Brookhaven Graphite Research Reactor (BGRR) Decommissioning Project

REMOVAL ACTION COMPLETION REPORT FOR PILE FAN SUMP, PIPING, AND SOILS REMOVAL

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BROOKHAVEN NATIONAL LABORATORY
BROOKHAVEN SCIENCE ASSOCIATES
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- Letter dated March 14, 2000 from G. Malosh (DOE/BHG) to J. Lister (NYSDEC) and M. Logan (EPA), Subject: Brookhaven National Laboratory (BNL) Interagency Agreement (IAG): Brookhaven Graphite Research Reactor Decommissioning Project (BGRR-DP) - Sampling and Analysis Program for the Cleanup Verification of Soil and Disposal of Debris from the Removal of the Pile Fan Sump, Piping, and Above Ground Ducts.
- Letter dated March 1, 2000 from M. Schlender (BSA) to S. Mallette (DOE/BHG), Subject: Submission of BGRR Sampling and Analysis Program for the Cleanup Verification of Soil and Disposal of Debris from the Removal o the Pile Fan Sump, Piping, and Aboveground Ducts.
- Letter dated December 6, 1999 from J.B. Lister (NYSDEC) to G.J. Malosh (DOE/BHG), Subject: Draft Sampling and Analysis Plan, BGRR Pile Fan Sump and Above Ground Ducts, Brookhaven National Laboratory, ID 152009.
- Letter dated December 1, 1999 from J.P. Crua (NYSDOH) to J.B. Lister (NYSDEC), Subject: BGRR-Draft Sampling Plan, Brookhaven National Laboratories, Site #152009, Brookhaven, Suffolk County.
- Memo dated November 5, 1999 from R. Rommell (NYSDEC) to J. Lister (NYSDEC), Subject: Comments on Working Draft BGRR PFS SAP.
- Letter dated October 18, 1999 from J. Pim (Suffolk County Department of Health Services) to G. Malosh (DOE/BHG), Subject: BGRR Decommissioning Project: Pile Fan Sump and Above Grade Ducts Sampling and Analysis Plan.
- Letter dated October 1, 1999 from M. Schlender (BSA) to G.J. Malosh (DOE/BHG), Subject: BGRR Sampling and Analysis Program and Plans for the Pile Fan Sump and Above-Grade Duct Removals.

ACRONYMS, ABBREVIATIONS, AND UNITS OF MEASUREMENT

amsl	above mean sea level
AOC	Area of Concern
BGRR	Brookhaven Graphite Research Reactor
BHG	Brookhaven Group
BNL	Brookhaven National Laboratory
BSA	Brookhaven Science Associates
CERCLA	*Comprehensive Environmental Response, Compensation, and Liability Act*
Cs-137	Cesium-137
DCGL	Derived Concentration Guidelines Level
DOE	Department of Energy
DP	Decommissioning Project
EPA	U.S. Environmental Protection Agency
ERD	Environmental Restoration Division
ESSP	Environmental Survey and Site Assessment Program
IAG	Interagency Agreement
MARSSIM	Multi-Agency Radiation Survey and Site Investigation Manual
mrem/yr	millirem/year
NaI	sodium iodide
NEPA	*National Environmental Protection Act*
NESHAP	National Emission Standards of Hazard Air Pollutants
NYSDEC	New York State Department of Environmental Conservation
NYSDOH	New York State Department of Health
ORISE	Oak Ridge Institute for Science and Education
pCi/gm	picoCuries/gram
PFS	Pile Fan Sump
Ra-226	Radium-226
SAP	Sampling and Analysis Program
SE	Systems Engineering
Sr-90	Strontium-90
USID/SE	Unreviewed Safety Issue Determination/Safety Evaluation

1.0 INTRODUCTION

1.1 Purpose

This Removal Action Completion Report documents the activities conducted to complete the Pile Fan Sump Removal Action for the Brookhaven Graphite Research Reactor (BGRR). The report becomes part of the Administrative Record and satisfies the Interagency Agreement (IAG) between the U.S. Department of Energy (DOE), the U.S. Environmental Protection Agency (EPA) and the New York State Department of Environmental Conservation (NYSDEC) [1].

1.2 Removal Authority

Removal of the Pile Fan Sump, Piping and Associated Soils was governed by the following documents:

1. Letter dated June 17, 1999 from the Department of Energy, Brookhaven Group (DOE/BHG), G. Malosh to Brookhaven Science Associates (BSA), M. Schlender, Subject: Authorization to Proceed with the Removal of the Pile Fan Sump (see Attachment 1),
2. Approval of the *Comprehensive Environmental Response, Compensation, Liability Act* (CERCLA) action memorandum, Letter dated August 27, 1999 from DOE/ BHG, G. Malosh to BSA, M. Schlender, Subject: Approval of the Pile Fan Sump Action Memorandum for the Brookhaven Graphite Research Reactor Decommissioning Project (BGRR-DP) (see Attachment 2),
3. Action Memorandum Brookhaven Graphite Research Reactor Pile Fan Sump Removal Action, Rev. 1, Dated September 22,1999 (see Attachment 2),
4. Letter dated September 30, 1999 from DOE/BHG, G. Malosh to Mr. James Lister, NYSDEC and Ms. Mary Logan, EPA, Subject: Approved Pile Fan Sump Action Memorandum: Brookhaven Graphite Research Reactor Decommissioning Project (BGRR-DP) (see Attachment 2)
5. Brookhaven Graphite Research Reactor Sampling and Analysis Program for the Cleanup Verification of Soil and Disposal of Debris from the Removal of the Pile Fan Sump, Piping, and Above Ground Ducts, BGRR-008, dated February 28, 2000, Rev. 0 (for associated correspondence, see Attachment 4).
6. BGRR Pile Fan Sump Removal, National Emission Standards of Hazardous Air Pollutants (NESHAP) compliance evaluation, dated September 30, 1999 (see Attachment 5),

2.0 SITE DESCRIPTION AND HISTORY

2.1 Brookhaven National Laboratory

Brookhaven National Laboratory is located in Upton, Long Island, New York, near the geographic center of Suffolk County, approximately 60 miles east of New York City (Figure 1). Approximately 1.32 million people reside in Suffolk County and about 0.41 million people reside in Brookhaven Township, within which BNL is situated.

The BNL facility contains 5,265 acres (8.23 square miles). BNL terrain is gently rolling with elevations varying between 44 and 120 feet above mean sea level (amsl). The land lies on the western rim of the shallow Peconic River watershed, with a principal tributary of the river in the north and west sections of BNL.

