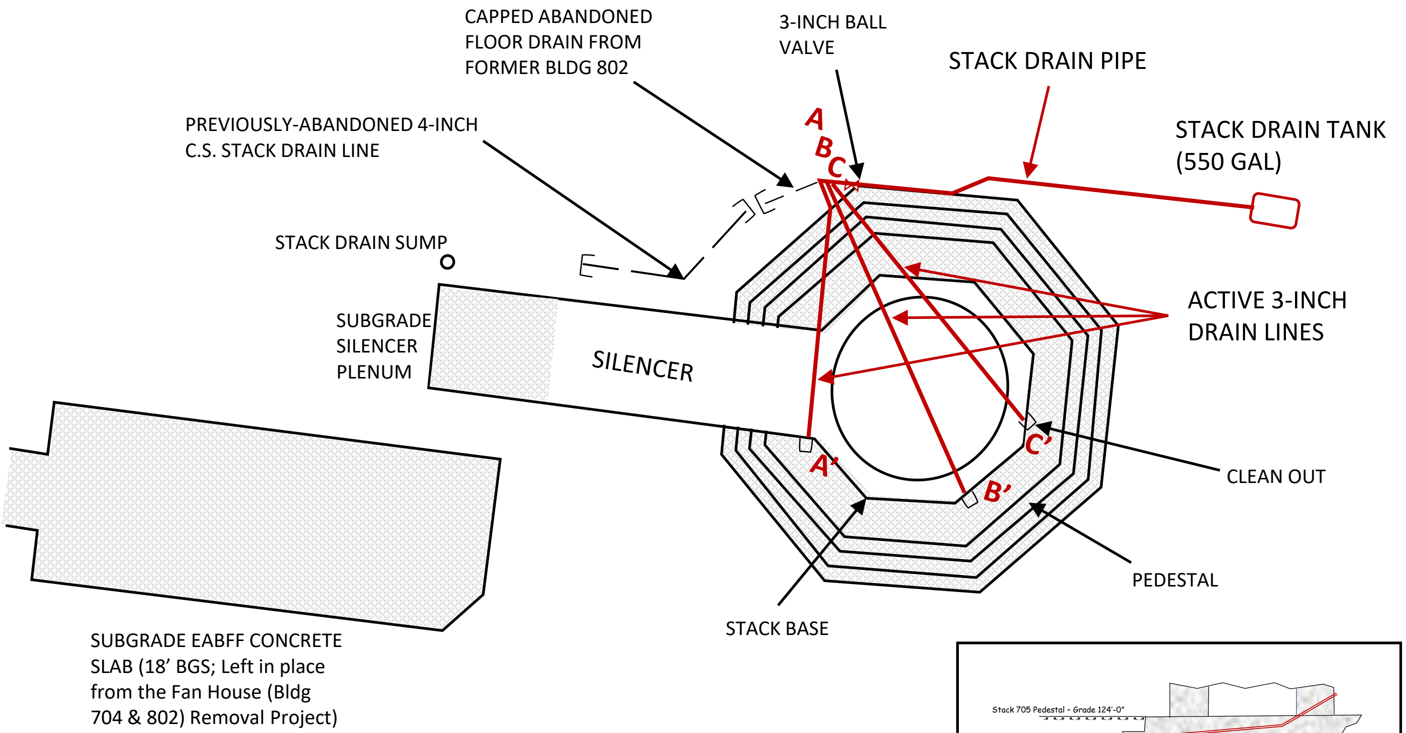
USACE
Baltimore District

FIGURE 1-4

Building 705
Stack Details

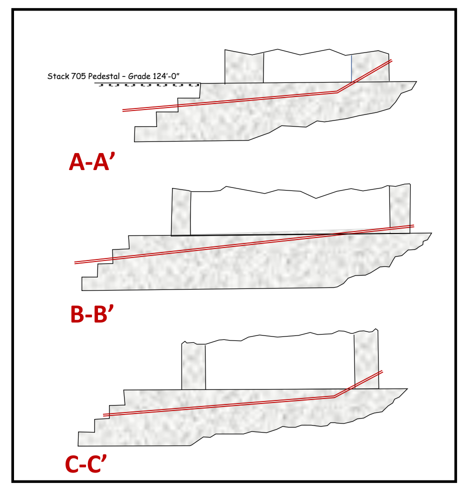
Olgoonik FPM JV, LLC
CABRERA SERVICES
INTERNATIONAL CHIMNEY CORPORATION

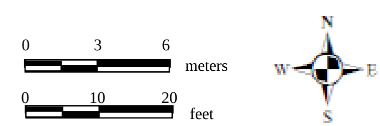
2022



TANK DRAIN SYSTEM COMPONENTS

SUBGRADE STRUCTURE





Brookhaven National Laboratory
High Flux Bean Reactor Stack, Bldg. 705
Decommissioning & Demolition

