

Public Health Assessment
BROOKHAVEN NATIONAL LABORATORY
UPTON, SUFFOLK COUNTY, NEW YORK

CERCLIS NO. NY7890008975

Site and Radiological Assessment Branch
Division of Health Assessment and Consultation
Agency for Toxic Substances and Disease Registry

ATSDR and the Public Health Assessment Process at Department of Energy Facilities

The Agency for Toxic Substances and Disease Registry (ATSDR) is part of the U.S. Public Health Service. ATSDR's mission is to prevent or mitigate adverse human health effects and diminished quality of life resulting from exposure to hazardous substances in the environment. ATSDR has no regulatory authority; it does, however, recommend public health actions that address potential adverse health effects resulting from environmental releases from hazardous waste sites.

The public health assessment is the principal means by which ATSDR addresses public health issues. The document discusses available information about site-related hazardous substances and evaluates whether exposure to them—in the past, present, or future—might cause adverse health effects in members of the community.

ATSDR is responsible for preparing public health assessments, according to the Comprehensive Environmental Response, Compensation, and Liability Act, as amended, (CERCLA or Superfund) section 104 (i)(6) (42 U.S.C. 9604 (i)(6)). As mandated by that law, ATSDR conducts public health assessments of hazardous waste sites listed or proposed for listing on the U.S. Environmental Protection Agency's (USEPA) National Priorities List (NPL). ATSDR also responds to requests (petitions) to conduct public health assessments.

Three primary sources of information are used in a public health assessment: environmental data, community health concerns, and health outcome data. ATSDR does not routinely perform environmental sampling. The environmental data used in public health assessments are provided by the Department of Energy (DOE) component involved; by the USEPA, by state and local environmental and health agencies, and by other groups or individuals. In addition, ATSDR health assessors conduct site visits to observe firsthand current conditions at the site, land use, public accessibility, and demographic characteristics of the nearby community.

Other sources of community health concerns are records from the installation's Public Affairs Office, USEPA's community relations representative, and state and local health and environmental agencies.

Health outcome databases document health effects that occur in populations. Those data, which come from sources such as state tumor registry databases, birth defects databases, vital statistics records, or other records, might provide information about the general health of the community living near a site. Other, more specific records, such as hospital and medical records and records from site-specific health studies, might also be used. Analysts use demographic data that provide information on population characteristics (e.g., age, sex, and socioeconomic status) when they analyze health outcome data.

ATSDR representatives identify actual and perceived site-related health effects and the level of public health hazard posed by the site. ATSDR staff members then make recommendations to the appropriate DOE components, to USEPA, and to relevant state and local agencies on preventing or alleviating human exposures to site-related contaminants. When circumstances

warrant, ATSDR identifies a need for any follow-up health activities, such as epidemiologic studies, registries, or community health education. Finally, ATSDR provides a mechanism to re-evaluate health issues as site conditions change (e.g., after site remediation or changes in land use) or when new data or information are available.

The public health assessment includes a public health action plan (PHAP). The PHAP contains a description of actions ATSDR and other parties will take at and in the vicinity of the site. The purpose of the PHAP is to provide a plan of action for preventing and mitigating adverse human health effects resulting from exposure to hazardous substances in the environment. ATSDR monitors the implementation of the plan annually. Public health actions might include, but are not limited to, restricting site access, sampling, surveillance, registries, health studies, environmental health education, and applied substance-specific research.

Public health assessments are typically distributed in three phases: an initial release (red cover), a public comment release (brown cover), and a final release (blue cover). The initial release document, which is prepared as part of the process of gathering, analyzing, and drawing conclusions and recommendations from the vast amount of information evaluated in a public health assessment, is provided for review and comment to the DOE component involved, to USEPA, and to state and local environmental and health agencies. The red cover release gives agencies the opportunity to comment on the completeness of information they have provided and the clarity of the presentation. The initial release comment period lasts 45 days. Following the initial release, ATSDR prepares the document for distribution to the general public.

The public is notified of the document's availability at repositories (e.g., libraries and city halls) in the site area through advertisements and public notices in newspapers. The comment period typically lasts 30 days. ATSDR addresses all public comments and revises or appends the document as appropriate. The final public health assessment is then released; that document includes written responses to all public comments.

A public health assessment is an ongoing process. ATSDR revises final documents if new information about the environment, community health concerns, and health outcome data becomes available and is found to modify previous conclusions and recommendations. For more information about the ATSDR public health assessment process and related programs, please write to the following address:

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Special note on the public health assessment for the Brookhaven National Laboratory

A public health assessment (PHA) for the Department of Energy's (DOE) Brookhaven National Laboratory was released for public comment and independent peer review on September 30, 2005. Due to a lack of funding by DOE in fiscal year 2006, we were unable to respond to the comments we did receive on the PHA. A copy of the stakeholder letter sent in December 2005 is also attached in Appendix H.

Ultimately, DOE funding was restored and we were recently able to complete the PHA. If ATSDR receives data or information that would change our conclusions, we will update this evaluation.

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Document Notes

This public health assessment (PHA) addresses potential off-site exposures to radioactive and non-radioactive substances released from the Brookhaven National Laboratory (BNL). The specific exposure pathways considered include:

- Exposures to contaminants found in off-site soils, groundwater, surface water, sediments, air, and biota.
- Exposures to contaminants found in on-site potable wells.

For these exposure pathways, the PHA evaluates both current and past exposures to contaminants that originated from BNL, while also considering contaminants from other sources, as appropriate. The timeframes considered for past exposures varied across exposure pathways, because sampling data needed to evaluate the pathways were collected over different timeframes. The following table lists the specific timeframes considered for the exposure pathways evaluated in this PHA.

| <i>Exposure Pathway</i> | <i>Locations Considered</i> | <i>Time Period Evaluated in the PHA*</i> |
|----------------------------------|-----------------------------|--|
| Residential drinking water wells | Off site | 1981–1995 |
| Ambient air | | 1948–2003 |
| Soil | | 1974–1999 |
| Surface water | | 1974–1999 |
| Sediment | | 1974–1999 |
| Fish | | 1973–2002 |
| Shellfish | | 1987–1999 |
| Deer | | 1986–1999 |
| Small mammals | | 1986–1993 |
| Vegetation | | 1984–1999 |
| BNL potable wells | On site | 1984–2001 |
| Soil | | 1974–1999 |

*Time periods are the range of years evaluated; data might not have been available, however, for the entire time period. See each section of the PHA for more details. Moreover, even though this PHA presents data summaries mostly for studies conducted up through 1999, the main conclusions in the PHA apply to time frames up to and including the year this final PHA was issued.

While the focus of this PHA is almost entirely on off-site contamination levels, readers should note that the PHA summarizes on-site contamination levels in some environmental media. These

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data summaries are included largely to the extent that they provided information necessary to assess the off-site exposure evaluations.

With the exception of on-site potable wells, the assessment does not address on-site exposures of BNL workers to radioactive or hazardous materials. For some radioactive and hazardous materials used at BNL, workers may be expected to be exposed at higher levels than the general public. However, workers are required to be trained in the use and safe handling of hazardous materials, and monitoring of their exposures is also required. Current Department of Energy (DOE) internal regulations require all DOE facilities to meet worker safety and health standards developed by the Department of Labor, Occupational Safety and Health Administration (OSHA).

This PHA focuses largely on environmental sampling data collected through 1999; more recent data were not available or were not fully validated when ATSDR first began writing this document. ATSDR has reviewed a large volume of sampling data collected since 1999 and determined that contamination levels have largely decreased due to the site remediation efforts (see Appendix E). Therefore, ATSDR believes the conclusions in this PHA remain valid today. Readers should note that in some cases (particularly for soil, sediment, and groundwater), data cited in the text and tables in this document represent environmental contamination levels measured *before* remediation activities occurred.

During the 1940s and the 1950s, air monitoring of the reactor emission stacks was not performed with the sophistication that improved instrumentation allowed for during the 1960s, 1970s, and through the present day. BNL representatives retrieved old log books and estimated the amount of radioactive material released as a result of the 28 fuel ruptures that occurred during this time frame. The document entitled “Radiological Emissions and Environmental Monitoring for Brookhaven National Laboratory, 1948-1961” was the result of their efforts. Similar ruptures had occurred at the Oak Ridge Reservation, and an attempt was made to correlate the two.

Also, this public health assessment does not explicitly address exposures to hazardous materials of visitors to the Brookhaven National Laboratory. ATSDR does not think that visitors have been, or will be, exposed to hazardous or radioactive materials at levels of health concern.

At the end of this document ATSDR has included a glossary of terms frequently used by public health officials. Not all the terms in the glossary are used in this public health assessment. The glossary was prepared by ATSDR for many purposes. It is included in this document to help readers become familiar with the terminology used.

Summary

Introduction

The Brookhaven National Laboratory (BNL) is located on Long Island, New York. It is a Department of Energy (DOE) facility that has been in operation since 1947. Activities at BNL include research in the fields of physics, chemistry, biology, materials science, and medicine. Over the years, the waste disposal from some of these operations was not always to current standards. As a result, various environmental media (e.g., soil, water, air, and biota) were contaminated. The contamination led in December 1989 to the U.S. Environmental Protection Agency listing the site on the National Priorities List (NPL).

Soil contamination

As the result of accidental spills, leaking sewer lines, and the disposal of radioactive and chemical materials into unlined pits and landfills, soil contamination occurred in many on-site areas. But soil contamination did not occur in off-site areas. Many of the areas formerly contaminated have been remediated. The Former and Current landfills have been capped. The remaining areas of contamination are fenced or are buried deep below the surface, as is the case with the Brookhaven Graphite Research Reactor (BGRR). Thus only workers remediating the soils risk contaminant exposure. Remediation workers are expected to wear protective gear and are expected to be trained in the removal of contaminated soil as documented in the site worker health and safety plan

Groundwater contamination

BNL has collected thousands of groundwater samples over the years to assess the extent of groundwater contamination. Groundwater monitoring data indicate that the highest contaminant concentrations at on-site locations are between depths of 30 to 50 meters (m) below ground level (bgl), with maximum concentrations at about 50 m bgl at the site boundary (BNL/ERD 1998). At on-site locations, contaminant levels detected at several monitoring wells exceed current drinking water standards. This condition has been observed for several radiological contaminants (e.g., strontium-90, radium-226, and tritium) and nonradiological substances (e.g., trichloroethylene, carbon tetrachloride, perchloroethylene and 1,1,1-trichloroethane). It is important to note, however, that water from these monitoring wells is not used for household purposes. Nevertheless, although these detected concentrations do not present a health hazard, they do suggest the need to

continue evaluating groundwater in the future to ensure that contaminants do not migrate into potable water (i.e., water suitable for drinking, cooking, bathing) wells at levels of health concern.

Groundwater migration

Multiple studies and extensive monitoring data confirm that some of the contaminated groundwater beneath BNL has migrated to off-site locations, primarily south and southeast of the facility. Monitoring by the DOE and the Suffolk County Department of Health Services (SCDHS) indicated the presence of multiple contaminant plumes on site, five of which (two plumes commingled) have flowed off site, and two that have originated off site. Both plumes that originated off site contaminated area residential wells. One of the plumes that originated off site was attributed to an industry in the Brookhaven R & D Industrial Park, the other to a gasoline station at the intersection of Moriches Middle Island Road and William Floyd Parkway. For several plumes, high concentration pulses have migrated downgradient. These pulses have the potential for historical contaminant concentrations that exceed recently measured values. But monitoring data and the analysis results indicate that the high concentration zones are deeper than typical residential well depths.

Remedial actions for off-site wells

After discovering and characterizing the groundwater contamination beneath the BNL facility, BNL sampled approximately 675 residential wells in the areas of North Shirley, Shirley, East Yaphank, and Manorville. Monitoring results indicated that some of the wells contained levels of volatile organic compounds (VOCs) and a pesticide above the federal and New York State drinking water standards. Importantly, however, no radiological contaminants were found at levels greater than drinking water standards in the off-site wells. DOE offered residents in the potentially affected areas the option of connecting their residences to the public water supply. In conjunction with the Suffolk County Water Authority, DOE connected approximately 1,500 residences and commercial properties to the public water supply. Seven residents declined the hookup and continue to use their private wells. Routine annual monitoring indicates that these private wells have not been affected by the contaminant plumes (BNL August 2004). As a precautionary measure, however, DOE has offered free, annual private well sampling to these residents to ensure that the wells continue to provide safe drinking water. DOE has completed numerous remedial actions to reduce the levels of contaminants in the groundwater. Officials continue to monitor the public water supply. The public water supply has not been affected by the plumes.

Remediation of some on-site wells Some of the Brookhaven National Laboratory (BNL) potable supply wells were previously found contaminated with 1,1,1-trichloroethane (1,1,1-TCA) and other volatile organic compounds. These wells were either taken out of service or activated carbon filters were installed in them to remove the contamination. The contamination levels reported to date, including those reported before the wells were taken out of service, are not expected to result in any adverse health effects.

Air not contaminated at health-effect levels Throughout BNL history, several reactors have been in operation. Routine air emissions associated with the operation of BNL from 1948 through 1961 were mainly from the Brookhaven Graphite Research Reactor (BGRR). The reactor operated on the use of natural uranium fuel from 1951 to 1957. During this time, 28 fuel cartridge ruptures were reported. Each rupture released noble gases, particulates, and radioiodines into the reactor-cooling air stream. ATSDR used computer models to estimate the radiological dose an person might have received during specific periods of time. ATSDR determined that the combined estimated doses for the years with the highest releases were less than ATSDR's lifetime radiogenic cancer comparison value of 5,000 mrem over 70 years. They were not expected to cause any observable or detectable adverse health effects. Current emissions from today's laboratory facilities are in compliance with their permitted releases and do not pose a health hazard.

Surface water and sediments do not pose a health risk Although individual samples from the Peconic River contained elevated inorganic contaminants (e.g., arsenic, cadmium, lead, manganese, mercury, and thallium), the average annual concentrations were below health screening values. The maximum concentrations detected for organic compounds (toluene 3ppb; total xylenes 3ppb) were below health screening values. Tritium was detected at a maximum concentration of 5,800 picocuries per liter (pCi/L). Any exposure (s) to contaminants in surface water at these levels would not be expected to cause adverse health effects.

The areas of elevated levels of mercury and polychlorinated biphenyls in the sediments of the Peconic River on site and just off site have been removed, and restoration is complete (BNL 2005).

**Biota
contamination**

Fish sampling was first conducted in the 1970s, but most samples were only analyzed for radionuclide contamination. Although strontium-90 and cesium-137 levels were elevated compared with background levels, the radiation doses to those consuming fish were not at levels known to or expected to pose a public health concern. Inorganics, pesticides, and PCBs were analyzed from 1996–2003. Fish from on-site and off-site Peconic River locations contained elevated levels of PCBs and mercury. Contaminant levels are higher in the fish samples collected on site and decrease in downstream samples. The Peconic River is an intermittent stream on site. Thus edible-size fish are not likely to be present throughout the year.

**Long Island
fish advisory**

The New York State Department of Health (NYSDOH) has issued a fish advisory for fresh waters of Long Island. The advisory states that no one should eat more than one meal of fish per week from any of the state's fresh waters. Currently, if people adhere to the fish advisory, adverse health effects are not be expected to occur.

Deer sampling

Deer sampling confirmed the presence of potassium-40 (a naturally occurring radionuclide), strontium-90, and cesium-137. The NYSDOH estimated the effective dose equivalent (EDE) from consuming contaminated deer meat to be 7.1 millirem (mrem) — lower than the national average EDE (10 mrem) from eating foods containing naturally occurring radionuclides. Therefore, the consumption of deer meat would not result in adverse health effects.

**The BNL site
poses no health
hazard**

Currently, the site poses no health hazard. The site contains no current, completed exposure pathway(s) to chemicals or radionuclides at levels of public health concern. Past airborne radionuclide releases from the various reactors appear to have been large, but the radiological doses are relatively small. The reason for the low doses is based on the properties of the respective, released radionuclides. The properties of the radionuclides that were released were either low energy emitters (tritium) or were not absorbed to a great extent in the body (argon-41). Past exposures to groundwater contaminants do not appear to have been at levels that would result in adverse health effects. ATSDR modeled the groundwater contaminant plumes to determine the likelihood of the wells becoming contaminated before they were sampled. Our modeling of the groundwater plumes indicated that the

contaminant levels in the residential wells would not have been above those detected at the time of sampling.

**Health
Outcome Data**

The high incidence of breast cancer on the eastern end of Long Island is a major health concern of residents living near the Brookhaven National Laboratory. In response to their concern, ATSDR reviewed health outcome data pertaining to studies now conducted on breast cancer and the incidence rates of breast cancer and other forms of cancer.

**Breast cancer
studies
reviewed**

ATSDR staff reviewed several breast cancer studies conducted in the northeastern United States. A study conducted by the National Cancer Institute (NCI) looked at demographic data and age-specific breast cancer mortality rates for women in 11 northeastern states and the District of Columbia for 1988–1992. Results indicated that the increased breast cancer mortality on Long Island was statistically significant and that the increase was not confined to this area—it extended into parts of New Jersey and Philadelphia. The New York City-Philadelphia metropolitan area had a 7.4 percent excess compared with the rest of the Northeast, which in turn had a 12.4 percent excess compared with the rest of the country (NCI 1997). The risk factors analyzed in this study included age at first birth, age at menopause, breastfeeding, genetic mutations, and environmental factors.

**Long Island
Breast Cancer
Study**

The Long Island Breast Cancer Study Project (LIBCSP) — the result of Public Law 103-43 — was to determine whether certain environmental contaminants increased the risk of breast cancer among women in Long Island’s Nassau and Suffolk counties. Researchers from the LIBCSP concentrated their research on organochlorine compounds, including the pesticide DDT, its metabolite DDE, and polychlorinated biphenyls (PCBs). This study is one of the largest and most comprehensive environmental epidemiologic studies ever done for breast cancer. Results from the study project indicated no increased rate of breast cancer among women who may have been exposed to organochlorine compounds or PCBs (Gammon 2002).

ATSDR also looked at the following cancers in the health outcome data: liver, prostate, brain and other nervous system, thyroid, Non-Hodgkin’s lymphomas, multiple myelomas, and leukemias. ATSDR found that none of these cancers were elevated in Suffolk County compared with the neighboring Nassau County or with New York state as a whole.

1 Background

1.1 Site Description and History

The Brookhaven National Laboratory (BNL) is a DOE research laboratory that opened in 1947 on the site of the United States Army's former Camp Upton. BNL is located on Long Island, New York, in the geographic center of Suffolk County. The main mission of BNL is basic and applied research in the fields of physics, chemistry, biology, materials science, and medicine. The disposal of wastes from the various research projects done at BNL was not always done by today's standards, which resulted in both chemical and radioactive contamination.

Much of the research conducted throughout BNL's history occurred in industrial facilities called reactors. The reactors were generally used to create subatomic particles for research purposes. Several reactors have been used throughout the history of BNL operations. The history of BNL reactors began in 1950 with the operation of the Brookhaven Graphite Research Reactor (BGRR). The BGRR was the main source of emissions in the early years of operation (1950–1968). During the operation of the BGRR, 28 ruptures of the fuel cartridges were reported. In 1952, the Cosmotron became operational, and in 1960 the Alternating Gradient Synchrotron (AGS) came on line. The AGS was built to surpass the capabilities of the Cosmotron. In 1970, the Tandem Van de Graaff accelerator became operational.

The High Flux Beam Reactor (HFBR) began operating in 1965 and operated until 1989 when it was shut down to analyze the potential for loss of coolant. It was restarted in 1991 and operated until 1997. In 1997, BNL officials shut the reactor down because of a leak in the spent fuel pool. The HFBR was permanently shut down in 1999. The Laboratory's last operating reactor, the Medical Research Reactor (MRR) was permanently shutdown in 2000.

Past activities at BNL have contaminated the soil, sediment, surface water, groundwater, air, and biota on BNL property, and some of the contaminants migrated off site. As a result, BNL was included on the USEPA's National Priorities List on December 21, 1989. This listing triggered extensive environmental investigations at BNL, which ultimately led to several cleanup activities in order to reduce potential risks to human health and the environment as defined by USEPA. Before characterizing the site and evaluating the feasibility of different remediation options, BNL representatives grouped known and suspected areas of contamination into six operable units (OUs). Figure 1 in Appendix B shows the locations of the OUs on BNL property.

1.2 Site Visits

ATSDR staff made several visits to BNL. The initial site visit was conducted in July 1996. During the initial site visit, ATSDR staff viewed the areas of contamination on laboratory property. ATSDR staff made additional visits to view specific areas of the site and to meet with site personnel who are familiar with the various areas of contamination. ATSDR staff returned to BNL in November 1996 to attend a community work group health symposium at the local high school in Yaphank. The staff presented an overview of ATSDR and described its mission regarding the site. Staff members also provided community members with an introduction to radiation and the health effects associated with it.

ATSDR met with residents of the community to gather their concerns regarding contamination at BNL. The community requested that ATSDR prepare health consultations on the groundwater and air pathways and determine if individuals had been, are currently, or could be exposed in the future to any of the contaminants in these media. Health consultations are not as comprehensive as a public health assessment; health consultations are a means of providing advice on a specific public health issue related to real or possible human exposure to toxic material.

ATSDR completed the initial release of the groundwater consultation (October 1997) and recommended that individuals living south of the laboratory who had a private well accept the offer from the Department of Energy to be connected to the public water supply. ATSDR staff presented the final results of the groundwater consultation to the Brookhaven Executive Roundtable on August 24, 1999.

When ATSDR staff began to write the health consultation for the air pathway, they identified a data gap for emissions from the late 1940s until 1961. Without this information, ATSDR could not evaluate exposures to airborne emissions. In response to ATSDR's request for data, BNL staff reviewed old archives (laboratory log books) and interviewed individuals who worked at the site during that time. BNL staff identified what records were available and what materials were used. A final DOE document regarding historical air emissions for the Brookhaven Graphite Research Reactor was completed in May 2001 (BNL 2001).

The most recent ATSDR site visit, conducted in August 2004, involved ATSDR staff viewing the stretches of the Peconic River that are on site and in the Peconic River County Park just south of BNL boundary. Surface water and sediments are contaminated in the Peconic River on site with metals, organic chemicals, and radionuclides. ATSDR viewed different stretches of the Peconic River to determine the river's accessibility and flow and to determine the likelihood of exposure to off-site residents. At this time, most of the on-site portion of the Peconic River had been remediated, and the remaining on-site areas were being remediated. Since our last visit, remediation and restoration both on site and off site have been completed.

1.3 Demographics, Land Use, and Natural Resources Use

Approximately one-third of the 1.36 million people who reside in Suffolk County live in the Brookhaven Township where BNL is located (LIPA 1998). Eight thousand of these people live within 1 mile of the BNL boundary. Figure 9 in Appendix B details the demographics and specific age group statistics within 1 mile of the site (Bureau of Census 2000). Approximately 250–300 people reside in apartments and cottages on site (BNL 2000). The apartments and cottages are located in the western portion of the site. Residence in these on-site facilities is generally short in duration — usually less than 3 months — and rarely more than a year.

BNL comprises 5,263 acres, and approximately one-third of the site is developed. The developed portion of the site is located near the center of the property. Much of the land within 10 miles of the site is either undeveloped or cultivated; however, recent trends have shown an increase in residential housing, and those trends are expected to continue.

The soil on Long Island is very porous; as a result, there is little surface runoff. BNL is part of the upper drainage area of the Peconic River, which is the principal drainage feature of the

Manorville drainage basin. The surface drainage is poor in the Manorville drainage basin, and much of the land near the river is swampy. Six wetland areas are on site.

The Peconic River enters BNL property northwest of the Sewage Treatment Plant (STP) outfall and exits the property to the southeast. The discharge from the STP accounts for approximately 90% of the water flow in the Peconic during the spring and almost 100% during the late summer and fall. The effluent from the STP flows into the Peconic River and into the surrounding aquifer when the water table is below the bottom of the riverbed. In the general vicinity of the STP outfall, the Peconic is a gaining stream because it receives groundwater seepage from the surrounding aquifer. The situation reverses as the downstream distance from the STP outfall increases.

Many factors influence groundwater flow beneath BNL. Groundwater in the northeast and northwest sections of the site flows toward the Peconic River. On the western portion of the site, groundwater flow is to the south, and along the southern and southeastern portions of the site, the flow tends to be towards the south to southeast. South of the southwestern boundary, the groundwater flow is southwest because of the influence of the Carmans River. In the southeastern portion of the site, the Peconic River influences the groundwater to flow to the southeast. Figure 4 in Appendix B details the hydrogeologic cross section and groundwater flow directions in the vicinity of BNL (BNL 1997b). Groundwater from BNL site flows predominately southward in the unconfined to semi-confined Upper Glacial aquifer. Although net groundwater transport from BNL is southward, BNL facility overlies a deep flow recharge zone such that initial groundwater flow is downward (ITC 1998b).

Hydrogeologic evaluations of BNL site indicate that near the surface, groundwater flows vertically downward. But as depths increase, groundwater flows in a lateral southerly direction. To determine the vertical extent of the contamination, BNL defined three sampling zones within the Upper Glacial Aquifer and one within the Magothy Aquifer. The Upper Glacial Aquifer zones are (1) the water table from 0 to 50 feet above mean sea level (msl), (2) the mid glacial zone from 0 to 60 feet below msl, and (3) the deep glacial zone from 60 to 150 feet below msl. The Magothy Aquifer sampling zone extends from 150 to 250 feet below msl. A detailed description of the hydrogeology underlying BNL facility and the methods used in the modeling of the plumes is included in Appendix D.

In the Upper Glacial aquifer, the upper boundary of the saturated groundwater system is defined by the water table, which is 16 feet or less below ground surface. Water table elevations are significantly affected by recharge from settling basins and by discharges to streams and pumping wells (ITC 1998b). Although the Magothy aquifer is in direct contact with the Upper Glacial aquifer over most of BNL site, groundwater flow occurs preferentially in the Upper Glacial aquifer as a result of much higher permeabilities (ITC 1998b). The Upper Glacial aquifer is partially separated from the underlying Magothy aquifer by the Gardiners Clay or Cretaceous-age clays of the Monmouth Group (ITC 1998). The Upper Glacial aquifer is predominately sandy to gravelly permeable glacial outwash deposits, with some finer-grained glacial lake deposits and near-surface silts and clays (CDM Federal Programs 1996a).

Precipitation averages about 122 cm/year, with about 58 cm/year recharge to the aquifer system. The remaining precipitation is lost as evapo-transpiration or surface runoff (CDM Federal Programs 1996a). Surface streams are controlled by groundwater discharge from the Upper

Glacial aquifer, which constitutes about 95 percent of the base flow. Upper reaches of the Peconic River and other area streams have intermittent flow and often go dry when the water table is lower than the stream channels (ITC 1998a).

Fifteen mammal species are native to the site. During the early 1990s, white-tailed deer populations were estimated to be at least 100 per square mile (Thomlinson 1993). More recent surveys conducted between November and December 2000 estimated the deer population at 236 deer per square mile (BNL 2000). The increase in deer population has left BNL officials with the task of determining the best method for controlling it. Although hunting is prohibited on BNL property, hunting does take place off site. Several endangered species inhabit BNL property, including the tiger salamander, the banded sunfish, and the swamp darter.

Many industrial facilities other than BNL are located in Suffolk County as well as in nearby Nassau County. According to the USEPA's Toxic Chemical Release Inventory (TRI) database, in 2004, 30 industrial facilities in Suffolk County reported releasing a wide range of toxic chemicals into the environment or managing toxic chemicals as waste (USEPA 2004). Facilities that meet certain reporting criteria are required to report releases of selected chemicals to the environment on a yearly basis. Specifically, these facilities must disclose their releases to air, surface water, and land; and they also must indicate the quantities of chemicals managed as waste (e.g., through underground injections, disposal, treatment, recycling). The TRI is a publicly available database that contains an inventory of chemical releases and other waste management activities reported annually by certain industry groups as well as by federal facilities. It is accessible on the Internet at <http://www.epa.gov/tri>.

2 Environmental Contamination and Other Hazards

This section presents the contaminants of concern in each environmental medium (surface soils, subsurface soils, surface water, sediments, air, groundwater, vegetation, and biota). Each environmental medium has been tested for a large number of chemicals and radionuclides. The following sections address whether individuals have been exposed or could be exposed to the contaminants and whether those exposures are of public health significance.

ATSDR selects and discusses contaminants by using criteria such as concentrations and locations of contaminants on site and off site, field data quality, laboratory data quality, frequency of detection, and comparison of concentrations of contaminants to comparison values (CVs) for cancerous and noncancerous health effects.

ATSDR and other agencies have developed CVs to provide guidelines for identifying levels of contaminants in environmental media that might pose public health hazards. These values include Cancer Risk Evaluation Guidelines (CREGs), Environmental Media Evaluation Guidelines (EMEGs), USEPA's Reference Doses (RfDs), Reference Concentrations (RfCs), Risk-Based Concentrations (RBCs), and Lifetime Health Advisories (LTHAs).

ATSDR derives CREGs from USEPA's cancer slope factor, which predicts no more than one excess cancer in a million persons exposed over a lifetime (70 years). Standard body weights and daily ingestion rates for both adults and children are assumed in the derivation of these values. EMEGs are concentrations in water, air, or soil that should not cause adverse noncancerous effects, even if exposure occurred daily. EMEGs are calculated from ATSDR's Minimal Risk Levels (MRLs). Both MRLs and RfDs are estimates of the daily exposure to contaminants that

are unlikely to cause adverse noncarcinogenic health effects over a lifetime. USEPA's LTHAs are concentrations at which adverse noncancerous health effects are not expected to occur. USEPA also has maximum contaminant levels (MCLs), which are enforceable drinking water regulations that are protective of human health to the "extent feasible" over a lifetime.

2.1 On-Site Contamination

Contamination at BNL has been grouped into six operable units. Appendix E contains a description of the type of contamination found in the soil and groundwater associated with each operable unit. Contamination in surface water, sediments, biota, air, and vegetation are discussed on a site-wide basis rather than for each operable unit. Figure 1 in Appendix B shows the operable unit locations. Contamination associated with the Brookhaven Graphite Research Reactor (BGRR) is discussed in the air emissions section.

2.2 Potable Water Well Contamination

Figure 7 in Appendix B shows the locations of the potable and supply wells at BNL. Potable well water at BNL is currently tested on a quarterly basis for radionuclides, volatile organic compounds (VOCs), metals, pH and temperature, dissolved solids, conductivity, phosphorous, nitrate-nitrogen, and dissolved oxygen. Sampling for VOCs, specifically 1,1,1-TCA, TCE, chloroform, and PCE, however, did not occur until 1984. Because VOCs were detected in 1984 in potable water wells, the wells were sampled monthly in 1985; but the samples were analyzed by BNL, which at the time was not certified to do the analysis. In 1985, VOC samples were only analyzed once by a certified laboratory.

An important note is that the majority of the samples from the wells were collected prior to the water going through the water filtration/treatment plant. Therefore, these concentrations were not at the tap, (i.e., where people would actually be drinking the water). Only a very limited number of samples were taken at the tap. Because laboratory certified sampling data were available for only 1 month in 1985, ATSDR also used the data from the uncertified laboratory as an indication of concentrations at various times throughout the year. Because of quality assurance and quality control, ATSDR prefers to use certified laboratory data as opposed to non-certified laboratory data methods and procedures. The data from the non-certified laboratory was used only to compare with the limited amount of data from the certified laboratory.

For the years 1984 through 1989, very limited tap sampling data exist. The maximum 1,1,1-TCA concentration detected at the tap was 45 ppb, collected in September 1986 in Building 901A, room 102. The tap was resampled the next month, October 1986. The original laboratory detected 1.5 ppb, and a different laboratory found 15 ppb of 1,1,1-TCA from the same tap.

Potable water wells 1, 2, 4, 6, 7, 10, 11 and 12 have had 1,1,1-trichloroethane (1,1,1-TCA) contamination problems in the past. The New York State Department of Health (NYSDOH) advisory guideline for 1,1,1-TCA was 50 ppb until 1989. In 1989, NYSDOH established a drinking water standard at 5 ppb for 1,1,1-TCA.

The periods of operation for the wells were:

- Well # 1 1941— September 1986
- Well # 2 1942 — August 1985
- Well # 3 1948 — December 1986
- Well # 4 1960 — October 1990 (back in service January 1991)
- Well # 6 1960 — Present
- Well # 7 1964 — Present
- Well # 10 1980 — August 1989 (back in service September 1992)
- Well # 11 1981 — October 1989 (back in service March 1992)
- Well # 12 1986 — Present.

The following paragraphs present a highly detailed account of analytical data reported for on-site potable wells. The data shown are for contamination levels of three volatile organic compounds: 1,1,1-TCA (state drinking water standard is 5 ppb; federal drinking water standard or maximum contaminant level (MCL) is 200 ppb); chloroform (the MCL for total trihalomethanes, which include chloroform is 80 ppb); and TCE (federal drinking water standard is 5 ppb).

Concentrations of 1,1,1-TCA in well #1 ranged from non-detectable (ND) to 11 ppb in 1984. During this timeframe, the levels were below the New York state advisory guideline of 50 ppb. The state's guideline was in effect until 1989 and thereafter it was 5 ppb. In 1985, the average 1,1,1-TCA concentration in well #1 was 12 ppb. Between 1985 and 1986, 1,1,1-TCA concentrations in well #1 increased. In 1986, concentrations ranged from 60 ppb to 390 ppb, with an average of 137 ppb. Well #1 was removed from service in September 1986 because of the 1,1,1-TCA contamination (BNL 1987). The maximum concentration detected (390 ppb) was found in the well during October 1986, after the well had been shut down.

In 1984, 1,1,1-TCA concentrations ranged from ND to 4 ppb in well #2. Both chloroform and TCE were also detected in the well at a maximum concentration of 9 ppb (BNL 1985). Twenty-one samples were collected from well #2 in 1985, and the average 1,1,1-TCA concentration was 86 ppb (BNL 1986). The maximum concentration (212 ppb) was found in May 1985. This analytical result was from a non-certified laboratory. In August 1985, samples were analyzed by both BNL and a certified laboratory. The maximum concentration detected by the certified laboratory was 142 ppb. BNL analysis was almost identical at 134 ppb. Well #2 was removed from service in August 1985. Wells #1 and #2 were sealed in 2002.

Low concentrations of chloroform (3 ppb) and 1,1,1-TCA (1 ppb) were detected in well #3 from 1984 through 1985. Chloroform was not detected in well #3 during 1986. 1,1,1-TCA was detected (14 ppb) in September 1986. Well #3 was removed from service in November 1986 because it had the potential to draw contamination from the 1977 fuel oil/solvent spill at the Central Steam Facility. For a description of the contamination related to this spill, see the Operable Unit IV contamination section in Appendix E. Well #3 was sealed in 2002.

Chloroform was detected in well #4 from 1984 through 1990 at concentrations ranging from 3 ppb to 17 ppb. 1,1,1-TCA was also present in well #4 in 1984 at a maximum concentration of 4 ppb. In 1985, the average concentration was 4 ppb. 1,1,1-TCA was not detected in the well

from 1986 through 1988. The average concentration in 1989 was 1.1 ppb, and in 1990 the average concentration was 4.8 ppb. In October 1990, well #4 was removed from service because 1,1,1-TCA was detected at 7.5 ppb, a level above the new drinking water standard (5 ppb).

Water from potable wells #4, #6 and #7 is treated at BNL Water Treatment Plant for the removal of naturally occurring iron. BNL conducted a testing program for the purpose of evaluating the ability of the existing aeration processes at BNL Water Treatment Plant to remove organic compounds. On the basis of the results of the testing program, the SCDHS granted authorization to return potable well #4 to service in February 1991 (BNL 1992b). Aeration of the water during the treatment process has reduced the 1,1,1-TCA concentrations in well #4 to levels below the detection limit.

1,1,1-TCA concentrations were detected in well #6 at a maximum concentration of 4 ppb in 1984 and at an average concentration of 3 ppb in 1985. It was not detected in the well during 1986 and 1987. From 1988 through 1990, concentrations averaged 1 to 2 ppb. During 1991, chloroform was detected in well #6 at a maximum concentration of 17 ppb and an average of 11 ppb. These concentrations are below the drinking water standard of 80 ppb. 1,1,1-TCA was detected in well #7 at an average concentration of 2 ppb in 1985, but it was not detected in the well thereafter.

In 1985, concentrations of 1,1,1-TCA averaged 15 ppb and 9 ppb in wells #10 and #11, respectively. In 1986, 1,1,1-TCA averaged 8 ppb in both wells. 1,1,1-TCA was not detected in well #10 during 1987, but in well #11 1,1,1-TCA concentrations averaged 12 ppb, with a maximum of 14 ppb. In 1988, wells #10 and #11 had average concentrations of 7 ppb and 13 ppb, respectively (BNL 1989). In 1989, wells #10 and #11 had average concentrations of 1,1,1-TCA of 5.8 ppb and 7 ppb, respectively (BNL 1990). Wells #10 and #11 were shut down in August and October 1989, respectively.

Wells #10 and #11 remained out of service during 1991, and carbon filtration systems were installed on both wells during 1992, and they were returned to service (BNL 1996b). Low 1,1,1-TCA concentrations (7-8 ppb) have been detected in well #11 in recent years, but these concentrations are in samples taken from the wellhead. The carbon absorption treatment devices installed in 1992 have reduced the concentrations of TCA to non-detectable levels in the potable water prior to it being used at the tap.

Water in well #12 contained 1,1,1-TCA concentrations just below the MCL of 5 ppb. BNL has installed a granular activated carbon filter on well #12 to remove the 1,1,1-TCA, and this well is currently in service (BNL 1996b).

The SCDHS inspected BNL drinking water supply system August 18, 1994, and again September 13, 1995. Analysis of water samples showed all analytical parameters met the New York State drinking water standards (BNL 1995; BNL 1996b). Six potable water wells (4, 6, 7, 10, 11, and 12) are currently operating at BNL (BNL 1994b). Potable wells #4, #6, and #7 were not used for potable purposes during 1996 because of construction activities at the Water Treatment Plant (WTP). The SCDHS inspected the potable water supply in November 1996 and found that all water samples met the New York State drinking water standards. After construction activities were completed at the WTP in 1997, potable wells #4, #6, and #7 were used on a limited basis.

Sampling of BNL potable water supply was conducted in April and June 2001, and all biological and chemical constituents were within the applicable drinking water standards set forth by the NYSDOH (BNL 2002).

BNL installed an air stripper tower at the Water Treatment Plant to ensure complete removal of VOCs prior to distributing the water to its various facilities. The system is inspected on an annual basis by the SCDHS and has been in compliance with the necessary requirements.

2.2.1 Surface Water

Surface waters located on site include recharge basins, wetlands, and the Peconic River. Wetlands and marsh areas on the northern portion of the site form part of the headwaters of the Peconic River (BNL 2000); wetlands also exist in other parts of the site. The Peconic River is an intermittent stream at on-site locations, with flows greatest during periods of sustained precipitation, usually in the spring. Water flow in the Peconic River varies greatly with seasonal fluctuations in precipitation. During dry periods, the Peconic River at on-site locations is essentially dry, with the discharge from the STP gradually flowing into groundwater. Evidence of this dryness is indicated by the fact that BNL could not collect surface water samples at the site boundary many times during its history because the Peconic River at this location had no flowing, or even standing, water (ITC 1998b). During wet periods, however, water may be present throughout the on-site portions of the Peconic River. For example, in May 1997, enough water was flowing in the on-site portions of the Peconic River for fish samples to be collected at the site boundary (ITC 1998a). The highest concentrations of several inorganic compounds, gross alpha radiation, gross beta radiation, tritium, and thorium-234 all exceeded corresponding screening values.

2.2.1.1 Data for On-Site Recharge Basins and Wetlands

The highest concentrations of organic compounds in the recharge basin sampling data provided by NYSDEC are as follows: hydroxyethylidene diphosphonic acid, 2,150 ppb; bromodichloromethane, 6 ppb; chloroform, 7 ppb; and tolyltriazole, 500 ppb.

2.2.1.1.1 Data for On-Site Sections of the Peconic River

The site environmental reports document nearly 25 years of sampling the Peconic River, with a focus on two locations: the former site perimeter (roughly 0.5 mile downstream of the STP outfall) and the current site boundary (more than 1.5 miles downstream of the STP outfall). Samples were collected at these two locations as often as three times per week, as flow permitted. Some analytes (e.g., gross alpha, gross beta, and tritium) were analyzed in every sample collected, while other analytes were analyzed in only a subset of the samples.

BNL has collected samples from additional on-site locations, but such sampling is conducted far less frequently. These additional sampling locations include three locations upstream of the STP outfall and an on-site tributary to the Peconic River not impacted by the STP discharges. Also, two remedial investigation studies included samples at on-site locations along the Peconic River from the STP outfall to the current site boundary.

Very limited information is available for organic sampling in the Peconic River on site. The limited data — primarily documented in the 1991 and 1993 Site Environmental

Reports — indicate the following: (1) very few organics were detected in the surface water (i.e., toluene, trichloroethane, dichloroethane); (2) the detections are infrequent; and (3) the detections are at levels marginally higher than detection limits. For the following three reasons, ATSDR does not view the lack of extensive surface water sampling data for organics in the on-site Peconic River as an important data gap: (1) no site report evidence suggests that BNL processes large volumes of organic chemicals that are discharged to surface waters; (2) the site's discharge monitoring data is generally in compliance with the limited sampling requirements for organics; and (3) exposure to on-site surface water is believed to be extremely infrequent.

2.2.2 Sediments

Sediments are found on site at many locations, including the Peconic River, wetlands, recharge basins, and other areas (e.g., at the on-site fields used for various agricultural experiments). Sediments were sampled for organic and inorganic compounds, pesticides, and radionuclides. The following contaminants were in concentrations greater than corresponding health-based comparison values: sodium-22, potassium-40, strontium-90, cesium-137, lead-210, radium-226, arsenic, cadmium, mercury, benzo (a) pyrene, benzo (b) fluoranthene, and two different mixtures of PCBs (Aroclor 1254 and 1260).

BNL representatives collected sediment samples from more than 20 on-site locations along the Peconic River during the various remedial investigations. Of the 19 inorganic contaminants listed in Table SD1, only three — arsenic, cadmium, and mercury — were at concentrations higher than the corresponding ATSDR comparison values. The highest arsenic levels measured (9.7 ppm) are comparable to those measured at off-site control locations (see Table SD2). The highest cadmium concentration (18.8 ppm) is within the same order of magnitude as the corresponding ATSDR comparison value (10 ppm), which is based on chronic exposure assumptions. Later sampling confirmed mercury levels as high as 39.7 ppm.

Of all the analytes sampled for, three exceeded their respective health-based comparison values, all by very small margins: the highest concentration of benzo (a) pyrene was 0.46 ppm, compared with the CREG value of 0.1 ppm; the highest detection of benzo (b) fluoranthene was 1.2 ppm, compared with the risk-based concentration of 0.87 ppm; and the highest concentration of Aroclor-1254 was 1.5 ppm, compared with the EMEG of 1.0 ppm.

2.2.2.1 Data for Sediments in On-Site Recharge Basins, Wetlands, and Agricultural Fields

Two rounds of sampling, one in 1989 and another in 1994, examined levels of sediment contamination at on-site locations other than the Peconic River. The sampling results indicate that numerous contaminants were in sediments at these on-site locations — a result that is not surprising, given that some of these locations (e.g., the recharge basins) receives BNL's wastewater. Sodium-22, potassium-40, strontium-90, cesium-137, and lead-210 concentrations were higher than the National Council on Radiation Protection (NCRP) soil screening limits.

Arsenic and three organic compounds (benzo (a) pyrene, benzo (b) fluoranthene, and Aroclor-1260) had at least one surface sediment concentration higher than their corresponding health-based comparison values. The highest arsenic concentration (9 ppm) in these on-site sediments is consistent with the level measured in the on-site sections of the Peconic River and at off-site control locations, suggesting that the level detected might be naturally occurring. The three

organic compounds that exceeded comparison values all did so by less than an order of magnitude.

2.3 Off-Site Contamination

For the past 20 years, various parties have extensively studied the nature and extent of non-radiological compounds that have migrated in groundwater from BNL to off-site locations. A few plumes containing site-related contaminants have moved off site to the south and southeast of BNL, and most of the contaminants are confined to areas within a mile of the site boundary. Carbon tetrachloride, ethylene dibromide, tetrachloroethylene (PCE), 1,1,1-trichloroethane (TCA), and trichloroethylene (TCE) are the contaminants of concern. In a very small subset of private wells, contamination levels for some of the contaminants were found at levels exceeding drinking water standards. However, as later sections of this PHA note, actions were promptly taken to eliminate exposures.

Extensive sampling was conducted to determine whether radiological contaminants in the groundwater beneath BNL migrated to off-site locations. Off-site sample results indicate that none of the wells contained radiological contaminants at levels above drinking water standards.

An additional source of volatile organic compounds (VOCs) in groundwater was identified because of monitoring wells located in off-site areas. In May 1988, the SCDHS detected 1,1,1-TCA concentrations as high as 1,200 ppb in a leaching pool on the east side of the Precision Concepts building in the Brookhaven R & D Industrial Park. From May through October 1990, the SCDHS installed and sampled groundwater monitoring wells in the industrial park to isolate the source of the contamination. Monitoring wells were also installed between BNL and the industrial park to determine if contaminants were moving off BNL property. Samples collected from the monitoring wells between BNL and the industrial park contained contaminants in the middle and deep portions of the Upper Glacial aquifer (30 to 110 feet below the water table). 1,1,1-TCA was found at a maximum of 15 ppb, while trichloroethylene (TCE) and 1,1-DCE ranged from non-detection (ND) to 6 ppb, and PCE ranged from 2 ppb to 5 ppb (SCDHS, 1990).

Higher levels of 1,1,1-TCA appeared in profile wells just south of the Precision Concepts building in the industrial park. The 1,1,1-TCA was 30 to 40 feet below the water table, and concentrations ranged from ND to 9,300 ppb. Other solvents were also in the same wells, including 95 ppb of 1,1-DCA, 290 ppb of PCE, and 430 ppb of 1,1-dichloroethylene (1,1-DCE) (SCDHS 1990). The contaminant plume was approximately 3,100 feet long, and it was determined that Precision Concepts was the source of that plume. Lower concentrations of TCE and 1,1-DCE (37 ppb) were deeper in the aquifer, at 80 to 100 feet below the water table. This contamination probably originated from BNL.

2.3.1 Residential (Private) Well Sampling

The SCDHS conducted private well sampling in areas south and east of BNL in 1979 and repeated the sampling in 1981 and 1983. SCDHS tested the samples for radionuclide contamination. In 1985, quarterly sampling of private wells from 16 different locations located north, south, and east of BNL was conducted, and samples were analyzed for volatile organic compounds (VOC) and radionuclide contamination. Sampling continued through 1995, and approximately 732 samples were collected (SCDHS 1996). Private well sampling data collected

from the North Shirley area in the 1980s indicated 1, 1, 1-TCA and trichloroethylene (TCE) contamination. This contamination was attributed to homeowner solvent use within the area.

Residential wells downgradient of BNL have also been contaminated from other sources. For example, in July 1982, elevated levels of benzene, toluene, and xylenes (BTX) were detected in a residential well on William Floyd Parkway in North Shirley. In January 1985, three additional residential wells were found to be contaminated with BTX. Two of the wells are located on Auburn Avenue, and the third well is on Belmont Drive. In the latter part of 1987, two more wells had elevated concentrations of BTX. These wells are located on Belmont Drive and Patton Drive. After mapping the locations of the contaminated wells, investigators were able to trace the contamination back to a source upgradient of the first contaminated well. The source of the contamination was a leaking underground storage tank at a gasoline station located at the corner of Moriches Middle Island Road and William Floyd Parkway (SCDHS 1990).

In March 1990, BNL informed the SCDHS that 1,1,1-TCA and dichloroethane (DCA) were detected in monitoring wells near the southern boundary of the site at concentrations of 11 ppb and 4 ppb, respectively (SCDHS 1990). From March through June 1990, the SCDHS sampled 90 private wells in an area of North Shirley, town of Brookhaven, New York, bounded by Carleton Drive East, Wellwood Drive, Crestwood Drive, and William Floyd Parkway. Five private wells were found to be contaminated with 1,1,1-TCA and 1, 1-dichloroethene (1,1-DCE). The 1,1,1-TCA concentrations ranged from 41 ppb to 340 ppb, and 1,1-DCE ranged between 2 ppb and 20 ppb. The contamination was at 40 to 60 feet below the water table. Owners of the wells were provided with carbon filters to remove the contaminants.

BNL requested the SCDHS to perform a private well survey in October 1995 to determine whether known contamination at the site was reaching residential wells in the communities of North Shirley, Shirley, East Yaphank, and Manorville. From October 1995 through March 1996, SCDHS officials sampled 528 private wells, and the samples were analyzed for VOC and tritium contamination (SCDHS 1996). They sampled a total of 404 wells in North Shirley-East Yaphank and 124 in Manorville. Monitoring results indicated 10 wells with VOCs above the maximum contaminant level (MCL): 7 in North Shirley, and 3 in Manorville. In North Shirley-East Yaphank, five wells contained 1,1,1-TCA concentrations ranging from 5–180 parts per billion (ppb), and two wells contained Freon compounds ranging from 6–10 ppb. Table 1 below summarizes the contaminants found in residential wells.

The source of the 1,1,1-TCA contamination was attributed to a business, Precision Concepts, in the industrial park southwest of BNL, and the Freon contamination was attributed to homeowner use. The Freon contamination is not listed in the table because it was an isolated incident and Freon is not a contaminant of concern at BNL unlike the TCA that was from multiple sources. In Manorville, one well contained ethylene dibromide at 0.16 ppb, and one well contained TCE at 8 ppb. The source of contamination in these two wells was attributed to BNL, and a third well contained xylene at 33 ppb, which was attributed to a gasoline spill. Sampling continued in both areas through November 1996.

Table 1. Contaminants in Residential Wells**

| <i>Chemical</i> | <i>Concentration Range (ppb)</i> | <i>Comparison Value (ppb)</i> | <i># of wells with contaminants equal to or exceeding the comparison value</i> |
|-----------------------------------|---|---------------------------------------|---|
| Chloroform | ND – 10 | 6 (CREG) 80 (USEPA MCL) | 1 |
| 1,1-Dichloroethylene (1,1-DCE) | ND– 20 | 0.06 (CREG) 7 (USEPA MCL) 5 (NYS MCL) | 8 |
| Ethylene Dibromide (EDB) | ND– 1.2 | 0.0004 (CREG) 0.05 (USEPA MCL) | 2 |
| Perchloroethylene (PCE) | ND – 10 | 0.7 (CREG) 5 (USEPA MCL) | 14 |
| 1,1,1-Trichloroethane (1,1,1-TCA) | ND– 340 | 5 (NYS MCL) 200 (USEPA MCL) | 19 |
| Trichloroethylene (TCE) | ND– 8 | 3 (CREG) 5 (USEPA MCL) | 3 |
| Strontium-90* | ND – 1.25 | 8 (USEPA MCL) | 0 |
| Tritium* | ND– 7,238 | 20,000 (USEPA MCL) | 0 |

* Strontium-90 and tritium concentrations are in picocuries per liter (pCi/L)

ppb: parts per billion

USEPA MCL: Environmental Protection Agency Maximum Contaminant Level (the data for chloroform presents the MCL for total trihalomethanes, because chloroform is regulated within this group of chemicals).

NYS MCL: New York State Maximum Contaminant Level

CREG: Cancer Risk Evaluation Guide

ND: Non-detection

** Summary of contaminants found in wells during 1981–1996

Radiological analysis of private well water has been performed since 1979. The SCDHS submitted split samples to the NYSDOH to confirm the results of BNL's analyses. Sampling results have indicated detectable concentrations of tritium in 18 private wells. The maximum concentration of tritium was detected in September 1993 at 7,238 picocuries per liter (pCi/L), which is approximately one-third of the MCL (SCDHS 1996). Sampling data from May 22, 1996 indicated tritium contamination in six wells on North Street, with concentrations ranging from 393 – 3,930 pCi/L (SCDHS 1996). ATSDR scientists believe that the levels of tritium in private wells, well below the MCL, would not be expected to cause adverse health effects. Tritium has not been detected above background levels in any of the Suffolk County public water supply wells.

Strontium-90 was also detected in some residential wells, but the levels were far below the MCL of 8 pCi/L. The maximum strontium-90 concentration (1.25 pCi/L) in residential wells was in a well on Weeks Avenue (USDOE 1996a). ATSDR believes that this level would not cause adverse health effects.

2.3.1.1 ATSDR's Modeling of the Groundwater Plumes

DOE and its contractors have conducted several groundwater modeling analyses to define aquifer properties and to predict the response of the groundwater system to remedial actions (CDM 1995; CDM 1996d; ITC 1998e). These models are good representations of the hydrogeological system and they provide valuable information about hydrogeological parameters. They do not, however, address the early progression of the contaminant plumes after contaminant introduction but before detection in off-site monitoring or residential wells. Sampling of residential wells near BNL before 1985 was limited to approximately 50 wells, and these were sampled for radionuclide contamination only. To determine if residential wells were affected by the contaminant plumes prior to their being sampled, ATSDR staff conducted groundwater modeling for the seven on-site plumes and the one plume emanating from the industrial park off site. Also, ATSDR staff wanted to determine if any of the contaminant concentrations were higher than what was found during the 1985–1995 sampling period.

Although uncertainty surrounds assigning a specific time and location of origin to individual plumes, most of the sources have been sufficiently characterized to estimate durations of plume migration and distances of source origins to residential well locations. Ongoing monitoring has also characterized the current distribution of the contaminant plumes.

The contaminant transport evaluation was based on one dimensional (1-D) and three dimensional (3-D) groundwater flow equations. The 1-D model was used to evaluate vertical transport, and the 3-D model was used for lateral transport. Analysis indicated that downward vertical flow predominates at the ground surface to about 35 m, and southward flow at depths from 35 m to 80 m. The plume durations listed in Table 2 represent a maximum duration and an estimate of contaminant migration that is very protective of public health.

Table 2. Groundwater Plume Durations

| <i>Plumes or Sources</i> | <i>Contaminants</i> | <i>Plume Duration</i> | <i>Source to Fence Length</i> | <i>Source to Off-Site Wells Length</i> | <i>Total Plume Length</i> |
|--|--------------------------|----------------------------------|-------------------------------|--|---------------------------|
| 1) Precision Concepts | TCA | 10– 12 years | Off site source | 500 m Carleton Dr. | 1150 m |
| 2) OU-III Multiple Sources a) Bldgs. 96, 208 | PCE, TCA, Ctet, TCE | 53 years | 1400 m | 2400 m Carleton Dr. | 3900 m |
| b) Unknown | CCI-4 | 53 years | 3100 m | 3900 m | 4400 m |
| 3) OU-IV Waste Solvent Spill | TCA, TCE, PCE, DCE, BTEX | 20 years | 1500 m | 2000 m Carleton Dr. | 2000 m |
| 4) Former Landfill | TCA, TCE, PCE, DCE, | 50 years | 1300 m | 1600 m North St. | 2100 m |
| 5) Haz. Waste Mgmt. Area | TCA, Tritium | >35 years | 1300 m | 1600 m North St. | 2100 m |
| 6) Current Landfill Area | TCA | 28 years | 1300 m | 1600 m North St. | 2100 m |
| 7) Biology Fields | EDB, TCA, Tritium | Unknown (approximately 25 years) | 800 m | 1200 m North St. | 1500 m |
| 8) Sewage Treatment Plant | TCE, TCA | Unknown | 400 m | 1600 m | 1900 m |

In the above table, “plume duration” refers to the estimated number of years that lapsed between the initial release of contaminants from the specific source mentioned and the year (1997) when ATSDR conducted its modeling evaluation. “Source to fence length” refers to the distance between the source of contamination and the BNL property line; and “source to off-site well length” refers to the distance between the source of contamination and the nearest off-site private well. “Total plume length” refers to the estimated length of the plume in 1997 based on groundwater monitoring data. Note that all lengths presented in this table were measured using geographic information system software (i.e., ARC/VIEW) and that plume duration estimates were developed from several references (CDM 1995; CDM 1996b; ITC 1998).

The shortest flow paths and longest plume duration present the greatest potential for contaminant exposure. From Table 2, the critical flow paths are plume 2 (OU-III), with a path length of 2400 m and a potential duration of greater than 50 years; plume 4, with a path length of 1600 m and a duration of 45 years; and, plume 5, with a path length of 1600 m and a potential duration of more than 35 years. Contaminant concentrations were estimated for path lengths of 1500 m, 2000 m, and 2500 m for 10-year time intervals.

Initial transport of contaminants from BNL sources is downward. One-dimensional vertical modeling indicates that it took about 4 years for contaminants to migrate downward to 50 m depth. The 1-D vertical flow model indicates that it takes about 10 years for maximum contaminant concentrations to migrate to a 50 m depth in the aquifer. Including time for vertical transport, contaminants have been migrating southward at a rate of 100 to 125 m/yr. Horizontal contaminant transport is occurring predominantly within the zones of higher hydraulic conductivity.

For the contaminant plume to travel 1500 m downgradient of the source takes about 10 years. After 20 years, contamination concentrations level off at the 1500 m location, and after 30 years for the 2000 m and 2500 m locations. At the 2000 m location (40 m depth), appreciable contaminant concentrations occur after 20 years and reach an asymptotic maximum of 450 µg/l after 30 years. Maximum concentrations for the 2000 m location (30 m depth) reach about 250 µg/l after 30 years. At the 2500 m location, contamination is present after 20 years, and it increases rapidly to 300 µg/l for the 40 m depth and 200 µg/l for the 30 m depth after 30 years.

Most of the measured contaminant values are lower than the modeled values with the exception of carbon tetrachloride in wells 000-112, 000-130, 000-154, and 000-161. All these higher measured values are attributed to the OU-III (a; bldg. 96) plume except the 000-154 samples, which are attributed to the Former Landfill plume. The samples with high carbon tetrachloride concentrations (>800 µg/l) are all taken from depths greater than 50 m.

Contaminant concentrations from plume 2, assuming a constant source release, were never higher than measured values. In the constant source release scenario, the modeled values increase to an asymptotic maximum and were never higher than monitored values. A declining source concentration scenario (e.g., a contaminant spill event such as the OU-IV waste solvent spill), however, creates a high concentration pulse that migrates downgradient. As the pulse migrates past a point, contaminant concentrations will increase and then decrease. This type of source scenario is likely for only two of the eight BNL plumes.

The contaminant concentrations derived by use of the analytical transport equation at a 40 m depth are generally higher than those detected in either residential or monitor wells. Modeled concentrations at a 30 m depth are comparable to measured values in residential and monitor wells (ATSDR 1999). Although knowledge of the depth of residential wells is limited, the data available indicate that most residential wells are relatively shallow, with depths between 30 and 37 m, while the zones of maximum contamination have migrated to depths of 50 m or more (BNL/ERD 1998).

For the five contaminant plumes that match the constant release scenario, contaminant concentrations have probably never been higher than 1985–1987 values, and exposure at those locations was not likely before 1987. For two plumes that fit the declining source release scenario (OU-IV waste solvent spill and OU-I former landfill plume), contaminant

concentrations at specific locations first increase and then decrease as the high concentration pulses migrate past those locations. Contamination has been present in limited off-site areas since about 1980. Because, however, the high concentration contaminant zones occur at depths below most residential wells, it is unlikely that contaminant concentrations in residential wells have ever been significantly higher than levels reported by the SCDHS.

For five of the eight plumes illustrated in Figure 5 of Appendix B (plumes 3, 5, 6, 7, and 8), most of the results in this analysis indicate that it is unlikely that groundwater contaminants had migrated to areas of potential off-site exposure prior to 1987. According to the results of this analysis, portions of plume 2 and plume 4 had reached areas of potential exposure between 1977 and 1980. The source of contamination from the Precision Concepts plume (plume 1) is only about 500 m from residential wells, and contaminants from that source probably reached residential wells less than 5 years after source introduction into the aquifer.

2.3.2 Air Emissions

In 1996, the BNL Community Work Group and DOE separately requested that ATSDR evaluate the public health implications of exposure to BNL's historical air emissions. Many sources of air emissions are located on BNL property. BNL has 66 permitted air sources that include, for example, the Central Steam Facility (CSF), the pathological incinerator, several boilers, and two gas stations. BNL has several emission sources that are subject to state or federal regulatory requirements that do not mandate emissions monitoring. The CSF is the only BNL emission source required to monitor nonradiological emissions (BNL 2000). Figure 8 in Appendix B shows the air monitoring station locations at BNL.

Emissions from the CSF include particulates, carbon monoxide, carbon dioxide, nitrogen oxides, sulfur dioxides, and volatile organic compounds (VOCs). In 1997, natural gas replaced residual oil (#6) as the main source of fuel for operating the four boilers in the CSF. The use of natural gas has reduced the annual particulate, nitrogen oxide, and sulfur dioxide emissions (BNL 2000). The use of natural gas, however, produces greater emissions of VOCs compared to the use of residual oil. Levels of VOC emissions have increased since 1997. VOC emission levels are reported as tons of total VOCs released; a level is not reported for each VOC.

Air releases of radioactive material have occurred throughout the operational history of BNL. These release points are currently under control of the National Emission Standards for Hazardous Air Pollutants (NESHAPS) and the Clean Air Act. Under these environmental laws, BNL is regulated by the NESHAPS part H, which, in part states that "emissions of radionuclides to the ambient air from Department of Energy facilities shall not exceed those amounts that would cause any member of the public to receive in any year an effective dose equivalent of 10 mrem/yr." Radiological emission sources include the High Flux Beam Reactor (HFBR), the Brookhaven Medical Research Reactor (BMRR), the Brookhaven LINAC Isotope Production facility (BLIP), the Alternating Gradient Synchrotron (AGS), the Relativistic Heavy Ion Collider (RHIC) Accelerator, Building 801, and the Tritium Evaporator, which is used to evaporate waste water containing low levels of tritium generated from facilities around the site.

2.3.2.1 Past Emissions

ATSDR reviewed historical site environmental reports covering the time frame of 1948 through 1998 and the 2003 site environmental report. ATSDR believes that generally, environmental reports do not contain sufficient information to perform a complete historical dose reconstruction. However, there usually is sufficient data to evaluate in terms of public health impacts. For the most part, this is the case at BNL. Of interest is the omission of H-3 (tritium) releases from the 2000 report on radiological emissions between 1948 and 1961 from the BGRR (BNL 2001). In this report, the major focus was on Ar-41 and fuel ruptures during operations of the BGRR and these fuel ruptures could have released tritium as well as the radionuclides covered in the report. Routine air emissions from BNL from 1948 to 1961 mainly were from the BGRR with contributions from other sources such as the BMRR, a hot cell, and accelerators operating on site. These reactors were air-cooled so that air flowed through the system and the neutrons released from the operations were absorbed by naturally occurring argon. This argon was converted to Ar-41 with a radioactive half-life of about 1.8 hours. BNL estimates the total emissions of Ar-41 during this time was about 30 million curies and I-131, produced during nuclear fission and having a radiological half-life of 8 days, totaled about 12 curies (BNL 2001).

The Brookhaven Graphite Research Reactor (BGRR) was completed in 1950. The BGRR was designed as an air-cooled, graphite-moderated and reflected reactor, originally fueled with aluminum-canned natural uranium elements. The BGRR was in operation from 1950–1969; it served as the primary source of routine air emissions during this time frame. Argon-41 was the main radionuclide released during the BGRR operational history. Argon-41 is a short-lived radionuclide with a half-life of 1.83 hours.

From 1950 until 1957, a natural-uranium fuel was used in the BGRR. During the operation of the BGRR, the fuel elements were subject to stress-related failures. From 1952 to 1957, a total of 28 malfunctions (fuel ruptures) at the BGRR resulted in the emission of radioiodines, noble gases, and particles. The ruptures lasted from a few minutes to several hours. Some of the ruptures occurred when the prevailing winds were blowing in the direction of dairy farms that existed at the time. The fuel element failures resulted in the oxidation of the uranium metal, causing dispersion of the uranium/fission product/plutonium oxide particles to the graphite channels, the air ducts, and the air filters. Fission products were also released as the result of leaks in the fuel element claddings or of fissioning of uranium contamination on the outer surfaces of elements. Larger releases occurred when there were actual breaks in the cladding.

The primary contaminants within the vicinity of BGRR were the result of spreading oxidized uranium particles; the contaminants included fission products such as cesium-137 and strontium-90 and the activation product cobalt-60 (BNL 1997f). Several areas within or surrounding the BGRR are known to have or are suspected of having contamination present. The Reactor Building (Building 701) contains the Reactor Pile (Building 702), and portions of the Reactor Building were contaminated during operations. Accessible areas within the Reactor Building were surveyed and decontaminated where necessary following the shutdown of the BGRR. Reactor experiments stopped in June 1968. The presence of contamination in areas that are inaccessible in the building, such as drains, sewers, trenches, is currently being determined during the decommissioning of the building.

Radioactive contamination, primarily cesium-137 (Cs-137) and strontium-90 (Sr-90), has been detected in the secondary liner and surrounding soils in the below-ground areas of Building 701.

Soil in the pipe trench that traverses the north end of the building and all of the drains are also contaminated with Cs-137 and Sr-90 in the first few feet of soil. At the base of the north duct air plenum significant quantities of radionuclides including plutonium-238, plutonium 239/240, uranium 233/234, uranium 235, cobalt-60, Cs-137 and strontium-90 were detected (BNL 2003).

Dose rates within the fuel channels of the Reactor Pile were as high as 10 rads per hour. The highest doses measured were at the center and bottom of the pile. Graphite samples contained the full ranges of fission products and transuranics with carbon-14 and tritium being the predominant radionuclides (BNL 2003).

At BNL, the release points in the past and the present, included the Medical Research Reactor (BMRR), the Graphite Research Reactor (BGRR), the High Flux Beam Reactor (HFBR), LINAC Isotope Production Facility (BLIP) and associated operations including a 3 MeV Van De Graaff Accelerator (VDGG), Tritium Evaporator Facility, and a waste incinerator. The HFBR, BGRR, Bldg. 801 and Bldg. 802 all shared a common stack noted as Bldg. 705). The radioactive materials released from these sources enter the atmosphere through stacks on site. Other potential release points include emergency waste water hold-up ponds from which evaporation may occur. These ponds are used to prevent releases of radiological materials to the Peconic River in the event of an accidental discharge. Table 3 lists the release points, stack height and operations associated with that release point.

Table 3. BNL stack atmospheric release points*

| RELEASE POINT | STACK HEIGHT (METERS) | ASSOCIATED FACILITIES |
|---------------|-----------------------|--|
| Building 931 | 10 | BLIP |
| Building 705 | 100 | HFBR, BGRR, Bld. 801 Hot Lab and Bld. 802 (tritium evaporator) |
| Building 491 | 46 | BMRR |
| Building 444 | 10 | Incinerator |
| Building 555† | 16 | Chemistry Roof |

*(BNL1995), (BNL1990).

BNL evaluated these release points by considering measurements from stack monitors, calculated release rates from reactor operations, and air measurements taken at air monitoring stations. The locations of air monitoring stations were on the grounds of BNL, the perimeter of

the laboratory, and off-site locations. During the data review, ATSDR found that the number of perimeter and off-site locations changed over time. Table 4 gives the distance to several perimeter monitoring locations from the central stack associated with the BGRR which was shut down in 1970 (BNL 1998 b).

Table 4. Distances from the BGRR stack

| <i>Station</i> | <i>Degrees</i> | <i>Distance from Stack</i> |
|-----------------------|-----------------------|-----------------------------------|
| O-6 background | 167 | 8700 meters |
| E-9 perimeter | 217 | 2750 |
| E-7 perimeter | 321 | 2500 |
| O-1 background | 352 | 6000 |
| E-3 perimeter | 32 | 1800 |
| E-5 | 243 | 1700 |
| E-4 | 65 | 2200 |

Source: Determination of radioactive background during routine operation of an air-cooled nuclear reactor (no date given) by IA Singer, M Smith, R Bartlett and C Nagle. Meteorology Group BNL.

The majority of the radioactive materials released from these release points over their operational history have been either of two radioactive elements. These are hydrogen-3 (H-3; tritium) and argon-41 (Ar-41). Tritium can be produced in various ways from cosmic ray interactions in the atmosphere, nuclear weapons testing, and nuclear interactions associated with nuclear reactors. At BNL, the tritium produced is from the reactor operations associated with nuclear fission and neutron interactions with non-radioactive water or other testing materials. The radiological half-life of tritium is 12.3 years and decays to stable helium. When in the body, the biological half-life is approximately 10 days (ICRP 1994).

Similarly, Ar-41 production is from the naturally occurring argon in the atmosphere. As outside air for cooling flowed through the BGRR and the BMRR, this argon absorbed neutrons from the reactors and was transmuted to Ar-41. Argon is an inert gas and has a radiological half-life of 110 minutes and decays to stable potassium. Argon-41 is not absorbed in the body nor does it attach to dust in the air; therefore, exposure to Ar-41 does not result in an internal radiation dose. However, submersion in a cloud of Ar-41 (i.e., when an individual is completely surrounded by the passing gaseous plume) does result in an external radiation dose to both the skin and the whole body. According to USEPA, the resulting dose is extremely low and for the purposes of public health impacts, is essentially zero (less than one trillionth of a rem) (USEPA 1993).

Evaluation of Historical Tritium, Argon-41, and Iodine-131 Releases

Via public meetings and information received by ATSDR, a major concern of the community around BNL is the release of tritium from the facilities, especially the HFBR. Tritium from the HFBR can be released in two different forms- as elemental tritium and as tritiated water vapor (HTO). The elemental forms of tritium can be converted to tritiated water vapor. Beginning in 1967, BNL was in the process of developing monitoring methods for HTO so no measurements exist prior to 1974 (BNL 1998b).

To evaluate the impact of releases from BNL (either routine or accidental), ATSDR randomly evaluated selected annual environmental reports. Although ATSDR realized that emission would be variable, initial review of reports from 1970 to the present showed that releases were usually in the same order of magnitude.

Tritium data from 1975 to the present are readily available and show great variability in the amounts released from the HFBR and the 3 MeV Van De Graaff systems (Figure 1). These data show that the most tritium as either elemental or HTO was released not from the HFBR but from the VDGG operations when a total of 1365 Ci were released and 1263 Ci or 92.5% were from the VDGG. The HFBR maximum tritium release occurred in 1973 when it released 775 Ci to the environment. Over the last 20 years, the amount of tritium released from the HFBR has decreased as shown in Figure 2 and Figure 3. More specifically, as Figures 1-3 show, air emissions of tritium from BNL reactors were typically 400 Curies or less between 1975 and 2003. While higher releases clearly occurred in 1977 and 1978, the influence of these elevated releases on the cumulative doses over a lifetime is actually minimal. Although tritium emissions from the HFBR increased in 2003 (most likely due to groundwater remediation activities), the magnitude of this increase is extremely small compared to the tritium emissions that occurred in the prior decades. Releases of the radionuclide Ar-41 also occurred and in many cases, these releases exceeded the releases of tritium. As previously stated (refer back four paragraphs), Ar-41 exposures result in a submersion dose because of the cloud formed during its release. Figure 4 shows the relationship between the releases of Ar-41 from the BMRR and the total tritium released from all stack locations. While Figure 4 suggests that Ar-41 releases from the BMRR steadily increased between 1975 and 1992, a review of more recent data shows that this increase leveled off between 1993 and 2000, with an average annual emission rate during that timeframe of 2,007 Curies. These emissions dropped dramatically after 2000, when the BMRR was permanently shut down. While Ar-41 emissions clearly varied from one year to the next between 1975 and 2000, the emission rates for every year in this timeframe are orders of magnitude lower than the Ar-41 emissions that previously occurred from the BGRR in the 1950s and 1960s.

Figure 1. Tritium releases from BNL operations: 1975 to 1992.

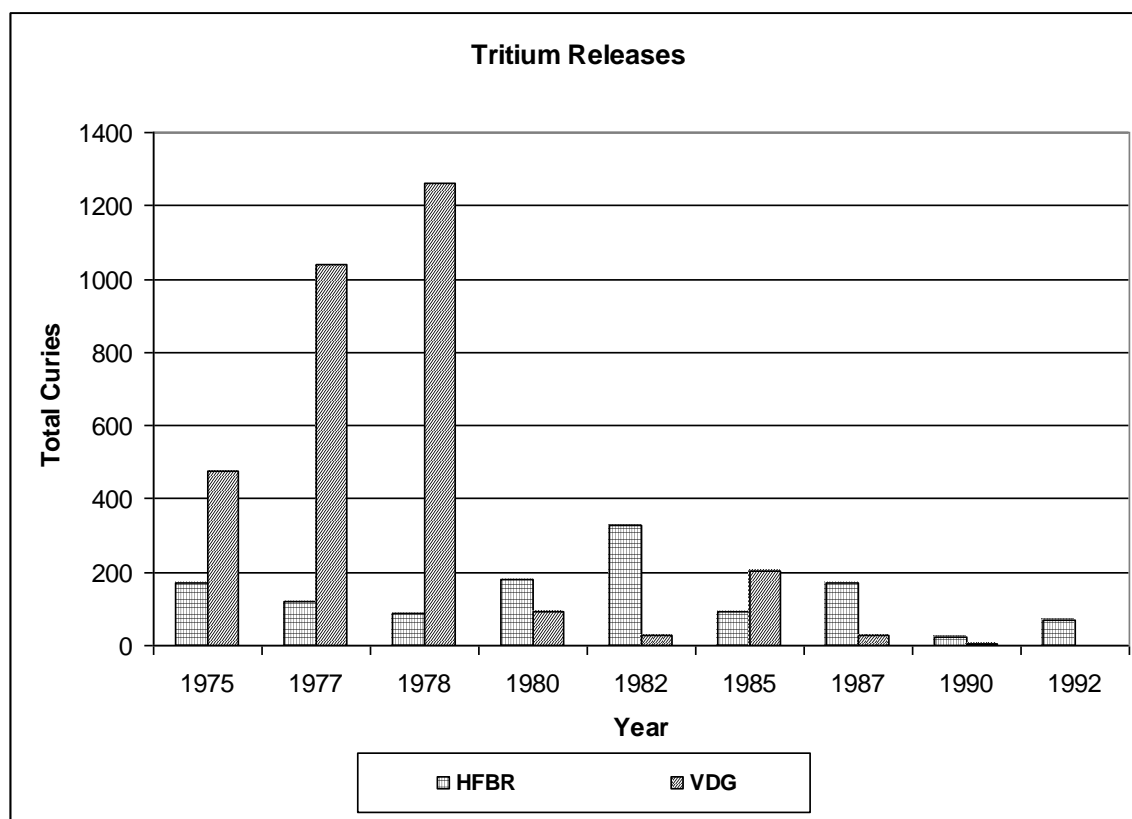


Figure 2. Ten year trend in tritium releases from HFBR: 1988 to 1997

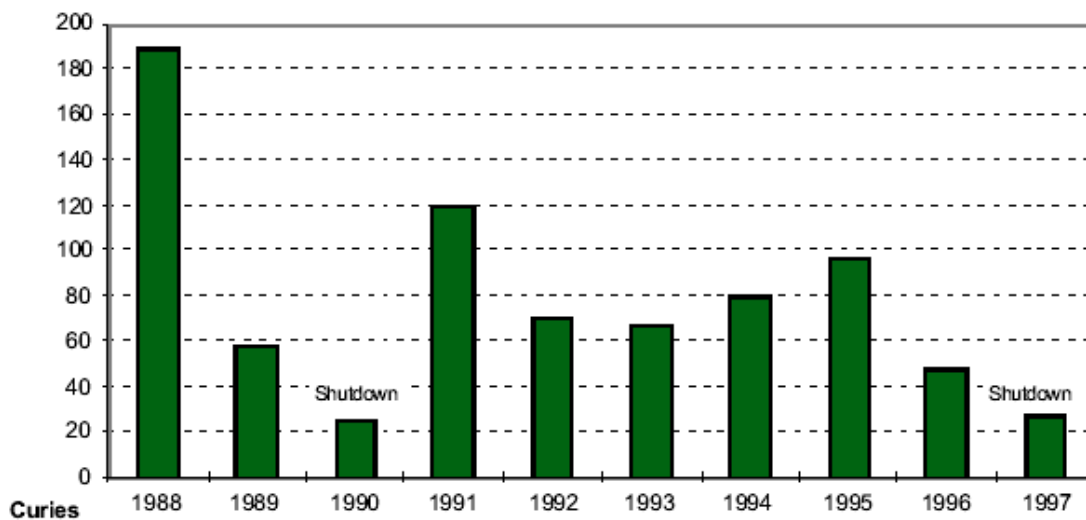


Figure 5-2. HFBR Airborne Tritium Emissions, 10 Year Trend

BNL 1999a. Available on-line at <http://www.bnl.gov/ewms/ser/>

Figure 3. Ten year tritium releases from HFBR: 1994 to 2003

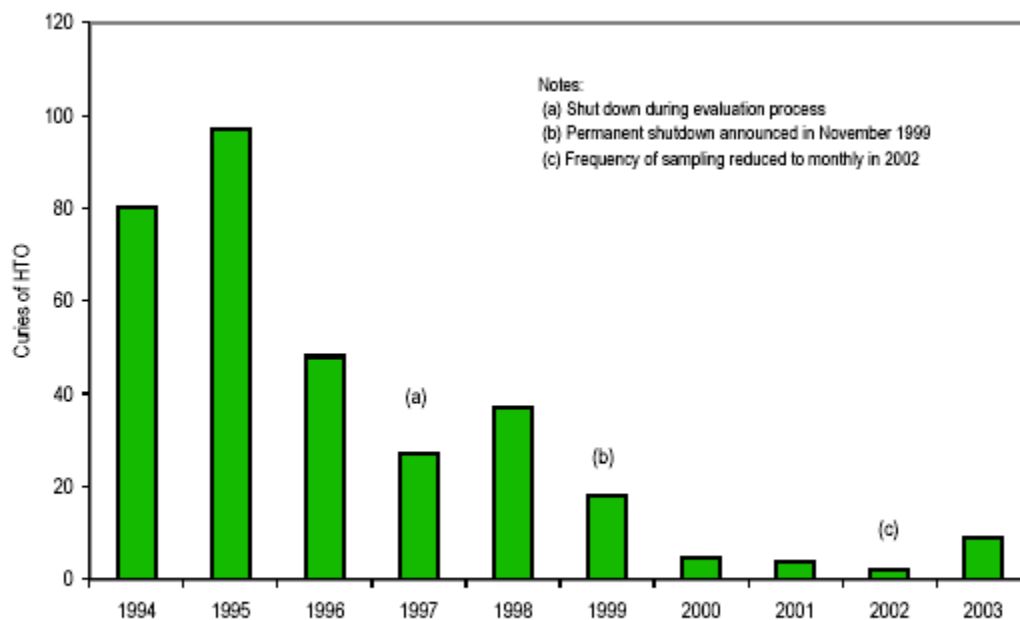
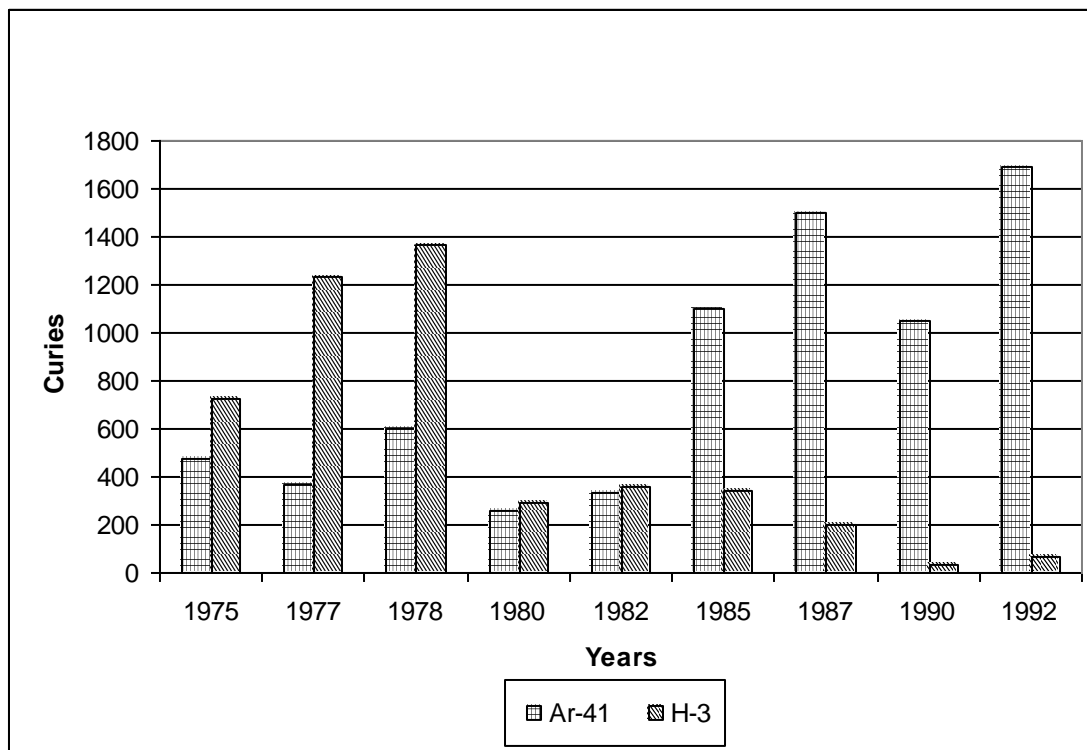


Figure 4-2. High Flux Beam Reactor Tritium Emissions, Ten-Year Trend (1994 – 2003).