Figure 1. BNL Location Map

The principal facilities at BNL are located, with few exceptions, near the geographic center of the site. The facilities are contained in an area of approximately 900 acres, of which about 500 acres were originally developed for U.S. Army uses. The remaining 400 acres are occupied, for the most part, by various large research facilities. Outlying facilities occupy about 550 acres and include apartment areas,

biology research fields, a solid waste management area, closed landfills, a sewage treatment plant, and firebreaks. The balance of the site, approximately 75 percent of its total area, is largely wooded. The BNL site, formerly known as Camp Upton, was used by the U.S. Army during World Wars I and II and by the Civilian Conservation Corps Camp between the wars. In 1947, ownership was transferred to the Atomic Energy Commission for peaceful research on atomic energy and materials. The site was subsequently transferred to the Energy Research and Development Administration in 1975, and finally to the DOE in 1977. These later transfers were the result of agency name changes, not changes in occupancy or function.

Brookhaven National Laboratory carries out basic and applied research in the fields of high-energy nuclear and solid state physics, fundamental material and structure properties and the interactions of matter, nuclear medicine, biomedical, and environmental sciences, and selected energy technologies.

2.2 Brookhaven Graphite Research Reactor

The BGRR at BNL was the first reactor built for the sole purpose of providing neutrons for research. During its years of operation, it was one of the principal research reactors in the United States. Construction on the BGRR was completed in August 1950, and initial criticality of the reactor was achieved the same month. The BGRR operated until June 10, 1968, when operation of the reactor was terminated and deactivation of the facility was initiated. In June of 1972, defueling and shipment of the fuel to the DOE Savannah River site was completed. The BGRR complex was described as being in a safe shutdown condition by the U.S. Atomic Energy Commission and became a Surplus Facility within the DOE complex. From 1977 until 1997, portions of the facility were used as the BNL Science Museum.

The BGRR was an air-cooled graphite moderated reactor. The Primary Air-Cooling System utilized cooling fans that were located in a building (704) separate from the reactor building (701). Exhaust ducting constructed of reinforced concrete runs in two separate ducts below the ground from the reactor exhaust plenums to the system cooler and filters. Downstream of the filters, the ducting rises above the ground and combined into one large duct, which was located on, and supported by, the Fan House (704). The individual cooling fans took suction through 48-inch-diameter ducts, which penetrated the building roof and connected at the duct bottom. There was approximately 225 feet of above-grade ducting. The Above Grade Duct Removal Action is approximately 70 percent complete. Figure 2 shows an aerial picture of the BGRR site.

During reactor operations, filtered outside cooling air was drawn across the reactor pile through this ductwork by the fans. The air then moved through the ductwork to the Fan House, where it was cooled, filtered, and eventually exited through the 320-foot-tall exhaust stack.

Figure 2. BGRR Site Looking North

2.3 Pile Fan Sump

The Pile Fan Sump is a reinforced concrete structure 5 feet wide by 7 feet long by 10 feet deep with a 1 cubic foot volume low point region. The Pile Fan Sump was physically located below the roadway south of Building 801, and was a low point collection for several drain locations. Drains from the main stack, Fan House Building 802 floor drain, Fan House Building 704 fan room drains, and the low point of the Building 801 acid fume hood ventilation line all drained into the Pile Fan Sump. When the sump filled to a predetermined level, the water in the sump was pumped using an installed eductor to the collection tanks in the basement of Building 801. The water was then sampled. Based on the results of the water analysis, the water in the collection tanks would be sent to Building 811 for processing and ultimate disposal of the contaminants.

During the BNL Facility review in 1997, radioactively contaminated water was found in the Pile Fan Sump. It was determined that the sump had not been pumped in several years. The sump was emptied and placed on a routine surveillance and monitoring program for pumping. Reactor Division personnel performed the surveillance, monitoring, and pumping of the Pile Fan Sump until it was removed from service in the fall of 1999.

In 1999, during the BGRR decommissioning planning, the Reactor Division was assisting the Plant

Engineering Department in replacing the main stack drain line with a double-wall drain line to bring the stack drain system into compliance with Suffolk County Sanitary Code, Article 12. The main stack drains are to run directly from the main stack to collection tanks in the basement of Building 801. Those plans did not include the Pile Fan Sump. In a concurrent effort to reduce the "footprint" of the BGRR complex, the BGRR Decommissioning Project planned to remove the primary air-cooling fans from the Fan House (Building 704). As the result of meetings held with the Reactor Division and Plant Engineering personnel, it was decided that it would be prudent to include the removal of the Pile Fan Sump, associated piping, and soils. This effort would reduce the cost of installation of the stack drain line because it would not require radiological work during the installation except for the final connection to the main stack. Additionally, it would provide for the remediation of any contaminated soils by excavation that were associated with the Pile Fan Sump and associated piping. It became essential for continuous communication and coordination of the Pile Fan Sump removal effort so as not to interfere with the main stack drain line installation. At the same time, through correspondence with the EPA, the Pile Fan Sump was designated as Area of Concern (AOC) 9D, becoming subject to the IAG milestone commitments.

2.4 Stakeholder Participation

Stakeholders, including the public, regulators, legislators, and BNL employees, have been informed and involved in the Pile Fan Sump removal action through several planned media releases and scheduled events. Initially, the BGRR Decommissioning Project informed the stakeholders what the planning case was for the decommissioning of the BGRR and solicited "community values" from the stakeholders that could be evaluated with the values set forth in the *National Environmental Protection Act* (NEPA) and CERCLA regulations to determine a path forward for the decommissioning. In parallel with these efforts, the *Removal Action Alternative Study* [2] was being prepared by an independent contractor, and the Pile Fan Sump characterization effort was being performed by the BGRR Project staff. In August 1999, the *Pile Fan Sump Removal Action Memorandum* was prepared and submitted to the DOE, EPA, and NYSDEC for review and comment. Following the incorporation of comments from the regulatory agencies, the *Pile Fan Sump Action Memorandum* was approved September 30, 1999 by the DOE and submitted to the NYSDEC and EPA. *The Pile Fan Sump Action Memorandum* was included in the Administrative Record of the Brookhaven National Laboratory IAG. Public notices were prepared and published in *Newsday* on September 30, 1999 and in *Suffolk Life* on October 6, 1999.

The Community Advisory Council was briefed on the Pile Fan Sump work in November of 1999 and again in March of 2000. The Brookhaven Executive Roundtable was briefed in February of 2000.

