BGRR-015, Rev. 0

Brookhaven Graphite Research Reactor Decommissioning Project

Removal Action Alternatives Study

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BROOKHAVEN NATIONAL LABORATORY
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LIST OF ACRONYMS AND ABBREVIATIONS

μrem/hr	microrem/hour
ACM	asbestos-containing material
AEC	Atomic Energy Commission
Ag	Silver
ALARA	as low as reasonably achievable
Am	Americium
AOCs	area(s) of concern
ARARs	Applicable Or Relevant And Appropriate Requirements
Ba	Barium
Be	Beryllium
BEIs	Biological Exposure Indices
BER	Brookhaven Executive Roundtable
BGRR	Brookhaven Graphite Research Reactor
BNL	Brookhaven National Laboratory
BOP	Balance of Plant
C	Carbon
Ca	Calcium
CEQ	Council on Environmental Quality
CERCLA	*Comprehensive Environmental Response, Compensation, and Liability Act* of 1980
Cf	Californium
CFR	Code of Federal Regulations
Cl	Chlorine
CLP	Contract Laboratory Program
Cm	Curium
Co	Cobalt
COC	contaminants of concern
COE	Corps of Engineers
COPCs	Contaminants of Potential Concern
Cs	Cesium
Cu	Copper
D&D	Decontamination and Decommissioning

DCGL	Derived Concentration Guideline Level
DOE	United States Department of Energy
DOT	Department of Transportation
dpm	disintegrations per minute
EE/CA	Engineering Evaluation/Cost Analysis
EPA	United States Environmental Protection Agency
EU	enriched uranium
Eu	Europium
Fe	Iron
FFA	Federal Facilities Agreement
FS	Feasibility Study
ft	foot or feet
Gal	Gallons
Glacial	Glacial deposits of Pleistocene age
GPM	gallons per minute
H-2	Deuterium
H-3	Tritium
HEPA	high efficiency particulate air
HEPA	High Efficiency Particulate Air
HFBR	High Flux Beam Reactor
Hg	Mercury
IAG	Interagency Agreement
Kd	equilibrium distribution coefficients
Kg	kilograms
KV	kilovolts
LCC	Life Cycle Cost
LIE	Long Island Expressway
LILCO	Long Island Lighting Company
LIPA	Long Island Power Authority
Magothy	Matawan Group – Magothy Formation
MARSSIM	Multi-Agency
Mo	Molybdenum
MOA	Memorandum of Agreement
mrem	millirem

MWt	megawatts thermal
N	no
NA	not applicable
NAAQS	National Ambient Air Quality Standards
Nb	Niobium
NCP	National Contingency Plan
NEPA	*National Environmental Protection Act*
NESHAP	National Emissions Standards for Hazardous Air Pollutants
NESHAPS	National Emissions Standards for Hazardous Air Pollutants
Ni	Nickel
NPDES	National Pollutant Discharge Elimination System
NPL	National Priority List
NRC	Nuclear Regulatory Commission
NU	natural uranium
NWI	National Wetland Inventory
NYCRR	New York Code of Rules and Regulations
NYPA	New York Power Authority
NYSDEC	New York State Department of Environmental Conservation
O&M	Operation and Maintenance (same as S&M)
OSHA	Occupational Safety and Health Administration
Pa	Protactinium
PAHs	polynuclear aromatic hydrocarbons
PCBs	polychlorinated biphenols
Pci/G	picocuries per gram
PFS	Pile Fan Sump
Pm	Promethium
POTW	Privately-Owned Treatment Works
PPE	Personnel Protective Equipment
PRGs	Preliminary Remediation Goals
Psi	pounds per square inch
psig	per square inch gage
Psig	pounds per square inch gage
Ra	Radium
RAAS	Remedial Action Alternatives Study

RAOs	Remedial Action Objectives
RCRA	*Resource Conservation and Recovery Act*
RHIC	Relativistic Heavy Ion Collider
RESRAD	Residual Radioactive Material Guidlines
Rn	Radon
ROI	Region of Influence
S	Sulfur
S&M	surveillance and monitoring
SAP	Sampling and Analysis Plan
SARA	*Superfund Amendment and Reauthorization Act*
Sb	Antimony
SHPO	State Historic Preservation Office
Si	Silicon
Sm	Samarium
Sr	Strontium
SWMUs	solid waste management units
TAGM	Technical and Administrative Guidance Memorandum
TBC	To Be Considered
Tc	Technetium
Th	Thorium
TLD	Thermoluminescent Dosimetry
TMV	Toxicity, Mobility, or Volume
ToB	Town of Brookhaven
TSCA	*Toxic Substances Control Act*
U	Uranium
WBS	Work Breakdown Structure
WESTON	Roy F. Weston, Inc.
WMD	Waste Management Division
WMF	Waste Management Facility
Y	yes
Y	Yttrium
Zn	Zinc

EXECUTIVE SUMMARY

EXECUTIVE SUMMARY

A Removal Action Alternatives Study (RAAS) for the Brookhaven Graphite Research Reactor (BGRR) Decommissioning was prepared by the Cabrera Services, Inc. Team for Brookhaven National Laboratory (BNL). The purpose of the RAAS was to perform an evaluation of the selected Removal Action Alternatives for final decommissioning of the BGRR.

The BGRR is located at Brookhaven National Laboratory on Long Island, NY. It was the world's first research reactor constructed solely for the peaceful use of atomic energy research and was operated from 1950 to 1969. The primary reasons for the BGRR Decommissioning project are to remove and/or permanently isolate sources of contamination, reduce any potential threat to public health and the environment, comply with local, state and federal regulatory requirements, satisfy community values, and retire a facility no longer in use by the Department of Energy (DOE).

Seven Decommissioning Alternatives were developed by the project team based on input from members of the public, BNL, US Environmental Protection Agency (EPA), and DOE. The alternatives span from "No Action" to "total removal" of all affected areas including the pile, the reactor building, and all associated fans, ductwork, piping, and soils. "No Action" is used as the baseline against which all of the other alternatives are evaluated, and is required to be considered for the analyses of alternatives under the Comprehensive Environmental response, Compensation, and Liability Act of 1980 (CERCLA). All seven of the removal alternatives were evaluated with respect to CERCLA, National Environmental Protection Act (NEPA), and Community Values.

The seven alternatives are broken down into work elements that together constitute the full scope of work under the alternative. In general, the level of effort and degree of removal increases as the alternative number increases. Alternatives 2 through 7 share common work elements which include: disposal of water collected from the underground cooling ducts (completed); removal of the fans and decontamination of Fan House; removal of the pile fan sump; removal of the former museum walls and displays

(completed); isolation of Building 703 from Building 701; and removal of remaining soils (sub-Area of Concern [AOC] 9C) found to be contaminated above Derived Concentration Guideline Levels (DCGLs) during construction activities, or during pre-removal characterization sampling.

The work to be conducted for each alternative is described as follows:

- Alternative 1 (No Action) excludes the work items considered common work elements. Under this alternative, all structures would remain intact, with surveillance and monitoring for 50 years.

- Alternative 2 addresses only those elements which are specifically included in the Interagency Agreement (IAG) (sub-AOCs 9A, 9B, 9C, and 9D), sealing of the pile, and the common work elements.

- Alternative 3 includes those elements which are specifically included in the IAG (sub-AOCs 9A, 9B, 9C, and 9D), sealing of the pile, and the common work elements. In addition, the below ground ducts, filters, coolers, Instrument House, the Canal House, Water Treatment House, and canal would be removed. Alternative 3 would also include removal of above ground ducts and any associated soil, removal of below ground piping and systems and soil outside of Building 701, dispositioning of Building 701, and removal of Building 701 experimental equipment.

- Alternative 4 would also include those elements specifically included in the IAG (sub-AOCs 9A, 9B, 9C, and 9D), sealing of the pile, and the common work elements. In addition, the below ground ducts, filters, coolers, Instrument House, the Canal House, Water Treatment House, and canal would be removed along with the above ground ducts and any associated soil as well as the below ground piping and systems and soil outside of Building 701. Dispositioning of Building 701, and removal of Building 701 experimental equipment would also be included. Additionally, the alternative would include

the removal of Building 701 equipment and systems, such as the control rod drive mechanisms and charging elevator.

- Alternative 5 would include the IAG elements (sub-AOCs 9A, 9B, 9C, and 9D), sealing of the pile, and the common work elements. In addition, the below ground ducts, filters, coolers, Instrument House, the Canal House, Water Treatment House, and canal will be removed. This alternative would also include removal of above ground ducts and any associated soil, removal of below ground piping and systems and soil outside of Building 701, and removal of Building 701 experimental equipment and Building 701 equipment and systems, such as the control rod drive mechanisms and charging elevator. In addition Building 701 would be removed and a cocoon constructed around Building 702 (the Pile).

- Alternative 6 would include those elements which are specifically included in the IAG (sub-AOCs 9A, 9B, 9C, and 9D), sealing of the pile, and the common work elements. In addition, the below ground ducts, filters, coolers, Instrument House, the Canal House, Water Treatment House, and canal would be removed. This alternative would also include removal of above ground ducts and any associated soil, removal of below ground piping and systems and soil outside of Building 701, dispositioning of Building 701, and removal of Building 701 experimental equipment and Building 701 equipment and systems, such as the control rod drive mechanisms and charging elevator. In addition, Building 702, the reactor pile and biological shield wall, would be removed. In this alternative, Building 701 would remain in place.

- Alternative 7 would remove all BGRR-related structures and equipment, including both Buildings 701 and 702. Those elements which are specifically included in the IAG (sub-AOCs 9A, 9B, 9C, and 9D), sealing of the pile, and the common work elements would be included. In addition, the below ground ducts, filters, coolers, Instrument House, the Canal House, Water Treatment House, and canal would be removed. This alternative would also include

removal of above ground ducts and any associated soil, removal of below ground piping and systems and soil outside of Building 701, and removal of Building 701 experimental equipment. In addition, the alternative would include the removal of Building 701 equipment and systems, such as the control rod drive mechanisms and charging elevator. Buildings 701 and 702 would also be removed.

All seven of the alternatives are considered technically feasible and capable of protecting human health and the environment with the exception of Alternative 1, No Action. The alternatives were scored subjectively to represent how well the alternative addresses the particular concern with respect to the other six alternatives being considered. The evaluations consider the Remedial Action Objectives (RAOs) as well as the criteria categories. A value of seven (7) is assigned to the alternative which best addresses the issue, and conversely, a score of one (1) is assigned to the alternative which addresses the issue the least. The total scores for each alternative with respect to the CERCLA Remedial Process, NEPA Values, and Community Values are shown in the following summary table.

Table ES-1

Alternatives Ranking Summary

Alternative	1	2	3	4	5	6	7
CERCLA Remedial Process Total Score	31	37	41	43	40	38	40
NEPA Values Total Score	61	50	50	50	41	43	39
Community Values Total Score	87	93	114	123	95	90	92

Alternatives 3 and 4 received the highest scores in each category and Alternative 1, as expected, received the lowest. Several items included in the alternatives discussions and analyses will require additional information and evaluation. Alternatives 2, 5, and 7 are not recommended for further consideration. However, Alternatives 3, 4, and 6 are recommended for further consideration in another phase of analysis (i.e. the Engineering Evaluation/ Cost Analysis [EE/CA] phase). Alternative 1 will be further utilized as a baseline alternative for the analysis. The characterization of the facility is still in progress

and data gathered during the characterization can have a significant impact on the work process, scope, and costing.

SECTION 1

INTRODUCTION

1. INTRODUCTION

Cabrera Services, Inc. has been commissioned by the Brookhaven National Laboratory (BNL) to complete the task of performing a Removal Action Alternatives Study (RAAS) Report for the Brookhaven Graphite Research Reactor (BGRR) Decommissioning. The RAAS Report was a collaborative effort between Cabrera Services, Inc. and Roy F. Weston, Inc. (WESTON®) to perform an evaluation of the selected Removal Action Alternatives for final decommissioning of the BGRR. This work is being performed within the criteria of the *Comprehensive Environmental Response, Compensation, and Liability Act* of 1980 (CERCLA), as updated by the *Superfund Amendment and Reauthorization Act* of 1986 (SARA), and the *National Environmental Protection Act* (NEPA) of 1969. This document also includes community value statements gleaned from public roundtable discussions, Department of Energy (DOE) facility staff, and various community groups potentially impacted by future actions taken at BGRR. These community value statements are discussed in detail in Subsection 4.3 of this document. Seven alternatives were evaluated against CERCLA requirements in accordance with the regulatory guidelines, with consideration also given to the NEPA values and the community value statements, to determine how many of the seven decommissioning alternatives for the BGRR effectively satisfy the criteria.

This document is not intended to serve as a Feasibility Study (FS) or an Engineering Evaluation/Cost Analysis (EE/CA) under CERCLA. Rather, it is intended as a screening tool for determining how many of the seven alternatives most effectively satisfy the CERCLA, NEPA, and community value evaluation criteria.

This document consists of six primary sections and five appendices, as described below:

- Section 1, Introduction, discusses the BGRR site history with an introduction to the three sub-areas of concern (sub-AOCs) identified in 1991 and the one sub-AOC added in 1999. The BGRR Layout and Unit Processes Section discusses, in detail, the present status of the equipment and facilities, including expected contamination. NEPA Applicability is also introduced in Subsection 1.3.

- Section 2, Systematic Approach to Develop Alternatives, discusses the potential future land uses for the BGRR facility. The contaminants of potential concern are introduced, including a discussion of the past processes and activities that resulted in the existing condition of the BGRR facility. Further, it discusses the potential Applicable or Relevant and Appropriate Requirements (ARARs) and To Be Considered (TBC) requirements for the BGRR Project. Exposure pathways including conceptual models of fate, transport and exposure are included. Remedial Action Objectives (RAOs) and Preliminary Remediation Goals (PRGs) are also discussed.

- Section 3, Development of Decommissioning Alternatives, reviews the available decommissioning methods, and introduces the Work Breakdown Structure (WBS) elements. The seven decommissioning alternatives are then constructed by grouping the WBS elements into different logical combinations.

- Section 4, Detailed Comparative Analysis of Alternatives, reviews the CERCLA, NEPA, and Community Values evaluation criteria and discusses how these criteria are used to determine which of the alternatives are viable for potential implementation at the BGRR facility. This section presents how each of the alternatives addresses each of the evaluation criteria.

- Section 5, Recommended Removal Action Alternatives, uses the information presented in Section 4 to develop a ranking of the alternatives against one another. A range of alternatives which are considered feasible and should be further considered in the EE/CA process are recommended. Additionally, this section lists the issues requiring further consideration before the selection of a removal alternative for implementation should be recommended.

- Section 6, References, includes the various documents which were used in the development of this document.

- The Appendices include the NEPA Considerations, Decommissioning Technology Applications, Estimates of Alternative Costs, Cost Normalization Table, and ARARs Tables.

The primary reasons for the BGRR Decommissioning Project are to remove and/or isolate sources of contamination, reduce any potential threat to public health and the environment, comply with local, state and federal regulatory requirements, satisfy community values, and retire a facility no longer in use by the DOE.

1.1 BGRR SITE HISTORY

1.1.1 Operational History

The construction of the BGRR was completed in August 1950. The BGRR was the first peacetime reactor constructed in the United States to provide neutrons exclusively for research (B&R, 1989). The reactor pile reached criticality on August 22, 1950. The BGRR was designed as an air-cooled, graphite-moderated and reflected reactor, originally fueled with aluminum-canned natural uranium (NU) elements. The original fuel elements were subject to stress-related failures. Twenty-eight fuel element failures resulted in the oxidation of the uranium metal causing dispersion of the resultant uranium/fission product/plutonium oxide particles to the graphite channels, the air ducts, and the air filters.

In April 1958, the natural uranium fuel elements were replaced with aluminum-clad, enriched uranium-aluminum alloy plate fuel elements. The newer enriched uranium (EU) fuel elements were not subject to deterioration or in-service failure with the exception of occasional fuel plate overheating due to blockage in the graphite channel (B&R, 1989). The nominal power level of the BGRR was 28 megawatts thermal (MWt) during the NU fuel loading, and 20 MWt during the EU fuel loading (B&R, 1989). The primary contamination within the vicinity of the BGRR facility is the result of the spread of oxidized uranium particles containing fission products, such as cesium-137 (Cs-137) and strontium-90 (Sr-90) and activation products such as cobalt-60 (Co-60) (BNL, 1999f). Experimental use of the BGRR terminated in June 1968.

The Brookhaven High Flux Beam Reactor (HFBR) began operation in 1966. The HFBR, which used the same stack as the BGRR, produced more than a 100-fold increase in neutrons over the BGRR facility and had a lower background radiation level (B&R, 1989). Facility stabilization for the BGRR were initiated in 1969. The graphite moderator was regularly annealed during operation, and was again annealed in 1970 to remove any residual stored energy.

Following permanent shutdown, the control rods were disconnected from the drives and inserted into the graphite reactor pile. The biological shield penetrations for the control rods were covered with metal plates which were tack-welded into place. The experimental openings were closed or plugged (B&R, 1989).

Radioactive equipment was removed from the experimental area and the underwater canal. The canal water was pumped down to the Building 801 Radioactive Waste Processing Facility. The canal was cleaned with detergent and water (which was also pumped to Building 801) and covered with concrete slabs for shielding (B&R, 1989). The remaining drained fuel elements were shipped off site to the DOE-Savannah River fuel reprocessing plant in 1972 (B&R, 1989; ERDA, 1977).

Between 1985 and 1986, the piping and equipment were removed from the water treatment and canal houses, the sumps and drains in the east yard pads were sealed, paint flaking from the walls of the canal walkway was scraped, and all accessible areas in the canal facilities were cleared of debris (B&R, 1989). As of September 1999, the 320 foot (ft.) stack from the BGRR facility was available for use by the HFBR facility.

The BGRR facility was described as being in a safe shutdown condition by the U.S. Atomic Energy Commission (AEC) and became an "orphaned" facility within the DOE complex. From 1977 until 1997, portions of the BGRR facility were used as BNL's Science Museum (B&R, 1989).

1.1.2 Regulatory History

BNL was included on the CERCLA National Priority List (NPL) under Section 120 of CERCLA on December 21, 1989. A Draft Federal Facilities Agreement (FFA), herein referred to as the Interagency Agreement (IAG), was negotiated in May 1992 by the DOE, EPA, and the New York State Department of Environmental Conservation (NYSDEC). The IAG addresses the environmental impacts associated with BNL. The IAG was written to ensure compliance with CERCLA, the corrective action requirements of the Resource Conservation and Recovery Act (RCRA), NEPA, and corresponding New York State Regulations. The IAG serves as the vehicle for BNL to adequately

investigate environmental conditions associated with past and present facility activities with the appropriate regulatory oversight. As appropriate, response actions are developed and implemented under the IAG (IT, 1999).

In correspondence from George J. Malosh, DOE's Brookhaven Group Manager, to Bernadette Castro of the State Historic Preservation Office (SHPO), a draft Memorandum of Agreement was submitted with the final *Request for Determination of Eligibility, Brookhaven Graphite Research Reactor Complex, Brookhaven National Laboratory, Upton, New York* and final *Determination of Effects Finding* on October 13, 1999 (BNL, 1999n).

1.1.3 Areas of Concern (AOCs)

The IAG designated specific areas of the BNL complex to be "Areas of Concern" (AOCs). The IAG defined AOCs as: (1) solid waste management units (SWMUs) where releases of hazardous substances might have occurred, and (2) locations where there have been releases or threats of releases of a hazardous substance, pollutant, or radiological constituent into the environment. AOCs were identified in the *SWMU Classification Report* (BNL, 1991a), and were grouped into operable units in the *Response Strategy Document* (SAIC, 1991).

The BGRR is AOC 9. There are presently four sub-AOCs that are addressed by this Removal Action Alternatives Study, which are described in the following sections:

- Sub-AOC 9A - BGRR Canal Contaminated Soils, described in Subsection 1.2.11.
- Sub-AOC 9B - Underground Duct Work Contaminated Soils, described in Subsection 1.2.6.
- Sub-AOC 9C - Spill Sites Associated with the East Yard, described in Subsection 1.2.12.
- Sub-AOC 9D - Pile Fan Sump Soils, described in Subsection 1.2.13.

1.1.4 Current Status of BGRR Facility

Since 1973, very little has been done to the reactor pile itself, though activities have taken place in the ancillary facilities. The current status of the BGRR facility is as follows:

- The graphite has been annealed.
- The fuel has been removed.
- Boron shots were placed in the shot-wells [1].
- The sixteen control rods were cut from their drive mechanisms and fully inserted into the graphite. Also, the openings for the control rods were covered with tack-welded steel plates.
- The experimental holes were closed or plugged.
- The removable core experimental facility remains inside the reactor pile and its opening was plugged.
- The removable roof is intact.
- The animal- and instrument-tunnels' access-ways were plugged.
- The exhaust duct's isolation valves were closed.
- The east and west air-inlet ducts were closed off at their ends with plywood.
- A negative-pressure system for the reactor pile was installed in the east intake filter house to provide for flow of air from Building 701 to Building 702. This system operates at all times and is monitored.
- The thermocouples (approximately 100-200) were cut from their indicating devices and left inside the reactor pile. These devices are a source of cobalt-60 (Co-60).
- Various apparatus may remain in the graphite, plenums, exhaust duct heels, or between the beams under the reactor pile. This equipment includes pneumatic tubing, experimental piping associated with the Chemo-Nuclear Loop, the

[1] A boron-shot system was designed to shut down the reactor in case of an emergency where the control-rod shutdown system was inoperable. The boron-shot system's function was to add a sufficient quantity of "poison" (boron-steel shots) to the reactor to shut it down. The boron-steel shots were dropped by gravity into wells located within the reactor. A total of four boron shot wells are located in the reactor, two in the graphite and two in the 3-inch gap (BNL, 1999f).

target-conveyor equipment, the stabilizing springs for the reactor pile, and the chromel-alumel thermocouples used on fuel elements.

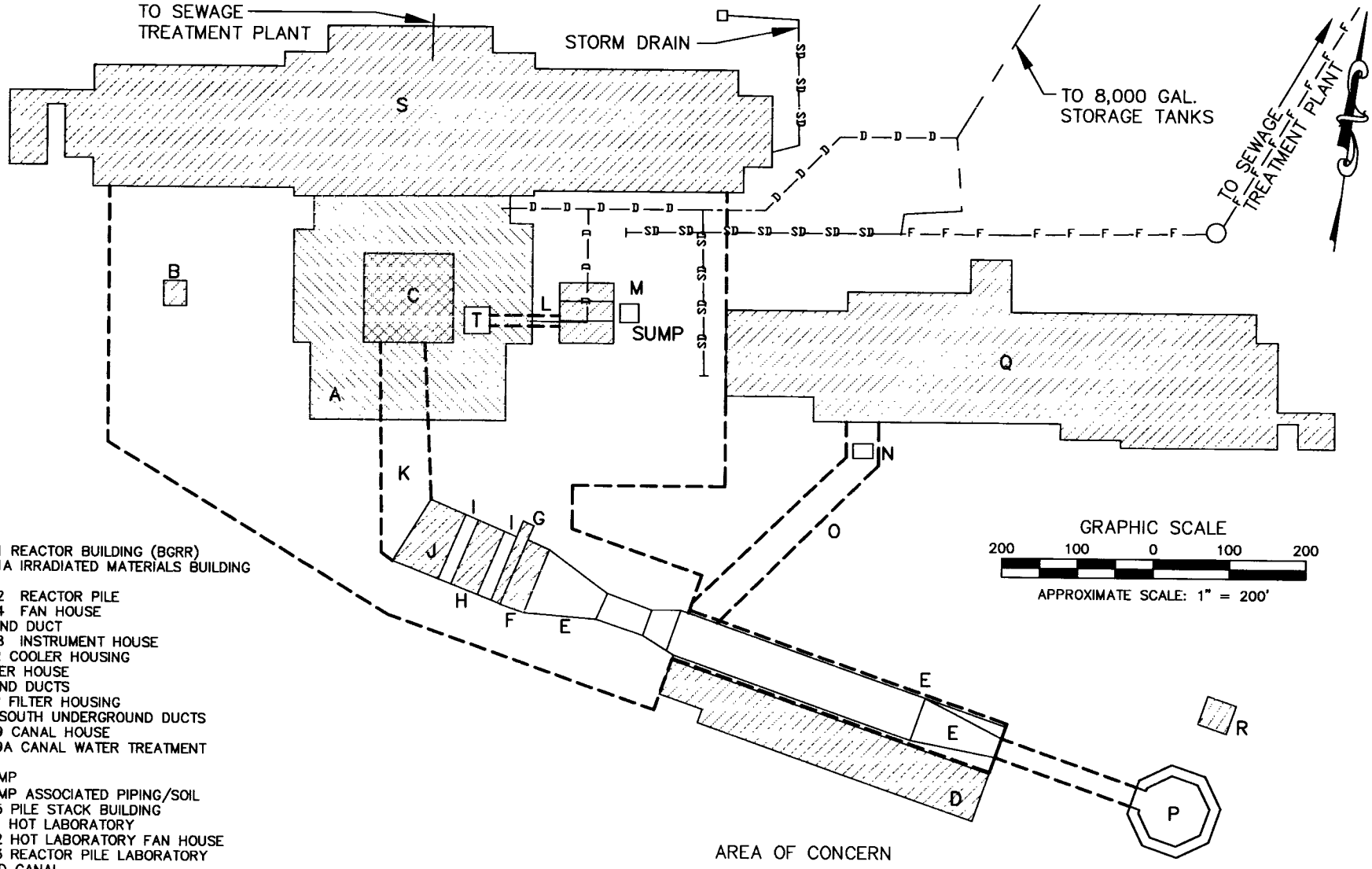
- The pneumatic tubes entering Buildings 801 and 703 were physically isolated.
- All water from the deep drain sump was removed (approximately 57,000 gallons).
- In accordance with the *Hazard Classification and Auditable Safety Analysis for BGRR Decommissioning Project* (BNL, 1999f), various monitoring and surveillance is routinely conducted at the BGRR facility, as described in detail in the BGRR-SOP-0901, *Brookhaven Graphite Research Reactor (BGRR) Monitoring and Surveillance Procedure.*

1.2 BGRR LAYOUT AND UNIT PROCESSES

The basic BGRR facility layout and main unit processes used during the BGRR operations (1950 through 1968), as well as the nature and extent of known or suspected contamination present within and surrounding the BGRR facility, are discussed in the following subsections. The BGRR structures and areas of concern in building number order are the following:

- Reactor Building, Experimental Equipment, Equipment and Systems
- Reactor Pile
- Above Ground Ductwork
- Fan House
- Below Ground Ductwork and Instrument House, Below Ground Duct Soils
- Fuel Canal, Canal House and Water Treatment House, Below Ground Piping and Systems, Canal Soils
- Soils from East-Yard Outdoor Pads, Sump, and Storage Vault
- Pile Fan Sump

The locations of the structures are shown in Figures 1-1 and 1-2. The structures, areas of concern, and potential contaminants are discussed in the subsections that follow.



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SITE SKETCH

BROOKHAVEN GRAPHITE RESEARCH REACTOR
LONG ISLAND, NEW YORK

ROY F. WESTON, INC.
WESTON
MANAGERS DESIGNERS/CONSULTANTS

DRAWN	DATE	APPROVED	W. O. NO.	DWG. NO.
JBT	OCT 99		12334-001-001	FIGURE 1-1

SITE OVERVIEW PHOTO

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JBT	OCT 99			12334-001-001
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1.2.1 Reactor Building (Building 701)

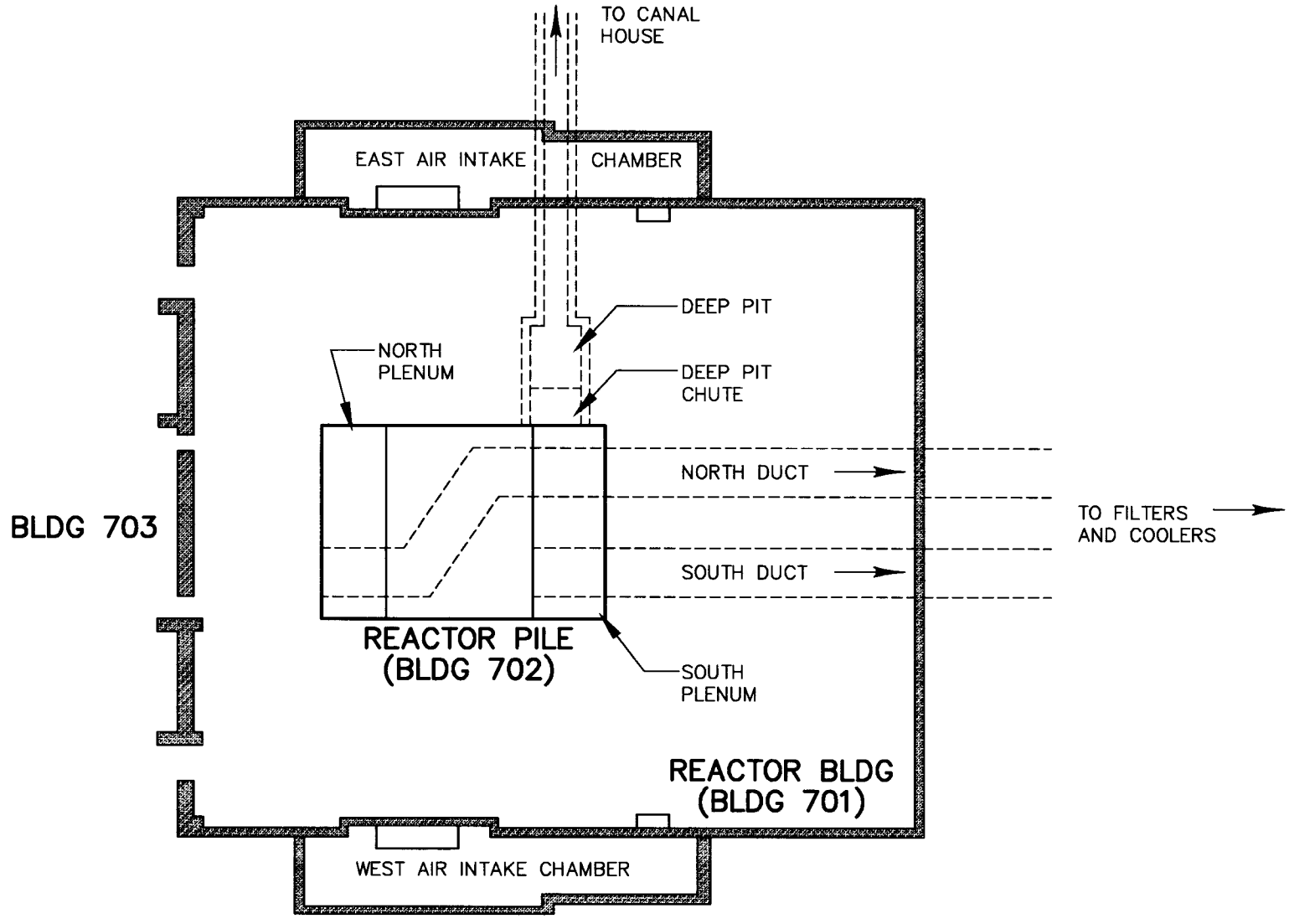
The main facility building during the operation of the BGRR was Building 701, the Reactor Building. The building encloses the Reactor Pile (Building 702). In addition, Building 701 contained office spaces, a machine shop, reactor control room, and a green or new fuel storage vault. Building 701 also housed building ventilation systems, control-rod drive mechanisms, experimental equipment, the fuel-loading elevator, an overhead crane, a deep pit for the storage canal, and support utilities for the experiments. A plan view of Building 701 is shown in Figure 1-3 and a photograph is shown in Figure 1-4.

The northern wall of Building 701 abuts the southern wall of Building 703, the reactor pile Laboratory. Access between these two structures (Building 701 and Building 703) is currently restricted through locked entry doors. Building 703 is not included in the BGRR Decommissioning Project. However, two Building 701 ventilation units are housed in Building 703, and these must be considered during decommissioning activities.

Between 1977 and 1997, portions of Building 701 were utilized as the BNL Science Museum. Presently, portions of Building 701 are utilized by the BGRR Decommissioning Project Team and for Relativistic Heavy Ion Collider (RHIC) support.

Parts of Building 701 were contaminated during operations, including walkways which are routinely surveyed. At the present time, there is one posted Radiation Area where sealed sources are stored. This Radiation Area will be gone before decontamination when the sealed sources are removed. Additionally, there are posted Contamination Areas and High Contamination Areas within the building, although there are no High Radiation Areas (BNL, 1999a). The normally accessible regions of the Reactor Building were decontaminated, cleaned, and surveyed following shutdown of the BGRR.

The presence of contamination in the inaccessible regions of the building, such as the trenches, manholes, drains, etc., is presently unknown. However, during operations, the general area frequently became contaminated necessitating decontamination. During operations or decontamination efforts, this contamination may have migrated to areas not



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PLAN VIEW OF BLDG 701 AND BLDG 702

BROOKHAVEN GRAPHITE RESEARCH REACTOR
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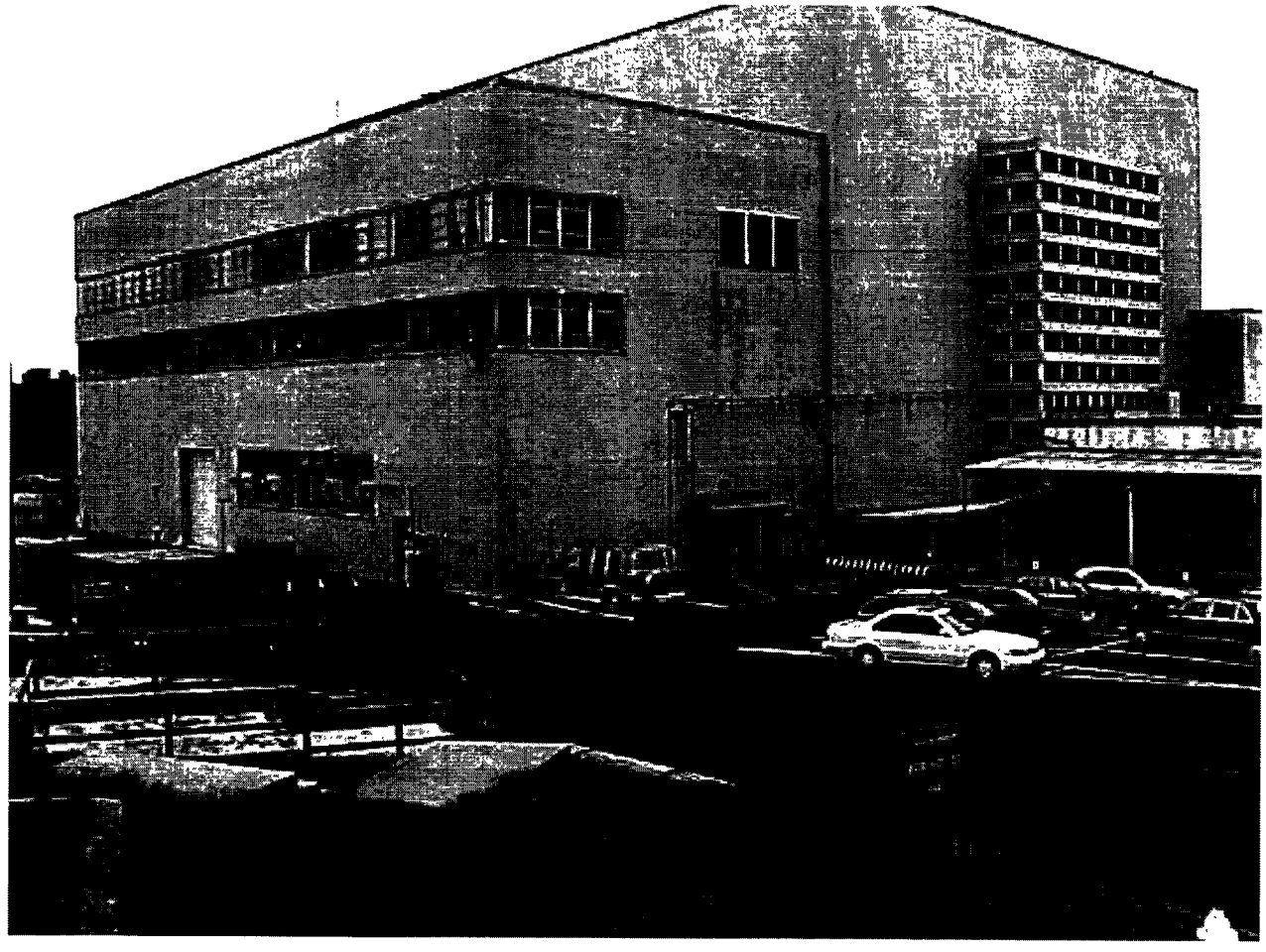
Figure 1-4

Photo of Reactor Building



normally exposed, such as under floor coverings, inside floor trenches via accessway cover seals, on painted wall surfaces, and down floor drains. Additionally, some contamination may have been covered when the floors were retiled (B&R, 1989).

1.2.2 Experimental Equipment

Experimental equipment includes the chemo-nuclear related equipment and shielding both inside and outside Building 701, beam guide equipment and sample change equipment, temporary tanks, portable shielding, and collection tanks on the 110 ft. elevation.

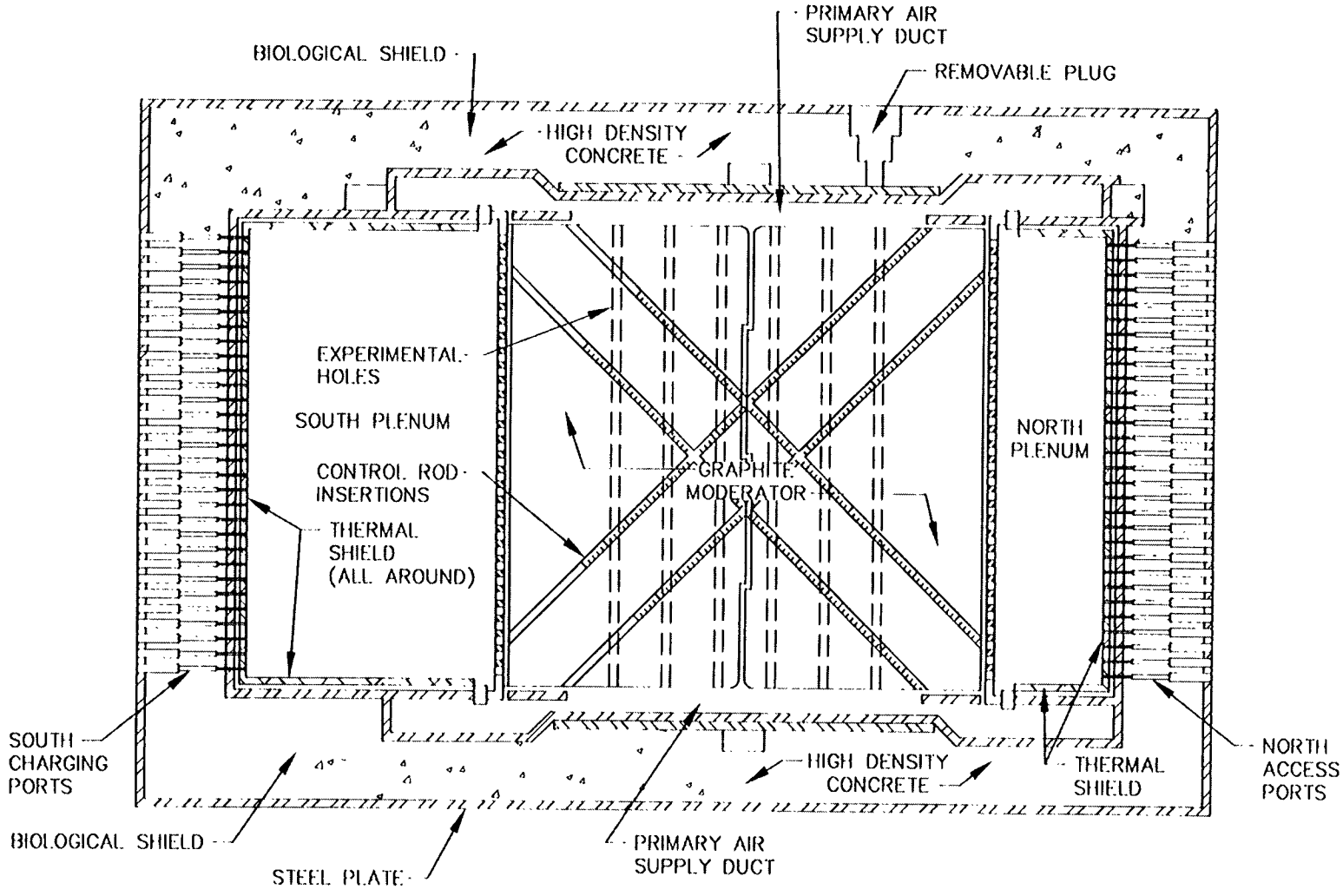
1.2.3 Equipment and Systems

This category includes Building 701 control rod drive mechanisms, charging elevator and associated structural steel, and the following piping systems: domestic water, sanitary drains, compressed air, compressed gas, steam heating, chilled water cooling, storm drains, and pneumatic tube transfer system.

1.2.4 Reactor Pile (Building 702)

Building 702, the Reactor Pile, is situated in the central portion of the Reactor Building (Building 701). Building 702 consists of the graphite reactor pile, ductwork below the reactor pile, and the north and south exhaust plenums surrounded by the biological shield, which is the exterior surface of Building 702. The graphite reactor pile is a 25 ft. cube, which weighs 750 tons and consists of sixty thousand graphite blocks in 2,600 different shapes. The graphite moderated the speed of the neutrons, which allowed for steady and predictable operation of the BGRR. Figure 1-5 and Figure 1-6 provide plan and cross sectional schematic views of the reactor pile and biological shield. Figure 1-7 is a photograph of the biological shield.

A 3-inch vertical gap traverses the reactor pile in the east/west direction, along the full height and width of the central portion of the reactor pile. A 12-inch thick steel belt



G:\DESIGN\DWG\BROOKHVN\ FIG:-4.DWG PLOTTED ON 03DEC1999 AT 08:20 BY CAD

PLAN VIEW OF REACTOR PILE

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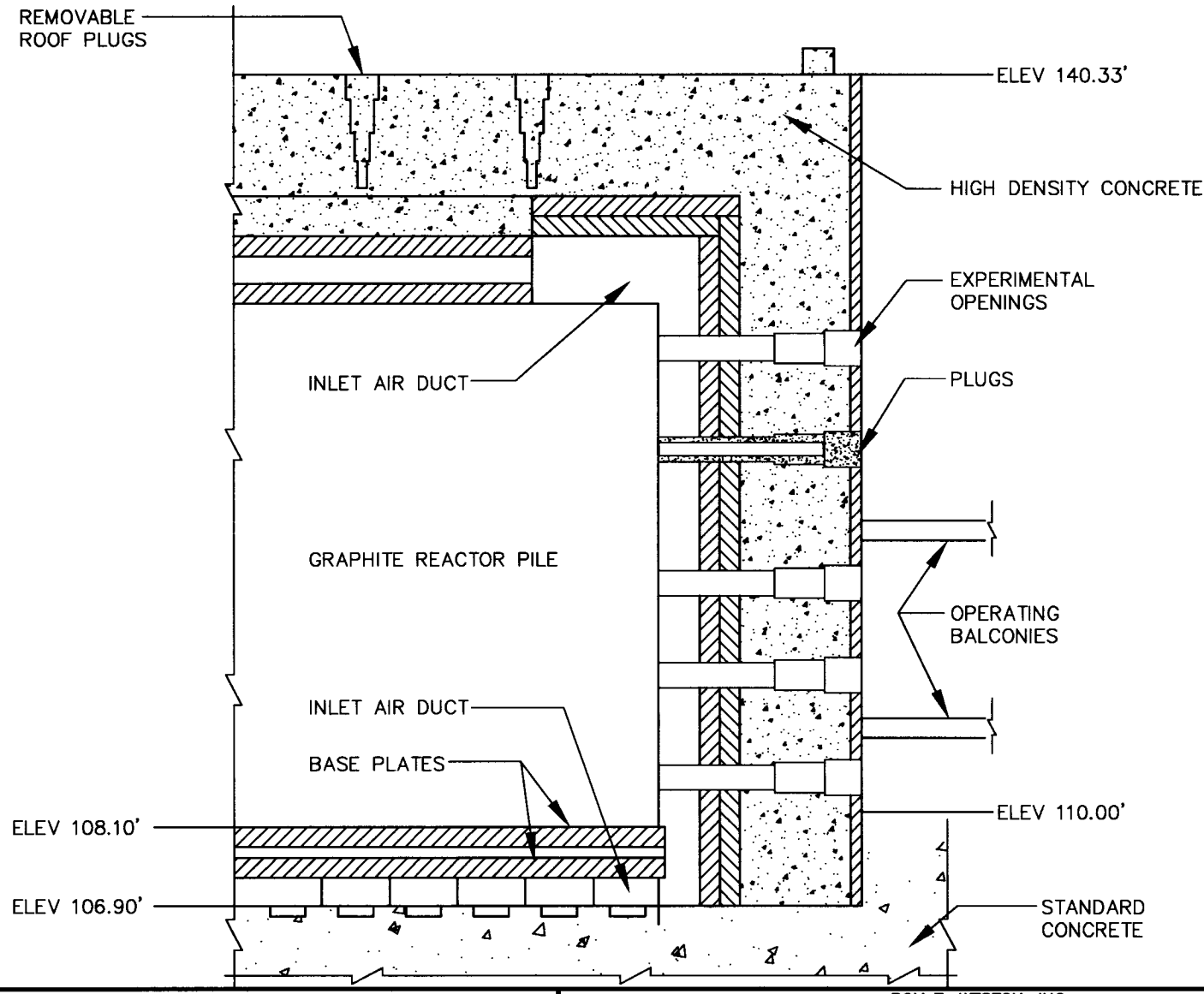

* NOT TO SCALE

SECTION OF BIOLOGICAL SHIELD

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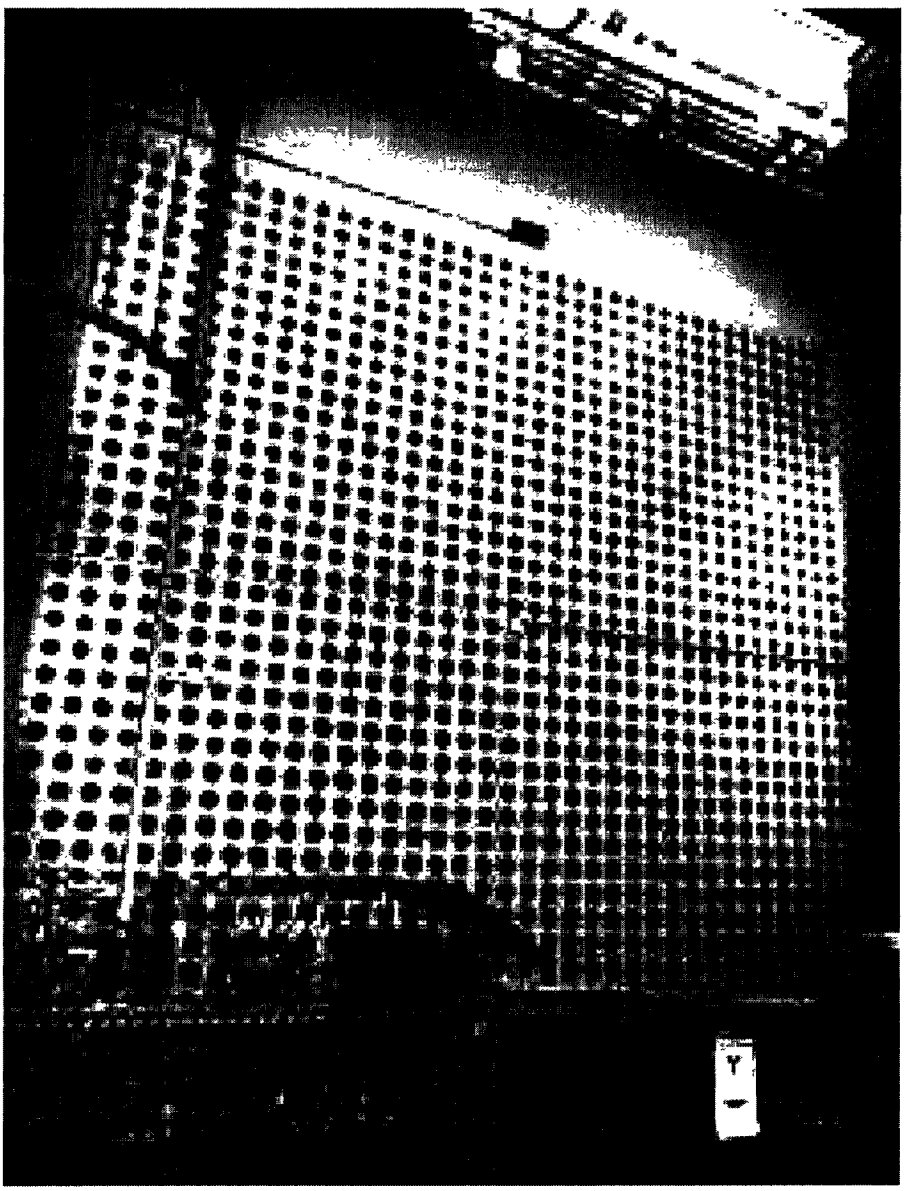
Figure 1-7

Photo of Biological Shield



surrounds the gap. During BGRR operations, filtered cooling air was drawn into the gap and circulated through the reactor pile to cool fuel elements and graphite. The exhaust air exited through the north and south plenums and two underground exhaust ducts.

A biological shield was constructed over all four sides and the top of the reactor pile to protect the people who worked at the BGRR from radiation. The shield contains an inner layer of steel 6 inches thick, 4.25 ft. of high-density concrete, and an outer casing (reactor pile sides only) of 3 inches of steel plate. The top (roof) portion of the shield contains removable plugs for experiment purposes. The biological shield weighs approximately 5,000 tons.

Based upon an analysis of plant operations, an inventory of remaining radiological material was prepared. The activation for the graphite was estimated at 2.5×10^{-6} Curies per gram (Ci/g) for Type A graphite and 2.06×10^{-6} Ci/g for Type B graphite, gamma and beta combined. The principal gamma activation radioactivity for Type A graphite comes from cobalt-60 (Co-60), europium-154 (Eu-154), and silver-108m (Ag-108m). Type B gamma activation is primarily from Co-60 and Eu-154. Beta activation for both types is due to carbon-14 (C-14) and tritium (H-3).

The original NU fuel elements were subject to stress-related can failures. These twenty-eight can failures resulted in the oxidation of the uranium metal and the dispersion of the resultant fuel fragments and associated transuranic radionuclides (e.g., plutonium) to the graphite channels, air ducts, and air filters. In addition, small amounts of fission products were typically released either as a result of leaks in fuel element claddings, or through fissioning of uranium contamination on the outer surfaces of elements. Larger amounts were released when actual breaks in the cladding occurred (ERDA, 1977). A small percentage of fuel channels are considered to be contaminated, and the possibility exists that fuel parts, either natural or enriched, may still be present somewhere within the graphite, plenums, exhaust duct heels, or between the beams under the reactor pile (B&R, 1989).

In April 1958, the NU fuel elements were replaced with aluminum-clad, enriched uranium-aluminum alloy plate fuel elements. The newer EU fuel elements were not

subject to deterioration or in-service failure with the exception of occasional fuel plate overheating due to blockage in the graphite channel (B&R, 1989).

Since the shutdown in 1968, the general area outside of the reactor pile and the biological shield external faces have been decontaminated. However, portions of the biological shield external faces remain contaminated to various levels, and are currently posted.

In addition to contamination, the reactor pile, associated structural materials, and the biological shield will contain radioactivity due to activation of materials by bombardment of neutrons from the fission of fuel in the reactor pile. Because the BGRR was shut down in 1968, the induced radioactivity in these materials has had more than 30 years to decay. Based on the half-lives of the typical neutron-activation products produced and the passage of time since the BGRR last operated, activation-induced exposure rates from the biological shield are significantly lower than immediately after operational periods.

The linings of the experimental holes, charging tubes, target conveyor, and the removable core that pass through the shield are expected to be contaminated. However, by design, these openings were lined with steel and the biological shield was protected from contamination (B&R, 1989).

1.2.4.1 Experimental Facilities

Two chambers located underneath the reactor pile, the animal tunnel and the instrument tunnel, were utilized to expose large samples to radiation. One of the chambers was used to irradiate laboratory animals. The other chamber was used as an instrument tunnel to irradiate large miscellaneous samples and instruments. The tunnels were located north and south of the reactor pile centerline, traversing in the east/west direction. From outside the biological shield, the samples were placed in a four-wheeled cart and transported to the designated point within the tunnel. The tunnels extended beyond the biological shield on both sides, and are expected to be contaminated.

Thirty experimental holes or ports extended from the west face of the reactor pile through the center of the reactor pile to the east face. The experimental holes lined up with the

corresponding openings on the east and west faces of the biological shield. These experimental holes were plugged during the initial deactivation of the BGRR from 1969 to 1972. There are also experimental ports (pneumatic tubes) and a removable shield block in the faces of the reactor pile. These experimental ports were used to insert samples for irradiation. Long-lived isotopes and lodged irradiated samples may be present within the reactor pile and the pneumatic tubes that run from the north face of the reactor pile to the Hot Laboratory (Building 801) (B&R, 1989).

1.2.4.2 Fuel Elements and Control Rods

The south face of the reactor pile contains 1,369 round, horizontal channels which bore through the center to the north face of the reactor pile corresponding with channels in the biological shield. These channels contained the fuel elements. The fuel elements were inserted and removed from the south face of the reactor pile through openings in the biological shield which match the fuel channels in the reactor pile. Once the fuel elements were inserted, the ends of the ports were temporarily plugged to prevent exposure of workers to radiation. The spent fuel elements were discharged into a chute, which extends from the floor on the east side of the south plenum to the bottom of the deep pit of the storage canal. Spent fuel elements were placed underwater in the deep pit to cool and later moved underwater to the canal house, where they were prepared and loaded into casks for shipment to the DOE Savannah River site.

The original NU fuel elements consisted of an 11 ft. aluminum can which contained 33 natural uranium slugs. The aluminum cans were cut into pieces to remove the uranium slugs as part of preparation for shipment. Corrosion of the cans during underwater storage in the canal and the method by which the NU fuel elements were prepared for shipment resulted in contamination of the canal water. In April 1958, the NU fuel elements were replaced with aluminum-clad, EU-aluminum alloy plate fuel elements. The newer EU fuel elements were not subject to deterioration in the canal or in-service failure, with the exception of occasional fuel plate overheating due to blockage in the graphite channel (B&R, 1989). During the initial stabilization, all of the fuel rods were removed and shipped to a safe storage facility.

Sixteen (16) borated steel control-rods were inserted along two corners of the south face of the cube to control reactor power. These borated steel rods absorbed neutrons produced by the BGRR. Between 1970 and 1973, the control rods were cut from their drive mechanisms and completely inserted into the reactor pile, whereupon their ports were covered and tack welded closed.

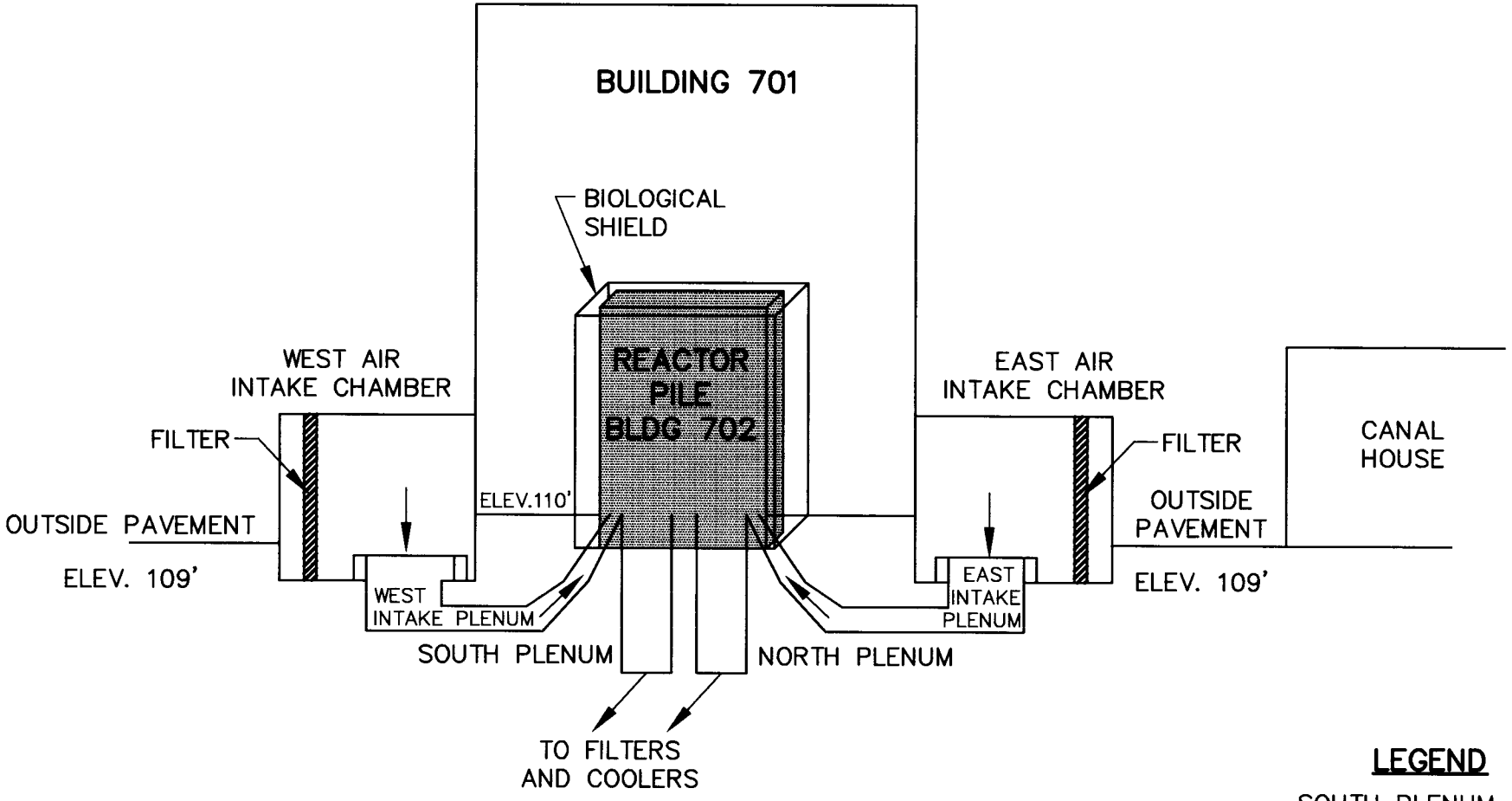
The control-rod areas are posted contaminated areas. Within the last 10 years, the control rod drive structure was decontaminated, except under the lead shielding where some contamination may remain. In addition, the control rod drive mechanisms and structure were cleaned of residual oil deposits, however possibly not sufficiently cleaned to remove all radioactive contamination (B&R, 1989).

1.2.5 Below Ground Ducts and Instrument House (Bldg. 708)

During BGRR operations, cooling air was drawn through the east and west air intake chambers. Incoming air passed through roughing filters and entered the east and west intake plenums. Filtered air drawn in from the plenums traveled through eastern and western ducts running along the outer sides of the reactor pile inside of the biological shield. Air was pulled in and through the 3-inch vertical gap in the center of the reactor pile and around the reactor pile to remove heat produced by the fuel and cool the graphite. Figure 1-8 provides a schematic of the reactor pile air flow system.

The primary cooling air passed through filters, coolers, and primary exhaust fans and eventually discharged into the 320 ft. high stack. Historically, the underground ductwork was contaminated with uranium oxide, plutonium, and considerable amounts of fission products (SAIC, 1992). Considering the decay period of over 30 years since use of uranium fuel was terminated, the major remaining fission products should be cesium-137 and strontium-90 (B&R, 1989). The underground ducts are identified as sub-AOC 9B in the IAG.

The north and south exhaust plenums and all ductwork up to the coolers were constructed with double walls to protect the concrete from the high temperature air exiting the reactor pile (approximately 428 ^{o}F).



