6 Natural and Cultural Resources

The Brookhaven National Laboratory Natural Resource Management Program is designed to protect and manage flora and fauna and the ecosystems in which they exist. The Laboratory's natural resource management strategy is based on an understanding of the site's resources and on compliance with applicable regulations. The goals of the program include protecting and monitoring the ecosystem, conducting research, and communicating with staff and the public. BNL focuses on protecting New York State threatened and endangered species, as well as on the Laboratory's role within the greater Long Island Central Pine Barrens ecosystem.

Monitoring to determine whether current or historical activities are affecting natural resources is also part of this program. In 2002, deer and fish sampling results were consistent with previous years. Local farm-grown produce and vegetables grown in the BNL garden plot continue to support historical analyses that there are no Laboratory-generated radionuclides in farm produce.

Completing the second year of operation of the Upton Ecological and Research Reserve (Upton Reserve), its advisory group approved funding for research on the 530-acre area. Multiple research grants to investigate important local ecological issues were awarded.

The BNL Cultural Resource Management program is currently being developed to identify, assess, and document BNL's historic and cultural resources. Additional goals of the program include maintaining compliance with various historic preservation and archeological laws and regulations, and ensuring the availability of identified resources to on-site personnel and the public for research and interpretation. The overriding goal of the Cultural Resource Management Program is to ensure that proper stewardship of BNL/DOE historic resources is established and maintained. In 2002, cultural resource surveys of WW I training trenches and foundations were completed.

6.1 NATURAL RESOURCE MANAGEMENT PROGRAM

The purpose of the Natural Resource Management Program at BNL is to promote stewardship of the natural resources found at the Laboratory, as well as to integrate natural resource protection with BNL's mission. To meet this purpose, the Laboratory has a Wildlife Management Plan that describes the program strategy, elements, and planned activities (Naidu 1999). The plan and related information about natural resources at the Laboratory can be found at the Environmental Services Division website, http://www.bnl.gov/esd/wildlife/.

6.1.1 Identification and Mapping

An understanding of the environmental baseline is the foundation of natural resource management planning. The use of a geographic information systems (GIS) aids the understanding

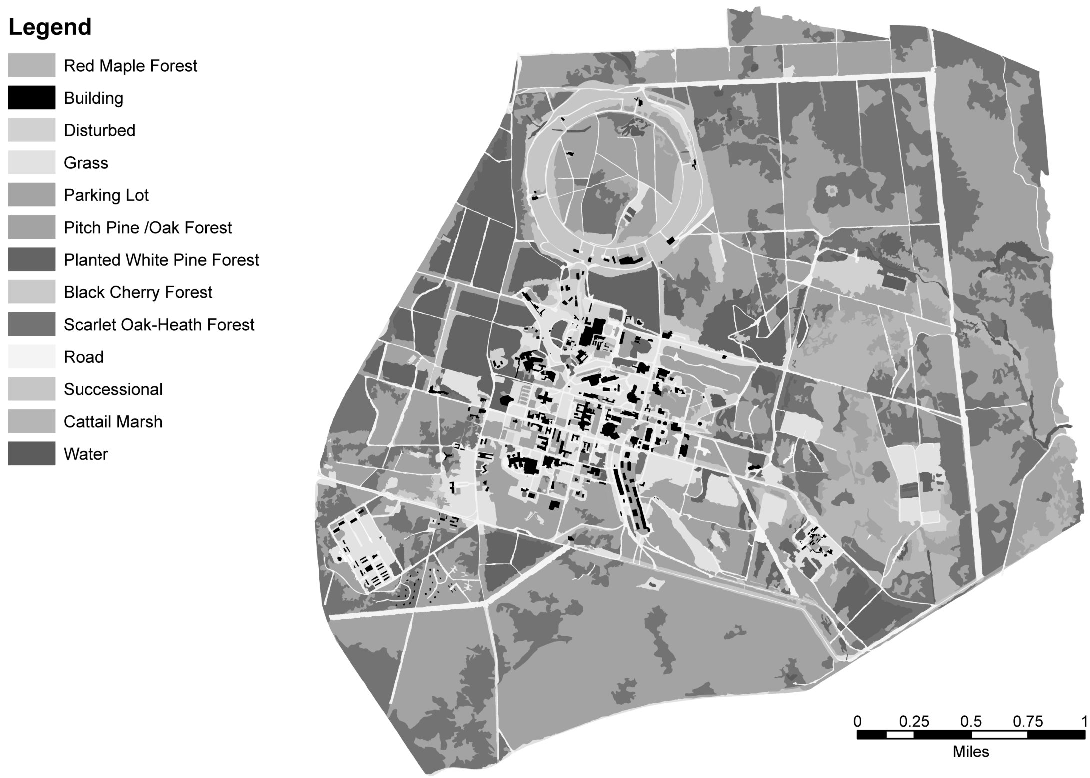

Figure 6-1. Vegetation Map of BNL.

of interactions between varying parts of an ecosystem. In 2001, through funding managed by the U.S. Fish & Wildlife Service (FWS), the entire BNL property was surveyed using the National Vegetation Standard; a new map was produced that clearly identifies the major vegetation complexes and their extents (Figure 6 -1). An additional tool provided with the vegetation map allows the user to predict distributions of key animal species based on the presence of suitable habitat. In addition to the vegetation map, natural resource monitoring activities were added to BNL's GIS system in order to track changes over time and interactions between components of the ecosystem, and to identify the locations of management activities on the 5,265-acre property.

As noted in Chapter 1, a wide variety of vegetation, birds, reptiles, amphibians, and mammals reside at BNL. The only New York State endangered species known to inhabit BNL property is the tiger salamander (*Ambystoma t. tigrinum*). Three New York State threatened species have been positively identified on site and a fourth species is considered likely. The banded sunfish (*Enneacanthus obesus*), the swamp darter (*Etheostoma fusiforme*), and the stiff goldenrod plant (*Solidago rigida*) have been previously reported (BNL 2000). A fourth species, the frosted elfin butterfly (*Callophrys irus*) has been identified as possibly being at BNL, based on historic documentation and the presence of its preferred habitat and host plant (wild lupine). In addition, several species that inhabit the BNL site or visit during migration are listed as "rare," "species of special concern," or "exploitably vulnerable" by New York State (Table 6-1).

6.1.2 Habitat Protection and Enhancement

BNL takes many precautions to protect on-site habitat and natural resources. Activities to eliminate or minimize negative effects on sensitive or critical species are either incorporated into BNL procedures or into specific program or project plans. Environmental restoration efforts remove pollutant sources that could contaminate habitats. Human access to critical habitats is limited. In some cases, habitats are enhanced to improve survival or increase populations. Routine activities that are not expected to affect habitat (such as road maintenance) are not undertaken until they have been duly evaluated.

6.1.2.1 Tiger Salamander Efforts

To safeguard tiger salamander breeding areas, a map of those locations is reviewed when new projects are proposed. Distribution of the map is limited, to protect the tiger salamander from exploitation by collectors and the pet trade. Other efforts to protect this state endangered species include determining when adult salamanders are migrating toward breeding locations, when metamorphosis has been completed, and when juveniles are migrating after metamorphosis. During these times, construction and maintenance activities near tiger salamander habitat are postponed. BNL environmental protection staff must review any project planned near tiger salamander habitat, and every effort is made to minimize impacts.

Water quality testing is conducted as part of the routine monitoring of water basins. In cooperation with the New York State Department of Environmental Conservation (NYSDEC), habitat surveys have been conducted annually since 1999. Biologists conducting egg mass surveys have confirmed that 15 on-site ponds are used by tiger salamanders. Normally all ponds that had egg masses during the spring surveys are surveyed again in June and July to check for the presence of larval salamanders; unfortunately, drought conditions that existed during most of 2002 prevented the development of eggs to larva and larva to adults. Information acquired from surveys is entered into a database and will eventually be linked to a GIS. These data will be used to visualize distributions, track reproductive success, and identify areas for focused management or study.

6.1.2.2 Other Species

As part of the tiger salamander surveys, incidental information is recorded on other amphibian species located in and around the tiger salamander habitat. Other species recorded include the northern redback salamander (*Plethodon c. cinereus*), marbled salamander

Table 6-1. New York State Threatened, Endangered, and Species of Special Concern.

Common Name	Scientific Name	State Status
Insects		
Frosted elfin	*Callophrys iris*	T
Fish		
Banded sunfish	*Enniacanthus obesus*	T
Swamp darter	*Etheostoma fusiforme*	T
Amphibians		
Eastern tiger salamander	*Ambystoma tigrinum tigrinum*	E
Marbled salamander	*Ambystoma opacum*	SC
Reptiles		
Spotted turtle	*Clemmys guttata*	SC
Eastern box turtle	*Terrapene carolina*	SC
Eastern hognose snake	*Heterodon platyrhinos*	SC
Birds (nesting or common)		
Horned lark	*Eremophila alpestris*	SC
Whip-poor-will	*Caprimulgus vociferus*	SC
Vesper sparrow	*Pooecetes gramineus*	SC
Grasshopper sparrow	*Ammodramus savannarum*	SC
Plants		
Butterfly weed	*Asclepias tuberosa*	V
Spotted wintergreen	*Chimaphila maculata*	V
Flowering dogwood	*Cornus florida*	V
Pink lady's slipper	*Cypripedium acaule*	V
Winterberry	*Ilex verticillata*	V
Sheep laurel	*Kalmia angustifolia*	V
Narrow-leafed bush clover	*Lespedeza augustifolia*	R
Ground pine	*Lycopodium obscurum*	V
Bayberry	*Myrica pensylvanica*	V
Cinnamon fern	*Osmunda cinnamomera*	V
Clayton's fern	*Osmunda claytoniana*	V
Royal fern	*Osmunda regalis*	V
Swamp azalea	*Rhododendron viscosum*	V
Stiff goldenrod	*Solidago rigida*	T
New York fern	*Thelypteris novaboracensis*	V
Marsh fern	*Thelypteris palustris*	V
Virginia chain-fern	*Woodwardia virginica*	V

Notes:
Table information is based on 6 NYCRR Part 182, 6 NYCRR Part 193, and BNL survey data.
No federally listed threatened or endangered species are known to inhabit the BNL site.
E = Endangered
R = Rare
SC = Species of special concern
T = Threatened
V = Exploitably vulnerable

(*Ambystoma opacum*), spring peeper (*Pseudacris crucifer*), wood frog (*Rana sylvatica*), gray tree frog (*Hyla versicolor*), bullfrog (*Rana catesbiana*), green frog (*Rana clamitans*), and Fowler's toad (*Bufo fowleri*).

Banded sunfish protection efforts include ensuring that adequate flow of the river is maintained within areas currently identified as sunfish habitat, ensuring that existing vegetation in the sunfish habitat is not disturbed, and evaluating all river remediation efforts for potential impacts on these habitats. River surveys in 2002 identified a single banded sunfish east of monitoring station HM-N. In an attempt to rescue banded sunfish and swamp darters from severe drought conditions, a large coastal plain pond was seined to remove the remaining fish. Of the fish rescued, only six banded sunfish survived. The rescued fish were kept by fisheries experts at the Cold Spring Harbor Museum and Fish Hatchery in Cold Spring Harbor, New York and were to be released when the pond filled with water.

BNL's Wildlife Management Plan also calls for habitat enhancement. A total of 216 species of birds have been identified at BNL since 1948, of which at least 85 are known to nest on site. Some of these nesting birds have shown declines in their populations nationwide over the past 30 years. The Laboratory conducts routine monitoring of songbirds along six permanent bird survey routes in various habitats on site. A sixth route was established, in 2002, within the Upton Reserve, in order to gain data on that parcel of land. Monthly surveys were conducted, starting at the end of March and extending to the end of October. The surveys in 2002 resulted in the identification of 73 species during the year. Of those species, seven species were seen that had not been counted on previous surveys, resulting in a total of 100 species having been identified during surveys in the past three years; 48 of these species were present each year. Variations in the number and species make-up identified may simply be an artifact of the time of sampling, variations in weather patterns between years, or actual changes in the environment. The two most diverse transects pass near wetlands by the Biology Fields and the Peconic River. The four transects passing through the various forest types (white pine, moist pine barrens, and dry pine barrens) showed a less diverse bird community. Data are stored in an electronic database that is linked to BNL's GIS.

The eastern bluebird (*Sialia sialis*) has been identified as one of the declining species of migratory birds in North America. This decline is due to loss of habitat and to nest site competition from European starlings (*Sturnus vulgaris*) and house sparrows (*Passer domesticus*). In 2002, BNL installed additional bluebird boxes around the RHIC ring, bringing the total to 46 boxes around open grassland areas of the site to enhance the bluebird population. Boxes were monitored approximately every three weeks during the breeding season to determine use and nesting success. Nineteen bluebird nests were observed. Other birds using the houses included house wrens (*Troglodytes aedon*) (12 nests), black-capped chickadees (*Poecile atricapilla*) (two nests), and tree swallows (*Tachycineta bicolor*) (four nests).

6.1.3 Population Management

BNL also monitors and manages other populations, including "species of interest," to ensure that they are sustained and to control invasive species.

6.1.3.1 Wild Turkeys

The wild turkeys (*Meleagris gallopavo*) on site are doing well. The forested areas of BNL provide good nesting and foraging habitat for this large bird. The on-site population was estimated at 60 to 80 birds in 1999 and had grown to around 250 birds by the end of 2001. Due to drought conditions the population dropped to around 175 birds by the end of 2002. This drop appeared to be more a result of dispersal than to starvation or lack of water. Updated population reports are periodically sent to NYSDEC to assist with their population estimates. At year's end, NYSDEC was planning to transfer some of the turkeys at BNL to other localities on Long Island to better establish the population. BNL will continue to monitor the turkey population and cooperate with NYSDEC to ensure the turkeys' success at BNL and on Long Island.

6.1.3.2 White-Tailed Deer

BNL consistently updates information on the resident population of white-tailed deer (*Odocoileus virginianus*). As there are no natural predators on site and hunting is not permitted at BNL, there are no significant pressures on the population to migrate beyond their typical home range of approximately one square mile. A 1992 study indicated that the population of deer on site exceeded 700, or approximately 85 per square mile (Thomlinson 1993). Normally, a population density of 10 to 30 per square mile is considered an optimum sustainable level for a given area. This would equate to approximately 80 to 250 deer inhabiting the BNL property under normal circumstances. This was the approximate density in 1966, when the Laboratory reported an estimate of 267 deer on site (Dwyer 1966). The current estimate, based on surveys conducted late in 2002, is 1,100 deer, or approximately 135 deer per square mile.

The deer surveys are conducted three times per year: mid-spring before fawns are born, late summer after all fawns are born, and late fall. These surveys track reproductive success and mortality. In 2002, spring surveys indicated a population of 1,169 animals. Late summer surveys estimated 1,606 animals, for a 37 percent increase in the population over the previous year. By early winter, the population estimate was 1,100 animals. This indicated a decline of nearly 32 percent, which could not be supported by evidence of dead animals. The survey methods depend on good weather for accurate counts. Toward the end of 2002, the drought had ended and a pattern of cold wet weather consistently prevented accurate surveys. The actual year-end population was likely somewhat higher than the 1,100 deer recorded, but lower than the 1,606 deer recorded in the summer surveys (Dyer 2002).

Deer overpopulation can affect animal and human health (e.g., animal starvation, Lyme disease from deer ticks, collision injuries—both human and animal), species diversity (songbird species reduction due to selective grazing and destruction of habitat by deer), and property values (auto damage, browsing damage to ornamental plantings). In 2002, there were 20 deer-related collisions on site, compared to the eight accidents documented in 2001. This dramatic increase in the number of on-site collisions is attributed to increasing populations. Deer health appeared to be affected due to drought conditions reducing the summer and fall food sources. Deer damage to vegetation around buildings was much less during the winter of 2001–2002, due to mild temperatures and little snow cover. However, damage from deer browse the previous winter was still evident on much of the ornamental vegetation around the Laboratory. Although damage to shrubbery is not a threat to human health, it is undesirable because it may result in the need to replace shrubs, at substantial cost.

BNL submitted National Environmental Policy Act (NEPA) documentation for deer management to DOE for review and approval in October 2001. The preparation of an environmental assessment was delayed in 2002 because another agency was creating a document to cover the entire state of New York. At year's end this document had not been completed, but once it has been, BNL can adopt the document, prepare site-specific information, and finalize the findings based on local data and input. Since management of a large deer population is controversial, BNL continues to carefully consider options and continues to work with NYSDEC to develop options.

6.1.4 Compliance Assurance and Potential Impact Assessment

The NEPA review process at BNL is one of the keys to ensuring that environmental impacts of a proposed action or activity are adequately evaluated and addressed. BNL will continue to use NEPA (or NEPA-like) values under the Comprehensive Environmental Response, Compensation and Liability Act (Environmental Restoration Program) when identifying potential environmental impacts associated with site activities—especially with physical alterations. As appropriate, stakeholders such as the U.S. Environmental Protection Agency (EPA), NYSDEC, Suffolk County Department of Health Services, The Nature Conservancy, the Town of Brookhaven, the Community Advisory Council, and local environmental advocacy groups are involved in reviewing major projects that have potentially significant environmental impacts.

6.2 UPTON ECOLOGICAL AND RESEARCH RESERVE

On November 9, 2000, then-Secretary of Energy Bill Richardson, and Susan MacMahon, Acting Regional Director of Region 5 U.S. Fish & Wildlife Service, dedicated 530 acres of Laboratory property as an ecological research reserve. The property was designated by the Department of Energy as the Upton Ecological and Research Reserve (Upton Reserve) and is managed by FWS under an Interagency Agreement (DOE–FWS 2000). Additional information on the establishment of the Upton Reserve and accomplishments during 2002 is available on the Internet at http://www.bnl.gov/esd/reserve/default.htm. The Upton Reserve, near the eastern boundary of BNL (Figure 6-2), is home to a wide variety of flora and fauna. It contains wetlands and is largely within the core preservation area of the Long Island Central Pine Barrens. Based on information from the 1994–1995 biological survey of BNL, experts believe the reserve is home to more than 200 plant species and at least 162 species of mammals, birds, fish, reptiles, and amphibians (LMS 1995).

In establishing the Upton Reserve, DOE committed to provide FWS with $1 million over a five-year period, to manage the reserve. In 2001, the first full year of the reserve's existence, FWS hired two biologists, formally established the boundary, and posted the area. During 2002, the staff conducted baseline biological survey work, initiated basic research, and funded educational programs in conjunction with BNL, Suffolk County Community College, and Longwood High School.

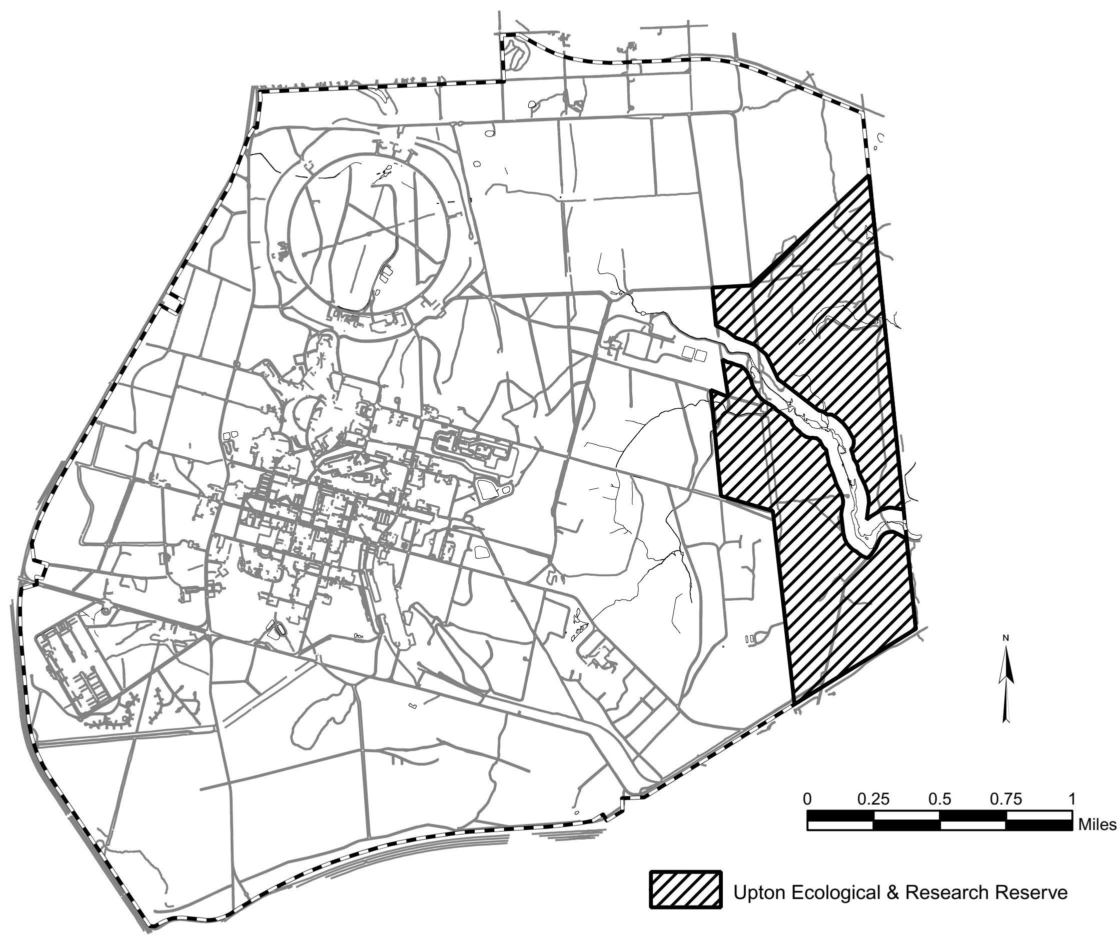

Figure 6-2. BNL Site Map Indicating the Boundary of the Upton Ecological and Research Reserve.