BNL 2005

Figure 4. Argon-41 and Tritium Releases



Radioiodines released during the 12 year period from 1950 to 1961 averaged about 1 Ci of iodine per year. However, during this time frame, 28 accidents were reported, all related to fuel failure, ruptures in the cladding surrounding the fuel. Although the accidental releases included other fission products, the iodines released can be considered having the potential for greatest impact on public health. The most iodine released among these accidents occurred on April 11, 1954, when about 155 Ci of I-131 were released. Calculations by BNL indicate the greatest potential for deposition was toward the north-northeast of the facility 2.5 kilometers (1.55 miles) from the release point but still on BNL property. Computer modeling also indicated that the concentration of I-131 deposited on the ground was on the order of 0.7 microcuries per square meter.

Radiological dose assessment To perform this part of the assessment, ATSDR relied on computer models to estimate the radiological dose an individual might have received during specific periods of time. The model used for the assessment of routine releases is the CAP-88PC program which, in general, was developed under the NESHAPS for monitoring emissions and compliance procedures for Department of Energy (DOE) facilities (40 CFR 61.93 (a)) require the use of CAP-88 or AIRDOS-PC computer models, or other approved procedures, to calculate effective dose equivalents to members of the public.

ATSDR modeling assessment estimated cumulative doses associated with radiological exposures that may have occurred over a lifetime. In such cases, selecting an emission rate representative of long term exposures is appropriate. Based on its review of the entire record of air emissions data, ATSDR used emissions data for two specific years as the input to its modeling. ATSDR selected 1982 because it had the highest tritium emission rate from the HFBR between 1975 and 1992 (see figure 1), and selected 1962 because it had the greatest amount of Ar-41 released from the BGRR (BNL 2001). In both cases, the doses for both radionuclides were included to give the combined radiological dose. The following tables show the modeling results.

Table 5. Maximum radiological dose and cancer estimates

| Year | Tritium dose | Argon 41 dose | Total Dose (mrem/y) | Percent of the ATSDR Comparison Value (100 mrem/y) |
|------|--------------|---------------|---------------------|--|
| 1982 | 8.28E-07 | 4.39E-02 | 4.39E-02 | 0.04% |
| 1962 | -- | 185 | 185* | 185 |

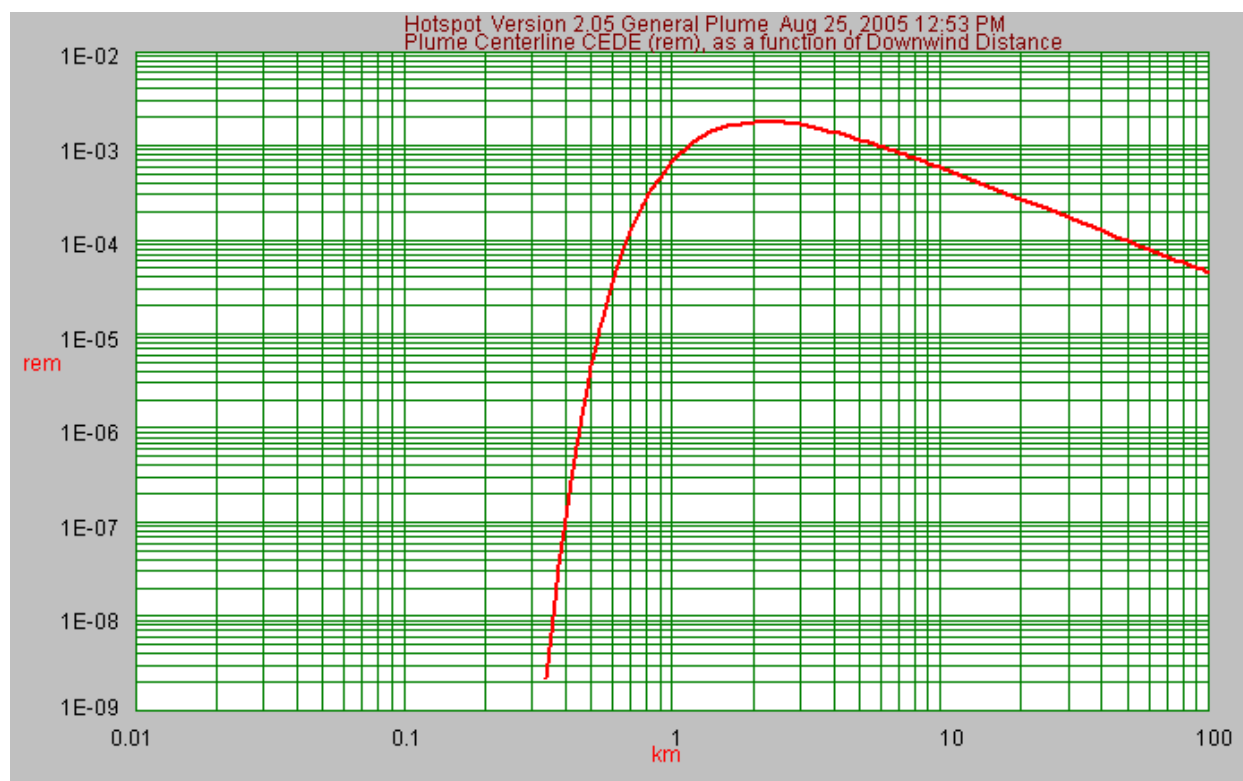
*The computer program estimated the maximum dose to be 750 meters (0.46 miles) north of the release point. As shown in Table 4, this maximum exposure point is well within the boundaries of BNL. Therefore, the public would not be exposed to the maximum dose.

Table 6. Directional Dose from 1962 Ar-41 releases.

| <i>Distance and direction from Stack</i> | <i>Concentration</i> | <i>Estimated radiological dose</i> | <i>Computer Generated lifetime cancer risk for an individual</i> |
|--|---------------------------|------------------------------------|--|
| 750 meters/0.5 mile north | 25,800 pCi/m ³ | 185 millirem/y | 0.005 |
| 2500 /1.5 north | 20,600 | 150 | 0.0041 |
| 4500 /2.7 northeast | 14,600 | 100 | 0.0029 |

The results between the 1962 annual report and the computer model appear to be in relative agreement with the dose assessment as reported in the 1962 environmental report. In that year, the average radiological dose from Ar-41 releases as measured in the northeast (perimeter sample E-9) was 1.08 milliroentgen per week or an annual dose of about 56 millirem/y, about 30% of the maximum dose calculated by CAP 88-PC. The difference can be explained by the distance of the air sampler (perimeter) in relation to the release point and computer generated maximum location. The annualized Ar-41 dose resulting from the releases in July 1962, about 120 millirem, would be within the uncertainty range of the annual dose estimates.

To assess I-131 releases, ATSDR first identified the event that had the highest release rate on record over the entire history of BNL's operations; that release event, known as "Rupture Number 16", occurred on April 11, 1954 (BNL, 2001). Based on the estimated I-131 emission rates from the worst-case event, ATSDR's modeling analysis predicts that the maximum radiation dose to the whole body would have been about 2 millirem (Figure 5). The estimated dose to the critical organ (thyroid) was 40 millirem, calculated using a tissue weighting factor of 0.05. The committed effective dose equivalent (CEDE) is a 50 year CEDE as calculated by the program. The next section and the "Exposure Pathways Analysis" section review the significance of these estimates.

Figure 5. Whole body dose as the result of a ^{155}Ci I-131 release.

Comparison to Regulatory Limits

Throughout operation history of the Department of Energy and its predecessors, regulatory limits have been changed. In the early days of operation, dose limits were in place to protect workers with little apparent concern for off-site radiation doses. Early worker dose limits were 5000 millirem per year. In 1959, the US Department of Commerce published maximum limits for many radionuclides. These limits were both for a 40 hour work week and a continuous exposure of 168 hours (continuous, weekly exposure). In the case of air immersion, the tritium limits were 400,000 pCi/m³, and for Ar-41, the limit was 400 pCi/m³ (USDOC 1959). Department of Energy sites currently are required to meet the National Emission Standards for Radionuclides released to ambient air. The standards require that DOE shall not exceed those amounts that would cause any member of the public to receive in any year an effective dose equivalent (dose to the whole body) of 10 mrem/yr (10 CFR 40.61 Subpart H).

Historical releases from BNL met the dose limitations in existence at those times and current releases meet current regulatory dose limits. However, computer modeling of the 1962 Ar-41 releases indicated an annual dose of 120 millirem/yr at the BNL property line. While this estimated dose for 1962 is greater than ATSDR's current minimal risk level (100 millirem/yr), other observations suggest that the likelihood that anyone was exposed at the estimated level is extremely low. For instance, the estimated dose applies to 1962, when much of the land within 10 miles of BNL was undeveloped with little or no residential housing. Because no one was likely exposed continuously at the property boundary, off-site residents' actual exposure doses in 1962 were likely considerably lower than 120 millirem. While areas surrounding BNL became

increasingly populated in more recent years, Ar-41 emissions from BNL decreased by several orders of magnitude after BGRR operations ceased in 1968. Thus, ATSDR concluded that off-site residents' exposures to past air emission were not at levels expected to harm public health.

2.2.2.2 Current Emissions

ATSDR also evaluated current air emissions from BNL. In this evaluation, it is important to note that three sources that previously accounted for the bulk of BNL's radionuclide emissions— the BGRR, the High Flux Beam Reactor, and the BMRR— were all shut down by December 2000. Though some current operations at BNL release radionuclides, emissions from these processes are limited by (among other regulations) the National Emissions Standard for Hazardous Air Pollutants part H. This regulation requires facility-wide air emissions of radionuclides not cause anyone from the public to receive an effective dose equivalent of 10 millirems/year. The material ATSDR reviewed for this assessment indicate that BNL complies with these regulations, suggesting that current air emissions from the site do not present a public health hazard and are therefore not evaluated further in this document.

2.3.3 Surface Water Contamination

The Peconic River's headwaters are located west of BNL site. The river flows east as it enters the site, picks up discharge from the Sewage Treatment Plant (STP) outfall midway through the site, then flows southeast through the property before leaving through the eastern site boundary. Throughout its history BNL has handled wastewater in two ways. Some wastewater is pooled on site in basins that gradually evaporate or recharge the underlying groundwater aquifer. Other wastewater is treated at the STP and then discharged to the Peconic River. The STP has been in operation for the site's entire history, though the type and efficiency of treatment operations has changed over the years. Currently, BNL has hold-up tanks in many of its facilities to prevent the discharge of untreated wastewater to the Peconic River, but these hold-up tanks were not always present. As a result, earlier in its history, BNL discharged untreated wastewater to the Peconic River.

In addition to direct discharges of wastewater, contaminants from BNL enter local surface water by other processes. Contaminants in sediments can be an ongoing source of releases to surface water. A specific example of sediments that caused surface water contamination at BNL is the leaching of cesium-137 from sand filter beds at the treatment plant (BNL 2000). Groundwater contamination can flow into surface waters, particularly during times with above-normal precipitation, leading to the discharge of groundwater into the Peconic River and its tributaries. Air emissions from BNL can be washed into local surface water during rainstorms.

BNL discharges process and non-process related wastewater at several on-site locations. NYSDEC has permitted all of these discharges under the State Pollutant Discharge Elimination System (SPDES). The SPDES permit requires BNL to measure levels of contamination in the discharges and ensure that these levels are lower than permitted thresholds. BNL currently has 10 permitted outfalls. The discharge from the STP (outfall 001) flows directly into the Peconic River. The discharges from the other outfalls are primarily cooling water and storm water, and they flow into various on-site recharge basins. The monitoring requirements vary from one outfall to the next, with the most extensive monitoring required at outfall 001.

This section summarizes two sets of discharge measurements: those from the STP and those from all other discharge measurements. This distinction is made because only the STP discharge flows directly into the Peconic River (where exposures at downstream locations can potentially occur), while all other discharges flow into on-site recharge basins (where exposures are expected to occur infrequently, if at all).

Two sets of sampling data were available for outfall 001. First, BNL routinely collects samples from the outfall and analyzes them for constituents specified in the facility's wastewater discharge permit. Second, as part of the facility's ongoing environmental surveillance efforts, BNL analyzes samples for numerous radionuclides to characterize releases of contaminants that NYSDEC does not require BNL to measure.

As Table SW 1 indicates, several non-radiological contaminants have been detected in BNL's effluent to the Peconic River. The discharge monitoring data indicate, however, that contaminant levels either rarely or never exceeded corresponding health-based comparison values during the 1990s — the time frame of sampling data that NYSDEC provided. The following non-radiological contaminants had at least one measured concentration higher than its corresponding comparison value: bis (2-ethylhexyl) phthalate, chromium, copper, lead, mercury, methylene chloride, nickel, and silver.

Table SW 2 shows the radionuclide concentrations greater than screening levels, including short-term peak levels of gross beta (94.2 pCi/L) and tritium (67,300 pCi/L). Annual average concentrations for these and all other contaminants were below the screening levels.

Many different types of surface water (e.g., creeks, rivers, ponds) are located off site. Most site documents split these surface waters into two categories: the Peconic River and background locations. The background locations include all surface waters not directly affected by wastewater discharges from BNL, though they may still be contaminated by laboratory operations as a result of atmospheric deposition or air releases.

Since 1970, both BNL and NYSDOH have conducted extensive water quality monitoring in the Peconic River. Most of the samples were collected at four locations along the Peconic River:

- At Schultz Road, approximately 1.5 miles downstream from BNL site boundary
- At Wading River, approximately 2.8 miles downstream from the site boundary
- In the town of Manorville,¹ approximately 5 miles downstream from the site boundary
- In the town of Riverhead, at the mouth of the Peconic River, approximately 10 miles downstream from the site boundary

Of these four locations, samples were collected most frequently at Manorville and Riverhead, and surface water contamination at the other locations is not as well characterized. At all locations, the sampling studies evaluated primarily concentrations of radiological contaminants.

¹ Both BNL and NYSDOH collect samples from a location designated as Manorville. The sampling documentation indicates that NYSDOH's Manorville sampling station is *upstream* of BNL's Schultz Road sampling station, while BNL's Manorville sampling station is *downstream* from the Schultz Road station.

Specifically, concentrations of gross alpha radiation, gross beta radiation, and tritium were measured in most samples collected; concentrations of certain isotopes (e.g., strontium-90 and cesium-137) were detected more frequently than others. Sampling for inorganic contaminants has also been conducted routinely, but to a lesser extent than for the radiological contaminants. The inorganic analytes measured have varied from year to year. For instance, analysis of cadmium and lead concentrations has taken place since at least 1977, but analysis of manganese levels was not documented in the Site Environmental Reports until 1991, and later still for other analytes (e.g., cobalt, molybdenum, and thallium).

Four rounds of sampling were conducted in the Peconic River during 2003 to determine what the levels of total mercury, methylmercury, and PCBs were in various sections of the Peconic River. Total mercury concentrations decreased with distance downstream of the STP during all sampling rounds by a factor of three to four times between the stations just downstream of the STP (37 to 80 nanograms(ng)/L) and the one at Schultz Road (11 to 21ng/L)(QEA 2003). Methylmercury concentrations differed somewhat because the concentrations between BNL's property line and Schultz Road were consistently higher than those on BNL property. Sample results from further downstream at Donahue's Pond indicate that both total mercury and methylmercury concentrations are consistent with background levels. Total PCB concentrations were consistent with background levels.

2.3.3.1.1 *Inorganic contaminants*

Arsenic, cadmium, lead, manganese, and thallium were occasionally found at concentrations higher than their corresponding lowest health-based comparison values. Closer examination of the sampling data reveals, however, that the average concentrations of these contaminants (e.g., annual average levels) are lower than the listed comparison values.

2.3.3.1.2 *Radiological contaminants*

In some off-site surface water samples, gross alpha radiation, gross beta radiation, and tritium were detected at levels higher than their corresponding health-based comparison values. To characterize realistic long-term exposure scenarios, the 30-year record of sampling data compiled by NYSDOH was examined to determine average, rather than peak, levels of contamination. The NYSDOH data reveal that gross alpha radiation was not detectable in most samples, the highest annual average concentration of gross beta radiation was 15 pCi/L, and the highest annual average concentration of tritium was 5,800 pCi/L.

2.3.3.1.3 *Organic compounds*

Quarterly monitoring for volatile organic compounds occurs at up to six stations downstream of BNL's Sewage Treatment Plant. Site environmental reports only document when compounds were detected and do not present non detections. ATSDR's review of these reports identified detections of toluene (3 ppb) and total xylenes (3 ppb) at levels lower than corresponding health-based comparison values.

Data for "control locations" (i.e., off-site surface waters other than the Peconic River)

Although the Peconic River is the only surface water that directly receives wastewater discharges from BNL, many other surface water bodies are located in the vicinity of the site. These surface

water bodies include small tributaries to the Peconic River, the Carmans River, the Connetquot River, and several lakes and ponds (e.g., Artist Lake, Lake Panomoka, Sandy Pond, and Swan Pond). Because they are not directly affected by liquid effluents from BNL, these surface waters have not been extensively tested. Site-related contamination in these waters, if any, must originate from atmospheric deposition of air pollution. All these locations appear to be accessible to the public; thus, the potential for exposure does exist.

Sampling of these waters occurred in fewer locations and with less frequency than in the areas described above. The sampling results, which considered 21 inorganic analytes and 19 radiological contaminants, indicate that most analytes were never detected. Lead was the only analyte detected at concentrations higher than its corresponding health-based comparison value. Elevated lead concentrations were found in samples from the Carmans River with a maximum of 119.4 ppb and an average of 31 ppb; and four in Artist Lake (62.3 ppb, 57 ppb, 30 ppb, and 16 ppb). The source of the lead is not known. That atmospheric deposition from BNL would account for all of the lead contamination in just these control locations is, however unlikely, given that comparable levels of lead were not observed in other nearby surface waters.

2.3.4 Off-Site Sediment Contamination

Some of the contaminants detected in surface waters have also been detected in sediments. This is especially true for hydrophobic compounds (e.g., PCBs) and compounds with an affinity for soils (e.g., metals). Many radionuclides are known to accumulate in sediments because of their chemical and physical properties, such as relative insolubility and lack of biodegradability, and having a high affinity for soil. Though most site-related contaminants entered surface waters at on-site locations, these contaminants have gradually been transported to downstream locations in runoff or under the force of river flow. Therefore, site-related contaminants are present not only in sediments near BNL's wastewater discharges, but also in downstream locations.

Sediments at many off-site locations have been sampled to identify contamination that might be related to BNL's operations. Contaminated sediments are located in various rivers, lakes, and ponds, but most of the available data characterize levels of contamination in the Peconic River. The contaminants originate from many sources, including BNL, runoff from roads and farms, municipal and industrial discharges, and atmospheric fallout.

Throughout the Peconic River basin, exposure to contaminants in sediments can occur via various pathways, including

- incidental ingestion of sediments,
- dermal contact with sediments,
- inhalation of dusts created during low water conditions when contaminated sediments may be dried and exposed, and
- external radiation from sediments with radiological contamination.

In general, residents who live near BNL and off-site surface waters and children who play in these areas could potentially be exposed to the contaminated sediments.

Several studies conducted by BNL, NYSDOH, and SCDHS have documented contamination in off-site sediments, with the measured contaminants originating from multiple sources, and not

strictly from BNL. These studies include BNL's Remedial Investigations, environmental sampling data collected by NYSDOH, and a sampling effort coordinated by SCDHS and involving BNL, SCDHS, and Fish Unlimited.² Overall, the studies document levels of sediment contamination both in areas throughout the Peconic River basin and in areas outside of this basin. Specifically, sampling has been conducted along the entire Peconic River, Flanders Bay, Northport Bay, Peconic Bay, Donahues Pond, and Peconic Lake (also known as Forge Pond).

Samples were also taken at "control locations," or locations not directly affected by BNL's wastewater discharges. These locations included the Peconic River upstream of BNL site boundary, Carmans River, Connetquot River, Lloyd Harbor, Yaphank Lake, Sandy Pond, and Swan Pond. Sandy Pond and Swan Pond feed into but do not receive water from the Peconic River.

Table SD2 summarizes the sediment sampling results reported for off-site locations. To put the levels of contamination into context, the sediment sampling results for off-site locations were split into two categories: samples collected along off-site portions of the Peconic River and samples collected at the control locations.

2.3.4.1.1 *Data for Off-Site Sections of the Peconic River*

Sediment data was obtained primarily from BNL's Site Environmental Reports, BNL's Remedial Investigation studies (including the follow-up 2000 plutonium contamination characterization study), NYSDOH's 1996 report on radioactive contamination in the Peconic River (NYSDOH 1996), and SCDHS's 1998 study on the same topic (SCDHS 1998). Table SD2 in Appendix C presents the maximum sediment concentrations measured across these studies for three groups of contaminants: radionuclides, pesticides and PCBs, and inorganics.

As Table SD2 shows, five radionuclides—strontium-90, cesium-137, radium-226, thorium-232, and uranium-233/234—had at least one concentration in off-site Peconic River sediments greater than the corresponding lowest NCRP soil screening limit. Of these, radium-226 levels exceeded the screening limit by the greatest margin, a factor of 20. For the remaining 19 radiological contaminants listed in Table SD2, one of the following is true: the contaminant was not detected ("ND"); the contaminant was not analyzed for in the samples that were collected ("NM"); the contaminant does not have an NCRP soil screening limit ("NA"), or the highest concentration is lower than the corresponding NCRP soil screening limit. The NCRP soil screening limits used in this analysis are based on land uses (e.g., farming) that realistically will not take place in the off-

² According to the SCDHS report, the Independent Group (Fish Unlimited) did not continue to participate in this study following sample collection and distribution to each group. The [Memorandum of Understanding] required all participants to share their analytical data for the purposes of writing of this report. The Independent Group failed to provide adequate information regarding their analytical results. . . . Therefore this report includes only SCDHS and BNL/DOE analytical results (SCDHS 1998).

site Peconic River sediments. The comparisons shown in Table SD2 should be interpreted accordingly.

The SCDHS expressed concern over detections of americium-241 in the Peconic River sediments, because this radionuclide is a decay product of plutonium (SCDHS 1998). It is not clear, however, whether the americium in the sediments resulted from discharges of americium or from discharges of plutonium that later decayed to americium. Plutonium has been detected in the Peconic River sediments.

Of the 18 inorganic analytes listed in Table SD2, only arsenic had a sediment concentration higher than its corresponding health-based comparison value. Because this concentration (24.2 ppm) was measured far downstream from BNL site, near the town of Riverhead, whether the arsenic detected can be attributed to BNL operations is questionable. Moreover, the comparison value for arsenic used is a CREG, which is derived under the assumption of lifetime exposure to the contaminant. The probability that an individual would be exposed to sediments near Riverhead over such durations is low.

When compared with the on-site sediments, the off-site sediments had fewer contaminants at levels exceeding health-based comparison values. The contaminants that did exceed comparison values were strontium-90, cesium-137, radium-226, thorium-232, uranium-233/234, and arsenic. None of the PCBs and pesticides that were detected in the Peconic River sediments was found at concentrations higher than their corresponding ATSDR health-based comparison value.

The sampling that was conducted in the Peconic River during 2003 indicated that sediments between BNL boundary and Shultz Road had higher concentrations of methylmercury compared to the concentrations in sediments upstream on BNL property. It appears that the mercury contaminated sediments on site have migrated downstream and are pooling just off site. Mercury levels between Shultz Road and Donahue's Pond have declined and are consistent with background levels at Donahue's Pond.

2.3.4.2 Data for Control Locations (i.e., Off-Site Sediments Other Than Those in the Peconic River)

To assess the extent to which sediment contaminants can be attributed to BNL operations, various agencies have compared levels of contamination in the Peconic River to off-site control locations. These locations do not receive waters from the Peconic River and therefore are not downstream from BNL's wastewater discharges. It is possible that BNL operations have introduced some contaminants to surface waters and sediments in the control locations by way of atmospheric deposition of the site's air emissions.

Sediment sampling of control locations was noted in many documents, including BNL's Remedial Investigation reports and the SCDHS cooperative sediment sampling program. The results of these and other studies are shown in Table SD2. Of all the contaminants listed in the table, three — radium-226, uranium-233/234, and arsenic — were at levels greater than their corresponding health-based comparison values. The levels of the two radionuclides exceed the comparison values by relatively small margins (not greater than 12), and the comparison is a very conservative screen for toxicity, given that sediments at the control locations probably will never be used for the land uses for which NCRP derived its screening limits. In the case of

arsenic, the peak concentration (9.1 ppm) appears to be a level indicative of naturally occurring contamination, and the public health implications of this contamination are expected to be minimal, given that residents probably come into contact with the off-site sediments only sporadically.

2.3.5 Biota Contamination

Various researchers have sampled biota from areas surrounding BNL, including BNL's Environmental and Waste Management Services Division, Suffolk County Department of Health Services (SCDHS), New York State Department of Health (NYSDOH), New York State Department of Environmental Conservation (NYSDEC), and contractors for BNL (specifically International Technology Corporation (ITC) and Camp Dresser and McKee Corporation (CDM)). Much of the data from these sampling efforts are used in this evaluation.

This section reviews the results of biota sampling studies performed between 1973 and 2002. The five general categories of biota that were sampled and included in this review are fish, shellfish, wildlife (deer), vegetation (plants), and milk. The species and contaminants selected for sampling and the laboratory analytical methods varied from one sampling program to the next.

The combination of these factors makes comparing the monitoring data across years quite difficult. Some of the factors considered in the interpretation of the biota sampling data are as follows:

2.3.5.1.1 Sampling Locations

Levels of soil, sediment, and surface water contamination vary from location to location near BNL site. Thus, one would expect concentrations in vegetation and wildlife to vary with location as well. This is particularly true for vegetation and species that forage in a limited area.

2.3.5.1.2 Sampling and Analytical Method Limitations

The sampling studies date from the early 1970s to 2002 — a time-frame over which laboratory analytical methods for many contaminants improved greatly. Therefore, comparing results across different studies is difficult because analytical laboratories used many different methods (and some studies did not document the methods used). Moreover, the various studies sampled different tissues from biota (and some did not document which tissues were sampled), further complicating data interpretations; given that people tend to eat only certain parts of the biota.

2.3.5.1.3 Other Concerns

Other factors must be considered when one is interpreting data. For example, the age, size, or sex of the sample may have an impact. Depending on species, older or larger specimens may have higher concentrations of pollutants. Different types of contaminants accumulate in different parts of the body. PCBs tend to be stored in the fatty tissues of fish and mammals. Metallic mercury will accumulate in the kidneys and can enter the brain of mammals. For some mammals, the female forages in a smaller area and could be more affected by a contaminated on-site area than the male, which typically forages in a large area likely to encompass both on- and off-site territory.

2.3.5.2 Fish

Fish sampling studies conducted by BNL and the NYSDOH from 1973 through 1999 were included in the following documents: BNL's Environmental Monitoring Reports, Site Environmental Reports, and the Remedial Investigation Studies (including the 2000 Plutonium Contamination Characterization and Radiological Dose and Risk Assessment Report), and NYSDOH's 1996 Radioactive Contamination in the Peconic River. The sampling studies investigated fish living in the Peconic River not only on site and off site, but also in off-site background locations. All together, 763 samples were collected. The NYSDOH studies were conducted between 1973 and 1999 in off-site Peconic River locations and in control locations.

Laboratory analysis of fish samples differed among the different laboratories for the sample study time frame (1973–1999). Segregated analysis of fish (i.e., analyzing flesh and skin, viscera and bones, and whole fish separately) allows for more realistic dose calculations, because different radionuclides may become localized in different tissues (BNL 2000). Separating the analyses allows for the localization of radionuclide contamination within the fish. For example, strontium-90 mimics calcium within an organism and localizes in the bone. Because bones are not typically eaten, the potential dose from consumption is reduced. The following summary notes the type of sample used if the information was available.

The amount of sampling that was conducted depleted the number of larger fish in the Peconic River and as a result BNL suspended most on-site sampling beginning in 2001 (BNL 2002). In order to allow the fish populations to rebound to the numbers that were present in past years, BNL decided to suspend on-site sampling for three years. Sampling of fish from the Peconic River occurred only in off-site areas in 2001 and 2002.

2.3.5.2.1 *On-site Fish Sampling*

On-site fish sampling locations included the Peconic River at the former site perimeter (0.8 km downstream of the STP outfall), the current site boundary (2.6 km downstream), and the STP outfall itself. All together, 122 samples were taken on site. Samples were analyzed for radionuclides, specifically potassium-40, strontium-90, and cesium-137. Inorganics, pesticides, and polychlorinated biphenyls (PCBs) were analyzed in on-site fish samples only from 1996 – 1999. Data were usually presented as wet weight, although data in dry weight were occasionally provided.

The maximum potassium-40 concentrations (wet weight) were found in pumpkinseed (20.212 pCi/g), chain pickerel bone/viscera (7.536 pCi/g), and brown bullhead (6.625 pCi/g). Maximum strontium-90 concentrations (wet weight) were found in largemouth bass (5.447 pCi/g), brown bullhead (4.786 pCi/g), and pumpkinseed (4.752 pCi/g). Maximum cesium-137 concentrations were found in pumpkinseed (25.0 pCi/g), sunfish flesh (11.016 pCi/g), chain pickerel bone/viscera (9.312 pCi/g), and brown bullhead (8.0 pCi/g).

Mercury was the only inorganic detected at concentrations above comparison values. The maximum concentrations were found in chain pickerel (1.6 mg/kg) and pumpkinseed (1.2 mg/kg). Mercury levels in fish increased in 2000 to 3.01 mg/kg in brown bullhead catfish and 3.72 mg/kg in chain pickerel. Both of these samples were whole body composites composed of several small fish. The comparison value for fish consumption (0.14 mg/kg, RBC) is based on

an assumption of residents consuming nearly 1 pound of locally caught fish per week over a 30-year period. Refer to the biota evaluation in the section on Potential Exposure Pathways for further information on likely fish ingestion rates and NYSDOH's advisory for eating fish caught from the state's fresh waters.

2.3.5.2.2 *Off-site Fish Sampling*

The off-site portion of the Peconic River flows for 16.75 kilometers from BNL site perimeter through Donahue's Pond and Forge Pond (currently known as Peconic Lake) before emptying into Peconic Bay at Riverhead. Sampling occurred most often in Donahue's Pond and Forge Pond.

Samples were analyzed primarily for the radionuclides potassium-40, strontium-90, and cesium-137. Inorganics, pesticides, and PCBs were analyzed only from 1996–1999. All together, 363 samples were taken from the Peconic River off site.

Highest wet weight concentrations of potassium-40 (see Table B9) were found in pumpkinseed bone/viscera (6.49 ± 5.32 pCi/g), bluegill flesh/skin (6.40 ± 2.15 pCi/g), and chain pickerel flesh/skin (5.03 ± 1.45 pCi/g), although the levels for all fish species sampled were in the same order of magnitude.

Highest wet weight concentrations for strontium-90 (see Table B10) were found in the bone of an unspecified top feeders (7.90 ± 0.474 pCi/g), brown bullhead (3.328 pCi/g), and golden shiner (2.597 pCi/g). The highest levels for strontium-90 were recorded between the mid-1970s and the mid-1980s.

For cesium-137, the highest wet weight concentrations (see Table B11) were found in the flesh of an unspecified top feeders (2.8 ± 0.56 pCi/g), another unspecified so-called top feeder (2.59 ± 0.13 pCi/g), and the flesh of an unspecified so called bottom feeder (2.33 ± 0.193 pCi/g). All three samples were recorded by NYSDOH during the mid-1970s. The highest concentration of cesium-137 for a more recent sample was for an unspecified fish caught in 1997 (1.66 pCi/g).

Mercury and arsenic exceeded health-based comparison values (see Table B14) in at least one sample. Almost all samples exceeded USEPA's RBC for mercury, with the highest wet weight levels for largemouth bass (0.914 mg/kg), chain pickerel (0.645 mg/kg), and pumpkinseed (0.418 mg/kg). Fish sampling data for 2001 indicated mercury levels at 1.3 mg/kg and in 2002 mercury levels were below 1.0 mg/kg in all fish sampled off site. Arsenic was highest (wet weight) in the flesh of largemouth bass (0.91 mg/kg). As noted previously, NYSDOH has issued a fish consumption advisory for all fresh waters in the state.

2.3.5.3 *Control Fish Sampling*

Samples were taken at control locations off site to determine background levels of contaminants. Control locations included Carmans River, Connetquot River, Meadow Lake, Hempstead Lake, Lake Panamoka, Lake Ronkonkoma, Smith Pond, Fresh Pond, Massapequa Pond, Upper Twin Pond, Searington Pond, Willow Pond, Kahler's Pond, Artist Lake, Sandy Pond, and Swan Pond. None of these locations receive waters from the Peconic River. Sandy Pond and Swan Pond both feed into the Peconic River, while the other locations are not connected to the Peconic River.

Samples were analyzed for the following radionuclides: potassium-40, strontium-90, and cesium-137. Inorganics, pesticides, and PCBs were analyzed only in 1997. All together, 278 samples were taken in off-site background locations. Tables B16 through B21 list the contaminants that were found in background samples.

The highest wet weight concentrations for potassium-40 were found in black crappie (12.91 ± 4.48 pCi/g), gizzard shad flesh/skin (7.15 ± 2.05 pCi/g), and carp (6.89 pCi/g). Other fish species had similar potassium-40 levels.

Strontium-90 maximum wet weight concentrations were found in an unspecified species (4.31 pCi/g), a bluegill (1.78 ± 0.08 pCi/g), and a brown bullhead bone/viscera (1.10 ± 0.06 pCi/g). The highest levels were recorded in the late 1990s.

Highest wet weight concentrations for cesium-137 were found in an unspecified bottom feeder (1.77 ± 0.071 pCi/g), a brown bullhead (1.687 pCi/g), and an unspecified mixed feeder (1.20 ± 0.020 pCi/g).

Fish collected from off-site control locations had detectable levels of several non-radiological substances. Two pesticides (DDD and DDE) were found at concentrations in some samples higher than their respective comparison value. Mercury was also found in fish samples from control locations at levels exceeding health-based comparison values; however fish caught from the Peconic River typically showed higher mercury levels than fish from control locations. Overall, these detections suggest that some non-radiological substances in fish tissue may have originated, in part, from sources other than BNL. However, this observation does not detract from the fact that releases from BNL have contaminated sediments in the Peconic River and some of this contamination has in turn accumulated in the aquatic food chain.

2.3.5.4 Shellfish

Off-site shellfish sampling locations included Flanders Bay, Indian Point, and Peconic Bay. Shellfish samples were analyzed for radionuclides, including potassium-40, strontium-90, and cesium-137, and for inorganic metals. Concentrations of potassium-40 in shellfish ranged from nondetectable to 9.21 pCi/g, wet weight, with the maximum concentration found in 1999. Cesium-137 concentrations ranged from non-detectable to 0.510 pCi/g, wet weight (maximum concentration found in 1976), and strontium-90 was found in concentrations ranging from non-detectable to 1.390 pCi/g, wet weight (maximum concentration found in 1980).

Maximum wet weight shellfish concentrations recorded by NYSDOH were lower than concentrations recorded by BNL for potassium-40 (2.50 pCi/g and 9.21 pCi/g, respectively). NYSDOH detected higher concentrations for cesium-137 and strontium-90 (0.510 pCi/g and 1.390 pCi/g by NYSDOH, 0.14 pCi/g and 0.053 pCi/g by BNL), though concentrations were the same order of magnitude.

Shellfish samples exceeded health-based comparison values for arsenic. Highest wet weight concentrations of arsenic were found in off-site control samples (2.61 and 2.12 mg/kg). All samples were contaminated with arsenic levels above the USEPA RBC. The RBC is based upon the assumption that residents eat approximately 1 pound per week of locally harvested shellfish over a 30-year period. Refer to the biota evaluation in the section on Potential Exposure

Pathways for a more detailed evaluation of the public health significance of the detected shellfish contamination.

ATSDR also reviewed the results of shellfish samples from control locations, which are locations not expected to be affected by releases from BNL. Control sample locations included various areas along the northern shore of Long Island (e.g., Lloyd Harbor, Northport Bay) and extending to Raritan Bay, a major industrial area in close proximity to New York City and Newark. Refer to Table B22 for control location sampling results for radionuclides in shellfish.

2.3.5.5 Deer

A 1996 site environmental report released by BNL in 1998 documented cesium-137 concentrations in deer meat samples taken on and off site. A local group of citizens known as Standing for Truth about Radiation (STAR) felt that the concentrations could be harmful to people who hunt and consume deer in the vicinity of BNL. STAR petitioned the NYSDEC to implement a formal hunting ban on BNL property and issue a consumption advisory for deer from the area around BNL. In response, the NYSDEC conducted biota sampling on deer from an area adjacent to BNL between August 18 and October 12, 1998 to determine the levels of radiological contaminants contained in the deer tissues. Because only a few samples were collected, data were compiled for meat samples from deer killed on site and in the vicinity of the site between 1992 and 1999. Samples from a total of 32 deer were analyzed.

The NYSDOH estimated the effective dose equivalent (EDE) from exclusive consumption of local deer meat to be 7.1 millirem (mrem). Because the average EDE from eating foods containing naturally occurring radionuclides is 10 mrem per year, NYSDOH did not impose any restrictions on consuming locally grazing deer (NYSDOH 1999).

The following paragraphs summarize deer meat contaminant levels measured at or near BNL. To be consistent with the data presentation format used throughout this PHA, summaries are presented separately for on-site and off-site contaminant levels. However, because deer can easily move on and off BNL property, the distinction between on-site and off-site contamination for deer meat has little bearing on estimated doses.

2.3.5.5.1 On-site Deer Populations

On-site deer samples were taken at several locations, including the South and Main Gates, the West Boundary, AGS, the Observatory, and Buildings 1001 and 830. Samples were analyzed for radionuclides, including potassium-40, strontium-90, and cesium-137. The levels detected are listed in Tables B23, B24, and B25, respectively.

The maximum potassium-40 concentration detected was 7.72 pCi/g found in deer flesh.

The highest concentration of cesium-137 was found in deer liver, measuring 14.59 ± 2.88 pCi/g. Concentrations in other tissues and samples also had levels at the same order of magnitude, though concentrations ranged from undetectable to the maximum of 14.59 pCi/g.

Strontium-90 was undetectable in the majority of samples.

2.3.5.5.2 *Off-site Deer Populations*

Off-site deer samples were taken at several locations, ranging from 0.25 miles (Wm Floyd Parkway) to 38 miles (East Hampton, NY) from BNL. Locations included the Brookhaven State Park, Camp Wawepea, Bridgehampton, Yaphank, Hubbard Park, Mattituck, Watermill, and Shelter Island. The levels found are in Tables B26 through B28 in Appendix C.

The maximum potassium-40 concentration detected in an off-site sample was 21.23 ± 18.14 pCi/g, taken from a thyroid gland. This concentration was much higher than the maximum concentrations found in flesh and liver (6.32 ± 1.46 and 4.44 ± 1.22 pCi/g; respectively).

The maximum cesium-137 concentration was found in a deer flesh sample, at 4.71 ± 0.80 pCi/g. Similar to the range of samples taken on site, the cesium-137 concentration in off-site samples was from undetectable amounts to 4.71 ± 0.80 pCi/g.

Strontium-90 was not detected in off-site samples, though it may have been present at less than the detection limit of 0.04 pCi/g.

2.3.5.6 Small Mammals

BNL representatives conducted sampling studies of small mammals living on and off site. The mammals sampled included cats, raccoons, foxes, and opossums. All together, at least 14 samples were taken (the 1993 sampling study did not report the number of samples — only a minimum and maximum concentration). Tables B30 and B31 show the levels found in small mammals on site and off site, respectively.

Samples were analyzed for cesium-137 and potassium-40. Cesium-137 concentrations (wet weight) ranged from 0.132 to 8.17 pCi/g. Small mammal species caught off site showed reductions in cesium-137, with a range of 0.010 to 0.262 pCi/g, wet weight. In general, cesium-137 concentrations were 2 to 6 times greater in flesh than in liver tissues. Potassium-40 concentrations (wet weight) ranged from 1.36 to 3.38 pCi/g.

Even though the small mammal species sampled by BNL might not be eaten by local residents, contamination levels might be similar to those of other small mammal species that might be eaten.

2.3.5.7 Vegetation

ATSDR reviewed vegetation sampling studies conducted by BNL and the SCDHS from 1973 through 1999. The sampling studies investigated edible vegetation grown on farms in close proximity to BNL and inedible vegetation, such as grass and tree leaves, growing on site.

Grass and tree leaves were monitored at BNL from 1985 to 1995 at various locations on site. Concentrations of potassium-40, cesium-137, beryllium-7, thorium-228, and radium-226 were found. A 1992 analysis of tree leaves in the vicinity of Building # 830 was performed in response to a leak in the facility. Maximum concentrations of cesium-137, potassium-40, thorium-232, and cobalt-60 in leaves were 1300, 7.45, 18.60, and 0.23 pCi/g, respectively. Both cobalt-60 and cesium-137 were present in the liquid spill (BNL 1993).

Local farms surrounding BNL were sampled for potassium-40, cesium-137, beryllium-7, and strontium-90. Samples were analyzed by BNL analytical services laboratory, with some analyses performed cooperatively with SCDHS. BNL and SCDHS concluded that the radionuclides detected were naturally occurring and at levels typical of global fallout. No radionuclides attributable to BNL operations were observed.

Though the available sampling data do not characterize levels of radionuclide contamination in all plant species at all locations near BNL, they do provide useful insights into levels of contamination at several nearby farms. More specifically, maximum concentrations of potassium-40 in edible vegetation were found in carrot leaves (6.59 pCi/g, wet weight) and Italian hot peppers (6.0 ± 1.5 pCi/g, wet weight). Maximum concentrations of cesium-137 and strontium-90 in edible vegetation were found in strawberries (cesium-137, 2.22 pCi/g, wet weight) and carrot leaves (strontium-90, 0.040 ± 0.008 pCi/g, wet weight).

3 Pathways Analysis

A release of a chemical or a radionuclide into the environment does not always result in human exposure. When these substances are present in environmental media such as air, drinking water, surface water, or soil, people can be exposed by eating, breathing, or contacting them. Unlike chemicals, radionuclides at high enough concentrations in the environment can result in external (or direct) radiation exposures to persons who are close to the material.

To determine whether nearby residents have been or currently are exposed to contaminants on site or off site, respectively, ATSDR evaluated the environmental and human components that could lead to an exposure. A pathway consists of the following five elements:

1. a source of contamination,
2. transport through an environmental medium,
3. a point of exposure,
4. a route of human exposure, and
5. an exposed individual or a population.

ATSDR characterizes an exposure pathway as completed or potential if it cannot be eliminated.

Completed pathways occur when all five elements are present and there are indications that exposure to a contaminant has occurred in the past, is currently happening, or will occur in the future. A potential exposure pathway exists when evidence of one or more of the five elements is missing, but the missing elements are plausible. Potential pathways indicate that exposure to a contaminant could have occurred in the past, could be occurring now, or could happen in the future. An exposure pathway can be eliminated if at least one of the five elements is missing and is not likely to be present. Exposure is defined by ATSDR as “contact at a boundary between a human being and the environment with a contaminant of a specific concentration for an interval of time.”

An example of an exposure pathway scenario might include chemicals or radionuclides being released from a facility onto the ground (soil) during routine operations or an accident (the contaminant source). These substances may then dissolve in rainwater that percolates down through the soil to the underlying groundwater (the environmental media). If the contaminated

groundwater is being used as a drinking water source (the point of exposure and exposed population), then people may be drinking or bathing (the routes of exposure) in water that contains these contaminants. All elements of the pathway must be present before the pathway is complete.

The focus of the ATSDR public health assessment is on current and past exposure to chemicals and to radioactive materials from the site. ATSDR scientists also evaluated potential future exposure to chemical and radioactive materials released from the site to the environment, when such an exposure was applicable.

The “Exposure Pathways Analyses” section describes the first tier of a multi-tiered approach to evaluate public health hazards in the public health assessment. This first tier, the exposure pathways analysis, is essentially a screening step to enable rapid identification of which pathways and contaminants are unlikely to cause adverse health effects and therefore require no further evaluation. Using conservative assumptions about exposure, ATSDR scientists estimated exposure doses for chemicals and doses for radioactive materials in completed or potential exposure pathways. For chemicals, the estimated exposure doses are compared to a variety of health-based guidelines. The health-based guidelines are used to identify whether contaminant exposure merits further evaluation, not to quantify health risk. When the estimated chemical exposure dose exceeds an appropriate health guideline, a second tier of analysis involving a more in-depth, weight-of-evidence approach is used to evaluate any health hazard. The weight-of-evidence approach involves a thorough evaluation of the quality and relevance of scientific information that is the basis of health guidelines, considering various factors. The weight-of-evidence evaluation also considers whether human exposure will occur under hypothetical but realistic conditions of exposure. For radioactive contaminants, ATSDR scientists evaluate all site exposure pathways that contribute to radiological doses (committed effective doses and equivalent doses to the target organ).

Many uncertainties exist regarding the different exposure scenarios that could occur in the Peconic River. The upstream (on site) portions of the Peconic River are inaccessible in many areas, is either dry or has very little flow during parts the year, and the number and size of the fish vary compared to other areas of the river. These uncertainties can have an effect on the exposure rates. If there is little or no flow in the Peconic River during parts of the year then the amount of fish that a person consumes will be affected. Sampling results have indicated that downstream (off site) locations have lower contaminant concentrations in the water and sediment than those in the upstream (on site) locations. Where the fish was collected during the sampling could have an effect on the amount of contaminants the fish has accumulated.

Other uncertainties include what portion of the fish was sampled (whole fish or only edible portions of the fish). Extrapolating concentrations found in whole fish to only parts of the fish that are edible can be difficult because some contaminants concentrate in the bone or fatty tissues, which are generally not consumed. Concentrations may be overestimated or underestimated based upon where the contaminant concentrates in the fish. Additional factors that complicate efforts to evaluating exposures due to fish ingestion include different consumption patterns (e.g., some people eat only fillets and some people use all fish body parts when preparing meals) and preparation methods (e.g., pan fried, grilled, boiled).

3.1 Child Health Considerations

Women and children may sometimes be affected differently from the general population by contaminants in the environment. Both are physically smaller than the population average and are affected by smaller quantities of the contaminants. The effect of hormonal variations, pregnancy, and lactation can change the way a woman's body responds to some substances. Exposure during pregnancy and lactation can expose the fetus or infant if contaminants cross the placenta or get into the mother's milk. Depending upon the stage of pregnancy, exposure of the fetus could result in death (miscarriage or stillbirth) or birth defects. If the mother is exposed during lactation, her milk may concentrate certain contaminants, increasing the exposure of her infant.

ATSDR recognizes that a developing young person, whether fetus, infant, or child, has unique vulnerabilities. For example, some exposures would affect children more than adults because of children's lower body weight and higher ingestion rate, with the result of an increased dose or amount taken into the body compared to their body weight. Because children are shorter, their breathing zones are closer to the ground, and thus closer to soil contaminants and low-lying layers in the air. Different behavioral characteristics include more hand-to-mouth behavior, increasing the ingestion of soil or dust contaminants.

Furthermore, children's metabolic pathways are less developed than those of adults, especially in the first months after birth. In some instances, children are better able to deal with environmental toxins, but in others, they are more vulnerable. Some chemicals that are not toxic to adults are highly toxic to infants.

Children grow and develop rapidly in their first months and years of life. Some organ systems, especially the nervous and respiratory systems, may experience permanent damage if exposed to high concentrations of certain contaminants during this period. Because of rapid growth and development, a child's genetic material (deoxyribonucleic acid or DNA) is more likely to be exposed than later in life, making it more vulnerable to damage. Children have more future years than adults, giving more time for the development of illnesses that require many years to progress from the earliest initiation to the manifestation of the disease. Finally, young children have less ability to avoid hazards because of their lack of knowledge and their dependence on adults for decisions that may affect children but not adults.

The Exposure Pathways Analyses section indicates whether women and children were, are, or could be exposed to chemical and radioactive contaminants of concern in the completed and potential exposure pathways for the site. In the following section, "Public Health Implications," this report discusses the public health hazard from exposures via these pathways.

3.2 Completed Exposure Pathways

3.2.1 Past Completed

Residential well sampling done by the SCDHS indicated that some of the wells contained contaminants at levels above current drinking water standards. ATSDR staff conducted different modeling scenarios for the contamination that exists in on- and off-site groundwater. When the model was run with a constant source concentration (at 50m depth), the resulting concentrations

in residential wells were never significantly higher than the values measured in the late 1980s and 1990s.

For a single spill or for a very short-term type of contaminant release, off-site contaminant concentrations could have been higher prior to 1985. According to source and other on-site monitoring, this scenario is likely for only two plumes (the OU-IV waste solvent plume and the OU-I former landfill plume). ATSDR estimated the rate of contaminant migration and the estimated concentrations at specific locations and times.

Although several different contaminants have been detected, most of these are VOCs with similar physical properties such that behavior of the different plumes will be very similar. Because all the plumes are adjacent, it is further assumed that hydrogeological properties for the different plume areas are similar. Differences in the plumes are based on distance from plume origin to area of potential exposure and duration of plume migration (based on time of contaminant release at source). Distances of plume migration to areas of potential exposure range from 500 to 3900 m, and migration times from 12 to 53 years.

Depending on the specific plume and residential well location, exposure to several plumes could have occurred 5 to 7 years before initial detection in 1985. Limited data on depths of residential wells indicate, however, that the zones of highest contaminant concentration are below the screened well depths, so that actual exposures are much lower than potential exposures that are based on the assumption of lateral plume migration. Contaminant concentrations estimated for a depth of 30 m are very close to values measured in off-site residential and monitoring wells. Retardation and attenuation of contaminants within the groundwater flow system has reduced the concentrations of potential exposures relative to conservatively modeled concentrations.

3.3 Potential Exposure Pathways

3.3.1 Air

Throughout the history of BNL, several reactors have been in operation. Routine air emissions associated with the operation of BNL from 1948 through 1961 were mainly from the Brookhaven Graphite Research Reactor (BGRR). The reactor operated on the use of natural uranium fuel from 1951 to 1957. During this time, 28 ruptures of the fuel cartridges were reported. Each rupture released noble gases, particulates, and radioiodines into the air stream that cooled the reactor. Air monitoring was conducted during this time frame, but not with the sophistication of today's instrumentation standards.

Radiological releases from operations at the Brookhaven National Laboratory have resulted in atmospheric releases. Although these releases on the surface appear to be quite large, the radiological doses are relatively small with respect to doses known to cause observable adverse health effects. The reasoning for these low doses is based on the properties of the respective atoms. Tritium is a very low energy beta emitter that is uniformly distributed throughout the human body and is rapidly removed from the body. Argon-41, the largest contributor to the radiologic dose, is an inert gas, is not absorbed to a great extent in the body, and delivers the greatest amount of its radiologic dose to the skin surface. As noted previously in this PHA, ATSDR's modeling of historic air emissions, based on the highest reported release of I-131 from the BGRR, estimated a maximum radiation dose to the thyroid of 40 millirem. ATSDR does not

have a comparison value specific to radiation doses to the thyroid, but results from the Chernobyl accident suggest that adverse health effects are not expected at doses less than 5 rem (CDC 2002; ATSDR 2005). Accordingly, no observable adverse health effects would be expected because the maximum estimated thyroid dose associated with releases from BNL (40 millirem) is 125 times lower than the doses associated with no adverse effects at Chernobyl. Therefore, ATSDR does not expect any observable adverse health effect that can be tied to these releases.

ATSDR has established a comparison value for the evaluation of radiogenic cancers (ATSDR 2004. Public Health Assessment Y-12 Uranium Releases Oak Ridge Reservation (USDOE) Oak Ridge, Anderson County, Tennessee. Atlanta: ATSDR.). This value is a lifetime dose not to exceed ATSDR's lifetime radiogenic cancer comparison value of 5,000 millirem over 70 years and therefore is not expected to cause any observable or detectable adverse health effects.

3.3.2 Surface Water and Sediments

3.3.2.1 Contamination in Wastewater Discharges

Sampling of BNL's various wastewater discharges confirms that the laboratory releases trace levels of contaminants into local surface waters. Inorganic and radiological contaminants were detected most frequently — but only a small subset of these contaminants had at least one concentration higher than corresponding health-based comparison values. Direct exposure to BNL's wastewater discharges is not likely, and any such exposure would be infrequent.

3.3.2.2 Contamination in On-Site Surface Water

BNL has routinely sampled its on-site recharge basins, the wetlands, and the Peconic River, finding that several inorganic and radiological contaminants exceeded corresponding health-based comparison values in at least one sample collected. No contaminants, however, routinely exceeded these values. Because exposure is limited, the contamination in the on-site surface waters is not believed to be a public health hazard. Factors limiting exposure include the restricted access to the site and the limited flow in the Peconic River.

3.3.2.3 Contamination in Off-Site Surface Water

Exposures to off-site surface waters appear to be limited to dermal contact, which may be frequent for some individuals (e.g., anglers), and to occasional ingestion (e.g., accidental ingestion when swimming or canoeing/kayaking in the Peconic River). At downstream locations, human exposure to the Peconic River waters clearly occurs, particularly via the dermal exposure route. In these locations, the Peconic River is accessible to anyone wishing to swim, boat, or observe wildlife. BNL and NYSDOH have collected samples from the Peconic River and other nearby bodies of water. Inorganic contaminants (arsenic, cadmium, lead, manganese, and thallium) and radiological contaminants (gross alpha radiation, gross beta radiation, and tritium) were found at levels higher than health-based comparison values in at least one sample collected.

Exposure to off-site sediments is believed to occur more often than exposure to on-site sediments, because off-site surface waters (e.g., the Peconic River, lakes and ponds) are accessible to anyone wishing to swim or fish in them. In the case of the Peconic River, people

probably do not come into contact with submerged sediments often, but many upstream portions of the Peconic River periodically have little or no flow, with the result that potentially contaminated sediments are directly accessible to anyone walking or otherwise using the dry riverbed. Many BNL sampling efforts have confirmed that the Peconic River is often dry near, and downstream from, the site boundary.

3.3.3 *Biota*

Biota is considered a potential human exposure pathway for residents near BNL. Site-related contaminants can be taken up from water, sediment, and food by aquatic organisms and by terrestrial animals through the food chain or by ingestion of sediment and soil. For example, some of the heavy metals and radionuclides that have been detected in the sediment, groundwater, and surface water can accumulate and concentrate in aquatic biota (e.g., fish and mussel). The Peconic River has several species of edible fish, including bluegill, perch, largemouth bass, crappie, and pumpkinseed.

Hunting on BNL property is prohibited, but it is allowed in areas surrounding BNL. The deer study conducted by the NYSDEC and analyzed by the NYSDOH indicates that on-site deer have elevated levels of cesium-137 compared with deer in areas far enough away from BNL as to not be affected by BNL contaminants. Although the levels of cesium-137 are elevated, they are not elevated to the point that they would cause adverse health effects if someone were to eat the deer. Estimated exposure doses fall between 5 mrem and 9 mrem for 1 year of intake. This exposure dose is below the 10 mrem/year limit, and therefore hunting restrictions relating to the consumption of deer meat were not warranted.

Local anglers in the area have access to areas on site and off site along the Peconic River as well as residents who live off site along the Peconic River. The on-site portion of the Peconic River during parts of the year is either dry or has very little flow — too little to support thriving fish populations. Sampling results have indicated that fish from the on-site portion (upstream) of the Peconic tend to be smaller in size than those in off-site locations. Fish sampling conducted in the on-site portion of the Peconic has indicated that most samples are of insufficient size to eat, and the sampling results have been reported for whole-body contaminant loads. Extrapolating sampling results from whole body contaminant measures as opposed to concentration measures in the edible portions adds uncertainty regarding those contaminants to which an individual might be exposed.

Fish consumption rates for populations who live near and fish from the Peconic River are not known. The national average ingestion rates of freshwater fish are 6.6 grams/day for the general population and 17 grams/day for recreational or sports fishermen (USEPA 1997).

The majority of the samples were analyzed for radionuclides. Inorganics, pesticides, and PCBs were only analyzed from 1996 – 1999, 2003. Mercury and PCB concentrations have been detected at levels above comparison values in several species (largemouth bass, chain pickerel, creek chub sucker, and pumpkinseed) mainly in on-site portions of the Peconic River and in a few off-site locations. The maximum mercury concentration detected in fish on site was 3.72 mg/kg, and off site the maximum concentration was 0.914 mg/kg. A maximum concentration of mercury (0.364 mg/kg) was detected in fish from control or background locations. Although the level is lower than that found near the site, it is a clear indication of multiple sources of

contamination in areas surrounding BNL. Average mercury concentrations in edible fish tissue samples outside BNL property were 0.62 ppm and 0.02 ppm PCBs. Fish on BNL property were analyzed as whole body samples. The average concentrations for the on-site samples were 0.68 ppm mercury and 1.77 ppm PCB.

The New York State Department of Health has issued a health advisory for ingesting fish caught from the state's fresh waters. The advisory states that no one should eat more than one meal of fish per week from any of the state's fresh waters (NYSDOH 2003). If residents and anglers follow the recommendations in the advisory, adverse health effects are not expected. If residents and anglers were to subsist from fish in the on-site portion of the Peconic River, adverse health effects from PCBs and mercury may be expected. The maximum concentrations of mercury found in fish on site are above the action level of 1 ppm for methylmercury in fish (FDA 1996). FDA also recommends that the regular consumption of fish with methylmercury levels around 1 ppm be limited to approximately 7 ounces per week; for fish with levels averaging 0.5 ppm, the limit is about 14 ounces per week.

ATSDR performed a screening dose assessment to determine if a more in-depth dose assessment would be necessary. The screening dose assessment for non-radiological substances found that estimated exposure doses of mercury and PCBs for ingesting fish caught from the Peconic River are lower than their corresponding minimal risk levels, both for residential and angler fish ingestion rates. Therefore, more detailed analyses of these exposures are not warranted. The following paragraphs describe the screening dose assessments performed for radiological contaminants. For this screening, ATSDR did not select the various species analyzed, but rather chose the biota samples with the highest detected concentration of the radionuclide. For fish, the whole sample (flesh and bone) was evaluated. In the case of deer, only the flesh was evaluated. For shellfish, the species evaluated was not given.

For ingestion rates, ATSDR used values for deer derived from a previous BNL assessment, which assumed that a hunter would consume 29 kilograms (64 pounds) of a deer a year. In the case of fish, shellfish, and edible vegetables, ATSDR used values derived from the USEPA Exposure Factors Handbook. In the evaluation of the radiation dose, dose coefficients derived from Federal Guidance 13 were used.

The following tables present the results of ATSDR's dose analysis. Because some radionuclides concentrate in specific organs, delivering a higher dose to those organs, ATSDR evaluated doses both to the whole body and to the critical organ. Table 7 shows the radiological dose to the whole body.

Table 7. Radiation Dose (mrem/year) to the Whole Body Following Ingestion of Listed Foods*

| | <i>Cs-137</i> | <i>Sr-90</i> | <i>U-234</i> | <i>U-238</i> | <i>Total Dose^H</i> |
|------------------------------------|---------------|--------------|--------------|--------------|-------------------------------|
| Fish (maximum concentration found) | 1.66 | 1.06 | 0.0268 | 0.00108 | 2.75 |
| Shellfish | 0.0226 | 0.124 | | | 0.1147 |
| Deer | 17.2 | 0.118 | | | 17.3 |
| Vegetables | 7.63 | 0.28 | | | 7.91 |
| Off-site Fish | 0.186 | | | | 0.186 |
| Control Fish | 0.0372 | 0.121 | 0.000629 | 0.000412 | 0.159 |
| Off-site Deer | 6.90 | | | | 6.90 |

* the listed value for a food does not necessarily mean the same sample had all the listed radionuclides

^H dose is expressed in millirems per year

An individual would receive the highest dose from consuming deer obtained from on-site locations. Nonetheless, the estimated dose of 17 millirems per year is not considered by ATSDR as a public health hazard. Furthermore, if a hunter consumed both deer and vegetables from off-site locations, the total dose would be approximately 15 millirems, a dose that is also not considered a public health hazard.

Table 8 lists the estimated radiological dose to the critical organ. The critical organs are the lower large intestinal (LLI) wall for Cs-137 and the bone surfaces for Sr-90, U-234, and U-238. The radionuclides of greatest concern in this analysis are Cs-137 and Sr-90. As with the radiation dose to the whole body, these doses are not a public health concern.

Table 8. Radiation Dose^H (mrem/year) to the Critical Organ Body Following Ingestion of the Listed Foods*

| | <i>Cs-137</i> | <i>Sr-90</i> | <i>U-234</i> | <i>U-235</i> |
|------------------------------------|---------------|--------------|--------------|--------------|
| Fish (maximum concentration found) | 2.03 | 15.7 | 0.426 | 0.0173 |
| Shellfish | 0.0277 | 1.84 | | |
| Deer | 21.1 | 1.75 | | |
| Vegetables | 9.35 | 4.15 | | |
| Off-site Fish | 0.228 | | | |
| Control Fish | 0.0456 | 1.79 | 0.010 | 0.00657 |
| Off-site Deer | 8.45 | | | |
| Critical Organ | LLI Wall | Bone Surface | Bone Surface | Bone Surface |

* the listed value for a food does not necessarily mean the same sample had all the listed radionuclides

^H doses are expressed in millirems per year

Cesium-137 and strontium-90 are byproducts of nuclear reactors and nuclear weapons; until nuclear weapons testing, they were not found in nature. There are few regulatory restrictions limiting the public to exposures to these radionuclides specifically. Internal dose limits have, however, been codified in the Code of Federal Regulations by both the Nuclear Regulatory Commission (NRC) and the Department of Energy (DOE). These agencies' dose limits vary, but they are much higher than the doses ATSDR calculated. For example, the NRC limits for internal and external dose to individual members of the public from its licensees and their operations do not exceed 100 millirems in a year (10 CFR 20.1301).

The DOE has no regulations in effect that protect the public from internal doses resulting from the intake of radiological materials. Still, DOE regulations that limit the occupational doses do exist. These limits are not to exceed 5000 millirems per year for general employees (10 CFR 835.202), 500 millirems to the fetus considered from conception to birth (10 CFR 835.206), and 100 millirems per year to a minor (10 CFR 835.207) or a member of the public during direct on-site access at a DOE site or facility (10 CFR 835.208).

To evaluate the exposures to cesium and strontium, ATSDR considered both the potential for radiological and chemical hazards. The hazard associated with radiation from food ingestion does not appear to be a problem because the estimated annual exposure dose (see Table 7) are lower than ATSDR's minimal risk level for ionizing radiation (100 mrem/year). Also, the estimated lifetime dose is safely below ATSDR's radiogenic cancer comparison value of 5,000 mrem over 70 years. In general, health effects are not observed with any radioactive material until the dose exceeds 5,000 to 10,000 millirem levels. These levels are much higher than those estimated by ATSDR for ingestion of foods around BNL. A summary of the health effects associated with cesium (stable or radioactive) indicates there are no immunological effects at doses less than 100 rad (similar to 100,000 millirems), and no reproductive effects at doses less than 300,000 millirems (ATSDR, 2004a). The chemical hazards associated with cesium and strontium occur at levels greater than what has been found in biota samples around BNL.

ATSDR's toxicological profile for strontium states that the data for adverse health effects of stable strontium in humans are sparse (ATSDR, 2004b). An epidemiological study found no positive association between strontium ingestion and certain kinds of heart disease. Strontium chloride had no adverse effect on the function of stored human sperm in in-vitro fertility assays. However, numerous animal studies demonstrated adverse effects of excess stable strontium on skeletal development following oral ingestion.

Because absorbed Sr-90 is a bone-seeking radionuclide, it is preferentially retained in bone, and internal exposures will lead to chronic internal exposure to ionizing radiation. Consequently, the most significant effects of exposure to absorbed radioactive strontium are necrosis and cancers of bone and tissues adjacent to bone. Persons with Paget's disease (osteitis deformans) may be vulnerable to radioactive strontium because of their higher than normal rates of retention in focal sites of bone deposition.

3.3.4 Soil

3.3.4.1 OU I

The highest concentrations of contaminants detected in soils were at various locations in and around the Hazardous Waste Management Facility (HWMF). Workers were probably exposed to these soils, but their exposure was infrequent and of short duration. The HWMF is fenced and access to the facility is controlled, thereby restricting access to the public or trespassers. This site is unlikely to be visited by anyone other than the workers.

3.3.4.2 OU III

The highest concentrations of contaminants that exceeded CVs or RBCs and were detected in soils were found in samples taken from the Recharge Basins HP (arsenic and iron) and the TCE Spill Area (benzo (a) pyrene). Mercury-contaminated soils from Building 464 were removed and are no longer present. OU III is not completely fenced in, and occasional trespassers could enter these areas (ITC 1998d).

Residential areas in OU III are located southwest of the Recharge Basin HP, but residents are not expected to enter this area because the Recharge Basin HP is not easily accessible via roadways. Contaminant levels are not high enough to result in adverse health effects in the unlikely event

an occasional visitor comes into contact with contaminated soil. Exposure to these contaminants is probably infrequent, if at all.

3.3.4.3 OU IV

The highest concentrations of contaminants detected in soils are mostly located at the Sump Outfall of Building 650. OU IV is located near the center of BNL property, and on-site residential areas are located to the southwest, some distance from OU IV. Contaminated areas of OU IV are unlikely to be visited by anyone other than the workers.

3.3.4.4 OU V

The highest concentrations of contaminants detected in soils in OU V are at various locations in and around the Sewage Treatment Plant (STP). Because the STP is in a remote area of BNL, it is unlikely to be visited by anyone other than workers. Exposure to these contaminants is probably infrequent, if at all. Contaminated areas in OU V are some distance from on-site residential areas.

3.3.4.5 OU VI

BNL personnel are not expected to be working regularly in any of the three areas of concern in OU VI. The highest concentrations of contaminants detected in soils were at various locations throughout the upland recharge/meadow marsh area. Anyone temporarily working in these areas is presumed to wear appropriate protective clothing. These areas are in a remote area of BNL, and they are unlikely to be visited by anyone other than BNL personnel.

4 Public Health Implications

4.1 Toxicologic Evaluation

The evaluation of toxicological properties of contaminants and their effects on human health takes a variety of factors into account. First, a person must be exposed to a chemical by coming in contact with it. The routes of exposure can include breathing, drinking, eating, or dermal contact with a substance that contains the contaminant. Second, the type and severity of adverse health effects resulting from an exposure to a contaminant depend on the concentration of the chemical, the frequency and duration of exposure, the route of exposure, whether the exposure was to a single contaminant or a mixture of contaminants, and whether there were multiple exposures.

The following is a listing of the comparison values used in ATSDR's analysis and a description of what they measure:

Minimal Risk Level (MRL)—An estimate of daily exposure of a human being to a chemical (in milligrams per kilogram per day [mg/kg/day]) that is likely to be without an appreciable risk of deleterious effects (noncarcinogenic) over a specified duration of exposure. MRLs are based on human and animal studies and are reported for acute (less than or equal to 14 days), intermediate (15–364 days), and chronic (greater than or equal to 365 days) durations (ATSDR 1992b).

MRLs have been derived from animal data for both short- and long-term exposure and used to provide a basis for hazard estimates in humans, based upon all known experimental data on the chemical of concern. Because the method for deriving MRLs does not use any information about cancer, an MRL does not imply anything about the presence, absence, or level of risk of cancer. For carcinogenic substances, USEPA has established the Cancer Slope Factor (CSF) as a health guideline. The CSF is used to determine the number of excess cancers expected from exposure to a carcinogenic contaminant.

Lowest-Observed-Adverse-Effect-Level (LOAEL)—the lowest exposure dose in a dose-response experiment at which there is a biologically or statistically significant increase in frequency or severity of adverse effects between the exposed population and its appropriate control. It is the level at which adverse health effects first appear.

No-Observed-Adverse-Effect-Level (NOAEL)—the dose of chemical at which there were no statistically or biologically significant increases in frequency or severity of adverse effects seen in the exposed population above its appropriate control. Effects may be produced at this dose, but they are not considered to be adverse. It is the highest exposure level at which no harmful effects were seen in the organ system(s) studied. The following formula is used in determining an exposure dose:

$$ED = \frac{(C \times IR \times EF)}{BW}$$

where

ED = exposure dose (mg/kg/day),

C = contaminant concentration,

IR = intake rate,

EF = exposure factor, and

BW = body weight.

Standard intake rates are used for the ingestion of soil and water. A conservative estimate of 0.5 liter per day for incidental surface water ingestion was used in the calculation of an estimated exposure dose. Standard body weights used in the calculations are 16 kg for children and 70 kg for adults.

The maximum concentration for a contaminant is used to calculate an exposure dose most protective of public health. Exposures might vary — different groups of the population will be exposed at different frequencies. An exposure factor is used in certain situations, because exposures can be intermittent and not continuous.

ATSDR staff used the following variables in calculating the estimated exposure doses by various pathways for the different exposure scenarios:

1. Ingestion Rate (drinking water): Adults = two liters per day, Children = one liter per day
2. Exposure Factor: Adults and Children assumed to be exposed daily
3. Body Weight: Adults = 70 kilograms (kg); Children = 16 kg for ages 1 through 6; and 10 kg for an infant.

ATSDR compares data collected from animal testing and human epidemiological studies, as well as occupational studies, with estimated exposure doses calculated from known or potential exposures at hazardous waste sites. On comparison, ATSDR can evaluate the likelihood of adverse noncancerous health effects and cancerous effects or cancer risk. Very few epidemiological studies, however, have been carried out on low-level exposure to VOCs, thus making production of reliable cancer estimates difficult. In this public health assessment, ATSDR has evaluated exposures on an individual contaminant basis because of the limited amount of toxicological information on mixtures. Most occupational studies involve subjects who were exposed to high concentrations (in parts per million levels) for short periods of time (8 hours or less) to the undiluted chemical.

4.1.1 Trichloroethylene (TCE)

Trichloroethylene (TCE) is a nonflammable, colorless liquid at room temperature with a sweet odor and a sweet, burning taste. TCE is used mainly as a solvent to remove grease from metal parts and to formulate other chemicals. TCE is also a degradation (breakdown) product of tetrachloroethylene (PCE).

The intermediate MRL for ingestion of TCE that was used as a comparison value in the groundwater consultation has since been withdrawn because of a lack of adequately designed studies examining suitable end points. A chronic MRL for oral exposure has not been derived either. No health guideline is available for chronic TCE exposure (greater than 1 year duration) for either inhalation or ingestion.

In the past, TCE was used as an anesthetic. Studies involving TCE exposures in humans indicate that the central nervous system is the primary system affected. Effects include headache, vertigo, fatigue, short-term memory loss, impaired word associations, central nervous system depression, and anesthesia.

The highest concentration of TCE detected in residential wells surrounding BNL was 8 ppb at an unknown depth. Other concentrations of TCE detected in residential wells were at or just below the MCL of 5 ppb. The only oral (ingestion) MRL that exists for TCE is for acute exposure (14 days or less). That MRL is equal to 0.2 mg/kg/day (ATSDR 1997b). The MRL was based on a study in which mouse pups between the ages of 10 and 16 days were dosed by gavage with 0, 50, or 290 mg/kg/day TCE in a 20% peanut oil emulsion (Fredricksson et al 1993). ATSDR estimated exposure doses for children and adults by using the highest level found in residential wells. The estimated adult dose is equal to 0.00023 mg/kg/day, and the dose for children is 0.0008 mg/kg/day. The estimated doses are below the acute MRL of 0.2 mg/kg/day, and they are not expected to produce adverse health effects.

A MRL for acute inhalation exposure to TCE is equal to 2 ppm. The MRL was based on a study in which volunteers were exposed to 200 ppm TCE for 5 days, 7 hours per day. A LOAEL was observed for mild neurological effects, such as fatigue and drowsiness. The MRL for intermediate inhalation exposures to TCE is 0.1 ppm, based on a study of rats showing an increase in sleep-apneic episodes and cardiac arrhythmias after the rats' exposure to TCE. Indoor air monitoring for TCE was not conducted.

Occupational studies have shown that workers who have had dermal contact with pure or concentrated TCE have had adverse effects including skin rashes and dermatitis; potential effects of low levels of TCE exposure on the skin are however, unknown (ATSDR 1997b).

The International Agency for Research on Cancer (IARC) and the National Toxicology Program consider TCE to be a probable carcinogen in humans (ATSDR 1997b). The maximum TCE concentration detected in residential wells (8 ppb) was used to determine a lifetime excess cancer risk for children and adults. ATSDR assumed exposure durations of 20 years in the calculation of excess cancer risk; the site has not been in operation for 70 years, and the modeling conducted indicates that the earliest any of the plumes would have reached the residential wells was 1977. At this concentration, neither children nor adults would be expected to develop cancer.

A study of a Tucson, Arizona population evaluated exposure to TCE (6 to 239 ppb) and other contaminants (1,1-dichloroethylene [1,1-DCE] and chromium) in the drinking water from certain wells. The study showed an association between the elevated levels of TCE in drinking water and congenital heart disease in children whose mothers were exposed during the month before conception and during the first trimester of pregnancy (Goldberg et al 1990). A limitation of this study is the exposures to other well contaminants besides TCE. 1,1-DCE was also found in some of the residential wells around BNL, but chromium was not. None of the residential wells around BNL contained both TCE and 1,1-DCE above their respective drinking water standard.

4.1.2 1,1-Dichloroethylene (1,1-DCE)

1,1-Dichloroethylene is a man-made chemical used for certain plastics (such as packaging materials and flexible food wraps and flame-retardant coatings for fiber and carpet backing. It is a colorless liquid that evaporates quickly at room temperature. Also, 1,1-DCE is a breakdown product of 1,1,1-trichloroethane (1,1,1-TCA).