USACE
Baltimore District

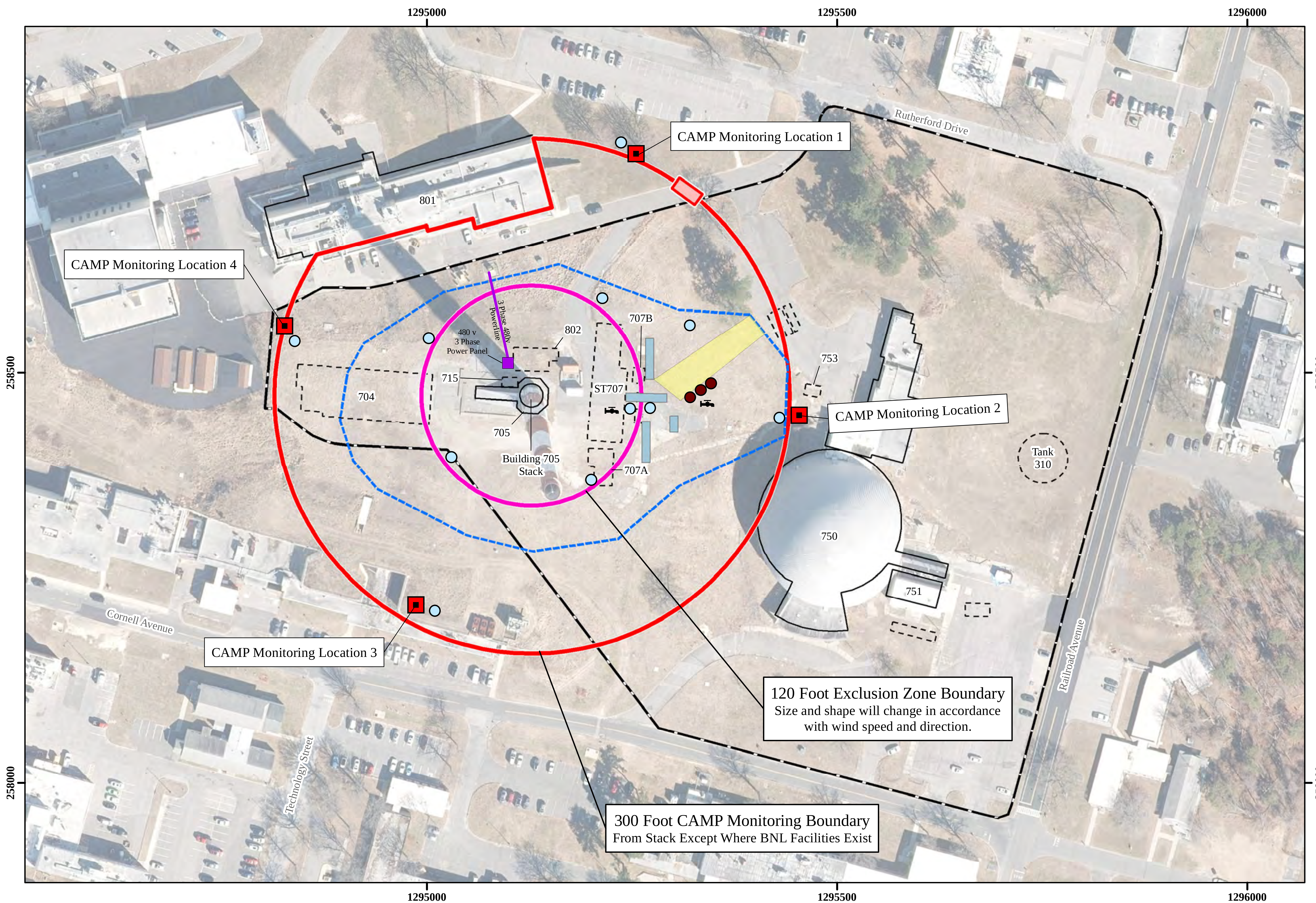
FIGURE 1-5

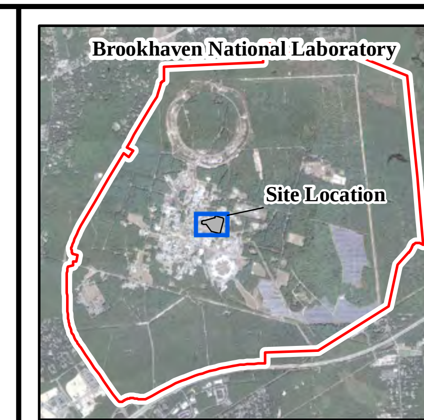
Stack Tank and Stormwater Collection System

Olgoonik FPM JV, LLC
CABRERA SERVICES
INTERNATIONAL CHIMNEY CORPORATION

2021

Source: Stack Drain Tank General Arrangement DWG. NO. 603-13-AB-01; Cross Section Inset DWG NO. M-705-4A





Key Features

- Potable Water Hookup
- Bathroom Facilities
- Hookup Location for 6 110v Outlet
- 480v 3 Phase Power, Must Be Hardwired (ICC Panel)
- CAMP Monitoring Locations
- 3 phase 480v PowerLine
- Access Road
- OFJV Fenced Site Control Boundary
- Trailer Location
- 16-20 Foot Gate
- CAMP Monitoring Boundary 300 Feet
- Exclusion Zone Boundary 120 Feet from stack house
- Existing Building
- Former Building/Infrastructure
- HFBR Complex Boundary

Brookhaven National Laboratory
High Flux Beam Reactor Stack, Bldg. 705
Decommissioning & Demolition

USACE
Baltimore District

FIGURE 3-1

Site Setup

Notes:
1. Trailer, fencing, and bathroom locations are approximate.
2. Revision Date: 2/8/2022

Coordinate System: NAD 1983 StatePlane New York Long Island FIPS 3104 Feet
Projection: Lambert Conformal Conic
Datum: North American 1983
Units: Foot US
Service Layer Credits: Source: Esri, Maxar, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community
Basemap Date: February 26, 2016

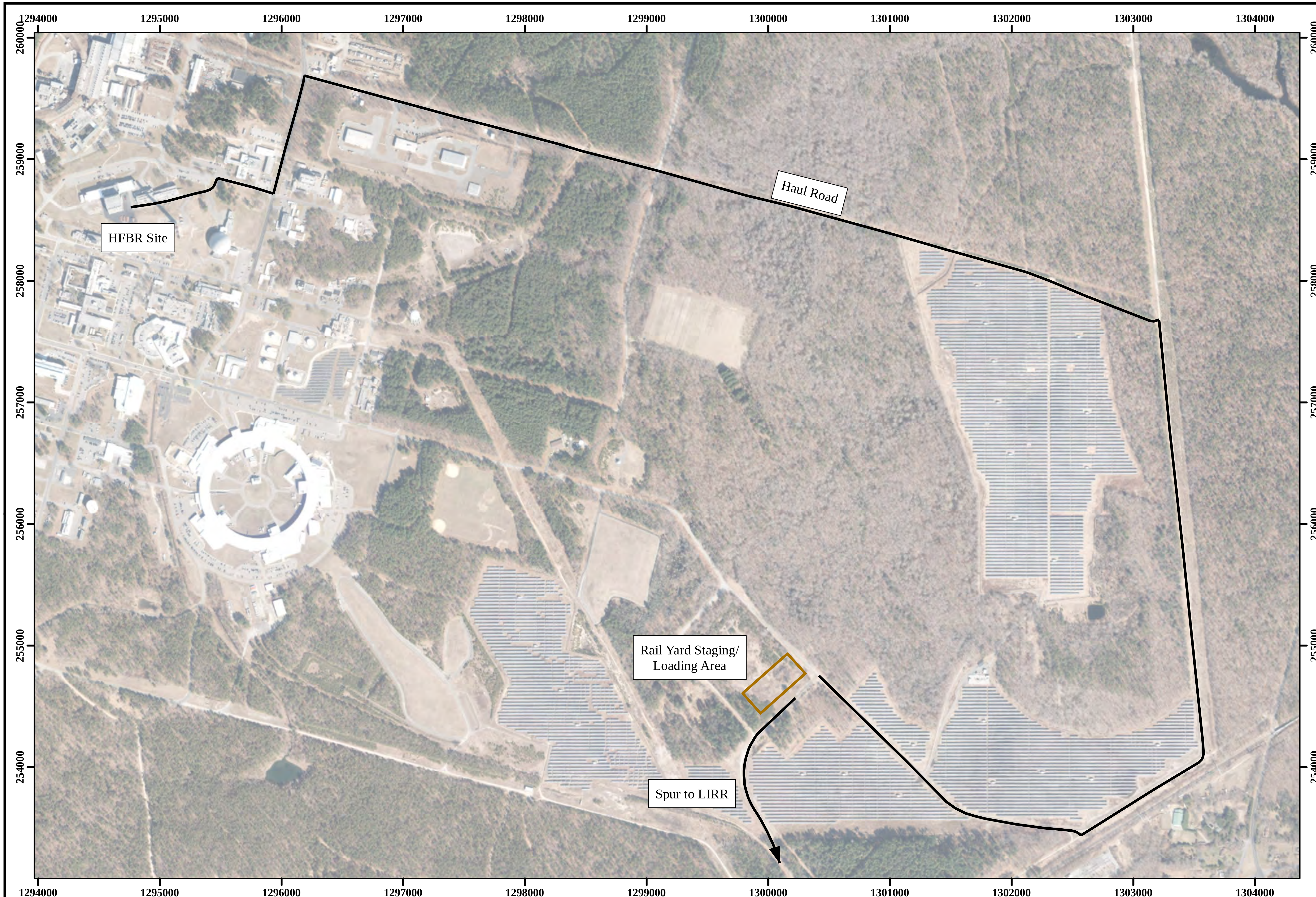
0 9 18 36 Meters
0 30 60 120 Feet

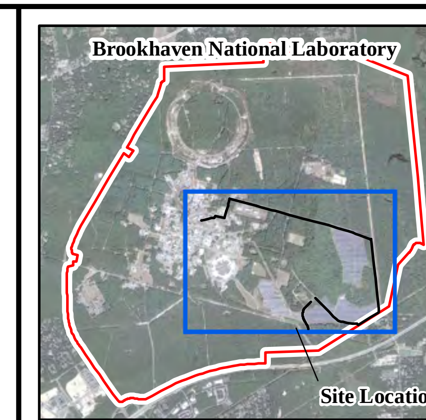
N W E S

Olgoonik FPM JV, LLC
CABRERA SERVICES
INTERNATIONAL CHIMNEY CORPORATION

2022

Path: Y:\GIS_Projects\Brookhaven\Projects\Site_Closeout_Report\Fig3_1_Site_Setup.mxd