The *cleanupdate*, Vol. 5/No. 1/April 2000, a newsletter prepared by BNL Environmental Restoration Division, contains an article and pictures of the removal of the Pile Fan Sump. The *Brookhaven Bulletin*, April 28, 2000, published weekly by the Media & Communications Office for the employees,

facility-users and retirees of BNL, contained a picture and article on the removal of the Pile Fan Sump.

Attachment 3, Community Relations, captures some of the media used to present information regarding the progress of the BGRR Decommissioning Project and the removal of the Pile Fan Sump. It demonstrates the commitment the Project has to informing and involving stakeholders in all facets of the BGRR Decommissioning Project.

3.0 REMOVAL ACTIVITY

3.1 Objectives

Remove the Pile Fan Sump, associated piping, and contaminated soils to reduce the "footprint" of the BGRR Complex and complete remediation of AOC 9D in accordance with the IAG and Time Critical Removal Action Memorandum.

3.2 Activities

3.2.1 Remediation Criteria

The sampling and analysis plan (Removal Authority #7, *Brookhaven Graphite Research Reactor Sampling and Analysis Program for the Cleanup Verification of Soil and Disposal of Debris from the Removal of the Pile Fan Sump, Piping, and Above Ground Ducts*) [3], was used to perform the cleanup verification of soil and disposal of debris from the removal of the Pile Fan Sump, piping and soils and is included in Attachment 4 of this report. This plan explains the hazardous materials remediation criteria and discusses in detail the development of radiological remediation criteria. The remediation criteria established for this activity is presented below.

The remediation criteria for the soils associated with the removal of the Pile Fan Sump and associated piping was established by the DOE, EPA, and NYSDEC. The cleanup goals were developed using an above-background dose rate of 15 millirem/year (mrem/yr), Residential Land use, and fifty years of continued Federal Government control of the site. This results in a maximum allowable concentration cleanup goal of 23 picoCuries/gram (pCi/gm) for Cesium-137 (Cs-137).

The Strontium-90 (Sr-90) cleanup goal is based on an evaluation of groundwater impacts, and was calculated to be 15 pCi/gm. This limit is also protective of potential future residential and industrial uses.

The regulatory limit for Radium-226 (Ra-226) of 5 pCi/gm is based on DOE Order 5400.5, "Radiation Protection of the Public and the Environment." The EPA also commonly uses this limit.

When multiple radionuclides exist, the sum of the fractions will be used to insure the maximum total dose limit of 15 mrem/yr is not exceeded.

3.2.2 Characterization Information

The water and sludge in the Pile Fan Sump was characterized and removed for disposal before the Pile Fan Sump was removed. Additional characterization sampling was conducted under the Pile Fan Sump 14-inch-pipe at the south and north penetration walls of the sump (see Attachment 5, NESHAPS Evaluation. Attachment 6 contains characterization data summaries for removal of the Pile Fan Sump.

3.2.3 Planned Activities

1. Prepare a sampling and analysis plan for the cleanup verification of soil and disposal of debris from the removal of the Pile Fan Sump, piping, and Above Ground Ducts and submit to the DOE, EPA, and NYSDEC for review, comment, and approval.
2. Install modification to the stack drain system to collect stack drain water and place in service.
3. Locate and characterize the Pile Fan Sump, piping, and associated soils.
4. Use a gamma spectroscopy instrument to perform *in-situ* field measurements and as a field laboratory gamma spectroscopy sample analyzer for real-time field analysis of soils, in particular for Cs-137 contamination concentrations during soils remediation.
5. Use a Beta scintillation instrument as a field beta particle analyzer to provide real- time Sr-90 contamination concentrations during soil remediation.
6. Remove and segregate overburden to access the drain piping.
7. Perform overburden verification sampling.
8. Remove piping by cutting on either side of the leaded joints.
9. Sample soils below the piping and remediate as necessary to meet at a maximum the established remediation criteria.
10. Backfill the excavations with the overburden that was sampled and meets at a maximum the established remediation criteria.
11. Remove the piping between the Pile Fan Sump and Building 801.
12. Remove the isolated Pile Fan Sump.
13. Sample and remediate associated soils.
14. Conduct Independent Contractor and Regulator Verification Sampling.
15. Conduct geoprobe sampling and analysis of the soils to the ground water in the pile fan sump removal area to determine the presence/absence of Sr-90 in the vadose zone.

Attachment 7 provides a pictorial review of the remediation activity.

3.2.4 Stack Drain System Modification Installation and Operation and Characterization Activities

Refer to Figure 3, Pile Fan Sump System Diagram.

When the Removal Action began, the Pile Fan Sump was still in service collecting water from the various drain locations. It was necessary to isolate the drains that were no longer needed and divert the stack drains into a suitable collection container that could be monitored and pumped as necessary.

In Building 801, there are hooded work areas that are maintained at a negative air pressure with respect to the worker occupied area. These hooded areas are called acid fume hoods. When work is performed in the hood area, any vapors resulting from the chemicals used are controlled by removing them away from the worker to the acid fume hood ventilation line that provides an elevated release point at the top of the main stack. The first piping isolation was capped was the acid fume hood ventilation line at the top of the stack. A steel cover was made and installed on the top of the ventilation line that extends up the inside of the stack. This prevented any rainwater from entering into the acid fume hood ventilation line. The drain in the Fan House Building 802 was grouted to prevent water from entering into the stack drain line header, as were the drains from the Fan House (Building 704) fan rooms. This left the three stack drains to be diverted into a suitable collection facility so that the Pile Fan Sump, associated piping, and contaminated soils could be removed.

The BGRR Decommissioning Project engineered and installed a Suffolk County Department of Health Services compliant collection system for the stack drains. The system consists of a secondarily contained sump that was placed into the basement of the Fan House (Building 704), #5 Fan Room. The drain line was cut and the stack drain portion was diverted into the sump. The sump contains two independent pumps that will automatically start on redundant high-level sensor switches and pump any collected water from the stack drains into a large tank located in the #5 Fan Room. The system is equipped with an electrical inverter with a battery backup for operating the pumps in the unlikely event that there is a sustained electrical power failure. Procedures for the surveillance, monitoring, and pumping of the system were prepared and are being maintained, along with the collection system, by High Flux Beam Reactor Project personnel.