The Interagency Agreement that established the Upton Reserve specified the formation of a Technical Advisory Group (TAG), which includes the reserve's supervisory FWS biologist and representatives from NYSDEC, Suffolk County Parks Department, Central Pine Barrens Joint Policy and Planning Commission, DOE, BNL's Citizens Advisory Council, Brookhaven Executive Roundtable, Brookhaven Science Associates, and The Nature Conservancy. The TAG's primary responsibility is to provide technical input into the development of a comprehensive natural resource management plan for both BNL and the Upton Reserve. This plan will eventually replace the existing Wildlife Management Plan. The TAG also has developed criteria for soliciting and reviewing proposals and awarding funds for research to be conducted within the Upton Reserve. The TAG has approved research proposals that include an assessment of the effects of prescribed fire on the survival of orange-striped oakmoth (*Anisota senatoria*) pupae, and a project to investigate why some vines are more invasive than others. Preliminary results of one previously funded research project on the physiological effects of fall defoliation by the orange-striped oakmoth caterpillar were presented at the annual Pine Barrens Research Forum held at BNL in October.

Additionally, education programs funded by the Upton Reserve began investigating the effects of deer browse on forest health. Five deer exclosures (10 ft. x 50 ft. fenced areas) were established to keep deer out of specific areas. Baseline data for vegetation growth and spatial coverage was acquired both inside each fenced area and at a comparable reference site outside each fence. Annual visitation and measurement at these locations will build the needed base of information to document the effects of deer browse as well as the effectiveness of deer management once it is implemented at the Laboratory. Students from Longwood High School took on the task of monitoring gypsy moth (*Lymantria dispar*) egg mass distributions within the Upton Reserve. The gypsy moth has historically caused moderate to severe damage to oak trees, due to spring defoliation. The information gained from this study will assist the U.S. Forest Service in determining potential management activities that may be conducted in 2003. The information is important to the Upton Reserve and BNL, due to the coupled effects of spring defoliation by the gypsy moth and late season defoliation by the orange-striped oak moth caterpillar. This double defoliation, if it occurs year after year, can result in tree death; large sections of oak forest at BNL might be lost.

Management activities of the Upton Reserve included mapping trails, assisting with bird and deer surveys, educating and involving the public, managing fire prevention and suppression measures, and coordinating researcher access and training requirements. FWS also coordinated two aerial surveys by the U.S. Forest Service to document damage to oak trees by the gypsy moth in the spring and the oak moth in the fall. The surveys, along with monitoring, will document the long-term effects of defoliation on forest health.

6.3 MONITORING FLORA AND FAUNA

BNL conducts routine monitoring of flora and fauna to determine the impact of past and present Laboratory activities. Because soils contaminated with cesium-137, a radioactive isotope of cesium, were used in some BNL landscaping projects at some point in the past, traces of contamination are found in deer and possibly in other animals and plants. Most radionuclide tables in this chapter list both potassium-40 (a naturally occurring isotope of potassium) and cesium-137 data. Potassium-40 occurs naturally in the environment and is not uncommon in flora and fauna. It is presented as a comparison to cesium-137, because cesium-137 competes with potassium at a cellular level. General trends indicate that cesium-137 will outcompete potassium when potassium salts are limited in the environment, which is the typical case on Long Island. In general, potassium-40 values do not receive significant discussion in the scientific literature due to this relationship and the fact that potassium-40 occurs naturally. The paragraphs below describe the results of the annual sampling conducted under the flora and fauna monitoring program.

6.3.1 Deer Sampling

Deer in New York State typically are large, with males weighing, on average, about 150 pounds; females typically weigh one-third less, about 100 pounds. However, deer on Long Island tend to be much smaller, weighing an average of 80 pounds. The available meat on local deer ranges from 20 to 40 pounds per deer. This fact has implications for calculations of radiation dose from the consumption of deer meat containing cesium-137.

In 2002, as in recent years, an off-site deer sampling program was conducted with the NYSDEC Wildlife Branch and FWS. NYSDEC samples provide data on deer moving beyond BNL boundaries, where they can be legally hunted, and also provides control data on deer living far from BNL. Also, FWS informed BNL staff of deer killed in or near the Wertheim National Wildlife Refuge and other FWS properties on Long Island. BNL sampling technicians then collected the samples and processed them for analysis. Samples were also obtained from road kill on and near BNL, and hunter donations were obtained from Laboratory employees. The total number of samples obtained near the BNL site increased from past years, due to a larger number of deer–vehicle accidents that occurred on and off site; hunter donations remained the same as in past years. In all, 21 deer were obtained on site and 43 were from off-site locations, ranging from adjacent to BNL along the William Floyd Parkway, to as far away as East Islip, New York.

6.3.1.1 Cesium-137 in Deer

It has been previously established (BNL 2000) that deer sampled on the BNL site contain higher concentrations of cesium-137 (half-life = 30 years) than deer from off site. This is most likely the result of deer consuming contaminated soil and grazing on vegetation growing in soil where elevated cesium-137 levels are known to exist. Cesium-137 in soil can be transferred to aboveground plant matter via root uptake, where it then becomes available to browsing animals.

Removal of contaminated soil areas at BNL has occurred under the site Environmental Restoration Program. All major areas of contamination in lawn soils were remediated in 2000. Some soil contamination is still present in areas that are part of Operable Units (OU) I/VI and V. The cleanup of areas covered by the *Record of Decision for Operable Units I and Radiologically Contaminated Soils* (BNL 1999) is scheduled and will be completed as funds are available. Cleanup of one of the two remaining contaminated soil areas under the OU I/VI actions was completed in 2002, leaving only the Former Waste Management Facility still to be cleaned up. A Record of Decision for the Sewage Treatment Plant, a part of OU V, was signed in 2001; cleanup there began in 2002 and is scheduled for completion in 2003.

The number of deer taken for sampling has steadily increased since 1996. In 1998, a statistical analysis based on existing data suggested that 40 deer from off site and 25 deer from BNL locations were needed to achieve a statistically sound data set. Since that analysis was completed, BNL has attempted to obtain the required number of deer. The number taken each year has varied, due to the sampling method that depends on vehicle/deer accidents and people reporting dead deer on the side of the roads. The number of deer hit by cars varies widely from year to year, depending on the population of deer present near major roadways. Figure 6-3 shows the location of all deer samples taken within a 5-mile radius of BNL since 1992. The majority of the off-site samples are concentrated along the William Floyd Parkway on the west boundary of BNL, while the on-site concentration is near the front gate area and the constructed portions of BNL. This distribution is due largely to the fact that people see dead deer on the way to work and report them. Deer are hit on site primarily early or late in the day, when they are more active.

In 2002, cesium-137 concentrations in deer meat samples taken at BNL ranged from 0.01 to 4.95 pCi/g wet weight. (The "wet weight" concentration is before a sample is dried for analysis, and is the form most likely to be consumed. Dry weight concentrations are typically higher than wet weight values.) The maximum 2002 on-site concentration (4.95 pCi/g wet weight) is slightly higher than the highest

Figure 6-3. Distribution of Deer Samples 1992–2002.

level reported in 2001 (4.31 pCi/g wet weight) but much lower than the highest level ever reported (11.74 pCi/g wet weight, in 1996). In 2001, the maximum off-site concentration of cesium-137 in deer meat samples was 10.56 pCi/g wet weight from a road-kill deer provided by NYSDEC (see below for a discussion of high off-site values). The arithmetic average concentration in on-site meat samples was 1.05 pCi/g. The average concentration in off-site meat samples was 1.22 pCi/g wet weight.

Cesium-137 concentrations in off-site deer meat samples were separated into two groups: samples taken within one mile of BNL and samples taken farther away (see Table 6-2). Concentrations in meat samples nearby range from 0.06 to 10.56 pCi/g wet weight, with an average of 2.07 pCi/g wet weight; concentrations in meat taken from farther away ranged from 0.02 to 3.48 pCi/g wet weight, with an average of 0.60 pCi/g wet weight.

Figure 6-4 compares the average values of cesium-137 concentrations in meat samples collected in 2002 from four different location groupings. Although the figure does not show this, the majority of all samples taken both on and off site are at or below 1 pCi/g wet weight (see Table 6-2).

Figure 6-5 presents the five-year trend of on-site and near off-site cesium-137 averages in deer meat. Although there is no statistical difference between the values across the five years, there is a statistical difference between values in 2000 (when landscape soils were cleaned up) and values in 2002. There is an overall downward trend in cesium-137 found in deer sampled on and around the Laboratory.

When possible, liver samples are taken concurrently with meat samples. Liver generally accumulates cesium-137 at a lower rate than muscle tissue (meat). The lower values in liver allow the results to be used somewhat as a validity check for meat values (i.e., if liver values are higher than meat values, results should be confirmed). In liver samples collected on site, the range of cesium-137 concentrations was 0.02 to 1.12 pCi/g wet weight, with an average of 0.30 pCi/g wet weight. The off-site cesium-137 concentration in liver ranged from nondetectable to 1.81 pCi/g wet weight, with an average for all off-site liver samples being 0.24 pCi/g wet weight.

The potential radiological dose resulting from deer meat consumption is discussed in Chapter 8. The New York State Department of Health (NYSDOH) has formally considered the potential public health risk associated with elevated cesium-137 levels in on-site deer and determined that neither hunting restrictions nor formal health advisories are warranted (NYSDOH 1999). Their report may be accessed at http://www.bnl.gov/esd/wildlife/deer_issues.htm.

With respect to the health of the on-site deer based on their exposure to radionuclides, the International Atomic Energy Agency (IAEA) has concluded that chronic dose rates of 100 millirad per day to even the most radiosensitive species in terrestrial ecosystems are unlikely to cause detrimental effects in animal populations (IAEA 1992). A deer containing a uniform distribution of cesium-137 at the highest levels observed to date (11.74 pCi/g wet weight, reported in 1996) would carry a total body burden of about 0.2 µCi. Under these conditions, an animal would receive an absorbed dose of approximately 3 millirad per day, which is only 3 percent of the threshold evaluated by the IAEA. The deer observed and sampled on site appear to have no health effects from the level of cesium-137 found in their tissues, although the general health of the herd is not optimal because of overpopulation.

6.3.1.2 Unusual Cesium-137 Results in Deer Meat

Two deer taken along William Floyd Parkway on the west boundary of BNL had levels of cesium-137 of 8.28 and 10.56 pCi/g wet weight. Both of these values are statistical outliers with levels of cesium-137 likely from limited access to a single location of contaminated soil at BNL. Therefore, these two values are not considered in the dose assessment prepared for discussion in Chapter 8. The deer with the 8.28 pCi/g wet weight value was originally analyzed at BNL with a value of 21 pCi/g wet weight, which was twice as high as any value previously seen in the monitoring

Table 6-2. Radiological Analysis of Deer Tissue.

Sample Location	Collection Date	Tissue	K-40 pCi/g, Wet Wt.	Cs-137 pCi/g, Wet Wt.	Sr-90 pCi/g, Dry Wt.
BNL					
Outer RHIC Rd., south of Bldg. 1006	1/9/02	Flesh	3.37 ± 0.77	1.78 ± 0.34	
		Liver	1.79 ± 0.33	0.30 ± 0.05	
		Bone			3.32 ± 0.49
Inside Main Gate	1/14/02	Flesh	3.55 ± 0.88	4.95 ± 0.91	
		Bone			2.27 ± 0.47
Child Development area	2/8/02	Flesh*	2.81 ± 0.44	2.78 ± 0.43	
		Bone			2.68 ± 0.54
Water Treatment Plant	2/8/02	Flesh	2.07 ± 0.36	0.28 ± 0.05	
		Liver	2.19 ± 0.39	0.05 ± 0.01	
		Bone*			0.91 ± 0.39
Old settling pond west of Station EA	2/26/02	Flesh	2.72 ± 0.28	0.51 ± 0.05	
		Liver	2.37 ± 0.37	0.43 ± 0.05	
		Bone			5.88 ± 0.34
North side of RHIC Ring	4/9/02	Flesh	3.13 ± 0.34	0.03 ± 0.01	
		Bone			0.70 ± 0.14
East Fifth Ave., west of Bldg. 930	4/11/02	Flesh	2.67 ± 0.29	0.01 ± 0.01	
		Bone			1.88 ± 0.41
RHIC Ring, Bldg. 1004	5/2/02	Flesh	2.99 ± 0.33	0.26 ± 0.03	
		Liver	2.10 ± 0.51	0.11 ± 0.03	
		Bone			2.12 ± 0.28
Upton Rd. at Bldg. 50	5/31/02	Flesh	2.93 ± 0.41	0.15 ± 0.02	
		Liver	2.32 ± 0.25	0.07 ± 0.01	
		Bone			1.08 ± 0.29
Bldg. 1002 outside RHIC Ring	6/18/02	Flesh	3.36 ± 0.35	1.02 ± 0.08	
		Liver	2.32 ± 0.30	1.12 ± 0.10	
		Bone			9.17 ± 0.75
Main Gate, outbound, 100 ft. east of guard booth	7/10/02	Flesh	3.03 ± 0.49	0.05 ± 0.03	
		Bone			3.54 ± 0.43
By Bldg. T96	7/26/02	Flesh	3.00 ± 0.35	0.08 ± 0.02	
		Liver	1.89 ± 0.27	0.08 ± 0.01	
		Bone			2.31 ± 0.37
50 ft. east of Main Gate	8/1/02	Flesh	3.35 ± 0.37	0.13 ± 0.01	
		Liver	3.21 ± 0.45	0.04 ± 0.01	
		Bone			1.75 ± 0.35
100 ft. south of Bldg. 1004, outer RHIC Rd.	8/2/02	Flesh	3.13 ± 0.30	0.21 ± 0.03	
		Liver	3.02 ± 0.88	ND	
		Bone			3.97 ± 0.46
West of Bldg. 600	8/15/02	Flesh	2.82 ± 0.56	0.09 ± 0.03	
		Liver	2.81 ± 0.37	0.02 ± 0.01	
		Bone			1.71 ± 0.32
South of Bldg. 1004, outside RHIC Ring	9/13/02	Flesh	2.77 ± 0.30	0.15 ± 0.02	
		Bone			2.62 ± 0.43
North Gate access road	10/30/02	Flesh	3.28 ± 0.34	3.93 ± 0.49	
		Liver	2.78 ± 0.40	0.83 ± 0.10	
		Bone			1.62 ± 0.22
BERA ballfield driveway by fields 1 & 2	11/1/02	Flesh	3.79 ± 0.39	1.09 ± 0.09	
		Liver	2.00 ± 0.25	0.33 ± 0.03	
		Bone			1.44 ± 0.24

* Average of multiple analyses of tissue from same deer; errors are propogated from individual sample errors.

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Table 6-2. Radiological Analysis of Deer Tissue *(continued)***.**

Sample Location	Collection Date	Tissue	K-40 pCi/g, Wet Wt.	Cs-137 pCi/g, Wet Wt.	Sr-90 pCi/g, Dry Wt.
100 ft. west of Main Gate outbound lane	11/20/02	Flesh	3.16 ± 0.34	1.55 ± 0.12	
		Liver	2.33 ± 0.28	0.44 ± 0.04	
		Bone			1.13 ± 0.24
West of Bldg. 1008, inside RHIC Ring Rd.	11/26/02	Flesh	3.07 ± 0.33	1.69 ± 0.21	
		Liver	2.66 ± 0.37	0.37 ± 0.05	
		Bone			2.74 ± 0.49
South Gate access road	12/16/02	Flesh*	3.50 ± 0.36	1.40 ± 0.14	
		Liver	1.92 ± 0.23	0.30 ± 0.04	
		Bone			2.47 ± 0.45
Off Site < 1 mile					
Near Brookhaven—donated by hunter	11/24/01	Flesh	1.58 ± 0.29	1.98 ± 0.34	
		Bone			2.72 ± 0.23
Ridge/Brookhaven—donated by hunter	11/13/01	Liver	2.09 ± 0.37	1.81 ± 0.30	
		Heart	2.42 ± 0.44	5.00 ± 0.87	
Wm. Floyd Prkwy. east of Colonial Pines	12/15/01	Flesh*	2.53 ± 0.04	10.6 ± 1.5	
Wm. Floyd Prkwy. south of Whispering Pines	1/9/02	Flesh*	2.00 ± 0.34	8.28 ± 0.71	
		Bone			3.46 ± 0.52
Rte. 25 just west of Wm. Floyd Prkwy.	1/25/02	Flesh	2.25 ± 0.60	0.60 ± 0.13	
Rte. 25 east of Firefighters' Museum in Ridge	1/29/02	Flesh	2.56 ± 0.44	2.87 ± 0.48	
Wm. Floyd Prkwy. near North Gate	2/22/02	Flesh	2.29 ± 0.41	1.24 ± 0.21	
		Liver	2.19 ± 0.39	0.36 ± 0.07	
		Bone			4.58 ± 0.37
Wm. Floyd Prkwy. just north of Main Gate	2/26/02	Flesh	3.25 ± 0.54	2.06 ± 0.23	
		Liver	2.51 ± 0.86	0.52 ± 0.11	
		Bone			3.56 ± 0.30
Wm. Floyd Prkwy. North Gate exit ramp	2/27/02	Flesh	3.14 ± 0.35	0.67 ± 0.05	
		Liver	1.95 ± 0.32	0.16 ± 0.02	
		Bone			2.44 ± 0.30
Wm. Floyd Prkwy. half-mile north of LIE	3/15/02	Flesh*	3.01 ± 0.46	1.26 ± 0.19	
		Liver	2.52 ± 0.37	0.33 ± 0.04	
		Bone			3.3 ± 0.4
Rte. 25 west of Wm. Floyd Prkwy.	5/22/02	Flesh	2.65 ± 0.37	0.06 ± 0.01	
		Bone			2.11 ± 0.37
Wm. Floyd Prkwy. just north of Colonial Pines	5/29/02	Flesh	2.70 ± 0.47	0.28 ± 0.05	
		Bone			2.15 ± 0.40
Wm. Floyd Prkwy. half-mile north of Main Gate	6/6/02	Flesh*	3.42 ± 0.40	0.49 ± 0.06	
		Liver	1.89 ± 0.22	0.21 ± 0.03	
		Bone			3.94 ± 0.49
LIE westbound service road at BNL South Gate	6/20/02	Flesh	2.96 ± 0.60	0.08 ± 0.03	
		Liver	2.59 ± 0.36	0.05 ± 0.01	
		Bone			2.86 ± 0.53
Longwood Rd. half-mile west of Main Gate	8/26/02	Flesh	3.66 ± 0.43	0.11 ± 0.01	
		Liver	2.12 ± 0.32	0.04 ± 0.01	
		Bone			5.39 ± 0.51
Rte. 25 west of Randall Rd. in Ridge	10/23/02	Flesh	3.13 ± 0.30	1.07 ± 0.13	
		Liver	2.77 ± 0.92	0.24 ± 0.09	
		Bone			5.86 ± 0.73
Wm. Floyd Prkwy. south of Whispering Pines	10/25/02	Flesh	2.99 ± 0.41	2.77 ± 0.28	
		Liver	2.35 ± 0.25	0.69 ± 0.08	
		Bone			1.61 ± 0.23

* Average of multiple analyses of tissue from same deer; errors are propogated from individual sample errors.

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Table 6-2. Radiological Analysis of Deer Tissue *(continued)*.