LEGEND

SOUTH PLENUM (SP)
NORTH PLENUM (NP)

REACTOR PILE AIR FLOW SYSTEM DIAGRAM

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				FIG 1-8

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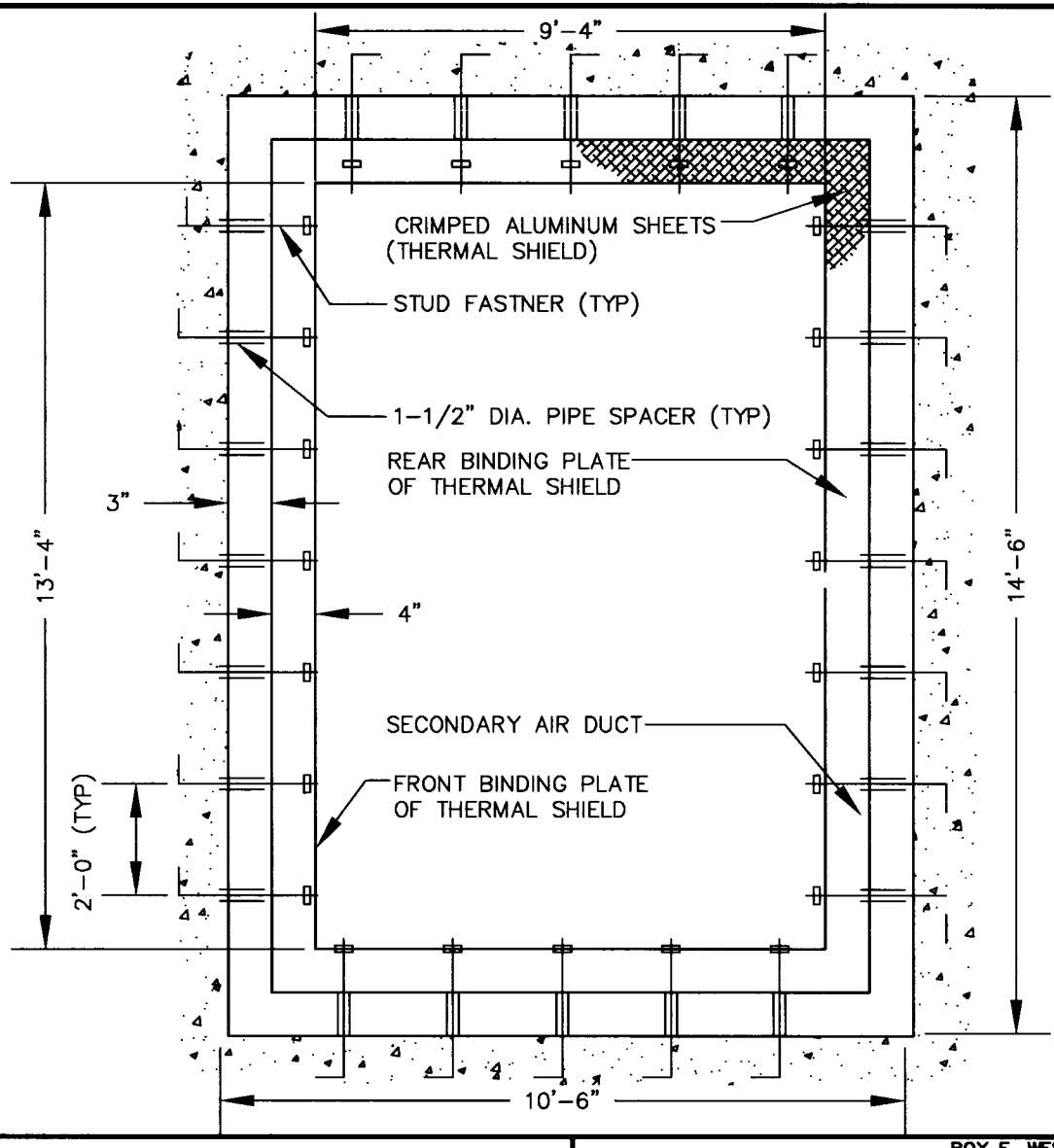
Figure 1-9 is a schematic of secondary air cooling system. The outer duct (secondary air) is constructed of concrete and lined with 3/8 inch steel plate. The inner duct (primary air) consists of 3/8 inch outer steel plate (cold binding plate) followed by 4 inches of thermal shield consisting of crimped aluminum sheets and an inner 3/8 inch steel plate (hot binding plate). The primary air duct runs down the center of the secondary air duct and is attached to it with "J" hooks. Secondary cooling air ran through the three-inch wide annular space around the primary cooling duct.

The air-intake ducts have low-point drains that discharged to the subsoil (drywells) near the bottom of the reactor pile's foundation. The intake air-filter banks are still in place, although not the original intake filter media. There is considerable dust loading on the filters, which poses a radiological concern. Survey data indicate that the east-intake filter elements originally were contaminated due to work conducted nearby at the canal during the reactor pile operations.

The north and south plenums extend south from Building 701 as shown in Figure 1-8. The air filters and coolers are located in the underground ducts. The exhaust air was drawn through the filters then moved downstream into the coolers. Cold water was circulated through the cooling coils, and the exhaust air was blown over the coils.

The primary air exhaust ducts from the reactor pile to the coolers are surrounded on all sides by the thermal shield and the secondary air duct. Due to the construction of the primary duct wall, contamination would likely enter and deposit within the thermal shield (several crimped aluminum sheets) and on the thermal shield side of the secondary duct inner wall (B&R, 1989). Water intrusion has left the secondary duct outer wall, the concrete duct, and the outer expansion joints potentially contaminated.

The deep drain sump is located at the 110 foot (ground level) elevation of Building 701. The deep drain sump in Building 701 was designed to collect water that accumulated in the north and south air-cooling ducts that run under the Reactor Pile (Building 702). It appears that this sump collected water from both the primary and secondary air ducts. However, as noted previously, it is not clear whether this is a design feature or is caused by failure of a seal or some other component of the system.



SECONDARY AIR COOLING SYSTEM IN EXTERIOR PRIMARY AIR EXHAUST DUCT DIAGRAM

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The original exhaust filters are still in place and are expected to be highly contaminated. The filters were 95% efficient, which was considered an acceptable efficiency at the time they were installed and used. The original filters remain in place. The fin tube coolers downstream of the filters may have adherence of contamination to the large surface area of the coolers (B&R, 1989). The equipment and controls for the filters and coolers were located within the Instrument House (Building 708). The internals of this building contain hazardous materials, but are not expected to contain radiological contamination. The building and surrounding grounds are posted as an Underground Radioactive Materials Area. The non-radioactive hazardous material is asbestos and mercury from the mercury-containing manometers used to monitor differential pressure across the filters and downstream coolers. The exit air probes were brought into this building to be read, therefore, the potential for some contamination exists (BNL, 1999f).

The air exhaust ducts beneath the Reactor Pile flooded during the period of operation. Sounding devices were used to detect water in the ducts. An investigation was performed in 1997 to ascertain the sources of the water in the ducts. This investigation concluded that there are two sources of water into the exit air ducts. The first is from cooling lines and the second is rainwater intrusion. Ruptured tubes in the cooling coils resulted in leakage from the service water system, and a broken cooler blowdown line allowed cooling water to flow into the instrument house and then, through penetrations, into the air duct. It is expected that leakage into the ducts via this path was significant during prior to 1983. This source was eliminated when the service lines from the pump house were cut and blanked in 1983.

Degraded areas in the exit air system were believed to have permitted rainwater to infiltrate the ducts. The water removed from the ducts, approximately 57,000 gallons, which has been disposed, was determined to have tritium contamination. The source of the tritium is uncertain, however, it is expected to have been the result of ambient tritium contamination of the air which flowed through the ducts. Possible corrosion of the underground ducts during the time the water was in the ducts may have lead to radioactive release into the surrounding soils and, potentially, groundwater. The sources of leakage have been sealed to prevent reoccurrence (BNL, 1997b).

1.2.6 Below Ground Duct Soils (sub-AOC 9B)

The air exhaust ducts beneath the reactor pile flooded during the period of operation, and there were sounding devices to detect water in the ducts. The flooding, on at least one occasion, was caused by cooling water leakage from the coolers. Precipitation leakage via the filter and cooler vault covers, or water from reactor pile plenum washdown are other potential sources of water. Furthermore, it was apparently necessary to pump the water from the ducts after water intrusion was discovered (B&R, 1989). The underground ducts are known to have periodically contained water, resulting in the potential for corrosion and radioactive release into the surrounding soil and groundwater.

1.2.7 Above Ground Ducts

Cooling air traveled from the center of the reactor pile through the fuel element channels, which ran horizontally through the reactor pile. High temperature primary cooling air contaminated with particulate, vapor, and gaseous radionuclides was discharged from the reactor pile through plenums. Underground ducts run between the reactor pile (Building 702) and the air coolers. Downstream of the coolers, the ducts emerge from under the ground and run across the top of the Fan House (Building 704). Figure 1-10 provides a schematic of the above ground ducts on the Fan House. The ductwork is constructed of concrete and did not require secondary cooling because the already cooled air did not pose a threat to the integrity of the concrete.

The duct downstream of the coolers is bare concrete. The extent of contamination is unknown, but the fans and silencers located downstream of this duct did at times become contaminated due to fuel ruptures. Thus, some of the contamination that passed through the filters has potentially contaminated the inside surface of the concrete duct, expansion joints, valves, etc. all the way to the stack (B&R, 1989). An analysis of a side wall of the above ground duct in August 1999 showed cesium-137 and americium-241 (BNL, 1999o). A survey performed in January 1991 additionally showed cobalt-60 (BNL, 1999b).

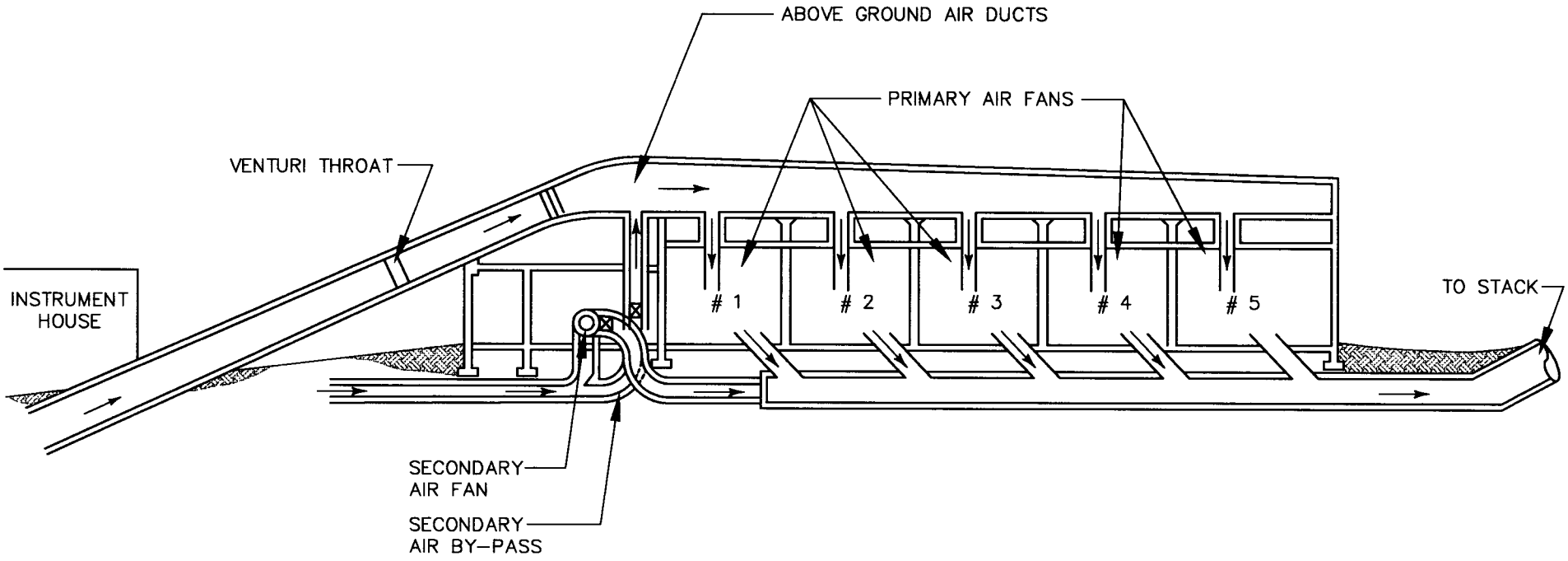

DIAGRAM OF ABOVE GROUND DUCTS ON FAN HOUSE

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1.2.8 Fan House (Building 704)

This building contains the motors and fans that provided the primary and secondary cooling-air suction to the reactor pile. The north and south underground ducts travel beneath the Instrument House and emerge from the ground. They then run over the roof of the Fan House (Building 704). A photograph of the above ground ducts on the Fan House is shown in Figure 1-11 and a plan view of the BGRR main duct system is shown in Figure 1-12. Five primary exhaust fans and one secondary exhaust fan are located within the Fan House. Air was drawn from the aboveground ducts into the fans and discharged into the fan outlet duct running in the basement of the building, which discharged to the base of the 320 ft. high Pile Stack Building.

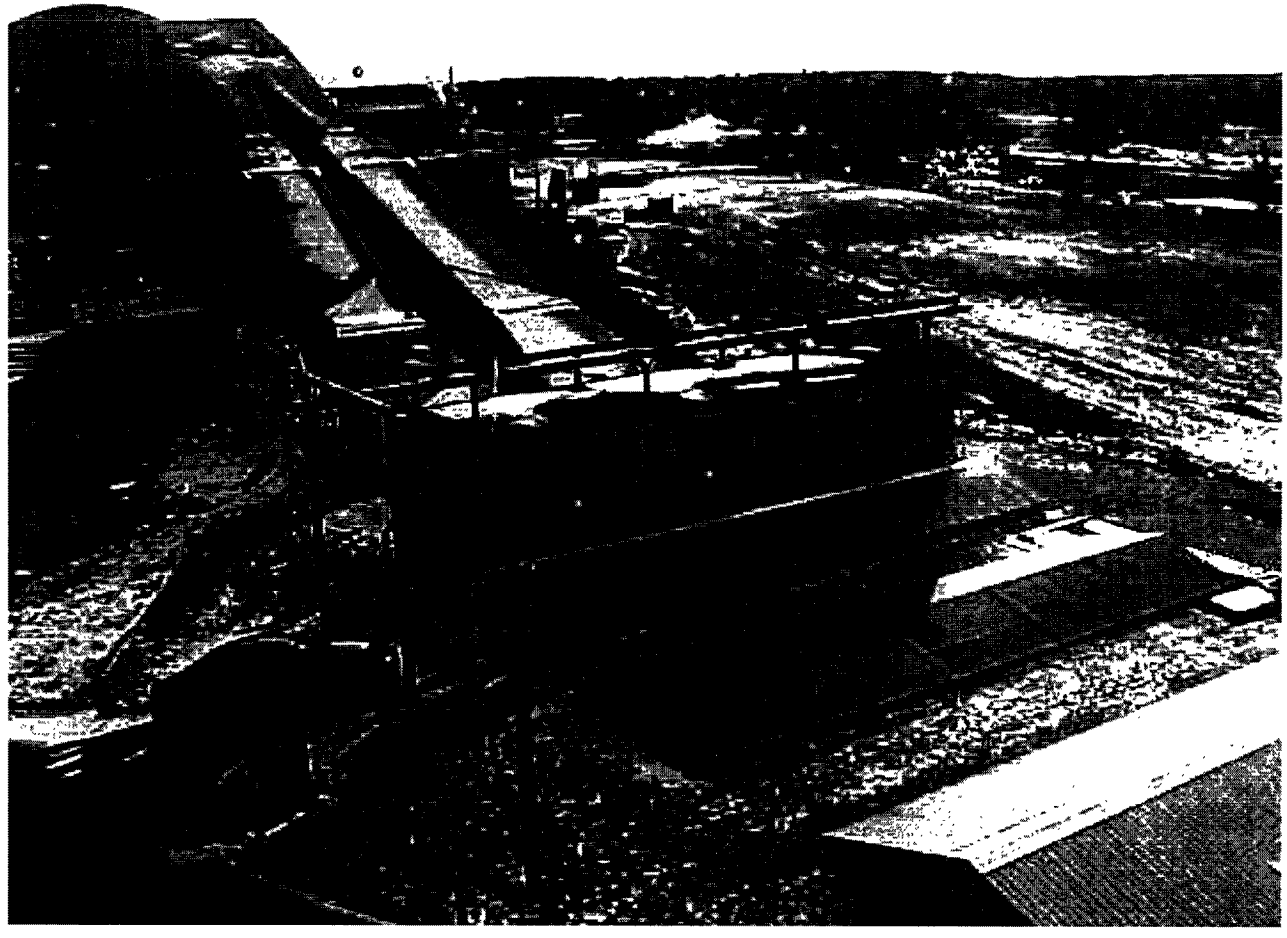
The interiors of the duct work have various levels of fixed- and removable-contamination[2], as do the fan rooms within the building. The building has posted Contamination Areas. The Instrument Room is a posted Radiation Area. The gravel around the building is also posted as Underground Radioactive Material Area (BNL, 1999f).

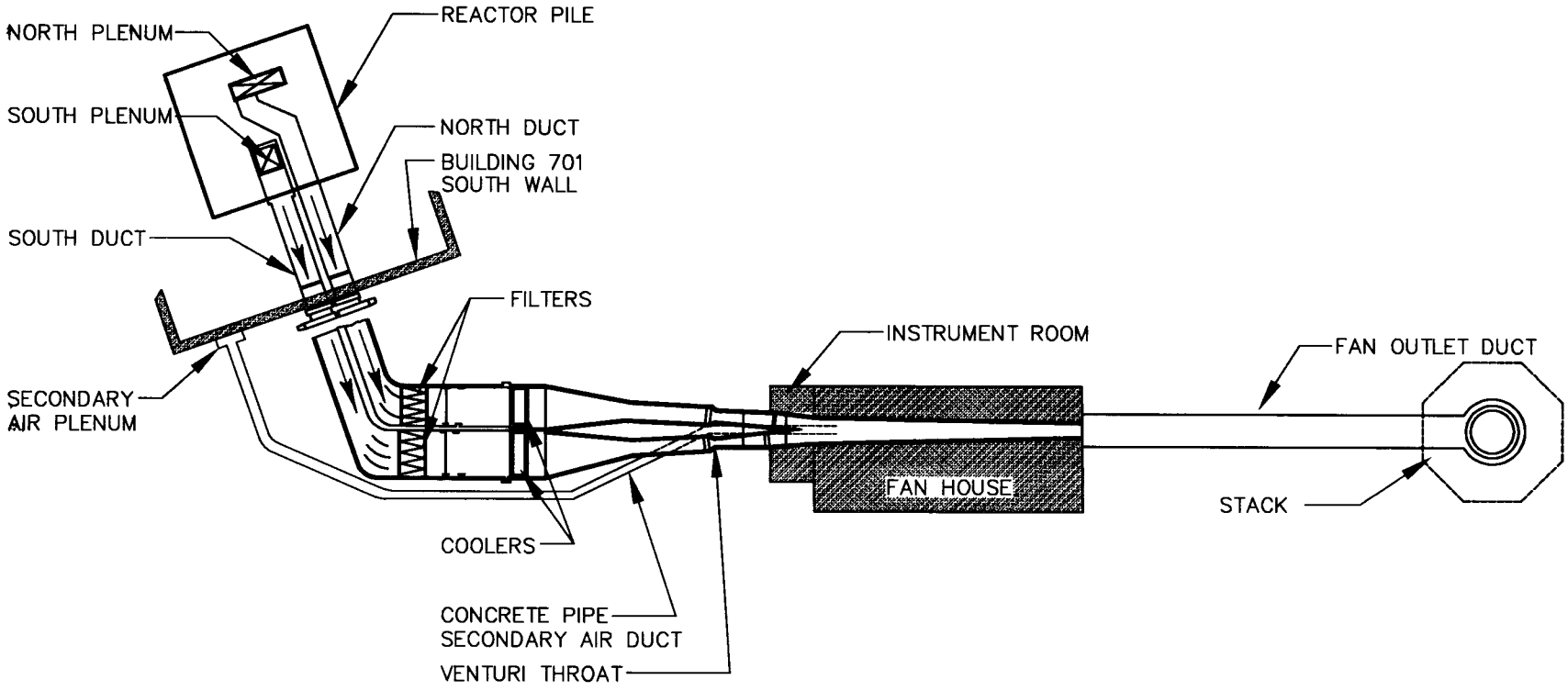
This work area includes the six fan rooms, gas engine room, emergency fan room, and instrument room on the north half of the building. It does not include the motor room and switch-gear area on the south side of the building or the basement where the fan outlet duct is located. After removal of the fans, the building interior will be decontaminated to meet operational needs and control of the facility ceded to the HFBR. These areas will not be decontaminated for unrestricted release because the building will continue to be used to support the HFBR and the fan outlet duct is part of the boundary of the HFBR exhaust system.

[2] Fixed contamination is a contamination that is not readily transferable. Removable contamination is dispersible radioactive material where it doesn't belong.

Figure 1-11

Photo of Above Ground Ducts on Fan House





PLAN VIEW OF MAIN DUCTS

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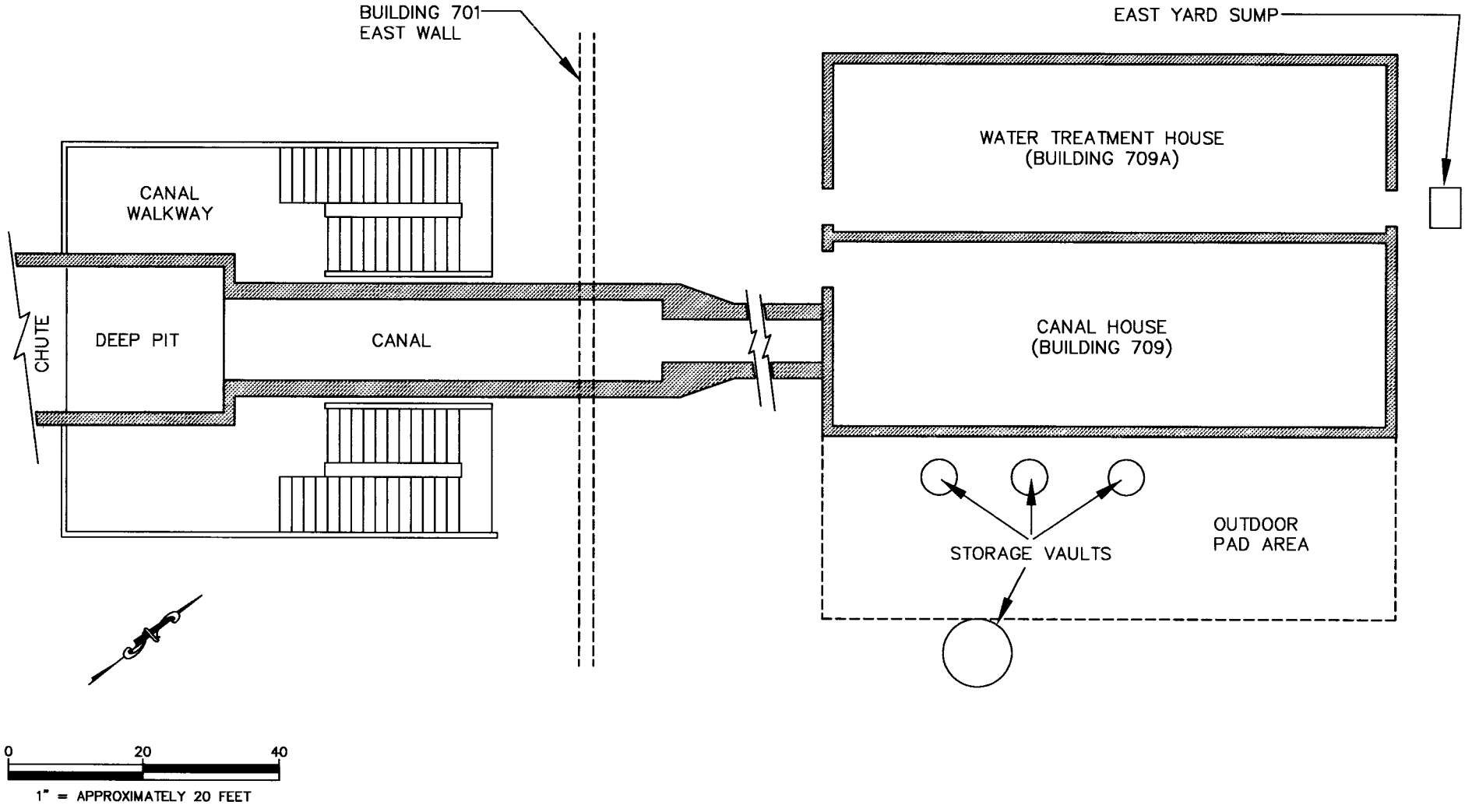
Building 704 also contains a secondary air exhaust fan that drew suction on the concrete secondary air exhaust duct and discharged to the fan outlet duct. The secondary air exhaust duct could also be connected to the above ground duct via a by-pass duct, which was used to provide flow when the secondary fan was out of service. The secondary air exhaust duct extends from the Fan House and runs parallel to the southern below ground duct to the southeast corner of the Reactor Building where it enters the secondary air plenum.

The purpose of the secondary air plenum was to provide a source of negative pressure to induce flow though the annular secondary air ducts to regulate the temperature in this space. Flow into the secondary air ducts came through six filtered inlets in the west air inlet chamber and two filtered inlets in the Instrument House.

1.2.9 Canal House (Bldg. 709) and Water Treatment House (Bldg. 709A)

The canal is identified as sub-Area of Concern 9A (sub-AOC 9A) in the IAG of 1992. The Canal House (Building 709), located to the east of the Reactor Building, was used to store and prepare fuel, irradiated equipment, and radioactive materials for shipment and disposal. Building 709 also provided weather protection and containment for the canal and cask handling areas. The canal continues through the foundation of Building 701 into the deep pit. A schematic diagram of the Canal House and Water Treatment House is shown in Figure 1-13 and a photograph is shown in Figure 1-14. The Canal House contains the shallow portion of the spent fuel canal.

The fuel storage canal consists of a deep pit of water and a shallow canal in the Reactor Building, which continues through the east foundation and runs underground to the Canal House. The canal is 64 ft. long and 8.5 ft. deep in the shallow section, and 20 ft. deep in the deep pit portion near the reactor pile. Radioactive fuel elements from the BGRR were discharged into a chute extending from the floor of the south plenum to the bottom of the deep pit. The freshly discharged fuel required a decay period prior to being placed in longer-term storage in the shallow portion of the canal (SAIC, 1992).



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PLAN VIEW OF CANAL HOUSE AND WATER TREATMENT HOUSE

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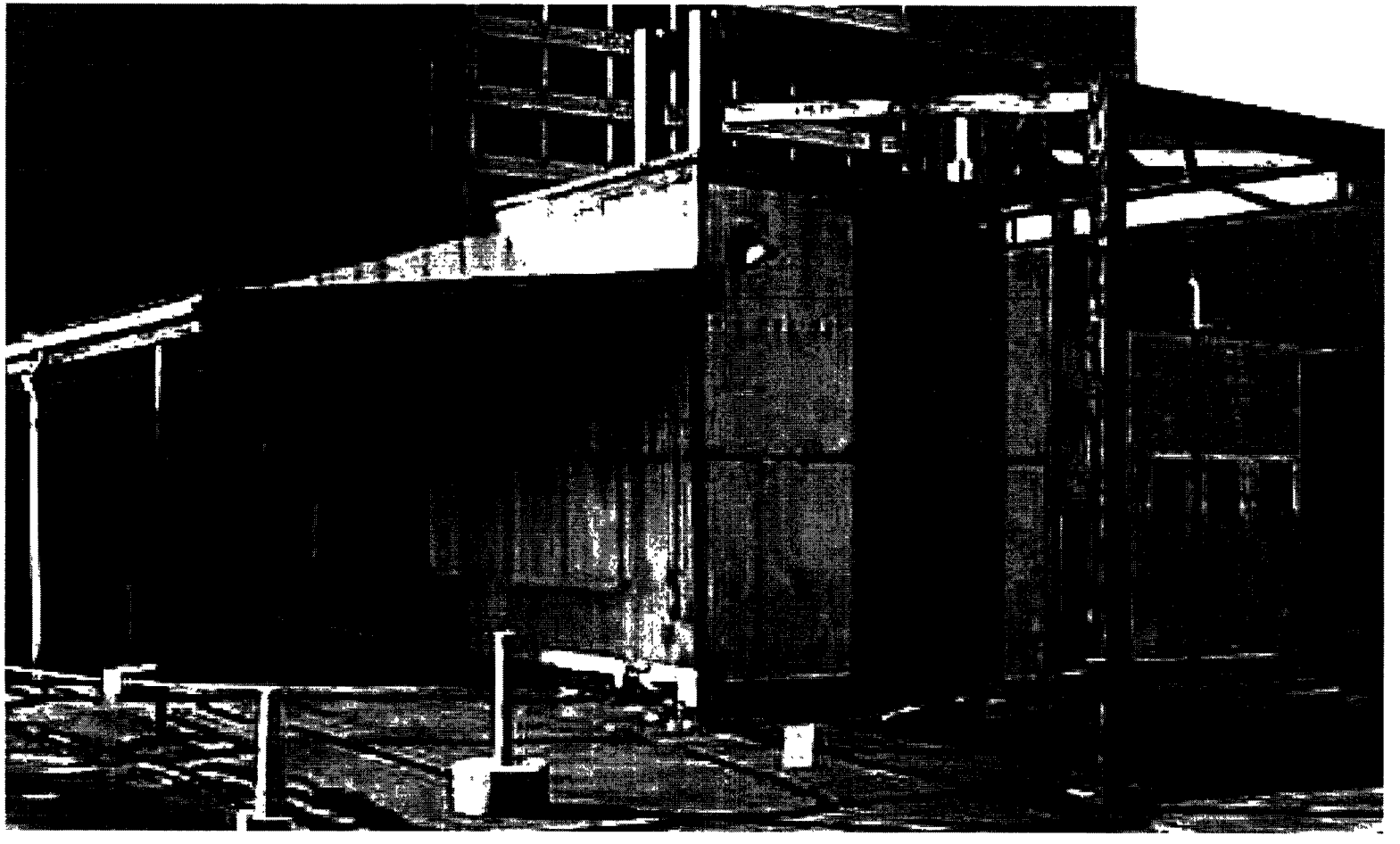
				FIGURE 1-13

Figure 1-14

Photo of Canal House and Water Treatment House



The canal held 55,000 gallons of water. The canal water was kept as clean as possible by circulating approximately 25 gallons per minute (gpm) of water continuously through a diatomaceous earth filter and then through ion exchange columns. Except for cleaning operations, which involved adding water and pumping water from various sumps (sometimes directly to the waste treatment facility), the canal water system was operated as a closed loop (SAIC, 1992).

Prior to 1973, the storage canal was drained, cleaned with detergents and water, and covered with concrete slabs for shielding. Between 1985 and 1986, the piping and equipment were removed from the water treatment and canal houses, the storage vaults and drains in the east yard pads were sealed, paint flaking from the walls of the canal walkway were scraped, and all accessible areas in the canal facilities were cleared of debris (B&R, 1989).

During the 1950s, prior to replacement of the natural uranium fuel slugs, there was a substantial problem with corrosion of fuel elements in the canal. This fuel was subject to deterioration and oxidation while in storage, making the fuel slugs "dusty" when they were eventually prepared for shipment. This contributed to the contamination of the canal (SAIC, 1992).

Another operational procedure led to the eventual gross contamination of the canal. The procedure involved preparing the spent fuel elements for shipment. Each of the original fuel elements had 33 natural-uranium slugs contained in an 11 ft. long finned aluminum tube. The fuel elements were opened and the 33 slugs removed as part of the preparation for shipment and disposal. This grossly contaminated the water with uranium oxide, some plutonium and considerable fission products. The new type of fuel elements, which replaced the older fuel elements in 1958, consisted of two-foot-long curved plates of aluminum-clad enriched-uranium-aluminum alloy, which did not require chopping before shipment (SAIC, 1992) and were not subject to deterioration when stored in the canal.

It is likely that the deep pit and canal surfaces contain significant radioactive contamination that was not removed during prior cleanings. Some of the tiles lining the deep pit have dislodged, and the extent of contamination migration through the grout

between tiles is unknown. The canal walls are still contaminated with fission products such as cesium-137 (Cs-137) and strontium-90 (Sr-90), and with uranium and plutonium from the spent fuel elements. Water contained within the canal walkway sump following decommissioning work completed in 1986 measured 50-75 milliRoentgen per hour (μR/hr) on contact. The canal walkway area in 1986 measured 2-25 μR/hr, the source being under paint and in concrete surfaces. A drain pipe at the east end above the sump and a spot in the north walkway measured 80 μR/hr (B&R, 1989).

An outdoor pad area is located to the south of the Canal House. Storage vaults are located within this pad area. Between 1950 and 1958, the storage vaults were used to hold empty aluminum rods after the spent natural uranium fuel had been removed. The area also contains wash down pads and the east yard sump.

The Water Treatment House (Building 709A) is attached to the northern portion of the Canal House. The Water Treatment House contained water filtration and purification equipment to maintain canal water chemistry and clarity, as well as providing weather protection and confinement for radioactive wastewater treatment. This building was cleared of contaminated components and piping. Radiation measurements ranged from 2-80 (μR/hr), the higher readings being near the pump pads in the northwest corner and in the equipment cells. The floor drains are contaminated, and pass under the floor to the east yard sump (B&R, 1989). This building's outdoor pad area is connected to Building 709's outdoor pad area and is known to contain fixed contamination under several layers of paint and asphalt.

1.2.10 Below Ground Piping Systems

These lines include the canal deep pit sump pump discharge lines, the canal walkway sump pump discharge line, east yard sump discharge line, reactor pile area drain line, east yard pad drain line, west wing waste discharge line east of the Reactor Building, east wing waste drain line, sample transfer tubes from Reactor Building to the east and west wings of Buildings 703 and to Building 801, and irradiated materials pad floor drain. The reactor pile area drain line runs parallel to the east wing of Building 703 and discharges

to the F waste tank in Building 801. The three large east yard and north pads also drain to the reactor pile area drain line.

A buried line, which is currently capped at two ends, formerly ran from the deep pit sump at the canal to the contaminated waste trench. This line was used to pump highly radioactive wastewater and suspended uranium oxide to the tanks at Building 811. Surface contamination remains in this line, although it has been drained. The canal walkway's sump pump discharge line runs to Building 801's "D" waste holding tanks. The canal walkway sumps handled uranium oxide, and contaminated caustics and diatomaceous earth from the water-treatment operation. The east yard sump pump discharge line ties into the canal walkway sump pump discharge line. Since contamination is expected in the east yard sump, it is likely that this line contains significant contamination (B&R, 1989).

The size, material, and routing of these pipes is shown on many construction drawings, however there is a question of consistency between the drawings. A summary of the lines found on various drawings is included in B&R, 1989, Subsection 3.3.10.1.1. Expected contamination in these lines varies from very low to significant, however, generally there has been no characterization of these lines. Sampling and preparation of accurate survey data will be required prior to disruption of these lines which may occur during excavation activities. Additionally, these lines may be corroded and therefore, potentially contaminating surrounding soils, and subsequently, groundwater. The soils around these pipes are part of sub-AOC 9C which is discussed in Subsection 1.2.12.

1.2.11 Canal Soils (Deep Pit, Canal, and Canal Walkway) (sub-AOC 9A)

The extent of the canal water leakage during the twenty years of operation is not known. However, leakage is known to have occurred through the concrete slab expansion joints. The expansion joints in the canal walls and floor where they penetrate the Reactor Building foundation are likely locations for leakage. Drawings indicate a major expansion joint at the Reactor Building outer wall (column line 7) (B&R, 1989).

Survey data showed radiological contamination inside the Canal House on the cask washdown/decontamination area (20-80 mR/hr), with possible contamination of the soil around buried drain lines and under floor cracks. The Canal House general area radiation measurements ranged from 1-5 mR/hr. The floor drain lines which lead underground to the canal walkway sump are likely contaminated. This building is constructed of "Cementos" (asbestos-based cement) siding over a structural steel framework (B&R, 1989).

1.2.12 Soils from East-Yard Outdoor Pads, Sump, and Storage Vault (sub-AOC 9C)

The east yard outdoor pad area around Building 709 has several localized areas of soil contamination, identified as sub-AOC 9C, Spill Site, in the IAG. In order to transfer radioactive material from the canal to some other area, such as the Hot Lab, the irradiated material was loaded into shielded carriers under water and lifted out of the canal onto trucks by a hoist. The irradiated material included radioactive fuel cartridges and assemblies, and hot lab shields. Contamination is suspected to have been washed onto the ground during decontamination and materials handling operations (SAIC, 1992).

During decontamination of the material removed from the canal, contaminated detergent and water solution was discharged onto the canal house concrete pads and into the "hot" (D-waste) drains. The drain pads in the east yard and the small "front porches" at each end of the canal house drained to D-waste sumps. Other pads on the east and north of the Canal House drained to the F-Waste System (SAIC, 1992). Numerous cracks in these have been observed, mostly between the east yard sump and Canal House, between the east and south pads, between the south pad and west door pad, and along the south and west building walls. Contamination under the pads is likely, especially around the east yard sump (B&R, 1989).

Parts of the yard underneath the pad are listed as possibly "lightly contaminated." The storm drain system is listed as possibly "very lightly contaminated." The outdoor pad

area has fixed contamination under several layers of asphalt and concrete. The outside area around the Canal House is posted as a Controlled Area-TLD[3] Required. During operations, some of the contaminated water was allowed to drain onto the pavement next to the Canal House and onto the surrounding soil as a result of either inappropriate work practices, rain, or from back up of the sump. An underground Radioactive Material Area Survey verified contamination present in soils in this area. A storage vault in this area was used to store natural uranium fuel elements with low radioactivity, fuel-cask liners, and activated and/or contaminated items. Internal contamination is likely (B&R, 1989).

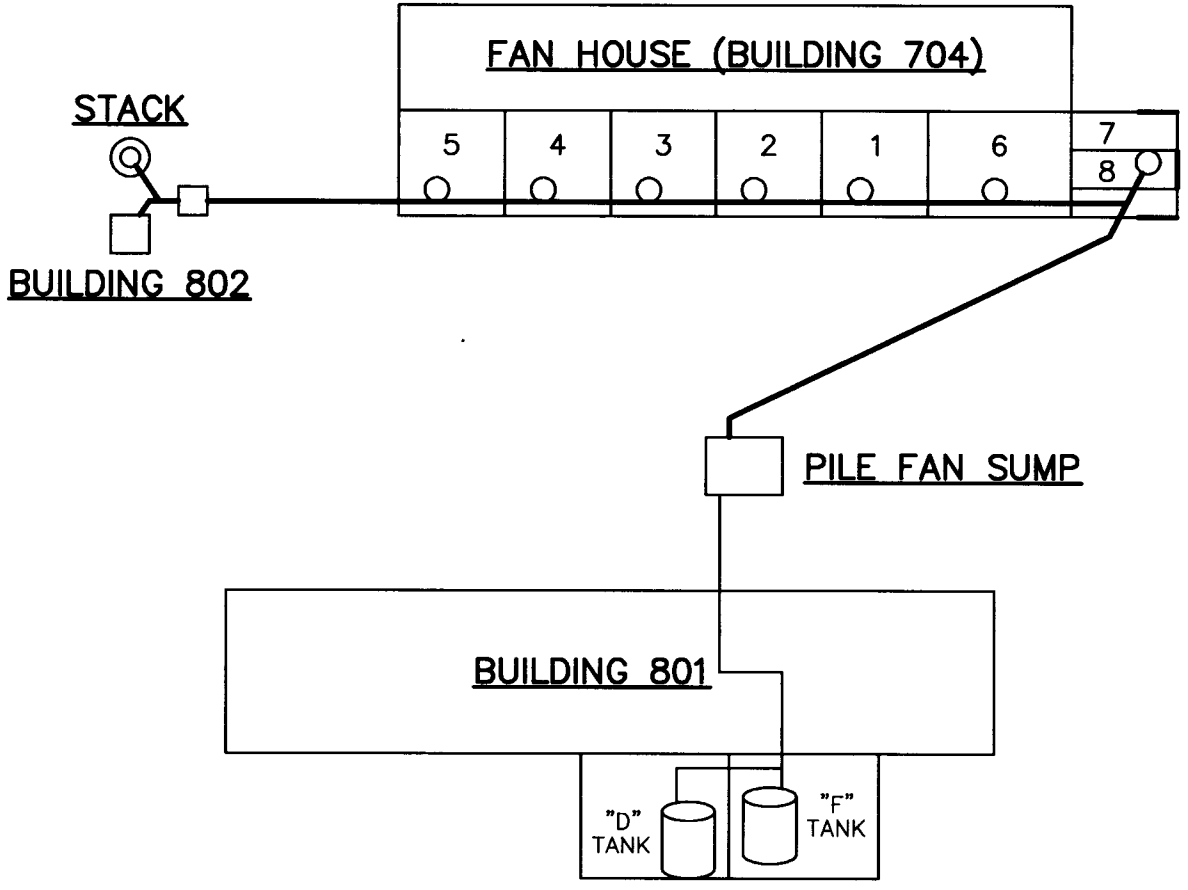
In addition, the rollup door areas (east and west side of Building 701) and east yard area were historically contaminated by equipment and contaminated waste (SAIC, 1992).

1.2.13 Pile Fan Sump and Soils (Sub-AOC 9D)

The pile fan sump is an operational sump located approximately 45 ft. south of the western end of the Hot Laboratory (Building 801). The sump is a concrete structure that weighs approximately 13.5 tons and is connected to approximately 250 ft. of drain piping. The underground concrete sump is 10 ft. deep, 7 ft. long and 5 ft. wide. The sump receives water from the BGRR and HFBR Stack as well as the Fan House and ancillary facilities. Three drain lines from the Pile Stack Building (Building 705) and one drain line from the Hot Laboratory Fan House (Building 802) join in a common drain header. The drain line enters the east side of the Fan House, runs along the northern edge, exits from the western side, and runs to the pile fan sump. A schematic diagram of the Fan House floor drain system to the pile fan sump is shown in Figure 1-15. Floor drains from the Fan House discharge to the line in the building. A discharge line runs from the pile fan sump to Building 801. An acid vent header runs from Building 801 through the sump to Building 802. The line has a low point drain that discharges to the sump.

[3] TLD – Thermoluminescent Dosimetry, a type of badge worn by radiation workers to provide a record of workers exposure to penetrating radiation.

FILE NAME: G:\DESIGN\DWG\BROOKHVN\FIG1-8.DWG (PLOT 1=1)



LEGEND

1 THRU 5 : PRIMARY FAN ROOMS
6 : SECONDARY FAN ROOM
7 : GAS ENGINE ROOM
8 : EMERGENCY FAN ROOM

○ : FAN ROOM FLOOR DRAINS

—— : DRAIN LINE

BGRR FAN HOUSE FLOOR DRAIN SYSTEM TO PILE FAN SUMP

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				FIG 1-15

Low-level radioactive contamination was discovered in 1996 in the sump. At that time, rainwater was collecting in the sump from the surrounding pavement and filling it to a level where there was obvious penetration to the surrounding soils. Under a separately planned removal action, the pile fan sump, contaminated soils, and about 250 feet of the associated piping systems are to be removed to coincide with modifications made to comply with the Suffolk County Sanitary Code Article 12 (BNL, 1999b). This site is designated sub-AOC 9D.

During the Operable Unit III Remedial Investigation (IT, 1999), the pile fan sump was identified as a potential source for a strontium-90 groundwater plume in the area. Additional soil sample data collected in early 1998 indicated cesium-137 in the soil (142 picoCuries per gram [pCi/g]) near one of the sump penetrations, and lesser amounts of strontium-90 and gross alpha- and beta-contamination (BNL, 1999b).

Water and sludge were removed from the pile fan sump and piping, and the interior surfaces were inspected between December 1997 and March 1998. During an inspection of the sump in March 1998, a piping penetration point was observed which allowed leakage to the soil column. This leakage was a probable source of soil contamination (BNL, 1999b).

1.3 NEPA APPLICABILITY

In conjunction with CERCLA and other federal laws, NEPA establishes policies and goals for protecting the quality of the environment. NEPA Section 102(2) mandates that federal agencies consider the possible effects (both adverse and beneficial) of all proposed activities or actions. Federal NEPA regulations are promulgated by the Council on Environmental Quality (CEQ) established by NEPA. These regulations state that, "Federal agencies shall to the fullest extent possible . . . (c) integrate the requirements of NEPA with other planning and environmental review procedures required by law or by agency practice so that all such procedures run concurrently rather than consecutively" (40 CFR 1500.2).

In accordance with DOE Order 5400.1E (DOE, 1989) and Title 10 Code of Federal Regulations (CFR) 1021, the considerations (values) of NEPA must be evaluated during the CERCLA process. DOE Order 451.1A (DOE, 1997b), states:

> "Each Secretarial Officer and Head of a Field Organization shall, for matters under the office's purview:...(13) Incorporate NEPA values, such as analysis of cumulative, off-site, ecological, and socioeconomic impacts, to the extent practicable, in DOE documents prepared under the Comprehensive Environmental Response, Compensation, and Liability Act."

On June 13, 1994, Secretary of Energy Hazel O'Leary issued the Secretarial Policy Statement on NEPA (DOE, 1994a), which strengthens the NEPA procedural process within DOE and streamlines the NEPA process in areas where duplication or inefficiencies have been identified. The policy states that, as a general practice, DOE will rely on the CERCLA process for review of actions taken under CERCLA and will address NEPA values and public involvement procedures by incorporating NEPA values into the CERCLA process and making CERCLA documents available to the public as early as possible.

There are similarities between the NEPA and CERCLA processes. Both processes:

- Require consideration of a No Action Alternative.
- Require the identification and analysis of alternative courses of action.
- Provide for public participation and receipt of oral and written comments.
- Provide for the concurrent consideration of other environmental review and regulatory requirements.
- Allow for a scoping phase.
- Have a data collection phase.
- Result in formally documented Records of Decisions.

The NEPA values are further discussed in Subsection 4.2 and Appendix A.

SECTION 2

SYSTEMATIC APPROACH TO DEVELOP ALTERNATIVES

2. SYSTEMATIC APPROACH TO DEVELOP ALTERNATIVES

Decommissioning is a controlled process used to safely retire a facility that is no longer needed. During decommissioning, radioactive and hazardous materials, equipment, and structures are decontaminated, isolated, sealed, enclosed, or removed so that the facility does not pose a risk to public health or the environment.

To facilitate decommissioning planning for the BGRR, the project team gathered input on community and stakeholder values during a series of roundtable meetings in the summer of 1999. The results of these meetings are available in a document entitled *Summary of Roundtable Discussions on Decommissioning of the BGRR* (BNL, 1999i). This input has been considered during the evaluation and screening of decommissioning alternatives. Additional opportunities for public input will arise as the project proceeds.

Along with public input, the following broad categories of evaluation criteria were considered in assembling decommissioning alternatives:

- Overall protectiveness to public health and welfare and the environment.
- Feasibility/implementability of alternatives in achieving the prescribed remedial action objectives.
- Projected potential costs estimated for implementation of each alternative.
- Impacts to the overall mission of the entire BNL Environmental Restoration Project.

In keeping with the CERCLA process for removal actions (EPA, 1988b), the standard approach used to develop the removal alternatives evaluated in this document are:

1. Determination of potential exposure pathways.
2. Determination of Contaminants of Potential Concern (COPCs).
3. Determination of potential Applicable or Relevant and Appropriate Requirements (ARARs).

4. Development of Remedial Action Objectives (RAOs), and Preliminary Remediation Goals (PRGs) which address the land use, COPCs, ARARs, and exposure pathways determined in Steps 1 through 3.

5. Development of general response actions capable of addressing the RAOs in Step 4.

6. Screening of technologies capable of achieving the general response actions in Step 5 Technologies can be eliminated from incorporation into an alternative, based upon such criteria as infeasibility, prohibitive costs, or lack of a proven track record of success in similar circumstances.

7. Development of representative process options for the technologies retained in Step 6. For instance, if a broad technology (such as surface decontamination) is under consideration, one process option (such as solvent washing) might be used if it is considered most representative of available applicable decontamination methods.

8. Combining process options into viable alternatives for decommissioning the BGRR facility. These alternatives should cover a range of cost and complexity, from No-Action (which must be considered as a baseline for comparison under CERCLA) to complete removal of all buildings, structures, appurtenances, and environmental media impacted by historical activities.

It should be noted that because there are a limited number of accepted methods available for decommissioning of the BGRR (e.g., leave in place, remove, isolate, seal or enclose), Steps 6 and 7 are redundant (i.e., technology = removal, process option = removal). Therefore, for the purposes of assembling BGRR decommissioning alternatives in accordance with both CERCLA and DOE long-term planning and budget allocations, steps 6 and 7 will be combined, and referred to as development of representative process options.

2.1 LAND USE

To identify appropriate RAOs, the future land use must be considered. Roundtable meetings with the public, stakeholders, and the project team discussed future land uses. Additional future land use options will be considered after the nature and extent of contamination has been determined at the BGRR facility.

The BGRR facility is located within a developed area of the BNL property. Ranging from 100 to 120 feet above sea level, the BGRR facility was constructed on the highest point of land within the BNL complex. The structures that were constructed to support or be supported by the BGRR include the Reactor Building (Building 701), the Reactor Pile (Building 702), the Reactor Laboratory (Building 703), the Fan House (Building 704), the Reactor Pile Stack (Building 705), the Instrument House (Building 708), the Canal House (Building 709), the Water Treatment Facility (Building 709A), the Hot Laboratory (Building 801), and the Pile Fan Sump.

Future-use options for the BGRR facility may include but are not limited to the following:

- Administrative Offices: Portions of the BGRR facility would be used as administrative office space for BNL personnel or other administrative offices. Adequate radiation monitoring, environmental surveillance, and appropriate security procedures would be implemented to ensure health and safety of the workers and the public. Presently, portions of Building 701 are used as office space for the BGRR Decommissioning Project Team.

- Non-warehouse use: Portions of the BGRR facility would be used for purposes other than warehouse space (i.e. offices, laboratories, and equipment rooms). The building codes which would apply if BNL were to turn the building into useable warehouse space would make that action impractical. For any further use of the buildings, adequate radiation monitoring, environmental surveillance, and appropriate security procedures would be implemented to ensure health and safety for workers and the public, and protection of the environment.

- Private Development: Other less restrictive future-use scenarios, such as development for recreational or residential purposes would be considered after contamination characterization and necessary Decontamination and Decommissioning (D&D) of the BGRR facility have been completed in accordance with the selected Alternative.

- Other use: Other potential land uses would be considered depending upon contamination characterization results of the BGRR facility.

2.2 EXPOSURE PATHWAYS

Without a complete characterization and risk assessment, assumptions about potential exposure pathways will be based on existing information and thus will be more

qualitative than quantitative. The rural residential family-farm scenario recommended as default (ANL, 1993) includes all environmental pathways. A farmer may receive doses from direct external exposure to radiation, inhalation of resuspended dust from surface contamination, inhalation of radon, ingestion of contaminated soil, ingestion of plant foods, ingestion of meat from livestock, ingestion of milk from this livestock, ingestion of water, and ingestion of aquatic animals from a nearby pond that has been contaminated. Since contamination of a nearby pond is unlikely, the exposure pathway "ingestion of aquatic animals" may be eliminated. Figure 2-1 illustrates this scenario.

Further refinements to the scenario should be made based on site conditions. This includes future land use and the nature of the contamination. Other scenarios such as residential without subsistence farming or industrial may be more applicable after these considerations. Figure 2-2 illustrates all the potential pathways to potential human exposure after decommissioning is complete. All the pathways in Figure 2-2 apply to both radioactive and non-radioactive contaminants except for direct external radiation (see Subsection 2.2.1.3).

2.2.1 General Assumptions of the Conceptual Model

This conceptual model will form part of the basis for conducting a qualitative risk analysis of the alternatives under evaluation. The evaluation will include risks to workers, the general public, and the environment. The conceptual model along with site-specific data will be used to develop preliminary remediation goals based on relative dose or risk

Figure 2-1
Site Conceptual Model

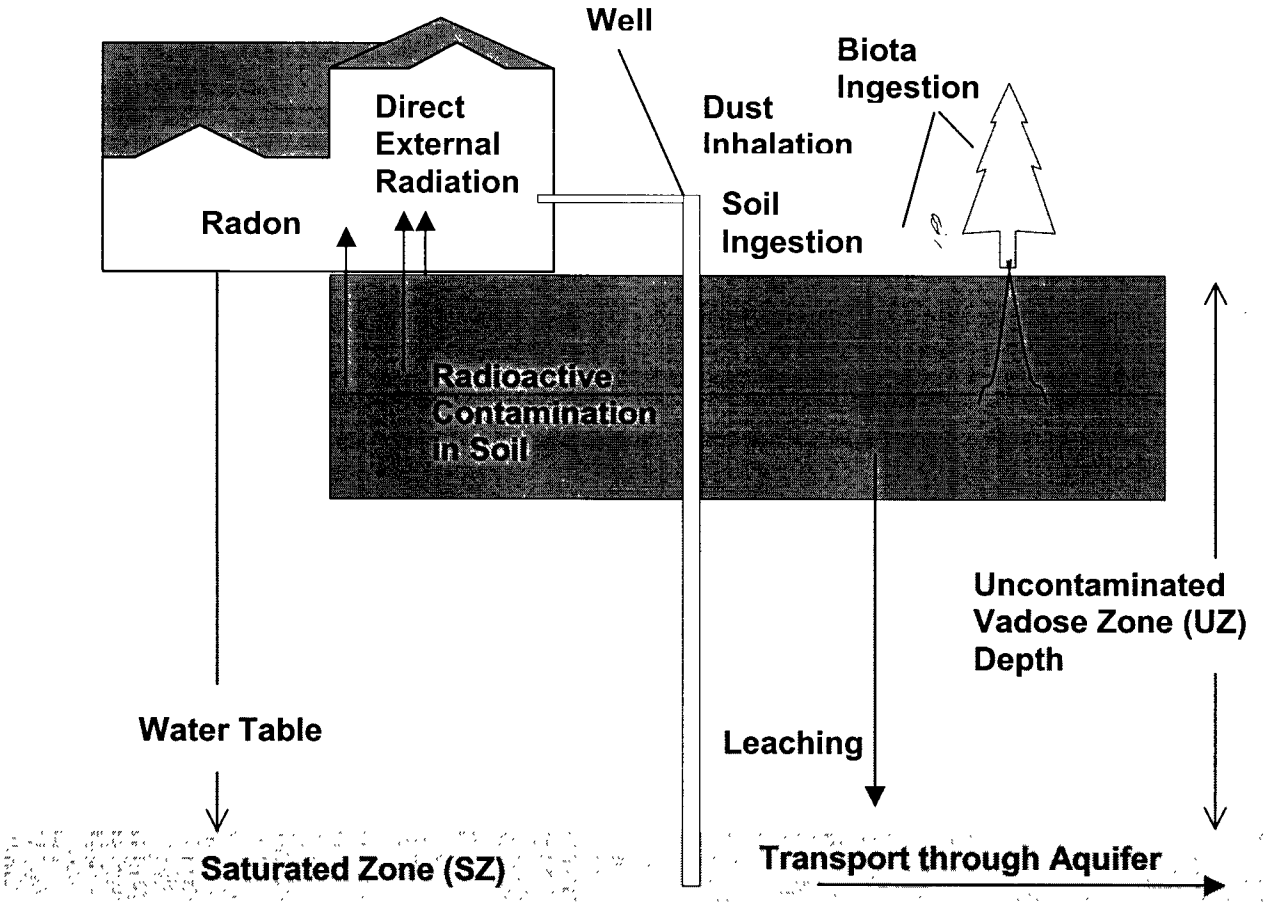
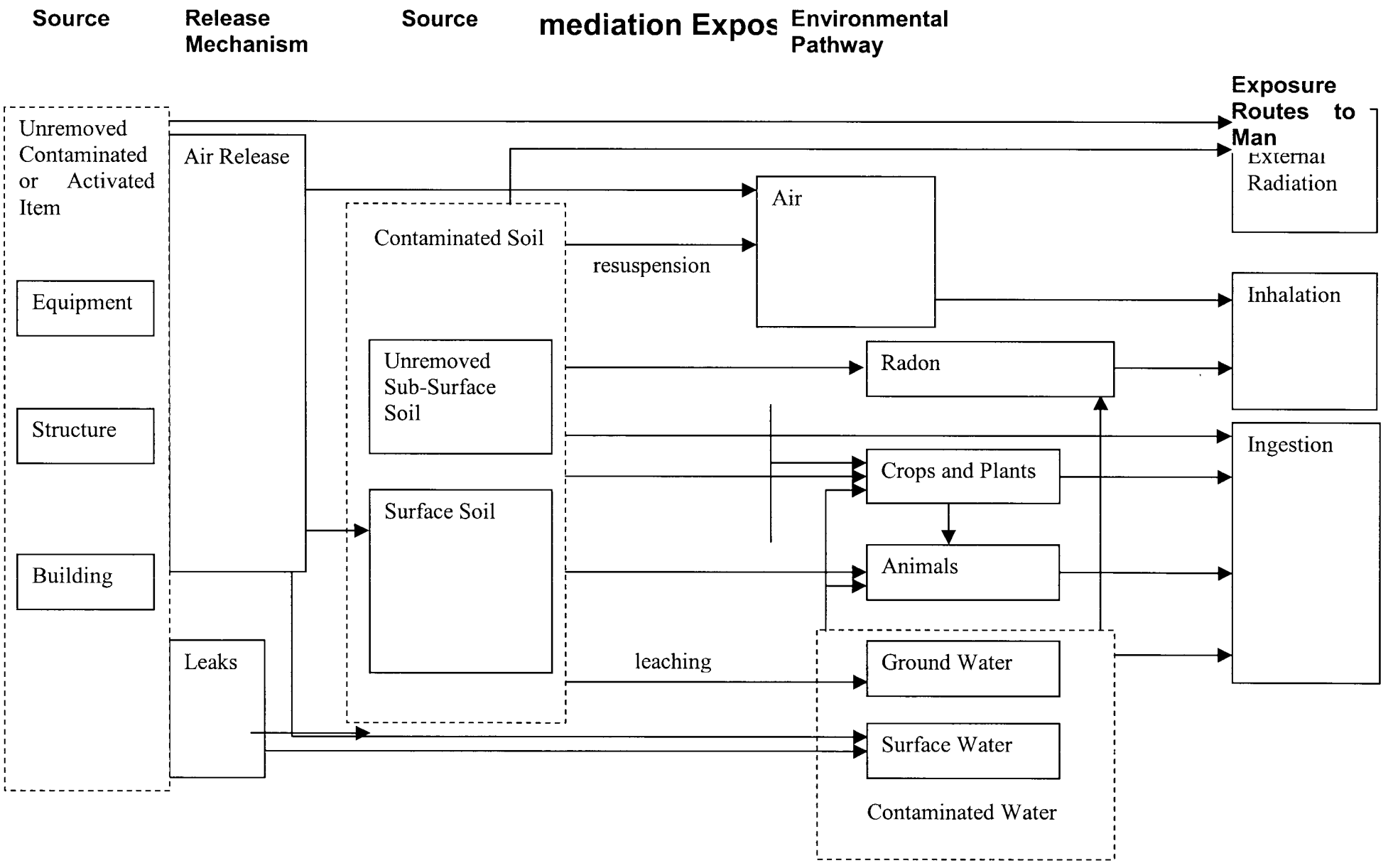


Figure 2-2


Source
Release Mechanism
Source
mediation Expos
Environmental Pathway
Exposure Routes to Man
Unremoved Contaminated or Activated Item
Equipment
Structure
Building
Air Release
Leaks
Contaminated Soil
Unremoved Sub-Surface Soil
Surface Soil
resuspension
leaching
Air
Radon
Crops and Plants
Animals
Ground Water
Surface Water
Contaminated Water
External Radiation
Inhalation
Ingestion

(see Subsection 2.6). Both the period during and after remediation will be considered. While the risks include both industrial hazards and hazardous substances, only exposure to hazardous radiological and non-radiological substances is considered for exposure pathways.

2.2.1.1 Industrial hazards

Industrial hazards include falls, electrical shock, confined spaces, hoisting and lifting, heat, noise, transportation accidents, seismic events, high winds, and fire. Some of these possibilities may also lead to release of hazardous substances.

2.2.1.2 Hazardous substances

Hazardous substances include both radiological and non-radiological contaminants. Subsection 2.3 lists the contaminants of potential concern. Appropriate DCGL values must be derived based on potential short-term doses as well as long-term exposure. While a detailed characterization is not available, the range of radiological contaminant activities[4] shown in the *Hazard Classification and Auditable Safety Analysis for Brookhaven Graphite Research Reactor (BGRR) Decommissioning Project*, Brookhaven National Laboratory, September 8, 1999 (BNL, 1999f) varies by at least six orders of magnitude from radionuclide to radionuclide. This suggests the list of contaminants of potential concern may be narrowed. Fifty (50) year institutional controls will allow radionuclides with shorter half-lives to decay. Thus, while Co-60 may be a significant contaminant of concern during remediation with its contribution to direct external exposure, in 50 years, due to its five-year half life, only 0.1 % of its present day activity will exist (see Subsection 2.2.1.5). Both Sr-90 and Cs-137 have half-lives around 30 years. These too will disappear quicker than the longer lived isotopes of concern such as C-14 with a 5,700-year half-life, plutonium-239 (Pu-239) with a 24,000-year half-life, and plutonium-240 (Pu-240) with a 6,600-year half-life. For long-term

[4] Activity is a measure of how many atoms of a radioisotope are undergoing decay per a time period, such as disintegrations per minute. Activity can be thought of as a measure of how much of a radioactive isotope is present.

environmental effects, (e.g., chronic human health effects such as cancer, or genetic environmental effects, etc.) long-lived radioisotopes and their progeny[5] need to be addressed.

2.2.1.3 Internal and External Exposure for Radioactive Contaminants

A main difference between radioactive contaminants and other contaminants is that some radioisotopes are a health concern from the direct external effects of radiation emitted from the contaminant as well as the internal effects after an uptake of the contaminant. External effects are primarily from gamma radiation. While many radionuclides emit gamma radiation, the energy of gamma radiation from different radioisotopes varies by many orders of magnitude. Thus, even modest amounts of shielding materials such as soil can eliminate the external effects from isotopes that emit low energy gamma radiation such as plutonium-241[6] (Pu-241). Internal exposure occurs from the inhalation or ingestion of contamination, and by direct absorption through the skin. Internal effects are primarily from beta and alpha radiation. Internal exposures are from sources such as contamination in drinking water and radon inhalation, or from ingestion of plants and animals that have themselves had an internal deposition. The effects in the body depend on target organs, body retention, radioactive decay, and the radioisotope's daughter products.

There are different means for minimizing the effect from external and internal hazards. Shielding by materials such as soil, concrete, lead, steel, etc., can help eliminate the external radiation risks from those radioisotopes such as Co-60 and Cs-137 that present an external hazard. Increasing the distance from a source or decreasing the time spent around a source will also reduce external effects. Preventing the route of entry of a contaminant into the body prevents internal exposure. During remediation, protective clothing, HEPA filtration, and good work practices will be some of the means used to minimize internal exposure.

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[5] Some radioactive elements decay into another element that is also radioactive. This is called a daughter product. A daughter can also decay into another radioactive isotope. The daughter products are also called progeny.

[6] Plutonium does not emit gamma radiation, rather low energy x-rays are emitted that have the same external concerns as gamma radiation.

2.2.1.4 Radioactive Contamination

Materials in a nuclear reactor may contain radioactivity from both activation and contamination processes. Activation is a process by which a material such as steel is made radioactive from the bombardment with neutrons. The neutrons are produced by the fissioning of uranium fuel. Radioactivity is induced throughout the material such that the entire material may be considered radioactive. While activated steel can not be cleaned of its radioactive content, the radioactive content can not be transported unless the steel itself is degraded (e.g., through cutting or abrasion) and transported.

Radioactive contamination generally refers to loose or fixed radioactive material that is transported and deposited onto surfaces. This contamination may result from processes such as abrasion, oxidation or erosion of fission and activation products. Radioactive surface contamination may be easily transported from surface to surface with direct contact. Loose surface contamination such as dust can become airborne contamination and be deposited in other locations. In this document, contamination refers to both activated materials and the material that is transferable or can become transferable. It is important, however, for the alternatives under consideration to make the distinction that activated materials are a greater external exposure concern while contaminated materials are a greater internal exposure concern. Furthermore, during remediation activities such as cutting, jack hammering, and other intrusive techniques, the potential for internal exposure is increased.