Key Features

- Spur to LIRR
- Haul Roads
- Rail Yard/ Staging/Loading Area

Brookhaven National Laboratory
High Flux Beam Reactor Stack, Bldg. 705
Decommissioning & Demolition

USACE
Baltimore District

FIGURE 3-2

BNL Haul Roads
and Rail Yard

Notes:
1. Revision Date: 5/11/2021

Coordinate System:
NAD 1983 StatePlane New York Long Island FIPS 3104 Feet
Projection: Lambert Conformal Conic
Datum: North American 1983
Units: Foot US
Service Layer Credits: Source: Esri, Maxar, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community
Basemap Date: February 26, 2016

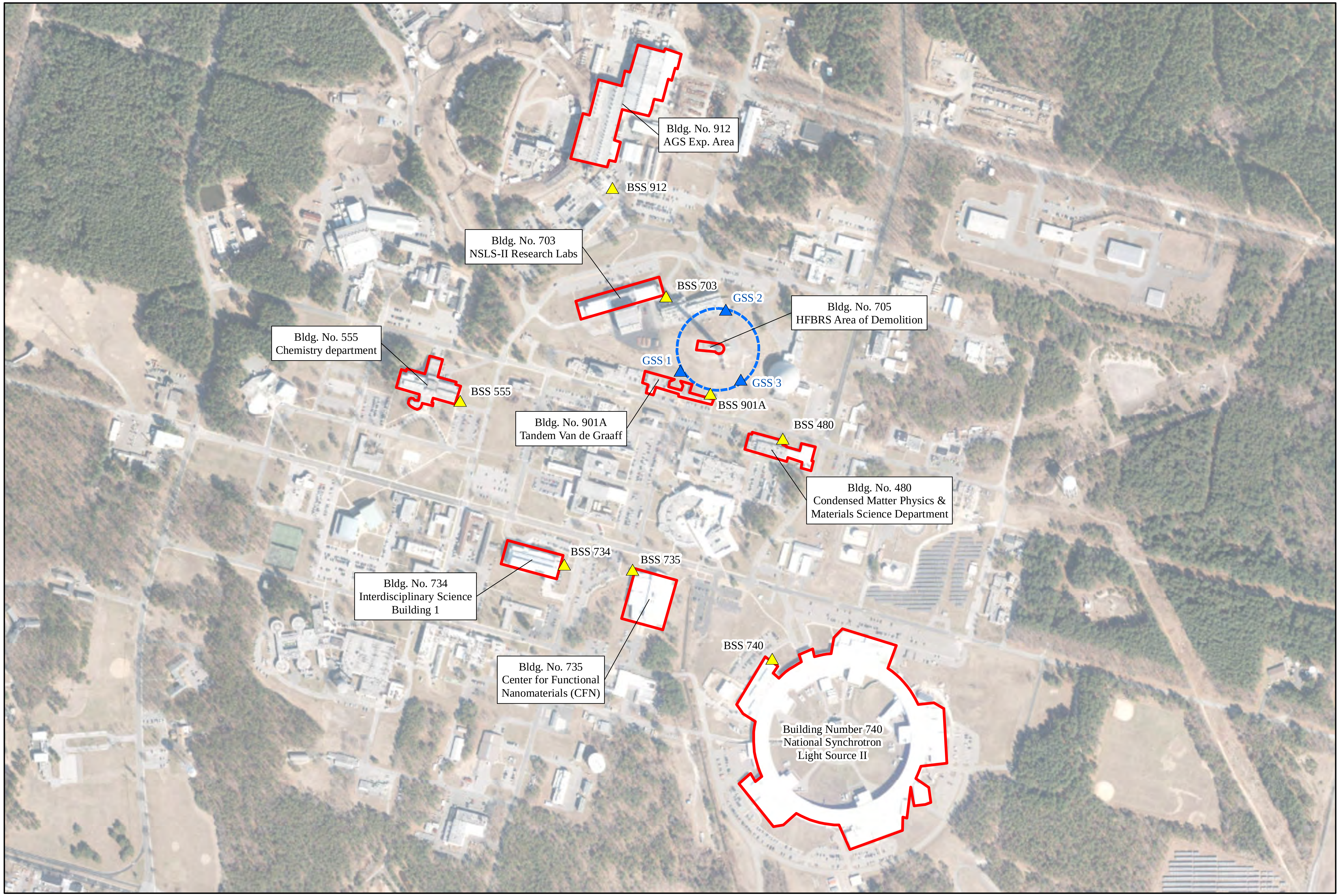
0 100 200 400 Meters
0 400 800 1,600 Feet

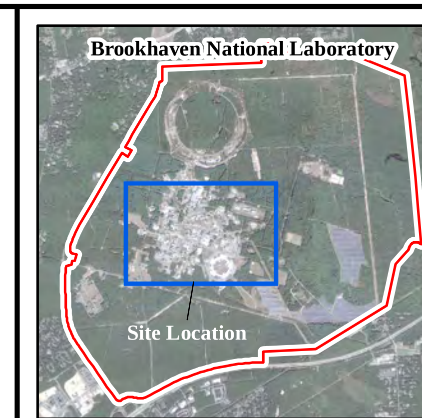
N
W E
S

Olgoonik FPM JV, LLC
CABRERA SERVICES
INTERNATIONAL CHIMNEY CORPORATION

2021

Path: Y:\GIS_Projects\Brookhaven\Projects\Site_Closeout_Report\Fig3_2_Haul_Roads.mxd





Key Features

Seismograph Monitoring Locations

- Demolition Monitoring Location
- Background Monitoring Location
- Building
- 230ft Radius Demolition Range

Brookhaven National Laboratory
High Flux Beam Reactor Stack, Bldg. 705
Decommissioning & Demolition

