Public Comment Period - March 1 to March 31, 1999

Proposed Plan for
Operable Unit III
Brookhaven National Laboratory

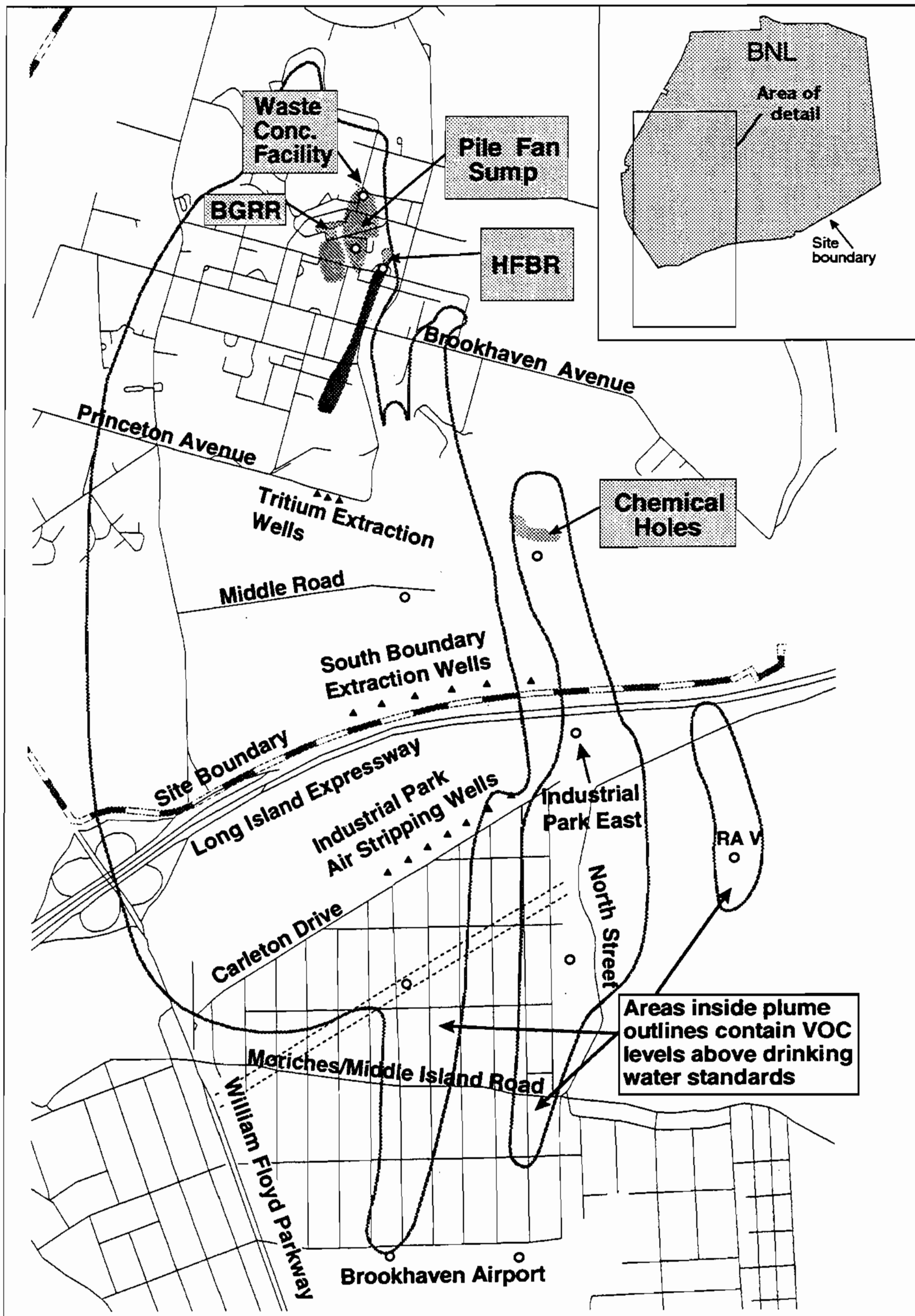

Figure 1. *Extent of tritium, strontium-90 and total VOC plumes, with existing and potential treatment locations shown.*

Inside This Plan

LEGEND

- Volatile organic compounds at levels greater than drinking water standard
- Tritium at levels greater than drinking water standard
- Strontium-90 at levels greater than drinking water standard
- ○ Potential groundwater extraction or treatment system
- ▲ Existing/planned groundwater extraction or treatment wells

Public Meetings/ Poster Sessions*

Public Meeting
Berkner Hall, BNL
March 24, 1999
7:00 - 9:00 p.m.

Information Sessions:

Berkner Hall, BNL
March 10, 1999
5:00 - 7:00 p.m.

Longwood H.S.
Middle Island
March 16, 1999
7:00 - 9:00 p.m.

Berkner Hall, BNL
March 18, 1999
11:30 a.m. - 1:30 p.m.

*Briefings for other communities and groups can be arranged by calling BNL Community Relations at (516) 344-7459.

Proposed Plan - document requesting public input on a proposed remedial alternative (cleanup plan).

Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) - a federal law that establishes a program to identify, evaluate, and remediate sites where hazardous substances may have been released, leaked, poured, spilled, or dumped into the environment; also known as Superfund.

Remedial Investigation/Feasibility Study (RI/FS) - studies required by CERCLA to characterize the nature and extent of contamination due to past releases of hazardous and radioactive substances to the environment, to assess risks to human health and the environment from potential exposure to contaminants, and to evaluate cleanup actions.

(*Note:* Technical and administrative terms are used throughout this Proposed Plan. When these terms are first used, they are printed in ***bold italics***. Explanations of these terms, document references, and other helpful notes are provided in the margins.)

I. Introduction

This Proposed Plan describes remedies for addressing contaminated groundwater in the central and southern portions of Brookhaven National Laboratory (BNL) known as Operable Unit III, and in the vicinity of residential homes off site, beyond the southern BNL property boundary. Figure 1 illustrates the general location of contaminated groundwater.

The U.S. Department of Energy (DOE) has identified these proposed alternatives as its cleanup recommendations. DOE, with the concurrence of the U.S. Environmental Protection Agency (EPA) and the New York State Department of Environmental Conservation (NYSDEC), will select the actual remedy only after the public comment period has ended and the information submitted during this time has been reviewed and considered.

The proposed remedies may be modified or different removal/remedial actions may be selected based upon public comments. The public is encouraged to review and comment on all alternatives identified here and in the Feasibility Study.

This ***Proposed Plan***, required by the Superfund Law (***Comprehensive Environmental Response, Compensation and Liability Act of 1980***), summarizes information from two documents:

1. The ***Operable Unit III Remedial Investigation Report*** describes the nature and extent of contamination at a particular area of the BNL site. The Baseline Risk Assessment portion of this document reports on the risk to both human health and the environment in the absence of cleanup.
2. The ***Operable Unit III Feasibility Study*** describes how the cleanup options were developed and evaluated.

These reports and other documents pertaining to Operable Unit III are included in the site's ***Administrative Record***, which contains information that will be used to determine the final remedies. This Record is available for public review at locations listed on page 11 and at the end of this document.

II. Proposed Remedy

As shown in Figure 1, groundwater contamination issues at BNL include ***volatile organic compounds*** (VOCs) in on- and off-site groundwater, and strontium-90 and tritium in on-site groundwater. Several alternatives (discussed in detail in Section IX) have been evaluated for each of these contaminated groundwater plumes.

Based on these detailed evaluations, proposed cleanup actions (called the remedy) were recommended for the three plumes and are summarized below. The public is invited to comment on the proposed remedy as well as the other alternatives considered.

The remedy ultimately selected by DOE and approved by EPA and NYSDEC will be implemented in a timely manner. It is expected that the approved remediation facilities will be installed within two to five years of final remedy selection.

The design, off-site land access, and construction are the primary tasks that will need to be completed for the installation of the groundwater treatment systems. The installation of the groundwater treatment systems will be prioritized to address the highest VOC concentrations and portions of the plume with the greatest potential to impact receptors such as the Carmans River.

The proposed remedies identified below for the three major contaminants will meet the following cleanup objectives:

- Meet drinking water standards in groundwater for VOCs, strontium-90, and tritium.
- Complete cleanup of the groundwater in a timely manner. For the Upper Glacial Aquifer, this goal is thirty years or less. For the Magothy Aquifer, this goal is sixty years.
- Prevent or minimize further migration of contaminants.

The difference in cleanup times between the Upper Glacial and Magothy Aquifers is due to the slower movement of groundwater in the Magothy Aquifer. The slower groundwater movement results in a longer time to achieve ***Maximum Contaminant Levels (MCLs)*** via natural attenuation. The depth of contamination in the Magothy makes it more difficult to treat.

It is important to acknowledge that meeting the cleanup objectives in a timely manner does not mean active treatment of the groundwater for that entire period of time. Some systems, such as those associated with cleanup at source areas, may involve just a few years of active treatment followed by continued monitoring to meet that objective. However, other treatment systems may require longer operational periods, followed by further reduction of contaminants over time through natural attenuation, and monitoring. These later systems may be located, depending on the contaminant, at the downgradient or leading edge of the plume to help limit further migration.

If monitoring indicates that continued operation of the components of the selected remedy is not producing further reductions in the concentrations of contaminants in groundwater, in accordance with the National Contingency Plan, DOE, NYSDEC, and EPA will evaluate whether discontinuance of the remedy is warranted. The criteria for discontinuation will include an evaluation of the operating conditions and parameters, as well as a determination that the remedy has attained the feasible limit of contaminant reduction and that further reductions would be impracticable.

Two essential constituents of each of the remedies identified below are natural attenuation of the plumes and groundwater monitoring. First, natural attenuation involves a reduction in contaminant strength (concentration, toxicity or mobility) due to natural processes which may include the natural degradation and decay of contaminants over time. This "weakening" of a plume can occur through a variety of physical, chemical, and biological processes, such as radiological decay, sorption/adherence to soils, degradation, and dispersion. The primary natural attenuation processes for the plumes include: radiological decay and dispersion for the tritium; radiological decay and sorption for the strontium-

Administrative Record - documents including correspondence, public comments, and technical reports upon which the agencies base their remedial action selection.

Volatile organic compounds (VOCs) - organic chemicals commonly used as solvents, degreasers, paints, thinners and fuels

Maximum Contaminant Levels - standards set by the EPA and the DEC for contaminants in drinking water. These concentrations represent levels that the regulatory agencies believe are safe for people to drink. DEC standards often apply a safety factor and are more stringent than the Federal standards. MCLs used in this document are the more stringent of the EPA or DEC standards for a contaminant.

United States Environmental Protection Agency

The **U.S. Environmental Protection Agency** (EPA) is one of the three agencies identified in the Interagency Agreement, which establishes the scope and schedule of remedial investigations at BNL. Correspondence with EPA Region II staff concerning this project can be found in the Administrative Record under Operable Unit III.
For additional information concerning the EPA's role in preparing this proposed plan, contact:

Mary Logan
U.S. Environmental Protection Agency Region II
290 Broadway
New York, NY 10007-1866
(212) 637-4321

90; and dispersion and chemical/biological degradation for the VOCs. In order to attain the remedial action objectives of meeting drinking water standards in a timely manner, groundwater treatment would be combined with natural attenuation. Attenuation also provides reduction in on- and off-site concentrations of contaminants in groundwater.

Second, to ensure continued protection of human health and the environment, an integral component of the remedy is continuation of an enhanced groundwater monitoring program. Long term monitoring, which includes sampling and analysis of the groundwater, will include the use of existing and planned wells both on and off site. These wells will be located adjacent to the treatment systems and along the downgradient plumes. They will help determine the effectiveness of each treatment system in reducing the concentration of contaminants over time. Long-term monitoring will also determine the ultimate duration for operation of the treatment systems and will support the future need for any changes to the final remedy.

The following proposed remedy for tritium, strontium-90 and VOCs in groundwater provides an aggressive combination of groundwater treatment and monitoring and restores the portion of Long Island's sole source aquifer contaminated by BNL as a source of drinking water in a timely manner.

Volatile Organic Compounds (VOCs)

Several accelerated actions have already begun to address VOC contamination and are part of the proposed remedy. These actions include:

• A groundwater treatment system began operation in June 1997 through which VOC-contaminated groundwater is extracted at the south boundary of BNL and treated by air stripping. The goal of the system is to prevent additional off-site migration of the most contaminated part of the plume.

• Another groundwater treatment system is being implemented along the southern side of the Industrial Complex south of the Laboratory. This system will address further migration of the highest concentrations of the deep VOC plume using in-well air stripping.

• Public water has been provided to an area south of BNL, and will provide protection of public health while the groundwater cleanup is under way.

• A source removal using air sparging/soil vapor extraction is underway just south of Building 96, at the site of a former truck wash and drum storage area, in order to remediate VOCs in the groundwater.

• Two underground storage tanks and contaminated soils, potential sources of groundwater contamination, are being removed from Building 830.

In addition to these activities, the proposed remedy, Alternative V10b, includes a proposed groundwater treatment system on site at Middle Road to prevent migration and further contamination of the deeper Magothy Aquifer and to reduce the duration of remediation in the Upper Glacial Aquifer. Finally, additional off-site groundwater treatment systems are proposed to capture and treat VOCs. These systems will be located at the LIPA right-of-way, North Street, the

New York State Department of Environmental Conservation

The **New York State Department of Environmental Conservation** (NYSDEC) is one of the three agencies identified in the Interagency Agreement, which establishes the scope and schedule of remedial investigations at BNL. Correspondence with NYSDEC staff concerning this project can be found in the Administrative Record under Operable Unit III.
For additional information concerning the state's role in preparing this proposed plan, contact:

Jim Lister
NYSDEC
50 Wolf Rd.
Albany, NY 12233
(518) 457-3976

Brookhaven Airport, downgradient of Removal Action V, and the eastern portion of the Industrial Park. Details of the specific number of treatment systems and locations needed to meet the performance objective will be determined during the design process.

Due to the depth of the contaminants and the slow movement of groundwater, monitoring and natural attenuation is proposed for the Magothy Aquifer. This includes minimizing further contamination of the Magothy Aquifer. At present, limited characterization has been performed in the Magothy Aquifer, so additional characterization and groundwater monitoring wells are planned. Upon completion of this characterization and monitoring, the selected remedy for the Magothy Aquifer will be reevaluated.

Tritium

A pump-and-recharge system, which includes three pumping wells located on site along Princeton Avenue, was installed in May 1997 to extract the tritium-contaminated groundwater and discharge it further north to a recharge basin on site. This action of pumping the leading edge of the plume was taken as a precautionary measure to move contaminated groundwater further away from the site boundary and allow more time for the tritium to decay (tritium is a radioactive element with a half-life of 12.3 years). A carbon filtration unit is included as part of the interim removal action (IRA) system to remove VOCs that are also present in the groundwater.

picoCuries per liter (pCi/l) - a unit of measure of radioactivity per liter of groundwater.

Alternative T4 proposes monitored natural attenuation with a contingency remedy to address tritium contamination in groundwater. Additional monitoring wells will be added to supplement the existing groundwater monitoring network downgradient of the High Flux Beam Reactor (HFBR) spent fuel pool. The tritium pump-and-recharge system on Princeton Avenue will be put on stand-by and operated as an integral component of the tritium plume contingency remedy. Specific contingencies identified are 1) to evaluate the need to reactivate the Princeton Avenue IRA if tritium concentrations exceed 25,000 ***pCi/l*** at the Chilled Water Plant Road and/or 2) reactivate the Princeton Avenue IRA if tritium concentrations exceed 20,000 pCi/l at Weaver Drive.