2.2.1.5 Radioactive Decay

Radioisotopes naturally decay causing a decrease in their activities or concentrations. Each radioisotope has a unique half-life that is a measure of how long it will take for the half of the radioactive isotope to decay. This can be expressed by the equation:

$$C_t = C_o \left(\frac{1}{2}\right)^{t/T_{1/2}}$$

Where: C_t = Concentration of the radioisotope at time t
C_o = The original concentration of the radioisotope at time 0
t = the amount of time that has passed
$T_{1/2}$ = the half life of the radioisotope in the same units as t (months, years, etc.)

For example, for a radioisotope with a half-life of 5 years, after 50 years, the fraction of concentration left is:

$$\frac{C_t}{C_o} = \left(\frac{1}{2}\right)^{50/5} = 0.001 = 0.1\ \%$$

2.2.2 Conceptual Model of Environmental Fate, Transport, and Exposure

This qualitative conceptual model is intended to evaluate the potential human health and environmental hazards associated with the known and suspected contaminants at the BGRR facility. The focus is on the potential contaminant release mechanisms, the pathways, and the associated risks if contamination is released to the environment. The potential exposure pathways are described below.

2.2.2.1 Direct Radiation Exposure

Direct radiation exposure may occur if there are sufficient quantities of one or more radionuclides capable of delivering an external exposure both close enough to a human receptor and without sufficient shielding. Direct exposure is a concern during remediation efforts. Sources of external exposure after remediation may include elements not removed during remediation and from soil contamination. Radiation that is energetic enough to be an external concern is still not capable of activating other materials or causing contamination. Thus, there are no transport mechanisms to other media.

2.2.2.2 Air

Airborne contamination is a pathway that could pose a potential exposure risk to a worker or member of the public during remediation. Methods employed to decontaminate equipment and building surfaces may result in concentrations of airborne radioactive contamination within the BGRR facility. The transport of contaminants from the BGRR facility to the atmosphere could occur by means of fugitive dust emissions and vapor transport. The exposure pathway is the inhalation of airborne contaminants.

Soil contaminated with radium (Ra-226) may lead to exposure from radon (Rn-222). Radon is a gas that may be released from soil. However, unless there is a closed structure, radon and its daughters can not become concentrated and pose a potential hazard.

2.2.2.3 Surface Soil

Contamination of surface soil can occur through the deposition of airborne contamination and surface spills. Subsurface contamination has occurred from underground piping and ducts. During remediation, the failure of the HEPA filters may allow airborne contamination within the BGRR facility to be released and deposited on the ground. Human intrusion, such as digging a well, may bring contaminated material to the surface after remediation. The exposure pathways for surface soil are inhalation of fugitive dust, ingestion of soil and biota (see Subsection 2.2), and direct contact with soil contaminants. External exposure from radionuclides in soil was also discussed in Subsection 2.2. Hazardous substances in surface soil can be transported through the vadose zone and leached into groundwater.

2.2.2.4 Vadose Zone

One of the primary mechanisms for contaminant transport is vertical contaminant migration downward to the groundwater. Contaminants generally move as a dissolved phase in water, and their rates of migration are controlled both by water migration rates and by adsorption and desorption reactions involving the surrounding soils. Some contaminants are strongly sorbed on soils, and their downward movement through the stratigraphic column is greatly retarded. The equilibrium distribution coefficient, K_d, is the amount of radionuclide sorbed on sediment divided by the amount of radionuclide left in solution. It is a measure of the transport of radionuclides through porous geology. Radionuclides with low values of K_d are more easily transported.

Table 2-1 lists the equilibrium distribution coefficients (K_d) for several radioisotopes of concern as reported in the PFS Sampling and Analysis Plan (SAP) (BNL, 1999m). As seen from the table, there are both contaminants that tend not to leach, such as cesium and plutonium, as well as contaminants that may readily be transported to groundwater, such as strontium and radium. Groundwater in the Upper Glacial aquifer generally exists in

unconfined conditions. This will allow contaminants in the vadose zone to leach to groundwater.

Exposure pathways from the vadose zone include direct external exposure and inhalation of radon gas. After remediation, the potential for vadose zone migration of contaminants could result from compromising engineering barriers of contaminated elements left after remediation.

Table 2-1

Radionuclide Solubilities

Radionuclide	K_d *	Solubility
Hydrogen (H-3) (Tritium)	0	Soluble
Carbon (C-14)	0	Soluble
Cobalt (Co-60)	60	Relatively insoluble
Nickel (Ni-63)	100	Relatively insoluble
Strontium (Sr-90)	7	Soluble
Technetium (Tc-99)	0	Soluble
Iodine (I-129)	1	Soluble
Cesium (Cs-137)	190	Relatively insoluble
Samarium (Sm-151)	7	Soluble
Europium (Eu-152)	580	Insoluble
Radium (Ra-226)	500	Insoluble
Thorium (Th-228, -230, -232)	3200	Insoluble
Uranium (U-234, -235, -238)	13	Soluble
Plutonium (Pu-238, -239, -240)	3000	Insoluble
Americium (Am-241)	3000	Insoluble

* K_d from BNL, 1999m.

2.2.2.5 Groundwater

Humans (workers and the public) can be exposed to groundwater contaminants either from groundwater obtained from wells or surface water. Exposure pathways include ingestion of water and biota (see Subsection 2.2), direct contact through bathing, and inhalation of radon gas.

During remediation, these contaminant pathways will not be of concern. After remediation and during the period of active institutional control, (50 years) the use of groundwater in the BGRR Area may be restricted. After the period of institutional control of the BGRR facility and areas downgradient of the BGRR facility, the groundwater may be a source of these exposures. However, while models have been used to predict groundwater flow and transport at BNL, modeling can not predict exact concentrations in groundwater downgradient of the BGRR due to the assumptions and simplifications inherent in groundwater models as stated in the *Operable Unit III Remedial Investigation* (IT, 1999).

2.2.2.6 Biota

Uptake of hazardous substances from air, surface soil, vadose zone, and groundwater by biota can result in the transport of contaminants through the food chain and eventually to humans. A farm scenario may lead to ingestion by animals. For example, while grazing, domestic animals and wildlife can ingest soil or plants containing hazardous substances. Surface water may directly impact biota subsequently consumed by human receptors. Human ingestion of soil and groundwater was discussed in Subsections 2.2.2.3 and 2.2.2.5 respectively. Biota can also receive external radiation exposure. However, as mentioned previously, the effects of external sources of radiation can not induce radioactivity (in biota). Consequently, there is no transport mechanism to a human receptor through external exposure of the biota.

After remediation, exposure to biota in the BGRR Area could occur if compromised engineering barriers exposed contamination. Plant pathways include irrigation of crops and root uptake from soil. Animal pathways include plant ingestion, groundwater ingestion, and soil ingestion. However, the limited available habitat around the BGRR would minimize the pathways to non-domestic terrestrial wildlife.

2.3 CONTAMINANTS OF POTENTIAL CONCERN

In the context of this report, contaminants of potential concern (COPCs) are the contaminants present that may have to be addressed by decommissioning actions. As mentioned in the Pile Fan Sump/Above-Ground Duct and Balance of Plant (BOP) Sampling and Analysis Plans (SAPs) (BNL, 1999k and BNL, 1999m), COPCs are not fully defined at this point.

Consequently, actual contaminants of concern (COC) for the BGRR will be identified in future CERCLA documentation since a significant amount of quantitative radiological data is not available at the present time.

COPCs are those contaminants associated with the previous operation of the BGRR. Because either no data or limited data are available regarding contaminant concentrations, the historical and operational data, and process knowledge are the major sources of COPCs for this facility. Potential COPCs which may remain within the BGRR include:

1. Fuel residues, including uranium and transuranic radionuclides.
2. Long-lived fission products exclusive of inert gasses.
3. Activation products in structural material and equipment within and around the reactor pile.
4. Activation of experiments introduced into the reactor pile.
5. Entrained particulate material.
6. Miscellaneous chemicals and radionuclides dispersed through the facility during experiments.

In addition to COPCs within the BGRR and associated systems, there were a number of known or suspected spills outside the confines of the facility resulting in surface and possibly subsurface contamination near the facility. These included leakage from the fuel canal (sub-AOC 9A), water in-leakage and subsequent out-leakage from the underground air cooling ducts (sub-AOC 9B), spill sites in the west yard and in the east yard around the Canal House and Water Treatment Facility (sub-AOC 9C), and the pile fan sump for the air cooling discharge system (sub-AOC 9D). Detailed information is not available regarding the complete identification and concentration of contaminants associated with these spill areas.

There are several sources of radiological COPCs associated with prior operation of the BGRR: 1) the formerly used uranium fuel and associated fission and activation products; 2) historic activation of the reactor pile and structural material and equipment within and around the reactor pile; 3) historic activation of experiments introduced to the reactor pile; and 4) entrained particulate material.

2.3.1 Uranium Fuel & Daughters, Fission & Activation Products

Although the fuel has been removed from the reactor pile and the storage canal and shipped offsite, fuel residues, its radioactive decay progeny, and fission and activation products remain in the reactor and associated systems. Originally, the BGRR fuel consisted of natural uranium metal slugs in aluminum tubes. This fuel had a tendency to fail, which resulted in the gross release of fission and activation products within the fuel channels and reactor pile. In 1958, the BGRR was retrofitted with enriched uranium fuel, replacing the natural uranium metal fuel altogether. The new fuel elements were stable and did not fail with the exception of one or two occasions when the fuel plates overheated due to channel blockage (B&R, 1989).

Both types of fuel also released contamination as a result of leaks in fuel element cladding or through fission and activation of trace amounts of uranium contamination on the outer surfaces of the elements. Larger amounts were released when actual breaks in the tube, can, or cladding occurred.

Contamination due to these fission and activation products was transported from the fuel channels into the primary air cooling system, where it was deposited in the plenums, underground ducts, exhaust air filters, and even downstream of the filters in the above ground ducts, fans, and stack. The exhaust air filters were designed to be 95% efficient for particulate matter, which resulted in downstream contamination during the 18 years of BGRR operation.

During routine operation, penetrations in the biological shield may also have been contaminated with these fission and activation products including fuel charging tubes, experimental holes, and control rod drive mechanisms. Since these penetrations are generally lined with steel, the biological shield has been protected from contamination via these avenues; however, the linings are likely contaminated.

When the BGRR was operating, spent fuel was removed from the reactor pile via the south plenum fuel chute, moved into the deep pit, and subsequently into the canal. Contamination on the fuel cladding was spread to these areas.

Over 2,414 spent fuel elements, generated in an 18-year period, were shipped from the canal. The contaminated water, filter media, and back flushing from the ion exchange columns were pumped to the storage tanks at the Waste Concentration Facility, Building 811.

Numerous radioactive isotopes exist of uranium fuel, its decay progeny, fission products and activation products. The half-lives of these radioisotopes vary from very short to very long. Since it has been over 31 years since the BGRR was shut down (June 1968), any isotope with a half-life of two years or less will have undergone over 15 half-lives. This would result in a reduction in the activity of these isotopes by a factor of approximately 50,000. Although trace amounts of these radioisotopes may still be present, their concentrations will be negligible compared to the longer-lived radioisotopes. Table 2-2 shows radioisotopes with half-lives greater than two years that are thermal neutron fission products, of Uranium-235 (U-235) or Pu-239 (GE, 1989). These isotopes must all be considered as COPCs. In addition, some of them have radioactive decay progeny that are also radioactive and must also be considered as COPCs in isolated areas of the facility.

Table 2-3 presents the transuranic radionuclides with half-lives greater than one year resulting from nuclear activation of U-235 and U-238 in fuel elements. These isotopes must all be considered as COPCs. In addition, some of them have radioactive decay progeny that are also radioactive and must also be considered as COPCs.

The radioisotopes that comprise uranium fuel are U-234, U-235 and U-238. U-236 is a neutron activation product of U-235 but is also present in fuel that has been manufactured from recycled uranium. These uranium radioisotopes must be considered as COPCs. All of these radioisotopes decay into a series of progeny that are also radioactive. However, only the immediate progeny will have an activity concentration similar to that of the parent and must be considered as COPCs. Other progeny will be present in much smaller concentrations and are considered negligible in comparison. The relationship between uranium radioisotopes and their decay progeny is shown in Table 2-4.

Table 2-2

Radioisotopes

FISSION PRODUCTS		
Isotope	**Half-Life**	**Source**
H-3 [1]	12.3 Years	Fission product
Be-10 [1]	1.6E+06 Years	Fission product
C-14 [1]	5730 years	Fission product
Se-79	6.50E+04 years	Fission product
Kr-85	10.73 years	Fission product
Sr-90	29.1 years	Fission product
Zr-93	1.50E+06 years	Fission product
Nb-93m	16.1 years	Fission product
Tc-99	2.13E+05 years	Fission product
Pd-107	6.50E+06 years	Fission product
Cd-113m	14.1 years	Fission product
Sn-121m	55 years	Fission product
Sn-126	1.00E+05 years	Fission product
Sb-125	2.758 years	Fission product
I-129	1.57E+07 years	Fission product
Cs-134	2.07E+00 years	Fission product
Cs-135	2.30E+06 years	Fission product
Cs-137	30.17 years	Fission product
Pm-147	2.623 years	Fission product
Sm-146	1.03E+08 years	Fission product
Sm-151	90 years	Fission product
Eu-154	8.59 years	Fission product
Eu-155	4.71 years	Fission product

[1] In addition to binary fission, ternary fission, or breakup into three (3) products, can occur. This process produces light nuclei, such as H-3, Be-10, C-14, up to carbon nuclei. The long-lived nuclei can build up in nuclear fuel (GE, 1989)

Table 2-3

Uranium Fuel Activation Products

Isotope	Half-Life	Source
U-236	2.43E+07 years	Activation U-235
Np-237	2.14E+06 years	Activation U-238
Pu-238	87.7 years	Activation Np-237
Pu-239	2.41E+04 years	Activation U-238
Pu-240	6.56E+03 years	Activation U-238 (multiple neutron capture)
Pu-241	14.4 years	Activation U-238 (multiple neutron capture)
Pu-242	3.75E+05 years	Activation U-238 (multiple neutron capture)
Pu-244	8.07 years	Activation U-238 (multiple neutron capture)
Am-241	432.7 years	Daughter Pu-241
Am-242m	141 years	Activation Am-241
Am-243	7.37E+03 years	Activation U-238 (multiple neutron capture)
Cm-2[1]	> 2 years	Activation U-238 (multiple neutron capture)
Cf-2[2]	>2 years	Activation U-238 (multiple neutron capture)

[1] Curium isotopes including Cm-242, 243, 244, 245, 246, 247, 248, and 250 are possible activation products but have much lower yields compared to the Plutonium and Americium radioisotopes and are considered insignificant by comparison.

[2] Californium isotopes including Cf-249, 250, 251 are possible activation products but have much lower yields compared to Plutonium and Americium radioisotopes and are considered insignificant by comparison.

Table 2-4

Uranium Fuel and Progeny Radioisotopes

Isotope	Half-Life	Source
U-238	4.47E+09 years	Uranium Fuel
Th-234	24.1 days	Decay progeny
Pa-234m	1.17 minutes	Decay progeny
Pa-234	6.69 hours	Decay progeny
[1]		Other progeny less than 1 millionth concentration of U-238
U-234	2.46E+05 years	Uranium fuel and decay progeny of U-238
[2]		Other progeny less than 1 millionth concentration of U-234
U-235	7.04E+08 years	Uranium fuel
[3]		Less than 1 thousandth concentration of U-235
Th-231	25.5 hours	Decay progeny
U-236	2.34E+07 years	Recycled uranium fuel and activation product of U-235
[4]		Less than 1 billionth concentration of U-236

[1] Decay progeny of U-238 in Uranium Series
[2] Decay progeny of U-234 in Uranium Series
[3] Decay progeny of U-235 in Actinium Series
[4] Decay progeny of U-236

2.3.2 Activation of Reactor Pile and Structural Material & Equipment Within and Around Reactor Pile

In addition to graphite, construction of the reactor pile included substantial amounts of structural material, shielding, operational equipment, experimental equipment, monitoring devices, and cooling structures. This material was subject to activation from the high neutron flux associated with operation of the BGRR.

The biological shield surrounding the reactor pile contains steel reinforcing rods, steel punchings, and limonite ore. The inner side of the shield is covered with six inches of steel. A twelve-inch steel belt surrounds the gap in the core. The core is also surrounded by an airtight steel membrane. Various experimental and operating apparatus may remain in Building 701,

in and around the reactor pile. With the exception of the biological shield, most of these components are constructed of various types of steel and other metals. The pneumatic tubes are constructed of aluminum, plastic, and copper.

Table 2-5 shows possible neutron activation products of air and reactor pile materials. Graphite contains trace amounts of beryllium (Be), copper (Cu), samarium (Sm), silicon (Si), sulfur (S), deuterium (D or H-2), silver (Ag), iron (Fe), chlorine (Cl) that may become activated. Steel may contain iron (Fe-55), cobalt (Co-60), nickel (Ni-59, Ni-63), and molybdenum (Mo-93) as activation products. Concrete may contain calcium (Ca-41) as an activation product. All of these radioisotopes are plausible activation products for the BGRR and should be considered as COPCs. Gaseous activation products are not likely to have been retained in the BGRR.

2.3.3 Activation Of Experiments Introduced To The Reactor Pile

Throughout its 18 years of operation, a number of different experiments were introduced into the reactor pile for activation. Various activated experiments or production radioisotopes may remain in the graphite, plenums, exhaust duct heels, or between the beams under the reactor pile. After the new type of fuel was loaded, one of the functions of the BGRR was to produce Co-60 sources. Some of the sources were dropped or otherwise misplaced and therefore remain in the reactor pile. However, the majority of the sources were processed through the deep pit and canal for off-site shipment. Possible activation products for experiments with half-lives greater than two years are the same as those for reactor pile materials and are shown in Table 2-5 as COPCs.

2.3.4 Activation Of Cooling Air And Entrained Particulate Material

Table 2-5 shows possible neutron activation products of air including C-14, chlorine (Cl-36), argon (Ar-39 and Ar-42), and krypton (Kr-81) as gaseous activation products. However, with the exception of C-14 they are relatively inert gases which would have passed through the air cooling system and exited the stack. The intake air system included roughing filters that would have removed much of the entrained particulate matter before it could be activated in

Table 2-5

Activation Products Of Air And Reactor Pile Materials

Isotope[1]	Half-Life[2]	Source
H-3	12.3 years	Activation of hydrogenous material (e.g. plastic, water, graphite)
C-14	5730 years	Activation of carbon in graphite and naturally occurring nitrogen gas in air
Cl-36	3.01E+05 years	Activation of naturally occurring chlorine gas in air
Ar-39	269 years	Activation of naturally occurring argon gas in air
Ar-42	33 years	Activation of naturally occurring argon gas in air
Ca-41	1.03E+05 years	Activation of calcium
Fe-55	2.73 years	Activation of iron
Co-60	5.27 years	Activation of cobalt
Ni-59	7.60E+04 years	Activation of nickel
Ni-63	100 years	Activation of nickel
Kr-81	2.10E+05 years	Activation of naturally occurring krypton gas in air
Nb-94	2.00E+04 years	Activation of naturally occurring niobium
Mo-93	3.50E+03 years	Activation of naturally occurring molybdenum
Tc-97	2.60E+06 years	Activation naturally occurring ruthenium
Tc-98	4.20E+06 years	Activation naturally occurring ruthenium
Ag-108m	130 years	Activation of naturally occurring silver

[1] Other activation radioisotopes with higher atomic numbers exist but would probably be minor constituents of structural material and equipment

[2] half-life greater than 2 years

the reactor pile. Particulate matter that entered the reactor pile would likely result in the activation products previously shown in Table 2-5.

2.3.5 Radioactive Material In Bldg. 701 Nuclear Material Storage Vault

Building 701's Nuclear Material Storage Vault is a segmented and separate facility. The information in Table 2-6 represents the current inventory of the vault. This does not include materials present that are packaged in Department of Transportation (DOT) Type B containers or special forms (i.e., sealed sources) maintained as such.

Plans are underway to relocate the entire inventory of nuclear material from Building 701's Nuclear Material Storage Vault to other accountable storage locations onsite or to transfer it offsite as waste for final disposition. This action is scheduled to be completed before any significant decommissioning work begins within Building 701 (BNL, 1999f).

Table 2-6

Building 701 Nuclear Material Storage Vault Inventory

Radioisotope	Mass (g)	Specific Activity (Ci/g)	Activity (Ci)
Americium (Am-241)	6.00E-03	3.44	2.06E-02
Californium (Cf-252)	3.59E-05	538	1.93E-02
Neptunium (Np-237)	1.22E-01	7.05E-04	1.00E-04
Thorium (Th-232)	5.08E-04	1.09E-07	5.56E-03
Uranium (U-238)	8.19E+06	3.36E-07	2.75
Radium (Ra-226)	1.61E+01	3.366E-02	0.59

Based on Quarterly Inventory Printout for 701 Nuclear Material Storage Vault 21 and subsequent transfers or repackaging.

2.3.6 BGRR Inventory

Subsections 2.3.1 though 2.3.5 above identify radiological COPCs that are likely to exist in the reactor pile. However, these sections do not attempt to quantify the amount of these contaminants or discuss the relative amounts of the different contaminants. The amount of each COPC present in the BGRR depends on a complex relationship between its manner of production, the mass lost in the system, the mass of material available for activation, and the half-life of the radioisotope. The absolute and relative amount of most COPCs and their progeny will continue to change over time because of their different half-lives.

A conservative bounding estimate was made for the BGRR Balance-of-Plant (BOP) radiological inventory (BNL, 1999f). This estimate was developed from the calculated burn-up of the maximum number of natural uranium fuel slugs that are unaccounted. A balance of 14.62 kilograms (Kg, approximately 12.5 slugs) are unaccounted for as shown in Table 2-7 (BNL, 1999f). While portions of the inventory were released to the air cooling system as airborne material, the entire inventory is assumed to be present as BOP material for the sake

of conservatism. No BGRR enriched uranium fuel was considered as adding to the inventory because it was not cut, lost, nor dispersed in the BGRR canal.

Table 2-7

Sources of Potential BOP Inventory

Source	Natural Uranium Fuel Slugs	
	Number of Slugs	Mass of Slugs (Kg)
In reactor ruptures	69	80.73
Miscellaneous errors in reporting	78	91.62
In-canal ruptures	92	107.63
Sum of Above	239	279.62
Amount removed from D Tanks as waste	~226.5	265
BOP Inventory	~12.5	14.62

Reproduced from BNL, 1999f.

The BGRR natural uranium fuel-cycle and burn-up estimates of mixed fission products, and uranium fuel, activation, and progeny were calculated based on a conservative model (BNL, 1999f). The calculated BOP inventory is shown in Table 2-8.

With all fuel elements removed and all fuel channels rodded to remove any slugs, a rough bounding estimate was made of the total activity remaining in the BGRR reactor pile (BNL, 1999f). Activation of the graphite was estimated at 2.5E-06 Ci/g for Type A graphite, and 2.0E-06 Ci/g for Type B graphite, combined gamma and beta activities. The principal gamma activation contaminant for Type A graphite comes from Co-60, Eu-154, and Ag-108m. Type B gamma activation is primarily from Co-60 and Eu-154. Beta activation contamination for both types is due to C-14 and H-3. These results assumed the BGRR was running at full power 100% of the time for its 18-years of operation. The actual operating history included periods when the BGRR was not operating at full power or during scheduled shutdowns, so these estimates are very conservative.

Table 2-8

BGRR Balance of Plant Inventory

Radioisotope	Inventory (Ci)	Radioisotope	Inventory (Ci)
H-3	1.77E-02	Ra-226	8.50E-05
C-14	6.03E-01	Th-231	1.96E-04
Fe-55	1.40E+03	Th-234	4.90E-03
Co-60	6.98E+01	Pa-233	2.55E-03
Ni-63	2.13E-02	Pa-234	2.55E-05
Kr-85	2.92 E-01	Pa-234m	4.90E-03
Sr-90	1.35E+01	U-235	1.96E-04
Y-90	1.35E+01	U-236	1.45E-04
Zr-93	8.50E-04	U-238	5.10E-03
Nb-93m	7.23E-04	Np-237	2.55E-05
Tc-99	5.95E-03	Pu-238	9.52E-03
Cd-113m	1.28E-03	Pu-239	7.05E-01
Sb-125	8.50E-05	Pu-240	1.33E-01
Cs-137	1.56E+01	Pu-241	3.71E-01
Ba-137m	1.48E+01	Am-241	7.33E-02
Pm-147	1.87E-03	Am-242	5.10E-05
Sm-151	1.77E-01	Am-242m	5.10E-05
Eu-152	3.74E-03	Cm-242	4.25E-05
Eu-155	1.29E-02	Cf-252	1.53E-04

Reproduced from BNL, 1999f

The final COPC list, shown in Table 2-9, has been submitted to the regulators for review as part of the pile fan sump SAP (BNL, 1999m). These COPCs will be confirmed at the end of the review stage.

2.3.7 Non-Radiological Contaminants of Concern

At present, no specific quantitative data are available for the non-radionuclide potential inorganic and organic contaminants of concern. However, there is a sampling and analysis program presently in progress for the pile fan sump, process piping, above ground ductwork,

Table 2-9

Final COPC List

Soil Location	COPC	
All soils	Radionuclides:	
	Americium-241	Plutonium-238, 239/240
	Carbon-14	Radium-226
	Cesium-137	Strontium-90
	Cobalt-60	Technetium-99
	Tritium	Thorium-232
	Europium-152, 154, 155	Uranium-234, 235, 238
	Iodine-129	
	Nickel-63	
Pipe and pile fan sump overburden, pipe trench soils at visible leaks and joints, soil under the pile fan sump	All radionuclides Contract Laboratory Program (CLP) volatiles, semivolatiles, pesticide/ poly chlorinated biphenols (PCBs) and metals*	
Soil under the air ducts	All radionuclides, lead and PCBs if found in exterior paint on the air duct, pesticides	

*The CLP list will be shortened after initial pile fan sump sludge and samples from potential leakage areas are analyzed.

Nondetects or analytes present below the Technical and Administrative Guidance Memorandum (TAGM) limit will be removed from the COPC list.

and associated soils. At this point, the sludge located in the pile fan sump is believed to contain the "worst-case" concentrations of heavy metals (Hg, Cd, etc.). Heavy organics, such as PCBs, would also be likely to concentrate in the sludge. Chemical analysis of the pile fan sump sludge is currently being performed. The pile fan sump SAP (BNL, 1999m) states that until these data are available, the regulators concur that the non-radionuclide COPCs will be based on the compounds published in the inorganic and organic Contract Laboratory Program (CLP).

Non-radiological contamination at the site is likely the result of historical practices (mercury-containing instruments, PCB or lead-based paint, leaded solder joints, etc.), residual process chemicals (experimental tubes, mechanical systems, etc.), housekeeping (spills, leaks, etc.), and building materials (asbestos, etc.).

Though the full extent of non-radiological contamination can not be determined until characterization sample results are received, the potential for non-radiological contamination of some of the areas presently under investigation has been considered. The potential non-radiological contaminants of concern were outlined in the pile fan sump SAP (BNL, 1999m) and the WBS. These areas are:

- Air Ducts: The above-ground ducts are assumed to contain lead and/or PCBs in the exterior paint. This paint is expected to flake during removal operations (BNL, 1999m). It is presently unknown whether there is also a coating on the inside of the ducts. If an interior coating is found, it will be tested for PCBs and lead, and materials will be managed accordingly.

- Instrument House: Some of the instruments are known to contain mercury, some of which may have been released to building surfaces during the period of operation. In addition, the cooler water piping includes asbestos.

- Pile Fan Sump: The coating on the inside of the concrete is expected to contain PCBs and/or lead.

- Piping: The process piping may still contain residues including lubricants or solvents. Though no records were kept of these materials entering piping, the presence of such materials would be consistent with historic uses. Heavy metal residual contamination may still be present in the lines due to sample transport or from samples stuck in the tubes. The piping joints are known to contain lead.

- Soils under and around the above ground pile fan sump and piping: Soils immediately adjacent to piping may contain lead that has leached from the lead pipe seals. Any chemical contaminants found in the pile fan sump sludge may have leached into the adjacent soils whenever leaks occurred.

- Soils under and around cooling air duct: Non-radiological chemical contamination is not expected since filtered fresh air was used in the ducts. The coating on the exterior of the ducts may include lead or PCBs. Pesticides from previous pest control operations may be present in soil under the cooling air ducts, however, contamination of this type would only be expected in the top six inches (6") of soil.

- Overburden soil above drain line: Surface soils may contain some pesticides from on-going pest control activities.

- Overburden soil overlain by asphalt: The only class of non-radiological contamination expected is polynuclear aromatic hydrocarbons (PAHs) which are a component of the tar in the asphalt.

- Asphalt residue: Aside from PAHs inherent in the asphalt, no non-radiological contamination is expected.

- Miscellaneous flammable materials: Some materials, including plywood which was used to isolate areas when Building 701 housed the Science Museum, may be flammable. Though not considered a non-radiological contaminant of concern, BNL has expressed concern with flammable materials and a desire to remove them with the other non-radiological COPCs.

- Reactor pile: Graphite dust may be produced during sealing of the reactor pile, which could become a fire or respiratory hazard.

- Canal and water treatment house: This structure was constructed with "Cementos" siding (a mixture of cement and asbestos), which is an asbestos-containing material (ACM). Any activities, such as demolition, which will impact this material must use proper asbestos abatement procedures, including, but not limited to, the use of proper personal protective equipment, proper handling of waste materials, and air monitoring. The New York State regulations specific to removal of "In Plant" non-friable materials permits this type of material to be removed without the use of the standard containment, however, it requires the removal personnel be licensed and certified. In addition, it requires air monitoring, notifications, and proper record keeping, as well as compliance with Occupational Safety and Health Act (OSHA) Regulations. This exemption does not apply to any piping insulation material. Pipe insulation must be removed in accordance with 12 New York Code of Rules and Regulations (NYCRR) Part 56 and EPA regulations. BNL personnel are equipped to perform this sort of removal and re-insulation in accordance with the regulations. Other building materials that should be tested for potential asbestos content include brick mortars, window caulking, window glazing, roofing materials, piping insulation, radiator insulation, floor tiles, and any other suspected asbestos-containing materials.

- Biological shield: The BGRR used lead, concrete, and steel as shielding materials. Any activities which will disturb the biological shield, such as dismantling the reactor pile, will require proper handling and disposal of the lead in accordance with state and federal regulations.

- Mechanical systems: In the event that any mechanical systems are dismantled, the presence of oils, fuels, and lubricants must be considered. Handling and disposal of these materials must be in accordance with applicable regulations.

- Chemonuclear equipment: The remaining equipment used to support BGRR experiments will require evaluation for the presence of hazardous materials.

Further sampling/confirmation will be required prior to removal activities in order to fully assess the effort and financial requirements of decommissioning the BGRR.

2.4 POTENTIAL APPLICABLE OR RELEVANT AND APPROPRIATE REQUIREMENTS, AND TO BE CONSIDERED REQUIREMENTS

The National Contingency Plan (NCP), 40 CFR 300, and Section 121(d) of CERCLA, as amended by SARA, require that primary consideration be given to alternatives implemented at a federal facility that attain or exceed promulgated Federal and State applicable or relevant and appropriate requirements (ARARs) to the extent practicable, or that a waiver of an ARAR is obtained. State requirements must be attained under Section 121 of SARA, if they are legally enforceable and consistently applied statewide. The EPA has indicated that ARARs must be identified for each site on the National Priority List (NPL).

This section presents a preliminary determination of the potential ARARs for the BGRR Decommissioning Project/removal action. This removal action will meet the ARARs referenced below and discussed further in Subsection 4.1.2 and Appendix D to the fullest extent practicable. This section also presents an identification of federal, state, and local non-enforceable criteria, advisories, and guidance that could be used for evaluating alternatives, defined as To Be Considered (TBC) requirements.

"For the purposes of identification and notification of promulgated state standards, the term ***promulgated*** means that the standards are of general applicability and are legally enforceable" (NCP, 300.400(g)(4)). The most stringent promulgated standards are applied as ARARs (Preamble to the NCP, 55 FR 8741, 8 March 1990).

> Applicable requirements, as defined in 40 CFR 300.5, are those clean-up standards, standards of control, and other substantive requirements, criteria, or limitations promulgated under federal environmental or state environmental or facility siting laws that specifically address a hazardous substance, pollutant, contaminant, remedial action, location, or other circumstance found at a CERCLA site. Only those state standards that are identified by a state in a timely manner and that are more stringent than federal requirements may be applicable.

Actions must comply with state ARARs that are more stringent than the corresponding federal ARARs. State ARARs are also used in the absence of a federal ARAR, or where a state ARAR is broader in scope than the federal ARAR.

> Relevant and appropriate requirements, also defined in 40 CFR 300.5, are those clean-up standards, standards of control, and other substantive requirements, criteria, or limitations promulgated under federal environmental or state environmental or facility siting laws, that, while not 'applicable' to a hazardous substance, pollutant, contaminant, remedial action, location, or other circumstance at a CERCLA site, address problems or situations sufficiently similar to those encountered at the CERCLA site that their use is well suited to the particular site. Only those state standards that are identified in a timely manner and are more stringent than federal requirements may be relevant and appropriate.

Relevant and appropriate requirements are intended to have the same weight as applicable requirements.

As defined in 40 CFR 300.400(g)(3), the TBC category "consists of advisories, criteria, or guidance developed by the U.S. Environmental Protection Agency, other federal agencies, or states that may be useful in developing CERCLA remedies." Use of TBCs is discretionary rather than mandatory, as opposed to the use of ARARs, which is mandatory. TBCs are not promulgated regulatory standards or requirements, and, therefore, are not under the definition of ARARs.

The ARARs Tables, shown in Appendix D, present a complete listing of the identified potential ARARs and TBCs for the BGRR Decommissioning Project, as well as their primary requirements and a preliminary determination of their applicability to the project. There are numerous ARARs related to groundwater quality shown in the tables that are noted to be "Not Applicable." The BGRR decommissioning should indirectly benefit groundwater quality beneath the site by removing soils that represent a potential source of contamination to groundwater. However, currently groundwater is not addressed under this Removal Action. Therefore, these regulations have been determined to not be applicable for the present project.

These regulations may in fact be applicable in the future if groundwater remediation is conducted at the BGRR site as part of a separate action. For a similar reason, regulations pertaining to effluent discharge limits may be applicable in the future if groundwater treatment with discharge to the Peconic River or a Privately-Owned Treatment Works (POTW) is implemented at the BGRR site as part of a separate action.

Some ARARs may only apply in certain cases, such as if asbestos-containing building materials are encountered and must be removed as part of various alternatives (Federal asbestos regulations), or if specific temporary, on-site treatment processes are employed, such as air treatment and off gassing (Federal and State stationary emission source regulations). Therefore, these such regulations have been identified as only "Potentially Applicable." Other regulations pertain to discharge or other permits in effect at off-site waste disposal facilities that will receive, treat, and/or dispose of wastes generated during the decommissioning project. These regulations have been considered TBCs. The selection process for off-site disposal facilities will ensure that wastes are disposed at appropriately licensed and permitted facilities. However, these regulations do not apply directly to the BGRR project site, and therefore are TBCs.

2.4.1 ARAR Categories

In general, there are three categories of ARARs:

- Chemical-specific requirements
- Location-specific requirements
- Performance, design, or other action-specific requirements

A description of these three categories and the preliminary chemical-specific, location-specific and action-specific ARARs for the BGRR site are discussed in the following subsections.

2.4.2 Chemical-Specific ARARs

Chemical-specific ARARs are usually health- or risk-based numerical values used to establish the acceptable limits of a chemical or radiological contaminant that may be found in, or

discharged to, various environmental media. Chemical-specific ARARs are based on human health, ecological risks, and exposure pathways. The ARARs may influence the selection of the removal alternative by setting objectives that the alternative must meet to reduce risks to health and the environment. If a chemical or radiological contaminant has more than one such requirement that is an ARAR, the most stringent generally should be applied.

A summary of potential chemical-specific ARARs for the contaminants at the BGRR site is presented in the Tables D-1 and D-4. The health-based, chemical-specific ARARs are primarily derived from federal and state health and environmental statutes and regulations. As discussed below and in the referenced tables, in some instances these standards are classified as items "To Be Considered". Table E1 presents the potential federal chemical-specific ARARs that are applicable to the BGRR site, and Table E4 presents the potential State of New York chemical-specific ARARs.

2.4.3 Location-Specific ARARs

Location-specific ARARs are statutes or regulations which set restrictions on the concentration of hazardous substances or the conduct of activities solely because they are in specific locations. Some examples of special locations include floodplains, wetlands, and sensitive ecosystems or habitats. The potential location-specific ARARs are presented in Table D-2 (potential federal ARARs), and Table E5 (potential State of New York ARARs).

2.4.4 Action-Specific ARARs

Action-specific ARARs are usually technology- or activity-based requirements or limitations on actions taken with respect to the various removal alternatives. Performance, design, and other action-specific requirements set controls or restrictions on particular kinds of activities related to management of hazardous or radiological contaminants. These requirements are triggered by the particular remediation activities that are selected to accomplish a remedy. Very different requirements can come into play depending on these activities. These action-specific requirements do not in themselves define the removal alternative; rather, they indicate how a selected alternative must be achieved.

Potential action-specific ARARs are the Resource Conservation and Recovery Act (RCRA) standards for transport and disposal of hazardous materials. The potential action-specific ARARs for the BGRR Decommissioning Project are presented in Table D-3 (potential federal ARARs), and Table D-6 (potential State of New York and local (Suffolk County Department of Health Services [SCDHS]) ARARs.

2.4.5 To Be Considered (TBC) Requirements

TBCs consist of non-enforceable advisories, criteria, or guidance developed by federal, state, or local agencies that may be useful in developing CERCLA remedies. TBCs are not promulgated regulatory standards or requirements, and, therefore, are not under the definition of ARARs. Potential TBCs are included in Tables D-1 through D-6.

The following important TBC guidance will be considered as part of the BGRR Decommissioning Project:

1. New York State Department of Environmental Conservation (NYSDEC), Division of Air Guidelines for Control of Toxic Ambient Air Contaminants, Air Guide 1: This guide will be used to assess the impacts of air emissions and to assist with evaluating the need for having air-emissions control equipment for any temporary air treatment systems.

2. NYSDEC Technical and Administrative Guidance Memorandum (TAGM) #4003, "Remediation Guideline for Soils Contaminated with Radioactive Materials", September 1993: This memorandum contains State guidance on cleanup objectives for radiological constituents in soils. The State's value of 10 millirem per year (mrem/yr) above background serves as an additional goal for remediation that will be evaluated during field excavation work.

3. NYSDEC TAGM #4046, "Determination of Soil Remediation Objectives and Remediation Levels", January 1994: This memorandum contains State guidance for cleanup objectives for non-radiological contaminants in soils.

4. Department of Energy (DOE) Order 5400.5, and draft 10 Code of Federal Regulations 834 "Radiation Protection of the Public and the Environment": The draft regulation (10 CFR 834) sets basic exposure limits (100 mrem for public offsite) and requires the site to prepare an Environmental Protection Plan that will describe the methods for compliance with the dose limit.

5. DOE Order 435 "Radioactive Waste Management": This order provides guidance and requirements for management and disposal of radioactive waste generated at DOE facilities.

2.4.6 Identification And Evaluation Of ARARs

Development of a preliminary list of potential chemical-specific ARARs allows the establishment of a list of preliminary remediation goals (PRGs) in the decommissioning process, described in more detail in Subsection 2.6. The PRGs are essentially a tentative listing of contaminants together with initially anticipated clean-up concentrations or risk-based levels for each medium. PRGs serve to focus the development of alternatives on remedial technologies that can achieve the remediation goals, thereby limiting the number of alternatives to be considered in the detailed analysis conducted later in the removal alternatives analysis process.

At the beginning of the removal alternatives analysis process, a preliminary consideration of location- and action-specific ARARs is commonly conducted. As alternatives are screened, action-specific ARARs are identified. When the detailed analysis of the removal alternatives is conducted, all action-specific ARARs are refined to a much more detailed form with respect to each alternative. The ARARs will be finalized based on the review and recommendations of BNL, DOE, and other members participating in the IAG. These final ARARs (with some modification based on background levels) in conjunction with the risk based concentrations will be used to establish media-specific cleanup objectives for the BGRR site.

Once a preferred removal action alternative is formally selected, all chemical, location, and action-specific ARARs are identified. If it is found that the most suitable removal action alternative does not meet an ARAR, the NCP provides for waivers of ARARs under certain circumstances. According to 40 CFR 300.430(f)(1)(ii)(C).

> An alternative that does not meet an ARAR under federal environmental or state environmental or facility siting laws may be selected under the following circumstances:
>
> 1. The alternative is an interim measure and will become part of a total remedial action that will attain the applicable or relevant and appropriate federal or state requirement.

2. Compliance with the requirement will result in greater risk to human health and the environment than other alternatives.

3. Compliance with the requirement is technically impracticable from an engineering perspective.

4. The alternative will attain a standard of performance that is equivalent to that required under the otherwise applicable standard, requirement, or limitation through use of another method or approach.

5. With respect to a state requirement, the state has not consistently applied, or demonstrated the intention to consistently apply, the promulgated requirement in similar circumstances at other remedial actions within the state.

6. For Fund-financed response actions only, an alternative that attains the ARAR will not provide a balance between the need for protection of human health and the environment at the site and the availability of Fund monies to respond to other sites may present a threat to human health and the environment.

Accordingly, if any of the alternatives selected for the BGRR site are expected to not attain an ARAR, this expectation must be expressed together with an appropriate justification that relates to at least one of the ARAR waiver circumstances identified above. An evaluation of compliance of the various removal alternatives for the BGRR site with ARARs is presented in Table D-7 in Appendix D.

2.5 REMEDIAL ACTION OBJECTIVES

This section describes the elements used to develop the Remedial Action Objectives (RAOs), and presents the RAOs used to evaluate alternatives. RAOs are media-specific or operable unit-specific objectives for protecting human health and the environment. RAOs are developed considering land use, COPCs, potential ARARs, and exposure pathways (as in the conceptual model). Specific remediation goals are also identified so that an appropriate range of decommissioning options can be developed for evaluation.

The RAOs were evaluated by the BGRR project team with respect to public and stakeholder values. The RAO process begins by identifying potential future land use and the COPC for the BGRR facility. This information ensures that removal alternatives being considered can adequately address the types of contaminants present, and facilitate the refinement of potential ARARs. The RAOs also provide the basis for developing the general response actions that

will satisfy the objectives of protecting human health and the environment. The RAOs are defined as specifically as possible without limiting the range of general response actions that can be applied.

The RAOs for decommissioning the BGRR facility are based on discussions previously presented in this report. The objectives reflect community and stakeholder values as discussed with the project team during roundtable meetings. The RAOs for the BGRR Decommissioning Project are stated below. The RAOs are not presented in any particular order.

1. Protect workers from physical, chemical, and radiological hazards posed by the BGRR facility.
2. Prevent negative impact to human and ecological receptors by preventing contaminant releases to air, soil and groundwater above ARARs and health-based criteria, and preventing direct exposure to hazardous substances.
3. Minimize physical, ecological, or cultural impacts caused by remediation and/or decommissioning of the BGRR facility.
4. Maximize opportunities to achieve cost efficiencies and cost savings to the extent that these practices do not adversely affect the protection of public and worker health and safety, and environmental quality.
5. Remove or permanently isolate contaminants of potential concern.
6. Minimize the amount of all types of waste generated from the decommissioning project in order to minimize waste management and disposal costs, transportation impacts, and the potential for environmental release.
7. Maximize opportunities to preserve the historical significance and educational value of the BGRR.
8. Support future land-use objectives for BNL after determining the nature and extent of contamination at BGRR facility.
9. Meet all applicable, relevant and/or appropriate standards, requirements, criteria, or limitations defined under federal and/or state environmental laws.
10. Share information with the community in a timely and ongoing manner.

2.6 PRELIMINARY REMEDIATION GOALS

Preliminary remediation goals (PRGs)[7] have already been developed for several operable units (OUs) at BNL. PRGs for the BGRR will be similar to these other OUs if factors such as land use, exposure pathways, contaminated soil zone parameters, hydrology data and external gamma parameters are comparable. The *Sampling and Analysis Program for the Disposal of Debris from Decommissioning Activities at the BGRR Reactor Complex* (BNL, 1999k) summarized PRGs from those developed for these other OUs as well as lists the PRGs developed for that document. These have been submitted to the regulatory agencies for review. The PRGs listed in this document have not yet been approved for BGRR decommissioning activities.

2.6.1 Radiological Constituents in Soils and Groundwater

As stated in the *Record of Decision (ROD) for Operable Unit I and Radiologically Contaminated Soils* (BNL, 1999g), the cleanup goal for radionuclides is based on a total dose limit of 15 mrem/yr above background. Soil PRGs are calculated using the DOE Residual Radioactive Material Guidelines (RESRAD) computer code or are based on regulatory documents. Fifty (50) years of institutional control were assumed when running the RESRAD code and this time period is critical when developing PRGs for radionuclides with half lives less than this 50 year time period. Contaminants such as Cs-137, Sr-90, Co-60, and H-3 (tritium), will all decay to less than half their present day concentration during this period of control. The choice of residential or industrial land use also influences the soil PRGs. The potential for contamination in soil to leach into groundwater is also considered to be more significant for those radionuclides including strontium, radium and uranium with low K_d values (See Figure 2-1). Cleanup goals for Ra-226 are based on DOE Order 5400.5 (DOE, 1993). The OUI ROD lists the cleanup goals for Cs-137 and Sr-90. PRGs for other

[7] The term Preliminary Remediation Goals (PRGs) is in accordance with CERCLA guidance documents. In other BNL submittals concerning the BGRR decommissioning to the regulators, BNL has used the term "targets" to describe these values.

radionuclides should be similar to those listed in the pile fan sump SAP (BNL, 1999m). Table 2-10 summarizes the radionuclide PRGs. These values have not yet been approved for the BGRR Decommissioning Project.

Final DCGLs may reflect these preliminary dose-based goals, they may be risk-based (pending results of additional characterization or full risk analysis), or they may be a combination of both dose-based preliminary goals and risk-based goals.

Table 2-10

Radionuclide Preliminary Soil Remediation Goals

Radionuclide	Soil Cleanup PRG Residential Land Use (pCi/g)	Radionuclide	Soil Cleanup PRG Residential Land Use (pCi/g)
Carbon-14	31	Europium-155	1.50 E+05
Cobalt-60	1300	Radium-226	5
Nickel-63	2.9 E+05	Thorium-232	5
Strontium-90	15	Uranium-234	9 [3]
Technetium-99	44	Uranium-235	9
Iodine-129	2.4	Uranium-238	9
Cesium-137	23	Plutonium-238	66
Samarium-151	1.0 E+06	Plutonium-239	40
Europium-152	49	Plutonium-240	40
Europium-154	170	Americium-241	40

Source: Consolidated from pile fan sump SAP (BNL, 1999m)

2.6.2 Radiological Constituents for the BGRR Facility

It is anticipated that the ongoing characterization effort will address data gaps in this area. However, based on the expected mix of radionuclides and yearly allowable dose release criteria, surface contamination concentration guidelines may be derived. Values for the release of building surfaces exist in DOE Order 5400.5 (DOE, 1993). However, DOE, EPA and Nuclear Regulatory Commission (NRC) accept the decommissioning strategies in the Multi-Agency Radiation Survey and Site Investigation Manual (MARSSIM, NUREG 1997) and site-specific values may be generated. Computer codes that can be utilized to calculate

realistic site-specific surface contamination release levels include the DOE's RESRAD-Build and the NRC's Decontamination and Decommissioning (D & D) code. One or more of these codes (or other codes) is applied to the appropriate scenarios with the dose limit of 15 mrem per year that has already been determined for this project. Establishment of total and removable surface contamination release levels in disintegrations per minute (dpm)/100 cm^2 will be important for alternatives that leave buildings, equipment, or other structures in place.

The use of very conservative assumptions may result in unwarranted costs or inefficient remediation requirements. For this reason, site-specific parameters have been developed and are to be used instead of generic default parameters in these codes. This provides realistic dose estimates instead of over-estimating potential dose. Exposure scenarios based on site-specific parameters include the extent of potential future exposure to residual radioactivity.

2.6.3 Non Radiological Constituents

PRGs for nonradiological constituents in soils, groundwater, and BGRR facility structures and equipment are discussed below. The primary focus of removal actions is on the radiological constituents of concern. Considering the history of the BGRR (discussed in detail in Section 1), any nonradiological constituents of concern, if present, would be expected to be more localized in distribution and found in smaller volumes than the radiological constituents. The nonradiological constituents will be addressed and remediated in conjunction with the radiological constituents, due to their anticipated smaller volumes and close association with radiologically contamination at the BGRR facility.

2.6.3.1 Soils and Groundwater

Preliminary remediation goals for nonradiological COCs in soils developed previously for other OUs at BNL may be applied at the BGRR site. For example, a PRG was calculated for mercury in soils as part of the Chemical/Animal Pits and Glass Holes project. The development of this PRG is summarized in Appendix E of the *Final Feasibility Study Report Operable Unit I and Radiologically-Contaminated Soils* (CDM, 1999). These PRGs have been developed based on background levels in soils at BNL, NYSDEC soil cleanup objectives (TAGM #4046, *Determination of Soil Remediation Objectives and Remediation Levels,*

January 1994), and other federal soils cleanup guidance. The specific nonradiological constituents involved will be determined as decommissioning work proceeds. Soils PRGs are generally set at levels that are protective of groundwater. Groundwater is not the objective of BGRR removal actions. Groundwater PRGs may be determined at a future date as part of potential groundwater remediation activities handled under a separate phase of the BNL Environmental Restoration Project.

2.6.3.2 BGRR Facility Structures and Equipment

Other constituents may exist in or on (such as painted surfaces) BGRR facility structures or equipment that will be dismantled and removed, including lead, asbestos, mercury, etc. These constituents will be characterized, removed, and disposed and/or treated at appropriately licensed and permitted off-site waste disposal facilities in conjunction with removal of the structures or equipment. For this reason, the application of PRGs is not directly appropriate. Instead, all of the constituents associated with structures or equipment to be removed will also be removed and disposed of properly. The applicable requirements to be followed include the requirements of RCRA, OSHA, Toxic Substance Control Act (TSCA), and pertinent State regulations.

SECTION 3

DEVELOPMENT OF DECOMMISSIONING ALTERNATIVES

3. DEVELOPMENT OF DECOMMISSIONING ALTERNATIVES

In this section, the seven decommissioning alternatives are developed by combining the affected areas with appropriate decommissioning methods. The first objective of this section is to identify and introduce the potential decommissioning methods for each affected area. The work activities associated with each affected area are analyzed separately as work breakdown items. The work breakdown items then will be stacked in different workable combinations to form the seven decommissioning alternatives that encompass a range of appropriate site cleanup options for the BGRR.

The goal of the project is to implement the safe, timely, and cost-effective decommissioning of the BGRR facility. Decommissioning will be undertaken in accordance with the RAOs discussed in Subsection 2.5. The alternatives for the decommissioning were developed by the project team with input from the public, EPA, and DOE, taking into consideration the information gathered at the public meetings, the existing conditions, and experience on similar projects. The alternatives span levels of cost and complexity from no action to total removal of all affected areas including the reactor pile, the Reactor Building, and all associated fans, ductwork, piping, and soils. The No Action Alternative is used as the baseline against which all of the other alternatives are evaluated, and is required to be considered for all analyses of remediation alternatives under CERCLA.

The EPA guidance for conducting Engineering Evaluations/Cost Analyses (EE/CAs) under CERCLA requires that alternatives should consider the following:

- Meet CERCLA goals with respect to preventing or minimizing the migration of hazardous substances and simultaneously protect public health and the environment.
- Minimally attain applicable or relevant Federal public health and environmental standards.
- Exceed applicable and relevant Federal standards, where possible.
- Involve off site treatment, storage, and disposal facilities which are permitted under RCRA and meet other applicable standards

- Represent containment technologies utilizing little or no treatment of contamination.
- Include a "No Action" alternative, including monitoring and security activities, as appropriate.

There are several tasks which have been completed, are presently occurring, or will be performed for all alternatives except No Action (Alternative 1). These activities, referred to as the "common elements" are included in Alternatives 2-7 and are discussed in Subsection 0.

A 50-year period of institutional control is required for all alternatives, and surveillance and monitoring (S&M) will be conducted during that time, as needed. The extent (number and type of surveillance samples) of the S&M program will vary depending on the extent of the building, equipment, and appurtenance removal performed in each specific alternative. In general, the larger the amount of contaminated media removed, the less robust the S&M program is required to be, while still maintaining protectiveness of public health and welfare, and the environment. Alternative 7 does not require continued S&M, because all contaminated structures, appurtenances, equipment, and environmental media are to be removed.

Sealing of the reactor pile openings is included in all of the alternatives, with the exception of the No Action Alternative. However, the scope of this element will vary by alternative, depending on whether the reactor pile remains, the reactor pile is removed, or a cocoon (described in Subsection 3.1.3) is constructed around the reactor pile.

It should be noted that for the purpose of this document, the seven alternatives consider the total removal of the items specified. It may be determined, during the characterization which will precede each removal action, that total removal is unwarranted or otherwise ill-advised. In these situations, the actions taken may include in-place decontamination and/or isolating, sealing, or enclosing the affected items. The actual determination of the extent of the action will be determined during the EE/CA phase.

3.1 DECOMMISSIONING OPTIONS

The decommissioning options described are the remedies that satisfy the RAOs. The decommissioning options developed were based on the BGRR's specific physical characteristics, the type and concentration of contaminants present, the volume of contaminated material, and affected area preliminary remediation goals. Presently the final decisions have not been made on several of the WBS Items, even though the focus of this document is on removal. For each affected unit at the BGRR, there are four potential decommissioning options available, as follow.

3.1.1 No Action (Surveillance and Maintenance)

This action consists of no specific near-term decommissioning activities but does require continuing surveillance, including adequate radiological monitoring, environmental monitoring, and appropriate security measures to ensure public health and safety. This should include the accumulation of data needed to adequately plan future decommissioning operations. Maintenance may include general maintenance activities such as roof repair, re-pointing of brick work, or repair of any leaks, but does not include the removal of contaminated materials.

3.1.2 Decontaminate and Leave in Place

All residual radioactivity, radioactive fluids and wastes, and selected radioactive components will be removed from surfaces and soils. This necessitates establishing adequate radiation monitoring, environmental surveillance, and appropriate security procedures to ensure public health and safety. Possible actions may include cleaning of steel duct linings, scabbling of concrete surfaces, or power washing of contaminated surfaces.

3.1.3 Isolate, Seal, or Enclose and Leave in Place

This option, also known as entombing or cocooning, consists of removing all residual radioactivity, radioactive fluids and wastes, and selected components, followed by

sealing of the remaining major radioactive and contaminated components within a structure that provides adequate shielding and integrity over the period of time in which significant quantities of radioactivity are to remain in place. An appropriate and continuing surveillance program is required to assure public health and safety. Possible activities include applying a fixative to surfaces to prohibit leaching of surface contamination, construction of a protective enclosure over items (such as the reactor pile) which will create a barrier between contamination and the environment, and filling of empty spaces (such as duct work) with grout to stabilize the structures and prevent any materials from entering or leaving the unit.

3.1.4 Remove and Dispose in Permitted Waste Disposal Facility

This option consists of removing all residual radioactive material and components having radioactivity above predetermined acceptable levels. Removal of the non-radioactive facilities may also be included where appropriate. Waste materials will be transported to an appropriate waste disposal facility. Removal actions may involve pieces of the unit or the unit in its entirety, depending upon the physical attributes of the unit. Demolition materials will be reduced to the extent possible and containerized for safe transport as low-level radioactive waste. To the extent possible, non-contaminated materials will be recycled or reused. Units which are removed will not require continued maintenance, however, monitoring of any remaining structures will continue in accordance with site-wide practices, if any.

3.2 WORK BREAKDOWN STRUCTURE

This section presents a discussion of the work breakdown items at the BGRR that will be required for implementation of one or more of the decommissioning options detailed above. Each of the following subsections includes the associated Work Breakdown Structure (WBS) identification number that corresponds to the work item being described. The WBS considers five areas of consideration at the BGRR facility. The five areas of consideration are:

- Fan House, Pile Fan Sump, and Contaminated Water
- Museum Walls, Biological Shield, Building 701/703 Interface

- Underground Air Cooling System
- Canal House and Remaining Soils
- Reactor Building, Reactor Pile, and Associated Equipment

The WBS elements are used to develop the alternatives which will be discussed in Section 4. The WBS was prepared as part of the Project Baseline (BNL, 1999l) by the BGRR Decommissioning Project Team. The WBS lists the activities that are required to complete the work systematically to allow evaluation of each item for health and safety, potential environmental impacts, regulatory compliance, and community concerns. The full WBS is presented in Figure 3-1.

Figure 3-1

Work Breakdown Structure

WBS 1.0 **Area #1**	**WBS 2.0** **Area #2**	**WBS 3.0** **Area #3**	**WBS 4.0** **Area #4**	**WBS 5.0** **Area #5**
1.1- Water Disposal	2.1- Museum Walls and Materials Removal – Bldg. 701	3.1a -Underground Air Plenum to Bldg. 701 and Soils Removal (3.1b includes only soils removal)	4.1a – Above and Below Ground Canal and Water Treatment House and Soils Removal (4.1b includes only soils removal)	5.1- Bldg. 701 Disposition (5.1a – Reactor Building remains) (5.1b – Reactor Building is removed) (5.1c – Reactor Building and Reactor Pile are removed)
1.2 - Fan removal and Decontaminate Fan House	2.2 - Seal Reactor Pile Openings at Bio-Wall	3.2 - Underground Filter Removal	4.2 - Below Ground Piping Systems and Soils Removal	5.2 - Bldg. 702 Disposition (5.2a – Removal of Building 702 and ancillary systems) (5.2b – Building 702 stays, Ancillary systems removed)
1.3 - Pile Fan Sump, piping, and soils Removal	2.3 – Isolate Bldg. 701 from 703	3.3 - Underground Cooler Removal	4.3 - Remaining Soils	5.3 - Experimental Equipment Removal from Bldg. 701
1.4 - Above Ground Duct and Instrument House Removal				5.4 - Equipment and Systems Removal

3.2.1 Removal Area #1

3.2.1.1 Water Disposal (WBS 1.1)

After discovering the water that had accumulated in the deep drain sump, the water was removed and transferred to the BNL Waste Management Division (WMD) where approximately 35,700 gallons were stored in two temporary tanks pending processing. The two tanks were covered with a leased temporary structure. WMD technicians and supervision performed necessary surveillance and monitoring of the stored water. Note: This activity has been completed.

Table 3-1 shows how WBS 1.1 is incorporated into each of the Decommissioning Alternatives.

Table 3-1

WBS 1.1 Decommissioning Options by Alternative

Alternative 1	No Action
Alternative 2	Remove Water
Alternative 3	Remove Water
Alternative 4	Remove Water
Alternative 5	Remove Water
Alternative 6	Remove Water
Alternative 7	Remove Water

3.2.1.2 Fan Removal and Decontamination of Fan House (WBS 1.2)

The scope of work considered in this Alternatives Analysis for the Building 704 Fan House is limited to removal of the primary and secondary fans and decontamination of the north side of the building. Surveys and decontamination will only be performed to reduce contamination for future operational requirements. After completion of remediation activities, control of the building will be returned to the HFBR. Table 3-2 shows how the aforementioned decommissioning options are integrated into the Decommissioning Alternatives.

Table 3-2

WBS 1.2 Decommissioning Options by Alternative

Alternative 1	No Action
Alternative 2	Remove Fans and Decontaminate Fan House
Alternative 3	Remove Fans and Decontaminate Fan House
Alternative 4	Remove Fans and Decontaminate Fan House
Alternative 5	Remove Fans and Decontaminate Fan House
Alternative 6	Remove Fans and Decontaminate Fan House
Alternative 7	Remove Fans and Decontaminate Fan House

3.2.1.3 Pile Fan Sump (WBS 1.3) (Sub-AOC 9D)

The pile fan sump (Sub-AOC 9D) removal action has been completed. The action included the removal of the pile fan sump, its associated piping, and contaminated soil adjacent to the sump structure. Prior to this latest removal action, several remediation activities have taken place at the pile fan sump. These include:

- Removal of water and sludge from the pile fan sump and piping, and inspection of the interior surfaces.
- Installation of a new weather-tight cover on the pile fan sump to prevent further intrusion of rainwater.
- Installation of instrumentation in the pile fan sump to continually monitor the water level.

During an inspection of the sump in March 1998, a piping penetration point was observed which allowed leakage to and probable contamination of the soil column. Soil will be surveyed and removed as needed to meet remediation goals and a final status survey will be performed to verify that the area meets the remediation goals. Decommissioning options considered for the WBS 1.3 are either no action or removal, as presented in Table 3-3 for each Decommissioning Alternative.

Table 3-3

WBS 1.3 Decommissioning Options by Alternative

Alternative 1	No Action
Alternative 2	Remove pile fan sump
Alternative 3	Remove pile fan sump
Alternative 4	Remove pile fan sump
Alternative 5	Remove pile fan sump
Alternative 6	Remove pile fan sump
Alternative 7	Remove pile fan sump

3.2.1.4 Above Ground Duct (WBS 1.4)

General response actions considered for this area are no action or removal. The above ground duct and Instrument House cleanup activities will include preparation of the Instrument House for removal, removal of the ductwork in sections, and the survey, characterization, and remediation of the soil located under the ducts as needed to meet the specified remediation goals. A final status survey will be conducted to ensure that the soil meets the remediation goals. Table 3-4 shows the decommissioning options associated with each of the Decommissioning Alternatives.

Table 3-4

WBS 1.4 Decommissioning Options by Alternative

Alternative 1	No Action
Alternative 2	No Action
Alternative 3	Remove Above-Ground Duct and Prepare Instrument House
Alternative 4	Remove Above-Ground Duct and Prepare Instrument House
Alternative 5	Remove Above-Ground Duct and Prepare Instrument House
Alternative 6	Remove Above-Ground Duct and Prepare Instrument House
Alternative 7	Remove Above-Ground Duct and Prepare Instrument House

3.2.2 Removal Area #2

3.2.2.1 Museum Walls & Materials Removal from Building 701 (WBS 2.1)

Several elevations of Building 701 and the top of the reactor pile were modified in 1977 to become a museum for BNL. Temporary walls and barriers were constructed and installed to delineate the museum area from other areas that were not made accessible to the public. When use of this location for a museum was discontinued in 1997, the displays were moved to the new museum location, and several displays, walls, rooms, and barriers were abandoned.