Evidence from animal studies indicates that 1,1-DCE toxicity is mediated by metabolism to reactive intermediates that act at the cellular level and ultimately compromise the viability of the target tissues (ATSDR 1994b). Therefore, the toxicity in humans would most likely depend on the extent to which 1,1-DCE is metabolized and the concentration of intermediates formed. Animal studies have indicated that animals are much less tolerant of continuous exposure (23B24 hours per day) to 1,1-DCE than of intermittent exposure. For example, there was no evidence of toxicity in beagle dogs exposed to 100 ppm of 1,1-DCE via the inhalation route for 8 hours/day, 5 days/week for 42 days, but continuous exposure to 48 ppm of 1,1-DCE for 90 days caused marked liver damage (ATSDR 1994b).

The highest concentration of 1,1-DCE detected in residential wells was found in 1990 by the SCDHS Bureau of Drinking Water in an area of North Shirley at a concentration of 20 ppb (SCDHS 1990). The SCDHS was investigating contamination from the Precision Concepts business in the Brookhaven Industrial Park. It was determined that the source of the 1,1-DCE in this particular residential well was from Precision Concepts. Because similar concentrations were found off site, ATSDR has used the maximum concentration found in residential wells to determine the likelihood of adverse health effects.

ATSDR staff used the maximum detected concentration of 1,1-DCE (20 ppb) in residential wells to estimate a daily exposure dose via ingestion for adults and children. The estimated exposure doses from ingestion are 0.0006 mg/kg/day for adults and 0.0013 mg/kg/day for children. A

chronic exposure MRL equal to 0.009 mg/kg/day was derived for the ingestion route (ATSDR 1994b). There is no intermediate ingestion MRL for 1,1-DCE, but it can be assumed that the level would be greater than the chronic MRL. Therefore, there is no expectation that adverse health effects would occur for people ingesting this level of 1,1-DCE.

The liver, the kidneys, and possibly the lungs can be considered target organs when individuals are exposed to 1,1-DCE through ingestion (oral) and/or inhalation (ATSDR 1994b). 1,1-DCE is associated with liver and kidney toxicity in humans after repeated, low-level exposure (ATSDR 1994b). The actual level that caused the toxic effects was not reported in the study.

The intermediate inhalation MRL for 1, 1-DCE is 0.02 ppm (ATSDR 1994b). The MRL is based on a no-observed-adverse-effect-level (NOAEL) of 5 ppm for hepatic effects in guinea pigs continuously exposed to 1, 1-DCE. Air sampling was not done and as a result ATSDR does not know what levels people were exposed to via the air pathway.

Other off-site detections were at levels below the 20 ppb concentration. The concentrations of 1,1-DCE in residential wells are not at levels at which adverse health effects would be expected. No information is available concerning the human organs that are targets of dermal exposure to 1,1-DCE, and no studies regarding 1, 1-DCE dermal absorption were located. 1,1-DCE has a high vapor pressure (greater than 500 torr at room temperature), and as a result, the rate of evaporation would be rapid, leaving little time for skin penetration.

Evidence of carcinogenicity in animals is limited. Animal studies involving the ingestion of 1,1-DCE have not shown statistically significant increases in the incidence of cancer when the exposed animals are compared with the control (non-exposed) animals. The USEPA has determined that 1,1-DCE is a possible human carcinogen and has derived an oral cancer slope factor of 0.6 mg/kg/day. The IARC has determined that 1,1-DCE is not classifiable as to its carcinogenicity in humans. No relationship has been demonstrated between the occurrence of cancer in humans and occupational exposure (primarily chronic inhalation exposure) (ATSDR 1994b). No studies have been located regarding cancer in humans after oral or dermal exposure to 1, 1-DCE (ATSDR 1994b).

The likelihood that residents were drinking this level (20 ppb) of 1, 1-DCE for more than 20 years is very low, because the maximum concentration was from the Precision Concepts plume, which had a duration of 10–12 years. ATSDR's modeling indicates that it would have taken approximately 5 years after introduction of 1, 1-DCE to the aquifer before it reached the residential wells. Assuming this scenario, a residential well may have had the contamination for 5–7 years. The excess cancer risk based on this scenario would be very low.

The extensive residential well sampling conducted in 1995–1996 did not indicate 1,1-DCE contamination above the New York state drinking water standard of 5 ppb.

4.1.3 Chloroform

Chloroform is a colorless liquid with a nonirritating odor and a slightly sweet taste. It is found in waste water from sewage treatment plants, and small amounts are formed as an unwanted product during the process of chlorinating water. Exposure to chloroform via ingestion of drinking water is expected to be extensive because most U.S. community drinking-water supplies are chlorinated. Typical levels in drinking water range from 2 to 68 ppb (Brass et al 1977;

USEPA/AMWA 1989; Furlong et al 1986; Kasso et al 1981; Krasner et al; 1989 Rogers et al 1987).

The chronic oral (ingestion) MRL and the chronic-duration oral reference dose (RfD), both derived from the LOAEL of 15 mg/kg/day in dogs, are equal to 0.01 mg/kg/day (ATSDR 1997a). The dose was adjusted for intermittent exposure and divided by an uncertainty factor of 1,000 (10 for extrapolation from animals to humans, 10 for the use of a LOAEL, and 10 for human variability). A NOAEL of 2.46 mg/kg/day for liver and kidney effects was determined in humans who used a mouthwash containing 0.43% chloroform for 1-5 years (Desalva et al 1975). The maximum chloroform concentration detected in residential wells was 10 ppb. This level is one-eighth of the federal drinking water standard for total trihalomethanes, the group of compounds under which chloroform is currently regulated. Estimated exposure doses were calculated by use of this concentration. The resulting doses were equal to 0.0003 mg/kg/day for adults and 0.0006 mg/kg/day for children. These doses are two orders of magnitude below the chronic MRL, and adverse health effects would not be expected.

Many incidents of occupational exposure to chloroform via inhalation are documented. LOAELs are available for both intermediate and chronic duration. Workers exposed for 1 to 6 months experienced vomiting and nausea at concentrations of 14 ppm and 22 ppm, respectively (Phoon, Goh, Lee, et al. 1983). Workers also experienced toxic hepatitis and jaundice when exposed to 14-400 ppm for 1 to 6 months (Phoon, Goh, Lee, et al. 1983). Similar conditions have been reported for workers exposed chronically. An MRL of 0.02 ppm has been derived for chronic-duration inhalation exposure to chloroform (ATSDR 1997a). The MRL was based on a LOAEL of 2 ppm in workers exposed to concentrations of chloroform ranging from 2 to 205 ppm for 1-4 years (Bomski 1967).

These levels are in the part-per-million range, and the maximum concentration in the wells was in the part-per-billion range. The levels detected in the wells are one thousand times lower than the MRL. ATSDR did not have any air monitoring results to determine what concentrations people may have been exposed to. There was no clinical evidence of liver injury in workers exposed to chloroform at levels as high as 71 and 237 ppm chloroform for intermediate and chronic durations, respectively (Challen et al 1958). No other studies indicated any observed adverse effects in individuals exposed to chloroform concentrations below the part-per-million level. No studies were located regarding systemic effects in humans after dermal exposure to chloroform. Chloroform has been found to be carcinogenic in animals after oral exposure. However, the data are not sufficient to support any conclusion regarding the carcinogenic potential in humans exposed to chloroform by the inhalation, oral, or dermal routes.

4.1.4 1,1,1-Trichloroethane (1,1,1-TCA)

1, 1, 1-TCA is a synthetic colorless liquid that has a sweet, sharp odor. The liquid evaporates quickly and becomes a vapor in the air. It is often used as a solvent to dissolve other substances, such as glues and paints. In industry, it is widely used to remove oil or grease from manufactured metal parts. The maximum concentration of 1, 1, 1-TCA detected in residential wells was 340 ppb at an unknown depth. ATSDR calculated estimated daily exposure doses for children and adults. At 340 ppb, a child's ingestion exposure dose would be 0.0213 mg/kg/day. The estimated ingestion exposure dose for adults at this concentration would be 0.0097 mg/kg/day.

MRLs for the ingestion pathway for acute, intermediate, and chronic exposures do not exist. Unpublished studies, which were considered as potential candidates for deriving acute-, intermediate-, and chronic-duration oral MRLs, were peer-reviewed and found to be of inadequate design. The only available exposure data for the ingestion of 1, 1, 1-TCA in humans were from two acute exposures in which the people had ingested 600 mg/kg/day (ATSDR 1995). This level is much greater than the levels associated with the groundwater contamination around BNL. Studies performed with rats that received doses of up to 3 mg/kg/day indicated no observed adverse effects. No documented studies of animals and humans demonstrate adverse health effects for exposure to concentrations below 3 mg/kg/day (ATSDR 1995).

An intermediate MRL of 0.7 ppm exists for the inhalation pathway of 1,1,1-TCA (ATSDR 1995). Assuming that the inhalation dose is similar to the ingestion dose, the estimated inhalation exposure doses for 1,1,1-TCA-contaminated well water were 340 ppb (0.340 ppm) for adults and approximately half the intermediate MRL for children. A chronic MRL for the inhalation pathway does not exist. Nevertheless, two occupational studies of workers who had been exposed for 6 years and 6.7 years to concentrations of 150 and 200 ppm, respectively, did not identify adverse effects (ATSDR 1995). These levels are much greater than those found in the residential wells, and ATSDR does not believe that exposures to 1,1,1-TCA in well water at this site are sufficient to cause adverse effects.

There is no documented information available on the extent and speed of skin absorption of 1,1,1-TCA from aqueous (mixed in water) solutions (ATSDR 1995). Because of 1, 1, 1-TCA's high volatility, exposure doses of less than 1 mg/kg/day — the likely scenario around BNL — would produce no dermal reactions. Occupational exposures to undiluted (pure) 1, 1, 1-TCA have produced a mild burning and a mild erythema to exposed areas of the skin (ATSDR 1995). But the effects were reversible after the exposure ended.

No studies were located regarding cancer in humans exposed to 1, 1, 1-TCA through the inhalation and dermal routes. A study performed by Isacson et al in 1985 involved the relationship between the presence of organic chemicals, including 1, 1, 1-TCA, in drinking water and the incidence of cancer in Iowa residents (Isacson et al 1985). The authors found no difference in the incidence of bladder, colon, lung, rectal, breast, or prostate cancer in people over age 55 (Isacson et al 1985). No other studies regarding the risks of cancer in humans after oral exposure to 1, 1, 1-TCA were located. Neither a cancer slope factor nor a CREG has been derived for 1, 1, 1-TCA.

4.1.5 Ethylene Dibromide (EDB)

Ethylene dibromide (EDB), also referred to as 1,2-dibromoethane, is a pesticide. In the past, it was used as a leaded gasoline additive to produce better fuel efficiency. In the 1970s and early 1980s, it was used in soil to kill insects and worms that were destroying fruits, vegetables, and grain crops. The maximum concentration detected in residential wells around BNL was 1.2 ppb, approximately one-third of the maximum detected in off-site monitoring wells. Detections of EDB in two residential wells on Weeks Avenue indicate that the levels of EDB are decreasing (from 1.2 ppb to 0.12 ppb and from 0.2 ppb to no detection) over time. The decreasing concentrations might be the result of EDB's high water solubility or of differing sensitivities in monitoring equipment.

Most of the available information on the effects of EDB in humans comes from cases of acute poisoning following accidental or intentional ingestion and from occupational exposures in agricultural industries (ATSDR 1992a). Acute exposures (less than or equal to 14 days) have caused depression and collapse because of neurologic effects and erythema and necrosis of tissue at the point of contact (e.g., oral and pharyngeal ulcers for ingestion, skin blisters and peeling for dermal exposure) (ATSDR 1992a). Except for occupational exposures, which have caused adverse reproductive effects in men, there have been no documented chronic effects of EDB exposure in humans (ATSDR 1992a). Studies have led researchers to determine that the liver and the kidneys are the target organs following human dermal and oral exposure to EDB (ATSDR 1992a).

ATSDR staff used the highest concentration detected in residential wells (1.2 ppb) to determine estimated ingestion doses of 0.00003 mg/kg/day for adults and 0.00012 mg/kg/day for children. Because of a lack of quantitative exposure data, no MRLs for EDB are available. Animal studies showed the LOAELs in bulls given 4 mg/kg/day for 20 days (Amir 1975; Amir et al. 1977). The study indicated that the bulls had transient sperm anomalies. This concentration is much greater (10,000 times) than the estimated exposure doses people might experience around BNL, and it was the lowest concentration at which adverse effects were noted. ATSDR merely used the LOAEL to indicate what adverse effects might be experienced at such low concentrations. It is important to note that using a brief duration (20 days) of EDB exposure in adult animals is difficult to compare to chronic exposure in humans.

The respiratory tract, particularly the nasal cavity, is the point-of-contact organ affected by inhalation of EDB (ATSDR 1992a). A study by Nitschke in 1981 indicated a NOAEL in rats through inhalation at 2 ppm (Nitschke et al 1981). This determination was based on studies of rats and mice exposed to 3 ppm EDB for 13 weeks, 5 days/week, 6 hours/day (Nitschke et al. 1981). In the scientific literature, no adverse health effects have been documented in animals or humans exposed at concentrations below 1 ppm. The estimated inhalation doses at BNL are well below the 1 ppm level; therefore, there is no expectation of adverse health effects.

ATSDR staff reviewed two epidemiological studies regarding workers exposed occupationally to EDB, primarily through respiration (ATSDR 1992a). Neither study indicated an increased risk of cancer in people occupationally exposed to EDB through inhalation. USEPA has classified EDB as a B2 carcinogen. A B2 classification indicates that evidence for carcinogenicity is inadequate or nonexistent according to human studies but is sufficient according to animal studies. The IARC has classified EDB as a 2A carcinogen. The class 2A carcinogen classification recognizes limited evidence of carcinogenicity from human studies, indicating that a causal relationship is credible but not conclusive. Subsequent sampling has indicated that the concentrations of EDB in the wells are decreasing over time to very low to no levels of EDB.

4.1.6 Perchloroethylene (PCE)

Perchloroethylene (PCE), also known as tetrachloroethylene, is a synthetic chemical widely used for dry cleaning and metal-degreasing operations. It is also used as a starting material for making other chemicals and as a component of some consumer products. PCE evaporates easily into the air and has a sharp, sweet odor. The highest concentration of PCE detected in residential wells was found at 10 ppb in 1985 on Avondale Drive; the depth of the well was not provided. The residence was connected to the public water supply in August 1991.

ATSDR calculated estimated exposure doses for the maximum concentration (10 ppb) found off site in residential wells. The acute (14 days or less) oral MRL for PCE is 0.05 mg/kg/day (ATSDR 1997c). Intermediate- and chronic-duration oral MRLs have not been derived. The estimated ingestion doses based on the maximum concentration detected in residential wells are 0.0003 mg/kg/day for adults and 0.0006 mg/kg/day for children. Both doses are below the acute MRL. The acute oral MRL is not very appropriate because it is for exposures of 14 days or less. Wells have been contaminated longer than this, and exposures are assumed to have been also longer. A chronic reference dose (RfD), which is appropriate for chronic exposures, calculated by the USEPA is equal to 0.01 mg/kg/day. The estimated exposure doses are two orders of magnitude lower than the RfD and as a result, adverse health effects would not be expected.

LOAELs in humans for intermediate and chronic exposure also do not exist. NOAELs and LOAELs have been determined in animal studies for intermediate and chronic exposures. For intermediate exposures, a study of Sprague-Dawley rats showed increased kidney/body weight ratios when the rats were exposed to concentrations of PCE at 400mg/kg/day for 90 days (Hayes 1986). No effects on the kidneys were observed at a dose of 14 mg/kg/day (NOAEL). Chronic-duration oral studies in animals have not identified NOAELs or less serious LOAELs at doses below those causing decreased survival of rats and mice (NCI 1977).

ATSDR calculated estimated inhalation exposure doses for adults and children by using the 10 ppb concentration. An intermediate duration inhalation MRL has not been derived because of inadequate data. The chronic-duration inhalation MRL for PCE is equal to 0.04 ppm (ATSDR 1997c). This level is four times greater than that found in the residential wells, and adverse health effects would not be expected to occur.

The MRL was derived from a study in which women were exposed to PCE at an average concentration of 15 ppm for an average period of 10 years (Ferroni et al 1992). Significantly prolonged reaction times were observed in the women. Another study did not reveal any effects on neurological function among fourteen persons who lived above or next to dry cleaning facilities for 1-30 years. A median air concentration of 0.2 ppm was detected in the apartments of the exposed individuals. Because no adverse health effects were noted among these individuals, the 0.2 ppm concentration is considered a NOAEL. The LOAEL in humans exposed to PCE occurred in an occupational setting where the worker had been exposed to 10 ppm for 14 years (Franchini et al 1983). The worker experienced increased urinary levels of lysozyme and beta-glucuronidase, suggestive of mild renal tubular damage (Franchini et al 1983).

Very little information is available regarding human dermal exposure to PCE. The information that is available indicates that adverse dermal/ocular effects can occur in humans exposed to moderate concentrations. In a study by Wayne and Orcutt, volunteers were exposed to vapors of PCE at 5 or 20 ppm, and no appreciable eye irritation resulted from the exposure (Wayne 1960). Intense ocular irritation has been reported in humans after acute exposure to PCE vapor at concentrations greater than 1,000 ppm (Carpenter 1937; Rowe et al 1952). The concentrations in these studies are in the ppm range, whereas the contaminant levels in wells around BNL are in the ppb range (1000 times lower).

No studies were located regarding cancer in humans after oral and dermal exposure to PCE. No documentation has been found of carcinogenic effects in exposed workers. The International Agency for Research on Cancer (IARC) classifies PCE as probably carcinogenic and the

National Toxicology Program (NTP), within the National Institutes of Health, classifies PCE as reasonably anticipated to be carcinogenic. However, no cancer slope factor has been assigned to PCE. A number of epidemiology studies have been conducted of dry cleaning and laundry workers exposed to PCE via inhalation. Many of these studies are complicated by potential exposure to other petroleum products. The only investigation of dry cleaning workers with no known exposure to petroleum solvents was a retrospective mortality study of a sub-cohort of workers employed in shops where PCE was the primary solvent (Brown 1987). Excess risk for cancer at any site was not identified in this sub-cohort. Other studies were inconclusive because workers were also exposed to petroleum solvents and other dry cleaning agents, and factors such as smoking and alcohol consumption were not considered in the analyses.

4.1.7 1,1-Dichloroethane (1,1-DCA)

1,1-DCA is a colorless, oily, man-made liquid. It can also be found in the environment as a breakdown product of 1,1,1-TCA in landfills where oxygen does not come in contact with the 1,1,1-TCA. 1,1-DCA is used to dissolve other substances, such as paint, varnish and finish removers, and to remove grease. In 1989, 1,1-DCA was detected in a residential well on Carleton Drive at 8 ppb. No other residential wells contained 1,1-DCA above the MCL of 5 ppb.

Very little information is available on the health effects of 1,1-DCA in animals or humans. The limited available animal data indicate it is less toxic than its isomer, 1,2-dichloroethane (Bruckner 1989). Studies of animals (mice) that ingested 1,1-DCA on a chronic basis indicated that adverse effects did not appear at doses lower than 475 mg/kg/day (NCI 1977). One study indicated body weight depression during a sub-chronic exposure scenario. Other studies have not provided any conclusive evidence of adverse toxic effects associated with oral exposure to 1,1-DCA. Based on a potential drinking water exposure concentration of 8 ppb, the estimated ingestion doses of 1,1-DCA would be 0.00023 mg/kg/day for adults and 0.0008 mg/kg/day for children. These exposure doses are several orders of magnitude lower than the lowest effects levels (LOAELs) documented in ATSDR's toxicological profile (ATSDR, 1990). Therefore, adverse health effects associated with ingesting the maximum concentration would not be expected to cause adverse health effects.

No studies were found regarding humans exposed to 1,1-DCA through ingestion or inhalation. Because of the limited information on the ingestion or inhalation of 1,1-DCA, no MRLs have been derived for these routes of exposure. A study performed with cats exposed to 1,1-DCA at 500 ppm for 13 weeks, 6 hours/day, for 5 days/week showed no adverse effects in the hematological, hepatic, or renal systems. In the same study, a decreased body weight was noted at the 1,000 ppm level. No studies were identified regarding adverse health effects in animals or humans after dermal exposure to 1,1-DCA. In the past, it was used as an anesthetic, but it was discontinued after the discovery that it induced cardiac arrhythmias in humans at doses of 26,000 ppm.

Evidence concerning 1,1-DCA carcinogenicity in humans is inconclusive. The USEPA has classified 1,1-DCA as a Class C chemical, a possible human carcinogen (IRIS 1990). USEPA has not derived an oral slope factor for 1,1-DCA. There have been no documented cases of individuals developing cancer when exposed to levels of 1,1-DCA similar to those found in private wells around BNL.

4.1.8 Carbon Tetrachloride

Carbon tetrachloride is a clear liquid that evaporates very rapidly. In the past, carbon tetrachloride was widely used as a cleaning fluid. Dry cleaning establishments and industries used it as a degreasing agent, and in households it was used as a spot remover for clothing, furniture, and carpeting. Most of these uses discontinued in the mid-1960s. It was used as a pesticide until 1986 (ATSDR 1994a). Carbon tetrachloride has not been detected in residential wells. The past detections of carbon tetrachloride in off-site monitoring wells occurred at depths greater than 140 feet (see Table MW3) and modeling has indicated that the maximum concentrations of carbon tetrachloride are at depths greater than 160 feet. These observations are significant because residential wells in the area are not believed to draw water from these depths. Accordingly, ATSDR concludes that potential exposures to carbon tetrachloride are not a public health hazard. Please see the following paragraphs for a summary of toxicity on carbon tetrachloride.

The intermediate MRL was calculated by use of a NOAEL of 1 mg/kg/day, based on the absence of detected adverse hepatic effects in rats (Bruckner 1986). Slightly elevated blood levels of sorbitol dehydrogenase and centrilobular vacuolation of the liver were observed at a LOAEL of 10 mg/kg/day, but not at 1 mg/kg/day. No adverse health effects have been documented in humans exposed orally to levels of carbon tetrachloride below 40 mg/kg/day (ATSDR 1994a).

Acute and intermediate MRLs have been derived for inhalation exposure to carbon tetrachloride. The acute MRL is equal to 0.2 ppm, and the intermediate MRL is 0.05 ppm (ATSDR 1994a). The intermediate MRL was calculated by use of a NOAEL of 5 ppm, based on the absence of liver effects in rats (Adams 1952). Fatty degeneration was evident at concentrations of 10 ppm, and cirrhosis occurred at 50 ppm. A NOAEL of 10 ppm for acute exposures in humans based on a LOAEL of 50 ppm exists (ATSDR 1994a). For intermediate exposures, a LOAEL of 20 ppm exists. Both the NOAEL and the LOAEL for intermediate exposure are greater than the estimated exposure dose(s) of less than 1 ppm.

Very little information exists for dermal exposure in animals. The available information on human dermal exposure to carbon tetrachloride is not sufficient to determine the adverse health effects people might encounter if exposed to the levels found around BNL. Again, carbon tetrachloride was not detected in any of the residential wells.

IARC has classified carbon tetrachloride as possibly carcinogenic to humans, and USEPA has determined that it is a probable human carcinogen. Two studies located reported the occurrence of liver cancer in humans exposed to carbon tetrachloride fumes; however, the evidence was not strong enough to establish a cause-and-effect relationship. No studies were identified regarding carcinogenic effects in humans following oral or dermal exposure to carbon tetrachloride.

4.1.9 Mercury

Mercury occurs naturally in the environment and can exist in various forms depending on the conditions of the environment. The most common organic compound that microorganisms and natural processes generate from other forms is methylmercury. Methylmercury is of particular concern because it can bioaccumulate (i.e., build up) in certain edible freshwater and saltwater fish and marine mammals to levels that are many times greater than levels in the surrounding water. Mercury is deposited primarily in the muscle tissue of fish, rather than in fatty tissue.

Thus unlike PCBs, dioxins, and other organochlorine pesticides, trimming and skinning of mercury contaminated fish does not reduce the mercury content of the fillet (Armbuster et al 1988; Gutenmann and Lisk 1991).

The maximum mercury concentration was found in the chain pickerel on site at 3.72 mg/kg. Concentrations were lower in fish sampled off site. The maximum concentration found in fish off site was in a large mouth bass at 0.914 mg/kg. The Food and Drug Administration (FDA) recommends that regular consumption of fish species with methylmercury levels around 1 ppm be limited to approximately 7 ounces per week; for fish with levels averaging 0.5 ppm, the limit is about 14 ounces per week (FDA 1996).

As stated, fishing on BNL property is not permitted, and sampling has indicated the fish on site are too small to be legally kept for consumption. Fish are able to migrate on site and off site easily, but there are times throughout the year that the river goes dry. During these periods the on-site fish are confined to the on-site portion of the river. On-site fish populations have declined considerably the past few years because of drought conditions and over-sampling. Off-site sampling has indicated that the mercury levels are right at or below the action level of 1 ppm. Estimated exposure doses of mercury for residents and anglers ingesting fish caught from the Peconic River are below ATSDR's minimal risk levels. ATSDR recommends people comply with the fish advisory that is in place to ensure that a safe amount of fish are eaten and thereby limiting their exposure to contaminants in fish.

4.2 Health Outcome Data Evaluation

A major concern among residents of Long Island, New York is the elevated rates of breast cancer in New York compared with other states in the northeastern United States and with the country as a whole. Breast cancer is the most common type of cancer diagnosed among women nationally (National Cancer Institute (NCI)), as well as in New York State (New York State Cancer Registry). According to the American Cancer Society, aging and having a family history of breast cancer account for only about a quarter of breast cancer cases. A number of other factors may be associated with the other 75% of breast cancer cases. These include age at menarche, age at first child birth, age at menopause, the practice of breast-feeding, country of birth, alcohol consumption, access to health care, and various environmental factors.

ATSDR staff reviewed several studies regarding breast cancer in the northeastern United States. A study conducted by the NCI looked at demographic data and age-specific breast cancer mortality rates for women in 11 northeastern states and the District of Columbia for 1988-1992. Results indicated that the increased breast cancer mortality on Long Island was statistically significant and that the increase was not confined to this area but extended into parts of New Jersey and Philadelphia. The New York City-Philadelphia metropolitan area had a 7.4 percent excess compared with the rest of the Northeast, which in turn had a 12.4 percent excess compared to the rest of the country (Kulldorff et al 1997).

Increased age at menarche, decreased age at menopause, the practice of breast feeding, and younger age at first full-term pregnancy have been shown to reduce the risk of breast cancer (John, Kelsey 1993). Researchers in this study did not have information regarding local variation within the Northeast to determine if these factors contributed to the elevated rates in the Northeast. Other studies have indicated that age at first full-term pregnancy is greater in the

Northeast than in the rest of the country and that this may affect the elevated mortality rates, but researchers did not have a more local distribution, which might explain some of the excess in the New York-Philadelphia area (Blot et al 1977).

Approximately 0.5% of U.S. women have a genetic mutation that increases their risk of developing breast cancer and results in 5 percent of all cases (Baker and Freedman 1995). The occurrence of one of the mutations has been observed mostly in Ashkenazi Jews, who reside in significant numbers in and around New York City (Struewing et al 1995). This may account for some of the increase in breast cancer cases.

Exposure to environmental contaminants has also been suggested as a potential factor in increased rates. A case-control study was conducted in Connecticut from 1994 to 1997 to investigate the relationship between exposure to the organochlorinated compounds dichlorodiphenyldichloroethane (DDE) and dichlorodiphenyltrichloroethane (DDT) and the incidence of breast cancer (Zheng et al 1999). Adipose tissue was collected from the cases (women who had breast cancer) as well as the controls (women who did not have breast cancer) to determine if the levels of DDE and DDT in the tissues were significantly different. The age-adjusted geometric mean tissue levels of DDE and DDT were similar between the two groups. A study conducted in Europe revealed a significant inverse association between the adipose tissue level of DDE and breast cancer risk (van't Veer et al 1997). This study indicated that as DDE levels increased, the risk of breast cancer decreased.

Intense concern among residents led to federal legislation under which the National Cancer Institute initiated a group of epidemiological studies known as The Long Island Breast Cancer Study Project (LIBCSP). The LIBCSP, the result of Public Law 103-43, was to determine whether certain environmental contaminants increased the risk of breast cancer among women in Nassau and Suffolk counties on Long Island. Researchers from the LIBCSP concentrated their research on organochlorine compounds, including the pesticide DDT, its metabolite DDE, and polychlorinated biphenyls (PCBs). This study is one of the largest and most comprehensive environmental epidemiologic studies ever done for breast cancer. Results from the study project indicated no increased rate of breast cancer among women who may have been exposed to organochlorine compounds or PCBs (Gammon 2002).

ATSDR looked at health outcome data for cancers of the liver, prostate, brain and other nervous system, and thyroid, as well as for Non-Hodgkin's lymphomas, multiple myelomas, and leukemias, and found that none of them were elevated in Suffolk County compared with the neighboring Nassau County or the state of New York. ATSDR used the age-adjusted rates with 95% confidence intervals provided by the New York State Cancer Registry within the New York State Department of Health (NYSDOH 1999). A study conducted by the Brookhaven National Laboratory Task Force incorporated a 15-mile radius around BNL to compare rates and similar findings, but these studies have shown no increase in cancer levels within the 15-mile radius compared with outside the 15 miles (BNLETF 1998). Correlations between plume and wind directions with cancer incident cases were investigated, but no correlations were noted.

4.2.1 Worker Study

At the request of the Department of Energy, a study was conducted by the New York State Cancer Registry in 1999-2000. The study compared cancer rates among former and current BNL

workers with those of residents of New York State. Cancer cases diagnosed from 1979-1996 were used in the analysis. This time period was used because cancer cases that were diagnosed prior to 1979 were no longer on the active Cancer Registry database, and the reporting of cancer cases diagnosed after 1996 was incomplete. To control for possible regional variations in the distribution of cancer, the New York State Cancer Registry used three separate comparison populations in the analysis: New York State exclusive of New York City, Nassau County, and Suffolk County.

The study revealed a proportionate deficit of respiratory cancers among BNL employees compared to what would be expected. The study population (cohort) was mainly composed of men (73%), and as a result the majority of the observed cancers occurred in men. The overall distribution of cancers in this cohort did not deviate significantly from what was expected. Also, radiosensitive solid cancers were not proportionately elevated compared to the same cancers in the control population (Schymura 2001).

5 Community Health Concerns and Evaluation

Evaluation of community health concerns assists in determining whether people who live or work near BNL are experiencing specific health effects. Information from the public also helps ATSDR determine how people might have been or might be exposed to hazardous substances in the environment. Throughout the public health assessment process, ATSDR staff members talk with people living or working at or near the site about their site-related health concerns. The community that surrounds BNL includes the townships of East Yaphank, Manorville, and Yaphank. The health-related concerns that these communities have expressed regarding BNL include adverse health effects such as cancer or non-cancerous effects. Other concerns are also discussed below.

Members of the community surrounding BNL are concerned that emissions from the lab could result in exposures that may lead to someone developing a disease or cancer. A major concern is the high rate of breast cancer on the eastern end of Long Island. Several research projects, including the Long Island Breast Cancer Study Project, have been undertaken by various universities to determine what the cause(s) of the high rates are associated with. Because the concern for breast cancer is so great, ATSDR has reviewed the research and presented the results in this health assessment.

5.1 Breast Cancer

Although most breast cancers are diagnosed in women, breast cancer does occur very rarely in men. However, the following discussion pertains only to female breast cancer, because there is limited information on risk factors for male breast cancer. Breast cancer is the most common cancer diagnosed in women, the second leading cause of cancer deaths in women, and the leading cause of death in women between 40 and 55 years of age. The number of newly diagnosed breast cancer cases rose by 4% per year during the 1980s, but the increase has since leveled off. Although a variety of factors have been associated with an increased risk for breast cancer, it is important to note that some people who get breast cancer do not have any of these risk factors (ACS 1999). Also, some people who have some or all of these risk factors do not get cancer.

Sex can be considered a risk factor, because women are 100 times more likely to develop breast cancer than men. The risk of developing breast cancer increases with age. Whites tend to develop breast cancer at a higher rate than African-Americans, but African-American women are more likely to die from the disease. Asian and Hispanic women have lower rates of this disease than do African-American women. Other risk factors are a family history of breast cancer, therapeutic irradiation of the chest area, and alcohol abuse. Factors associated with a slightly increased risk are early age of first menstruation or late age of menopause, use of oral contraceptives, late age (more than 30 years of age) of first childbirth or not having children, and estrogen replacement therapy. Genetics is thought to play a role in an estimated 5% to 10% of breast cancer cases (ACS 1999). Numerous inconclusive studies have evaluated the association between breast cancer and various other risk factors, such as having a child but not breast-feeding, consuming a diet high in animal fat, obesity, and a low level of physical activity.

Whether an association exists between exposures to certain environmental contaminants, called endocrine disruptors, and breast cancer is a subject of much controversy in the scientific community. Endocrine disruptors are so named because of their ability to behave like hormones and other substances that occur naturally in the body and in some foods. Once taken into the body, these chemicals alter the function (e.g., by increasing or decreasing the response) of the endocrine system, and they may cause adverse effects on an organism or its offspring (NIOSH 1998). Within the category of endocrine disruptors, much attention has been given to two widely spread contaminants, polychlorinated biphenyls (PCBs) and the banned insecticide DDT and its metabolite, DDE. Some scientists believe that these chemicals contribute to the development of breast cancer in humans, because they have been found to mimic the activity of the hormone estrogen in laboratory experiments (Feigelson et al. 1996; Rudel 1997). In these experiments, the contaminants bind to the estrogen receptors of breast cells grown in vitro (in a test tube), causing the cells to divide and grow continuously, which is a common feature of cancerous cells. Other scientists point to evidence of endocrine disruption in certain wildlife populations exposed to these chemicals in the environment (Soto 1998). Still other scientists not convinced that these chemicals contribute significantly to breast cancer development in humans, point out that human health studies have failed to show a definite association between occupational or environmental exposure to endocrine disruptors and an increase in the risk of developing breast cancer (Davidson 1998; Datson et al. 1997; Safe 1997). Almost all scientists, however, agree that more studies are needed on how diet (Schildkraut et al. 1999; Verma et al. 1998), genetics (Moysich et al. 1998), and environmental exposures may together affect an individual's risk for this disease.

USEPA's Office of Prevention, Pesticides and Toxic Substances has an Endocrine Disruptor Screening and Testing Advisory Committee (EDSTAC) that is responsible for selecting chemicals for screening as to potential endocrine effects. EDSTAC provides a method for screening chemicals for their potential for endocrine disruption, which is an area of significant ongoing research (USEPA 2000). For more information, please see the EDSTAC home page available on the Internet at: <http://www.epa.gov/scipoly/oscpendo/edspoverview/edstac.htm>.

Other concerns expressed by the community include the following:

- If the water is not contaminated, why are they (BNL) offering residents to be hooked up to the public water supply?

The levels of contamination in residential wells are not at levels that are known to cause adverse health effects in humans. The extent of some of the plumes and the depths of residential wells is uncertain. Because of this uncertainty, ATSDR believes that in the interest of public health it is safer to obtain water from a source area that has not been affected by the contamination from BNL or other facilities and that is monitored regularly. Because on-site remedial actions will take years to get groundwater contaminants below drinking water standards, and because off-site remedial actions have only recently been initiated, ATSDR believes that it is “safer” to provide to the residents a source area of water that is known not to have been contaminated from BNL or from other facilities in the area, rather than assume that all wells that could be affected already have been. Also, wells that have not been contaminated could potentially become so in the future.

- If you are using BNL’s data, how do you know it is reliable?

In preparing this public health assessment, ATSDR relied on the information provided in the referenced documents. The agency assumes that adequate quality assurance and quality control measures were followed with regard to chain-of-custody, laboratory procedures, and data reporting. The validity of analyses and conclusions drawn for this public health assessment depends on the completeness and reliability of the referenced information.

Specifically, the data available in the remedial investigation reports have gone through quality assurance and quality control procedures to assure that the data have met appropriate data quality objectives. The data in these reports have been reviewed by EPA, and the final validated results meet all appropriate EPA requirements for the site investigation reports. Various field quality control samples such as trip blanks, field blanks, and field duplicates were collected from the different media (soil, surface water, groundwater) sampled. The data collected are validated and checked for accuracy, sensitivity, precision, representative quality, and completeness. Screening concentrations for inorganic compounds, organic compounds, pesticides and polychlorinated biphenyls, and radiologicals are used for each type of media sampled. The screening criteria are based on applicable requirements that are promulgated under federal or state laws that specifically address a hazardous substance, a remedial action, or other circumstance at a hazardous waste site. Others are based upon relevant and appropriate requirements that are also promulgated under federal or state law not applicable to a hazardous substance, a remedial action, or other circumstance at a hazardous waste site, but that address situations similar to those encountered and that are well suited for use at the hazardous waste site.

In the past, BNL has had problems with some of the work and analyses provided by some of its contractors. BNL used several contractors within a short time frame during 1984-1986 to analyze sample media. Also, some of the data that were generated in the past were not developed by a certified laboratory. For example, in 1985, potable well water samples were analyzed only once by a certified laboratory. BNL was analyzing some of the samples, but at the time BNL was not certified to do the analysis on the potable well water samples. ATSDR had only one round of potable well water sample results from 1985 completed by a certified laboratory on which to base any conclusions. The results from BNL were used only to do a comparison with the certified results. Because the results did not significantly differ from either the non-certified and certified laboratory, ATSDR used all the results.

In June 1996, radium-226 was found at concentrations above 3 pCi/L in 6 of the 83 on-site monitoring wells, and a maximum concentration of 130 pCi/L was found in an off-site monitoring well (ITC 1997). The range of radium-226 in on-site monitoring wells was 17.9 pCi/L-77.3 pCi/L (ITC 1997). In ATSDR's groundwater health consultation, dated September 29, 1997, ATSDR recommended resampling the well containing the 130 pCi/L level. BNL sampled the monitoring well to confirm the 130 pCi/L level by a more specific analytical method. ATSDR received the resampling results and wrote an addendum to the September 29, 1997 version. The original result appears to have been an anomaly or interference from another radionuclide. ATSDR has recommended that BNL use more specific methods to analyze its samples. For example, ATSDR recommends that the radon emanation method be used in conjunction with the gamma spectroscopy scan when elevated or inconsistent gamma levels are detected.

- What made you question the elevated radium-226 reading?

The elevated reading was questioned because no other readings off site were consistent with this reading, and the highest concentration on site was about half the off-site reading. The rest of the groundwater contaminants were much higher on site than they were off site. That the elevated radium-226 reading was off site caught ATSDR's attention. After a more specific method was used for analyzing the sample, it was evident that the first reading was an anomaly or the result of interference from another radionuclide.

- Are there multiple contaminants in the wells that have been found to be contaminated?

Yes. None of the wells, however, contained all the chemical contaminants. The monitoring results from the residential wells indicated that none of the wells had more than one contaminant above their respective drinking water standard, except for two of the wells that were affected by the leaking underground storage tank at a nearby gasoline station, which was not BNL-related. The people using these wells were provided with a filter to place on their taps (one resident) or they were provided an alternate source of water (bottled water). The residents were then offered hookups to the public water supply.

- How do we know the wells were not contaminated prior to the sampling?

ATSDR used groundwater models to reconstruct expected levels prior to sampling. Modeling of the various plumes indicates that five of the eight plumes had not reached areas of potential off-site exposure before 1987. Two plumes had reached areas of potential off-site exposure between 1977 and 1980. The Precision Concepts plume reached the residential wells within 5 years after source introduction into the aquifer. For further clarification, please see the section "ATSDR's modeling of the groundwater plumes."

The majority of BNL potable well water samples were collected at the well head prior to the water going to the water filtration/treatment plant. At the water treatment plant, the water was being treated for elevated levels of iron. Very few samples were collected from the tap, which is where employees would have been exposed to the contaminated water. Most likely, because the water was being treated prior to being distributed to the tap (point of exposure), the concentrations of VOCs would have been much lower than the concentrations in the samples

taken at the well head. In the few tap samples collected, the concentrations of contaminants were not at levels that would cause adverse health effects.

- Is the evaporation from the recharge basin hazardous?

The levels of tritium in the recharged water have been below the MCL. Air was monitored for tritium at the HFBR pump and recharge system basin. The level of tritium evaporated would not be high enough to cause adverse effects unless someone lived within a few feet of the recharge basin.

Community members were concerned about the air emissions from the lab and requested ATSDR to write a consultation regarding the emissions. ATSDR began writing the health consultation and found a large data gap for emissions from the reactors from the time the lab started operation (1947) through 1961. In addition there was a gap from 1967 through 1970. Apparently monitoring had been done, but an environmental report was not published for those years.

BNL staff went back through old log books and compiled emissions monitoring results for the different reactors. The reports “Radiological Emissions and Environmental Monitoring for Brookhaven National Laboratory, 1948 – 1961” and “Radiological Environmental Monitoring Report for Brookhaven National Laboratory 1967-1970” were the result of their efforts.

ATSDR has analyzed the monitoring results and addressed the concerns of the community in section 3.2.1.

6 Conclusions

ATSDR categorized exposures to the different environmental media as follows:

1. Soil No health hazard
2. Groundwater Not expected to harm people's health
3. Air Not expected to harm people's health
4. Surface Water Not expected to harm people's health
5. Biota Not expected to harm people's health
6. Sediment Not expected to harm people's health

Soils: On-site soils are contaminated in several areas, and those areas are currently undergoing remediation or already have been remediated. Those areas that are undergoing remediation are either fenced off, or the contaminants are buried beneath the surface of the soil, as is the case with the Brookhaven Graphite Research Reactor (BGRR). With the exception of the workers removing the contaminated soils, no one is expected to be exposed to the contaminated soil. Workers are aware of the contamination and are trained in removing the contaminated soil. Adequate protective clothing is required during the removal of the contaminated soil.

Groundwater:

○ *On-site potable wells:* Some of the Brookhaven National Laboratory (BNL) potable supply wells were previously found to be contaminated with 1,1,1-trichloroethane (1,1, 1-TCA) and other volatile organic compounds. These wells were either taken out of service or had activated carbon filters installed to remove the contamination. The contamination levels that have been reported to date, including those reported before the wells were taken out of service, are not expected to result in any adverse health effects.

○ *Off-site private wells:* Radiological contaminants have been evaluated in hundreds of drinking water samples collected from off-site locations, but the resulting levels have never been above drinking water standards.

Past conditions: No sampling data are available to assess off-site migration of groundwater contamination in years prior to 1985. Thus, ATSDR conducted a modeling study to assess the potential exposures that could have resulted prior to 1985. Depending on the specific plume and residential well location, exposure to several plumes could have occurred 5 to 7 years before initial detection in 1985. However, limited data on depths of off-site private wells indicate that the zones of highest contaminant concentration were likely deeper than the screened well depths, so that actual exposures were expected to be much lower than potential exposures based on lateral plume migration. Therefore, ATSDR determined that potential exposures to groundwater contaminants in off-site private wells would not pose a public health hazard.

Current conditions: Non-radiological contaminants were sampled for in off-site private wells in the areas of North Shirley, Shirley, East Yaphank, and Manorville. In a small portion of private wells located in close proximity to BNL's southern property line, the levels of VOCs and a pesticide were detected above federal and New York state drinking water standards. Owners of these wells were either provided an alternate water supply

(bottled water) or a carbon filter was installed to remove the contaminants. Moreover, DOE as a precautionary measure, offered approximately 1,500 residents living south of the laboratory free hookups to the public water supply. Only seven residents declined, but DOE offered these residents free annual testing of their water to ensure that their drinking water meets federal and state standards.

Anticipated future conditions: The potential for future exposures to groundwater contaminants originating from BNL has been eliminated for those residents who hooked up to the public water supply. Ongoing monitoring requirements and remedial actions will help ensure that the plumes do not migrate toward any active off-site private wells or toward the public water supply itself. The public water supply is routinely sampled and has not been affected by BNL contamination.

Air:

ATSDR believes that past air releases are not expected to harm people's health. Although the releases appear to be quite large, the resulting doses are relatively small with respect to doses known to cause observable adverse health effects. The combined estimated doses for the years with the highest releases from BNL is less than ATSDR's lifetime radiogenic cancer comparison value of 5,000 mrem over 70 years and therefore is not expected to cause any observable or detectable adverse health effects.

Surface water, sediments, and fish:

The Peconic River is contaminated with arsenic, cadmium, lead, manganese, thallium, mercury, and PCBs. Contaminant concentrations are higher in on-site portions of the Peconic River compared to off-site locations. The contaminant levels detected in off-site surface waters and sediments do not present a public health hazard due to the low levels measured and the infrequent contact that occurs with these environmental media.

Mercury concentrations in some of the on-site fish are above the FDA action level; however on-site fishing is not permitted and the river runs dry periodically throughout the year. Off-site fish samples have mercury concentrations below the action level. Estimated exposure doses of mercury for residents and anglers ingesting fish caught from the Peconic River are lower than ATSDR's minimal risk level.

Residents should read and follow the fish advisory instituted by the NYSDOH for fresh waters of Long Island. Contaminated sediments in the on-site portion and off-site portion of the Peconic River were removed in the summer and fall of 2004. Sampling to confirm the removal of contaminants has been completed, and the areas are currently being restored with native plants.

Deer:

Deer sampling confirmed the presence of potassium-40, strontium-90, and cesium-137. The estimated effective dose equivalent (EDE) from consuming contaminated deer meat is 7.1 millirems (mrem). This is lower than the national average EDE (10 mrem) from eating foods containing naturally occurring radionuclides. Adverse health effects would not be expected from the consumption of deer meat.

7 Recommendations

DOE should continue to sample the wells of the seven residents who declined the public water hookup to determine whether the contaminant plumes are affecting the wells in these areas. If any of the seven wells are found to contain contaminants at levels above drinking water standards in the future, residents should immediately cease using the wells and DOE should provide alternative water sources to those individuals until the private well data are found to meet drinking water standards. The residents should also consult with SCDHS about their water quality.

As a prudent public health measure, any resident in East Yaphank, Shirley, and Manorville townships who plans to use a private well(s) should first have their well tested for contamination. SCDHS provides water testing services to county residents, although residents are responsible for the costs associated with sample collection and lab analysis. Residents should cease using their well(s) if the water quality does not meet drinking water standards.

As required in the Record of Decision for Operable Unit V, DOE should continue to sample sediments, surface water, and fish in on-site and off-site portions of the Peconic River to ensure that recent remedial actions have effectively removed the contaminants.

Anglers and residents who fish in the Peconic are encouraged to abide by the guidelines set forth in the New York State Department of Health's statewide fish advisory, which recommends limiting intake of fish caught from the state's fresh waters to no more than one meal per week. A copy of the most current fish advisory can be viewed on the Internet at <http://www.health.state.ny.us/environmental/outdoors/fish/docs/fish.pdf>.

8 Public Health Action Plan

The Public Health Action Plan (PHAP) for the Brookhaven National Laboratory (BNL) site contains a description of actions taken and those to be taken by ATSDR, the Suffolk County Department of Health Services, the U.S. Environmental Protection Agency, and the New York Department of Environmental Conservation at and in the vicinity of the site after the completion of this PHA. The purpose of the PHAP is to ensure that this PHA not only identifies public health hazards, but also provides a plan of action designed to mitigate and prevent adverse human health effects resulting from exposure to hazardous substances in the environment. The public health actions that are completed, being implemented, or planned are as follows:

8.1 Completed Actions

Because several off-site private wells contained levels of volatile organic compounds above the federal and state regulatory limits and because of the uncertainty of the depths of many of the private wells, the Department of Energy (DOE), as a precautionary measure, offered connections to the public water supply to well owners living in a defined area. The area is bounded to the south by Sunrise Highway, to the north by Carleton Drive and North Street, to the east by Wading River Road, and to the west by River Road (BNL 1996d). Figure 3 in Appendix B details the hookup areas. Because ethylene dibromide (EDB) was detected on and off site, the DOE and the Suffolk County Water Authority also offered to provide public water to private well owners on South Street between Rosewood Drive and North Street, on the northern portion

of Woodland Avenue, on North Street north of the Long Island Expressway to the Long Island Railroad tracks, on North Weeks Avenue, on Weeks Avenue from North Street to just south of Victoria Lane, and on Douglas Lane and Calendar Road off Weeks Avenue (BNL 1996e).

The closest downgradient public water supply well field providing water to these areas is approximately two miles southeast of the contaminant plumes and has not been impacted by the contaminant plumes. Monitoring wells are north of the water supply well field and will detect any potential contamination before it reaches the well field. DOE offered the free public water hookups and the Suffolk County Water Authority connected approximately 1,500 residences and commercial properties to the public water supply.

A large network of groundwater monitoring wells is in place both on and off site. Characterization of the plumes is complete. A groundwater extraction and treatment system was implemented for the HWMF and Current Landfill contaminant plumes in December 1996. In addition, a hydraulic containment and treatment system was installed to prevent additional off-site migration and to remove the volatile organic compounds to levels below drinking water standards. Currently there are seven monitoring wells adjacent to the Former Landfill in up-gradient and down-gradient locations, and these are monitored on a quarterly basis. Similarly, a network of eleven monitoring wells surrounds the Current Landfill, and these are also monitored on a quarterly basis.

DOE has conducted several soil monitoring events to characterize the nature and extent of contamination in soil at the site and in the vicinity. The Current Landfill was capped in 1995, and the Former Landfill was capped in 1996. Capping of the landfills will help to prevent water from percolating into the contaminated soil and prevent further migration of contaminants into the groundwater. The Chemical/Glass Holes and the Animal Pits were remediated during the summer of 1997. The soil and debris were removed and shipped off site to a licensed hazardous waste facility.

Remedial actions to remove contaminated sediments have recently been completed in the off-site portions of the Peconic River. On-site areas A-D of the Peconic River have been excavated, regraded and restored as of September 2004. Area E restoration was completed in April 2005 (BNL 2005b).

BNL has completed numerous remedial actions in fulfilling the requirements stated in the Record of Decision. The site chronology in Appendix E identifies some of the activities, and readers interested in more detailed information on these completed actions should refer to BNL's Final Five-Year Review Report, which should be available from local records repositories and is also available online (see: http://www.bnl.gov/erd/5_yr_rev.asp).

8.2 Ongoing Actions

Remedial actions have been ongoing for a number of years. BNL, under oversight by EPA and the New York State Department of Environmental Conservation, continues to implement the remedial actions required in the respective Records of Decision. These remedial actions are being conducted to meet health protective cleanup goals for different environmental media and future land use scenarios. Specific information on cleanup activities at the various contaminated

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areas can be found in documents placed at the records repositories or the fore-mentioned web site.

9 Contributors

The Brookhaven National Laboratory Public Health Assessment was prepared with input from many persons. The contributors have different expertise that includes hydrogeology, toxicology, health physics, and environmental health science. The ATSDR scientists and editor who contributed to the public health assessment include:

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In addition to the references listed above, ATSDR reviewed numerous documents to evaluate the levels of environmental contamination measured on and around BNL since 1999. These additional documents include the following:

- BNL Site Environmental Reports and Groundwater Status reports through 2005.
- BNL's Final Five-Year Review Report (July 2006).
- BNL's Baseline Human Health Risk Assessment for the Peconic River (March 2003).
- SCDHS's Health and Environmental Assessment for the Peconic River (May 2004).
- Magothy Aquifer Characterization Report (May 2004), prepared by BNL contractors.

Appendix A. ATSDR Plain Language Glossary of Environmental Health Terms

Absorption

The process of taking in. For a person or animal, absorption is the process of a substance getting into the body through the eyes, skin, stomach, intestines, or lungs.

Acute

Occurring over a short time [compare with chronic].

Acute exposure

Contact with a substance that occurs once or for only a short time (up to 14 days) [compare with intermediate duration exposure and chronic exposure].

Additive effect

A biologic response to exposure to multiple substances that equals the sum of responses of all the individual substances added together [compare with antagonistic effect and synergistic effect].

Adverse health effect

A change in body function or cell structure that might lead to disease or health problems.

Aerobic

Requiring oxygen [compare with anaerobic].

Ambient

Surrounding (for example, ambient air).

Anaerobic

Requiring the absence of oxygen [compare with aerobic].

Analyte

A substance measured in the laboratory. A chemical for which a sample (such as water, air, or blood) is tested in a laboratory. For example, if the analyte is mercury, the laboratory test will determine the amount of mercury in the sample.

Analytic epidemiologic study
A study that evaluates the association between exposure to hazardous substances and disease by testing scientific hypotheses.

Antagonistic effect

A biologic response to exposure to multiple substances that is less than would be expected if the known effects of the individual substances were added together [compare with additive effect and synergistic effect].

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Background level

An average or expected amount of a substance or radioactive material in a specific environment, or typical amounts of substances that occur naturally in an environment.

Biodegradation

Decomposition or breakdown of a substance through the action of microorganisms (such as bacteria or fungi) or other natural physical processes (such as sunlight).

Biologic indicators of exposure study

A study that uses (a) biomedical testing or (b) the measurement of a substance [an analyte], its metabolite, or another marker of exposure in human body fluids or tissues to confirm human exposure to a hazardous substance [also see exposure investigation].

Biologic monitoring

Measuring hazardous substances in biologic materials (such as blood, hair, urine, or breath) to determine whether exposure has occurred. A blood test for lead is an example of biologic monitoring.

Biologic uptake

The transfer of substances from the environment to plants, animals, and humans.

Biomedical testing

Testing of persons to find out whether a change in a body function might have occurred because of exposure to a hazardous substance.

Biota

Plants and animals in an environment. Some of these plants and animals might be sources of food, clothing, or medicines for people.

Body burden

The total amount of a substance in the body. Some substances build up in the body because they are stored in fat or bone or because they leave the body very slowly.

CAP

See Community Assistance Panel.

Cancer

Any one of a group of diseases that occurs when cells in the body become abnormal and grow or multiply out of control.

Cancer risk

A theoretical risk of for getting cancer if exposed to a substance every day for 70 years (a lifetime exposure). The true risk might be lower.

Carcinogen

A substance that causes cancer.

Case study

A medical or epidemiologic evaluation of one person or a small group of people to gather information about specific health conditions and past exposures.

Case-control study

A study that compares exposures of people who have a disease or condition (cases) with people who do not have the disease or condition (controls). Exposures that are more common among the cases may be considered as possible risk factors for the disease.

CAS registry number

A unique number assigned to a substance or mixture by the American Chemical Society Abstracts Service.

Central nervous system

The part of the nervous system that consists of the brain and the spinal cord.

CERCLA [see Comprehensive Environmental Response, Compensation, and Liability Act of 1980]

Chronic

Occurring over a long time (more than 1 year) [compare with acute].

Chronic exposure

Contact with a substance that occurs over a long time (more than 1 year) [compare with acute exposure and intermediate duration exposure].

Cluster investigation

A review of an unusual number, real or perceived, of health events (for example, reports of cancer) grouped together in time and location. Cluster investigations are designed to confirm case reports; determine whether they represent an unusual disease occurrence; and, if possible, explore possible causes and contributing environmental factors.

Community Assistance Panel (CAP)

A group of people, from a community and from health and environmental agencies, who work with ATSDR to resolve issues and problems related to hazardous substances in the community. CAP members work with ATSDR to gather and review community health concerns, provide information on how people might have been or might now be exposed to hazardous substances, and inform ATSDR on ways to involve the community in its activities.

Comparison value (CV)

Calculated concentration of a substance in air, water, food, or soil that is unlikely to cause harmful (adverse) health effects in exposed people. The CV is used as a screening level during the public health assessment process. Substances found in amounts greater than their CVs might be selected for further evaluation in the public health assessment process.

Completed exposure pathway [see exposure pathway].

Comprehensive Environmental Response, Compensation, and Liability Act of 1980 (CERCLA)

CERCLA, also known as Superfund, is the federal law that concerns the removal or cleanup of hazardous substances in the environment and at hazardous waste sites. ATSDR, which was created by CERCLA, is responsible for assessing health issues and supporting public health activities related to hazardous waste sites or other environmental releases of hazardous substances.

Concentration

The amount of a substance present in a certain amount of soil, water, air, food, blood, hair, urine, breath, or any other media.

Contaminant

A substance that is either present in an environment where it does not belong or is present at levels that might cause harmful (adverse) health effects.

Delayed health effect

A disease or injury that happens as a result of exposures that might have occurred in the past.

Dermal

Referring to the skin. For example, dermal absorption means passing through the skin.

Dermal contact

Contact with (touching) the skin [see route of exposure].

Descriptive epidemiology

The study of the amount and distribution of a disease in a specified population by person, place, and time.

Detection limit

The lowest concentration of a chemical that can reliably be distinguished from a zero concentration.

Disease prevention

Measures used to prevent a disease or reduce its severity.

Disease registry

A system of ongoing registration of all cases of a particular disease or health condition in a defined population.

DOD

United States Department of Defense.

DOE

United States Department of Energy.

Dose (for chemicals that are not radioactive)

The amount of a substance to which a person is exposed over some time period. Dose is a measurement of exposure. Dose is often expressed as milligram (amount) per kilogram (a measure of body weight) per day (a measure of time) when people eat or drink contaminated water, food, or soil. In general, the greater the dose, the greater the likelihood of an effect. An Aexposure dose@ is how much of a substance is encountered in the environment. An Aabsorbed dose@ is the amount of a substance that actually got into the body through the eyes, skin, stomach, intestines, or lungs.

Dose (for radioactive chemicals)

The radiation dose is the amount of energy from radiation that is actually absorbed by the body. This is not the same as measurements of the amount of radiation in the environment.

Dose-response relationship

The relationship between the amount of exposure [dose] to a substance and the resulting changes in body function or health (response).

Environmental media

Soil, water, air, biota (plants and animals), or any other parts of the environment that can contain contaminants.

Environmental media and transport mechanism

Environmental media include water, air, soil, and biota (plants and animals). Transport mechanisms move contaminants from the source to points where human exposure can occur. The environmental media and transport mechanism is the second part of an exposure pathway.

USEPA

United States Environmental Protection Agency.

Epidemiologic surveillance

The ongoing, systematic collection, analysis, and interpretation of health data. This activity also involves timely dissemination of the data and use for public health programs.

Epidemiology

The study of the distribution and determinants of disease or health status in a population; the study of the occurrence and causes of health effects in humans.

Exposure

Contact with a substance by swallowing, breathing, or touching the skin or eyes. Exposure may be short-term [acute exposure], of intermediate duration, or long-term [chronic exposure].

Exposure assessment

The process of finding out how people come into contact with a hazardous substance, how often and for how long they are in contact with the substance, and how much of the substance they are in contact with.

Exposure-dose reconstruction

A method of estimating the amount of people's past exposure to hazardous substances. Computer and approximation methods are used when past information is limited, not available, or missing.

Exposure investigation

The collection and analysis of site-specific information and biologic tests (when appropriate) to determine whether people have been exposed to hazardous substances.

Exposure pathway

The route a substance takes from its source (where it began) to its end point (where it ends), and how people can come into contact with (or get exposed to) it. An exposure pathway has five parts: a source of contamination (such as an abandoned business); an environmental media and transport mechanism (such as movement through groundwater); a point of exposure (such as a private well); a route of exposure (eating, drinking, breathing, or touching), and a receptor population (people potentially or actually exposed). When all five parts are present, the exposure pathway is termed a completed exposure pathway.

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Exposure registry

A system of ongoing followup of people who have had documented environmental exposures.

Feasibility study

A study by USEPA to determine the best way to clean up environmental contamination. A number of factors are considered, including health risk, costs, and what methods will work well.

Geographic information system (GIS)

A mapping system that uses computers to collect, store, manipulate, analyze, and display data. For example, GIS can show the concentration of a contaminant within a community in relation to points of reference such as streets and homes.

Grand rounds

Training sessions for physicians and other health care providers about health topics.

Groundwater

Water beneath the earth's surface in the spaces between soil particles and between rock surfaces [compare with surface water].

Half-life (t_2)

The time it takes for half the original amount of a substance to disappear. In the environment, the half-life is the time it takes for half the original amount of a substance to disappear when it is changed to another chemical by bacteria, fungi, sunlight, or other chemical processes. In the human body, the half-life is the time it takes for half the original amount of the substance to disappear, either by being changed to another substance or by leaving the body. In the case of radioactive material, the half life is the amount of time necessary for one half the initial number of radioactive atoms to change or transform into another atom (that is normally not radioactive). After two half lives, 25% of the original number of radioactive atoms remain.

Hazard

A source of potential harm from past, current, or future exposures.

Hazardous Substance Release and Health Effects Database (HazDat)

The scientific and administrative database system developed by ATSDR to manage data collection, retrieval, and analysis of site-specific information on hazardous substances, community health concerns, and public health activities.

Hazardous waste

Potentially harmful substances that have been released or discarded into the environment.

Health consultation

A review of available information or collection of new data to respond to a specific health question or request for information about a potential environmental hazard. Health consultations are focused on a specific exposure issue. Health consultations are therefore more limited than a

public health assessment, which reviews the exposure potential of each pathway and chemical [compare with public health assessment].

Health education

Programs designed with a community to help it know about health risks and how to reduce these risks.

Health investigation

The collection and evaluation of information about the health of community residents. This information is used to describe or count the occurrence of a disease, symptom, or clinical measure and to estimate the possible association between the occurrence and exposure to hazardous substances.

Health promotion

The process of enabling people to increase control over, and to improve, their health.

Health statistics review

The analysis of existing health information (i.e., from death certificates, birth defects registries, and cancer registries) to determine if there is excess disease in a specific population, geographic area, and time period. A health statistics review is a descriptive epidemiologic study.

Indeterminate public health hazard

The category used in ATSDR's public health assessment documents when a professional judgment about the level of health hazard cannot be made because information critical to such a decision is lacking.

Incidence

The number of new cases of disease in a defined population over a specific time period [contrast with prevalence].

Ingestion

The act of swallowing something through eating, drinking, or mouthing objects. A hazardous substance can enter the body this way [see route of exposure].

Inhalation

The act of breathing. A hazardous substance can enter the body this way [see route of exposure].

Intermediate duration exposure

Contact with a substance that occurs for more than 14 days and less than a year [compare with acute exposure and chronic exposure].

In vitro
In an artificial environment outside a living organism or body. For example, some toxicity testing is done on cell cultures or slices of tissue grown in the laboratory, rather than on a living animal [compare with in vivo].

In vivo

Within a living organism or body. For example, some toxicity testing is done on whole animals, such as rats or mice [compare with in vitro].

Lowest-observed-adverse-effect level (LOAEL)

The lowest tested dose of a substance that has been reported to cause harmful (adverse) health effects in people or animals.

Medical monitoring

A set of medical tests and physical exams specifically designed to evaluate whether an individual's exposure could negatively affect that person's health.

Metabolism

The conversion or breakdown of a substance from one form to another by a living organism.

Metabolite

Any product of metabolism.

Mg/kg

Milligram per kilogram.

Mg/cm²

Milligram per square centimeter (of a surface).

Mg/m³

Milligram per cubic meter; a measure of the concentration of a chemical in a known volume (a cubic meter) of air, soil, or water.

Migration

Moving from one location to another.

Minimal risk level (MRL)

An ATSDR estimate of daily human exposure to a hazardous substance at or below which that substance is unlikely to pose a measurable risk of harmful (adverse), noncancerous effects. MRLs are calculated for a route of exposure (inhalation or oral) over a specified time period (acute, intermediate, or chronic). MRLs should not be used as predictors of harmful (adverse) health effects [see reference dose].

Morbidity

State of being ill or diseased. Morbidity is the occurrence of a disease or condition that alters health and quality of life.

Mortality

Death. Usually the cause (a specific disease, condition, or injury) is stated.

Mutagen

A substance that causes mutations (genetic damage).

Mutation

A change (damage) to the DNA, genes, or chromosomes of living organisms.

National Priorities List for Uncontrolled Hazardous Waste Sites (National Priorities List or NPL)

USEPA's list of the most serious uncontrolled or abandoned hazardous waste sites in the United States. The NPL is updated on a regular basis.

No apparent public health hazard

A category used in ATSDR's public health assessments for sites where human exposure to contaminated media might be occurring, might have occurred in the past, or might occur in the future, but where the exposure is not expected to cause any harmful health effects.

No-observed-adverse-effect level (NOAEL)

The highest tested dose of a substance that has been reported to have no harmful (adverse) health effects on people or animals.

No public health hazard

A category used in ATSDR's public health assessment documents for sites where people have never and will never come into contact with harmful amounts of site-related substances.

NPL [see National Priorities List for Uncontrolled Hazardous Waste Sites]

Physiologically based pharmacokinetic model (PBPK model)

A computer model that describes what happens to a chemical in the body. This model describes how the chemical gets into the body, where it goes in the body, how it is changed by the body, and how it leaves the body.

Pica

A craving to eat nonfood items, such as dirt, paint chips, and clay. Some children exhibit pica-related behavior.

Plume

A volume of a substance that moves from its source to places farther away from the source. Plumes can be described by the volume of air or water they occupy and the direction they move. For example, a plume can be a column of smoke from a chimney or a substance moving with groundwater.

Point of exposure

The place where someone can come into contact with a substance present in the environment [see exposure pathway].

Population

A group or number of people living within a specified area or sharing similar characteristics (such as occupation or age).

Potentially responsible party (PRP)

A company, government, or person legally responsible for cleaning up the pollution at a hazardous waste site under Superfund. There may be more than one PRP for a particular site.

Ppb

Parts per billion.

Ppm

Parts per million.

Prevalence

The number of existing disease cases in a defined population during a specific time period [contrast with incidence].

Prevalence survey

The measure of the current level of disease(s) or symptoms and exposures through a questionnaire that collects self-reported information from a defined population.

Prevention

Actions that reduce exposure or other risks, keep people from getting sick, or keep disease from getting worse.

Public comment period

An opportunity for the public to comment on agency findings or proposed activities contained in draft reports or documents. The public comment period is a limited time period during which comments will be accepted.

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Public availability session

An informal, drop-by meeting at which community members can meet one-on-one with ATSDR staff members to discuss health and site-related concerns.

Public health action

A list of steps to protect public health.

Public health advisory

A statement made by ATSDR to USEPA or a state regulatory agency that a release of hazardous substances poses an immediate threat to human health. The advisory includes recommended measures to reduce exposure and reduce the threat to human health.

Public health assessment (PHA)

An ATSDR document that examines hazardous substances, health outcomes, and community concerns at a hazardous waste site to determine whether people could be harmed from coming into contact with those substances. The PHA also lists actions that need to be taken to protect public health [compare with health consultation].

Public health hazard

A category used in ATSDR's public health assessments for sites that pose a public health hazard because of long-term exposures (greater than 1 year) to sufficiently high levels of hazardous substances or radionuclides that could result in harmful health effects.

Public health hazard categories

Public health hazard categories are statements about whether people could be harmed by conditions present at the site in the past, present, or future. One or more hazard categories might be appropriate for each site. The five public health hazard categories are no public health hazard, no apparent public health hazard, indeterminate public health hazard, public health hazard, and urgent public health hazard.

Public health statement

The first chapter of an ATSDR toxicological profile. The public health statement is a summary written in words that are easy to understand. The public health statement explains how people might be exposed to a specific substance and describes the known health effects of that substance.

Public meeting

A public forum with community members for communication about a site.

Radioisotope

An unstable or radioactive isotope (form) of an element that can change into another element by giving off radiation.

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Radionuclide

Any radioactive isotope (form) of any element.

RCRA [See Resource Conservation and Recovery Act (1976, 1984)]

Receptor population

People who could come into contact with hazardous substances [see exposure pathway].

Reference dose (RfD)

An USEPA estimate, with uncertainty or safety factors built in, of the daily lifetime dose of a substance that is unlikely to cause harm in humans.

Registry

A systematic collection of information on persons exposed to a specific substance or having specific diseases [see exposure registry and disease registry].

Remedial Investigation

The CERCLA process of determining the type and extent of hazardous material contamination at a site.

Resource Conservation and Recovery Act (1976, 1984) (RCRA)

This Act regulates management and disposal of hazardous wastes currently generated, treated, stored, disposed of, or distributed.

RFA

RCRA Facility Assessment. An assessment required by RCRA to identify potential and actual releases of hazardous chemicals.

RfD

See reference dose.

Risk

The probability that something will cause injury or harm.

Risk reduction

Actions that can decrease the likelihood that individuals, groups, or communities will experience disease or other health conditions.

Risk communication

The exchange of information to increase understanding of health risks.

Route of exposure

The way people come into contact with a hazardous substance. Three routes of exposure are breathing [inhalation], eating or drinking [ingestion], or contact with the skin [dermal contact].

Safety factor [see uncertainty factor]

SARA [see Superfund Amendments and Reauthorization Act]

Sample

A portion or piece of a whole. A selected subset of a population or subset of whatever is being studied. For example, in a study of people the sample is a number of people chosen from a larger population [see population]. An environmental sample (for example, a small amount of soil or water) might be collected to measure contamination in the environment at a specific location.

Sample size

The number of units chosen from a population or environment.

Solvent

A liquid capable of dissolving or dispersing another substance (for example, acetone or mineral spirits).

Source of contamination

The place where a hazardous substance comes from, such as a landfill, waste pond, incinerator, storage tank, or drum. A source of contamination is the first part of an exposure pathway.

Special populations

People who might be more sensitive or susceptible to exposure to hazardous substances because of factors such as age, occupation, sex, or behaviors (for example, cigarette smoking). Children, pregnant women, and older people are often considered special populations.

Stakeholder

A person, group, or community who has an interest in activities at a hazardous waste site.

Statistics

A branch of mathematics that deals with collecting, reviewing, summarizing, and interpreting data or information. Statistics are used to determine whether differences between study groups are meaningful.

Substance

A chemical.

Substance-specific applied research

A program of research designed to fill important data needs for specific hazardous substances identified in ATSDR's toxicological profiles. Filling these data needs would allow more accurate assessment of human risks from specific substances contaminating the environment. This research might include human studies or laboratory experiments to determine health effects resulting from exposure to a given hazardous substance.

Superfund Amendments and Reauthorization Act (SARA)

In 1986, SARA amended CERCLA and expanded the health-related responsibilities of ATSDR. CERCLA and SARA direct ATSDR to look into the health effects from substance exposures at hazardous waste sites and to perform activities including health education, health studies, surveillance, health consultations, and toxicological profiles.

Surface water

Water on the surface of the earth, such as in lakes, rivers, streams, ponds, and springs [compare with groundwater].

Surveillance [see epidemiologic surveillance]

Survey

A systematic collection of information or data. A survey can be conducted to collect information from a group of people or from the environment. Surveys of a group of people can be conducted by telephone, by mail, or in person. Some surveys are done by interviewing a group of people [see prevalence survey].

Synergistic effect

A biologic response to multiple substances where one substance worsens the effect of another substance. The combined effect of the substances acting together is greater than the sum of the effects of the substances acting by themselves [see additive effect and antagonistic effect].

Teratogen

A substance that causes defects in development between conception and birth. A teratogen is a substance that causes a structural or functional birth defect.

Toxic agent

Chemical or physical (for example, radiation, heat, cold, microwaves) agents which, under certain circumstances of exposure, can cause harmful effects to living organisms.

Toxicological profile

An ATSDR document that examines, summarizes, and interprets information about a hazardous substance to determine harmful levels of exposure and associated health effects. A toxicological profile also identifies significant gaps in knowledge on the substance and describes areas where further research is needed.

Toxicology

The study of the harmful effects of substances on humans or animals.

Tumor

An abnormal mass of tissue that results from excessive cell division that is uncontrolled and progressive. Tumors perform no useful body function. Tumors can be either benign (not cancer) or malignant (cancer).

Uncertainty factor

Mathematical adjustments for reasons of safety when knowledge is incomplete. For example, factors used in the calculation of doses that are not harmful (adverse) to people. These factors are applied to the lowest-observed-adverse-effect-level (LOAEL) or the no-observed-adverse-effect-level (NOAEL) to derive a minimal risk level (MRL). Uncertainty factors are used to account for variations in people's sensitivity, for differences between animals and humans, and for differences between a LOAEL and a NOAEL. Scientists use uncertainty factors when they have some, but not all, the information from animal or human studies to decide whether an exposure will cause harm to people [also sometimes called a safety factor].

Urgent public health hazard

A category used in ATSDR's public health assessments for sites where short-term exposures (less than 1 year) to hazardous substances or conditions could result in harmful health effects that require rapid intervention.

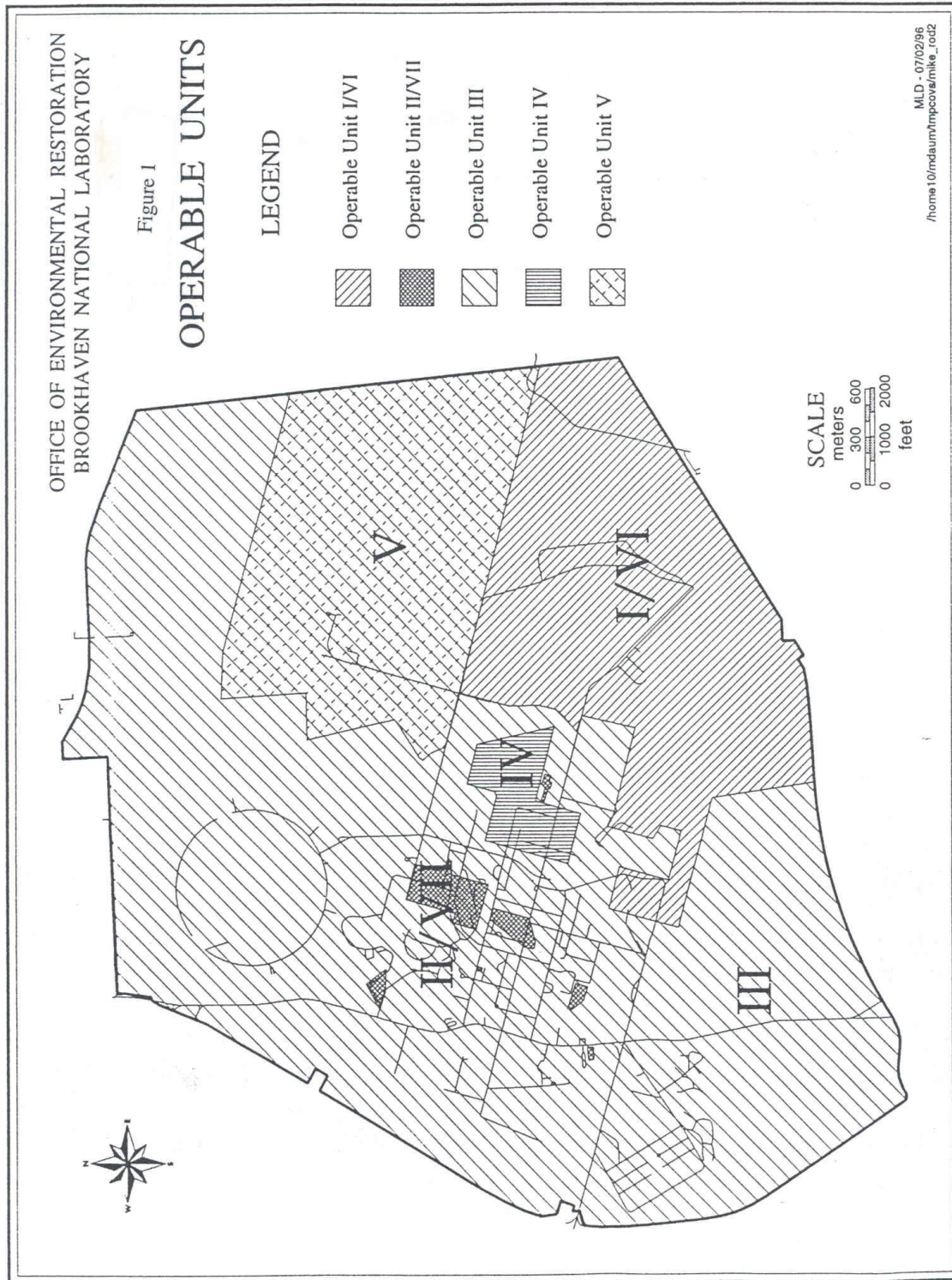
Volatile organic compounds (VOCs)

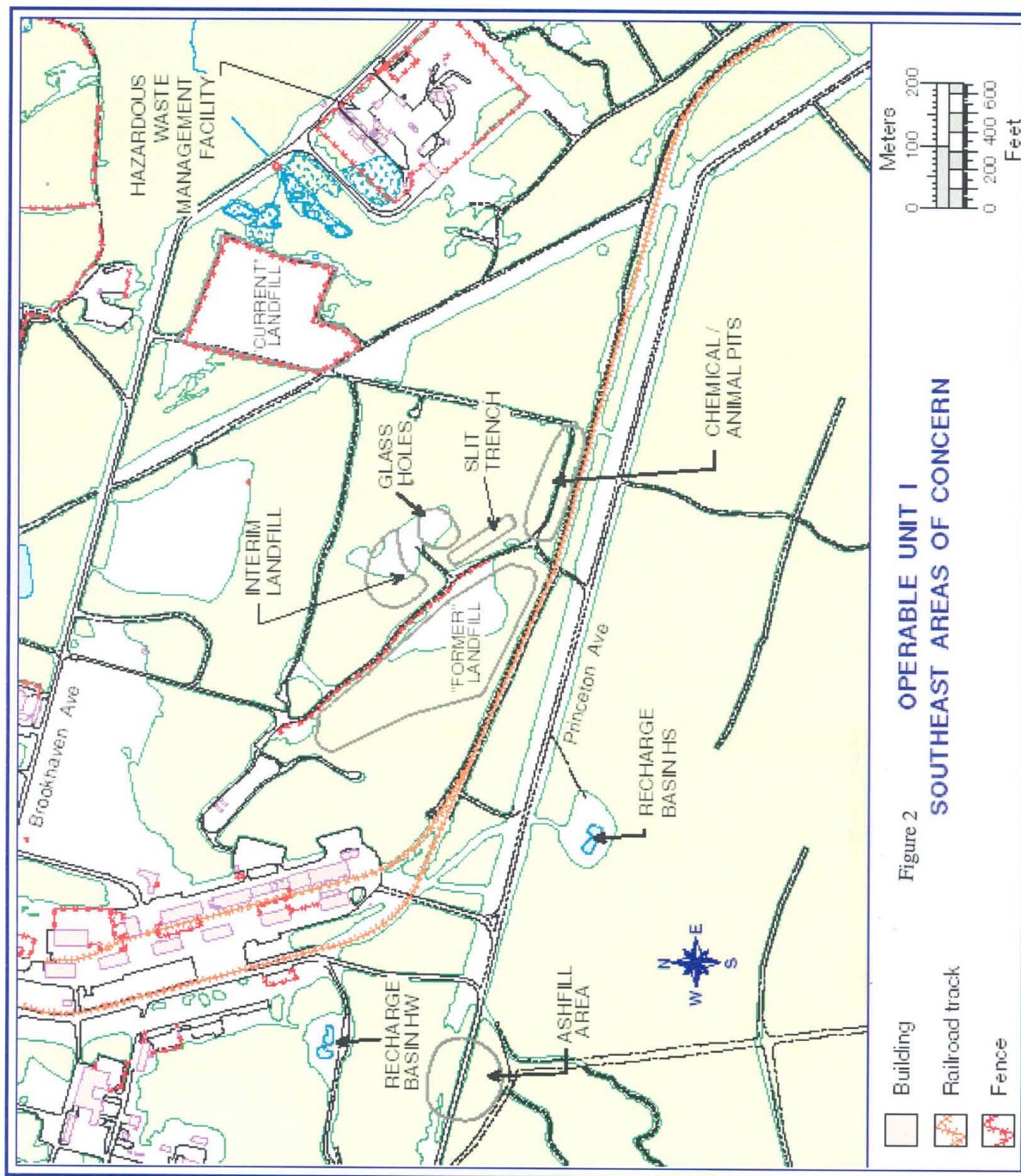
Organic compounds that evaporate readily into the air. VOCs include substances such as benzene, toluene, methylene chloride, and methyl chloroform.