A low-flow extraction system will be installed in the most concentrated area of tritium contamination near the HFBR and activated if concentrations exceed 2,000,000 pCi/l at the front of the reactor. This system would be used, if needed, to remove groundwater containing the highest concentrations of tritium from the aquifer. The extracted tritiated water will be disposed of off site. Additional monitoring wells will be installed at the HFBR and included in the existing network.

Although it is expected that tritium will decay sufficiently to avoid off-site migration,these contingencies will ensure that the cleanup objectives are met.

Strontium-90

There are concentrated areas of strontium-90 contamination in the groundwater at three on-site locations, namely the Chemical Holes area, the Brookhaven Graphic Research Reactor (BGRR) Pile Fan Sump, and the Waste Concentration Facility. Strontium-90 is a radioactive element with a half-life of 29.1 years.

United States Department Of Energy

The **U.S. Department of Energy (DOE)** is one of the three agencies identified in the Interagency Agreement, which establishes the scope and schedule of remedial investigations at BNL. Correspondence with DOE staff concerning this project can be found in the Administrative Record under Operable Unit III.
For additional information concerning DOE's role in preparing this proposed plan, contact:

John Carter
U.S. Department of Energy
Brookhaven Group
P.O. Box 5000
Upton, NY 11973-5000
(516) 344-5195

The proposed remedy, Alternative S5a, involves the installation of extraction wells and the use of ion exchange to remove the strontium-90 from the extracted water. Residual waste from the treatment process that contains strontium-90 will be disposed of off site.

III. Community Role in Selection Process

DOE encourages public input to ensure that the preferred remedy for Operable Unit III effectively meets community needs and protects human health and the environment.

To ensure early and effective community input in this process, DOE and BNL began reaching out to the community before the proposed plan was released. In August and September of 1998 stakeholders were invited to participate in Community Roundtables, and canvassing of residents was conducted. In October 1998 a Community Workshop on OU III cleanup options was held (10/22/98). This input was used to help develop and evaluate cleanup alternatives in the Feasibility Study.

Written comments on the Feasibility Study and the Proposed Plan will be accepted for a period of 30 days. For your convenience, a postage-paid comment sheet can be found on the last page of this document. At the public meeting on March 24, 1999 in Berkner Hall at BNL, oral and written comments will be accepted.

During the comment period, informational sessions will be held as noted on page 2. Additional community relations activities will include briefings to elected officials and community groups, and articles in the BNL Environmental Restoration Division newsletter *cleanupdate*. Also, during this period other supporting information will be available, including the Remedial Investigation/ Risk Assessment Report and the Feasibility Study.

Record of Decision (ROD) - documents the regulators' decision on a selected remedial action, and includes the responsiveness summary and a bibliography of documents that were used to reach the remedial decision. When the ROD is finalized, remedial design and construction can begin.

After considering public comments, DOE, EPA, and NYSDEC will make a final decision on the cleanup remedies for Operable Unit III, and the decision will be formalized in a document called the ***Record of Decision (ROD)***. Attached to the ROD will be a Responsiveness Summary that summarizes public comments and DOE responses to those comments. Following final remedy selection, these documents will be available for public review. Finally, the public will be kept informed during the remedy implementation phase.

IV. Site Background

BNL is a Department of Energy laboratory conducting research in physical, biomedical, and environmental sciences, as well as in selected energy technologies. Brookhaven Science Associates, a not-for-profit research management organization, operates BNL under a contract with DOE.

BNL is located 60 miles east of New York City, close to the geographic center of Suffolk County on Long Island (Figure 2). It is bordered on the west by the William Floyd Parkway, on the east by residential areas and parkland, on the north by residential areas, and on the south by the Long Island Expressway.

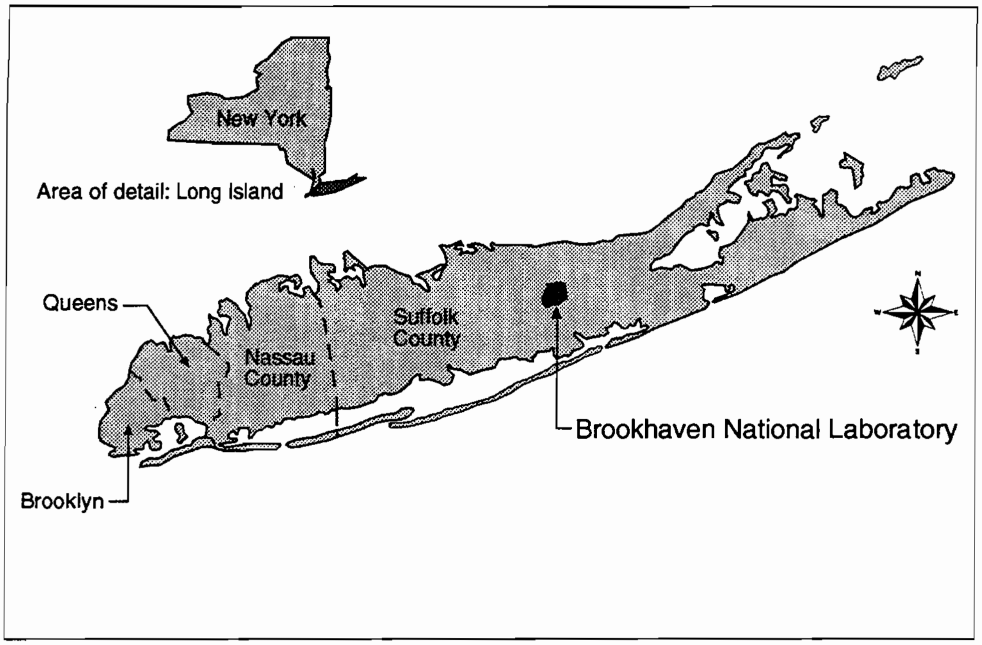

Figure 2. *Brookhaven National Laboratory's location with respect to New York State and Long Island.*

In 1980, the BNL site was placed on NYSDEC's list of Inactive Hazardous Waste Disposal Sites. In 1989, it was included on EPA's ***National Priorities List*** of Superfund sites. BNL's inclusion on the Superfund and NYSDEC lists was due primarily to the effects of past operations, which pose a threat to Long Island's sole source aquifer.

BNL has a total of 29 ***Areas of Concern (AOCs)***. To ensure effective management, these areas were grouped into six distinct ***Operable Units (OUs)*** (Figure 3).

Operable Unit III was developed to address site-specific AOCs, concentrating on groundwater plumes originating from the western portion of the site. During the original investigations in 1995 and 1996, the eleven AOCs in

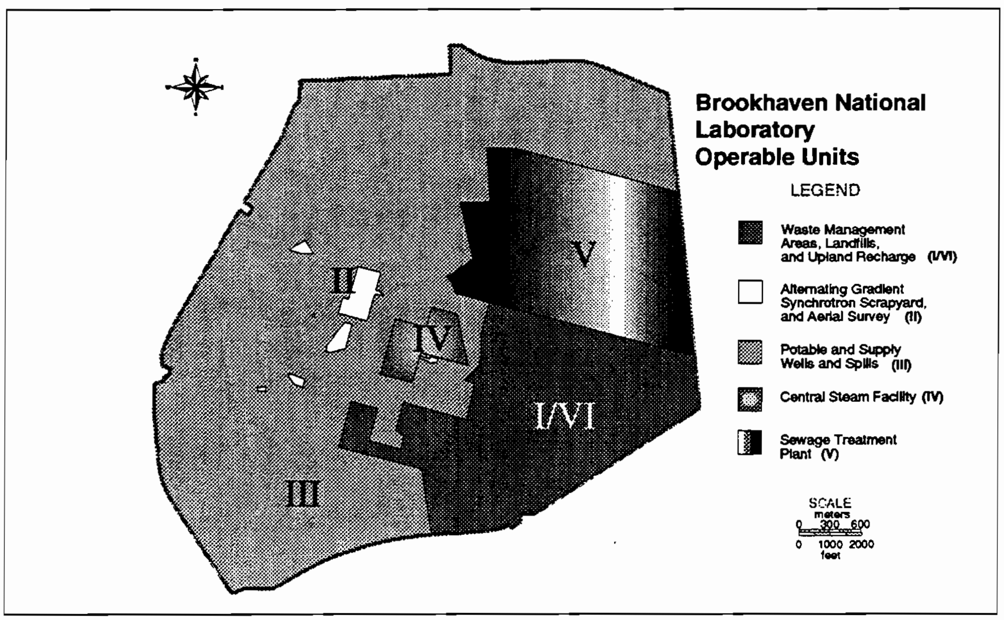

Figure 3. *Brookhaven National Laboratory's six Operable Units.*

National Priorities List - a formal listing of the CERCLA sites that have been identified for possible remediation. Sites are ranked by the EPA based on their potential for affecting human health and the environment.

Area of Concern (AOC) - a geographic area of BNL where there has been a release or the potential for a release of a hazardous substance, pollutant or other contaminant. There are 29 areas of concern at BNL.

Operable Unit (OU) - an administrative designation grouping geographical portions of a site, specific site problems, or initial phases of an action. Operable Units may also consist of any set of actions performed over time or any actions that are concurrent but located in different parts of a site. BNL has six Operable Units.

Operable Unit III plus four located in Operable Unit II/VII were all evaluated within Operable Unit III in terms of groundwater impact.

Based on the results of this investigation and the discovery in late 1996 of tritium in groundwater, one additional AOC and four additional areas of investigation were added to the investigation in 1997 (Figure 4). Table 1 lists these 20 AOCs and Areas of Investigation. A complete discussion of these areas can be found in the Remedial Investigation Report.

Table 1. OU III Areas of Concern and Areas of Investigation

Area of Concern	Historical Description
Paint Shop (AOC 7)	Paint- and thinner-stained soils excavated and backfilled. Septic tank and cesspool: tank removed, cesspool pumped and backfilled.
Building 830 Pipe Leak (AOC 11)	Leak in transfer line between building and underground storage tanks. Pipe and contaminated soil removed.
Building 830 Underground Storage Tanks (AOC 12)	Underground storage tanks containing liquid and sludge contaminated with radionuclides. Tanks and their contents, and a valve pit, have been removed. Soils are currently being removed.
Bubble Chamber Spill Area (AOC 14)	Hazardous materials handling and storage area with documented spills.
Leaking Sewer Pipes (AOC 21)	Pipes carried laboratory and sanitary wastes. Poor condition of pipes may have resulted in exfiltration of wastewater to soil and groundwater.
Potable, Supply and Monitoring Wells (AOC 15)	Contamination in potable and supply wells from source areas in OU III. Leaking sewer pipes and cesspools probable source. Wells are out of service or are being treated with activated carbon. Monitoring well at the southern boundary contains VOCs above MCLs.
TCE Spill Area (AOC 19)	Approximately 1,800 gallons of TCE discharged on the ground between 1951 and 1953.
Old Firehouse (AOC 22)	Radiation levels above background were found under concrete floor. Following demolition, soil was excavated.
Process Supply Wells and Recharge Basins (AOC 24)	Process supply wells for the Brookhaven Medical Research Reactor contaminated with VOCs. One well shut down; the other treated with carbon adsorption unit. One recharge basin with organic compounds above limits, source is probably contamination pumped by supply well. Potential discharge of radiologically contaminated wastewater to a second recharge basin.
Heavy Machine Shop (AOC 25)	Historical use of hydraulic oils, cutting fluids and lubricants. Documented leaks and spills. PCB contaminated soil excavated.
Central Shops (AOC 26)	TCA detected in sewer lines leading to old vapor degreasing pit. No soil remediation required. Vapor degreaser removed.
Building 464 (AOC 27)	Abandoned catch basin containing high levels of mercury and detectable PCBs in soils. Soils were excavated.

Brookhaven Graphite Research Reactor (AOC 9)	Potential for leakage of radioactively contaminated liquid from the spent fuel canal. Potential releases of radioactive materials to underground duct work and subsequent flooding with rainwater and leakage. Spill area may have been inadequately remediated and may have impacted groundwater.
Waste Concentration Facility (AOC 10)	Temporary storage area for liquid radioactive waste that is distilled to remove particulates, suspended solids and dissolved solids. Tanks have leaked into vault area. Aboveground tanks dismantled. Six USTs still contain sludge. Waste transfer line may have released radioactive liquid. Line was removed and replaced.
AGS Scrapyard (Boneyard) (AOC 18)	Improper storage of radioactive materials, particles of radioactive steel may have contaminated soil.
North End of Linear Accelerator (LINAC) (AOC 20)	Improper discharge of waste into a recharge basin.
High Flux Beam Reactor Spent Fuel Pool and Tritium Plume (AOC 29)	The High Flux Beam Reactor spent fuel pool has leaked tritium to the groundwater. Fuel pool was emptied. There is an on-site plume of tritium downgradient of the HFBR.
BGRR Pile Fan Sump	The sump, located near the BGRR and Bldg. 801, may have acted as a source of tritium and strontium-90 groundwater contamination. This was added to the remedial investigation to further define the strontium-90 plume.
OU I Chemical Holes Area	High levels of strontium-90 have been detected in monitoring wells south of the Chemical Holes.
Building 96	The primary source of VOCs in the groundwater is an area south of Building 96. This was added to the remedial investigation to further define the contamination.

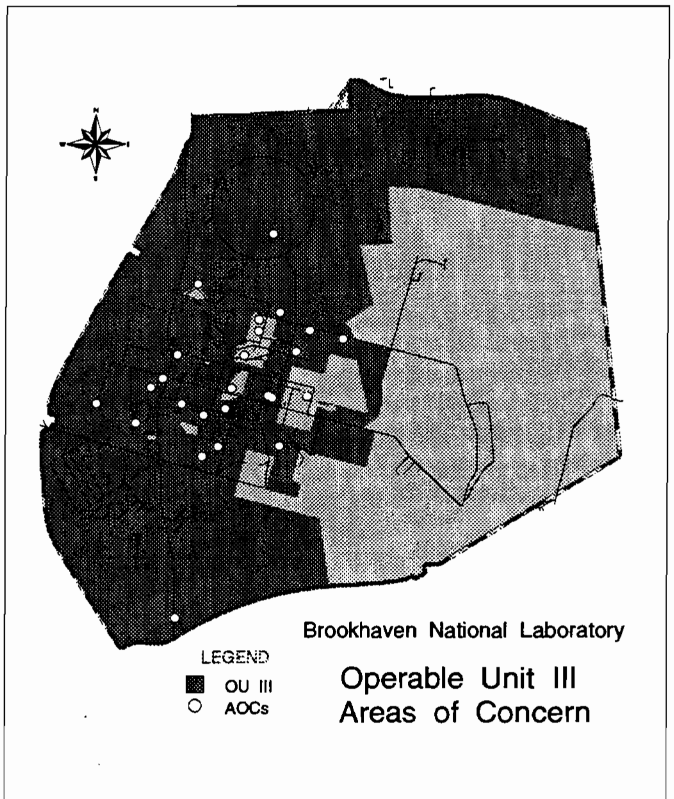

Figure 4. *Areas of Concern in Operable Unit III.*

V. Remedial Investigation Summary

The Remedial Investigation sought to identify the nature and extent of soil and groundwater contamination at Operable Unit III. The investigation included the following: radiological surveys; sampling of soil, groundwater, surface water, and sediment; chemical and radiological analyses; data validation; and preparation of the Remedial Investigation and Risk Assessment Report.