Sample Location	Collection Date	Tissue	K-40 pCi/g, Wet Wt.	Cs-137 pCi/g, Wet Wt.	Sr-90 pCi/g, Dry Wt.
LIE just west of Exit 68	11/1/02	Flesh	3.39 ± 0.54	0.85 ± 0.10	
		Bone			1.81 ± 0.31
Off Site > 1 mile					
Calverton east of Grumman—donation by hunter	1/7/02	Flesh*	1.48 ± 0.28	0.21 ± 0.04	
		Liver	2.43 ± 0.42	0.06 ± 0.01	
		Heart	2.07 ± 0.40	0.12 ± 0.02	
		Bone			1.71 ± 0.32
		Bone			2.68 ± 0.54
Seatuck Wildlife Preserve Deer Cull Deer 1	1/9/02	Flesh	2.45 ± 0.54	0.02 ± 0.01	
		Liver	2.12 ± 0.37	0.01 ± 0.01	
		Bone			1.26 ± 0.32
Seatuck Wildlife Preserve Deer Cull Deer 2	1/9/02	Flesh	2.23 ± 0.40	0.13 ± 0.02	
		Liver	2.02 ± 0.37	0.04 ± 0.01	
		Bone			1.77 ± 0.41
Seatuck Wildlife Preserve Deer Cull Deer 3	1/9/02	Flesh*	2.72 ± 0.46	0.15 ± 0.03	
		Liver	5.24 ± 2.65	ND	
		Bone			0.9 ± 0.3
Seatuck Wildlife Preserve Deer Cull Deer 4	1/9/02	Flesh	3.15 ± 0.78	0.08 ± 0.04	
		Liver	2.32 ± 0.41	0.01 ± 0.01	
		Bone			1.41 ± 0.43
Seatuck Wildlife Preserve Deer Cull Deer 5	1/9/02	Flesh	2.68 ± 0.45	0.07 ± 0.01	
		Liver	1.44 ± 0.28	0.02 ± 0.01	
		Bone			0.89 ± 0.28
Seatuck Wildlife Preserve Deer Cull Deer 6	1/9/02	Flesh*	2.90 ± 0.49	0.06 ± 0.01	
		Liver	1.82 ± 0.43	0.02 ± 0.01	
		Bone			0.92 ± 0.39
Seatuck Wildlife Preserve Deer Cull Deer 7	1/9/02	Flesh	2.34 ± 0.40	0.04 ± 0.01	
		Liver	4.2 ± 1.4	ND	
		Bone			1.57 ± 0.40
Seatuck Wildlife Preserve Deer Cull Deer 8	1/9/02	Flesh	3.42 ± 0.77	0.11 ± 0.03	
		Liver	1.92 ± 0.35	0.02 ± 0.01	
		Bone			2.03 ± 0.37
Donation J. McGovern DEC Area #27	1/14/02	Flesh*	2.23 ± 0.26	3.02 ± 0.31	
Seatuck Deer Cull	1/23/02	Flesh	2.05 ± 0.38	0.02 ± 0.01	
		Liver	2.26 ± 0.40	ND	
		Bone			1.54 ± 0.36
Smith Rd. and Ranch Dr., Shirley	2/4/02	Flesh	2.41 ± 0.41	1.01 ± 0.17	
		Liver	1.87 ± 0.46	0.18 ± 0.05	
		Bone			0.68 ± 0.52
Smith Rd., Shirley	2/8/02	Flesh	5.1 ± 1.1	0.65 ± 0.15	
		Liver	3.21 ± 0.75	0.19 ± 0.05	
		Bone			1.01 ± 0.29
Seatuck Deer Cull	2/8/02	Flesh	2.50 ± 0.71	0.10 ± 0.04	
		Liver	ND	ND	
		Bone			0.9 ± 0.3
Seatuck Deer Cull Buck	2/12/02	Flesh	2.50 ± 0.42	0.03 ± 0.01	
		Liver	4.1 ± 1.1	ND	
		Bone			1.33 ± 0.32
Seatuck Deer Cull Doe	2/12/02	Flesh	2.80 ± 0.71	0.04 ± 0.02	
		Liver	2.24 ± 0.40	0.02 ± 0.01	
		Bone			1.57 ± 0.40

* Average of multiple analyses of tissue from same deer; errors are propogated from individual sample errors.

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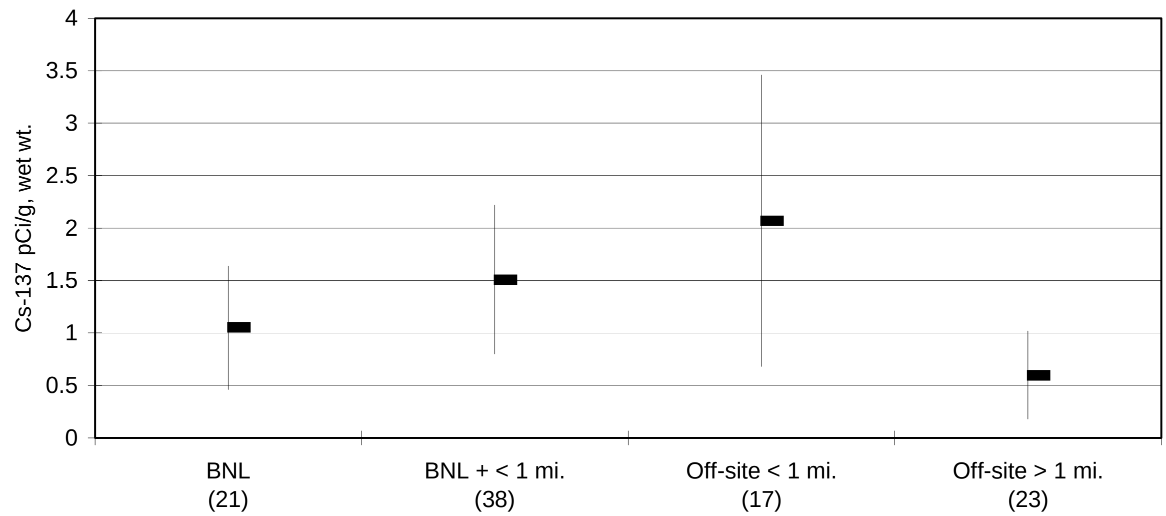
Table 6-2. Radiological Analysis of Deer Tissue *(concluded)*.

Sample Location	Collection Date	Tissue	K-40 pCi/g, Wet Wt.	Cs-137 pCi/g, Wet Wt.	Sr-90 pCi/g, Dry Wt.
Rte. 25, Calverton National Cemetery	2/19/02	Flesh	2.30 ± 0.40	0.46 ± 0.08	
		Bone			1.53 ± 0.20
Carmen's View Drive, Shirley	3/14/02	Flesh	2.22 ± 0.81	0.22 ± 0.05	
		Liver	2.26 ± 0.25	0.14 ± 0.02	
		Bone			1.7 ± 0.3
Wading River Rd. at Pine Hills entrance	3/17/02	Flesh	2.65 ± 0.50	0.53 ± 0.08	
		Bone			2.91 ± 0.50
LIE quarter-mile west of Exit 69	3/20/02	Flesh	3.25 ± 0.43	0.07 ± 0.01	
		Liver	2.27 ± 0.25	0.02 ± 0.01	
		Bone			1.7 ± 0.3
Entrance to Wertheim	5/22/02	Bone			<MDL
Barns Rd. half-mile south of Moriches—Middle Is. Rd.	8/20/02	Flesh	3.07 ± 0.41	0.37 ± 0.04	
		Liver	3.03 ± 0.35	0.16 ± 0.02	
		Bone			3.95 ± 0.51
Rte. 25, quarter-mile east of Woodlot Rd.	10/9/02	Flesh*	2.94 ± 0.33	2.90 ± 0.25	
		Liver	2.06 ± 0.26	0.95 ± 0.12	
		Bone			2.71 ± 0.45
West of Yaphank Rd., north of Sunrise Hwy	11/21/02	Flesh	2.83 ± 1.00	3.48 ± 0.51	
		Liver	2.61 ± 0.31	1.11 ± 0.11	
		Bone			3.61 ± 0.47

Averages by Tissue	No. of Samples	K-40 pCi/g, Wet Wt.	Cs-137 pCi/g, Wet Wt.	Sr-90 pCi/g, Dry Wt.
Flesh				
Average for all samples	61	2.9 ± 1.1	1.2 ± 3.7	
BNL on-site avg.	21	3.1 ± 0.7	1.0 ± 2.7	
BNL on-site and off-site < 1 mile avg.	38	3.0 ± 0.9	1.5 ± 4.4	
Off-site avg.	40	2.7 ± 1.2	1.2 ± 4.2	
Off-site < 1 mile avg.	17	2.8 ± 1.1	2.1 ± 5.7	
Off-site > 1 mile avg.	23	2.7 ± 1.3	0.6 ± 2.0	
Liver				
Average for all samples	45	2.4 ± 1.5	0.3 ± 0.7	
BNL on-site avg.	15	2.4 ± 0.8	0.3 ± 0.6	
BNL on-site and off-site < 1 mile avg.	25	2.4 ± 0.7	0.4 ± 0.8	
Off-site avg.	30	2.4 ± 1.8	0.2 ± 0.8	
Off-site < 1 mile avg.	10	2.3 ± 0.6	0.4 ± 1.0	
Off-site > 1 mile avg.	20	2.5 ± 2.1	0.2 ± 0.6	
Bone				
Average for all samples	59			2.4 ± 3.0
BNL on-site avg.	21			2.6 ± 3.7
BNL on-site and off-site < 1 mile avg.	36			2.9 ± 3.3
Off-site avg.	38			2.3 ± 2.5
Off-site < 1 mile avg.	14			3.3 ± 2.6
Off-site > 1 mile avg.	24			1.7 ± 1.7

Notes:
All values shown with a 95% confidence interval.
K-40 occurs naturally in the environment and is presented as a comparison to Cs-137.
All averages are the arithmetic averages and include nondetections as 0 and <MDL as detection limit.
MDL = Minimum Detection Limit
ND = not detected
* Average of multiple analyses of tissue from same deer; errors are propogated from individual sample errors.

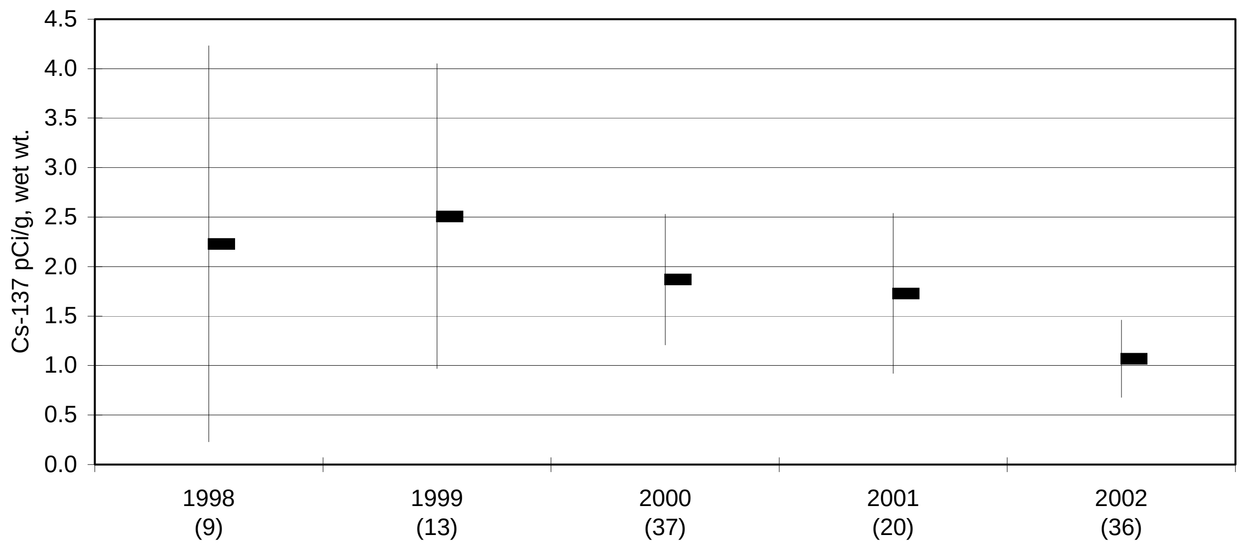


Notes:

Averages are reported for samples collected on site, on site plus off site within 1 mile of BNL, off site but within 1 mile, and off site greater than one mile. Numbers in parentheses indicate the number of samples in that data set.

All values are shown with a 95% confidence interval. A statistical outlier was removed from two of the data sets (see text).

Figure 6-4. Comparison of Cs-137 Average Concentrations in Deer, 2002.



Notes:

Averages are shown for samples collected at BNL and within a 1-mile radius. Numbers in parentheses indicate the number of samples in that data set.

All values are shown with a 95% confidence interval. Two statistical outliers were removed from each year's data set.

There is no significant difference between years, except between 2000 and 2002 averages.

Figure 6-5. Five-Year Cs-137 Concentration Trends in Deer Meat at BNL and within 1 Mile.

program. This increased value was verified and actions subsequent to the verification included notification of the public, submission of the sample to NYSDOH for re-analysis, review of sampling practices, a review of historic documents concerning contaminated soils at BNL, and an assessment of fenced areas containing cesium-137 contamination.

When NYSDOH reanalyzed the sample, they determined that the cesium-137 content was around 8.5 pCi/g wet weight, or about one third the value reported by BNL. The sample was then returned to BNL's Analytical Services Laboratory and analyzed on all eight of the detectors used there. In the comparative reanalysis it was discovered that one detector (the one used for the original analysis) produced erroneous readings due to detector configuration, sample geometry, and correction factors used for specific geometries and sample matrixes. The end result of the reanalysis was improved laboratory procedure, the purchase of a matrix-specific calibration sample comparable to the density of deer meat, and the finalization of an Environmental Event Response protocol that is used when unusual data are received.

The review of historic documents concerning cesium-137 contamination within landscape soil and other areas did not reveal any new or overlooked sources. Because of this, the focus for concern was on two facilities, the 650 Sump area and the Former Waste Management Facility, that were either in the process of cleanup or were scheduled for cleanup. The 650 Sump Area was determined to be secure, with no evidence of deer having entered the facility. The Former Waste Management Facility was discovered to have holes in the fence that allowed access to the facility, and evidence of deer having moved in and out of the holes was present. All holes in the fence were repaired. Samples of vegetation growing along the margin of the fence were taken and analyzed and those plants showing cesium-137 at elevated levels were removed. A species-specific vegetation study looking at uptake was completed to determine if plants that deer might eat differentially accumulated cesium-137. The results of that study are discussed in section 6.3.6.3, Special Vegetation Sampling. The assessment of access to the facility resulted in procedures to ensure deer could not get in. Besides sealing access points, periodic inspections of the fence are now made to ensure that no deer enter the facility through new holes. Since the changes were implemented, there has been no evidence of deer entering the facility. The facility is scheduled for cleanup in the FY03–05 time frame.

The second deer mentioned above, with a value of 10.56 pCi/g wet weight, was below the level of the historic high results for cesium-137 in deer meat. This value was verified through repeated analysis of two sub-samples of the animal provided by NYSDEC. As all actions implemented from the review of the first deer samples were taking place, no additional work review was carried out.

6.3.1.3 Strontium-90 in Deer Bone

BNL began testing deer bones (when available) for strontium-90 content in 2000 and continued this analysis in 2002. Strontium-90 content ranged from 0.7 to 9.17 pCi/g dry weight in on-site samples, 1.61 to 5.86 pCi/g dry weight in samples taken within one mile of BNL, and 0.68 to 3.95 pCi/g dry weight in samples taken from locations greater than a mile from BNL. This overlap in values between all samples suggests that strontium-90 is present in the environment at background levels; it is likely a result of worldwide fallout from nuclear weapons testing. Strontium-90 is present at very low levels in the environment, is readily incorporated into bone tissue, and may concentrate over time. BNL will continue to test for strontium-90 in bone to develop baseline information on this radionuclide and its presence in deer.

6.3.2 Small Mammal Sampling

BNL continued small mammal sampling in 2002. The original idea for this sampling was to determine the suitability of using small mammals, primarily squirrels, as a surrogate for deer sampling. Squirrels are readily trapped and tend to eat similar food as deer, but have a much more restricted range and therefore can indicate areas where low levels of contamination may be present. Squirrels were sent to an off-site laboratory for dissection and analysis. The meat was separated from the bone and tested for gamma-emitting radionuclides and the bone was tested for strontium-90. Results of the analyses are presented in Table 6-3. Cesium-137 in off-site samples ranged from 0.05 to 0.67 pCi/g wet weight. On-site samples contained cesium-137 ranging from 0.23 to 8.69 pCi/g wet weight. Strontium-90 was found in the bone samples of eight squirrels, six on site and two off site.

The cesium-137 level in one squirrel was elevated, 8.69 pCi/g wet weight, compared to all other squirrels analyzed in 2002. The area where this squirrel was taken is near old sewer lines that contain cesium-137. Contaminated sewer lines in the area have been isolated from the sewer system. The issue of cleanup of these lines or abandonment in place has been addressed in the Record of Decision for the Sewage Treatment Plant portion of Operable Unit V. Small mammals will continue to be sampled to obtain additional information about their usefulness in environmental surveillance and to better define where they may be acquiring cesium-137.

6.3.3 Other Animals Sampled

Occasionally, other animals of interest are found dead along the roads of BNL and the immediate vicinity. The wild turkey is prevalent at BNL and has a diet similar to deer, eating mostly insects in the spring and summer and acorns during the fall and winter. In 2002, one of BNL's turkeys was killed by a motor vehicle. This resulted in the opportunity to see if the wild turkeys on site might contain cesium-137 in the meat. The results of the analysis on the turkey indicated a cesium-137 concentration of 0.04 pCi/g wet weight, which is comparable to the far off-site values found in deer meat.

6.3.4 Fish Sampling

In collaboration with the NYSDEC Fisheries Division, BNL maintains an ongoing program for collecting and analyzing fish from the Peconic River and surrounding freshwater bodies. The annual sampling at BNL over the past several years has depleted the number of larger fish. As a result, it would be necessary to take more of the smaller fish to obtain a sufficiently large sample to complete all analyses desired. For this reason, BNL suspended most on-site sampling beginning in 2001 and will continue with the suspension for up to three years to allow the on-site fish populations to recover and mature. To determine

Table 6-3. Radiological Analysis of Small Mammals (Squirrels).

Location	Collection Date	K-40 (pCi/g, wet weight)	Cesium-137 (pCi/g, wet weight)	Strontium-90 (pCi/g, dry weight)
BNL				
Trailer 533	1/15/02	15.30 ± 2.48	0.58 ± 0.14	< MDL
Berkner Hall	1/16/02	15.80 ± 3.21	0.27 ± 0.15	< MDL
Railroad St. north of Fifth Ave.	3/14/02	13.80 ± 4.40	8.69 ± 1.28	0.77 ± 0.35
East of Fleming House	3/27/02	12.70 ± 1.60	1.11 ± 0.14	< MDL
Trailer 533	4/19/02	1.89 ± 0.34	0.24 ± 0.03	0.05 ± 0.03
Southwest of STP	4/24/02	2.56 ± 0.42	1.58 ± 0.19	0.10 ± 0.03
Trailer 533	9/30/02	14.10 ± 2.28	1.33 ± 0.22	< MDL
Trailer 533	10/22/02	14.50 ± 2.08	1.55 ± 0.23	0.30 ± 0.13
Rochester and Bell	10/25/02	12.30 ± 2.56	0.23 ± 0.13	0.34 ± 0.15
Ballfield #5	11/4/02	12.50 ± 1.81	0.47 ± 0.09	0.20 ± 0.10
Off Site				
Moriches	2/7/02	13.90 ± 2.26	0.34 ± 0.10	< MDL
Moriches	3/17/02	9.20 ± 1.21	0.26 ± 0.05	< MDL
Moriches	4/21/02	2.50 ± 0.37	0.05 ± 0.02	< MDL
Moriches	11/2/02	14.20 ± 2.22	0.67 ± 0.13	0.36 ± 0.15
Moriches	12/14/02	13.90 ± 2.17	0.46 ± 0.11	0.60 ± 0.21

Notes:
All values are shown with a 95% confidence interval.
MDL = Minimum Detection Limit
K-40 occurs naturally in the environment and is presented as a comparison to Cs-137.

population recovery, a population assessment was conducted and the results are discussed below.

Off-site sampling continued as in the past. All samples were analyzed for whole-body content of each of the analytes reported; in most instances, the samples were a composite of several fish to ensure adequate sample size for analysis. In 2002, various species of fish were collected off site from Swan Pond, Donahue's Pond, Forge Pond, and Lower Lake on the Carmans River (see Chapter 5, Figure 5-8 for locations). Swan Pond is a semi-control location on the Peconic River system and Lower Lake on the Carmans River is the non-Peconic control site. Sampling is carried out in cooperation with NYSDEC and through a contract with Cold Spring Harbor Fish Hatchery and Museum. The number of species and number of samples taken in 2002 dropped compared to previous years. This is due primarily to the drought that occurred across much of the northeast, which made sampling more difficult.

6.3.4.1 Radiological Analysis of Fish

The species collected in 2002 by BNL, NYSDEC, and through contract labor for radiological analysis included Brown bullhead (*Ictalurus nebulosus*), chain pickerel (*Esox niger*), largemouth bass (*Micropterus salmoides*), bluegill (*Lepomis macrochirus*), and pumpkinseed (*Lepomis gibbosus*). Gamma spectroscopy analysis was performed on all samples. Table 6-4 presents specific information on the sampling location, species collected, and analytical results. All sample results are presented as wet weight concentrations.