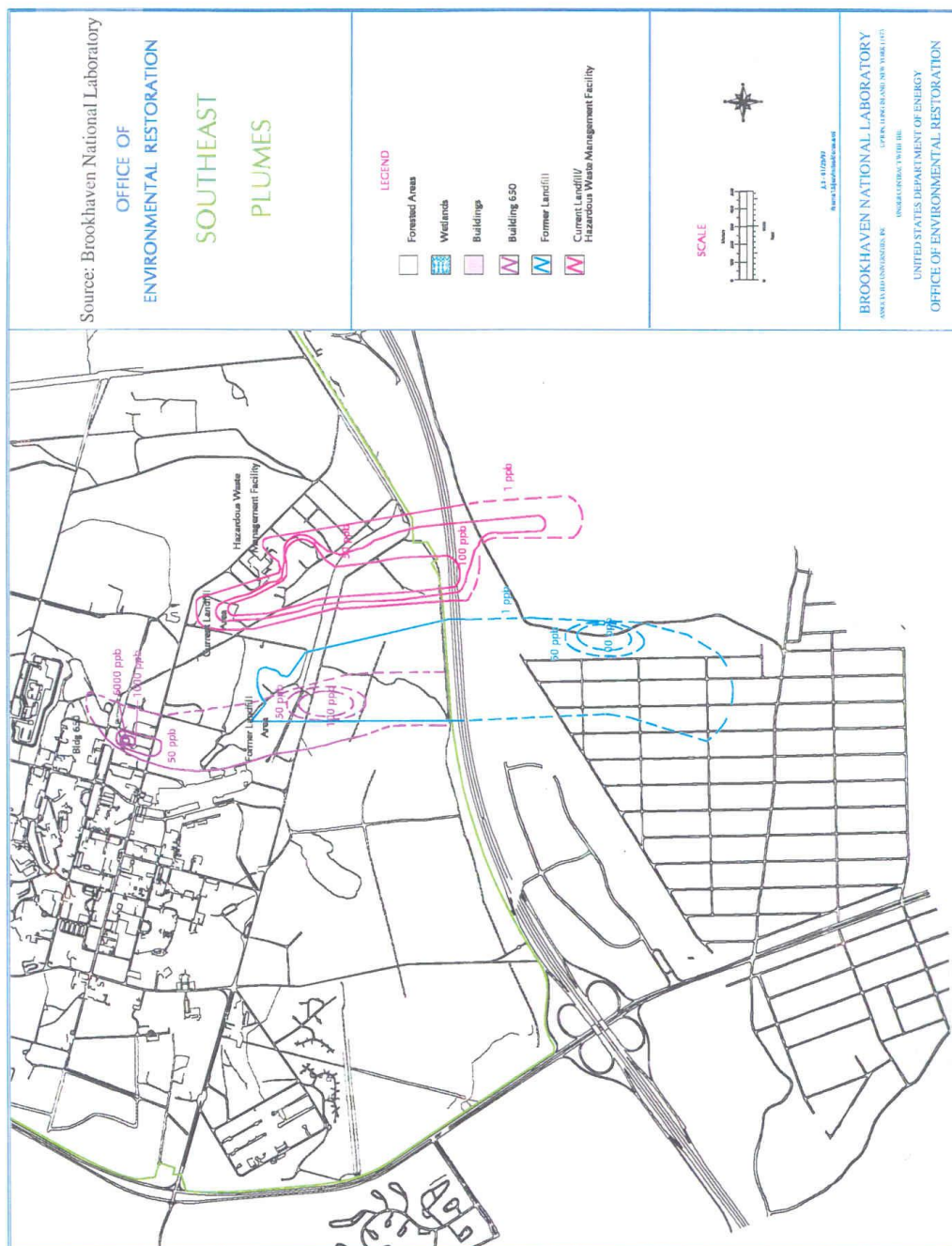
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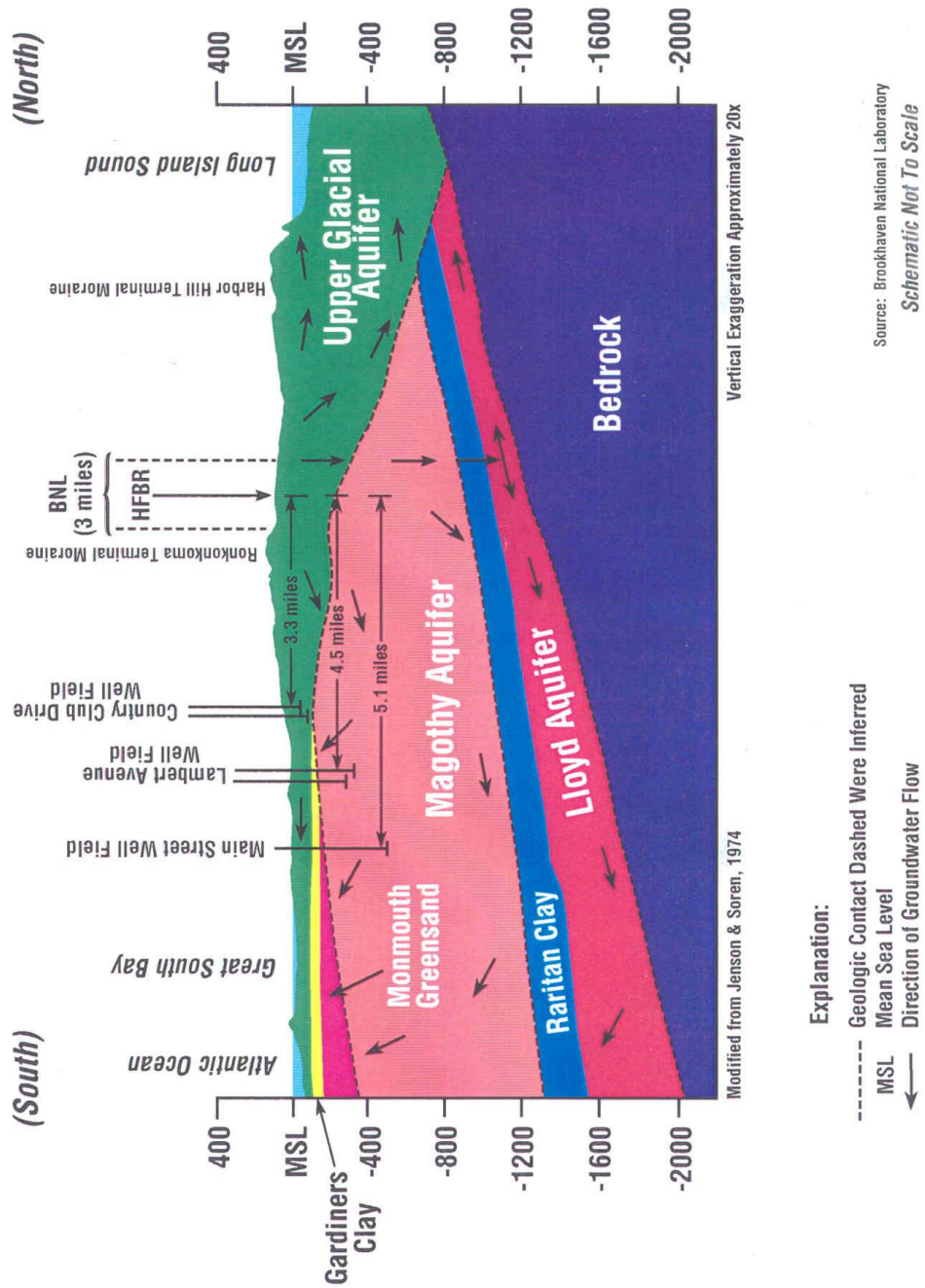
Appendix B. Figures







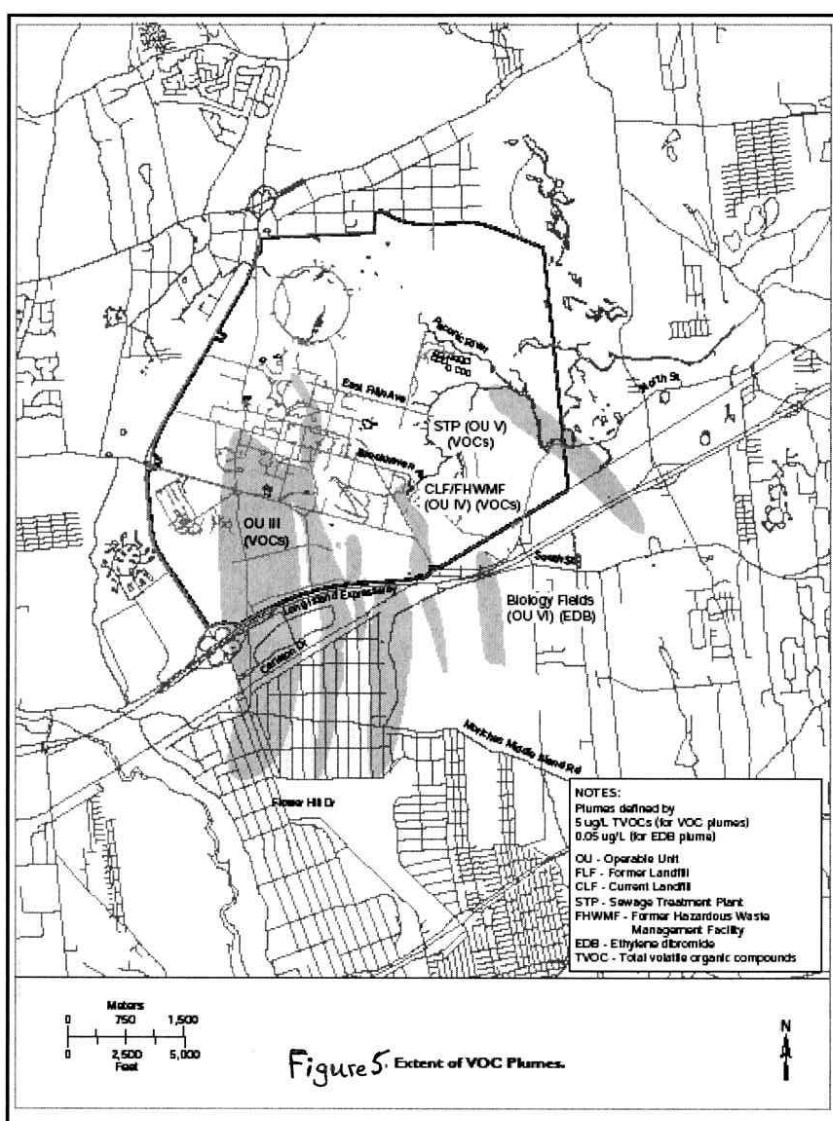
**Figure 4. Generalized Geologic Cross Section in
Vicinity of Brookhaven National Laboratory**



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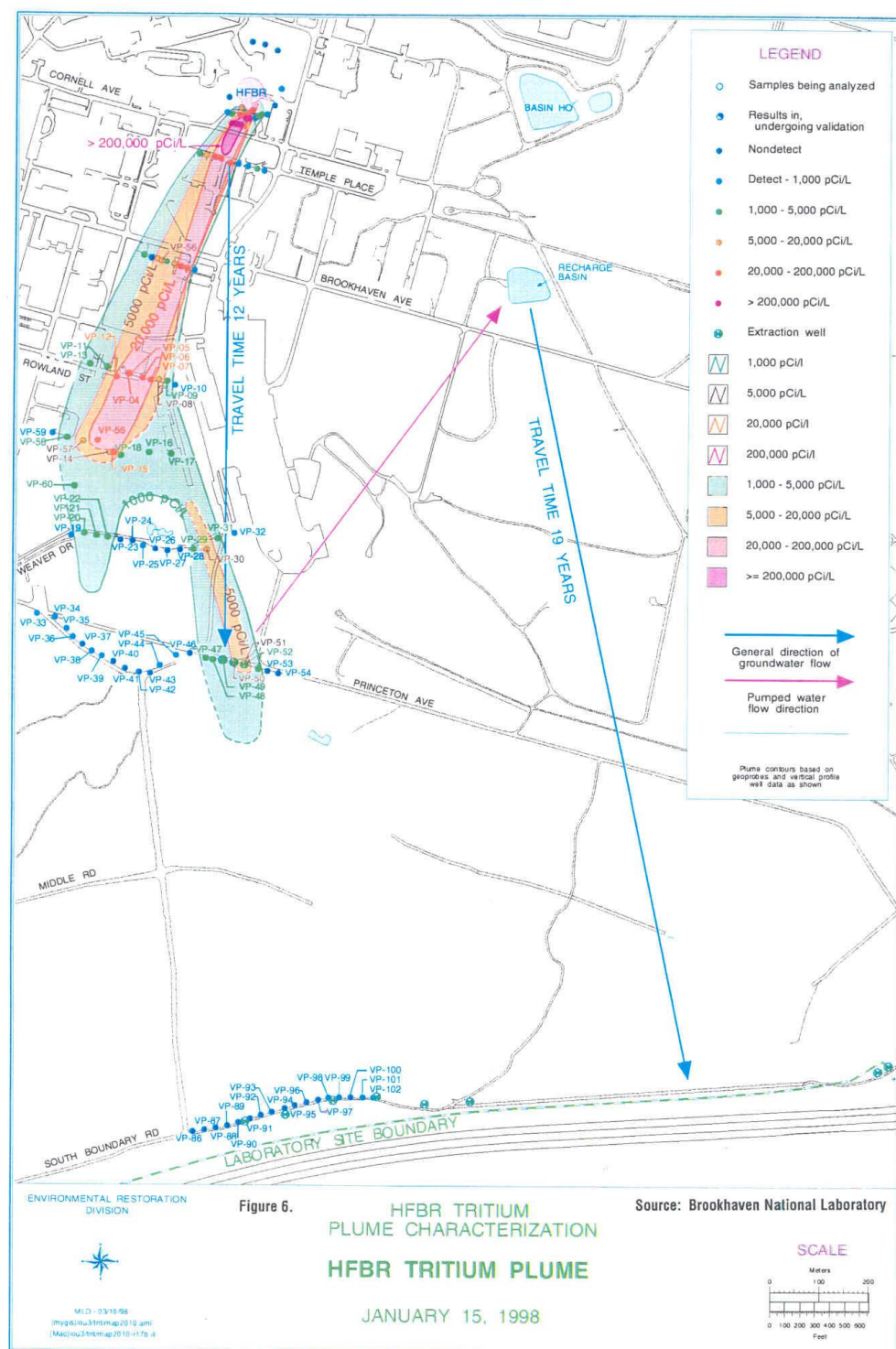


Figure 7. On Site: Potable and Supply Wells and Recharge Sumps



Source: Brookhaven National Laboratory

Brookhaven National Laboratory Effluent Release Points and On-site Environmental Monitoring Stations

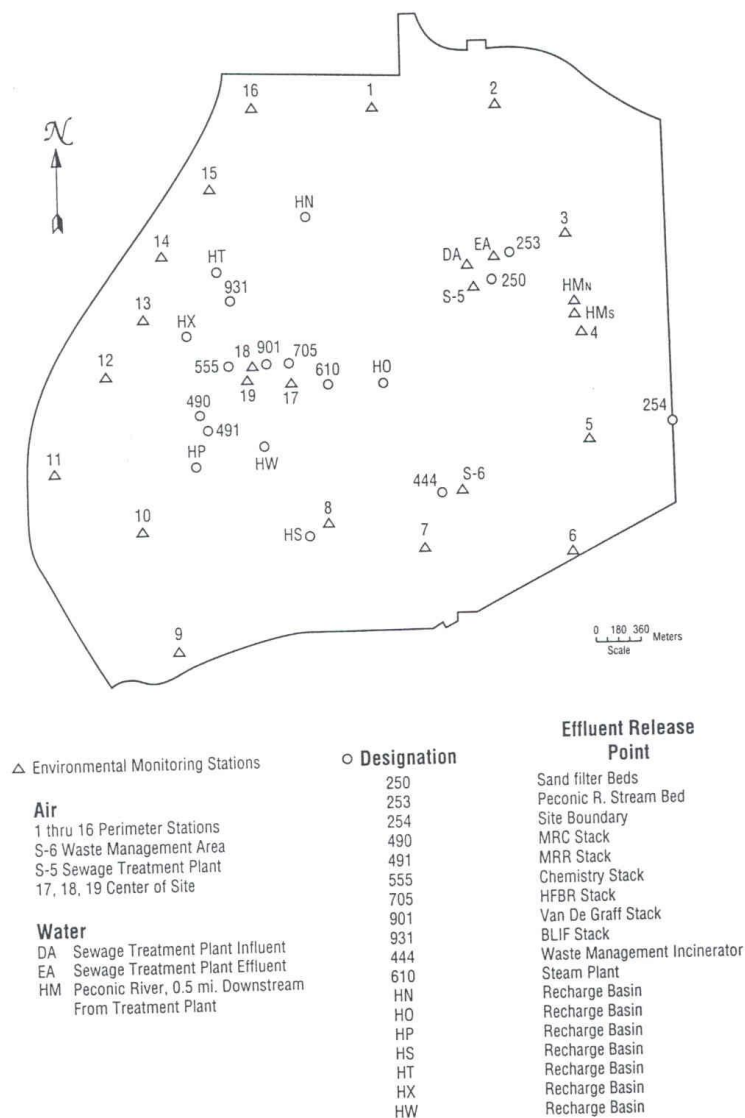
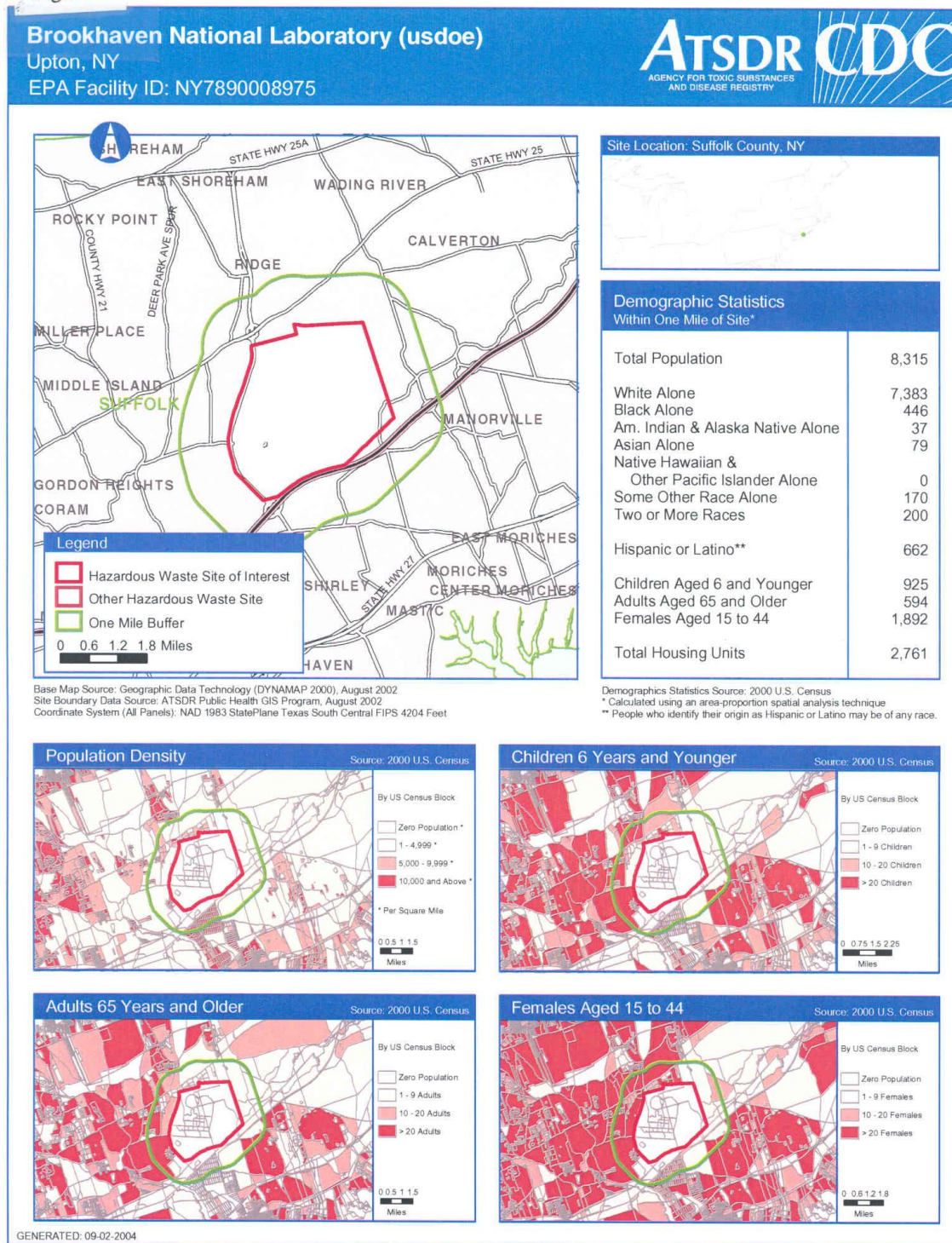


Figure 8

Figure 9



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Appendix C. Tables

Table MW1. On-Site Monitoring Well Contaminants

| <i>Chemical</i> | <i>Concentration Range (ppb)</i> | <i>Depth of Contamination(feet below land surface)</i> | <i>Comparison Value(ppb)</i> |
|----------------------------------|----------------------------------|--|------------------------------|
| Carbon Tetrachloride | ND-179,000 | 120-230 | 5 (USEPA MCL) |
| Chloroform | ND-100 | 80-240 | 80 (USEPA MCL) |
| 1,1-Dichloroethane(1,1-DCA) | ND-870 | 82-225 | 5 (NYS MCL) |
| 1,1-Dichloroethylene(1,1-DCE) | ND-580 | 92-200 | 7 (USEPA MCL) |
| Ethylene Dibromide(EDB) | ND-0.78 | 15-69 | 0.05 (USEPA MCL) |
| Perchloroethylene(PCE) | ND-6,180 | 30-95 | 5 (USEPA MCL) |
| 1,1,1-Trichloroethane(1,1,1-TCA) | ND-1,500 | 150-200 | 5 (NYS MCL)200 (USEPA MCL) |
| Trichloroethylene(TCE) | ND-100 | 126-260 | 5 (USEPA MCL) |

ppb: parts per billion

USEPA MCL: Environmental Protection Agency Maximum Contaminant Level

NYS MCL: New York State Maximum Contaminant Level

ND: Non-detection

Table MW2. Radionuclides in On-Site Monitoring Wells

| <i>Radionuclide</i> | <i>Concentration Range (pCi/L)</i> | <i>Drinking Water Standard (USEPA MCL) (pCi/L)</i> | <i>Location (OU)</i> |
|----------------------------|---|---|-----------------------------|
| Lead-210 | 130–3,340† | 1.2 | 3,5 |
| Strontium-89 | 8–24.2 | 8 | 3 |
| Strontium-90 | 8–769 | 8 | ¼, 3, 5 |
| Tritium | 245–1,590,000 | 20,000 | 1, 3, 5 |
| Potassium-40* | 187–660 | 280 | 3, 5 |
| Radium-226 | 17.9–77.3 | 3 | 3, 4 |

Minimum detection limit for tritium was 245 pCi/L

pCi/L: picocuries per Liter

MCL: Maximum Contaminant Level

OU: Operable Unit

*: Potassium-40 is a naturally occurring radionuclide

†The maximum concentration of lead-210 was noted as being suspect because of the considerable background interference, large error values, and absence of the parent nuclide radium-226.

Table MW3. Contaminants in BNL and Off-Site Suffolk County Department of Health Services Monitoring Wells

| <i>Chemical</i> | <i>Concentration Range (ppb)</i> | <i>Depth of Contamination(feet below land surface)</i> | <i>Comparison Value(ppb)</i> |
|-------------------------------|----------------------------------|--|------------------------------|
| Carbon Tetrachloride | 5–5,100 | 140–290 | 5 (USEPA MCL) |
| Chloroform | 1–113 | 175–185,275–295 | 80 (USEPA MCL)* |
| 1,1-Dichloroethane(1,1-DCA) | 1–65.1 | 125–209 | 5 (NYS MCL) |
| 1,1-Dichloroethylene(1,1-DCE) | 0.6–16 | 125–230 | 7 (MCL) |
| Ethylene Dibromide(EDB) | 0.04–3.5 | 20–70 | 0.05 (USEPA MCL) |
| Perchloroethylene(PCE) | 0.6–1,000 | 205–210 | 5 (USEPA MCL) |
| Trichloroethylene(TCE) | 3–110 | 79–297 | 5 (USEPA MCL) |

ppb: parts per billion

USEPA MCL: Environmental Protection Agency Maximum Contaminant Level

MCL is for total trihalomethanes.

Chloroform is one chemical within the group of trihalomethanes.

NYS MCL: New York State Maximum Contaminant Level

Table SSC. Summary of On-site Surface Soil Contamination

| <i>Chemical</i> | <i>Maximum Concentration (mg/kg)</i> | <i>Comparison Value (mg/kg)</i> | <i>Type</i> | <i>Exceedances/ Detections/ Samples**</i> | <i>Locations of Exceedances</i> |
|-----------------|--------------------------------------|---------------------------------|-------------|---|--|
| Aroclor-1260 | 4.1 | 0.32 | RBC-C | 8 / 32 / 124 | SB16A, SB18A, SB20A, SB23A, SB29A, SB30A, SB44A, B1-06 |
| Arsenic | 28.1 | 20 | CV (C-EMEG) | 1 / 82 / 155 | SB41A |

| <i>Chemical</i> | <i>Maximum Concentration (mg/kg)</i> | <i>Comparison Value (mg/kg)</i> | <i>Type</i> | <i>Exceedances/ Detections/ Samples**</i> | <i>Locations of Exceedances</i> |
|--------------------|--------------------------------------|---------------------------------|--------------------|---|---|
| | | | -child) | | |
| | | 0.43 | RBC-C | 82 / 82 / 155 | CA0101, CA0201, CP0201, CP0301, CP0401, CP0501, CP0601, CP0701, CP0801, CP0901, CP1001, CP1101, CP1201, CP1301, SB16A, SB17A, SB18A, SB19A, SB20A, SB21A, SB22A, SB23A, SB24A, SB25A, SB26A, SB27A, SB28A, SB29A, SB30A, SB31A, SB32A, SB33A, SB34A, SB35A, SB37A, SB38A, SB39A, SB40A, SB41A, SB42A, SB43A, SB44A, SB45A, SB46A, SB47A, SB48A, SB49A, SB50A, SB51A, SB52A, SB53A, SB54A, SB55A, SB58A, SB59A, HPB01, HPB02, MN02, MN03, SB01, SB02, SB03, SB13, SB33, SB35, SB36, SB37, SB38, SB39, SB40, SB41, SB42, SB43, SB45, SB46, SB47, SB48, SB49, SB59, SB60, 7703, 7629 |
| Aroclor-1254 | 1.5 | 1 | CV (C-EMEG -child) | 2 / 27 / 123 | B1-06, B1-08 |
| Benzo(a)anthracene | 7.4 | 0.87 | RBC-C | 8 / 35 / 154 | B1-01, SB28A, SB30A, SB36A, SB09, SB45, SB46, SB49 |

| <i>Chemical</i> | <i>Maximum Concentration (mg/kg)</i> | <i>Comparison Value (mg/kg)</i> | <i>Type</i> | <i>Exceedances/ Detections/ Samples**</i> | <i>Locations of Exceedances</i> |
|---------------------------|--------------------------------------|---------------------------------|-------------|---|--|
| Benzo(a)pyrene | 5.0 | 0.087 | RBC-C | 23 / 30 / 154 | SB17A, SB24A, SB25E, SB27A, SB28A, SB29A, SB30A, SB34A, SB36A, SB46A, SB48A, SB50A, B1-01, MN02, MN03, SB72A, SB09, SB18, SB45, SB46, SB49, SB36, SB37 |
| Benzo(b)-fluoranthene | 9.0 | 0.87 | RBC-C | 11 / 36 / 151 | SB27A, SB28A, SB29A, SB30A, SB36A, B1-01, SB09, SB18, SB45, SB46, SB49 |
| Benzo(g,h,i)-perylene | 2.8 | -- | none | -- / 16 / 153 | (SB30A) |
| 4-Chloro-3-methylphenol | 7.0 | -- | none | -- / 2 / 156 | (SB36A) |
| Endrin ketone | 0.006 | -- | none | -- / 5 / 124 | (SB23A/SB41A) |
| Indeno(1,2,3-cd)-pyrene | 3.5 | 0.87 | RBC-C | 4 / 15 / 149 | SB28A, SB30A, SB36A, SB46 |
| Iron | 43,600 | 23,000 | RBC-N | 8 / 170 / 170 | SB48A, HPB01, HPB02, MN02, MN03, SB01, SB02, SB03 |
| Mercury | 184 | 7.8 | RBC-N* | 8 / 78 / 167 | SB18A, SB20A, SB41A, SB48A, SB53A, A-01, B1-06, B1-08 |
| N-Nitroso-din-propylamine | 2.8 | 0.091 | RBC-C | 2 / 2 / 156 | SB36A, SB56A |
| Phenanthrene | 29.0 | -- | none | -- / 31 / 155 | (SB28A) |

| <i>Chemical</i> | <i>Maximum Concentration (mg/kg)</i> | <i>Comparison Value (mg/kg)</i> | <i>Type</i> | <i>Exceedances/ Detections/ Samples**</i> | <i>Locations of Exceedances</i> |
|-------------------|--------------------------------------|---------------------------------|-------------|---|---------------------------------|
| Trichloroethylene | 0.02 | -- | none | -- / 1 / 156 | (SB38) |

Notes:

Location of maximum detection in bold. If there were no exceedances, maximum location is given in parentheses.

RBC = USEPA Region III Risk-Based Concentration (C = Carcinogenic, N = Non-carcinogenic)

C-EMEG-child = Environmental Media Evaluation Guide for Chronic exposure to a child

* RBC for methylmercury

Table SSR. Summary of Radionuclides in On-site Surface Soils

| Isotope | Maximum Concentration (pCi/g) | Average Concentration* (pCi/g) | Detections / Samples** | Location of Maximum |
|---------------|-------------------------------|--------------------------------|------------------------|---------------------|
| Actinium-228 | 2.9 | 0.99 | 47 / 94 | CP0801 |
| Americium-241 | 5.41 | 1.23 | 24 / 116 | B-SB03-SB01 |
| Bismuth-212 | 1.23 | 0.68 | 4 / 4 | B1-SB16 |
| Bismuth-214 | 2.2 | 0.65 | 63 / 101 | CP0801 |
| Cesium-137 | 810,000 | 12,100 | 149 / 175 | SB37A |
| Cobalt-57 | 0.069 | 0.069 | 1 / 1 | B-GP13 |
| Cobalt-60 | 6.5 | 1.61 | 21 / 114 | SB34, SB50A |
| Gross alpha | 170 | 17.1 | 111 / 115 | SB45 |
| Gross beta | 1,100,000 | 22,000 | 114 / 115 | SB37A |
| Lead-210 | 16 | 2.62 | 13 / 100 | 455Comp |
| Lead-212 | 1.7 | 0.64 | 124 / 143 | CA0201 |

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| Isotope | Maximum Concentration (pCi/g) | Average Concentration* (pCi/g) | Detections / Samples** | Location of Maximum |
|--------------|-------------------------------|--------------------------------|------------------------|---------------------|
| Lead-214 | 2 | 0.62 | 97 / 129 | CP1001 |
| Potassium-40 | 12 | 6.86 | 145 / 154 | SB76, SB35A |
| Radium-224 | 5.83 | 2.2 | 5 / 5 | B-GP09 |
| Radium-226 | 0.63 | 0.34 | 26 / 85 | C1-GP01 |
| Radium-228 | 0.61 | 0.55 | 7 / 7 | MN03 |
| Sodium-22 | 0.69 | 0.49 | 3 / 51 | SB47 |
| Strontium-89 | 6.85 | 1.21 | 14 / 64 | B-GP07 |
| Strontium-90 | 1,300 | 34.4 | 128 / 175 | SB37A |
| Thallium-208 | 1.6 | 0.61 | 84 / 126 | CA0101 |
| Thorium-228 | 3.63 | 1.07 | 4 / 4 | B-GP15 |
| Thorium-232 | 0.25 | 0.22 | 3 / 3 | SB02 |
| Thorium-234 | 4.4 | 1.5 | 12 / 101 | SB76A |
| Tritium | 14 | 0.67 | 126 / 175 | SB20A |
| Uranium-234 | 1.49 | 0.86 | 3 / 3 | A-GP01 |
| Uranium-235 | 0.23 | 0.13 | 8 / 96 | SB91C |
| Uranium-238 | 0.72 | 0.51 | 3 / 3 | A-GP01 |
| Sieved Soil | | | | |
| Cesium-137 | 44,000,000 | 3,500,000 | 16 / 16 | SB37A-C |
| Gross alpha | 450 | 70 | 16 / 16 | SB36A-C |

| Isotope | Maximum Concentration (pCi/g) | Average Concentration* (pCi/g) | Detections / Samples** | Location of Maximum |
|--------------|-------------------------------|--------------------------------|------------------------|---------------------|
| Gross beta | 32,000,000 | 3,000,000 | 16 / 16 | SB37A-C |
| Strontium-90 | 5,600 | 5,700 | 15 / 15 | SB37A-C |

*The average concentration is a representative value for the contaminated areas of the operable unit. This average does not represent an average concentration for the whole operable unit. Nondetected values were not included in the average concentration.

** A total of 59 surface soil and 16 sieved soil samples were collected. Some samples were rejected for quality control reasons.

Table SS1. Surface Soil Contaminants in OU I

| Chemical | Maximum Concentration (mg/kg) | Comparison Value (mg/kg) | Type | Exceedances/ Detections/ Samples** | Locations of Exceedances |
|-----------------------|-------------------------------|--------------------------|-------------------|------------------------------------|--|
| Aroclor-1260 | 4.1 | 0.32 | RBC-C | 7 / 11 / 43 | SB16A, SB18A, SB20A, SB23A, SB29A, SB30A, SB44A |
| Arsenic | 28.10 | 20 | CV (C-EMEG-child) | 1 / 55 / 55 | SB41A |
| Benzo(a)anthracene | 7.4 | 0.87 | RBC-C | 3 / 16 / 42 | SB28A, SB30A, SB36A |
| Benzo(a)pyrene | 5.0 | 0.087 | RBC-C | 12 / 12 / 40 | SB17A, SB24A, SB25E, SB27A, SB28A, SB29A, SB30A, SB34A, SB36A, SB46A, SB48A, SB50A |
| Benzo(b)-fluoranthene | 9.0 | 0.87 | RBC-C | 5 / 12 / 39 | SB27A, SB28A, SB29A, SB30A, SB36A |
| Benzo(g,h,i)peryl | 2.8 | -- | none | -- / 8 / 39 | (SB30A) |

| Chemical | Maximum Concentration (mg/kg) | Comparison Value (mg/kg) | Type | Exceedances/ Detections/ Samples** | Locations of Exceedances |
|----------------------------|-------------------------------|--------------------------|--------|------------------------------------|-----------------------------------|
| ene | | | | | |
| 4-Chloro-3-methylphenol | 7.0 | -- | none | -- / 2 / 43 | (SB36A) |
| Endrin ketone | 0.006 | -- | none | -- / 5 / 43 | (SB23A/SB41A) |
| Indeno(1,2,3-cd)-pyrene | 3.5 | 0.87 | RBC-C | 3 / 7 / 38 | SB28A, SB30A, SB36A |
| Iron | 30,100 | 23,000 | RBC-N | 1 / 57 / 57 | SB48A |
| Mercury | 184 | 7.8 | RBC-N* | 5 / 41 / 52 | SB18A, SB20A, SB41A, SB48A, SB53A |
| N-Nitroso-di-n-propylamine | 2.8 | 0.091 | RBC-C | 2 / 2 / 43 | SB36A, SB56A |
| Phenanthrene | 29.0 | -- | none | -- / 18 / 42 | (SB28A) |

Notes:

Location of maximum detection in bold. If there were no exceedances, maximum location is given in parentheses.

* RBC for methylmercury

** A total of 57 samples were collected and analyzed for inorganics and a total of 43 samples were collected and analyzed for all other analytes. Some samples were rejected for quality control reasons.

C-EMEG-child ‘ Environmental Media Evaluation Guide for Chronic exposure to a child

RBC ‘ USEPA Region III Risk-Based Concentration (C ‘ Carcinogenic, N ‘ Non-carcinogenic)

Table SS2. Radionuclides Detected in Surface Soil in OU I

| Isotope | Maximum Concentration (pCi/g) | Average Concentration* (pCi/g) | Detections / Samples** | Location of Maximum |
|---------------|-------------------------------|--------------------------------|------------------------|---------------------|
| Actinium-228 | 2.9 | 1.2 | 21/59 | CP0801 |
| Americium-241 | 4.5 | 1 | 6/58 | SB36A |

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|--------------|------------|-----------|-------|---------|
| Bismuth-214 | 2.2 | 0.86 | 28/59 | CP0801 |
| Cesium-137 | 810,000 | 36,000 | 50/59 | SB37A |
| Cobalt-60 | 6.5 | 1.6 | 10/59 | SB50A |
| Gross alpha | 110 | 19 | 59/59 | SB44A |
| Gross beta | 1,100,000 | 42,000 | 59/59 | SB37A |
| Lead-210 | 16 | 5 | 4/59 | 455Comp |
| Lead-212 | 1.7 | 0.8 | 40/59 | CA0201 |
| Lead-214 | 2 | 0.93 | 28/59 | CP1001 |
| Potassium-40 | 12 | 10.9 | 51/59 | SB35A |
| Strontium-90 | 1,300 | 74 | 59/59 | SB37A |
| Thallium-208 | 1.6 | 0.89 | 24/59 | CA0101 |
| Thorium-234 | 1.48 | 1.1 | 2/59 | SB58E |
| Tritium | 14 | 1.4 | 59/59 | SB20A |
| Uranium-235 | 0.08 | 0.08 | 1/58 | CP0101 |
| Sieved Soil | | | | |
| Cesium-137 | 44,000,000 | 3,500,000 | 16/16 | SB37A-C |
| Gross alpha | 450 | 70 | 16/16 | SB36A-C |
| Gross beta | 32,000,000 | 3,000,000 | 16/16 | SB37A-C |
| Strontium-90 | 5,600 | 5,700 | 15/15 | SB37A-C |

*The average concentration is a representative value for the contaminated areas of the operable unit. This average does not represent an average concentration for the whole operable unit. Nondetected values were not included in the average concentration.

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** A total of 59 surface soil and 16 sieved soil samples were collected. Some samples were rejected for quality control reasons.

Table SS3. Surface Soil Contaminants in OU III

| Chemical | Maximum Concentration (mg/kg) | Comparison Value (mg/kg) | Type | Exceedances/ Detections/Samples* | Locations of Exceedances |
|----------------------|-------------------------------|--------------------------|-------|----------------------------------|--|
| Arsenic | 8.1 | 0.43 | RBC-C | 7 / 7 / 7 | HPB01, HPB02, MN02, MN03, SB01, SB02, SB03 |
| Iron | 43,600 | 23,000 | RBC-N | 7 / 7 / 7 | HPB01, HPB02, MN02, MN03, SB01, SB02, SB03 |
| Benzo(a)pyrene | 0.26 | 0.087 | RBC-C | 2 / 4 / 5 | MN02, MN03 |
| Benzo(g,h,i)perylene | 0.15 | -- | none | -- / 2 / 5 | (MN02) |
| Phenanthrene | 0.048 | -- | none | -- / 1 / 5 | (SB01) |

Notes:

*PCB/Pesticides were only analyzed for in 5 of the 7 of the surface soil samples.

Location of maximum detection in bold. If there were no exceedances, maximum location is given in parentheses.

RBC = USEPA Region III Risk-Based Concentration (C = Carcinogenic, N = Non-carcinogenic)

Table SS4. Radionuclides Detected in Surface Soil in OU III

| <i>Isotope</i> | <i>Maximum Concentration (pCi/g)</i> | <i>Average Concentration * (pCi/g)</i> | <i>Detections / Samples**</i> | <i>Location of Maximum</i> |
|----------------|--------------------------------------|--|-------------------------------|----------------------------|
| Bismuth-212 | 0.6 | 0.49 | 3 / 3 | SB02 |
| Bismuth-214 | 0.5 | 0.39 | 5 / 5 | MN03 |
| Cesium-137 | 67.6 | 26.1 | 5 / 5 | SB03 |
| Cobalt-60 | 3.06 | 2.11 | 3 / 3 | SB02 |
| Gross alpha | 9.97 | 9.97 | 1 / 5 | MN02 |
| Gross beta | 62.4 | 33.3 | 4 / 5 | SB03 |

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|--------------|------|-------|-------|------|
| Lead-210 | 1.95 | 1.51 | 3 / 3 | SB02 |
| Lead-212 | 0.63 | 0.56 | 5 / 5 | MN02 |
| Lead-214 | 0.59 | 0.49 | 5 / 5 | SB02 |
| Potassium-40 | 6.09 | 5.36 | 5 / 5 | SB01 |
| Radium-224 | 1.77 | 1.49 | 2 / 2 | MN02 |
| Radium-226 | 0.52 | 0.43 | 5 / 5 | SB02 |
| Radium-228 | 0.61 | 0.59 | 4 / 4 | MN03 |
| Strontium-90 | 0.94 | 0.94 | 1 / 5 | MN02 |
| Thallium-208 | 0.27 | 0.21 | 5 / 5 | SB03 |
| Thorium-228 | 0.28 | 0.22 | 3 / 3 | SB01 |
| Thorium-232 | 0.25 | 0.22 | 3 / 3 | SB02 |
| Thorium-234 | 0.6 | 0.60 | 1 / 1 | MN02 |
| Tritium | 0.1 | 0.069 | 5 / 5 | SB02 |

*The average concentration is a representative value for the contaminated areas of the operable unit. This average does not represent an average concentration for the whole operable unit. Nondetected values were not included in the average concentration.

** A total of 5 samples were collected and analyzed for radionuclides. Not all radionuclides were analyzed for in each sample collected.

Table SS5. Surface Soil Contaminants in OU IV

| <i>Chemical</i> | <i>Maximum Concentration (mg/kg)</i> | <i>Comparison Value (mg/kg)</i> | <i>Type</i> | <i>Exceedances /Detections/ Samples*</i> | <i>Locations of Exceedances</i> |
|------------------------|--------------------------------------|---------------------------------|-------------|--|--|
| Arsenic | 5.7 | 0.43 | RBC-C | 20 / 20 / 20 | SB13, SB33, SB35, SB36, SB37, SB38, SB39, SB40, SB41, SB42, SB43, SB45, SB46, SB47, SB48, SB49, SB59, SB60, 7703, 7629 |
| Benzo(a)anthrene | 1.8 | 0.87 | RBC-C | 4 / 7 / 36 | SB09, SB45, SB46, SB49 |
| Benzo(b)fluoranthrene | 3.3 | 0.87 | RBC-C | 5 / 8 / 36 | SB09, SB18, SB45, SB46, SB49 |
| Benzo(a)pyrene | 1.9 | 0.087 | RBC-C | 7 / 7 / 36 | SB09, SB18, SB36, SB37, SB45, SB46, SB49 |
| Benzo(g,h,i)perylene | 1.1 | none | -- | -- / 3 / 36 | (SB46) |
| Indeno(1,2,3-cd)pyrene | 1.3 | 0.87 | RBC-C | 1 / 3 / 36 | SB46 |
| Phenanthrene | 2.2 | none | -- | -- / 5 / 36 | (SB09) |
| Trichloroethylene | 0.02 | none | -- | -- / 1 / 36 | (SB38) |

Notes:


Location of maximum detection in bold. If there were no exceedances, maximum location is given in parentheses.

RBC = USEPA Region III Risk-Based Concentration (C = Carcinogenic, N = Non-carcinogenic)

A total of 36 surface soil samples were collected, only 20 samples were analyzed for arsenic.

Table SS6. Radionuclides Detected in Surface Soil in OU IV

| <i>Isotope</i> | <i>Maximum Concentration (pCi/g)</i> | <i>Average Concentration* (pCi/g)</i> | <i>Detections / Samples</i> | <i>Location of Maximum</i> |
|----------------|--------------------------------------|---------------------------------------|-----------------------------|----------------------------|
| Cesium-137 | 89 | 18.5 | 12/16 | SB48 |
| Cobalt-60 | 6.5 | 1.61 | 7/16 | SB34 |
| Gross alpha | 170 | 25.7 | 16/16 | SB45 |
| Gross beta | 73 | 26.8 | 16/16 | SB45 |
| Sodium-22 | 0.69 | 0.49 | 3/16 | SB47 |
| Strontium-90 | 9.8 | 2.32 | 16/16 | SB49 |
| Tritium | 0.077 | -0.0039** | 16/16 | SB41 |

 *The average concentration is a representative value for the contaminated areas of the operable unit. This average does not represent an average concentration for the whole operable unit. Nondetected values were not included in the average concentration.

**No explanation is provided in the site-related documents regarding this negative concentration.

Table SS7. Surface Soil Contaminants in OU V

| <i>Chemical</i> | <i>Maximum Concentration (mg/kg)</i> | <i>Comparison Value (mg/kg)</i> | <i>Type</i> | <i>Exceedances/ Detections/ Samples</i> | <i>Locations of Exceedances</i> |
|-----------------|--------------------------------------|---------------------------------|------------------|---|---------------------------------|
| Aroclor-1254 | 1.5 | 1 | CV(C-EMEG-child) | 2 / 26 / 37 | B1-06, B1-08 |
| Aroclor-1260 | 0.38 | 0.32 | RBC-C | 1 / 20 / 37 | B1-06 |

| | | | | | |
|----------------------|------|-------|--------|-------------|--------------------|
| Benzo(a)anthracene | 3.2 | 0.87 | RBC-C | 1 / 6 / 37 | B1-01 |
| Benzo(a)pyrene | 0.57 | 0.087 | RBC-C | 1 / 4 / 37 | B1-01 |
| Benzo(b)fluoranthene | 3.3 | 0.87 | RBC-C | 1 / 11 / 37 | B1-01 |
| Mercury | 15.1 | 7.8 | RBC-N* | 3 / 31 / 37 | A-01, B1-06, B1-08 |
| Phenanthrene | 0.77 | -- | none | -- / 5 / 37 | (B1-01) |

Notes:

Location of maximum detection in bold. If there were no exceedances, maximum location is given in parentheses.

* RBC for methylmercury

C-EMEG-child ' Environmental Media Evaluation Guide for Chronic exposure to a child

RBC ' USEPA Region III Risk-Based Concentration (C ' Carcinogenic, N ' Non-carcinogenic)

Table SS8. Radionuclides Detected in Surface Soil in OU V

| <i>Isotope</i> | <i>Maximum Concentration (pCi/g)</i> | <i>Average Concentration * (pCi/g)</i> | <i>Detections / Samples**</i> | <i>Location of Maximum</i> |
|----------------|--------------------------------------|--|-------------------------------|----------------------------|
| Americium-241 | 5.41 | 1.31 | 18 / 18 | B-SB03-SB01 |
| Bismuth-212 | 1.23 | 1.23 | 1 / 1 | B1-SB16 |
| Bismuth-214 | 0.35 | 0.32 | 2 / 2 | B1-GP04 |
| Cesium-137 | 98.8 | 9.81 | 58 / 60 | B1-SB07 |
| Cobalt-57 | 0.069 | 0.069 | 1 / 1 | B –GP13 |
| Cobalt-60 | 0.25 | 0.25 | 1 / 1 | B-GP13 |
| Lead-210 | 2.7 | 1.56 | 3 / 3 | B-GP08 |
| Lead-212 | 0.75 | 0.39 | 46 / 46 | B1-SB05 |

| <i>Isotope</i> | <i>Maximum Concentration (pCi/g)</i> | <i>Average Concentration * (pCi/g)</i> | <i>Detections / Samples**</i> | <i>Location of Maximum</i> |
|----------------|--------------------------------------|--|-------------------------------|----------------------------|
| Lead-214 | 0.63 | 0.34 | 30 / 30 | C1-GP01 |
| Potassium-40 | 6.33 | 3.41 | 55 / 55 | B1-SB05 |
| Radium-224 | 5.83 | 2.68 | 3 / 3 | B-GP09 |
| Radium-226 | 0.63 | 0.32 | 21 / 21 | C1-GP01 |
| Radium-228 | 0.51 | 0.49 | 3 / 3 | B-GP04 |
| Strontium-89 | 6.85 | 1.21 | 14 / 60 | B-GP07 |
| Strontium-90 | 1.47 | 0.47 | 17 / 60 | B-SB03-SB01 |
| Thallium-208 | 0.31 | 0.18 | 24 / 27 | B1-SB05 |
| Thorium-228 | 3.63 | 3.63 | 1 / 1 | B-GP15 |
| Thorium-234 | 2.35 | 1.54 | 6 / 6 | B1-SB13 |
| Tritium | 0.25 | 0.093 | 11 / 60 | D-GP03 |
| Uranium-234 | 1.49 | 0.86 | 3 / 3 | A-GP01 |
| Uranium-238 | 0.72 | 0.51 | 3 / 3 | A-GP01 |

*The average concentration is a representative value for the contaminated areas of the operable unit. This average does not represent an average concentration for the whole operable unit. Nondetected values were not included in the average concentration.

** A total of 60 samples were collected. Some samples were rejected for quality control reasons.

Table SS9. Surface Soil Contaminants in OU VI

| <i>Chemical</i> | <i>Maximum Concentration (mg/kg)</i> | <i>Comparison Value (mg/kg)</i> | <i>Type</i> | <i>Exceedances/ Detections/ Samples</i> | <i>Locations of Exceedance s</i> |
|------------------------|---|--|--------------------|--|---|
| Benzo(a)pyrene | 0.13 | 0.087 | RBC- C | 1 / 3 / 35 | SB-72A |
| Benzo(g,h,i)perylene | 0.076 | -- | none | -- / 3 / 35 | (SB-72A) |
| Phenanthrene | 0.062 | -- | none | -- / 2 / 35 | (SB-72) |

Notes:

Location of maximum detection in bold. If there were no exceedances, maximum location is given in parentheses.

RBC = USEPA Region III Risk-Based Concentration (C = Carcinogenic, N = Non-carcinogenic)

Table SS10. Radionuclides Detected in Surface Soil in OU VI

| <i>Isotope</i> | <i>Maximum Concentration (pCi/g)</i> | <i>Average Concentration * (pCi/g)</i> | <i>Detections / Samples</i> | <i>Location of Maximum</i> |
|----------------|--------------------------------------|--|-----------------------------|----------------------------|
| Actinium-228 | 1.60 | 0.82 | 26/35 | SB80C |
| Bismuth-214 | 0.92 | 0.58 | 28/35 | SB95A |
| Cesium-137 | 0.92 | 0.35 | 24/35 | SB85A |
| Gross alpha | 22.00 | 10.20 | 35/35 | SB74A |
| Gross beta | 28.00 | 14.04 | 35/35 | SB80A |
| Lead-210 | 2.60 | 1.60 | 3/35 | SB85A |
| Lead-212 | 1.30 | 0.70 | 35/35 | SB85A |
| Lead-214 | 1.10 | 0.62 | 34/35 | SB96A |
| Potassium-40 | 12.00 | 6.62 | 34/35 | SB76A |
| Strontium-90 | 11.00 | -0.15** | 35/35 | SB95A |
| Thallium-208 | 1.30 | 0.79 | 31/35 | SB96A |
| Thorium-234 | 4.40 | 1.99 | 3/35 | SB76A |
| Tritium | 0.14 | -0.03** | 35/35 | SB82A |
| Uranium-235 | 0.23 | 0.14 | 7/35 | SB91C |

*The average concentration is a representative value for the contaminated areas of the operable unit. This average does not represent an average concentration for the whole operable unit. Nondetected values were not included in the average concentration.

**No explanation is provided in the site-related documents to explain this negative concentration.

Table SS11. Radionuclides Detected in Surface Soil from Off-Site Areas

| <i>Isotope</i> | <i>Maximum Concentration (pCi/g)</i> | <i>Average Concentration* (pCi/g)</i> | <i>Detections / Samples</i> | <i>Location of Maximum</i> |
|----------------|--------------------------------------|---------------------------------------|-----------------------------|----------------------------|
| Actinium-228 | 2.24 | 1.10 | 9/10 | Glover's Farm |
| Bismuth-214 | 1.73 | 1.06 | 9/10 | Glover's Farm |
| Cesium-137 | 0.44 | 0.19 | 8/10 | NYS Farm |
| Lead-212 | 2.29 | 1.02 | 10/10 | Glover's Farm |
| Lead-214 | 2.03 | 1.03 | 10/10 | Glover's Farm |
| Potassium-40 | 11.82 | 7.45 | 10/10 | Glover's Farm |
| Thallium-208 | 0.76 | 0.38 | 10/10 | Glover's Farm |
| Thorium-232 | 2.13 | 1.13 | 8/10 | Glover's Farm |

*This average does not represent an average concentration for the entire BNL surrounding areas. Nondetected values were not included in the average concentration.

Table SW1. STP Discharges (Outfall 001): 1989–1999

Refer to notes at the end of the table for information on assumptions and selection of health-based comparison values (CVs)

| <i>Analyte</i> | <i>Highest Concentration</i> | <i>CV</i> | <i>Type of CV</i> | <i>Date of maximum</i> | <i>Number of samples greater than CV/Number of samples</i> | <i>Average Concentration (if highest concentration is above CV)</i> |
|----------------------------|------------------------------|-----------|-------------------|------------------------|--|---|
| 1,1,1-Trichloroethane | 80 ppb | 200 ppb | LTHA | 4/30/91 | 0/130 | -- |
| 1,2-Dichloroethane | ND | 5 ppb | MCL | NA | 0/18 | -- |
| 2-Butanone | 5 ppb | 6,000 ppb | RMEG-c | 8/31/95 | 0/57 | -- |
| Bis(2-Ethylhexyl)Phthalate | 14 ppb | 100 ppb | EMEG-ic | 3/31/99 | 0/36 | -- |
| Bromodichloromethane | ND | 200 ppb | RMEG-c | NA | 0/18 | -- |
| Chlorine, Total | 450 ppb | 1,000 ppb | RMEG-c | 3/31/93 | 0/126 | -- |
| Chloroform | ND | 80 ppb | MCL | -- | 0/18 | -- |
| Chromium, Total | 413 ppb | 100 ppb | LTHA | 3/31/99 | 2/18 | 53.5 ppb |
| Copper, Total | 2,080 ppb | 5,000 ppb | IOM TUIL | 3/31/99 | 0/149 | -- |
| Cyanide, Total | 20 ppb | 200 ppb | RMEG-c | 3/31/96 | 0/92 | -- |

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| <i>Analyte</i> | <i>Highest Concentration</i> | <i>CV</i> | <i>Type of CV</i> | <i>Date of maximum</i> | <i>Number of samples greater than CV/Number of samples</i> | <i>Average Concentration (if highest concentration is above CV)</i> |
|----------------------------------|------------------------------|------------|-------------------|------------------------|--|---|
| Di-N-butyl phthalate | 7 ppb | 1,000 ppb | RMEG-c | 9/30/97 | 0/36 | -- |
| Iron, Total | 15,700 ppb | 22,500 ppb | IOM TUIL | 3/31/99 | 0/149 | -- |
| Lead, Total | 32 ppb | 15 ppb | EAL | 3/31/90 | 1/131 | 7.4 ppb |
| Manganese, Total | 141 ppb | 500 ppb | RMEG-c | 3/31/99 | 0/18 | -- |
| Mercury, Total | 3 ppb | 2 ppb | MCL | 2/28/99 | 1/26 | 0.31 ppb |
| Methylene chloride | 44 ppb | 5 ppb | MCL | 12/31/95 | 10/57 | 4.17 ppb |
| Nickel, Total | 234 ppb | 100 ppb | LTHA | 3/31/99 | 2/75 | 8.04 ppb |
| Polychlorinated biphenyls | ND | 0.5 ppb | MCL | -- | 0/1 | -- |
| Propylene glycol monobutyl ether | 1,500 ppb | NA | NA | 3/31/98 | NA/14 | -- |
| Radioactivity | 56.3 pCi/L | 50.0 pCi/L | SDWA | 1/31/89 | 1/74 | 15.7 pCi/L |
| Radium-226, Total | 3 pCi/L | 60 pCi/L | ALI | 10/31/94 | 0/72 | -- |
| Silver, Total | 713 ppb | 50 ppb | RMEG-c | 9/30/96 | 7/166 | 12.8 ppb |

| <i>Analyte</i> | <i>Highest Concentration</i> | <i>CV</i> | <i>Type of CV</i> | <i>Date of maximum</i> | <i>Number of samples greater than CV/Number of samples</i> | <i>Average Concentration (if highest concentration is above CV)</i> |
|---------------------|------------------------------|--------------|-------------------|------------------------|--|---|
| Strontium-90, Total | 9.3 pCi/L | 500 pCi/L | ALI | 1/31/89 | 0/30 | -- |
| Tetrachloroethylene | ND | 5 ppb | MCL | -- | 0/18 | -- |
| Toluene | 2 | 200 ppb | EMEG-ic | 4/30/97 | 0/57 | -- |
| Tritium, Total | 28,900 pCi/L | 20,000 pCi/L | SDWA | 9/30/92 | 1/72 | 6,8400 pCi/L |
| Zinc, Total | 1,160 ppb | 2,000 ppb | LTHA | 3/31/99 | 0/149 | -- |

Notes:

Source of data: NYSDEC discharge monitoring data on file.

NA - Not applicable. No date of maximum is listed for contaminants that were never detected in the discharge from outfall 001.

ND - Nondetect. For contaminants not detected in any discharge samples, the maximum concentration is listed as a ND. Nondetects were replaced with concentrations equal to one-half the detection limit to compute average concentrations.

The number of samples varies from contaminant to contaminant primarily because the frequency of sampling required by the SPDES permit also varies from contaminant to contaminant.

Data are not presented for general water quality indicators (e.g., temperature, pH, alkalinity, concentrations of nitrogen, phosphorous, and oil and grease, etc.) or for contaminants that do not have comparison values.

The NYSDEC data does not specify what is meant by Aradioactivity.@ Review of the site environmental reports indicates that gross beta accounts for a much larger portion of the detectable radiation than gross alpha. Thus, the comparison value for gross beta radiation is used here.

All data shown are from the STP discharge (outfall 001). Frequent exposure to the water at this location, whether by ingestion or dermal contact, is not expected to occur. Nonetheless, comparison values that assume people drink the water in the STP discharge were used to examine the health implications of whether these waters are used as a drinking water supply. The following types of comparison values are used in the table:

LTHA ATSDR Lifetime Health Advisory for drinking water

RMEG-c ATSDR Reference Dose Media Evaluation Guide for children's exposure

EMEG-ic ATSDR Environmental Media Evaluation Guide, for children's exposure of intermediate duration

IOM TUIL Institute of Medicine's Tolerable Upper Intake Level

EAL USEPA action level for lead in drinking water

MCL USEPA Maximum Contaminant Level

SDWA Safe Drinking Water Act level

ALI Annual Limit on Intake

Contaminants shown in bold font have at least one concentration higher than the corresponding health-based comparison value.

These concentrations would require further evaluation if people were using the effluent from the treatment plant as a water supply.

However, exposures to this water are believed to be extremely infrequent, and the periodic elevated concentrations are not believed to be associated with adverse health effects.

The comparison value for hexavalent chromium is used in this table, even though the measurements were for total chromium.

Table SW2. Radiological Contamination in the STP Discharge (Outfall 001): 1977–1999

| <i>Contaminant</i> | <i>Annual Average Data</i> | | <i>Short-Term Peak Data</i> | | <i>Screening Values</i> | |
|---|-----------------------------------|-----------------------------|------------------------------------|-----------------------------|--------------------------------------|-------------------------|
| | Highest Concentration(pCi/L) | Year Highest Level Occurred | Highest Concentration (pCi/L) | Year Highest Level Occurred | Magnitude of Screening Value (pCi/L) | Type of Screening Value |
| Data for radiological contaminants other than for radionuclides | | | | | | |
| Gross alpha | 2.48 | 1982 | 12.34 | 1993 | 15 | SDWA |
| Gross beta | 28.5 | 1979 | 94.2 | 1989 | 50 | SDWA |
| Tritium | 4,650 | 1988 | 67,300 (±1,570) | 1997 | 20,000 | SDWA |
| Data for radionuclides in order of increasing atomic number | | | | | | |
| Beryllium-7 | 3.04 | 1977 | 19.13 | 1977 | 600,000 | ALI |
| Sodium-22 | 2.54 | 1978 | 31.76 | 1977 | 6,000 | ALI |
| Potassium-40 | 3.78 | 1982 | 15.86 | 1991 | 4,000 | ALI |
| Chromium-51 | 0.25 | 1985 | 1.00 | 1985 | 500,000 | ALI |
| Manganese-54 | 0.67 | 1977 | 1.63 | 1978 | 30,000 | ALI |
| Cobalt-57 | 0.09 | 1979 | 0.81 | 1995 | 60,000 | ALI |
| Cobalt-58 | 0.04 | 1995 | 0.4 | 1995 | 20,000 | ALI |
| Cobalt-60 | 0.68 | 1982 | 1.5 | 1984 | 3,000 | ALI |
| Zinc-65 | 0.65 | 1981 | 0.9 | 1983 | 5,000 | ALI |
| Rubidium-83 | 0.26 | 1983 | 1.1 | 1983 | 9,000 | ALI |

| | | | | | | |
|--------------|-------|------|-------|------|---------|-----|
| Rubidium-84 | 0.12 | 1983 | 0.57 | 1983 | 7,000 | ALI |
| Strontium-90 | 3.89 | 1988 | 18.6 | 1988 | 500 | ALI |
| Iodine-131 | 1.69 | 1980 | 5.1 | 1984 | 1,000 | ALI |
| Cesium-134 | 2.57 | 1977 | 6.137 | 1977 | 8,000 | ALI |
| Cesium-137 | 15.57 | 1989 | 29.3 | 1989 | 700,000 | ALI |
| Cerium-141 | 0.016 | 1986 | 0.115 | 1986 | 30,000 | ALI |
| Radium-226 | ND | 1988 | ND | 1988 | 60 | ALI |

Notes:

Source of data: BNL's annual Site Environmental Reports, 1977–1999. These reports present summary statistics only and do not contain raw data.

ND - Non detect

Sampling data in this table are from the effluent of the sewage treatment plant. Frequent exposure to the water at this location, whether by ingestion or dermal contact, is not expected to occur. Nonetheless, comparison values that assume people drink the water in the STP discharge were used to examine the health implications of whether these waters are used as a drinking water supply. Contaminants in bold font have at least one measured concentration higher than the corresponding health-based comparison value. The following types of comparison values are used in the table:

ALI Annual Limit on Intake

SDWA Safe Drinking Water Act

Data presented were collected in the outfall of the STP, which the Site Environmental Reports refer to as sampling location EA or output from the chlorine House. The Site Environmental Reports did not use consistent reporting practices throughout the time frame considered. For instance, some radionuclides have sampling data documented in almost every Site Environmental Report, while other radionuclides have sampling data documented in just one or a few reports. Additionally, the names of parameters reported changed over the site's history (e.g., BNL reported concentrations of hydrogen-3 from 1977 to 1985, but instead reported concentrations of tritium in the following years; even though these analytes are synonymous). Finally, the descriptive statistics used to summarize the data varied from year to year, and from contaminant to contaminant. For instance, the short-term peak data represent different statistics for different contaminants. For most of the radionuclides listed, the short-term peak data are the highest monthly-average concentration reported. For gross alpha, gross beta, and tritium, however, the short-term peak data are the highest measured concentrations (which presumably are 24-hour average results).

BNL did not report measurement uncertainty for any of the discharge monitoring data until 1996. Therefore, uncertainty bounds are presented only for those contaminants with highest concentrations occurring between 1996 and 1999.

As stated above, BNL reported concentrations of hydrogen-3 from 1977 to 1985, and then reported concentrations of tritium from 1986 to 1999. All these sampling records were pooled and are summarized in the field labeled tritium.

Table SW3. Contaminants Measured in On-site Recharge Basins and Wetlands

Refer to notes at the end of the table for information on assumptions and selection of health-based comparison values (CVs).

| <i>Contaminant</i> | <i>Sampling Data</i> | | | <i>Screening Values</i> | |
|--|---------------------------------------|------------------------------------|--------------------------|-------------------------------------|--------------------------------|
| | <i>Highest Concentration Reported</i> | <i>Year Concentration Measured</i> | <i>Sampling Location</i> | <i>Magnitude of Screening Value</i> | <i>Type of Screening Value</i> |
| Data for inorganic contaminants other than for radionuclides | | | | | |
| Aluminum | 38,600 ppb | 1994 | OUI wetland | 20,000 ppb | EMEG-ic |
| Antimony | 25.8 ppb | 1999 | CSF basin | 4 ppb | RMEG-c |
| Arsenic | 8.7 ppb | 1994 | OUI wetland | 3 ppb | RMEG-c |
| Barium | 676.3 ppb | 1998 | BMRR basin | 700 ppb | RMEG-c |
| Beryllium | 1.2 ppb | 1994 | OUI wetland | 4 ppb | MCL |
| Cadmium | 1,520 ppb | 1979 | HU basin | 2 ppb | EMEG-cc |
| Chromium | 8,100 ppb | 1979 | HU basin | 100 ppb | MCL |
| Cobalt | 18.7 ppb | 1994 | OUI wetland | 2,200 ppb | RBC-n |
| Copper | 16,100 ppb | 1979 | HU basin | 5,000 ppb | IOM TUIL |
| Lead | 5,320 ppb | 1979 | HU basin | 15 ppb | EAL |
| Manganese | 1,410 ppb | 1994 | OUI wetland | 500 ppb | RMEG-c |
| Mercury | 0.37 ppb | 1998 | HW basin | 2 ppb | LTHA |
| Molybdenum | 10 ppb | 1999 | HW basin | 40 ppb | LTHA |
| Nickel | 131 ppb | 1999 | CSF basin | 100 ppb | LTHA |
| Selenium | 33.4 ppb | 1998 | HO basin | 50 ppb | EMEG-cc |

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|--|---------------------------------------|------------------------------------|--------------------------|-------------------------------------|--------------------------------|
| Silver | 70 ppb | 1992 | HX basin | 50 ppb | RMEG-c |
| Vanadium | 342.4 ppb | 1999 | CSF basin | 30 ppb | EMEG-ic |
| Contaminant | Sampling Data | | | | Screening Values |
| | <i>Highest Concentration Reported</i> | <i>Year Concentration Measured</i> | <i>Sampling Location</i> | <i>Magnitude of Screening Value</i> | <i>Type of Screening Value</i> |
| Zinc | 95,600 ppb | 1979 | HU basin | 2,000 ppb | LTHA |
| Data for radiological contamination other than for radionuclides | | | | | |
| Gross alpha | 38 (\pm 13) pCi/L | 1994 | OUI wetland | 15 pCi/L | SDWA |
| Gross beta | 1,858 pCi/L | 1979 | HT basin | 50 pCi/L | SDWA |
| Tritium | 25,590 pCi/L | 1979 | HT basin | 20,000 pCi/L | SDWA |
| Data for radionuclides in order of increasing atomic number | | | | | |
| Beryllium-7 | 299 pCi/L | 1990 | HN basin | 600,000 pCi/L | ALI |
| Sodium-22 | 3.56 pCi/L | 1988 | HN basin | 6,000 pCi/L | ALI |
| Sodium-24 | 182 pCi/L | 1998 | HN basin | 50,000 pCi/L | ALI |
| Potassium-40 | 240 (\pm 230) pCi/L | 1994 | HS basin | 4,000 pCi/L | ALI |
| Vanadium-48 | 10.5 pCi/L | 1995 | HNbasin | 9,000 pCi/L | ALI |
| Chromium-51 | 50.1 pCi/L | 1995 | HN basin | 500,000 pCi/L | ALI |
| Manganese-52 | 14.7 pCi/L | 1990 | HN basin | 10,000 pCi/L | ALI |
| Manganese-54 | 9.59 pCi/L | 1991 | HN basin | 30,000 pCi/L | ALI |
| Manganese-56 | 0.16 pCi/L | 1985 | HN basin | 70,000 pCi/L | ALI |

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|--------------|--------------------------|------|-------------|---------------|-----|
| Cobalt-56 | 1.2 (\pm 0.7) pCi/L | 1996 | HN basin | 6,000 pCi/L | ALI |
| Cobalt-57 | 1.26 pCi/L | 1990 | HN basin | 60,000 pCi/L | ALI |
| Cobalt-58 | 3.78 pCi/L | 1990 | HN basin | 20,000 pCi/L | ALI |
| Cobalt-60 | 17.3 pCi/L | 1995 | HN basin | 3,000 pCi/L | ALI |
| Zinc-65 | 3.85 pCi/L | 1995 | HN basin | 5,000 pCi/L | ALI |
| Strontium-90 | 11 (\pm 1) pCi/L | 1994 | OUI wetland | 500 pCi/L | ALI |
| Cesium-137 | 44 (\pm 15) pCi/L | 1994 | OUI wetland | 700,000 pCi/L | ALI |
| Bismuth-214 | 58 (\pm 32) pCi/L | 1994 | OUI wetland | 300,000 pCi/L | ALI |
| Lead-214 | 48 (\pm 28) pCi/L | 1994 | OUI wetland | 100,000 pCi/L | ALI |
| Thorium-234 | 147.5 (\pm 500) pCi/L | 1994 | OUI wetland | 30 pCi/L | ALI |

Notes:

Source of data: BNL's annual Site Environmental Reports, 1977–1999; BNL's Remedial Investigation reports. Because some of these reports only present summary statistics and not the raw sampling data, average concentrations cannot be calculated.

Data presented were collected in onsite recharge basins and wetlands; data presented only for those contaminants that were detected.

Sampling data in this table are for onsite recharge basins and wetlands, which have extremely restricted access. As a result, frequent exposure to the water at this location, whether by ingestion or dermal contact, is not expected to occur. Nonetheless, comparison values that assume people drink the water at these locations were used to examine the health implications of whether these waters are used as a drinking water supply. Contaminants in bold font have at least one measured concentration higher than the corresponding health-based comparison value. The following types of comparison values are used in the table:

LTHA ATSDR Lifetime Health Advisory for drinking water

RMEG-c ATSDR Reference Dose Media Evaluation Guide for children's exposure

EMEG-ic ATSDR Environmental Media Evaluation Guide, for children's exposure of intermediate duration

IOM TUIL Institute of Medicine's Tolerable Upper Intake Level

EAL USEPA action level for lead in drinking water

MCL USEPA Maximum Contaminant Level

SDWA Safe Drinking Water Act level

ALI Annual Limit on Intake

The analytes considered in the recharge basin sampling apparently changed from year to year. For instance, concentrations of molybdenum were apparently not measured until the late 1990s. BNL did not report measurement uncertainty in many of the Site Environmental Reports. Therefore, uncertainty bounds are not presented for all analytes.

The health-based comparison value for hexavalent chromium is used to screen concentrations of chromium; the health-based comparison value for inorganic mercury is used to screen concentrations of mercury; and the ALI for thorium-232 is used to screen concentrations of thorium-234 (because no ALI has been published for thorium-234).

The highest concentrations of cadmium, chromium, copper, iron, lead, and zinc are outliers, and all from a single sample collected in 1979. The second highest concentrations of these analytes are considerably lower.

As the text of the memo describes, exposure to the levels of contamination shown in this table is not expected to occur.

Table SW4. Contaminants Measured in On-site Sections of the Peconic River

Refer to notes at the end of the table for information on assumptions and selection of health-based comparison values (CVs).

| <i>Contaminant</i> | <i>Sampling Data</i> | | | <i>Screening Values</i> | |
|--|---------------------------------------|------------------------------------|--------------------------|-------------------------------------|--------------------------------|
| | Highest Concentration Reported | Year Concentration Measured | Sampling Location | Magnitude of Screening Value | Type of Screening Value |
| Data for inorganic contaminants other than for radionuclides | | | | | |
| Aluminum | 1,503 ppb | 1999 | Former site boundary | 20,000 ppb | EMEG-ic |
| Antimony | 7.74 ppb | 1999 | Downstream from STP | 4 ppb | RMEG-c |
| Arsenic | 2 ppb | 1995 | Downstream from STP | 3 ppb | RMEG-c |
| Barium | 86.8 ppb | 1998 | Upstream of STP | 700 ppb | RMEG-c |
| Beryllium | 0.63 ppb | 1995 | Downstream from STP | 4 ppb | MCL |
| Cadmium | 3 ppb | 1983 | Former site boundary | 5 ppb | MCL |
| <i>Contaminant</i> | <i>Sampling Data</i> | | | <i>Screening Values</i> | |
| | <i>Highest Concentration Reported</i> | <i>Year Concentration Measured</i> | <i>Sampling Location</i> | <i>Magnitude of Screening Value</i> | <i>Type of Screening Value</i> |
| Chromium | 25 ppb | 1987 | Former site boundary | 30 ppb | RMEG-c |
| Cobalt | 15.3 ppb | 1998 | Upstream of STP | 2,200 ppb | RBC-n |

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|--|--------------|------|----------------------|---------------|----------|
| Copper | 400 ppb | 1987 | Former site boundary | 5,000 ppb | IOM TUIL |
| Lead | 219 ppb | 1979 | Former site boundary | 15 ppb | EAL |
| Manganese | 514 ppb | 1998 | Upstream of STP | 500 ppb | RMEG-c |
| Mercury | 9 ppb | 1989 | Former site boundary | 2 ppb | LTHA |
| Nickel | 28.7 ppb | 1995 | Downstream from STP | 100 ppb | LTHA |
| Silver | 25 ppb | 1996 | Site boundary | 50 ppb | RMEG-c |
| Thallium | 5.2 ppb | 1995 | Downstream from STP | 0.5 | LTHA |
| Vanadium | 17.8 ppb | 1995 | Downstream from STP | 30 ppb | EMEG-ic |
| Zinc | 300 ppb | 1997 | Former site boundary | 2,000 ppb | LTHA |
| Data for radiological contamination other than for radionuclides | | | | | |
| Gross alpha | 21.7 pCi/L | 1999 | Former site boundary | 15 pCi/L | SDWA |
| Gross beta | 132 pCi/L | 1986 | Former site boundary | 50 pCi/L | SDWA |
| Tritium | 37,578 pCi/L | 1977 | Former site boundary | 20,000 pCi/L | SDWA |
| Data for radionuclides in order of increasing atomic number | | | | | |
| Beryllium-7 | 42.3 pCi/L | 1977 | Former site boundary | 600,000 pCi/L | ALI |

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| Sodium-22 | 29.67 pCi/L | 1977 | Former site boundary | 6,000 pCi/L | ALI |
|--------------------|---------------------------------------|------------------------------------|--------------------------|-------------------------------------|--------------------------------|
| Potassium-40 | 30.9 pCi/L | 1990 | Former site boundary | 4,000 pCi/L | ALI |
| Chromium-51 | 0.95 pCi/L | 1985 | Former site boundary | 500,000 pCi/L | ALI |
| Manganese-54 | 1.51 pCi/L | 1977 | Former site boundary | 30,000 pCi/L | ALI |
| Cobalt-57 | 0.23 pCi/L | 1986 | Former site boundary | 60,000 pCi/L | ALI |
| <i>Contaminant</i> | <i>Sampling Data</i> | | | <i>Screening Values</i> | |
| | <i>Highest Concentration Reported</i> | <i>Year Concentration Measured</i> | <i>Sampling Location</i> | <i>Magnitude of Screening Value</i> | <i>Type of Screening Value</i> |
| Cobalt-58 | 0.06 pCi/L | 1984 | Former site boundary | 20,000 pCi/L | ALI |
| Cobalt-60 | 6.49 pCi/L | 1977 | Former site boundary | 3,000 pCi/L | ALI |
| Zinc-65 | 0.95 pCi/L | 1984 | Site boundary | 5,000 pCi/L | ALI |
| Rubidium-83 | 1.4 pCi/L | 1983 | Former site boundary | 9,000 pCi/L | ALI |
| Rubidium-84 | 0.047 pCi/L | 1983 | Site boundary | 7,000 pCi/L | ALI |
| Strontium-89 | 1.03 pCi/L | 1995 | Downstream from STP | 8,000 pCi/L | ALI |
| Strontium-90 | 19.78 pCi/L | 1977 | Former site boundary | 500 pCi/L | ALI |
| Iodine-131 | 1.69 pCi/L | 1980 | Former site | 1,000 pCi/L | ALI |

| | | | | | |
|-----------------|-------------|------|----------------------|---------------|-----|
| | | | boundary | | |
| Cesium-134 | 4.396 pCi/L | 1977 | Former site boundary | 900 pCi/L | ALI |
| Cesium-137 | 64.6 pCi/L | 1989 | Former site boundary | 700,000 pCi/L | ALI |
| Europium-152 | 37.1 pCi/L | 1997 | Downstream from STP | 10,000 pCi/L | ALI |
| Radium-226 | 0.27 pCi/L | 1986 | Former site boundary | 60 pCi/L | ALI |
| Uranium-233/234 | 0.028 pCi/L | 1999 | Downstream from STP | 300 pCi/L | ALI |
| Uranium-238 | 0.062 pCi/L | 1999 | Downstream from STP | 300 pCi/L | ALI |
| Americium-241 | 0.058 pCi/L | 1999 | Downstream from STP | 20 pCi/L | ALI |

Notes:

Source of data: BNL's annual Site Environmental Reports, 1977–1999; BNL's Remedial Investigation and Plutonium Characterization reports.