State and Federal standards, criteria, and guidances were reviewed to evaluate the nature and extent of contamination in groundwater, surface water, soil and sediment. Screening criteria used to identify contamination were derived from these requirements. These screening criteria are identified in the Operable Unit III Remedial Investigation and Risk Assessment Report.

Table 2. Contaminants identified as being of potential concern after comparison to screening levels

AOC	Surface soil	Subsurface soil	Surface water	Sediment	Groundwater
Paint Shop (AOC 7)		Thallium			
Building 830 Pipe Leak and Underground Storage Tanks (AOC 11,12)	Thallium Mercury Cesium-137	Nickel Thallium Cesium-137 Thorium-230			Cobalt-60
Bubble Chamber Spill Area (AOC 14)		Nickel Thallium	Copper Benzo(a)pyrene		TCA
Leaking Sewer Pipes Potable, Supply and Monitoring Wells TCE Spill Area (AOC 19,21)	Benzo(a)-pyrene	Thallium Thallium			TCE TCA Carbon Tetrachloride
Old Firehouse (AOC 22)		Thallium Benzo(a)pyrene			
Process Supply Wells and Recharge Basins (AOC 24)	Copper Manganese	Manganese Thallium	Copper Iron		
Heavy Machine Shop Central Shops (AOC 25,26)					
Building 464 (AOC 27)					
Brookhaven Graphite Research Reactor (AOC 9)					Strontium-90
Waste Concentration Facility (AOC 10)					Strontium-90
AGS Scrapyard (Boneyard) (AOC 18)					
North End of Linear Accelerator (LINAC) (AOC 20)				Copper Lead Mercury Silver Zinc delta-BHC	
High Flux Beam Reactor Spent Fuel Pool and Tritium Plume (AOC 29)					Tritium
BGRR Pile Fan Sump					Strontium-90
OU I Chemical Holes Area					Strontium-90
Building 96					PCE TCA

Table 2 shows which contaminants were identified as being of potential concern based on a comparison to these screening levels in each media and area of concern.

Surface Soil

To evaluate the nature and extent of contamination in surface soils, samples were taken at the Building 830 Pipe Leak and Underground Storage Tanks, the TCE Spill Area and the Process Supply Wells and Recharge Basins AOC. Most of the inorganic analytes were detected at concentrations either slightly above or below screening concentrations. Thallium and mercury were detected at elevated levels in samples collected from the Building 830 area. Copper and manganese were detected at elevated concentrations in the recharge basins in the Process Supply Wells and Recharge Basins AOC. Volatile organic compounds, pesticides and PCBs were not detected in surface soil above screening levels. The only semi-volatile organic compound detected at a concentration more than two times the screening level was benzo(a)pyrene, in surface soils sampled from the TCE Spill area. Polycyclic aromatic hydrocarbons, such as benzo(a)pyrene, are commonly encountered in commercial/industrial areas, and can enter the environment in releases from truck and automobile exhaust. Cesium-137 was the only radionuclide detected at an activity above the screening concentration, in two of the samples from the Building 830 area, and cesium-137 in surface soils in this area may be of concern. These contaminated soils are currently being removed as part of an OU III ***Removal Action***, using soil cleanup levels developed under the OU I Feasibility Study.

Subsurface Soil

Subsurface soil sampling was conducted to determine the horizontal and vertical extent of soil contamination in OU III. Subsurface soil samples were collected from the Paint Shop, the Building 830 area, the Bubble Chamber Spill Area, the TCE Spill Area, Leaking Sewer Pipes, the Old Firehouse and the Process Supply Wells and Recharge Basins AOC. The average concentrations of most analytes found in subsurface soils were below the chemical screening concentration. Analytes detected at concentrations above screening levels and that warrant further study were: manganese, nickel, thallium, benzo(a)pyrene and cesium-137. Manganese was detected at elevated levels in subsurface samples from the recharge basins in the Process Supply Wells and Recharge Basins AOC. Nickel was elevated in samples from the Building 830 area and the Bubble Chamber Spill Area. Thallium concentrations were elevated in subsurface soil from the Paint Shop, the Building 830 area, the Bubble Chamber Spill Area, TCE Spill Area, Leaking Sewer Pipes and the Old Firehouse. Benzo(a)pyrene was detected at elevated concentrations in subsurface samples collected from the old firehouse. Cesium-137 and thorium -230 were detected above screening levels in a subsurface soil sample collected from the area of the Building 830 USTs. These contaminated soils are currently being removed as part of an OU III Removal Action, using soil cleanup levels developed under the OU I Feasibility Study.

Surface water

Three recharge basins were sampled as part of OU III: the two basins in the Process Supply Wells and Recharge Basins AOC and the recharge basin in the Bubble Chamber Spill Area. The Surface Water Investigation found no evidence of contamination of the Recharge Basins from radioactive wastewater discharges. The basin in the Bubble Chamber Spill Area had elevated levels of copper and benzo(a)pyrene. Iron and copper were found at elevated levels in the two basins

removal action - an action taken early and/or quickly to prevent, minimize or mitigate damage to public health or the environment that may otherwise result from a release or threatened release of hazardous substances, pollutants or contaminants

Administrative Record Locations

The Feasibility Study Report, Proposed Plan and all Administrative Record documents can be found at the following locations:

U.S. EPA — Region II
Administrative Records Room
290 Broadway
New York, NY 10001-1866
Phone: (212) 637-4296
Contact: Jennie Delcimento

Longwood Public Library
800 Middle Country Road
Middle Island, NY 11953
Phone: (516) 924-6400
Contact: Reference Librarian

Brookhaven National Laboratory
Research Library
Technical Information Division
Building 477A
Upton, NY 11973
(516) 282-3483
Contact: Reference Librarian

Mastics-Moriches-Shirley
Community Library
301 William Floyd Parkway
Shirley, NY 11967
Phone: (516) 399-1511
Contact: Reference Librarian

in the Process Supply Wells and Recharge Basins AOC. No elevated levels of volatile organics, pesticides or PCBs were found in OU III surface water.

Sediment

Sediment samples were taken from the recharge basins in AOC 24 (Process Supply Wells and Recharge Basins), an inactive cesspool associated with the Paint Shop, a recharge basin in the Bubble Chamber Spill Area, and the recharge basin at the North End of the LINAC. Sediment contamination was found only in Recharge Basin HT at the North End of LINAC. Sediment samples from this basin have elevated levels of mercury, copper, lead, silver and zinc. A separate sample contained elevated levels of PAHs and one pesticide, delta-BHC. Radionuclides were not detected in sediment in excess of screening levels. The petroleum hydrocarbon and pesticide contamination may be related to storm water runoff containing oils and greases from local asphalt paved roads and parking lots, and runoff from the LINAC area, which contains contaminated landscaping soils. These contaminated landscaping soils are being addressed under Operable Unit II/VII.

Groundwater

Groundwater sampling was conducted to define the vertical and horizontal extent of contamination in groundwater. The groundwater investigation identified the following contaminants: VOCs (carbon tetrachloride, tetrachloroethene, 1,1,1 trichloroethane, trichloroethene), strontium-90 and tritium.

Volatile Organic Compounds

Carbon tetrachloride was detected in the deep-glacial zone (60-150 ft. below sea level). The elevated levels of carbon tetrachloride extend in a north-south direction from an area south of Princeton Avenue on site to an area off site, south of Moriches-Middle Island Road. The carbon tetrachloride plume is approximately 9,500 feet long and up to 900 feet wide. The highest concentrations of carbon tetrachloride, greater than 1,000 parts per billion (ppb), are located between the BNL's south boundary and Carleton Drive. The highest concentration detected to date has been approximately 5,100 ppb. (The MCL for carbon tetrachloride is 5 ppb.) The 1,000 ppb plume is approximately 1,500 feet long by 200 feet wide. The exact source of the carbon tetrachloride contamination has not been identified. It is suspected that the source of the carbon tetrachloride no longer exists. Potential sources for carbon tetrachloride and other contaminants are still being evaluated under the Facility Review and Preliminary Assessment/Site Inspection programs under way at BNL.

Tetrachloroethene (PCE) was found in the vicinity of Building 96 in the water table zone and in the deep-glacial zone near the site boundary. The MCL for PCE is 5 ppb. PCE in groundwater samples ranged from 10 to 15,000 ppb. The main source of the PCE is the area immediately south of Building 96, which had been used as a truck wash station and drum storage area. In the water table zone the PCE plume is approximately 1,600 feet long by 500 feet wide. In the mid-glacial zone the plume is about 4,400 feet long by 600 feet wide. There are high concentrations of PCE (greater than 1,000 ppb) in the deep glacial zone from an area on site north of Princeton Avenue to the southern portion of the Industrial Park off site.

For More Information

For more information on this project in particular or Brookhaven National Laboratory's environmental restoration program in general, contact:

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1,1,1-trichloroethane (TCA) was found in groundwater samples above the MCL of 5 ppb at concentrations ranging from 6 to 1,600 ppb. The two areas with most of the elevated TCA concentrations are the area just south of Building 96 in the middle of the BNL site and the area around the Waste Concentration Facility (WCF) and Alternating Gradient Synchrotron (AGS) located in the northern portion of the site. The sources for the elevated concentrations of TCA near the WCF and AGS are probably the cesspools associated with the Bubble Chamber Area. The high concentrations of TCA are found at three locations between Brookhaven Avenue and South Boundary Road.

Trichloroethene (TCE) was detected in wells above the MCL of 5 ppb at levels ranging from 7 to 27 ppb. These elevated levels were found primarily in the area between Princeton Avenue and the South Boundary Road on site.

Because of the similarities of the VOCs found in groundwater in OU III, the horizontal and vertical extent of total volatile organic compounds (TVOCs) in groundwater was also assessed. In addition to the data collected as part of the OU III Remedial Investigation, groundwater data were collected for the OU I/IV and for Removal Action V (RA V) located in OU I.

Figure 1 shows the areal extent of TVOCs in groundwater. The TVOC contamination extends from the water table to 150 feet below mean sea level. The shape of the TVOCs in the vertical dimension is similar to the shape of the PCE contamination. However, the TVOC plume encompasses a larger area, due to the presence of other compounds such as carbon tetrachloride and TCA. The deep glacial plume is approximately 14,000 feet long and up to 2,000 feet wide. Elevated concentrations of TVOCs are located south of Building 96, in the AGS area, in the supply and material area and south of the former landfill.

Strontium-90

Strontium-90 was detected above the MCL of 8 ***picoCuries per liter (pCi/l)*** at concentrations ranging from 8.45 to 750 pCi/l. Most of the strontium-90 in groundwater is associated with three areas on site: the Brookhaven Graphite Research Reactor (BGRR), the Waste Concentration Facility (WCF) and the BGRR Pile Fan Sump (PFS). There are two distinct strontium-90 contaminated plumes (Figure 1). One was found around the BGRR, WCF and PFS, and the other area was the Chemical Holes.

picoCuries per liter (pCi/l) - a unit of measure of radioactivity per liter of groundwater.

The plume south of the BGRR is approximately 1,000 feet long and 500 feet wide. The larger of the two strontium-90 plumes is actually composed of two plumes. The northern half of the plume is composed of strontium-90 originating from the WCF and associated tanks and pipelines. The southern half of the larger strontium-90 plume originates from the BGRR Pile Fan Sump area. The larger WCF/Pile Fan Sump Plume is approximately 2,000 feet long and 500 feet wide.

Tritium

Elevated concentrations of tritium were detected downgradient of the High Flux Beam Reactor (HFBR). The source of this tritium was the HFBR spent fuel pool, which was emptied in December 1997. The highest tritium activity was 1,590,000 pCi/l in a monitoring well located directly in front of the HFBR. Tritium activity at the downgradient edge of the plume ranges between 1,000 and 5,000 pCi/l. The tritium plume is located entirely within the boundaries of the laboratory.

The portion of the plume that exceeds the drinking water standard for tritium (20,000 pCi/l) extends to a point approximately 4,500 feet north of the Lab's southern boundary at depths ranging from 40 to 150 feet below land surface. The dimensions of the 1,000 pCi/l plume are approximately 3,200 feet long and 625 feet wide. The 20,000 pCi/l plume is approximately 2,600 feet long and 250 feet wide. A second area with tritium concentrations greater than the drinking water standards is located immediately north of the HFBR stack.

VI. Summary of Site Risk

Baseline Risk Assessment - an assessment required by CERCLA to evaluate potential risks to human health and the environment. This assessment estimates risks/hazards associated with existing and/or potential human and environmental exposures to contaminants at an area, assuming no remedial action is taken.

risk - an estimate of the probability that exposure to contamination at a release site will cause cancer development or non-carcinogenic health effects.

contaminants of concern - contaminants detected at waste sites that present significant contributions to overall site risk. At BNL, these include radionuclides, volatile organic compounds, and heavy metals

Based upon the results of the Remedial Investigation, a ***Baseline Risk Assessment*** was conducted to evaluate the risks associated with current and future site conditions. The baseline risk assessment estimates the human health and ecological ***risk*** that could result from contamination at the site if no remedial action beyond that accomplished to date were performed.

Human Health Risk Assessment

The Process

A four-step process is used to assess site-related human health risks for a reasonable maximum exposure scenario: *Hazard Identification* - identifies the contaminants of concern at the site based on several factors such as toxicity, frequency of occurrence and concentration. *Exposure Assessment* - estimates the magnitude of actual and/or potential human exposures, the frequency and duration of these exposures and the pathways by which humans may be exposed (for example, drinking contaminated well water). *Toxicity Assessment* - determines the types of adverse health effects associated with exposures and the relationship between the magnitude of exposure (dose) and severity of adverse effects (response). *Risk Characterization* - summarizes and combines outputs of the exposure and toxicity assessments to provide a quantitative assessment of site risks.

The baseline risk assessment begins with selecting ***contaminants of concern*** that could make a significant contribution to overall site risks. Six inorganic constituents, 16 radionuclides, and 8 organics were identified as contaminants of potential concern for the risk assessment for OU III (Table 3). The contaminants of concern in Operable Unit III for the human health risk assessment include VOCs (such as PCE), metals (such as manganese), and radionuclides.

Two human health hazards were addressed in the risk assessment for Operable Unit III: cancer induction and non-carcinogenic toxicity.

Cancer risk is expressed in terms of the probability that a given ***receptor*** will develop cancer due to estimated exposures over a 70-year lifetime. Current federal guidelines for acceptable exposures are an individual lifetime excess carcinogenic risk in the range of one-in-ten-thousand (1×10^{-4}) to one-in-a-million (1×10^{-6}). Several of the contaminants found in Operable Unit III (radionuclides, benzo(a)pyrene, carbon tetrachloride, PCE) are known to cause cancer in laboratory animals and are suspected or known to be human carcinogens.

Potential non-carcinogenic effect risks due to Operable Unit III contaminants were estimated by dividing the estimated intake of a chemical by the acceptable intake over the period of exposure. These non-carcinogenic effects are expressed as Hazard Indices. According to federal guidelines, the maximum Health ***Hazard Index*** allowed is 1.0. A Hazard Index greater than 1.0 indicates a potential for non-carcinogenic health effects.