Cesium-137 was identified at low levels in all samples from the Peconic River system, ranging from 0.16 pCi/g wet weight in brown bullheads from Forge Pond, to 0.74 pCi/g wet weight in chain pickerel from Donahue's Pond. In 2002, fish taken from Lower Lake on the Carmans River (the non-Peconic control location) were below the minimum detection limit for the analysis, except for brown bullhead, which had a level of 0.09 pCi/g wet weight.

Strontium-90 is readily deposited in bone. In 2002, BNL continued the testing for strontium-90 that was initiated in 2000. Values ranged from less than minimum detection limit to 1.42 pCi/g dry weight. Because fish were analyzed for whole-body content, values for strontium-90 may vary somewhat, as seen in the data presented in Table 6-4. These variations result from random pieces of bone included in the aliquot of the sample used for analysis. BNL will continue to test for strontium-90 in off-site samples in order to build baseline values for future comparisons.

Some cesium-137 is detectable in the environment worldwide as a result of global fallout from past aboveground nuclear weapons testing. This is evident when examining the analytical results of fish from the control locations. To account for the different feeding habits and weights of various species, it is important to compare species with similar feeding habits (i.e., bottom feeders such as brown bullhead should be compared to other bottom feeders—in this case, other brown bullhead). Cesium-137 concentrations in bullhead collected at all locations along the Peconic River had values less than 0.26 pCi/g wet weight, whereas values for bullhead at Lower Lake on the Carmans River had 0.09 pCi/g wet weight. Levels of cesium-137 in all fish species appear to be declining compared to historic values.

Though it is clear from discharge records and sediment sampling that past BNL operations have contributed to anthropogenic (human-caused) radionuclide levels in the Peconic River system, most of these radionuclides—with the exception of tritium—were released between the late 1950s and early 1970s, and concentrations continue to decline over time through natural decay (cesium-137 has a half-life of 30 years).

6.3.4.2 Fish Population Assessment

As was mentioned earlier, in 2001 BNL suspended fish sampling on site because prior fish sampling had depleted the population and limited the remaining fish to smaller sizes. To document the number and size of fish in the on-site portions of the Peconic River, BNL conducted an electroshock survey (which does not harm the fish) from the Sewage Treatment Plant outfall to just beyond the east firebreak (HM-N). The results of the 2002 survey

Table 6-4. Radiological Analysis (Whole Body) of Fish from the Peconic River System and Control Locations.

	K-40 (pCi/g, wet weight)	Cs-137 (pCi/g, wet weight)	Sr-90 (pCi/g, dry weight)
Swan Pond			
Large Mouth Bass	10.80 ± 1.67	0.70 ± 0.13	0.48 ± 0.07
Pumpkinseed	7.55 ± 1.11	0.17 ± 0.04	0.46 ± 0.15
Forge Pond			
Chain Pickerel	10.40 ± 1.88	0.53 ± 0.12	< MDL
Brown Bullhead	8.54 ± 1.98	0.16 ± 0.07	0.79 ± 0.40
Pumpkinseed	6.65 ± 1.63	0.24 ± 0.09	1.24 ± 0.43
Donahue's Pond			
Blue Gill	7.48 ± 1.36	0.28 ± 0.07	1.42 ± 0.47
Brown Bullhead	7.78 ± 1.59	0.26 ± 0.10	1.14 ± 0.33
Chain Pickerel	11.00 ± 1.55	0.74 ± 0.11	< MDL
Lower Lake, Carmans River			
Blue Gill	9.58 ± 1.47	< MDL	< MDL
Brown Bullhead	11.80 ± 1.91	0.09 ± 0.08	< MDL
Large Mouth Bass	8.68 ± 1.52	< MDL	< MDL
Pumpkinseed	8.68 ± 1.48	< MDL	< MDL

Notes:
MDL = Minimum Detection Limit
K-40 occurs naturally in the environment and is presented as a comparison to Cs-137.
All values are presented with a 95% confidence interval.

compared to the 2001 survey are summarized in Table 6-5. In 2002, a total of 119 fish and six species were found in this section of river. The average length of fish ranged from 1.6 inches to 11.3 inches. The largest fish was an 11.3-inch chain pickerel. The total number of fish is indicative of poor population numbers. Unfortunately, the numbers sampled in 2002 were lower than in 2001. This was likely a result of drought conditions that kept water levels reduced. This reduced water level also had an effect on banded sunfish numbers. There was only one banded sunfish captured in 2002, compared to 18 in 2001. BNL will continue to monitor the fish population to determine when routine sampling may resume.

6.3.4.3 Nonradiological Analysis of Fish and Shellfish

In 1997, under the Operable Unit V remediation project, the BNL Environmental Restoration Program sampled and analyzed fish from the Peconic River for metals, pesticides, and polychlorinated biphenyls (PCBs). The contaminant levels found were not considered to have a health impact on fish or humans, but DOE directed that sampling and analysis should be done annually. This analysis was conducted

Table 6-5. 2001 and 2002 Fish Population Survey Results in the Peconic River (STP to HM-N).

	2001		2002	
Species	**No. Caught**	**Avg. Length** (in.)	**No. Caught**	**Avg. Length** (in.)
Banded Sunfish	18	2.8	1	2.1
Brown Bullhead	43	5.1	13	6.2
Chain Pickerel	20	7.1	1	11.3
Creek Chubsucker	53	3.6	4	2.6
Golden Shiner	9	4.4	23	1.8
Largemouth Bass	1	5.5	0	0
Pumpkinseed	15	3.9	77	1.6
Total no. caught	159		119	

Table 6-6. Metals Analysis of Fish and Shellfish from the Peconic River System and Control Locations.

		Arsenic	Barium	Cadmium	Chromium	Copper	Iron	Lead mg/kg	Manganese	Mercury	Nickel	Selenium	Silver	Sodium	Zinc
Swan Pond	Large Mouth Bass	< MDL	1.07	0.15	0.50	0.54	15.3	0.13	7.76	0.11	< MDL	0.54	0.28	1410	16.5
	Pumpkinseed	< MDL	4.36	< MDL	0.65	1.14	32.2	0.20	59.1	0.01	< MDL	0.50	0.25	1710	29.5
Forge Pond	Brown Bullhead	< MDL	0.32	< MDL	0.15	0.67	56.2	< MDL	1.38	0.05	0.14	0.53	< MDL	871	6.9
	Chain Pickerel	< MDL	0.39	< MDL	0.19	0.83	30.8	< MDL	3.54	0.33	0.08	0.54	< MDL	1260	54.8
	Pumpkinseed	0.62	71.2	0.03	< MDL	3.73	1300	< MDL	1460	0.08	0.17	0.83	0.18	1350	29.6
Donahue's Pond	Brown Bullhead	< MDL	3.09	< MDL	0.50	0.25	75	0.13	21.2	0.07	< MDL	0.67	< MDL	1110	16.5
	Blue Gill	< MDL	4.36	< MDL	0.53	0.27	14	0.21	14.6	0.13	0.09	0.45	< MDL	1520	40.5
	Chain Pickerel	< MDL	0.64	< MDL	0.20	0.22	7.74	< MDL	5.79	0.26	< MDL	0.43	< MDL	1200	55.9
Lower Lake, Carmans River	Blue Gill	< MDL	5.96	< MDL	0.63	0.20	7.26	< MDL	13.7	0.03	0.12	0.52	< MDL	1080	27.6
	Brown Bullhead	< MDL	0.25	< MDL	0.12	0.50	26.9	< MDL	0.55	0.02	< MDL	0.43	< MDL	910	4.94
	Large Mouth Bass	< MDL	1.15	< MDL	0.44	0.21	15.2	< MDL	2.60	0.40	< MDL	0.74	< MDL	1860	17.0
	Pumpkinseed	< MDL	1.42	< MDL	0.33	0.19	5.94	< MDL	10	0.03	0.12	0.66	< MDL	869	27.9
Connecticut Ave. (HC)	Freshwater mussels	0.75	1080	0.37	< MDL	0.89	8420	4.14	3470	0.05	0.23	2.72	5.80	339	81.3
	Freshwater mussels	3.48	0.64	0.04	0.26	3.62	95.8	0.31	2.42	0.11	0.20	0.88	0.95	4150	18.5
Forge Pond Peconic R. RGC	Freshwater mussels	< MDL	245	0.11	< MDL	0.65	941	0.10	876	0.01	< MDL	0.53	0.40	273	32.3
	Clams	2.03	0.19	0.08	0.17	10.4	10.6	0.21	2.55	< MDL	0.34	0.33	0.45	5760	8.8
	Clams	2.76	0.25	0.11	0.19	3.32	20.4	< MDL	2.46	< MDL	0.26	0.52	1.21	6400	12.9
Flanders Bay	Clams	2.29	0.18	0.09	0.19	0.78	12.9	< MDL	0.80	0	0.55	< MDL	0.56	6410	6.0
Indian Point	Blue Mussels	1.03	0.97	0.13	0.27	1.32	50.5	0.29	11.3	0	0.64	0.29	< MDL	6110	6.7
Moriches Bay	Clams	0.94	959	0.39	< MDL	1.11	7600	4.36	2660	0.07	< MDL	1.28	1.89	281	76.7

Notes:
See Figure 5-8 for sampling locations.
MDL = Minimum Detection Limit

on site in 1999 and 2000; analysis in 2002, as in 2001, was limited to off-site fish. The timing of sampling has varied from year to year, as well as the sample preparation (whole-body, tissue separation, composite sampling). In 1997, sampling was performed during April through May; in 1999, sampling was performed during September through December. Since 2000, sampling has occurred from July through August. Additionally, there has been a wide variation in fish size; samples have had to be composite whole-body to obtain significant mass for analysis. These variables make the comparisons from year to year difficult, as there can be significant seasonal variations in feeding, energy consumption, and incorporation of nutrients in tissues.

Table 6-6 shows the concentration levels of metals in fish and shellfish (clams and mussels) for 2002. None of the metal concentrations were considered capable of affecting the health of the consumers of such fish or clams. Mercury was found in all fish at levels less than 1.0 mg/kg, which is the consumption standard set by the U.S. Food and Drug Administration. The highest levels of mercury detected were in largemouth bass, taken from Lower Lake on the Carmans River.

Metals in shellfish are also presented in Table 6-6. In most samples, metals appear to be consistent with previous years' sampling efforts. However, unusually high levels (up to 1,080 mg/kg) of barium were detected in clams and mussels from Connecticut Avenue and beyond. Values were nearly three times higher than in 2001 (280 mg/kg). It is not certain why barium is present at these levels in shellfish when it is not present within the sediments (see Table 6-9), but fragments of shell within the tissue sample may partially account for the values. Also, manganese was detected at high levels in some shellfish, as it was in 2001.

Table 6-7 shows the concentrations of pesticides in fish and shellfish for 2002. The table reflects only samples with detectable levels of pesticide in the tissues. None of the shellfish showed measurable levels of pesticides. The levels detected in fish do not exceed any standards that may constitute a health impact to the consumers of such fish and thus are not considered harmful. The pesticides DDT, DDD, and DDE were detected at low levels at several off-site locations. DDD and DDE pesticides are breakdown products of DDT, a pesticide commonly used before 1970. Chlordane was also commonly used across Long Island and is found occasionally in fish samples. Heptachlor epoxide and Methoxychlor were detected at Swan Pond in Pumpkinseed and Largemouth Bass. Heptachlor epoxide was part of the formulation and is a breakdown product of Chlordane. Before 1988, it was used as a pesticide outdoors (on lawns and fields) and indoors. Methoxychlor is still in use, primarily as an agricultural pesticide.

No detectable levels of PCBs (Aroclor-1242 and Aroclor-1260) were found in fish taken from the Peconic River or control site locations. Historically, Aroclor-1260 was used in electrical equipment and this PCB has been found historically in fish taken on site at BNL.

6.3.5 Aquatic Sampling

6.3.5.1 Radiological Analysis

Annual sampling of clams, mussels, sediment, vegetation, freshwater and seawater in the Peconic River, Lower Lake Carmans River (control location), Peconic Bay, Flanders Bay, Indian Point, and Moriches Bay (control loca-

Table 6-7. Pesticide Analysis of Fish and Shellfish from the Peconic River System and Control Locations.

		4,4′-DDD	4,4′-DDE	4,4′-DDT	alpha-Chlordane	Heptachlor epoxide	Methoxy-chlor
		µg/kg					
Swan Pond	Large Mouth Bass	31.7	75.7	< MDL	< MDL	2.8	214
	Pumpkinseed	5.4	14.4	< MDL	< MDL	2.4	7.3
Forge Pond	Brown Bullhead	33.3	84.7	< MDL	4.3	< MDL	< MDL
	Chain Pickerel	71.8	103	20.1	< MDL	< MDL	< MDL
	Pumpkinseed	6.4	22.4	61.4	< MDL	< MDL	< MDL
Donahue's Pond	Blue Gill	15.1	45	11.6	< MDL	< MDL	< MDL
	Brown Bullhead	3.4	7.1	1.3	< MDL	< MDL	< MDL
	Chain Pickerel	10.6	31.1	7.3	< MDL	< MDL	< MDL
Lower Lake, Carmans River	Blue Gill	13.3	60.4	41	< MDL	< MDL	< MDL
	Brown Bullhead	2.1	7.3	3.8	< MDL	< MDL	< MDL
	Large Mouth Bass	27.7	201	384	< MDL	< MDL	< MDL
	Pumpkinseed	10.9	150	91.5	< MDL	< MDL	< MDL
Connecticut Ave. (HC)	Freshwater mussels	0.42	6.6	7.4	< MDL	< MDL	< MDL
	Freshwater mussels	< MDL	0.3	2	< MDL	< MDL	< MDL
Forge Pond	Freshwater mussels	< MDL	< MDL	1.1	< MDL	< MDL	< MDL
Peconic River-RGC	Clams	2.1	7.3	5.5	< MDL	< MDL	< MDL
	Clams	< MDL	2.6	2.8	< MDL	< MDL	< MDL
Flanders Bay	Clams	< MDL	13.2	6.9	< MDL	< MDL	< MDL
Indian Point	Blue Mussels	< MDL	2.8	9.3	< MDL	< MDL	< MDL
Moriches Bay	Clams	< MDL	0.55	0.67	< MDL	< MDL	< MDL

Notes:
MDL = Minimum Detection Limit

tion) was conducted in 2002. (See Chapter 5, Figure 5-8, for locations.) Stakeholder concern that BNL's discharges and ongoing work with Operable Unit V may affect the clamming industry has been the basis for this sampling program. As in past years, the NYSDEC Marine Fisheries Branch assisted BNL in coordinating the sampling with local baymen. Table 6-8 summarizes the radiological data. Low levels of cesium-137 were documented in vegetation taken on site at BNL, and levels below 0.25 pCi/g wet weight were detected in vegetation in the Peconic River and Moriches Bay (control location). Cesium-137 was detected in Peconic River sediments below 0.2 pCi/g dry weight, and also at a concentration of 0.80 pCi/g dry weight at the Lower Lake control location. Since sampling began in 1992, no BNL-generated nuclides have been detected in marine shellfish samples. Because there is a solid baseline of data indicating that cesium-137 is not present above background in shellfish, BNL will not sample marine/estuarine/freshwater locations on an annual basis beginning in 2003. BNL may periodically conduct confirmatory sampling to update its baseline in the future.

6.3.5.2 Metals in Aquatic Samples

Metals analysis (Table 6-9) was conducted on aquatic vegetation, water, and sediments from the Peconic River, bays, and estuaries. Most of the data indicate metals at background levels. The standard used for comparison of sediments is the soil cleanup objectives for heavy metals supported by Suffolk County Department of Health Services. Water sample results are compared to New York State Drinking Water Standards (see Chapter 3). Vegetation results are compared to both standards, because metals in vegetation may accumulate via uptake from sediment or water. Various metals are seen in vegetation at levels above drinking water standards but below sediment standards; this is likely due to some vegetation having the ability to concentrate metals.

Levels of chromium, copper, mercury, nickel, and silver were lower in vegetation taken on the BNL site from the Peconic River near the east firebreak. This area was included in a pilot study of cleanup options being considered for use in the Operable Unit V remediation activities. Off site,

Table 6-8. Radiological Analysis of Shellfish, Aquatic Vegetation, Water, and Sediment.

Location/ Sample Type	K-40 (pCi/g, wet weight)	Cs-137 (pCi/g, wet weight)
BNL (EA – HM-N)		
Algae	13.2 ± 1.7	2.71 ± 0.31
Burr reed	29.9 ± 4.1	0.11 ± 0.08
Burr reed	34.9 ± 4.6	0.16 ± 0.09
Duckweed	31.1 ± 3.6	1.35 ± 0.17
Duckweed	23.4 ± 3.2	0.88 ± 0.13
Connecticut Ave. (HC)		
Clams	2.5 ± 1.9	< MDL
Clams	1.78 ± 0.99	< MDL
Sediment	2.63 ± 0.46	0.05 ± 0.02
Vegetation	19.2 ± 3.5	< MDL
Water (pCi/L)	NV	< MDL
Forge Pond		
Freshwater mussels	1.66 ± 0.52	0.08 ± 0.03
Sediment	2.99 ± 1.14	0.2 ± 0.1
Vegetation (Lily Pad)	15.6 ± 2.4	0.25 ± 0.09
Water (pCi/L)	< MDL	< MDL
Swan Pond		
Sediment	1.39 ± 0.37	< MDL
Vegetation (Lily Pad)	19.4 ± 2.8	0.19 ± 0.07
Water (pCi/L)	< MDL	< MDL
Lower Lake, Carmans R.		
Sediment	9.13 ± 4.11	0.80 ± 0.36
Vegetation (Milfoil)	11 ± 11.8	< MDL
Water (pCi/L)	33.8 ± 16.4	< MDL
Peconic River - RGC		
Clams	10.5 ± 3.3	< MDL
Clams	10.6 ± 1.9	< MDL
Sediment	14.5 ± 1.6	0.09 ± 0.04
Vegetation	10 ± 3.2	< MDL
Water (pCi/L)	235 ± 41.9	< MDL
Indian Point		
Blue Mussel	12.9 ± 3.1	< MDL
Sediment	1.69 ± 0.35	< MDL
Vegetation	49.2 ± 6.3	< MDL
Water (pCi/L)	290 ± 48	< MDL
Flanders Bay		
Clams	12.1 ± 2.3	< MDL
Sediment	11.1 ± 1.3	0.09 ± 0.03
Water (pCi/L)	317 ± 50.1	< MDL
Moriches Bay		
Clams	12.4 ± 1.7	< MDL
Sediment	2.17 ± 0.49	< MDL
Vegetation	6.47 ± 2.95	0.06 ± 0.12
Water (pCi/L)	254 ± 65.3	< MDL

Notes:
All values shown with 95% confidence interval.
MDL = Minimum Detection Limit
NV = No value given
Sediment values are for dry weights.
Water values are given in pCi/L.

Table 6-9. Metals Analysis of Aquatic Vegetation, Water, and Sediments from the Peconic River System, Bays, and Control Locations.