BNL reported for different analytes from one year to the next: some analytes shown (e.g., tritium) have been sampled extensively for every year with data on record, while other analytes (e.g., europium-152) have been analyzed only in a few samples.

In the Site Environmental Reports from the 1970s, BNL reported activities of radionuclides, rather than reporting concentrations. ERG calculated the concentrations for these data points from the activities and the reported river flow rates.

Data presented only for those contaminants that were detected.

Sampling data in this table are for onsite sections of the Peconic River, which has restricted access and limited or no flow during periods of dry weather. As a result, frequent exposure to the water at this location, whether by ingestion or dermal contact, is not expected to occur. Nonetheless, comparison values that assume people drink the water in the onsite sections of the Peconic River were used to examine the health implications of whether these waters are used as a drinking water supply. Contaminants in bold font have at least one measured concentration higher than the corresponding health-based comparison value. The following types of comparison values are used in the table:

LTHA ATSDR Lifetime Health Advisory for drinking water

RMEG-c ATSDR Reference Dose Media Evaluation Guide for children's exposure
EMEG-ic ATSDR Environmental Media Evaluation Guide, for children's exposure of
intermediate duration

IOM TUIL Institute of Medicine's Tolerable Upper Intake Level

EAL USEPA action level for lead in drinking water

MCL USEPA Maximum Contaminant Level

SDWA Safe Drinking Water Act level

ALI Annual Limit on Intake

The health-based comparison value for hexavalent chromium is used to screen concentrations of chromium; the health-based comparison value for inorganic mercury is used to screen concentrations of mercury; and the ALI for thorium-232 is used to screen concentrations of thorium-234 (because no ALI has been published for thorium-234).

Table SW5. Contaminants Measured in Off-site Sections of the Peconic River

Refer to notes at the end of the table for information on assumptions and selection of health-based comparison values (CVs).

| <i>Contaminant</i> | <i>Sampling Data</i> | | | <i>Screening Values</i> | |
|--|--------------------------------|---------------|-----------------------|--------------------------------|-------------------------|
| | Highest Concentration Reported | Year Measured | Sampling Location | Magnitude of Screening Value | Type of Screening Value |
| Data for inorganic contaminants other than for radionuclides | | | | | |
| Aluminum | 515 ppb | 1998 | Riverhead | 20,000 ppb | EMEG-ic |
| Antimony | 3.14 ppb | 1999 | Schultz Road | 4 ppb | RMEG-c |
| Arsenic | 4.2 ppb | 1999 | Wading River | 3 ppb | RMEG-c |
| Barium | 48.1 ppb | 1998 | Wading River | 700 ppb | RMEG-c |
| Beryllium | 0.7 ppb | 1995 | <1 Mile from Boundary | 4 ppb | MCL |
| Cadmium | 2.5 ppb | 1977 | Calverton | 2 ppb | EMEG-cc |
| Chromium | 28 ppb | 1979 | Schultz Road | 30 ppb | RMEG-c |
| Cobalt | 7 ppb | 1995 | <1 Mile from Boundary | 2,200 ppb | RBC-n |
| Copper | 195.1 ppb | 1998 | Schultz Road | 5,000 ppb | IOM TUIL |
| Lead | 17 ppb | 1979 | Schultz Road | 15 ppb | EAL |
| Manganese | 731 ppb | 1995 | <1 Mile from Boundary | 500 ppb | RMEG-c |
| Mercury | 0.31 ppb | 1994 | Manorville | 2 ppb | LTHA |
| Molybdenum | 10 ppb | 1999 | Schultz Road | 40 ppb | LTHA |
| Nickel | 14 ppb | 1995 | <1 Mile from | 100 ppb | LTHA |

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|--|---------------------------------------|----------------------|--------------------------|-------------------------------------|--------------------------------|
| | | | Boundary | | |
| Silver | 3 ppb | 1977 | Riverhead | 50 ppb | RMEG-c |
| Thallium | 4.8 ppb | 1995 | <1 Mile from Boundary | 0.8 | RMEG-c |
| Vanadium | 9.8 ppb | 1995 | <1 Mile from Boundary | 30 ppb | EMEG-ic |
| Zinc | 391 ppb | 1995 | <1 Mile from Boundary | 2,000 ppb | LTHA |
| Contaminant | Sampling Data | | | Screening Values | |
| | <i>Highest Concentration Reported</i> | <i>Year Measured</i> | <i>Sampling Location</i> | <i>Magnitude of Screening Value</i> | <i>Type of Screening Value</i> |
| Data for radiological contamination other than for radionuclides | | | | | |
| Gross alpha | 45.3 pCi/L | 1995 | Riverhead | 15 pCi/L | SDWA |
| Gross beta | 130 pCi/L | 1992 | Manorville | 50 pCi/L | SDWA |
| Tritium | 24,900 pCi/L | 1976 | Manorville | 20,000 pCi/L | SDWA |
| Data for radionuclides in order of increasing atomic number | | | | | |
| Beryllium-7 | 9.13 pCi/L | 1991 | Wading River | 600,000 pCi/L | ALI |
| Sodium-22 | 0.16 pCi/L | 1989 | Schultz Road | 6,000 pCi/L | ALI |
| Potassium-40 | 6.2 pCi/L | 1990 | Schultz Road | 4,000 pCi/L | ALI |
| Manganese-54 | 0.14 pCi/L | 1990 | Riverhead | 30,000 pCi/L | ALI |
| Cobalt-60 | 1.67 pCi/L | 1989 | Manorville | 3,000 pCi/L | ALI |
| Strontium-90 | 14 pCi/L | 1974 | Manorville | 500 pCi/L | ALI |

| | | | | | |
|-------------|-------------|------|----------------|---------------|-----|
| Cesium-137 | 19 pCi/L | 1992 | Manorville | 700,000 pCi/L | ALI |
| Uranium-238 | 0.044 pCi/L | 1999 | Grangable Park | 300 pCi/L | ALI |

Notes:

Source of data: BNL's annual Site Environmental Reports, 1977–1999; BNL's Remedial Investigation and Plutonium Characterization reports (IT, 1998; IT, 2000); NYSDOH's Peconic River sampling data (NYSDOH, 1996). Some of these reports present only summary statistics and do not include raw data. Therefore, average concentrations for the contaminants listed cannot be calculated.

Contaminants in bold font have at least one measured concentration higher than the corresponding health-based comparison value.

BNL reported for different analytes from one year to the next: some analytes shown (e.g., tritium) have been sampled extensively for every year with data on records, while other analytes (e.g., europium-152) have been analyzed only in a few samples.

Sampling data in this table are for offsite sections of the Peconic River, which is not used as a source of public water supply. As a result, exposure to the water at this location is expected to be only periodic ingestion or dermal contact by visitors and recreational users. Nonetheless, comparison values that assume people drink the water in the offsite sections of the Peconic River were used to examine the health implications of whether these waters are used as a drinking water supply. Contaminants in bold font have at least one measured concentration higher than the corresponding health-based comparison value. The following types of comparison values are used in the table:

LTHA ATSDR Lifetime Health Advisory for drinking water

RMEG-c ATSDR Reference Dose Media Evaluation Guide for children's exposure

EMEG-ic ATSDR Environmental Media Evaluation Guide, for children's exposure of intermediate duration

IOM TUIL Institute of Medicine's Tolerable Upper Intake Level

EAL USEPA action level for lead in drinking water

MCL USEPA Maximum Contaminant Level

SDWA Safe Drinking Water Act level

ALI Annual Limit on Intake

The health-based comparison value for hexavalent chromium is used to screen concentrations of chromium; the health-based comparison value for inorganic mercury is used to screen concentrations of mercury; and the ALI for thorium-232 is used to screen concentrations of thorium-234 (because no ALI has been published for thorium-234).

Data presented only for those contaminants that were detected.

Table SD1. Contaminants in On-Site Sediments

| <i>Contaminant</i> | <i>Highest Sediment Concentration</i> | | <i>Seasonally Adjusted Health-Based Comparison Value (CV)</i> | <i>Type of CV</i> |
|--|---------------------------------------|--|---|-------------------|
| | On-site Peconic River | On-Site Recharge Basins, Wetlands, and Agricultural Fields | | |
| Data for radiological contamination in order of increasing atomic number | | | | |
| Gross alpha | 5.38 pCi/g | 44 pCi/g | NA | NA |
| Gross beta | 13.8 pCi/g | 44 pCi/g | NA | NA |
| Tritium (hydrogen-3) | 0.23 pCi/g | 0.39 pCi/g | NA | NA |
| Beryllium-7 | ND | 0.93 pCi/g | 1,188 pCi/g | NCRP-rs |
| Sodium-22 | NM | 9.4 pCi/g | 3.24 pCi/g | NCRP-rs |
| Potassium-40 | 8.51 pCi/g | 20 pCi/g | 66.0 pCi/g | NCRP-rs |
| Cobalt-60 | 0.49 pCi/g | ND | 2.48 pCi/g | NCRP-ps |
| Strontium-89 | 0.662 pCi/g | NM | 20.56 pCi/g | NCRP-ps |
| Strontium-90 | 3.91 pCi/g | 1.0 pCi/g | 0.864 pCi/g | NCRP-ps |
| Cesium-137 | 21.1 pCi/g | 13 pCi/g | 11.88 pCi/g | NCRP-ps |
| Europium-152 | 0.384 pCi/g | ND | 9.64 pCi/g | NCRP-rs |
| Europium-154 | 0.053 pCi/g | ND | 8.96 pCi/g | NCRP-rs |
| Europium-155 | 0.141 pCi/g | ND | 237.84 pCi/g | NCRP-rs |
| Thallium-208 | 0.26 pCi/g | 1.2 pCi/g | NA | NA |
| Lead-210 | 2.64 pCi/g | 14 pCi/g | 1.512 pCi/g | NCRP-rs |
| Lead-212 | 0.93 pCi/g | 1.2 pCi/g | NA | NA |

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| Lead-214 | 0.62 pCi/g | 1.1 pCi/g | NA | NA |
|--|---------------------------------------|---|---|-------------------|
| Bismuth-214 | NM | 0.79 pCi/g | NA | NA |
| Radium-226 | 0.851 pCi/g | ND | 0.40 pCi/g | NCRP-rs |
| Actinium-228 | NM | 1.7 pCi/g | NA | NA |
| Thorium-228 | 0.3 pCi/g | 0.43 pCi/g | 2.38 pCi/g | NCRP-rs |
| Thorium-234 | 1.02 pCi/g | 3.0 pCi/g | NA | NA |
| Uranium-233/234 | 1.38 pCi/g | NM | 14.04 pCi/g | NCRP-rs |
| Uranium-235 | 0.19 pCi/g | 0.22 pCi/g | 22.72 pCi/g | NCRP-rs |
| Uranium-238 | 0.74 pCi/g | NM | 67.04 pCi/g | NCRP-rs |
| Plutonium-238 | 0.01 pCi/g | NM | 34.6 pCi/g | NCRP-rs |
| Plutonium-239/240 | 0.16 pCi/g | NM | 31.36 pCi/g | NCRP-rs |
| Americium-241 | 1.91 pCi/g | ND | 35.68 pCi/g | NCRP-rs |
| Data for inorganic contaminants other than radionuclides | | | | |
| <i>Contaminant</i> | <i>Highest Sediment Concentration</i> | | <i>Seasonally Adjusted Health-Based Comparison Value (CV)</i> | <i>Type of CV</i> |
| | <i>On-site Peconic River</i> | <i>On-Site Recharge Basins, Wetlands, and Agricultural Fields</i> | | |
| Aluminum | 14,900 ppm | 32,700 ppm | 400,000 ppm | EMEG-ci |
| Arsenic | 9.6 ppm | 9 ppm | 20 ppm | RMEG-c |
| Barium | 197 ppm | 90.8 ppm | 16,000 ppm | RMEG-c |
| Beryllium | 1.2 ppm | 1.1 ppm | 200 ppm | EMEG-cc |
| Cadmium | 18.8 ppm | 3.2 ppm | 40 ppm | EMEG-cc |

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|---|------------|------------|------------|---------|
| Chromium | 137 ppm | 46.3 ppm | 800 ppm | RMEG-c |
| Cobalt | 11 ppm | 12.9 ppm | 18,800 ppm | RBC-n |
| Copper | 1,140 ppm | 143 ppm | 12,400 ppm | RBC-n |
| Cyanide | 0.11 ppm | ND | 4,000 ppm | RMEG-c |
| Iron | 11,200 ppm | 31,100 ppm | 92,000 ppm | RBC-n |
| Lead | 120 ppm | 297 ppm | 1,600 ppm | EAL |
| Manganese | 134 ppm | 461 ppm | 12,000 ppm | RMEG-c |
| Mercury | 24.5 ppm | 0.77 ppm | 80 ppm | RMEG-c |
| Nickel | 133 ppm | 37.8 ppm | 4,000 ppm | RMEG-c |
| Selenium | 5.5 ppm | 0.89 ppm | 1,200 ppm | EMEG-cc |
| Silver | 171 ppm | 6.4 ppm | 1,200 ppm | RMEG-c |
| Thallium | 1.5 ppm | 0.16 ppm | 22 ppm | RBC-n |
| Vanadium | 93.5 ppm | 85.9 ppm | 800 ppm | EMEC-ci |
| Zinc | 681 ppm | 806 ppm | 80,000 ppm | EMEG-cc |
| Data for organic contaminants, other than PCBs and pesticides | | | | |
| Acenaphthylene | 0.14 ppm | ND | NA | NA |
| Acetone | ND | 0.12 ppm | 20,000 ppm | RMEG-c |
| Benzo(a)anthracene | 0.4 ppm | 0.64 ppm | 3.48 ppm | RBC-c |
| Benzo(a)pyrene | 0.46 ppm | 0.85 ppm | NA | NA |
| Benzo(b)fluoranthene | 1.2 ppm | 1.4 ppm | 3.48 ppm | RBC-c |

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|------------------------------|---------------------------------------|---|---|-------------------|
| Benzo(g,h,i)perylene | 0.17 ppm | 0.68 ppm | NA | NA |
| Benzo(k)fluoranthene | 0.042 ppm | 1.0 ppm | 3.48 ppm | RBC-c |
| Bis(2-ethylhexyl)phthalate | 0.63 ppm | 3.3 ppm | 200 ppm | CREG |
| 2-Butanone | ND | 0.03 ppm | 120,000 ppm | RMEG-c |
| Butylbenzylphthalate | ND | 0.37 ppm | 40,000 ppm | RMEG-c |
| Chrysene | 0.52 ppm | 0.84 ppm | 348 ppm | RBC-c |
| Di-n-butylphthalate | 0.23 ppm | ND | 20,000 ppm | RMEG-c |
| Di-n-octylphthalate | 0.59 ppm | 0.22 ppm | 80,000 ppm | EMEG-ci |
| | | | | |
| Contaminant | Highest Sediment Concentration | | Seasonally Adjusted Health-Based Comparison Value (CV) | Type of CV |
| | <i>On-site Peconic River</i> | <i>On-Site Recharge Basins, Wetlands, and Agricultural Fields</i> | | |
| Fluoranthene | 0.95 ppm | 1.2 ppm | 8,000 ppm | RMEG-c |
| Indeno(1,2,3-cd)pyrene | 0.35 ppm | 0.78 ppm | 3.48 ppm | RMEG-c |
| Methylene chloride | ND | 0.059 ppm | 3000 | RMEG-c |
| Phenanthrene | 0.35 ppm | 0.52 ppm | NA | NA |
| Pyrene | 0.87 ppm | 1.7 ppm | 8,000 ppm | RMEG-c |
| Toluene | 0.023 ppm | 0.16 ppm | 4,000 ppm | EMEG-ci |
| Data for PCBs and pesticides | | | | |

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| | | | | |
|----------------------|-------------|------------|-----------|---------|
| 4,4'-DDD | 0.096 ppm | 0.047 ppm | 12.0 ppm | CREG |
| 4,4'-DDE | 0.089 ppm | 0.16 ppm | 8.0 ppm | CREG |
| 4,4'-DDT | 0.023 ppm | 0.12 ppm | 30 ppm | RMEG |
| alpha-Chlordane | 0.073 ppm | 0.008 ppm | 8.0 ppm | CREG |
| Aroclor-1254 | 1.5 ppm | 0.51 ppm | 4.0 ppm | EMEG-cc |
| Aroclor-1260 | ND | 1.8 ppm | 1.28 ppm | RBC-c |
| Chlordane, technical | 0.158 ppm | NM | 8.0 ppm | CREG |
| Dieldrin | 0.00326 ppm | 0.0041 ppm | 0.16 ppm | CREG |
| Endosulfan I | 0.018 ppm | 0.0052 ppm | 400 ppm | EMEG-cc |
| Endosulfan II | 0.0133 ppm | ND | 400 ppm | EMEG-cc |
| Endosulfan sulfate | ND | 0.058 ppm | NA | NA |
| Endrin | 0.00142 ppm | ND | 80 ppm | EMEG-cc |
| gamma-Chlordane | 0.043 ppm | 0.0077 ppm | 8.0 ppm | CREG |
| Methoxychlor | 0.398 ppm | ND | 1,200 ppm | RMEG-c |

Notes:

Source of data: BNL Remedial Investigation Reports and Site Investigation Reports; NYSDEC and NYSDOH sampling data.

NA: not applicable. ERG could not find any health-based comparison values for these contaminants or isotopes.

ND: not detected. Some sediment samples were analyzed for the contaminant, but the contaminant was not detected.

NM: not measured. Not all analytes were measured in the two different categories of sediments. Following is a key for the health-based comparison values used. These were derived from health-based comparison values for exposures to soils, and then, per ATSDR's direction, adjusted for seasonal exposures. ERG assumed that exposures to sediments were likely limited to just one season per year and increased all soil comparison values by a factor of four to account for this. Contaminants in bold font had at least one sediment concentration higher than the corresponding health-based comparison value for soils. Many of these comparison values assume prolonged

contact with the contaminated medium (sediment, in this case), which is an extremely unlikely exposure scenario for onsite locations at BNL.

NCRP-rs NCRP recommended soil screening limit for sparsely vegetated rural locations

NCRP-ps NCRP recommended soil screening limit for sparsely vegetated pasture locations

EMEG-cc ATSDR Environmental Media Evaluation Guide, for children's exposure of chronic duration

EMEG-ci ATSDR Environmental Media Evaluation Guide, for children's exposure of intermediate duration

CREG ATSDR Cancer Risk Evaluation Guide

RMEG-c ATSDR Reference Dose Media Evaluation Guide for children's exposure

RBC-c USEPA Region 3 Risk-Based Concentration for cancer outcomes

RBC-n USEPA Region 3 Risk-Based Concentration for noncancer outcomes

EAL USEPA Aearly action level@ or soil screening level for lead

The CV for hexavalent chromium was used to screen concentrations of chromium; the CV for mercuric chloride was used to screen concentrations of mercury. In cases where sampling reports documented concentrations of pairs of isotopes (e.g., uranium-233/234), the lowest comparison value of both isotopes was selected. The comparison value for chlordanes was used to screen concentrations of alpha-, gamma-, and technical chlordanes.

Data presented only for those contaminants that were detected in at least one sample, but not including inorganics known to be relatively benign (e.g., calcium, potassium, sodium). ATSDR adjusted all comparison values used in this table and Table SD 2 because residents are not expected to be exposed to sediments year round in a region with sub-freezing temperatures in the winter. ATSDR assumed that exposures are most likely limited to the summer months and therefore adjusted (i.e., increased) all health-based comparison values by a factor of 4 in this evaluation. These adjusted comparison values appear in the column labeled "Seasonally Adjusted Health-Based Comparison Value (CV)."

Table SD2. Concentrations of Contaminants in Off-Site Sediments

| Contaminant | Highest Sediment Concentration | | Seasonally Adjusted Health-Based Comparison Value (CV) | Type of CV |
|--|--------------------------------|----------------------------|--|------------|
| | Off-site Peconic River | Off-site Control Locations | | |
| Data for radiological contamination in order of increasing atomic number | | | | |
| Gross alpha | 29.7 pCi/g | 0.909 pCi/g | NA | NA |
| Gross beta | 19.4 pCi/g | 1.19 pCi/g | NA | NA |
| Beryllium-7 | 0.11 pCi/g | 0.90 pCi/g | 1,188 pCi/g | NCRP-rs |
| Potassium-40 | 5.89 pCi/g | 7.74 pCi/g | 66 pCi/g | NCRP-rs |
| Cobalt-60 | 0.029 pCi/g | 0.01 pCi/g | 2.48 pCi/g | NCRP-ps |
| Strontium-90 | 0.432 pCi/g | 0.16 pCi/g | 0.864 pCi/g | NCRP-ps |
| Cesium-137 | 16.6 pCi/g | 1.05 pCi/g | 11.88 pCi/g | NCRP-ps |
| Europium-152 | 0.223 pCi/g | 0.092 pCi/g | 9.64 pCi/g | NCRP-rs |
| Europium-154 | ND | 0.039 pCi/g | 8.96 pCi/g | NCRP-rs |
| Europium-155 | 0.163 pCi/g | 0.037 pCi/g | 237.84 pCi/g | NCRP-rs |
| Thallium-208 | 0.05 pCi/g | 0.09 pCi/g | NA | NA |
| Lead-212 | 0.72 pCi/g | 4.77 pCi/g | NA | NA |
| Lead-214 | 0.08 pCi/g | 0.22 pCi/g | NA | NA |
| Bismuth-214 | 0.16 pCi/g | 0.19 pCi/g | NA | NA |
| Radium-226 | 2.02 pCi/g | 1.19 pCi/g | 0.40 pCi/g | NCRP-rs |
| Actinium-228 | 0.78 pCi/g | 0.41 pCi/g | NA | NA |
| Thorium-228 | NM | 0.333 pCi/g | 2.38 pCi/g | NCRP-rs |

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| Thorium-232 | 1.14 pCi/g | ND | 0.272 pCi/g | NCRP-rs |
|--|---------------------------------------|-----------------------------------|---|-------------------|
| Uranium-233/234 | 4.39 pCi/g | 4.36 pCi/g | 14.04 pCi/g | NCRP-rs |
| Uranium-235 | 0.249 pCi/g | 0.23 pCi/g | 22.72 pCi/g | NCRP-rs |
| <i>Contaminant</i> | <i>Highest Sediment Concentration</i> | | <i>Seasonally Adjusted Health-Based Comparison Value (CV)</i> | <i>Type of CV</i> |
| | <i>Off-site Peconic River</i> | <i>Off-site Control Locations</i> | | |
| Uranium-238 | 4.01 pCi/g | 0.33 pCi/g | 67.04 pCi/g | NCRP-rs |
| Plutonium-238 | 0.018 pCi/g | 0.03 pCi/g | 34.6 pCi/g | NCRP-rs |
| Plutonium-239/240 | 0.148 pCi/g | 0.07 pCi/g | 31.36 pCi/g | NCRP-rs |
| Americium-241 | 0.615 pCi/g | 0.048 pCi/g | 35.68 pCi/g | NCRP-rs |
| Data for inorganic contaminants other than radionuclides | | | | |
| Aluminum | 10,600 ppm | 24,500 ppm | 400,000 ppm | EMEG-ci |
| Arsenic | 24.2 ppm | 9.1 ppm | 20 ppm | RMEG-c |
| Barium | 121 ppm | 86.4 ppm | 16,000 ppm | RMEG-c |
| Beryllium | 1.0 ppm | 1.6 ppm | 200 ppm | EMEG-cc |
| Cadmium | 6.9 ppm | 1.6 ppm | 40 ppm | EMEG-cc |
| Chromium | 44.8 ppm | 24.2 ppm | 800 ppm | RMEG-c |
| Cobalt | 7.4 ppm | 3.6 ppm | 18,800 ppm | RBC-n |
| Copper | 357 ppm | 52.5 ppm | 12,400 ppm | RBC-n |
| Iron | 10,300 ppm | 20,600 ppm | 92,000 ppm | RBC-n |
| Lead | 228 ppm | 97.6 ppm | 1600 ppm | EAL |

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|------------------------------|------------|------------|------------|---------|
| Manganese | 188 ppm | 84.3 ppm | 12,000 ppm | RMEG-c |
| Mercury | 9 ppm | 0.41 ppm | 80 ppm | RMEG-c |
| Nickel | 20.3 ppm | 13.2 ppm | 4,000 ppm | RMEG-c |
| Selenium | 6.3 ppm | 4.9 ppm | 1,200 ppm | EMEG-cc |
| Silver | 61.7 ppm | 0.48 ppm | 1,200 ppm | RMEG-c |
| Thallium | 1.8 ppm | ND | 22 ppm | RBC-n |
| Vanadium | 76.5 ppm | 73.3 ppm | 800 ppm | EMEC-ci |
| Zinc | 385 ppm | 158 ppm | 80,000 ppm | EMEG-cc |
| Data for PCBs and pesticides | | | | |
| 4,4'-DDD | 0.859 ppm | 0.0153 ppm | 12.0 ppm | CREG |
| 4,4'-DDE | 0.727 ppm | 0.10 ppm | 8.0 ppm | CREG |
| 4,4'-DDT | 0.099 ppm | 0.39 ppm | 30 ppm | RMEG-c |
| alpha-Chlordane | 0.0736 ppm | 0.0102 ppm | 8.0 ppm | CREG |
| Aroclor-1254 | 0.128 ppm | ND | 4.0 ppm | EMEG-cc |
| Dieldrin | 0.0122 ppm | ND | 0.16 ppm | CREG |
| gamma-Chlordane | 0.072 ppm | ND | 8.0 ppm | CREG |

Notes:

Source of data: BNL Remedial Investigation Reports and Site Investigation Reports; NYSDEC and NYSDOH sampling data.

NA: not applicable. ERG could not find any health-based comparison values for these contaminants or isotopes.

ND: not detected. Some sediment samples were analyzed for the contaminant, but the contaminant was not detected.

NM: not measured. Not all analytes were measured in the two different categories of sediments. Following is a key for the health-based comparison values used. These were derived from health-based comparison values for exposures to soils, and then, per ATSDR's direction, adjusted for

seasonal exposures. ERG assumed that exposures to sediments were likely limited to just one season per year and increased all soil comparison values by a factor of four to account for this. Contaminants in bold font had at least one sediment concentration higher than the corresponding health-based comparison value for soils. Many of these comparison values assume prolonged contact with the contaminated medium (sediment, in this case), which is an extremely unlikely exposure scenario for the sediments in this area.

NCRP-rs NCRP recommended soil screening limit for sparsely vegetated rural locations

NCRP-ps NCRP recommended soil screening limit for sparsely vegetated pasture locations

EMEG-cc ATSDR Environmental Media Evaluation Guide, for children's exposure of chronic duration

EMEG-ci ATSDR Environmental Media Evaluation Guide, for children's exposure of intermediate duration

CREG ATSDR Cancer Risk Evaluation Guide

RMEG-c ATSDR Reference Dose Media Evaluation Guide for children's exposure

RBC-c USEPA Region 3 Risk-Based Concentration for cancer outcomes

RBC-n USEPA Region 3 Risk-Based Concentration for noncancer outcomes

EAL USEPA Aearly action level@ or soil screening level for lead

The CV for hexavalent chromium was used to screen concentrations of chromium; the CV for mercuric chloride was used to screen concentrations of mercury. In cases where sampling reports documented concentrations of pairs of isotopes (e.g., uranium-233/234), the lowest comparison value of both isotopes was selected. The comparison value for chlordanes was used to screen concentrations of alpha-, gamma-, and technical chlordanes.

Data presented only for those contaminants that were detected in at least one sample, but not including inorganics known to be relatively benign (e.g., calcium, potassium, sodium).

Table B1. Summary of ^{137}Cs , ^{40}K , and ^{90}Sr in Biota for On- and Off-site Locations (1977–1999)

| <i>Biota Sampled</i> | <i>Radionuclide Concentrations pCi/g, wet</i> | | |
|----------------------|---|-------------------------------------|------------------------------------|
| | <i>^{40}K</i> | <i>^{137}Cs</i> | <i>^{90}Sr</i> |
| Fish | 20.212 | 25 | 7.90 ± 0.474 |
| Shellfish | 9.21 ± 11.6 | 0.510 ± 0.036 | 1.390 ± 0.264 |
| Deer (flesh) | 7.72 | 11.74 | 0.04 ± 0.10 |
| Other mammals | 3.38 | 8.17 | NA |
| Milk | 1.5×10^{-6} Ci/ml | NA | NA |
| Edible vegetation | 6.59 ± 1.10 | 2.2 | 0.040 ± 0.008 |
| Inedible vegetation | 13.90 | 1300 | |

Source: BNL SERs 1977-1999; NYSDOH 1996

Table B2. Potassium-40 concentrations in fish collected from the Peconic River on site (1977–1999)

| <i>Fish Species</i> | <i>Sample Type</i> | <i>Maximum Sample Concentration (pCi/g, wet)</i> | <i>Year</i> | <i>Maximum Sample Concentration (pCi/g, dry)</i> | <i>Year</i> |
|---------------------|--------------------------|--|-------------|--|-------------|
| Yellow Perch | whole | 3.58 ± 0.11 | 1999 | NA | NA |
| Chain Pickerel | flesh | 4.09 ± 0.04 | 1999 | 11.7 | 1989 |
| Chain Pickerel | flesh/skin | 4.58 ± 1.04 | 1998 | NA | NA |
| Chain Pickerel | bone/viscera | 7.536 | 1989 | 15.7 | 1989 |
| Chain Pickerel | whole | 3.74 ± 0.83 | 1998 | NA | NA |
| Chain Pickerel | deheaded and eviscerated | 4.938 | 1996 | NA | NA |
| Chain Pickerel | not specified | 6.713 | 1987 | 14.28 | 1990 |
| Brown Bullhead | flesh/skin | 3.22 ± 0.53 | 1998 | NA | NA |
| Brown Bullhead | bone/viscera | 3.06 ± 1.07 | 1998 | NA | NA |
| Brown Bullhead | whole | 2.87 ± 0.56 | 1998 | NA | NA |
| Brown Bullhead | not specified | 6.625 | 1989 | 12.5 | 1989 |
| Sunfish | not specified | 3.69 | 1977 | NA | NA |
| Sunfish | flesh | 2.441 | 1989 | 6.78 | 1989 |
| Bass | not specified | 5.13 | 1977 | NA | NA |
| Largemouth Bass | not specified | 2.185 | 1987 | NA | NA |
| Largemouth Bass | flesh | 3.475 | 1989 | 13.9 | 1989 |
| Shiner | not specified | 4.09 | 1977 | NA | NA |

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|----------------------|---------------|-------------|------|------|------|
| Pumpkinseed | not specified | 20.212 | 1989 | 65.2 | 1989 |
| Pumpkinseed | flesh | 3.276 | 1989 | 12.6 | 1989 |
| Creek Chub | not specified | 1.729 | 1986 | NA | NA |
| Creek Chub Sucker | whole | 2.27 ± 0.43 | 1998 | NA | NA |
| Goldfish | flesh | 3.45 | 1989 | 15.0 | 1989 |
| Daces | not specified | ND | 1991 | NA | NA |

Source: BNL SERs 1977-1999; NYSDOH 1996

Table B3. Strontium-90 Concentrations in Fish Collected from the Peconic River on Site (1977–1999)

| <i>Fish Species</i> | <i>Sample Type</i> | <i>Maximum Sample Concentration (pCi/g, wet)</i> | <i>Year</i> | <i>Maximum Sample Concentration (pCi/g, dry)</i> | <i>Year</i> |
|----------------------------|---------------------------|---|--------------------|---|--------------------|
| Chain Pickerel | not specified | 1.846 | 1989 | 5.43 | 1989 |
| Brown Bullhead | not specified | 4.786 | 1989 | 9.03 | 1989 |
| Largemouth Bass | not specified | 5.447 | 1989 | 11.59 | 1989 |
| Pumpkinseed | not specified | 4.752 | 1989 | 7.92 | 1989 |
| Creek Chub Sucker | deheaded and eviscerated | 0.45 | 1996 | NA | NA |
| Trout | not specified | 0.075 | 1989 | 1.3 | 1989 |
| Daces | not specified | 0.338 | 1991 | NA | NA |
| Unspecified | bone | 0.05 | 1978 | NA | NA |
| Unspecified | flesh | 0.072 | 1980 | NA | NA |
| Unspecified | not specified | 0.42 | 1987 | NA | NA |

Source: BNL SERs 1977-1999; NYSDOH 1996

Table B4. Cesium-137 concentrations in fish from the Peconic River on site (1977–1999)

| <i>Fish Species</i> | <i>Sample Type</i> | <i>Maximum Sample Concentration (pCi/g, wet)</i> | <i>Year</i> | <i>Maximum Sample Concentration (pCi/g, dry)</i> | <i>Year</i> |
|----------------------------|---------------------------|---|--------------------|---|--------------------|
| Yellow Perch | whole | 0.37 ± 0.20 | 1999 | NA | NA |
| Chain Pickerel | flesh | 3.894 | 1989 | 12.6 | 1989 |
| Chain Pickerel | flesh/skin | 0.73 ± 0.17 | 1998 | NA | NA |

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| <i>Fish Species</i> | <i>Sample Type</i> | <i>Maximum Sample Concentration (pCi/g, wet)</i> | <i>Year</i> | <i>Maximum Sample Concentration (pCi/g, dry)</i> | <i>Year</i> |
|----------------------------|---------------------------|---|--------------------|---|--------------------|
| Chain Pickerel | bone/viscera | 9.312 | 1989 | 19.4 | 1989 |
| Chain Pickerel | whole | 2.712 ± 0.314 | 1998 | NA | NA |
| Chain Pickerel | deheaded and eviscerated | 0.49 | 1996 | NA | NA |
| Chain Pickerel | not specified | 7.10 | 1977 | NA | NA |
| Brown Bullhead | flesh/skin | 0.34 ± 0.06 | 1998 | NA | NA |
| Brown Bullhead | bone/viscera | 0.689 ± 0.147 | 1998 | NA | NA |
| Brown Bullhead | whole | 1.189 ± 0.152 | 1998 | NA | NA |
| Brown Bullhead | not specified | 8.0 | 1988 | NA | NA |
| Sunfish | not specified | 8.5 | 1977 | NA | NA |
| Sunfish | flesh | 11.016 | 1989 | 30.6 | 1989 |
| Bass | not specified | 6.2 | 1977 | NA | NA |
| Largemouth Bass | not specified | 8.0 | 1988 | NA | NA |
| Largemouth Bass | flesh | 0.148 | 1989 | 0.593 | 1989 |
| Shiner | not specified | 5.75 | 1977 | NA | NA |
| Pumpkinseed | not specified | 25.0 | 1988 | NA | NA |
| Pumpkinseed | flesh | 6.864 | 1989 | 26.4 | 1989 |
| Creek Chub | not specified | 0.588 | 1986 | NA | NA |
| Creek Chub | whole | 1.988 ± 0.355 | 1998 | NA | NA |

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| <i>Fish Species</i> | <i>Sample Type</i> | <i>Maximum Sample Concentration (pCi/g, wet)</i> | <i>Year</i> | <i>Maximum Sample Concentration (pCi/g, dry)</i> | <i>Year</i> |
|----------------------------|---------------------------|---|--------------------|---|--------------------|
| Sucker | | | | | |
| Creek Chub Sucker | deheaded and eviscerated | 0.527 | 1996 | NA | NA |
| Goldfish | flesh | 0.041 | 1989 | 0.18 | 1989 |
| Daces | not specified | 0.305 | 1991 | NA | NA |
| Unspecified | flesh | 1.192 | 1978 | NA | NA |
| Unspecified | not specified | 1.880 | 1997 | NA | NA |

Source: BNL SERs 1977-1999; NYSDOH 1996

Table B5. Tritium, Gross Alpha, and Gross Beta concentrations in fish from the Peconic River on site (1977–1999)

| <i>Fish Species</i> | <i>Sample Type</i> | <i>Tritium, Maximum Sample Conc. (pCi/g, wet)</i> | <i>Year</i> | <i>Gross Alpha, Maximum Sample Conc. (pCi/g, wet)</i> | <i>Year</i> | <i>Gross Beta, Maximum Sample Conc. (pCi/g, wet)</i> | <i>Year</i> |
|----------------------------|---------------------------|--|--------------------|--|--------------------|---|--------------------|
| Chain Pickerel | deheaded and eviscerated | 0.522 | 1996 | NA | NA | 0.487 | 1996 |
| Creek Chub Sucker | deheaded and eviscerated | 0.449 | 1996 | 1.65 | 1996 | 0.469 | 1996 |
| Creek Chub Sucker | Fluid | 8,100 pCi/L | 1986 | NA | NA | NA | NA |
| Unspecified | not specified | NA | NA | NA | NA | 20.27 | 1997 |

Source: BNL SERs 1977–1999; NYSDOH 1996

Table B6. Uranium-234, Uranium-238, and Americium-241 Concentrations in Fish from the Peconic River on Site (1977–1999)

| <i>Fish Species</i> | <i>Sample Type</i> | <i>Uranium-234, Maximum Sample Conc. (pCi/g, wet)</i> | <i>Year</i> | <i>Uranium-238, Maximum Sample Conc. (pCi/g, wet)</i> | <i>Year</i> | <i>Americium-241, Maximum Sample Conc. (pCi/g, wet)</i> | <i>Year</i> |
|---------------------|--------------------|---|-------------|---|-------------|---|-------------|
| Brown Bullhead | not specified | 0.0022 ± 0.0008 | 1999 | 0.008 ± 0.0004 | 1999 | 0.0036 ± 0.0013 | 1999 |
| Brown Bullhead | Whole | NA | NA | 0.004 ± 0.002 | 1998 | NA | NA |
| Brown Bullhead | bone/viscera | 0.006 ± 0.002 | 1998 | 0.008 ± 0.002 | 1998 | NA | NA |
| Chain Pickerel | not specified | 0.0008 ± 0.0004 | 1999 | 0.0012 ± 0.0005 | 1999 | 0.0004 ± 0.0003 | 1999 |
| Chain Pickerel | Whole | 0.002 ± 0.001 | 1998 | 0.004 ± 0.002 | 1998 | NA | NA |
| Creek Chub Sucker | Whole | 0.003 ± 0.002 | 1998 | 0.005 ± 0.002 | 1998 | NA | NA |

Source: BNL SERs 1977-1999; NYSDOH 1996

Table B7. Inorganic Concentrations in Fish from the Peconic River on Site (1996–1999)

| <i>Fish Species</i> | <i>Sample Type</i> | <i>As, Max. Conc. (mg/kg, wet)</i> | <i>Ba, Max. Conc. (mg/kg, wet)</i> | <i>Cd, Max. Conc. (mg/kg, wet)</i> | <i>Cu, Max. Conc. (mg/kg, wet)</i> | <i>Pb, Max. Conc. (mg/kg, wet)</i> | <i>Mn, Max. Conc. (mg/kg, wet)</i> | <i>Hg, Max. Conc. (mg/kg, wet)</i> | <i>Ni, Max. Conc. (mg/kg, wet)</i> | <i>Ag, Max. Conc. (mg/kg, wet)</i> | <i>Zn, Max. Conc. Mg/kg wet</i> | <i>Fe, Max. Conc. Mg/kg wet</i> |
|----------------------------|---------------------------|---|---|---|---|---|---|---|---|---|--|--|
| Comparison Values | | 0.0021(RBC-C) | 95(RBC-N) | 1.4(RBC-N) | 54 (RBC-N) | none | 190(RB C-N) | 0.14 (RBC-N) | 27(RBC-N) | 6.8(RBC-N) | 410(RB C-N) | 410(RB C-N) |
| Chain Pickerel | flesh | ND | 1.62 | ND | 1.30 | ND | 2.24 | 0.10 | ND | 0.35 | 21.15 | 8.63 |
| Chain Pickerel | dehead. And evisc. | NA | NA | NA | NA | 0.14 | NA | 1.6 | NA | NA | NA | NA |
| Chain Pickerel | not specified | NA | NA | 0.205 | 5.42 | 0.48 | NA | 0.746 | 0.157 | 0.22 | NA | NA |
| Brown Bullhead | flesh | ND | 2.11 | ND | 2.15 | ND | 2.04 | 0.40 | 0.18 | ND | 14.25 | 39.3 |
| Brown Bullhead | dehead. And evisc. | NA | NA | NA | 2.0 | 0.14 | NA | 0.99 | NA | NA | NA | NA |
| Brown Bullhead | not specified | NA | NA | 0.196 | 8.49 | 0.324 | NA | 0.694 | 0.162 | 0.39 | NA | NA |

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| <i>Fish Species</i> | <i>Sample Type</i> | <i>As, Max. Conc. (mg/kg, wet)</i> | <i>Ba, Max. Conc. (mg/kg, wet)</i> | <i>Cd, Max. Conc. (mg/kg, wet)</i> | <i>Cu, Max. Conc. (mg/kg, wet)</i> | <i>Pb, Max. Conc. (mg/kg, wet)</i> | <i>Mn, Max. Conc. (mg/kg, wet)</i> | <i>Hg, Max. Conc. (mg/kg, wet)</i> | <i>Ni, Max. Conc. (mg/kg, wet)</i> | <i>Ag, Max. Conc. (mg/kg, wet)</i> | <i>Zn, Max. Conc. Mg/kg wet</i> | <i>Fe, Max. Conc. Mg/kg wet</i> |
|----------------------------|---------------------------|---|---|---|---|---|---|---|---|---|--|--|
| Creek Chub Sucker | dehead. And evisc. | NA | NA | NA | NA | 0.14 | NA | 0.96 | NA | NA | NA | NA |
| Creek Chub Sucker | not specified | NA | NA | 0.126 | 4.17 | 0.231 | NA | 0.616 | 0.167 | 0.15 | NA | NA |
| Common Shiner | dehead. And evisc. | NA | NA | NA | NA | NA | NA | 0.32 | NA | NA | NA | NA |
| Pumpkin-seed | dehead. And evisc. | NA | NA | NA | NA | NA | NA | 0.58 | NA | NA | NA | NA |
| Pumpkin-seed | not specified | NA | NA | 0.125 | 3.78 | 0.643 | NA | 1.26 | 0.137 | 0.28 | NA | NA |

Source: BNL SERs 1977–1999; NYSDOH 1996

Table B8. Pesticide and PCB Concentrations in Fish from the Peconic River on Site (1996–1999)

| <i>Contaminant</i> | <i>Highest Concentration (mg/kg, fish species, wet)</i> | <i>Comparison Value (CV) (mg/kg, fish species)</i> | <i>Type of CV</i> |
|---------------------------|--|---|--------------------------|
| alpha-BHC | 0.0017, pickerel 0.0097, bullhead | NA | NA |
| beta-BHC | 0.0017, pickerel 0.0017, bullhead | NA | NA |
| delta-BHC | 0.0017, pickerel 0.0017, bullhead | NA | NA |
| gamma-BHC (Lindane) | 0.0017, pickerel 0.0017, bullhead | NA | NA |
| Heptachlor | 0.0017, pickerel 0.0019, bullhead | 0.0007 | RBC-C |
| Aldrin | 0.0017, pickerel 0.0017, bullhead | 0.00019 | RBC-C |
| Heptachlor epoxide | 0.0017, pickerel 0.0017, bullhead | 0.00035 | RBC-C |
| Endosulfan I | 0.0017, pickerel 0.0017, bullhead | 8.1 | RBC-N |
| Dieldrin | 0.0033, pickerel 0.007, bullhead | 0.0002 | RBC-C |
| 4,4'-DDE | 0.0752, pickerel 0.0935, bullhead 0.0991, pumpkinseed 0.0511, creek chub sucker | 0.0093 | RBC-C |
| Endrin | 0.0033, pickerel 0.0033, bullhead | 0.41 | RBC-N |
| Endosulfan II | 0.0033, pickerel 0.0048, bullhead | 8.1 | RBC-N |

| Contaminant | <i>Highest Concentration (mg/kg, fish species, wet)</i> | <i>Comparison Value (CV) (mg/kg, fish species)</i> | <i>Type of CV</i> |
|--------------------|--|---|--------------------------|
| | bullhead | | |
| 4,4'-DDD | 0.016, pickerel0.017, bullhead0.142, pumpkinseed0.023, creek chub sucker | 0.013 | RBC-C |
| Endosulfan sulfate | 0.0033, pickerel0.0033, bullhead | NA | NA |
| 4,4'-DDT | 0.00557, pickerel0.0769, bullhead0.0226, pumpkinseed | 0.0093 | RBC-C |
| Methoxychlor | 0.017, pickerel0.017, bullhead | 6.8 | RBC-N |
| Endrin ketone | 0.0033, pickerel0.0033, bullhead | 0.41 | RBC-N |
| Endrin aldehyde | 0.0054, pickerel0.019, bullhead | 0.41 | RBC-N |
| alpha-Chlordane | 0.0136, pickerel0.0325, bullhead0.00788, creek chub sucker | 0.009 | RBC-C |
| gamma-Chlordane | 0.0015, pickerel0.0015, bullhead | 0.009 | RBC-C |
| Toxaphene | 0.17, pickerel0.17, bullhead | 0.0029 | RBC-C |
| Aroclor-1016 | 0.033, pickerel0.033, bullhead | 0.045 | RBC-C |

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| Contaminant | <i>Highest Concentration (mg/kg, fish species, wet)</i> | <i>Comparison Value (CV) (mg/kg, fish species)</i> | <i>Type of CV</i> |
|--------------------|--|---|--------------------------|
| Aroclor-1221 | 0.067, pickerel 0.067, bullhead | 0.0016 | RBC-C |
| Aroclor-1232 | 0.033, pickerel 0.033, bullhead | 0.0016 | RBC-C |
| Aroclor-1242 | 0.033, pickerel 0.033, bullhead | 0.0016 | RBC-C |
| Aroclor-1248 | 0.033, pickerel 0.033, bullhead | 0.0016 | RBC-C |
| Aroclor-1254 | 4.3, pickerel 3.68, bullhead 4.8, pumpkinseed 4.26, creek chub sucker | 0.0016 | RBC-C |
| Aroclor-1260 | 0.047, pickerel 0.170, bullhead | 0.0016 | |

Source: BNL SERs 1977–1999; NYSDOH 1996

Table B9. Potassium-40 concentrations in fish from the Peconic River off site (1973–1999)

| <i>Fish Species</i> | <i>Sample Type</i> | <i>Maximum Sample Concentration (pCi/g, wet)</i> | <i>Year</i> | <i>Maximum Sample Concentration (pCi/g, dry)</i> | <i>Year</i> |
|----------------------------|---------------------------|---|--------------------|---|--------------------|
| Yellow Perch | not specified | 3.140 | 1991 | NA | NA |
| Yellow Perch | whole | 3.19 ± 0.78 | 1996 | NA | NA |
| Yellow Perch | bone/viscera | 4.21 ± 2.12 | 1996 | NA | NA |
| Yellow Perch | flesh/skin | 3.40 ± 0.65 | 1998 | NA | NA |
| Chain Pickerel | flesh/skin | 5.03 ± 1.45 | 1996 | NA | NA |
| Chain Pickerel | bone/viscera | 3.76 ± 1.52 | 1996 | NA | NA |
| Chain Pickerel | whole | 4.86 ± 1.74 | 1997 | NA | NA |
| Chain Pickerel | not specified | 4.410 | 1991 | NA | NA |
| Brown Bullhead | flesh/skin | 3.97 ± 0.66 | 1998 | NA | NA |
| Brown Bullhead | bone/viscera | 1.65 ± 0.30 | 1996 | NA | NA |
| Brown Bullhead | whole | 2.7 | 1999 | NA | NA |
| Brown Bullhead | not specified | 4.22 | 1993 | NA | NA |
| Black Crappie | not specified | 2.760 | 1992 | NA | NA |
| Black Crappie | flesh/skin | 3.59 ± 0.85 | 1996 | NA | NA |
| Black Crappie | bone/viscera | 2.77 ± 0.61 | 1996 | NA | NA |
| Largemouth Bass | not specified | 4.611 | 1994 | NA | NA |
| Largemouth Bass | flesh | 1.36 ± 0.05 | 1999 | NA | NA |

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| <i>Fish Species</i> | <i>Sample Type</i> | <i>Maximum Sample Concentration (pCi/g, wet)</i> | <i>Year</i> | <i>Maximum Sample Concentration (pCi/g, dry)</i> | <i>Year</i> |
|----------------------------|---------------------------|---|--------------------|---|--------------------|
| Largemouth Bass | bone/viscera | 4.11 ± 0.07 | 1999 | NA | NA |
| Catfish | not specified | 3.0 | 1989 | 12.5 | 1989 |
| Pumpkinseed | not specified | 2.573 | 1994 | NA | NA |
| Pumpkinseed | whole | 2.77 ± 0.97 | 1997 | NA | NA |
| Pumpkinseed | flesh | 3.528 | 1989 | 14.7 | 1989 |
| Pumpkinseed | bone/viscera | 6.49 ± 5.32 | 1996 | NA | NA |
| Pumpkinseed | flesh/skin | 3.27 ± 0.64 | 1996 | NA | NA |
| Bluegill | not specified | 3.277 | 1989 | 11.3 | 1989 |
| Bluegill | whole | 3.46 ± 1.14 | 1997 | NA | NA |
| Bluegill | bone/viscera | 3.32 ± 1.99 | 1997 | NA | NA |
| Bluegill | flesh/skin | 6.40 ± 2.15 | 1997 | NA | NA |
| Golden Shiner | not specified | 4.384 | 1995 | NA | NA |
| Golden Shiner | whole | 4.88 ± 2.59 | 1997 | NA | NA |
| Golden Shiner | bone/viscera | 3.43 ± 0.80 | 1996 | NA | NA |
| Golden Shiner | flesh/skin | 3.82 ± 0.85 | 1996 | NA | NA |
| Eel | not specified | 2.045 | 1994 | NA | NA |
| Carp | not specified | 1.972 | 1995 | NA | NA |
| Unspecified, bottom feeder | not specified | 3.6 ± 0.40 | 1994 | NA | NA |

| <i>Fish Species</i> | <i>Sample Type</i> | <i>Maximum Sample Concentration (pCi/g, wet)</i> | <i>Year</i> | <i>Maximum Sample Concentration (pCi/g, dry)</i> | <i>Year</i> |
|----------------------------|---------------------------|---|--------------------|---|--------------------|
| Unspecified, bottom feeder | flesh | 3.4 ± 0.50 | 1992 | NA | NA |
| Unspecified, top feeder | not specified | 3.3 ± 0.80 | 1991 | NA | NA |
| Unspecified, mixed | not specified | 3.1 ± 0.40 | 1995 | NA | NA |
| Unspecified | not specified | 3.7 ± 0.70 | 1983 | NA | NA |

Source: BNL SERs 1977–1999; NYSDOH 1996

Table B10. Strontium-90 concentrations in fish from the Peconic River off site (1973–1999)

| <i>Fish Species</i> | <i>Sample Type</i> | <i>Maximum Sample Concentration (pCi/g, wet)</i> | <i>Year</i> | <i>Maximum Sample Concentration (pCi/g, dry)</i> | <i>Year</i> |
|----------------------------|---------------------------|---|--------------------|---|--------------------|
| Yellow Perch | not specified | 1.025 | 1985 | NA | NA |
| Yellow Perch | whole | 0.24 ± 0.03 | 1996 | NA | NA |
| Yellow Perch | bone/viscera | 0.40 ± 0.05 | 1996 | NA | NA |
| Yellow Perch | flesh/skin | 0.30 ± 0.04 | 1996 | NA | NA |
| Chain Pickerel | flesh/skin | 0.05 ± 0.01 | 1996 | NA | NA |
| Chain Pickerel | bone/viscera | 0.39 ± 0.04 | 1996 | NA | NA |
| Chain Pickerel | whole | 0.04 ± 0.01 | 1996 | NA | NA |
| Chain Pickerel | not specified | 0.788 | 1992 | NA | NA |
| Brown Bullhead | bone/viscera | 0.66 ± 0.05 | 1996 | NA | NA |
| Brown Bullhead | whole | 0.30 ± 0.05 | 1996 | NA | NA |

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| <i>Fish Species</i> | <i>Sample Type</i> | <i>Maximum Sample Concentration (pCi/g, wet)</i> | <i>Year</i> | <i>Maximum Sample Concentration (pCi/g, dry)</i> | <i>Year</i> |
|----------------------------|---------------------------|---|--------------------|---|--------------------|
| Brown Bullhead | not specified | 3.328 | 1985 | NA | NA |
| Black Crappie | not specified | 0.373 | 1992 | NA | NA |
| Black Crappie | bone/viscera | 0.42 ± 0.04 | 1996 | NA | NA |
| Largemouth Bass | not specified | 0.260 | 1993 | NA | NA |
| Catfish | not specified | 0.426 | 1989 | 1.64 | 1989 |
| Pumpkinseed | not specified | 0.787 | 1989 | 2.81 | 1989 |
| Pumpkinseed | bone/viscera | 0.93 ± 0.06 | 1996 | NA | NA |
| Pumpkinseed | flesh/skin | 0.32 ± 0.02 | 1996 | NA | NA |
| Bluegill | not specified | 0.769 | 1989 | 2.65 | 1989 |
| Bluegill | whole | 0.33 ± 0.03 | 1996 | NA | NA |
| Bluegill | bone/viscera | 0.42 ± 0.03 | 1996 | NA | NA |
| Golden Shiner | not specified | 2.597 | 1985 | NA | NA |
| Golden Shiner | whole | 0.37 ± 0.03 | 1996 | NA | NA |
| Golden Shiner | bone/viscera | 0.83 ± 0.06 | 1996 | NA | NA |
| Golden Shiner | flesh/skin | 0.30 ± 0.03 | 1996 | NA | NA |
| Eel | not specified | 0.295 | 1994 | NA | NA |
| Unspecified, bottom feeder | not specified | 0.51 ± 0.040 | 1974 | NA | NA |
| Unspecified, bottom feeder | flesh | 0.26 ± 0.036 | 1976 | NA | NA |

| <i>Fish Species</i> | <i>Sample Type</i> | <i>Maximum Sample Concentration (pCi/g, wet)</i> | <i>Year</i> | <i>Maximum Sample Concentration (pCi/g, dry)</i> | <i>Year</i> |
|----------------------------|---------------------------|---|--------------------|---|--------------------|
| Unspecified, top feeder | not specified | 1.21 ± 0.073 | 1976 | NA | NA |
| Unspecified, top feeder | flesh | 0.036 ± 0.007 | 1974 | NA | NA |
| Unspecified, top feeder | bone | 7.90 ± 0.474 | 1974 | NA | NA |
| Unspecified, mixed | not specified | 1.80 ± 0.13 | 1974 | NA | NA |
| Unspecified | not specified | 1.22 | 1997 | NA | NA |

Source: BNL SERs 1977–1999; NYSDOH 1996

Table B11. Cesium-137 concentrations in fish from the Peconic River off site (1973-1999)

| <i>Fish Species</i> | <i>Sample Type</i> | <i>Maximum Sample Concentration (pCi/g, wet)</i> | <i>Year</i> |
|----------------------------|---------------------------|---|--------------------|
| Yellow Perch | not specified | 0.90 | 1994 |
| Yellow Perch | whole | 0.26 ± 0.07 | 1996 |
| Yellow Perch | bone/viscera | 0.89 ± 0.26 | 1996 |
| Yellow Perch | flesh/skin | 1.319 ± 0.171 | 1998 |
| Chain Pickerel | flesh/skin | 1.445 ± 0.211 | 1998 |
| Chain Pickerel | bone/viscera | 0.797 ± 0.137 | 1998 |
| Chain Pickerel | whole | 0.46 ± 0.16 | 1997 |
| Chain Pickerel | not specified | 0.655 | 1994 |
| Brown Bullhead | flesh/skin | 0.46 ± 0.08 | 1996 |

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| <i>Fish Species</i> | <i>Sample Type</i> | <i>Maximum Sample Concentration (pCi/g, wet)</i> | <i>Year</i> |
|----------------------------|---------------------------|---|--------------------|
| Brown Bullhead | bone/viscera | 0.19 ± 0.04 | 1996 |
| Brown Bullhead | whole | 0.698 | 1998 |
| Brown Bullhead | not specified | 0.935 | 1993 |
| Black Crappie | not specified | 0.298 | 1992 |
| Black Crappie | flesh/skin | 0.32 ± 0.08 | 1996 |
| Black Crappie | bone/viscera | 0.18 ± 0.05 | 1996 |
| Largemouth Bass | not specified | 0.384 | 1993 |
| Largemouth Bass | whole | 0.29 ± 0.06 | 1997 |
| Largemouth Bass | flesh | 0.10 ± 0.02 | 1999 |
| Largemouth Bass | bone/viscera | 0.38 ± 0.10 | 1999 |
| Catfish | not specified | 1.0 | 1988 |
| Pumpkinseed | not specified | 0.60 | 1988 |
| Pumpkinseed | whole | 0.22 ± 0.12 | 1997 |
| Pumpkinseed | flesh | 0.20 ± 0.06 | 1999 |
| Pumpkinseed | bone/viscera | 0.47 ± 0.29 | 1997 |
| Pumpkinseed | flesh/skin | 0.47 ± 0.20 | 1996 |
| Bluegill | not specified | 0.70 | 1988 |
| Bluegill | whole | 0.42 ± 0.087 | 1998 |
| Bluegill | bone/viscera | 0.25 ± 0.10 | 1997 |

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| <i>Fish Species</i> | <i>Sample Type</i> | <i>Maximum Sample Concentration (pCi/g, wet)</i> | <i>Year</i> |
|----------------------------|---------------------------|---|--------------------|
| Bluegill | flesh/skin | 0.20 ± 0.05 | 1997 |
| Bluegill | flesh | 0.11 ± 0.03 | 1999 |
| Golden Shiner | not specified | 0.961 | 1994 |
| Golden Shiner | whole | 0.70 ± 0.30 | 1997 |
| Golden Shiner | bone/viscera | 0.10 ± 0.02 | 1996 |
| Golden Shiner | flesh/skin | 0.16 ± 0.03 | 1996 |
| Eel | not specified | 0.38 | 1994 |
| Carp | not specified | 0.204 | 1995 |
| Unspecified, bottom feeder | not specified | 1.79 ± 0.14 | 1973 |
| Unspecified, bottom feeder | flesh | 2.33 ± 0.193 | 1976 |
| Unspecified, top feeder | not specified | 2.59 ± 0.13 | 1975 |
| Unspecified, top feeder | flesh | 2.8 ± 0.56 | 1974 |
| Unspecified, mixed | not specified | 1.86 ± 0.074 | 1976 |
| Unspecified | not specified | 1.66 | 1997 |

Source: BNL SERs 1977–1999; NYSDOH 1996

Table B12. Tritium, Gross Alpha, and Gross Beta concentrations in fish from the Peconic River off site (1985–1999)

| <i>Fish Species</i> | <i>Sample Type</i> | <i>Tritium, Maximum Sample Conc. (pCi/g, wet)</i> | <i>Year</i> | <i>Gross Alpha, Maximum Sample Conc. (pCi/g, wet)</i> | <i>Year</i> | <i>Gross Beta, Maximum Sample Conc. (pCi/g, wet)</i> | <i>Year</i> |
|----------------------------|---------------------------|--|--------------------|--|--------------------|---|--------------------|
| Unspecified | not specified | NA | NA | 2.6 | 1997 | 13.85 | 1997 |
| Bluegill | not specified | 0.843 | 1985 | NA | NA | NA | NA |
| Yellow Perch | not specified | 0.926 | 1985 | NA | NA | NA | NA |
| Chain Pickerel | not specified | 0.709 | 1985 | NA | NA | NA | NA |
| Golden Shiner | not specified | 0.841 | 1985 | NA | NA | NA | NA |
| Brown Bullhead | not specified | 1.742 | 1985 | NA | NA | NA | NA |

Source: BNL SERs 1977–1999; NYSDOH 1996

Table B13. Uranium-234, Uranium-238, and Plutonium-239/240 concentrations in fish from the Peconic River off site (1977–1999)

| <i>Fish Species</i> | <i>Sample Type</i> | <i>Uranium-234, Maximum Sample Conc. (pCi/g, wet)</i> | <i>Year</i> | <i>Uranium-238, Maximum Sample Conc. (pCi/g, wet)</i> | <i>Year</i> | <i>Plutonium-239/240, Maximum Sample Conc.(pCi/g, wet)</i> | <i>Year</i> |
|----------------------------|---------------------------|--|--------------------|--|--------------------|---|--------------------|
| Bluegill | whole | 0.008 ± 0.0006 | 1999 | 0.005 ± 0.0005 | 1999 | 0.001 ± 0.001 | 1998 |
| Largemouth Bass | whole | 0.1113 ± 0.0006 | 1999 | 0.0014 ± 0.0006 | 1999 | NA | NA |
| Brown Bullhead | whole | 0.003 ± 0.002 | 1998 | 0.003 ± 0.001 | 1998 | NA | NA |
| Brown Bullhead | flesh/skin | NA | NA | 0.004 ± 0.002 | 1998 | NA | NA |
| Brown Bullhead | bone/viscera | 0.003 ± 0.002 | 1998 | 0.003 ± 0.002 | 1998 | NA | NA |
| Yellow Perch | flesh/skin | 0.002 ± 0.001 | 1998 | NA | NA | 0.001 ± 0.001 | 1998 |
| Yellow Perch | bone/viscera | NA | NA | 0.002 ± 0.001 | 1998 | NA | NA |

Source: BNL SERs 1977–1999; NYSDOH 1996

Table B14. Inorganics Found in Fish from the Peconic River off Site (1997–1999)

| <i>Fish Species</i> | <i>Sample Type</i> | <i>As, Max Conc. (mg/kg wet)</i> | <i>Ba, Max. Conc. (mg/kg, wet)</i> | <i>Cd, Max. Conc. (mg/kg, wet)</i> | <i>Cu, Max. Conc. (mg/kg, wet)</i> | <i>Pb, Max. Conc. (mg/kg, wet)</i> | <i>Mn, Max. Conc. (mg/kg, wet)</i> | <i>Hg, Max. Conc. (mg/kg, wet)</i> | <i>Ni, Max. Conc. (mg/kg, wet)</i> | <i>Ag, Max. Conc. (mg/kg, wet)</i> | <i>Zn, Max. Conc. (mg/kg wet)</i> | <i>Fe, Max. Conc. (mg/kg wet)</i> |
|----------------------------|---------------------------|---|---|---|---|---|---|---|---|---|--|--|
| Comparison Values | | 0.0021(RBC-C) | 95(RBC-N) | 1.4(RBC-N) | 54 (RBC-N) | none | 190(RBC-N) | 0.14 (RBC-N) | 27(RBC-N) | 6.8(RBC-N) | 410(RBC-N) | 410(RBC-N) |
| Bluegill | flesh | ND | 2.21 | ND | 0.59 | ND | 3.29 | 0.09 | 0.15 | ND | 21.62 | ND |
| Largemouth Bass | flesh | 0.91 | 0.24 | 0.12 | 2.05 | ND | 7.54 | ND | 0.42 | 0.20 | 8.74 | 31.5 |
| Large mouth Bass | not specified | NA | NA | 0.045 | 2.97 | 0.359 | NA | 0.914 | 0.165 | 0.009 | NA | NA |
| Creek Chub Sucker | not specified | NA | NA | 0.042 | 6.77 | 0.127 | NA | 0.335 | 0.269 | 0.02 | NA | NA |
| Brown Bullhead | not specified | NA | NA | 0.016 | 3.01 | 0.967 | NA | 0.196 | 0.177 | 0.04 | NA | NA |
| Pumpkin-seed | flesh | ND | 0.73 | ND | 0.62 | ND | 1.02 | 0.15 | 0.10 | ND | 15.55 | ND |
| Pumpkin-seed | not specified | NA | NA | 0.033 | 2.41 | 0.92 | NA | 0.418 | 0.225 | 0.02 | NA | NA |

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| | | | | | | | | | | | | |
|-------------------|------------------|----|----|-------|------|-------|----|-------|-------|------|----|----|
| Chain Pickerel | not specified | NA | NA | 0.073 | 5.51 | 0.535 | NA | 0.645 | 0.559 | 0.06 | NA | NA |
|-------------------|------------------|----|----|-------|------|-------|----|-------|-------|------|----|----|

Table B15. Pesticide and PCB Levels in Fish from the Peconic River off Site (1996–1999)

| <i>Contaminant</i> | <i>Highest Concentration (mg/kg, fish species, wet)</i> | <i>Comparison Value (CV) (mg/kg, fish species)</i> | <i>Type of CV</i> |
|---------------------|---|--|-------------------|
| alpha-BHC | 0.0017, bluegill 0.0017, largemouth bass 0.0017, pumpkin seed | NA | NA |
| beta-BHC | 0.0017, bluegill 0.0017, largemouth bass 0.0017, pumpkin seed | NA | NA |
| delta-BHC | 0.0017, bluegill 0.0017, largemouth bass 0.0017, pumpkin seed | NA | NA |
| gamma-BHC (Lindane) | 0.0017, bluegill 0.0017, largemouth bass 0.0017, pumpkin seed | NA | NA |
| Heptachlor | 0.0017, bluegill 0.0017, largemouth bass 0.0017, pumpkin seed | 0.0007 | RBC-C |
| Aldrin | 0.0017, bluegill 0.0017, largemouth bass 0.0017, pumpkin seed | 0.00019 | RBC-C |
| Heptachlor epoxide | 0.0017, bluegill 0.0017, largemouth bass 0.0017, pumpkin seed | 0.00035 | RBC-C |
| Endosulfan I | 0.0017, bluegill 0.0017, largemouth | 8.1 | RBC-N |

| <i>Contaminant</i> | <i>Highest Concentration (mg/kg, fish species, wet)</i> | <i>Comparison Value (CV) (mg/kg, fish species)</i> | <i>Type of CV</i> |
|---------------------------|---|---|--------------------------|
| | bass0.0017, pumpkin seed | | |
| Dieldrin | 0.0033, bluegill0.0033, largemouth bass0.0033, pumpkinseed | 0.0002 | RBC-C |
| 4,4'-DDE | 0.002, bluegill0.0752, largemouth bass0.065, pickerel0.0522, pumpkinseed0.0276, creek chub sucker0.0714, brown bullhead | 0.0093 | RBC-C |
| Endrin | 0.0033, bluegill0.0033, largemouth bass0.0033, pumpkinseed | 0.41 | RBC-N |
| Endosulfan II | 0.0033, bluegill0.0033, largemouth bass0.0033, pumpkinseed | 8.1 | RBC-N |
| 4,4'-DDD | 0.0033, bluegill0.0234, largemouth bass0.0689, pickerel0.0531, pumpkinseed0.0322, creek chub sucker0.0703, brown bullhead | 0.013 | RBC-C |
| Endosulfan sulfate | 0.0033, bluegill0.0033, largemouth bass0.0033, | NA | NA |

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| <i>Contaminant</i> | <i>Highest Concentration (mg/kg, fish species, wet)</i> | <i>Comparison Value (CV) (mg/kg, fish species)</i> | <i>Type of CV</i> |
|---------------------------|--|---|--------------------------|
| | pumpkinseed | | |
| 4,4'-DDT | 0.0033, bluegill0.0033, largemouth bass0.0033, pumpkinseed | 0.0093 | RBC-C |
| Methoxychlor | 0.017, bluegill0.017, largemouth bass0.017, pumpkinseed | 6.8 | RBC-N |
| Endrin ketone | 0.0033, bluegill0.0033, largemouth bass0.0033, pumpkinseed | 0.41 | RBC-N |
| Endrin aldehyde | 0.0033, bluegill0.0033, largemouth bass0.0033, pumpkinseed | 0.41 | RBC-N |
| alpha-Chlordane | 0.0017, bluegill0.0017, largemouth bass0.0017, pumpkin seed | 0.009 | RBC-C |
| gamma-Chlordane | 0.0017, bluegill0.0017, largemouth bass0.0017, pumpkin seed | 0.009 | RBC-C |
| Toxaphene | 0.17, bluegill0.17, largemouth bass0.17, pumpkinseed | 0.0029 | RBC-C |
| Aroclor-1016 | 0.033, bluegill0.033, largemouth bass0.033, pumpkinseed | 0.045 | RBC-C |

| <i>Contaminant</i> | <i>Highest Concentration (mg/kg, fish species, wet)</i> | <i>Comparison Value (CV) (mg/kg, fish species)</i> | <i>Type of CV</i> |
|---------------------------|--|---|--------------------------|
| Aroclor-1221 | 0.067, bluegill0.067, largemouth bass0.067, pumpkinseed | 0.0016 | RBC-C |
| Aroclor-1232 | 0.033, bluegill0.033, largemouth bass0.033, pumpkinseed | 0.0016 | RBC-C |
| Aroclor-1242 | 0.033, bluegill0.033, largemouth bass0.033, pumpkinseed | 0.0016 | RBC-C |
| Aroclor-1248 | 0.033, bluegill0.033, largemouth bass0.033, pumpkinseed | 0.0016 | RBC-C |
| Aroclor-1254 | 0.423, pickerel0.033, bluegill0.033, largemouth bass0.033, pumpkinseed | 0.0016 | RBC-C |
| Aroclor-1260 | 0.033, bluegill0.033, largemouth bass0.033, pumpkinseed | 0.0016 | RBC-C |

Source: BNL SERs 1977–1999; NYSDOH 1996

Table B16. Potassium-40 Concentrations in Fish from offsite Control Locations (1973–1999)

| <i>Fish Species</i> | <i>Sample Type</i> | <i>Maximum Sample Concentration (pCi/g, wet)</i> | <i>Year</i> | <i>Maximum Sample Concentration (pCi/g, dry)</i> | <i>Year</i> |
|----------------------------|---------------------------|---|--------------------|---|--------------------|
| Yellow Perch | not specified | 2.77 | 1991 | NA | NA |
| Yellow Perch | whole | 2.80 ± 0.57 | 1996 | NA | NA |
| Yellow Perch | bone/viscera | 3.45 ± 1.39 | 1996 | NA | NA |
| Yellow Perch | flesh/skin | 4.60 ± 1.67 | 1996 | NA | NA |
| Chain Pickerel | not specified | 3.865 | 1994 | NA | NA |
| Brown Bullhead | flesh/skin | 4.06 ± 2.54 | 1996 | NA | NA |
| Brown Bullhead | bone/viscera | 3.74 ± 1.00 | 1996 | NA | NA |
| Brown Bullhead | whole | 3.51 ± 0.89 | 1996 | NA | NA |
| Brown Bullhead | not specified | 5.456 | 1994 | NA | NA |
| Black Crappie | not specified | 2.37 | 1993 | NA | NA |
| Black Crappie | whole | 12.91 ± 4.48 | 1997 | NA | NA |
| Largemouth Bass | not specified | 4.548 | 1995 | NA | NA |
| Largemouth Bass | whole | 3.1 | 1999 | NA | NA |
| Largemouth Bass | flesh/skin | 2.69 ± 0.46 | 1996 | NA | NA |
| Largemouth Bass | bone/viscera | 1.76 ± 0.34 | 1996 | NA | NA |
| Pumpkinseed | not specified | 4.29 | 1993 | NA | NA |
| Pumpkinseed | whole | 3.54 ± 1.52 | 1996 | NA | NA |

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| <i>Fish Species</i> | <i>Sample Type</i> | <i>Maximum Sample Concentration (pCi/g, wet)</i> | <i>Year</i> | <i>Maximum Sample Concentration (pCi/g, dry)</i> | <i>Year</i> |
|----------------------------|---------------------------|---|--------------------|---|--------------------|
| Pumpkinseed | bone/viscera | 3.88 ± 2.49 | 1996 | NA | NA |
| Pumpkinseed | flesh/skin | 5.47 ± 1.92 | 1996 | NA | NA |
| Bluegill | not specified | 3.29 | 1993 | NA | NA |
| Bluegill | whole | 2.96 ± 1.36 | 1996 | NA | NA |
| Bluegill | bone/viscera | 3.75 ± 2.11 | 1996 | NA | NA |
| Bluegill | flesh/skin | 4.28 ± 1.54 | 1996 | NA | NA |
| Golden Shiner | not specified | 3.815 | 1994 | NA | NA |
| Golden Shiner | whole | 1.86 ± 0.67 | 1996 | NA | NA |
| Eel | not specified | 2.488 | 1994 | NA | NA |
| Eel | whole | 3.25 ± 0.57 | 1996 | NA | NA |
| Carp | not specified | 6.89 | 1991 | NA | NA |
| Carp | whole | 5.14 ± 3.57 | 1996 | NA | NA |
| Carp | bone/viscera | 2.65 ± 1.06 | 1997 | NA | NA |
| Brook Trout | not specified | 3.549 | 1987 | NA | NA |
| Pirate Perch | not specified | 1.536 | 1990 | 8.08 | 1990 |
| Darter | not specified | 0.283 | 1990 | 1.286 | 1990 |
| Redfin Pickerel | not specified | 5.297 | 1990 | 18.266 | 1990 |
| Rainbow Trout | flesh/skin | 3.21 ± 0.62 | 1996 | NA | NA |
| Rainbow Trout | bone/viscera | 1.34 ± 1.27 | 1996 | NA | NA |

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| <i>Fish Species</i> | <i>Sample Type</i> | <i>Maximum Sample Concentration (pCi/g, wet)</i> | <i>Year</i> | <i>Maximum Sample Concentration (pCi/g, dry)</i> | <i>Year</i> |
|----------------------------|---------------------------|---|--------------------|---|--------------------|
| Rainbow Trout | whole | 2.84 ± 0.97 | 1996 | NA | NA |
| Gizzard Shad | whole | 2.31 ± 0.50 | 1997 | NA | NA |
| Gizzard Shad | flesh/skin | 7.15 ± 2.05 | 1997 | NA | NA |
| Gizzard Shad | bone/viscera | 3.12 ± 0.68 | 1997 | NA | NA |
| White Perch | whole | 2.24 ± 0.38 | 1998 | NA | NA |
| White Perch | flesh/skin | 2.53 ± 0.43 | 1998 | NA | NA |
| White Perch | bone/viscera | 2.85 ± 0.93 | 1998 | NA | NA |
| Goldfish | flesh/skin | 2.33 ± 0.54 | 1997 | NA | NA |
| Goldfish | bone/viscera | 1.40 ± 0.62 | 1997 | NA | NA |
| Unspecified, bottom feeder | not specified | 3.30 ± 0.50 | 1994 | NA | NA |
| Unspecified, top feeder | not specified | 3.20 ± 0.30 | 1988 | NA | NA |
| Unspecified, mixed | not specified | 3.20 ± 0.50 | 1994 | NA | NA |
| Unspecified | not specified | 3.70 ± 0.30 | 1987 | NA | NA |

Source: BNL SERs 1977–1999; NYSDOH 1996

Table B17. Strontium-90 Concentrations in Fish from offsite Control Locations (1973–1999)

| <i>Fish Species</i> | <i>Sample Type</i> | <i>Maximum Sample Concentration (pCi/g, wet)</i> | <i>Year</i> | <i>Maximum Sample Concentration (pCi/g, dry)</i> | <i>Year</i> |
|----------------------------|---------------------------|---|--------------------|---|--------------------|
| Yellow Perch | not specified | 0.319 | 1994 | NA | NA |
| Yellow Perch | whole | 0.12 ± 0.02 | 1996 | NA | NA |
| Yellow Perch | bone/viscera | 0.21 ± 0.04 | 1996 | NA | NA |
| Yellow Perch | flesh/skin | 0.07 ± 0.03 | 1996 | NA | NA |
| Chain Pickerel | not specified | 0.125 | 1994 | NA | NA |
| Brown Bullhead | flesh/skin | 0.11 ± 0.01 | 1996 | NA | NA |
| Brown Bullhead | bone/viscera | 1.10 ± 0.06 | 1996 | NA | NA |
| Brown Bullhead | whole | 0.62 ± 0.04 | 1996 | NA | NA |
| Brown Bullhead | not specified | 0.544 | 1994 | NA | NA |
| Black Crappie | not specified | 0.083 | 1993 | NA | NA |
| Largemouth Bass | not specified | 0.137 | 1992 | NA | NA |
| Largemouth Bass | flesh/skin | 0.06 ± 0.02 | 1996 | NA | NA |
| Largemouth Bass | bone/viscera | 0.19 ± 0.03 | 1996 | NA | NA |
| Pumpkinseed | not specified | 0.105 | 1993 | NA | NA |
| Pumpkinseed | bone/viscera | 0.25 ± 0.04 | 1996 | NA | NA |
| Bluegill | not specified | 0.175 | 1989 | 0.50 | 1989 |
| Bluegill | whole | 0.90 ± 0.05 | 1996 | NA | NA |