During the installation of the stack drain collection system, the drain line that left the Fan House (Building 704) and ran to the Pile Fan Sump was uncovered at approximately 7 feet below grade next to the Fan House. This was done to characterize the area below the piping and especially the first pipe joint from the Fan House. Additionally, the drain line was uncovered at the south side of the Pile Fan Sump, and the interior of the sump was characterized. The initial data showed approximately 167 pCi/gm of Cs-137 pCi/gm below the first pipe joint from the Fan House. Radioactive contamination was also found under the 14-inch acid fume hood vent line where it penetrated the Pile Fan Sump on the south side of the sump. The highest measured level of Cs-137 was 205 pCi/gm, which was found 18 inches below the pipe at the south side of the sump.

The project used portable field measuring equipment to perform *in-situ* gamma spectroscopy measurements of the soils over the piping and pile fan sump area prior to excavation. The measurements recorded background levels except for some of the asphalt that indicated elevated levels of Cs-137.

3.2.5 Removal and Remediation Activities

During removal and remediation activities, soil samples were initially analyzed by field laboratory gamma spectroscopy. This provided real-time analysis to direct remediation activities. The only gamma-emitting radionuclide of concern was Cs-137. No other gamma-emitting radionuclides were identified other than those naturally occurring in nature; which were within expected background concentrations.

Final status survey samples were taken and sent to an off-site laboratory for analysis. These samples were analyzed for gamma-emitting radionuclides, gross alpha, and gross beta radioactivity including Sr-90. Verification sample results were compared to each cleanup goal level and the unity rule (sum-of-ratios) applied with both guideline conditions being satisfied. Additionally, selected samples were analyzed for metals and volatile organics. All analyses showed contamination levels less than the clean-up action limits. Naturally occurring radionuclides were not removed for the sum of the fractions testing, to insure the sum of the fractions demonstrated compliance using the most conservative data.

Specific sample results are presented in Attachment 8, Independent Off-Site Laboratory Results for the Final Status Survey.

Refer to Figure 4, Pile Fan Sump Piping Removal Diagram

Removal activities began with the removal of overburden—that is, the soil and other materials—from the piping trench starting next to the Fan House (Building 704). During the removal of the overburden, the portable gamma spectroscopy system was set up as a field laboratory system to analyze discreet samples taken from the materials being excavated. This provided the project team with real-time sample analysis. This reduced the amount of time and funds that would have been spent for on-site and off-site laboratory analysis. When the top of the piping was uncovered, the excavation was approximately 12 feet wide and 7 feet deep. Approximately 20 to 30 feet of piping was exposed at a time as the excavation proceeded towards the Pile Fan Sump connection some 150 feet to the northeast. A grid system was established so that sampling could be traced and reproduced if required. The grid system was 5 feet in length starting at the Fan House Building 704 north wall in the north and south direction, and 6 feet in length in the east west direction across the pipe location. Portable radiation instruments were used to conduct radiological surveys of the newly exposed earth and the 4-inch-diameter cast-iron drain piping. At location designated G1, the first leaded joint north of the Fan House (Building 704) radioactive contamination was found under the joint in the soils. Approximately 167 pCi/gm of Cs-137 was identified through gamma spectroscopy analysis of a soil sample from under

the pipe joint. The piping was cut so as not to disturb the leaded joint hazardous material. The piping was cut into manageable sections and bagged to contain any radiological or hazardous materials. Once the piping was removed, the contaminated soils were remediated by removal of contaminated soil to below the established criteria. Background levels of Cs-137 were identified at 18 inches below the initial contamination. The only other area under the drain piping that was found to be contaminated was the soil under the location at joint #3, with approximately 94 pCi/gm of Cs-137. Background levels of Cs-137 contamination were identified at approximately 24 inches below the initial contamination.

The 4-inch-diameter cast-iron drain line was successfully removed to the penetration of the Pile Fan Sump that was located on the south wall of the sump without any additional soil contamination being identified through field laboratory sample analysis.

The remediation by excavation of the contaminated soils was to typical background levels for Cs-137, significantly below the established remediation criteria of 23 pCi/gm for Cs-137.

Refer to Figure 5, Pile Fan Sump Excavation Diagram Looking North

During the excavation to uncover the piping and sump, the overburden that was removed was sampled. If it was found to be contaminated, it was segregated from the clean soils.

The process piping penetrations of the Pile Fan Sump, located on the south side of the sump, were the 4-inch-diameter drain line and the 14-inch-diameter stainless steel line for the acid fume hood ventilation from Building 801. It became evident that there had been leakage from the 14-inch-diameter piping from the soil samples that were taken under the penetration against the sump wall. The highest analyzed soil sample was approximately 2,169 pCi/gm of Cs-137.

The process piping that penetrated the north wall of the Pile Fan Sump consisted of a 2-inch-diameter stainless-steel sump discharge line and the 14-inch-diameter stainless-steel acid fume hood ventilation line from Building 801. No contamination of the soils was found under these lines from the Pile Fan Sump to the Building 801 south wall piping penetrations. Both were welded lines with very good integrity.

The excavation continued around the Pile Fan Sump to remove enough soil so that the sump could be removed in one piece using a crane.
Refer to Figure 6, Caisson Locations Layout Diagram

Once the Pile Fan Sump was removed, it was necessary to install a caisson to support the 24-inch-diameter concrete normal ventilation line (located approximately 7 feet below grade and 2 feet to the west of the Pile Fan Sump) and the 42-inch-diameter concrete main ventilation line (located approximately 7 feet below grade and 8 feet to the south of the Pile Fan Sump).

Each caisson section was 10 feet in diameter and 5 feet high. The large diameter was selected to allow the footprint of the Pile Fan Sump to fit into the center of the caisson. The first caisson placed surrounded the footprint of the Pile Fan Sump and provided shoring for the ventilation lines to the west and south during the excavation of the soils. The highest field analyzed soil sample was 366 pCi/g of Cs-137. The soil was excavated to a depth of approximately 23 feet below grade, approximately 11 feet below the bottom of the Pile Fan Sump. The soil was remediated by removal of the contaminated soils to typical Cs-137 background levels, well below the established remediation criteria of 23 pCi/gm.

Soil contamination was found northeast of the first caisson. A second caisson was placed to the northeast of the first caisson to continue soil remediation. The highest field analyzed soil sample was 88.8 pCi/gm of Cs-137. The soil was remediated to a depth of approximately 21 feet below grade, approximately 9 feet below and to the northeast of the bottom of the Pile Fan Sump. The soil was excavated to typical Cs-137 background levels that are well below the established remediation criteria of 23 pCi/gm.