Location/ Sample Type	Arsenic mg/kg	Barium mg/kg	Cadmium mg/kg	Chromium mg/kg	Copper mg/kg	Iron mg/kg	Lead mg/kg	Manganese mg/kg	Mercury mg/kg	Nickel mg/kg	Selenium mg/kg	Silver mg/kg	Sodium mg/kg	Zinc mg/kg
BNL (EA - HM-N)														
Algae	< MDL	4.17	0.16	0.75	14	165	1.02	23.5	0.09	0.5	0.27	1.31	115	32.6
Burr reed	< MDL	2.6	< MDL	0.27	1.88	21.1	0.18	8.17	0.02	0.3	< MDL	0.29	428	6.15
Burr reed	< MDL	4.67	< MDL	0.22	1.62	45.6	0.12	48.8	0.01	0.3	< MDL	0.3	363	5.05
Duckweed	< MDL	2.95	0.32	0.58	19.7	53	0.56	13	0.04	1.05	< MDL	1.21	557	30.9
Duckweed	< MDL	3.48	0.19	1.09	15.7	156	1.07	12.2	0.04	0.91	< MDL	2.25	285	19.8
Connecticut Ave. (HC)														
Sediment	1.37	2.87	0.06	14.9	3.09	1910	25.6	9.27	< MDL	1	< MDL	< MDL	10.9	10.7
Vegetation	< MDL	23	0.02	0.12	0.4	149	< MDL	284	0	< MDL	< MDL	< MDL	592	3.14
Water (mg/L)	< MDL	0.01	< MDL	< MDL	< MDL	2.38	< MDL	0.14	< MDL	< MDL	< MDL	< MDL	7.17	0
Forge Pond														
Sediment	0.84	12.9	< MDL	2.31	4.19	1730	7.61	23.9	0.01	1.07	< MDL	0.27	15	11.1
Veg. (Lily Pad)	< MDL	20.2	< MDL	0.19	< MDL	33.7	< MDL	44.8	< MDL	< MDL	< MDL	0.23	466	1.73
Water (mg/L)	< MDL	0.02	< MDL	0	< MDL	0.71	< MDL	0.04	< MDL	< MDL	< MDL	0	10.8	< MDL
Swan Pond														
Sediment	< MDL	2.42	< MDL	0.48	0.17	51.7	1.85	38	< MDL	0.11	< MDL	0.2	7.04	1.32
Veg. (Lily Pad)	< MDL	63.2	< MDL	< MDL	0.21	46.1	< MDL	806	< MDL	0.22	< MDL	0.24	344	5.22
Water (mg/L)	< MDL	0.01	< MDL	0	< MDL	0.08	0	0.44	< MDL	< MDL	< MDL	0	8.8	0
Lower Lake, Carmans R.														
Sediment	7.06	123	0.87	34.4	17.8	11860	104	566	0.18	10.4	3.23	< MDL	288	128
Vegetation	< MDL	22.5	< MDL	0.1	0.15	184	< MDL	265	0	< MDL	0.36	< MDL	1250	2.5
Water (mg/L)	< MDL	0.03	< MDL	0	0	1.58	0	0.07	< MDL	0	< MDL	< MDL	11.3	0.01
Indian Point														
Sediment	0.95	1.89	< MDL	1.73	1.06	1010	1.97	66.5	< MDL	0.53	< MDL	< MDL	4750	7.05
Vegetation	0.42	0.14	< MDL	0.2	< MDL	44.5	0.16	18.3	< MDL	< MDL	< MDL	< MDL	9450	0.34
Water (mg/L)	< MDL	0.02	< MDL	< MDL	< MDL	0.94	< MDL	0.15	< MDL	< MDL	< MDL	< MDL	9600	< MDL
Peconic River - RGC														
Sediment	17.8	48.6	1.08	42.7	61.9	55610	43.1	777	0.08	22.7	1.51	0.69	44830	155
Vegetation	3.63	6.31	0.08	0.87	3.57	2570	1.5	2260	0.01	2.21	0.27	< MDL	2530	13.4
Water (mg/L)	< MDL	0.02	< MDL	< MDL	< MDL	0.3	< MDL	0.13	0	< MDL	< MDL	< MDL	7420	< MDL
Flanders Bay														
Sediment	14	31.4	0.85	27.5	28.5	32190	26.1	481	0.07	15.1	< MDL	< MDL	19140	93.8
Water (mg/L)	< MDL	0.02	< MDL	< MDL	< MDL	< MDL	< MDL	0.07	0	< MDL	< MDL	< MDL	10150	< MDL
Moriches Bay														
Sediment	0.5	1.39	< MDL	2.02	0.49	828	1.67	10.1	< MDL	0.37	< MDL	< MDL	3430	2.32
Vegetation	0.83	1.41	0.02	0.24	0.23	126	0.3	37	0	0.13	< MDL	< MDL	10700	0.74
Water (mg/L)	< MDL	0.01	< MDL	< MDL	0	0.32	0	0.02	< MDL	< MDL	< MDL	< MDL	11130	0.08

Notes:
Water values are in mg/L.
MDL = Minimum Detection Liimit

chromium, copper, and nickel were detected at levels just above Suffolk County cleanup objectives in sediments from Connecticut Avenue (HC), Lower Lake - Carmans River, Peconic River near the Riverhead golf course, and in Flanders Bay.

6.3.5.3 Pesticides in Aquatic Samples

Pesticides and PCBs are reported in Table 6-10 for only those samples with detectable limits. No PCBs were detected in any vegetation, sediment, or water samples. DDT or its breakdown products, DDD and DDE, were detected in various samples of vegetation, sediment, and water at nearly all locations. Chlordane or its breakdown products were only detected in sediments at Connecticut Avenue (HC) on the Peconic River. Aldrin and beta-BHC were only detected in one sample of duckweed on site at BNL. All of these pesticides were used historically across Long Island, including at BNL.

6.3.6 Vegetation Sampling

6.3.6.1 Farm and Garden Plants

A variety of farm and garden vegetables were sampled in 2002. Samples were collected from farms near BNL as well as from an on-site garden (Figure 6-6). Samples were submitted for

Table 6-10. Pesticide and PCB Analysis of Aquatic Vegetation, Water, and Sediments from the Peconic River System, Bays, and Control Locations.

Location/ Sample Type	4,4′-DDD	4,4′-DDE	4,4′-DDT	Aldrin	alpha-Chlordane	gamma-Chlordane	beta-BHC
	mg/kg						
BNL (EA - HM-N)							
Algae	< MDL	< MDL	2.4	< MDL	< MDL	< MDL	< MDL
Duckweed	1.5	< MDL	< MDL	< MDL	< MDL	< MDL	< MDL
Duckweed	< MDL	< MDL	3.1	3.5	< MDL	< MDL	1.3
Connecticut Ave. (HC)							
Sediment	0.97	3.3	5.3	< MDL	0.51	0.4	< MDL
Vegetation	< MDL	< MDL	1.4	< MDL	< MDL	< MDL	< MDL
Water (ug/L)	0.01	0.16	0.1	< MDL	< MDL	< MDL	< MDL
Forge Pond							
Sediment	0.67	0.74	< MDL	< MDL	< MDL	< MDL	< MDL
Water (ug/L)	< MDL	< MDL	0.05	< MDL	< MDL	< MDL	< MDL
Swan Pond							
Lily Pad	1.7	< MDL	2.3	< MDL	< MDL	< MDL	< MDL
Sediment	0.5	0.3	< MDL	< MDL	< MDL	< MDL	< MDL
Water (ug/L)	< MDL	< MDL	0.05	< MDL	< MDL	< MDL	< MDL
Lower Lake, Carmans R.							
Sediment	7.7	16.4	4	< MDL	< MDL	< MDL	< MDL
Vegetation	< MDL	1.5	2	< MDL	< MDL	< MDL	< MDL
Water (ug/L)	0.01	< MDL	0.01	< MDL	< MDL	< MDL	< MDL
Indian Point							
Sediment	< MDL	0.37	2	< MDL	< MDL	< MDL	< MDL
Vegetation	< MDL	< MDL	2.8	< MDL	< MDL	< MDL	< MDL
Water (ug/L)	0.01	< MDL	0.08	< MDL	< MDL	< MDL	< MDL
Peconic River - RGC							
Sediment	< MDL	< MDL	2.7	< MDL	< MDL	< MDL	< MDL
Flanders Bay							
Sediment	1.2	2.6	6.6	< MDL	< MDL	< MDL	< MDL
Water (ug/L)	< MDL	< MDL	0.03	< MDL	< MDL	< MDL	< MDL
Moriches Bay							
Vegetation	< MDL	< MDL	1.2	< MDL	< MDL	< MDL	< MDL
Water (ug/L)	< MDL	< MDL	0.1	< MDL	< MDL	< MDL	< MDL

Notes:
Water values are in mg/L.
beta-BHC = benzene hexachloride
MDL = Minimum Detection Limit

radiological analysis and the results are presented in Table 6-11. As in the past, no radionuclides attributable to BNL operations were observed in farm produce off site. Cesium-137 was detected in acorn squash from the on-site garden and in crab apples taken near the on-site gas station at levels just above detection. Potassium-40, which occurs naturally, was the only radionuclide detected in all of the produce sampled. BNL plans to discontinue farm vegetation sampling off site because there is no longer a source for potential release from the BNL site (all reactor operations ceased when the Brookhaven Medical Research Reactor stopped operating in December of 2000) and because historic data indicate the absence of any BNL-related radionuclides in off-site farm vegetation. BNL may conduct confirmatory sampling periodically to update its database on farm vegetation. On-site garden vegetables will continue to be sampled annually because cesium-137 is occasionally detected in various vegetables grown on site.

6.3.6.2 Grassy Plants

BNL sampled grassy vegetation (Table 6-12) near the air monitoring stations to support surveillance monitoring associated with these locations. Vegetation sampling is carried out to determine if depositional material is accumulating on plant surfaces and soils and whether there is uptake by the vegetation. In 2002, the only anthropogenic radionuclide found in grassy vegetation was cesium-137. A single sample from air station P-4 near the apartment complex and the on-site vegetable garden indicated a very low cesium-137 level (0.01 pCi/g wet weight). This corroborates the presence of cesium-137 that was detected in acorn squash from the garden.

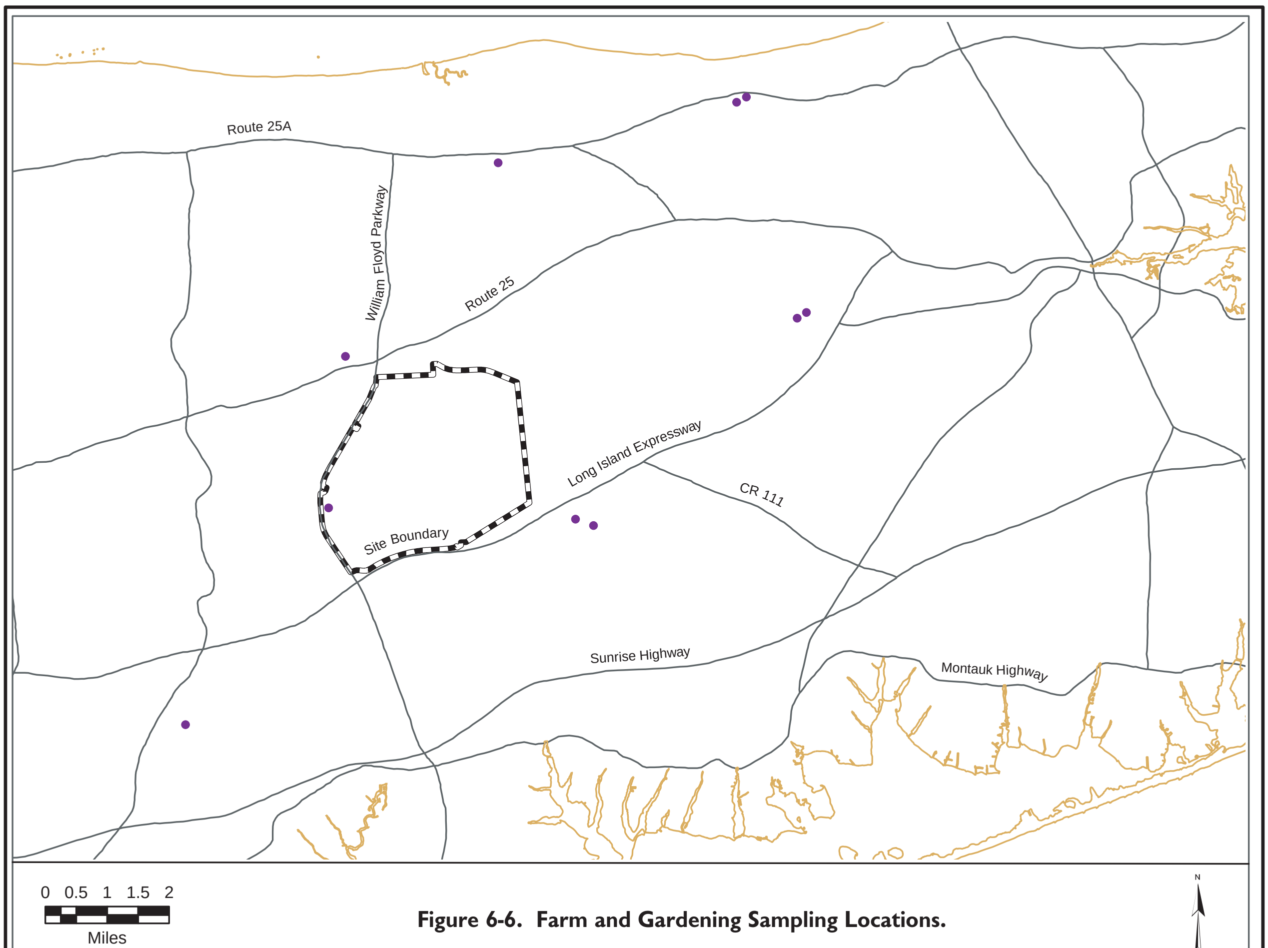


Figure 6-6. Farm and Gardening Sampling Locations.

Table 6-11. Radiological Analysis of Farm and Garden Produce.

Location/ Sample Type	K-40 (pCi/g, wet weight)	Cs-137 (pCi/g, wet weight)
BNL Fruit Trees		
Apple (Bldg. 555)	1.15 ± 0.14	ND
Apple (Bldg. 630)	1.39 ± 0.17	0.01 ± 0.00
Apple (Bldg. 630)	2.99 ± 0.29	ND
BNL Garden		
Acorn squash	2.45 ± 0.23	0.01 ± 0.00
Cucumber	1.21 ± 0.12	ND
Eggplant	2.14 ± 0.22	ND
Green pepper	1.72 ± 0.30	ND
Tomato	1.45 ± 0.22	ND
Bruno Farm		
Corn	2.15 ± 0.46	ND
Cucumber	1.86 ± 0.17	ND
Eggplant	2.43 ± 0.21	ND
Zucchini	1.91 ± 0.17	ND
Cheryl's Farm		
Pumpkin	2.15 ± 0.18	ND
Cornell Farm		
Corn	1.99 ± 0.49	ND
Fox Hollow Farms		
Strawberry	1.16 ± 0.14	ND
Kennedy Farm		
Pumpkin	ND	ND
Lewins Farm		
Brussel sprout	3.58 ± 0.37	ND
Cauliflower	ND	ND
Corn	2.39 ± 0.28	ND
Peach	1.67 ± 0.21	ND
Potato	4.09 ± 0.36	ND
Pumpkin	1.53 ± 0.36	ND
Red cabbage	1.78 ± 0.16	ND
String bean	2.77 ± 0.26	ND
Zucchini	1.88 ± 0.15	ND
Mays Farm		
Corn	1.98 ± 0.38	ND
Eggplant	2.85 ± 0.24	ND
Pumpkin	2.70 ± 0.25	ND
String bean	3.23 ± 0.34	ND
Tomato	2.08 ± 0.20	ND
Zucchini	2.06 ± 0.31	ND
River Road Farms		
Snap pea	1.13 ± 0.50	ND
Strawberry	1.14 ± 0.11	ND

Notes:
See Figure 6-6 for sampling locations.
All values shown with a 95% error.
K-40 occurs naturally in the environment and is presented as a comparison to Cs-137.
ND = Not Detected

Table 6-12. Radiological Analysis of Grass and Other Vegetation.

Location	K-40 (pCi/g, wet weight)	Cs-137 (pCi/g, wet weight)
BNL		
P-7	3.05 ± 0.60	ND
P-9	5.5 ± 2.2	ND
S-5	5.1 ± 1.2	ND
P-2	2.48 ± 0.53	ND
HT-E	2.48 ± 0.53	ND
P-4	2.87 ± 0.41	0.01 ± 0.01
Off Site		
NYSDEC Game Farm	5.39 ± 0.61	ND

Notes:
All values shown with 95% confidence interval.
K-40 occurs naturally in the environment and is presented as a comparison to Cs-137.
ND = Not Detected

6.3.6.3 Special Plant Sampling

BNL conducted special vegetation sampling in and around the Former Waste Management Facility (FWMF) in support of the assessment resulting from the suspected high cesium-137 content found in an off-site deer (see Section 6.3.1.2). The FWMF was identified as one of two areas that was a potential source for deer acquiring cesium-137. It was also discovered that the fence of this facility had vegetation growing through it and several holes existed that would allow deer to readily access the facility. The holes were patched and no deer have been documented in the facility since then.

Vegetation growing through the fence is available to deer for browse. This material, if contaminated with cesium-137, could consequently be absorbed by deer when consumed. A sampling of the vegetation growing through the fence showed that fungus, moss, high bush blueberry, and leaves of an ornamental tree (see Table 6-13) were the only species that accumulated significant amounts of cesium-137. The high bush blueberry and ornamental tree were cut away from the fence line to prevent deer from browsing on their leaves. Although moss and fungi were identified as containing significant amounts of cesium-137, there was no evidence that deer were eating that material, and there was not enough to significantly contribute to their diet.

Historically, deer had entered this facility; therefore a study was conducted to determine if individual plant species that may be browsed by deer were accumulating cesium-137. This study was significant because deer are highly selective in their feeding and will select foods containing needed nutrients over less nutritious species. Sampling occurred only in areas known to contain high levels of cesium-137 (see Table 6-14 and Section 6.4 for soil sample values), where plant and soil samples were obtained. Plants that had significant amounts of cesium-137 present in their above ground tissues included fern, mustard, white flowering aster, smartweed, and steeplebush. Of these plants, steeplebush had the highest concentrations of cesium-137, at 95.80 pCi/g wet weight. This plant was growing in soil containing cesium-137 between 46 and 79 pCi/g dry weight, indicating that it can concentrate this radionuclide (Tatum-Byers 2003). Other plants contained lesser amounts of cesium-137 yet, if made available to deer, they could result in elevated levels in deer tissues. Eliminating deer access to the facility greatly reduces the likelihood that deer will acquire cesium-137.

6.4 SOIL SAMPLING

Soil sampling was conducted to correspond with vegetation sampling near air stations, the on-site garden, local farms, and in association with the special vegetation sampling discussed above. Soil sampling is conducted as part of the surveillance program and is used to determine uptake in plants as well as to determine long-term deposition or lack thereof. Soil samples were analyzed for gamma-emitting radionuclides. Table 6-14 shows the sampling results of the radiological analysis of soils. All radionuclides, with the exception of cesium-137, that are detected in soils (other than from the Former Waste Management Facility) are found naturally in Long Island soils. Higher levels of some of the radionuclides, such as lead-212, lead-214, bismuth-214, and potassium-40 in some of the farm locations, are likely due to the addition of fertilizers to soils for growing crops. The maximum cesium-137 concentration in soils not associated with the Former Waste Management Facility was 0.62 pCi/g dry weight, seen in a

Table 6-13. Radiological Analysis of Special Vegetation Sampling at the Former Waste Management Facility (FWMF).

Location/ Sample Type	K-40	Cs-137
	(pCi/g, wet weight)	
Outside FWMF Fence		
Fungus	3.6 ± 1.5	69 ± 11
Moss	1.7 ± 1.2	50 ± 11
Blackberry fruit	1.61 ± 0.57	ND
Blackberry bush	3.1 ± 1.1	0.08 ± 0.07
Grape vegetation	2.14 ± 0.40	0.62 ± 0.07
Wild rose vegetation	3.51 ± 0.45	0.28 ± 0.04
Common Elderberry	4.17 ± 0.47	0.97 ± 0.09
Highbush Blueberry	0.94 ± 0.22	3.15 ± 0.35
Ornamental tree	2.16 ± 0.35	3.94 ± 0.35
Bittersweet vegetation	6.1 ± 1.6	ND
Swamp Red Maple	2.04 ± 0.37	0.12 ± 0.03
Choke Cherry	0.41 ± 0.05	0.12 ± 0.02
Inside FWMF Fence		
Fern	2.55 ± 0.53	66.5 ± 5.5
Mustard	2.07 ± 0.63	48.6 ± 4.2
Goldenrod - Yellow Flowering	4.7 ± 1.1	6.73 ± 0.74
Goldenrod- Yellow Flowering B	4.57 ± 0.57	6.27 ± 0.48
Common Mullein	6.9 ± 2.1	2.00 ± 0.36
Common Mullien B	6.52 ± 0.99	0.46 ± 0.06
Sweet Everlasting	7.0 ± 1.1	0.73 ± 0.10
Sweet Everlasting B	7.6 ± 1.2	0.58 ± 0.10
Sassafrass	2.46 ± 0.36	2.92 ± 0.25
Sassafrass B	2.18 ± 0.41	1.53 ± 0.18
Goldenrod (Euthamia)	4.28 ± 0.66	5.10 ± 0.64
Goldenrod (Euthamia) B	4.05 ± 0.56	4.29 ± 0.51
Small Flowered White Aster	4.1 ± 1.1	9.8 ± 1.2
Small White Flowering Aster B	4.1 ± 1.0	12.1 ± 1.3
Evening Primrose	2.89 ± 0.54	0.60 ± 0.08
Evening Primrose B	3.8 ± 1.3	0.87 ± 0.19
Wild Lettuce	4.39 ± 0.48	6.77 ± 0.51
Rumex	2.62 ± 0.27	9.77 ± 0.81
Dogwood	1.63 ± 0.36	6.08 ± 0.46
Dogwood B	1.76 ± 0.42	7.92 ± 0.78
Smartweed	2.53 ± 0.45	30.2 ± 3.0
Smartweed B	2.93 ± 0.39	30.6 ± 2.3
Steeplebush	3.07 ± 0.58	93 ± 1.1
Steeplebush B	1.97 ± 0.48	95.8 ± 6.9
Goldenrod	4.38 ± 1.18	0.40 ± 0.13
Goldenrod B	5.16 ± 0.82	0.87 ± 0.10
Off-Site Controls		
Dogwood	1.78 ± 0.27	ND
Sassafras	1.08 ± 0.22	ND

Notes:
All values shown with 95% confidence interval.
K-40 occurs naturally in the environment and is presented as a comparison to Cs-137.
ND = Not Detected

Table 6-14. Radiological Analysis of Soil Samples.