The baseline risk assessment evaluated the potential health effects that could result from exposure to chemical and radiological contamination as a result of dermal (skin) contact, inhalation and ingestion associated with current and potential future land uses.

receptor - someone or something that may receive an exposure to contaminants

Exposure Assumptions

For the Current Land Use chemical risk assessment, three scenarios were investigated: an on-site worker who could be exposed to surface soil through inhalation, ingestion, and direct contact; a trespasser to the site who might come into contact with contaminated soil, or sediment and surface water in the Re-

Table 3. Contaminants of potential concern evaluated in the baseline risk assessment

Contaminant	Surface soil	Subsurface soil	Surface water	Sediment	Groundwater
Inorganics					
Arsenic	+	+			+
Barium	+		+	+	
Beryllium	+		+		
Cadmium	+		+		+
Chromium VI	+	+		+	+
Manganese	+	+	+	+	+
Organics					
Benzo(a)pyrene		+	+	+	
Benzo(a)anthracene			+	+	
Benzo(b)fluoranthene			+	+	
Indeno 123 pyrene			+		
1,1 dichloroethene					+
Tetrachloroethene (PCE)					+
1,1,1 Trichloroethane (TCA)					+
Carbon tetrachloride					+
Radionuclides					
Americium-241		+		+	+
Cesium-137	+	+		+	
Cobalt-57				+	
Cobalt-60	+	+		+	+
Europium-155				+	
Lead-210	+			+	+
Manganese-54				+	
Neptunium-237				+	
Protactinium-231				+	
Radium-226					+
Strontium-90	+				+
Thorium-228					+
Thorium-230					+
Thorium-232					+
Tritium	+	+		+	+
Uranium-238					+

Hazard Index - an index used as a measure of the potential for site contaminants to present unacceptable non-carcinogenic toxic effects. When the hazard index is greater than 1, there may be concern for potential non-carcinogenic effects.

charge Basins; and current residents off site who have declined access to public water. Reasonable Maximum Exposure conditions were investigated for each potential receptor. For Future Land Use, four scenarios were investigated: an on-site commercial or industrial worker, an on-site construction worker involved in soil excavation, hypothetical future residents living in the Operable Unit III study area, and residents off site who have declined access to public water.

For the Current Land Use radionuclide risk assessment, three scenarios were investigated; an on-site industrial worker who spends the majority of the work day outdoors; a trespasser who visits the site 64 days per year; and an off-site resident that uses well water for domestic uses. Off-site residences have been offered connections to the public water supply, but a few residences have not elected to make this connection. Radiological exposure was calculated for current conditions as well as after 1, 5, 30, 50, and 100 years based on radioactive decay from current conditions.

For the Future Land Use chemical and radionuclide risk assessment, four scenarios were investigated: a short-term construction worker involved in excavation activities who could be exposed to sub-surface soils; an on-site industrial worker; an off-site resident that uses well water for domestic purposes; and a hypothetical future on-site resident who might reside at the site in 50 years if, for example, BNL no longer controlled the Operable Unit III study area. The hypothetical future on-site resident was assumed to be exposed to all possible environmental media, using groundwater as a potable water source and being nearly self-sufficient in terms of raising or harvesting a significant portion of their diet from the Operable Unit III site.

Results

The baseline chemical human health risk assessment conducted for the identified constituents of potential concern indicated that the calculated carcinogenic and non-carcinogenic health hazards for current on-site workers and trespassers are below the EPA's guidance for recommended carcinogenic target risk range, and the non-carcinogenic target value of unity.

Under current land use conditions, the cumulative chemical carcinogenic risk is 2×10^{-6} (0.000002) and 3×10^{-6}, respectively, for an on-site worker and an older child as an on-site trespasser. These risks are within the EPA's current recommended target range for carcinogenic risk (1×10^{-4} to 1×10^{-6}). The total cumulative non-carcinogenic hazards to the on-site worker and on-site trespasser were negligible (0.08 and <0.01, respectively). The current EPA recommended non-carcinogenic target value is 1.

The current carcinogenic risk and non-carcinogenic health hazard for carbon tetrachloride for the current off-site resident exposed to the maximum concentrations measured in groundwater were estimated to be 8×10^{-3} and 200, respectively, both of which exceed EPA guidance levels. TCA is not a human carcinogen and there is no EPA published value for non-carcinogenic risk; thus the risks associated with current land use exposure cannot be quantitatively estimated for off-site residents. However, the maximum concentration of TCA measured off-site (100 ppb) is 20 times the MCL (5 ppb). Thus the presence of TCA and carbon tetrachloride plumes in off-site groundwater poses a potential risk to the small number of off-site residents who still utilize their private wells. Residents who still use their private wells have been encouraged to test them regularly.

Under the future land-use conditions, the total chemical carcinogenic risks for a future on-site construction worker and an on-site industrial worker fell within or below the EPA target risk range of 1 x 10^{-4} to 1 x 10^{-6}, and the health hazard target of one.

The carcinogenic risks to the future on-site residential child and adult were slightly above the EPA's target risk range. The carcinogenic risk is driven by arsenic in groundwater, for which the risks are over-estimated because of the conservative slope factor derived by the EPA. The non-carcinogenic hazard index for the hypothetical future on-site resident adult and young child were estimated to be 3.27 and 8.49, respectively. Ingestion of manganese in groundwater contributed the most to the non-carcinogenic hazard index. The concentrations of manganese used in the risk assessment were based on unfiltered samples, which may not represent drinking water conditions. Manganese in groundwater is not considered a concern for human health.

For the future on-site risk assessment, the VOC plumes identified in OU III consist of groundwater contaminated with TCA, PCE and carbon tetrachloride. The risks to a future resident who would use groundwater at the highest concentration of the carbon tetrachloride and PCE found in these plumes exceeds the recommended risk threshold. TCA risks to a future resident were not calculated quantitatively, because there are no EPA established toxicity values for TCA. However, the maximum concentration of TCA detected in the on-site plume was 920 ppb, which is almost 200 times the MCL (5 ppb). Under this highly unlikely and conservative scenario, the presence of TCA, PCE and carbon tetrachloride plumes in groundwater on-site could pose a potential health concern for a future resident.

The carcinogenic risk and non-carcinogenic health hazard from carbon tetrachloride for the future off-site resident exposed to the maximum concentrations measured in groundwater were assumed to be the same as for the current risk assessment (8 x 10-3 and 200, respectively). Thus, the presence of TCA and carbon tetrachloride plumes in off-site groundwater could present a public health concern for future off-site residents who do not have access to publicly supplied water.

The radiological risk analyses conducted for OU III found that under current land use conditions, the risk for industrial workers at year 1 was 4 x 10^{-4}. This is slightly above the EPA's acceptable risk range of 1 x 10^{-4} to 1 x 10^{-6}. For the on-site trespasser, risks at 1, 30 and 50 years from now were 4 x 10^{-5}, 1 x 10^{-5} and 6 x 10^{-6}, which fall below EPA's guidance level. External gamma exposure was the dominant pathway, and the major contributing radionuclides were cesium-137 and cobalt-60.

Because a few residents off site elected not to be connected to the public water supply, the radiological risks to a current off-site resident were evaluated. These risks did not exceed the EPA's recommended level.

The conservative future land-use scenario for radionuclide exposure assumed an on-site resident who was nearly self-sufficient in terms of raising or harvesting a significant portion of their diet from the OU III site. The calculated risk for this unlikely scenario suggests that OU III would pose potential cancer risk slightly above acceptable limits to a future on-site population (3 x 10^{-4} at year 30 and 1 x 10^{-4} at year 50). The major contributing pathway is exposure to external gamma radiation from radionuclides in soil. For the future industrial worker, risk at year 30 is 1×10^{-4} which is the EPA target level. Risks to industrial workers at years 50 and 100 were below the EPA guidance level at years 30 and 100. The risk to a short-term construction worker involved in excavation activities in year 30 and beyond was very small (2×10^{-7} in year 30, 8×10^{-8} in year 50).

An additional risk assessment was done for the future on-site risk assessment, assuming exposure to the highest concentrations of tritium and strontium-90 measured in groundwater in OU III. The conservative assumption was made that future (30 years) residential houses would be built near the highest detected concentrations of these on-site contaminants, and the residents would use the residential wells as the sole water supply for domestic uses. Cancer risks to a future on-site resident via the groundwater ingestion pathway for strontium-90 was 1×10^{-4}, and for tritium, 2×10^{-3}, which are at or above the EPA's recommended cancer threshold level of 1×10^{-4}.

The risk to off-site residents in the future was assumed to be the same as for the current off-site residents who have declined access to public water. This calculated risk did not exceed the EPA's screening level of 1×10^{-4}.

Ecological Risk Assessment

The Ecological Risk Assessment was performed to determine whether historical activities at Operable Unit III have resulted in levels of chemical and radiological contamination that would adversely affect the ecosystems there. The assessment focused on the aquatic communities of the recharge basins of Operable Unit III and the terrestrial wildlife exposed to contaminants in the recharge basins.

A standard ecological risk assessment consists of a four-step process used for assessing related ecological risks: *Problem Formulation* - a qualitative evaluation of a contaminant's release, migration and fate; identification of contaminants of concern, receptors, exposure pathways and known ecological effects of the contaminants; and selection of endpoints for further study. *Exposure Assessment* - a quantitative evaluation of the release, migration and fate of the contaminant; characterization of exposure pathways and receptors; and measurement or estimation of exposure point concentrations. *Ecological Effects Assessment* - literature reviews, field studies and toxicity tests linking contaminant concentrations to effects on ecological receptors. *Risk Characterization* - measurement or estimation of current and future adverse effects.

The soil contamination to which terrestrial organisms could be exposed was limited to two small areas: one area at the TCE Soil Area is in a building courtyard virtually inaccessible to wildlife, and the other area occupies very limited surface area within the developed portions of OU III at the Building 830 Underground Storage Tank area. Therefore, terrestrial wildlife exposure to soil contaminants is insignificant.

Based on a comparison of surface water concentrations in the Recharge Basins to available New York State standards, the screening risk assessment indicated that the most significant risks to aquatic communities are due to copper in all three recharge basins investigated (HT: North End of LINAC AOC; HN01, HN02: Process Supply Wells and Recharge Basins AOC). Discharges to the recharge basins are subject to State Pollution Discharge Elimination System permits. In addition, cadmium concentrations in Recharge Basin HN01 were elevated. This analysis is very conserva-

How You Can Participate

Whether you are new to BNL and are reviewing this type of document for the first time, or you are familiar with the Superfund process, you are invited to:

- **Read** this proposed plan and review additional documents in the Administrative Record file at Information Repository locations listed on pages 11 and 32; and access fact sheets and other information about the Lab on the internet at **www.oer.dir.bnl.gov.**

- **Call** BNL Community Relations (516-344-7459) to ask questions, request information, or make arrangements for a briefing.

- **Attend** a public meeting or information session (listed on front cover and page 2).

- **Comment** on this plan at the meeting or submit written comments (see comment form on back cover).

- **Contact** state of New York, EPA Region II, DOE or BNL project managers (see pages 3, 4, 5 and 12).

tive, as the risk was estimated by comparing criteria for dissolved metals to a total measured metal concentration, which will necessarily overestimate risk.

The potential risk to the benthic community (organisms living in or on sediments in the basin bottoms) was most significant in Recharge Basin HT, located at the north end of the LINAC. Mercury, copper, silver and several PAHs (polycyclic aromatic hydrocarbons) were more than an order of magnitude greater than the sediment quality criteria applied. Mercury posed a marginal risk in all other recharge basins. However, the benthic community that is expected in recharge basins is limited due to low water levels, the intermittent presence of water, high temperatures, and low dissolved oxygen levels. Applying sediment criteria to recharge basins is expected to overestimate the potential risk to the community, and risk is expected to be minimal. BNL is currently preparing a habitat management plan with the New York State Department of Environmental Conservation that will detail the routine maintenance of the recharge basins.

Terrestrial consumption of surface water from the recharge basins were also evaluated. Surface water concentrations of contaminants were orders of magnitude less than the target species (cottontail rabbit) drinking water no-observed-effect concentration.

VII. Actions to Date

Several actions have been taken to date to remove sources of groundwater contamination. These include contamination source removal activities (Table 4). Additional actions have been taken to remove potential sources of groundwater contamination at other locations on site. These include the landfills removal action, removal of cesspools and cesspool contents, removal of underground storage tanks and the replacement of leaking sewer pipes.

BNL has also embarked on an extensive Facility Site Review process to identify potential release points of contaminants from BNL facilities to the environment. The review began in April 1997 and is an important element of BNL's comprehensive plan to delineate and characterize environmental issues at the site and to develop cleanup and remediation strategies. The Preliminary Assessment /Site Inspection (PA/SI) investigation was developed to address a number of areas of interest identified in the April 1997 Facility Review. The PA/SI consisted of a field investigation that included collecting and analyzing soil and groundwater samples. The results of this investigation will be used to determine if an identified area of interest needs further investigation or cleanup. Facility Review follow-up activities continue to be conducted.

In addition, the following six interim removal actions (IRAs) have been or are being undertaken to immediately reduce concentrations, migration, or exposure to groundwater contaminants:

• **On-site OU III Southern Boundary Groundwater Interim Removal Action (IRA):** This IRA was implemented in June 1997 in response to the detection of a plume of VOCs in groundwater both on and off site. The goal is to prevent additional off-site migration of VOCs in the most concentrated part of the plume at the southern boundary. The IRA consists of a groundwater recovery system at the southern boundary (Figure 5), extraction of groundwater through six wells, and treatment through air stripping. The clean water is then discharged to a recharge basin.

• **Off-site OU III Industrial Complex Groundwater Interim Removal Action:** This IRA is being implemented to address the off-site migration of the highest concentrations of the deep VOC plume beyond the industrial complex located south of OU III. The objective of this interim removal action is to hydraulically control, extract, and treat groundwater through in-well air stripping, using an array of seven wells along the southern side of the industrial complex. Start-up of this interim removal action is scheduled for July 1999.

• **Off-site Public Water Hookup Interim Action:** To ensure that the health of the residents located downgradient of OU III and OU I is protected, a residential public water hookup was implemented and is in place. Public water was provided to homes potentially in the path of contaminated groundwater associated with BNL. Long-term monitoring of groundwater off site will be conducted.

• **Tritium Groundwater Interim Removal Action:** This IRA was implemented in response to elevated levels of tritium detected downgradient of the HFBR. This IRA consists of: (1) removal of spent fuel from the pool and installation of a stainless steel liner, (2) elimination of potential sources of leakage, and (3) groundwater

Table 4. **Source Removal Actions to Date**

Location	Action	Contaminants of Concern
Cesspools/Septic Tanks Removal Action	Cesspools removed, tanks emptied.	Solvents (TCA)
Building 464 Removal Action	Contaminated soil removed.	Mercury
Paint Shop	Soil removed.	Solvents (TCA)
Brookhaven Graphite Research Reactor	Canal drained and covered with concrete. Deep drain sump pumped out.	Sr-90, Tritium, Cs-137
Waste Concentration Facility	Tanks, underground piping and soil removed or removal planned under OU I.	Sr-90, Cs-137
Building 830 Pipe Leak and Underground Storage Tanks	Tanks pumped out, contaminated soils under waste transfer line removed. Tanks removed. Removal and disposal of contaminated soil is underway.	Co-60, Cs-137
Old Firehouse, Bubble Chamber Spill Area, Heavy Machine Shop	Contaminated soil removed.	Cs-137, Sr-90, Solvents, PCBs
BGRR Pile Fan Sump	Sump pumped out.	Sr-90, Cs-137, Tritium
Central Shops, Building 208	Solvent/degreaser pit removed.	Solvents (TCA)
Current/Former Landfills, Chemical Holes	Landfills capped. Chemical Holes excavated. Contaminated soils addressed under OU I.	Solvents, Mercury, Sr-90

pumping at the leading edge of the plume. Although tritium concentrations are expected to decrease over time and will not cross the BNL boundary, three wells have been installed along Princeton Avenue as a precautionary measure to extract tritium-contaminated groundwater. The groundwater is treated for chemical contamination via carbon adsorption and discharged to a recharge basin to allow additional time for the tritium to decay. This system began operation in May 1997.