3.2.5 Final Status Surveys and Independent Contractor Verification

The Environmental Survey and Site Assessment Program (ESSP) of the Oak Ridge Institute for Science and Education (ORISE) performed the on-site portion of the independent verification survey of the Pile Fan Sump trench from March 13-16, 2000.

When any final verification soil sampling was performed by BNL's Environmental Restoration Division (ERD) sampling technicians, the ORISE and NYSDEC personnel witnessed the sampling. These samples were sent off-site to an independent laboratory for hazardous and radioactive materials analysis.

Verification activities performed by ESSP included a document and data review (Type A verification) of the Pile Fan Sump trench and of the associated piping drain piping trench soils that extended from Buildings 704 and 801 to the Pile Fan Sump. This review included two samples provided by BNL for confirmatory analysis. The document review concluded that the BNL revised sampling and analysis plan for the Pile Fan Sump appeared to adequately identify radiological and/or chemical contamination.

The ESSP also performed independent surveys (Type B verification) by performing 100 percent gamma radiation scans using sodium iodide (NaI) detectors coupled to rate meters with audible indicators and collected random and judgmental samples. The gamma scans were at or near background levels. The samples analyzed were below the established Cs-137 Derived Concentration Guideline Level (DCGL) of 23 pCi/gm. No other gamma-emitting radionuclides were identified, other than those naturally occurring in nature, and these were within expected background concentrations. Sample analyses results for metals and volatile organics were less than the BNL clean-up action limits.

See Attachment 9 for the complete ORISE Report.

The NYSDEC's Division of Solid and Hazardous Materials, Bureau of Radiation and Hazardous Site Management, Radiation Section conducted independent verification surveys and sampling of the Pile Fan Sump (Sub-AOC 9D) from March 14-16, 2000. The Pile Fan Sump area was surveyed using portable gamma-radiation-detection instruments and 11 soil samples were obtained for laboratory analysis. In its summary, the NYSDEC report states, "No residual contamination exceeding cleanup goals or areas exhibiting elevated radioactivity were detected after remediation was complete." See Attachment 10 for the complete NYSDEC report.

Following the satisfactory results of the independent verification sampling, the area was restored. Soil was replaced on the hillside and the hillside was seeded. Curbing was reinstalled along the affected roadways and the former location of the pile fan sump was resurfaced with asphalt.