Sampling Location	Potassium-40 pCi/g	Cobalt-60 pCi/g	Cesium-137 pCi/g	Thallium-208 pCi/g	Actinium-228 pCi/g	Lead-212 pCi/g	Lead-214 pCi/g	Thorium-232 pCi/g
BNL								
S6	1.1 ± 0.9	ND	0.11 ± 0.05	ND	0.37 ± 0.20	0.16 ± 0.14	ND	ND
P7	6.6 ± 1.1	ND	0.41 ± 0.08	0.25 ± 0.05	0.69 ± 0.10	0.70 ± 0.11	0.51 ± 0.08	0.60 ± 0.25
P9	5.2 ± 1.8	ND	ND	0.43 ± 0.16	ND	1.11 ± 0.34	0.51 ± 0.40	ND
S5	4.2 ± 1.3	ND	0.22 ± 0.09	0.18 ± 0.11	ND	0.60 ± 0.16	ND	ND
P2	3.4 ± 0.7	ND	ND	0.13 ± 0.04	ND	0.27 ± 0.07	0.27 ± 0.09	ND
P4 Garden	1.5 ± 0.9	ND	0.24 ± 0.06	ND	ND	0.29 ± 0.15	ND	ND
P4	4.6 ± 0.8	ND	0.13 ± 0.04	0.25 ± 0.05	0.69 ± 0.10	0.70 ± 0.10	0.55 ± 0.09	0.62 ± 0.27
Bldg 555	5.6 ± 1.0	ND	0.17 ± 0.04	0.26 ± 0.06	0.73 ± 0.10	0.87 ± 0.13	0.58 ± 0.15	0.93 ± 0.21
Bldg 630	2.6 ± 1.0	ND	0.08 ± 0.05	0.20 ± 0.08	0.51 ± 0.23	0.61 ± 0.17	ND	ND
Former Waste Management Facility Soils*								
FWMF - goldenrod/everlasting	2.9 ± 1.0	ND	455 ±77	ND	ND	ND	ND	ND
FWMF - mullien	5.6 ± 1.0	2.37 ± 0.28	1050 ±173	0.23 ± 0.16	ND	0.71 ± 0.36	0.47 ± 0.13	ND
FWMF - mullien B	6.8 ± 1.8	ND	2.87 ± 0.54	0.31 ± 0.14	ND	0.92 ± 0.21	ND	ND
FWMF - sassafras	8.2 ± 2.2	0.16 ± 0.11	588 ±114	0.43 ± 0.37	ND	0.96 ± 0.82	ND	ND
FWMF- sassafras B	5.7 ± 1.0	0.09 ± 0.02	339 ±56	0.35 ± 0.14	ND	0.84 ± 0.28	ND	ND
FWMF - aster/primrose	5.0 ± 1.3	ND	68 ±12	ND	ND	0.57 ± 0.36	ND	ND
FWMF - aster/primrose B	3.6 ± 0.7	0.05 ± 0.01	69 ±11	0.14 ± 0.06	ND	0.36 ± 0.11	0.36 ± 0.25	ND
FWMF - rumex/wild lettuce	3.7 ± 0.7	0.25 ± 0.04	149 ±25	0.19 ± 0.08	ND	0.36 ± 0.18	0.43 ± 0.24	ND
FWMF - rumex/wild lettuce B	8.8 ± 2.2	0.37 ± 0.12	269 ±52	ND	ND	ND	ND	ND
FWMF - fern	4.3 ± 0.8	1.36 ± 0.16	908 ±150	ND	ND	ND	ND	ND
FWMF - fern B	4.2 ± 1.3	1.30 ± 0.20	1010 ±174	ND	ND	ND	ND	ND
FWMF - smartweed	3.6 ± 0.7	0.11 ± 0.02	161 ±27	0.15 ± 0.07	ND	0.41 ± 0.17	0.22 ± 0.16	0.63 ± 0.39
FWMF - smartweed B	3.8 ± 0.7	ND	68 ±11	0.20 ± 0.07	ND	ND	ND	ND
FWMF - steeplebush	1.0 ± 0.9	ND	79 ±13	ND	ND	0.32 ± 0.25	ND	ND
FWMF - steeplebush B	3.5 ± 0.7	0.03 ± 0.02	46 ± 8	0.17 ± 0.07	ND	0.44 ± 0.12	0.37 ± 0.23	0.57 ± 0.30
FWMF - mustard	4.4 ± 0.8	0.35 ± 0.05	157 ±26	0.13 ± 0.07	ND	0.42 ± 0.15	0.25 ± 0.18	ND
FWMF - mustard B	4.5 ± 0.8	0.43 ± 0.06	158 ±26	0.23 ± 0.08	ND	0.50 ± 0.16	0.37 ± 0.17	ND
FWMF - ornamental tree	4.0 ± 1.3	ND	5.30 ± 0.96	0.23 ± 0.14	ND	0.43 ± 0.17	0.53 ± 0.20	ND
FWMF - ornamental tree B	3.3 ± 0.6	ND	13.9 ± 2.3	0.14 ± 0.05	0.48 ± 0.08	0.42 ± 0.09	0.37 ± 0.09	0.75 ± 0.26
FWMF - highbush blueberry	3.7 ± 0.7	ND	1.87 ± 0.32	0.16 ± 0.05	0.41 ± 0.09	0.52 ± 0.09	0.37 ± 0.13	0.63 ± 0.23
FWMF - highbush blueberry B	5.6 ± 1.6	ND	4.88 ± 0.99	0.42 ± 0.15	ND	0.68 ± 0.26	0.94 ± 0.26	ND
FWMF - goldenrod	9.4 ± 2.3	0.21 ± 0.11	338 ±65	0.60 ± 0.39	ND	1.42 ± 0.74	ND	ND
FWMF - goldenrod B	1.4 ± 0.9	ND	3.91 ± 0.67	ND	ND	ND	ND	ND
FWMF - dogwood	3.7 ± 0.7	0.09 ± 0.02	230 ±38	0.20 ± 0.12	ND	0.41 ± 0.22	ND	ND

(continued on next page)

Table 6-14. Radiological Analysis of Soil Samples *(concluded)*.

Sampling Location	Potassium-40 pCi/g	Cobalt-60 pCi/g	Cesium-137 pCi/g	Thallium-208 pCi/g	Actinium-228 pCi/g	Lead-212 pCi/g	Lead-214 pCi/g	Thorium-232 pCi/g
Off-Site Control Location*								
Long Beach soil	3.51 ± 0.70	ND	0.62 ± 0.11	0.11 ± 0.03	0.37 ± 0.09	0.30 ± 0.06	0.26 ± 0.05	ND
Middle Island soil	2.30 ± 0.96	ND	0.13 ± 0.05	0.16 ± 0.08	0.61 ± 0.22	0.47 ± 0.15	ND	ND
Farm Soils								
Lewin's Farm	9.6 ± 2.4	ND	ND	0.53 ± 0.22	1.85 ± 0.47	1.84 ± 0.41	1.41 ± 0.34	1.82 ± 1.10
Bruno's Farm	6.7 ± 1.2	ND	0.10 ± 0.03	0.25 ± 0.05	0.82 ± 0.12	0.79 ± 0.12	0.68 ± 0.10	0.89 ± 0.28
May's Farm	3.7 ± 1.1	ND	0.09 ± 0.06	0.23 ± 0.09	0.75 ± 0.22	0.76 ± 0.18	ND	ND
Cornell Coop	7.0 ± 1.2	ND	0.15 ± 0.04	0.37 ± 0.07	0.98 ± 0.14	0.93 ± 0.14	0.71 ± 0.16	1.17 ± 0.39
NYSDEC Game Farm	4.33 ± 0.80	ND	0.34 ± 0.07	0.22 ± 0.04	0.66 ± 0.09	0.61 ± 0.09	0.45 ± 0.07	0.61 ± 0.26

Notes:
All values shown with 95% confidence interval.
K-40 occurs naturally in the environment and is presented as a comparison to Cs-137.
ND = Not Detected
* = Soil samples are from special uptake program and are associated with vegetation sample results shown in Table 6-13.

control sample taken in Long Beach. The lower values are considered to be consistent with background levels resulting from worldwide fallout from historic aboveground nuclear weapons testing.

The soils taken from the FWMF show the levels of cesium-137 and cobalt-60 contamination still present at this facility. As mentioned above, the soil sampling in the FWMF was conducted in association with vegetation sampling in order to calculate uptake of cesium-137 by specific species of plants that may be consumed by deer. The highest level of cesium-137 (1,050 pCi/g dry weight) was found near the eastern portion of the facility. The highest level of Co-60 (2.37 pCi/g dry weight) was found in the same sample that contained the highest level of cesium-137. The higher levels of radionuclide contamination in these soils is a potential source for deer to acquire cesium-137. However, restrictive measures and repairs to the fence surrounding the FWMF are preventing deer from entering the facility to feed.

6.5 BASIN SEDIMENTS

BNL tests basin sediment samples on a two-year cycle. There are 14 basins associated with outfalls that receive discharges permitted under the State Pollutant Discharge Elimination System (SPDES) permit (see Figure 5-6 for basin locations). One basin, HZ, was added to the list in 2002; data presented in this report form the baseline for this new basin. Names for the basins have suffixes indicating their locations: E = east, N = north, M = middle, R = canal north of the railroad tracks, S = South.

6.5.1 Chemical Analysis

Table 6-15 presents the results of analysis for semivolatile organic compounds in basin sediments. Only those basins and chemicals that were detected are presented. The majority of all chemicals present in the table are estimated values, meaning that the chemical was detected but the value was below the required detection limit. All of the chemicals listed were detected above the detection limit in at least one basin. The phthalates listed are likely a result of cross contamination from the sample bottles used for shipping samples to the analytical laboratory. Phthalates are commonly used as plasticizers. The other listed chemicals represent petroleum breakdown products typically found in road run-off. All of the basins represented in Table 6-15 receive stormwater discharges from the road system at BNL.

6.5.2 PCBs and Pesticides

Basin sediments were analyzed for PCBs and pesticides. The results of these analyses are presented in Tables 6-16 and 6-17, respectively.

The PCBs Aroclor 1254 and Aroclor 1260 were detected in basin sediments from the HS outfall, HS canal, HS basin, HW basin, HT-E basin, HT-W basin, HN outfall, HN south basin, and the HN middle basin. PCBs have been detected in the HS and HW basins in the past. Present results are similar to past results in these basins. In 2002, sampling of the outfall and canal associated with the HS basin was completed to document the level of PCBs that were suspected of being present. Both HS and HW basins were covered under one or more Records of Decision associated with the environmental cleanup of the Laboratory. The presence of PCBs in the other basins and canals, while not unexpected, had never been documented by past sampling. BNL will continue to periodically sample all basins to maintain the baseline for PCBs.

The pesticides shown in Table 6-17 were commonly used throughout Long Island, including at BNL. The levels indicated in the table are fairly low, with most below or just above detection limits. All of the pesticides detected are long-lived and tend to persist in the environment at low concentrations. Continued periodic monitoring of basin sediments will enable BNL to track the continued degradation of these chemicals.

6.5.3 Metals

Table 6-18 presents the results of metals analysis on basin sediments. Samples from all basins were analyzed for metals, except for basins associated with the outfall at HN. With a few exceptions, all metals in all basins were within regulatory standards established for environmental cleanup. The exceptions to this include copper, lead, mercury, and nickel. Copper was found in excess of the Suffolk County action levels for cleanup in basin HT-E. Lead was also found in HT-E above the cleanup standard but below action levels. Mercury and nickel were found in both HW and HT-E basins above cleanup standards but below action levels. Cleanup actions for both basins have been covered under one or more Records of Decision for the environmental cleanup of the Laboratory and have been determined not to need remedial actions.

6.5.4 Radiological Analysis

All basins were sampled and analyzed for gamma-emitting radionuclides. The results of this sampling and analysis are presented in Table 6-19. All of the radionuclides presented, with the exception of cobalt-60 and cesium-137, are naturally occurring and are seen at similar levels in soil samples from elsewhere on site and from local farms. Cesium-137 levels are considered to be at background, are similar to values seen elsewhere, and result from worldwide fallout from historical aboveground nuclear weapons testing. The cobalt-60 seen in sediments in the HN area basins is likely from past Laboratory practices and is at levels consistent with those reported in 2000.

6.6 TOXICITY TESTS, SEWAGE TREATMENT PLANT

Under the SPDES discharge permit, BNL conducted toxicity testing for the Sewage Treatment Plant effluent. Two species were evaluated—the fathead minnow (*Pimephales promelas*) and the water flea (*Ceriodaphnia dubia*). Results from this testing program are presented in Chapter 3.

6.7 PRECIPITATION MONITORING

As part of the Environmental Monitoring Program, precipitation samples were collected approximately quarterly at air monitoring Stations P4 and S5 (see Chapter 4, Figure 4-4 for station locations) and analyzed for radiological content. Four samples were taken from each of these two stations in 2002. Gross alpha activity

Table 6-15. Semivolatile Organic Compound Analysis of Basin Sediments.

Basin Depth **Analyte**	**HS** 0"-2" µg/kg	**HS** 2"-4" µg/kg	**HS** 4"-6" µg/kg	**HS-R** 0"-2" µg/kg	**HS-R** 2"-4" µg/kg	**HS-R** 4"-6" µg/kg	**HS BASIN** 0"-2" µg/kg	**HS BASIN** 2"-4" µg/kg	**HW BASIN** 0"-2" µg/kg	**HW BASIN** 2"-4" µg/kg	**HW BASIN** 4"-6" µg/kg
2-Methylnaphthalene	< MDL	< MDL	< MDL	< MDL	< MDL	< MDL	< MDL	< MDL	< MDL	< MDL	< MDL
Acenaphthene	< MDL	< MDL	< MDL	< MDL	< MDL	< MDL	< MDL	< MDL	< MDL	< MDL	< MDL
Anthracene	< MDL	< MDL	< MDL	< MDL	< MDL	< MDL	< MDL	< MDL	< MDL	< MDL	< MDL
Benzo(a)anthracene	100*	100*	200*	300*	300*	200*	200*	< MDL	400*	300*	200*
Benzo(a)pyrene	100*	100*	200*	300*	200*	200*	200*	80*	400*	200*	200*
Benzo(b)fluoranthene	< MDL	< MDL	200*	200*	300*	200*	300*	< MDL	560	200*	200*
Benzo(ghi)perylene	< MDL	< MDL	< MDL	100*	100*	< MDL	90*	< MDL	100*	100*	< MDL
Benzo(k)fluoranthene	< MDL	< MDL	< MDL	300*	200*	< MDL	< MDL	< MDL	400*	200*	< MDL
Bis(2-ethylhexyl)phthalate	100*	< MDL	< MDL	100*	< MDL	< MDL	100*	< MDL	1200	660	400*
Butyl benzyl phthalate	< MDL	< MDL	< MDL	< MDL	< MDL	< MDL	< MDL	< MDL	< MDL	< MDL	< MDL
Carbazole	< MDL	< MDL	< MDL	< MDL	< MDL	< MDL	< MDL	< MDL	< MDL	< MDL	< MDL
Chrysene	100*	100*	200*	300*	300*	200*	200*	90*	510	300*	300*
Di-n-butyl phthalate	< MDL	< MDL	< MDL	< MDL	< MDL	< MDL	< MDL	< MDL	< MDL	< MDL	< MDL
Di-n-octyl phthalate	< MDL	< MDL	< MDL	< MDL	< MDL	< MDL	< MDL	< MDL	< MDL	< MDL	< MDL
Dibenzofuran	< MDL	< MDL	< MDL	< MDL	< MDL	< MDL	< MDL	< MDL	< MDL	< MDL	< MDL
Fluoranthene	200*	200*	400*	560	470	300*	300*	100*	830	550	400*
Fluorene	< MDL	< MDL	< MDL	< MDL	< MDL	< MDL	< MDL	< MDL	< MDL	< MDL	< MDL
Indeno(1,2,3-cd)pyrene	< MDL	< MDL	< MDL	100*	100*	< MDL	90	< MDL	100*	100*	< MDL
Naphthalene	< MDL	< MDL	< MDL	< MDL	< MDL	< MDL	< MDL	< MDL	< MDL	< MDL	< MDL
Phenanthrene	90*	100*	200*	200*	100*	100*	100*	< MDL	400*	300*	200*
Pyrene	200*	200*	300*	480	410	300*	300*	100*	670	490	400*

Basin Depth **Analyte**	**HT-E** 0"-2" µg/kg	**HT-E** 2"-4" µg/kg	**HT-E** 4"-6" µg/kg	**HN** 0"-2" µg/kg	**HN** 2"-4" µg/kg	**HN** 4"-6" µg/kg	**HN-N** 0"-2" µg/kg	**HN-N** 2"-4" µg/kg	**HN-N** 4"-6" µg/kg	**HN-M** 0"-2" µg/kg	**HN-M** 2"-4" µg/kg
2-Methylnaphthalene	< MDL	< MDL	< MDL	< MDL	< MDL	70	< MDL	< MDL	< MDL	< MDL	< MDL
Acenaphthene	< MDL	300*	< MDL	< MDL	50*	430	< MDL	< MDL	< MDL	< MDL	< MDL
Anthracene	< MDL	300*	< MDL	< MDL	100*	540	< MDL	< MDL	< MDL	50*	< MDL
Benzo(a)anthracene	200*	1300	500*	70*	400*	1200	60*	< MDL	< MDL	300*	< MDL
Benzo(a)pyrene	200*	960	500*	70*	440	1100	90*	< MDL	< MDL	300*	< MDL
Benzo(b)fluoranthene	200*	1400	400*	60*	400*	1100	100*	< MDL	< MDL	300*	< MDL
Benzo(ghi)perylene	< MDL	300*	200*	60*	300*	640	70*	< MDL	< MDL	200*	< MDL
Benzo(k)fluoranthene	< MDL	850	500*	80*	570	1200	100*	< MDL	< MDL	400*	< MDL
Bis(2-ethylhexyl)phthalat	100*	200*	400	100*	1600	400*	100*	< MDL	< MDL	590	< MDL
Butyl benzyl phthalate	< MDL	< MDL	< MDL	< MDL	200*	< MDL	< MDL	< MDL	< MDL	< MDL	< MDL
Carbazole	< MDL	510	< MDL	< MDL	80*	430	< MDL	< MDL	< MDL	50*	< MDL
Chrysene	300*	1500	590*	80*	540	1300	100*	< MDL	< MDL	400*	< MDL

(continued on next page)

Table 6-15. Semivolatile Organic Compound Analysis of Basin Sediments *(concluded)*.