USACE
Baltimore District

FIGURE 3-3

Vibration Monitoring System

Olgoonik FPM JV, LLC
CABRERA SERVICES
INTERNATIONAL CHIMNEY CORPORATION

2021

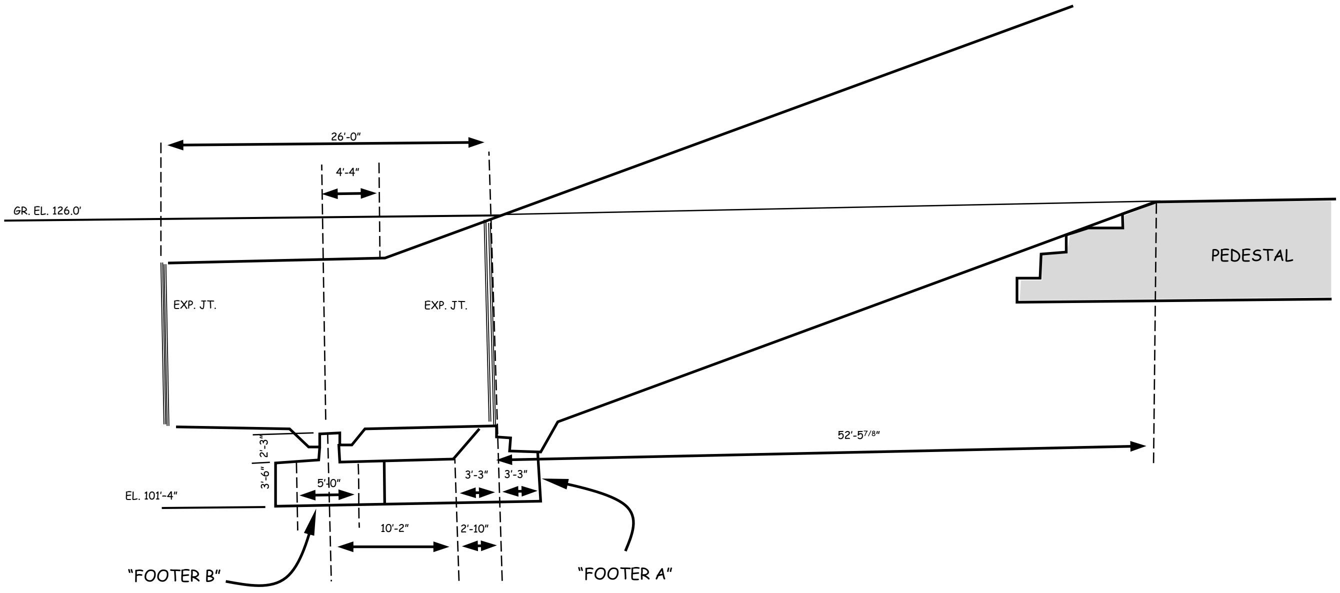
Notes:
1. Revision Date: 5/11/2021

Coordinate System:
NAD 1983 StatePlane New York Long Island FIPS 3104 Feet
Projection: Lambert Conformal Conic
Datum: North American 1983
Units: Foot US
Service Layer Credits: Source: Esri, Maxar, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community
Basemap Date: February 26, 2016

0 75 150 300 Meters
0 250 500 1,000 Feet

N W E S

Path: Y:\GIS_Projects\Brookhaven\Projects\Site_Closeout_Report\Fig3_3_Vibration_MonitoringSystem.mxd

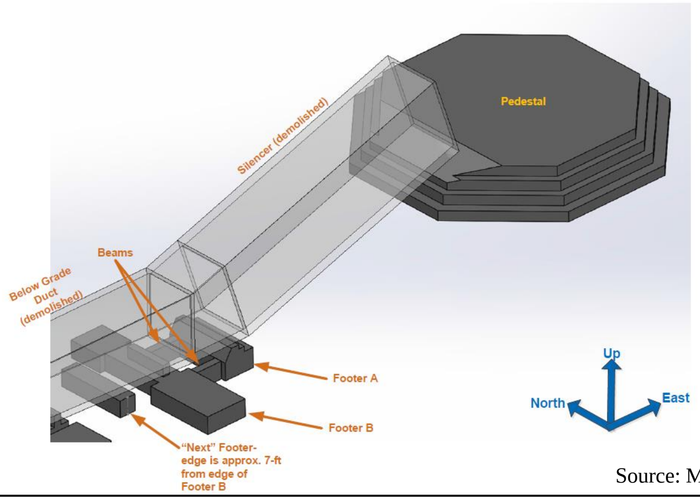


Brookhaven National Laboratory
High Flux Bean Reactor Stack, Bldg. 705
Decommissioning & Demolition