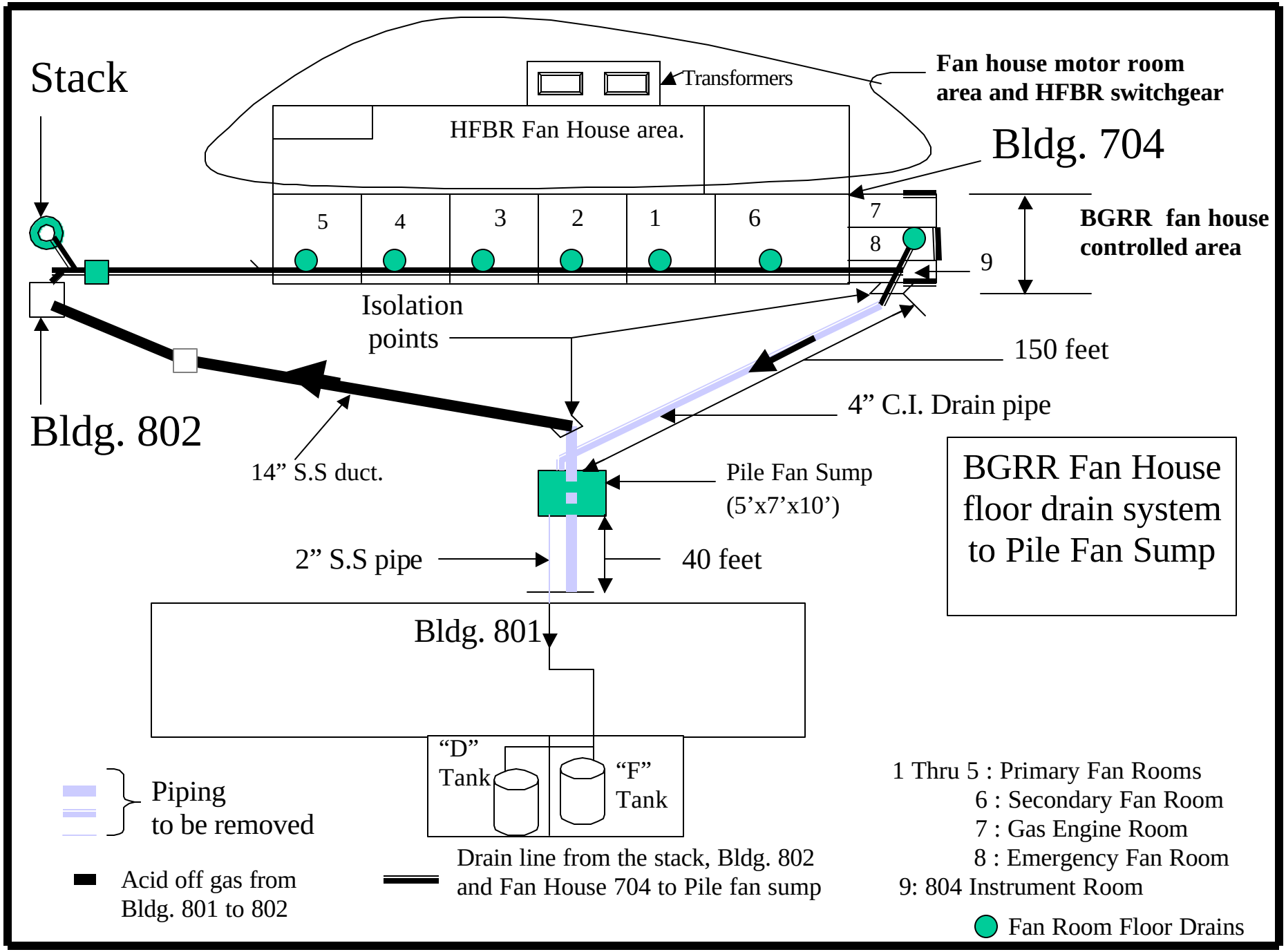

Figure 3. Pile Fan Sump System Diagram

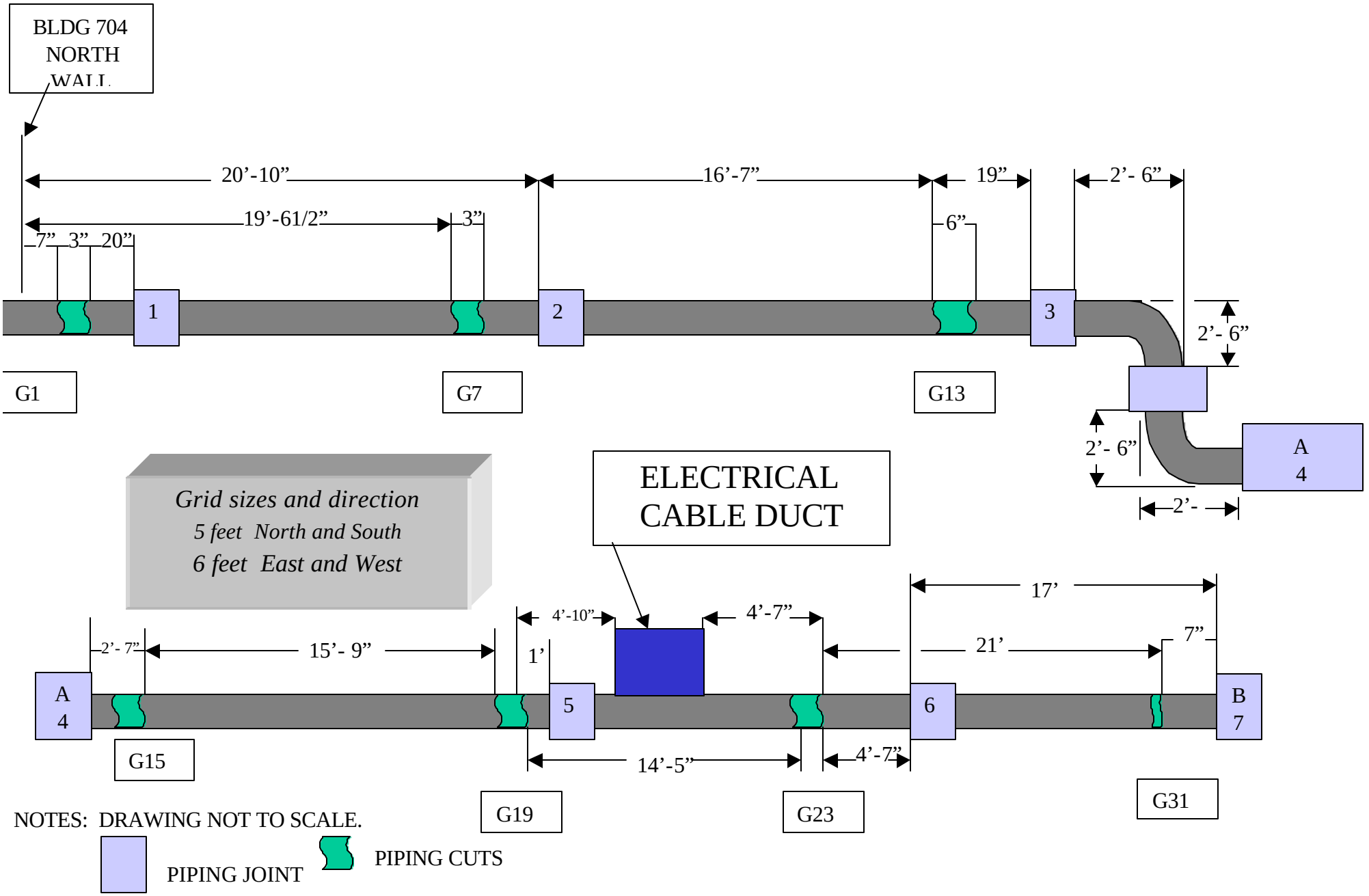

Figure 4. Pile Fan Sump Piping Removal Diagram

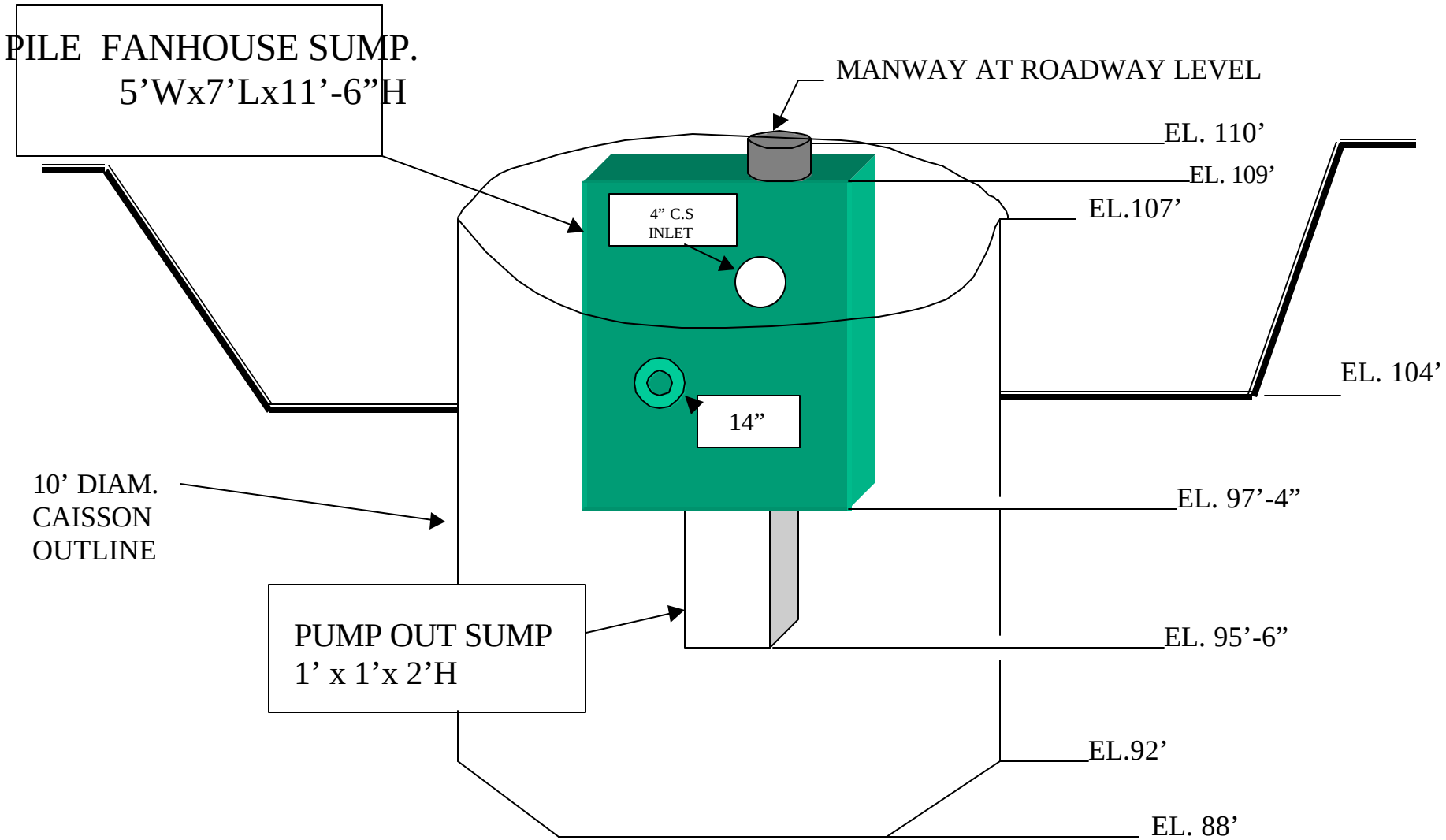

Figure 5. Pile Fan Sump Excavation Diagram Looking North

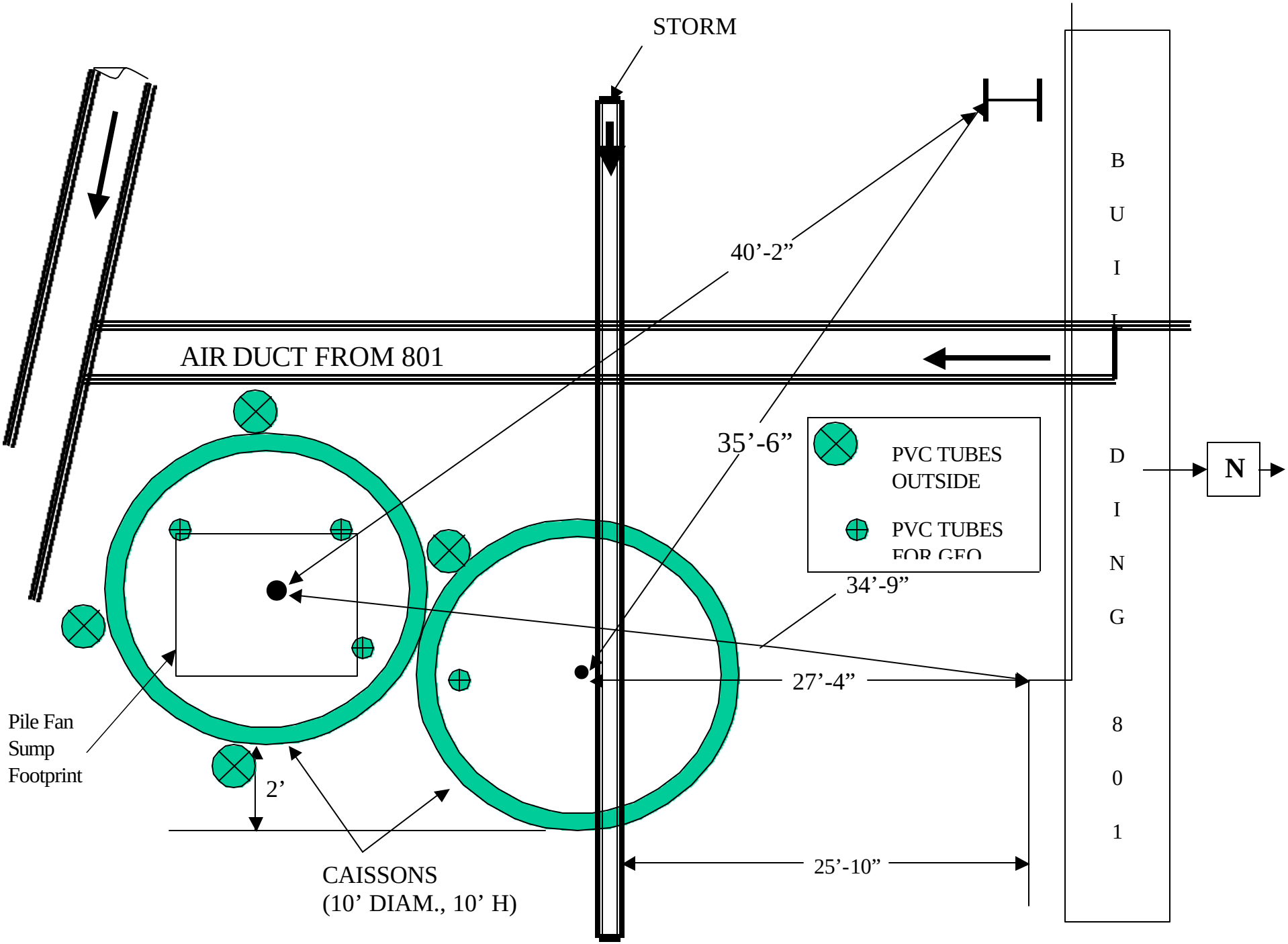

Figure 6. Caisson Locations Layout

3.3 Final Conditions

The Pile Fan Sump was excavated and removed, along with the associated piping from the Fan House (Building 704) north wall to the Pile Fan Sump, and from the Pile Fan Sump to the south wall of Building 801. The 14-inch-diameter stainless-steel acid fume hood ventilation line was cut and capped approximately 6 feet south of the Pile Fan Sump and removed from there northward to the south wall of Building 801. The Pile Fan Sump 2-inch-diameter discharge line from the Pile Fan Sump northward to the south wall of Building 801 was removed. The section of the 14-inch-diameter stainless-steel acid fume hood ventilation line that was left below ground was capped with a steel pipe cover and bagged with plastic to prevent any water intrusion to the piping. The integrity of the line is exceptionally good. The sections are welded and run approximately 7 to 12 feet below the ground to the ventilation equipment located in Building 802. There were positive indications of low levels of smearable radioactivity on the internal surfaces of the pipe where it was capped and bagged. As stated above, the integrity of the stainless steel piping is very good and can contain the radioactivity until the piping is removed. The piping will be removed when the Building 801 normal ventilation system is removed. The Building 801 normal ventilation piping is in close proximity to the stainless steel piping making removal of only the stainless steel piping difficult and costly at this time.