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| <i>Fish Species</i> | <i>Sample Type</i> | <i>Maximum Sample Concentration (pCi/g, wet)</i> | <i>Year</i> | <i>Maximum Sample Concentration (pCi/g, dry)</i> | <i>Year</i> |
|----------------------------|---------------------------|---|--------------------|---|--------------------|
| Bluegill | bone/viscera | 1.78 ± 0.08 | 1996 | NA | NA |
| Bluegill | flesh/skin | 0.40 ± 0.02 | 1996 | NA | NA |
| Bluegill | flesh | | | NA | NA |
| Golden Shiner | not specified | 0.245 | 1994 | NA | NA |
| Eel | not specified | 0.110 | 1994 | NA | NA |
| Eel | whole | 0.06 ± 0.03 | 1996 | NA | NA |
| Carp | not specified | 0.027 | 1991 | NA | NA |
| Rainbow Trout | flesh/skin | 0.38 ± 0.02 | 1996 | NA | NA |
| Rainbow Trout | bone/viscera | 0.06 ± 0.03 | 1996 | NA | NA |
| Catfish | not specified | 0.180 | 1989 | 0.75 | 1989 |
| Unspecified, bottom feeder | not specified | 0.57 ± 0.40 | 1975 | NA | NA |
| Unspecified, bottom feeder | flesh | 0.130 ± 0.020 | 1974 | NA | NA |
| Unspecified, bottom feeder | bone | 0.920 ± 0.060 | 1974 | NA | NA |
| Unspecified, top feeder | not specified | 0.32 ± 0.030 | 1989 | NA | NA |
| Unspecified, top feeder | flesh | 0.31 ± 0.27 | 1974 | NA | NA |
| Unspecified, top feeder | bone | 1.10 ± 0.077 | 1974 | NA | NA |

| <i>Fish Species</i> | <i>Sample Type</i> | <i>Maximum Sample Concentration (pCi/g, wet)</i> | <i>Year</i> | <i>Maximum Sample Concentration (pCi/g, dry)</i> | <i>Year</i> |
|----------------------------|---------------------------|---|--------------------|---|--------------------|
| Unspecified, mixed | not specified | 0.125 ± 0.009 | 1994 | NA | NA |
| Unspecified, mixed | flesh | 0.50 ± 0.040 | 1974 | NA | NA |
| Unspecified, mixed | bone | 0.60 ± 0.048 | 1974 | NA | NA |
| Unspecified | not specified | 4.31 | 1997 | NA | NA |

Source: BNL SERs 1977–1999; NYSDOH 1996

Table B18. Cesium-137 Concentrations in Fish from offsite Control Locations (1973–1999)

| <i>Fish Species</i> | <i>Sample Type</i> | <i>Maximum Sample Concentration (pCi/g, wet)</i> | <i>Year</i> | <i>Maximum Sample Concentration (pCi/g, dry)</i> | <i>Year</i> |
|----------------------------|---------------------------|---|--------------------|---|--------------------|
| Yellow Perch | not specified | 0.45 | 1994 | NA | NA |
| Yellow Perch | whole | 0.23 ± 0.05 | 1998 | NA | NA |
| Yellow Perch | bone/viscera | 0.34 ± 0.08 | 1998 | NA | NA |
| Yellow Perch | flesh/skin | 0.43 ± 0.10 | 1998 | NA | NA |
| Chain Pickerel | whole | 0.305 | 1985 | NA | NA |
| Chain Pickerel | not specified | 0.319 | 1987 | NA | NA |
| Brown Bullhead | flesh/skin | 0.66 ± 0.24 | 1996 | NA | NA |
| Brown Bullhead | bone/viscera | 0.28 ± 0.10 | 1996 | NA | NA |
| Brown Bullhead | whole | 0.27 ± 0.07 | 1996 | NA | NA |
| Brown Bullhead | not specified | 1.687 | 1994 | NA | NA |

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| <i>Fish Species</i> | <i>Sample Type</i> | <i>Maximum Sample Concentration (pCi/g, wet)</i> | <i>Year</i> | <i>Maximum Sample Concentration (pCi/g, dry)</i> | <i>Year</i> |
|----------------------------|---------------------------|---|--------------------|---|--------------------|
| Black Crappie | not specified | 0.135 | 1993 | NA | NA |
| Largemouth Bass | not specified | 0.212 | 1987 | NA | NA |
| Largemouth Bass | whole | 0.02 | 1999 | NA | NA |
| Largemouth Bass | flesh/skin | 0.15 ± 0.03 | 1996 | NA | NA |
| Largemouth Bass | bone/viscera | 0.08 ± 0.02 | 1996 | NA | NA |
| Catfish | not specified | 0.30 | 1988 | NA | NA |
| Pumpkinseed | not specified | 0.226 | 1989 | 0.902 | 1989 |
| Pumpkinseed | whole | 0.05 ± 0.02 | 1998 | NA | NA |
| Pumpkinseed | bone/viscera | 0.05 ± 0.04 | 1996 | NA | NA |
| Bluegill | not specified | 0.127 | 1987 | NA | NA |
| Bluegill | whole | 0.56 ± 0.11 | 1996 | NA | NA |
| Bluegill | bone/viscera | 0.45 ± 0.10 | 1996 | NA | NA |
| Bluegill | flesh/skin | 0.69 ± 0.17 | 1996 | NA | NA |
| Golden Shiner | not specified | 0.204 | 1988 | 0.887 | 1988 |
| Eel | not specified | 0.235 | 1990 | 0.783 | 1990 |
| Eel | whole | 0.05 ± 0.01 | 1996 | NA | NA |
| Carp | not specified | 0.19 | 1991 | NA | NA |

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| <i>Fish Species</i> | <i>Sample Type</i> | <i>Maximum Sample Concentration (pCi/g, wet)</i> | <i>Year</i> | <i>Maximum Sample Concentration (pCi/g, dry)</i> | <i>Year</i> |
|----------------------------|---------------------------|---|--------------------|---|--------------------|
| Carp | whole | 0.03 ± 0.01 | 1998 | NA | NA |
| Brook Trout | not specified | 0.105 | 1987 | NA | NA |
| Darter | not specified | 0.056 | 1990 | 0.254 | 1990 |
| Redfin Pickerel | not specified | 0.048 | 1990 | 0.166 | 1990 |
| Rainbow Trout | flesh/skin | 0.03 ± 0.02 | 1996 | NA | NA |
| Gizzard Shad | whole | 0.02 ± 0.01 | 1997 | NA | NA |
| White Perch | whole | 0.08 ± 0.02 | 1998 | NA | NA |
| White Perch | flesh/skin | 0.08 ± 0.02 | 1998 | NA | NA |
| Unspecified, bottom feeder | not specified | 1.77 ± 0.071 | 1975 | NA | NA |
| Unspecified, bottom feeder | flesh | 0.091 ± 0.014 | 1974 | NA | NA |
| Unspecified, top feeder | not specified | 0.68 ± 0.027 | 1980 | NA | NA |
| Unspecified, top feeder | flesh | 0.18 ± 0.010 | 1974 | NA | NA |
| Unspecified, mixed | flesh | 1.20 ± 0.020 | 1974 | NA | NA |
| Unspecified | not specified | 0.89 ± 0.050 | 1981 | NA | NA |

Source: BNL SERs 1977–1999; NYSDOH 1996

Table B19. Gross Beta, Uranium-234, and Uranium-238 Concentrations in Fish from offsite Control Locations (1985–1999)

| <i>Fish Species</i> | <i>Sample Type</i> | <i>Gross Beta, Maximum Sample Conc.(pCi/g, wet)</i> | <i>Year</i> | <i>Uranium-234, Max.Sample Conc.(pCi/g, wet)</i> | <i>Year</i> | <i>Uranium-238, Max. Sample Conc. (pCi/g, wet)</i> | <i>Year</i> |
|---------------------|--------------------|---|-------------|--|-------------|--|-------------|
| Unspecified | not specified | 12.96 | 1997 | NA | NA | NA | NA |
| Pumpkinseed | not specified | NA | NA | 0.0029 ± 0.0012 | 1999 | 0.0019 ± 0.0009 | 1999 |
| Bluegill | not specified | NA | NA | 0.0013 ± 0.0007 | 1999 | 0.0013 ± 0.0007 | 1999 |

Source: BNL SERs 1977–1999; NYSDOH 1996

Table B20. Inorganic Concentrations in Fish from Off-Site Control Locations (1997)

| <i>Fish Species</i> | <i>Sample Type</i> | <i>Cd, Max. Conc.(mg/kg, wet)</i> | <i>Cu, Max. Conc.(mg/kg, wet)</i> | <i>Pb, Max. Conc.(mg/kg, wet)</i> | <i>Hg, Max. Conc.(mg/kg, wet)</i> | <i>Ni, Max. Conc. (mg/kg, wet)</i> | <i>Ag, Max. Conc. (mg/kg, wet)</i> |
|---------------------|--------------------|-----------------------------------|-----------------------------------|-----------------------------------|-----------------------------------|------------------------------------|------------------------------------|
| Comparison Values | | 1.4(RBC-N) | 54(RBC-N) | none | 0.14 (RBC-N) | 27(RBC-N) | 6.8(RBC-N) |
| Largemouth Bass | not specified | 0.067 | 3.54 | 0.737 | 0.364 | 0.222 | 0.008 |
| Pickrel | not specified | 0.074 | 3.17 | 0.657 | 0.197 | 0.175 | 0.03 |
| Pumpkinseed | not specified | 0.049 | 1.98 | 0.762 | 0.096 | 0.103 | ND |
| Brown Bullhead | not specified | 0.022 | 2.9 | 0.653 | 0.239 | 0.309 | 0.01 |

Source: BNL SERs 1977–1999; NYSDOH 1996

Table B21. Pesticide Concentrations in Fish from Off-Site Control Locations (1997)

| <i>Contaminant</i> | <i>Highest Concentration (mg/kg, fish species, wet)</i> | <i>Comparison Value (CV) (mg/kg, fish species)</i> | <i>Type of CV</i> |
|--------------------|---|--|-------------------|
| 4,4'-DDE | 0.136, largemouth bass 0.0202, pickerel 0.0724, pumpkinseed 0.0433, brown bullhead | 0.0093 | RBC-C |
| 4,4'-DDD | 0.0387, largemouth bass 0.00917, pickerel 0.10, pumpkinseed 0.0401, brown bullhead | 0.013 | RBC-C |

Source: BNL SERs 1977–1999; NYSDOH 1996

Table B22. Cesium-137, Potassium-40, and Strontium-90 Concentrations in Shellfish from Off-Site Control Locations (1987–1999)

| <i>Species Sampled</i> | <i>Year</i> | <i>Radionuclide Concentrations pCi/g, wet</i> | | |
|------------------------|-------------|---|-----------------|--------------|
| | | Cesium-137 | Potassium-40 | Strontium-90 |
| Hard shell clam | 1987 | ND | 0.745 (average) | |
| Clams | 1996 | ND | 1.75 ± 0.89 | <0.011 |
| Clams | 1997 | ND | 1.83 ± 0.47 | |

Source: BNL SERs 1987–1999; NYSDOH 1996

Table B23. Potassium-40 in Deer Collected On Site (1986–1999)

| <i>Sample Type</i> | <i>Maximum Sample Concentration (pCi/g, wet)</i> | <i>Year</i> |
|--------------------|--|-------------|
| Liver | 4.72 ± 1.15 | 1998 |
| Flesh | 7.72 | 1992 |
| Tumor | 1.41 ± 0.37 | 1999 |

Source: BNL SERs 1986–1999

Table B24. Cesium-137 in Deer from On Site (1986–1999)

| <i>Sample Type</i> | <i>Maximum Sample Concentration (pCi/g, wet)</i> | <i>Year</i> |
|--------------------|--|-------------|
| Liver | 14.59 ± 2.88 | 1998 |
| Flesh | 11.74 ± 2.27 | 1996 |
| Tumor | 0.35 ± 0.08 | 1999 |

Source: BNL SERs 1986–1999

Table B25. Strontium-90 in Deer from On Site (1986–1999)

| <i>Sample Type</i> | <i>Maximum Sample Concentration (pCi/g, wet)</i> | <i>Year</i> |
|--------------------|--|-------------|
| Liver | <0.10 | 1996 |
| Flesh | 0.04 ± 0.10 | 1996 |
| Tumor | ND | 1999 |

Source: BNL SERs 1986–1999

Table B26. Potassium-40 in Deer from Off Site (1986–1999)

| <i>Sample Type</i> | <i>Maximum Sample Concentration (pCi/g, wet)</i> | <i>Year</i> |
|--------------------|--|-------------|
| Liver | 4.44 ± 1.22 | 1999 |
| Flesh | 6.32 ± 1.46 | 1998 |
| Thyroid | 21.23 ± 18.14 | 1998 |

Source: BNL SERs 1986–1999

Table B27. Cesium-137 in Deer from Off-Site (1986–1999)

| <i>Sample Type</i> | <i>Maximum Sample Concentration (pCi/g, wet)</i> | <i>Year</i> |
|--------------------|--|-------------|
| Liver | 2.16 ± 0.45 | 1999 |
| Flesh | 4.71 ± 0.80 | 1997 |
| Thyroid | 4.3 ± 2.87 | 1998 |

Source: BNL SERs 1986–1999

Table B28. Strontium-90 in Deer from Off Site (1986–1999)

| <i>Sample Type</i> | <i>Maximum Sample Concentration (pCi/g, wet)</i> | <i>Year</i> |
|--------------------|--|-------------|
| Liver | <0.04 | 1996 |
| Flesh | <0.04 | 1996 |
| Thyroid | ND | 1998 |

Source: BNL SERs 1986–1999

Table B29. Potassium-40 in Small Mammals from On Site (1986–1993)

| <i>Mammal Species</i> | <i>Sample Type</i> | <i>Maximum Sample Concentration (pCi/g, wet)</i> | <i>Year</i> |
|-----------------------|--------------------|--|-------------|
| Fox | flesh | 3.380 | 1992 |

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| | | | |
|---------|---------------|-------|------|
| Fox | liver | 1.470 | 1992 |
| Opossum | flesh | 1.740 | 1992 |
| Opossum | liver | 2.580 | 1992 |
| Cat | flesh | 3.220 | 1992 |
| Cat | liver | 1.750 | 1992 |
| Raccoon | not specified | 2.231 | 1986 |
| Raccoon | flesh | 2.760 | 1992 |
| Raccoon | liver | 1.800 | 1992 |

Source: BNL SERs 1986–1999

Table B30. Cesium-137 in Small Mammals from On Site (1986–1993)

| <i>Mammal Species</i> | <i>Sample Type</i> | <i>Maximum Sample Concentration (pCi/g, wet)</i> | <i>Year</i> |
|-----------------------|--------------------|--|-------------|
| Raccoon | not specified | 1.380 | 1993 |
| Raccoon | flesh | 0.480 | 1992 |
| Raccoon | liver | 0.280 | 1992 |
| Cat | flesh | 0.513 | 1992 |
| Cat | liver | 0.339 | 1992 |
| Opossum | flesh | 0.809 | 1992 |
| Opossum | liver | 0.729 | 1992 |
| Fox | flesh | 8.170 | 1992 |
| Fox | liver | 2.980 | 1992 |

Source: BNL SERs 1986–1999

Table B31. Cesium-137 in Small Mammals from Off Site (1986–1993)

| <i>Mammal Species</i> | <i>Sample Type</i> | <i>Maximum Sample Concentration (pCi/g, wet)</i> | <i>Year</i> |
|-----------------------|--------------------|--|-------------|
| Raccoon | not specified | 0.262 | 1993 |

Source: BNL SERs 1986–1999

Table V1. Radionuclides in edible vegetation from off site (1984–1999)

| <i>Contaminant</i> | <i>Sample Type</i> | <i>Maximum Sample Concentration (pCi/g, wet)</i> | <i>Year</i> |
|--------------------|--------------------|--|-------------|
| Cesium-137 | Strawberries | 2.22 | 1992 |
| Potassium-40 | Carrot leaves | 6.59 ± 1.10 | 1996 |
| Beryllium-7 | Not specified | 0.990 | 1984 |

| | | | |
|--------------|---------------|---------------|------|
| Strontium-90 | Carrot leaves | 0.040 ± 0.008 | 1996 |
|--------------|---------------|---------------|------|

Source: BNL SERs 1984–1999

Table V2. Radionuclides in Inedible Vegetation from on Site (1984–1999)

| <i>Contaminant</i> | <i>Sample Type</i> | <i>Maximum Sample Concentration (pCi/g, wet)</i> | <i>Year</i> |
|--------------------|--------------------|--|-------------|
| cesium-137 | Tree leaves | 1300 | 1992 |
| potassium-40 | Grass | 13.90 | 1990 |
| Beryllium-7 | Grass | 4.925 | 1994 |
| Thorium-228 | Grass | 0.072 | 1985 |
| Thorium-232 | Tree leaves | 18.60 | 1992 |
| Radium-226 | Grass | 0.469 | 1988 |
| Cobalt-60 | Tree leaves | 0.23 | 1992 |

Source: BNL SERs 1984–1999

Appendix D. Hydrogeology and Modeling

Evaluation of Groundwater Contaminant Migration and Potential Exposure at Brookhaven National Laboratory, Upton New York

Summary

Groundwater contaminants from the Brookhaven National Laboratory and other off-site industrial sources have been detected in off-site residential drinking water wells. Most of the contaminants are VOCs (1,1,1-TCA; 1,1-DCA; Ctet; Chloroform; EDB; PCE; and TCE). Tritium and strontium-90 have also been detected, but at concentrations much lower than levels of public health concern. The off-site contaminants were initially detected in 1985, and ongoing monitoring has determined the current distributions. Although residents were provided with alternate water during the contaminant discovery process, the distribution and concentrations of contaminants before 1985 is unknown. This contaminant transport modeling study provides estimates of the rate of contaminant migration and estimated concentrations at off-site locations before the contaminant plumes were discovered in 1985.

Eight contaminant plumes have been identified adjacent to BNL facility. Seven of the plumes originate from BNL sources and the eighth from a now defunct off-site industrial facility. Information from source characterization and groundwater monitoring studies was used to derive the approximate times of origin and source locations of the plumes. This information was used to determine significant plume characteristics such as plume duration, distance to BNL boundary, distance to nearest down-gradient wells, and total plume length.

This contaminant transport evaluation is based on 1-D and 3-D analytical groundwater flow equations. The 1-D model is used to evaluate vertical transport, and the 3-D model, lateral transport. Hydrogeological parameters used in the models are derived from several different groundwater monitoring and modeling reports developed by DOE and its contractors, and other published sources. Input variables include groundwater velocity (hydraulic conductivity/porosity x hydraulic gradient), dispersion in X, Y, and Z directions, aquifer thickness, porosity, recharge, and contaminant half- life.

The 3-D model utilized a 6000 x 6000m lateral grid and a vertical dimension of 100m. Analyses were run in a deterministic mode using hydrogeological parameter means to evaluate contaminant distributions over the entire grid. Monte Carlo analyses were run to evaluate contaminant concentrations at points 1500m, 1800m, and 2500m down-gradient of a source at 10-year intervals.

Hydrogeological evaluations of BNL site indicate that downward vertical flow predominates from the ground surface of BNL facility, with southward flow at depth. The 1-D vertical flow model indicates that it takes about four years for contaminants to migrate to a 50 m depth in the aquifer. Consequently, the contaminant transport models used two different source release scenarios that include a four-year time lag for introduction of contaminants to a 50 m depth. A constant release scenario assumed that it took four years to reach a constant concentration of 5000 µg/l (µg/l'ppb) at 50m depth (1 µg/l at year 0; 500 µg/l at year 3; and 5000 µg/l for years 4 to 50). The declining source release scenario emulated a waste spill with the source

concentration declining after 9 years (1 µg/l at year 0; 500 µg/l at year 3; 5000 µg/l for years 4 to 9; and 1000 µg/l for years 10-50).

Contaminant migration rates calculated from plumes with known source times and locations range from about 105 to 120 m/year. The average groundwater transport velocity was adjusted (within the reported range) so that modeled plume migrations matched measured plume migration distances and durations. In the constant source release scenario, down-gradient contaminant concentrations reach a constant level after 20 years for the 1500m location, and after 30 years for the 1800m and 2500m locations. For the five contaminant plumes that match this release scenario, contaminant concentrations have probably never been higher than 1985–87 values, and exposure at those locations was not likely before 1987.

For two plumes that fit the declining source release scenario (OU-IV waste solvent spill and OU-I former landfill plume), contaminant concentrations at specific locations first increase and then decrease as the high concentration pulses migrate past those locations. Contamination has been present in limited off-site areas since about 1980. However, because the high concentration contaminant zones occur at depths below most residential wells, it is unlikely that contaminant concentrations in residential wells have ever been significantly higher than levels reported by the Suffolk County Department of Health Services. A public health consultation by the Agency for Toxic Substances and Disease Registry has determined that exposure to contaminants at reported levels is not of public health concern.

Introduction

Process operations and disposal of hazardous materials have contributed to groundwater contamination at the Brookhaven National Laboratory. Groundwater monitoring has identified eight contaminant plumes that have affected or may potentially affect residential drinking water wells in neighborhoods adjacent to the laboratory (an additional plume, the HFBR tritium plume, has not migrated off-site). Seven of these eight plumes originate from BNL contaminant sources and one from an off-site source. Although the neighboring community has been provided with an alternate water source, it is unknown whether the residents were exposed to contaminants from BNL before the discovery of the off-site contamination and the subsequent provision of alternate water. If such exposure did occur, the duration and concentrations of such exposure are also unknown.

DOE and its contractors have conducted several groundwater modeling analyses that seek to define aquifer properties and to predict the response of the groundwater system to remedial actions (CDM Federal Programs, 1995; CDM, 1996; ITC, 1998). While these models are good representations of the hydrogeological system and provide valuable information about hydrogeological parameters, they do not address the early progression of the contaminant plumes after contaminant introduction, but before detection in off-site wells.

This analysis addresses two questions concerning exposure to groundwater contaminants in neighborhoods adjacent to the Brookhaven National Laboratory. These questions are (1) how long were off-site residential wells contaminated and (2), could past contaminant concentrations have been higher than the concentrations detected in a series of water tests taken between 1985 and 1995 (Suffolk County, Dept. of Health, 1996; and Suffolk County, Dept. of Health, 1990). The results of this modeling report are applicable to any of the VOCs determined to be contaminants of concern in off-site residential wells (chloroform, 1,1-dichloroethylene, ethylene dibromide, perchloroethylene, 1,1,1-trichloroethane, and trichloroethylene; ATSDR, 1999). Two radionuclides (tritium and strontium-90) have never been detected in residential wells at levels of potential health concern.

Table 1 lists the eight plumes that have contributed to contamination of drinking water wells and the primary contaminants of each plume. The table also lists the estimated duration of each plume (from source introduction to 1997) and the distance from each plume source to off-site residential wells. Source durations, as listed, conservatively overestimate the travel times of the contaminant plumes. Durations are based on time of initiation of source area (i.e., the opening of a landfill or hazardous waste facility). These waste facilities operated for several years, and contaminants may not have been introduced into the source area at the opening. It may also take several years before the contaminants leach out of the source area and into the groundwater. Consequently, the durations assume contamination was co-incident with facility opening and represent maximum migration times.

Distances from source origins to site boundary and closest residential wells (predominately along Carleton Dr. E. and North Street) were measured by use of the ARC/VIEW measurement tool parallel to the direction of groundwater flow (170 to 175 degrees south). Although source locations have been characterized for most of the plumes, the OU-III plume contains several

sources with both known and unknown source locations. . For example, several plumes probably originated during World War II-era operations (e.g., the Bldg. 96 truck wash site and the unknown CCl-4 source).

Although there is some uncertainty in assigning a specific time and location of origin to individual plumes, there has been sufficient characterization of most of the sources to permit estimation of durations of plume migration and distances of source origins to residential well locations. Ongoing monitoring has also characterized the current distribution of the contaminant plumes. There is a great deal of uncertainty associated with the initiation of contaminant introduction into the groundwater system and consequently, the duration of plume migration. The plume durations listed in Table 1 represent a maximum duration and represent an estimate of contaminant migration that is protective of public health.

Table 1. Plume durations

| <i>PLUMES or SOURCES</i> | <i>Contaminants</i> | <i>Plume Duration</i> | <i>Source to fence length</i> | <i>Source to off-site wells length</i> | <i>Total Plume Length</i> |
|--|----------------------------|------------------------------|--------------------------------------|---|----------------------------------|
| 1) Precision Concepts | TCA | 10–12 years | Off site source | 500 mCarleton Dr. | 1150 m |
| 2) OU-III Multiple Sources a) Bldgs. 96, 208 | PCE, TCA, Ctet, TCE | 53 years | 1400 m | 2400 mCarleton Dr. | 3900 m |
| b) Unknown | CCI-4 | 53 years | 3100 m | 3900 m | 4400 m |
| 3) OU-IV Waste Solvent Spill | TCA, TCE, PCE, DCE, BTEX | 20 years | 1500 m | 2000 m Carleton Dr. | 2000 m |
| 4) Former Landfill | TCA, TCE, PCE, DCE, | 50 years | 1300 m | 1600 mNorth St. | 2100 m |
| 5) Haz. Waste Mgmt. Area | TCA, H-3 | >35 years | 1300 m | 1600 mNorth St. | 2100 m |
| 6) Current Landfill Area | TCA | 28 years | 1300 m | 1600 mNorth St. | 2100 m |
| 7) Biology Fields | EDB, TCA, H-3 | Unknown (25 years) | 800 m | 1200 mNorth St. | 1500 m |
| 8) Sewage Treatment Plant | TCE, TCA | Unknown | 400 m | 1600 m | 1900 m |

Table 1. Distances and durations of eight groundwater contaminant plumes at or adjacent to BNL. Distances are measured to areas of closest residences for each plume using the ARC/VIEW measurement tool. Durations are from several source characterization references (CDM Federal Programs 1995; CDM Federal Programs, 1996b; ITC, 1998).

Off-site contaminants have been measured in a number of residential and monitoring wells. However, there is very little information about off-site contaminant concentrations before 1985–87. The groundwater transport models will be used to evaluate how long contamination may have been present in off-site areas and whether contaminant concentrations could have been greater than the earliest measured values. As such, it is necessary to determine the critical distances and times for evaluation. The shortest flow paths and longest plume duration present the greatest potential for contaminant exposure. From Table 1, the critical flow paths are: plume

2 (OU-III) with a path length of 2400 m and a potential duration of greater than 50 years; plume 4 with a path length of 1600 m and a duration of 45 years; and, plume 5 with a path length of 0 m and a potential duration of more than 35 years. Contaminant concentrations will be estimated for path lengths of 1500 m, 2000 m, and 2500 m for 10-year time intervals.

Hydrogeological Setting

Groundwater from BNL site flows predominately southward in the unconfined to semi-confined Upper Glacial aquifer. Although net groundwater transport from BNL is southward, BNL facility overlies a deep flow recharge zone such that initial groundwater flow is downward (ITC, 1998). Under and south of BNL site, the Pleistocene-age Upper Glacial aquifer is from 30 to 60 m in thickness (CDM, 1996). The thicker portions of the glacial deposits are present as valley fill where fluvial erosion has removed the underlying Gardiners Clay and Cretaceous-age Magothy Formation. Borehole information indicates that the thickness of the Upper Glacial aquifer varies between 35 and 55 m within the area of groundwater contamination (CDM, 1996).

Most of the Upper Glacial aquifer is unconfined such that the upper boundary of the saturated groundwater system is defined by the water table, which is 5 m or less below ground surface. Water table elevations are significantly affected by recharge from settling basins and discharges to streams and pumping wells (ITC, 1998). The Upper Glacial aquifer is partially separated from the underlying Magothy aquifer by the Gardiners Clay and/or Cretaceous-age clays of the Monmouth Group (ITC, 1998). The Upper Glacial aquifer is predominately sandy to gravelly permeable glacial outwash deposits with some finer-grained glacial lake deposits and near-surface silts and clays (CDM, 1996). Although the Magothy aquifer is in direct contact with the Upper Glacial aquifer over a portion of BNL site, groundwater flow occurs preferentially in the Upper Glacial aquifer as a result of much higher permeabilities (ITC, 1998).

Precipitation averages about 122 cm/year, with about 58 cm/year recharge to the aquifer system, and most of the remaining precipitation is lost as evapo-transpiration or surface runoff (CDM Federal Programs, 1996). Surface streams are controlled by groundwater discharge from the Upper Glacial aquifer, which constitutes about 95 percent of the base flow. Upper reaches of the Peconic River and other area streams have intermittent flow and often go dry when the water table is lower than the stream channels (ITC, 1998).

Methods

Contaminant plume migration was evaluated by use of one-dimensional and three-dimensional analytical groundwater flow models with Monte Carlo analysis to address the inherent variability of hydrogeological parameters. The analytical models are part of the ACTS (Analytical Contaminant Transport System) software package developed by the Georgia Institute of Technology for ATSDR (Aral 1998). The analytical equation, required parameters, and citations are presented in Attachment 1. Results of the contaminant transport modeling are compared with contaminant concentrations from offsite wells to ensure that model results reflect the current distribution of the contaminant plumes. Assuming that the model results do describe current conditions, then the model will be used to evaluate plume migration and contaminant concentrations in the years before 1997.

Evaluation of hydrogeological conditions at BNL site indicates that initial hydraulic flow is downward (ITC 1998). The time required for this initial downward flow is estimated by use of a one-dimensional model with relevant vertical hydrogeological parameters (Table 2). The time required for downward transport is represented by a time-lag in introduction of contaminants into the three-dimensional model.

The specific three-dimensional transport equation used in this report assumes an infinite, saturated aquifer with a finite/patch contaminant source and constant dispersion coefficient (Aral 1998). Although several of the plumes modeled at this site contain multiple sources, these multiple, discrete sources can be represented by a source of finite length perpendicular to the direction of groundwater transport. These models assume that the aquifer system is relatively shallow, that vertical dispersion is minimal, and that the contaminant is well mixed in the vertical direction.

The model was run in both deterministic and Monte Carlo modes. The deterministic mode calculates contaminant transport at all grid points in x-y, x-z, and y-z locations. The model grid was a 6000m by 6000m area at 500 m lateral nodes and 10 m vertical nodes. Ten year time steps were calculated for a 0 to 60 year time frame. The deterministic mode uses means of hydrogeological parameters as single input values for the analytical equation and results in a single best estimate of contaminant concentration at each node.

The Monte Carlo or probabilistic analysis uses multiple solutions to the transport equation and varies the value of the hydrogeological parameters for each solution. The specific values used depend on the frequency distribution of the parameter such that average values are used more frequently than the less likely occurrence of minimum or maximum values. This analysis used 500 iterations of the transport equation, resulting in a probability distribution of a contaminant concentration at specific locations and depths down-gradient of the plume sources.

The aquifer parameters used in the ACTS model are based on values reported in various BNL reports and hydrogeological reference documents. The ACTS Monte Carlo simulation uses parameter ranges and probability distributions in multiple analyses to account for the natural variability present in these parameters. Because most of the hydraulic parameters are directly controlled by the distribution of sedimentological properties and such sediment properties usually vary in a lognormal distribution (USEPA 1991; Myers 1997), most hydraulic properties used in the Monte Carlo simulation are assumed to vary lognormally.

Hydraulic Conductivity: Ranges of horizontal and vertical hydraulic conductivity values were reported as part of a Groundwater Modeling Report (CDM Federal Programs, 1996). These values included measurements from pumping tests, other values reported in the literature, and average values used in other groundwater models. The values presented in that report were converted from ft/day to meters/year and used to generate the distribution of groundwater velocities with corrections for retardation (contaminant transport velocity = hydraulic conductivity/porosity x hydraulic gradient/retardation factor). Specific discharge or Darcy Velocity does not include the porosity term or the retardation factor (Darcy Velocity = hydraulic conductivity/porosity x hydraulic gradient/retardation factor). Hydraulic conductivities and the resulting groundwater velocities are assumed to vary in a triangular distribution.

Table 2. Hydrogeological Flow Parameters

| | <i>Mean</i> | <i>Range</i> | <i>Standard Deviation</i> | <i>Freq. Distribution</i> |
|-------------------------------|------------------------|----------------------------|---------------------------|---------------------------|
| Darcy Velocity | 26 m/yr | 4–36 m/yr | 7.2 | Triangle |
| Longitudinal Dispersion Coef. | 237 m ² /yr | 30–910 m ² /yr | 72.0 | Lognormal |
| Lateral Dispersion Coef. | 24 m ² /yr | 3–91 m ² /yr | 8.5 | Lognormal |
| Vertical Dispersion Coef. | 3.8 m ² /yr | 0.4–5.3 m ² /yr | 1.2 | Lognormal |
| Aquifer Thickness | 60m | 40–80m | 8.2 | Normal |
| Aquifer Porosity | 0.25 | 0.18–0.30 | 0.03 | Lognormal |
| Contaminant Half-Life | 70 years | 55–90 years | 4.4 | Lognormal |
| Aquifer Recharge | 0.58 m/yr | | | |

Table 2. Values of hydrogeological parameters used in contaminant transport models. Mean values are used for deterministic analyses and frequency distributions are used in Monte Carlo simulations. (Darcy velocity = specific discharge / hydraulic conductivity x hydraulic gradient)

The average groundwater velocity used in this analysis is higher than the average values in the site reports for several reasons. First, although velocities may exhibit a substantial range, transport will preferentially occur within the zones of lowest resistance or higher velocities. Second, documentation of the waste solvent plume (OU-IV) indicates that it migrated 7500ft (2286m) over a period of 20 years (BNL/ERD 1998), which translates to a contaminant transport rate of approximately 114m/year.

Hydraulic Gradient: The hydraulic gradient is the change in water table or aquifer elevation over distance (either horizontal or vertical). Relatively consistent values of 0.001 have been reported and used in other models and are used in this report to convert horizontal hydraulic conductivity values to groundwater velocities (CDM Federal Programs 1996; ITC 1998). A vertical hydraulic gradient of 0.05 (Geraghty & Miller 1996) was used for evaluating vertical transport in the one-dimensional model.

Dispersion: Dispersion is the process of mechanical mixing and molecular diffusion that tends to disperse a solute in conjunction with advective transport. Dispersion occurs in three dimensions (longitudinal, lateral, and vertical). ITC (1997) indicates that 9.1 m is a reasonable estimate of

the longitudinal dispersivity and that the lateral dispersion is 1/10 and vertical dispersion 1/100 of the longitudinal dispersion. The analytical equations in ACTS use dispersion coefficients, which are the product of dispersivity and groundwater velocity. Dispersivity coefficients are assumed to vary in a lognormal distribution.

Published values of dispersivity for glacial tills vary considerably from 0.05 to 21m (Gelhar and Welty 1992). The dispersivity value of 9.1m is considered reasonable for the aquifer system, based on contaminant migration assessments conducted in similar geologic settings and a published range of typical values (ITC, 1997). Sensitivity analyses indicate only a 10 percent change in annual contaminant migration rates (100 to 111 m/yr) as dispersion coefficient values vary from 170 to 2100 m²/yr (respectively).

Aquifer Thickness: Estimates of aquifer thickness are based on bore-hole data and cross-sections presented in several reports (CDM Federal Programs 1996; ITC 1998). Model aquifer thickness values are comparable to measured values that range from 35 m to more than 100 m and are estimated to have an average thickness of about 50 m. It is assumed that aquifer thickness varied with a normal frequency distribution.

Aquifer Porosity: Measured porosity values for the Upper Glacial aquifer vary from 0.18 to 0.36, with an average value of 0.25 (CDM Federal Programs 1996; ITC 1998). These values were utilized in the model and are assumed to vary with a lognormal distribution.

Recharge: A constant recharge value of 58 cm/year was used in the analysis. Although this value changes from year to year with precipitation, 58 cm/yr is the long term average precipitation rate. Use of the long term average is justified on the basis of the sixty year period of this analysis.

Source Concentration: Characterization of groundwater contaminant sources has shown concentrations of specific VOCs up to 5,000 µg/l (CDM, 1996; ITC, 1998). Two source release scenarios are used in this analysis. In the first, a constant release is assumed, with the source concentration of 1 µg/l at year 0; 500 µg/l at year 3; and 5,000 µg/l for years 4 to 50. In the second scenario, a single spill is assumed with 1 µg/l at year 0; 500 µg/l at year 3; 5,000 µg/l for years 4 to 9; and 1,000 µg/l for years 10 to 50.

The contaminant source geometry (3-D analysis) is assumed to occur along a 30 m line perpendicular to groundwater flow with a center at 50 m below ground surface and an overall thickness of 20 m. Although the specific source geometry is unknown, this dispersed geometry at depth is reasonable due for most sources originating from waste pits, the downward flow gradients in the source areas, and VOC densities greater than water.

Retardation and Contaminant half-life: Transport of groundwater contaminants is often impeded by interactions with aquifer materials. The rate at which contaminant transport is retarded depends on the specific contaminant and the chemistry of the aquifer materials. Most of the contaminants at BNL are volatile organic compounds (VOCs) that are relatively soluble and have minimal retardation. Retardation factors vary from about 1 to more than 4. A conservative retardation factor of 1.1 is used to estimate contaminant transport rates (ITC 1998). Higher retardation factors may reduce measured downgradient contaminant concentrations.

Contaminant half-life is the rate at which contaminants are chemically altered or degraded by interaction with aquifer materials and microbial organisms. Half-lives are also contaminant-specific and vary considerably with aquifer properties. Experimental half-lives of 1,1,1-TCA have been reported to range from 1 year to no degradation (ATSDR 1990) and for PCE from 6B10 years to no degradation. 1,1-DCA can be formed from the degradation of 1,1,1-TCA. The down-gradient concentrations of 1,1-DCA suggest that significant degradation is occurring within the time frame of these contaminant plumes. This analysis uses a half-life for VOCs that ranges from 55 to 90 years, with a 70 year average and a lognormal frequency distribution.

Results

The modeled rate of downward contaminant transport is shown in Figure 1. This figure indicates the amount of time required for a 5,000 µg/l contaminant source, released at the surface, to migrate to different depths in the aquifer (10B50 m below ground surface). Groundwater monitoring data indicate that the highest contaminant concentrations at on-site locations are between depths of 30 to 50 m, with maximum concentrations at about 50 m below ground level (bgl) at the site boundary (BNL/ERD, 1998). Figure 1 indicates that it takes about 3 years for measurable contamination to occur at the 50 m depth and only 4 years before the contaminant plume has reached its maximum value at that depth. Consequently, contaminant introduction in the 3-D model, centered on a 50 m depth, will utilize concentrations of 1 µg/l concentration at year 0; 500 µg/l at year 3; and 5,000 µg/l for years 4 to 50.

Contaminant breakthrough curves were calculated for 1500m, 2000m, and 2500m distances downgradient of source by use of the 3-D model in a deterministic mode (using mean values for all hydrogeological parameters). The breakthrough curves for those down-gradient locations at 30 and 40m depths are presented in Figure 2; they show the amount of time required for contaminant migration to reach each point. Notice that the contaminants reach each depth/distance location at the same time, but that peak concentrations are much higher for the locations at 40m depths relative to the 30m depths.

It takes about 10 years for the contaminant plume to travel 1500m down-gradient of the source. After 20 years, contamination concentrations level off at the 1500m location and after 30 years for the 2000m and 2500m locations. At the 2000m location (40m depth), appreciable contaminant concentrations occur after 20 years and reach an asymptotic maximum of 450 µg/l after 30 years. Maximum concentrations for the 2000m location (30m depth) are about 250 µg/l after 30 years. At the 2500m location, contamination is present after 20 years, increasing rapidly to about 300 µg/l for the 40m depth, and 200 µg/l for the 30m depth after 30 years.

Table 3 lists the 50th and 95th percentile concentrations derived from the Monte Carlo simulation. The 50th percentile values are similar to the values shown in the breakthrough curves (Figure 2). In Table 3, maximum contaminant concentrations are observed at the 1500m and 1800m locations after 30 years and at the 2500m location after 40 years. All these estimates of plume concentrations are evaluated at a depth of 30m and along the centerline of the plume.

Table 3. Estimated Concentrations at Downgradient Locations at 30m depth

| <i>Duration of Plume</i> | <i>1500 m50th % – 95th %</i> | | <i>1800 m50th % – 95th %</i> | | <i>2500 m50th % – 95th %</i> | |
|--------------------------|---|------|---|-----|---|-----|
| 10 years | 0 | 0.31 | 0 | 0 | 0 | 0 |
| 20 years | 262 | 488 | 13 | 410 | 0 | 28 |
| 30 years | 324 | 493 | 271 | 427 | 143 | 307 |
| 40 years | 324 | 493 | 272 | 427 | 178 | 307 |
| 50 years | 324 | 493 | 272 | 427 | 178 | 307 |

Table 3. Estimated concentrations at specified distances downgradient of source and durations of plume migration. All concentrations are in µg/l and are estimated by use of Monte Carlo simulation with 500 iterations. Concentrations listed are the 50th and 95th percentiles of the 500 iterations. All concentrations are calculated at a depth of 30m and are based on a 1µg/l source at year one; 500 µg/l at year three, and 5,000 µg/l for years 4 to 50.

The locations of BNL and Suffolk County offsite monitoring wells with contaminants detected are shown in Figure 3, and the associated contaminant concentrations are listed in Table 4. Most of the measured contaminant values are lower than the modeled values with the exception of carbon tetrachloride in wells 000–112, 000–130, 000–154, and 000–161. All these higher measured values are attributed to the OU-III (a; bldg. 96) plume except the 000–154 samples, which are attributed to the former landfill plume. The samples with high carbon tetrachloride concentrations (>800 µg/l) are all taken from depths greater than 50 m.

Modeled values at the 30m depth (Table 3) are consistently higher than measured values from both monitor and residential wells, with the exception of the carbon tetrachloride samples. However, the down-gradient migration distance of the measured plumes is directly comparable to the modeled plumes. The waste solvent spill plume (OU-IV) has migrated a distance of 2000m over 20 years (1977 to 1997; BNL/ERD 1998). Figure 4 shows the modeled distance at 20 years to be approximately 2000m (for the 5µg/l contour). Similarly, the OU-III plume has migrated approximately 5300m over an estimated 52-year duration (5 µg/l contour; BNL/ERD, 1998), while the modeled 50-year migration has been approximately 5100m (5 µg/l contour; Figure 4). Within the uncertainty of the time of origin of the contaminant sources and of the hydrogeological parameters, the modeled and measured plume migration rates are similar, a fact that allows use of the modeled plume behavior to predict historic trends of groundwater contamination.

In the constant source scenario illustrated in figures 2 and 4, historic contaminant concentrations were probably never higher than the levels detected in monitoring and residential wells.

However, if a declining source concentration scenario is assumed, contaminant concentrations before 1985 may have been higher than values measured after 1985 for wells located more than

1500m downgradient of the sources. Figure 5 illustrates the breakthrough curves, assuming source concentrations declined to 1000 µg/l for years 9–50. The breakthrough curves for the 2000m and 2500m locations peak at 30 years after source introduction and then decline to constant concentrations of less than 100 µg/l as a high concentration contaminant pulse migrates downgradient.

Although the surficial source releases have been controlled, monitoring information indicates that the on-site contaminant concentrations at depth have not declined (BNL/ERD 1998). Monitoring data suggest that a declining source release is appropriate only for the OU-IV waste solvent spill plume and for the OU-I former landfill/animal/chemical pits and glass holes plume. These plumes do show distinct contaminant pulses with higher down-gradient concentrations. However, for the OU-IV plume, the high concentration pulse has currently not migrated off-site (BNL/ERD 1998). Source concentrations for the other plumes are higher at up-gradient locations compared to down-gradient locations, indicating that a constant source release scenario is more appropriate than a declining source release scenario.

Site-wide hydrogeological studies and contaminant monitoring indicate that initial groundwater flow from BNL is downward; followed by southward lateral transport (BNL/ERD 1998). This modeling analysis reproduces this flow pattern by introducing a four-year time lag for source introduction centered at 50m below ground level. Subsequent lateral migration of modeled contaminant plumes produces plume migration rates that are very close to monitored plume migration rates. These results indicate that modeled plume behavior can be used to interpolate contaminant behavior prior to establishment of the groundwater monitoring network.

Figure 6 shows the 1997 locations of the plumes based on monitoring results in the 1997 site-wide groundwater monitoring report (BNL/ERD, 1998). The leading edge of the plumes (5 µg/l contour) is shown for 1997 and prior 10-year periods by subtracting the 10-year plume migration rate ($\sim 100 \text{ m/yr} \times 10 \text{ yr} = 1000 \text{ m}$) from each plume. This figure shows that contaminants had migrated to areas of potential contamination for the OU-III plumes and the FLF plume some time between 1977 and 1980. However, this figure ignores the vertical distribution of the plumes and depths of residential wells.

The depth zonation of contaminant concentrations is supported by the results of the analytical model. Figure 7 is an X-Z (distance-depth) plot of modeled concentration contours after 30 years of plume migration in the declining source release scenario. This plot is taken along the centerline of the plume and calculated in a deterministic mode (using average hydrogeological parameters). This figure shows a pulse of high concentrations migrating down-gradient and the effect of depth on those contaminant concentrations. Most of the high concentration portion of the plume is below 30m depth. The depth zonation of the measured groundwater plumes will also be constrained by preferential flow in permeable units. The model assumes a homogeneous aquifer which increases estimated vertical dispersion. Note the exaggeration of the vertical scale in Figure 7. This modeled plume behavior closely matches monitoring results for the former landfill plume (BNL/ERD 1998).

Monte Carlo analyses of the declining release source scenario calculated at a depth of 30m produce modeled results that closely match monitored results (Table 5). The highest estimated

contaminant concentration for this scenario is located 1500m down-gradient of the source after 20 years. The 50th percentile value is 166 µg/l, while the 95th percentile value is 449 µg/l.

Table 4. Estimated Concentrations Using a Declining Source Scenario

| <i>Duration of Plume</i> | <i>1500 m50th % – 95th %</i> | | <i>1800 m50th % – 95th %</i> | | <i>2500 m50th % – 95th %</i> | |
|--------------------------|---|------|---|-----|---|-----|
| 10 years | 0 | 0.03 | 0 | 0 | 0 | 0 |
| 20 years | 166 | 449 | 13 | 401 | 0 | 28 |
| 30 years | 71 | 150 | 63 | 150 | 53 | 226 |
| 40 years | 66 | 102 | 56 | 93 | 40 | 73 |
| 50 years | 65 | 99 | 54 | 85 | 37 | 63 |

Table 4. Estimated concentrations at specified distances down-gradient of source and durations of plume migration. All concentrations are in µg/l and are estimated by use of Monte Carlo simulation with 500 iterations. Concentrations listed are the 50th and 95th percentiles of the 500 iterations. All concentrations are calculated at a depth of 30m and are based on the declining source scenario 1 µg/l source at year one; 500 µg/l at year three; 5,000 µg/l for years 4 to 9; and 1,000 µg/l for years 10 to 50.

Discussion

This report presents the results of a groundwater modeling study that estimates the migration of the contaminant plumes and the potential plume concentrations in the years before the contamination was discovered. The results of this modeling report are applicable to any of the VOCs determined to be contaminants of concern in off-site residential wells (chloroform, 1,1-dichloroethylene, ethylene dibromide, perchloroethylene, 1,1,1-trichloroethane, and trichloroethylene; ATSDR, 1999). Two radionuclides (tritium and strontium-90) have never been detected in residential wells at levels of potential health concern, and modeled concentrations would be additionally reduced by radioactive half-lives that are more rapid than the 70-year average used in the model (12.5 years for tritium and 28.6 years for strontium-90).

The most likely results of this analysis indicate that it is unlikely that groundwater contaminants had migrated to areas of potential off-site exposure prior to 1987 for five of the eight plumes illustrated in Figure 7 (plumes 3,5,6,7, and 8). According to the results of this analysis, portions of plume 2 and plume 4 had reached areas of potential exposure between 1977 and 1980. The source of contamination from the Precision Concepts plume (plume 1) is only about 500m from residential wells, and contaminants from that source likely reached residential wells less than five years after source introduction into the aquifer.

Contaminant concentrations from plume 2, assuming a constant source release, were never higher than measured values. In the constant source release scenario, the modeled values increase to an asymptotic maximum and were never higher than monitored values. However, a declining source concentration scenario (e.g., a contaminant spill event such as the OU-IV waste

solvent spill) creates a high concentration pulse that migrates down-gradient. As this pulse migrates past a point, contaminant concentrations increase and then decrease. This type of source scenario is likely for only two of the eight BNL plumes.

The contaminant concentrations derived by use of the analytical transport equation at a 40m depth are generally higher than those detected in either residential or monitoring wells. Modeled concentrations at a 30m depth are comparable to measured values in residential and monitor wells (ATSDR, 1999). Monitoring data indicate that the initial movement of the contaminants is downward. Although knowledge of the depth of residential wells is limited, the data available indicate that most residential wells are relatively shallow, with depths between 30 and 37 m, while the zones of maximum contamination have migrated to depths of 50 m or more (BNL/ERD 1998).

The most significant exception to the depth zonation of contaminant concentrations is the Precision Concepts plume, which has not migrated vertically to the same extent as BNL-originated plumes because vertical hydraulic gradients are much higher in the vicinity of BNL contaminant sources (Geraghty & Miller 1996). Residential wells down-gradient of the Precision Concepts plume also have the highest contaminant concentrations. Because the Precision Concepts plume does not migrate vertically to the same extent as plumes originating on BNL facility, the results of this model are not directly applicable to the Precision Concepts plume. In addition to differences in well and plume depths, the modeled plume concentrations were derived for the exact centerline of the plume, resulting in a maximum plume concentration. Wells located off the plume centerlines will have lower than modeled concentrations.

The contaminant half-life used in the analytical model (70 year average) is quite conservative for VOCs. The presence of 1,1-DCA and chloroform at down-gradient locations indicates that degradation of 1,1,1-TCA and carbon tetrachloride (respectively) are significant with respect to the durations of the plumes. Use of a shorter half-life will lead to lower down-gradient plume concentrations. It is also important to point out that the retardation of the specific VOCs may be higher than assumed for the model. Retardation factors are specific to individual contaminants and to the aquifer materials. For this analysis, the retardation factors are integrated into a composite groundwater velocity. While total contaminant migration rates of modeled and monitored plumes are comparable, increased retardation of specific contaminants would lead to decreased down-gradient concentrations of those contaminants.

Several other factors may also lead to reductions in down-gradient plume concentrations. For example, release of contaminants from landfills, leaking pipes, etc. may have been much more gradual than the source term used in the models. A slower source release will also lead to lower down-gradient concentrations. Additionally, monitoring of on-site production wells has indicated the presence of contaminants several years before detection of the off-site contamination. Removal of contaminants by on-site wells will reduce down-gradient contaminant migration for the limited capture area of those wells. Similarly, this modeling analysis ignores potential effects from the several pump-and-treat extraction systems along the facility boundary. However, these systems were not in place until late 1996, and they did not affect plume migration before that time.

One factor that could lead to increased contaminant concentrations relative to the modeled concentrations is the addition or co-mingling of plumes. As a result of the proximity of several of the OU-III plume sources, the measured concentrations reflect the addition of those plumes. The modeled plume concentrations do not account for the addition of co-mingled plumes. However, plume concentrations are generally much lower along plume margins, so that co-mingling along plume margins will not produce concentrations that exceed centerline concentrations. Measured contaminants from residential and monitoring wells do not have concentrations that reflect co-mingling of the high concentration zones of plumes (2 times plume centerline values).

The agreement between measured and modeled plume distribution and concentrations indicates that the results of this analysis are relevant to understanding the rates of plume migration. The contaminant concentrations for several different source release scenarios, down-gradient locations, and aquifer depths were estimated by use of both deterministic and Monte Carlo modes. Contaminants migrated laterally to the area of residential wells beginning about 1980, or about 5-7 years before initial measurement of contaminants in residential wells.

High concentration pulses have migrated down-gradient for several plumes. Although these pulses present the potential for historical contaminant concentrations that exceed recently measured values, monitoring data and the results of this analysis indicate that the high concentration zones are deeper than residential well depths. It is unlikely that historical contaminant concentrations for the other six plumes have ever exceeded recently measured values.

Conclusions

Eight groundwater contaminant plumes have been detected in the vicinity of the Brookhaven National Laboratory. Seven of these plumes originate from BNL facility, and all eight plumes have migrated to areas of potential exposure. Contaminants were detected in off-site drinking water wells beginning in 1985, and residents were provided with water filters and later with hook-ups to an alternate water source. This study uses an analytical groundwater flow model to evaluate contaminant concentrations and distributions at areas of potential exposure prior to off-site detection of the plumes.

Although several different contaminants have been detected, most of these are VOCs have similar physical properties so that behavior of the different plumes will be very similar. Because all the plumes are adjacent, it is further assumed that hydrogeological properties for the different plume areas are similar. Differences in the plumes are based on distance from plume origin to area of potential exposure and duration of plume migration (based on time of contaminant release at source). Distances of plume migration to areas of potential exposure range from 500 to 3900 m, and migration times from 12 to 53 years.

Initial transport of contaminants from BNL sources is downward. 1-D vertical modeling indicates that it took about 4 years for contaminants to migrate downward to 50m depth. Including time for vertical transport, contaminants have been migrating southward at a rate of 100 to 125 m/yr. Horizontal contaminant transport is occurring predominantly within the zones of higher hydraulic conductivity.

Assuming a constant source concentration (at 50m depth), concentrations in residential wells were never significantly higher than the values measured in late 1980s and 1990s. Off-site contaminant concentrations could have been higher prior to 1985 for a single spill or a very short-term type of contaminant release. According to source and other on-site monitoring, this scenario is likely for only two plumes (the OU-IV waste solvent plume and the OU-I former landfill plume.)

Depending on the specific plume and residential well location, exposure to several plumes could have occurred 5 to 7 years before initial detection in 1985. However, limited data on depths of residential wells indicate that the zones of highest contaminant concentration are below the screened well depths, so that actual exposures are much lower than potential exposures based on lateral plume migration. Contaminant concentrations estimated for a depth of 30 m are very close to values measured in off-site residential and monitoring wells. Retardation and attenuation of contaminants within the groundwater flow system have reduced the concentrations of potential exposures relative to conservatively modeled concentrations.

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Analytical Solution for an Infinite Aquifer with a Finite Line Source

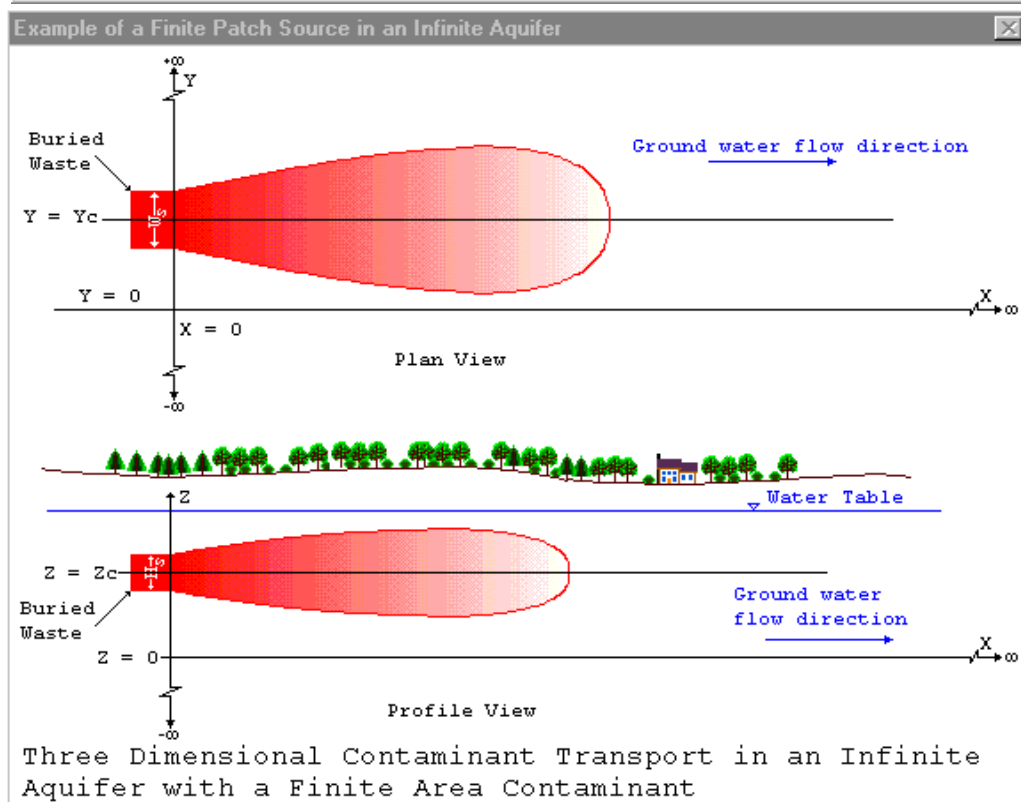
The following equation was obtained from E. J. Wexler Analytical Solutions for One-, Two-, and Three-Dimensional Solute Transport in Ground-Water Systems with Uniform Flow (1989, p 84)

$$C(x, y, z, t) = \frac{C_0 x \exp\left(\frac{Vx}{2D_x}\right)}{8\sqrt{\pi D_x}} * \int_{\tau=0}^{\tau=t} \tau^{-\frac{3}{2}} \exp\left\{-\left(\frac{V^2}{4D_x} + \lambda\right)\tau - \frac{x^2}{4D_x\tau}\right\} \left\{\operatorname{erfc}\left(\frac{(Y_1 - y)}{2\sqrt{D_y\tau}}\right) - \operatorname{erfc}\left(\frac{(Y_2 - y)}{2\sqrt{D_y\tau}}\right)\right\} \left\{\operatorname{erfc}\left(\frac{(Z_1 - z)}{2\sqrt{D_z\tau}}\right) - \operatorname{erfc}\left(\frac{(Z_2 - z)}{2\sqrt{D_z\tau}}\right)\right\} d\tau$$

Where

$$Y_1 = Y_c - \frac{W_s}{2} \quad Z_1 = Z_c - \frac{H_s}{2}$$

$$Y_2 = Y_c + \frac{W_s}{2} \quad Z_2 = Z_c + \frac{H_s}{2}$$



Appendix E. Operable Units History

Operable Unit(s) Contamination

In the late 1990s, when ATSDR was first evaluating contamination levels in multiple media at BNL, the Agency assessed the status of the different Operable Units to inform the ongoing public health assessment activities. The information in this appendix presents the results of ATSDR's data summary efforts conducted in the late 1990s. Readers should view this appendix as a "snap-shot" of the nature and extent of contamination and planned or ongoing cleanup activities as of the late 1990s. Due to the extensive remediation activities that have occurred since this time, however, the information presented in this section may not represent current site conditions. ATSDR used the information in this appendix when evaluating the public health implications of past exposures to site-related environmental contamination.

E.1 Operable Unit 1

Operable Unit 1 is in the southeastern area of BNL property. It encompasses approximately 950 acres. Contaminated areas within OU1 include the Former Landfill, Animal/Chemical Pits and Glass Holes, the former Hazardous Waste Management Facility (HWMF), the Current Landfill, the National Weather Service (NWS) stockpiled soil, the southern component of the tritium groundwater plume, Recharge Basin HSO005, and the Weaver Road recharge basin.

The Former Landfill was used from the time BNL started operating (1947) until 1966 for the purpose of disposing of a variety of wastes, including chemical and low-level radioactive wastes, sewage sludge, construction debris, and animal carcasses. A series of pits (55) in an area east of the Former Landfill were used between 1960 and 1966 for disposal of glassware containing chemical and radioactive waste and animal carcasses containing radioactive tracers. This area is referred to as the Animal/Chemical pits. Used glassware was also disposed of in shallow pits located north of the Animal/Chemical pits from 1966 through 1981. This area is referred to as the Glass Holes. The Glass Holes are directly east of the Former Landfill, and the Animal/Chemical Pits are southeast of the Former Landfill.

The use of the Current Landfill started in January 1967, after the Former Landfill was filled and covered. The Current Landfill was used for disposal of animal carcasses containing short-lived radionuclides and for disposal of laboratory waste, sewage sludge, and mouse litter containing tritium. This practice was stopped in September 1978. Trash and building materials were disposed of in the landfill starting in 1967. Since February 1981, rotten and foul-smelling garbage (putrescible) has been disposed of off-site at the Brookhaven Town Landfill. The Current Landfill was closed in December 1990.

From 1947 until 1997, the HWMF was the central receiving Resource Conservation Recovery Act (RCRA) facility for processing, limited treatment (neutralization), and storage of radioactive wastes and RCRA hazardous wastes generated through BNL (ITC 1998a). Prior to 1947, the HWMF was a munitions storage area and a livery stable for Camp Upton. Various buildings and operational areas are within the facility. Access to the facility, which is 12 acres in size and fenced, is controlled. Figures 2 and 3 in Appendix B detail the location of the HWMF.

E.1.1 Soil

During the remedial investigation (RI), soil samples were collected from the HWMF and the ash pit within the Former Landfill area. The ash pit is located on the northwestern end of OU I, and the HWMF is located on the northeastern end. All samples were taken from a soil depth of 0 to 6 inches. A total of 59 surface soil samples were collected between January 31, 1994 and November 25, 1994, and between July 24, 1995 and July 27, 1995 (ITC 1998a).

Several areas of contamination within the HWMF area were analyzed as part of the RI: the open burning/detonation area, the spray aeration area, the salvage storage areas, the HWMF fields (Agrassy area@), the drum rinsing area, the radioactive material (fission product) injection site, the miscellaneous spill sites (Apaved area@), the oil-water separator, the neutralization tank and area, the HWMF wetland, the underground storage tank 445-03 area, and the dry well area adjacent to building 444.

The open burning/detonation area was used until 1988 to burn or detonate nonradioactive wastes deemed too hazardous to dispose of under normal procedures. The salvage storage areas contain used, slightly radioactive equipment from the Alternating Gradient Synchrotron (AGS). The HWMF fields (grassy area) were sprayed with 1,1,1-trichloroethane for weed control in 1979. The drum rinsing area was used to rinse drums that contained various chemicals. Very little is known about the contents of the drums.

The radioactive material (fission product) injection site consists of a water supply well contaminated in 1960 when a BNL employee accidentally pumped radioactive slurry into the well. Miscellaneous spills of fission products onto the asphalt area at the HWMF occurred from 1950 to 1967 when the Brookhaven Graphite Research Reactor (BGRR) was in operation. Waste materials from the BGRR were handled at the HWMF. The oil-water separator is an above-ground settling tank used to separate non-radioactive miscellaneous oils from water prior to shipment of the oil off site for disposal.

The ash pit was used from 1943 to 1963 for the disposal of ash and slag from an army solid waste incinerator, used from World War I to the early 1950s (ITC 1998a), and for disposing of coal ash from various BNL buildings. Located southwest of the Former Landfill area, the ash pit occupies approximately 2 acres. Surface soil samples were collected from the ash pit and analyzed for inorganic and radiological compounds.

Nine chemicals were detected above ATSDR's CVs or USEPA's Risk-Based Concentrations (RBCs) in the surface soils collected: Aroclor-1260, arsenic, benzo(a)anthracene, benzo(a)pyrene, benzo(b)fluoranthene, indeno(1,2,3-cd)pyrene, iron, mercury, and N-nitroso-di-N-propylamine (see Table SS1 in Appendix C). Five of these chemicals (Aroclor-1260, benzo(a)pyrene, benzo(b)fluoranthene, mercury, and N-nitroso-di-N-propylamine) were detected at levels more than an order of magnitude above their CVs or RBCs. Four additional pollutants, which have no CVs or RBCs, were detected in surface soil: benzo (g,h,i)perylene, 4-chloro-3-methylphenol, endrin, ketone, and phenanthrene.

Maximum concentrations of many of the semi-volatile compounds (Aroclor-1260, benzo(a)anthracene, benzo(a)pyrene, benzo(b)fluoranthene, and benzo(g,h,i)perylene) were detected in the drum rinsing area. Maximum concentrations of arsenic, 4-chloro-3-methylphenol, endrin ketone, and N-nitroso-di-N-propylamine occurred in the miscellaneous spill sites. The

highest concentrations of indeno(1,2,3-cd)pyrene and phenanthrene occurred in the HWMF fields.

The main soil contaminants in this OU are radioactive elements, primarily cesium-137 and strontium-90, especially in the HWMF. The 59 samples collected from the ash pit and the HWMF were analyzed for 35 radionuclides. Sixteen radionuclides were detected (see Table SS2). Cesium-137, potassium-40, lead-212, lead-214, and bismuth-214 were detected in at least half the samples. The principal contaminant, cesium-137, was found at concentrations reaching 180,000 picocuries per gram (pCi/g) of soil. Eight samples had cesium-137 concentrations one to two orders of magnitude higher than all other cesium-137 samples. Six of these samples were located in miscellaneous spill sites, one sample was located in the HWMF fields, and one was located in the salvage storage area. Strontium-90 was also detected at levels up to 1,300 pCi/g.

E.1.2 Groundwater

The contaminants of concern found in groundwater monitoring wells within areas of the Former Landfill, the Animal/Chemical Pits, and the Glass Holes are carbon tetrachloride, trichloroethane (TCA), dichloroethylene (DCE), trichloroethylene (TCE), and chloroform. A groundwater plume extends south from these areas approximately 11,500 feet and has reached Crestwood Drive. The highest concentrations within the plume are off site near Stratler Drive in North Shirley, New York. Figure 3 in Appendix B shows the extent of the plumes in OU 1.

E.1.2.1 Volatile Organic Contamination

Routine groundwater monitoring near the HWMF in 1984 indicated levels of 1,1,1-trichloroethane (1,1,1-TCA) above the New York State drinking water standard of 5 ppb. BNL scientists investigated the 1,1,1-TCA contamination and determined the need for a groundwater extraction and treatment system to remove the 1,1,1-TCA from the groundwater. The chosen method of remediation involved the use of a spray-aeration system. Groundwater was extracted from a series of wells and discharged to the atmosphere via spray aeration nozzles as a means of volatilizing the contaminants, and the water was then recharged to the ground downgradient of the HWMF. The spray-aeration system operated continuously from April 1986 until the spring of 1990, with the exception of December 1986 through April 1987, when the spray nozzles experienced problems with freezing (CDM 1995). The operation of the groundwater extraction and treatment system ended in the spring of 1990 because the New York State Department of Environmental Conservation (NYSDEC) was concerned that the air quality impacts had not been evaluated and that the plume was not adequately characterized.

From 1985 through 1989, levels of 1,1,1-TCA, trichloroethene (TCE), perchloroethene (PCE), and chloroform were above New York State drinking water standards in monitoring wells southeast of the HWMF. Before 1991, levels of 1,1,1-TCA were typically found above

250 parts per billion (ppb). For example, in 1985, a maximum concentration of 2,100 ppb was detected in a well south of the HWMF, and in 1988, a maximum concentration was detected in a separate well at 870 ppb (CDM 1995). A maximum PCE concentration of 800 ppb was detected downgradient of the HWMF in 1985.

Monitoring results indicate that groundwater pumping from the spray-aeration system most likely dispersed contaminants both vertically and horizontally and, as a result, the plumes from the HWMF and the Current Landfill, also within OU I, mixed with one another. The co-mingling

of the plumes most likely occurred between 1986 and 1989. The spray aeration system was not effective in capturing the vertical extent of contamination because of an unidentified deeper plume from the Current Landfill. The Suffolk County Department of Health Services (SCDHS) conducted groundwater sampling at BNL from July through October 1992 and found concentrations of 1,1-dichloroethane (1,1-DCA) and 1,1,1-TCA at 870 and 150 parts per billion, respectively, near the southeastern site boundary, downgradient of the Current Landfill (CDM 1995). The maximum concentrations of compounds detected in 1992 downgradient of the HWMF included 1,1,1-TCA at 220 ppb, TCE at 16 ppb, PCE at 38 ppb, and dichloroethene (DCE) at 24 ppb (CDM 1995).

Two rounds of groundwater sampling occurred in OU I between August and December 1994. PCE, 1,1,1-TCA, and 1,1-DCA were detected above MCLs in monitoring wells downgradient of the HWMF. The maximum concentrations detected for each contaminant included PCE at 172 ppb, 1,1,1-TCA at 37.9 ppb, and 1,1-DCA at 16.2 ppb (CDM 1996b).

Other areas in OU1 that are sources of VOC contamination include the Former Landfill, the Glass Holes, and the Animal/Chemical Pits. The primary contaminants detected in monitoring wells in the Former Landfill-Animal/Chemical Pits and Glass Holes areas include carbon tetrachloride, 1,1,1-TCA, DCE, TCE, and chloroform. The contaminants are found in the shallow Glacial Aquifer near these source areas, and as the plume moves toward the southern site boundary, the contaminants are found in the mid-Upper Glacial aquifer. As the contaminants move off site, they are found in the deep Upper Glacial aquifer to an area near Crestwood Drive. The highest concentrations of VOCs within the plume are in the vicinity of Sleepy Hollow Drive (BNL/ERD 1998).

The compounds that have historically been detected above New York State drinking water standards downgradient of the Former Landfill include 1,1,1-TCA, TCE, and PCE. 1,1,1-TCA was also present in wells near the Glass Holes and the Animal/Chemical Pits. The maximum 1,1,1-TCA concentration detected was equal to 150 ppb. PCE was also detected frequently in wells upgradient and downgradient of the Former Landfill, the Glass Holes, and the Animal/Chemical Pits. A maximum concentration of 23 ppb was detected in a monitoring well downgradient of the Former Landfill.

A maximum concentration of chloroform, 54 ppb, was detected south of the Former Landfill. The chloroform was at depths ranging from 35 feet bgs to 202 feet bgs. The source of chloroform is not known, but it may be a biodegradation product of the carbon tetrachloride present in the area. Carbon tetrachloride is known to transform into chloroform and other products in water (ATSDR 1994).

Chloroform, 1,1-DCA, PCE, TCE, and 1,1,1-TCA have been detected in temporary wells downgradient of the Current Landfill at levels above New York State's MCLs. The New York State MCLs for these contaminants is 5 ppb, with the exception of chloroform, which has a standard of 100 ppb. Maximum concentrations included chloroform at 100 ppb, 1,1-DCA at 870 ppb, PCE at 37 ppb, 1,1,1-TCA at 150 ppb, and TCE at 22 ppb (CDM 1995). Downgradient of the Current Landfill and at the site boundary, 1,1-DCA was consistently found in 1992 and 1993 at concentrations ranging from 100 to 200 ppb. Concentrations decreased to 10 to 50 ppb by late 1993.

E.1.2.2 Radiological Contamination

Groundwater samples obtained from monitoring wells around the HWMF have contained levels of tritium and strontium-90 that exceed New York State MCLs. All radionuclide levels above MCLs in OU I have occurred within or downgradient of the HWMF, the Current Landfill, and the Former Landfill/Animal Pits. Historically, tritium was detected at levels exceeding the MCL of 20,000 picocuries per liter (pCi/L) in 1980B81, 1984, 1986, and 1989. The highest level of tritium detected in 1981 was 64,200 pCi/L, and in 1984 a concentration of 85,000 pCi/L was detected (CDM 1995). In 1987, wells east and downgradient of the HWMF had tritium levels above the MCL.

The groundwater extraction and treatment system previously mentioned might have accelerated the movement of tritium downgradient from the HWMF. Tritium concentrations found above the MCL occurred in the HWMF near the Open Burn Area. A maximum tritium concentration of 70,000 pCi/L was detected in 1989 (CDM 1995). Tritium concentrations have fluctuated in this area over the past decade. By 1992, tritium concentrations were within the 1,000 pCi/L range. However, during 1995, average tritium concentrations downgradient of the HWMF were approximately 2,000 pCi/L, although a maximum of 42,200 pCi/L was detected.

The radionuclide strontium-90 has historically been detected above the MCL (8 pCi/L) near the HWMF. In 1970B71, strontium-90 concentrations ranged from 75 pCi/L to 100 pCi/L (CDM 1995). Over the years, strontium-90 concentrations declined to a range of 10 to 30 pCi/L, but they were still above the MCL. In 1992, concentrations of strontium-90 continued to fluctuate; a maximum concentration was detected at 290 pCi/L. Monitoring of downgradient wells, closer to the southern boundary, has not shown any strontium-90. Unlike tritium, strontium-90 is not very mobile in water. Strontium-90 was also above the MCL in wells near the Former Landfill in 1986 through 1989. Concentrations ranged from 9 pCi/L to 50 pCi/L. Tritium was detected in the same area, but concentrations were below the MCL.

Tritium and strontium-90 concentrations exceeded MCLs in the groundwater downgradient of the Current Landfill in the 1970s and also between 1985 and 1989. The maximum concentration of strontium-90 detected near the Current Landfill was 453 pCi/L in 1971. The well that contained this level has since been abandoned because of the capping of the landfill. Tritium concentrations ranged from 20,000 to 30,000 pCi/L, with a maximum of 60,000 pCi/L. The highest concentrations of tritium have occurred downgradient of the Current Landfill. In 1992, tritium was detected in a monitoring well south of the landfill at a concentration of 20,500 pCi/L.

Strontium-90 was found in a shallow well downgradient of the Animal Pits at 240 pCi/L during the OU 1 remedial investigation. Strontium-90 concentrations averaged 300 pCi/L in a monitoring well in the Animal/Chemical Pits and Glass Holes area from October 1995 until the end of March 1997. Since then, the concentrations have been increasing. Monitoring conducted in September 1997 indicated a maximum concentration of strontium-90 at 769 pCi/L (BNL/ERD 1998). Sampling conducted in January 1998 indicated a strontium-90 concentration around 300 pCi/L. Low levels of strontium-90 have been detected downgradient of this area as far south as Middle Road.

E.1.2.3 Remedial Actions

Personnel from BNL, the New York State Department of Environmental Conservation (NYSDEC), and the Environmental Protection Agency (USEPA) have used groundwater monitoring results to trace the sources of contamination and to determine the best methods of remediation. It appears that the spray aeration was not effective in capturing the vertical extent of contamination because of the presence of a deeper plume from the Current Landfill. A groundwater extraction and treatment system was implemented for the HWMF and Current Landfill contaminant plumes in December 1996. In addition, a hydraulic containment and treatment system was installed to prevent additional off-site migration and to remove the volatile organic compounds to levels below drinking water standards.

The Current Landfill was capped in 1995, and the Former Landfill was capped in 1996. Capping of the landfills will help to prevent water from percolating into the contaminated soil and also prevent further migration of contaminants into the groundwater. The Chemical/Glass Holes and the Animal Pits were remediated during the summer of 1997. The soil and debris were removed and shipped off site to a licensed hazardous waste facility.

Currently, there are seven monitoring wells adjacent to the Former Landfill in upgradient and downgradient locations, and these are monitored on a quarterly basis. Similarly, a network of eleven monitoring wells surround the Current Landfill, and these are also monitored on a quarterly basis.

E.2 Operable Unit II/VII

Operable Unit (OU) II/VII is located in the western half of BNL property, near the center of the property. The areas of concern in OU II/VII include the Waste Concentration Facility (WCF), five fields adjacent to some of the facility's buildings, the Former Low-Mass Criticality Facility, the Alternating Gradient Synchrotron Storage Yards (Bone Yard), and various piles of contaminated landscaping soils. OU II/VII is shown in figure 1 of Appendix B.

Since 1949, liquid radioactive waste was temporarily stored and eventually distilled to remove particulates as well as suspended and dissolved solids at the WCF. The WCF consisted of three 100,000-gallon aboveground storage tanks (out of service since 1987 and removed in September 1994); six 8,000-gallon underground storage tanks; two 25,000-gallon aboveground storage tanks (added in 1987 to replace the three 10,000 gallon tanks); a 4,000-gallon aboveground receiving tank; two 5,000-gallon aboveground blending tanks (removed in October 1994); and the evaporator/concentration apparatus (no longer in service).

After the liquids were distilled, most of the radionuclides were concentrated in the slurry residue, but tritium was distributed between the distillate and the residue fractions. The distillate was piped to the Sewage Treatment Plant (STP) and then discharged to the Peconic River. This practice was stopped in 1985. From 1985 to 1995, the distillate was trucked to poly-lined hold-up ponds at the STP, where it evaporated and/or mixed with precipitation and diverted effluent from the STP. In 1995, a tritium evaporator facility designed specifically to eliminate Peconic River tritium discharges became operational.

The Waste Concentration Facility is an operational facility that was used since 1949 for reducing the volume of liquid radioactive waste prior to disposal. Three large storage tanks were used in this area from 1949 to 1987, but they were removed in 1994. Cesium-137 and strontium-90 were

detected in soils near the facility at maximum concentrations of 1,486 and 454 pCi/g; respectively. They were also detected in soils and sediments at the reclamation facility and in a sump outfall east of the facility, which was used from the late 1950s through the late 1960s to remove radioactive contaminants from clothing and equipment. Water from decontamination of equipment was discharged at the sump outfall area until 1969. Cesium-137 concentrations reached levels up to 2,800 pCi/g. Strontium-90 levels reached 140 pCi/g and plutonium-239/240 was detected at a maximum concentration of 170 pCi/g.

The Upland Recharge/Meadow Marsh Area was used in sewage treatment experiments from 1973 to 1978. Sediments in two of the manmade basins contain elevated levels of copper, zinc, and aluminum. Two storm basins are used to recharge runoff that enters BNL's storm sewer system. Sediment samples contained elevated levels of copper, lead, and organic chemicals.