USACE
Baltimore District

FIGURE 3-4

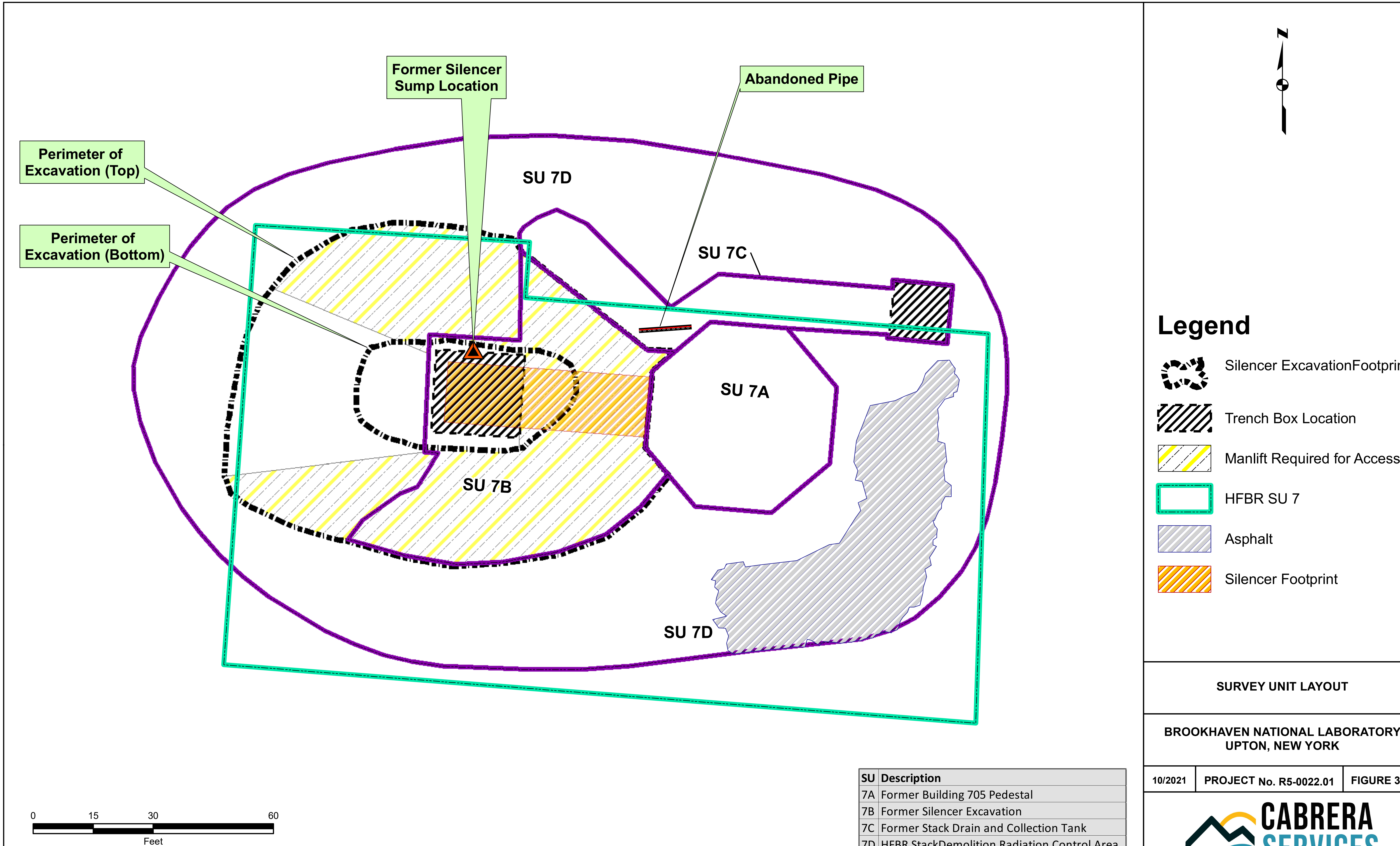
Silencer Structure



Source: MPR

Olgoonik FPM JV, LLC
25 YEARS CABRERA SERVICES
INTERNATIONAL CHIMNEY CORPORATION

2020



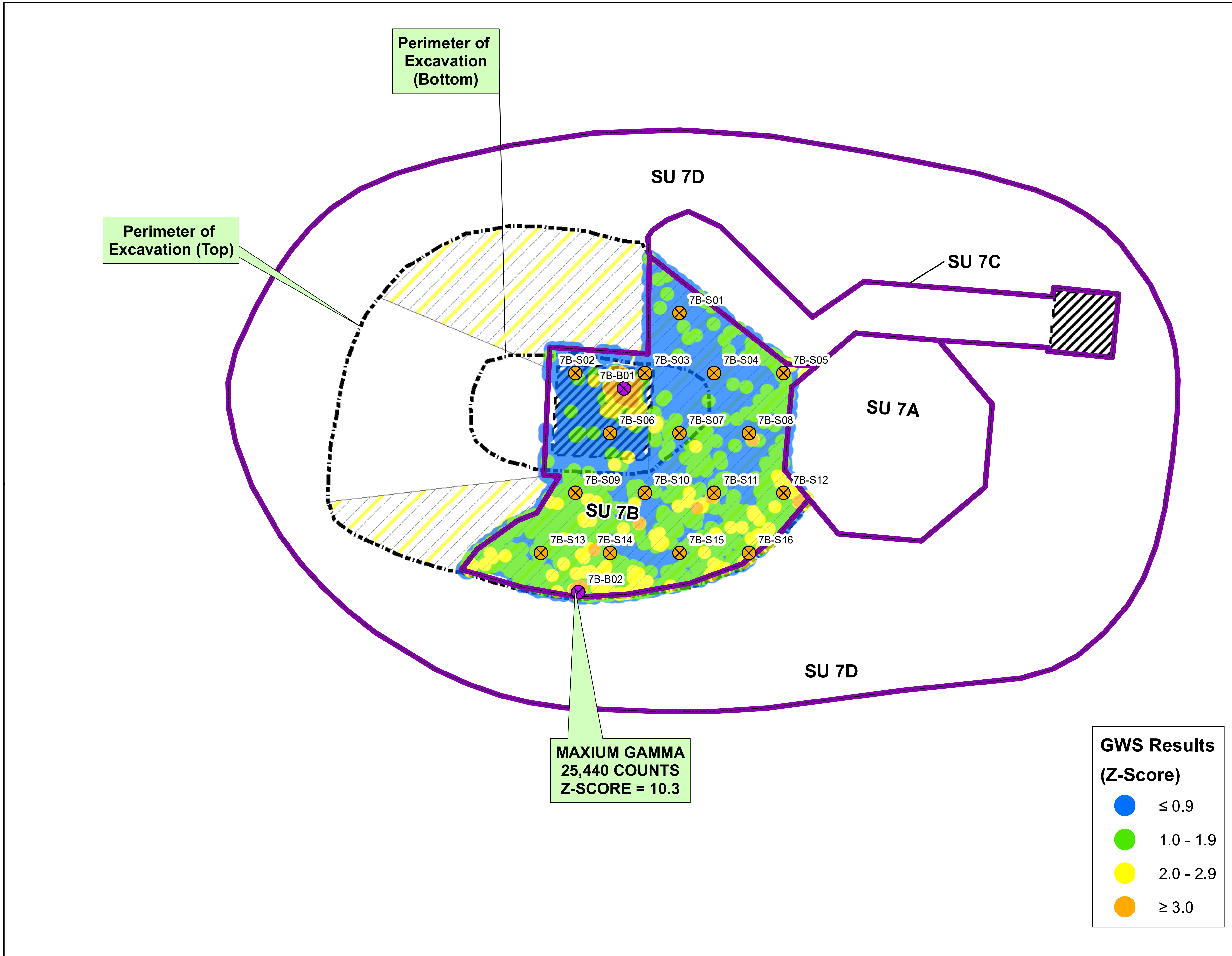
SU	Description
7A	Former Building 705 Pedestal
7B	Former Silencer Excavation
7C	Former Stack Drain and Collection Tank
7D	HFBR StackDemolition Radiation Control Area

SURVEY UNIT LAYOUT

BROOKHAVEN NATIONAL LABORATORY
UPTON, NEW YORK

10/2021	PROJECT No. R5-0022.01	FIGURE 3-5

CABRERA SERVICES
CHALLENGE ACCEPTED

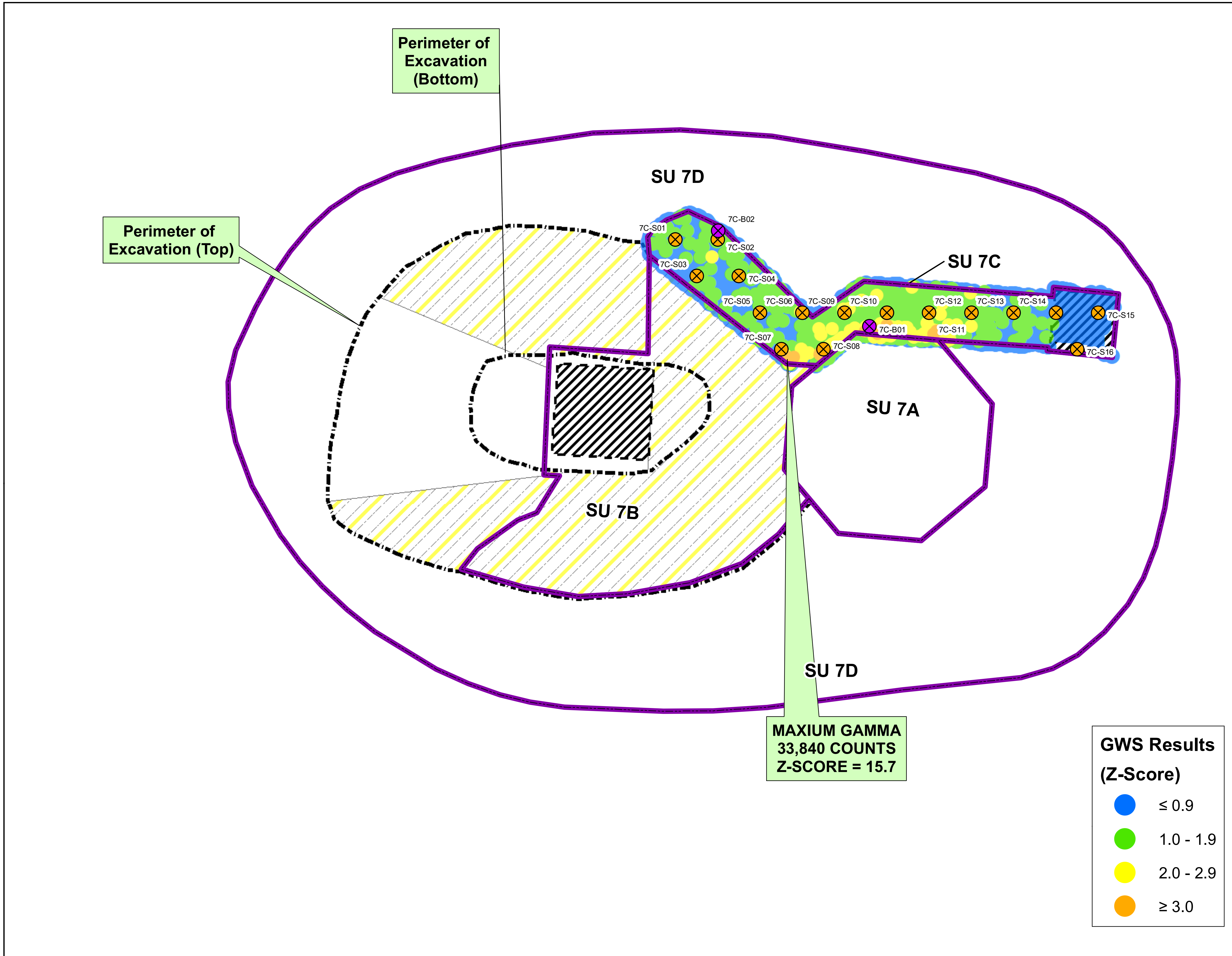


7B SAMPLE LOCATIONS

BROOKHAVEN NATIONAL LABORATORY
UPTON, NEW YORK

10/2021	PROJECT No. R5-0022.01	FIGURE 3-6

CABRERA SERVICES
CHALLENGE ACCEPTED



Legend

- Survey Unit (SU) Boundary
- Silencer Excavation Footprint
- Trench Box Location
- Manlift Required for Access
- 7C Bias Locations
- 7C Systematic Locations

Note: Survey Conducted with a Ludlum 2221/ 44-20 (3x3 NaI).