Carpenters and laborers have removed the walls, displays, and materials that were used to support the museum, as well as waste material. All materials that were removed were surveyed to demonstrate compliance with the unrestricted release criteria. This activity has already been completed. Table 3-5 shows how the aforementioned decommissioning options are integrated into the Decommissioning Alternatives.

Table 3-5

WBS 2.1 Decommissioning Options by Alternative

Alternative 1	No Action
Alternative 2	Remove Museum Walls
Alternative 3	Remove Museum Walls
Alternative 4	Remove Museum Walls
Alternative 5	Remove Museum Walls
Alternative 6	Remove Museum Walls
Alternative 7	Remove Museum Walls

3.2.2.2 Seal Reactor Pile Openings at the Biological Shield (WBS 2.2)

This work item will be part of every Decommissioning Alternative, except for the No Action Alternative. In alternatives where the reactor pile is removed or a cocoon is constructed, some methods of sealing of the reactor pile openings will differ. Table 3-6

shows how the aforementioned decommissioning options are integrated into the Decommissioning Alternatives.

Table 3-6

WBS 2.2 Decommissioning Options by Alternative

Alternative 1	No Action
Alternative 2	Seal Reactor Pile Openings at biological shield (Reactor Pile to Remain)
Alternative 3	Seal Reactor Pile Openings at biological shield (Reactor Pile to Remain)
Alternative 4	Seal Reactor Pile Openings at biological shield (Reactor Pile to Remain)
Alternative 5	Seal Reactor Pile Openings at biological shield (Cocoon Reactor Pile)
Alternative 6	Seal Reactor Pile Openings at biological shield (Reactor Pile Removed)
Alternative 7	Seal Reactor Pile Openings at biological shield (Reactor Pile Removed)

3.2.2.3 Isolate Building 701 from Building 703 (WBS 2.3)

Regardless of the disposition of Building 702, Building 703 will have to be isolated from Building 701. This will consist of the removal of the air handling units 01 and 03 from service, construction of a barrier between Building 701 and Building 703, the installation of an exhaust HEPA filter system to maintain Building 701 at negative pressure, and the installation of new ventilation systems including heating and cooling coils. Table 3-7 shows how the aforementioned decommissioning options are integrated into the Decommissioning Alternatives.

Table 3-7

WBS 2.3 Decommissioning Options by Alternative

Alternative 1	No Action
Alternative 2	Isolate Building 701 from Building 703
Alternative 3	Isolate Building 701 from Building 703
Alternative 4	Isolate Building 701 from Building 703
Alternative 5	Isolate Building 701 from Building 703
Alternative 6	Isolate Building 701 from Building 703
Alternative 7	Isolate Building 701 from Building 703

3.2.3 Removal Area #3

3.2.3.1 Below Ground Ducts and Instrument House (WBS 3.1)

There are two potential approaches which may be taken to address this work item, WBS 3.1a or WBS 3.1b. If WBS 3.1a is undertaken, removal of all subsurface ductwork and the Instrument House (Building 708) will occur. In addition, contaminated soils in the vicinity of the ductwork and Instrument House will be characterized and removed (sub-AOC 9B). Under WBS 3.1b, which addresses sub-AOC 9B only, the contaminated soils in the vicinity of the contaminated ductwork will be characterized and removed but the ducts and Instrument House will be decontaminated to release limits and left in place. Table 3-8 shows how the aforementioned decommissioning options are integrated into the Decommissioning Alternatives.

Table 3-8

WBS 3.1 Decommissioning Options by Alternative

Alternative 1	No Action
Alternative 2	Remove Contaminated Soils associated with Below Ground Ducts (WBS 3.1b)
Alternative 3	Remove Below Ground Ducts, Instrument House and Associated Soils (WBS 3.1a)
Alternative 4	Remove Below Ground Ducts, Instrument House and Associated Soils (WBS 3.1a)
Alternative 5	Remove Below Ground Ducts, Instrument House and Associated Soils (WBS 3.1a)
Alternative 6	Remove Below Ground Ducts, Instrument House and Associated Soils (WBS 3.1a)
Alternative 7	Remove Below Ground Ducts, Instrument House and Associated Soils (WBS 3.1a)

3.2.3.2 Underground Filters (WBS 3.2)

This work item will involve removal action and disposal of the original air filters. Table 3-9 shows how the aforementioned decommissioning options are integrated into the Decommissioning Alternatives.

Table 3-9

WBS 3.2 Decommissioning Options by Alternative

Alternative 1	No Action
Alternative 2	Remove and Dispose Air Filters
Alternative 3	Remove and Dispose Air Filters
Alternative 4	Remove and Dispose Air Filters
Alternative 5	Remove and Dispose Air Filters
Alternative 6	Remove and Dispose Air Filters
Alternative 7	Remove and Dispose Air Filters

3.2.3.3 Below Ground Primary Air Exhaust Coolers (WBS 3.3)

The contaminated air exhaust coolers will be removed and the sources of precipitation inflow and possible drain lines will be investigated to prevent re-contamination of remediated areas. Table 3-10 shows how the aforementioned decommissioning options are integrated into the Decommissioning Alternatives.

Table 3-10

WBS 3.3 Decommissioning Options by Alternative

Alternative 1	No Action
Alternative 2	Remove Air Coolers
Alternative 3	Remove Air Coolers
Alternative 4	Remove Air Coolers
Alternative 5	Remove Air Coolers
Alternative 6	Remove Air Coolers
Alternative 7	Remove Air Coolers

3.2.4 Removal Area #4

3.2.4.1 Canal, Water Treatment House, and Soils (WBS 4.1) (Sub-AOC 9A)

Work under this work element has been divided into two options depending on the level of the removal action performed in a given Decommissioning Alternative. WBS 4.1a includes removal of Canal and Water Treatment Houses, and the canal up to the foundation of the Reactor Building. Remaining openings in the Reactor Building will be sealed. Additionally, WBS 4.1a includes the work under 4.1b, which is limited to characterization and remediation of the east sump, pads, storage vaults, and contaminated soils and piping in the immediate vicinity of the Canal to address Sub-AOC 9A only.

Decommissioning options considered for this area are no action, removal of soils only or removal of the entire Fuel Canal, Water Treatment House and soils. These actions, by alternative, are shown in Table 3-11.

Table 3-11

WBS 4.1 Decommissioning Options by Alternative

Alternative 1	No Action
Alternative 2	Remove Soils Only (WBS 4.1b)
Alternative 3	Remove Canal, Water Treatment House, and Soils (WBS 4.1a)
Alternative 4	Remove Canal, Water Treatment House, and Soils (WBS 4.1a)
Alternative 5	Remove Canal, Water Treatment House, and Soils (WBS 4.1a)
Alternative 6	Remove Canal, Water Treatment House, and Soils (WBS 4.1a)
Alternative 7	Remove Canal, Water Treatment House, and Soils (WBS 4.1a)

3.2.4.2 Below Ground Piping Systems and Soils (WBS 4.2)

Surveying and sampling of the below ground piping systems will be performed prior to any of the lines being excavated or disturbed. Removal actions include the pneumatic tube trench that exits the east side of the Reactor Building and all enclosed piping in the trench. The removal action also includes removal of the trench which runs to the east side of Building 703 and to Building 801, the french drains from Building 701 on all sides of

the building, and all other lines on the east side of the reactor that are known or suspected to be contaminated (e.g., radioactive waste lines, canal sump discharge, storm drains, etc). Removal will also include the drain line from Irradiated Material pad on west side of the Reactor Building. The removal action associated with this work item will be performed as part of the canal removal action (WBS 4.1). Decommissioning options considered for this area are no action or removal, as shown in Table 3-12.

Table 3-12

WBS 4.2 Decommissioning Options by Alternative

Alternative 1	No Action
Alternative 2	No Action
Alternative 3	Remove Below Ground Piping Systems and Soils
Alternative 4	Remove Below Ground Piping Systems and Soils
Alternative 5	Remove Below Ground Piping Systems and Soils
Alternative 6	Remove Below Ground Piping Systems and Soils
Alternative 7	Remove Below Ground Piping Systems and Soils

3.2.4.3 Remaining Soils (Sub-AOC 9c) (WBS 4.3)

This activity includes removal of all contaminated soils greater than the cleanup criteria on the west side and east side of the Reactor Building except for those that have already been included in WBS Items 4.1 and 4.2. The total area requiring remediation is estimated to be 1 acre, to a depth of three feet.

Decommissioning options considered for the canal area and below ground piping, systems, and associated soils range from no action to full removal. The options to be taken on this WBS item for each Decommissioning Alternatives are presented in Table 3-13.

Table 3-13

WBS 4.3 Decommissioning Options by Alternative

Alternative 1	No Action
Alternative 2	Remove Soils
Alternative 3	Remove Soils
Alternative 4	Remove Soils
Alternative 5	Remove Soils
Alternative 6	Remove Soils
Alternative 7	Remove Soils

3.2.5 Removal Area #5

3.2.5.1 Remove Reactor Building (WBS 5.1)

There are three potential approaches which may be taken to address this work item: WBS 5.1a, WBS 5.1b, or WBS 5.1c. This removal action work item addresses the Reactor Building (Building 701). WBS item 5.1a includes the work required to leave both Buildings 701 and 702 in place. WBS 5.1b includes the work required to remove Building 701, while leaving 702 in place, and WBS 5.1c presents the activities which will take place if both Buildings 701 and 702 are removed.

WBS 5.1a *Disposition of the Reactor Building* - These activities will be conducted as part of Alternatives 2, 3, 4, and 6.

a. Survey of walls, floors and materials, including east and west intake structures. Decontaminate as needed.

b. Seal fuel transfer chute.

c. Decontaminate and disposition of the deep pit and canal.

d. Decontaminate the floor drains and mezzanine areas, and/or remove mezzanines.

e. Point the exterior bricks, replace the roofs, and refurbish exterior doors and windows.

f. Install sheet metal covers over intakes to replace existing plywood covers.

WBS 5.1b *Removal of the Reactor Building* - These activities will be conducted as part of Alternative 5.

a. Survey of walls, floors and materials, including east and west intake structures. Decontaminate as needed.

b. Seal fuel transfer chute.

c. Decontaminate and disposition the deep pit and canal.

d. Decontaminate the floor drains and mezzanine areas, and/or remove mezzanines.

e. Remove Reactor Building to 110' elevation (ground level). Seal stairwells and manway to deep pit area. Seal any other openings in 110' elevation, as needed.

f. Survey east and west inlet ducts and associated french drains. Decontaminate as needed. Backfill ducts with concrete to seal openings in biological shield.

g. Construct a cocoon around biological shield (Building 702).

WBS 5.1c *Removal of the Reactor Building along with Reactor Pile* - These activities will be conducted as part of Alternative 7. (This is the same as WBS 5.1b except that a cocoon will not be constructed around the reactor pile because it is being removed.)

a. Survey of walls, floors and materials, including east and west intake structures. Decontaminate as needed.

b. Seal fuel transfer chute.

c. Decontaminate and disposition the deep pit and canal.

d. Decontaminate the floor drains and mezzanine areas, and/or remove mezzanines.

e. Remove Reactor Building, including the reactor pile, to 106'-9" elevation (below ground level). Seal stairwells and manway to deep pit area. Seal any other openings in 110' elevation, as needed.

f. Survey east and west inlet ducts and associated french drains. Decontaminate as needed. Backfill ducts with concrete to seal openings in biological shield.

Decommissioning options for Building 701 under WBS 5.1 are outlined in Table 3-14 for each Alternative.

Table 3-14

WBS 5.1 Decommissioning Options by Alternative

Alternative 1	No Action
Alternative 2	Disposition Reactor Building (WBS 5.1a)
Alternative 3	Disposition Reactor Building (WBS 5.1a)
Alternative 4	Disposition Reactor Building (WBS 5.1a)
Alternative 5	Remove Reactor Building (WBS 5.1b)
Alternative 6	Disposition Reactor Building (WBS 5.1a)
Alternative 7	Remove Reactor Building (WBS 5.1c)

3.2.5.2 Removal of the Reactor Pile (WBS 5.2)

Work under this work element has been divided into two options depending on whether the reactor pile is removed. The removal action for Building 702, WBS 5.2, will consist of the following elements:

a. Remove graphite and all internal structures.

b. Remove primary and secondary air ducts within biological shield. Remove/decontaminate underground plenums to edge of Reactor Building, as needed.

c. Remove base plate, and supporting girders to 106' 9" elevation (below ground level).

d. Remove biological shield to 106' 9" elevation.

e. Survey animal and instrument tunnels and remaining concrete beneath the reactor pile. Remove contaminated and activated materials, as needed.

f. Remove steel from underground ducts beneath reactor pile and Reactor Building. Survey remaining concrete in foundation and underground ducts, and remove contaminated and activated materials, as needed.

Table 3-15 shows how the decommissioning options discussed in this section coincide with the Decommissioning Alternatives.

Table 3-15

WBS 5.2 Decommissioning Options by Alternative

Alternative 1	No Action
Alternative 2	Seal biological shield
Alternative 3	Seal biological shield
Alternative 4	Seal biological shield
Alternative 5	Enclose 702
Alternative 6	Remove 702
Alternative 7	Remove 702

3.2.5.3 Remove Experimental Equipment from Building 701 (WBS 5.3)

This activity includes the removal of the chemo-nuclear related equipment and shielding both inside and outside of Building 701, the beam guide equipment and sample change equipment, and the temporary tanks, portable shielding, and collection tanks on 110 ft. elevation.

Decommissioning options for the Building 701 Experimental Equipment, under WBS 5.3 are outlined in Table 3-16 for each alternative.

Table 3-16

WBS 5.3 Decommissioning Options by Alternative

Alternative 1	No Action
Alternative 2	No Action
Alternative 3	Remove Experimental Equipment from Building 701
Alternative 4	Remove Experimental Equipment from Building 701
Alternative 5	Remove Experimental Equipment from Building 701
Alternative 6	Remove Experimental Equipment from Building 701
Alternative 7	Remove Experimental Equipment from Building 701

3.2.5.4 *Remove Equipment and Systems from Building 701 (WBS 5.4)*

This activity includes removal of the control rod drive mechanisms, charging elevator and associated structural steel, and piping systems. The piping systems include domestic water, sanitary drains, compressed air, compressed gas, steam heating, chilled water cooling, storm drains, and the pneumatic tube transfer system.

Table 3-17 shows how the WBS element discussed in this section coincides with the Decommissioning Alternatives.

Table 3-17

WBS 5.4 Decommissioning Options by Alternative

Alternative 1	No Action
Alternative 2	No Action
Alternative 3	No Action
Alternative 4	Remove Building 701 Equipment and Systems
Alternative 5	Remove Building 701 Equipment and Systems
Alternative 6	Remove Building 701 Equipment and Systems
Alternative 7	Remove Building 701 Equipment and Systems

3.3 CONSTRUCTION OF DECOMMISSIONING ALTERNATIVES

Once a decommissioning option, described in Subsection 3.1, was selected for a given affected area, a work element, or WBS item (presented in the preceding section), was designed which detailed a construction approach to implement the response action. Each WBS item is considered as the removal decommissioning option, however, any of the four options may occur after further characterization and assessment. The WBS items were combined to form the seven detailed Decommissioning Alternatives presented in Figure 3-2. The seven alternatives developed provide different combinations of decommissioning options to yield solutions that vary in their level of complexity, cost, and protectiveness. Figure 3-3 shows the potential end states of the alternatives from 1 to 7. Figures 3-4 through 3-10 schematically depict those structures and items to be

Figure 3-2
ALTERNATIVES MATRIX

ALTERNATIVE 1	ALTERNATIVE 2	ALTERNATIVE 3	ALTERNATIVE 4	ALTERNATIVE 5	ALTERNATIVE 6	ALTERNATIVE 7
Continue S&M	S&M	S&M	S&M	S&M	S&M	
	Common Elements	**Common Elements**	**Common Elements**	**Common Elements**	**Common Elements**	**Common Elements**
(No Further Action)	1.1 Water Disposal	1.1 Water Disposal	1.1 Water Disposal	1.1 Water Disposal	1.1 Water Disposal	1.1 Water Disposal
	1.2 Fans and Decon Fan House	1.2 Fans and Decon Fan House	1.2 Fans and Decon Fan House	1.2 Fans and Decon Fan House	1.2 Fans and Decon Fan House	1.2 Fans and Decon Fan House
	1.3 Pile Fan Sump (9D)	1.3 Pile Fan Sump (9D)	1.3 Pile Fan Sump (9D)	1.3 Pile Fan Sump (9D)	1.3 Pile Fan Sump (9D)	1.3 Pile Fan Sump (9D)
	2.1 Museum Walls	2.1 Museum Walls	2.1 Museum Walls	2.1 Museum Walls	2.1 Museum Walls	2.1 Museum Walls
	2.3 Isolate 701	2.3 Isolate 701	2.3 Isolate 701	2.3 Isolate 701	2.3 Isolate 701	2.3 Isolate 701
	4.3 Remaining Soils (9C)	4.3 Remaining Soils (9C)	4.3 Remaining Soils (9C)	4.3 Remaining Soils (9C)	4.3 Remaining Soils (9C)	4.3 Remaining Soils (9C)
	Additional Elements	**Additional Elements**	**Additional Elements**	**Additional Elements**	**Additional Elements**	**Additional Elements**
	3.1b BG Duct Soils (9B)					
	4.1b Canal Soils (9A)					
	2.2 Seal Pile (to remain)	2.2 Seal Pile (to remain)	2.2 Seal Pile (to remain)			
				2.2 Seal Pile (for cocoon)		
					2.2 Seal Pile (for removal)	2.2 Seal Pile (for removal)
	5.1a Disposition 701	5.1a Disposition 701	5.1a Disposition 701		5.1a Disposition 701	
		1.4 AG Ducts	1.4 AG Ducts	1.4 AG Ducts	1.4 AG Ducts	1.4 AG Ducts
		3.1a BG Ducts/Inst. House/Soils (9B)	3.1a BG Ducts/Inst. House/Soils (9B)	3.1a BG Ducts/Inst. House/Soils (9B)	3.1a BG Ducts/Inst. House/Soils (9B)	3.1a BG Ducts/Inst. House/Soils (9B)
		3.2 BG Filters	3.2 BG Filters	3.2 BG Filters	3.2 BG Filters	3.2 BG Filters
		3.3 Air Coolers	3.3 Air Coolers	3.3 Air Coolers	3.3 Air Coolers	3.3 Air Coolers
		4.1a Canal House/ Water Treatment House/ fuel canal/ soils (9A)	4.1a Canal House/ Water Treatment House/ fuel canal/ soils (9A)	4.1a Canal House/ Water Treatment House/ fuel canal/ soils (9A)	4.1a Canal House/ Water Treatment House/ fuel canal/ soils (9A)	4.1a Canal House/ Water Treatment House/ fuel canal/ soils (9A)
		4.2 Pipe and Sys.	4.2 Pipe and Sys.	4.2 Pipe and Sys.	4.2 Pipe and Sys.	4.2 Pipe and Sys.
		5.3 Exp. Equip.	5.3 Exp. Equip.	5.3 Exp. Equip.	5.3 Exp. Equip.	5.3 Exp. Equip.
			5.4 Eq. & Systems	5.4 Eq. & Systems	5.4 Eq. & Systems	5.4 Eq. & Systems
				5.1b Bldg. 701,cocoon 702		
					5.2 Building 702	5.2 Building 702
						5.1c 701 (no cocoon for 702)

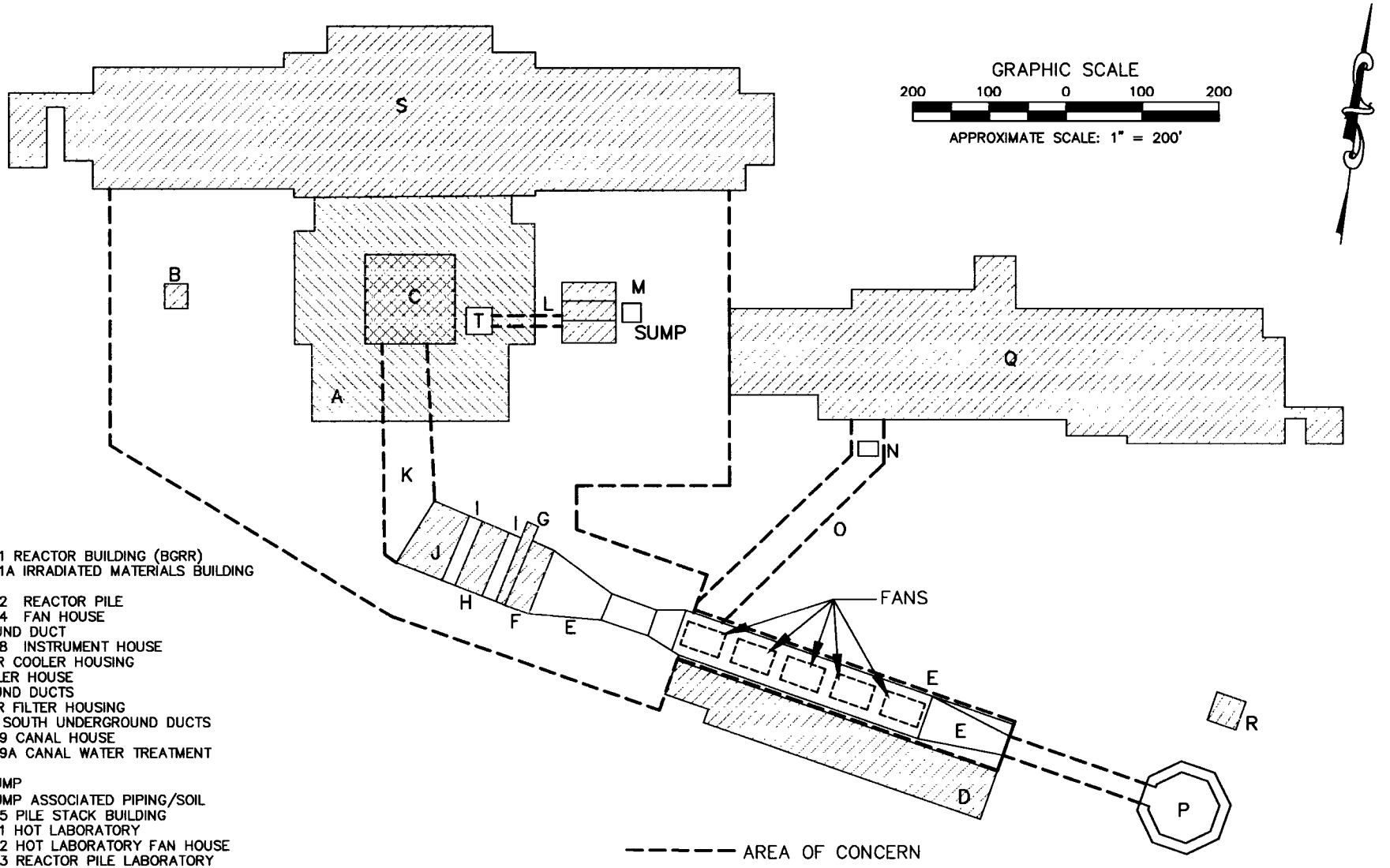
Notes:

S&M = Surveillance and Maintenance
AG = Above Ground
BG = Below Ground
Eq = Equip = Equipment
Exp = Experimental
9A = Area of Concern - Canal Soils
9B = Area of Concern - BG Duct Soils
9C = Area of Concern - Remaining Soils
9D = Area of Concern - Pile Fan Sump Soils
Numbers, e.g. 3.1b, 2.2, 5.4, indicate the Work Breakdown Structure (WBS) item included in the work.
Removal of item is implied unless specified otherwise

Figure 3-3

Potential End States

Alternative	Description of Potential End States
1	No action alternative, continue surveillance and monitoring
2	Excavate and remove known contaminated soils (per the IAG between the EPA, NYSDEC and the DOE.)
3	All work from Alternative 2 and Remove above ground ducts and Decontaminate or isolate or remove canal and below ground ducts and Seal biological shield for Building 702 (Reactor Pile) and Remove Building 701 Experimental Equipment
4	All work from Alternative 3 and Remove Building 701 Equipment and Systems
5	All work from Alternative 4 and Remove Reactor Building (701) and Build a safe storage enclosure around Building 702 (Reactor Pile)
6	All work from Alternative 4 and Leave Reactor Building (701) and Remove Building 702 (Reactor Pile)
7	All work from Alternative 6 and Remove Building 701



A BUILDING 701 REACTOR BUILDING (BGRR)
B BUILDING 701A IRRADIATED MATERIALS BUILDING PAD
C BUILDING 702 REACTOR PILE
D BUILDING 704 FAN HOUSE
E ABOVE GROUND DUCT
F BUILDING 708 INSTRUMENT HOUSE
G EXHAUST AIR COOLER HOUSING
H FUTURE BOILER HOUSE
I BELOW GROUND DUCTS
J EXHAUST AIR FILTER HOUSING
K NORTH AND SOUTH UNDERGROUND DUCTS
L BUILDING 709 CANAL HOUSE
M BUILDING 709A CANAL WATER TREATMENT FACILITY
N PILE FAN SUMP
O PILE FAN SUMP ASSOCIATED PIPING/SOIL
P BUILDING 705 PILE STACK BUILDING
Q BUILDING 801 HOT LABORATORY
R BUILDING 802 HOT LABORATORY FAN HOUSE
S BUILDING 703 REACTOR PILE LABORATORY
T DEEP PIT AND CANAL

ALTERNATIVE 1 – NO ACTION

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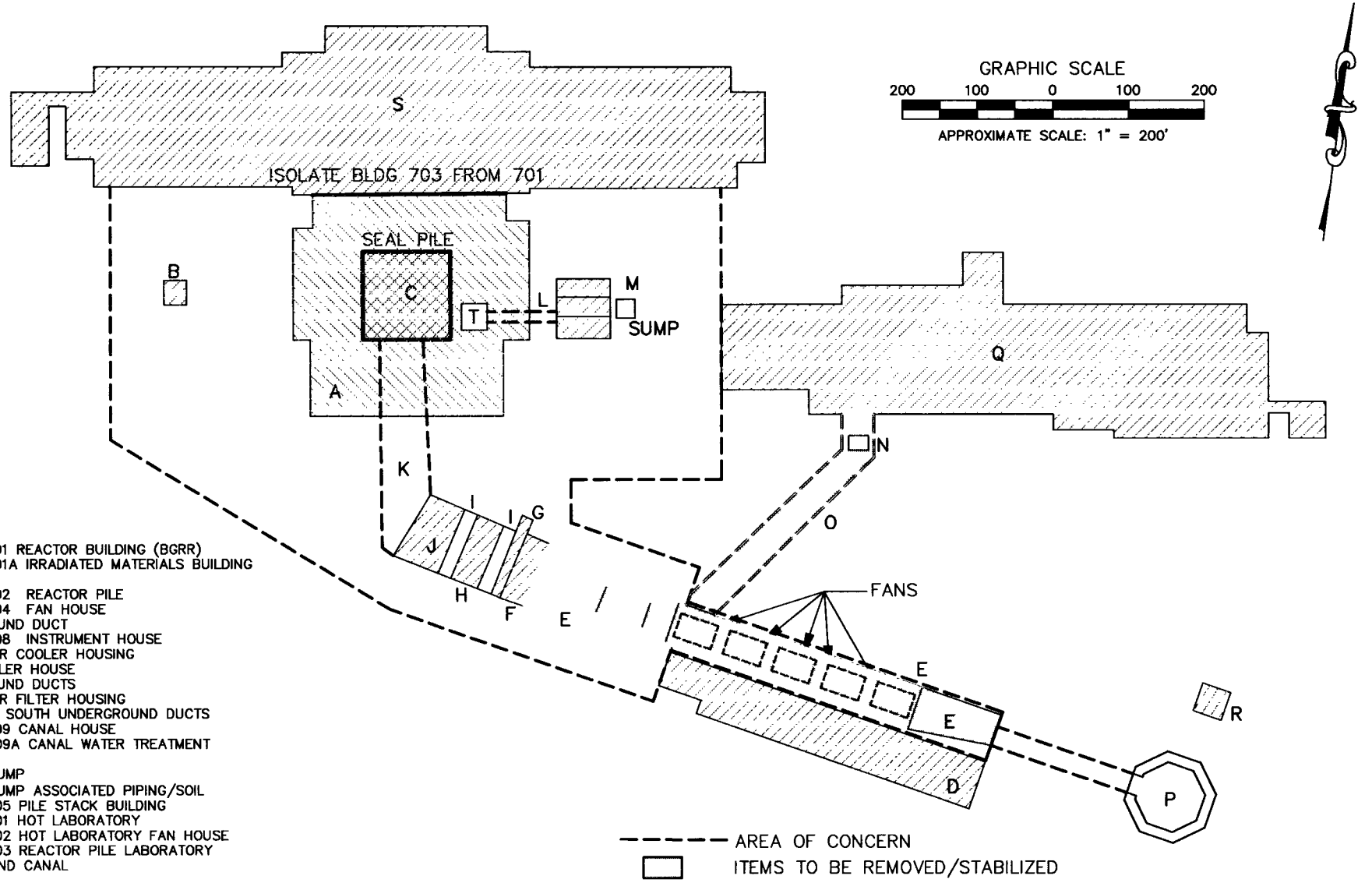

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R BUILDING 802 HOT LABORATORY FAN HOUSE
S BUILDING 703 REACTOR PILE LABORATORY
T DEEP PIT AND CANAL

STRUCTURES/ITEMS TO BE REMOVED UNDER ALTERNATIVE 2

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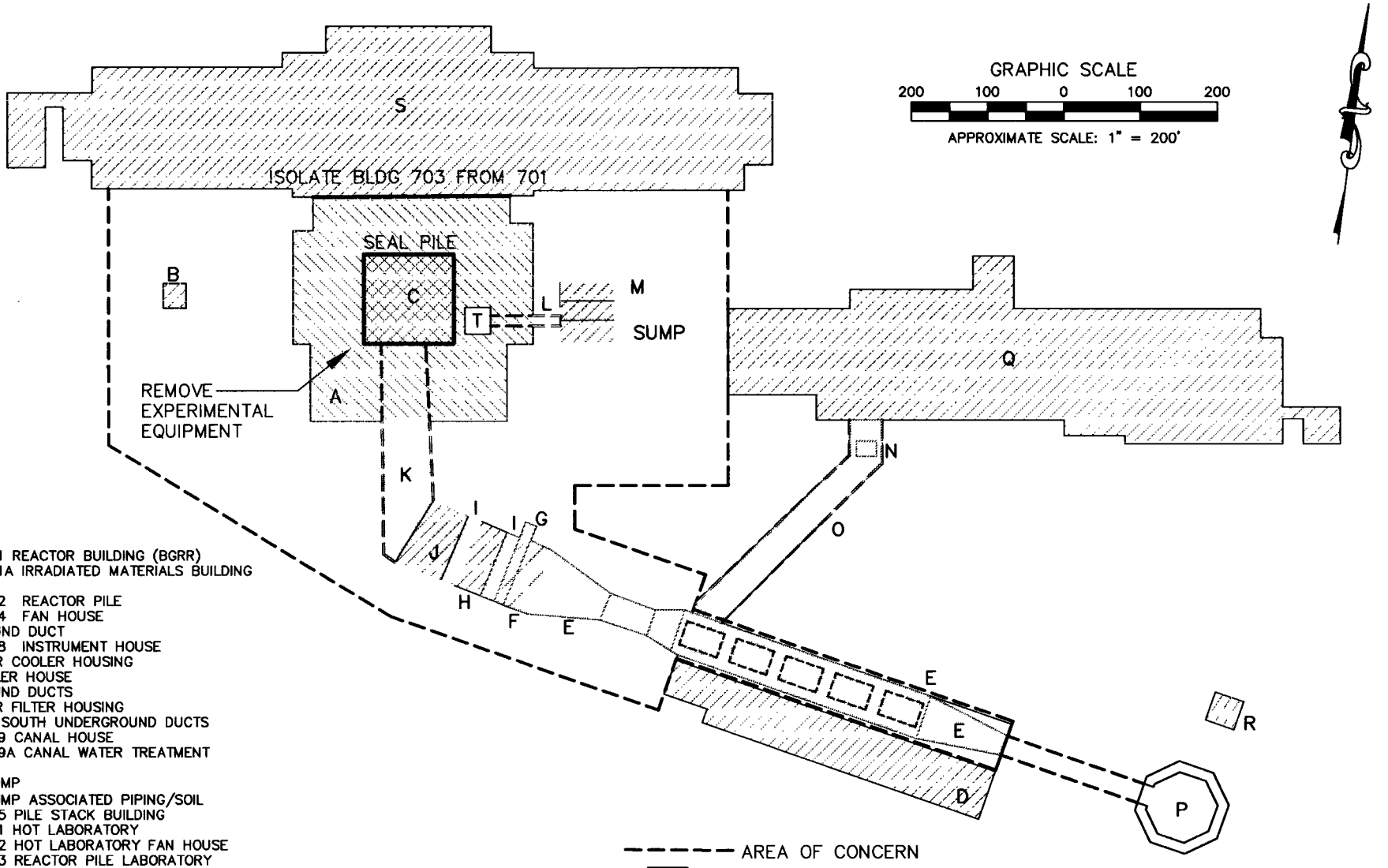

A BUILDING 701 REACTOR BUILDING (BGRR)
B BUILDING 701A IRRADIATED MATERIALS BUILDING PAD
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R BUILDING 802 HOT LABORATORY FAN HOUSE
S BUILDING 703 REACTOR PILE LABORATORY
T DEEP PIT AND CANAL

STRUCTURES/ITEMS TO BE REMOVED UNDER ALTERNATIVE 3

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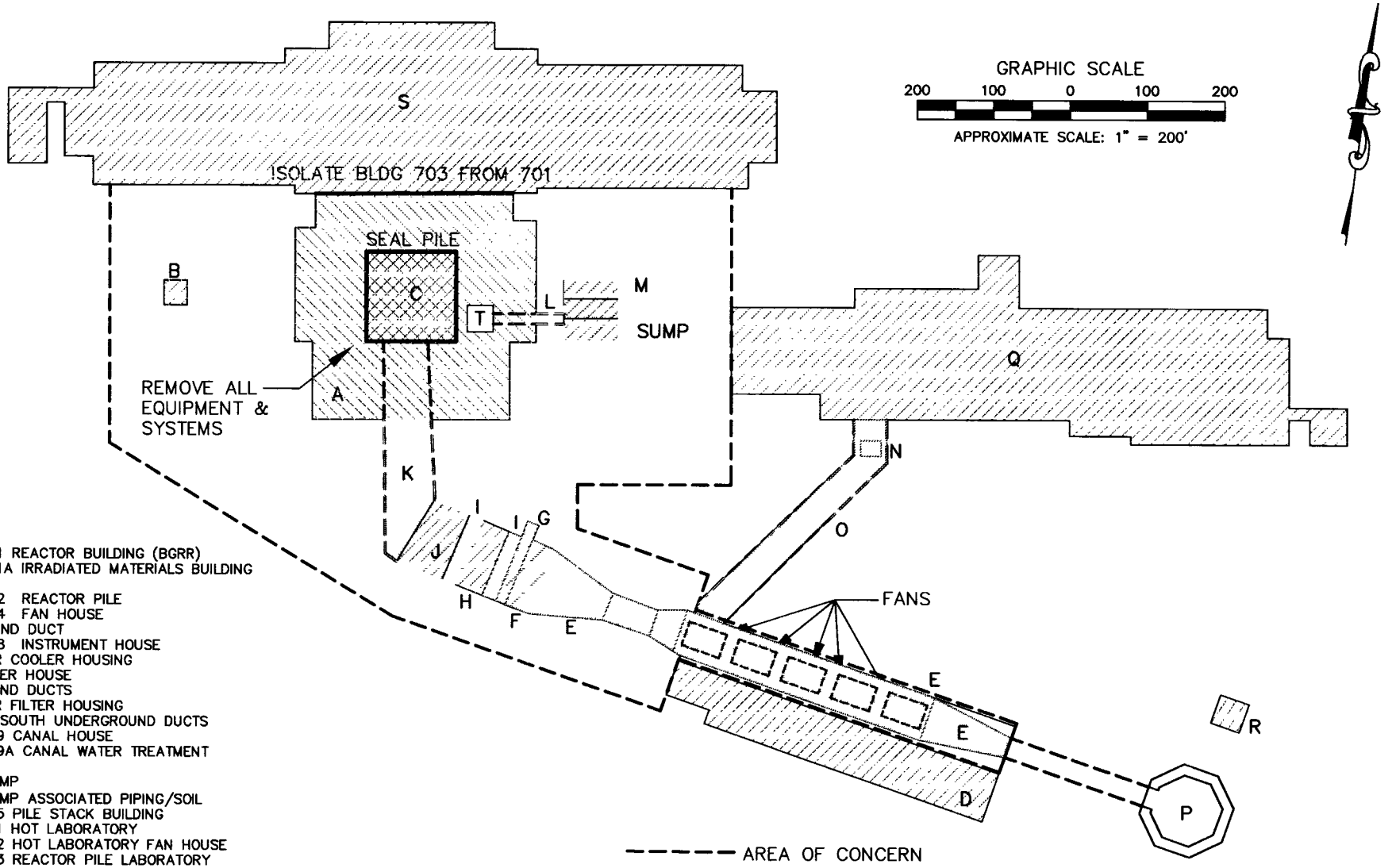

A BUILDING 701 REACTOR BUILDING (BGRR)
B BUILDING 701A IRRADIATED MATERIALS BUILDING PAD
C BUILDING 702 REACTOR PILE
D BUILDING 704 FAN HOUSE
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H FUTURE BOILER HOUSE
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O PILE FAN SUMP ASSOCIATED PIPING/SOIL
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R BUILDING 802 HOT LABORATORY FAN HOUSE
S BUILDING 703 REACTOR PILE LABORATORY
T DEEP PIT AND CANAL

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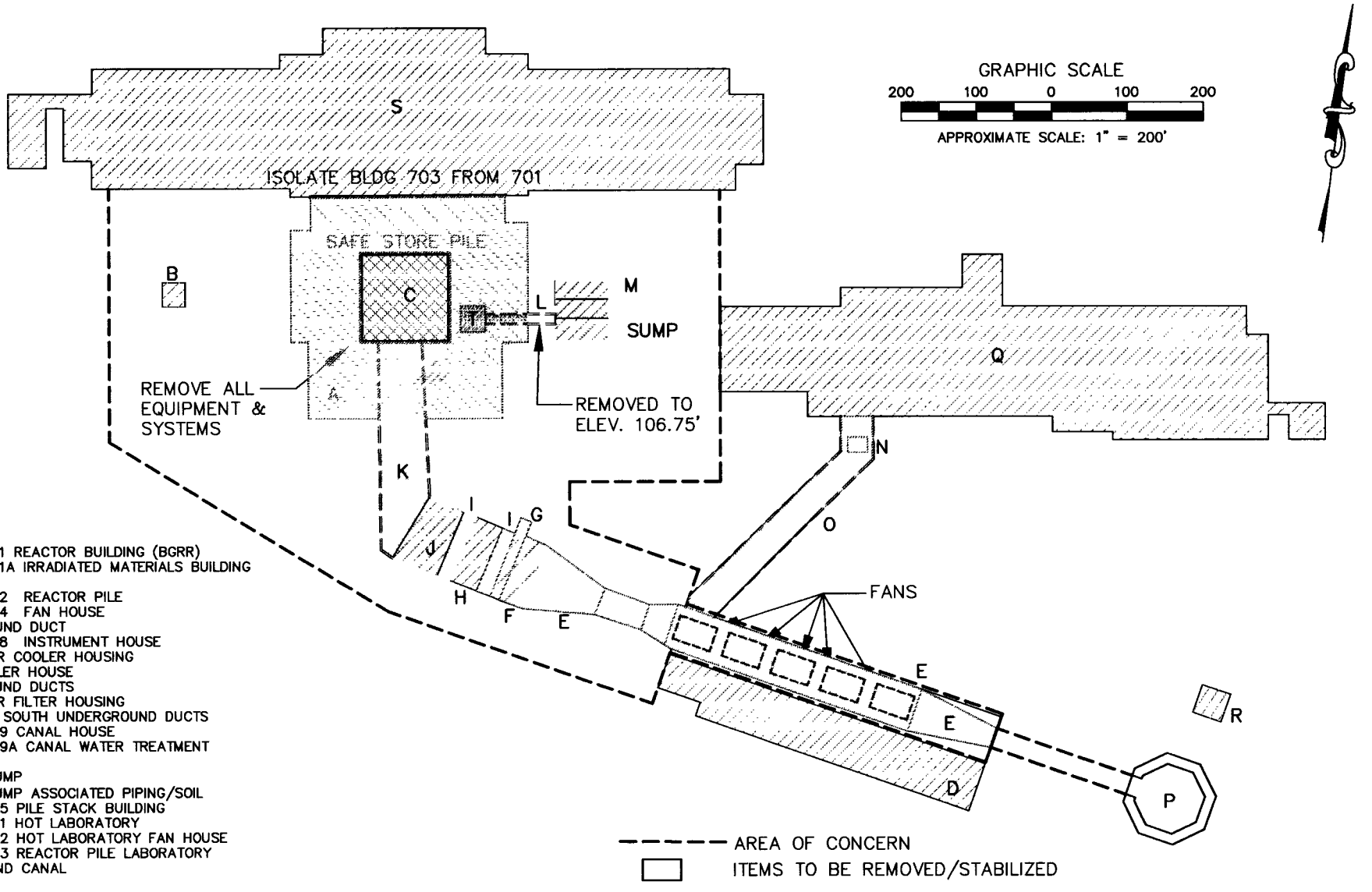

A BUILDING 701 REACTOR BUILDING (BGRR)
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R BUILDING 802 HOT LABORATORY FAN HOUSE
S BUILDING 703 REACTOR PILE LABORATORY
T DEEP PIT AND CANAL

STRUCTURES/ITEMS TO BE REMOVED UNDER ALTERNATIVE 5

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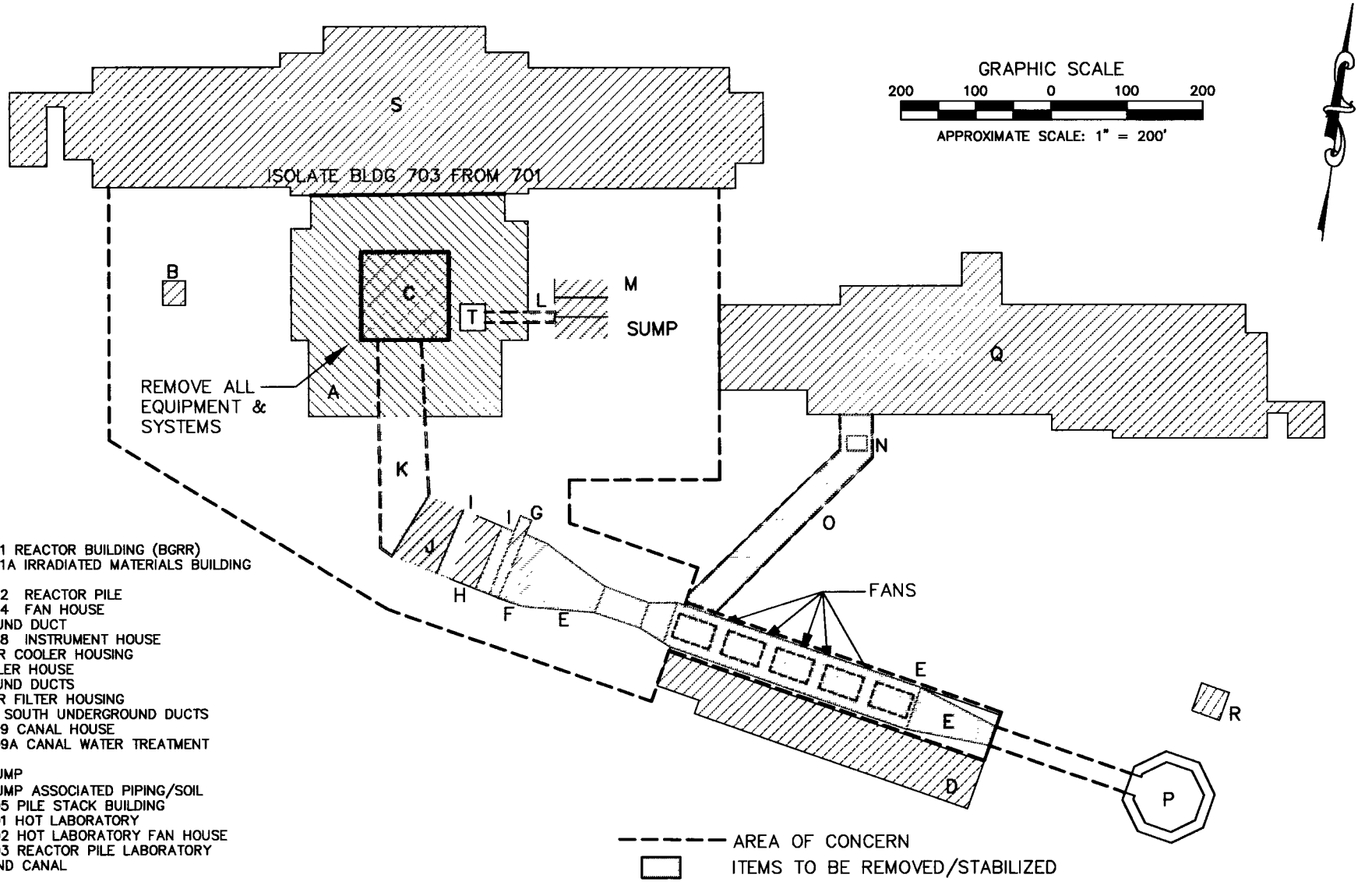

A BUILDING 701 REACTOR BUILDING (BGRR)
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R BUILDING 802 HOT LABORATORY FAN HOUSE
S BUILDING 703 REACTOR PILE LABORATORY
T DEEP PIT AND CANAL

STRUCTURES/ITEMS TO BE REMOVED UNDER ALTERNATIVE 6

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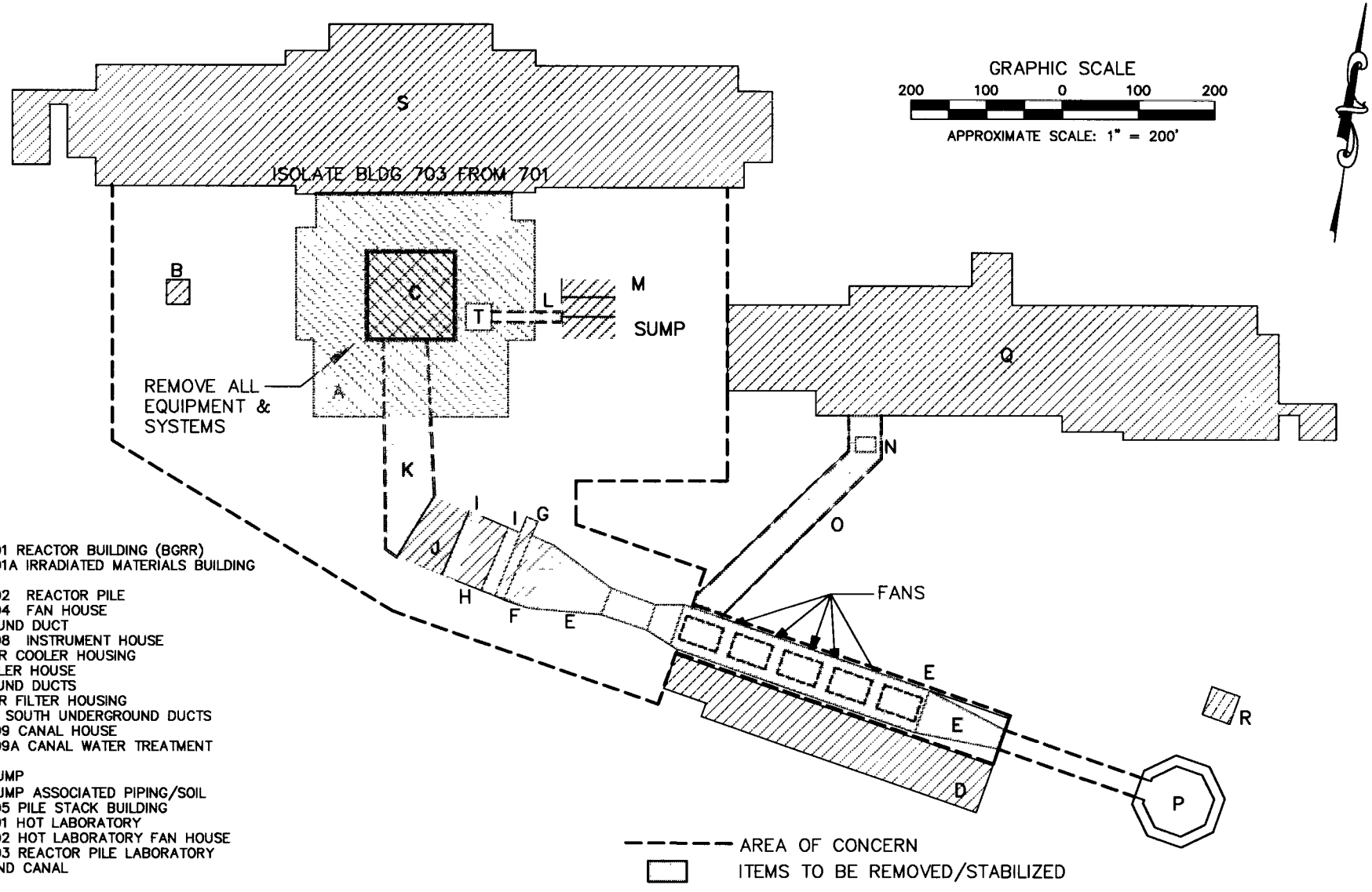

A BUILDING 701 REACTOR BUILDING (BGRR)
B BUILDING 701A IRRADIATED MATERIALS BUILDING PAD
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R BUILDING 802 HOT LABORATORY FAN HOUSE
S BUILDING 703 REACTOR PILE LABORATORY
T DEEP PIT AND CANAL

STRUCTURES/ITEMS TO BE REMOVED UNDER ALTERNATIVE 7

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removed under each of the alternatives. The alternatives span from no action to total removal action of affected areas including the reactor pile, the reactor building, and all associated fans, ductwork, piping, and soils, leaving only concrete foundations meeting the cleanup criteria. The alternatives are evaluated in Section 4.

3.3.1 Description Of Common Elements

The following items are the common elements, which are included in all of the alternatives, except Alternative 1, the No Action Alternative. The description following each work item (WBS #.#) refers to the Work Breakdown Structure (WBS) element associated with that work item as defined in the BGRR Project Baseline (BNL, 1999l). The common work elements are:

1. Disposal of water collected from the underground cooling ducts (WBS 1.1 - completed).
2. Removal of the fans and decontamination of Fan House (WBS 1.2 – In Progress).
3. Removal of the pile fan sump (sub-AOC 9D) (WBS 1.3 – In Progress).
4. Removal of the former museum walls and displays (WBS 2.1 - completed).
5. Isolation of Building 703 from Building 701 (WBS 2.3).
6. Removal of remaining soils (sub-AOC 9C) found to be contaminated above DCGLs during construction activities, or during pre-removal characterization sampling (WBS 4.3).

The common elements are not included in the alternative discussions that follow because they will be performed regardless of the chosen alternative. However, for the purposes of representing a CERCLA No Action Alternative, these actions will not be included in Alternative 1.

3.3.2 Description Of Alternatives

Seven alternatives were selected for initial analysis in this document. Each alternative is currently broken down into work elements that together constitute the full scope of work

under the alternative, as shown in Figure 3-3, Alternatives Matrix. In general, the level of effort and degree of remediation increases as the alternative number increases.

In Section 4, each alternative will be evaluated with respect to the CERCLA and NEPA considerations, and community values. Costs will be evaluated using the existing WBS, with corrections to existing work element costs, and addition of new work elements, as needed, to describe the range of alternatives. The seven removal action alternatives are described in the subsections that follow:

3.3.2.1 Alternative 1

This alternative (No Action) excludes the work items considered common elements. Under this alternative, all structures will remain intact, with surveillance and monitoring (S&M) for 50 years. The No Action Alternative is included as required by CERCLA. It provides a baseline against which all of the alternatives can be compared. Activities that are presently in progress or already completed will be backed out of the analyses for comparison purposes (i.e., for cost comparisons, the costs associated with the common elements described previously will be removed from the No Action cost). S&M will be performed to prevent deterioration of the facilities left in place and to control the spread of contamination. Figure 3-4 depicts the No Action Alternative as a site sketch (baseline).

3.3.2.2 Alternative 2

This alternative represents the minimal action alternative, which addresses only those elements which are specifically included in the IAG (sub-AOCs 9A, 9B, 9C, and 9D) and the common elements. Figure 3-5 depicts the items to be removed under Alternative 2. The ducts, Instrument House, Canal House, Water Treatment House, and Canal will remain in place, however the associated soils will be remediated. Buildings 701 and 702 remain under this alternative. The work elements specifically called for in this alternative are:

1. Common Elements 1-6 (as described in Subsection 3.3.1)
2. Surveillance and monitoring

3. Characterization and remediation of below ground duct contaminated soils (sub-AOC 9B) (WBS 3.1b)

4. Characterization and remediation of fuel canal contaminated soils (sub-AOC 9A) (WBS 4.1b)

5. Sealing of the reactor pile (Building 702), reactor pile to remain (WBS 2.2)

6. Disposition Building 701 for weatherproof containment of Building 702 (WBS 5.1a)

3.3.2.3 Alternative 3

The work elements specifically called for in this alternative include all of the elements in Alternative 2. In addition, the below ground ducts, filters, coolers, and Instrument House will be removed and associated soils remediated (sub-AOC 9B) and the Canal House, Water Treatment House, and canal will be removed and associated soils remediated (sub-AOC 9A). Alternative 3 also includes a removal action for the above ground ducts and any associated soil, a removal action for the below ground piping and systems and soil outside of Building 701, and a removal action for the Building 701 experimental equipment. Figure 3-6 depicts the items to be removed under Alternative 3. In summary, the following work items will be performed under this alternative:

1. Common Elements 1-6 (as described in Subsection 3.3.1)

2. Surveillance and monitoring

3. Sealing of the reactor pile (Building 702), reactor pile to remain (WBS 2.2)

4. Removal of above ground ducts (WBS 1.4)

5. Removal of below ground ducts, Instrument House, and associated contaminated soils (sub-AOC 9B) (WBS 3.1a)

6. Removal of below ground duct filters (WBS 3.2)

7. Removal of below ground duct air coolers (WBS 3.3)

8. Removal of Canal House, Water Treatment House, fuel canal, and associated contaminated soils (sub-AOC 9A) (WBS 4.1a)

9. Removal of below ground piping and systems (WBS 4.2)

10. Disposition Building 701 for weatherproof containment of Building 702 (WBS 5.1a)

11. Removal of Building 701 experimental equipment (WBS 5.3)

3.3.2.4 Alternative 4

The work elements specifically called for in this alternative include all of the elements in Alternative 3. In addition, the alternative includes a removal action for Building 701 equipment and systems, such as the control rod drive mechanisms and charging elevator. Figure 3-7 depicts the items to be removed under Alternative 4.

In summary, Alternative 4 consists of the following items:

1. Common Elements 1-6 (as described in Subsection 3.3.1)
2. Surveillance and monitoring
3. Sealing of the reactor pile (Building 702), reactor pile to remain (WBS 2.2)
4. Removal of above ground ducts and associated contaminated soils (WBS 1.4)
5. Removal of below ground ducts, Instrument House, and associated contaminated soils(sub-AOC 9B) (WBS 3.1a)
6. Removal of below ground duct filters (WBS 3.2)
7. Removal of below ground duct air coolers (WBS 3.3)
8. Removal of Canal House, Water Treatment House, fuel canal, and associated contaminated soils (sub-AOC 9A) (WBS 4.1a)
9. Removal of below ground piping and systems (WBS 4.2)
10. Disposition Building 701 for weatherproof containment of Building 702 (WBS 5.1a)
11. Removal of Building 701 experimental equipment (WBS 5.3)
12. Removal of Building 701 equipment and systems (WBS 5.4)

3.3.2.5 Alternative 5

This alternative includes a removal action for Building 701 and the construction of a cocoon around Building 702 (Reactor Pile). Alternative 5 does not include the dispositioning of Building 701, as the building is to be removed. All other elements of Alternative 5 are identical to those included in Alternative 4. Figure 3-8 depicts the items to be removed under Alternative 5. The alternative consists of:

1. Common Elements 1-6 (as described in Subsection 3.3.1)
2. Surveillance and monitoring
3. Sealing of the reactor pile, for cocooning (WBS 2.2)
4. Removal of above ground ducts and associated contaminated soils (WBS 1.4)
5. Removal of below ground ducts, Instrument House, and associated contaminated soils (sub-AOC 9B) (WBS 3.1a)
6. Removal of below ground duct filters (WBS 3.2)
7. Removal of below ground duct air coolers (WBS 3.3)
8. Removal of Canal House, Water Treatment House, fuel canal, and associated contaminated soils (sub-AOC 9A) (WBS 4.1a)
9. Removal of below ground piping and systems (WBS 4.2)
10. Removal of Building 701 to 110' elevation (ground level) and construction of a cocoon around the reactor pile (Building 702) (WBS 5.1b)
11. Removal of Building 701 experimental equipment (WBS 5.3)
12. Removal of Building 701 equipment and systems (WBS 5.4)

3.3.2.6 Alternative 6

The activities under Alternative 6 include all of the elements of Alternative 5, with the exception of the removal action for Building 701 and the construction of a cocoon around of Building 702. Instead, Building 702 will be removed and Building 701 will be left in-place under Alternative 6. This alternative also includes the dispositioning of Building

701. Figure 3-9 depicts the items to be removed under Alternative 6. The work elements specifically called for in this alternative are:

1. Common Elements 1-6 (as described in Subsection 3.3.1)
2. Surveillance and monitoring
3. Sealing of the reactor pile, reactor pile to be removed (WBS 2.2)
4. Removal of above ground ducts and associated contaminated soils (WBS 1.4)
5. Removal of below ground ducts, Instrument House, and associated contaminated soils(sub-AOC 9B) (WBS 3.1a)
6. Removal of below ground duct filters (WBS 3.2)
7. Removal of below ground duct air coolers (WBS 3.3)
8. Removal of Canal House, Water Treatment House, fuel canal, and associated contaminated soils (sub-AOC 9A) (WBS 4.1a)
9. Removal of below ground piping and systems (WBS 4.2)
10. Disposition of Building 701 (WBS 5.1a)
11. Removal of Building 702 to 106' 9" elevation (WBS 5.2)
12. Removal of Building 701 experimental equipment (WBS 5.3)
13. Removal of Building 701 equipment and systems (WBS 5.4)

3.3.2.7 Alternative 7

This alternative removes all BGRR-related structures and equipment and therefore represents the most complete removal action. This alternative includes all of the components of Alternative 6, with the exception of surveillance and monitoring, which is not required for this alternative because everything will be removed. In addition, Building 701 will be dispositioned and removed under this alternative. Following removal of Buildings 701 and 702, some remaining foundation materials will be left in place, however any residual radioactivity will be below the DCGLs. Figure 3-10 depicts the items to be removed under Alternative 7. The major work elements involved in the implementation of this alternative are:

1. Common Elements 1-6 (as described in Subsection 3.3.1)
2. Sealing of the reactor pile for removal (WBS 2.2)
3. Removal of above ground ducts and associated contaminated soils (WBS 1.4)
4. Removal of below ground ducts, Instrument House, and associated contaminated soils(sub-AOC 9B) (WBS 3.1a)
5. Removal of below ground duct filters (WBS 3.2)
6. Removal of below ground duct air coolers (WBS 3.3)
7. Removal of Canal House, Water Treatment House, fuel canal, and associated contaminated soils (sub-AOC 9A) (WBS 4.1a)
8. Removal of below ground piping and systems (WBS 4.2)
9. Removal of Building 701 to 106'-9" elevation without constructing cocoon around Building 702 (WBS 5.1c)
10. Removal of Building 702 to 106' 9" elevation (WBS 5.2)
11. Removal of Building 701 experimental equipment (WBS 5.3)
12. Removal of Building 701 equipment and systems (WBS 5.4)

SECTION 4

DETAILED COMPARATIVE ANALYSIS OF ALTERNATIVES

4. DETAILED COMPARATIVE ANALYSIS OF ALTERNATIVES

In this section, a comparative analysis of each alternative identified in Subsection 3.3 is made. The purpose of this evaluation process is to eliminate, based on existing information, the alternatives that are not feasible or have severe limitations that might prevent achievement of the remedial action objectives (RAOs). Each alternative is evaluated with respect to the CERCLA criteria, the NEPA criteria, and community values. The criteria are discussed for each of the alternatives to enable decision makers to readily access the significant relative advantages and disadvantages for each alternative.

4.1 CERCLA CRITERIA

The nine CERCLA criteria are broken into three groups, as shown in Figure 4-1: 1) Threshold Criteria, 2) Primary Balancing Criteria, and 3) Modifying Criteria. The Threshold Criteria comprise the minimum requirements the alternative must meet in order to be chosen for implementation. These criteria deal with overall protection and regulatory compliance. No alternative can be considered for actual application that does not meet these two criteria. The Primary Balancing Criteria serve to distinguish the alternatives from one another and to indicate the alternatives that hold the most promise. These can then be maintained for further consideration in future decision-making, in this case, in the EE/CAs which will be prepared for each of the sub-projects in the WBS. The Modifying Criteria are also considered along with the other criteria, in order to ensure the selection of the best alternative actions. A table ranking all the alternatives against one another is shown in Section 5.

4.1.1 Overall Protection of Human Health & the Environment

This criterion evaluates whether or not a remedy provides adequate protection of human health and the environment, and describes how risks posed through each pathway are eliminated, reduced, or controlled through treatment, engineering controls, or institutional controls. This section will provide an overall assessment and ranking of risks for each of the alternatives.