Basin	**HT-E**	**HT-E**	**HT-E**	**HN**	**HN**	**HN**	**HN-N**	**HN-N**	**HN-N**	**HN-M**	**HN-M**
Depth	0"-2"	2"-4"	4"-6"	0"-2"	2"-4"	4"-6"	0"-2"	2"-4"	4"-6"	0"-2"	2"-4"
Analyte	µg/kg	µg/kg	µg/kg	µg/kg	µg/kg	µg/kg	µg/kg	µg/kg	µg/kg	µg/kg	µg/kg
Di-n-butyl phthalate	< MDL	< MDL	< MDL	50*	60*	50*	60*	< MDL	60*	70*	< MDL
Di-n-octyl phthalate	< MDL	< MDL	< MDL	< MDL	90*	< MDL	< MDL	< MDL	< MDL	< MDL	< MDL
Dibenzofuran	< MDL	400*	< MDL	< MDL	< MDL	200*	< MDL	< MDL	< MDL	< MDL	< MDL
Fluoranthene	510	3000	1000	200*	960	3000	200*	50*	< MDL	660	50*
Fluorene	< MDL	300*	< MDL	< MDL	50*	300*	< MDL	< MDL	< MDL	< MDL	< MDL
Indeno(1,2,3-cd)pyrene	< MDL	300*	200*	50*	300*	660	60*	< MDL	< MDL	200*	< MDL
Naphthalene	< MDL	< MDL	< MDL	< MDL	< MDL	100*	< MDL	< MDL	< MDL	< MDL	< MDL
Phenanthrene	400*	3200	500*	90*	490	2600	60*	< MDL	< MDL	300*	< MDL
Pyrene	400*	2200	860	100*	800	2100	100*	40*	< MDL	550	40*

Basin	**HN-M**	**HN-S**	**HN-S**	**HT-W**	**HT-W**	**HT-W**	**HX-W**	**HX-W**	**HX-E**
Depth	4"-6"	0"-2"	4"-6"	0"-2"	2"-4"	4"-6"	0"-2"	2"-4"	2"-4"
Analyte	µg/kg	µg/kg	µg/kg	µg/kg	µg/kg	µg/kg	µg/kg	µg/kg	µg/kg
2-Methylnaphthalene	< MDL	< MDL	< MDL	< MDL	< MDL	< MDL	< MDL	< MDL	< MDL
Acenaphthene	< MDL	< MDL	< MDL	100*	200*	< MDL	< MDL	< MDL	< MDL
Anthracene	< MDL	60*	< MDL	300*	300*	90*	< MDL	< MDL	< MDL
Benzo(a)anthracene	< MDL	300*	< MDL	840	630	300*	< MDL	< MDL	< MDL
Benzo(a)pyrene	< MDL	400	< MDL	770	600	300*	< MDL	40*	< MDL
Benzo(b)fluoranthene	< MDL	440	< MDL	640	480	300*	< MDL	< MDL	< MDL
Benzo(ghi)perylene	< MDL	200*	< MDL	570	470	200*	< MDL	< MDL	< MDL
Benzo(k)fluoranthene	< MDL	410	< MDL	870	680	300*	< MDL	< MDL	< MDL
Bis(2-ethylhexyl)phthalat	40*	200*	< MDL	200*	100*	60*	< MDL	70*	< MDL
Butyl benzyl phthalate	< MDL	70*	< MDL	< MDL	< MDL	< MDL	< MDL	< MDL	< MDL
Carbazole	< MDL	60*	< MDL	200*	200*	70*	< MDL	< MDL	< MDL
Chrysene	< MDL	440	< MDL	940	730	300*	< MDL	40*	< MDL
Di-n-butyl phthalate	40*	50*	40	60*	< MDL	60*	50*	40*	40*
Di-n-octyl phthalate	< MDL	< MDL	< MDL	< MDL	< MDL	< MDL	< MDL	< MDL	< MDL
Dibenzofuran	< MDL	< MDL	< MDL	60*	80*	< MDL	< MDL	< MDL	< MDL
Fluoranthene	< MDL	730	< MDL	2000	1700	720	< MDL	70*	< MDL
Fluorene	< MDL	< MDL	< MDL	100*	100*	< MDL	< MDL	< MDL	< MDL
Indeno(1,2,3-cd)pyrene	< MDL	200*	< MDL	560	440	200*	< MDL	< MDL	< MDL
Naphthalene	< MDL	< MDL	< MDL	50*	60*	< MDL	< MDL	< MDL	< MDL
Phenanthrene	< MDL	300*	< MDL	1100	1300	430	< MDL	< MDL	< MDL
Pyrene	< MDL	590	< MDL	1500	1200	520	< MDL	60*	< MDL

Notes:
MDL = minimum detection limit
* = Values that are below the detection limit, but above the instrument detection limit.
Only basins and depths with detections above the minimum detection limit are provided in table format.

Table 6-16. PCB Analysis of Basin Sediments.

Basin	Depth	Aroclor 1254 µg/kg	Aroclor 1260 µg/kg
HS	0"-2"	96	68
HS	2'-4"	93	66
HS	4"-6"	130	78
HS-R	0"-2"	70	61
HS-R	2"-4"	65	56
HS-R	4"-6"	62	54
HS Basin	0"-2"	50	45
HW Basin	0"-2"	180	360
HW Basin	2"-4"	180	1000
HW Basin	4"-6"	160	1700
HT-E	0"-2"	220	36*
HT-E	2'-4"	870	120
HT-E	4"-6"	930	110
HT-W	0"-2"	30*	160
HT-W	2"-4"	< MDL	55
HT-W	4"-6"	42	40
HN	0"-2"	30*	< MDL
HN	2'-4"	58	48
HN	4"-6"	180	50
HN-M	0"-2"	30*	< MDL
HN-S	0"-2"	69	43

Notes:
Only basins with detectable levels of PCBs are included in this table.
* = Values are estimated based on laboratory qualifiers.
MDL = Minimum Detection Limit

measurements above the minimum detection limit were found in samples taken in January, July, and October at Station S5 and in January, April, and October at Station P4. The samples from the P4 location showed a maximum of 16.7 pCi/L activity, whereas the samples from the S5 location had a maximum activity level of 89.7 pCi/L. Both of these values are within the range of historic values reported for gross alpha activity. Gross beta activity was measured in all samples at each of the sampling locations, except for the July sample taken at P4. In general, radioactivity in precipitation comes from naturally occurring radionuclides in dust and from activation products that result from solar radiation. Location P4 had a maximum gross beta activity level of 14.0 pCi/L, with an average of 6.64 pCi/L. Location S5 had a maximum of 77.7 pCi/L, with the average activity of 24.0 pCi/L. Gross beta activity values were within the range of values historically observed at these two locations. Tritium was not detected in any of the samples from either location. Gamma analysis of samples showed the presence of beryllium-7 at a maximum of 41.7 pCi/L at Station P4 in April and 55.1 pCi/L in January at Station S5. Beryllium-7 is a naturally occurring radionuclide resulting from solar flare activity.

6.8 WILDLIFE PROGRAMS

BNL sponsors a variety of educational and outreach activities involving natural resources. These programs are designed to help participants understand the ecosystem and to foster interest in science. Wildlife programs are conducted at BNL in collaboration with DOE, local agencies, colleges, and high schools. Ecological research is also conducted on site to update the current natural resources inventory, gain a better understanding of the ecosystem, and guide management planning.

In 2002, the Environmental Services Division (ESD) hosted two student interns during the summer. One intern was from the University of Georgia and continued research on the tiger salamander and other amphibians that was started in 2001. The research focus was on the use of coverboards and the variability of relative humidity on the distribution of amphibians. Unfortunately, the drought of 2002 resulted in less than optimal conditions for this research.

The second intern, from the University of Rhode Island, looked at population estimating techniques using BNL's deer population. Estimating deer populations is difficult and may result in a wide range of variability. One of the more difficult methodologies utilizes a method called Distance Sampling. This method requires the observer to identify each deer or cluster of deer, measure the vertical distance from the observer's path, and estimate the deer's angle from the observer's path. The data are then entered into a program that estimates population levels. This method was used by the student and compared to the standard method used by BNL, as well as two modifications of this method. The resulting population estimates ranged from 567 animals using the Distance Sampling approach, to 1,866 animals by modifying the standard method used by BNL and dropping the area of open fields from the calculation. The results of the research highlighted the variability in population estimating and the importance of using standardized methodology.

Table 6-17. Pesticide Analysis of Basin Sediments.

Basin	**HS**	**HS**	**HS**	**HS-R**	**HS-R**	**HS-R**	**HS BASIN**	**HS BASIN**	**HS BASIN**	**HW BASIN**
Depth	0"-2"	2"-4"	4"-6"	0"-2"	2"-4"	4"-6"	0"-2"	2"-4"	4"-6"	0"-2"
Analyte	µg/kg	µg/kg	µg/kg	µg/kg	µg/kg	µg/kg	µug/kg	µg/kg	µg/kg	µg/kg
4,4′-DDD	2.7*	3.5*	5.9	< MDL	< MDL	< MDL	3.3*	< MDL	< MDL	4.9
4,4′-DDE	3.8*	4.5*	6.6	3.1*	2.5*	< MDL	4.3*	< MDL	< MDL	11
4,4′-DDT	9.6	10	11	3.2*	2.9*	2.5*	11	4.8	2.6	< MDL
alpha-BHC	< MDL	< MDL	< MDL	< MDL	< MDL	< MDL	< MDL	< MDL	< MDL	< MDL
alpha-Chlordane	1.4*	1.2*	2.0*	< MDL	< MDL	< MDL	1.9*	1.1*	< MDL	3.1
delta-BHC	< MDL	< MDL	< MDL	< MDL	< MDL	< MDL	1.8*	< MDL	< MDL	< MDL
Endosulfan I	2.6	1.5*	2.2	2.4	2.0	1.9*	1.8*	< MDL	< MDL	6.7
Endosulfan sulfate	< MDL	< MDL	< MDL	< MDL	< MDL	< MDL	< MDL	< MDL	< MDL	< MDL
Endrin	< MDL	3.0*	2.9*	2.5*	2.8*	< MDL	< MDL	< MDL	< MDL	6.0
Endrin aldehyde	< MDL	< MDL	< MDL	< MDL	< MDL	< MDL	< MDL	< MDL	< MDL	< MDL
Endrin ketone	< MDL	< MDL	< MDL	< MDL	< MDL	< MDL	< MDL	< MDL	< MDL	< MDL
gamma-Chlordane	1.7*	1.8*	2.5	< MDL	1.1*	< MDL	1.1*	< MDL	< MDL	2.2*
Heptachlor	< MDL	< MDL	< MDL	< MDL	< MDL	< MDL	< MDL	< MDL	< MDL	< MDL
Heptachlor epoxide	< MDL	< MDL	< MDL	< MDL	< MDL	< MDL	< MDL	< MDL	< MDL	< MDL
Methoxychlor	< MDL	< MDL	< MDL	< MDL	< MDL	< MDL	< MDL	< MDL	< MDL	< MDL

Basin	**HW BASIN**	**HW BASIN**	**HT-E**	**HT-E**	**HT-E**	**HT-W**	**HT-W**	**HT-W**	**HN**	**HN**
Depth	2"-4"	4"-6"	0"-2"	2"-4"	4"-6"	0"-2"	2"-4"	4"-6"	0"-2"	2"-4"
Analyte	µg/kg	µg/kg	µg/kg	µg/kg	µg/kg	µg/kg	µg/kg	µg/kg	µg/kg	µg/kg
4,4′-DDD	8.2	7.2	< MDL	4.0*	17	2.0	< MDL	4.5	< MDL	2.0*
4,4′-DDE	7.3	5.3	2.8*	10	9.4	3.0*	4.1	5.9	< MDL	< MDL
4,4′-DDT	< MDL	< MDL	< MDL	6.6	8.0	3.0*	3.0*	3.0*	< MDL	< MDL
alpha-BHC	< MDL	< MDL	< MDL	< MDL	< MDL	< MDL	< MDL	< MDL	< MDL	1.0*
alpha-Chlordane	3.1	2.4	< MDL	3.4	2.9*	2.0*	2.0*	< MDL	1.0*	1.0*
delta-BHC	< MDL	MDL	< MDL	< MDL	< MDL	< MDL	< MDL	< MDL	< MDL	< MDL
Endosulfan I	7.8	3.9	4.7	3.3	7.0	< MDL	1.0*	2.0	< MDL	2.0*
Endosulfan sulfate	< MDL	< MDL	< MDL	< MDL	< MDL	3.0*	4.4	< MDL	< MDL	< MDL
Endrin	8.6	8.7	3.2*	8.0	14	7.9	6.9	5.1	< MDL	< MDL
Endrin aldehyde	< MDL	< MDL	< MDL	< MDL	< MDL	< MDL	6.5	< MDL	< MDL	< MDL
Endrin ketone	2.2*	3.3*	< MDL	< MDL	< MDL	4.4	17	< MDL	< MDL	< MDL
gamma-Chlordane	2.9	3.3	2.6	10	10	2.0*	2.0*	2.7	< MDL	1.0*
Heptachlor	< MDL	< MDL	< MDL	< MDL	2.6*	< MDL	< MDL	< MDL	< MDL	< MDL
Heptachlor epoxide	< MDL	< MDL	< MDL	2.8	< MDL	2.0*	< MDL	< MDL	< MDL	3.3
Methoxychlor	< MDL	16*	< MDL	< MDL	< MDL	< MDL	23	< MDL	< MDL	< MDL

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Table 6-17. Pesticide Analysis of Basin Sediments *(concluded)*.

Basin	**HN**	**HN-W**	**HN-W**	**HN-W**	**HN-M**	**HN-M**	**HN-M**	**HN-S**	**HN-S**
Depth	4"-6"	0"-2"	2"-4"	4"-6"	0"-2"	2"-4"	4"-6"	0"-2"	2"-4"
Analyte	µg/kg	µg/kg	µg/kg	µg/kg	µg/kg	µg/kg	µg/kg	µg/kg	µg/kg
4,4'-DDD	< MDL	< MDL	< MDL	< MDL	< MDL	< MDL	< MDL	2.0*	< MDL
4,4'-DDE	< MDL	< MDL	< MDL	< MDL	< MDL	< MDL	< MDL	3*	< MDL
4,4'-DDT	2.0*	< MDL	< MDL	< MDL	< MDL	< MDL	< MDL	2.0*	< MDL
alpha-BHC	< MDL	< MDL	< MDL	< MDL	< MDL	< MDL	< MDL	< MDL	< MDL
alpha-Chlordane	< MDL	< MDL	2.5	2.0	2.0*	< MDL	2.0	2.0	< MDL
delta-BHC	< MDL	< MDL	< MDL	< MDL	< MDL	< MDL	< MDL	< MDL	< MDL
Endosulfan I	< MDL	< MDL	< MDL	< MDL	< MDL	< MDL	< MDL	1.0*	< MDL
Endosulfan sulfate	< MDL	< MDL	< MDL	< MDL	< MDL	< MDL	< MDL	3.0*	< MDL
Endrin	< MDL	< MDL	< MDL	< MDL	< MDL	< MDL	< MDL	< MDL	< MDL
Endrin aldehyde	3.0*	< MDL	< MDL	< MDL	< MDL	< MDL	< MDL	3.0*	< MDL
Endrin ketone	< MDL	< MDL	< MDL	< MDL	< MDL	< MDL	< MDL	3.0*	< MDL
gamma-Chlordane	2.0*	< MDL	< MDL	< MDL	< MDL	< MDL	< MDL	1.0*	< MDL
Heptachlor	< MDL	< MDL	< MDL	< MDL	< MDL	< MDL	< MDL	< MDL	< MDL
Heptachlor epoxide	< MDL	1.0*	6.1	4.7	2.3	1.0*	6.9	14	2.2
Methoxychlor	< MDL	< MDL	< MDL	< MDL	< MDL	< MDL	< MDL	< MDL	< MDL

Notes:
MDL = Minimum Detection Limit
* = Values that are below the detection limit, but above the instrument detection limit.
Only basins and depths with detections above the minimum detection limit are provided in table format.

The results of both research projects can be used to modify management strategies for the tiger salamander as well as altering deer population estimating protocols.

Additionally, Suffolk County Community College, in association with FWS and BNL, conducted summer field research opportunities for local high school students. These opportunities also allowed two undergraduate students from the University of Puerto Rico to gain teaching skills through the Pre-Service Teacher program. The high school students worked on several projects collecting useful data on deer browse, forest health, oak seedling recruitment, and fuel loading. The students also had the opportunity to visit nearly all of the ecosystems present on Long Island.

In addition to hosting interns, members of ESD and other departments volunteer as speakers to schools and civic groups and provide on-site ecology tours. ESD also hosted activities in association with Earth Day 2002 and provided activities to educate Laboratory employees and the general public on the environment and conservation during a Summer Sunday event. BNL hosted the Seventh Annual Pine Barrens Research Forum in October, providing a venue for researchers who are conducting work on pine barrens ecosystems to share and discuss their results. BNL also hosted the annual Wildland Fire Academy offered by NYSDEC and the Central Pine Barrens Commission. This academy trains fire fighters in the methods of wildland fire suppression, prescribed fire, and fire analysis, all using the Incident Command System of wildfire management.

Table 6-18. Metals Analysis of Basin Sediments.

Basin	HO-W	HO-W	HO-W	HO-E	HO-E	HO-E	HS	HS	HS	HS-R
Depth	0"-2"	2"-4"	4"-6"	0"-2"	2"-4"	4"-6"	0"-2"	2"-4"	4"-6"	0"-2"
Analyte	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg
Aluminum	784	612	581	859	589	576	1490	2250	1540	1820
Antimony	< MDL	0.36	< MDL	0.40	0.48	< MDL	0.66	0.66	0.46	0.39
Arsenic	0.30	0.35	< MDL	0.94	0.23	0.61	0.71	0.67	0.34	0.42
Barium	14	9.7	8.7	26.4	14.9	11.4	8.3	12.6	7.5	10.2
Beryllium	0.05	0.05	0.03	0.05	0.04	0.03	0.04	0.06	0.04	0.05
Cadmium	0.05	< MDL	< MDL	< MDL	< MDL	< MDL	< MDL	0.06	0.04	0.06
Calcium	214	129	127	241	259	121	295	419	282	454
Chromium	2.1	3.4	1.2	2.1	1.5	1.5	8.0	4.4	3.0	2.6
Cobalt	1.3	0.93	0.75	1.7	0.93	0.83	1.1	1.9	0.84	1.1
Copper	7.5	5.4	3.7	9.5	5.4	4.6	11.4	13.2	8.4	11.8
Iron	2280	2270	1500	4300	2490	2190	5270	4200	2100	2370
Lead	2.2	1.5	1.3	2.8	1.6	1.4	12.4	18	11.8	8.4
Magnesium	254	169	183	227	155	159	241	422	266	329
Manganese	192	127	108	304	170	134	42.1	62.5	31.2	52.7
Mercury	< MDL	< MDL	< MDL	< MDL	< MDL	< MDL	< MDL	0.02	0.02	< MDL
Nickel	2.8	4.1	1.7	2.3	1.3	1.2	3.8	4.4	2.6	3.6
Potassium	54.6	48.6	50.4	54.9	37.7	35.4	70.1	89.8	72.5	79.3
Selenium	0.21	0.32	0.34	0.21	< MDL	< MDL	0.58	0.44	< MDL	0.44
Silver	< MDL	< MDL	< MDL	< MDL	< MDL	< MDL	< MDL	< MDL	< MDL	< MDL
Sodium	18.6	14	14.6	14.9	13.4	13.2	37.3	53.6	38.0	56.5
Thallium	0.38	0.33	< MDL	< MDL	0.4	0.43	0.48	< MDL	< MDL	< MDL
Vanadium	3.4	3.8	1.9	3.9	2.3	2.1	5.5	7.1	4.7	5.0
Zinc	18.7	25.8	10.2	20.9	11.2	11.2	43.4	62	39.5	59.6

Basin	**HS-R**	**HS-R**	**HS BASIN**	**HS BASIN**	**HS BASIN**	**HW BASIN**	**HW BASIN**	**HW BASIN**	**HTE**
Depth	2"-4"	4"-6"	0"-2"	2"-4"	4"-6"	0"-2"	2"-4"	4"-6"	0"-2"
Analyte	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg
Aluminum	1530	1600	3630	2970	1800	8400	7850	8390	2520
Antimony	0.44	0.58	0.48	0.46	< MDL	1.1	0.78	0.9	0.61
Arsenic	0.34	0.45	1.1	0.96	0.81	1.7	1.8	2.8	0.58
Barium	8.7	8.8	14.1	11.4	6.4	29.3	24.4	25.6	16.0
Beryllium	0.05	0.05	0.09	0.08	0.06	0.22	0.20	0.21	0.09
Cadmium	0.06	0.05	0.13	0.08	0.05	2.9	0.80	1.3	0.30
Calcium	342	269	479	313	224	1320	815	785	2750
Chromium	2.3	2.9	5.6	4.6	3.0	20.2	13.4	17.1	6.8
Cobalt	0.92	1.1	1.8	1.3	0.86	4.4	3.1	3.0	3.1
Copper	9.6	8.6	12.9	10.8	6.1	54.3	22.8	27.1	74.7
Iron	1920	2260	4950	3810	2610	9200	8090	7950	7520
Lead	7.3	9.8	18.2	13.8	6.0	99.6	46.2	70.7	25.5
Magnesium	241	268	602	438	285	1340	1140	966	1680
Manganese	43.7	65.4	66.2	53.3	29.0	68.0	52.6	50.8	48.1
Mercury	< MDL	< MDL	< MDL	< MDL	< MDL	0.48*	0.19*	0.3*	0.15*

(continued on next page)

Table 6-18. Metals Analysis of Basin Sediments *(concluded)*.