• **Building 830 Underground Storage Tanks Removal Action:** This action addresses the removal of two out-of-service underground storage tanks, a concrete valve pit, associated piping and contaminated soils and vegetation. The tanks have been removed and the Removal Action is in progress.

• **Interim Removal Action V:** This Removal Action addresses on-site groundwater associated with the Current Landfill and former Hazardous Waste Management Facility, both located in OU I. A pump-and-treat system was installed at the south boundary in December 1996 to intercept groundwater containing VOCs migrating from the two source areas and prevent them from moving off site. The system includes two extraction wells and an air stripping tower. The clean water is recharged via the RA V recharge basin in the center of the Lab site.

VIII. Remedial Action Objectives

Based on the results of the Remedial Investigation and Baseline Risk Assessment, it was determined that contaminants in all environmental media, except groundwater, posed minimal risk to human health and the environment. Soil contamination that exceeded screening levels in the Remedial Investigation study were found not to present significant risks to human or ecological health with

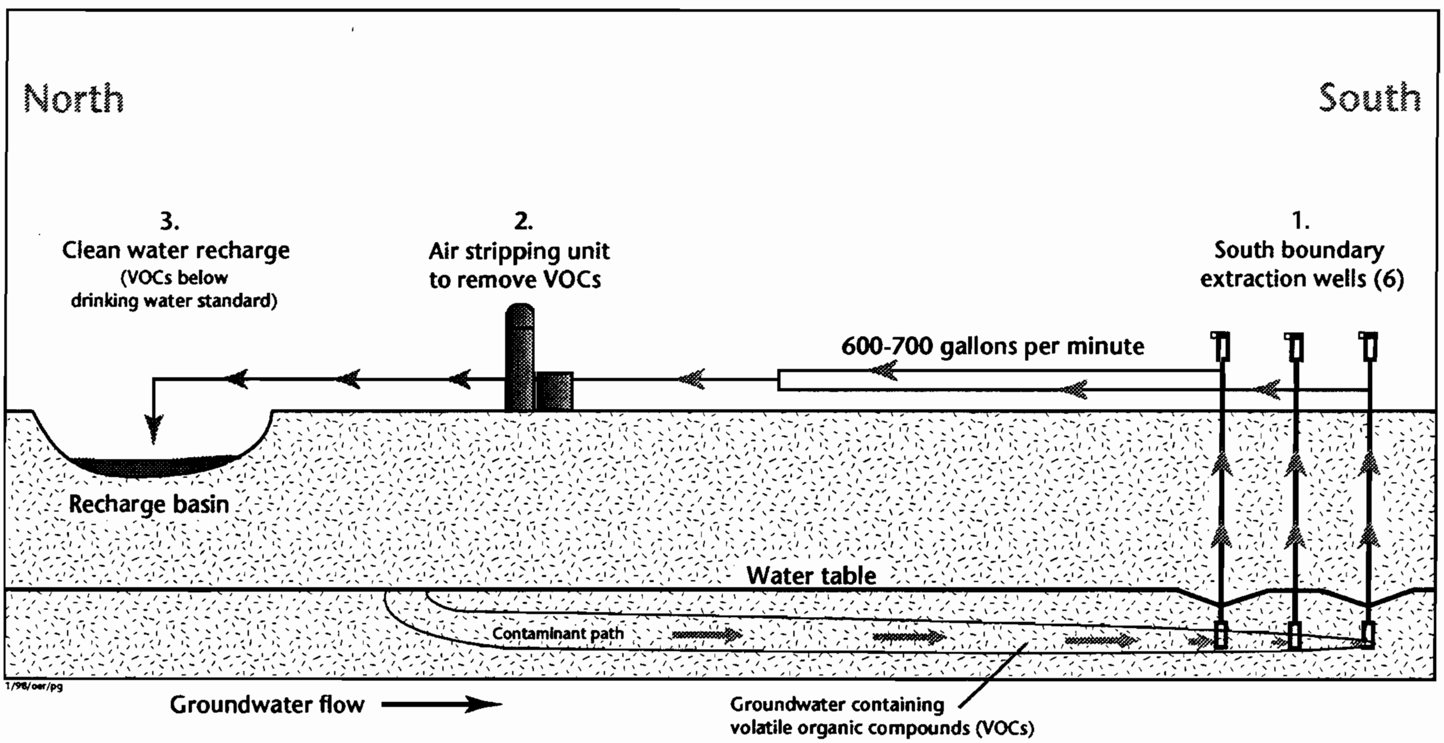

Figure 5. *Schematic showing the existing Operable Unit III South Boundary Pump-and-Treat System.*

one exception, the soils contaminated with cesium-137 at the Building 830 underground storage tanks. This soil contamination is currently being removed under a Removal Action. It should be noted that many source areas of contaminated soil and sediment have already been remediated or will be addressed in the future.

Residents immediately south of the Laboratory were offered a hookup to public water supplies. For most residents, this eliminates the potential source of exposure and risk to groundwater contaminants. However, some residents elected not to be connected to public water, or still use well water for various purposes, like watering a garden, filling a swimming pool, etc. The human health risk assessment found that the presence of VOCs in groundwater could present a public health concern to the very small number of off-site residents who have declined publicly supplied water.

The following contaminated groundwater plumes have been identified to be of concern:

On-site groundwater contaminated with strontium;
On-site groundwater contaminated with tritium;
On-site and off-site groundwater contaminated with VOCs.

The remedial action alternatives presented in the Feasibility Study and this Proposal Plan address these plumes. In addition, six interim removal actions (IRAs) have been undertaken to immediately reduce concentrations, impact, migration, or exposure to groundwater contaminants.

Remedial action objectives (RAOs), or "cleanup objectives," are specific goals to protect human health and the environment. These objectives are based on available information standards, such as applicable or relevant and appropriate requirements (ARARs), and risk-based levels established in the risk assessment. Based on the evaluation of the nature and extent of contamination in soils, groundwater, surface water, and sediment and the assessment of chemical and radiological risks associated with exposure to contaminants of potential concern, the following remedial action objectives were developed:

- Meet drinking water standards in groundwater for VOCs, strontium-90 and tritium.
- Complete cleanup of the groundwater in a timely manner. For the Upper Glacial Aquifer, this goal is 30 years or less; for the Magothy Aquifer, this goal is 60 years.
- Prevent or minimize further migration of contaminants.

The primary contaminants identified in groundwater were carbon tetrachloride, tetrachloroethene, trichloroethane, strontium-90, and tritium. Groundwater contamination in OU III has been separated into four areas according to the type and location of contaminants.

These four areas are: 1) the on-site TVOC area which includes the TVOC contamination present in the water table and Upper Glacial aquifer on the BNL property; 2) the off-site TVOC area which includes TVOC contamination present in the water table, Upper Glacial aquifer, and Magothy aquifer off-site and south of BNL; 3) the strontium-90 contamination in the water table zone present at the

BGRR/WCF and the Chemical Holes area; and, 4) the tritium plume in the vicinity of the HFBR (Figure 1 shows all four areas).

IX. Summary of Remedial Alternatives

CERCLA requires that each site remedy be protective of human health and the environment, be cost effective, comply with other statutory laws, and utilize permanent solutions and alternative treatment technologies and resource recovery alternatives to the maximum extent practicable. In addition the statute includes a preference for use of treatment as a principal element for the reduction of toxicity, mobility or volume of the hazardous substances.

The balance of this document does two things. First, it outlines the remedial action alternatives retained for Operable Unit III, after initial screening of other alternatives. Second, it presents the analysis of each alternative against nine evaluation criteria established by EPA and presented later in this report. Based on the evaluations, the preferred cleanup remedies for Operable Unit III are described in Section II. The preferred remedy may change based on public comments, so the public is encouraged to comment on any of the remedial action alternatives.

Remedial action alternatives evaluated in the Operable Unit III Feasibility Study Report addressed on-site groundwater contaminated with strontium, on-site groundwater contaminated with tritium, and on- and off-site groundwater contaminated with VOCs. The following alternatives were retained for detailed analysis in the Feasibility Study Report. Details of the cleanup systems will be refined and finalized during the design and construction of the selected remedy.

Strontium-90 Contaminated Groundwater Cleanup

Alternatives investigated in detail to remediate strontium-90 in groundwater are described below. Costs and time to meet Remedial Action Objectives are summarized in Table 5.

S1 - No Action

The no action alternative includes no remedial activities. In accordance with the National Contingency Plan, the No Action Alternative must be assessed for comparison to the other alternatives.

S2 - Natural Attenuation

Under this alternative, the Sr-90 contamination in the water table zone near the Brookhaven Graphite Research Reactor, Waste Concentration Facility and Pile Fan Sump (BGRR/WCF/PFS) is slowly reduced through natural attenuation without any control, removal, treatment, or other mitigating actions. Groundwater modeling and monitoring is required for this alternative to evaluate the possibility of impacting potential receptors, such as surface water bodies, supply and potable wells. The monitoring program involves installation of new monitoring wells to monitor the extent and boundaries of the plumes.

S4 - In Situ Precipitation/Natural Attenuation

In this innovative alternative, a two step in-situ chemical precipitation is used to contain the strontium-90 plume. In the first step of this process, solutions containing dissolved phosphate are forced through the groundwater and soil, via injection wells, to react with the strontium contaminants, and convert them to

Table 5.	Strontium-90 Remedial Alternatives		
Alternative	**Description**	**Years to RAOs**	**Cost Capital/Present Worth**
S1	No Action	60+	$0
S2	Natural Attenuation	60+	$156,000 $949,000
S4	In-situ Precipitation/Natural Attenuation	60+	$1,038,000 $1,999,300
S5a	Groundwater Extraction/Ion Exchange/ On-Site Recharge/Off-site Disposal of Residual Waste	30	$1,552,000 $5,840,000
S7	Extraction/Ion Exchange at BGRR/ Permeable Reactive Wall at Chemical Holes/ Off-site Disposal of Residual Waste	30+	$2,191,000 $6,011,000

other more insoluble compounds. Phosphate salts of strontium are very insoluble. In the second step of the process, solutions of lime are also injected into the aquifer. This forms calcium hydroxyapatite (a calcium phosphate), which can also co-precipitate or adsorb the strontium. The strontium is bound in place and migration is prevented while radioactive decay gradually reduces the concentration. Continued groundwater monitoring would also be a part of this alternative.

S5a - Groundwater Extraction/Ion Exchange/On-Site Discharge

This alternative includes the extraction of groundwater from two wells within the BGRR/WCF/PFS plume and one well downgradient of well 106-16 located south of the Chemical Holes area. At each of the two locations (BGRR area and Chemical Holes area), a system will be installed for the treatment of groundwater. Treatment of groundwater will be by ion exchange prior to recharge to an on-site recharge basin. Ion exchange resin will be disposed of off site. BGRR and WCF pumps would operate for 25 to 30 years and the Chemical Holes pumps would operate for 8 years. Continued groundwater monitoring would also be a part of this alternative. Figure 7 shows a schematic of this system.

S7 - Extraction and Treatment at BGRR/Permeable Reactive Wall at Chemical Holes

Under this alternative, the WCF/BGRR/PFS strontium plume will be remediated utilizing two extraction wells with groundwater treatment via ion exchange, similar to Alternative S5a. However, the Chemical Holes strontium plume remediation will be accomplished using a permeable reactive barrier. The permeable reactive walls will consist of a 3-foot-thick bed of granular clinoptilolite. As the groundwater flows through this zeolite mineral, strontium will be absorbed on the bed. Continued groundwater monitoring would also be a part of this alternative.

Tritium Contaminated Groundwater Cleanup

Remedial alternatives are being developed to address different sections of the tritium plume. Of special interest is the "hot spot" of the plume, which is located along the downgradient edge of the HFBR building footprint. Several alternatives address containment or removal of this high-contamination groundwater. Alternatives were also developed that address the leading edge of the 20,000 pCi/l tritium plume.

Currently, a tritium Interim Removal Action (IRA) system is in operation that recovers approximately 120 gallons per minute from three wells located on site along Princeton Avenue. The groundwater is treated by carbon adsorption for the removal of VOCs and discharged to the RA V basin for recharge into the subsurface. Because the HFBR spent fuel pool was emptied, no additional source of tritium exists.

Alternatives investigated in detail to remediate tritium in groundwater are described below. Costs and time to meet Remedial Action Objectives are summarized in Table 6.

T1 - No Action

The No Action alternative provides a comparative baseline against which other alternatives can be evaluated. Under this alternative, a remedial action will not occur and the contaminated media will be left "as is," without the implementation of any control, removal, treatment, or other mitigating actions. Long term monitoring and modeling will not be performed for the No Action alternative.

T2 - Natural Attenuation/No IRA

This alternative will consist of natural attenuation with the deactivation of the tritium IRA at Princeton Avenue. Natural attenuation is the process by which concentrations of tritium will decrease in the groundwater by diffusion, dilution, and radioactive decay. The natural attenuation process can effectively reduce contaminant toxicity, mobility or volume to levels that are protective of human health and the environment. This option requires groundwater modeling, evaluation of contaminant degradation rates and pathways; and evaluation of site-specific human health. The primary objective of site modeling is to demonstrate that natural processes of contaminant decay can reduce contaminant concentrations to levels below regulatory standards. Sampling and analysis must be conducted throughout the natural attenuation process to confirm that degradation is proceeding at rates consistent with those predicted through groundwater modeling. The monitoring program will involve the use of at a minimum 88 existing monitoring wells. Additional monitoring wells are currently being planned. The wells will be sampled and analyzed for tritium on a quarterly basis for five years and annually for the next 20 years. The 20-year time frame is a conservative estimate.

T3 - Natural Attenuation/IRA

This alternative is the same as Alternative T2 except it includes the continued operation of the tritium IRA. Natural attenuation is the process by which concentrations of tritium will decrease in the groundwater by diffusion, dilution, and radioactive decay. Consideration of this option requires modeling, evaluation of contaminant degradation rates and pathways, and evaluation of site-specific human health and ecological risks. Sampling and analysis must be conducted throughout the natural attenuation process to confirm that degradation is proceeding at rates consistent with those predicted through groundwater modeling. The monitoring program will involve the use of at a minimum 88

Treatment Methods Considered in the OU III Feasibility Study

Pump-and-Treat: Pump and treat systems involve extracting the groundwater using recovery wells, and treating the extracted groundwater using various processes, depending on the contaminant in the water.

Air Stripping: Air stripping involves exposure of extracted groundwater containing volatile organic compounds to the air. This allows the volatile components in the water to volatilize into the air stream. If concentrations of contaminants in the air exiting the stripper exceed emissions criteria, the air is treated to remove these contaminants before release.

In-well Air Stripping: In-well air stripping involves installation of a dual purpose (extraction and reinjection) well into the impacted groundwater zone. Air is injected into the well to create an air lift pump effect. At the same time, the injected air will strip VOCs from the groundwater. The vapor is than treated, if necessary, prior to discharge.