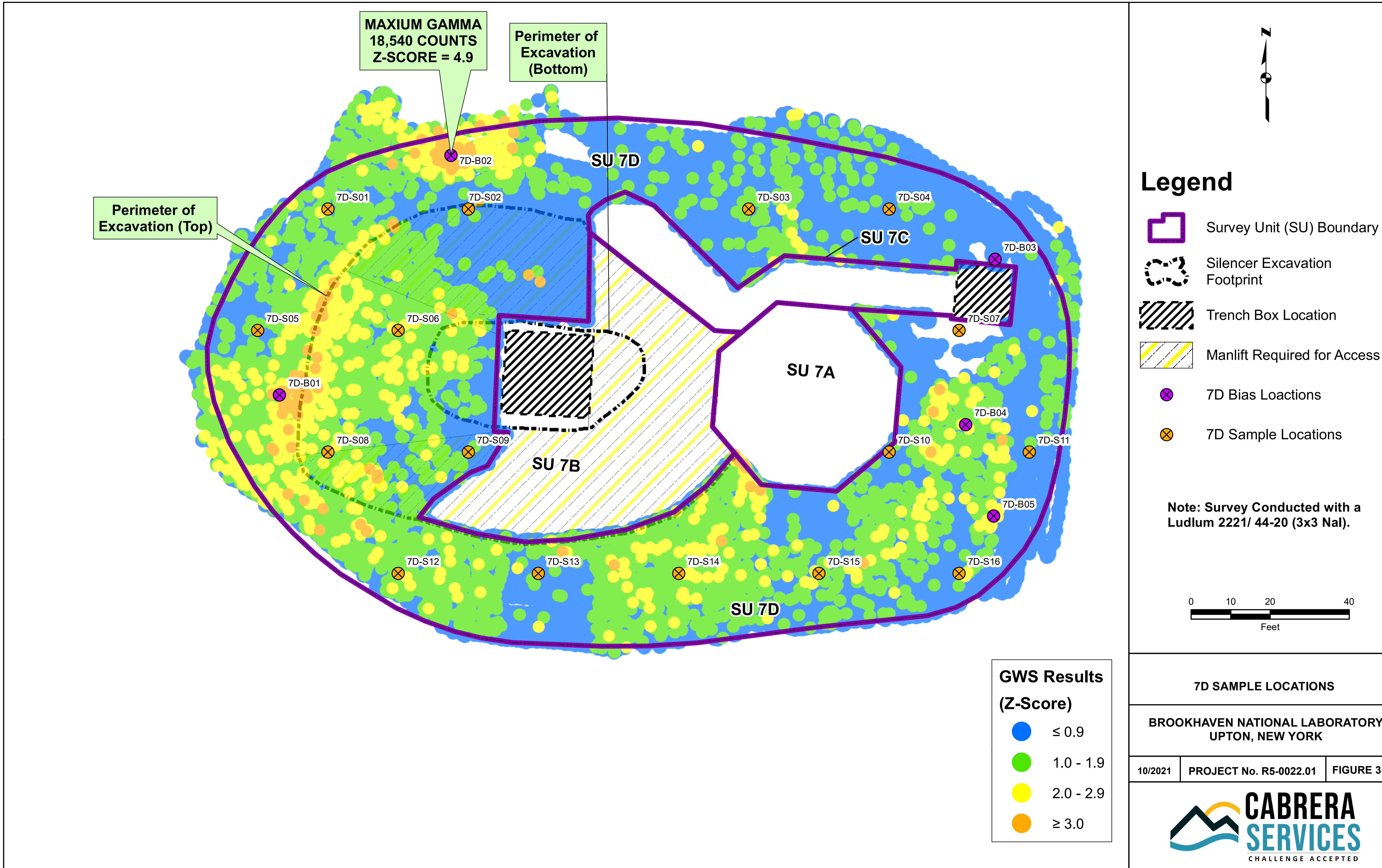
0 10 20 40
Feet

7C SAMPLE LOCATIONS

BROOKHAVEN NATIONAL LABORATORY
UPTON, NEW YORK

10/2021	PROJECT No. R5-0022.01	FIGURE 3-7

CABRERA SERVICES
CHALLENGE ACCEPTED

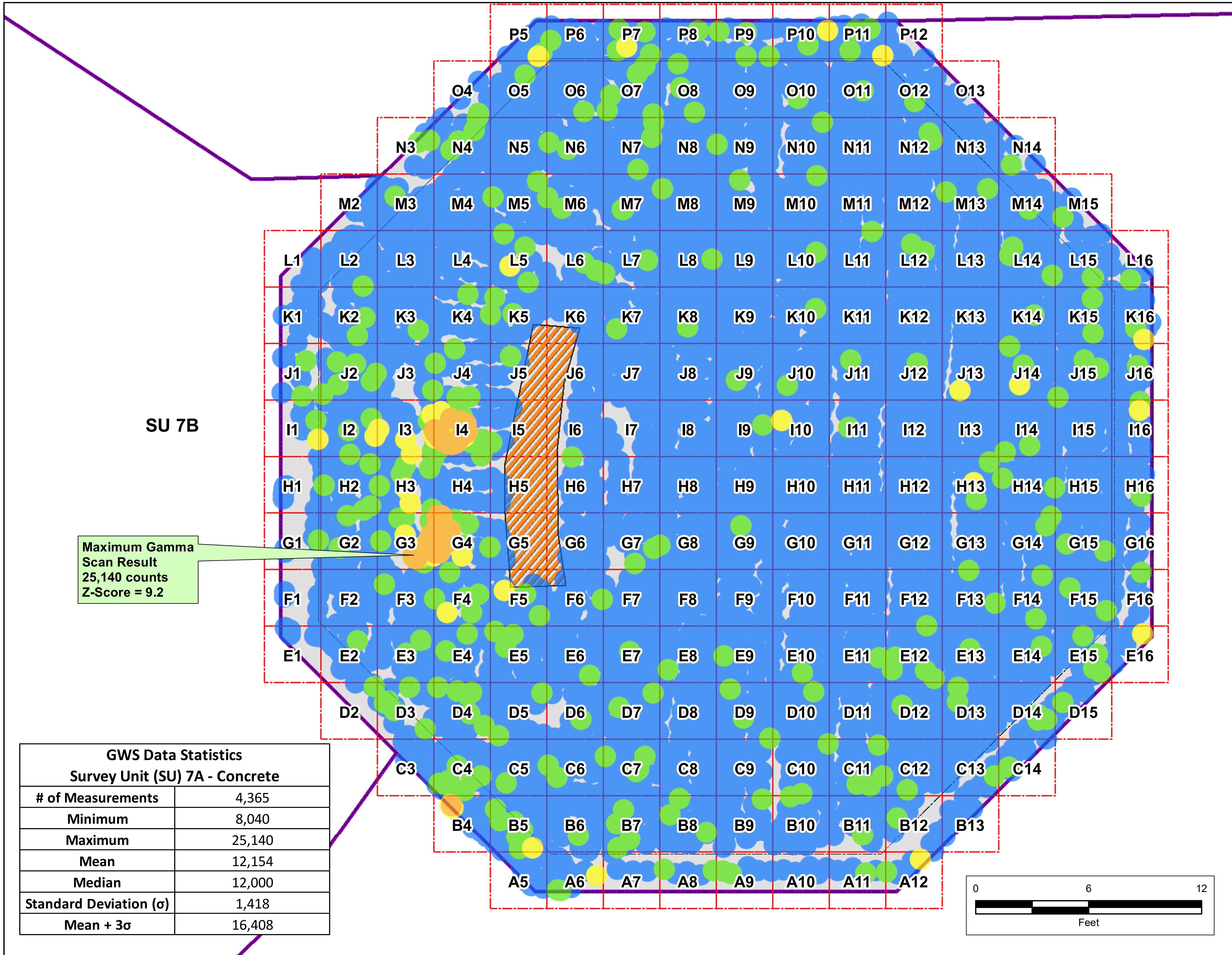


7D SAMPLE LOCATIONS

BROOKHAVEN NATIONAL LABORATORY
UPTON, NEW YORK

10/2021	PROJECT No. R5-0022.01	FIGURE 3-8

CABRERA SERVICES
CHALLENGE ACCEPTED



GWS Data Statistics Survey Unit (SU) 7A - Concrete	
# of Measurements	4,365
Minimum	8,040
Maximum	25,140
Mean	12,154
Median	12,000
Standard Deviation (σ)	1,418
Mean + 3σ	16,408

Legend

- Survey Grid
- Survey Unit (SU) 7A