Figure 4-1

CERCLA Criteria

Threshold Criteria
Overall protection of Human Health and the Environment
Compliance with ARARs
Primary Balancing Criteria
Long Term Effectiveness and Permanence of the Alternative, along with the degree of certainty that the alternative will prove successful
Reduction of toxicity, mobility, or volume through treatment
Short-term risks to public health, workers, and the environment and the time required to achieve protection
Ease or difficulty of implementing the alternatives, including technical, administrative, and logistic feasibility
Capital and Annual O&M Costs and net present value
Modifying Criteria
State Acceptance
Community Acceptance

4.1.1.1 Alternative 1

This alternative provides for S&M activities only. This alternative is considered protective of human health as long as Federal control of the BGRR facility is maintained (before loss of federal control). Fifty (50) years of S&M activities will potentially expose S&M personnel to contamination and external radiological risks. Radiological control will provide sufficient protection to workers from the effects of external radiation hazards and internal effects from contamination, however it will not be protective of the environment.

This alternative is not considered protective of human health or the environment after Federal control is relinquished. All potential exposure pathways exist including external exposure to radiation and internal exposure through inhalation, ingestion, or direct contact with contaminated materials. Degradation of structures may eventually lead to soil and air contamination via fugitive particulates and leaching to groundwater.

4.1.1.2 Alternative 2

This alternative provides greater overall protection than Alternative 1 by implementing the common elements (discussed in Subsection 3.3.1) as well as sealing the reactor pile openings in the biological shield, removal and disposal of the below ground duct soils, and removal and disposal of the canal soils. The common elements would provide minimal additional protection of human health and environment. Sealing of the reactor pile openings would minimize risk of exposure to radioactive elements within the reactor pile, but would provide little long-term effectiveness for the ductwork, canal, and Canal House. While this alternative would reduce contamination at the site, many contaminated and activated systems would remain. The hazardous elements of these contaminated and activated systems would not be reduced by the activities included in this alternative. As in Alternative 1, human health would be protected as long as Federal control is maintained. The potential for the release of contamination to the environment would exist both during and after Federal control.

4.1.1.3 Alternative 3

This alternative and all subsequent alternatives include removing or stabilizing below ground ducts, underground filters, below ground primary air exhaust coolers, canal, treatment houses and fuel canal up to foundation of Reactor Building, below ground pipe and systems, and experimental systems removal from Building 701. Additionally, in this alternative, Building 701 would be decontaminated and Building 702 (Reactor Pile) would remain and be placed into safe storage (SAFESTOR).

There would potentially be an increase of short term-risks to on-site workers during construction activities through exposure to radionuclides and construction hazards. Short-term effects can be minimized through the appropriate radiological protection and control measures. Generation of waste materials during removal activities could lead to potential environmental releases during loading and transportation activities. Transportation would be in accordance with Federal and State Transportation Regulations.

Human health would be protected as long as Federal control is maintained and radiation control practices are followed during decommissioning activities. There is a potential for contamination spreading to additional soils during remediation activities. Following the loss of Federal control, it is assumed there would still be some type of control over Buildings 701 and 702, which would remain. Barring the occurrence of unusual events such as earthquake, human health and the environment should be protected after the loss of Federal control since the vast majority of the remaining contaminants are sealed within the biological shield.

4.1.1.4 Alternative 4

This decommissioning option is very similar to Alternative 3 except that in addition to the experimental equipment, additional equipment and systems in Building 701 would be removed. This would eliminate S&M requirements for these items, along with the associated risks to S&M personnel. There would be a minimally increased risk of transportation releases or accidents due to the generation of additional radioactive waste. Overall protection of human health and the environment would essentially be the same as in Alternative 3.

4.1.1.5 Alternative 5

This alternative would add the removal of Building 701 to the 110-ft. elevation (ground level) and the construction of a cocoon around Building 702. This alternative would introduce the potential for additional exposure to contamination by workers and to the environment during the demolition of Building 701. There would be an increase in construction type hazards and environmental releases or accidents due to transportation activities. The cocooning of Building 702 would reduce the potential for contamination releases to the environment from the reactor pile. This alternative would provide a permanent reduction in potential contamination from Building 701. Overall human health and the environment would be protected as long as Federal control is maintained. However, the reactor pile will remain. With the reactor pile still in place, the secondary containment once provided by Building 701 would be lost.

4.1.1.6 Alternative 6

This option includes all of the elements of Alternative 4, and, additionally, includes the removal of Building 702 while leaving Building 701 in place. This would eliminate the potential for environmental releases from the reactor pile, but would create a potential for increased contamination in Building 701 as a result of the removal activities. Because of the longer duration required to remove Building 702 and the higher levels of contamination within the reactor pile, the potential for exposure of workers and the environment would be significantly higher during the demolition of Building 702 than with other alternatives. There would be significant construction, lifting, and transportation hazards associated with this alternative. Short-term risks to workers would be mitigated through proper industrial and radiological safety practices. Overall protection of human health and the environment would be provided in this option.

4.1.1.7 Alternative 7

This alternative calls for removal of all structures associated with the BGRR. This alternative is the most complete and provides for removal of all potentially contaminated structures. All of the potential short-term risks associated with construction, demolition and transportation would be present. For most of the systems that would be removed, there would be a short-term potential increase in airborne contamination and thus a decrease in overall protection to human health and the environment. However, Alternative 7 would provide the greatest long-term effectiveness and permanence due to the removal of all BGRR components. Upon completion, the former BGRR facility would be released to unrestricted access and S&M requirements would be minimal and include only groundwater. In addition, there would be no further risk to human health or the environment. Overall protection of human health and the environment would be provided in this option.

4.1.2 Compliance With ARARs

This criterion addresses whether or not a remedy will meet all of the Applicable or Relevant and Appropriate federal and state environmental statutes and Requirements (ARARs) or whether grounds exist for a waiver. This section is necessarily organized differently from

the other sections. The issues are discussed in groups and a table summarizes the alternatives' responsiveness to each of the ARARs.

Removal actions under CERCLA are required to comply with ARARs to the extent practicable, or be waived for actions conducted pursuant to CERCLA. The selected removal action for the BGRR site will be carried out in accordance with ARARs to the fullest extent practicable. A list of potential ARARs for the BGRR site, and conditions for granting waivers from specific ARARs, were discussed previously in Subsection 2.4 and are presented in Tables D-1 through D-6. Compliance of the various removal alternatives with potential ARARs and To Be Considered (TBCs) is summarized in Table D-7. Compliance in this table is indicated with a "yes (Y)," "no (N)," or "not applicable (NA)" designation. The primary ARARs categories related to the Decommissioning Project and the degree of compliance achieved are discussed below.

4.1.2.1 Waste Management Standards

RCRA and the implementing State requirements and other Federal waste transport regulations regulate the management, handling, characterization, transport, and disposal of hazardous, dangerous, mixed, and industrial (or non-hazardous) wastes. These requirements are applicable to any wastes generated under the relevant waste designations. All alternatives will comply with these regulations. Wastes generated as a result of the construction activities will be transported and treated and/or disposed at appropriately licensed and permitted facilities.

Performance objectives for land disposal of low-level radioactive waste are provided in 10 CFR 61, Subpart C. Although not applicable to DOE facilities, these standards are relevant and appropriate to any disposal activity conducted under Alternatives 2 through 7.

4.1.2.2 Air Emissions Control Standards

The Clean Air Act (CAA), New York State Air Quality Regulations, and specific DOE orders (as TBCs) regulate both toxic and radioactive airborne and fugitive dust emissions. These standards apply to any fugitive, diffuse, and point-source air emissions generated

where waste removal and construction activities may result in emissions to ambient air. To comply with the requirements, all alternatives would implement fixation of surface contaminants, misting, and HEPA filtration of enclosed areas to control radioactive emissions during decommissioning operations. Demolition activities will use standard construction techniques to control fugitive dust emissions which should adequately control fugitive emissions of radionuclides and toxic air pollutants.

4.1.2.3 Cultural Resource Protection Standards

The National Historic Preservation Act of 1966 (implemented via 36 CFR 800) requires federal agencies to evaluate and mitigate adverse effects of Federal activities on any site eligible for inclusion on the National Register of Historic Places, a designation placed on the BGRR. DOE will remain cognizant of this designation, although historical significance alone will not be the sole determining factor in selecting or eliminating any alternative.

The Archeological and Historical Preservation Act of 1974 requires action to recover and preserve artifacts in areas where activity may cause irreparable harm, loss, or destruction of significant artifacts. This requirement is applicable due to potential to find archaeological resources during the project.

4.1.2.4 Radiation Protection Standards

The CAA, OSHA regulations, and regulations contained within Title 10 of the CFR and DOE Implementation manuals and guidance establish radiation protection standards, limits, and program requirements for protecting workers and visitors from ionizing radiation resulting from activities at DOE facilities. They also require that measures be taken to maintain radiation exposure to As Low As Reasonably Achievable (ALARA). To ensure that these requirements are met by Alternatives 1 through 7, a combination of the following would be used:

- Personnel Protective Equipment (PPE)
- Personnel training

- Physical design features (e.g., confinement, remote handling, and shielded containers)
- Administrative controls (e.g., limiting time in radiation zones)

All alternatives would meet the requirements for maintaining exposure ALARA by decontaminating surfaces and fixing loose contamination prior to dismantlement. Individual monitoring will be performed, as necessary, to verify compliance with these requirements.

Various DOE Orders (as TBCs) including 5400.1, 5480.1B, 440.1, and 5481.1 establish requirements relating to safety, health, and environmental protection. The substantive requirements of these TBC requirements will be met for any S&M, decommissioning or demolition activities. Site and activity-specific requirements and controls will be implemented, including contingency plans and emergency response plans.

4.1.2.5 Polychlorinated Biphenyls

The removal and disposal of PCBs and PCB waste, including management of spills and cleanup of materials suspected to contain PCB waste, are regulated under the TSCA and OSHA requirements. Currently, there are no known specific locations of PCB-containing regulated materials at the BGRR. However, if found during decommissioning activities, any regulated wastes will be handled, transported, and disposed of at a TSCA-approved disposal facility, or, if necessary, an appropriate mixed waste facility. Any alternatives involving dismantling, removal, and possible disposal of mechanical equipment (i.e., Alternatives 4 through 7), have the greatest likelihood of encountering regulated, PCB-containing wastes.

4.1.2.6 Asbestos

Removal and disposal of asbestos and ACM is regulated under the CAA and OSHA regulations. These regulations provide for special precautions to prevent exposure of workers or airborne emissions of asbestos fibers during removal actions. All of the alternatives will comply with these requirements for any actions that will disturb or otherwise manage or dispose of ACM. These regulations apply to Alternatives 2 through 7

where potential to encounter ACM is likely during decommissioning activities. They are not expected to apply under Alternative 1, the No Action Alternative, unless incidental asbestos is encountered and must be managed or removed during routine surveillance and maintenance activities.

4.1.3 Long-Term Effectiveness And Permanence

This criterion assesses the ability of a remedy to maintain reliable protection of human health and the environment over time, once cleanup goals have been met. This section provides an evaluation of the long-term effectiveness and permanence of the selected decommissioning alternatives at the BGRR. Alternatives are presented in increasing order of removal and level of effort. In general, the degree of permanence and long-term effectiveness increases with the alternative number. All alternatives will include a 50-year period of S&M to allow Life Cycle Cost[8] (LCC) comparison, independent of the level of removal however, the extent of the S&M will be reduced where fixtures are removed permanently. With the exception of Alternative 1 (No Action), the following common work elements will be performed:

- Disposal of the water in the deep drain sump in Building 701 (WBS 1.1)
- Removal of fans and decontamination of the Fan House (WBS 1.2)
- Modification and removal of piping within the Pile Fan Sump (WBS 1.3)
- Removal of above ground ductwork and instrument house (Building 708) (WBS 1.4)
- Removal of Museum Walls and Materials from Building 701 (WBS 2.1)
- Isolation of Building 701 from Building 703 (WBS 2.3)
- Removal of soil from construction and pre-decommissioning activities (WBS 4.3)

[8] LCC — Life Cycle Cost — is the total of the direct, indirect, recurring, nonrecurring, and other related costs incurred or estimated to be incurred in the design, development, production, operation, maintenance, support, deactivation, and/or disposition or a project or system over its anticipated useful lifespan.

The removals included in the common elements above, such as the removal of the contaminated soil and disposal of the deep drain sump water, will provide a long-term solution for contaminated media. These fixtures and other media will be out of the way and will not impede subsequent decommissioning or decontamination work. In addition, there will be no risk of worker exposure to the removed contaminated media and the maintenance requirements for contaminated fixtures will not be required. Removal of contaminated fixtures provides a permanent remedy.

4.1.3.1 Alternative 1

This is the No Action Alternative and provides for S&M only. None of the common elements will be included in this option. During this period, contaminated structures and equipment will remain onsite in their existing condition within the confines of BGRR and generally inaccessible to the public. Some general maintenance of existing structures is to be expected in order to maintain protective measures and increased maintenance would likely be required in the later years of the S&M period. Though some radioactive decay would occur in contaminated media over the surveillance period, it is unlikely that this decay in radioactivity levels would allow an unrestricted release of the structures following completion of S&M. This alternative would provide no permanent solution to the structure decommissioning.

4.1.3.2 Alternative 2

This alternative includes the common elements and associated benefits detailed above and would provide for sealing of the reactor pile openings in the biological shield, removal and disposal of the below ground duct soils, and removal and disposal of the canal soils. The isolation of Building 703 from 701 would allow Building 703 to remain in operation during decommissioning activities.

This alternative would provide significantly more permanence and would be more effective over the long term than Alternative 1 because of the increased amount of work performed (specifically the aforementioned common elements). Though total removal of the reactor pile is not included in this alternative, sealing of the reactor pile openings would isolate the

graphite reactor pile and minimize risk of exposure to radioactive elements and graphite. In addition, the below ground ductwork and canal system would be left in place. Eventually, these systems would require removal or modification in the event that unrestricted redevelopment may be performed in the area.

The soils associated with the below ground ducts (sub-AOC 9B) and in the vicinity of the canal and underground piping areas (sub-AOC 9A) will be characterized and removed under this alternative. This would only be performed as part of this alternative because the ducts, canal, and Canal Buildings would not be removed. This would provide a permanent solution for existing contaminated soils, but would provide little long-term effectiveness for the ductwork, canal, and Canal Building. This alternative may open new pathways for contact with and spread of contamination, contamination of additional soils, and recontamination of the soils beneath the remaining fixtures.

4.1.3.3 Alternative 3

In this alternative, a significant amount of removal work would be performed over and above the removal performed in Alternative 2. This alternative would include the removal of the primary and secondary below ground ductwork and filters leading from the reactor pile to the Fan House, the air coolers, the Canal House (Building 709) and Water Treatment House (Building 709A), below ground piping and associated contaminated soils, and experimental equipment from Building 701. The experimental equipment includes chemo-nuclear related equipment and shielding both inside and outside Building 701, beam guide equipment and sample change equipment, temporary tanks, portable shielding, and collection tanks on the 110 ft. elevation (ground level). The removal associated with this option would be a permanent solution to contaminated fixtures, and would decrease the long-term maintenance liability. Alternative 3 would provide a permanent solution to the ductwork and canal system left in place in Alternative 2. In this alternative, Building 702 (Reactor Pile) would remain and be placed into safe storage (SAFESTOR), but would require continual S&M for a period of 50 years. This option also would provide a higher degree of permanence over Alternative 2 because the below ground ductwork and canal would be removed, minimizing future liability.

4.1.3.4 Alternative 4

This decommissioning option is similar to Alternative 3 except that in addition to the experimental equipment, the following equipment and systems in Building 701 would be removed: control rod drive mechanisms, charging elevator and associated structural steel, and piping systems. The piping systems include compressed air, compressed gas, and pneumatic tube transfer system. This alternative would provide a permanent solution for the systems in Building 701 and would eliminate S&M requirements for these items.

4.1.3.5 Alternative 5

Alternative 5 would add the removal of Building 701 (to the 110 ft. elevation [ground level]), sealing the biological shield, and the construction of a cocoon to Alternative 4. Sealing the biological shield openings would prevent graphite dust from becoming a hazard in the Reactor Building and prevent an impact to the reactor pile from removal activities. This alternative would provide a permanent solution for Building 701 and has more long-term effectiveness than Alternative 4, but would provide only a short-term solution for the reactor pile.

4.1.3.6 Alternative 6

This alternative as compared to Alternative 5, would leave Building 701 in place, would remove the reactor pile, would remove the biological shield, but would not construct the cocoon (which would not be needed because the reactor pile would be removed). This alternative would provide a permanent solution for the reactor pile, eliminating the risk of exposure to radioactive elements and graphite, but would leave Building 701 intact, subject to extended S&M, for some other reuse option.

4.1.3.7 Alternative 7

Alternative 7 would provide the greatest long-term effectiveness and permanence because all of the BGRR components would be removed. Upon completion, the former BGRR Facility would be released to unrestricted access and there would be no S&M requirements.

Alternative 7 would include the removals of both the reactor pile and Building 701. The removals would provide a long-term solution for contaminated media. Fixtures and other media would not impede subsequent decommissioning or decontamination work. In addition, there would be no risk, following removal, of worker exposure to the removed contaminated media. Maintenance requirements for contaminated fixtures would not be required. Removal of contaminated fixtures would provide a permanent remedy.

4.1.4 Reduction Of Toxicity, Mobility, Or Volume

This criterion assesses the anticipated performance of the treatment technologies used within each removal action. This section discusses the anticipated performance of the proposed treatment technologies.

4.1.4.1 Alternative 1

This is the No Action Alternative and provides for the S&M only. None of the common elements would be included in this option. Some radioactive decay will occur in contaminated media over the surveillance period, however, this alternative provides no other reductions.

4.1.4.2 Alternative 2

This alternative would incorporate all of the common elements previously discussed, along with sealing the reactor pile, removal of contaminated below ground duct soils, and remediation of contaminated soils surrounding the fuel storage canal. While this alternative would reduce contamination at the site, many contaminated and activated systems would remain. There would be no reduction of contamination in those systems that remain, which include the above ground ducts, fuel canal, and Buildings 701 and 702. The soil removal would only be performed under Alternative 2 because the ducts, canal, and Canal Building would not be removed as part of this alternative. This would provide a reduction of volume for existing contaminated soils, but would not reduce the potential for contamination spreading to additional soils. Though total removal of the reactor pile is not included in this alternative, sealing of the reactor pile openings would isolate the reactor pile and reduce the mobility of radioactive elements and graphite. In this alternative, Building 702 (Reactor

Pile) would remain and be placed into safe storage (SAFESTOR), but would require continual S&M for a period of 50 years. The reduction of the spread of contamination would rely solely on S&M.

4.1.4.3 Alternative 3

This alternative and all subsequent alternatives include the following elements: removal of below ground ducts, removal of underground filters, removal of below ground primary air exhaust coolers, removal of canal, treatment houses and fuel canal up to the foundation of the Reactor Building, removal of below ground pipe and systems, decontamination and disposition of Building 701, and experimental systems removal from Building 701. There would be a permanent reduction in toxicity to the ductwork and canal system left in place in Alternative 2. However, the reduction of the spread of contamination on all remaining systems would rely solely on S&M.

4.1.4.4 Alternative 4

This decommissioning option is similar to Alternative 3 except that in addition to the experimental equipment, the following equipment and systems in Building 701 would be removed: control rod drive mechanisms, charging elevator and associated structural steel, and piping systems. The piping systems include compressed air, compressed gas, and the pneumatic tube transfer systems. This alternative would provide a permanent reduction in toxicity for these systems in Building 701.

4.1.4.5 Alternative 5

This alternative would add removing Building 701 to the 110 ft. elevation (ground level) and cocooning Building 702. This would include backfilling and sealing the ducts with concrete, decontamination of the deep pit and canal area in the Reactor Building, sealing the fuel transfer chute, sealing manways and stairwells to the deep pit, sealing the biological shield, and construction of a cocoon. The cocooning of Building 702 would reduce the mobility of contaminants from the reactor pile. The isolation of Building 703 from Building 701 would reduce the mobility of contaminants during Building 701

decommissioning activities. This alternative would provide a permanent reduction in toxicity for Building 701, but would not reduce the volume of contaminants for the reactor pile.

4.1.4.6 Alternative 6

This option calls for all of the elements of Alternative 4, and, additionally, for the removal of Building 702 while leaving Building 701 in place. This would include removal of the reactor pile, base plate, and supporting girders down to 106 ft. 9 inch elevation, the biological shield to 106 ft. 9 inch elevation, and the removal or decontamination of the underground plenums to the edge of the Reactor Building, as needed.

This alternative would further reduce volume and toxicity by eliminating the reactor pile. However, Building 701 would potentially have an increase in contamination during demolition.

4.1.4.7 Alternative 7

This alternative would call for removal of all structures associated with the BGRR to 106 ft 9 inch elevation. This alternative is the most complete and would provide the greatest reduction in toxicity and volume. However, demolition activities may lead to releases of airborne contaminants. Transportation accidents may also lead to contamination releases.

4.1.5 Short-term Effectiveness

This criterion addresses the period of time needed to achieve protection and considers any adverse impacts on human health and the environment that may be posed during the construction and implementation period until the cleanup goals are achieved.

4.1.5.1 Alternative 1

This alternative only provides S&M. None of the common elements would be included in this option. There are no short-term risks to workers for decontamination or demolition activities. However, long-term S&M activities would potentially expose S&M personnel to

contamination and external radiation risks. There would be a minimal short-term environmental impact since nothing would be disturbed or transported.

4.1.5.2 Alternative 2

This alternative would include the common elements and associated benefits detailed above and would provide for sealing of the reactor pile openings in the biological shield, removal and disposal of the below ground duct soils, and removal and disposal of the canal soils.

Transportation of hazardous waste would have a short-term risk of environmental releases during loading and actual transportation. Continual S&M for a period of 50 years would potentially expose S&M personnel to contamination and external radiation risks. Potential short term-risks to on-site workers would include undermining of structures during soils removal, construction hazards, and potential for exposure to radionuclides in soil during excavation. Short-term effects can be minimized through the appropriate radiological protection and control measures.

4.1.5.3 Alternative 3

This alternative and all subsequent alternatives include the following elements: remove below ground ducts, remove underground filters, remove below ground primary air exhaust coolers, remove canal, treatment houses and fuel canal up to the foundation of the Reactor Building, remove below ground pipe and systems, decontaminate and disposition Building 701, and remove experimental systems from Building 701.

Potential short term-risks to on-site workers would include construction hazards and the potential for exposure to radionuclides in soil during excavation. Short-term effects can be minimized through the appropriate radiological protection and control measures. Transportation of hazardous waste could have a short-term risk of environmental releases during loading and actual transportation. Continual S&M for a period of 50 years would potentially expose S&M personnel to contamination and external radiation risks.

4.1.5.4 Alternative 4

This decommissioning option is similar to Alternative 3 except that in addition to the experimental equipment, the following equipment and systems in Building 701 would be removed: control rod drive mechanisms, charging elevator and associated structural steel, and piping systems. The piping systems include compressed air, compressed gas, and the pneumatic tube transfer systems. This would eliminate S&M requirements for these items and the associated risks to S&M personnel. There would be an increased short-term risk due to transportation releases or accidents.

4.1.5.5 Alternative 5

Alternative 5 would add removal of Building 701 (to the 110 ft. elevation), sealing the biological shield, and construction of a cocoon around the reactor pile to Alternative 4. The cocooning of the reactor pile would reduce the short-term hazards to S&M personnel and potential releases to the environment from the reactor pile. There would be an increase in construction type hazards during the removal of Building 701. This alternative would introduce additional potential contamination to workers and the environment during the demolition of Building 701. There would be a progressive increase to the short-term risk from transportation environmental releases or accidents.

4.1.5.6 Alternative 6

This alternative as compared to Alternative 5, would leave Building 701 in place, and would remove the reactor pile. It would not permanently seal the biological shield to the same extent as the other alternatives because it would be removed. This alternative would result in an increase in the short-term hazard to workers and the environment during the removal of Building 702 over all other alternatives except Alternative 7 (in which the reactor pile would also be removed). Removing the reactor pile would increase the risk to workers from potential contamination releases. There would be an increase in construction type hazards during the removal of Building 702. This alternative would introduce additional potential contamination to workers and the environment during the demolition of Building 702. The weight of the graphite reactor pile would create a lifting and transportation hazard. Leaving

Building 701 intact would subject S&M personnel to potential radiological risks if the building is not fully decontaminated of all radioactivity added as a result of removing the reactor pile.

4.1.5.7 Alternative 7

Alternative 7 would create the most short-term hazards. As most systems would be removed, there is an increase in airborne contamination and thus an increase in exposures to the workers, public, and environment. All of the potential risks associated with construction, demolition and transportation would be present. This alternative would return the area to a safe condition but would produce the greatest quantity of radioactively contaminated waste material for transport and disposal. Additionally, the potential for the spread of contamination to the workers, public, and the environment would be greatest when both Buildings 701 and 702 undergo demolition. However, since the areas would be released to unrestricted access, risks to S&M personnel would be minimized over all other options.

4.1.6 Implementability

Implementability addresses the alternatives' technical and administrative feasibility. The technical feasibility of a removal action includes the availability of materials and services needed to implement a particular option, and evaluates the availability of services and materials needed to implement the alternative to maintain the removal schedule. Availability factors include personnel and technology, off-site treatment, storage and disposal, services and materials, and prospective technologies. This criterion also considers those activities needed to coordinate with other offices and agencies including statutory limits and requirements for permits and waivers. The sections below consider how easy or difficult it would be to implement the work elements.

4.1.6.1 Alternative 1

Equipment, materials, and technical expertise needed for S&M are expected to be readily available and would not impose a constraint to the implementation of this alternative. Coordination with governing agencies and subcontractors would not present significant

obstacles in the implementation of the alternative. All alternatives include S&M for items and areas that would not be removed for the next 50 years of institutional control. However, by implementing Alternative 1, the S&M would ultimately expose the structural degradation, spread of contaminants, and potential emergency response, and ultimately require the removal and disposal of materials by other alternative measures.

4.1.6.2 Alternative 2

This alternative includes the common elements that are expected to be readily feasible using current technologies, methodology, and existing work practices. Coordination with governing agencies and subcontractors would not present significant obstacles in the implementation of these common elements.

This alternative would provide sealing of the reactor pile openings in the biological shield, removal and disposal of the below ground duct soils, and removal and disposal of the canal soils. The soil removal (sub-AOC 9A and sub-AOC 9B) would only be performed under Alternative 2 because the ducts, canal, and Canal Building would not be removed as part of this alternative. Alternative 2 could be implemented using industry-standard, proven, and reliable technologies for decontamination, and overall disposal of materials. However, the removal of soils may involve undermining structures. Technical expertise may impose a constraint to alternative implementation with regards to undermining structures. Coordination with governing agencies and subcontractors would not present significant obstacles in the implementation of the alternative. However, as a part of obtaining approval from the EPA for any alternative, characterization would have to be performed for the Sub-AOCs including soils associated with the Canal House (sub-AOC 9A), below ground ducts (sub-AOC 9B), remaining soils (sub-AOC 9C) and pile fan sump (sub-AOC 9D).

4.1.6.3 Alternative 3

This alternative would add removal of the below ground ducts (WBS 3.1a), removal of underground filters (WBS 3.2), removal of below ground primary air exhaust coolers (WBS 3.3), removal of Canal and Treatment Houses and fuel canal up to the foundation of the Reactor Building (WBS 4.1a), removal of below ground pipe and systems (WBS 4.2),

decontamination and disposition of 701 (WBS 5.1a), and removal of experimental systems from Building 701 (WBS 5.3) to Alternative 2. The removal of the below ground ducts would include removal of the Instrument House. WBS 4.1a would includes the removal of the east sump, pads, storage vaults, and contaminated soils and piping in the immediate vicinity. WBS 4.2 would include the pneumatic tube trench that exits the east side of the Reactor Building and all of the enclosed piping in the trench, as well as the removal of the trench. It also includes all lines on the east side of the reactor pile that are known or suspected to be contaminated (e.g. radioactive waste lines, canal sump discharge, storm drains, etc.). This alternative would include the drain line from the irradiated material pad on the west side of the Reactor Building. WBS 5.1a would include the disposition of the building to prepare for the safe storage of the reactor pile. Alternative 3 could also be readily implemented using industry-standard, proven, and reliable technologies for removal, decontamination, and overall disposal of materials. Availability of equipment, materials, and technical expertise would not impose a constraint to alternative implementation. Coordination with governing agencies and subcontractors would not present significant obstacles in the implementation of the alternative.

4.1.6.4 Alternative 4

Alternative 4 adds removal of experimental equipment and systems from Building 701 (WBS 5.4) to Alternative 3. Alternative 4 could be readily implemented using industry-standard, proven, and reliable technologies for removal, decontamination, and overall disposal of materials. Availability of equipment, materials, and technical expertise would not impose a constraint to implementation of this alternative. Coordination with governing agencies and subcontractors would not present significant obstacles in the implementation of the alternative.

4.1.6.5 Alternative 5

This alternative adds the removal of 701 and cocooning 702 (WBS 5.1b), and "Do not Seal Reactor Pile" (WBS 2.2) to Alternative 4. The removal of Building 701 and cocooning Building 702 would include the removal of the Reactor Building to the 110 ft. elevation

(ground level). This would include backfilling and sealing the inlet ducts with concrete, decontamination of the deep pit and canal area in the Reactor Building, sealing the fuel transfer chute, sealing manways and stairwells to the deep pit,. sealing of biological shield, and construction of a cocoon. Alternative 5 could also be readily implemented using industry-standard, proven, and reliable technologies for removal, decontamination, and overall disposal of materials. Availability of equipment, materials, and technical expertise would not impose a constraint to implementation of this alternative. Coordination with governing agencies and subcontractors would not present significant obstacles in the implementation of the alternative.

4.1.6.6 Alternative 6

This alternative would add removal of reactor pile (WBS 5.2), and "Do not remove Building 701" and "Do not cocoon Building 702" (WBS 5.1b) to Alternative 5. The removal of the reactor pile would also include the base plate, and supporting girders down to the 106 ft 9 inch" elevation. Biological shields would be removed to the 106 ft 9 inch elevation, and the underground plenums would be removed and/or decontaminated to the edge of the Reactor Building, as needed. Alternative 6 could also be readily implemented using industry-standard, proven, and reliable technologies for removal, decontamination, and overall disposal of materials. However, the removal of the reactor pile due to graphite handling and disposal would increase the level of difficulty of the removal operations. Availability of equipment, materials, and technical expertise would not impose a constraint to alternative implementation. Coordination with governing agencies and subcontractors would not present significant obstacles in the implementation of the alternative.

4.1.6.7 Alternative 7

This alternative adds removal of Building 701 but "Do not cocoon Building 702" (WBS 5.1c) to Alternative 6. Alternative 7 is the same as Alternative 6 except that it would also include the removal of the entire Reactor Building to the 110 ft. elevation (ground level). The cocoon would not be constructed and the biological shield would not be sealed. Alternative 7 could also be readily implemented using industry-standard, proven, and

reliable technologies for removal, decontamination, and overall disposal of materials. However, the removal of the reactor pile, due to graphite handling and disposal, does increase the level of difficulty of the removal operations. Availability of equipment, materials, and technical expertise would not impose a constraint to implementation of this alternative. Coordination with governing agencies and subcontractors would not present significant obstacles in the implementation of the alternative.

4.1.7 Cost

Each removal action alternative was evaluated to determine its projected cost. The following cost items were considered:

- Direct capital costs — construction, equipment and material, land and site acquisition, buildings and services, relocation, transportation and disposal, and treatment and operating costs as well as contingency allowances.
- Indirect capital costs — engineering and design expenses, legal fees and license or permit costs, and startup and breakdown costs.
- Annual costs — S&M costs, auxiliary materials and energy, disposal of residuals, monitoring costs, and support costs.

The seven alternatives were compared based on their projected costs. The costs developed for each decommissioning alternative are presented as two components: construction and S&M. A present worth cost comprised of construction and S&M was also calculated for each alternative. The project life for each alternative was assumed to be 50 years to account for DOE S&M requirements for Life Cycle Cost. The present worth costs normalize costs for each alternative so that a direct comparison in current dollars can be made. During cost calculations, every attempt was made to achieve a high level of accuracy. However, due to the scarcity of information on certain work items (especially the lack of complete characterization) simplifying assumptions were necessary for a number of cost elements. As site characterization improves, and as other information becomes available, these estimates can be refined in an EE/CA.

A summary table showing WBS elements and associated construction, S&M, and Present Worth costs for each decommissioning alternative is shown in Appendix C. A detailed cost estimate for all WBS elements is included in Appendix D.

Base construction costs have been scaled by an inflationary factor relative to the year in which 50 percent of the total construction costs have been incurred. Alternative 1 contains no construction costs. In Alternatives 2 through 4 and 5 through 7, 50 percent of the total costs are incurred at the end of years 1 and 2, respectively. As a result, construction costs have been scaled by 2.8 percent (one year's inflation) for Alternatives 2 through 4 and 5.68 percent (two years at 2.8 percent) for alternatives 5 through 7. Annual costs for S&M of contaminated structures and appurtenances which were not removed during the construction effort were assessed based upon the area of the remaining structure or appurtenance. All costs include traditional labor markups, general and administrative costs, and assumed contractor profit. Project management costs for S&M activities were assumed to be 10 percent of the total S&M cost. Management costs for the construction effort were based upon the construction duration.

Table 4-1 shows the present worth costs for each alternative using durations of S&M other than 50 years. Relative ranking of the alternatives based on the cost criterion alone does not change as the life of the project is either increased or decreased.

4.1.7.1 Alternative 1

As shown in Table 4-2, this alternative would provide for S&M activities and contains no construction costs. Costs for this No-Action Alternative are used as the baseline against which costs for other alternatives are compared.

4.1.7.2 Alternative 2

This alternative would include completion of the common WBS elements and removal of contaminated soil in the vicinity of the fuel canal and below ground ducts. As shown in Table 4-3, performing these work items would reduce the estimated S&M costs by approximately 40 percent versus the No Action Alternative for a similar present worth cost.

Table 4-1

Alternative Costs Using Varying S&M durations (in millions)

	Decommissioning Alternative						
S&M Duration (years)	**1**	**2**	**3**	**4**	**5**	**6**	**7**
5	$3.5	$14.7	$41.2	$42.8	$51.4	$75.1	$81.0
10	$6.6	$16.5	$42.2	$43.8	$51.6	$75.5	$81.0
20	$11.6	$19.4	$43.9	$45.4	$52.0	$76.3	$81.0
25	$13.7	$20.6	$44.5	$46.0	$52.2	$76.7	$81.0
30	$15.5	$21.6	$45.1	$46.6	$52.3	$76.9	$81.0
40	$18.3	$23.3	$46.1	$47.5	$52.5	$77.4	$81.0
50	$20.5	$24.5	$46.8	$48.2	$52.7	$77.7	$81.0
75	$24.0	$26.5	$48.0	$49.2	$53.0	$78.3	$81.0
100	$25.7	$27.5	$48.5	$49.8	$53.1	$78.5	$81.0

Table 4-2

Alternative 1 Cost Breakdown

Component	**Cost ($1M)**
Construction	$0
S&M	$0.80/year
Present Worth	$20.5

Table 4-3

Alternative 2 Cost Breakdown

Component	**Cost ($1M)**
Construction	$12.7
S&M	$0.40/year
Present Worth	$24.5

4.1.7.3 Alternative 3

This alternative would add complete removal of the below ground ducts and soils, above ground ducts, air coolers, filters, fuel canal/soils, below ground piping and systems, disposition of Building 701, and removal of experimental equipment. As shown in Table 4-4, the additional removal would add significantly to the construction costs but also reduces the S&M costs by about 40 percent over that of Alternative 2. As a result, the present worth cost for this alternative is about twice that of Alternative 2.

4.1.7.4 Alternative 4

This alternative would add removal of equipment and systems. As shown in Table 4-5, the additional construction work would provide for minimal changes in construction, S&M, and present worth costs over costs incurred in Alternative 3.

Table 4-4

Alternative 3 Cost Breakdown

Component	Cost ($1M)
Construction	$40
S&M	$0.30/year
Present Worth	$46.8

Table 4-5

Alternative 4 Cost Breakdown

Component	Cost ($1M)
Construction	$41.7
S&M	$0.20/year
Present Worth	$48.2

4.1.7.5 Alternative 5

In addition to work performed in Alternative 4, this alternative would add removal of Building 701 and construction of a cocoon around Building 702. As shown in Table 4-6, performing these work items significantly reduces the S&M requirements but increases the construction costs by about 20 percent. Because of the reduced S&M requirements, the present worth costs (over 50 years) would increase only slightly over those in Alternative 4.

Table 4-6

Alternative 5 Cost Breakdown

Component	Cost ($1M)
Construction	$51.1
S&M	$0.10/year
Present Worth	$52.7

4.1.7.6 Alternative 6

This alternative would include all of the WBS elements contained in Alternative 4 and would additionally include removal of Building 702, leaving Building 701 in place. As shown Table 4-7 and detailed in the cost summary sheet (Appendix C), the removal of Building 702 would increase the construction costs significantly. In addition, the construction schedule is also extended. S&M costs for remaining fixtures would decrease by about 30 percent from Alternative 4, but would not be as low as Alternative 5 because Building 701 must be maintained over the S&M period.

Table 4-7

Alternative 6 Cost Breakdown

Component	Cost ($1M)
Construction	$74.5
S&M	$0.10/year
Present Worth	$77.7

4.1.7.7 Alternative 7

Decommissioning Alternative 7 would provide for the complete removal of all contaminated structures and appurtenances and would require negligible S&M. As shown in Table 4-8, all of the costs associated with this alternative would be construction-related.

Table 4-8

Alternative 7 Cost Breakdown

Component	Cost ($1M)
Construction	$81
S&M	$0.0/year
Present Worth	$81

4.1.8 State Regulatory Acceptance

This criterion indicates whether the State agencies having jurisdiction concur, oppose, or have no comment on the proposed alternative. An interagency agreement, in accordance with CERCLA, includes DOE, the EPA, and NYSDEC and has been in place since May 1992. The agreement sets forth a framework for site characterization and cleanup. Contaminated areas and facilities at BNL have been prioritized for cleanup activities and placed into operable units. The BGRR area is Area of Concern 9. There are four sub -AOCs that the regulators have agreed to: 1) Sub-AOC 9A - BGRR Canal; 2) Sub-AOC 9B - Underground Duct Work; 3) Sub-AOC 9C - Spill Sites Associated with the East Yard; and 4) Sub-AOC 9D - Pile Fan Sump.

The Brookhaven Executive Roundtable (BER), which includes regulators, elected officials, and business and community members, provides a forum for bi-monthly discussion of issues. The status of the BGRR Removal Action Alternatives Study would be a topic of discussion.

As additional BER and community discussions take place, information concerning the State's position concerning the proposed alternatives would be better understood. This

Removal Action Alternatives Study would be provided to the State to be used as an information tool in assisting them in the evaluating the alternatives.

4.1.9 Community Acceptance

This criterion considers the acceptance of the proposed alternative by the community, based upon the community values discussed in Subsection 4.3. DOE and BNL conducted three roundtable meetings on July 27 and 28, and August 3, 1999. The subject of the meetings was the decommissioning of the BGRR. A draft report summarizing the meetings was issued in August 1999. Overall, there appears to be a high level of community interest in the Decommissioning Project.

4.2 NEPA VALUES/RESOURCE IMPACTS

In addition to the nine CERCLA criteria (40 CFR 300.430(e)(2)(iii)), specific environmental resources and NEPA values are considered during the selection of alternatives. Environmental resources and NEPA values were evaluated for each of the removal action alternatives. Several of the CERCLA evaluation criteria involve consideration of environmental resources, but the emphasis is frequently directed at the potential effects of contaminants on living organisms. Environmental resources in the NEPA context also include consideration of potential effects on resources during decommissioning such as transportation, air quality, socioeconomic and visual resources. In addition, the NEPA process also considers several issues, such as the potential impacts from accidents, indirect and direct cumulative impacts, the irreversible and irretrievable commitment of resources, and the actions that may be taken to avoid or mitigate environmental impacts. The NEPA-related resources and issues for each alternative are described in subsequent sections.

4.2.1 Transportation Impacts

The proposed decommissioning alternatives are not expected to create any long-term negative transportation impacts. If adverse impacts from transportation are detected, decommissioning activities would be modified or halted until the impact is mitigated. Commercial shipping, by rail or barge, is a means of transportation that is being investigated

to eliminate any potential problems associated with transport of materials through the populated metropolitan areas of New York.

Alternative 1 (No Action) would not affect transportation and would not require the transportation of any equipment, construction materials, or waste. Commuter traffic flow would not increase or decrease.

Alternatives 2, 3, 4, 5, 6, and 7 would require transport of equipment, construction materials (both contaminated and non-contaminated), and solid waste that could result in transportation impacts. Transportation routes through heavily-populated areas of Long Island and through New York City would be the largest concern to be addressed. Commercial shipping by rail or barge is a transportation means that is being investigated as a means to mitigate some of the issues of transporting hazardous/radioactive contaminated materials through these populated metropolitan areas.

Alternatives 2, 3, 4, 5, and 6 would have similar impacts to transportation from construction-related and commuter (worker) traffic flow. Alternative 7 would have a greater impact from construction-related traffic and may impact commuter flow. This is because of the greater volume of waste to be transported from the site and increased number of workers needed to complete the actions identified in this alternative.

4.2.2 Ecological Impacts

Alternative 1, 2, 3, 4 would have no impact on the existing natural resource conditions.

Alternatives 5, 6, and 7 would also have no impact on existing natural resources. However, these alternatives require the removal of buildings and subsequently would increase the amount of available open land. Currently, these alternatives do not include revegetation or other habitat enhancement activities. Without revegetation activities, the site would not return to its native (e.g., grasses, shrubs, woodlands) condition.

4.2.3 Air Quality Impacts

The proposed alternatives are not expected to cause long-term negative impacts to the existing air quality.

Alternative 1 would have no impact to short-term or long-term air quality in that no changes would be made to the present facilities and surveillance and monitoring would continue.

Alternatives 2, 3, 4, 5, 6, and 7 could have short-term air impacts during the removal of equipment and/or the demolition of structures. Dust suppression controls would be established during removal and demolition activities to reduce or eliminate any airborne release of contaminants. Ambient noise monitoring would be performed in other impacted areas of BNL during decommissioning activities. Where necessary, noise reduction measures such as relocation of staff would be implemented.

4.2.4 Cultural Resources

Alternatives 1 and 2, would not impact any cultural resources as Buildings 701 and 702 and their associated equipment used historically during experiments would remain in place.

Alternatives 3, 4, 5, 6, and 7 would impact Buildings 701 and 702 and their associated experimental equipment. Alternatives 3 and 4 require that some of the experimental equipment be removed from Buildings 701 and 702. Alternatives 5, 6, and 7 require that experimental equipment, as well as structural aspects of Buildings 701 and 702 be removed.

Mitigation measures to preserve the cultural and historical significance pertaining to the BGRR have been developed and have been submitted to the NY SHPO in a draft Memorandum of Agreement pursuant to 36 CFR 800.6(b)(1)(iv). This memorandum of agreement outlines DOE's intent to preserve the cultural and historical value of the BGRR Facility through mitigation measures. These measures include the development of both written (e.g., interviews with retired experts, documentation of activities) and visual (e.g., video, interactive CD, photographs) archives which would be made available to the public in the BNL Research Library and would be available for public interpretation through loan or assignment.

4.2.5 Socioeconomic Impacts

Alternative 1 would not impact socioeconomics because S&M activities would continue with no change to the workforce or population.

Alternatives 2, 3, 4 would have minimal impacts to the local socioeconomics. Additional employment requirements for removal operations would be minimal and short-term.

Alternatives 5, 6, and 7 would still have minimal impacts to the local socioeconomics, but would require a larger workforce over a longer period of time.

4.2.6 Noise and Visual Resource Impacts

No long-term noise impacts are anticipated from any of the decommissioning alternatives. Short-term noise impacts would occur during any equipment removal (Alternatives 2, 3, 4, 5, 6, and 7) or demolition of structures (Alternatives 5, 6, and 7) from increased construction noises and transportation noises associated with removal of waste. During any equipment removal or demolition activities, hearing protection would be worn by workers, per OSHA requirements. Noise levels would return to site background levels following the decommissioning actions. Ambient noise monitoring would be performed in other impacted areas of BNL during decommissioning actions. Where necessary, noise reduction measures, such as relocation of staff, would be implemented.

Alternatives 1, 2, 3, and 4 would have no impact on the visual resources of the Brookhaven site. However, Alternatives 5, 6, and 7 would change the visual resources by the removal of Buildings 701, and/or 702. The removal of these buildings would have long-term impacts on the visual resources of the site.

4.2.7 Irreversible and Irretrievable Commitment of Resources

All of the alternatives would have no irreversible and irretrievable commitment of resources because they would not consume natural or depleted raw materials or fuel, and would not require the taking of additional lands for construction or waste management purposes.

4.2.8 Direct and Indirect Cumulative Impacts

Alternative 1 would not have direct or indirect cumulative impacts because no changes to the current surveillance and maintenance activities would take place.

Alternatives 2, 3, 4, 5, 6, and 7 would have positive cumulative impacts to the overall cleanup actions taking place on the BNL site. Potential sources of contamination to workers, air and groundwater would be removed under these alternatives. Cumulatively this would add to the overall goal of reducing risk/impacts to the human environment.

4.2.9 Environmental Justice

Based on existing information, none of the alternatives would have environmental justice impacts because there would be no substantial economic or health impacts to any potentially affected populations. Therefore, there would be no disproportionate adverse impacts to either low-income or minority populations.

4.3 COMMUNITY VALUES

The public meetings, discussed in Subsection 4.1.9 resulted in the development of issues which are of importance to the community members into a list of community values. The community values, which are included in the sections which follow, fall into the following groups:

- Environmental safety and health
- Waste management, transportation, and disposal
- Cost and schedule
- Future land use
- Cultural and historic resources
- Local economy/employment
- Communication and trust

All of the issues identified, with the exception of "cost and schedule" and "communication and trust," would also be considered NEPA values and will be addressed in greater detail in Subsection 4.1 and Appendix A. The cost and schedule, in relation to the alternatives, are discussed in Subsection 4.1.7. Communication and trust are issues that are BNL-wide, and

won't necessarily influence the choice of alternatives. The evaluation of the alternatives with respect to these values is included in the corresponding CERCLA or NEPA Section, where applicable. Additional input from the community will be received during the course of the CERCLA process.

The following are the community values that were established at the Roundtable Meetings.

4.3.1 Environmental Safety and Health

- Prevent negative impacts to public health and the environment by minimizing contaminant releases to the air, soil, and groundwater and direct exposure to hazardous substances.
- Protect workers and the public from physical, chemical, and radiological hazards.
- Include environmental assessments in project documentation and monitor for hazards as work is being done.
- Utilize qualified, experienced personnel, communicate within the project team, and coordinate with appropriate environmental, health and safety professionals and emergency response organizations to ensure overall project safety, including the safety of workers and the public.
- Achieve the established environmental clean-up goals and demonstrate that these clean-up goals are met. Exceed the established clean-up goals to the extent practicable.
- Ensure that environmental clean-up actions are effective and durable over time.

4.3.2 Waste Management, Transportation, and Disposal

- Minimize the amount of all types of waste generated in order to minimize waste management and disposal costs, transportation impacts, and the potential for environmental release.
- Maximize opportunities for recycling and reuse of materials, equipment, and structures to the extent that these practices are economically feasible and comply with environmental requirements.
- Ensure that waste management, transportation, and disposal activities on this project are efficient, safe, secure, comply with regulations and protect public health and the environment.

- When waste is transported, use the route and transportation method that has the least impact on the public.

4.3.3 Cost and Schedule

- Maximize opportunities to achieve cost efficiencies and cost savings to the extent that these practices do not adversely affect the protection of public health worker health and safety, and the environment.
- Assure that adequate funding is available and obtained so that the project can be completed in a safe, timely, and efficient manner.

4.3.4 Future Land Use

- Determine future land use issues after determining the nature and extent of contamination present.
- Consider opportunities for reuse of building and structures following clean-up to the extent that reuse is cost-efficient, safe, and reflective of DOE, laboratory, and community needs and interests.

4.3.5 Cultural and Historic Resources

- Maximize opportunities to preserve and provide public access to the historically significant aspects and educational value of the BGRR.
- Ensure that historic preservation actions do not adversely impact public health, worker safety, or environmental protection.
- Avoid demolition and removal of unique and culturally significant structures, components, and equipment to the extent that such actions are protective of public health and the environment, necessary and desirable from an historic preservation perspective, and the life cycle cost for such preservation is acceptable when compared to other mitigation measures.

4.3.6 Local Economy/ Employment

- Utilize qualified workers from the local area, including BNL employees, to the extent possible.

4.3.7 Communication and Trust

- Share information with the community in a timely and ongoing manner. Use a variety of methods to communicate this information and ensure that communications are clear, easy to understand, and straightforward. Avoid the use of technical terms and jargon.

- Provide regular, ongoing opportunities throughout the project for public involvement, information exchange, and input on project decisions.

- Demonstrate to the community that the project is being conducted in a safe and responsible manner and that community values are being considered in the decision making process.

SECTION 5

RECOMMENDED REMOVAL ACTION ALTERNATIVES

5. RECOMMENDED REMOVAL ACTION ALTERNATIVES

The seven removal action alternatives were evaluated in Section 4 with respect to CERCLA, NEPA, and community values. They are considered technically feasible and capable of protecting human health and the environment (to some degree) with the exception of Alternative 1, the No Action Alternative. Of the alternatives considered to be technically feasible, Alternatives 3 and 4 are recommended for inclusion in the next level of analysis (i.e., included in the Engineering Evaluation/Cost Analysis [EE/CA]). These alternatives address the IAG Areas of Concern (AOCs) and are the "best fit" for fully achieving the CERCLA criteria and NEPA values, achieve agreement with stakeholder values, and meet the Removal Action Objectives (RAOs) for the BGRR Decommissioning Project. Alternative 6 is also recommended for further evaluation in the EE/CA because it addresses the removal and disposition of the reactor core and biological shield wall (Building 702), as well as contamination that may be present in below-grade ducts directly under the reactor core.

Alternatives 2, 5, and 7 are not recommended for further investigation for the reasons cited below. Alternative 1, though not considered a viable option, will be retained for further study to provide a baseline against which the remaining actions will be measured, as required by CERCLA.

5.1 SUMMARY OF ALTERNATIVES ANALYSIS

Each of the criteria is reviewed, as discussed in Section 4, and given a score in this section. The score assigned to the alternative represents subjectively how well the alternative addresses the particular concern with respect to the other six alternatives being considered. The evaluations consider the RAOs. The alternatives are assigned a score from 1 to 7, which represents the alternative's effectiveness at responding to the specific criterion. A value of 7 is assigned to the alternative which most completely and effectively addresses the issue, and conversely, a score of 1 is assigned to the alternative that addresses the issue in the least complete manner. In some cases, there is no difference between two or more alternatives and therefore they each received the same value.

Alternatives 3 and 4 received the highest scores overall and Alternative 1, as expected, received the lowest. Due to the fact that the alternatives do not vary widely one from another, the scores do not vary widely either. The scores are discussed in detail in the sections that follow.

5.1.1 CERCLA Criteria

This section ranks the alternatives against one another with respect to the CERCLA criteria. The criteria are separated into the three groups discussed in Subsection 4.1.

5.1.1.1 CERCLA Threshold Criteria

Overall Protection of Human Health and the Environment is addressed to the greatest extent by the most complete removal action, Alternative 7. Overall protection is addressed the least by Alternative 1, which provides only for continued monitoring of the BGRR facility. The Alternatives in between 1 and 7 are given values that increase as the level of removal increases. Compliance with ARARs is fully addressed by Alternatives 3, 4, 5, 6, and 7, while Alternatives 1 and 2 do not address the ARARs completely.

Table 5-1

Evaluation of Alternatives Versus CERCLA Threshold Criteria

ALTERNATIVE	1	2	3	4	5	6	7
Overall protection of Human Health and the Environment	1	2	3	4	5	6	7
Compliance with ARARs	3	5	7	7	7	7	7

5.1.1.2 CERCLA Primary Balancing Criteria

Because no contaminated items would be removed, Alternative 1 does not address Long Term Effectiveness and Permanence at all. Since Alternative 2 only addresses the AOCs; it provides a minimal level of effectiveness and permanence. As the alternative number increases and the level of structure/soil/equipment removal increases, the long term effectiveness and

permanence of the action are also increased. Removal of the reactor pile in Alternatives 6 and 7 provides the most effective, most permanent solution. Success of the alternative is expected to be the same with all of the alternatives, as there is no use of innovative technologies or anything which has questionable potential successful implementation.

Although Reduction of Toxicity, Mobility, or Volume (TMV) generally refers to treatment, in the case of the BGRR decommissioning, the question is: Do the removal activities under this alternative reduce toxicity, mobility, or volume of the contamination? Alternatives 1 and 2 provide little or no reduction in TMV. Alternatives 3 through 5 provide a graduated increase in reduction of TMV at the facility, through removal of structures, soils, and appurtenances. By fully removing all components of the BGRR, Alternative 7 provides the most reduction of on-site materials. The waste materials from any alternative will be reduced to the extent possible and shipped for long-term storage to a licensed radiological waste facility.

The scores assigned to the alternatives in Short-term Effectiveness decrease as the alternative number, and hence, level of removal, increases. The site is in a controlled state at present, so any removal action will increase the short-term risks.

Implementability is affected by the level of difficulty, which increases with the alternative number. Therefore the scores reflect the increasing difficulty and reduced logistic feasibility expected as the level of complexity of the removal action increases. Of particular note is the fact that in Alternatives 5, 6, and 7, removal of the Reactor Building (5, 7) or of the reactor pile (6, 7) may impact the structural integrity of Building 703, which is slated to remain irrespective of the alternative implemented.

Capital and Annual S&M Costs and Net Present Value are discussed in detail in Subsection 4.1.7, Appendices C and D. The Capital Costs, or costs to institute each alternative, will generally be lower for the alternatives which include less removal activity. The costs over time, or S&M Costs, to continue to monitor and maintain facilities, as needed, will be higher for the items that remove the least, as the remaining items will require continued maintenance. However, the S&M costs are significantly lower than the capital costs and therefore, the final result is that capital costs are the deciding factor in ranking the alternatives.

Table 5-2

Evaluation of Alternatives Versus CERCLA Primary Balancing Criteria

ALTERNATIVE	1	2	3	4	5	6	7
Long Term Effectiveness and Permanence of the Alternative, along with the degree of certainty that the alternative will prove successful	1	2	3	4	5	6	7
Reduction of Toxicity, Mobility, or Volume through treatment	1	2	3	4	5	6	7
Short-Term Risks to public health, workers, and the environment and the time required to achieve protection	7	6	5	4	3	2	1
Ease or Difficulty of Implementing the Alternatives, including technical, administrative, and logistic feasibility	7	6	5	4	3	2	1
Capital and Annual O&M[9] Costs and Net Present Value	7	6	5	4	3	2	1

The Construction and S&M Costs and Present Worth ranking is shown in the following table which is based upon the cost normalization in Appendix C.

Table 5-3

Breakdown of Alternatives Evaluation Versus Cost

ALTERNATIVE	1	2	3	4	5	6	7
Construction	7	6	5	4	3	2	1
S&M	1	2	3	4	5	6	7
Present Worth	7	6	5	4	3	2	1

5.1.1.3 CERCLA Modifying Criteria

CERCLA State acceptance, based upon the concerns expressed in the IAG, would not be achieved by Alternative 1. Alternative 2, though it addresses the AOCs, does not satisfy the requirements of the State regulations. Alternatives 4 and 5 are considered the same with

[9] The O&M (Operation and Maintenance) costs shown in the CERCLA table are equivalent to the S&M costs referred to elsewhere in this document. O&M is a standard CERCLA term.

respect to State regulations. The higher Alternatives, 6 and 7, will address more State requirements and are, therefore, given a higher score.

The CERCLA community acceptance scores assigned to the alternatives are an interpretation of the concerns expressed by the community at the Roundtable Meetings. There are work elements in every alternative which may not be desirable to the community, such as transportation of waste materials off the site, even though the alternative provides a greater degree of contaminant removal. Transportation of waste materials off site has been an issue of concern for the community and therefore the rankings of Alternatives 6 and 7 are the lowest in this category. Additionally, the prospect of leaving the cocooned reactor pile on site while removing Building 701, under Alternative 5, is less desirable than leaving it in place, as in Alternative 2. Alternative 4 involves leaving the reactor pile sealed and in place within Building 701, enhancing receptor protection while minimizing contaminated waste transport through the community by leaving the most contaminated items intact. Therefore, this alternative would score the highest based upon community acceptance. Alternatives 2 and 3 will address the community's concerns, to a lesser extent.

Table 5-4

Evaluation of Alternatives Versus CERCLA Modifying Criteria

ALTERNATIVE	1	2	3	4	5	6	7
State Acceptance	1	3	4	5	5	6	7
Community Acceptance	3	5	6	7	4	1	2

5.1.2 NEPA Values

Each alternative is also evaluated with respect to the NEPA values, which were discussed in Subsection 4.2. NEPA values differ from CERCLA considerations in that NEPA looks at how the actions taken will impact resources, including air, transportation, and visual resources, while CERCLA looks more at the impacts of the contaminants on living organisms. The ranking of the alternatives is focussed on defining to what extent the alternative will impact the resources listed. In general, it appears that the alternatives will have little direct impact on

the resources. Transportation and socioeconomics are not impacted at all by Alternative 1 and impacted to a relatively insignificant amount by Alternatives 2 through 7. All seven alternatives will have no impact on Environmental Justice. Ecological impacts are expected to be less for Alternatives 1 through 3 and more for Alternatives 4 through 7 due to the disruption (demolition) of the contaminated structures and the potential for subsequent contaminant release.

Table 5-5

Evaluation of Alternatives Versus NEPA Values

ALTERNATIVE	1	2	3	4	5	6	7
Transportation	7	6	6	6	6	6	6
Ecological	6	6	6	6	4	4	4
Air Quality	7	5	5	5	5	5	3
Cultural Resources	6	6	6	6	2	2	2
Socioeconomics	7	5	5	5	5	5	5
Noise and Visual Resources	7	5	5	5	2	4	2
Irreversible and Irretrievable Commitment of Resources	7	7	7	7	7	7	7
Direct and Indirect Impacts	7	3	3	3	3	3	3
Environmental Justice	7	7	7	7	7	7	7

5.1.3 Community Values

The community values developed at the public meetings were discussed in Subsection 4.3. In this section, the seven decommissioning alternatives are rated with respect to how well they address each of these values. Key issues identified at the Roundtable Meetings are further outlined in the sections which follow.

5.1.3.1 Environmental Safety and Health

These values include the same issues as the CERCLA items discussed in Subsection 5.1.1. Prevention of negative impacts and the protection of workers and the public score highest when the removal consists of only that which is presently required by regulations along with

structures which are expected to be contaminated, and scores lowest where these potentially contaminated structures remain in place. The ability to monitor the work as it is being done is best served by either total removal or removal which does not require buildings to be demolished, due to the extensive characterization which will be required. Minimization of short term impacts may lead to increased long term impacts, and vice versa. Preliminary remediation goals are not met by Alternative 1, but are addressed to greater degrees as the amount of removal for the alternative increases. The same theory applies to the long-term goals. The ranking with respect to the use of qualified personnel is the same for all alternatives.

Table 5-6

Evaluation of Alternatives Versus Environmental Safety and Health Community Values

ALTERNATIVE	1	2	3	4	5	6	7
Prevent negative impacts to public health and the environment by minimizing contaminant releases to the air, soil, and groundwater and direct exposure to hazardous substances.	1	1	3	7	5	6	4
Protect workers and the public from physical, chemical, and radiological hazards.	1	1	4	5	2	3	3
Include environmental assessments in project documentation and monitor for hazards as work is being done.	2	3	6	6	5	4	7
Utilize qualified, experienced personnel, communicate within the project team, and coordinate with appropriate environmental, health and safety professionals and emergency response organizations to ensure overall project safety, including the safety of workers and the public.	5	5	5	5	5	5	5
Achieve the established environmental clean-up goals and demonstrate that these clean-up goals are met. Exceed the established clean-up goals to the extent practicable.	1	1	3	4	5	6	7
Ensure that environmental clean-up actions are effective and durable over time.	1	1	2	4	5	6	7

5.1.3.2 Waste Management, Transportation, and Disposal

These value items deal with waste management and disposal of waste materials that are removed during the decommissioning. The points assigned to each alternative for each value

item reflect the impact on each of the values by each alternative. The greater values are assigned where there is little negative impact and conversely, where a negative impact is potentially expected, the score given is lower. So, for example, in the areas of waste transport, the alternatives resulting in the least removal are assigned higher scores while the alternatives with the greater amount of removal received a lower score. Recycling and reuse score higher where buildings are left in place for reuse.

Table 5-7

Evaluation of Alternatives Versus Waste Management Transportation and Disposal Community Values

ALTERNATIVE	1	2	3	4	5	6	7
Minimize the amount of all types of waste generated in order to minimize waste management and disposal costs, transportation impacts, and the potential for environmental release.	7	6	5	4	3	2	1
Maximize opportunities for recycling and reuse of materials, equipment, and structures to the extent that these practices are economically feasible and comply with environmental requirements.	1	5	6	7	4	2	2
Ensure that waste management, transportation, and disposal activities on this project are efficient, safe, secure, comply with regulations and protect public health and the environment.	7	6	5	4	3	2	1
When waste is transported, use the route and transportation method that has the least impact on the public.	7	6	5	4	3	2	1

5.1.3.3 Cost and Schedule

These values reflect the community's concerns that cost should not be the deciding factor in selecting the alternative. However, at the same time, community members also want to ensure that the dollars spent are not wasted. The scores assigned with respect to saving money reflect the costs in Subsection 4.1.7. Funding issues will be a concern for Alternatives 5, 6, and 7. Adequate funding for these items may not be available. Items 1 through 4 will be adequately funded, for the present, however, if future removal of the reactor pile becomes a consideration in these alternatives, the scores may go down.

Table 5-8

Evaluation of Alternatives Versus Cost and Schedule Community Values

ALTERNATIVE	1	2	3	4	5	6	7
Maximize opportunities to achieve cost efficiencies and cost savings to the extent that these practices do not adversely affect the protection of public health worker health and safety, and the environment.	7	6	5	4	3	2	1
Assure that adequate funding is available and obtained so that the project can be completed in a safe, timely, and efficient manner.	7	7	7	7	1	1	1

5.1.3.4 Future Land Use

These issues deal with the potential for reuse of the BGRR areas and facilities. Future land use will vary considerably, depending upon the level of removal and characterization that will accompany such removal. The ability to fully characterize some currently inaccessible structures, such as the reactor pile, will improve the ability to base future land use on the determination of the nature and extent of contamination. The ability to base future land use on characterization will therefore be improved by increased removal. Reuse of buildings is given a lower score where the buildings are removed.