Air Sparging/Soil Vapor Extraction: In an AS/SVE system, air is forced under pressure through the contaminated soil and groundwater via air sparging injection wells to strip VOCs from the groundwater and soils. Vapors are then recovered by vapor extraction wells. The vapors are then discharged to the atmosphere, or first treated by an emission control system.

Ion-exchange: Ion-exchange is used to remove inorganic contaminants (such as Sr-90) from extracted groundwater. In an ion-exchange system, toxic ions are removed from the aqueous phase by exchanging with harmless ions held by the ion exchange material.

Natural Attenuation-The natural degradation and decay of contaminants over time. Natural attenuation, while effective, often takes place over a long time period, depending on the individual contaminant.

existing monitoring wells. Additional monitoring wells are currently being planned. The wells will be sampled and analyzed for tritium on a quarterly basis for five years and annually for the next 15 years.

T4 - Natural Attenuation with Contingency Based Remediation

This alternative relies on natural attenuation to address the tritium contamination present in the Upper Glacial Aquifer south of the HFBR similar to Alternative T2 without the operation of the Princeton Avenue IRA. However, active remediation through re-activation of the Princeton Avenue IRA and/or hot spot removal near the HFBR will occur if tritium concentrations change significantly. Three specific contingencies have been identified for this alternative: 1) evaluate the need to re-start the tritium IRA if tritium concentrations exceed 25,000 pCi/l at the Chilled Water Plant Road 2) reactivate the Princeton Avenue IRA if tritium concentrations exceed 20,000 pCi/l at Weaver Drive and/or 3) Hot spot removal through low-flow pumping at the base of the reactor building if concentrations exceed 2,000,000 pCi/l at the reactor.

T5 – Extraction/Recirculation/No IRA

This alternative will actively contain the tritium plume containing concentrations above 20,000 pCi/l. The alternative includes groundwater extraction at the most downgradient portion of the 20,000 pCi/l plume and recirculation of the extracted groundwater to the RA V recharge basin. This alternative is similar to the current tritium IRA except for the location of the extraction wells. This alternative assumes that the tritium IRA will be placed in standby mode.

T6 – Low Flow Pumping, Hot Spot Removal/On-Site Storage/Natural Attenuation/No IRA

This alternative utilizes two extraction wells, pumping at very low rates to contain and capture the highest concentrations of tritium in front of the HFBR building. The goal of this alternative is to decrease the entire tritium plume extent, migration, and the duration of time to achieve 20,000 pCi/l concentration, given a one-year focused tritium hot spot removal action. Two extraction wells will be installed directly downgradient of the HFBR pumping 1 gpm each. The extraction wells will operate for one year and will remove a total of 1.05 million gallons of groundwater. The recovered groundwater will be pumped and stored in a 1.2 million-gallon aboveground tank. The recovered groundwater will be stored in the tank for approximately 50 years, until the concentration of tritium, through natural radioactive decay, reaches activities below drinking water standards (20,000 pCi/l). The groundwater will then be pumped to recharge basin RA V where it will percolate through the soil column into the water table. The monitoring program will involve the use of at a minimum 88 existing monitoring wells. Additional monitoring wells are currently being planned. This alternative assumes that the tritium IRA will be placed in standby mode.

T7 – Low Flow Pumping, Hot Spot Removal/Off-Site Evaporation/Natural Attenuation/No IRA

This alternative includes the installation of the same groundwater extraction system discussed in Alternative T6. However, instead of on-site storage, this alternative includes off-site evaporation of the tritiated groundwater. The extracted groundwater will be transferred directly to a 20,000 gallon feed tank.

Table 6.	Tritium Remedial Alternatives		
Alternative	**Description**	**Years to RAOs**	**Cost Capital/Present Worth**
T1	No Action	--	$0/$0
T2	Natural Attenuation/No IRA	20-25	$0/$1,997,000
T3	Natural Attenuation/IRA	20-25	$0/$3,257,000
T4	Natural Attenuation with Contingency Based Remediation	20-25	$456,000/$4,890,000
T5	Extraction/Recirculation/No IRA	15-20	$853,000/$3,949,000
T6	Continuous Hot Spot Removal/On-Site Storage/Natural Attenuation/No IRA	20	$1,349,000/$3,669,000
T7	Continuous Hot Spot Removal/Off-Site Evaporation/Natural Attenuation/No IRA	20	$331,000/$26,776,000
T8	Continuous Hot Spot Removal/On-Site Evaporation/Natural Attenuation/No IRA	20	$628,000/$3,026,000

This tank will feed into tanker trucks that will be transported to a disposal facility for evaporation. No residuals will result from this treatment. This alternative assumes that the tritium IRA will be placed in standby mode.

T8 - Low Flow Pumping, Hot Spot Removal/On-Site Evaporation/Natural Attenuation/No IRA This alternative includes the installation of the same groundwater extraction system discussed in Alternative T6. However, instead of on-site storage, this alternative will evaporate the tritium into the atmosphere by using an existing evaporator. The evaporator will evaporate the water with the tritium to the atmosphere from a stack 70 feet from the base of the evaporator skid. No residuals will be produced from this process. This alternative assumes that the tritium IRA will be placed in standby mode.

VOC Contaminated Groundwater Cleanup

Most of the alternatives to remediate VOCs in groundwater involve combinations of different locations, using in-well air stripping systems or other appropriate technologies. Possible locations for these off-site treatment systems include the Long Island Power Authority (LIPA) right of way, North Street, the Eastern Portion of the Industrial Park, and at two locations at the northern end of the Brookhaven Airport.

All of the alternatives (except No Action) also require a groundwater treatment system located on the BNL site at Middle Road, a Building 96 Removal Action, continued operation of the south boundary pump-and-treat system, and completion and operation of the Industrial Park in-well air stripping system. These all will help prevent further migration of contaminants into the deeper Magothy Aquifer. All of the alternatives also rely on natural attenuation to further reduce concentrations and include extensive monitoring and modeling of the plume over time.

Alternatives investigated in detail to remediate VOCs in groundwater are described below. Costs and time to meet Remedial Action Objectives are summarized in Table 7.

V1 - No Action:

The no action alternative includes no remedial activities for site-wide VOC contamination. In accordance with the National Contingency Plan, the No Action Alternative must be assessed for comparison to the other alternatives.

V2 – Natural Attenuation

Under this alternative, VOC contamination in groundwater will be remediated through the continued operation of three IRAs: the Southem Boundary IRA treatment system; the Off-site Industrial Complex IRA; and the Off-site Public Water Hookup Interim Action. This alternative will also include a source removal system in the vicinity of Building 96. Additional reductions in on- and off-site concentrations of VOCs in groundwater will be achieved through natural attenuation. Natural attenuation occurs when physical, chemical and biological processes act to reduce the mass, toxicity and mobility of subsurface contamination in a way that reduces risk to human health and the environment to acceptable levels. Installation of new monitoring wells and groundwater monitoring and modeling will be required for this alternative to evaluate the possibility of impacting potential receptors, such as surface water bodies, supply wells, and potable wells.

V7 - On-Site In-Well Air Stripping/Off-Site In-Well Air Stripping With Hot Spot Containment (4 wells in RA V) and 4 Wells in Westem OU III Low Level VOC Plume

This alternative involves active remediation of both on-site and off-site VOC contamination. It includes the on-site systems in alternative V2: the operation of the on-site and off-site IRAs, and the installation of a source removal system in the vicinity of Building 96. This alternative also involves the installation of an in-well air stripping system on site at Middle Road, and the installation of in-well air stripping systems at five locations off site: 1 in-well air stripping well at the LIPA right-of-way, 8 wells at Brookhaven Airport, 3 at North Street/Sleepy Hollow Drive, 4 near North Street in the OU I RA V plume and 4 located within the western OU III low level VOC plume.

V10b On-Site In-Well Air Stripping/Off-Site In-Well Air Stripping at Hot Spots (1 well in RA V)

This alternative includes all the components of Alternative V7, with the addition of 1 well located in the OUs I/IV Industrial Complex (East) and without the in-well air stripping wells located in the western OU III low level VOC plume. This alternative involves active remediation of both on-site and off-site VOC contamination. It includes the on-site systems: the operation of the on-site and off-site IRAs, installation of an in-well air stripping system at Middle

Table 7.	VOC Remedial Alternatives		
Alternative	**Description**	**Years to RAOs**	**Cost Capital/Present Worth**
V1	No Action	30+	$0/$0
V2	On-site In-well Air Stripping (B96)/ Off-site Natural Attenuation	30+	$1,697,000/$11,786,000
V7	On-site In-well Air Stripping/Off-site In-well Air Stripping with Hot Spot Containment (4 wells in RA V) and 4 Wells in Western OU III Low-level VOC Plume	30+	$10,814,000/$25,598,000
V10b	On-site In-well Air Stripping/Off-site In-well Air Stripping at Hot Spots (1 well in RA V)	30	$9,728,000/$23,880,000
V10c	On-site In-well Air Stripping/Off-site In-well Air Stripping with Hot Spot Containment (1 well in RA V) and 2 Wells in Western OU III Low-Level VOC Plume	30	$10,513,000/$25,142,000
V11	On-site In-well Air Stripping and Off-site In-well Air Stripping with No Residential Wells	30+	$9,142,000/$23,615,000
V13	On-site/Off-site Extraction and Treatment/On-site Discharge	30+	$8,261,000/$25,056,000

Road, and the installation of a source removal system in the vicinity of Building 96. This alternative also involves the installation of in-well air stripping systems at five locations off-site: 1 well in the industrial park east, 3 in-well air stripping wells at the LIPA right-of-way, 7 wells at Brookhaven Airport, 4 at North Street/Sleepy Hollow Drive, and 1 near North Street in the OU I RA V plume.

10c On-Site In-Well Air Stripping/Off-Site In-Well Air Stripping With Hot Spot Containment (1 well in RA V) and 2 Wells in the Western OU III Low Level VOC Plume

This alternative involves active remediation of both on-site and off-site VOC contamination. It includes the on-site systems: the operation of the on-site and off-site IRAs, installation of an in-well air stripping system at Middle Road, and the installation of a source removal system in the vicinity of Building 96. In this configuration, one in-well air stripping well will be located within the RA V plume and two in-well air stripping wells will be located on site within the western portion of the low level VOC plume. The Brookhaven Airport containment systems, and the OU III and OU I/IV hot spot containment systems will be identical to Alternative V10b. The objectives of this alternative are to capture and contain the OU III, OU I/IV, and RA V plumes in a similar well configuration as alternative V10b, in addition to capture and containment of the western low level VOC plume.

V11 On-Site In-Well Air Stripping/Off-Site In-Well Air Stripping at Hot Spots

This alternative involves active remediation of both on-site and off-site VOC contamination. It includes the on-site systems: the operation of the on-site and off-site IRAs, installation of an in-well air stripping system at Middle Road, and the installation of a source removal system in the vicinity of Building 96. This alternative also involves the installation of in-well air stripping systems at three locations off site: 1 well in the industrial park east, 10 wells at Brookhaven Airport, 4 at North Street/Sleepy Hollow Drive. This alternative has no treatment at the LIPA right-of way and therefore has a greater number of treatment wells located downgradient at the airport.

V13 - On-Site/Off-site Extraction and Treatment/On-Site Discharge

The configuration for this alternative will be identical to the configuration of the Alternative V10b. Groundwater collected by all the extraction wells will be pumped via piping to a treatment system located on site, treated by an air stripper for the removal of the volatiles, and discharged to the OU III basin. This alternative includes the on-site systems: the operation of the on-site and off-site IRAs, installation of extraction wells at Middle Road, and the installation of a source removal system in the vicinity of Building 96. This alternative also involves the installation of extraction wells at five locations off site: 1 well in the industrial park east, 1 well at the LIPA right-of-way, 7 wells at Brookhaven Airport, 4 at North Street/Sleepy Hollow Drive.

X. Analysis and Comparison of Alternatives

During the detailed evaluation of remedial alternatives, each alternative is assessed against nine evaluation criteria, namely, overall protection of human health and the environment, compliance with applicable or relevant and appropriate requirements, long-term effectiveness and permanence, reduction of toxicity, mobility or volume, short-term effectiveness, implementability, cost, and state and community acceptance.

The evaluation criteria are described below.

1. Overall Protection of Human Health and the Environment addresses whether an alternative provides adequate protection, and describes how risks are eliminated, reduced, or controlled through treatment, engineering controls or institutional controls.

2. Compliance with Applicable or Relevant and Appropriate Requirements (ARAR) considers if a remedy meets all federal and state ARARs, including provisions for invoking a waiver.

3. Long-Term Effectiveness addresses the amount of remaining risk and the ability of an alternative to protect human health and the environment over time, once cleanup goals have been met.

4. Reduction of Toxicity, Mobility, or Volume addresses the anticipated performance of treatment that permanently and significantly reduces the toxicity, mobility, or volume of waste.

5. Short-Term Effectiveness and Environmental Impacts addresses the impact to the community and site workers during construction or implementation, and includes the time needed to finish work.

6. Implementability addresses the technical and administrative feasibility of an alternative, including the availability of materials and services required for cleanup.

7. Cost compares the differences in cost, including capital, operation, and maintenance costs. Cost estimates are based on present day costs and contain a high level of uncertainty.

8. State Acceptance addresses whether the State agrees with, opposes, or has no comment on the preferred alternative. State acceptance is not formally evaluated until after the public comment period ends.

9. Community Acceptance addresses the issues and concerns the public may have regarding each of the alternatives. This criterion is not evaluated formally until comments of the Proposed Plan are reviewed.

DOE has identified its preferred remedies by evaluating all of the alternatives against nine evaluation criteria established by EPA: The comparison of alternatives, including advantages and disadvantages, is summarized in Tables 9, 10, and 11.

Strontium Remedial Alternatives

Groundwater strontium contamination was detected around the BGRR, WCF, PFS, and the Chemical Holes area. Five remedial alternatives were evaluated in detail to address the groundwater strontium contamination. In-situ technologies included in-situ chemical precipitation (Alternative S4), and reactive permeable barrier (Alternative S7). Other remedial technologies evaluated included ion exchange (Alternative S5a).

The natural attenuation alternative S2 is protective of human health and the environment because of the slow migration rate of the strontium in groundwater. No receptors are impacted for the duration of the remedial alternative, 60 years. However, this alternative does not result in compliance with RAOs within 30 years. Pump-and-treat alternative S5a is effective in removing strontium from the aquifer, and results in compliance with RAOs within 30 years.

In-situ technologies use containment as a means of addressing the strontium contamination in the groundwater. These technologies prevent any further migration and rely on radioactive decay to comply with RAOs. However, because strontium is not very mobile in the aquifer and because of the flat groundwater gradient around the BGRR, these technologies are not cost-effective and do not result in compliance with RAOs in a timely manner.

Tritium Remedial Alternatives

The HFBR spent fuel pool tritium plume extends from the HFBR to Princeton Avenue and is currently being remediated with the Princeton Avenue IRA system. A total of eight remedial alternatives for the tritium plume were evaluated in detail. They include variations of natural attenuation (T2, T3, T4), and hot spot removal at the reactor (T6, T7, T8).

Hot spot extraction alternatives present three methods of managing the tritium contaminated water: 1) on-site evaporation, 2) off-site evaporation, or 3) on-site storage. No cost-effective treatment technologies are available for the removal of tritium from groundwater. Therefore, no treatment alternatives were carried forward for a detailed analysis.