E.2.1 Remedial Actions

The contaminated landscaping soils were removed in September 2000, and the area was re-seeded in the spring of 2001.

E.3 Operable Unit III

The OU III study area extends from the central developed region of the site to the southern boundary. OU III is bounded by the northern, southern, and western property boundaries of BNL; it encompasses approximately 50% of the total BNL area. Figure 1 in Appendix B details the location of OU III.

E.3.1 Soil

Surface soil samples were collected from four potential sources of environmental contamination in OU III: the Building 830 pipe leak and underground storage tanks (USTs), the TCE Spill Area, the Recharge Basin HP, and Building 464. These areas are located in the center of OU III.

From July 1984 to August 1986, leakage from a transfer pipe between radioactive liquid waste tanks took place between Building 830 and the USTs. An estimated 825 to 900 gallons of liquid radioactive wastes were released into the soil. A total of seven surface (zero to 6 inches) soil samples were collected from the Building 830 Pipe Leak and UST, TCE Spill Area, and the Recharge Basin HP in OU III on October 10, 1995; November 21, 1995; and September 30, 1996 and analyzed for organics, inorganics, and radionuclides. Three chemicals were detected above CVs and RBCs in surface soil: arsenic, iron, and benzo(a)pyrene. Arsenic was detected one order of magnitude above its RBC. Arsenic and iron were detected above their RBCs in all seven samples. Two additional pollutants that have no CV or RBC were detected in surface soil: benzo (g,h,i)perylene and phenanthrene. Table SS3 in Appendix C indicates the chemicals that were detected.

Of the seven surface soil samples collected from the Building 830 Pipe Leak and UST and TCE Spill Area, five were analyzed for radionuclides. Table SS4 indicates the 19 radionuclides that were detected. Cesium-137 and gross beta were detected at two orders of magnitude higher than most other detected radionuclides. The leaking pipe was removed, and the tanks are currently out of service. The contaminated soil under the waste transfer line was removed during September and October 1988.

The TCE Spill Area was located in an open courtyard in the Building 515 complex. Approximately 5 gallons of cleaning water were released to the environment every other day from January 1951 to August 1953 (BNL 1994a).

The Recharge Basin HP receives cooling water from the Brookhaven Medical Research Reactor (BMRR) and local storm water runoff. In 1990, organic compounds were detected above set limits, and discharges to the basin were halted. The organics were believed to be originating from contaminated supply wells. A carbon absorption unit was installed to the supply well of concern, and discharge operations resumed.

Building 464 was the former chemistry complex for BNL. In 1993, during construction near the building, mercury was discovered in the soil. After further investigation, polychlorinated biphenyls (PCBs) were also discovered. Before remediation procedures took place, sampling conducted during May–June 1993 near Building 464 identified mercury concentrations in the range of 0.1 mg/kg to 17,000 mg/kg. PCBs were also detected at levels below 50 mg/kg. Remediation of all contaminated soils was completed by October 7, 1993. All mercury and PCB-contaminated soils were drummed and sent to an RCRA-permitted landfill in Model City, New York, or drummed and stored on site at the HWMF to await off-site disposal (BNL 1994b). The surface soil sampling results presented in Table SS3 do not include levels of contamination previously detected in OU III soils that have since been remediated (BNL 1994b).

E.3.2 Groundwater

Several plumes of volatile organic compounds have been delineated in the OU III area of the site. Three are on-site 1,1,1-trichloroethane (1,1,1-TCA) pockets of contamination in the water table zone. The downgradient extent of the 1,1,1-TCA in the water table zone is located just north of Princeton Avenue. The 1,1,1-TCA contamination is more widespread in the mid glacial zone; it extends off the laboratory boundary to just north of Carleton Drive. 1,1,1-TCA in the mid glacial zone exists as three pockets of contamination between Brookhaven Avenue and South Boundary Road. In the deep glacial zone, the maximum concentration of 1,1,1-TCA (1,120 parts per billion [ppb]) was at the southern boundary of the site. Figure 5 in Appendix B provides a depiction of all the groundwater plumes.

Lower concentrations (less than 10 ppb) have been detected in monitoring wells just south of Carleton Drive off site in the deep glacial zone (BNL 1997a). Monitoring results indicate that the higher concentrations are centered on the Waste Concentration Facility (WCF), the Alternating Gradient Synchrotron (AGS) in the northern portion of the site, and Building 96 in the middle of the site. The sources for the elevated 1,1,1-TCA concentrations around the WCF and the AGS are thought to be the former D-waste tanks at the WCF and the cesspools around the Bubble Chamber Area (BNL 1997b).

A maximum 1,1-dichloroethene (1,1-DCE) concentration, 280 ppb, was also detected in the same location as the detected maximum 1,1,1-TCA concentration. The depth of the maximum 1,1-DCE concentration was 195 feet bgs in the deep glacial zone near South Boundary Road. The source of the 1,1-DCE is most likely a degradation (break-down) product from the 1,1,1-TCA. Under abiotic (free of biological organisms) conditions, the 1,1,1-TCA will degrade to 1,1-DCE.

A PCE plume is present in the central portion of the site, extending to an area south of the southern site boundary. The main source of the PCE appears to be in an area south of Building 96, which was used as a truck wash station. The plume varies in depth across the area. In the central portion of the site, near the source, the contamination is shallow and within the water table zone. A maximum concentration of 15,000 ppb was detected in this area. The plume is within the mid-glacial zone as it moves south of Princeton Avenue on site to just north of the southern boundary. The PCE has also been detected in the deep glacial zone from an area north of Princeton Avenue on site to an area just south of the site's southern boundary (BNL 1997b). It reaches a depth of about 200 feet bgs at the southern site boundary. Beyond the southern boundary (i.e. off site), the maximum concentration detected was 3,900 ppb in the deep glacial zone.

Monitoring results indicate that a carbon tetrachloride plume appears to be 150 to 210 feet below ground surface (bgs) in the deep glacial zone. The maximum detected concentration of carbon tetrachloride (5,100 ppb) was in an off-site monitoring well at a sampling depth of 180 feet bgs. The plume extends north-south from south of Princeton Avenue off site to south of Middle Island-Moriches Road (BNL 1997a). The highest concentrations of carbon tetrachloride, greater than 1,000 ppb, are located between BNL southern boundary and Carleton Drive.

Carbon tetrachloride was also in the Magothy zone (225 to 325 feet bgs), but the vertical extent within the Magothy is still being defined. Carbon tetrachloride has not been detected in the shallower portions of the aquifer, an indication that the carbon tetrachloride is largely found at depth. Because of the distance the carbon tetrachloride has traveled, the source of the carbon tetrachloride may not ever be determined. The upgradient extent of the carbon tetrachloride plume is between Princeton Avenue and Middle Road (ITC 1998b).

The presence of 1,1-DCA and chloroform at downgradient locations indicates that degradation of 1,1,1-TCA and carbon tetrachloride (respectively) are significant with respect to the durations of the plumes.

E.3.2.1 Remedial Actions

A hydraulic containment and treatment system, similar to the one operating in OU 1, was installed and began operation at the southern boundary of BNL in June 1997 as a means of preventing any additional off-site migration and beginning remediation of the 1,1,1-TCA and perchloroethylene (PCE) plumes. The method of remediation being used is in-well air stripping. The closed system operates by pumping clean air into the well casing and circulating the air through the system. Recirculating the air eliminates air emissions, and the VOCs are collected on a carbon filter that is changed periodically. Eight pumping wells have been installed at the southern boundary to facilitate the process. In 1999, an additional in-well air stripping system began operating in the area just off site in the industrial park just south of the laboratory's southern boundary.

An air sparging/soil vapor extraction system is currently operating south of Building 96 (a source area) to remove VOCs from the groundwater in that location. Two underground storage tanks and contaminated soils in the area are also being removed because they are thought to be the potential sources of groundwater contamination. Additional systems have been and will continue to be installed off site to capture and remove the VOCs in groundwater off site.

The Record of Decision (ROD) for OU III concluded that additional characterization and monitoring was needed for the Magothy Aquifer before a remedy for the removal of contaminants could be determined. Additional characterization and monitoring have been completed and the selected remedy includes the continued operation of the existing extraction wells for approximately ten years and the installation of two additional extraction wells off site. These wells were installed in the summer of 2004 and they are located at Stratler Drive (south of Carlton Drive) and in the Industrial Park East location (REF Explanation of Significant Differences to Groundwater ROD).

E.3.2.2 Pile Fan Sump

In December 1996, a leaking underground concrete sump (referred to as the Pile Fan Sump) was identified near the formerly active Brookhaven Graphite Research Reactor (BGRR). The sump was used to collect water from the former BGRR fan rooms, from the drains at the base of the 100 meter HFBR stack, from a floor drain in the BGRR's Pile Fan House, and from a low point drain in a 14-inch line of the acid off-gas system from the Hot Laboratory. The sump contained approximately 750 gallons of water. Analysis of the water resulted in the detection of concentrations of tritium up to 340,000 picocuries per liter (pCi/L), strontium-90 up to 2,270 pCi/L, and cesium-137 up to 2,458 pCi/L.

The sump was resampled on March 12, 1997, and tritium was detected at 260,000 pCi/L, as well as cesium-137 at 2,000 pCi/L and radium-226 at 2,300 pCi/L. The results from monitoring wells located approximately 45 feet south of the tank indicate strontium-90 concentrations as high as 566 pCi/L; 70 times the drinking water standard of 8 pCi/L (BNL1997c). The strontium-90, as previously mentioned, is highly immobile in groundwater and is approximately a mile and a half away from the site's boundary. It would take several hundred years for the strontium-90 to reach the site boundary. Laboratory testing of the Brookhaven National Laboratory's water supply wells has not indicated that this contamination has affected any of them. The water in the sump was pumped out and transferred to the radioactive liquid waste facility.

E.3.2.3 High Flux Beam Reactor Contamination

Groundwater monitoring results from December 1996 indicated that tritium concentrations in wells southeast of the High Flux Beam Reactor (HFBR) exceeded the maximum contaminant level (MCL) (BNL 1997a). The MCL for tritium is 20,000 picocuries per liter (pCi/L). The maximum detected concentration was equal to 44,700 pCi/L. Additional sampling confirmed the presence of tritium above the MCL. A series of test wells were installed north and south of the HFBR to permit tracking the extent and isolating the source of the contamination.

Figure 6 in Appendix B details the locations of the wells and the levels of contamination found in them. Sampling continued in January 1997, and results indicated tritium levels as high as 651,000 Ci/L in the water table zone within 200 feet downgradient of the HFBR. In July 1997, tritium was detected in a monitoring well near the spent fuel pool with concentrations as high as 1,590,000 pCi/L. Other wells in the same proximity contained tritium concentrations in the 100,000–200,000 pCi/L range.

A collection of water samples taken from a series of monitoring wells located along Temple Place, approximately 400 feet south of the HFBR, have indicated the presence of tritium above the MCL. Samples from well #20 indicated a maximum tritium concentration of 175,200 pCi/L, and the samples collected from adjacent wells, numbered 30 and 13, indicated concentrations of 89,200 and 45,700 pCi/L, respectively. As the plume approaches Temple Place, the contamination enters the mid-glacial zone (0 to 60 feet below msl). Six temporary monitoring wells were installed in locations approximately 1,000 feet south of the HFBR and 100 feet south of Brookhaven Avenue in an effort to determine the downgradient extent of the plume. Sampling results from February 1997 indicated a maximum tritium concentration of 102,000 pCi/L in well 37. An adjacent well (# 38) contained a tritium concentration of 30,300 pCi/L. The other four wells had tritium concentrations below the MCL.

Vertical profile wells have been installed along Rowland Street, Weaver Drive, and Princeton Avenue to help in determining the extent of the leading portion of the plume. Tritium concentrations are above the drinking water standard from the HFBR to just south of Rowland Street (ITC 1998b). The plume is approximately 100 feet wide at the HFBR, gradually widening to approximately 200 feet at Rowland Street. The plume is also moving deeper into the Upper Glacial Aquifer. The contamination is confined to the upper 20 feet of the Upper Glacial Aquifer near the source; approximately 2,000 feet away, it is about 175 feet below ground surface (BNL 1997d). As Figure 6 shows, the plume branches out as it approaches Weaver Drive. The concentrations within the leading edge of the plume are below the drinking water standard from north of Weaver Drive to south of Princeton Avenue.

Sampling results from monitoring wells north of the HFBR have not indicated the presence of tritium. Samples from site boundary wells and off-site wells have not indicated tritium levels above normal background concentrations. On-site drinking water supply wells have not been affected by the tritium contamination, because the wells are upgradient of the contamination, and groundwater flow is to the south. The leading edge of the plume is approximately 1 mile from the southern boundary. The tritium contamination does not pose a current threat to the public's health because no one is being exposed to the contamination.

E.3.2.3.1 Remedial Actions

Brookhaven National Laboratory (BNL) personnel determined that the reactor vessel was not the source of the leak because the reactor vessel's sensitive leak detectors did not detect any leaks. The source of the tritium was the 68,000-gallon spent fuel pool in the lower level of the reactor building (BNL 1997e). A detailed leak-rate test showed that the spent fuel pool was leaking at a rate of 6 to 9 gallons per day. The Department of Energy (DOE) and BNL worked with the USEPA, the NYSDEC, and the SCDHS to address options for cleanup. BNL officials installed a pump-and-recharge system to remedy the situation. The contaminated water was pumped to a recharge basin 3,000 feet north of the existing southern edge of the plume to prevent further migration of the plume. Figure 6 in Appendix B shows the location of the recharge basin and provides the estimated time it will take the plume to reach the site boundary.

The pump-and-recharge system has been operating since May 12, 1997, and sampling has confirmed that water being discharged into the recharge basin contains tritium concentrations of less than 2,000 pCi/L, one-tenth of the drinking water standard (BNL 1997c). The pump-and-

recharge system serves as an interim action that may be terminated once the characteristics of the plume have been better defined.

Prior to the spent-fuel pool being emptied, the fuel elements and other equipment within the pool had to be shipped to other DOE facilities. On December 30, 1997, the remaining tritiated water in the spent-fuel was pumped to double-walled tanks on BNL site. Sediment was also removed from the pool bottom. DOE is currently conducting an environmental review of the reactor to determine the future of the reactor.

E.4 Operable Unit IV

Operable Unit (OU) IV is on the east-central edge of the developed area of BNL. It is approximately 91 acres in size. Figure 1 in Appendix B shows the location of OU IV.

There are four potential sources of environmental contamination in OU IV: the Central Steam Facility (CSF), the Reclamation Facility Building 650, the Sanitary and Storm Sewer Lines, and the Recharge Basin HO (CDM 1994).

E.4.1 Soil

Surface soil samples were collected from two potential sources: the CSF and the Reclamation Facility Building 650. Only subsurface soil samples were collected in the remaining potential sources of environmental contamination in OU IV.

The CSF is located in the center of OU IV on the western boundary. It functions to supply heating and cooling to all BNL facilities. This area consists of 21 aboveground receiving and mixing fuel tanks, which are connected via aboveground and underground pipelines (CDM 1994). In 1976, the CSF utilized alternative liquid fuel as a fuel source. This fuel was comprised of a mixture of t Number 6 fuel oil or other heavy oils and government surplus fuels (JP-4, JP-5, and Light Feed Stocks). The CSF is approximately 13 acres in size, divided into 8 areas. Surface soil samples were collected from 6 of these areas, which included Soil Piles; Excavated Trenches, Oil/Solvent, UST Pit/Former Catch Basins; Former Leaching Pits; CSF Fuel Unloading Areas; a Drainage Area; and other potential sources of contamination.

In 1977, approximately 87,055 to 94,625 liters of oil and solvent (roughly 25,000 gallons) were released from a ruptured pipe (CDM 1994). The mixture was composed of 60% Number 6 fuel and 40% mineral spirits. In 1993, soil surrounding the spill was removed.

The Former Leaching Pits were installed in the 1950s or 1960s to receive waste oil and cleaning wash water from Building 610 equipment (CDM 1994). The leaching pit foundation and sludge waste were excavated in 1989.

CSF Fuel Unloading Areas are located in eight locations around the storage tanks; each consists of a four-square-foot area constructed of pavement, bluestone, and concrete (CDM 1994). Numerous small fuel spills have occurred during fuel transfer. In 1988, 1990, and 1993, three separate No. 6 fuel spills of 60 gallons were reported. CSF personnel attempted to contain spills with sand, berms, or absorbent pads; contaminated soil was removed and stored in drums. In 1991, one fluid ounce of mercury was spilled on the concrete slab near Tank 1 and collected with a mercury vacuum.

In 1977, a tank truck was unloading fuel in the Drainage Area and spilled approximately 250 to 500 gallons of No. 6 “Bunker Oil” (CDM 1994). The fuel spilled onto the ground and entered an adjacent catch basin. The amount of oil recovered is unknown.

The Reclamation Facility Building 650 was constructed to serve as a decontamination facility for the removal of radiation from clothing and heavy equipment (CDM 1994). It is located on the northwestern edge of OU IV and extends to the northeast. Wash operations, both outdoors and indoors, began in 1959. Two tanks near Building 650 were used to store the residual wash water. In late 1969, five curies of tritium were accidentally released into the sewer system from the Building 650 Sump. Tritium was not detected at the sewer treatment plant. After further investigation, it was discovered that the drainage pipe behind Building 650 led to a natural depression (Sump Outfall) extending to the northeast. Building 650 is now used as a laundry facility.

A total of 36 surface soil samples collected from two areas in OU IV between February 11, 1993, and April 6, 1993 were chemically analyzed (CDM 1994). Surface and subsurface soil samples were collected from the CSF and the Reclamation Facility Building 650. All samples were taken from a soil depth of 0 to 2 feet. All samples were analyzed for TCL VOCs and TCL SVOCs. Selected samples were analyzed for TCL PCBs/pesticides, TAL inorganics, and radionuclides.

Five chemicals were detected above CVs or RBCs in surface soil: arsenic, benzo(a)anthrene, benzo(b)fluoranthrene, benzo(a)pyrene, and indeno(1,2,3-cd)pyrene (Table SS5). Arsenic and benzo(a)pyrene were detected at levels one order of magnitude or more above their RBCs. Three additional pollutants that have no CVs or RBCs were detected in surface soil: benzo(g,h,i) perylene, phenanthrene, and trichloroethylene.

The maximum concentrations and most exceedances of all chemicals in Table SS5 were found in the Reclamation Facility Building 650. Maximum concentrations of arsenic, benzo(a) anthrene, benzo(b)fluoranthrene, benzo(a)pyrene, benzo(g,h,i)perylene, and indeno(1,2,3-cd)pyrene were detected at sampling points SB45 or SB46. These sampling points are northeast of Building 650 at the Sump Outfall.

Sixteen surface soil samples collected in the Reclamation Facility Building 650 area were analyzed for nine radionuclides. Seven radionuclides were detected, and they are shown in Table SS6. Tritium, strontium-90, gross alpha, and gross beta were detected in all 16 soil samples.

E.4.2 Groundwater

Volatile organic compound (VOC) contamination in groundwater beneath OU IV is from two primary sources. The first source is the decontamination pad area behind Building 650. A VOC plume composed primarily of 1,1,1 trichloroethane (1,1,1-TCA) is near the northern side of Building 650. The maximum 1,1,1-TCA concentration detected was an estimated value of 8.5 parts per billion (ppb) (CDM 1994). The second source is an oil solvent spill that occurred in 1977.

On November 25, 1977, approximately 23,000 to 25,000 gallons of waste oil and solvent were released from a ruptured pipe southeast of the Central Steam Facility (CSF). The pipe ruptured when a nearby empty 5,000-gallon underground storage tank (UST) rose off its mount as a result of water accumulating beneath the tank and the connecting lines being sheared (BNL 1996b). The plume associated with the 1977 oil/solvent spill and UST is composed of VOCs, semi-

volatile organic compounds, and polynuclear aromatic hydrocarbons. Investigators collected groundwater samples from monitoring wells near the spill in April 1993. Monitoring results indicated maximum levels of toluene and total xylenes at 2,000 ppb and 1,700 ppb, respectively. A second round of groundwater monitoring, conducted in August 1993, indicated maximum levels of toluene and total xylenes at 2,700 ppb and 2,200 ppb, respectively. Other contaminants detected above their respective MCLs included 1,2 dichloroethene at 64 ppb, 1,1,1-TCA at 14 ppb, TCE at 20 ppb, tetrachloroethene (PCE) at 43 ppb, and ethylbenzene at 590 ppb.

The OU IV plume extends from the 1977 Waste Oil Solvent Spill to an off-site area between the southern site boundary and Carleton Drive. The contamination is present in the shallow Glacial Aquifer near the source area; it enters the deep Glacial Aquifer as it approaches the southern site boundary. The contamination is in the upper Magothy Aquifer as it migrates off site.

E.4.2.1 Radiological Contamination

Radionuclide monitoring conducted in August 1993 indicated the presence of strontium-90 (Sr90) at 53 picocuries per liter (pCi/L), greater than the federal maximum contaminant level (MCL) 8pCi/L, in a monitoring well downgradient of the Sump Outfall Area (BNL 1996b). Prior monitoring (April 1993) results did not indicate that strontium-90 was above the MCL. Although there were isolated spots of radionuclide contamination, the contamination of groundwater resulting from radionuclides does not indicate any consistent pattern of MCL violations. Therefore, it was decided in the ROD that remediation of the groundwater for radiological contamination was not required (BNL 1996b). The source of the radionuclides is operations at Building 650 and the 650 Sump Outfall.

Radium-226 was detected by gamma spectroscopy in monitoring wells at a maximum concentration of 41 pCi/L during sampling in 1997. The wells were resampled during early 1998 and analyzed by a more specific method. Radium-226 was not detected above the minimum detection level in any of the wells.

E.4.2.2 Remedial Actions

A 5,000-gallon underground storage tank was removed from this area in October 1993. A remedial investigation determined that the only area that was required to have groundwater remediation was in the CSF, where the 1977 oil/solvent spill occurred.

A selected remedial action for OU IV was presented in the record of decision (ROD) dated March 14, 1996. The method of remediation chosen to remove the VOCs included a combination of soil vapor extraction and air sparging (BNL 1996b). Air sparging involves stripping the volatile and some of the semi-volatile contaminants from the groundwater into their vapor phase. The soil vapor extraction phase involves the collection of the sparged air and the volatile organics from the soil. The system includes 48 air sparging units and 23 soil vapor extraction wells. The system operated from November 1997 until January 2001. Groundwater monitoring in late 2000 indicated levels of VOCs in monitoring wells at levels below drinking water standards. As a result, the system was shut down and monitoring continues. If VOC levels increase toward the drinking water standards, the system can be started again.

E.5 Operable Unit V

Operable Unit (OU) V is on the eastern side of BNL property north of the OU I/VI border. Figure 1 in Appendix B identifies the location of OU V.

There are three potential sources of environmental contamination in OU V: the Sewage Treatment Plant (STP), leaking sewage pipes, and the suspected source of the off-site tritium plume (BNL 1999). The STP processes an average of 0.72 million gallons per day (mgd) of effluent in non-summer months and 1.25 mgd in summer months, with a maximum capacity of 3 mgd (ITC 1998a). This effluent consists of wastewater from all parts of BNL, including residential areas as well as biological and medical research and other research laboratories. In the past, radionuclides were discharged accidentally and routinely to the STP.

Presently, radionuclide levels in STP discharges are analyzed in accordance with BNL Environmental Monitoring Plan. Many of the facilities on site currently have hold-up tanks for wastewater analysis prior to discharge. Outfall from the STP is permitted under a New York State Pollutant Discharge Elimination System permit that limits the releases of specific chemicals. The discharge contains volatile and semi-volatile organic compounds, inorganic compounds, and radionuclides.

Several areas of contamination within the STP were also analyzed as a part of the RI. These areas are parts of the sewage treatment process. The areas sampled include the following: sludge drying beds (4A), sand filter beds (4B), sand filter berms/adjacent areas (4B1), the sludge disposal area (4C1), hold-up ponds (4D), and the satellite disposal area (4E). The sludge drying beds are used to dewater sludge from the Imhoff Tank and the clarifier. The Imhoff Tank (4C) was used from 1947 to 1967 for separation of solids. The sand filter beds receive treated wastewater from the treatment plant and filter the effluent as it percolates through the beds. Sand filter berms and adjacent areas are located around the perimeter of the sand filter beds. Two hold-up ponds (4D) used for emergency storage when influent flow exceeds STP capacity are located adjacent to the sand filter beds. The satellite disposal area is not part of the STP, but it is located nearby. This area was used during the early 1960s for disposal of unknown chemicals and leaking bromine trifluoride cylinders. The cylinders were removed in 1985, along with two boxes of chemicals that were found buried in this area.

Approximately 3,400 feet of underground sewer lines are located within OU V; they were originally installed in 1917 and upgraded in 1942 (BNL 1999). These sewer lines carried wastewater from various laboratories, the Instrumentation Division, film processing operations, medical research, and biology research facilities. Inspection programs in 1987 and 1988 discovered deterioration of the sewer lines that had resulted in an estimated loss of 317,000 gallons per day of wastewater to the surrounding soil and groundwater. The leaking pipes were replaced with a new line in January 1993, but past releases from the leaky lines have resulted in contamination in this area.

E.5.1 Soil

A total of 37 surface soil samples were collected from six areas at the STP between January 23 and March 27, 1995 and chemically analyzed (BNL 1997 ER, 1999). All samples were taken from a soil depth of zero to six inches.

Six chemicals were detected above CVs or RBCs in surface soil: Aroclor-1254, Aroclor-1260, benzo(a)anthracene, benzo(a)pyrene, benzo(b)fluoranthene, and mercury (Table SS7). Phenanthrene was detected five times. No chemicals were detected more than an order of magnitude above their CVs or RBCs.

The maximum concentrations of all contaminants were found in area 4B1, the sand filter berms/adjacent areas. Sample B1-08, from a sand filter berm, had the highest concentration of mercury. The locations at which other chemical maximum concentrations were found were all in areas adjacent to the STP. Sample B1-01, just to the northwest of the sand filter beds, contained the maximum concentrations of polycyclic aromatic hydrocarbons (PAHs). The maximum detected concentrations of Aroclor-1254 and Aroclor-1260 were located just to the southeast of the sand filter beds.

The maximum concentrations of radionuclides (Table SS8) were found in the sand filter beds, berms, or adjacent areas (4B or 4B1). It is also noteworthy that the maximum concentration of tritium was detected in the hold-up ponds area. Tritium was also detected in samples from the sand filter beds, berms and adjacent areas, and satellite disposal areas (4B, 4B1, and 4E).

E.5.2 Groundwater

Three areas within OU V are contaminated: the STP, leaking sewer pipes, and an off-site tritium and VOC plume. Groundwater quality within OU V was assessed on the basis of data collected from January 16, 1995, to June 30, 1995 (ITC 1996). The contaminants found in OU V that exceeded ATSDR comparison values are 1,1-dichloroethane (1,1-DCA), chloroform, trichloroethene (TCE), and 1,1,1-trichloroethane (1,1,1-TCA). Elevated concentrations were mainly found between 170 feet and 260 feet below ground surface. Table MW1 contains the contaminant concentrations from OU V that fall within the respective ranges. No active groundwater supply well exists within OU V (ITC 1996).

The Suffolk County Department of Health Services (SCDHS) collected and analyzed 65 samples from off-site residential wells downgradient of OU V/VI. Three of the 65 wells had levels of VOCs above the New York State MCLs (ITC 1996). The first well contained 4 parts per billion (ppb) of benzene and 33 ppb of total xylenes. These contaminants were not detected in any upgradient or on-site wells at OU V. These contaminants are known to be in petroleum products, and it is possible that a gasoline or an oil spill occurred in the area. The second well contained 0.12 ppb of 1,2-dibromoethane, more commonly referred to as ethylene dibromide (EDB). The source of the EDB is not known, but it could be from pesticide application in the area. The third well contained TCE at the MCL of 5 ppb.

E.5.2.1 Radiological Contamination

The tritium plume in OU V originates from the STP outfall and lies on the eastern boundary of BNL (CDM 1995). Tritium reaches the STP from three sources: High Flux Beam Reactor (HFBR) sanitary system releases; small, infrequent batch releases; and the release of tritiated distillate generated by the on-site liquid waste concentration process. Tritium-contaminated wastewater was released to the STP in late October and early November 1984 (ITC 1996). The source of the tritium was distillate from the evaporation process at the Waste Concentration Facility that was discharged to the STP. Tritium is routinely released from the STP at levels below the drinking water standard. The highest concentration of tritium detected in on-site

monitoring wells was 2,280 picocuries per liter (pCi/L), approximately one-tenth of the drinking water standard (20,000 pCi/L). Results from groundwater samples collected in off-site monitoring wells indicated that some of the wells contained concentrations of tritium at levels exceeding the drinking water standard. BNL requested the SCDHS to collect 21 water samples from private residential wells in an area south of the Peconic River. Low levels of tritium were detected in some of the residential well samples, but all concentrations were below the drinking water standard (ITC 1996).

E.6 Operable Unit VI

Operable Unit VI is in the southeastern portion of the laboratory property. Figure 1 in Appendix B outlines the boundary of the OU. There are four potential areas of environmental contamination in OU VI: the suspected source of the ethylene dibromide (EDB) groundwater plume, the upland recharge/meadow marsh area, the biology fields, and the gamma field (ITC 1998). The EDB plume consists of low concentrations of EDB in groundwater, located within and downgradient of OU VI. Groundwater in this part of the site flows to the south-southeast. EDB has been found above the New York State drinking water standards at BNL site boundary of OU VI and off site. The precise sources and times of release are unknown.

The upland recharge/meadow marsh area was the site of experiments to evaluate the capacity of small natural and man-made terrestrial and aquatic ecosystems to treat sewage and recharging ground and surface waters (ITC 1998). Liquid effluent from residential cesspools and treated and untreated effluent from BNL sewage treatment plant were applied to various study areas within this area. The biology fields consist of four Army spray research fields, two plowed biology fields, and a nursery stock area. The gamma field was used for research to evaluate the effects of gamma radiation, acid preparation, sulfur oxide, and ozone on crop growth.

The suspected source of contamination is the Biology Fields within OU VI. The EDB was used as a soil fumigant to sterilize the soils. USEPA banned EDB as a soil and grain fumigant in 1984 (ATSDR 1992). However, EDB is still used today for controlling termites and bark beetles in wood, for controlling wax moths in beehives, and as a chemical intermediate for dyes, resins, waxes, and gums (ATSDR 1992).

E.6.1 Soil

A total of 35 surface (zero to 6 inches) soil samples were collected from the upland recharge/meadow marsh area, the biology fields, and the gamma field between October 17, 1994, and April 21, 1995. These samples were chemically analyzed for TCL VOCs, TCL SVOCs, TCL PCBs/pesticides, TAL inorganics, EDB, herbicides, and radionuclides including tritium (ITC 1998).

Soil sampling did not reveal any EDB concentrations in the Biology Fields area. Studies performed on EDB at the Connecticut Agricultural Experiment Station showed that it persisted in agricultural topsoils up to 19 years after its last known application to the soil (Steinberg et al 1987). The residual EDB appears to have strong sorptive capabilities with the soil, and that may explain why it is highly resistant to both mobilization and microbial degradation (Steinberg et al 1987). It appears that if there were EDB use in this area, it most likely happened in the 1960s or the early 1970s. One chemical, benzo(a)pyrene, was detected above its RBC (it has no CV) in surface soil (Table SS9).

The maximum concentrations of most organic analytes were found at the southern end of the upland recharge/meadow marsh area (sampling point SB-72). The maximum concentrations of inorganic analytes were also found in the upland recharge/meadow marsh area. The only exceedence of CVs or RBCs for benzo(a)pyrene occurred at sampling point SB-72.

The concentrations of radionuclides (Table SS10) throughout OU VI were approximately equal to background levels. Twelve radionuclides were detected in surface soil samples. Three compounds (strontium-90, lead-212, and tritium) were detected in all samples. The maximum concentrations of all the compounds were detected in the upland recharge/meadow marsh area.

E.6.2 Groundwater

Before 1993, OU VI did not have an extensive network of monitoring wells. The pesticide 1,2-dibromoethane (EDB) was found in on-site monitoring wells in OU VI. A maximum concentration of 0.21 ppb was detected. The New York State MCL for EDB is 0.05 ppb. Results of groundwater monitoring downgradient of the biology fields have indicated levels of EDB above the New York State and federal MCL. In 1993, the SCDHS detected EDB in a private residential well downgradient of OU VI. To determine the horizontal and vertical extent of the EDB plume, the SCDHS installed 30 profile wells on site, along the site boundary, and off site.

Detections of EDB in groundwater near the Biology Fields are at shallow depths; near the site boundary, the detections are at greater depths. In the Biology Fields area, the vertical extent of EDB contamination ranges from 20 feet below ground surface (bgs) to 45 feet bgs. As the plume approaches the property boundary and North Street, the vertical profile of EDB contamination ranges between 50 feet bgs and 145 feet bgs (CDM 1996). Between December 1994 and April 1995, two rounds of sampling for on-site wells south and east of the Biology Fields indicated concentrations ranging from 0.04 to 0.78 ppb (CDM 1996). Groundwater modeling has indicated that the EDB is migrating toward a wooded area south of North Street and west of Weeks Avenue (CDM 1996). Figure 5 in Appendix B details the extent of the plume. The plume is below the southeastern boundary of the site. Samples also indicated EDB in two private wells on Weeks Avenue and in two adjacent temporary monitoring wells on South Street near its intersection with Weeks Avenue (CDM 1996). EDB was detected in two separate wells on Weeks Avenue between April 1992 and June 1995 (CDM 1996). One well sampled in October 1994 revealed EDB at 1.2 ppb and methyl-t-butyl-ether (MTBE) and 1,2-dichloroethane (1,2-DCA). Resampling of the well in June 1995 indicated a level of EDB at 0.12 ppb. Sampling of the well in December 1992 had not revealed any EDB, MTBE, or 1,2-DCA contamination. At the recommendation of SCDHS, the homeowner installed a carbon filter (USDOE 1996). An April 1992 sampling of the adjacent well detected a concentration of 0.2 ppb of EDB. A sample collected from the well, which was drilled deeper sometime between April and September, in September 1992 had undetectable levels of EDB and MTBE.

These off-site detections do not appear to be directly downgradient of the OU VI contamination. Monitoring wells located between the OU VI contaminant plume and the two residential wells on Weeks Avenue have not indicated the presence of EDB. Another source of contamination is possible, and various spills in this area have been reported to the New York State Department of Environmental Conservation (CDM 1996). The presence of MTBE and 1,2-DCA indicate that a gas spill might have occurred. Both these compounds and EDB have been used as leaded gasoline additives.

Samples from two SCDHS wells on South Street in 1993 revealed EDB. EDB was also detected in a SCDHS well on North Street at 3 ppb. In April 1995, EDB was detected in a vertical profile well on North Street at 3.4 ppb (BNL 1996a). EDB has also appeared in an undeveloped area of Manorville, approximately 1,000 feet west of Weeks Avenue and about 500 feet south of North Street (USDOE 1996). The EDB was between 90 and 130 feet deep at concentrations ranging from 1.2 to 3.5 ppb.

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Appendix F. Responses to peer review comments

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Public Health Assessment - Final

ATSDR received the following comments from independent peer reviewers for the *Brookhaven National Laboratory (USDOE)* public health assessment. ATSDR verified or corrected the statements for those comments that questioned the validity of the statements.

| <i>Question</i> | <i>Peer Reviewer Comment</i> | <i>ATSDR's Response</i> |
|--|--|--|
| <i>Does the public health assessment adequately describe the nature and extent of contamination?</i> | | |
| 1 | Generally, yes. Despite 'holes' in the available data, the assessment performed by ATSDR seems reasonable and adequate and overall is well done although some expansion of the discussion, particularly with respect to tritium and home grown foodstuffs, might be appropriate. Also, while these are unlikely to have any significant public health impacts, at least for completeness some mention needs to be made with respect to activation products associated with the reactor and accelerators. | <p>ATSDR provided an extensive discussion of tritium in the PHA under the section "Air Emissions," including an extensive evaluation of historical tritium (and argon-41 and iodine-131) releases.</p> <p>ATSDR agrees that home grown foodstuffs should be considered in the evaluation of exposure. In addition to the evaluations presented in the draft PHA, ATSDR more recently reviewed the most current Site Environmental Report (2005). The effective dose from air emissions was calculated as 0.053 mrem, and the ingestion pathway dose was estimated as 0.32 mrem from consumption of deer meat and 0.08 mrem from consumption of fish caught on the BNL site. This resulted in a total annual dose to the Maximally Exposed Individual</p> |

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| | | <p>(MEI) from all pathways of 0.45 mrem. The dose from home grown foodstuffs via the ingestion pathway would only make up an extremely small fraction of the total annual dose. In short, even using health-protective estimates of dose from the air pathway and ingestion of local deer meat and fish, the cumulative dose from current BNL operations is well below the dose that could be received from a single chest x-ray. Thus, ATSDR remains confident in its conclusion that exposures via home grown foodstuffs are not a public health hazard.</p> <p>ATSDR agrees that activation products are unlikely to have any significant public health impact, and for this reason, did not think a discussion in the PHA was warranted.</p> |
| 2 | <p>Yes. The report gives a very thorough and detailed summary of the location of the BNL and activities and studies conducted on and off site of the location of possible contamination. An extensive report besides the summary is given along with numerous tables, figures, graphs, maps and other reports.</p> | <p>Thank you for your comment.</p> |

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| 3 | The PHA is thorough in categorizing contamination of applicable environmental media (soil, groundwater, air, surface water, biota, and sediment). ATSDR concludes that, with the exception of soil (no health hazard), there is no apparent health hazard due to off-site exposure derived from the other five media listed. While contamination from BNL source is described as present in groundwater, air, surface water, biota and sediment, ATSDR has concluded that no health effects are expected. | All of the groundwater contamination plumes at BNL are being addressed through Records of Decision developed and signed by DOE and EPA. ATSDR has reviewed these documents and concluded that the ongoing monitoring requirements and clean-up specifications are sufficient for ensuring that groundwater contamination levels will continue to decline and not reach any off-site residents at levels of health concern. ATSDR believes the existing information on groundwater contamination and the ongoing clean-up and monitoring efforts—combined with the knowledge that no off-site residents are using private wells in affected areas—are sufficient for reaching defensible conclusions on potential exposures. ATSDR has clarified several parts of the PHA (in response to public comments) to emphasize the extent of monitoring and remediation that continues to occur at BNL. |

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| <i>Does the public health assessment adequately describe the existence of potential pathways of human exposure?</i> | | |
| 4 | Yes, although there could be somewhat greater emphasis on the ingestion pathway, particularly with regard to home grown foodstuffs. | ATSDR agrees that home grown foodstuffs should be considered in the evaluation of exposure. In addition to the evaluations presented in the draft PHA, ATSDR more recently reviewed the most current Site Environmental Report (2005). The effective dose from air emissions was calculated as 0.053 mrem, and the ingestion pathway dose was estimated as 0.32 mrem from consumption of deer meat and 0.08 mrem from consumption of fish caught on the BNL site. This resulted in a total annual dose to the Maximally Exposed Individual (MEI) from all pathways of 0.45 mrem. The dose from home grown foodstuffs via the ingestion pathway would only make up an extremely small fraction of the total annual dose. In short, even using health-protective estimates of dose from the air pathway and ingestion of local deer meat and fish, the cumulative dose from current |

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| | | BNL operations is well below the dose that could be received from a single chest x-ray. Thus, ATSDR remains confident in its conclusion that exposures via home grown foodstuffs are not a public health hazard. |
| 5 | Yes. Adequate discussions of possible routes are presented. Evaluations of air, soil, water, biota, and routes such as sediments and recharge basins among others are evaluated. Detailed tables and paragraph discussions are presented of on and off site evaluations. | Thank you for your comment. |
| 6 | The PHA provides a thorough description of potential pathways for exposure. The PHA does not consider the mass flux of VOCs in the dissolved aqueous phase from the saturated zone to unsaturated soils. This can result in the inhalation of VOCs by humans particularly in below-ground structures (i.e., basements or houses partially located below grade) or in buildings with cracked foundations. | The groundwater clean-up Records of Decision that BNL has entered into with EPA were developed to be protective of indirect exposures, or exposures that may occur via inhalation pathways (e.g., through vapor intrusion). These observations, combined with the fact that groundwater contamination levels continue to decrease due to pump-and-treat and other remedial activities, all suggest that additional study of groundwater contamination (beyond the extensive study that already occurs) is not necessary. |

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| | | ATSDR will not revise the PHA in response to this comment. |
| <i>Are all relevant environmental and toxicological data (i.e., hazard identification, exposure assessment) being appropriately used?</i> | | |
| 7 | <p>Apparently not. While, quite appropriately, heavy reliance has been placed on ATSDR toxicological profiles, some of the older toxicological literature does not seem to have been consulted, nor is there reference to such standard and well accepted publications such as the ACGIH <i>Documentation of Threshold Limit Values</i> which contains much useful toxicological information in summary form. As a result, the discussions of the potential public health implications of the various organic chemicals do not inspire confidence and indeed are a bit troubling. For example, with reference to carbon tetrachloride, on page 60 of the draft report, the fourth paragraph begins with the sentence "Very little information exists for dermal exposure in animals, and as a consequence no MRLs have been derived for dermal exposure in humans." Yet there would seem to be a significant body of literature extant with respect to dermal exposure to carbon tetrachloride. Public Health Service Publication 414 (von Oettingen, W.F., <i>The Halogenated Aliphatic, Olefinic, Cyclic, Aromatic and Aliphatic-Aromatic Hydrocarbons Including the Halogenated Insecticides, Their Toxicity and Potential Dangers</i>, USDEW, 1955) devotes nearly half a page to skin absorption (p. 80) citing no less than 5 articles, noting in a 1941 study, chronic carbon tetrachloride intoxication was induced in rabbits by daily application of a 5% solution to the shaved skin of the back, and concludes its discussion noting that skin absorption of carbon tetrachloride may in fact be greater in humans than in animals.</p> | <p>The comment calls into question ATSDR's approaches for conducting toxicological evaluations, particularly the agency's reliance on its Toxicological Profiles. ATSDR notes that its Toxicological Profiles are prepared according to peer-reviewed guidelines, and every individual profile undergoes extensive internal and (independent) external review before being published. Moreover, many Toxicological Profiles are updated as more current information becomes available. Thus, ATSDR believes it is entirely appropriate to rely heavily on information in the Toxicological Profiles when evaluating the public health implications of exposure to environmental contamination.</p> <p>The comment specifically calls into question a statement in the</p> |

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| | | PHA about why MRLs are not available for dermal exposure to carbon tetrachloride. ATSDR appreciates receiving this comment, because it points out an error made in the original sentence. Specifically, ATSDR derives MRLs only for oral and inhalation exposures—not for dermal exposures. ATSDR has revised the sentence in question to clarify this point. |
| 8 | As far as I could determine, all relevant environmental and toxicological data were mentioned. The study presented a very good first attempt at compiling data collected and evaluated over the years. Toxicological evaluations were presented in terms of concentrations of chemicals in edible flesh and potential for adverse health outcomes through fish consumption. Studies of breast cancer and health were commented upon. Evaluations of data on cancer of various organs were done to determine if there were differences in persons residing in Suffolk County as compared to other locations. Wind and plume locations were correlated with the incidence of cancer and outcomes determined. Evaluations of endocrine disruption and health effects were of concern in the report and possibly additional study needs to be done in this area of endocrine disruption and environmental toxicity. Community exposures and toxicological evaluations could possibly undergo further scrutiny. Detailed studies funded by ATSDR or similar agencies could further assess the toxicological evaluation as deemed necessary. The characterization of exposure through various media was the strong point of | ATSDR appreciates receiving the comment. The comment mostly presents observations, with one suggestion in the second-to-last sentence (i.e., funding further study to support toxicological evaluations). ATSDR certainly encourages additional toxicological research to better inform environmental health evaluations. In fact, ATSDR's Toxicological Profiles include sections titled "Identification of Data Needs" that list information gaps and potential research needs. While |

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| | the present report. | ATSDR certainly supports such ongoing research into chemical toxicity, ATSDR does not believe site-specific research (e.g., an exposure investigation, a health study) is needed to reach defensible conclusions for the BNL site. |
| 9 | <p>One key problem with the PHA is in the use of contaminant plume data. No analysis is provided on the stability of the various contaminant plumes. This is relevant to addressing potential future exposure. The PHA should address the basic questions: (1) Are the plumes increasing or decreasing in size and mass over time and (2) Are the data sufficient to quantify stability? The modeling study in Appendix D does not address these questions and should. Furthermore, the PHA does not address a basic requirement for assessing the natural attenuation of contaminant plumes: What attenuation mechanisms are active and responsible for plume containment? This is related to the question of plume stability. Consistent with this concern is that the geochemistry and biodegradation activity within the groundwater system is inadequately described. The PHA includes a description of the hydrogeology at BNL but lacks an adequate description of the biogeochemistry of the groundwater system. Geochemistry is important in assessing the potential for natural attenuation of volatile organic compounds (VOCs), semi-VOCs, and radiological contaminants.</p> <p>Plume maps in the PHA are representations of the horizontal extent of contamination. Data should be presented to accurately represent the vertical extent and distribution of contaminant concentrations in the plumes.</p> | <p>This comment touches on several issues presented in earlier comments. As stated in responses to those comments (e.g., Comment #6), the main consideration in ATSDR's evaluation is whether enough information is available to determine whether or not residents are being exposed to contamination at levels that might present a health hazard. While information on plume stability, geochemistry, and attenuation mechanisms are clearly important for evaluating clean-up alternatives and fully understanding every aspect of a groundwater plume, ATSDR believes the information available for this site—extensive</p> |

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| | | <p>perimeter monitoring of plumes, monitoring data spanning several decades for some plumes, information comparing on the spatial extent of plumes relative to locations of active private wells—is sufficient for reaching public health conclusions. ATSDR has revised sections of the text to emphasize this point.</p> <p>The comment also recommends that ATSDR consider including figures depicting the vertical extent of contamination in the various plumes. The PHA already includes information on the lateral extent of the plumes, which ATSDR believes is sufficient for describing whether plumes underlie specific residents. Information on the vertical extent of the plumes can be found in BNL's annual Groundwater Status Reports, which are available in records repositories for the BNL site.</p> |
| <i>Does the public health assessment accurately and clearly communicate the health threat posed by the site?</i> | | |
| 10 | Generally yes, in so far as accuracy is concerned, but the communication of the health threat could be much improved. The following suggestions are | This comment raises many issues pertaining to |

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| | <p>made with an eye towards improving readability and precision of language:</p> <ol style="list-style-type: none"> 1. While some acronyms and abbreviations are included in the Glossary, there are such a large number of acronyms and it is virtually impossible for even a very astute reader to be familiar with them all, or to remember what each one stands for. The document should include as a separate section comparable to the glossary a complete list of acronyms and abbreviations used in the text. 2. The Glossary needs review and revision; some of the definitions are imprecise and some additions are needed. Specifically, radiation dose terms need to be both clarified and added; among other things, the definition of EDE (effective dose equivalent) needs to be added to the Glossary. 3. Usage of scientific terms is sometimes imprecise, inconsistent, obsolete or inaccurate, as exemplified by the following examples: <ol style="list-style-type: none"> a) The term synergism is used inappropriately when potentiation is meant. b) Care needs to be exercised with respect to the usage and expression of dose quantities and units to ensure that they are correctly used. For example, on p. 31 and pp. 52-53 the term 'critical organ' is used but is neither explained in the text nor defined in the Glossary. It should be noted the term 'critical organ' as applied to internal radiation dose, was introduced in 1959 in the Committee II report of the International Commission on Radiological Protection and is now obsolete. It is not clear whether the term is being used in the obsolete ICRP context or to merely call out the tissues (not organs – e.g. bone surfaces are a tissue and part of the organ known as the skeleton) that receive the greatest doses. Another obsolete term that is used, apparently inadvertently, is 'exposure dose' (see, p.50 line 31). It is not clear what dose quantity is meant here, but presumably it is EDE | <p>communication of the health threat. ATSDR addressed these comments as follows:</p> <p>ATSDR provided an acronym or abbreviation the first time a term is introduced in the document and believes that this is sufficient. ATSDR appreciates the comment on Glossary terms, and notes that a definition of "radiation dose" can be found in the Glossary under the term "Dose (for radioactive chemicals)." ATSDR included and defined effective dose equivalent (EDE) in the Glossary of the final PHA. Note that the Glossary included in this PHA is a copy of the standard Glossary that ATSDR has developed to include in its various public health assessments and health consultations. Thus, the standard definitions included will not be revised.</p> <p>ATSDR appreciates the comment on the usage of scientific terms and would like respond accordingly:</p> |

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| | <p>and if so should be so stated.</p> <p>c) Greater care needs to be taken when expressing doses; an annual dose is actually a dose rate and should be specified as such. Figure 5 on page 32 is based on the CEDE dose quantity, which is neither explained or defined. On page 8, first paragraph, it is not clear whether the doses cited are in fact CEDE, or EDE over some other period of time.</p> | <p>The comment on “synergism” pertains to a standard entry in ATSDR’s Glossary. ATSDR has reviewed the use of this term and believe it is applied correctly in this instance. (Note: The term only appears in the Glossary, and does not appear anywhere else in the public health assessment.)</p> <p>For the dose assessment, ATSDR looked at the organ receiving the highest radiological dose and the radiation dose delivered to the whole body. ATSDR revised the term “critical organ” in the PHA.</p> <p>ATSDR appreciates the comment on exposure doses, and has searched through the text and revised terminology as appropriate.</p> |
| 11 | <p>No. In my estimation the study was a little weak in this area. Studies planned for residents in the vicinity and those who have lived on the site could be continued in a very detailed approach. Possibly attention to organization of the present report would help in communicating the information contained as regards health threats posed by the site.</p> | <p>ATSDR strives to ensure that its public health assessments both communicate important findings and describe the thought process used to reach those findings. In</p> |

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| | | <p>general, the “Summary” and “Conclusions” section of PHAs are intended to appeal to the broadest possible audience. However, the text in the other sections of the document must cover an extremely broad range of topics. ATSDR recognizes that it may be difficult to follow lengthy PHAs for sites with numerous exposure pathways and contaminants of concern, like BNL. Consequently, attempts were made to ensure that the discussion is not at an overly complicated level and ordered in a logical fashion. The structure of the PHA follows internal document formatting procedures, which call for organizing the document by the time frame of exposure (e.g., past and present), the area of contamination (e.g., on site and off site), and the type of contaminant (e.g., radioactive and non-radioactive). To be responsive to this comment (and to several public comments), ATSDR has heavily revised text in the “Summary” and</p> |

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| | | “Conclusions” sections to better communicate the findings from this PHA. |
| 12 | The health threat posed by contamination derived from BNL is logically presented in the PHA in a well organized fashion. However, concerns with potential health hazard posed through groundwater should be better addressed in the PHA. Accuracy in communicating the health threat will only be improved by addressing potential pathway for human exposure resulting from (a) inhalation of contaminants and (b) future utilization of groundwater resources under scenarios of non-stable plumes. | The comment recommends additional study of groundwater contamination near the BNL facility. While ATSDR certainly agrees that further study of groundwater contamination may reveal interesting insights into the fate and transport of some contaminants, ATSDR believes that the data currently available are more than sufficient for making conclusions regarding the public health implications of exposure. More specifically, in terms of direct exposure to groundwater contaminants, the plumes that have migrated off site are closely and frequently monitored, and this monitoring will continue under the oversight of EPA and the New York State Department of Environmental Conservation. More importantly, none of the residents who live in the areas where off-site groundwater contamination exists use private wells for a |

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| | | source of drinking water. (The only residents near the site using private wells for drinking water do not live in areas directly impacted by the groundwater plumes.) Moreover, the groundwater clean-up Records of Decision that BNL has entered into with EPA were developed to be protective of indirect exposures, or exposures that may occur via inhalation pathways (e.g., through vapor intrusion). These observations, combined with the fact that groundwater contamination levels continue to decrease due to pump-and-treat and other remedial activities, all suggest that additional study of groundwater contamination (beyond the extensive study that already occurs) is not necessary. ATSDR will not revise the PHA in response to this comment. |
| <i>Are the conclusions and recommendations appropriate in view of the site's condition as described in the public health assessment?</i> | | |
| 13 | Yes, but the case is weakened by imprecise and in some cases incorrect or confusing use of scientific terminology in the text. | Same response as number 10. |

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| 14 | The conclusions are the result of a first attempt at reporting a comprehensive understanding of the exposures and consequences from the activities at the BNL site. A more detailed monitoring plan could be put in place and followed for many years. Health evaluations of persons living on and off the site could be continued and a much more detailed and systematic study planned and executed. | <p>The comment recommends implementation of a comprehensive monitoring plan and a health study of local residents. ATSDR carefully considered these suggestions. In the case of a comprehensive monitoring plan, ATSDR notes that such a plan is currently in place. Specifically, BNL has an Environmental Monitoring Plan, which is updated every 3 years, and calls for extensive monitoring of multiple media. Additionally, the Records of Decision issued for the various contaminated areas also require extensive monitoring. ATSDR believes that these monitoring efforts are more than sufficient for tracking the nature and extent of contamination at BNL.</p> <p>The comment also recommends that ATSDR conduct a health study of nearby residents. ATSDR will not recommend such an action, because the extensive evaluation in the PHA found that all potential exposures to site-related contaminants are</p> |

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| | | safely below health-protective guidelines. Under such circumstances, ATSDR typically does not recommend that health studies take place. |
| 15 | <p>The conclusions of the PHA on off-site exposure to groundwater are not proven and justified given the data and analysis presented in the PHA. Recommendations to address this concern include (a) characterization of the mass and volume of contaminant sources, (b) determine stability of plumes, (c) determine the mechanisms for plume attenuation and quantify rates (requiring analysis of redox chemistry and biogeochemistry), and (d) evaluate potential exposure through inhalation of vapors derived from the saturated zone. These may necessitate the collection of substantially more field data.</p> <p>Appendix D (modeling study) does not contribute to or address these critical concerns. In fact, the models used in the study are too simplistic and the method of analysis of comparing simulated to observed data is technically flawed. Input parameters are not justified. The clear conclusion from the study should be that further study is required.</p> <p>The recommendations of the PHA are valid but should clearly identify the need for long-term performance monitoring and additional field characterization (to address data deficiencies required for the analysis of items (a) through (d) above). In addition, the health threat posed through consumption of fish seems to be downplayed assuming that institution efforts to curtail fish consumption will be effective.</p> | <p>The comment raises several issues about ATSDR's evaluation of groundwater contamination, and ATSDR's responses to these issues follow:</p> <p>The first paragraph in the comment recommends extensive additional study of the groundwater contamination near BNL. While ATSDR agrees that such additional study would reveal further insight into the fate and transport of groundwater contamination, the critical issue ATSDR must consider is whether such further study is necessary for ensuring that the public does not experience unhealthy exposures to contaminants from the groundwater (whether through indirect or direct pathways). As the response to Comment #6</p> |

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| | | <p>explains, ATSDR believes its public health conclusions are based on an extensive data set, both in terms of groundwater monitoring and information on drinking water supply, and therefore is not recommending that additional studies of groundwater contamination be conducted.</p> <p>The second paragraph of the comment criticizes ATSDR's modeling study for not providing highly detailed insights on the groundwater contamination (e.g., the mass and volume of the groundwater plumes, the stability of these plumes, and the mechanisms for plume attenuation). ATSDR emphasizes, however, that its modeling study was conducted to answer one basic question: Were off-site wells affected by groundwater plumes in the years before sampling detected the presence of contamination? ATSDR strongly believes its modeling study, though admittedly simplistic, was</p> |

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| | | <p>sufficient for answering this question. As the previous paragraph and the response to Comment #6 explain further, ATSDR believes the type of modeling suggested in the comment, though certainly interesting from an academic perspective, is not necessary for reaching important public health conclusions regarding potential exposures to groundwater contaminants.</p> <p>The third paragraph raises two points. First, it suggests that ATSDR consider revising its conclusions and recommendations. In response to public comments, ATSDR has clarified several parts of this section in the document. ATSDR is not going to recommend that BNL conduct any additional monitoring beyond the fairly extensive monitoring that the facility must already conduct in fulfillment of its site clean-up requirements. Second, the comment questions whether recommending that residents</p> |

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| | | <p>heed the state fish advisory will be sufficient in protecting against potential exposures. This is an issue that ATSDR encounters on many sites. In this case, ATSDR believes the recommendation is sufficient, especially considering that (1) the state informs all residents of the fishing advisory when they apply for fishing permits and (2) the areas found to have the highest levels of fish tissue contamination are not frequently used by recreational fishers. This finding has been clarified in the PHA.</p> |
| <i>Are there any other comments about the public health assessment that you would like to make?</i> | | |
| 16 | None | |
| 17 | <p>The report is a very detailed accounting of the ATSDR evaluation of public health assessment at the Brookhaven National Laboratory. Due to the extensive amount of data contained in the report, the significant review the report deserves could not be completed in the time allotted.</p> <p>I appreciated the historical perspective provided of BNL and the potential contamination posed by the operations undertaken at the site. Hydrologic</p> | <p>ATSDR appreciates these comments. The points raised in this comment that are strictly editorial in nature have been addressed. Those comments that requested clarification of certain</p> |

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| | <p>evaluations were very well presented. However, a thorough and detailed monitoring plan seems warranted and should be put in place to ensure continued proper environmental protection on and off the site. It seems the report here reviewed is a first step. Obviously much more needs to be done to ensure continued safety of individuals who have lived and worked on and off the site and for those continuing to do so. The health and toxicologic evaluations are not as thorough in evaluation as the hydrogeologic.</p> <p>Research to evaluate the health effects of those individuals electing not to have the public waters should be done. Longitudinal investigations of their health status should be on-going. Tracking and understanding the health status of those individuals living in the cottages on the site should be initiated.</p> <p>Grouping of the health data could have been presented. For instance page 32 presents "comparison to regulatory limits." Here information is given and the statement is made that "computer modelling of the 1962 Ar-41 releases indicated an annual dose at the perimeter of 120 millirem. This dose estimate is above the current standard of 100 millirem (the standard in 1962 was 500 millirem)." The information is followed by surface water. In my estimation placing all the toxicological health assessment data in one place would be advisable. One would then be able to better evaluate the significance of such studies without it seemingly being buried among other data.</p> <p>More specific comments follow:</p> | <p>issues have been carefully considered and addressed where feasible and possible. However, some comments have not been incorporated, either because the comments fell outside the scope ATSDR's mission for the PHA, ATSDR did not agree with the comment, or the tremendous effort required for addressing such issues would not be possible given ATSDR's limited available resources.</p> <p>Following are ATSDR's responses to the individual comments:</p> <p>Page 7, first paragraph: Data collection efforts at BNL are ongoing. To avoid the impression that data collection may have ceased, ATSDR is removing "only" from the sentence in question.</p> <p>Page 7, second paragraph: ATSDR's conclusion regarding the fish ingestion pathway was based on a site-specific evaluation. Specifically, ATSDR considered the contamination</p> |

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| | <p>p. 7, paragraph on Air: Are lifetimes dose estimates adequate predictors for short-term exposures?</p> <p>p. 7, 1st paragraph on Biota: “only analyzed from 1996-2003”—should not this be a continuing evaluation?</p> <p>p. 7, 2nd paragraph on Biota: “no one should eat more than one meal of fish per week”—Is this a true statement if elevated levels of PCB and mercury were found to occur? What of “specialized” rivers where severe contamination could result? Would you still say no more than one fish meal per week or should a special health advisory apply?</p> <p>p. 10, 3rd paragraph, “DOE document...in May 2001.” Where is this report citation?</p> <p>p. 11, 2nd paragraph: Reconcile this statement with those on page 16 in paragraph on surface water.</p> <p>p. 42-43, section on shellfish: Report data by year of sampling and compare data obtained by labs for trends and other evaluations. Determine which methods followed the EPA standard methods. What of the precision and accuracy of other methods employed? How much validity can be assumed? Have any studies been determined recently to see how each of the methods compare for values reported with the analytical workup used? Are there seasonal variations for control locations?</p> <p>pp. 43-44, section on deer: Give the age of the deer and the length of life. What was the exposure period? “The maximum cesium-137 concentration”—Only one sample? Age of deer? Body weight?</p> | <p>levels detected in the fish and “reasonable maximum” ingestion rates. ATSDR found that, by abiding by the New York statewide fishing advisory limitations, residents would not be exposed to contamination at levels of health concern.</p> <p>Page 10, third paragraph: ATSDR agrees that the citation should have been included for the sentence in question and has added that in the final version of the PHA.</p> <p>Page 11, second paragraph: The comment appears to ask ATSDR to verify that the statements regarding surface water on pages 11 and 16 are consistent. ATSDR has reviewed these and believes they offer a consistent account of the extent of surface water flow in the Peconic River.</p> <p>Pages 42 and 43: The comment requests extensive additional information on the fish and shellfish sampling data. When preparing this PHA, ATSDR found an extremely large volume</p> |

| <i>Question</i> | <i>Peer Reviewer Comment</i> | <i>ATSDR's Response</i> |
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| | <p>p. 45, end of vegetation section: What are the levels expected for non-exposed area?</p> <p>p. 47, paragraph before "Child Health Considerations": Is it possible to do a little study to determine the relationship of whole body concentration in fish to that in different fish flesh parts and do correlation studies on results found?</p> <p>p. 50, 1st paragraph: "periodically"—Less than once per month? year? or some other designation?</p> <p>p. 50, 2nd paragraph: "Occasionally"—How often?</p> <p>p. 56, NOAEL section: Why place this in the body of the report and not the appendix? Laboratory analytical methods were not detailed or mentioned. Should this NOAEL information be so prominent? Although useful knowledge it would seem such could be placed elsewhere. What of the methods for the modeling estimates given on page 30, the CAP—88 PC program for modeling? No significant discussions were given there on CAP methodology.</p> <p>p. C3, Table SSC: At first glance where are these samples located, on or off site?</p> <p>p. C5, Table SSR: Where are the samples located, on or off site? I would have found it useful to have each of the comparison values of standard values from EPA for permissible levels in soils for comparison purposes. Similarly for the tables that follow, where insufficient information is given to review tables without the benefit of the report.</p> <p>p. C47, Table B15: How significant are these values? Why are so many of</p> | <p>of environmental sampling data available for review and every effort was made to have the PHA provide a complete summary, without becoming an excessively long document. While ATSDR appreciates the significance of the issues raised in the comment (and these issues were considered when reviewing the data), ATSDR does not believe they must be included in the PHA. It must be emphasized that ATSDR's health evaluations were based on the maximum contamination levels detected in the fish. Therefore, the finer details requested in the comment would not change the outcome of ATSDR's evaluation.</p> <p>Pages 43 and 44: All information on contamination levels in deer meat were based on data collected during NYSDEC's field study (and samples that BNL reported in its Site Environmental Reports). The information provided is based on samples collected from 32 different deer (as stated on page</p> |

| <i>Question</i> | <i>Peer Reviewer Comment</i> | <i>ATSDR's Response</i> |
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| | <p>the reported values the same?</p> <p>p. D1, 3rd paragraph: How were these values obtained?</p> <p>p. E9, 4th paragraph: Why does this indicate that it “has traveled quite a distance into the aquifer?”</p> | <p>43 of the peer review draft). The age of the deer sampled was documented in roughly half of the samples, and the age ranged from 1 to 7.5 years, which provides an adequate representation of the different life stages.</p> <p>Page 45, end of vegetation section: ATSDR's evaluations were based on the highest levels of contamination observed and therefore are believed to be health-protective. While information on contamination in “non-exposed areas” (or so-called “background” levels) might be interesting to note, they would not change the overall conclusions of the document and are therefore not presented.</p> <p>Page 47, paragraph before “Child Health Considerations”: The comment seems to suggest further exploratory analyses of the fish tissue contamination data. While ATSDR agrees that such further study may be interesting from an academic perspective, the evaluation</p> |

| <i>Question</i> | <i>Peer Reviewer Comment</i> | <i>ATSDR's Response</i> |
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| | | <p>requested is not necessary for reaching a public health conclusion. As noted above, it must be emphasized that ATSDR's health evaluations were based on the maximum contamination levels detected in the fish. Therefore, the finer details requested in the comment would not change the outcome of ATSDR's evaluation.</p> <p>Page 50, first paragraph: ATSDR has revised the sentence in question to be responsive to this comment.</p> <p>Page 40, second paragraph: ATSDR has revised the sentence in question to be responsive to this comment.</p> <p>Page 56, NOAEL section: age 56, NOAEL section: The comment questions why detailed background information is presented on some topics (e.g., the NOAELs) and not for others (e.g., the CAP-88 modeling). When preparing PHAs, ATSDR uses judgment in deciding which topics require more detailed</p> |

| <i>Question</i> | <i>Peer Reviewer Comment</i> | <i>ATSDR's Response</i> |
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| | | <p>background information, and those decisions are based on past experience, discussions with stakeholders on issues of greatest interest, Agency guidance, and other factors. While ATSDR appreciates receiving the suggestion of moving the NOAEL background information into an appendix, ATSDR decided to keep this information in the body of the report given that the underlying concept is mentioned many times during the toxicological evaluations.</p> <p>Page C3, Table SSC: ATSDR noted earlier in the PHA that all surface soil samples available for review were collected from on-site locations. ATSDR revised the name of the table accordingly.</p> <p>Page C5, Table SSR: ATSDR noted earlier in the PHA that all surface soil samples available for review were collected from on-site locations. ATSDR revised the name of the table accordingly.</p> |

| <i>Question</i> | <i>Peer Reviewer Comment</i> | <i>ATSDR's Response</i> |
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| | | <p>Page C47, Table B15: As noted above, ATSDR's final interpretations of the fish ingestion pathway are based on the highest concentrations measured. Thus, the significance of the individual observations is somewhat limited. The comment notes that many chemicals have the same highest concentration reported, which generally occurred when a contaminant was not detected (i.e., a detection limit is presented).</p> <p>Page D-1, third paragraph: The contaminant asks ATSDR for information on how certain values were obtained. ATSDR assumes the comment refers to the "input values" mentioned at the end of the paragraph. All values used as inputs in the modeling and run-time options were taken either from site-specific reports or from general modeling practice.</p> <p>Page E-9, fourth paragraph: The sentence in question was meant to refer to the depth (i.e., vertically) over which the carbon</p> |

| <i>Question</i> | <i>Peer Reviewer Comment</i> | <i>ATSDR's Response</i> |
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| | | tetrachloride contamination has traveled, not the distance (i.e., laterally) that the plume has migrated. ATSDR has revised the sentence in question accordingly. |
| 18 | Appendix D only contained Figure 1 and was missing six of seven figures. | ATSDR has corrected this and all figures are now in Appendix B. |

Appendix G. Responses to Public Comments

ATSDR received the following comments from the public for the *Brookhaven National Laboratory (USDOE)* public health assessment. ATSDR verified or corrected the statements for those comments that questioned the validity of the statements.

| # | <i>Public Comment</i> | <i>ATSDR's Response</i> |
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| 1 | The document is very confusing, and contradicts itself in many areas, such as the time period covered, and in its discussion of on-site vs. off-site exposures. | <p>ATSDR included a “Document Notes” section in the Public Comment Release PHA to explain some important issues about the scope of the document. In general, the PHA evaluates both current and past exposures, over the time frame supported by the available data. The PHA focuses almost entirely on off-site exposures, with the exception of potential exposures that may have occurred from the use of on-site potable wells. That being said, the PHA does present additional information regarding on-site contamination in certain environmental media; however, ATSDR presented and evaluated this information in the PHA primarily to inform the off-site evaluations.</p> <p>To be responsive to this comment, ATSDR rewrote much of the “Document Notes” section to clarify the scope of the PHA and has inserted a table into this section that clearly states the time periods evaluated for each exposure pathway considered. This new table also explains that the only on-site pathway considered was use of on-site potable wells.</p> |
| 2 | Page 5 – Document Notes: The first sentence states that only off-site exposures will be considered; however, the document has several lengthy discussions regarding on-site exposures (pages 13-18 and 52-54). The report should be clear as to what is covered. | As noted in the response to Comment #1, ATSDR rewrote much of the “Document Notes” section to clarify the scope of the document and inserted a table into this section that clearly states the on-site and off-site exposure pathways considered. As the revised text indicates, ATSDR did review some on-site contamination data for certain environmental media, but primarily to provide information necessary to evaluate off-site exposures. The <i>only</i> on-site exposure pathway considered (i.e., for which conclusions are drawn) was ingestion of drinking water from on-site potable wells. |
| 3 | Page 17 and 18 – Section | ATSDR thoroughly evaluated available off-site sediment contamination data, given |

| # | <i>Public Comment</i> | <i>ATSDR's Response</i> |
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| | labeled Sediments: The section labeled Sediments on pages 17 and 18 is part of the On-Site Contamination section. Off-site sediment contamination exists in the Peconic River but is not discussed in the section labeled Off-Site Contamination. Only off-site groundwater contamination is discussed in this section. | that this contamination has been extensively studied. The section on off-site contamination addresses the following media: residential (private) well sampling, air emissions, surface water contamination, sediment contamination, and biota contamination. ATSDR has updated the PHA's table of contents to clear indicate that the evaluation of off-site sediment contamination is indeed part of the off-site contamination section of the PHA. |
| 4 | The report often does not reference critical post-1999 information, including toxicological data like USEPA reference doses or cancer slope factors, sampling studies of Peconic River surface water and fish, the Suffolk County Health and Environmental Assessment for the Peconic River (May 2004), the Magothy Aquifer Characterization Report (May 2003), and BNL's annual Groundwater Status reports. | <p>ATSDR started evaluating BNL contamination issues in the mid-1990s and first began to write this PHA in 2002. At that time, the evaluations focused on environmental sampling data collected up through 1999, largely because more recent data were not available or had not been fully validated at that time. Thus, the comment is correct in noting that the PHA focuses largely on data collected through 1999.</p> <p>ATSDR is well aware that site conditions have changed considerably in the past several years. Most notably, since 1999, substantial quantities of contaminated soils and sediments have been safely removed from BNL property and billions of gallons of potentially contaminated groundwater have been treated. Additionally, extensive monitoring occurs to ensure that contamination is not spreading into previously uncontaminated areas. Given these observations, the current waste management practices at BNL, and the very extensive remediation projects that have removed BNL-related contamination from on- and off-site areas, ATSDR believes that the conclusion in the Public Comment Release PHA is still valid (i.e., that residents who live near BNL are not exposed to harmful levels of laboratory-related contamination in air, drinking water, river water, fish, game, or soils).</p> <p>To better explain this issue to readers, ATSDR has: (1) added a text box at the</p> |

| # | <i>Public Comment</i> | <i>ATSDR's Response</i> |
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| | | beginning of the document to acknowledge the extensive remediation work that has already taken (and continues to take place) at BNL; (2) appended to the "References" section a list of additional key post-1999 reports that ATSDR has obtained and reviewed since the initial preparation of the Public Comment Release PHA; and (3) added a detailed chronology of events at BNL, including important remediation milestones that have occurred in the past 7 years (see Appendix E). Note that ATSDR has also reviewed its toxicological evaluations to ensure that none of the health guidelines used in the assessment changed in a manner that would alter the PHA conclusions. |
| 5 | The fish data from the 2001 sampling program was not evaluated in the draft Public Health Assessment. This data was collected in direct response to concerns from the public and the Suffolk County Department of Health Services. | As the response to the previous comment notes, the PHA focuses largely on sampling data collected up through 1999. Thus, the comment is correct in stating that the PHA does not consider fish tissue sampling data collected from the Peconic River in 2001. However, ATSDR has obtained those sampling results and notes that the average fish tissue contamination levels from the more recent sampling efforts are lower than the maximum concentrations that ATSDR used in the PHA to assess the health implications of ingesting fish caught from the Peconic River. As a result, the newer fish tissue sampling data certainly offer useful insights into local contamination levels, but do not change the conclusions of the PHA: adverse health effects associated with ingesting fish from the Peconic River are not expected to occur, provided residents follow the recommendations in the New York State Department of Health's fishing advisory (which are communicated to anglers when they apply for their fishing licenses). ATSDR strongly encourages residents to abide by the fishing advisory's recommendations. |
| 6 | The Health and Environmental Assessment for the Peconic River (May 2004), prepared by Cashin Associates for the Suffolk County Department of Health Services, is not | ATSDR's response to Comment #4 addresses this issue. To summarize relevant parts of that response, ATSDR reviewed the document mentioned in the comment (plus many other documents that present sampling data collected since 1999) and determined that the more recent data do not change the conclusions currently documented in the PHA. Thus, the PHA does not actually present the data cited in the comment, though these data were considered before ATSDR released this final |

| # | <i>Public Comment</i> | <i>ATSDR's Response</i> |
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| | included in the list of references. This study was a major undertaking, with significant public involvement, and it is not discussed or evaluated in the draft Public Health Assessment. | version of the PHA. |
| 7 | Throughout the document there are discussions of data without adequately identifying the years in which the data was collected. To provide an adequate perspective on the data, it is essential that for all discussions of data it should be clarified when it was taken and how any remedial actions at the site have further reduced the exposures. There also seems to be no substantive assessments using recent data, specifically after 1999. | <p>This comment raises several points about the time frame of sampling data considered in this PHA. The comment correctly notes that some contamination levels cited in the report were measured <i>before</i> remediation occurred. ATSDR has explicitly acknowledged this in the text box added to the beginning of the document (see response to Comment #4).</p> <p>Additionally, the comment notes that the Public Comment Release PHA does not present detailed evaluations of data collected since 1999. ATSDR has since reviewed many key reports and other documents that present sampling data collected after 1999 (see the updated References list in the PHA), and the Agency has determined that the more recent data do not change the conclusions currently documented in the PHA. Thus, the PHA does not actually present the data cited in the comment, though they were considered before ATSDR released this final version of the PHA.</p> |
| 8 | EPA develops human health risk assessments for all Superfund sites that evaluate current and future exposures. EPA does not address past exposures. However, within this document, considerable | This comment addresses several issues. First, it notes that EPA human health risk assessments tend to evaluate current and future exposures, while ATSDR's public health assessments also consider past exposures. This distinction is correct and reflects the different mandates under which EPA and ATSDR operate. For more information on differences between human health risk assessments and public health assessments, refer to the following fact sheet that EPA and ATSDR prepared on this topic: |

| # | <i>Public Comment</i> | <i>ATSDR's Response</i> |
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| | <p>information is provided regarding historical data and exposures, yet recent information regarding remedial actions are not provided in great detail. The failure to provide current information on the status of the site including exposures may lead to confusion among residents and other individuals reading this document. It is suggested that the document include in the beginning a summary identifying all the actions taken by DOE to date on the various operable units and list the remaining actions to be taken. Also the document should be reorganized so that it provides a detailed discussion regarding potential current exposures with historical information provided in Appendices.</p> | <p>http://www.atsdr.cdc.gov/publications/CitizensGuidetoRiskAssessments.html</p> <p>Next, the comment correctly notes that the Public Comment Release PHA did not address site-related activities (both sampling and remediation) that have occurred since 1999. As the response to Comment #4 notes, ATSDR has since obtained and reviewed several key reports prepared post-1999, and the Agency has determined that the more recent data do not change the conclusions currently documented in the PHA.</p> <p>The comment also notes that the PHA could be improved by including some information on the chronology of remedial actions. ATSDR agrees with this comment and has included this information in Appendix E and referred to that appendix early in the document. ATSDR has also updated the Public Health Action Plan to more explicitly account for the events that have occurred at BNL since 1999.</p> <p>Finally, the comment recommends that parts of the document be reorganized. While ATSDR appreciate receiving such suggestions, the document is currently organized according to formats consistent with internal Agency guidance and will not be changed.</p> |
| 9 | <p>Page 76: Ongoing Actions: This section can be expanded tremendously to capture much of the remedial work completed since the inception</p> | <p>The comment correctly notes that the section on “Ongoing Actions” in the Public Comment Release version of the PHA is no longer up-to-date. ATSDR has updated both the “Completed Actions” and “Ongoing Actions” of the Public Health Action Plan to more accurately reflect the current status of remediation activities at BNL. Much of the detailed information requested in this comment has been placed in</p> |

| # | <i>Public Comment</i> | <i>ATSDR's Response</i> |
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| | of ATSDR activities. All soil clean-ups associated with the Operable Units and clean up of the Peconic River have been completed. Sixteen groundwater treatment systems are operating as of the end of FY 2005. This section provides details on two of the treatment systems, but not the other 14 operating systems. | Appendix E, which presents a chronology of site events and summarizes the status of removal actions at the various "areas of concern" at and near BNL. |
| 10 | The discussion of the Toxic Release Inventory data [page 12] does not identify the criteria for selecting the chemicals of concern. Are these the chemicals with the highest releases and if so what is the level of release? Also, is 1999 representative of the latest TRI data since many companies provide estimates and may have replaced these chemicals during the past six years. Please clarify. | The 1999 TRI data presented in the Public Comment Release PHA accounted for industrial facilities that released selected volatile organic compounds, but did not account for the entire range of industrial facilities that disclosed environmental releases to TRI. ATSDR has updated this paragraph with TRI data from 2004, which are the most recent data available at the time the Agency was responding to public comments. |
| 11 | The presentation of the conclusions is confusing. Previously in the document a case was made for on-site and off-site and this section | <p>The comment raises several points, which ATSDR addresses as follows:</p> <ul style="list-style-type: none"> ○ The comment notes that the conclusions in the Public Comment Release PHA are not clearly listed as applying to on-site or off-site locations. ATSDR has updated all of the findings at the beginning of |

| # | <i>Public Comment</i> | <i>ATSDR's Response</i> |
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| | <p>provides a categorical determination regarding the various media. Also, the statement “no health effect expected” requires further clarification regarding whether this was before or after remediation. Also, the basis for this determination should also be provided. The text, especially, should be updated with information from the remedial actions at the site.</p> <p>On page 75 the indication is that the County Health Department should post the river. Is NYSDOH in agreement with the posting of the river? It is my understanding that NYSDOH does not post rivers indicating fishing restrictions, but indicates fishing restrictions when one applies for fishing licenses, which is part of the ROD for the Peconic River. Is the document indicating that this is not sufficient?</p> <p>Pages 75 and 76 should be updated to reflect the most</p> | <p>the “Conclusions” section to clearly note the areas covered.</p> <ul style="list-style-type: none"> ○ The comment asks ATSDR to clarify whether the statement “no health effects expected” in the “Conclusions” pertains to time frames before or after remediation. In response, ATSDR has added time frames to these statements. ATSDR based these findings on its review of the sampling data, evaluation of plausible exposure scenarios, and consideration of implemented institutional controls. ○ The comment also questions the recommendation that ATSDR made in the Public Comment Release PHA that SCDHS “...post signs along the Peconic River alerting residents and anglers of the fish advisory that is in effect.” Since originally making this recommendation, large quantities of contaminated sediments (which were believed to contribute to the contamination levels in fish tissue) have been removed from the site. Considering this, ATSDR agrees with the comment that posting signs along the Peconic River about the fishing advisory is no longer necessary. Accordingly, ATSDR removed this recommendation from the PHA, but still strongly encourages residents and anglers to abide by the guidelines set forth in the statewide advisories. <p>Finally, the comment recommends that ATSDR update its Public Health Action Plan to reflect the most recent remediation activities at the site. ATSDR agrees with this comment and updated the text accordingly (see responses to Comments #8 and #9).</p> |

| # | <i>Public Comment</i> | <i>ATSDR's Response</i> |
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| | recent remedial actions at the site. It appears that the updates are current through 1999 and further updates would be helpful. | |
| 12 | The information in the report is outdated and does not reflect the significant progress that the Department of Energy has made in cleaning up the BNL site. For example, significant changes have occurred in plume characteristics since the 1996/1998 period used in the report. At a minimum, the Summary, the section on Ongoing Actions (page 76), and Appendix E should be updated to provide a status of the Brookhaven Cleanup. Most of the areas described have already been remediated and current plume information shows that the plumes are now significantly smaller. | The comment correctly notes that the Public Comment Release PHA does not discuss much of the remediation activities that have occurred at BNL since the late 1990s. ATSDR has acknowledged this by changing text in the Summary, the Public Health Action Plan, and in appendixes. Refer to the responses to Comments #4, #8, and #9 for information on the specific changes that ATSDR made, which are now reflected in the final PHA. |
| 13 | Page 17 and 18 – Section labeled Sediments: In 2001, the Department of Energy and Brookhaven National | The comment correctly notes that the Public Comment Release PHA only summarized data that were available and validated through 1999. ATSDR has since obtained and reviewed the reports listed in the comment, and the Agency has determined that the more recent data do not change the conclusions currently |