Basin Depth **Analyte**	**HS-R** 2"-4" mg/kg	**HS-R** 4"-6" mg/kg	**HS BASIN** 0"-2" mg/kg	**HS BASIN** 2"-4" mg/kg	**HS BASIN** 4"-6" mg/kg	**HW BASIN** 0"-2" mg/kg	**HW BASIN** 2"-4" mg/kg	**HW BASIN** 4"-6" mg/kg	**HT-E** 0"-2" mg/kg
Nickel	3.0	3.1	4.7	3.9	2.4	17.5*	9.6	12.1	6.2
Potassium	66.0	75.6	155	125	96.3	371	283	279	123
Selenium	< MDL	< MDL	0.47	0.48	< MDL	0.83	0.96	0.9	0.35
Silver	< MDL	< MDL	< MDL	< MDL	< MDL	0.25	0.23	0.12	0.14
Sodium	42.2	40.2	47.9	35.9	29.1	109	87.2	65.7	59.3
Thallium	0.44	< MDL	0.76	0.44	0.55	< MDL	0.62	0.65	0.64
Vanadium	4.2	4.5	9.9	7.8	4.9	32.1	23	24.5	7.9
Zinc	46.7	54.7	69.6	59.1	35.4	256	132	128	65.6

Basin Depth **Analyte**	**HT-E** 2"-4" mg/kg	**HT-E** 4"-6" mg/kg	**HP-E** 0"-2" mg/kg	**HP-E** 2"-4" mg/kg	**HP-E** 4"-6" mg/kg	**HP-W** 0"-2" mg/kg	**HP-W** 2"-4" mg/kg	**HP-W** 4"-6" mg/kg	**HZ**[1] 2"-4" mg/kg
Aluminum	5450	7350	767	450	516	853	685	857	1514
Antimony	0.93	0.87	< MDL	< MDL	< MDL	< MDL	< MDL	0.37	< MDL
Arsenic	1.3	4.2	1.6	0.6	1.2	1.6	1.4	0.67	0.85
Barium	29.9	52	27.2	15.9	16.7	71.8	41.4	21.7	4.3
Beryllium	0.19	0.26	0.06	0.02	0.03	0.05	0.04	0.04	0.06
Cadmium	0.58	1.4	< MDL	< MDL	< MDL	< MDL	< MDL	< MDL	< MDL
Calcium	1660	2400	136	98	99.1	235	220	135	122
Chromium	15.8	20.8	2.2	0.97	1.2	3.0	2.5	1.8	2.5
Cobalt	5.2	6.6	1.4	0.85	0.91	3.0	1.7	1.2	0.99
Copper	207*	535**	22.4	10.5	14.6	32.9	22.6	11	2.07
Iron	7090	9110	3600	1620	1880	6130	4030	2460	2560
Lead	70.9	130*	1.7	0.92	1.4	2.1	1.6	1.4	1.92
Magnesium	1380	1200	161	104	127	254	209	284	306
Manganese	48.3	43	333	204	223	765	415	202	43.0
Mercury	0.15*	0.22*	< MDL	< MDL	< MDL	< MDL	< MDL	< MDL	< MDL
Nickel	9.9	15.6*	1.6	1.2	1.4	2.4	1.7	1.5	1.50
Potassium	235	223	49.8	31	45.7	69.4	59.1	66.3	116
Selenium	0.83	2.3	0.66	0.58	0.45	0.69	0.56	0.42	< MDL
Silver	0.77	2.3	0.2	0.09	0.22	0.2	0.22	0.21	< MDL
Sodium	84.4	105	14.0	10.9	11.8	13.5	14.2	17.1	22.5
Thallium	0.67	0.62	0.32	< MDL	< MDL	< MDL	0.35	< MDL	0.45
Vanadium	15.7	25.5	2.7	1.5	1.7	3.5	2.6	2.5	4.1
Zinc	109	195	7.3	4.8	4.5	6.3	4.7	5.9	5.3

Notes:
MDL = Minimum Detection Lmit
[1] = HZ is a new basin installed in 2002. Values are averaged from ten samples taken as baseline information.
* = Values above Suffolk County cleanup objectives but below action levels.
**= Values above Suffolk County action levels.

Table 6-19. Radiological Analysis of Basin Sediments.

Location	Depth	Potassium-40 pCi/g	Co-60 pCi/g	Cesium-137 pCi/g	Thallium-208 pCi/g	Lead-212 pCi/g	Lead-214 pCi/g	Actinium-228 pCi/g	Thorium-232 pCi/g
HO-W	0"-2"	3.2 ± 0.6	ND	ND	0.08 ± 0.03	0.32 ± 0.06	0.14 ± 0.08	0.27 ± 0.07	ND
HO-W	2"-4"	3.4 ± 1.5	ND	ND	0.23 ± 0.13	0.54 ± 0.21	ND	ND	ND
HO-W	4"-6"	3.0 ± 1.1	ND	0.09 ± 0.07	0.11 ± 0.06	0.24 ± 0.10	ND	ND	ND
HO-E	0"-2"	3.4 ± 0.7	ND	0.04 ± 0.03	0.15 ± 0.04	0.35 ± 0.07	0.27 ± 0.10	0.43 ± 0.09	0.46 ± 0.20
HO-E	2"-4"	3.1 ± 0.6	ND	ND	0.09 ± 0.03	0.29 ± 0.06	0.20 ± 0.06	0.35 ± 0.08	ND
HO-E	4"-6"	3.8 ± 0.7	ND	ND	0.09 ± 0.03	0.26 ± 0.05	0.18 ± 0.05	ND	ND
HS	0"-2"	ND	ND	0.08 ± 0.04	0.08 ± 0.08	ND	ND	ND	ND
HS	2"-4"	2.7 ± 0.5	ND	0.06 ± 0.02	0.08 ± 0.03	0.25 ± 0.05	0.22 ± 0.05	0.28 ± 0.06	0.24 ± 0.12
HS	4"-6"	2.5 ± 1.3	ND	ND	ND	0.25 ± 0.20	ND	ND	ND
HS-R	0"-2"	2.8 ± 1.1	ND	ND	ND	0.18 ± 0.10	ND	ND	ND
HS-R	2"-4"	3.4 ± 0.7	ND	0.05 ± 0.03	0.12 ± 0.03	0.25 ± 0.06	0.21 ± 0.09	0.33 ± 0.08	ND
HS-R	4"-6"	2.3 ± 0.5	ND	0.05 ± 0.02	0.09 ± 0.03	0.22 ± 0.05	0.21 ± 0.05	0.27 ± 0.08	ND
HS BASIN	0"-2"	3.3 ± 0.6	ND	0.09 ± 0.03	0.15 ± 0.04	0.39 ± 0.07	0.29 ± 0.05	0.41 ± 0.08	0.49 ± 0.19
HS BASIN	2"-4"	6.6 ± 1.1	ND	0.08 ± 0.03	0.12 ± 0.03	0.36 ± 0.06	0.29 ± 0.06	0.29 ± 0.07	0.50 ± 0.17
HS BASIN	4"-6"	ND	ND	0.05 ± 0.03	ND	ND	ND	ND	ND
HW BASIN	0"-2"	4.7 ± 0.8	ND	0.30 ± 0.06	0.19 ± 0.04	0.57 ± 0.09	0.36 ± 0.06	0.56 ± 0.09	0.60 ± 0.23
HW BASIN	2"-4"	9.4 ± 2.3	ND	ND	0.54 ± 0.21	1.52 ± 0.38	0.80 ± 0.27	ND	1.20 ± 0.96
HW BASIN	4"-6"	5.7 ± 1.6	ND	0.37 ± 0.12	0.27 ± 0.11	0.80 ± 0.17	0.51 ± 0.17	ND	ND
HT-E	0"-2"	4.3 ± 0.8	ND	0.08 ± 0.04	0.14 ± 0.04	0.52 ± 0.09	0.35 ± 0.12	0.52 ± 0.10	ND
HT-E	2"-4"	4.3 ± 0.8	ND	0.17 ± 0.04	0.17 ± 0.04	0.48 ± 0.08	0.43 ± 0.07	0.50 ± 0.09	0.55 ± 0.24
HT-E	4"-6"	5.2 ± 1.6	ND	0.87 ± 0.29	0.34 ± 0.17	0.88 ± 0.32	0.50 ± 0.25	ND	ND
HT-W	0"-2"	3.7 ± 0.7	ND	0.37 ± 0.07	0.10 ± 0.04	0.40 ± 0.07	0.21 ± 0.09	0.38 ± 0.07	0.39 ± 0.20
HT-W	2"-4"	3.4 ± 0.7	ND	0.29 ± 0.06	0.15 ± 0.04	0.49 ± 0.08	0.28 ± 0.10	0.51 ± 0.08	0.51 ± 0.24
HT-W	4"-6"	1.9 ± 1.0	ND	0.31 ± 0.07	ND	0.36 ± 0.15	0.34 ± 0.21	ND	ND
HP-E	0"-2"	1.4 ± 0.9	ND	ND	0.13 ± 0.10	0.38 ± 0.14	ND	ND	ND
HP-E	2"-4"	2.0 ± 0.5	ND	ND	0.09 ± 0.03	0.23 ± 0.05	0.19 ± 0.09	ND	ND
HP-E	4"-6"	1.9 ± 0.4	ND	ND	0.08 ± 0.03	0.17 ± 0.05	0.15 ± 0.05	ND	ND
HP-W	0"-2"	3.1 ± 0.6	ND	ND	0.17 ± 0.04	0.51 ± 0.08	0.31 ± 0.06	0.56 ± 0.09	0.49 ± 0.19
HP-W	2"-4"	5.0 ± 0.9	ND	ND	0.12 ± 0.04	0.39 ± 0.07	0.19 ± 0.05	0.37 ± 0.08	0.44 ± 0.19
HP-W	4"-6"	ND	ND	ND	ND	ND	ND	ND	ND
HN	0"-2"	2.1 ± 0.4	0.06 ± 0.01	0.04 ± 0.02	0.12 ± 0.03	0.39 ± 0.07	0.23 ± 0.05	ND	0.44 ± 0.18
HN	2"-4"	2.3 ± 0.5	0.07 ± 0.02	0.06 ± 0.03	0.13 ± 0.03	0.36 ± 0.07	0.23 ± 0.05	0.39 ± 0.08	0.49 ± 0.20
HN	4"-6"	ND	ND	0.05 ± 0.03	ND	ND	ND	0.27 ± 0.23	ND
HN-N	0"-2"	2.8 ± 0.5	0.03 ± 0.01	0.07 ± 0.02	0.12 ± 0.03	0.33 ± 0.06	0.24 ± 0.05	0.35 ± 0.07	0.28 ± 0.14
HN-N	2"-4"	4.1 ± 1.5	ND	ND	0.32 ± 0.14	0.53 ± 0.21	ND	ND	ND

(continued on next page)

Table 6-19. Radiological Analysis of Basin Sediments *(concluded).*

Location	Depth	Potassium-40 pCi/g	Co-60 pCi/g	Cesium-137 pCi/g	Thallium-208 pCi/g	Lead-212 pCi/g	Lead-214 pCi/g	Actinium-228 pCi/g	Thorium-232 pCi/g
HN-N	4"-6"	3.2 ± 1.1	ND	ND	0.22 ± 0.08	0.38 ± 0.13	0.32 ± 0.14	ND	1.10 ± 0.57
HN-M	0"-2"	3.4 ± 0.7	0.05 ± 0.02	0.12 ± 0.03	0.13 ± 0.04	0.40 ± 0.07	0.26 ± 0.07	0.47 ± 0.10	0.52 ± 0.23
HN-M	2"-4"	4.1 ± 0.8	ND	0.04 ± 0.02	0.14 ± 0.04	ND	ND	0.38 ± 0.09	ND
HN-M	4"-6"	1.4 ± 0.9	ND	ND	ND	ND	ND	ND	ND
HN-S	0"-2"	4.4 ± 0.8	0.07 ± 0.02	0.13 ± 0.03	0.15 ± 0.04	0.41 ± 0.07	0.30 ± 0.09	0.37 ± 0.08	0.38 ± 0.18
HN-S	2"-4"	3.0 ± 0.6	ND	ND	0.12 ± 0.04	0.34 ± 0.07	0.18 ± 0.11	ND	ND
HN-S	4"-6"	2.8 ± 0.6	ND	ND	0.14 ± 0.04	ND	ND	ND	ND
HX-E	0"-2"	2.2 ± 0.5	ND	ND	0.12 ± 0.04	0.29 ± 0.05	0.22 ± 0.05	ND	ND
HX-E	2"-4"	2.0 ± 0.4	ND	ND	0.08 ± 0.03	0.27 ± 0.05	0.20 ± 0.05	0.26 ± 0.06	0.46 ± 0.16
HX-E	4"-6"	ND	ND	ND	ND	ND	ND	ND	ND
HX-W	0"-2"	2.6 ± 0.5	ND	0.02 ± 0.02	0.15 ± 0.04	0.43 ± 0.07	0.27 ± 0.10	0.51 ± 0.08	0.58 ± 0.15
HX-W	2"-4"	3.3 ± 0.6	ND	ND	0.15 ± 0.05	0.40 ± 0.08	0.31 ± 0.07	0.56 ± 0.10	0.70 ± 0.26
HX-W	4"-6"	3.3 ± 0.6	ND	ND	0.19 ± 0.04	ND	ND	0.42 ± 0.10	ND
HZ*	2"-4"	3.0 ± 3.0	ND	ND	0.11 ± 0.15	0.4 ± 0.4	0.25 ± 0.26	0.33 ± 0.16	0.45 ± 0.27

Notes:
ND = Not Detected
* HZ is a new basin installed in 2002. Results are baseline information averaged from 10 samples across the bottom of the basin.
All values are shown with a 95% confidence interval.

6.9 CULTURAL RESOURCE ACTIVITIES

The Cultural Resource Management Program is being developed to ensure that the Laboratory fully complies with the numerous cultural resource requirements. BNL is working toward meeting an accelerated schedule for development of the BNL Cultural Resources Management Plan (CRMP), including having a draft plan submitted to DOE by December 2003. Development of a formal CRMP will guide the management of all of BNL's cultural resources. Along with achieving compliance with applicable regulations, one of the major goals of the Cultural Resource Management Program is to fully assess both known and potential cultural resources. The range of BNL cultural resources potentially includes buildings and structures, World War I (WWI) earthwork features, the Camp Upton Historical Collection, scientific equipment, photo archives, and institutional records. As various cultural resources are identified, plans for their long-term stewardship will be developed and implemented. Achieving these goals will ensure that the contributions BNL and the BNL site have made to the national history and culture are documented and available for interpretation.

BNL has three structures or sites that have been determined to be eligible for listing on the National Register of Historic Places: the Brookhaven Graphite Research Reactor (BGRR) complex, the High Flux Beam Reactor (HFBR) complex, and the World War I training trenches associated with Camp Upton.

As part of developing the management plan, several projects were initiated in 2002. In one project, BNL contracted with an outside firm to evaluate the on-site WWI features for National Register eligibility and preservation or restoration concepts. This project included mapping the training trenches and many of the remaining Camp Upton footprint foundations. Ten separate trench and three foundation complexes were surveyed as part of this effort. Figure

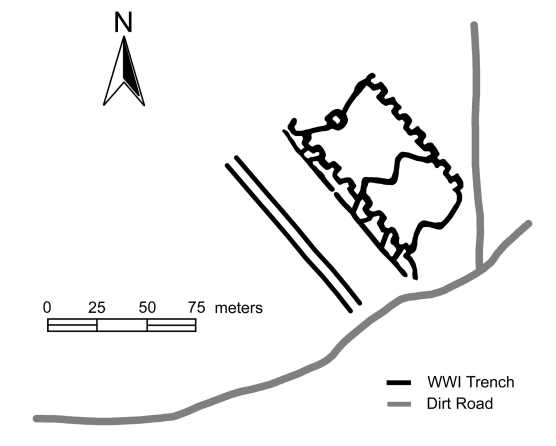

Exhibit A. Overhead view of BNL trench 6.

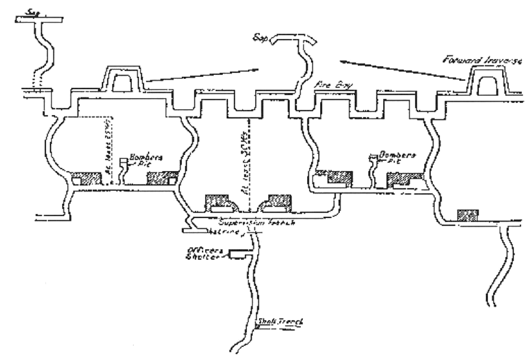

Exhibit B. Trench layout from *British Trench Warfare, 1917 — 1918*, by the British General Staff.

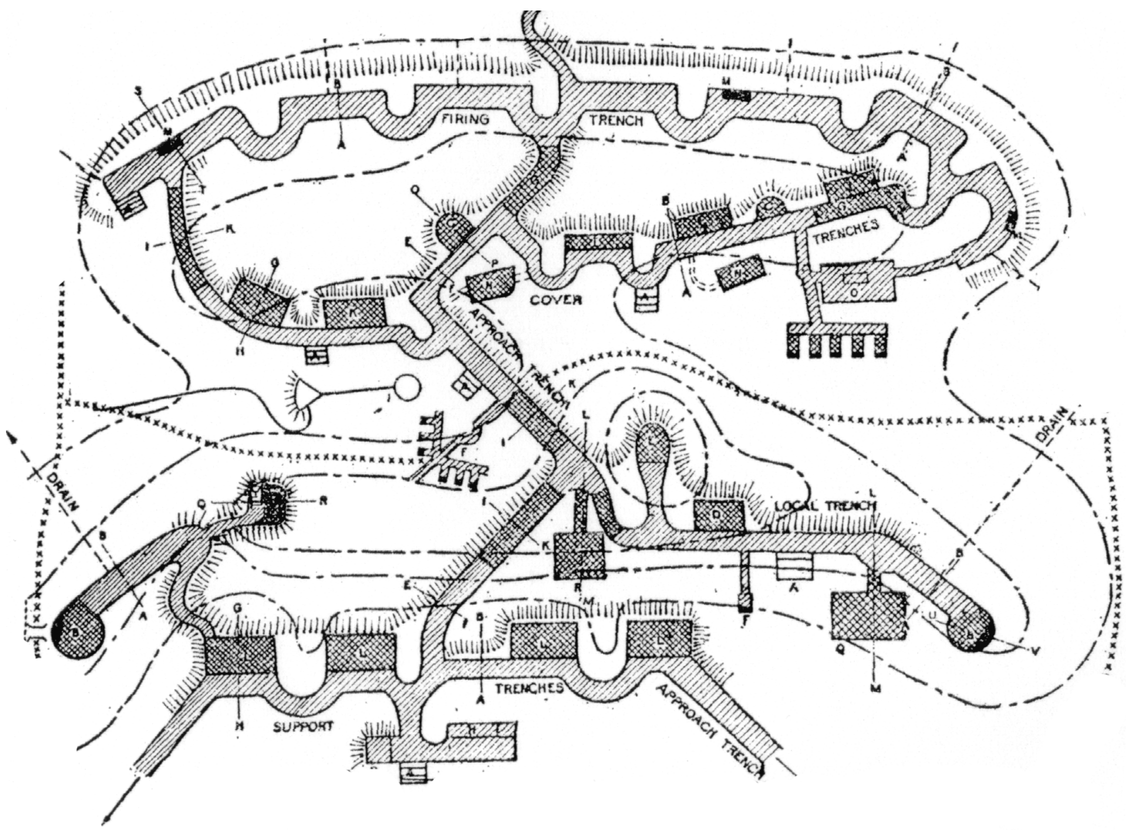

Exhibit C. Trench layout from *1918 Engineer Field Manual*, U.S. Army Corps of Engineers.

Figure 6-7. Typical World War I Trench Configurations.

Figure 6-8. WWI Training Trench at Camp Upton, Circa 1918.

Figure 6-9. WWI Training Trench As It Appears on the BNL Site Today.

6-7 illustrates an example of how this project provides insight into one of BNL's most unique cultural resources, the World War I training trenches.

Exhibit A of Figure 6-7 shows the result of mapping Trench 6. An overhead view was produced that provides a complete perspective of how this particular trench network was arranged. Exhibits B and C present two diagrams of trench construction methods, from British, and American army field manuals. When the Trench 6 layout is compared to the two field manual methods, similarities become quite apparent.

Figure 6-8 is a photograph from WWI Camp Upton showing a trench warfare training exercise, circa 1918. Figure 6-9 is a recent photograph depicting how the trenches appear today, approximately 85 years later. The BNL trenches may be the only existing examples of World War I earthworks in the United States.

Another contracted project that produced valuable results was the inventory and cataloging of the Camp Upton Museum Collection according to museum standards. This completed project includes more than 2,040 items cataloged and labeled; items organized and stored using standard museum methods and materials; a database established with accession, collection, and photo tables; forms and a procedure created for an accession and collection records system; and each item digitally photographed.

BNL continued to develop documentation concerning the BGRR associated with the "Memorandum of Agreement Between BHG and New York State Historic Preservation Office Concerning Decommissioning Project" (Desmarais 2000). An initial draft of the BGRR History Video was completed and a draft version was distributed in December 2002 to DOE for submittal to the New York State Historic Preservation Officer for review and comment. Copies were also distributed internally to other interested BNL parties.

In 2002, BNL also identified the potential remains of two 19th-century home sites located on BNL property. See Chapter 3, Section 3.4, Historic Preservation and Archeology, for additional cultural resource compliance accomplishments performed in 2002. The overall goal of the cultural resource program is to establish processes that assure proper stewardship of the historic resources on the BNL site.

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