Groundwater modeling results for natural attenuation without the current IRA system indicated that the current IRA has little to no effect on the tritium plume and does not result in a shorter remediation timeframe for the plume. Therefore, most of the alternatives assumed that the Princeton IRA system would not be in operation.

Alternative T4 is based on natural attenuation of the tritium plume with contingency (pumping) based remediation at the HFBR and at Princeton Avenue. The contingencies were developed to address concerns regarding potential migration of tritium in excess of the simulated results and potential high levels of tritium which have not been detected at the HFBR. In the event that 1) the tritium plume in excess of 25,000 pCi/l reaches the Chilled Water Plant, an evaluation of the need to reactivate the Princeton Avenue IRA will be conducted, and/or 2) the tritium plume in excess of 20,000 pCi/l migrates to Weaver Drive, the Princeton Avenue IRA system will be reactivated. In the event that tritium levels at the HFBR exceed 2,000,000 pCi/l, selective hot-spot pumping will take place at the reactor building.

Alternatives T7 and T8 involve on- and off-site evaporation of the extracted tritium, which introduces an additional risk to the public.

VOC Remedial Alternatives

For VOC contaminated groundwater, a total of seven alternatives were evaluated in detail. The alternatives include natural attenuation to address all or portions of plumes which might not be under the direct influence of an active remedial system. This remedial approach allows for a cost-effective and efficient approach for the restoration of the VOC contaminated groundwater.

Additionally, most alternatives do not directly remediate the VOC contamination present in the Magothy aquifer. Alternatives focus on the restoration of the Upper Glacial aquifer due to the higher velocity of groundwater, more potential receptors, and increased potential for VOC plume growth and migration. The remediation of the Upper Glacial aquifer will also result in the reduction of VOCs migrating into the Magothy, resulting in faster cleanup of the deeper aquifer.

A number of alternatives (V7, V10b, V10c, V11, V13) included the installation of treatment wells at the downgradient edge of the VOC plume at Brookhaven Airport to minimize plume migration and growth past Flower Hill Drive. These wells result in the reduction of plume migration south of Flower Hill Drive.

Two alternatives (V7 and V10c) also have remedial subsystems which address the low level VOC plume present to the west of the main VOC plume. These alternatives attempt to reduce the migration and plume growth of the low levels of VOC which eventually discharge to the Carmans River. Although the groundwater modeling scenarios did not include a component for the treatment of the low VOC plume, an evaluation was conducted based on cost and implementation of these alternatives. Groundwater modeling simulations for the remediation of the low level VOCs will be conducted.

With the exception of no action, Alternative V1, all alternatives include a source remediation system in the vicinity of Building 96, and the continued operation of the southern boundary and Industrial Complex IRAs. Capital and operating costs for these three items have also been included for each alternative in order to represent the total cost of remediation of the VOCs.

Due to the depth to contaminants in the groundwater, type of contaminants, and type of geology, only two types of groundwater extraction technologies were utilized for the development of alternatives, groundwater extraction wells and in-situ in-well air stripping. Treatment technologies evaluated included air stripping, carbon adsorption, and UV oxidation.

See Table 8 for a summary of the proposed remedy for each contaminant.

XI. Administrative Record Repository Locations

The feasibility Study Report, Proposed Plan and all Administrative Record documents can be found at the following locations:

U.S. EPA - Region II Administrative Records Room
290 Broadway
New York, NY 10001-1866
Phone (212) 637-4296
Contact: Jennie Delcimento

Longwood Public Library
800 Middle Country Road
Middle Island, NY 11953
Phone: (516) 924-6400
Contact: Reference Librarian

Brookhaven National Laboratory Research Library
Technical Information Division
Building 477A
Upton, NY 11973
(516) 282-3483
Contact: Reference Librarian

Mastics - Moriches - Shirley Community Library
301 William Floyd Parkway
Shirley, NY 11967
Phone: (516) 399-1511
Contact: Reference Librarian

Table 8.	Summary of Proposed Remedies for VOCs, Strontium-90 and Tritium		
Major Contaminant and Media	**Description of Remedy**	**Cost - Total Present Worth**	**Cleanup Time Frame**
Strontium-90 in Groundwater	**Alternative S5a –** Installation of a Groundwater Extraction/Ion Exchange system to capture strontium-90 plumes at WCF/PFS and Chemical Holes and discharge to recharge basins. Monitoring and natural attenuation.	$5,840,000	25-30 years
Tritium in Groundwater	**Alternative T4 –** Contingency-based remediation if tritium concentrations exceed 2,000,000 pCi/l at the reactor, or if tritium exceeds 25,000 pCi/l at the Chilled Water Plant Road and/or 20,000 pCi/l at Weaver Drive. Monitoring and natural attenuation.	$4,890,000 (Includes costs for contingency pumping)	20-25 years
VOCs in Groundwater	**Alternative V10b –** On- and off-site IRA systems and source removal at Building 96 and on-site in-well air stripping at Middle Road. Off-site in-well air stripping wells at Industrial Park, LIPA, Airport, North St., and RA V. Monitoring and natural attenuation.	$23,880,000	30 years

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Table 9- Comparison of Strontium-90 Alternatives

Assessment Factors	S1 - No Action	S2 - Natural Attenuation
Key Components	Regulatory requirements mandate the detailed evaluation of the No Action alternative.	Reduction of contaminants through natural means. Public awareness program and long-term monitoring. Installation of additional monitoring wells to monitor the degradation of the strontium-90 plume. Institutional controls.
Short-Term Effectiveness[a]	No impacts.	Potential risks to workers during drilling of monitoring wells, material handling and sampling activities.
Long-Term Effectiveness[a]	Cannot verify the long-term effectiveness without long-term monitoring and modeling. Strontium present in aquifer above MCLs beyond 30 years.	Minimal migration expected due to low mobility in aquifer Long-term effectiveness is verified by long term monitoring and modeling results.
Reduction of Toxicity, Mobility and Volume[a]	No direct reduction since no treatment is involved.	Natural attenuation results in reduction of toxicity and volume without significant migration.
Implementability[a]	No technical difficulties will be experienced.	No major construction involved. Requires monitoring which can be easily implemented.
Cost - Capital/ Total Present Worth[a]	$0.00/$0.00	$156,000/$949,000
Compliance with ARARs[b]	Groundwater quality ARARS are not achieved at the Chemical Holes, WCF and BGRR in 30 years.	Groundwater quality ARARS are not achieved at the Chemical Holes, WCF and BGRR in 30 years. RAOs are not met as Sr-90 exceeds MCLs after 30 years.
Overall Protection of Human Health and the Environment[b]	Does not insure	Provides for protection of human health through public awareness programs, land-use controls, and on-site monitoring.
State Acceptance[c]		
Community Acceptance[c]		

a. Balancing criteria, used to compare alternatives
b. Threshold criteria that must be met by selected alternative
c. Modifying criteria used in the final evaluation of alternatives

S4 - In-situ Precipitation	S5a - Groundwater Extraction/ Ion Exchange/On-site Discharge/ Natural Attenuation	S7 -Pump-andTreat at WCF/Reactive Wall at Glass Holes
Immobilize Sr-90 by the injection of sodium phosphate and lime to precipitate the Sr-90 from groundwater. Instituional controls.	Installation of a Groundwater Extraction/Ion Exchange system to capture Sr-90 plumes at WCF/PFS and Chemical Holes and discharge to on-site recharge basins.	Installation of a two-well extraction system, treatment via ion exchange, and discharge to a basin for the WCF/PFS Sr-90 plume. Installation of a barrier wall at the Chemical Holes to prevent migration of Sr-90. Institutional controls.
Potential risks to workers during drilling of injection wells, material handling and sampling activities.	Potential risk to workers through dermal contact and inhalation.	Potential risk to workers through dermal contact and inhalation.
Reduces the migration of Sr-90 within the aquifer. However, due to low mobility and flat gradient at Chemical Holes, Sr-90 migrates very little under natural attenuation conditions. Effective for the Chemical Holes area, preventing migration of the plume.	Complete treatment after 25-30 years of treatment down to MCLs at WCF/PFS. Complete treatment at Chemical Holes after 10 years. Rad waste from the ion exchange system will need to be disposed of.	Complete treatment after 25-30 years of treatment down to MCLs at WCF/PFS. Complete treatment at Chemical Holes after 10 years. Rad waste from the ion exchange system will need to be disposed of. Sr-90 at Chemical Holes allowed to decay in-situ without any plume migration.
Mobility of the strontium-90 is reduced by the precipitation of the strontium-90. Radioactive decay will reduce toxicity and volume.	A permanent reduction down to the 8 pCi/l MCL is achieved at all areas after 25-30 years resulting in the reduction of toxicity. Mobility and plume growth is reduced at the Chemical Holes area.	A permanent reduction down to the 8 pCi/l MCL is achieved at all areas after 25-30 years resulting in the reduction of toxicity. Mobility and plume growth is reduced at the Chemical Holes area.
Drilling contractors readily available. Injection wells are shallow wells. A pilot study is required for final design. Sampling for treatment effectiveness and groundwater monitoring can be implemented.	Treatment equipment readily available. A treatability study is required for final design. Sampling for treatment effectiveness and groundwater monitoring can be implemented.	Pump and treat equipment readily available and implementable. Reactive wall may be difficult to install.
$1,038,000/$1,999,000	$1,552,000/$5,840,000	$2,191,000/$6,011,000
Groundwater quality ARARS may be met as Sr-90 is removed from the groundwater into the soil matrix, but not removed from the environment.	Chemical-specific ARARS of 8 pCi/l are reached at all locations within 25-30 years. Treated discharge will comply with action-specific ARARs. Ion exchange is a proven technology for Sr-90 removal.	Chemical-specific ARARS of 8 pCi/l are reached at all locations within 25-30 years. Reactive wall will remove Sr-90 down to below MCLs as water passes through for approximately 30 years. Sr-90 remains in ground beyond 30 years as it decays
This alternative is protective of human health and the environment as Sr-90 is treated in-situ without the potential exposure to Sr-90 associated with ex-situ alternatives.	This alternative will protect human health and the environment through contaminant reduction, and minimize further migration of Sr-90. Potential exposure to Sr-90 will increase due to O&M activities for the treatment systems and the management, transportation and disposal of residual waste.	Potential exposure to Sr-90 has increased in this alternative due to O&M activities for the treatment systems and the management, transportation and disposal of residual waste. Risks would be reduced as a result of less teatment at the Chemical Holes.

Table 10- Comparison of Tritium Alternatives

Assessment Factors	T1 - No Action	T2 - Natural Attenuation	T3 - Natural Attenuation with Tritium IRA System
Key Components	Regulatory requirements mandate detailed evaluation of the No Action alternative.	Reduction of contaminants through naturally occurring means with the existing Tritium IRA in standby. Groundwater monitoring.	Reduction of contaminants through naturally occurring means with the existing Tritium IRA. Groundwater monitoring.
Short-Term Effectiveness[a]	This alternative would provide for short-term protection of human health and the environment. Remedial action objectives cannot be achieved.	Possible risk to workers exists through dermal contact.	Possible risk to workers exists through dermal contact.
Long-Term Effectiveness[a]	Long-term effectiveness cannot be verified without long-term monitoring and modeling results.	Tritium plume size and levels will decrease to below MCLs within 20-25 years. Plume does not significantly migrate. No long-term exposure to residuals.	Tritium plume size and levels will decrease to below MCLs within 20-25 years. Plume does not significantly migrate. No advantage to the operation of the IRA system. No long-term exposure to residuals. Carbon for the treatment of VOCs can be regenerated and re-used.
Reduction of Toxicity, Mobility and Volume[a]	Some reduction of tritium achieved, but cannot be evaluated without monitoring and modeling results.	Tritium concentrations are reduced to be below MCL concentrations within 20-25 years. Further groundwater sampling and modeling will confirm the rate of attenuation.	Tritium concentrations are reduced to below MCL concentrations within 20-25 years. Further groundwater sampling and modeling will confirm the rate of attenuation.
Implementability[a]	No technical difficulties will be experienced.	No major construction involved. Groundwater monitoring can be easily implemented. Requires acceptance by regulatory agencies.	No major construction involved. IRA system is currently in operation. Groundwater monitoring can be easily implemented.
Cost - Capital/ Total Present Worth[a]	$0.00/$0.00	$0.00/$1,997,000	$0.00/$3,257,000
Compliance with ARARs[b]	May not comply.	Complies after 20-25 years.	Complies after 20-25 years.
Overall Protection of Human Health and the Environment[b]	May not be protective of human health and the environment.	Protective: Groundwater is reduced to below MCLs without migrating off site.	Protective: Groundwater is reduced to below MCLs without migrating off site.
State Acceptance[c]			
Community Acceptance[c]			

a. Balancing criteria, used to compare alternatives

b. Threshold criteria that must be met by selected alternative

c. Modifying criteria used in the final evaluation of alternatives

T4 - Contingency Based Remediation	T5 - Extraction/ Recirculation	T6 - Hot Spot Removal/ On-Site Storage	T7 - Hot Spot Removal/ Off-Site Evaporation T8 - Hot Spot Removal/ On-Site Evaporation
Contingency based remediation if tritium concentrations exceed 2,000,000 pCi/l at the reactor, or if tritium exceeds 25,000 pCi/l at the Chilled Water Plant Road and/or 20,000 pCi/l at Weaver Drive. Remediation based on reactivation of IRA system or start-up of 10 extraction well low flow pumping systems with off-site disposal.	Installation of four extraction wells to contain the 20,000 pCi/l tritium concentrations. Extracted water will have TVOCs removed via air stripper and discharged to RA-V recharge basins. Tritium IRA in standby. Groundwater monitoring.	Contain the highest tritium concentrations with two low flow extraction wells pumping for one year. Extracted water will be stored in an on-site storage tank for 50 years. Tritium IRA in standby. Groundwater monitoring.	Both alternatives contain the highest tritium concentrations with two low flow extraction wells pumping for one year. **T7**- Extracted water will be disposed of off-site by evaporation. **T8**- Extracted water will be disposed of on-site by evaporation. Tritium IRA in standby. Groundwater monitoring.
Potential risk to workers through dermal contact and inhalation.	Potential risk to workers through dermal contact and inhalation.	Potential risk to workers through dermal contact and inhalation.	Potential risk to workers through dermal contact and inhalation.
Tritium plume size and levels will decrease to below MCLs within 20-25 years. Plume does not significantly migrate. No long-term exposure to residuals. Carbon for the treatment of VOCs can be regenerated and re-used.	Tritium plume size and levels will decrease to below MCLs within 15-20 years. Plume does not migrate off site. No long-term exposure to residuals.	Tritium plume size and levels will decrease to below MCLs within 20 years. Plume does not migrate off site. Possible exposure to stored tritium for up to 50 years.	Tritium plume size and levels will decrease to below MCLs within 20 years. Plume does not migrate off site. Possible off-site exposure to evaporated tritium, below air discharge limits.
This alternative offers additional protection from plume migration. Tritium concentrations are reduced to below MCL concentrations within 20-25 years. Further groundwater sampling and modeling will confirm the rate of attenuation.	Tritium concentrations are reduced to below MCL concentrations within 15-20 years. Further groundwater sampling and modeling will confirm the rate of attenuation. No great reduction in migration when compared to T2.	Tritium concentrations are reduced to below MCL concentrations within 20 years. Further groundwater sampling and modeling will confirm the rate of attenuation. No great reduction in migration when compared to T2.	Tritium concentrations are reduced to below MCL concentrations within 20 years. Further groundwater sampling and modeling will confirm the rate of attenuation. No great reduction in migration when compared to T2.
No major construction involved. IRA system is currently in operation. The technologies and equipment required are readily proven and commercially available. Coordination for transportation of tritium might pose some difficulties. Groundwater monitoring can be easily implemented.	The technologies and equipment required are readily proven and commercially available. Groundwater monitoring can be easily implemented.	The technologies and equipment required are readily proven and commercially available. Groundwater monitoring can be easily implemented.	The technologies and equipment required are readily proven and commercially available. Groundwater monitoring can be easily implemented. Permitting difficulties with approvals for the discharge of tritium to the atmosphere.
$456,000/$4,890,000	$853,000/$3,949,000	$1,349,000/$3,669,000	**T7**- $331,000/$26,776,000 **T8**- $628,000/$3,026,000
Complies after 20-25 years.	Complies after 15-20 years.	Complies after 20 years.	Complies after 20 years.
Protective: Groundwater is reduced to below MCLs without migrating off site. Tritium requiring off-site evaporation will result in small exposures.	Protective: Groundwater is reduced to below MCLs without migrating off site.	Protective: Groundwater is reduced to below MCLs without migrating off site.	Protective: Groundwater is reduced to below MCLs without migrating off site. Tritium requiring on- and off-site evaporation will result in small exposures.