Table 5-9

Evaluation of Alternatives Versus Future Land Use Community Values

ALTERNATIVE	1	2	3	4	5	6	7
Determine future land use issues after determining the nature and extent of contamination present.	1	1	2	3	5	4	7
Consider opportunities for reuse of building and structures following clean-up to the extent that reuse is cost-efficient, safe, and reflective of DOE, Laboratory, and community needs and interests.	3	3	6	7	2	2	1

5.1.3.5 Cultural and Historic Resources

These items address the community's concern that significant historical resources may be lost by demolition of specific BGRR structures. However, conversely, the community does not

want to see the historic preservation issue become a detriment to health and safety. These issues are scored in accordance with their responsiveness. That is, if the community wants access to the historically significant structures, tearing them down results in a score of 1, while, conversely, if they don't want the historic preservation actions to impact the decision, then, removal options score higher.

Table 5-10

Evaluation of Alternatives Versus Cultural and Historic Resources Community Values

ALTERNATIVE	1	2	3	4	5	6	7
Maximize opportunities to preserve and provide public access to the historically significant aspects and educational value of the Brookhaven Graphite Research Reactor.	1	1	6	7	2	1	1
Ensure that historic preservation actions do not adversely impact public health, worker safety, or environmental protection.	5	5	6	6	7	7	7
Avoid demolition and removal of unique and culturally significant structures, components, and equipment to the extent that such actions are protective of public health and the environment, necessary and desirable from an historic preservation perspective, and the life cycle cost for such preservation is acceptable when compared to other mitigation measures.	3	5	7	7	2	1	1

5.1.3.6 Local Economy/Employment

This issue calls for the use of local workers as much as possible. Since BNL currently employs many local people, there will continue to be opportunities for these people to work on the BGRR Decommissioning Project, in accordance with their qualifications. All alternatives will practice this to the extent possible, so all alternatives scored 7 points.

Table 5-11

Evaluation of Alternatives Versus Local Economy/Employment Community Values

ALTERNATIVE	1	2	3	4	5	6	7
Utilize qualified workers from the local area, including BNL employees, to the extent possible.	7	7	7	7	7	7	7

5.1.3.7 Communication and Trust

These values reflect the community members' desire to be kept abreast of decision-making processes at BNL. BNL has involved the community in this project from the start and plans to continue to keep the community informed and fully involved in the decisions made. Since Alternatives 1 and 2 are predetermined, they are given lower scores with respect to community involvement.

Table 5-12

Evaluation of Alternatives Versus Communication and Trust Community Values

ALTERNATIVE	1	2	3	4	5	6	7
Share information with the community in a timely and ongoing manner. Use a variety of methods to communicate this information and ensure that communications are clear, easy to understand, and straightforward. Avoid the use of technical terms and jargon.	7	7	7	7	7	7	7
Provide regular, ongoing opportunities throughout the project for public involvement, information exchange, and input on project decisions.	5	5	7	7	7	7	7
Demonstrate to the community that the project is being conducted in a safe and responsible manner and that community values are being considered in the decision making process.	7	7	7	7	7	7	7

5.2 ALTERNATIVES ANALYSIS

In summary, all of the considerations in the preceding sections were used to analyze the alternatives. This section uses the rankings and the ability of the alternative to satisfy the provisions of the IAG to determine which alternatives should be maintained for further consideration. With respect to the rankings in Subsection 5.1, CERCLA criteria are the primary consideration, however the NEPA values are also considered, along with the community values. The basis for the recommendation to keep or drop each alternative from further consideration is summarized in Table 5-13 and in the subsections that follow.

Table 5-13

Alternatives Analysis Rankings

CERCLA REMEDIAL PROCESS								
	ALTERNATIVE	**1**	**2**	**3**	**4**	**5**	**6**	**7**
Threshold Criteria	Overall protection of Human Health and the Environment	1	2	3	4	5	6	7
	Compliance with ARARs	3	5	7	7	7	7	7
Primary Balancing Criteria	Long Term Effectiveness and Permanence of the Alternative, along with the degree of certainty that the alternative will prove successful	1	2	3	4	5	6	7
	Reduction of toxicity, mobility, or volume through treatment	1	2	3	4	5	6	7
	Short-term risks to public health, workers, and the environment and the time required to achieve protection	7	6	5	4	3	2	1
	Ease or difficulty of implementing the alternatives, including technical, administrative, and logistic feasibility	7	6	5	4	3	2	1
	Capital and Annual O&M Costs and net present Value	7	6	5	4	3	2	1
Modifying Criteria	State Acceptance	1	3	4	5	5	6	7
	Community Acceptance	3	5	6	7	4	1	2
	TOTAL	31	37	41	43	40	38	40

NEPA VALUES								
	ALTERNATIVE	**1**	**2**	**3**	**4**	**5**	**6**	**7**
NEPA Values	Transportation	7	6	6	6	6	6	6
	Ecological	6	6	6	6	4	4	4
	Air Quality	7	5	5	5	5	5	3
	Cultural Resources	6	6	6	6	2	2	2
	Socioeconomics	7	5	5	5	5	5	5
	Noise and Visual Resources	7	5	5	5	2	4	2
	Irreversible and Irretrievable Commitment of Resources	7	7	7	7	7	7	7
	Direct and Indirect Impacts	7	3	3	3	3	3	3
	Environmental Justice	7	7	7	7	7	7	7
	TOTAL	61	50	50	50	41	43	39

Table 5-13
Alternative Analysis Rankings
(Continued)

COMMUNITY VALUES								
	ALTERNATIVE	**1**	**2**	**3**	**4**	**5**	**6**	**7**
Environmental Safety and Health	Prevent negative impacts to public health and the environment by minimizing contaminant releases to the air, soil, and groundwater and direct exposure to hazardous substances.	1	1	3	7	5	6	4
	Protect workers and the public from physical, chemical, and radiological hazards.	1	1	4	5	2	3	3
	Include environmental assessments in project documentation and monitor for hazards as work is being done.	2	3	6	6	5	4	7
	Utilize qualified, experienced personnel, communicate within the project team, and coordinate with appropriate environmental, health and safety professionals and emergency response organizations to ensure overall project safety, including the safety of workers and the public.	5	5	5	5	5	5	5
	Achieve the established environmental clean-up goals and demonstrate that these clean-up goals are met. Exceed the established clean-up goals to the extent practicable.	1	1	3	4	5	6	7
	Ensure that environmental clean-up actions are effective and durable over time.	1	1	2	4	5	6	7
Waste Management, Transportation, and Disposal	Minimize the amount of all types of waste generated in order to minimize waste management and disposal costs, transportation impacts, and the potential for environmental release.	7	6	5	4	3	2	1
	Maximize opportunities for recycling and reuse of materials, equipment, and structures to the extent that these practices are economically feasible and comply with environmental requirements.	1	5	6	7	4	2	2
	Ensure that waste management, transportation, and disposal activities on this project are efficient, safe, secure, comply with regulations and protect public health and the environment.	7	6	5	4	3	2	1
	When waste is transported, use the route and transportation method that has the least impact on the public.	7	6	5	4	3	2	1
Cost and Schedule	Maximize opportunities to achieve cost efficiencies and cost savings to the extent that these practices do not adversely affect the protection of public health worker health and safety, and the environment.	7	6	5	4	3	2	1
	Assure that adequate funding is available and obtained so that the project can be completed in a safe, timely, and efficient manner.	7	7	7	7	1	1	1

Table 5-13
Alternative Analysis Rankings
(Continued)

COMMUNITY VALUES (contd.)								
	ALTERNATIVE	**1**	**2**	**3**	**4**	**5**	**6**	**7**
Future Land Use	Determine future land use issues after determining the nature and extent of contamination present.	1	1	2	3	5	4	7
	Consider opportunities for reuse of building and structures following clean-up to the extent that reuse is cost-efficient, safe, and reflective of DOE, laboratory, and community needs and interests.	3	3	6	7	2	2	1
Cultural and Historic Resources	Maximize opportunities to preserve and provide public access to the historically significant aspects and educational value of the research reactor.	1	1	6	7	2	1	1
	Ensure that historic preservation actions do not adversely impact public health, worker safety, or environmental protection.	5	5	6	6	7	7	7
	Avoid demolition and removal of unique and culturally significant structures, components, and equipment to the extent that such actions are protective of public health and the environment, necessary and desirable from an historic preservation perspective, and the life cycle cost for such preservation is acceptable when compared to other mitigation measures.	3	5	7	7	2	1	1
Local Economy/ Employment	Utilize qualified workers from the local area, including BNL employees, to the extent possible.	7	7	7	7	7	7	7
	Share information with the community in a timely and ongoing manner. Use a variety of methods to communicate this information and ensure that communications are clear, easy to understand, and straightforward. Avoid the use of technical terms and jargon.	7	7	7	7	7	7	7
	Provide regular, ongoing opportunities throughout the project for public involvement, information exchange, and input on project decisions.	5	5	7	7	7	7	7
	Demonstrate to the community that the project is being conducted in a safe and responsible manner and that community values are being considered in the decision making process.	7	7	7	7	7	7	7
	TOTAL	87	93	114	123	95	90	92

5.2.1 Alternative 1

The No Action Alternative is required by CERCLA to be included in the full analysis. It provides a baseline against which all of the alternatives can be compared. Activities which are presently in progress or already completed will be backed out of the analyses for comparison purposes (i.e., for cost comparisons, the costs associated with the common elements described previously will be removed from the No Action Cost). This alternative ranked the lowest primarily because it offers the least amount of protection of human health and the environment and compliance with the ARARs, and does not achieve the remedial action objectives. Additionally, it does not address the AOCs, which are specifically included by the IAG. This alternative did receive a high placement in the areas of implementation and minimization of short-term risks to workers, but these factors were not sufficient to make the alternative viable. This alternative scored the highest in the area of the NEPA values, but scored the worst with respect to community values. However, as stated above, because this analysis in being conducted under CERCLA, this alternative must be maintained as a baseline.

5.2.2 Alternative 2

This alternative incorporates all of the common elements previously discussed in Subsection 3.3.1, along with sealing of the reactor pile, removal of below ground duct soils, and remediation of canal soils. This alternative reduces contamination at the site and addresses the AOCs, however, it is not a permanent solution. There will be a need for long-term S&M. Additionally, contaminated equipment and systems associated with the reactor pile will remain on site. These hazardous substances may pose a potential threat to human health and the environment over the long term. This alternative ranked higher than Alternative 1 with respect to protectiveness, but not sufficiently to warrant further consideration. This alternative, with Alternatives 3 and 4 scored second highest among NEPA values, due to the limited scope of work. This alternative is not recommended for further study.

5.2.3 Alternative 3

This alternative addresses the common elements and all of the additional elements of Alternative 2, and also includes removing the above and below ground ducts, filters, coolers,

fuel canal, pipes and systems, and experimental equipment from Building 701. This alternative reduces contamination at the site, but it, too, is not a permanent solution. This alternative leaves most of the contaminated equipment and systems associated with the operation of the BGRR reactor contained inside the Building 701 structure, and therefore, the scores in reduction in toxicity, mobility, or volume are lower than those in the more complete removal actions. This alternative offers compliance with the ARARs and scored higher than Alternative 2 due to the removal of additional affected materials. This alternative scored second highest in addressing community values, and, as stated above, tied with Alternatives 2 and 4 with respect to NEPA values. Because this alternative at least partially addresses the CERCLA criteria and adequately addresses NEPA and community values at a low cost (relative to alternatives with greater levels of removal), it is suggested that this alternative be retained for additional analysis in the subsequent EE/CA phase.

5.2.4 Alternative 4

This alternative addresses all of the elements of Alternative 3, as well as removing the reactor operations equipment and systems (control rod rack mechanisms, fuel charging elevator and service elevator) which were not included for removal as part of Alternative 3. This alternative does not introduce any potential spread of contamination to the 701 Building high bay area or to any of the office space. This alternative also improves upon the protectiveness and effectiveness over the preceding alternative and received the highest ranking among the CERCLA scores for the seven alternatives. Additionally, this alternative received the best score when evaluated against the community values, and tied for second place against the NEPA Values. This alternative achieves the most protection while generating the least waste, which addresses the community's concerns with respect to waste generation and transportation. This alternative is recommended for for further analysis in the subsequent EE/CA phase.

5.2.5 Alternative 5

In addition to all of the work elements required for Alternative 4, this alternative calls for the removal of Building 701, which is presently acting as a protective cover over Building 702.

This alternative removes additional structures and reduces maintenance costs by removing Building 701, however concerns have been raised with the structural stability of Building 703 when Building 701 is removed. This alternative receives high marks for overall protection of human health and compliance with ARARs, as well as long-term effectiveness, however, this alternative received low marks for implementation, costs, and short-term risks. This alternative scored second lowest in NEPA values and third among Community values. This alternative is not recommended for retention for further consideration in the EE/CA phase, due to its low scores in NEPA and Community Values. Furthermore, the potential for operational and structural impacts to Building 703 requires further investigation.

5.2.6 Alternative 6

This alternative calls for all of the elements of Alternative 4, and, additionally, for dismantlement and removal of Building 702, the Reactor Pile, while leaving Building 701 in place for some other future re-use. This alternative will offer greater protection of human health and the environment than previous alternatives because the reactor pile and biological shield wall are fully removed under this alternative. The demolition of Building 702 increases the potential risks of short-term exposure to the public and workers. The reactor pile is constructed from small pieces of graphite that fit together like building blocks. Because of anticipated high radiation levels within the graphite reactor due to induced radiation and potential fuel residue, the graphite pile must be dismantled remotely, behind shielding, and in reverse order to maintain safety and stability during the dismantling. Additionally, dismantling and packaging the biological shield wall presents engineering and decommissioning technology challenge. This alternative, along with Alternative 7, generates a greater quantity of radioactive waste that must be packaged and safely transported to a waste disposal facility. Alternative 6 is ranked about the same as Alternative 2 in the CERCLA analysis, but at a higher cost in terms of both budget and schedule. This alternative ranked lower in the NEPA values and ranked only slightly better than the No Action Alternative in the community values summary due to the increased radioactive waste volumes. This alternative represents a scenario for removing one of the major radiological source terms from Brookhaven National Laboratory and eliminates a future environmental and waste

management legacy. For these reasons, this alternative is recommended for further evaluation in subsequent EE/CA documents.

5.2.7 Alternative 7

This alternative calls for removal of all structures associated with the BGRR. As with Alternatives 5 and 6, potential operational and structural impacts to Building 703 could result from implementation of this alternative. This alternative also eliminates any opportunity to re-use the Building 701 high-bay and office space for other Laboratory needs. This alternative would return the area to a reusable condition but will produce the greatest quantity of radioactively contaminated waste material for associated packaging, transportation and disposal. Additionally, the potential for release of the contaminated materials to external receptors is increased when Buildings 701 and 702 are demolished. This alternative, at its conclusion, achieves a minimal increase in the protectiveness of human health and the environment, and increases worker exposure during implementation. While this alternative is the most complete, it also has the highest cost. This alternative is technically feasible, though the high cost may not be justified by the marginal improvement in risk reduction. This alternative scored the lowest in the NEPA values due to the large-scale and extensive demolition efforts required. This alternative scored low in the community values area due to the large waste quantities which will be generated and require transportation. It is recommended that this alternative be dropped from further consideration because it removes a useful building, and generates large waste volumes.

5.3 ISSUES REQUIRING FURTHER EVALUATION

Several items included in the alternatives discussions will require additional information and evaluation. Among these are the following:

1. The characterization of the BGRR facility is still in progress and data gathered during the characterization can have a significant impact on the work process, scope, and cost. The items that require characterization include the following:

- Potential leakage from the Pile Fan Sump into the soil vadose zone
- The fuel processing and storage canal and canal house
- Potential leakage from the fuel canal into the soil vadose zone
- Below grade ducts, filters and cooling coils
- Potential leakage from the below-grade ducts into the vadose zone soil
- The reactor graphite pile and biological shield walls

2. Volume of contaminated soil to be removed to protect groundwater.
3. The future re-use decision for the Building 701 high-bay and office space.
4. A decision on the continued programmatic and operational use of the 703 Building has a bearing on the decision to remove the 701 Building. Removing the 701 Building has the potential for a significant operational and structural integrity impact on the 703 Building. The most cost-effective method for removing the 701 Building is to combine the demolition of both buildings into one project at the end of the Building 701 and 703 life-cycle. Should the Laboratory decide that Building 701 has no further use, the decision to exclude Alternative 7 from the EE/CA will be re-evaluated.
5. Selecting Alternative 3 or 4 will result in leaving a legacy radiological source term within the reactor graphite pile, biological shield walls and remaining exhaust air plenums under the reactor pile. DOE will be required to make a future decision for permanent disposition of these remaining elements sometime within the 50-year period of institutional control. Life-cycle costs for final disposition of Buildings 701 and 702 are not included in these alternatives. Removing the reactor pile and biological shield walls has significant worker health and safety and waste management impacts.

SECTION 6

REFERENCES

6. REFERENCES

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APPENDIX A

NEPA CONSIDERATIONS

APPENDIX A: NEPA CONSIDERATIONS

A1.0 INTRODUCTION

The National Environmental Policy Act (NEPA) was created in 1969 and is implemented by the Council on Environmental Quality (CEQ). CEQ's regulations (40 CFR 1500) provide the framework by which NEPA issues, and values are to be considered. CEQ requires that every federal agency develop their own specific regulation or implementing procedures for complying with the intent of NEPA (40 CRF 1500.2). The Department of Energy's (DOE) regulations for implementing NEPA are found in 10 CFR 1021. Included in DOE's implementing procedures are requirements for the integration, whenever possible, of NEPA and with other environmental reviews (e.g., CERCLA) (10 CFR1021.341).

It is the DOE's intent to integrate the NEPA and CERCLA process for the decommissioning and decontaminating of the Brookhaven Graphite Research Reactor (BGRR). While the CERCLA process contains elements that are also required by the NEPA process (e.g., community involvement, evaluation of alternatives, and consideration of environmental resources), NEPA requires the evaluation of impacts to the entire human environment (e.g., socioeconomics, environmental justice, utilities and infrastructure).

A1.1 RESOURCES

The following sections provide Brookhaven Site-wide information on the affected environment and where available, BGRR-specific information. The information provided references the site:

- Geology
- Hydrology
- Meteorology
- Cultural Resources
- Ecological Resources
- Visual Resources
- Noise
- Socioeconomics
- Environmental Justice

- Transportation
- Utilities

A1.1.1 Geology

The BNL site is located in the central portion of Suffolk County on Long Island, New York. Long Island is situated within the Atlantic Coastal Plain physiographic province, which is underlain by a wedge of unconsolidated sediments that thickens and dips to the southeast toward the Atlantic Ocean. These unconsolidated deposits, ranging from Late Cretaceous to recent underlie the mid-island area. Surficial Holocene deposits of soil and some swamp accumulations occur from place to place, but the principal deposits of land surface are Pleistocene in age. The unconsolidated deposits rest uncomformably on crystalline bedrock, consisting of Precambrian gneiss, which is considered to be the bottom of the groundwater reservoir on Long Island.

The unconsolidated deposits, from the land surface downward, include Glacial deposits of Pleistocene age (Glacial); the Monmouth Group and the Matawan Group – Magothy Formation (Magothy), undifferentiated, from the Late Cretaceous; and the Raritan Clay and Lloyd Sand Members of the Raritan Formation, also Late Cretaceous.

The soils at BNL are predominately coarse, sandy soils derived largely from glacial outwash materials. The soils in the area show distinct layering. Coarse gravel is often overlain by finer material. Surface deposits, which vary in texture, range from coarse Duke's sand in the north and east to finer Sassafras sandy loam in the southwest. The soil types on site, in order of increasing coarseness, are Sassafras loam, Sassafras fine sandy loam, Sassafras sandy loam, Plymouth sand loam, Duke's loamy sand, Plymouth sand, and Duke's sand. Babylon sand and meadows soil are associated with wet sites (ERDA, 1977).

A1.1.2 Hydrology

The BNL site is near the western boundary of the Manorville drainage basin. BNL forms the upper drainage area of the headwaters of the Peconic River. The surface drainage is poor in the Manorville drainage basin and accounts for much of the land near the Peconic River being swampy. East of the Manorville drainage basin, the Peconic River Valley widens and forms

the Riverhead Basin (ERDA, 1977). The Peconic River drains in an easterly direction and then flows into Flanders Bay, an arm of the Great Peconic Bay. The marshy area in the northern and eastern sections of BNL have the potential to be a principal tributary of the Peconic River. However, this tributary has been essentially dry during the 1990s. The absence of this tributary is most likely related to a regional drought lowering the water table, and to increased residential development.

The hydrology and geology in this area indicate that the uppermost Pleistocene deposits, the Upper Glacial Aquifer, have a thickness of approximately 30 m to 60 m (100 ft to 200 ft) and are primarily composed of highly permeable glacial sands and gravels.

A1.1.3 Meteorology

Weather conditions at the BNL site have been recorded since August 1948. BNL is broadly influenced by continental and maritime weather systems. Locally, the major weather systems are modified by the Long Island Sound, the Atlantic Ocean and associated bays, which influence wind directions and humidity, and provide a moderating influence on extreme summer and winter temperatures. BNL is a well-ventilated site, with an annual distribution of wind direction reflecting a predominance of westerly components. Prevailing winds are from the southwest during the summer, from the northwest during the winter, and about equally from these two directions during the spring and fall (SAIC, 1992a).

The average annual air temperature is 49.8° F. January is the coldest month with an average monthly temperature of 28.8°F; July is the warmest with an average monthly temperature of 71.6°F (BNL, 1996). Temperature extremes of 102 °F to -20 °F have been recorded. The growing season on Long Island is approximately 180 – 200 days, extending from the end of April to the end of October (USGS, 1968).

Average yearly precipitation at BNL is approximately 48.23 inches, with approximately 21 inches lost to evapotranspiration (ERDA, 1977). The greatest amount of precipitation tends to fall from November through March. Average groundwater recharge is estimated to be approximately 23 inches/year. The percentage of precipitation that becomes direct runoff (4.23), therefore, can be considered relatively small. As a result of minimal runoff,

groundwater seepage accounts for more than 95 percent of total stream flow throughout the area.

A1.1.4 Cultural Resources

The Deputy Commissioner for Historic Preservation of the New York State Office of Parks, Recreation, and Historic Preservation issued a determination on April 2, 1991, stating that the Reactor Building (Building 701) was one of three areas of the site considered eligible for preservation activities (BNL, 1995). In compliance with the National Historic Preservation Act, specifically Section 106 and its implementing regulations 36 CFR 800, DOE has evaluated the National Register eligibility of the BGRR complex, and identified the potential effects decommissioning may have on this historic property. Informational drafts of the *Request for Determination of Eligibility* and *Determination of Effects Finding* were provided to the SHPO in September 1999. In addition, DOE has provided to the SHPO a draft Memorandum of Agreement (MOA) (pursuant to 36 CFR 800.6(b)(1)(iv)) as the first step in reaching an accord on those measures which will adequately mitigate the effects of decommissioning. Mitigation measures to preserve the cultural and historical significance pertaining to the BGRR have been developed and have been submitted to the SHPO in a draft MOA. These measures include the development of both written (e.g., interviews with retired experts, documentation of activities) and visual (e.g., video, interactive CD, photographs) archives which would be made available to the public in the BNL Research Library and would be available for public interpretation through loan or assignment. It is DOE's intent to adopt measures that ensure mitigation of the maximum potential impacts up to and including demolition of facilities. DOE is seeking creative and public-oriented mitigative measures in accordance with recent guidance from the Advisory Council on Historic Preservation.

A1.1.5 Ecological Resources

A total of 15 ecological communities have been identified on or within 0.8 km (0.5 mi.) of the BNL property (LMS, 1995). The communities were classified according to the dominant vegetation and the habitat each provides using the ecological classification system developed

for New York State (Reschke, 1990.) The dominant ecological community is shared by pine/oak forest and deciduous forest.

A1.1.5.1 Terrestrial

Pine Plantations: Pine plantations, consisting of pine monocultures or mixtures of deciduous and coniferous species, are scattered throughout the site. The tree stands, composed of red pine (10 to 20 percent) and white pine (80 to 90 percent), are estimated to be approximately 60 years of age. Most of the trees are 12 m to 18 m (40 ft to 60 ft) tall and form a dense evergreen canopy, resulting in a sparse or absent shrub and ground cover layer. The scarce food supply offered by the pine plantation habitat limits wildlife use. Several large nests observed in the pines were probably used by American crows that were observed roosting in the plantations.

Moderately Mature Pitch Pine/Oak Forest: Located in the southern and northeastern portions of the BNL site, these forests consist chiefly of a coniferous open forest of pitch pine with scattered fire cherry, black locust, red pine, and oaks. The shrub layer is dominated by huckleberry and lowbush blueberry. Trees in the overstory are 7.5 m to 12 m (25 ft to 40 ft) in height, with diameters of 20 cm to 25 cm (8 in to 10 in) with no evidence of fire damage. The understory varies from sparse to very dense, depending on the density of the overhead tree canopy. This was the most common habitat on BNL and within the study area, based on estimated extent. The greatest number and diversity of wildlife species of any of the communities has been observed in the pitch pine/oak community. White-tailed deer, gray squirrel, cottontail, and chipmunk were common. Birds sighted included blue jay, downy and hairy woodpeckers, northern orioles, mourning dove, gray catbird, rufous-sided towhee, and warblers.

Predominantly Deciduous Forest: The predominantly deciduous forest community was the second largest ecological community identified on the site and within the study area. Dominant trees are generally 6 m to 12 m (20 ft to 40 ft) in height and 15 cm to 20 cm (6 in to 8 in) in diameter, while the remaining pitch pines are 25 cm to 41 cm (10 in to 16 in) in diameter. The ground cover consists of a sparse mixture of poverty grass, orchard grass, bracken fern, witchgrass, and fall panicum. Coralberry is a common shrub in the southern

portion of the site, particularly along wooded roadsides. Several specimens of American chestnut were found in this community. A variety of birds use the deciduous forest as a resting and feeding area; bird species observed include cedar waxwing, blue jay, northern cardinal, American goldfinch, northern mockingbird, and gray catbird.

Disturbed/Developed Areas: Located in the central and southern parts of the BNL complex, including the BGRR site, these areas include buildings, paved areas, fuel tanks, small patches of forest, lawn area, and plowed, planted fields. This was the third largest community identified within the BNL study area. Due to development, human activity, and broken, discontinuous habitat, the wildlife using this community consists chiefly of species tolerant of humans. Vegetative communities are represented by lawn, shrub/sapling community, patches of predominantly deciduous forest, and plantings of nonnative grasses/crops, shrubs, and trees. Planted trees consist of Norway spruce, Norway maple, and London planetree. European starling, house sparrow, house finch, mourning dove, chimney swift, and barn swallow were observed in the developed portions of the site.

A1.1.5.2 Wetlands

Palustrine Forested Wetlands: Extensive forested wetlands mapped by NYSDEC and National Wetland Inventory (NWI) are found in the northern and eastern areas of the site. These wetlands are identified by NWI as "PFO1C" (palustrine forested, broad-leaved deciduous, seasonally flooded) or "PFO1E" (palustrine forested, broad-leaved deciduous, seasonally flooded/saturated). Palustrine wetlands include all nontidal wetlands dominated by trees, shrubs, and persistent emergents. These areas have a canopy of red maple and gray birch, a shrub layer of swamp azalea and pepperbush, and a ground cover of moss, sedges, and rushes. Wildlife species observed included white-tailed deer, downy woodpecker, American robin, scarlet tanager, black-capped chickadee, and tufted titmouse.

Herbaceous Wetlands: These wetlands, present on the northern portion of BNL and associated with the headwaters of the Peconic River, are generally found where a prolonged period of inundation or saturation prevents growth of a forested or shrub community. This wetland type is identified on the NWI maps as "PEM1E" (palustrine emergent, persistent, seasonally flooded/saturated). Observed plant species include sedges, rushes, smartweed,

swamp loosestrife, and common reed. The dense cover afforded by the common reed and cattail stands may provide nesting habitat for some bird species, such as the red-winged blackbird and field sparrow. Wildlife observed in herbaceous wetlands include raccoon (tracks), black-capped chickadee, red-breasted nuthatch, field sparrow, and white-throated sparrow.

A1.1.5.3 Aquatic Resources

Coastal Plain Ponds: The eleven ponds found in the northern portion of BNL and within the study area are naturally occurring ponds with permanent standing water (associated with the Peconic watershed) or manufactured ponds within the RHIC particle accelerator ring. Virtually all of the ponds were less than 2 ha (5 acres) in size, circular in shape, without a defined inlet or outlet, shallow (0.6 m – 1.2 m [2 ft – 4 ft] deep), and with a dense substrate of organic ooze and fallen leaves. Seven of the coastal plain ponds are recognized as wetlands by NWI and mapped as "POWF" (palustrine open water, semipermanently flooded), "POWZ" (palustrine open water, intermittently exposed), or "POWH" (palustrine open water, permanently flooded). Aquatic vegetation commonly observed in these ponds includes coontail, duckweed, watershield, pondweeds, and white water lily. Waterfowl observed in the ponds includes Canada goose, wood duck, mallard, and greenwinged teal. Characteristic fish species for coastal plain ponds are chain pickerel and banded sunfish (Reschke, 1990). Golden shiner, goldfish, mummichog, banded sunfish, pumpkinseeds, and brown bullhead were found in coastal plain ponds in the 1994 fish survey (LMS, 1995).

Coastal Plain Streams: This ecological community is found throughout the north-south drainage of the Peconic River basin to Horn Pond (east of the site). NWI maps these coastal plain streams as "R20WH" (riverine, lower perennial, open water, permanent). These riverine wetlands are regulated concurrently by the U.S. Army Corps of Engineers (COE) and NYSDEC. Coastal plain streams are low-gradient, low-velocity, slightly acidic waters with a moderate-to-dense growth of aquatic vegetation. Common aquatic plants include pondweeds, water-starwort, spiked bur-reed, duckweed, and bladderwort. The dense aquatic growth provides cover for fish and invertebrates and forage for mammals such as muskrat and white-tailed deer. Most of the stream channel is moderately to heavily shaded by a tree canopy of

red maple and black gum. Streamflows are heavily influenced by groundwater level, with infiltration into the streambed from groundwater during periods of high rainfall and absorption of streamflow into the streambed during periods of low rainfall. Characteristic fishes expected in this habitat include American eel, redfin pickerel, eastern banded killifish, pumpkinseed, banded sunfish, and swamp darter (Reschke, 1990). Painted turtles, snapping turtles, a stinkpot, and green frogs were observed in the stream during the site surveys.

A1.1.5.4 Threatened and Endangered Species

Various State and Federally protected wildlife species were observed on BNL in 1994, including eastern tiger salamander (State endangered), osprey (State threatened), and common nighthawk, eastern bluebird, spotted turtle, spotted salamander, banded sunfish, and eastern hognose snake (special concern species). Onsite breeding areas were confirmed for the tiger salamander during a species-specific study (LMS, 1995).

Five plant species and eight fern species found on BNL are classified as protected plants under New York State law. The plant species found were the butterflyweed, spotted wintergreen, lady's slipper, bayberry, and flowering dogwood. The eight species of protected ferns found were hayscented fern, shield fern, sensitive fern, cinnamon fern, Clayton's fern, royal fern, marsh fern, and Virginia chain fern (LMS, 1995). In addition, one protected plant species, drowned horned rush, is reported by the Natural Heritage Program to occur in the site vicinity but has not been identified onsite (NYSDEC, 1998).

A1.1.6 Visual Resources

The Town of Brookhaven contains many significant environmental features that represent visual resources and are an integral part of the town's quality-of-life resources. Included among the visual resources are roads, bridges, government buildings, communication towers, houses, commercial and industrial areas, parks, farms, schools, and hospitals. In addition, visual resources include environmental and geologic features (such as kettleholes, moraines, glacial erratics), wetlands, rivers, freshwater ponds, and the Pine Barrens. The Town of Brookhaven is relatively flat, however there are areas of rolling terrain. Such terrain consists of glacial moraines which are found along the central and northern portions of the town. The

two major moraines are the Harbor Hill moraine, located along the north shore, and the Ronkonkoma moraine which runs through the center of the town (TOB, 1996). Wetlands provide a habitat for breeding and nursery grounds for wildlife and are found throughout the Town of Brookhaven, primarily along river beds such as the Carmans, Forge, and Peconic River systems (TOB, 1996).

BNL lies in a section of the Oak-Chestnut Forest Region known as the Atlantic Coastal Plain Physiographic Province. The site is on the west rim of the shallow Peconic River watershed, which is bordered by two lines of low hills which extend east and west nearly the full length of Long Island. The terrain within BNL is gently rolling, with elevations varying between 13 m and 37 m (44 ft and 120 ft) above sea level (BNL, 1995).

The BNL property line is bordered by indigenous evergreen trees having a dark green dense texture which visually isolates BNL from the surrounding communities. Within BNL, landforms include roads, flat to rolling topography, closed landfills, grass fields, and landscape features. Structural features include a research campus-like setting with laboratories, research facilities, hospital, housing, gas station, recreational facilities, offices, and parking lots. A visual landmark on the BNL site is Building 701 and the BGRR/HFBR exhaust stack. The exhaust stack is recognized as the highest point on the BNL site and can be seen from almost anywhere on the site. Spatially, BGRR facility structures are centrally located within BNL with fields and dense vegetation encircling the core area.

Portions of the Peconic River, located predominantly east of BNL, are protected under the New York State *Wild, Scenic, and Recreational River Systems Act*. The dense evergreen tree buffer along the eastern property line effectively isolates BNL from the scenic values of the river offsite.

Of the approximately 2,150 ha (5,300 acres) that comprise BNL, approximately 670 ha (1,675 acres) are developed and the balance is largely wooded. The site contains fresh water ponds, wetlands, the headwaters of the Peconic River, and forested areas comprising the Pine Barrens. The BGRR is located within the developed portion of the site (BNL, 1995).

A1.1.7 Noise levels

The major noise sources for the region are those related to transportation. There are three major airports serving Long Island. Long Island Islip MacArthur Airport, located in Ronkonkoma in the central portion of Long Island, offers scheduled flights through nine airlines. Over a million passengers pass through the 560 ha (1,400 acre) airport annually. Just over the Nassau County border in adjacent Queens County are JFK International and LaGuardia Airports. Four additional airports located on Long Island feature full-service fixed-based operators and also serve executive and privately owned planes. They are Republic Airport in East Farmingdale, Francis S. Gabreski Airport in Westhampton Beach, Brookhaven Calabro Airport in Shirley, and East Hampton Airport.

Other sources of noise include the three major express routes that run east and west through Long Island. The Long Island Expressway (LIE) (Interstate Route 495) runs from New York City to Riverhead and is adjacent to the southern boundary of the site. The Northern State Parkway runs from Queens to Hauppauge and the Southern State Parkway runs from Brooklyn and Queens to Oakdale.

The Long Island Railroad (LIRR), the nation's largest commuter railroad, operates 740 passenger trains daily on three major east-west routes from New York City along the entire length of the Nassau-Suffolk County region. With over 1,100 passenger cars and approximately 1,130 km (700 mi.) of track, the LIRR services 134 stations in communities throughout Long Island and carries over a quarter million passengers daily. The mid-island route of the LIRR is located along the southern boundary of the site.

In addition there are noises associated with industrial facilities and residential and commercial construction surrounding the BNL site. On the BNL site are also noises associated with daily operations. Noise generated from the proposed alternatives would most likely not propagate off of the site at audible levels much greater than those in the surrounding BNL area. The BGRR is located near the center of the site, and there is a large amount of wooded area near the BNL boundaries that creates a barrier to reduce noise. The closest sensitive receptors to the site boundary would be residences located approximately 1.3 miles to the west.

A1.1.8 Socioeconomics

Employment: BNL exerts an important influence on the regional economy. During Fiscal Year 1998, BNL employed approximately 3,100 permanent workers. In addition, BNL hosts an additional 3,200 temporary workers, primarily visiting scientists (BNL, 1995). BNL's permanent workforce population is projected to remain stable through the year 2000. BNL's impact on the local economy is amplified by the large proportion of high wage jobs generated by the facility. Almost 50 percent of the staff are classified as scientific, engineering, or other professional, and another 25 percent are managers or technicians. BNL has an annual budget of $400 million, and through secondary effects of BNL spending, the total effect of BNL on the Long Island economy is estimated at approximately $1 billion per year (BNL, 1995).

The BNL Region of Influence (ROI) is suburban in character, although numerous local governments have in recent years purchased farm and park lands to preserve the rural aspects of the region. The western portion of the ROI is more developed and contains a higher density of commercial and manufacturing establishments than the eastern sections of the ROI. Almost all of the region's small agricultural output is produced in Suffolk County.

Over the past decade, the regional economy has become more diversified and less dependent on defense-oriented manufacturing. Growth industries in the ROI include high-tech electronics, software development, biotechnology, biomedical instrumentation and support services, and health care information systems. The service sector is the single largest source of jobs in the ROI, providing almost 35 percent of the total employment in the region. Retail and wholesale sales, government, finance, insurance, and real estate and manufacturing are also significant contributors to ROI employment. Together, these sectors provide almost 90 percent of the total employment in the region (BEA, 1997).

Population: From 1970 to 1995, ROI population grew very slowly. From 1970 to 1980 the ROI increased from approximately 2,553,100 to 2,605,800, an increase of only 2.1 percent or an annual growth rate of 0.2 percent. During the 1980s, population growth slowed further, increasing only 0.1 percent over the entire decade, and remained slow through the beginning of the 1990s. The population growth rate has accelerated over the past few years and is

projected to increase at an annual rate of 0.3 percent through the year 2000, and 0.5 percent between 2000 and 2005.

The largest cities in the region are Hempstead and Freeport, both of which are in Nassau County, with 1996 populations of approximately 46,600 and 40,160, respectively. The largest city in Suffolk County is Lindenhurst, with a population of 26,879.

Public Schools: The ROI contains a total of 128 school districts. Suffolk County's 71 school districts had an enrollment of 223,905 students during the 1995-1996 school year. Approximately 180,270 students were enrolled in the 57 school districts located in Nassau County. The student-teacher ratio was about 13.0:1 in Nassau County and 14.4:1 in Suffolk County (LIBN, 1997).

Law Enforcement: Law enforcement in the ROI is provided by 31 police departments that employed 6,774 sworn officers and 2,002 civilians in 1995. Nassau County and the Suffolk Police Department are the two largest law enforcement agencies in the area, and together employ 85 percent of the police officers in the ROI. The other police departments in the ROI are operated by municipalities and range in size from one employee (one officer) in Greenport Town, Suffolk County to 122 employees (95 officers) in Hempstead Village, Nassau County (DOJ, 1996).

BNL maintains its own security force to provide site-wide protection against theft, sabotage, vandalism, and terrorism. The force, which numbers over 50 employees, are highly trained and are on duty at all times. The protective force is also trained to respond to and provide assistance during National disasters such as fires, floods, and radiological and toxicological accidents.

Fire Protection: Suffolk County is served by 110 volunteer fire departments and 30 volunteer ambulance corps, which answered 132,024 emergency calls in 1996. The Suffolk County Department of Fire, Rescue and Emergency Services operates a county-wide fire rescue dispatch center, which is staffed by 31 emergency services dispatchers, six shift supervisors, and one chief of communications. Nassau County has 71 fire districts with fire-fighting capacity and emergency response services. In addition, BNL has its own Fire/Rescue group

that provides fire-fighting and emergency medical services to the facility and its onsite personnel. The BNL Fire/Rescue Group is a full-time paid department staffed with five firefighters and one officer per shift (BNL, 1997). The BNL Fire/Rescue Group owns two pump trucks and one rescue vehicle. Finally, Suffolk County, which surrounds BNL, has developed emergency plans to be implemented in the event of a hazardous materials emergency. Each emergency plan identifies facilities with extremely hazardous substances and defines transportation routes for these substances. The emergency plans also include procedures for notification and response, listings of emergency equipment and facilities, evacuation routes, and training programs.

Medical Services: The ROI contains 27 hospitals with a capacity of 11,457 beds (AHA, 1996). About 56 percent of the hospital beds are in Nassau County and 44 percent in Suffolk County. The Nassau County Medical Center with 1,384 beds, and the North Shore University Hospital, also in Nassau County with 958 beds, are the two largest hospitals in the ROI. The largest medical facility in Suffolk County is a Veterans Hospital. The Good Samaritan Hospital Center with a total of 525 beds is the largest general admission hospital in Suffolk County. During 1995, these hospitals had a bed occupancy rate of approximately 80 percent.

BNL also has an onsite occupational medicine clinic, which provides routine employee health services. For emergencies, BNL relies on Emergency Medical Technicians associated with the Fire and Rescue Department. Patients are transported to one of several local hospitals. In addition, BNL has access to the Suffolk County Police MEDIVAC helicopter, which is designated to go to the University Hospital at State University of New York, Stony Brook.

Environmental Justice: The ROI contains a relatively small racial minority population. In 1990, the ROI population was 88.4 percent white compared to 74 percent for the State of New York. African-Americans comprised 7.4 percent of the population compared to 15.9 percent for the State. Other minority groups comprise less than 5 percent of the total population of the ROI and 11 percent of the State population. Persons of Hispanic ethnicity accounted for 6.3 percent of the ROI residents and 12.3 percent of State residents. Finally, the ROI is relatively affluent with only 4.2 percent of the population living below the poverty level

(defined in 1990 as income less than $13,359 for a family of four) compared to 13 percent of all residents of New York. There are no identified Tribal areas or concentrated low-income or minority populations in the census tracts immediately surrounding the BGRR.

Transportation: Traffic associated with each alternative, on a regional basis, focuses on two major roadways: the LIE and the William Floyd Parkway. The LIE runs east-west through the center of Long Island connecting Riverhead to New York City. BNL is located just north of Exit 68 on the LIE. Along the LIE, BNL is approximately 100 km (60 mi.) from New York City and 23 km (14 mi.) from Riverhead. The William Floyd Parkway traverses north-south across Long Island connecting Wading River to Smith Point County Park at the Fire Island National Seashore. BNL is located approximately 6 km (4 mi.) south of Wading River and 16 km (10 mi.) north of Smith Point County Park, along the east side of the William Floyd Parkway.

In 1996, the Town of Brookhaven prepared the *1996 (100 Day) Land Use Plan* that included traffic data (SECE, 1996). Traffic data supplied by the Town of Brookhaven over a 100-day period demonstrated that the average daily traffic volume (two ways) is 61,500 vehicles at Exit 68 on the LIE. The average daily traffic volume (two ways) on the William Floyd Parkway north of Exit 68 was 22,500 vehicles. Continuing north on the William Floyd Parkway, between Route 25 and 25A, average daily two-way traffic volume is reported to be about 9,600 vehicles. For comparative purposes, the Town of Brookhaven *1996 (100 Day) Land Use Transportation Plan* reports that County Road 83 (North Ocean Avenue) north of the LIE handles average daily two-way traffic of approximately 46,200 vehicles, New York State Route 112 has approximately 22,500 vehicles daily, and Route 25 between Miller Place-Coram Road and Wading River Road had approximately 30,600 vehicles travelling on it daily (SECE, 1996).

In 1998, approximately 46 trucks transported Department of Transportation specified hazardous materials (per 49 CFR 172 these would include: compressed gas, flammable liquids, radioactive materials, corrosive liquid and non-regulated hazardous materials) over the LIE either coming into or out of the BNL site. The majority of the hazardous material was compressed gas (approximately 1700 tons). Two shipments of radioactive materials were

transported from BNL totaling approximately 147 tons of radioactive material (of which 133 tons were transported to Hanford, WA for ultimate storage). (NTP, 1999).

In 1995, DOE prepared a programmatic environmental impact statement titled *Spent Nuclear Fuel Management Programmatic Environmental Impacts Statement* (SNF PEIS). In that EIS it is stated that, "No transportation related radiological fatalities have ever occurred in the U.S." (DOE, 1995a).

Utilities: The sewage system consists of approximately 50 km (30 mi.) of piping, most dating back to World War II. There is an ongoing major project to repair or replace this piping. A new sewage treatment plant with a planned 6 million liters per day (MLD) (1.5 million gallons per day [MGD]) capacity has been constructed and opened in December, 1997. This plant supplements the existing sewage treatment plant that has an 11 MLD (3 MGD) capacity (BNL, 1995).

Electricity is purchased from the New York Power Authority (NYPA), the former Long Island Lighting Company (LILCO), and the Long Island Power Authority (LIPA). The current peak demand of 54 MWe is expected to increase to 75 MWe by the year 2000 due to RHIC operation. BNL has two main substations for stepping down the power from 69 kilovolts (KV) to 13.8 KV (BNL, 1995).

Steam for site heating and other requirements is produced in a central steam facility. This facility contains four boilers with a combined capacity of approximately 180,000 kg per hour (400,000 pounds per hour) of steam. No. 6 fuel oil (approximately 19 million liters per year [5 million gal per year]) purchased from a commercial fuel supplier was the primary fuel source to fire the boilers in the past; however, a natural gas connection was recently established for this purpose. Natural gas is purchased from Brooklyn Union Gas. A reduced amount of No. 6 fuel oil (about 10 percent of past years' consumption) continues to be used (BNL, 1995).

The BGRR has been in a safe shutdown mode since 1977 (B&R, 1989) and has had minimal usage of the BNL site utilities. The only utilities used by the BGRR have been those to operate the BNL Science Museum from 1977 to 1997 and those used to conduct routine S&M

activities. Following completion of any of the proposed decommissioning activities, there would be a minimal decline in overall utility usage on the BNL site.

Additional support facilities maintained at BNL include apartments, dormitories, the guest rooms building, cottages, mobile homes, efficiency apartments, an auditorium and cafeteria facility, a child care facility, a fire house with emergency and rescue equipment, and a new 7 ha
(18 acre) state-of-the-art Waste Management Facility (WMF) to process BNL's radiological and hazardous waste (BNL, 1995). The WMF will not be utilized by the BGRR project during for any removal activities. Waste removed during the BGRR project will be transported directly off-site for storage or disposal. It has not been determined to date where the waste will be transported.

APPENDIX B

DECOMMISSIONING TECHNOLOGY APPLICATIONS

APPENDIX B – DECOMMISSIONING TECHNOLOGY APPLICATIONS

B1.0 INTRODUCTION

This appendix identifies industry standard technologies for decontaminating and decommissioning (D&D) nuclear facilities. The information in this appendix represents a synopsis of information contained in the DOE Decommissioning Handbook (DOE, 1994b). The technologies have been broadly classified as technologies associated with the following:

- Decontamination
- Equipment removal and size reduction
- Demolition

B1.1 DECONTAMINATION

Decontamination is regularly used to reduce occupational exposure, reduce the potential for the release and uptake of radioactive material, permit reuse of a component, and facilitate waste management. The decision to decontaminate should be weighed against the total dose and cost.

Decontamination techniques are primarily categorized as chemical or mechanical. Selection of the appropriate technology or technologies for a particular decontamination activity should consider the following:

- Cost
- Surface layer thickness to be removed
- Final end state of the material surface
- Decontamination aim (the purpose to reduce exposure to personnel or release for unrestricted use)
- Allow dosage level to personnel
- Amount of secondary waste generation and treatment required

B1.1.1 Chemical Decontamination Techniques

Chemical decontamination techniques use concentrated or dilute solvents in contact with contaminated surface. The advantages of chemical decontamination include the following:

- Can be used for inaccessible surfaces
- Requires fewer work hours
- Can decontaminate process equipment and piping in place
- Can usually be performed remotely
- Produces few airborne hazards
- Uses chemical agents that are readily available
- Produces wastes that can be handled remotely
- Generally allows the recycling of the wash liquors after further processing

The disadvantages of chemical decontamination include the following:

- Not usually effective on porous surfaces
- Can produce large volumes of waste
- May generate mixed wastes
- Can result in corrosion and safety problems when misapplied
- Requires different reagents for different surfaces
- Requires drainage control
- For large jobs, generally requires construction of chemical storage and collecting equipment
- Requires addressing criticality concerns, where applicable

Common reagents used for chemical decontamination include water/steam, strong mineral acids, acid salts, weak acids, alkaline salts, completing agents, oxidizing and reducing agents, detergents and surfactants, and organic solvents.

B1.1.2 Mechanical Decontamination Techniques

Mechanical decontamination techniques are physical techniques that can generally be considered as surface cleaning or surface removing. Mechanical decontamination can be used in lieu of or in conjunction with chemical decontamination, and used on any surface (which

typically achieves superior results). Mechanical decontamination processes require the work piece surface to be accessible. Crevices and corners are difficult to decontaminate using mechanical techniques. Many mechanical techniques also tend to create airborne dusts. Industry-standard mechanical decontamination techniques are briefly described in the following sections.

B1.1.2.1 Flushing with Water

This technique involves flooding a surface with hot water. The hot water dissolves the contaminants, and the resulting wastewater is pushed to a central collection area. This method is usually performed after scrubbing, especially on floors. The volume of the wastewater can also be reduced by using a water treatment system to recycle the flush water.

B1.1.2.2 Dusting, Vacuuming, Wiping, and Scrubbing

This technique refers to physical removal of dust and particles from building and equipment surfaces by using common cleaning techniques.

B1.1.2.3 Fixative/Stabilizer Coatings

Various agents can be used as coatings on contaminated residues to fur or stabilize the contaminant in place and decrease or eliminate exposure hazards. No removal of contaminants is achieved.

B1.1.2.4 Turbulator

A turbulator is a large tank with propellers that direct the flow of a cleaning solution across a component.

B1.1.2.5 Metal-Based Paint Removal

Metals such as lead, cadmium, chromium, and mercury have been used as ingredients in paints used to coat the interior surfaces of buildings. In some instances, these paints (especially lead) may still be used to coat piping and other metallic structures or components.

If decontamination of any such surface is required, use of paint- removal techniques could be used.

B1.1.2.6 Strippable

The use of a strippable coating involves the application of a polymer mixture to a contaminated surface. As the polymer reacts, the contaminants are stabilized, becoming entrained in the polymer. In general, the contaminated layer is pulled off, containerized, and disposed.

B1.1.2.7 Steam Cleaning

Steam cleaning physically extracts contaminants from buildings and equipment surfaces. The steam is applied using hand-held wands or automated systems, and condensate is collected for treatment.

B1.1.2.8 Sponge Blasting

This technique was originally developed for the painting industry as a surface-preparation activity. This technique cleans by blasting surfaces with various grades of foam-cleaning media (i.e., sponges). The sponges are made of a water-based urethane. During surface contact, the sponges expand and contract, creating a scrubbing effect. Most of the energy of the sponges is transferred onto the surface being cleaned.

B1.1.2.9 $C0_2$ Blasting

A variation of grit blasting in which CO_2 pellets are used as the cleaning medium. Small dry-ice pellets are accelerated through a nozzle using compressed air at 50-250 pounds per square inch gage (psig). The pellets shatter when they impact the surface, and the resulting kinetic energy causes them to penetrate the base material and shatter it, blasting fragments laterally and releasing the contaminant from the base material.

B1.1.2.10 Wet Ice Blasting

This technique is similar to other decontamination technologies that direct a high-velocity stream of fine particles such as steel pellets, plastic pellets, or glass beads onto a surface to remove contamination. This system employs low-pressure air and wet ice for cleaning and surface preparation. Because this system uses water in the form of ice as its medium, no other consumables are required.

B1.1.2.11 Hydroblasting

In this technology, a high-pressure (more than 103 pounds per square inch [psi]) waterjet is used to remove contaminated debris from surfaces. The debris and water are then collected, treated, and disposed.

B1.1.2.12 Ultra-High Pressure Water

In this technique, water is pressurized up to 55,000 psi by an ultra high-pressure intensifier pump. The water is then forced through a small-diameter nozzle that generates a high-velocity water jet at speeds of up to 914 m/s (3,000 ft/s).

B1.1.2.13 Shot Blasting

An airless method that strips, cleans, and etches the surface simultaneously. The technique is virtually dust free, so the potential for airborne contamination is very low. Portable shotblasting units move along the surface that is being treated as the abrasive is fed into the center of a completely enclosed centrifugal blast wheel. As the wheel spins, the abrasives are hurled from the blades, blasting the surface. The abrasive and removed debris are bounced back to a separation system that recycles the abrasive and sends the contaminant to a dust collector, Larger shot removes more concrete, and the etch depth can be controlled by varying the speed of the unit. Units are available that can remove an up to 0.63 cm (0.25 in.) thick surface in a single pass.

B1.1.2.14 Wet Abrasive Cleaning

A wet abrasive cleaning system is a closed-loop, liquid abrasive (wet grit blasting) decontamination technique. The system uses a combination of water, abrasive media, and compressed air and is applied in a self-contained, leaktight, stainless-steel enclosure. The system uses a high efficiency particulate air (HEPA) filtration system. The radioactive waste is mechanically separated from the cleaning media, resulting in a very low waste volume. The water can be recycled and filtered, eliminating any access to wastewater drainage.

B1.1.2.15 Grit Blasting

Commonly called sand blasting and abrasive jetting, this method uses abrasive materials suspended in a medium that is projected onto the surface being treated, resulting in uniform removal of surface contamination. Compressed air or water, or some combination of both, can be used to carry the abrasive. Several compressed air systems have HEPA-filtered vacuum systems, so there is no generation of airborne contamination.

B1.1.2.16 Grinding

The grinding technique removes thin layers of surface contamination from concrete. In many cases, the contamination is limited to the paint coating or concrete-surface finish. The technique involves abrading the surface that is being treated using coarse-grained abrasives in the form of water-cooled, diamond-grinding wheels or multiple tungsten-carbide surfacing discs. Supplementary contamination control can be accomplished using HEPA-filtered vacuum systems and wet vacuums attached to or held near the machine.

B1.1.2.17 Scarifiers

This technique physically abrades both coated and uncoated concrete and steel surfaces. The scarification process removes the top layers of contaminated surfaces down to the depth of sound, uncontaminated surfaces. For concrete surfaces, scabbling tools are used. For steel, a needle-scaling scarification process is used.

B1.1.2.18 Milling

There are two milling techniques: one for shaving metals and another for shaving concrete. Concrete milling is similar to concrete scabbling or scarifying, except that it may be applied to a much larger surface area Large, paving-type equipment is generally used to shave the concrete surface. Approximately 6.3 to 25.4 cm (2.5 to 10 in.) can be removed in this manner.

B1.1.2.19 Drill-and-Spall

The drill-and-spall technique was developed to remove contaminated concrete surfaces without demolishing the entire structure. The technique involves drilling 2.54 to 3.81cm (1 to 1.5 in.) diameter holes approximately 7.6 cm (3 in.) deep into which a hydraulically operated spalling tool is inserted. The spalling tool bit is an expandable tube of the same diameter as the hole. A tapered mandrel is hydraulically forced into the hole to spread the fingers and spall off the concrete.

B1.1.2.20 Paving Breaker and Chipping Hammer

Although paving breakers and chipping hammers are primarily used in demolition activities, they can be used to remove surface contamination up to 15.2 cm (6 in.) thick.

B1.1.2.21 Electropolishing

Electropolishing is an anodic-dissolution technique. A small, controlled amount of material (conductive metal) is stripped from the surface of the object being cleaned. This method is reverse electrolysis.

B1.1.2.22 Ultrasonic Cleaning

This technique uses a generator to produce an ultrasonic frequency. A transducer then converts this high-frequency energy into low-amplitude mechanical energy (vibrations) of the same frequency. A vigorous scrubbing action is produced by a cleaning solution and imparted into the object being cleaned.

B1.1.2.23 Vibratory Finishing

Objects are placed in a basket filled with abrasive media that is vibrated at a high frequency in a cleaning solution. The vibrating media produce a scouring action that removes contamination, including tape, paint, and corrosion products from most items.

B1.1.2.24 Light Ablation

This technique uses the absorption of light energy and its conversion to heat to selectively remove surface coating or contaminants. For a given frequency of light, some surfaces reflect the beam, some transmit the beam, and others absorb the light energy and convert it to heat. If the light intensity is high enough, the surface film can be heated to 1,000 to 2,000 °F in microseconds.

B1.1.2.25 Microwave Scabbling

This technique directs microwave energy at contaminated concrete surfaces and heats the moisture, present in the concrete matrix. Continued heating produces steam pressure-induced internal mechanical stresses and thermal stresses. When combined, these two stresses burst the surface layer of the concrete into small chips.

B1.1.2.26 Flaming

This technique uses controlled high-temperature flames applied to noncombustible surfaces to thermally degrade organic contaminants.

B1.1.2.27 Flame Scarifying

This technique is similar to flaming. The top layer of concrete is heated to cause differential expansion and spalling. Pieces of up to several centimeters in diameter erupt from the surface.

B1.1.2.28 Plasma Torch

Potential uses in decontamination of materials include breaking down oils PCBs into less harmful or harmless substances, achieving the rapid spalling of concrete and delaminating contaminants from underlying substrates.

B1.1.2.29 Electrical Resistance

This technique is a spalling technique that involves heating the steel reinforcing rods using electrical resistance or induction heating. This heating causes the bars to expand, which in turn induces the concrete to spall from the bars.

B1.2 EQUIPMENT REMOVAL AND SIZE REDUCTION

Equipment removal and size reduction refers to the physical dismantling and segmenting of equipment such as piping, pumps, tanks, hot cells, laboratories, etc. Equipment dismantling and segmenting techniques can be generally grouped into the three categories of mechanical, thermal, and other. The removal methods should be chosen based on the following major factors:

- Radiological criteria.
- Availability or adaptability of suitable equipment.
- Knowledge of problems to be tackled.
- Time available.
- Cost effectiveness of proposed solutions.

In general, the equipment chosen should be easy to use, familiar, reliable, well constructed, and proven. It should be capable of being used manually and adaptable for remote use.

B1.2.1 Mechanical Cutting Techniques

The following techniques use mechanical forces and/or motions to cut or break a component.

B1.2.1.1 Power Nibblers and Shears

A nibbler is a punch and die-cutting tool that normally operates at a rapid reciprocation rate of the punch against the die, "nibbling" a small amount of sheet metal work piece with each stroke. This process is ideal for cutting intricate shapes and turning corners. A shear is a two-blade or two cutter tool that operates on the same principle as a conventional pair of scissors. A blade shear primarily is used for in-line cutting of sheet metal, and a rotary shear is capable of producing irregular or circular cuts. In addition to the cutting of thin sheets, the power shear is also applicable to the cutting of small bore piping and tubing and, in some instances, can be used to segment tanks. The large mobile shears are capable of cutting 0.63 cm (0.25 in.) thick steel and can be used on structural steel, large-diameter piping, and above and below ground tanks.

B1.2.1.2 Conventional Mechanical Saws

Hacksaws, guillotine saws, and reciprocating-action saws are relatively common industrial tools used for cutting all metals with a reciprocating-action, hardened-steel saw blade. These saws are frequently selected for cutting piping systems because of their low operating cost, high-cutting speed, and ease of contamination control. These saws can be applied in either portable (hand-held or remote) or stationary models.

B1.2.1.3 Circular Cutters

A circular cutting machine is a self-propelled unit that cuts as it moves around the outside circumference of a pipe on a track. The machine may be powered either pneumatically, hydraulically, or electrically and is held to the outside of the pipe or component by a guide chain that is sized to fit the outside diameter.

B1.2.1.4 Abrasive Cutters

An abrasive cutter is an electrically, hydraulically, or pneumatically powered wheel formed of resin-bonded particles of aluminum oxide or silicon carbide. The wheels, usually reinforced with fiberglass matting for strength, cuts through the work piece by grinding the metal away.

The cutting technique generates a continuous stream of sparks, making it unsuitable for use near combustible materials. Because the particles are removed in very small pieces, contamination control is a significant problem.

B1.2.1.5 Wall and Floor Sawing

Wall and floor sawing is used when disturbance of the surrounding material must be kept to a minimum. A diamond or carbide wheel is used to abrasively cut through the concrete. The blades can be used to cut through reinforcing rods. Floor saws, also called slab saws and flat saws, feature a blade that is mounted on a walk-behind machine requiring only one operator. Wall saws, also called track saws, employ a blade on a track-mounted machine. The track mounted on a wall or incline will not permit the use of a floor saw. The operator manually advances the blade into the work. The dust produced by the abrasive cutting is controlled using a water spray.

B1.2.1.6 Diamond Wire Cutting

Diamond wire cutting involves a series of guide pulleys that draw a continuous loop of multi-strand wire strung with a series of diamond beads and spacers through a cut. Contact tension, in combination with the spinning wire, cuts a path through concrete and reinforcing rods. If an internal cut is required (e.g., doorway), core drilling is necessary, and the wire is fed through the holes. Almost any thickness can be cut with this technique. The wire saw can cut unusual configurations and allows easy and safe cutting in difficult areas. Water is used for cooling and lubricating. Potential concerns associated with wire saws include physical hazards caused by mechanical failure or contaminant transport.

B1.2.1.7 Explosive Cutting

Explosive cutting is a method of segmenting materials using an explosive that is formed in a geometric shape specially designed and sized to produce the desired separation of the work piece. The cutter is shaped like a chevron, and the apex is pointed away from the material to be cut. When detonated, the explosive core generates a shock wave that fractures the casing

inside the chevron and propels the casing into the material to be cut. This is a potentially dangerous process, and the application should be left to experts who specialize in that field.

B1.2.1.8 Core Drilling and Stitch Drilling

The core drilling technique makes use of a diamond- or carbide-tipped drill bit in an electric- or fluid-driven rotary drill. Precise, circular cuts of almost any diameter up to 152 cm (60 in.) can be drilled. The stitch drilling process, an extension of the core drilling process, involves the boring of a series of overlapping holes. Stitch drilling can also be performed by boring close-pitched holes with the centerline of the holes located along the desired breaking plane in the concrete. Core drilling produces no hazes or smoke, thereby facilitating contamination control. The dust produced by the drilling is controlled by a water spray that is also used to cool the drill bit. Stitch drilling is used where surrounding material must not be disturbed or where accessibility is limited. However, the slab to be removed must be amenable to the method used to shear the concrete (bar, slab, or wrecking ball) if overlapping holes are not drilled. The method of drilling close-pitched holes is not recommended for reinforced concrete because the remaining reinforcing rod inhibits shearing. The process is very slow and costly for large volumes of massive concrete removal.

B1.2.2 Thermal Cutting Techniques

Thermal cutters consist of flame producers and arc producers; both types of cutters are described in the following sections.