During the backfill operations, sampling tubes were installed at the pipe joints along the piping run to allow for sampling. The tubes were installed at the pipe joints to allow for independent sampling at the level of the pipe joint remotely. Once the independent sampling is completed, the tubes will be pulled or left in place and backfilled with soil. Additionally, sample tubing was installed at the contamination locations inside and outside the caissons to allow for sample reproducibility at sample locations. The tubing marked sample locations at the depth of the completed excavation. This allowed the area to be backfilled with soil. Once the area was backfilled with soil, a Geoprobe was used to take samples from the tube marked areas to depths below the completed excavation up to and including the depth of groundwater, where water samples were taken. This sampling was performed to verify there was no contamination that had migrated deeper into the ground undetected under and around the area of the soil remediation. The caissons placed at the 10 to 20 feet below grade supported the Building 801 48-inch-diameter concrete normal ventilation line that allowed excavation of the contaminated soil. These caissons were backfilled and left in place. Approximately 8,300 cubic feet of asphalt and soils were placed in containers for disposal at an off-site licensed commercial disposal facility.

All soils associated with the excavation of the piping and the area associated with the Pile Fan Sump were excavated to typical background levels of Cs-137, approximately 1.0 pCi/gm. This level is significantly below the established remediation criteria of 23 pCi/gm. No other gamma-emitting radionuclides were identified other than those naturally occurring in nature, and those were within expected background concentrations. Sample analyses results for metals and volatile organic substances

were less than the BNL clean-up action limits.

Attachment 11 provides a summary of the field laboratory gamma spectroscopy sampling which was conducted to determine when that remediation was complete and that final status survey and sampling could begin.

3.4 Conclusions

Refer to Attachment 8, Independent Off-Site Laboratory Results for the Final Status Survey and Attachment 12, Evaluation Results for the Radiological Sum of the Fractions and Signs Test.

The Pile Fan Sump, Piping, and Associated Soils have been successfully removed and the associated soils remediated to the following established criteria:

Dose rate of less than 15 millirem/yr,
Levels of Cs-137 less than 23 pCi/gm,
Levels of Sr-90 less than 15 pCi/gm, and
Sum of the fractions for all the identified radionuclides is less than unity.

The sum of the fractions is one of the methods used to determine that the dose limit of 15 mrem/yr has been met. The concentration result of each radionuclide that was identified during the sample analysis is divided by its cleanup goal criteria, after which all of the results are summed. A sum of less than one indicates that the combined effect of a large area contaminated with the detected radionuclide concentrations would result in a dose of less than 15 mrem/yr. A sum of one indicates that the dose from a large area with these concentrations would be equal to 15 mrem/yr, and a sum greater than one would indicate the resulting dose to be greater than 15 mrem/yr. Included in the sum of the ratios are the naturally occurring radionuclides. This provides the most conservative representation of the sum of the fractions evaluation.

Sample analyses results for metals and volatile organic substances were less than the BNL clean-up action limits.

Refer to Attachment 9, Independent Verification Contractor (ORISE) Sampling and Analysis Results and Attachment 10, NYSDEC Independent Radiological Verification Results.

The independent surveys, sampling and analysis performed by the NYSDEC and ORISE have concluded that the removal and remediation were performed satisfactorily and are below the established criteria.

Based on the amount of soils requiring remediation—approximately 8,300 cubic feet—and the low radioactivity level content of the soils, the leakage from the Pile Fan Sump was not sufficient to cause or be a major contributor to any identified Sr-90 contamination of the groundwater. Based on these findings, no further action is required for this Area of Concern under the IAG.

3.5 Activity Cost

The activity cost was approximately $773,000. The cost includes planning, execution, waste disposal, and closure of the activity.

4.0 WASTE MANAGEMENT

Approximately 8,300 cubic feet of waste in the form of asphalt, soils, piping, and one concrete sump were generated during the remediation activity. The materials were disposed of at the regulated disposal facility, Envirocare of Utah. The table below summarizes the type of waste, shipment date, the number of trucks used to transport the waste, the volume of waste shipped, and the final disposal facility.

Waste Type	Shipment Date	Number of Trucks	Volume (cu. ft.)	Disposal Facility
Soil/asphalt	07/20/2000	4	2,160	Envirocare of Utah
Soil/asphalt	07/21/2000	4	2,160	Envirocare of Utah
Soil/asphalt	07/24/2000	5	2,700	Envirocare of Utah
Sump and debris	08/28/2000	1	1,280	Envirocare of Utah
Total		14	8,300	

5.0 LESSONS LEARNED

1. Communication was one of the lessons learned during the performance of this activity. Whenever physical work is planned, it is necessary to communicate the work planned, its expected duration, and the increased traffic near the facility to the occupants of nearby buildings.

2. Trenching provides unique challenges to the workers. An excavation must appear safe, but more importantly, it must meet the proper regulatory requirements before personnel enter

the excavation.

3. Close coordination with the waste contractor is necessary to ensure adequate containers are available to package and transport the waste materials being removed to minimize schedule impacts for the project.

4. All remediation should be totally completed before scheduling the independent verification contractor and regulators to perform final status verification sampling.

5. Multi-Agency Radiation Survey and Site Investigation Manual (MARSSIM) should be used any time final verification survey and sampling is being conducted. The survey and sampling can and should be modified to suit the circumstances of the remediation and demonstrate that the remediation objectives have been achieved.

6. Attention to detail is required for postings and signs that designate work area.

7. When work is being performed or supplemented by subcontractor personnel, a contractor exit interview should be conducted to review project and worker safety before the personnel are released from the site.

6.0 REFERENCES

1. Federal Facility Agreement under CERCLA Section 120, Administrative Docket Number II-CERCLA-FFA-00201, United States Environmental Protection Agency, Region II, United States Department of Energy, and the New York State Department of Environmental Conservation. In the matter of the U.S. Department of Energy's Brookhaven National Laboratory, 1992.

2. Brookhaven National Laboratory, "Brookhaven Graphite Research Reactor Decommissioning Project Removal Action Alternatives Study," Report BGRR-015, Rev. 0, April 13, 2000.

3. Brookhaven National Laboratory, "Brookhaven Graphite Research Reactor, Sampling and Analysis Program for the Cleanup Verification of Soil and Disposal of Debris from the Removal of the Pile Fan Sump, Piping, and Aboveground Ducts," Report BGRR-008, Rev. 0, February 28, 2000.