Table 11- Comparison of Volatile Organic Compound Alternatives

Assessment Factors	V1 - No Action	V2 - Natural Attenuation	V7 - On-site In-well Air Stripping/Off-site In-well Air Stripping at Hot Spots and at Brookhaven Airport
Key Components	Regulatory requirements mandate detailed evaluation of the No Action alternative.	Source removal at Building 96 by AS/SVE system and continued operation of on/off-site IRAs. Reduction of contaminants through naturally occurring means.	On- and off-site IRA systems and source removal at Building 96 and on-site in-well air stripping at Middle Road. Off-site in-well air stripping wells at LIPA (1), Airport (8), North St. (3), RA V (1) and the western low-level VOC plume (4). Monitoring and natural attenuation
Short-Term Effectiveness[a]	Provides short-term protection of human health and the environment. Remedial action objectives cannot be achieved.	Potential risk to workers through dermal contact and inhalation.	Potential risk to workers through dermal contact and inhalation.
Long-Term Effectiveness[a]	Contaminants may continue to migrate and possibly impact downgradient receptors including Carmans River at 5-15 ppb. Health risks have been minimized through institutional controls like public water hookups Since no long term monitoring and modeling are available, long-term effectiveness cannot be ensured.	Significant contaminant removal from the aquifer through on/off site IRAs and source removal system. Long term monitoring and modeling will verify long-term effectiveness.	Significant contaminant removal from the aquifer through on/off site IRAs and source removal system. Long term monitoring and modeling will verify long-term effectiveness
Reduction of Toxicity, Mobility and Volume[a]	No direct reduction of contaminant toxicity, mobility or volume since no treatment is involved. Plume migrates down to Sunrise Highway at concentrations up to 50 ppb. Significant plume migration occurs offsite in this alternative.	Natural attenuation does result in reduction of contaminants through naturally occurring means, but the process is slow. Plume migrates down to Sunrise Highway at concentrations up to 50 ppb. Significant plume migration occurs offsite in this alternative.	Significant contaminants removed from aquifer. MCLs are reached in Upper Glacial in slightly over 30 years. Plume migration down to Brookhaven Airport (6,000 feet).
Implementability[a]	No technical difficulties will be experienced.	No major construction involved. Construction of off-site IRA and source removal system should pose no difficulties.	Requires the installation of wells in residential areas (LIPA, North St.). Requires access for installation of RA V wells on private property.
Cost - Capital/ Total Present Worth[a]	$0.00/$0.00	$1,697,000/$11,786,000	$10,814,000/$25,598,000
Compliance with ARARs[b]	Chemical specific ARARS will not be achieved.	ARARS will not be achieved in 30 years in the aquifer.	ARARS on-and off-site will not be achieved in 30 years because MCLs will still be exceeded at small areas near the airport.
Overall Protection of Human Health and the Environment[b]	This alternative will not protect human health and the environment. Possible receptors to be impacted by the VOC plume include the Carmans River. Risks have been minimized through public water hookups	The IRAs provide for the protection of human health and the environment by capturing the high-level VOCs on- and off-site. The source removal will prevent any further deterioration of the aquifer. VOCs will continue to migrate and impact the Carmans River within 30 years, but at low levels (5-15 ppb). Contaminants will continue migrating off-site, down to Sunrise Highway at concentrations exceeding 50 ppb.	Will protect human health and the environment through contaminant reduction both on- and off-site. Further plume migration and discharges to the Carmans River are reduced. MCLs are reached in the Upper Glacial aquifer in slightly over 30 years.
State Acceptance[c]			
Community Acceptance[c]			

a. Balancing criteria, used to compare alternatives
b. Threshold criteria that must be met by selected alternative
c. Modifying criteria used in the final evaluation of alternatives

V10b - On-site In-Well Air Stripping/Off-site In-well Air Stripping at Hot Spots and at Brookhaven Airport	V10c - On-site In-well Air Stripping/Off-site In-well Air Stripping at Hot Spots and at Brookhaven Airport	V11- On-site In-well Air Stripping/Off-site In-well Air Stripping at Non-residential Areas/No Treatment at LIPA	V13- On-site and Off-site Extraction Wells with Treatment System On-site
On- and off-site IRA systems and source removal at Building 96 and on-site in-well air stripping at Middle Road. Off-site in-well air stripping wells at Industrial Park (1), LIPA (3), Airport (7), North St. (4), and RA V (1). Monitoring and natural attenuation	On- and off-site IRA systems and source removal at Building 96 and on-site in-well air stripping at Middle Road. Off-site in-well air stripping wells at Industrial Park (1), LIPA (3), Airport (7), North St. (4), RA V (1) and the western low-level VOC plume (2). Monitoring and natural attenuation	On- and off-site IRA systems and source removal at Building 96 and on-site in-well air stripping at Middle Road. Off-site in-well air stripping wells at Industrial Park (1), Airport (10), North St. (3), and RA V (1). No treatment at LIPA. Monitoring and natural attenuation	On- and off-site IRA systems and source removal at Building 96 and on-site extraction well at Middle Road. On- and off-site extraction wells at Industrial Park (1), LIPA (3), Airport (7), North St. (4), and RA V (1). Monitoring and natural attenuation
Potential risk to workers through dermal contact and inhalation.	Potential risk to workers through dermal contact and inhalation.	Potential risk to workers through dermal contact and inhalation.	Potential risk to workers through dermal contact and inhalation.
Significant contaminant removal from the aquifer through on/off site IRAs and source removal system. Long term monitoring and modeling will verify long-term effectiveness	Significant contaminant removal from the aquifer through on/off site IRAs and source removal system. Long term monitoring and modeling will verify long-term effectiveness	Significant contaminant removal from the aquifer through on/off site IRAs and source removal system. Long term monitoring and modeling will verify long-term effectiveness	Significant contaminant removal from the aquifer through on/off site IRAs and source removal system. Long term monitoring and modeling will verify long-term effectiveness
Significant contaminants removed from aquifer. MCLs are reached in Upper Glacial in 30 years. Alternative meets RAOs for plume growth and cleanup of Upper Glacial within 30 years.	Significant contaminants removed from aquifer. MCLs are reached in Upper Glacial in 30 years. Alternative meets RAOs for plume growth and and cleanup of Upper Glacial within 30 years.	Significant contaminants removed from aquifer. MCLs are reached in Upper Glacial in slightly over 30 years.	Significant contaminants removed from aquifer. MCLs are reached in Upper Glacial in 30 years. Alternative meets RAOs for plume growth and and cleanup of Upper Glacial within 30 years.
Requires the installation of wells in residential areas (LIPA, North St.). Requires access for installation of RA V wells on private property.	Requires the installation of wells in residential areas (LIPA, North St.). Requires access for installation of RA V wells on private property.	Requires access for installation of RA Vwells on private property. Less difficult to implement due to the lack of wells in residential areas.	Requires the installation of wells in residential areas (LIPA, North St.). Requires access for installation of RA V wells on private property. requires the installation of piping throughout residential neighborhood. Requires installation of piping under the Long Island Expressway and railroad tracks.
$9,728,000/$23,880,000	$10,513,000/$25,142,000	$9,142,000/$23,615,000	$8,261,000/$25,056,000
ARARS are met within Upper Glacial aquifer within 30 years.	ARARS are met within Upper Glacial aquifer within 30 years.	ARARS are met within Upper Glacial aquifer slightly after 30 years.	ARARS are met within Upper Glacial aquifer within 30 years.
Will protect human health and the environment through contaminant reduction both on- and off-site. MCLs are reached in the Upper Glacial aquifer in 30 years.	Will protect human health and the environment through contaminant reduction both on- and off-site. Further plume migration and discharges to the Carmans River are reduced. MCLs are reached in the Upper Glacial aquifer in 30 years. Low level VOC migration and discharge to the Carmans River has been reduced.	Will assist in protectionof human health and the environment through contaminant reduction both on- and off-site. MCLs are reached in the Upper Glacial aquifer in slightly over 30 years. Provides for less protection against plume growth and migration but easier to implement due to no wells located in residential areas.	Will assist in protectionof human health and the environment through contaminant reduction both on- and off-site. MCLs are reached in the Upper Glacial aquifer in 30 years.

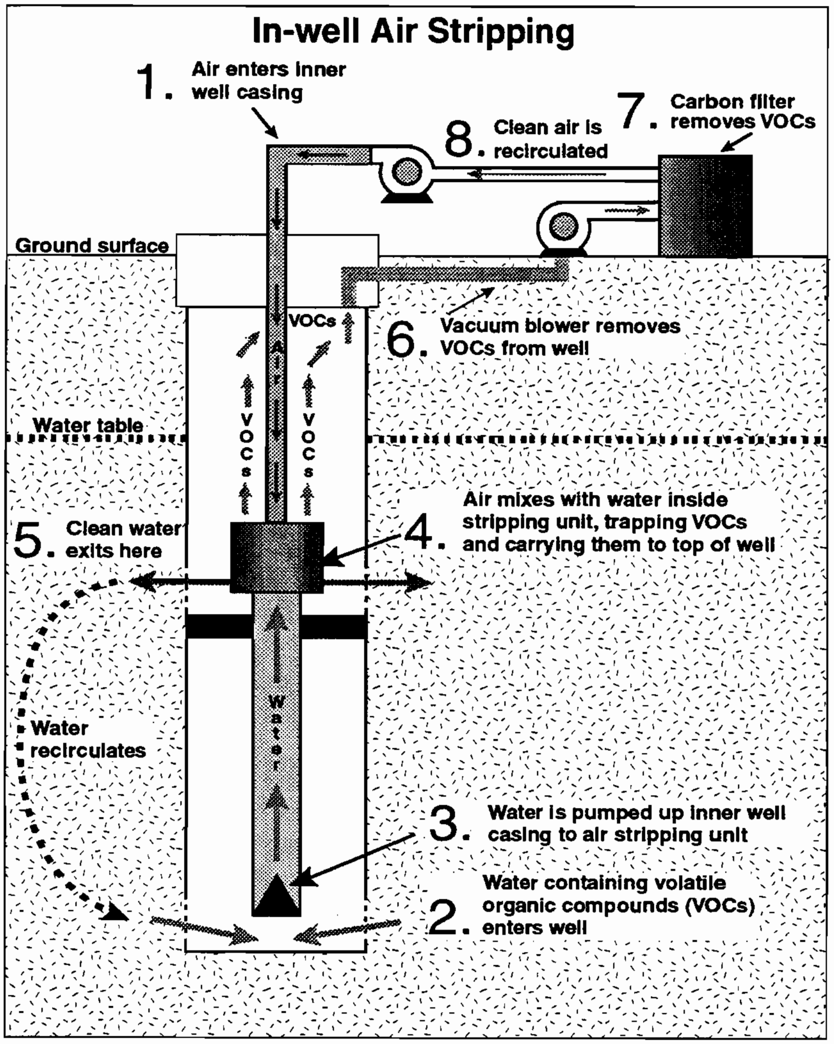

Figure 6. *Schematic showing a typical in-well air stripping system.*

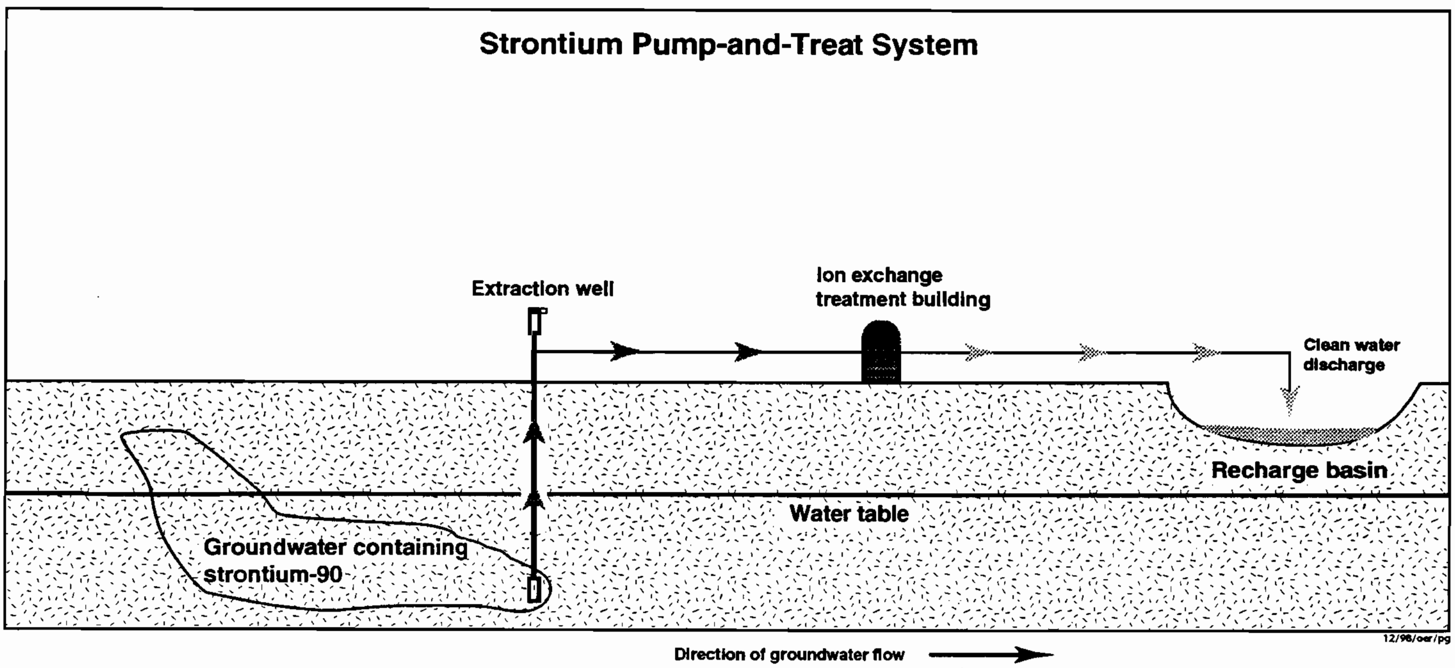

Figure 7. *Schematic showing strontium-90 ion exchange system.*

What's Your Opinion?

The DOE wants and needs to hear from you to effectively decide what actions to take at Brookhaven National Laboratory.

Comments:

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