B1.2.2.1 Plasma Arc Cutting

The plasma arc cutting technique is based on the establishment of a direct current arc between a tungsten electrode and any conducting metal. The arc is established in a gas, or gas mixture, that flows through a constricting orifice in the torch nozzle to the work piece. The stream or plasma consists of positively charged ions and free electrons. The plasma is ejected from the torch nozzle at a very high velocity and, in combination with the arc, melts the contacted work piece metal and literally blows the molten metal away. An automatic plasma arc cutting system would include torch positioning equipment; torch travel system; air, starting gas, and

plasma gas supply systems; pilot arc high-frequency power supply; plasma arc power supply; and associated gas flow, arc, and mechanical travel controls. Portable, hand-held automatic plasma cutting systems are available from various manufacturers as off-the-shelf items.

B1.2.2.2 Oxygen Burning

Oxygen burning, sometimes referred to as oxyacetylene cutting, consists of a flowing mixture of a fuel gas and oxygen ignited at the orifice of a torch. In general, the hand-held torch used in this process is readily adaptable to automated positioning and travel. The principal application of oxygen burning in equipment removal work would be for the general disassembly of structural carbon-steel members (e.g., beams, columns, and supports). Because the process is so widely known, skilled workers who can handle the equipment are readily available. Moreover, the equipment is inexpensive to obtain and maintain, and is quickly and easily set up. In hazardous environments, the torch can be mounted on a remotely operated positioner to reduce the potential for exposures to workers.

An oxygen-burning torch is ordinarily unable to cut aluminum and other nonferrous or ferrous/high-percent alloy metals, such as stainless steel.

B1.2.2.3 Flame Cutting

Flame cutting, a technique used to cut concrete, involves a thermite reaction in which a powdered mixture of iron and aluminum oxidizes in a pure oxygen jet. As the high temperature of the jet (as high as 16,000 °F) causes the concrete to decompose, the mass flow rate through the flame-cutting nozzle acts to clear the debris from the work piece area. Any reinforcing rods in the concrete add iron to the reaction, sustaining the flame and assisting the reaction. Heat and smoke that result from the process can be removed with a blower and directed through a flexible duct that houses a water fogger to hold down smoke particulates. The high operating temperatures preclude the use of HEPA filters for contamination control, making the flame-cutting technique poor for use in contaminated environments.

B1.2.2.4 Thermite Reaction Lance

The thermite reaction lance is an iron pipe packed with a combination of steel, aluminum, and magnesium wires through which a flow of oxygen gas is maintained. The lance cuts are achieved by a thermite reaction at the tip of the pipe in which all constituents are completely consumed. Temperatures at the tip range from 4,000 to 10,000 °F depending on the environment (air or underwater) and the ambient conditions of that environment. The lance is ignited in air by a high-temperature source such as an oxygen burning torch or an electric are. Typical lances are 3.2 m (10.5 ft) in length and have outside diameters of 3/8 in., ~2 in., 5/8 in., or 1 1/16 in. Use of the lance is practical only in a hand-held mode. The lance operator must also be provided with complete fireproof protective clothing and face shield.

B1.2.2.5 Arc Saw Cutting

The arc saw is an extension of non-consumable melting electrode technology. It is a circular, toothless saw blade that cuts any conducting metal without physical contact with the work piece. The cutting action is achieved by maintaining a high-current electric are between the blade and the material being cut. The blade can be made of any electrically conductive material (e.g., tool steel, mild steel, or copper) with equal success. The depth of cut is limited by blade diameter, and a maximum cut of 0.9 m (3 ft) is considered achievable.

B1.2.3 Other Techniques

Abrasive water-jet cutting is a technique that is neither mechanical or thermal. In this technique, the material is eroded away by an abrasive. The abrasive water-jet cutting technique involves the use of highly pressurized water (as high as 55,000 psi). The water is pressurized by a hydraulically driven intensifier pump. The water flows through a chamber where it is mixed with an abrasive, the most common being crushed garnet. This mixture of water and abrasive is then forced through a wear-resistant nozzle with a small orifice, which focuses the abrasive jet stream at the component being cut. The pressurized jet stream exits the orifice at extremely high velocities, producing erosion that yields a clean cut. If this process is applied to contaminated surfaces, the resulting slurry, consisting of cut particles of

material (i.e., concrete and. reinforcing bar), abrasive, and water, may require collection and treatment.

Abrasive water-jet cutting generates large quantities of water and used grit. It is possible to recycle the water, but such a recycling effort requires an ultra-pure filtration system with sufficient capacity to support operations. Without an ultra-pure filter, the cylinders of the intensifier pump will become scored more quickly, making the generation of the necessary high pressure virtually impossible. Moreover, the abrasives may also wear away the recycling system piping components, which could lead to leakage of contaminants, The cost of the filtration system adds to the high cost of the intensifier, making the overall process fairly expensive.

B1.3 DEMOLITION

Demolition techniques also can be generally divided into mechanical and thermal categories. Several of the techniques described under decontamination and equipment removal can also be applied to concrete demolition activities. Techniques not previously discussed are described below.

B1.3.1 Controlled Blasting

Controlled blasting is ideally suited for demolition of massive or heavily-reinforced, thick concrete sections. The process consists of drilling holes in the concrete, loading them with explosives, and detonating using a delayed firing technique. The delayed firing increases fragmentation and controls the direction of material movement. Each borehole fractures radially during the detonation. The radial fractures in adjacent boreholes form a fracture plane. The detonation wave separates the fractured surfaces and moves the material toward the structure's free face. Controlled blasting is the concrete demolition method recommended for all concrete greater than 0,6 m (2 ft) thick, provided noise and shock in adjacent occupied areas are not limiting. The process is well suited to heavily-reinforced concrete demolition because a high degree of fragmentation may be achieved with proper selection of the blast parameters. The exposed reinforcing bar may then be cut with an oxyacetylene torch or bolt cutter.

B1.3.2 Wrecking Ball or Slab

The wrecking ball is typically used for demolition of nonreinforced or lightly reinforced concrete structures less than 0.9 m (3 ft) in thickness. The equipment consists of a 2 to 5 ton ball or flat slab suspended from a crane boom. The ball may be used in either of two techniques to demolish structures. The preferred method is to drop the ball from a height of 3 to 6 m (10 to 20 ft) above the structure. The maximum height of the structure is limited to about 30 m (100 ft), This method develops good fragmentation of the structure with maximum control of the ball after impact. The second method is to swing the ball into the structure using a suck line for recovery after impact. The structure height is limited to about 15.2 m (50 ft) because of the crane instability during the swing and after impact. The latter method is not recommended because the target area is more difficult to hit and the ball may ricochet off the target and damage adjacent structures while putting side leads on the crane boom. The flat slab may only be used in the vertical drop mode, but offers the advantage of being able to shear through steel-reinforcing rods as well as concrete.

The wrecking ball or slab is recommended for nonradioactive concrete structures less than 0.9 m (3 ft) in thickness. It would be virtually impossible to control the release of radioactive dust during demolition due to the access needed for the crane to drop or swing the ball. For nonradioactive structures, the wrecking ball is an effective method and provides good fragmentation to expose reinforcing rods.

B1.3.3 Backhoe Mounted Rams

Backhoe mounted rams are used for concrete structures less than 0.6 (2 ft) thick with light reinforcement. The method is ideally suited for low noise, low-vibration demolition, and for interior demolition in confined areas. The equipment consists of an air or hydraulic-operated impact ram with a moil or chisel point mounted on a backhoe arm. With the ram head mounted on a backhoe, the operator has approximately a 6 to 7.6 m (20 to 25 ft) reach and the ability to position the ram in limited access structures. The ram is recommended for applications with limited access for heavy equipment, such as a wrecking ball, and where blasting is not permitted.

B1.3.4 Rock Splitter

The rock splitter is a method for fracturing concrete by hydraulically expanding a wedge into a pre-drilled hole until tensile stresses are large enough to cause fracture. The tool consists of a hydraulic cylinder that drives a wedge-shaped plug between two expandable guides (called feathers) inserted in the pre-drilled hole. Concrete may be separated at the fracture line using a backhoe mounted air ram or similar equipment. The reinforcing rod in reinforced concrete must be cut before separation is possible. The splitter is ideally suited for fracturing concrete in limited access areas where large air rams cannot operate. Reinforced concrete sections up to 2.4 m (8 ft) thick may be cut with a single large unit. Reinforced concrete sections 3 m (10 ft) thick will require two or more large units to operate simultaneously.

B1.3.5 Bristar Demolition Compound

Bristar concrete demolition compound is a chemically expanding compound that is poured into pre-drilled holes and causes tensile fractures in the concrete upon hardening. Bristar is a proprietary compound of limestone, siliceous material, gypsum, and slag. Cracks will form and propagate along the fracture line. The crack width will range between 0.63 cm (0.25 in.) after 10 hours to almost 5 cm (2 in.) after 15 hours. The fractured burden may then be removed with a paving breaker, backhoe, or bucket loader. If a reinforcing rod is encountered, it must be cut separately. The compound is not classified as a hazardous substance and can be readily stored and handled. Bristar is suited for use on massive nonreinforced concrete structure where noise, vibration, flyrock, dust or gas must be avoided. It is not recommended for slabs of concrete less than 30 cm (12 in.) in thickness.

B1.3.6 Paving Breakers and Chipping Hammers

Paving breakers and chipping hammers remove concrete (and asphalt) by mechanically fracturing localized sections of the surface. Fracturing is caused by the impact of a hardened tool steel bit of either a compressed air or hydraulic fluid pressure source. Paving breakers are recommended for use on floors to remove small areas that are inaccessible for heavy equipment. They may also be used to expose reinforcing rods after controlled blasting to permit cutting of the rods.

APPENDIX C

COST NORMALIZATION TABLE

COST NORMALIZATION TABLE

TASK	WBS	ALTERNATIVE 1 Construction	1 S&M	2 Construction	2 S&M	3 Construction	3 S&M	4 Construction	4 S&M	5 Construction	5 S&M	6 Construction	6 S&M	7 Construction	7 S&M
50-year Surveillance & Maintenance (annual)	7.0	$ -	$ 800,000	$ -	$ 400,000	$ -	$ 300,000	$ -	$ 200,000	$ -	$ 100,000	$ -	$ 100,000	$ -	$ -
Common Elements		$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
Water Disposal	1.1	$ -	$ -	$ 800,000	$ -	$ 800,000	$ -	$ 800,000	$ -	$ 800,000	$ -	$ 800,000	$ -	$ 800,000	$ -
Fan Removal & Fan House Decom	1.2	$ -	$ 100,000	$ 1,800,000	$ -	$ 1,800,000	$ -	$ 1,800,000	$ -	$ 1,800,000	$ -	$ 1,800,000	$ -	$ 1,800,000	$ -
Pile Fan Sump	1.3	$ -	$ -	$ 800,000	$ -	$ 800,000	$ -	$ 800,000	$ -	$ 800,000	$ -	$ 800,000	$ -	$ 800,000	$ -
Museum Walls	2.1	$ -	$ -	$ 300,000	$ -	$ 300,000	$ -	$ 300,000	$ -	$ 300,000	$ -	$ 300,000	$ -	$ 300,000	$ -
Isolate Building 701 from 703	2.3	$ -	$ -	$ 500,000	$ -	$ 500,000	$ -	$ 500,000	$ -	$ 500,000	$ -	$ 500,000	$ -	$ 500,000	$ -
Removal of Remaining Soils	4.3	$ -	$ 100,000	$ 2,900,000	$ -	$ 2,900,000	$ -	$ 2,900,000	$ -	$ 2,900,000	$ -	$ 2,900,000	$ -	$ 2,900,000	$ -
Seal Pile	2.2	$ -	$ -	$ 1,000,000	$ -	$ 1,000,000	$ -	$ 1,000,000	$ -	$ 1,000,000	$ -	$ 1,000,000	$ -	$ 1,000,000	$ -
Additional Elements		$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
Removal of Above Ground Ducts	1.4	$ -	$ -	$ -	$ -	$ 2,800,000	$ -	$ 2,800,000	$ -	$ 2,800,000	$ -	$ 2,800,000	$ -	$ 2,800,000	$ -
Below Ground Duct & Soil Removal	3.1(a)	$ -	$ -	$ -	$ -	$ 6,700,000	$ -	$ 6,700,000	$ -	$ 6,700,000	$ -	$ 6,700,000	$ -	$ 6,700,000	$ -
Removal of Below Ground Duct Soils Only	3 1(b)	$ -	$ -	$ 1,200,000	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
Below Ground Filter Removal	3.2	$ -	$ -	$ -	$ -	$ 1,200,000	$ -	$ 1,200,000	$ -	$ 1,200,000	$ -	$ 1,200,000	$ -	$ 1,200,000	$ -
Air Cooler Removal	3.3	$ -	$ -	$ -	$ -	$ 1,800,000	$ -	$ 1,800,000	$ -	$ 1,800,000	$ -	$ 1,800,000	$ -	$ 1,800,000	$ -
Canal & Water Treatment House Removal	4.1(a)	$ -	$ -	$ -	$ -	$ 3,600,000	$ -	$ 3,600,000	$ -	$ 3,600,000	$ -	$ 3,600,000	$ -	$ 3,600,000	$ -
Removal of Canal Soils Only	4.1(b)	$ -	$ -	$ 1,100,000	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
Below Grade Piping and Systems Removal	4.2	$ -	$ -	$ -	$ -	$ 1,300,000	$ -	$ 1,300,000	$ -	$ 1,300,000	$ -	$ 1,300,000	$ -	$ 1,300,000	$ -
Disposition of Building 701	5 1(a)	$ -	$ 100,000	$ -	$ 100,000	$ 7,900,000	$ -	$ 7,900,000	$ -	$ -	$ -	$ 7,900,000	$ -	$ -	$ -
Cocoon Building 702	5 1(b)	$ -	$ 100,000	$ -	$ 100,000	$ -	$ 100,000	$ -	$ 100,000	$ 15,100,000	$ -	$ -	$ -	$ -	$ -
Remove Building 701	5 1(c)	$ -	$ 100,000	$ -	$ 100,000	$ -	$ 100,000	$ -	$ 100,000	$ -	$ -	$ -	$ 100,000	$ 14,100,000	$ -
Remove Pile Building 702	5 2	$ -	$ 100,000	$ -	$ 100,000	$ -	$ 100,000	$ -	$ 100,000	$ -	$ 100,000	$ 27,600,000	$ -	$ 27,600,000	$ -
Experimental Equipment Removal	5.3	$ -	$ -	$ -	$ -	$ 800,000	$ -	$ 800,000	$ -	$ 800,000	$ -	$ 800,000	$ -	$ 800,000	$ -
Equipment and Systems Removal	5.4	$ -	$ -	$ -	$ -	$ -	$ -	$ 1,700,000	$ -	$ 1,700,000	$ -	$ 1,700,000	$ -	$ 1,700,000	$ -
Project Management	6.0	$ -	$ 100,000	$ 2,000,000	$ -	$ 4,800,000	$ -	$ 4,800,000	$ -	$ 5,300,000	$ -	$ 7,100,000	$ -	$ 7,100,000	$ -
CONSTRUCTION COST (present)		$ -	$ -	$ 12,300,000	$ -	$ 38,900,000	$ -	$ 40,600,000	$ -	$ 48,300,000	$ -	$ 70,400,000	$ -	$ 76,600,000	$ -
CONSTRUCTION COST (inc. inflation)		$ -	$ -	$ 12,700,000	$ -	$ 40,000,000	$ -	$ 41,700,000	$ -	$ 51,100,000	$ -	$ 74,500,000	$ -	$ 81,000,000	$ -
PRESENT WORTH O&M (50-years)		$ -	$ 20,500,000	$ -	$ 11,800,000	$ -	$ 6,800,000	$ -	$ 6,500,000	$ -	$ 1,600,000	$ -	$ 3,200,000	$ -	$ -
TOTAL ALTERNATIVE COST		**$ 20,500,000**	**$ -**	**$ 24,500,000**	**$ -**	**$ 46,800,000**	**$ -**	**$ 48,200,000**	**$ -**	**$ 52,700,000**	**$ -**	**$ 77,700,000**	**$ -**	**$ 81,000,000**	**$ -**

APPENDIX D

ARARS TABLE

APPENDIX D – ARARS TABLES

Table D-1
Potential Federal Chemical-Specific ARARs/TBCs

POTENTIAL ARARs/TBCs	CITATION OR REFERENCE	REQUIREMENTS	APPLICABILITY	COMMENTS AND ANALYSIS
Clean Air Act of 1963, as amended (42 USC 7401-7462)				
National Ambient Air Quality Standards (NAAQS)	40 CFR Part 50	Establishes primary and secondary NAAQS for ambient air quality to protect public health and welfare, for sulfur dioxide, nitrogen oxide, carbon monoxide, ozone, lead, and particulate matter.	Applicable	Applicable to alternatives that have the potential to impact ambient air quality.
National Emissions Standards for Hazardous Air Pollutants (NESHAPS)	40 CFR Part 61	Establishes emissions standards (NESHAPs) for those hazardous air pollutants for which no ambient air quality standards exists, but which cause, or contribute to, air pollution that may result in an increase in mortality or an increase in serious irreversible or incapacitating reversible illness.	Potentially Applicable	Applicable to alternatives that have the potential to impact ambient air quality.
Standards of Performance for New Stationary Sources	40 CFR 60	Establishes emission standards for pollutants from new or modified stationary (facility) sources.	Potentially Applicable	May be applicable if temporary on-site treatment and off gassing of air emissions occurs.
Threshold Limit Values (TLVs), American Conference of Governmental Industrial Hygienists	ACGIH, ISBN: 0-936712-92-9	TLVs and Biological Exposure Indices (BEIs) are listed as guidelines to assist in the control of health hazards.	Applicable	Applicable to all alternatives for the protection of decommissioning workers and DOE personnel working at the BGRR.

Table D-1
Potential Federal Chemical-Specific ARARs/TBCs

POTENTIAL ARARs/TBCs	CITATION OR REFERENCE	REQUIREMENTS	APPLICABILITY	COMMENTS AND ANALYSIS
Protection of the General Population from Releases of Radioactivity	10 CFR 61.41	Concentrations of radioactive material that may be released to the general environment must not result in an annual dose exceeding 25 mrem to the body or any organ of a member of the general public.	Applicable	Applicable to all alternatives for the protection of decommissioning workers and DOE personnel working at the BGRR.
National Emission Standards for Radon Emissions from Department of Energy (DOE) Facilities	40 CFR Part 61, Subpart A	Standards for emissions of radium-containing materials from storage and disposal facilities.	Not Applicable	Not applicable at the BGRR because no radium-containing materials are present.
Standards on Removal and Disposal of Asbestos and Asbestos-Containing Materials	40 CFR 61, Subpart M	Provide for special precautions to prevent exposure of workers or airborne emissions of asbestos fibers during removal actions, and packaging requirements.	Potentially Applicable	Applicable to all alternatives for the protection of decommissioning workers and DOE personnel working at the BGRR during asbestos removal, if present.
Clean Water Act, as amended (33 USC Sect. 1251-1376)				
Effluent Limitations	40 CFR 301*	Technology-based limitations for point source discharges to surface waters of conventional, nonconventional, and toxic pollutants.	To Be Considered	Pertains to any discharge permits in effect at off-site waste disposal facilities. All wastes generated from this Removal Action will be disposed at appropriately licensed and permitted facilities.

* Currently, groundwater is not addressed under this Removal Action. Therefore, these regulations are not applicable. These regulations may be applicable in the future if groundwater remediation is conducted at the BGRR site. Regulations pertaining to effluent discharge limits may be applicable in the future if groundwater treatment with discharge to the Peconic River or a POTW is implemented at the BGRR site.

Table D-1
Potential Federal Chemical-Specific ARARs/TBCs

POTENTIAL ARARs/TBCs	CITATION OR REFERENCE	REQUIREMENTS	APPLICABILITY	COMMENTS AND ANALYSIS
Water Quality Standards and Effluent Limitations	40 CFR 302	Protection of intended uses of receiving waters (e.g., public water supply, recreational uses).	To Be Considered	Pertains to any discharge permits in effect at off-site waste disposal facilities. All wastes generated from this Removal Action will be disposed at appropriately licensed and permitted facilities.
Toxic and Pretreatment Effluent Standards	40 CFR 307*	Establish list of toxic pollutants and promulgate pretreatment standards for POTWs discharges.	To Be Considered	Pertains to any permits to discharge to POTWs in effect at off-site waste disposal facilities. All wastes generated from this Removal Action will be disposed at appropriately licensed and permitted facilities.
National Pollutant Discharge Elimination System (NPDES) Permit Regulations	40 CFR 122, 125*	Establishes permitting requirements and criteria and standards for technology-based treatment requirements for effluent discharge and stormwater runoff.	To Be Considered	Pertains to any discharge permits in effect at off-site waste disposal facilities. All wastes generated from this Removal Action will be disposed at appropriately licensed and permitted facilities.
Water Quality Criteria	40 CFR Part 131 Quality Criteria for Water, 1976, 1980, 1986*	Sets criteria for water quality based on toxicity to aquatic organisms and human health.	Not Applicable	Groundwater is not addressed under this Removal Action.

* Currently, groundwater is not addressed under this Removal Action. Therefore, these regulations are not applicable. These regulations may be applicable in the future if groundwater remediation is conducted at the BGRR site. Regulations pertaining to effluent discharge limits may be applicable in the future if groundwater treatment with discharge to the Peconic River or a POTW is implemented at the BGRR site.

Table D-1
Potential Federal Chemical-Specific ARARs/TBCs

POTENTIAL ARARs/TBCs	CITATION OR REFERENCE	REQUIREMENTS	APPLICABILITY	COMMENTS AND ANALYSIS
Safe Drinking Water Act of 1974 (40 USC Sect. 300)				
National Primary Drinking Water Standards	40 CFR Part 141*	Establishes health-based standards (maximum-contaminant levels [MCLs]), monitoring requirements, and treatment techniques for public water systems.	Not Applicable	Groundwater is not addressed under this Removal Action.
National Secondary Drinking Water Standards	40 CFR Part 143*	Establishes aesthetic-based standards for public water systems.	Not Applicable	Groundwater is not addressed under this Removal Action.
Maximum Contaminant Level Goals (MCLGs)	40 CFR 141.50, 141.51, 141.52*	Establishes drinking water quality goals set at levels of no known or anticipated adverse health effects, with an adequate margin of safety.	Not Applicable	Groundwater is not addressed under this Removal Action.
Toxic Substances Control Act				
Asbestos and Polychlorinated Biphenyl Waste Removal	15 USC 2605 40 CFR 761	Applicable to storage and disposal of asbestos and PCB-contaminated material.	Potentially Applicable	Applicable to alternatives that involve removal of suspect asbestos-containing materials (ACM), and solid wastes/materials containing PCBs > 50 milligrams/liter, if present.
Resource Conservation and Recovery Act of 1976 (as amended by HSWA of 1984) (40 USC 6901)				
Identification and Listing of Hazardous Waste	40 CFR Part 261	Defines those solid wastes which are subject to regulation as hazardous waste under 40 CFR Parts 262-265 and Parts 124, 270, and 271.	Potentially Applicable	Applicable to alternatives involving off-site transport and disposal of classified hazardous wastes, if present.

* Currently, groundwater is not addressed under this Removal Action. Therefore, these regulations are not applicable. These regulations may be applicable in the future if groundwater remediation is conducted at the BGRR site. Regulations pertaining to effluent discharge limits may be applicable in the future if groundwater treatment with discharge to the Peconic River or a POTW is implemented at the BGRR site.

Table D-1
Potential Federal Chemical-Specific ARARs/TBCs

POTENTIAL ARARs/TBCs	CITATION OR REFERENCE	REQUIREMENTS	APPLICABILITY	COMMENTS AND ANALYSIS
Department of Energy (DOE) Orders				
Radiation Protection of the Public and the Environment	DOE Order 5400.5	This order establishes standards and requirements for DOE operations with respect to protection of members of the public against radiation and contains a discussion of DOE's as low as reasonably achievable (ALARA) approach.	To Be Considered	DOE orders are non-enforceable policies and guidelines, that must be followed at all DOE facilities.
Facility Safety	DOE 420.1 and 440.1	Identifies mandatory and reference ES&H standards.	To Be Considered	DOE orders are non-enforceable policies and guidelines, that must be followed at all DOE facilities.
Other Federal ARARs/TBCs				
Radiation protection for occupational workers	10 CFR 835 and Associated implementation manuals	Establishes radiation protection standards for workers.	To Be Considered	DOE orders are non-enforceable policies and guidelines, that must be followed at all DOE facilities.
Nuclear Regulatory Commission (NRC) Standards for Protection Against Radiation	10 CFR 20	Regulations contain the Nuclear Regulatory Commission Standards for protection against radiation, and contain an "ALARA" approach.	Not Applicable	DOE implements its own policies and guidelines on protection of the public and environment from radiation.
Atomic Energy Act of 1954	42 USC 2011 10 CFR 61	Establishes standards for the management of radioactive wastes. DOE shall follow its own standards and procedures to ensure safe operation of its facilities.	Applicable	DOE complies with this ARAR by establishing and following its own internal policies and guidelines.

Table D-1
Potential Federal Chemical-Specific ARARs/TBCs

POTENTIAL ARARs/TBCs	CITATION OR REFERENCE	REQUIREMENTS	APPLICABILITY	COMMENTS AND ANALYSIS
Federal Compliance with Pollution Control Standards	Executive Order 12088	Requires federal agency landlords to submit to OMB an annual plan for control of environmental pollution and to consult with EPA and state agencies regarding the best methods.	Not Applicable	The BGRR is not an operating facility.
Protection and Enhancement of Environmental Quality	Executive Order 11514	Requires federal agencies to demonstrate leadership in achieving the environmental quality goals of NEPA; provides for DOE consultation with federal, state, and local agencies.	Relevant and Appropriate	DOE will adhere to the requirements of NEPA for activities conducted under this Removal Action.

Table D-2
Potential Federal Location-Specific ARARs/TBCs

POTENTIAL ARARs/TBCs	CITATION OR REFERENCE	REQUIREMENTS	APPLICABILITY	COMMENTS AND ANALYSIS
Safe Drinking Water Act	40 CFR 149*	Sole source drinking water aquifer designation	Not Applicable	Groundwater is not addressed under this Removal Action.
National Historic Preservation Act of 1966	7 CFR 650 36 CFR 800	Establishes requirements for determining a site's eligibility for listing in the National Register of Historic Places	To Be Considered	Historic significance of the BGRR Facility is recognized but selection of a recommended alternative will not be decided on by historic significance alone.
Endangered Species Act of 1973	16 USC 1531 et seq. 50 CFR 402	Establishes requirements to protect species threatened by extinction and habitats critical to their survival	Relevant and Appropriate	Known endangered, threatened, or species of special concern have been identified at BNL, although not specifically at the BGRR site.
Resource Conservation and Recovery Act Standards for Owners and Operators of Hazardous Waste TSD Facilities	40 CFR 264.18	Establishes location standards including seismic considerations and flood plain requirements.	To Be Considered	Pertains to locations of any off-site waste disposal facilities. All wastes generated from this Removal Action will be disposed at appropriately licensed and permitted facilities

* Currently, groundwater is not addressed under this Removal Action, therefore, these regulations are not applicable. These regulations may be applicable in the future if groundwater remediation is conducted at the BGRR site.

Table D-2
Potential Federal Location-Specific ARARs/TBCs

POTENTIAL ARARs/TBCs	CITATION OR REFERENCE	REQUIREMENTS	APPLICABILITY	COMMENTS AND ANALYSIS
Floodplain Management	Executive Order 11988; 40 CFR Part 6, App. A	Establishes federal policy and guidance for activities completed in floodplains	Not Applicable	The BGRR site is not located in a regulated floodplain.
Wild and Scenic Rivers Act	16 USC 1271	Establishes the Wild and Scenic River System to protect rivers designated for their wild and scenic values from activities which may adversely effect those values	Not Applicable	May be applicable in the future if groundwater treatment with discharge to the Peconic River is implemented at the BGRR site.
Protection of Wetlands	Executive Order 11990	Requires minimization of destruction, loss, or degradation of wetlands.	Not Applicable	There are no wetlands located within the state or federal mandated buffer zone from the BGRR site.
Fish and Wildlife Coordination Act	16 USC 661-666 40 CFR 6.302 [g]	Requires consultation when a federal department or agency proposes or authorizes any modification of any stream or other water body; requires adequate provisions for protection of fish and wildlife resources. It also establishes policy for Executive Order 11990, "Protection of Wetlands."	Not Applicable	The BGRR Removal Action does not involve modification of any water bodies; the BGRR site is a completely developed parcel of land with no known significant wildlife habitats.

Table D-3
Potential Federal Action-Specific ARARs/TBCs

POTENTIAL ARARs/TBCs	CITATION OR REFERENCE	REQUIREMENTS	APPLICABILITY	COMMENTS AND ANALYSIS
Occupational Safety and Health Administration (OSHA) Regulations (29 USC 651)				
Standards on Removal and Disposal of Asbestos and Asbestos-Containing Materials	29 CFR 1910.1101	Provide for special precautions to prevent exposure of workers or airborne emissions of asbestos fibers during removal actions.	Potentially Applicable	Applicable to all alternatives for the protection of decommissioning workers and DOE personnel working at the BGRR during asbestos removal, if present.
Occupational Health and Safety Requirements	29 CFR 1910.120	Establishes limits for worker exposures during response actions at CERCLA sites.	Applicable	Applicable to all alternatives for the protection of decommissioning workers and DOE personnel working at the BGRR.
Health and Safety Requirements for Construction Activities	29 CFR Part 1926	Establishes construction standards.	Applicable	Applicable to all alternatives for the protection of decommissioning workers and DOE personnel working at the BGRR.
Clean Air Act				
National Primary and Secondary Ambient Air Quality Standards	40 CFR Part 50	Establishes standards for ambient air quality to protect public health and welfare (including standards for particulate matter and lead).	Applicable	Applicable to alternatives that have the potential to impact ambient air quality.

Table D-3
Potential Federal Action-Specific ARARs/TBCs

POTENTIAL ARARs/TBCs	CITATION OR REFERENCE	REQUIREMENTS	APPLICABILITY	COMMENTS AND ANALYSIS
National Emission Standards for Hazardous Air Pollutants (NESHAPS)	40 CFR Part 61	Regulates emissions of specific hazardous air pollutants and radionuclides other than radon from DOE facilities.	Applicable	Applicable to alternatives that have the potential to impact ambient air quality.
Resource Conservation and Recovery Act of 1976 (RCRA) (42 USC 6901)				
Standards for Waste Generators and Transporters	40 CFR Parts 262 and 263	Applicable to generators and transporters of hazardous waste. Requires that transporters must be licensed hazardous waste haulers.	Applicable	Applicable to alternatives that involve off-site transport and disposal of hazardous wastes.
Standards for Owners and Operators	40 CFR 264	Standards for owners and operators of hazardous waste facilities.	To Be Considered	Pertains to off-site waste disposal facilities. All wastes generated from this Removal Action will be disposed at appropriately licensed and permitted facilities.
Containers	40 CFR 264.171 through 264.178	Regulations cited under 40 CFR 264.171 to 264.178 (Subpart I) concern permanent on-site storage of hazardous wastes or temporary storage phases used during various cleanup actions such as removal or incineration.	Potentially Applicable	Applicable to alternatives which require use of temporary containers to hold hazardous wastes, if used.
Tanks	40 CFR 264.191 through 264.198	Regulations under 40 CFR 264.191 to 264.198 (Subpart J) apply to tank storage of hazardous materials.	Potentially Applicable	Applicable to alternatives which require use of temporary storage tanks to hold hazardous wastes, if used.

Table D-3
Potential Federal Action-Specific ARARs/TBCs

POTENTIAL ARARs/TBCs	CITATION OR REFERENCE	REQUIREMENTS	APPLICABILITY	COMMENTS AND ANALYSIS
RCRA Hazardous Waste Management Regulations, Subtitle C	40 CFR 264	Applicable to the treatment, storage, transportation and disposal of hazardous wastes listed under 40 CFR 261.	To Be Considered	Pertains to off-site waste disposal facilities. All wastes generated from this Removal Action will be disposed at appropriately licensed and permitted facilities.
RCRA Solid Waste Management Regulations, Subtitle D	40 CFR 264	Applicable to the management and disposal of non-hazardous wastes.	To Be Considered	Pertains to off-site waste disposal facilities. All wastes generated from this Removal Action will be disposed at appropriately licensed and permitted facilities.
Standards for Post-Closure for Units with Hazardous waste In Place	40 CFR 264.310	Post-closure care consists of cover maintenance, groundwater monitoring, and institutional controls.	Potentially Applicable	Applicable to alternatives where hazardous waste is left in place.
RCRA Hazardous Waste Permit Program	40 CFR 270	USEPA-administered hazardous waste permit program.	To Be Considered	Pertains to off-site waste disposal facilities. All wastes generated from this Removal Action will be disposed at appropriately licensed and permitted facilities.
Land Disposal Restrictions	40 CFR Part 268	Applicable to alternatives involving land disposal of hazardous wastes, and requires treatment to diminish a waste's toxicity and/or minimize contaminant migration.	Applicable	Pertains to off-site waste disposal facilities. All wastes generated from this Removal Action will be disposed at appropriately licensed and permitted facilities.

Table D-3
Potential Federal Action-Specific ARARs/TBCs

POTENTIAL ARARs/TBCs	CITATION OR REFERENCE	REQUIREMENTS	APPLICABILITY	COMMENTS AND ANALYSIS
Other Federal Waste Transport Regulations				
Hazardous Materials Transportation Act of 1974, as amended	49 CFR 170-189 23 CFR 1-1399	Federal Highway Administration, Department of Transportation, and National Highway Traffic Safety Administration regulations are codified in Title 23 (Highways) of the Code of Federal Regulations. DOE shall comply with the requirements governing hazardous materials and waste transportation.	Applicable	Applicable to alternatives that involve off-site transport and disposal of hazardous wastes.
Department of Energy (DOE) Orders				
National Environmental Policy Act Compliance Program	DOE 451.1A	Establishes DOE policies for complying with NEPA	To Be Considered	DOE orders are non-enforceable policies and guidelines, that must be followed at all DOE facilities.
Materials Transportation and Traffic Management	DOE 460.2		To Be Considered	DOE orders are non-enforceable policies and guidelines, that must be followed at all DOE facilities.
Hazardous Material Packaging for Transport-Administrative Procedures	DOE 460.2	Establishes administrative procedures for the certification and use of radioactive and other hazardous materials packaging by the DOE	To Be Considered	DOE orders are non-enforceable policies and guidelines, that must be followed at all DOE facilities.

Table D-3
Potential Federal Action-Specific ARARs/TBCs

POTENTIAL ARARs/TBCs	CITATION OR REFERENCE	REQUIREMENTS	APPLICABILITY	COMMENTS AND ANALYSIS
Project Management System	DOE 430.1A	Establishes DOE's policies on lifecycle assessment management and project management at DOE facilities.	To Be Considered	DOE orders are non-enforceable policies and guidelines, that must be followed at all DOE facilities.
General Environmental Protection Requirements	DOE 5400.1	Establishes environmental protection program requirements, authorities, and responsibilities for DOE operations to ensure compliance with Federal, State and Local environmental laws and regulations, Executive orders and internal department policies.	To Be Considered	DOE orders are non-enforceable policies and guidelines, that must be followed at all DOE facilities.
Hazardous and Radioactive Mixed Waste Program	DOE 5400.3	Establishes DOE hazardous and radioactive mixed waste policies and requirements, and implements the requirements of the Resource Conservation and Recovery Act (RCRA).	To Be Considered	DOE orders are non-enforceable policies and guidelines, that must be followed at all DOE facilities.
Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) Program.	DOE 5400.4	Establishes and implements DOE CERCLA policies and procedures as prescribed by the National Oil and Hazardous Substances Pollution Contingency Plan (NCP).	To Be Considered	DOE orders are non-enforceable policies and guidelines, that must be followed at all DOE facilities.
Environment, Safety, and Health Program for DOE Operations	DOE 5480.1B Chg. 5	Establishes the Environment, Safety, and Health (ES&H) Program for DOE operations.	To Be Considered	DOE orders are non-enforceable policies and guidelines, that must be followed at all DOE facilities.

Table D-3
Potential Federal Action-Specific ARARs/TBCs

POTENTIAL ARARs/TBCs	CITATION OR REFERENCE	REQUIREMENTS	APPLICABILITY	COMMENTS AND ANALYSIS
Safety Requirements for the Packaging and Transportation of Hazardous Materials, Hazardous Substances, and Hazardous Wastes	DOE 5480.3	Establishes requirements for the packaging and transportation of hazardous materials, hazardous substances, and hazardous wastes.	To Be Considered	DOE orders are non-enforceable policies and guidelines, that must be followed at all DOE facilities.
Fire Protection	DOE 5480.7	Establishes requirements for a comprehensive fire protection and related perils protection program sufficient to attain DOE objectives.	To Be Considered	DOE orders are non-enforceable policies and guidelines, that must be followed at all DOE facilities.
Contractor Occupational Medical Program	DOE 5480.8	Establishes requirements for the implementation of a Contractor Occupational Medical Program	To Be Considered	DOE orders are non-enforceable policies and guidelines, that must be followed at all DOE facilities.
Construction Safety and Health Program	DOE 5480.9	Establishes requirements for a Construction Safety and Health Program to protect DOE and contractor employees, the general public, and adjacent property from construction-generated hazards or damage.	To Be Considered	DOE orders are non-enforceable policies and guidelines, that must be followed at all DOE facilities.
Contractor Industrial Hygiene Program	DOE 5480.10	Establishes requirements to implement a Contractor Industrial Hygiene Program.	To Be Considered	DOE orders are non-enforceable policies and guidelines, that must be followed at all DOE facilities.
Conduct of Operations Requirements for DOE Facilities	DOE 5480.19	Establishes DOE requirements for conduct of operations at DOE facilities.	To Be Considered	DOE orders are non-enforceable policies and guidelines, that must be followed at all DOE facilities.

Table D-3
Potential Federal Action-Specific ARARs/TBCs

POTENTIAL ARARs/TBCs	CITATION OR REFERENCE	REQUIREMENTS	APPLICABILITY	COMMENTS AND ANALYSIS
Personnel Selection, Qualification and Training	DOE 5480.20A	Establishes DOE requirements for DOE staff and contractor personnel selection, qualifications, and training.	To Be Considered	DOE orders are non-enforceable policies and guidelines, that must be followed at all DOE facilities.
Unreviewed Safety Questions	DOE 5480.21	Establishes DOE requirements to evaluate changes for potential safety impacts.	To Be Considered	DOE orders are non-enforceable policies and guidelines, that must be followed at all DOE facilities.
Technical Safety Requirements	DOE 5480.22 Chg. 2	Establishes procedures to set bounding conditions for safety operations	To Be Considered	DOE orders are non-enforceable policies and guidelines, that must be followed at all DOE facilities.
Nuclear Safety Analysis Report	DOE 5480.23 Chg. 1	Establishes procedures to identify hazards, analyze hazards and accidents, and identify controls and mitigation measures to safely manage hazards.	To Be Considered	DOE orders are non-enforceable policies and guidelines, that must be followed at all DOE facilities.
Environmental Protection, Safety, and Health Protection Information Reporting Requirements	DOE 5481.1 Chg7	Establishes the requirements and procedures for reporting information having environmental protection, safety or health protection significance	To Be Considered	DOE orders are non-enforceable policies and guidelines, that must be followed at all DOE facilities.
Comprehensive Emergency Management System	DOE 151.1 Chg. 2	Establishes DOE policies for emergency planning preparedness, and response at DOE operations.	To Be Considered	DOE orders are non-enforceable policies and guidelines, that must be followed at all DOE facilities.
Occurrence Reporting and Processing Operations Information	DOE 232.1A	Establishes DOE requirements for reporting of unusual occurrences at DOE facilities.	To Be Considered	DOE orders are non-enforceable policies and guidelines, that must be followed at all DOE facilities.

Table D-3
Potential Federal Action-Specific ARARs/TBCs

POTENTIAL ARARs/TBCs	CITATION OR REFERENCE	REQUIREMENTS	APPLICABILITY	COMMENTS AND ANALYSIS
Radioactive Waste Management	DOE 435.1	Establishes policies, guidelines, and minimum requirements by which the DOE manages its radioactive and mixed waste and contaminated facilities	To Be Considered	DOE orders are non-enforceable policies and guidelines, that must be followed at all DOE facilities.
Quality Assurance	DOE 5700.6C	Establishes requirements for developing, implementing, and maintaining a Quality Assurance Program to ensure that risks and environmental impacts are minimized.	To Be Considered	DOE orders are non-enforceable policies and guidelines, that must be followed at all DOE facilities.
Other Federal ARARs				
Nuclear Regulatory Commission (NRC) Standards for Protection Against Radiation	10 CFR 20	Regulation contains the Nuclear Regulatory Commission standards for protection against radiation, and contains an "ALARA" approach.	To Be Considered	DOE implements its own policies and guidelines on protection of the public and environment from radiation.
Technical Requirements for Land Disposal Facilities	10 CFR 61, Subpart D	Establish near-surface disposal requirements for radioactive materials at NRC-licensed facilities.	Not Applicable	BNL is not a NRC-licensed facility.
Comprehensive Environmental Response, Compensation, and Liability Act of 1980, as amended (CERCLA)	40 CFR 300 42 USC 8601 et seq.	Requires cleanup and notification if there is a release or threatened release of hazardous substance; requires DOE to enter into IAGs with USEPA and states to control cleanup of each DOE site on the NPL.	Applicable	DOE has entered into an IAG to respond to environmental cleanup at BNL; the Removal Action for the BGRR will be completed under CERCLA requirements.

Table D-3
Potential Federal Action-Specific ARARs/TBCs

POTENTIAL ARARs/TBCs	CITATION OR REFERENCE	REQUIREMENTS	APPLICABILITY	COMMENTS AND ANALYSIS
Superfund Amendments and Reauthorization Act of 1986 (SARA)	Public Law 99-499	See CERCLA above.	Applicable	The Removal Action for the BGRR will be completed under CERCLA requirements.
Emergency Planning and Community Right-To-Know Act	42 USC 11001	Requires facilities to report the release of extremely hazardous substances and other specified chemicals, to provide material safety data sheets or lists, and to provide estimates of the amounts of hazardous chemicals on site.	Applicable	The Removal Action for the BGRR will be completed under CERCLA requirements.
Archaeological and Historical Preservation Act of 1974	Public Law 93--291	Requires action to recover and preserve artifacts in areas where activity my cause irreparable harm, loss, or destruction of significant artifacts.	Applicable	There are presently no known areas at the BGRR with potential to contain significant archaeological or historical artifacts.
Noise Control Act of 1972	42 USC 4901 et seq.	Requires facilities to maintain noise levels that do not jeopardize the health and safety of the public.	Applicable	Applicable to all alternatives that may generate noise.
Noise Pollution and Abatement Act of 1970	42 USCS 7641, 7642	To amend Clean Air Act to provide for a more effective program to improve the quality of the Nation's air (noise abatement).	Applicable	Applicable to all alternatives that may generate noise.
Discharges of Dredged or Fill Material into Waters of the U.S.	33 CFR Part 323	Establishes permit requirements for actions that involve dredging or filling in of a navigable waterway or wetland.	Not Applicable	The BGRR Removal Action does not involve dredging nor filling activities in waterways or wetlands.

Table D-3
Potential Federal Action-Specific ARARs/TBCs

POTENTIAL ARARs/TBCs	CITATION OR REFERENCE	REQUIREMENTS	APPLICABILITY	COMMENTS AND ANALYSIS
Clean Water Act	Section 404	Prohibits discharge of dredged or fill material into wetlands without a permit; preserves and enhances wetlands.	Not Applicable	The BGRR Removal Action does not involve dredging nor filling activities in wetlands.
National Pollutant Discharge Elimination System (NPDES) Permit Regulations	40 CFR Part 122*	Establishes permit requirements, discharge limits, and requirements for use of the Best Available Technology (BAT) for discharges of wastewaters and stormwater to surface waters.	To Be Considered	Pertains to any discharge permits in effect at off-site waste disposal facilities. All wastes generated from this Removal Action will be disposed at appropriately licensed and permitted facilities.
U.S. EPA Effluent Guidelines and Standards	40 CFR 403.5*	If wastes are discharged to a publicly-owned treatment works facility (POTW), the treatment process must not allow waste to pass through untreated or result in contaminated sewage sludge.	To Be Considered	Pertaining to any permits to discharge to POTWs in effect at off-site waste disposal facilities. All wastes generated from this Removal Action will be disposed at appropriately licensed and permitted facilities.
Department of Energy Organization Act of 1977	42 USC 7101		Relevant and Appropriate	

* Currently, groundwater is not addressed under this Removal Action, therefore these regulations are not applicable. These regulations may be applicable in the future if groundwater remediation is conducted at the BGRR site. Regulations pertaining to effluent discharge limits may be applicable in the future if groundwater treatment with discharge to the Peconic River or a POTW is implemented at the BGRR site.

Table D-3
Potential Federal Action-Specific ARARs/TBCs

POTENTIAL ARARs/TBCs	CITATION OR REFERENCE	REQUIREMENTS	APPLICABILITY	COMMENTS AND ANALYSIS
National Environmental Policy Act of 1969, as amended National Environmental Policy Act Implementing Procedures DOE's NEPA Implementing Procedures	42 USC 4321 et seq. 40 CFR 1500 - 1508 10 CFR 1021	Required to comply with NEPA, it's implementing procedures and DOE's implementing procedures.	Applicable	The BGRR Removal Action will be completed in compliance with NEPA requirements.
Soil and Water Resources Conservation Act of 1977	16 USCS 2001 (1991)	Provides for the conservation of soil, water and related resources for sustained use.	Relevant and Appropriate	
Nuclear Waste Policy Act of 1982	42 USC 10101 et seq.	DOE shall dispose of radioactive waste in accordance with 40 CFR 191	Applicable	Applicable to alternatives involving disposal of radioactive wastes.
Low-Level Radioactive Policy Act	42 USC 2021b-2021d	DOE shall dispose of low-level wastes (LLW) in accordance with the State in which it operates.	Applicable	Applicable to alternatives involving disposal of low-level radioactive wastes.
Superfund Implementation	Executive Order 12580	DOE shall comply with the NCP in addition to other requirements of the order.	Applicable	The Removal Action for the BGRR will be completed under CERCLA requirements.
Federal Facility Compliance Act of 1992	42 USC 6961	Waives sovereign immunity for federal facilities under RCRA and requires DOE to develop plans and enter into agreements with states as to specific management actions for specific mixed waste streams.	Applicable	DOE has entered into an IAG with New York State and USEPA for environmental restoration activities conducted at BNL.

Table D-3
Potential Federal Action-Specific ARARs/TBCs

POTENTIAL ARARs/TBCs	CITATION OR REFERENCE	REQUIREMENTS	APPLICABILITY	COMMENTS AND ANALYSIS
The Native American Grave Protection and Repatriation Act (NAGPRA)	Public Law 101-601 (Nov. 16, 1990)	Law provides for protection of Native American graves and for other related purposes	Applicable	There are presently no known areas at the BGRR with potential to contain Native American burial grounds.
The Migratory Bird Treaty Act	16 USC 703	Law makes it unlawful to take, kill, or possess any migratory bird, any part, nest, or eggs of any such bird.	Not Applicable	There are no known areas at the BGRR suitable for visitation by migratory birds.
The Archaeological Resources Protection Act of 1979	Public Law 96-95	Provides for the protection of archaeological resources on federal and Indian lands.	Applicable	There are presently no known areas at the BGRR with potential to contain significant archaeological resources.

Table D-4
Potential New York State Chemical-Specific ARARs/TBCs
Brookhaven National Laboratory

POTENTIAL ARARs/TBCs	CITATION OR REFERENCE	REQUIREMENTS	APPLICABILITY	COMMENTS AND ANALYSIS
Soil				
NYSDEC Soil Cleanup Objectives and Cleanup Levels	NYSDEC TAGM HWR-92-4046, Nov. 16, 1992	Applicable to the cleanup of contaminated soils. Cleanup goals recommended based on human criteria, ground water protection and background levels.	To Be Considered	These guidance values are non-enforceable criteria that will be consulted when developing site-specific PRGs for soils. The BGRR Removal Action will comply with these criteria to the extent practicable.
NYSDEC Soil Cleanup Guidelines for Radioactive Materials	NYSDEC TAGM 4003, Sept. 14, 1993	Describes allowable total radiation dose from material remaining onsite after cleanup	To Be Considered	These guidance values are non-enforceable criteria that will be consulted when developing site-specific PRGs for soils. The BGRR Removal Action will comply with these criteria to the extent practicable.
Air				
NYSDEC Division of Air Guidelines for the Control of Toxic Ambient Air Contaminants	Air Guide 1	Establishes air quality guidelines and standards	Applicable	Applicable to alternatives that have the potential to impact ambient air quality.
New York State Ambient Air Quality Standards	6 NYCRR 256-257	Establishes air quality standards	Applicable	Applicable to alternatives that have the potential to impact ambient air quality.

Table D-4
Potential New York State Chemical-Specific ARARs/TBCs
Brookhaven National Laboratory

POTENTIAL ARARs/TBCs	CITATION OR REFERENCE	REQUIREMENTS	APPLICABILITY	COMMENTS AND ANALYSIS
Groundwater and Surface Water				
New York State Ambient Water Quality Regulations	6 NYCRR Parts 700-705*	Describes classification system for surface water and groundwater. Establishes standards of quality and purity.	Not Applicable	Groundwater is not addressed under this Removal Action,
State Pollutant Discharge Elimination System Regulations	6 NYCRR 750-757*	Establishes permit requirements, application, standards, compliance schedule, duration, monitoring and reporting of SPDES permitting process.	To Be Considered	Pertains to any discharge permits in effect at off-site waste disposal or treatment facilities.
Public Water Supply Requirements – Maximum Contaminant Levels (MCLs)	10 NYCRR Part 5-1*	Implements the federal drinking water quality regulations in New York State.	Not Applicable	Groundwater is not addressed under this Removal Action.
Hazardous Waste:				
New York State Identification and Listing of Hazardous Waste Regulations	6 NYCRR Part 371	Identifies "characteristic" hazardous wastes and "listed" hazardous wastes.	Potentially Applicable	Applicable to alternatives involving off-site transport and disposal or treatment of classified hazardous wastes, if present.

* Currently, groundwater is not addressed under this Removal Action, therefore, these regulations are not applicable. These regulations may be applicable in the future if groundwater remediation is implemented at the BGRR site. Regulations pertaining to effluent discharge limits may be applicable in the future if groundwater treatment with discharge to the Peconic River or a POTW is implemented at the BGRR site.

Table D-5
Potential New York State Location-Specific ARARs/TBCs
Brookhaven National Laboratory

POTENTIAL ARARs/TBCs	CITATION OR REFERENCE	REQUIREMENTS	APPLICABILITY	COMMENTS AND ANALYSIS
Standards for the Management of Specific Hazardous Wastes and Specific Types of Hazardous Waste Management Facilities	6 NYCRR 374		To Be Considered	Pertains to off-site waste disposal and treatment facilities. All wastes generated from this Removal Action will be disposed at appropriately licensed and permitted facilities.
Endangered and Threatened Species of Fish and Wildlife; Species of Special Concern	6 NYCRR 182	Identifies endangered and threatened species of special concern.	Relevant and Appropriate	Removal alternatives are not expected to impact endangered, threatened, or species of special concern.
Draft Memorandum of Agreement Pursuant to the National Historic Preservation Act	Pursuant to 36 CFR 800.6	Agreement between DOE and New York State to conduct specific activities to document and evaluate the historic significance of the BGRR.	To Be Considered	Historic significance of the BGRR is recognized but selection of a recommended alternative will not be decided on by historic significance alone.
New York Air Pollution Control Regulations	6 NYCRR Parts 200-221	Provides regulations for the prevention and control of air contamination and air pollution.	Applicable	Applicable to alternatives that have the potential to impact ambient air quality.

Table D-6
Potential New York State/Local Action-Specific ARARs/TBCs
Brookhaven National Laboratory

POTENTIAL ARARs/TBCs	CITATION OR REFERENCE	REQUIREMENTS	APPLICABILITY	COMMENTS AND ANALYSIS
Air				
General Provisions	6 NYCRR 200 (200.6)		Potentially Applicable	Applicable to alternatives that involve temporary on-site treatment and off-gassing of air emissions.
General Process Emission Source	6 NYCRR Part 212	Establishes allowable emissions for general process sources.	Potentially Applicable	Applicable to alternatives that involve temporary on-site treatment and off-gassing of air emissions.
Air Permits and Certificates	6 NYCRR Parts 201	Describes requirements and procedures for obtaining air permits and certificates.	Potentially Applicable	Applicable to alternatives that involve temporary on-site treatment and off-gassing of air emissions.
General Prohibitions	6 NYCRR Part 211	Describes requirements and procedures of obtaining air permits and certificates.	Potentially Applicable	Applicable to alternatives that involve temporary on-site treatment and off-gassing of air emissions.
Water				
New York Water Pollution Control Regulations	6 NYCRR Parts 608, 610-614*	Establishes regulations for the use and protection of waters.	Not Applicable	Groundwater is not addressed under this Removal Action

* Currently, groundwater is not addressed under this Removal Action, therefore, these regulations are not applicable. These regulations may be applicable in the future if groundwater remediation is conducted at the BGGR site.

Table D-6
Potential New York State/Local Action-Specific ARARs/TBCs
Brookhaven National Laboratory

POTENTIAL ARARs/TBCs	CITATION OR REFERENCE	REQUIREMENTS	APPLICABILITY	COMMENTS AND ANALYSIS
Hazardous Waste				
New York Hazardous Waste Treatment, Storage and Disposal Facility Permitting Requirements.	6 NYCRR Part 373-1	Establishes permit requirements and construction and operations standards.	To Be Considered	Pertains to off-site waste disposal and treatment facilities. All wastes generated from this Removal Action will be disposed at appropriately licensed and permitted facilities.
New York Finals Status Standards for Owners and Operators of Hazardous Waste Treatment, Storage and Disposal Facilities.	6 NYCRR Part 373-2	Establishes minimum State standards that define the acceptable management of hazardous waste.	To Be Considered	Pertains to off-site waste disposal and treatment facilities. All wastes generated from this Removal Action will be disposed at appropriately licensed and permitted facilities.
New York Interim Status Standards for Owners and Operators of Hazardous Waste Facilities	6 NYCRR Part 373-3	Establishes minimum State standards that define the acceptable management of hazardous waste during the periods of interim status and until final closure of post-closure certification.	To Be Considered	Pertains to off-site waste disposal and treatment facilities.
New York General Hazardous Waste Management System Regulations	6 NYCRR Part 370	Provides definitions of terms and general standards applicable to hazardous waste management system regulations.	To Be Considered	Pertains to off-site waste disposal and treatment facilities.
New York Hazardous Waste Manifest System Regulations	6 NYCRR Part 372	Establishes record keeping requirements and standards related to the manifest system for hazardous wastes.	Potentially Applicable	Applicable to alternatives involving off-site transport and disposal or treatment of classified hazardous wastes, if present.

Table D-6
Potential New York State/Local Action-Specific ARARs/TBCs
Brookhaven National Laboratory

POTENTIAL ARARs/TBCs	CITATION OR REFERENCE	REQUIREMENTS	APPLICABILITY	COMMENTS AND ANALYSIS
Waste Transporter Permits	6 NYCRR Part 364	Regulates transportation of industrial and hazardous wastes in New York State.	Applicable	Applicable to alternatives involving off-site transport and disposal or treatment of industrial and classified hazardous wastes.
NYSDEC Land Disposal Restrictions	6 NYCRR Part 376	Identifies hazardous waste that are subject to land disposal restrictions.	Applicable	
Wetlands				
New York Wetlands Laws	NYCRR Articles 24, 25	Establishes requirements for the protection of freshwater and tidal wetlands.	Not Applicable	There are no wetlands located within the state or federal mandated buffer zones from the BGRR.
New York Wetlands Regulations	6 NYCRR Part 661: Tidal Wetlands Land Use Regulations	Establishes regulations for the protection of tidal wetlands.	Not Applicable	There are no wetlands located within the state or federal mandated buffer zones from the BGRR.
Drinking Water Supply				
Procedures for Handling Community Water System Emergencies	NYSDOH PWS 152*	Establishes procedures for handling community water system emergencies.	Not Applicable	Groundwater is not addressed under this Removal Action.
Responding to Organic Chemical Concerns at Public Water Systems	NYSDOH PWS 159*	Establishes procedures for responding to organic chemical concerns at public water systems.	Not Applicable	Groundwater is not addressed under this Removal Action.

* Currently, groundwater is not addressed under this Removal Action, therefore, these regulations are not applicable. These regulations may be applicable in the future if groundwater remediation is conducted at the BGGR site.

Table D-6
Potential New York State/Local Action-Specific ARARs/TBCs
Brookhaven National Laboratory

POTENTIAL ARARs/TBCs	CITATION OR REFERENCE	REQUIREMENTS	APPLICABILITY	COMMENTS AND ANALYSIS
Public Notification of Organic Chemical Incidents Regarding Public Water Supplies	NYSDOH PWS 160*	Establishes notification procedures for chemical incidents regarding public water supplies.	Not Applicable	Groundwater is not addressed under this Removal Action.
Other New York State				
Solid Waste Management Facilities	6 NYCRR Part 360	Regulations for the siting, design, construction, management, monitoring, and closure of solid waste facilities.	To Be Considered	Applicable to alternatives involving off-site transport and disposal or treatment of classified non-hazardous wastes. Pertains to off-site waste disposal and treatment facilities.
Protective Native Plants	6 NYCRR 193.3	Protects threatened native plants pursuant to Section 9-1503 of the Environmental Conservation Law.	Relevant and Appropriate	Removal alternatives are not expected to impact plants deemed Protective Native Plants by New York State.
Suffolk County/Other Local				
Water Pollution Control	Suffolk County Sanitary Code Article 7**	Agreement between County and BNL to comply with groundwater protection regulations.	To Be Considered	Groundwater is not addressed under this Removal Action.
Toxic and Hazardous Materials Storage and Handling Controls	Suffolk County Sanitary Code Article 12**	Agreement between County and BNL to comply with groundwater protection regulations.	To Be Considered	Applicable to alternatives involving on-site handling and storage of classified toxic or hazardous materials.

* Currently, groundwater is not addressed under this Removal Action, therefore, these regulations are not applicable. These regulations may be applicable in the future if groundwater remediation is conducted at the BGGR site.

** These regulations are part of the 1987 Agreement between Brookhaven National Laboratory (BNL) and Suffolk County. Under the Agreement, these county regulations must be followed by BNL during the BGRR decommissioning project and are referred to as To Be Considered (TBC).

Table D-6
Potential New York State/Local Action-Specific ARARs/TBCs
Brookhaven National Laboratory

POTENTIAL ARARs/TBCs	CITATION OR REFERENCE	REQUIREMENTS	APPLICABILITY	COMMENTS AND ANALYSIS
Long Island Pine Barrens Maritime Reserve Act	NY Environmental Conservation Law, Title 57, 0101, et seq.	Establishes limits for development in certain areas of Suffolk County's Pine Barrens.	To Be Considered	The BGRR is not located in an area identified under this regulation; the BGRR site is a completely developed parcel of land.