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| # | <i>Public Comment</i> | <i>ATSDR's Response</i> |
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| | <p>Laboratory conducted extensive sampling of sediments, surface water and fish in the Peconic River in direct response to public concerns over gaps in off-site fish and sediment data. These concerns were expressed by the public and the Suffolk County Department of Health Services during the 1999 public comment period on the Department of Energy's Proposed Cleanup Plan for the Peconic River. The Department of Energy subsequently withdrew its Proposed Cleanup Plan and conducted this additional sampling. Review of the references and data in the draft Public Health Assessment data indicates that not all of the data generated from the 2001 sampling program were evaluated. The reports titled Operable Unit V – Peconic River Analytical Results from the Supplemental Sediment Sampling Program Conducted September 4 – October 12,</p> | <p>documented in the PHA. Ideally, ATSDR would prefer to update the text in the PHA with observations from the most recent environmental investigations or perhaps present separate data tables for pre- and post-remediation contamination levels; however, current budget and scheduling restrictions prevent an extensive rewrite of the sections on environmental contamination.</p> |

| # | <i>Public Comment</i> | <i>ATSDR's Response</i> |
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| | 2001 (BNL, 2002) and the Baseline Human Health Risk Assessment Operable Unit V Peconic River (BNL, 2003) are not included in the list of references. The maximum concentration of mercury detected in sediments (i.e., 39.7 ppm) was found during the 2001 sampling program and is correct on page 17. However, other maximums cited in the text and sediment data tables SD1 and SD2 in Appendix C do not include the 2001 data. The sediment data tables in Appendix C contain data only through 1999. | |
| 14 | Page 17: The draft report indicates that there is very limited organic compound data for surface water in the Peconic River, which is not the case. Up to six stations downstream of the Brookhaven Sewage Treatment Plant are monitored quarterly for organic compounds. Data tables are not presented in the Site | ATSDR appreciates the insights about surface water sampling data in the Peconic River basin and revised text in the section on "Organic Compounds" (below the heading "Surface Water Contamination" under "Off-site Contamination") to reflect that extensive monitoring indicates limited evidence of contamination with volatile organic compounds. |

| # | <i>Public Comment</i> | <i>ATSDR's Response</i> |
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| | Environmental Report since most data are non-detectable. Any detection of organic compounds is discussed in the text of the Site Environmental Report. If the ATSDR would like to evaluate this data, a query can be prepared and a data-table generated for the past 10 years. | |
| 15 | Page 74 – Recommendations/Peconic River: In addition to sediment sampling, fish sampling should be included, given that methyl mercury has been found above health criteria. New York State is responsible for alerting the public to the general, statewide advisory on fish consumption, and the report does not present a clear case for additional measures, such as posting by the SCDHS. | The comment raises several points. First, as the response to Comment #11 indicates, ATSDR removed its recommendation for posting fish advisory information along the Peconic River, based on a review of remediation activities conducted since the Public Comment Release PHA was issued. Second, the comment suggests that ATSDR should expand a recommendation for future sediment sampling in the Peconic River to include fish tissue sampling. ATSDR agrees with this comment and has revised the “Recommendations” section accordingly. (Note: The Record of Decision for Operable Unit V also requires implementation of a monitoring program that includes fish tissue sampling.) |
| 16 | Page 13 discusses the use of non-QA/QCed data for screening analysis. Typically, within EPA we do not use data | ATSDR guidance places a clear preference on basing conclusions on certified laboratory data, as opposed to data whose quality is questionable (e.g., data from non-certified laboratories). However, in the case of the on-site potable wells, the majority of data were from a non-certified laboratory. Rather than excluding these |

| # | <i>Public Comment</i> | <i>ATSDR's Response</i> |
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| | that has not completed appropriate QA/QC analysis and a determination is made that the data is acceptable to use. | data altogether, ATSDR carefully reviewed the results and compared concentrations measured by the non-certified laboratory against those measured by the certified laboratory. Because these comparisons revealed minimal differences, ATSDR used all of the results when evaluating the exposure pathway of ingesting water from on-site potable wells. ATSDR acknowledges that use of data from a non-certified laboratory introduces some uncertainty into the evaluation; however, the concordance between measurements made by the certified and non-certified laboratories provides some confidence that use of the complete data set was justified. |
| 17 | Page 70 fails to indicate that the data available in the reports has gone through QA/QC review procedures to assure that the data has met appropriate data quality objectives and that data and its interpretation in the RI/FS for the specific documents meets all appropriate EPA requirements. | ATSDR agrees that these observations should be noted in the PHA and has revised the text in question accordingly. |

| # | <i>Public Comment</i> | <i>ATSDR's Response</i> |
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| 18 | Pages 7 and 27: Please add that an evaluation of historical air emissions was requested by the BNL Community Work Group on September 30, 1996, and the U.S. Department of Energy on December 9, 1996. | ATSDR has revised the PHA text accordingly. |
| 19 | Section on Potential Exposure Pathways: Information on exposure to sediments, both on and off-site related to the Peconic River, is missing from this section. | The comment is correct. In the Public Comment Release PHA, ATSDR had evaluated the health implications of contaminated sediments and reached conclusions about this medium, but did not include information on potential exposure scenarios in the section titled "Potential Exposure Pathways." ATSDR has moved several paragraphs of text that discuss potential exposure pathways for contaminated sediments from an earlier section of the document into the section titled "Potential Exposure Pathways." |
| 20 | Reports are sometimes referred to and summarized without adequate reference. | The comment recommends that ATSDR cite certain observations in the text, but does not specify any particular passages that require referencing. In response, ATSDR scanned through the PHA and inserted additional citations, as appropriate. |
| 21 | Page 66 – Health Outcome Data Evaluation: In the last paragraph on page 67, reports are referred to and summarized without adequate reference. | ATSDR has added a reference to statements made in the paragraph in question. |
| 22 | The report makes reference to appendices and sections that do not exist (e.g., "Appendix F" on page 13, "section 3.2.3" | Thank you for this comment. ATSDR has corrected these errors. |

| # | <i>Public Comment</i> | <i>ATSDR's Response</i> |
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| | on page 41, and “section 3.2.1” on page 72). | |
| 23 | <p>Page 43: In the discussion of shellfish, the reader is referred to Section 3.2.3 for more detailed information, but there is no such section.</p> <p>Additionally, control locations of Raritan Bay and Seaford are referenced, but their data is not provided. A review of data table B22 does not provide a site specific reference.</p> | <p>The comment raises two points about an overview of shellfish sampling data in the Public Comment Release PHA. First, as the response to the previous comment notes, ATSDR has corrected all text that previously referred to section numbers. Second, the comment seeks clarification on the “control locations” for which shellfish sampling data were collected. ATSDR revisited the original sampling data that were considered when preparing this text and revised the paragraph in question.</p> <p>Regarding the data in Table B22, the first row of data pertains to samples collected in Raritan Bay (as documented in BNL’s 1987 Site Environmental Report); the second row of data pertains to samples collected in Northport Bay (as documented in BNL’s 1996 Site Environmental Report); and the third row of data pertains to samples collected in Lloyd Harbor (as documented in BNL’s 1997 Site Environmental Report).</p> |
| 24 | <p>The report makes inappropriate recommendations regarding actions to be taken by the SCDHS, including the posting of the Peconic River, restricting of the use of private wells, and advising of new residents in the area to potential drinking water threats.</p> | <p>The comment addresses three specific actions that ATSDR recommended in the Public Comment Release PHA. First, as the response to Comment #11 indicates, ATSDR has deleted its recommendation that signs be posted along the Peconic River to inform anglers about the state fishing advisory. Second, the comment questions the recommendation ATSDR made about restricting use of private wells in the event that contamination is detected above drinking water standards. ATSDR continues to support this recommendation, but has changed the wording to no longer imply that SCDHS has authority to restrict use of private wells. Third, ATSDR has revised the recommendation about advising residents of potential drinking water threats to instead encourage residents to have their private well water tested before they consider using it for potable purposes.</p> |
| 25 | Page 74 – | ATSDR appreciates receiving this comment and has revised the recommendations |

| # | <i>Public Comment</i> | <i>ATSDR's Response</i> |
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| | <p>Recommendations/Groundwater: The SCDHS does not have the authority to “restrict the use” of private wells; it can only advise homeowners of the water quality situation, and possible remedial actions (e.g., bottled water or hookup to public water). The recommendation to advise new residents of existing homes of the potential for private well contamination is inconsistent with the findings of the report, and in any case is unworkable and ill advised.</p> | <p>in question (see response to Comment #24) accordingly. The updated recommendation still stresses the importance of testing private wells for the presence of environmental contamination, but clarifies the role of SCDHS in this process.</p> |
| 26 | <p>Page 24 – Air Emissions: Beginning on page 24, the discussion is very confusing: There are contradictory statements regarding the variability of tritium releases at BNL.</p> | <p>The comment pertains to the section that evaluates past air emissions from BNL and apparently questions the following statement from the Public Comment Release PHA: “Although ATSDR realized that [tritium] emissions would be variable, initial review of reports from 1970 to the present showed that releases were usually in the same order of magnitude.” ATSDR continues to support this statement. While it is true that air emissions of tritium were clearly higher in 1977 and 1978 (see Figure 1) as compared to the long-term trend, these peaks have limited influence on the overall cumulative dose over a lifetime of exposure. ATSDR has inserted additional text into the paragraph in question to clarify this issue.</p> |
| 27 | <p>Why did tritium releases from the HFBR go up in 2003 (see figure 3) when it has not been</p> | <p>The comment correctly notes that tritium air emissions from the High Flux Beam Reactor (HFBR) increased in 2003, even though the operation was shut down in November 1999. While this increase may seem unusual, readers should note that the magnitude of the increase is extremely small in comparison to past tritium</p> |

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| | in operation? | <p>emissions when this and other reactors were operational. For instance, as comparison of Figures 2 and 3 shows, the longer-term trend of tritium emissions from the HFBR quite clearly demonstrates (as one would expect) that air emissions in every year since shutdown were considerably lower than air emissions during years of active operations. Moreover, as comparison of Figures 1 and 3 shows, the historical emissions of tritium from the Van De Graaff Accelerator (VDGG) operations far outweigh the recent increase in tritium emissions observed in 2002.</p> <p>Nonetheless, to be responsive to this comment, ATSDR has added text to the section in question offering some explanations for why the tritium emissions recently increased (e.g., due to evaporative losses during groundwater remediation activities), and ATSDR has revised the titles of Figures 1, 2, and 3 to emphasize the different time frames that the individual figures cover.</p> |
| 28 | <p>Radiological dose assessment: why were the years 1982 and 1962 chosen, when these were not the worst years for tritium and argon releases, at least as presented in this document? Tritium releases from the VDGG was much higher in 1978, and argon releases were much higher in 1992.</p> | <p>The comment pertains to the section in the Public Comment Release PHA on "Radiological dose assessment" for air emissions, and specifically to the assumptions made when evaluating past exposures to tritium and argon.</p> <p>In the case of tritium, the comment correctly states that ATSDR's radiological dose assessment used emissions data from 1982 in its modeling. While tritium emission rates were higher in 1978, as the comment notes, ATSDR's modeling was designed to characterize cumulative doses representative of lifetime exposures. In such cases, selecting an emission rate representative of the average is entirely appropriate (as has now been clarified in the text). That being said, even if ATSDR had based its modeling on 1978 emissions data, the overall conclusion would still be the same. More specifically, as Table 5 shows, the total dose due to tritium exposures estimated using the 1982 emission rate amounted to only 0.04% of ATSDR's health-based comparison value for ionizing radiation, which is the Agency's minimal risk level of 100 mrem/year. Even if ATSDR had based this evaluation on the tritium emissions data for 1978, the total dose estimated would have been roughly three to four times higher (to a first approximation); and that dose is still considerably lower than the Agency's minimal risk level. Therefore, given the</p> |

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| | | <p>small contribution of tritium to the estimated exposure doses, basing the radiological dose assessment for airborne tritium on 1982 (as opposed to 1978 or some other year) does not appear to have any bearing on the conclusion regarding inhalation exposures to airborne tritium.</p> <p>In the case of argon, ATSDR focused its evaluation on 1962—the year when releases were highest from the Brookhaven Graphical Research Reactor. The comment states that argon releases were actually much higher in 1992, apparently based on the data depicted in Figure 4 of the Public Comment Release PHA. As that figure notes, the argon-41 releases in 1992 amounted to approximately 1,700 Curies. In 1962, however, the estimated argon-41 releases amounted to 5,600,000 Curies, which represents the highest emission rate between 1948 and 2000 (BNL, 2001). Therefore, ATSDR disagrees with the statement in the comment that argon-41 releases in 1992 were much higher than in 1962. Nonetheless, ATSDR revised text in the PHA to emphasize that the argon-41 emission rate selected is indeed the highest annual release rate reported dating back to 1948.</p> |
| 29 | <p>Page 28 indicates that ATSDR “randomly evaluated selected annual environmental reports.” It is unclear why a random approach was used and the potential impacts on the results by selecting only random reports.</p> | <p>ATSDR appreciates receiving this comment, because the radiological dose assessment for historic air emissions was based on a thorough review of emissions data reported between 1948 to the present—and was not a “random” evaluation as the text in the Public Comment Release draft may have implied. ATSDR has revised the text in question to more accurately portray the modeling that the Agency conducted.</p> |
| 30 | <p>Page 31, 1st paragraph: The year with the highest tritium release from the High Flux Beam Reactor is 1973, not</p> | <p>This comment raises two issues. First, the comment correctly notes that the highest amount of tritium released from the HFBR occurred in 1973, and ATSDR has revised the text to reflect this fact. Second, the comment implies that ATSDR's evaluation did not account for the highest tritium release rate. While the model may not have been run for the year with the highest release rate, one can infer from the</p> |

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| | 1982, as stated. As such, ATSDR did not evaluate the time period when the highest amount of tritium was released from the HFBR, as stated in the report. | <p>information provided in the PHA that exposures due to airborne tritium releases were not at levels of health concern.</p> <p>More specifically, as Table 5 shows, the total exposure dose due to tritium releases in 1982 amounted to only 0.04% of ATSDR's MRL for exposure to ionizing radiation (also see response to Comment #28). That conclusion was based on a year when total airborne releases of tritium were less than 400 Curies (see Figures 2 and 4). If ATSDR had used 1973 as a base year for its modeling, then the tritium release rates used as model inputs would have been higher (e.g., 775 Curies from the HFBR), but clearly by less than an order of magnitude. Therefore, the estimated doses for 1973, to a first approximation, would likely be less than 1% of ATSDR's MRL for ionizing radiation. In short, ATSDR's final conclusion regarding tritium exposures, though derived from modeling of releases during 1982, also applies to the entire range of years for which tritium release data were available.</p> |
| 31 | Page 24, 3 rd paragraph: The tritium evaporator is described as being used to evaporate tritium from the heavy water. This is incorrect. The evaporator was used to evaporate waste water containing low levels of tritium generated from facilities around the site. It was not used as a means of heavy water disposal. | ATSDR appreciates receiving this clarification and has revised text in the final PHA accordingly. |
| 32 | Where is there a discussion of "submersion dose" for the Ar-41 exposures, referred to on page 28? | The sentence in question was from page 28 of the Public Comment Release draft: "As previously stated, Ar-41 exposures result in a submersion dose because of the cloud formed during its release." Text on page 27 of the Public Comment Release draft explained why Ar-41 does not result in an internal radiation dose, but rather |

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| | | can result in an external radiation “submersion dose” to both the skin and whole body. To make this connection clearer, ATSDR has changed the sentence in question to refer the reader back four paragraphs, instead of only saying “as previously stated.” Further, ATSDR included additional information to explain what is meant by “submersion does” for exposures to Ar-41. |
| 33 | Figure 4 shows that Ar-41 emissions have been increasing since 1975. The text on page 28 indicates that this is from the BMRR. Since the last year reported on this figure, 1992, has the highest emission of any of the radiological air emissions reported in the document (approximately 1,700 curies), a detailed discussion of the BMRR is needed. Are these emissions still occurring, and have they increased from the 1992 levels? | <p>The comment is correct that Figure 4 in the Public Comment Release PHA suggests an upward trend of Ar-41 releases from the BMRR. To assess this issue further and to evaluate longer-term trends in releases from the BMMR, ATSDR obtained more recent air emissions estimates for Ar-41. This review considered emissions data from 1993 to 2000, after which the BMMR had virtually no air releases because it was permanently shut down.</p> <p>Between 1993 and 2000, annual Ar-41 emissions from the BMRR ranged from a minimum of 1,640 Curies (in 1999) to a maximum of 2,359 Curies (in 1998), with an average annual release rate during this time frame of 2,007 Curies. While this average release rate is indeed higher than the Ar-41 release data depicted in Figure 4 of the Public Comment Release PHA, ATSDR emphasizes that BNL's airborne releases of Ar-41 in the past few decades are several orders of magnitude lower than the release rates ATSDR used in the radiological dose assessment. Specifically, as the response to Comment #28 indicates, ATSDR's dose assessment was based on an Ar-41 emission rate of 5,600,000 Curies, which occurred back in 1962. Therefore, the conclusions reached in the Public Comment PHA still apply to the time frame of more recent emissions data.</p> <p>To be responsive to the comment, however, ATSDR has revised the paragraph that describes Ar-41 releases to include the observations stated above for the time frame of 1993 to 2000.</p> |
| 34 | Iodine-131 release estimates: more information about the release estimates used for the HOTSPOT dose estimates is | When conducting the radiological dose assessment for I-131, ATSDR reviewed site records to identify the release event that likely resulted in having the potential for the greatest impact on public health. After carefully reviewing all release data from 1940 through 2000, ATSDR found that a single event likely posed the greatest |

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| | necessary. The data were obtained from BNL, 2001. Are they estimates for just that year or are they a compilation of historical releases? Could whole body doses have been higher in the past? | potential for exposure. That event is known as "Rupture Number 16," and occurred on April 11, 1954 (BNL, 2001). Because the HOTSPOT evaluation is based on the event with the highest known release rate, ATSDR believes the radiological dose assessment evaluated the maximum possible exposure to I-131 that likely occurred. |
| 35 | Page 6 – Summary/Groundwater: The summary is confusing, particularly because of its inclusion of impacts on private wells from two plumes originating from sources other than BNL. The summary is written in a way that it can easily be misinterpreted as meaning that many of the private wells around the lab have been impacted by VOCs, strontium-90, and tritium from the lab. | ATSDR appreciates receiving this comment. The summary for groundwater attempts to convey many concepts, such as differences between on-site and off-site contamination, plumes originating from BNL versus plumes originating from other sources, and findings for different contaminants. ATSDR has reorganized the information presented in this summary to clarify the main conclusions. |
| 36 | Page 18 – Off-Site Contamination: Data from BNL's OU-III reports, which are included in Appendix E, should be presented and discussed in this section. The | ATSDR provided information regarding the Precision Concepts contamination, because it was an off-site plume that had the potential to contaminate private wells in the off-site areas near BNL. ATSDR included off-site sources to delineate the sources of contamination and the potential to contaminate well in the area. |

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| | Precision Concepts plume and private well data discussion is not really relevant, and should be eliminated to avoid confusion. The private well data are presented in a way that can easily be misinterpreted to mean that many of the private wells around the lab have been impacted by VOCs, strontium-90, and tritium from the lab; this section must be absolutely clear as to what was found over background levels, and where, and what the probable source is. | |
| 37 | Page 23 – The figure referred to in the last paragraph should be Figure 5 in Appendix B, which should be modified to include labels with the plume numbers. | ATSDR has revised the text in question to clarify that Figure 5 appears in Appendix B of the PHA and has replaced the version of Figure 5 that appeared in the Public Comment Release PHA with a new figure taken from BNL's 2005 Site Environmental Report. This new figure has text labels for the plumes that are consistent with the names of the plumes listed in Table 2 of the PHA. |
| 38 | Figure 5 (page B-6) and Figure 5a (page B-7): The public water hookup area is not correct on these figures. A correct figure can be generated | None of the text in the Public Comment Release PHA previously referred to Figure 5a, thus ATSDR decided to delete the figure from the document. As the response to the previous comment notes, ATSDR has replaced the version of Figure 5 that previously appeared in the Public Comment Release PHA with an updated image. These revisions have helped ensure that the PHA shows the most up-to-date |

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| | for ATSDR. | information on the extent of groundwater plumes, which ATSDR believes is more relevant to the PHA discussion than showing the hookup areas (given that nearly every resident eligible for the hookup has received one). |
| 39 | Page 73 – Conclusions/Groundwater: The conclusion should clearly distinguish between background levels, contamination coming from BNL, and contamination from other sources such as Precision Concepts; this is particularly true for the radiological detections, which were above background only in wells impacted by the STP [Sewage Treatment Plant] along the Peconic River. | ATSDR agrees that the conclusions of the PHA should be clear and has revised some of the text accordingly. The key message that ATSDR wishes to convey in this conclusion is that the groundwater contamination—regardless of the source and comparison to background levels—does not present a public health hazard due to the levels detected and the various measures in place to prevent exposures. |
| 40 | Page B-6 – Figure 5 still indicates “Proposed Hookup Area IV;” the word “proposed” should be eliminated. | ATSDR has replaced the figure in question (see response to Comment #37) with a more current figure. Thus, the editorial suggestion in this comment no longer applies. |
| 41 | Page B-7 – Figure 5a needs to include Hookup Areas III & IV. | As the response to Comment #38 indicates, ATSDR has deleted the figure in question. |

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| 42 | <p>Page 7 – Summary/Air Pathway: The report refers to a “lifetime dose recommendation” for potential radiation exposures estimated by ATSDR. This wording needs to be changed to reflect that it is a recommended dose limit, as opposed to recommended dose.</p> | <p>The comment correctly notes that the terminology used on page 7 in the Public Comment Release PHA was incorrect. However, ATSDR does not have a recommended lifetime dose limit, as the comment suggests. Rather, ATSDR typically compares estimated <i>annual</i> radiation doses to a minimal risk level (MRL) of 100 mrem/year and <i>lifetime</i> doses to ATSDR’s radiogenic cancer comparison value of 5,000 mrem over 70 years. ATSDR uses these comparison values to determine whether radiation exposures require further investigation. Estimated doses that are below ATSDR’s comparison values would not be expected to result in adverse health effects, and therefore would be considered safe. ATSDR’s comparison values are discussed in detail in the responses to comments #47 and #49</p> <p>Note that 100 mrem/year is not only ATSDR’s minimal risk level, but this value is also the annual dose limit recommended for the public by the International Commission on Radiological Protection (ICRP), the National Council on Radiation Protection and Measurements (NCRP), and the US Nuclear Regulatory Commission (NRC).</p> <p>To respond to this comment, ATSDR carefully reviewed the PHA and replaced all language regarding the lifetime dose recommendation with text reflecting ATSDR’s use of a lifetime radiogenic cancer comparison value.</p> |
| 43 | <p>Second paragraph on page 25, is this saying that the 28 malfunctions occurred just during the time period 1950 to 1957?</p> | <p>Yes, in its assessment of past radionuclide air releases from the BGRR, BNL reported that: “There were 28 reported ruptures of BGRR fuel during the period 1952-1957” (BNL, 2001). ATSDR has revised the text in question to clarify the time frame over which the malfunctions occurred.</p> |

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| 44 | There is a heading for past emissions (page 24) but none for current, though current is discussed somewhat on page 26. | ATSDR's detailed evaluations focused on past air emissions of radionuclides given that they were considerably higher than current levels and to respond to specific requests from DOE and community members (see response to Comment #18). However, ATSDR did not neglect evaluating present emissions. Rather, knowing that present air emissions are closely regulated under multiple strict environmental guidelines, ATSDR determined that current exposures do not present a health hazard—a finding that could also be inferred from the fact that past exposures, when emission were considerably higher, also were not a health hazard. To address this comment, ATSDR added a heading on "Current Emissions" and briefly discussed the rationale behind concluding that current exposures do not present a public health hazard. |
| 45 | What is the purpose of the discussion about changes in the monitoring stations? It doesn't seem to be used in the evaluation, and is difficult to read. | The Public Comment Release PHA did include a detailed discussion about changes in the locations of environmental monitoring stations at BNL. This was done to acquaint the reader with how ATSDR evaluated the available data. In retrospect, ATSDR agrees with the comment that this information is perhaps too detailed for the PHA and therefore not necessary. ATSDR has revised the text in question to acknowledge that environmental monitoring stations moved with time, but deleted much of the detailed information that was originally presented. |
| 46 | Table 5 does not present cancer estimates as its title states. The footnote to this table contradicts table 6 (0.15 versus 0.5 mi from the stack). What would the exposure have been to the public beyond the site boundary? The question that should be answered is not whether the public is exposed to the highest dose, but | <p>The comment raises several points, which are addressed as follows:</p> <ul style="list-style-type: none"> ○ The comment correctly states that Table 5 does not present cancer estimates. ATSDR has revised the title of the table accordingly. ATSDR also revised the title of Table 6 to correspond more appropriately with its contents. ○ The comment identifies a typographical error in the footnote to Table 5. The text should have referred to "0.5 miles" instead of "0.15 miles." ATSDR has corrected this error. ○ The comment inquires about exposure doses for individuals located at the site boundary. This information was presented in the Public |

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| | whether their exposure could be higher than the ATSDR comparison value. Just because its not 185 mrem/yr does not mean it's an acceptable level. | <p>Comment Release PHA in the paragraph that starts at the bottom of page 32 and continues on the top of page 33. Specifically, the estimated annual dose at the BNL property line of 120 millirem was due to the releases of Ar-41 in 1962. While this estimated dose is greater than ATSDR's minimal risk level, other observations suggest that the likelihood that anyone was exposed at this level is extremely low. For instance, note that this estimated dose applies to 1962. At this time, much of the land within 10 miles of BNL was undeveloped with little or no residential housing. Because no one was likely exposed continuously at the property boundary, off-site residents' actual exposure doses in 1962 would have been considerably lower than 120 millirem. While areas surrounding BNL became increasingly populated in more recent years, Ar-41 emissions from BNL decreased by several orders of magnitude after BGRR operations ceased in 1968, as the response to Comment #28 indicates. For these reasons, ATSDR concluded that the off-site residents' exposures to past air emissions were no apparent public health hazard.</p> <p>Some perspective on the meaning of health-based comparison values also is relevant to this discussion. Readers of the PHA should note that comparison values are not thresholds of toxicity. While exposure levels below comparison values can be considered safe, it does not automatically imply that exposures greater than comparison values would be expected to produce adverse health effects. Rather, ATSDR comparison values represent exposure levels that are many times lower than levels at which <u>no</u> effects were observed in studies on experimental animals or in human epidemiologic studies. Exposures at greater levels are evaluated on a case-by-case basis to determine the public health implications of exposure.</p> |
| 47 | What is the basis for the 100 mrem/yr comparison value? Why is it higher than the 10 | Different agencies develop different guidelines to evaluate environmental contamination levels. In this PHA, ATSDR consistently compares annual whole-body radiation doses to the Agency's minimal risk level (MRL), which is 100 |

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| | <p>mrem/yr limit in NESHAPS mentioned on page 24? Shouldn't the ATSDR health comparison value be at least as low as the NESHAPS limit?</p> | <p>mrem/year. This comparison value has undergone extensive independent peer review and is identical to the health-protective limits recommended for the public by the International Commission on Radiological Protection (ICRP), the National Council on Radiation Protection and Measurements (NCRP), and the US Nuclear Regulatory Commission (NRC). ATSDR's MRL for ionizing radiation was derived from numerous studies that evaluated health effects from exposures to background and occupational levels of radiation and was designed to be protective of all populations, including those who might be sensitive to the exposures. For these reasons, ATSDR believes that its comparison value is an appropriate level to use when evaluating the public health implications of exposures to ionizing radiation. Readers interested in more detailed information on this comparison value and how it was derived should review ATSDR's Toxicological Profile for Ionizing Radiation (ATSDR, 1999b).</p> |
| 48 | <p>Comparison to Regulatory Limits: this discussion is difficult to follow. It discusses changes in worker limits, which is not the subject of this health assessment and does not explain why the ATSDR health comparison value is higher than the regulatory limit. The discussion presented does not support the conclusion on page 32 that historical releases met the dose limits at the time, nor that current releases meet current standards. At the top of page 33, 100 mrem is referred to as</p> | <p>The comment raises several points. First, the comment questions why ATSDR presents historical context on the regulatory limits for radiation exposures. ATSDR believes this perspective on regulatory limits is relevant given the time frame considered in the evaluation of historic emissions. Moreover, the information on regulatory limits demonstrates how limits have decreased (i.e., become more health-protective) over time. Therefore, ATSDR has decided to leave this text in the PHA.</p> <p>The comment also notes that ATSDR's health-based comparison value (i.e., the minimal risk level for ionizing radiation) differs from current regulatory limits. However, as the response to the previous comment explains, ATSDR's comparison value is adequately protective of human health and consistent with dose limits recommended by other agencies and is entirely appropriate for this evaluation.</p> <p>Finally, the comment notes that a sentence on page 32 of the Public Comment Release PHA incorrectly referred to 100 millirem as being a "standard," when the text actually was intended to refer to ATSDR's minimal risk level (100 millirem/year). ATSDR has revised the text to use the correct terminology.</p> |

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| | a “standard,” which contradicts the standard of 10 mrem mentioned on page 32. | |
| 49 | <p>Page 49 – Potential Exposure Pathway/Air: The discussion regarding the air exposure pathway is not supported by the report, which indicates exposures higher than the comparison values, not to mention NESHAP standards. The last paragraph of this section appears to be comparing “yearly” dose estimates to “lifetime” criteria. What is the basis of the Chernobyl estimate (long-term cancer risks, immediate effects)? Why is ATSDR using this value, and not their comparison value?</p> | <p>This comment raises several points about the comparison values used in the PHA:</p> <ul style="list-style-type: none"> ○ The comment implies that ATSDR’s evaluation should give greater weight to the observation that past exposures to air emissions were higher than comparison values. A couple of points deserve clarification. First, ATSDR’s modeling found only one instance when off-site exposures to airborne emissions might have exceeded a comparison value. That instance was for Ar-41 emissions from the BMR that occurred in 1962, which is the year with the highest Ar-41 releases between 1940 and the present. As the response to Comment #46 indicates, ATSDR doubts that any off-site residents were continuously exposed to the estimated “fence-line” exposure levels estimated by the models, considering that the area surrounding BNL was sparsely populated at the time. Thus, off-site residents’ actual exposures during the 1960s were likely considerably lower than the maximum possible value estimated by the model (i.e., 120 millirem/year); and exposures since the 1960s were substantially lower due to the fact that the BGRR—the main source of Ar-41 releases—was not operating after 1968. It is for these reasons that ATSDR concluded the exposures to past air emissions were no apparent public health hazard. <p>Readers should also note that comparison values are not thresholds of toxicity. While exposure levels below comparison values can be considered safe, it does not automatically follow that exposures greater than comparison values would be expected to produce adverse health effects. Rather, ATSDR comparison values represent exposure levels that are many times lower than levels at which <u>no</u></p> |

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| | | <p>effects were observed in studies on experimental animals or in human epidemiologic studies.</p> <ul style="list-style-type: none"> ○ The comment also notes that text in the fourth paragraph on page 49 of the Public Comment Release PHA appeared to compare annual dose estimates to lifetime exposure criteria. When evaluating the health implications of exposure to historic air emissions, ATSDR estimated annual exposure doses and compared those to the corresponding minimal risk level (100 millirem/year). Additionally, ATSDR estimated lifetime exposure doses to determine the potential, if any, for adverse health effects to occur over life-long exposures. The text in the fourth paragraph on page 49 was meant to apply only to lifetime exposures, and ATSDR has revised the paragraph in question to clarify this point. <p>Finally, the comment questions why the third paragraph on page 49 of the Public Comment Release PHA presents information derived from the Chernobyl incident. This paragraph was <i>strictly</i> intended to evaluate the health implications of the estimated dose to the critical organ for radiological effects resulting from intakes of I-131. ATSDR uses its lifetime radiogenic comparison value to evaluate whole-body exposures, but the Agency does not have a comparison value for thyroid doses. Therefore, ATSDR referred to the available scientific literature for appropriate health-based screening estimates and found that the Chernobyl incident provided the most reliable basis for evaluating these exposures. ATSDR has revised this particular paragraph to emphasize that it focuses on thyroid exposures, to clarify that 5 rem is not a regulatory “dose limit” but rather a derived screening value, and to correct a typographical error—estimated exposures were actually 125 times lower than 5 rem, not 12.5 times lower.</p> |
| 50 | Page 74 – Conclusions/Air: As written, I do not think the conclusion regarding air | ATSDR determined that the estimated exposure doses were well below the lifetime dose recommendation. ATSDR considered the various pathways people may have been exposed in their analysis and concluded that the estimated doses from the |

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| | releases is consistent with the air section of the report, in which doses above the "lifetime dose recommendation" are presented. In addition, if 100 mrem/yr is a total dose, shouldn't the radiological dose across all pathways of exposure be used for comparison? | years with the highest emissions were not expected to cause adverse health effects. ATSDR then extrapolated the doses over a lifetime and determined the same conclusion. |
| 51 | It is unclear why evaluation of risks from 1948 to 1961 period is provided in this assessment and its relevance to current exposures. The reference to USEPA 1998 is not listed in the references. It is assumed that the reference is to the Exposure Factors Handbook. If so, the ingestion rate that is typically used in Superfund assessments are 8 and 25 g/day (see page 10-26). | <p>The comment raises two points. First, the comment questions why ATSDR evaluated exposures to historic air emissions from BNL. As the response to Comment #18 explains, ATSDR conducted this evaluation to respond to requests from the BNL Community Work Group and DOE. ATSDR also evaluated current emissions (see response to Comment #44) to provide a complete picture of the air exposure pathway.</p> <p>Second, the comment asks ATSDR to clarify information presented on fish ingestion rates. The reference questioned in this comment (USEPA, 1988) was indeed intended to be EPA's Exposure Factors Handbook. ATSDR has revised the text to include the correct year of publication (1989) and added this citation to the References section. The fish ingestion rates that ATSDR used in this evaluation were actually 6 grams/day for the general population and 17 grams/day for recreational and sports fishermen. These values are the recommended fish ingestion rates for freshwater fish, as reported in Tables 10-81 and 10-84 in the Exposure Factors Handbook (USEPA, 1989). ATSDR believes these values are justified. However, even if the higher ingestion rates were used, the radiation dose estimates for fish ingestion shown in Table 7 of the PHA would still be considerably lower than ATSDR's health-based comparison value (MRL of 100 mrem/year).</p> |

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| 52 | <p>Page 8 – Summary/Biota: The report concludes that because possible radiological dose (7.1 mrem) from the consumption of deer meat does not exceed the national average EDE (10 mrem), this pathway is not likely to result in adverse health effects. Using lead as an example, background exposure does not imply no effect/no risk. Any increase in exposure due to BNL should be added to background risk.</p> | <p>For reference, ATSDR's evaluation of deer meat contamination is based entirely on a study conducted by the New York State Department of Health (NYSDOH). After reviewing extensive deer meat sampling data from the area, that agency concluded that: "...no formal restrictions need to be placed on hunting in the areas where it is not currently prohibited, nor on consumption of deer harvested from these areas" (NYSDOH, 1999).</p> <p>ATSDR has clarified in the PHA that its conclusion is based on the magnitude of the estimated dose (5 mrem for the average hunter) and not on a comparison to national average exposures. It is worth noting that the dose estimated by NYSDOH assumes that a hunter ingests more than 60 pounds of deer meat per year—or more than 1 pound per week.</p> <p>Additionally, ATSDR made several minor revisions throughout the PHA to clarify its interpretations and to correct typographical errors.</p> |
| 53 | <p>Throughout the document, there are several comparisons to background locations and a determination is made regarding whether the concentrations are significant. Consistent with EPA's guidance on background, there is a need to evaluate the risks before providing information on background concentrations. Background is typically used to establish whether the concentrations are site-related or not and are typically used</p> | <p>The comment raises several points about how ATSDR presents background concentrations in the PHA. Please note that ATSDR's health conclusions in the PHA are based on doses estimated from measured levels of environmental contamination at and near BNL, regardless of the source. In other words, ATSDR evaluates the public health implications of exposure irrespective of the background concentrations. ATSDR's intent in presenting information on background concentrations was to provide some perspective on whether contamination levels near BNL are site-related.</p> |

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| | for naturally occurring metals. At times the presentation of this information in the document is confusing since there is not clear discussion regarding the significance of these concentrations in terms of exposures and risk. | |
| 54 | Page 20 – Table 1: The table should also note that the NYS MCL for 1,1-DCE is 5 ppb, and that the USEPA MCL for total trihalomethanes (including chloroform) is 80 ppb. | ATSDR has included this additional information in Table 1. |
| 55 | <p>In several places within the document, data is presented without providing comparison values (see page 14). It is recommended that in those cases where concentration data is presented further characterization of the comparison values i.e., MCL, etc. should be included in the text.</p> <p>On page 17, the discussion</p> | <p>The comment raises two issues. First, the comment indicates that the text on page 14 should mention the corresponding comparison values that ATSDR used when evaluating the data from on-site potable wells. ATSDR agrees and has inserted a new paragraph in the section on “Potable Water Well Contamination” that briefly summarizes the highly-detailed analytical results listed later in this particular section. This summary notes the drinking water standards for the contaminants that ATSDR considered.</p> <p>Second, the comment asks ATSDR to clarify the meaning of the comparison value used to evaluate PCB contamination in sediments (i.e., 1.0 ppm for Aroclor 1254). Because ATSDR does not develop comparison values specifically for sediments, the Agency typically uses comparison values developed for residential soil ingestion scenarios when screening environmental sampling data for sediments. In</p> |

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| | <p>identifies potential exposures to sediments as an area of concern. It is recommended that the text should clarify whether this evaluation is based on direct contact or uptake through the food chain. For example, 1 ppm is identified as the level of comparison for PCBs. However, this value equates to a residential exposure for a young child (0 to 6 years old) assuming 350 days/year for six years. It is unlikely that based on the size of the creek, depth of water, etc. that a young child will be there for the residential exposure period. Further clarification in the text would be necessary to further explain these exposures and the significance of exceeding the EMEG of 1 ppm.</p> | <p>this particular case, the 1.0 ppm comparison value was developed for children's exposures. As the comment correctly notes, it is unlikely that residents are frequently exposed to sediments for the various reasons stated. ATSDR has revised the text on page 17 to explain the origin of the comparison values and to acknowledge the unlikelihood of prolonged exposure to contaminated sediments.</p> <p>Additionally, ATSDR notes that its comparison values are based strictly on direct exposures and are not designed to protect against uptake through the food chain. This should not imply that ATSDR does not consider food chain exposures in its public health assessments. Rather, when evaluating contamination levels in food items, ATSDR typically calculates exposure doses and uses MRLs, reference doses, and other guidelines to identify contaminants of potential concern.</p> |
| 56 | <p>Page 21 – ATSDR's Groundwater Model: It is not clear why such a simplified model had to be developed, when very sophisticated models exist (e.g., the CDM</p> | <p>The comment correctly indicates that many models of varying complexity are available to evaluate the nature, extent, and migration of groundwater contamination. ATSDR scientists are familiar with the broad range of groundwater models, including the specific model identified in the comment. It is true that more sophisticated models are available in comparison to the simplified model that ATSDR used. However, ATSDR does not believe that sophisticated models should</p> |

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| | model), and could have been used to estimate flow paths and times of travel from any known or hypothetical discharge or spill at BNL. | automatically be used. In fact, ATSDR routinely uses screening or simplified environmental fate and transport models in cases where these models are believed to provide reliable answers to the questions of interest. In this particular case, ATSDR used models to resolve a very specific issue: whether off-site private wells had been affected by BNL's groundwater plumes in years prior to the sampling events (i.e., pre-1985). For this designated purpose, ATSDR is confident that the simplified model used in the PHA was entirely appropriate. |
| 57 | The text should explain does the column on plume duration reflect time to reach a specific concentration; what is meant by the source to off-site wells, and when the total plume length was identified. Further, it would be helpful to indicate whether this use of Arc/View is appropriate for these types of environmental data being evaluated at the Brookhaven Laboratory. Another concern is that specific street names are listed and concerns regarding confidentiality of street address should be considered. | <p>The comment raises several points, which ATSDR addresses separately:</p> <ul style="list-style-type: none"> ○ The comment asks ATSDR to clarify several terms used in Table 2 of the PHA. ATSDR has revised the footnotes to Table 2 to define these terms more clearly. ○ The comment suggests that ATSDR clarify whether the use of ARC/VIEW was appropriate for the data evaluation. ATSDR used ARC/VIEW only to measure distances from contamination sources to the property boundary and to the nearest off-site private wells. ARC/VIEW is entirely appropriate for this application. ATSDR has clarified the footnotes for Table 2 to explain that ARC/VIEW was used only to measure distances between fixed locations. <p>The comment raises confidentiality concerns about listing street names in the PHA. ATSDR has reviewed its internal policies for such matters and determined that street names can be listed in this PHA. It is important to note that no text in the PHA currently identifies households by specific street address or resident name.</p> |
| 58 | Page 37 – Off-Site Sediment Contamination: Many of the ponds and rivers presented as control locations should not be considered control locations | <p>The comment raises several points about the “control locations” for surface waters. ATSDR took several actions in response:</p> <ul style="list-style-type: none"> ○ ATSDR revised the list of control locations based on information provided in the comment. Note that ATSDR considers a “control location” to be surface waters that are not affected by direct or |

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| | <p>for the Peconic River, such as Hempstead Lake, Searington Pond, Lake Ronkonkoma, etc. [on page 42]. A control location should be one that would represent the contamination that would be expected in the Peconic River if there were no influence by BNL. Many of these locations clearly do not represent that. The last paragraph of the control fish sampling section on page 42 is misleading at best. A map indicating the locations of these control locations would be helpful. Similarly, Seaford and Raritan Bay should not be considered control locations for shellfish [on page 43]. What were the results of this “background” sampling? Also, Northport Bay is not part of the Peconic River basin [on page 37].</p> | <p>indirect water discharges from BNL.</p> <ul style="list-style-type: none"> ○ The comment notes that the last paragraph that previously appeared under “Control Fish Sampling” on page 42 of the Public Comment Release PHA was misleading. ATSDR has revised this text so as not to detract from the significance of the fish tissue contamination levels that have been detected in the Peconic River. ○ The comment questions the relevance of the shellfish control locations listed in the third paragraph that previously appeared on page 43 of the Public Comment Release PHA. As the response to Comment #23 notes, ATSDR revised this paragraph to more accurately describe the contamination levels from control locations. The revised text no longer refers to “background levels,” thus addressing another point raised in this comment. <p>The comment correctly notes that Northport Bay is not part of the Peconic River basin. However, the text in question notes that sampling was conducted “...throughout the Peconic River basin and beyond.” ATSDR has clarified this text to note that “beyond” refers to areas outside of the Peconic River basin.</p> |
| 59 | <p>Page 36 indicates that the concentration of 24.2 ppm in sediment exceeds the health based comparison value. Of concern is that the health based</p> | <p>The comment appears to pertain to the second full paragraph from page 38 of the Public Comment Release PHA, in which data are presented on a single elevated concentration of arsenic in Peconic River sediments far downstream from BNL. In this paragraph, ATSDR states that the comparison value used in the evaluation is based on an assumption of lifetime exposures, but notes the probability of a person</p> |

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| | criteria for direct contact assumes exposures for 350 days/year while the exposures at the creek sediment may be significantly less frequent and therefore this concentration is of less importance. | being exposed for this duration is low. ATSDR agrees that the limited access to Peconic River sediments highlights the extremely protective nature of ATSDR's screening approach. Refer to the response to Comment #55 for further information on the inherent assumptions in the process ATSDR uses when screening sediment contamination data. |
| 60 | Page 17 and 18 – Section labeled Sediments: Sediment Data and Comparison Values: The Adjusted Health Based Comparison Values contained in the sediment data tables in the appendices differ from the Comparison Values discussed in the Sediments section. ATSDR applied a factor of 4 to the soil Comparison Value when preparing the Adjusted Comparison Values for sediments as stated in Table SD1 on page C-28 in Appendix C. Consequently, the data that exceeds the Comparison Values as discussed in the text in the body of the report does not exceed the Adjusted Comparison Values for | The comment correctly identifies a discrepancy in the health-based comparison values that ATSDR used when evaluating sediment contamination data. When first evaluating environmental sampling data, ATSDR used seasonally-adjusted health-based comparison values to identify which contaminants detected in sediments might warrant further consideration, and these seasonally-adjusted values were used in all data summary tables in Appendix C. However, when writing the text in the main body of the Public Comment Release PHA, ATSDR quoted health-based comparison values that are not adjusted for seasonal exposures. To correct this situation, ATSDR revised the text on page 17 to list contaminants found at elevated levels, rather than presenting the detailed information on health-based comparison values. ATSDR does not expect the contamination levels to present a public health hazard, given the unlikelihood of frequent or prolonged direct exposure to the contaminated sediments. |

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| | <p>sediments contained in the Appendix C. For example, the Adjusted Comparison Values for arsenic, cadmium and mercury are 20, 40 and 80 parts per million (PPM), respectively, in Table SD1 on page C-27. The Comparison Value for cadmium stated and used for comparison purposes on page 17 is 10 ppm and the text states that arsenic concentrations exceed the Health-Based Comparison Values. When compared to the Adjusted Comparison Values contained in Tables SD1 and SD2, the maximum concentrations of 9.7 ppm of arsenic, 18.8 ppm of cadmium and 39.7 ppm of mercury are not above the Comparison Values as stated on page 17. Neither are the concentrations of benzo(b)fluoranthene and arochlor-1254 discussed in the same section. It is also stated that there is a health based comparison value for benzo(a)pyrene. However, Table SD1 does not contain a</p> | |

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| | Health-Based Comparison Value for this compound (i.e., the value is listed as NA – Not Applicable). | |
| 61 | Page 17 and 18 – Section labeled Sediments: Some of the radionuclide sediment data exceeds the Comparison Values contained in SD1 and SD2. The significance of this is not discussed. | The text in question pertains to on-site sediment contamination levels. As the response to Comment #60 notes, prolonged direct exposures to on-site sediments for people living off site are unlikely to occur, given the limited access to on-site locations and other factors. Due to this limited exposure, ATSDR believes the on-site sediment contamination levels do not present a public health hazard for direct contact. Please note, however, in its evaluation of the fish and shellfish ingestion pathways, ATSDR uses biota sampling data to consider the possibility that contaminants in on-site sediments might eventually enter the food chain. |
| 62 | Page 65: Mercury Section: Potential exposures to mercury-contaminated Peconic River sediments on and off-site are not discussed. Only potential exposures to eating mercury-contaminated fish are discussed. | The text in question (from page 65 of the Public Comment Release PHA) appears in the section on “Public Health Implications.” This section of the PHA presents more detailed analyses of environmental contamination found at levels above health-based comparison values. For mercury, only the fish tissue sampling results exceeded comparison values, and therefore required further evaluation in this section. As Table SD2 shows, the highest mercury concentration in off-site sediments based on the data that ATSDR reviewed was 9 ppm, which is nearly nine times lower than the seasonally-adjusted health-based comparison value. Therefore, the mercury in the sediments does not pose a hazard for direct contact exposure scenarios, and no further evaluation is necessary. |
| 63 | Page 39 – Biota Contamination: The report should clearly indicate the time period covered. It is stated that only results from sampling performed between 1973 and 1999 were evaluated; however, | As noted in the response to Comment #1, ATSDR added a table at the beginning of the PHA that clearly states the time periods evaluated for each exposure pathway considered. ATSDR also revised text in the “Biota Contamination” section to clarify the time frames considered for the fish tissue sampling data. |

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| | later in this section, results of more recent studies were reported. What is the justification for limiting the data used? | |
| 64 | Page 51 – Potential Exposure Pathway/Biota: Not all the fish data are whole body. In addition, since mercury is higher in fish tissue, the whole body analysis may actually underestimate levels in tissues consumed. Unless the control fish with 0.364 mg/kg mercury was from a control location similar to the Peconic River, the statement that “...it is a clear indication of multiple sources of contamination in areas surrounding BNL” is inaccurate. More information on the location of the control site should be provided. | The comment raises two main points. First, the comment correctly describes important distinctions between whole body fish samples and fish tissue samples. ATSDR was mindful of this when gathering and interpreting the available fish sampling data. Second, the comment seeks clarification on mercury levels detected in a fish sample collected from a control location. As noted in the response to Comment #58, ATSDR revised the text quoted in the comment to provide a more accurate interpretation of the control location sampling results. For reference, the control location sampling result for mercury (0.364 mg/kg) is based on a whole fish analysis of largemouth bass collected in Sandy Pond (ITC, 1988b). Sandy Pond does not receive flow from the Peconic River or its tributaries and is not influenced by direct or indirect discharges from industrial sources. For these reasons, this sampling location has been referred to as a “reference location” in some site documents. |
| 65 | Page 51 – Potential Exposure Pathway/Biota: The New York State Department of Health fish advisory is for freshwaters in New York State, not just Long Island. The FDA action | <p>The comment raises three points, which ATSDR addressed as follows:</p> <ul style="list-style-type: none"> ○ The comment correctly states that the New York State Department of Health’s health advisory applies to fish caught from the state’s freshwaters statewide, not just from the freshwaters in Long Island. ATSDR has revised the text on page 51 accordingly. ○ The comment questions the appropriateness of using FDA action |

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| | level for methylmercury is not appropriate for comparison. It appears that ATSDR is not using the most recent FDA recommendations regarding consumption of fish with mercury contamination. The screening dose assessment discussion should point out that it just pertained to radiological contaminants. | <p>levels for methylmercury when evaluating the fish tissue contamination data. To respond to this comment, ATSDR removed all references to the FDA action levels in the final PHA.</p> <p>The comment indicates that, in the Public Comment Release PHA, the screening dose assessment for the fish ingestion pathway pertained only to radiological contaminants. ATSDR has since conducted exposure dose calculations for mercury based on reasonable maximum exposure concentrations (0.86 mg/kg, as reported in BNL's 2003 Baseline Human Health Risk Assessment) using the fish ingestion rates noted in the PHA (6 grams per day for the general population and 17 grams per day for recreational and sport fishers). Under these assumptions, the estimated mercury exposure doses from fish ingestion for residential scenarios and for angler scenarios are below ATSDR's chronic oral MRL for methylmercury (0.0003 mg/kg/day). This comparison suggests that potential exposure to mercury by ingesting fish caught from the Peconic River does not present a public health hazard for residents or anglers. A similar calculation based on the PCB contamination levels also reveals that potential exposure doses due to ingesting fish caught from the Peconic River would be at levels below ATSDR's chronic oral MRL for Aroclor 1254 (0.00002 mg/kg/day).</p> |
| 66 | Page 52 – Potential Exposure Pathway/Biota: Regarding the radiological dose from consuming deer, it should be acknowledged that deer found on-site one day may be off-site another day. What is the basis for concluding that the radiological doses presented in Table 7 (e.g., 17 mrem) are not a health hazard, as concluded | <p>The comment correctly states that deer found on site at BNL may later be found at off-site locations. ATSDR inserted new text under the "Deer" section to acknowledge this. In addition, the comment questions conclusions for estimated radiation doses from consuming deer meat based on data that were previously presented in Table 7 of the Public Comment Release PHA. However, the data point in that version of the PHA was an error, and the correct radiation dose due to deer ingestion is 5 mrem/year; this is the dose that the New York State Department of Health estimated in its 1999 deer meat contamination study (NYSDOH, 1999). ATSDR concludes that this exposure dose (5 mrem/year) is not a public health hazard because it is 20 times lower than the Agency's MRL for ionizing radiation (100 mrem/year).</p> |

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| | at the bottom of the page? | |
| 67 | Page 53 – Potential Exposure Pathway/Biota: Toxicological Profiles for cesium and strontium are final as of 2004. Why is there a reference to effect levels? MRLs would be more appropriate for comparison. This leads to confusion, since prior sections of the report use 100 mrem. | The comment correctly notes that final Toxicological Profiles are available for cesium and strontium, and ATSDR revised the PHA to reflect this. ATSDR added text in the section on food ingestion scenarios to indicate that estimated annual radiation doses are considerably lower than ATSDR's minimal risk level (100 mrem/year) and that estimated lifetime doses are lower than ATSDR's radiogenic cancer comparison value of 5,000 mrem over 70 years. The information on health effects was included because cesium and strontium exposures can lead to both chemical toxicity and radiological toxicity. ATSDR has clarified the text on this matter. As requested, ATSDR removed text on the effects levels and referred readers who might be interested in such information to the Toxicological Profiles. |
| 68 | The discussion regarding sampling methods is very broad and theoretical. For the RI/FS, a Quality Assurance Project Plan was developed for the fish sampling and input was obtained from Ecological Risk Assessors. The sampling procedures also complied with Agency practices for sampling. One of the major problems was obtaining an adequate number of fish to analyze suggesting the limitations of this water body. It is unclear what additional information to inform an exposure assessment | <p>The comment raises two points. The first paragraph in the comment addresses several points, all suggesting that the paragraph in the Public Comment Release PHA on "Sampling and Analytical Methods" could be removed from the document without loss of content. ATSDR agrees and deleted the paragraph in question.</p> <p>The second paragraph pertains to a sentence in the paragraph that has been deleted from the final PHA.</p> |

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| | <p>was obtained by the discussion of the potential under estimate of fish levels. If this section is maintained, further discussion regarding the water body and ability to support a fish population should be included.</p> <p>Page 39, the discussion of samples being collected from 1970s to the present should be modified to indicate that the fish data analyzed appears to have ended in 1999 from the latter text.</p> | |
| 69 | <p>Page 39: The BNL Analytical Services Laboratory (ASL) did not conduct biota research. The ASL provided analytical services. All biota sampling was performed by the Environmental and Waste Management Services Division of BNL.</p> | <p>ATSDR appreciates this clarification and has revised the text accordingly.</p> |
| 70 | <p>Page 55 – The Public Health Implications: This section handles chemicals differently. In some cases, conclusions about whether health impacts are a concern or not are</p> | <p>The “Public Health Implications” section presents detailed toxicological information on eight volatile organic compounds and mercury. This section is also intended to further evaluate the estimated doses to conclude whether each potential exposure scenarios poses a public health hazard. However, the comment correctly notes that ATSDR did not include conclusions for some of the chemicals that were evaluated. Specifically, no conclusions were presented for exposures to 1,1-</p> |

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| | provided in this section, and in other cases, it just provides toxicological information. | dichloroethane and carbon tetrachloride. ATSDR revised this section to include conclusions regarding potential health impacts for these two chemicals. |
| 71 | Page 59 – 1,1-DCE: What is the basis of the conclusion that the likelihood of adverse health effects from the inhalation of 1,1-DCE at a concentration of 20 ppb in water would be low? An inhalation MRL is provided along with the assumption that the inhalation dose would be similar to the ingestion dose, though no dose estimates were provided. Assuming doses were calculated, what were they compared to, given that the MRL is an air concentration? Similarly, the 1,1,1-TCA discussion (page 61) seems to be confusing “doses” with air or water concentrations, and comparing air concentrations to water concentrations. Mathematical models exist that can estimate indoor air levels given a water concentration, and it is recommended that this | The “Public Health Implications” section assesses whether estimated exposure to site-related contamination might be expected to cause adverse health effects. For the volatile organic compounds considered, ATSDR focused on evaluating the public health implications of drinking (ingesting) contaminated water. Accordingly, the section compares estimated doses to corresponding health guidelines (e.g., MRLs and RfDs) and effects levels for ingestion exposures. For additional reference, the section also presents limited toxicological information on non-ingestion exposure routes, but ATSDR did not conduct quantitative assessments of these routes. To clarify this approach, ATSDR removed any text that might have implied that quantitative assessments of inhalation or dermal exposures were conducted. |

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| | approach be utilized. (The same comment applies to PCE, see below). | |
| 72 | Page 63 – PCE: In the second from the last paragraph, it is stated that 0.2 ppm was the lowest concentration that did not cause adverse effects, and that this was considered the NOAEL. A NOAEL is usually the “highest” concentration that does not cause adverse effects. The wording provided implies that no effects are noted at 0.2 ppm, but are noted at lower doses. | ATSDR agrees that the text, as previously written, was unclear and has revised the sentence in question. |
| 73 | Page 65 – Carbon tetrachloride: The term “dose” is again being confused with water concentrations. Is the report implying that because the concentration in water (in µg/L) is lower than a NOAEL air concentration (in µg/m ³) that the risks are not of concern? Why then is the NOAEL mentioned, when there is an ATSDR MRL? | As the response to Comment #71 notes, the primary purpose of the “Public Health Implications” section is to evaluate the health implications of drinking (ingesting) contaminated water. For additional reference, general toxicological information was included on dermal and inhalation routes, but ATSDR did not conduct quantitative assessments of these routes. The revised text in this section no longer implies that concentrations in water are somehow comparable with air comparison values. |

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| 74 | Page 65 – Mercury: Regarding methyl mercury, the FDA has updated its consumption advisory for mercury in fish. Reference to the action level of 1 ppm is not appropriate. Also, whether or not fishing on BNL property is permitted is irrelevant, since there have been reports that fishing for consumption purposes has occurred. | <p>The comment raises two points, which ATSDR addressed as follows:</p> <ul style="list-style-type: none"> ○ The comment notes that the FDA action level for methyl mercury in fish may not be appropriate for the PHA. As noted in the response to Comment #65, ATSDR removed all references to the FDA action level from the final PHA. <p>The comment questions the significance of statements about the extent of fishing that might occur on site. ATSDR believes information on fishing activity is very relevant to this PHA, because samples collected from the areas with greatest fishing activity (downstream reaches of the Peconic River) tend to have lower mercury levels in fish tissue. While ATSDR does not disagree that some fishing occurs at on-site locations, some key observations suggest that extensive fishing in this part of the Peconic River is highly unlikely. For example, according to BNL's 2003 baseline human health risk assessment, the Peconic River is completely dry at locations upstream of Schultz Road for roughly one-third of the year, and the fish caught in these locations (when water is present) tend to be too small to provide edible portions. These observations will continue to remain in the PHA.</p> |
| 75 | Page 70 – Community Health Concerns: ATSDR should point out that BNL's data were not the only data available; the SCDHS also collected groundwater, drinking water, and sediment data. | Community members voiced concern that the PHA relies in large part on the findings of BNL's sampling data. Thus, ATSDR's response to this concern focused primarily on the quality of BNL's data. However, the comment correctly notes that the PHA is based on data provided by additional parties, and ATSDR has revised the text in question to acknowledge this. |
| 76 | Page 71 – Community Health Concerns: Second Bullet: Private wells near the Peconic River were found to have multiple BNL-related | ATSDR appreciates receiving this clarification and has revised the response to the community health concern accordingly. |

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| | contaminants exceeding drinking water standards. | |
| 77 | <p>Much of the information presented in the document appears to be designed for readers that have broad understanding of sampling techniques, radiation and chemical risks, and regulatory programs. For a more general audience, it may be difficult for them to understand the roles and responsibilities of the various organizations and lead to unnecessary confusion. It is recommended that the document should concentrate on the Superfund portion of the evaluation and work at the Laboratory. Discussions of other regulatory programs such as air regulations, etc. should be separated from the general discussion of the Superfund related activities. In addition, if other programs are to be discussed, they should clearly define what a permit is and how it is designed to be protective of human health.</p> | <p>ATSDR strives to ensure that its public health assessments both communicate important findings and describe the evaluation process used to reach those findings. In general, the "Summary" and "Conclusions" section of PHAs are intended to appeal to the broadest public audience. However, the text in the other sections of the document must cover an extensive range of topics. ATSDR recognizes that it may be difficult to follow lengthy PHAs for sites with numerous exposure pathways and contaminants of concern, such as BNL. Consequently, attempts were made to ensure that the discussion is not overly complicated and is ordered in a logical fashion. The structure of the PHA follows internal document formatting procedures, which require organizing the document by the time frame of exposure (e.g., past and present), the area of contamination (e.g., on site and off site), and the type of contaminant (e.g., radioactive and non-radioactive).</p> <p>To be responsive to this comment, ATSDR has clarified the specific text mentioned about "reactors" and added information on the precautions BNL takes to prevent contamination from entering the environment.</p> |

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| | <p>For example, on page 9 of the document there is an extensive discussion of various reactors and ruptures of the fuel cartridges. The Glossary of Terms does not define "reactor" nor does this text explain the precautions that are taken to prevent leaks and the significance of the leaks identified in the text. Careful consideration should be given to the readers of this document and additional information provided so that they can understand the significance of the statements.</p> | |
| 78 | <p>In several sections of the report, there are statements that appear to be outside of ATSDR's regulatory responsibilities. For example, on page 1, the document indicates that "ATSDR's mission is to prevent or mitigate adverse human health effects and ...". Later in this same paragraph it indicates that "ATSDR has no regulatory authority ...". This</p> | <p>The comment asks ATSDR to clarify text in certain parts of the PHA. Most of the comment pertains to statements that were previously made on the first two pages of the Public Comment Release PHA, in the section titled "ATSDR and the Public Health Assessment Process at Department of Energy Facilities." This text is actually standard "boilerplate" text that appears in every PHA that the Agency prepares on Department of Energy facilities. The final PHA includes the most up-to-date standard text that ATSDR uses for these documents.</p> <p>The comment also notes that the text on page 9 correctly indicates that BNL is included on EPA's National Priorities List, but does not explain the significance of this listing in terms of clean-up activities. ATSDR added some background text to give a general overview of the clean-up process. ATSDR also revised the text that previously implied that BNL was required to remediate every contaminated area.</p> |

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| | <p>statement requires further clarification regarding the decision making process for decisions at Superfund sites. Specifically, EPA has a specific process for the evaluation of the extent of contamination, remedial investigation including a human health and ecological risk assessment, evaluation of the feasibility of remedial action including the analysis of the nine criteria identified in the Superfund regulation, a Proposed Plan and a Record of Decision that identified the remedy for the site. Page 9 suggests that EPA must remediate all sites on the National Priority List while only those contaminants exceeding the risk range identified in the NCP are remediated. This process has been followed throughout the evaluation of the Brookhaven Laboratory including the multiple Operable Units and is not mentioned in this</p> | <p>ATSDR does work with other health departments and environmental agencies to conduct sampling at some site, but not at all sites. ATSDR did not do any sampling at BNL</p> |

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| | <p>document.</p> <p>Further on page ii, the document indicates that ATSDR is conducting sampling. Has ATSDR collected any data at the Brookhaven Laboratory site? It would be helpful to clarify the type of sampling that they conduct and whether it has occurred at this site.</p> | |
| 79 | <p>EPA has issued a memo identifying the sources of toxicological information that are to be used within the Superfund program. It is unclear why the Region III Risk Base Concentrations were selected and how the data in the RBCs were updated to reflect current toxicological information. For example, several of the RBCs include toxicological data that has been withdrawn and it is unclear what selection process was used to select the RBCs to include in this analysis. Further, when was the toxicological information from</p> | <p>This comment raises many issues pertaining to the health-based comparison values and toxicological evaluations presented in the Public Comment Release PHA. ATSDR addressed these comments as follows:</p> <ul style="list-style-type: none"> ○ Several of the statements in this comment note that the PHA would benefit from having additional information on the derivation and meaning of the various health-based comparison values. Appendix H of the final PHA now includes standard text that ATSDR uses to describe different types of comparison values and appropriate inferences to draw in cases when contamination levels (or doses) exceed these values. ○ Some of the statements in this comment note that EPA and ATSDR sometimes evaluate environmental contamination levels differently. This observation is correct and merely reflects the slightly different missions of the two agencies. Readers interested in learning more about the approaches ATSDR takes when evaluating contaminated sites should refer to the Agency's <i>Public Health Assessment Guidance Manual</i>, which is available on the Internet at: |

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| | <p>the Integrated Risk Information System last updated?</p> <p>Other differences between the two agencies include the assumption of 70 years for the exposure duration while EPA typically assumes an exposure period of 30 years for a resident. The discussion on page 13 should be further clarified to explain the differences in exposure assumptions among the CREGs and EMEGs, etc. Further, the MCLS include both risk assessment with toxicity information and risk management evaluations which should be clarified in the discussion.</p> <p>It would also be helpful to explain that exceeding the individual comparison values does not necessarily mean that remedial action would be appropriate. The nine criteria, the degree in which the comparison value was exceeded, and technological</p> | <p>http://www.atsdr.cdc.gov/HAC/phamanual.</p> <ul style="list-style-type: none"> ○ The comment recommends that the PHA include information on how ATSDR develops Toxicological Profiles and derives toxicity values. A detailed account of this information is beyond the scope of this document, but interested readers can view all of the Agency's Toxicological Profiles on the Internet at: http://www.atsdr.cdc.gov/toxpro2.html. <p>The comment asks a specific question about an assumption used in one of the dose calculations in the "Public Health Implications" section of the PHA. Specifically, the comment asks why ATSDR assumed a 20-year exposure duration when evaluating potential cancer risks associated with ingesting TCE-contaminated drinking water. This duration represents the maximum time frame that residents might have been exposed to the highest contamination levels detected, based on ATSDR's groundwater modeling analysis. Given that exposures to the contaminated drinking water were eliminated after residents were hooked up to the municipal water supply, this exposure duration is justified. (Note that the seven households that did not accept the offer for free hookups to the water supply are not located in areas with groundwater contamination levels above drinking water standards.)</p> |

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| | <p>feasibility must also be considered.</p> <p>Further on page 55, there is a discussion regarding toxicity data that uses ATSDR's MRLs while earlier in the document reference is made to EPA's toxicity information i.e., RfDs, RfCs, etc. (see page 13). For example, there is a mention of EPA developing cancer slope factors yet the source of this data and its peer review are not identified.</p> <p>It may be helpful to provide more information on the development of the ATSDR Toxicological Profiles and associated toxicity values in addition to EPA's Integrated Risk Information System (IRIS) data.</p> <p>On page 58 the basis for the exposure period of 20 years is unclear. Is this apportioned for the child and adult? Please explain why the assessors did not use EPA's residential value of 30 years?</p> | |

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| | The level of detail provided for the various chemicals assumes significant knowledge of toxicology. It is suggested that further background discussion regarding the process for developing toxicity values, the types of data reviewed, etc. should be presented in this section. | |
| 80 | On page 58 and in other parts of the document there is a discussion regarding other sources of contamination. In this case, the specific facility is identified. It does not discuss whether NYSDEC has conducted a Superfund analysis and also reached this conclusion. Further discussion is needed regarding this site as a source of contamination and any such discussion should include references of supporting documentation indicating this site as a Potential Responsible Party. | <p>ATSDR received many comments asking that the PHA clarify statements about the origins of different groundwater contamination plumes. As the responses to Comments #35, #36, and #39 indicate, ATSDR extensively revised the text throughout the PHA to ensure that important findings are communicated clearly and consistently. Many of those revisions more precisely describe the origins of groundwater contamination for the various plumes.</p> <p>This comment asks ATSDR for specific information about statements made throughout the report regarding some groundwater contamination originating from Precision Concepts. The statements in the PHA about one plume originating from the former Precision Concepts operation that was previously located in the Brookhaven Research and Development Industrial Park are based on sampling performed by SCDHS(SCDHS 1990).</p> |
| 81 | Page 69 discusses EPA's Office of Prevention, | ATSDR appreciates receiving this clarification and has revised the text in question to provide more current information on EPA's ongoing research efforts into |

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| | <p>Pesticides and Toxic Substances Endocrine Disruptor Screening and Testing Advisory Committee. As indicated on EPA's homepage: http://www.epa.gov/scipoly/oscp/endo/edspoverview/edstac.htm, EDSTAC is responsible for selecting chemicals for screening as to potential endocrine effects. This section should clarify that this homepage does provide a method for screening chemicals and there is significant further research needed to identify an endocrine disrupting chemical.</p> | <p>endocrine disruptors in the environment.</p> |
| 82 | <p>The titles should be expanded to provide further details regarding what is being compared. Columns indicating where the comparison values are exceeded should also be included. In addition, Table SD1 indicates "Seasonally" adjusted health based comparisons values and this requires further discussion in</p> | <p>The comment pertains to data summary tables that ATSDR included in Appendix C of the Public Comment Release PHA. Generally, the titles to the data summary tables were selected to describe the environmental medium covered, the general location of measurements (i.e., on-site versus off-site), and the types of contaminants considered. For most of the tables in the appendix, measured environmental contamination levels are compared to health-based comparison values as an initial toxicity screening step.</p> <p>The comment recommends that every data point in the tables note the location where the corresponding sample was collected. While ATSDR agrees that such insights would be worthwhile, inserting this information into every table could not be done with our available resources and would not change the conclusions in this</p> |

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| | <p>the text and footnote. Also one needs to clarify where the maximum concentration was selected for the comparisons. Table B-7 is very difficult to interpret. Text in the title is needed to explain how to review the table and interpret the results.</p> | <p>document. Therefore, ATSDR did not revise the tables in response to this part of the comment.</p> <p>The comment recommends that ATSDR elaborate in a footnote the meaning of “seasonally-adjusted comparison values.” A new footnote has been included in Tables SD1 and SD2 to explain this concept.</p> <p>The comment requests that the tables specifically note when maximum concentrations are shown (as opposed to other values, presumably). ATSDR notes, however, that every table in Appendix C already has column headers that specify the statistic used when presenting environmental data. Examples of the column headers include “concentration range,” “maximum concentration,” “average concentration,” and so on.</p> <p>Finally, the comment notes that Table B7 is difficult to interpret. As the title implies, this table (which spans two pages) presents information on inorganic contamination levels in fish tissue samples from on-site sections of the Peconic River. The different rows in the table pertain to different species and sample types (e.g., flesh, de-headed, and eviscerated samples). As the column headers indicate, data are then presented for the maximum wet weight concentrations detected for different inorganic contaminants (i.e., “As” ‘ arsenic, “Ba” ‘ barium, “Cd” ‘ cadmium, “Cu” ‘ copper, “Pb” ‘ lead, “Mn” ‘ manganese, “Hg” ‘ mercury, “Ni” ‘ nickel, “Ag” ‘ silver, “Zn” ‘ zinc, and “Fe” ‘ iron).</p> |
| 83 | <p>The discussion of the data in Table 1 in the body of the report is very confusing and information from this section should be moved forward to aid the reader in interpreting the results of the analysis.</p> | <p>The comment indicates that the text description of the information in Table 1 is confusing. In response to this issue, which was also raised in Comment #36, ATSDR added two text boxes to this section that prominently feature an overview of the information on the different groundwater contamination plumes. See the response to Comment #36 for more information.</p> |
| 84 | <p>This section requires further</p> | <p>The comment pertains to Appendix E. When ATSDR was first evaluating the site</p> |

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| | clarification and an introduction. What is the purpose of this section and how does it relate to the remainder of the document? | in the late 1990s, the Agency assessed the status of the different Operable Units to inform the ongoing public health assessment activities. Appendix E represents the result of that effort. Readers should view Appendix E as a “snap-shot” of the nature and extent of contamination and planned or ongoing clean-up activities as of the late 1990s, which clearly do not represent current site conditions. ATSDR has inserted a paragraph at the beginning of Appendix E to explain the purpose of this section and why it was originally prepared. |
| 85 | Page 23: An undefined unit of Cg/L is used in the first paragraph. This should probably be mg/L. | Thank you for this correction. The unit in question should have been micrograms per liter (µg/L). This has been corrected in the final PHA. |
| 86 | The report mixes discussions of surface water and recharge basins. On page 34, the section entitled Discharges to Recharge Basins includes a long discussion of the Peconic and Carmans rivers. Recharge basins are not regulated surface waters and should not be discussed in the same context. Recharge basins are considered discharges to groundwater, are regulated by groundwater discharge standards listed in 6 NYCRR Part 703.6, and do not fall under Clean Water Act regulation (i.e., recharge basins | <p>The comment raises two points. First, the comment questions why ATSDR placed information on recharge basins in the discussion of surface water, given that recharge basins are regulated by groundwater discharge standards. While the comment correctly summarizes how environmental regulators might view recharge basins, ATSDR's public health assessment classifies environmental media first by direct exposure potential. Given that recharge basins contain water that an individual might contact, ATSDR has included the discussion of recharge basins under “Surface Water” headings. The text in the PHA does acknowledge (1) that residents have essentially no contact with the on-site recharge basin water and (2) that the recharge basins are a source of contamination to groundwater.</p> <p>Second, the comment notes that text on page 34 of the Public Comment Release PHA appears to be out of order. ATSDR agrees. Specifically, the heading “Discharges to On-Site Recharge Basins” and the paragraph that immediately followed were erroneously placed under the heading of “Off-Site Contamination.” This was an error, given that all of the recharge basins are located on site. ATSDR deleted the heading and paragraph in question.</p> |

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| | are not a Water of the United States). | |

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Appendix H. DOE Stakeholder Letter

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DEPARTMENT OF HEALTH & HUMAN SERVICES

Public Health Service
Agency for Toxic Substances
and Disease Registry

DEC - 8 2005

Dear Stakeholder:

Subject: ATSDR funding for Activities at Department of Energy Sites

As you may know, planned funding for health-related activities at Department of Energy (DOE) sites for fiscal year 2006 is uncertain. As a result, ATSDR cannot continue its full complement of activities at DOE sites. Nonetheless, ATSDR will continue to work toward our goal of protecting public health. To do this, we expect to use carryover funds from fiscal year 2005 to continue work.

ATSDR has developed a modified work plan that will maximize these funds to continue work into 2006. As a result, some previously planned public health activities will not be conducted this fiscal year. Our priority is to make publicly available as many health assessments as possible. In some cases, this means ATSDR will not respond to public comments and peer review. Although we do not know when we will be able to address comments, we encourage you to submit comments on our documents. Your comments are an important part of the public record.

Under this modified plan ATSDR is sharing its findings and recommendations with the community around the Hanford Site. However, these findings and recommendations will remain as drafts until funding is received for staff to address public and peer review comments.

Based on our modified work plan ATSDR plans the following activities for the Hanford Site in fiscal year 2006:

- Release the Hanford public health assessment for public comment,
- Release the birth cohort study for public comment,
- Cooperative agreements for the Hanford tribes will not be funded,
- Meetings of the Inter-tribal Council on Hanford Health Projects (ICHHP) will be cancelled, and
- There will be no support for the Hanford Community Health Project.

As information about funding levels becomes clear, we will inform you of any changes to the work plan.

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Hanford Site- Page 2

ATSDR appreciates that this information may be disappointing, and we share this frustration. We believe this compromise plan is the best way to respond to public health questions from the community. If you have site-specific questions please contact ATSDR; 1-888-42-ATSDR will continue to be a resource for people who need public health information.

Sincerely,

A handwritten signature in black ink, appearing to read 'H. Frumkin', is positioned above the printed name.

Howard Frumkin, M.D., Dr.P.H.
Director, National Center for
Environmental Health/Agency for Toxic
Substances and Disease Registry