- Pedestal Pad
- Cut Trench

SU 7A GWS Results (Z-Score)

- -2.9 - 0.9
- 1.0 - 1.9
- 2.0 - 2.9
- 3.0 - 9.6

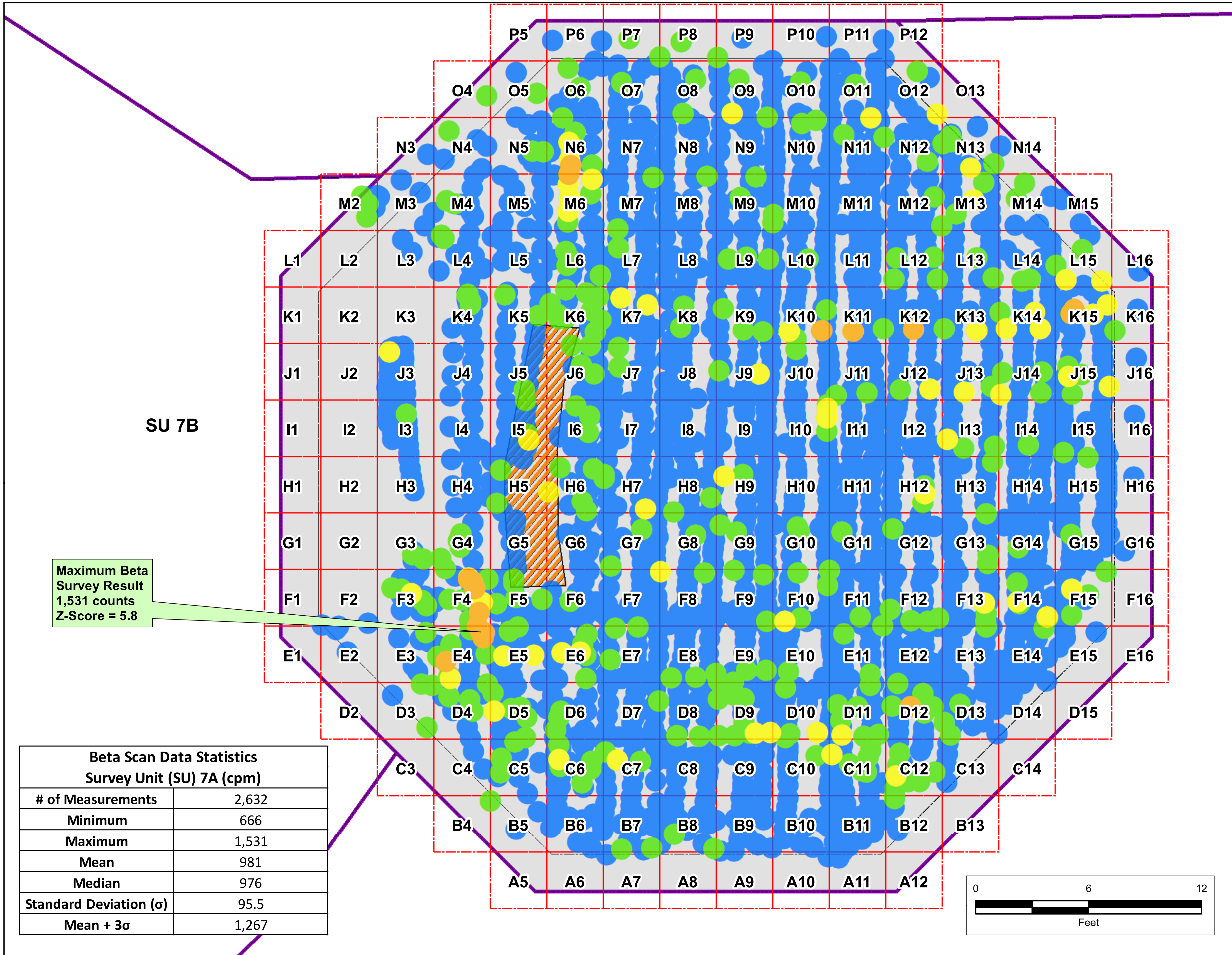
Note: Survey Conducted with a Ludlum 2360/ 43-37.

SU 7A GAMMA WALKOVER SURVEY RESULTS

BROOKHAVEN NATIONAL LABORATORY UPTON, NEW YORK

10/2021	PROJECT No. R5-0022.01	FIGURE 3-9

CABRERA SERVICES
CHALLENGE ACCEPTED



Beta Scan Data Statistics Survey Unit (SU) 7A (cpm)	
# of Measurements	2,632
Minimum	666
Maximum	1,531
Mean	981
Median	976
Standard Deviation (σ)	95.5
Mean + 3σ	1,267

Legend

- Survey Grid
- Survey Unit (SU) 7A
- Pedestal Pad
- Cut Trench

Beta Scan Results (Z-Score)