Table D-7
Compliance with ARARs
Brookhaven National Laboratory
Brookhaven Graphite Research Reactor Decommissioning Project

POTENTIAL ARARs	CITATION OR REFERENCE	REQUIREMENTS	COMPLIANCE OF ALTERNATIVES WITH POTENTIAL ARARs						
			1	2	3	4	5	6	7
POTENTIAL FEDERAL CHEMICAL-SPECIFIC ARARs									
Clean Air Act of 1963, as amended (42 USC 7401-7462)									
National Ambient Air Quality Standards (NAAQS)	40 CFR Part 50	Establishes primary and secondary NAAQS for ambient air quality to protect public health and welfare, for sulfur dioxide, nitrogen oxide, carbon monoxide, ozone, lead, and particulate matter.	Y	Y	Y	Y	Y	Y	Y
National Emissions Standards for Hazardous Air Pollutants (NESHAPS)	40 CFR Part 61	Establishes emissions standards (NESHAPs) for those hazardous air pollutants for which no ambient air quality standards exists, but which cause, or contribute to, air pollution that may result in an increase in mortality or an increase in serious irreversible or incapacitating reversible illness.	Y	Y	Y	Y	Y	Y	Y
Standards of Performance for New Stationary Sources	40 CFR 60	Establishes emission standards for pollutants from new or modified stationary (facility) sources.	NA	Y	Y	Y	Y	Y	Y

Notes regarding compliance with ARARs:

Y = Yes, Removal Action will comply with requirements of the ARAR
N = No, Removal Action will not comply with requirements of the ARAR
NA= Not Applicable

Table D-7
Compliance with ARARs
Brookhaven National Laboratory
Brookhaven Graphite Research Reactor Decommissioning Project

POTENTIAL ARARs	CITATION OR REFERENCE	REQUIREMENTS	COMPLIANCE OF ALTERNATIVES WITH POTENTIAL ARARs						
			1	2	3	4	5	6	7
Threshold Limit Values (TLVs), American Conference of Governmental Industrial Hygienists	ACGIH, ISBN: 0-936712-92-9	TLVs and Biological Exposure Indices (BEIs) are listed as guidelines to assist in the control of health hazards.	Y	Y	Y	Y	Y	Y	Y
Protection of the General Population from Releases of Radioactivity	10 CFR 61.41	Concentrations of radioactive material that may be released to the general environment must not result in an annual dose exceeding 25 mrem to the body or any organ of a member of the general public.	Y	Y	Y	Y	Y	Y	Y
Standards on Removal and Disposal of Asbestos and Asbestos-Containing Materials	40 CFR 61, Subpart M	Provide for special precautions to prevent exposure of workers or airborne emissions of asbestos fibers during removal actions, and packaging requirements.	Y	Y	Y	Y	Y	Y	Y
Toxic Substances Control Act									
Asbestos and Polychlorinated Biphenyl Waste Removal	15 USC 2605 40 CFR 761	Applicable to storage and disposal of asbestos and PCB-contaminated material.	Y	Y	Y	Y	Y	Y	Y

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Brookhaven National Laboratory
Brookhaven Graphite Research Reactor Decommissioning Project

POTENTIAL ARARs	CITATION OR REFERENCE	REQUIREMENTS	COMPLIANCE OF ALTERNATIVES WITH POTENTIAL ARARs						
			1	2	3	4	5	6	7
Resource Conservation and Recovery Act of 1976 (as amended by HSWA of 1984) (40 USC 6901)									
Identification and Listing of Hazardous Waste	40 CFR Part 261	Defines those solid wastes which are subject to regulation as hazardous waste under 40 CFR Parts 262-265 and Parts 124, 270, and 271.	NA	Y	Y	Y	Y	Y	Y
Other Federal ARARs/TBCs									
Atomic Energy Act of 1954	42 USC 2011 10 CFR 61	Establishes standards for the management of radioactive wastes. DOE shall follow its own standards and procedures to ensure safe operation of its facilities.	Y	Y	Y	Y	Y	Y	Y
Protection and Enhancement of Environmental Quality	Executive Order 11514	Requires federal agencies to demonstrate leadership in achieving the environmental quality goals of NEPA; provides for DOE consultation with federal, state, and local agencies.	N	N	Y	Y	Y	Y	Y
POTENTIAL FEDERAL LOCATION-SPECIFIC ARARs									
Endangered Species Act of 1973	16 USC 1531 et seq. 50 CFR 402	Establishes requirements to protect species threatened by extinction and habitats critical to their survival	Y	Y	Y	Y	Y	Y	Y

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POTENTIAL FEDERAL ACTION-SPECIFIC ARARs									
Occupational Safety and Health Administration (OSHA) Regulations (29 USC 651)									
Standards on Removal and Disposal of Asbestos and Asbestos-Containing Materials	29 CFR 1910.1101	Provide for special precautions to prevent exposure of workers or airborne emissions of asbestos fibers during removal actions.	Y	Y	Y	Y	Y	Y	Y
Occupational Health and Safety Requirements	29 CFR 1910.120	Establishes limits for worker exposures during response actions at CERCLA sites.	Y	Y	Y	Y	Y	Y	Y
Health and Safety Requirements for Construction Activities	29 CFR Part 1926	Establishes construction standards.	Y	Y	Y	Y	Y	Y	Y
Clean Air Act									
National Primary and Secondary Ambient Air Quality Standards	40 CFR Part 50	Establishes standards for ambient air quality to protect public health and welfare (including standards for particulate matter and lead).	Y	Y	Y	Y	Y	Y	Y
National Emission Standards for Hazardous Air Pollutants (NESHAPS)	40 CFR Part 61	Regulates emissions of specific hazardous air pollutants and radionuclides other than radon from DOE facilities.	Y	Y	Y	Y	Y	Y	Y

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			1	2	3	4	5	6	7
Resource Conservation and Recovery Act of 1976 (RCRA) (42 USC 6901)									
Standards for Waste Generators and Transporters	40 CFR Parts 262 and 263	Applicable to generators and transporters of hazardous waste. Requires that transporters must be licensed hazardous waste haulers.	NA	Y	Y	Y	Y	Y	Y
Containers	40 CFR 264.171 through 264.178	Regulations cited under 40 CFR 264.171 to 264.178 (Subpart I) concern permanent on-site storage of hazardous wastes or temporary storage phases used during various cleanup actions such as removal or incineration.	NA	Y	Y	Y	Y	Y	Y
Tanks	40 CFR 264.191 through 264.198	Regulations under 40 CFR 264.191 to 264.198 (Subpart J) apply to tank storage of hazardous materials.	NA	Y	Y	Y	Y	Y	Y
Standards for Post-Closure for Units with Hazardous waste In Place	40 CFR 264.310	Post-closure care consists of cover maintenance, groundwater monitoring, and institutional controls.	Y	Y	NA	NA	NA	NA	NA
Land Disposal Restrictions	40 CFR Part 268	Applicable to alternatives involving land disposal of hazardous wastes, and requires treatment to diminish a waste's toxicity and/or minimize contaminant migration.	NA	Y	Y	Y	Y	Y	Y

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Other Federal Waste Transport Regulations									
Hazardous Materials Transportation Act of 1974, as amended	49 CFR 170-189 23 CFR 1-1399	Federal Highway Administration, Department of Transportation, and National Highway Traffic Safety Administration regulations are codified in Title 23 (Highways) of the Code of Federal Regulations. DOE shall comply with the requirements governing hazardous materials and waste transportation.	NA	Y	Y	Y	Y	Y	Y
Other Federal ARARs									
Comprehensive Environmental Response, Compensation, and Liability Act of 1980, as amended (CERCLA)	40 CFR 300 42 USC 8601 et seq.	Requires cleanup and notification if there is a release or threatened release of hazardous substance; requires DOE to enter into IAGs with USEPA and states to control cleanup of each DOE site on the NPL.	Y	Y	Y	Y	Y	Y	Y
Superfund Amendments and Reauthorization Act of 1986 (SARA)	Public Law 99-499	See CERCLA above.	Y	Y	Y	Y	Y	Y	Y

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Emergency Planning and Community Right-To-Know Act	42 USC 11001	Requires facilities to report the release of extremely hazardous substances and other specified chemicals, to provide material safety data sheets or lists, and to provide estimates of the amounts of hazardous chemicals on site.	Y	Y	Y	Y	Y	Y	Y
Archaeological and Historical Preservation Act of 1974	Public Law 93-291	Requires action to recover and preserve artifacts in areas where activity my cause irreparable harm, loss, or destruction of significant artifacts.	Y	Y	Y	Y	Y	Y	Y
Noise Control Act of 1972	42 USC 4901 et seq.	Requires facilities to maintain noise levels that do not jeopardize the health and safety of the public.	Y	Y	Y	Y	Y	Y	Y
Noise Pollution and Abatement Act of 1970	42 USCS 7641, 7642	To amend the Clean Air Act to provide for a more effective program to improve the quality of the nations air.	Y	Y	Y	Y	Y	Y	Y
Department of Energy Organization Act of 1977	42 USC 7101		Y	Y	Y	Y	Y	Y	Y

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National Environmental Policy Act of 1969, as amended National Environmental Policy Act Implementing Procedures DOE's NEPA Implementing Procedures	42 USC 4321 et seq. 40 CFR 1500 – 1508 10 CFR 1021	DOE is required to comply with NEPA and it's implementing procedures.	Y	Y	Y	Y	Y	Y	Y
Soil and Water Resources Conservation Act of 1977	16 USCS 2001 (1991)	Provides for the conservation of soil, water, and related resources for sustained use.	N	Y	Y	Y	Y	Y	Y
Nuclear Waste Policy Act of 1982	42 USC 10101 et seq.	DOE shall dispose of radioactive waste in accordance with 40 CFR 191	NA	Y	Y	Y	Y	Y	Y
Low-Level Radioactive Policy Act	42 USC 2021b-2021d	DOE shall dispose of low-level wastes (LLW) in accordance with the State in which it operates.	NA	Y	Y	Y	Y	Y	Y
Superfund Implementation	Executive Order 12580	DOE shall comply with the NCP in addition to other requirements of the order.	Y	Y	Y	Y	Y	Y	Y

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			1	2	3	4	5	6	7
Federal Facility Compliance Act of 1992	42 USC 6961	Waives sovereign immunity for federal facilities under RCRA and requires DOE to develop plans and enter into agreements with states as to specific management actions for specific mixed waste streams.	Y	Y	Y	Y	Y	Y	Y
The Native American Grave Protection and Repatriation Act (NAGPRA)	Public Law 101-601 (Nov. 16, 1990	Law provides for protection of Native American graves and for other related purposes	Y	Y	Y	Y	Y	Y	Y
The Archaeological Resources Protection Act of 1979	Public Law 96-95	Provides for the protection of archaeological resources on federal and Indian lands.	Y	Y	Y	Y	Y	Y	Y
POTENTIAL STATE CHEMICAL – SPECIFIC ARARs									
Air: NYSDEC Division of Air Guidelines for the Control of Toxic Ambient Air Contaminants	Air Guide 1	Establishes air quality guidelines and standards	Y	Y	Y	Y	Y	Y	Y
New York State Ambient Air Quality Standards	6 NYCRR 256-257	Establishes air quality standards	Y	Y	Y	Y	Y	Y	Y

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			1	2	3	4	5	6	7
Hazardous Waste: New York State Identification and Listing of Hazardous Waste Regulations	6 NYCRR Part 371	Identifies "characteristic" hazardous wastes and "listed" hazardous wastes.	N	Y	Y	Y	Y	Y	Y
POTENTIAL STATE LOCATION-SPECIFIC ARARs									
Endangered and Threatened Species of Fish and Wildlife; Species of Special Concern	6 NYCRR 182	Identifies endangered and threatened species of special concern.	Y	Y	Y	Y	Y	Y	Y
New York Air Pollution Control Regulations	6 NYCRR Parts 200-221	Provides regulations for the prevention and control of air contamination and air pollution.	Y	Y	Y	Y	Y	Y	Y
POTENTIAL STATE/COUNTY ACTION-SPECIFIC ARARs									
Air: General Provisions	6 NYCRR 200 (200.6)		NA	Y	Y	Y	Y	Y	Y
General Process Emission Source	6 NYCRR Part 212	Establishes allowable emissions for general process sources.	NA	Y	Y	Y	Y	Y	Y
Air Permits and Certificates	6 NYCRR Parts 201	Describes requirements and procedures for obtaining air permits and certificates.	NA	Y	Y	Y	Y	Y	Y
General Prohibitions	6 NYCRR Part 211	Describes requirements and procedures of obtaining air permits and certificates.	NA	Y	Y	Y	Y	Y	Y

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			1	2	3	4	5	6	7
Hazardous Waste: New York Hazardous Waste Manifest System Regulations	6 NYCRR Part 372	Establishes record keeping requirements and standards related to the manifest system for hazardous wastes.	NA	Y	Y	Y	Y	Y	Y
Waste Transporter Permits	6 NYCRR Part 364	Regulates transportation of industrial and hazardous wastes in New York State.	NA	Y	Y	Y	Y	Y	Y
Solid Waste Management Facilities	6 NYCRR Part 360	Regulations for the siting, design, construction, management, monitoring, and closure of solid waste facilities.	NA	Y	Y	Y	Y	Y	Y
NYSDEC Land Disposal Restrictions	6 NYCRR Part 376	Identifies hazardous waste that are subject to land disposal restrictions.	NA	Y	Y	Y	Y	Y	Y
Other New York State: Protective Native Plants	6 NYCRR 193.3	Protects threatened native plants pursuant to Section 9-1503 of the Environmental Conservation Law.	NA	NA	NA	NA	NA	NA	NA

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APPENDIX E

COMMENTS ON DRAFT STUDY

APPENDIX E – COMMENTS ON DRAFT REMOVAL ACTION ALTERNATIVES STUDY

Table E-1
Response to Comments on Draft Removal Action Alternatives Stsudy

Comment	Resolution
Recommend alternative #4 as that option was considered overall most environmentally prudent	Noted.
Alternatives #5 and #6 with extensive dismantling of contaminated structures were considered to be introducing more risk than leaving the reactor core structure in a safe sealed off state	Noted.
Many ... hope the building structure will once again be a useful space and possibly once again be a visitor museum space commemorating the BGRR's landmark contributions	Noted.
Shouldn't the entire fan house be decontaminated?	The south end of the Fan House is not generally contaminated, though there are some posted contamination areas. The south side of the Fan House contains electrical distribution equipment that supports the HFBR. The north end of the Fan House areas are associated with the BGRR, and will be decontaminated or fixed in place until the final disposition of the Fan House is determined.
Can the Above Ground Ducts be allowed to remain (as suggested in alternative 2) when there is indication that they may be contaminated?	The Above Ground Ducts are to be removed this spring and summer, 2000. They have been evaluated and it has been determined that they should be removed under the CERCLA process using the "Time Critical Removal" action memorandum, which has been signed and approved by the DOE.
Is it feasible to remove building 702 (reactor pile) without contaminating building 701 (reactor building)?	Yes, it is. Removal of the reactor pile under Alternative 6 will be evaluated in a subsequent EE/CA. The basic premise, when dealing with radiation and contamination, is to control radioactivity as close to the source as possible and not to spread contamination. Controlling the contamination can be done by erecting a portable enclosure that will contain any contamination from the pile and prevent the spread of contamination to the surrounding Building 701.

What is the condition of the soil under the reactor pile?	The soil under the reactor pile has not been characterized at this point in time. Subsurface soil in and around the reactor will be characterized to support the EE/CA. One of the methods that will be used to determine the condition of the soils under the pile will be by characterizing the soils under the below ground duct work at the south wall of Building 701 and at the east wall below the fuel canal.
I personally favor Alternatives 4 and/or 6.	Noted.
Is alternative 4 safe in the future?	Alternative 4 is safe for the future. If Alternative 4 is eventually selected, a comprehensive surveillance and monitoring program will be developed to insure the pile configuration is not compromised during the institutional period of control.
Is alternative 6 safe during the removal, with building 701 staying?	Alternative 6 would be done in a safe manner. However, it must be stated that, if Alternative 6 is selected, there would be an associated increase in the risk to workers during the performance of the work. Removing the pile would take approximately 18 months.
There is no discussion about the potential degradation to the graphite from the water found under the pile.	The water found under the pile did not go through, over, or come in contact with the pile materials. It did, however, come in contact with the graphite dust that was carried from the pile during operations and deposited on the surfaces of the below ground ducts. The water that was pumped was dark in color indicated it had some graphite in it.
There is no mention of any characterization or visual inspection efforts relating to the graphite	The reactor pile will be characterized to determine the radiological inventory and structural integrity to support the development of the EE/CA. This characterization is scheduled to be performed by the end of FY2000.
Without assessing the potential damage to graphite structural integrity the water intrusion may have caused, it is not clear how the pile can be placed in a safestor mode	The reactor pile will be characterized to determine the radiological inventory and structural integrity to support the development of the EE/CA. Nonetheless, water has not contacted the graphite pile. Even if it would contact the pile, the pile is enclosed in a sheath of carbon steel and aluminum that will hold the pile in its built configuration, a cube.
Graphite will release radioactive radon gas.	To date, the monitoring of the pile fan negative pressure system has shown no radon levels above those that are associated with the building and the large amounts of concrete that exist in the structure.
Since the pile contains 750 tons of graphite, this source could have an impact on the viability of the decommissioning alternatives retained and should be examined.	The pile is being isolated from other decommissioning activities to prevent or negate any impact on or from the pile. The reactor pile will be characterized to determine the radiological inventory and structural integrity to support the development of the EE/CA.
Air handling units 01 and 03 are to be removed from service, and are physically located in the same machine room as the Building 703 fans. HVAC testing showed smearable contamination on the inlets vents of all three pile fan units.	These were the initial results. However, further evaluation concluded that the contamination was radon from the building concrete structure and not radioactive contamination from Building 701 operations.

Supply ducting is also located in the same room. Ducting is lined with encapsulated asbestos and may possibly be internally contaminated radiologically	These were the initial results. However, further evaluation concluded that the contamination was radon from the building concrete structure and not radioactive contamination from Building 701 operations.
Since this equipment belongs solely to the BGRR, it is not clear why it is not being removed with other BGRR support systems.	The equipment is not being removed in the event that the Building 701/703 barriers are removed, the ventilation system may be once again started to support the continued use of Building 701.
It is not clearly stated whether underground equipment (gas decay tanks, HEPA filters, piping, a valve gallery) is included in the outside portion of the work.	It is included in the below grade piping systems and associated soils removal activity.
If it is, the equipment to be removed should be listed in the study report	The equipment to be removed will be included in the EE/CA, in the work activity that supports that work, and in the closure report for the completed activity.
Reuse is a priority focus for me	Noted. All alternatives will evaluate opportunities to recycle and reuse equipment and construction materials, as well as to decontaminate and leave in place.
You ... are there in Building 701, in the office every day. Are you worried for your health with the equipment systems in place? Why? or Why not?	No. Anytime work is being performed there is at least one Health Physics technician that monitors the work place for radioactive materials. All work is performed using the BNL work control process that includes, but is not limited to, safety evaluations, special permits, radiation work permit, confined space entry permits, cutting and burning permits, trenching permits, lifting permits, etc. Whether or not work is being performed, surveillance and monitoring for radiological conditions is performed on a routine basis. All indications are that the workers in the building are not being exposed to radioactivity above background levels. All decommissioning work will continue to be completed in a manner that protects or avoids worker and public health and safety, including the BGRR project team.
The equipment systems, if not hampering health, should be left ... I feel they are learning tools	The equipment and systems are explained and for the most part are drawn and shown in detail in literature that was prepared for operations and maintenance of the facility. There have been considerable advancements in the systems that support the operation of a facility of this type: solid state electronics, sensors, DP cells, etc. Because there may be some historic value, however, with early equipment, DOE and the NY State Historic Preservation Officer have approved a Historic Mitigation Plan to preserve that information.
It is very necessary to completely characterize, and a full risk assessment must be defined fully	The BGRR will be characterized in order to support the development of the EE/CA. The characterization for the major work areas and pile are to be completed by the end of FY2000.
Isn't this process of decommissioning its own scientific research?	It is only scientific to the extent that there is not as much institutional knowledge available since it has been so long since the facility has been shut down, as compared to a unit that shuts down and moves immediately into decommissioning. The nuclear facility decommissioning industry is mature and there are many companies that compete for this type of work internationally.

The possibility of further contaminated soils or groundwater should be eliminated to the greatest extent of technological science we can employ	Soils are being remediated to regulatory criteria that has been established and to background levels wherever practicable. All decommissioning and soil remediation alternatives will be reviewed and approved by the New York State and Environmental Protection Agency that achieve accepted cleanup standards for future residential re-use after 50-years of institutional control by the DOE.
Under NO circumstances is the reactor pile, biological shield, or encasement buildings to be removed.	An Action Memorandum will document a joint DOE and regulator decision for the reactor's end-state, which will undergo stakeholder review and comment. Stakeholder comments have an influence on DOE decision-making.
The areas of tight location and ... confined space are disturbing. Does in-situ technology of today offer any form of melting hot silicate or polymer ... to encapsulate radionuclides?	An accepted method for macro-encapsulation of the hazardous material lead was developed here at BNL and is in use in the commercial business today. Several technologies have been experimented with: asphalt, glass, and cement are a few that are used to encapsulate radionuclides. The EE/CA will evaluate decommissioning technologies that may be used for permanent sealing and isolation.
I feel follow-up round table discussions must be on the record for community input before the final revision commences	DOE will consider this recommendation and include appropriate further public and stakeholder involvement into the decision process. There will be further opportunity for comment when the EE/CA -- which is the decision document -- is published.
My recommendation would be to go with alternative #4	Noted.
...the problems and expenses involved in trying to dissemble the pile are prohibitive	Noted. Cost is only one criteria for making a decision among the decommissioning alternatives.
By leaving building 701 in place, the building could be used as a museum. It has historical significance.	Yes, it does. DOE and BNL have been working closely with the New York State Historic Preservation Officer to preserve historically significant knowledge and information.
...if there is one thing a decommissioning ... should do, it should be to remove the reactor (that is, the graphite)	Noted. Alternatives 1, 3, 4 & 6 will be evaluated in further detail in the EE/CA. Alternative 6 addresses the removal of the reactor pile.
Would like to advise on the BGRR decommissioning	Noted. DOE will consider this and include appropriate public and stakeholder involvement into the decision process.
Building 701 shouldn't be torn down	Alternatives 1, 3, 4 & 6 will be evaluated in further detail in the EE/CA. Of the alternatives being considered for further evaluation, none include tearing down Building 701
No highly radioactive materials should be left on site	Noted. All decommissioning alternatives will meet NYS and EPA's cleanup standards.
All work required toward final decommissioning should be accomplished now and not left for a future date	Alternatives 1, 3, 4 & 6 will be evaluated in further detail in the EE/CA, which will undergo stakeholder review and comments. An Action Memorandum will be published that documents DOE's decision for the end-state of the decommissioning project.

Anything that is left on site should be in a perpetually benign condition that does not require maintenance or significant monitoring	That is the present plan. Alternatives 1, 3, 4 & 6 will be evaluated in further detail in the EE/CA, which will undergo stakeholder review and comments. An Action Memorandum will be published that documents DOE's decision for the end-state of the decommissioning project after 50-years of institutional control by DOE.
Anything left on site should be in a condition that cannot deteriorate in a way that could create a groundwater problem	That is the present plan.
The pile should be dismantled and removed	Noted. An EE/CA will be prepared that evaluates the alternative of fully dismantling and removing the reactor pile, along with a detailed cost estimate. This EE/CA will undergo stakeholder review and comment. A decision will be codified in an Action Memorandum.
Building 701 does not necessarily have to be removed	Noted.
Exterior appurtenances, such as above ground ducts, canal house, heat exchangers, and the internal machinery should be removed as planned	Noted.
The metal lining of the underground ducts should be removed	Noted.
The underground concrete ducts may only require some sort of surface cleaning	Noted.
The biological shield is probably potentially the most difficult part of the dismantling program	Not necessarily. The pile is the challenge.
We suggest that consideration be given to the possibility of cutting the shield into appropriately sized blocks that could then be stacked into the underground concrete duct structure	The biological shield wall can only be removed if the pile is dismantled and removed. This decommissioning alternative will be evaluated as part of the EE/CA.
If this could be done successfully and the volumes were appropriate, then any remaining voids could be poured completely full with concrete to form a solid monolithic impermeable structure of low radioactivity	Noted. This decommissioning alternative will be evaluated as part of the EE/CA.
This could be designed to be impermeable to precipitation to avoid the possibility of leaching occurring	Yes, it can. This decommissioning alternative will be evaluated as part of the EE/CA.
The entire structure could be buried permanently and, being monolithic, would be safe from future excavation activities	Noted.

This work could possibly be done without removing the structure of the 701 building, and in fact, the building would be a benefit while it exists because it would act as a weather cover over the underground entombment	Correct.
Under these circumstances, it might be possible to leave some radioactive material in pace without posing a threat to future generations or creating potential groundwater problems	The goal of the BGRR D&D project is to achieve a "no further action" record of decision.
We believe that building 701 should remain in place and that there should also be a cocoon constructed around Building 702	The biological shield wall offers the most protective least cost shield that can be used to protect the pile. Alternatives 1, 3, 4 & 6 will be evaluated in further detail in the EE/CA, which will undergo stakeholder review and comments. DOE will document its decision in a published Action Memorandum. The memorandum will define the end state of the decommissioned project after 50 years of institutional control by DOE.
There should be a follow-up to the HVAC report to ensure that issues associated with airflow are resolved	Agree. This will be accomplished following the isolation of Building 701 from 703.
We believe the project should proceed in a completely isolated manner so that there are no pathways for transport of contaminants by air.	Agree. The project is proceeding in this manner by isolating contamination at the source to prevent its spread and by fixing removable contamination in place before physical or intrusive work begins.
How will the public be assured that there will not be unmonitored pathways from the BGRR that can result in airborne radiation to the outside environment?	Air monitoring surveillance activities are performed on a routine basis and during work activities to ensure an unmonitored condition does not exist or occur. Alternatives 1, 3, 4 & 6 will be evaluated in further detail in the EE/CA, which will undergo stakeholder review and comments. DOE will document its decision in a published Action Memorandum. The memorandum will define the end state of the decommissioned project after 50 years of institutional control by DOE.
How will these pathways be monitored in the future?	The groundwater monitoring wells surrounding the BGRR will be monitored during the 50-year period of institutional control. Air monitoring surveillance activities will be a part of the routine monitoring activities that will be performed during the institutional control period following the decommissioning of the BGRR.
If there is an electric power outage at BNL and the HVAC system is unable to maintain a negative pressure in 702 and 701, what is the back up plan to prevent contamination to the outside environment?	Presently there is a negative pile pressure system that operates. To date, the pile has not had a release of radioactivity. After sealing the pile (in FY2000), a passive HEPA filtering system will be installed on the pile to allow air to be filtered as it expands outward or inward towards the pile. This system will not require the use of electricity except for the monitoring instruments. There is no need for a back up system for the proposed pile monitoring system.

Assuming that the Graphite Pile remains, how will BNL ensure the public that water will not weaken the integrity of the graphite when we have been informed by a reliable source that the water pumped out of the exhaust dump [sic] contained graphite and could indicate that the pile was being saturated.	The reactor pile will be characterized to determine the radiological inventory and structural integrity to support the development of the EE/CA. Moreover, water has not contacted the graphite pile. The water found under the pile did not go through, over, or come in contact with the pile materials. It did, however, come in contact with the graphite dust that was carried from the pile during operations and deposited on the surfaces of the below ground ducts. The water that was pumped was dark in color indicated it had some graphite in it. Even if it would contact the pile, the pile is enclosed in a sheath of carbon steel and aluminum that will hold the pile in its built configuration, a cube.
We believe that regardless of the remedy chosen that the BGRR air filters be analyzed for likely contaminants when they are removed	Agree. The air filters will be characterized sufficiently to protect the workers, the public, and the environment and for waste disposal.
Second, we formally request that the project include a comprehensive analysis of these filters and that the results be made public immediately thereafter	The results of the characterization of the filters, as well as any other areas, will be available to the public. Results for areas already characterized are currently available in the Administrative Record, and on the BGRR web pages (http://www.bgrr.bnl.gov) Moreover, DOE is considering the recommendation to conduct additional information and/or stakeholder roundtable meetings to share information. The Decommissioning Project team will also continue to provide status reports to the Community Advisory Council and the Brookhaven Executive Roundtable.
Alternative 6 looks best initially, but could result in Building 701 becoming contaminated, as well as could put workers and the environment in immediate jeopardy	Alternatives 1, 3, 4 & 6 will be evaluated in further detail in the EE/CA, which will undergo stakeholder review and comments. DOE will document its decision in a published Action Memorandum. The memorandum will define the end state of the decommissioned project after 50 years of institutional control by DOE. Work planning and controls should be sufficient to keep Building 701 from becoming contaminated. Controlled areas of Building 701 may be established to allow for contamination during work activities. All work will be done in a manner that protects the workers and the environment, and includes leaving Building 701 in a decontaminated, useable condition.
Because Alternative 6 could result in contamination, I support alternative 4	Alternatives 1, 3, 4 & 6 will be evaluated in further detail in the EE/CA, which will undergo stakeholder review and comments. DOE will document its decision in a published Action Memorandum. The memorandum will define the end state of the decommissioned project after 50 years of institutional control by DOE. All work will be done in a manner that protects the workers and the environment, and includes leaving Building 701 in a decontaminated, useable condition.

Study states "the general area outside of the reactor pile and the biological shield external faces have been decontaminated. However, portions of the biological shield external faces remain contaminated to various levels, and are currently posted." It would be helpful here to describe if the present contamination is removable or fixed contamination.	Remaining contamination is fixed.
..."the filters were 95% efficient, which was considered an acceptable efficiency at the time they were installed." Please clarify here what types of contaminants the 95% efficiency was valid for, and for what particle sizes.	Filter efficiency is for removal of particulate matter. The filters were designed to be 95% efficient for particles 5 microns and greater and 25 to 30% efficient for particles < 5 microns. After initial use and filters require a dust loading they were expected to be greater than 95% efficient for particles greater than 3 or 4 microns.
Also on page 1-24 is the statement, "the air exhaust ducts beneath the Reactor pile flooded during the period of operation." This statement is effectively repeated at the top of page 1-25. Both of these statements indicate that water leakage to the exhaust ducts was known to occur during operation, which ceased in 1968. These statements include that this leakage that occurred during operation was not adequately stopped, and led directly to the contamination of the 57,000 gallons of water that was detected in the ducts in 1997. This impression is reinforced by the statement in Section 1.2.6 on page 1-25 that, "there were sounding devices to detect water in the ducts." This is the first time I have encountered any information concerning previous water leakage into the BGRR's below ground ducts.	During the period of time when the reactor was operational, water was known to have periodically accumulated in the below ground ducts when the reactor was not operating. This was not considered a concern at the time because the water was quickly removed once the reactor started to operate because of the large volumes of high temperature air passing through the system.
U-233 is not mentioned in Tables 2-2 *Fission Products*, Table 2-3 *Uranium Fuel Activation Products*, or Table 2-4 *Uranium Fuel and Progeny Radioisotopes*. If U0233 is a COPC then it should be listed in one of these tables.	Uranium-233 is not considered a credible COPC, which is why it is not included in these tables.

...I do not believe that thorium breeding took place at the BGRR, and if it did not, it is unlikely to be a COPC here. It is also unlikely that U-233 fission products are present here in significant quantities to be considered COPCs without having sufficient amounts of U-233 present as well. Please (a) include U-233 in one of the above tables, or (b) consider rewording of the passage on page 2-16 to exclude mention of U-233.	The second paragraph on page 2-16 has been revised to remove the reference to U-233.
Re Section 3.2.1.3 on page 3-7, the PFS removal action was in its completion phases during the writing of this memorandum in march of 2000. Please ensure accurate status is reflected in the final form of this report.	Section 3.2.1.3 has been revised to state that the PFS removal action has been completed.
Please insure that WBS 5.1a item "e" is intended to read "point the exterior bricks" instead of "paint the exterior bricks".	The text is correct as written; "point" is the correct term.
If there is some future plan for Building 701, please specify it somewhere on pages 4-1 through 4-6.	Neither DOE or Brookhaven Science Associates have formalized a decision on the future re-use of the 701 Building. The EM Steering Committee have recommended that the 701 Building remain for some other undetermined re-use.
...Alternative 6 removes 702 but leaves 701 in place. Therefore, Alternative 6 does not change the visual resources, since Building 701 would look the same externally. Please correct the wording of Section 4.2.6.	During removal of Building 702, external changes to 701 would likely be necessary to accommodate contamination control and ventilation equipment, removal equipment (e.g. cranes), and excavations.

Table 5-5, *Evaluation of Alternatives Versus NEPA Values*, on page 5-6 shows that the transportation impacts only differ between Alternative 1 and all the other alternatives. Alternative 1 is given a ranking of 7 (least transportation impacts) and all other alternatives are rated as 6. This is incorrect, since in the page 4-30 description of transportation impacts the study states, "Alternative 7 would have a greater impact from construction-related and may impact commuter (worker) traffic flow. This is because of the greater volume of waste to be transported from the site and increased number of workers needed to complete the actions identified in this alternative."	These rankings were developed based on scorings that were performed by several NEPA subject matter experts. They were modified based on reviews performed by the BGRR staff and the DOE. In addition, they have been presented to the public for review and comment. In many cases, substantial discussions were held to reach consensus on particular scores. These scorings have a subjective aspect, which we endeavored to minimize by soliciting and considering input from numerous sources during development of the scores. Although your comment is reasonable, we do not feel it is appropriate to change the scorings because of the substantial review and discussion that went into development of the scores.
Following the reasoning of the last sentence above, Alternative 7 should be given a lower ranking than all the other action alternatives. Additionally, Alternatives 5&6 will generate substantially more waste than Alternatives 2-4, due to their removal of either Building 701 or 702. Thus these alternatives should be ranked between Alternatives 7 and Alternatives 2-4. Please correct Table 5-5.	These rankings were developed based on scorings that were performed by several NEPA subject matter experts. They were modified based on reviews performed by the BGRR staff and the DOE. In addition, they have been presented to the public for review and comment. In many cases, substantial discussions were held to reach consensus on particular scores. These scorings have a subjective aspect, which we endeavored to minimize by soliciting and considering input from numerous sources during development of the scores. Although your comment is reasonable, we do not feel it is appropriate to change the scorings because of the substantial review and discussion that went into development of the scores.
There are numerous inconsistencies in the decommissioning alternative rankings in Table 5-6, *Evaluation of Alternatives Versus Environmental Safety and Health Community Values*, on page 5-7. The first is that for four of the rankings (not counting the "utilize qualified, experienced personnel," which ranks all alternatives the same) the no-action alternative (#1) is ranked equivalent to the alternative which completes actions called for under the IAG (#2). In all of these four categories, the actions taken under the IAG would improve conditions on the site compared to no-action, and should be ranked accordingly. Please alter these rankings accordingly.	These rankings were developed based on scorings that were performed by several NEPA subject matter experts. They were modified based on reviews performed by the BGRR staff and the DOE. In addition, they have been presented to the public for review and comment. In many cases, substantial discussions were held to reach consensus on particular scores. These scorings have a subjective aspect, which we endeavored to minimize by soliciting and considering input from numerous sources during development of the scores. Although your comment is reasonable, we do not feel it is appropriate to change the scorings because of the substantial review and discussion that went into development of the scores.

Secondly, under the first category evaluated, *Prevent negative impacts to the public health and the environment...*, Alternative 4 is ranked a 7 (least negative impacts) whereas Alternative 3 is ranked 3. The only real difference between these alternatives is that Alternative 4 removes Building 701 equipment and systems in addition to the actions taken under Alternative 3. In terms of this category, these two alternatives should be ranked the same. Please correct.	These rankings were developed based on scorings that were performed by several NEPA subject matter experts. They were modified based on reviews performed by the BGRR staff and the DOE. In addition, they have been presented to the public for review and comment. In many cases, substantial discussions were held to reach consensus on particular scores. These scorings have a subjective aspect, which we endeavored to minimize by soliciting and considering input from numerous sources during development of the scores. Although your comment is reasonable, we do not feel it is appropriate to change the scorings because of the substantial review and discussion that went into development of the scores.
Thirdly, under the last category, *Ensure that environmental clean-up actions are effective and durable over time*, Alternative 3 and 4 are ranked with too great a difference. Please re-rank Alternative 3 as "3" instead of "2". There is simply not enough of a difference between these two alternatives from the standpoint of environmental safety and health to justify these large differences.	These rankings were developed based on scorings that were performed by several NEPA subject matter experts. They were modified based on reviews performed by the BGRR staff and the DOE. In addition, they have been presented to the public for review and comment. In many cases, substantial discussions were held to reach consensus on particular scores. These scorings have a subjective aspect, which we endeavored to minimize by soliciting and considering input from numerous sources during development of the scores. Although your comment is reasonable, we do not feel it is appropriate to change the scorings because of the substantial review and discussion that went into development of the scores.
Table 5-11, titled *Evaluation of Alternatives Versus Local Economy/Employment Community Value*, lists the same ranking for all alternatives on page 5-10. Although BNL states that it will use local workers as much as possible, some gradient should be displayed since the more work intensive alternatives (5-7) present enhanced opportunities for local worker employment. Please reconsider the rankings in Table 5-11.	These rankings were developed based on scorings that were performed by several NEPA subject matter experts. They were modified based on reviews performed by the BGRR staff and the DOE. In addition, they have been presented to the public for review and comment. In many cases, substantial discussions were held to reach consensus on particular scores. These scorings have a subjective aspect, which we endeavored to minimize by soliciting and considering input from numerous sources during development of the scores. Although your comment is reasonable, we do not feel it is appropriate to change the scorings because of the substantial review and discussion that went into development of the scores.

Section 5.2.7 on page 5-18 describes the reasons for removing Alternative 7 from further consideration, which are specified as its high cost and large quantity of waste generated which will impact transportation (which is oddly not reflected in this alternative's ranking under Table 5-5, see comment 9, above). **I emphatically disagree** that now is the appropriate time to remove this alternative from further consideration. Alternative 7 offers the most complete removal action possible and has not been the subject of substantial public input and debate. Please retain this alternative for discussion and consideration in the remainder of the decision-making process. [emphasis in original]	DOE and Brookhaven Science Associates have informally decided that the 701 Building should be retained for some future undetermined re-use option. Additionally, DOE has decided that a stand-alone EE/CA will be prepared for the disposition of the 702 Building and the final status of the 701 Building at the completion of the BGRR Decommissioning Project, including a long-term surveillance and maintenance plan.
... transportation impacts could also be minimized by selecting non-commuting times of day to perform the actual shipments of waste. I recommend that extensive use of these alternative transportation modes and scheduling be examined in much greater detail in the final study.	Noted.
Please change the heading in Section B1.1.2.17 on page B-6 from "Sacrificers" to "Scarifiers."	Done. Table of Contents also corrected.
Executive Summary: Who is the audience?	This report, including the executive summary, was written as a tool to assist BNL and the DOE in selecting a removal action alternative and as such, they are the primary audience. Consequently, the report assumes a level of regulatory and technical knowledge typically possessed by the primary audience.
After defining DOE, use acronym	Corrected.
p. ES-2 All of the museum walls haven't been removed; the Museum office and sales booth are still in place against the north wall.	A few minor sheetrock walls were retained by the BGRR-DP to facilitate operations, e.g. the former sales booth is now a 90 RCRA hazmat storage area.
p. ES-2 What are "construction" activities? Isn't this "destruction"?	Construction activities include a broad range of actions including destruction and demolition work.
p. ES-4 Should Building 703 be discussed at this time?	Building 703 is not part of the Brookhaven Graphite Research Reactor Project, except to the extent that it may be incidentally affected by work on Buildings 701 and 702.

p. ES-4 Should cost get more attention here, since it is a major concern?	Remediation under CERCLA requires that we take much more into consideration than just cost. Decisions are made based on much more than just cost. In fact, a major objective of this study is to evaluate possible options against the wide range of considerations addressed by CERCLA, NEPA, and community values.
p. 1-1 Will "the" always be put in front of BNL	"The" was used in the initial instance of "Brookhaven National Laboratory". BNL stands alone, without the definite article.
p. 1-1 Use RAA	Disagree. RAAS is already acronymed, and the addition of RAA would create opportunity for confusion. Moreover, reference to the Removal Action Alternatives is rare, where the RAAS is frequently referenced.
p. 1-1 Are these "decommissioning" alternatives? Isn't there a special meaning to decom?	Although decommissioning has a special meaning for reactors licensed by the Nuclear Regulatory Commission, it has no special meaning for the BGRR.
p. 1-3 What is "vicinity"? 100m, 500m?	In this paragraph, "vicinity" refers to the areas immediately adjacent to the BGRR that are included as an Area of Concern under CERCLA or areas containing ancillary equipment and facilities that will be effected during the removal action process.
p. 1-3 Define "annealed"	As used in this paragraph, the term refers to a heating and cooling process applied to the graphite pile, which safely releases stored energy. This is a precautionary safety practice, which is performed on all graphite reactors as a routine part of operations.
p. 1-4 Should it [stack height] be given in meters as well?	The height is given in feet because all drawings in the report use units of feet. All measurements in the document are presented using a single unit (e.g., feet, grams) and the height of the stack has no special importance so there is no reason to provide multiple units for the stack.
p. 1-4 Define "orphaned"	In this paragraph "orphaned" means that maintenance and upkeep of the BGRR was not funded specifically through a DOE Headquarters Research Program that had responsibility for the reactor. Maintenance and upkeep were instead performed as a part of site-wide surveillance and maintenance.
p. 1-5 How about a title for G. J. Malosh	Added.
p. 1-7 If "areas of concern" has not been given an acronym, capitalize it and give it one. If it has been given one, use it.	"Areas of Concern", in the regulatory sense, is acronymed when it is used in that sense. This is not one of those usages.
All figures, tables, etc, need page number on the "bottom" as document is bound.	These tables and figures are in a format that cannot be modified in the time than remains before the RAAS is due.
p. 1-10 Although the word is used in a title [High Radiation Areas], it might be worthwhile to define "High"	The term "High Radiation Area" has a special meaning as defined in Title 10 Part 835 of the code of federal regulations. This and other terms used in the report that have regulatory definitions are not defined in the report.

Figure 1-3 This figure should have North on the top as per convention and as done in most other figures in the document	These tables and figures are in a format that cannot be modified in the time than remains before the RAAS is due.
p. 1-13 Should radioactive waste lines be included?	No, these lines are part of the Canal House and Water Treatment House, which are discussed in 1.2.9. So these lines are discussed in Section 1.2.10 of the report.
p. 1-13 Define "D" and "F" waste somewhere	The 'D' and 'F' designations are included to identify waste systems that were in part used to support operation of the BGRR. Only piping from the BGRR complex to these systems is part of this study. Detailed descriptions of the systems was not considered necessary.
p. 1-13 Graphite also reflected the neutrons	Yes, that is true.
Figure 1-5 North should be at top	These tables and figures are in a format that cannot be modified in the time than remains before the RAAS is due.
p. 1-17 Express in Bq as well as Ci	The report was written with the convention that all measurements in the document are presented using a single unit.
p. 1-17 Define type A and type B graphite	These refer to the grade or quality of the graphite. The moderator used Type A graphite and the reflector used Type B graphite.
p. 1-17 Shouldn't this be "activity", not "activation"?	No, it was intended that this sentence describe the level of radioactivity due to activation of graphite in the pile by neutrons.
p. 1-17 Isn't there a more recent report. Perhaps Meinhold -1999	At the time the RAAS was prepared, Meinhold - 1999 had not been approved.
Figure 1-9 Arrow for rear binding plate ends in air duct. Shouldn't it be at plate?	These tables and figures are in a format that cannot be modified in the time than remains before the RAAS is due.
p. 1-24 Is it worth describing what the materials are, and including a comment about characterizing them?	The paragraph on page 1-24 states that they are likely to be mercury and asbestos.
p. 1-24 Either remove "during" or insert after during "the period"	The ducts were know to have accumulated water both during the period of operation and after the BGRR were shut down.
p. 1-24 Where did this "ambient tritium" come from?	Activation of water vapor in the cooling air as it passed through the pile.
p. 1-25 How was there "washdown" in the reactor plenum?	The term "washdown" refers to cleaning of the plenum walls by spraying them with water.
Figure 1-12 Arrow indicating North is not on diagram, as per others	These tables and figures are in a format that cannot be modified in the time than remains before the RAAS is due.
Figure 1-12 Secondary air plenum looks as though it ends outside of south wall. Does it?	Yes, however there are a number of piping connections from this plenum to the below ground ducts, which were not included in this simplified drawing.
Figure 1-13 North arrow does not point same as other similar graphs. It points more NW, while the buildings are still aligned the same as in other figures.	These tables and figures are in a format that cannot be modified in the time than remains before the RAAS is due.

p. 1-33 Give in liters also?	The report was written with the convention that all measurements in the document are presented using a single unit.
p. 1-34 These are first uses of R and milliRoentgen. Should they be Roentgen or rem?	They are correctly given in Roentgen based units, because these were exposure rate measurements
p. 1-34 ...whichever, they should be defined	They were defined later on the page, the definition has been moved to the appropriate place.
p. 1-34 In one case is used for prefix, whereas in second case "milli" is written out. Symbols and written out should not be mixed.	Corrected
p. 1-34 Also dose should be given in newer terminology -- Sv.	Dose is not used, these are exposure rate measurements.
p. 1-35 Insert "waste" after "D".	Inserted.
p. 1-35 D waste, and any others referred to by letter should be defined somewhere.	The 'D' and 'F' designations are included to identify waste systems that were in part used to support operation of the BGRR. Only piping from the BGRR complex to these systems is part of this study. Detailed descriptions of the systems was not considered necessary.
p. 1-35 Joints is plural -- should read "are likely locations"	Corrected.
p. 1-36 Should be given in Sv as well	The report was written with the convention that all measurements in the document are presented using a single unit.
p. 1-36 Is "Cementos" a copy write name? [I assume he means "trademarked" or "registered"]	This is presented as is shown on original plans for the Canal House.
p. 1-36 If so, it should have a footnote with the correct notation as to source, company, etc.	Same as above.
p. 1-36 Should this be noted as an asbestos hazard at this time? (Asbestos hazards are covered later.)	Not relevant to this document
p. 1-36 Define "D" and "F" wastes, as per previous page comment	The 'D' and 'F' designations are included to identify waste systems that were in part used to support operation of the BGRR. Only piping from the BGRR complex to these systems is part of this study. Detailed descriptions of the systems was not considered necessary.
p. 1-36 Has horizontal drilling been considered for sampling under these slabs?	Plans for detailed characterization for these slabs have not yet been developed.
p. 1-36 If not, is it desirable to drill through them?	Plans for detailed characterization for these slabs have not yet been developed.
p. 1-37 How was this determined [that the outdoor pad area has fixed contamination under several layers of asphalt and concrete]? Was it by the underground Radioactive Material Area Survey?	This was based on contamination measurements prior to the areas being covered.

p. 1-37 Needs capital S (on Radioactive Material Area Survey)	Corrected.
Figure 1-15 If this is meant to be a "map" type figure, should have North at the top.	This is a sketch of the floor drain system, not a map.
Figure 1-15 If not, there should be a North arrow, which points DOWN, as opposed to the convention of having North at the top. Building 801 is north of the fan house, the stack is East of the fan house and 802 is north of stack in other diagrams (maps).	These tables and figures are in a format that cannot be modified in the time than remains before the RAAS is due.
p. 1-39 Give value in BQ as well as Ci.	The report was written with the convention that all measurements in the document are presented using a single unit.
p. 2-1 Is it worth referencing a specific regulatory definition [of "decommissioning]?	No, since the BGRR removal actions are being conducted Under CERCLA, which does not have a specific regulatory definition of decommissioning.
p. 2-1 Insert "BNL"	Inserted.
p. 2-3 Include Irradiated Materials Building (701A) -- Only pad remains, but is discussed in document.	The pad will be removed as part of removal activities so it has no future use.
p. 2-3 Also ducts and hot lab fan house "R" as shown on maps.	Above ground ducts will be removed and below ground ducts will be abandoned in place if they are left behind, thus, there are no reasonable future uses. Building designated, as "R" is not part of the BGRR project and will continue on with its current function.
p. 2-3 Add to sentence "and environments" as per the phrasing used on following pages. [last sentence of the second bullet point]	Added.
p. 2-4 Add ingestion of H20 as per figure 2-2	Yes, ingestion of water should be added to this list.
Figure 2-2 Add ingestion of H20 ????	It is already included. Box containing ground water and surface water includes an arrow to the ingestion exposure route.
p. 2-7 Titles of for documents are generally in italics in other places	Corrected.
p. 2-7 Write out cobalt, carbon, etc. as per done for plutonium (or just be consistent).	Cobalt-60, Strontium-90, Carbon-14, and Cesium-137 had all been previously defined. Plutonium-239 and Plutonium-240 had not.
p. 2-8 Sentence is not too clear. Should "efforts" be "effects"	Yes, corrected.
p. 2-8 Should alpha, beta, and gamma be defined for first use. Depends on audience.	These terms are well know to the primary audience of this document.

p. 2-8 Include "animal by-products" - possibly milk?	This sections is intended to describe the difference between internal and external exposure. It is not intended to be a definitive description of internal pathways. Milk is part of the animal pathway and is included in the description on page 2-4.
p. 2-8 Insert "type of"?	Type of radioactive decay is not the only concern. More importantly, the energy and probability of photons and particles emissions is the real concern. The term radioactive decay was intended to include all of the radioactive decay variables without a detailed description of the specific variables such as type of decay.
p. 2-8 Include "concrete, lead, steel, etc."	Added.
p. 2-9 Use "with", not "of" [bombardment *with* neutrons]	Corrected.
p. 2-9 Not a very clear description. [sentence reads: While activated steel can not be cleaned of its radioactive nature, the radioactive nature can not be transported unless the steel itself is degraded (e.g., through cutting or abrasion) and transported.	"Nature" changed to "content". The steel will be treated as per the DOE "no rad added" policy and the BNL RadCon Manual
p. 2-9 May want to include "from liquid flow" [in discussion of how surface contamination can be transported]	This was not intended to be an exhaustive list of how loose contamination is transported. The intent was to provide some examples.
p. 2-9 Too small to read	These tables and figures are in a format that cannot be modified in the time than remains before the RAAS is due.
p. 2-10 "Fugitive" is jargon. Should it be defined?	This term is known to the primary audience of this document.
p. 2-12 Up until this point tritium has been used, but not defined. Perhaps define it as the heaviest and only radioactive isotope of hydrogen. Or at least include the name in the table	This term is known to the primary audience of this document. It will be included in the table.
p. 2-13 It is not "uptake of soil" (roots don't uptake soil, but contaminants "from" or "in" the soil.	Corrected.
p. 2-15 Define "altogether" [...replacing the natural uranium metal fuel altogether.]	In this context the term means that when the fuel change was made all of the old fuel was removed and replaced with the new fuel design prior to restarting the reactor.
p. 2-15 Should that be "on"	Corrected.
p. 2-16 Insert "spent"	Inserted.

General comment for all tables. If a number for a key is given at the bottom of the table it should appear somewhere in the title or the table. This has been done when more than one number appears in the key, but should also be done if just a "1" appears. This has been noted on tables 2-2, 2-5 (where there are two items in key both marked "1" and not noted.	Table 2-2, 2-3, and 2-4 include markings in the table and the correct number of footnotes. Table 2-5 has been corrected.
Table 2-7 Activities should also be given in Bq, unless it was an editorial decision not to do this.	The report was written with the convention that all measurements in the document are presented using a single unit.
Table 2-7 Key given twice -- bottom line of table and below table	Corrected.
p. 2-23 Insert "or during scheduled shutdowns"	Inserted.
Table 2-8 Note key number	Number removed.
Table 2-8 Give values in BQ also	The report was written with the convention that all measurements in the document are presented using a single unit.
p. 2-27 Insert "floor tiles" as a possible source of asbestos contamination	Added.
p. 2-36 Include the dose Sv as well as rem	The report was written with the convention that all measurements in the document are presented using a single unit. In addition, regulatory risk limits are always specified in mrem.
p. 2-36 Why not use the symbols here as above. They have all bee identified before	It appears that the subcontractor's style guide requires the definition of individual isotopes as separate entries, not entire elements
p. 2-36 Replace "to" with "the"	Corrected.
p. 2-37 Use PRGs -- it has been defined	Corrected.
p. 2-37 Include Bqs?	The report was written with the convention that all measurements in the document are presented using a single unit.
p. 2-38 RESRAD not on acronym list	Added.
p. 2-38 Include Sv	The report was written with the convention that all measurements in the document are presented using a single unit.
p. 2-38 Should be focuses ---- are, or focus --- is	Corrected.
p. 2-38 Insert be	Removed "to", instead.
p. 2-38 COC has been used	Corrected.
p. 2-38 Reference is not in usual format. Usual is title in italics followed by reference and year.	Changed.

p. 3-1 Should the term "stakeholders" be included. It is in most documents related to lab environmental activities or policies.	Disagree. The public, EPA, and DOE are stakeholders.
p. 3-1 Put [No Action Alternative] in acronym since the phrase is capitalized and used later.	Disagree. "No Action Alternative" is a specific term and is used exactly that way.
p. 3-4 As of March 2000, inside wooden walls of the museum office and sales booth remain on the north wall.	A few minor sheetrock walls were retained by the BGRR-DP to facilitate operations, e.g. the former sales booth is now a 90 RCRA hazmat storage area
p. 3-6 Should more be said about the evaluation of the water for contaminants and what they were	Although detailed information is available it was not considered germane to the objective of this report and so was not included.
p. 3-6 Should it be noted that water is characterized and removed.	All water has already been dispositioned; the last sentence of 3.2.1.1 states that this activity has been completed.
p. 3-6 Why only the North side of the building. [Re: decontamination of fan house]	The remainder of the building is used by another BGRR facility and is not part of the BGRR project.
p. 3-6 Should status be noted as per for other actions. [of fan removal and fan house decon, I assume]	Fan house is not an AOC
p. 3-7 Test [*sic*, text?] refers only to North wall -- should that be noted in table (space in table consideration)	The WBS for the fan house is limited to the north side of the building so it is not necessary to state that in the table.
p. 3-7 Is this [a new water-tight cover on the pile fan sump] a "permanent" cover?	No, the Pile Fan Sump has been removed.
p. 3-7 What is it [the cover] made of?	Pile Fan Sump has been removed.
p. 3-7 Only monitoring the level? [pile fan sump monitor] Not also for contamination?	Pile Fan Sump has been removed. No additional contamination was being introduced to the sump so there was no need to monitor the contamination levels.
p. 3-8 Present status [of the Above Ground Duct WBS]	The status of items that were not actively being worked on when the report was prepared was not addressed.
p. 3-9 As per previous note - museum office and sales boot still (March 2000) exist against North wall.	A few minor sheetrock walls were retained by the BGRR-DP to facilitate operations, e.g. the former sales booth is now a 90 RCRA hazmat storage area
p. 3-9 This ["This work item will be part of every Decommissioning Alternative, except for the No Action Alternative."] is a good statement for several of the alternatives.	Common elements are discussed in detail in Section 3.3.1
p. 3-10 Present status? [Of pile sealing]	The status of items that were not actively being worked on when the report was prepared was not addressed.

p. 3-12 If investigation shows contamination [in the below ground primary air exhaust coolers], what will actions be?	Actions will be determined at that time. Insufficient information is available at this time to determine future actions.
p. 3-13 Is the[pneumatic tube] trench shown on any diagram?	In BGRR file drawings
p. 3-13 With the position of bldg 801 relative to the reactor it might seem that the trench would go in the South side of 801 to eliminate an extra corve [*sic,* curve?] in the tubes. (If not that might be why rabbits got stuck in the tubes.)	This is observation rather than a comment so no response is needed.
p. 3-14 Why not written out, or if taken as a whole word, as in jargon, drop period. ["e.g., rad. waste lines,..."]	Changed. Radioactive waste lines is correct.
p. 3-14 What is the present status [of the remaining soils]? Anything being done that applies to this alternative [*sic*].	The status of items that were not actively being worked on when the report was prepared was not addressed.
p. 3-14 Any bore samples taken [of remaining soils]?	This area has not yet been characterized.
p. 3-15 Insert "of" ???	Inserted.
Figure 3-2 Is something left out for "Disposition of 701" in alternative 5? The phrase is shown in the table for other alternatives 2-6.	No, disposition of 701 is not included in alternatives 5 and 7 because Building 701 will be removed under these alternatives.
p. 3-21 Insert "reactor pile" as per other alternatives.	Inserted.
p. 3-21 If this "safe enclosure" is "cocoon" might indicate it as such.	They are intended to mean the same thing.
p. 3-29 Are there any sumps involved in this? [disposal of water collected from the underground cooling ducts]	Only sump involved in common elements is the Pile Fan Sump. Other sumps exist but will be addressed along with the system
p. 3-29 The museum office and sales booth are still present as of March 2000.	A few minor sheetrock walls were retained by the BGRR-DP to facilitate operations, e.g. the former sales booth is now a 90 RCRA hazmat storage area
p. 3-30 Delete spaces.	Deleted.
p. 4-1 How are community values document and evaluated.	They were documented based on a series of meetings that were held with the public. Information obtained in these meetings was categorized and evaluated as described in Section 4.3.
p. 4-2 Why capital on Value?	Corrected.
p. 4-4 This sentence is not clear. ["Overall human health would be environment are protected as long as Federal control is maintained."]	Corrected.

p. 4-5 The use of "will" and "would" are mixed in the document.	Editorial
p. 4-5 Isn't it induced "radioactivity" that gives off radiation? ["Because of anticipated high radiation levels within the graphite reactor due to induced radiation and potential fuel residue..."]	Existing statement is correct
p. 4-6 Shouldn't the acronym be moved up to follow its root words?	"Requirements" *is* the last root word.
p. 4-6 Use of comma in series not consistent. Sometimes before "and" sometimes not.	Corrected.
p. 4-8 The root words for an acronym should be capitalized to define the acronym.	Disagree with the generalization, but changed nonetheless.
p. 4-9 Footnote should appear on the bottom of the page where the number appears.	Agree.
p. 4-19 Does a "removal schedule" exist. [under section 4.1.6 Implementability]	A complete schedule for completion of activities cannot be developed until a decision is made regarding the selected removal action.
p. 4-19 Alternative 7 does not have S&M, as shown in figure 3-2.	No S&M is needed because the entire facility is removed under this option.
p. 4-20 Add "al" [to "remove"]	Added.
p. 4-21 Cocoon is specified as a noun in most dictionaries, but is often used as a verb. Next line the "ing" form is used. Best to be consistent.	Corrected.
p. 4-35 Use BGRR?	Corrected.
p. 5-4 Footnote 10 indicated in table 5-2, but 9 indicated in footnote	Corrected.
p. 5-17 Insert "graphite"	Text currently says, " The reactor pile is constructed from small pieces of graphite that fit together like building blocks."
p. A-1 Should be "on" not "or"?	Corrected.
p. A-2 Shouldn't somewhere it be indicated Long Island, NEW YORK.	Added.
p. A-3 Shouldn't it be Minus 20 (-20)	Corrected.
p. A-4 Insert "that" or "stating that"	Inserted.

p. A-5 There are large areas of planted trees from the Civilian Conservation Corp (CCC) activities. Planting rows are still visible in some areas of the lab. Should these be noted.	Not relevant to the purpose of the document.
p. A-6 Should wild turkeys and geese be included? In a later section geese are noted.	Not relevant to the purpose of the document.
p. A-7 This should be noted as the RHIC or the AGS.	Added RHIC.
p. A-10 Is it ever noted that BNL is in Suffolk County?	Added to page A-2.
p. A-10 Insert "County"	Inserted.
p. A-10 Insert "the mid-island route of the LIRR"	Inserted.
p. A-11 Insert "an annual"	Inserted.
p. A-11 Insert "per year"	Inserted.
p. A-13 Note that the firemen have also responded to off site forest and brush fires.	Not relevant to the purpose of the document.
p. A-13 Comment on nearest hospital.	Not relevant to the purpose of the document.
p. A-13 Insert "State University of New York, Stonybrook"?	Inserted.
p. A-14 What is "immediate"	"Immediately surrounding" is the phrase used -- meaning "adjacent". (The HFBR DEIS, from which this information was lifted, has a much longer discussion and census maps.)
p. A- 15 Has RHIC been defined? It was referred to it in an earlier comment [*sic*].	RHIC was defined and discussed in the first section of the document. It's also in the Acronym list.
p. A-16 "efficiencies" are apartments. Might insert that.	Inserted.
p. B-1 Further define "total dose". To who? [*sic*] Collective, etc.	This depends on the material being decontaminated and its disposition (is it being reused, disposed of as clean, being disposed of as contaminated, etc.). Collective dose or individual dose may be the controlling factor. Individual dose could be to a radiation worker, a non-radiation worker, a member of the public on-site or off-site, etc. The statement was purposely left generic to avoid this confusion.
p. B-3 Does this include use of detergents. During some DECON operations, a mixture of detergents and water are used.	Detergents are not typically used in these processes for large scale decontamination because it increases the difficulty of treating the waste stream.
p. B-4 Should be "are"	Corrected.

p. B-4 Why is "gage" used here, and not on next page #1? [Section B1.1.2.11 Hydroblasting]	That is how the information was stated which was referenced. Gage pressure subtracts atmospheric pressure from the total pressure. It is 14.7 so the subtraction does not change much. The units are quoted based on the available information. Gage pressure is quoted as psig whereas absolute pressure is usually stated as psi.
p. B-5 Insert "gage" as per above?	This unit is absolute pressure and not gage so the unit is correct.
p. B-6 How about wire brush disks? [Section B1.1.2.16 Grinding]	This is considered to be included as part of B.1.2.2. e.g. Scrubbing
p. B-14 Insert space	Inserted.
p. B-15 The new BNL developed "RAPTOR" technique for splitting concrete might be mentioned. It is patented but still in development.	The current plan would not benefit from this technology or be able to sustain the cost of deployment.
p. C-1 Needs document identification at top.	These tables and figures were created by the subcontractor, and are in a format that cannot be modified without considerable time and effort.
p. D-1 Needs document identification at top.	The current text is: *Draft Brookhaven Graphite Research Reactor Decommissioning Project Removal Action Alternative Study*
p. D-1 When to capitalize "s" in ARARS - in some titles but not all? In text?	Fixed.
Table D-1 The key for the "*" is given at the end of the table. Might be good to put it on the first page of the table to make it "handy".	The key has been added to the pages where it is specifically referenced.
p. D-4 The title for the next section in the bottom line might be moved to the next page top.	Fixed, sub-heads clarified
p. D-7 Does the listing of the "Acts" need a title line above them? This seems to be a new subject.	It's a new table, as the title states.
p. D-8 This title seems incomplete.	The title is correct.
p. D-11 Should this title be at the top of next page?	Corrected.
p. D-26 "wetlands" hangs over from previous page. Possible to use some abbreviations in paragraph on previous page to make room for wetlands there???	Corrected, along with other formatting issues.
p. D-28 Put key at bottom for Y, N and NA rather than just on last page.	Put into page footer, for ease of access
p. D-29 Is this a complete reference, or just meant to be a subject heading?	Title is correct
p. D-32 Move title to next page?	Corrected.

p. D-36 For other tables, the subject headings are not in caps as on other pages.	Corrected.
p. D-37 Should the boldface **Hazardous Waste** be a title line.	Corrected.
p. D-38 Should the boldface **Other New York State** be a title line.	Corrected.
General comments	
What is the target audience. Must assume that the document will get to the science community, public and selectively to the media, no matter how it is released.	The science community is one audience.
Each page should have document identification on top or bottom, as per SER. This is particularly important for graphs and tables which may be copied or used for slides or overheads.	Not necessary for this level of formality
Use English and Metric (gallons - liters), (feet - meters), etc., old and new radiation designations (rem - Sv) (Ci-Bq)? Just be consistent.	Units are not always consistent because material obtained from various references was incorporated into this document using the units included in the original effort. Old radiological units were used throughout.
If doses or units of activity are given as being measured or expected, compare with limits and background values.	Outside of document scope and objectives.
Give BNL credit where possible. Example might be possible use of BNL developed RAPTOR for concrete breakup.	Outside of document scope and objectives.
Define jargon words such as "orphaned" "fugitive", "high" level, "immediate vicinity", "washdown" in plenum (I don't believe there should be any water in plenum to wash down)	Water accumulated as the result of washdowns it is not stored in the plenum to perform washdowns.
For figures; If maps, put North at top with arrow.	These tables and figures are in a format that cannot be modified in the time than remains before the RAAS is due.
Be consistent with "would" and "will". In some alternatives "will" is used which sounds as though the action was settled upon, which it may be, but in other similar cases "would" is used.	Editorial

Might define tritium when first mentioned "as the heaviest and only radioactive isotope of hydrogen". Whereas other isotopes have the same name as their stable isotopes, not all readers may be aware that tritium is hydrogen, and because of that travels with water, etc..	Audience has an awareness of Tritium and what it is.
It was noted that the water "level" in the pile sump (meaning depth of water?) would be monitored, but will activity also be monitored? (page 3-7) This would probably be true for all sumps.	The pile fan sump has been removed.
Decommissioning has a definite meaning with some government agencies. Are the activities described in this document governed by any of these? (Sample attached)	[If there was a sample attached, it didn't stay attached]
If jargon is used, terms should be defined. Examples are: "orphaned", "fugitive", "washdown" (when referring to possible contamination from the plenums), "immediate vicinity" (inches, yards, miles, etc.?). Are "safe enclosure" and cocoon the same?	Noted
Waste types should be defined. "D", "F", etc.	Noted
Should the term "stakeholders" be used somewhere in the document? It seems to be a popular term in many BNL and government documents related to the environment. I don't remember seeing it in this draft.	Noted
For multi page tables, having the key to symbols put on the bottom of the first page as well as the last will make it easier for the reader. In the longer tables the headers for new topics are not consistent with format (typeface, capitalization, etc.) The titles for new subject groups should not appear as the last line on a page. Carry it over to the next page where the subject begins.	Tables reformatted.