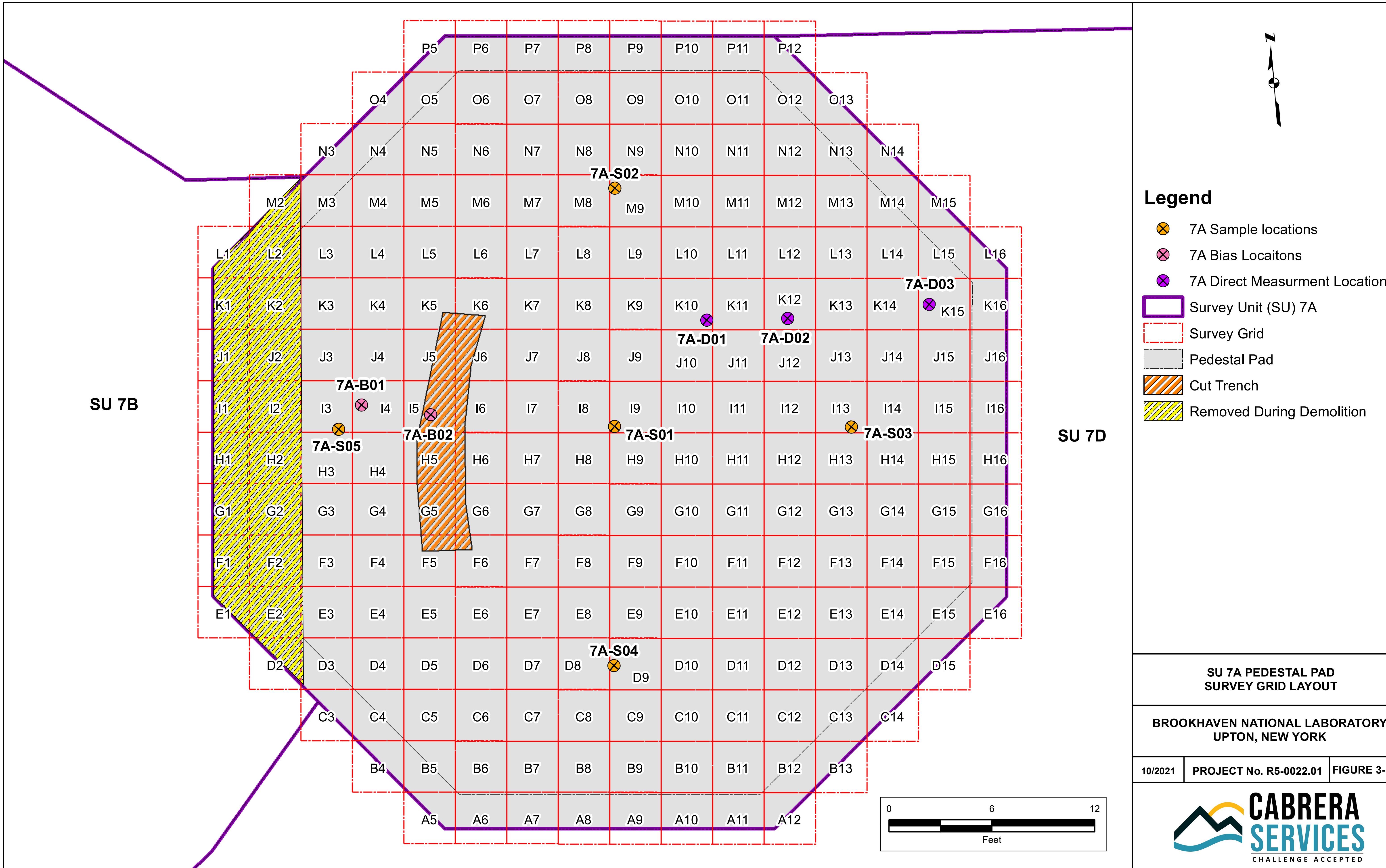
- -3.3 - 0.9
- 1.0 - 1.9
- 2.0 - 2.9
- 3.0 - 5.8

SU 7A BETA SCAN SURVEY RESULTS

BROOKHAVEN NATIONAL LABORATORY
UPTON, NEW YORK

10/2021	PROJECT No. R5-0022.01	FIGURE 3-10

CABRERA SERVICES
CHALLENGE ACCEPTED

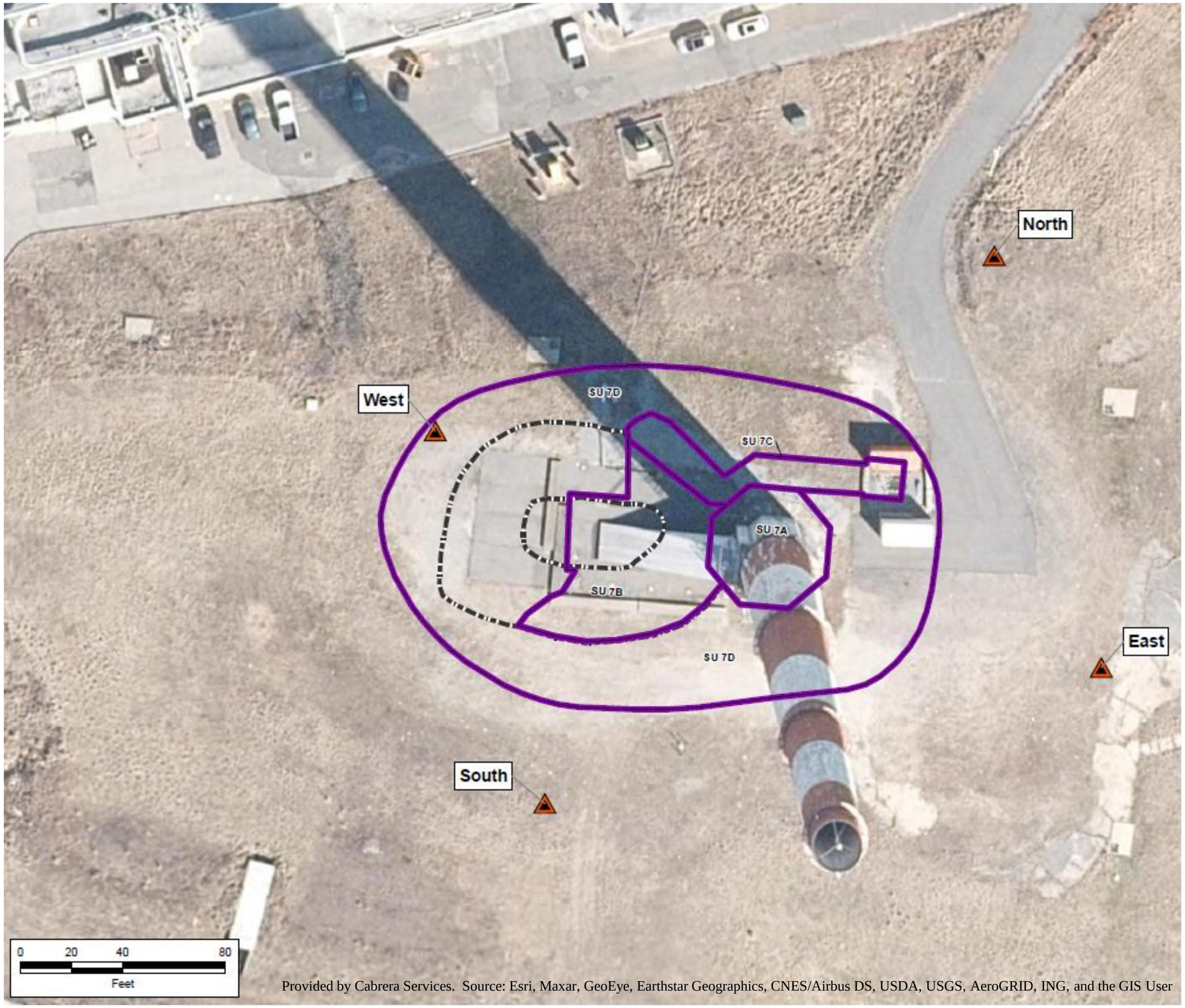


**SU 7A PEDESTAL PAD
SURVEY GRID LAYOUT**

**BROOKHAVEN NATIONAL LABORATORY
UPTON, NEW YORK**

10/2021	PROJECT No. R5-0022.01	FIGURE 3-11

CABRERA SERVICES
CHALLENGE ACCEPTED



N

Legend

- Air Sampler Location
- Survey Unit (SU) Boundary
- Silencer Excavation Footprint

Brookhaven National Laboratory
High Flux Bean Reactor Stack, Bldg. 705
Decommissioning & Demolition

USACE
Baltimore District

FIGURE 4-1

OFJV Radiologic Air Sampling Locations

Olgoonik FPM JV, LLC

25 YEARS CABRERA SERVICES

INTERNATIONAL CHIMNEY CORPORATION

2021