6 Natural and Cultural Resources

The Brookhaven National Laboratory (BNL) 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 maintaining compliance with applicable regulations. The goals of the program include protecting and monitoring the ecosystem, conducting research, and communicating with staff and the public on ecological issues. BNL focuses on protecting New York State threatened and endangered species on site, as well as continuing the Laboratory's leadership 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 2004, deer and fish sampling results were consistent with previous years. Vegetables grown in the BNL garden plot continue to support historical analyses that there are no Laboratory-generated radionuclides in produce grown on site.

Completing the fourth year of managing the Upton Ecological and Research Reserve, its technical advisory group approved funding for research on the 530-acre area. Multiple research grants to investigate important local ecological issues were awarded and are discussed in this chapter.

The overriding goal of the BNL Cultural Resource Management Program is to ensure that proper stewardship of BNL and DOE historic resources is established and maintained. 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. A BNL Cultural Resource Management Plan has been developed to identify, assess, and document BNL's historic and cultural resources. In 2004, two archeological surveys 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 management and protection with BNL's scientific mission. To meet this purpose, the Laboratory completed and issued the *Natural Resource Management Plan for Brookhaven National Laboratory* (NRMP) (BNL 2003a). The NRMP describes the program strategy, elements, and planned activities for managing the various resources found on site. The plan and related information about natural resources at the Laboratory can be found at 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. In 2004, BNL updated the vegetation map that was produced through funding managed by the U.S. Fish & Wildlife

Service (FWS). The update is a continuous process in which "ground truthing" (ground-based verification) of the map produces minor changes that more accurately reflect the actual vegetation present. Using a geographical information system (GIS), BNL staff produced a map overlay that clearly identifies the major vegetation complexes on site (Figure 6-1). In addition to the vegetation map, overlays for soil types and the locations of wetlands, other natural resource elements, and monitoring stations were added to BNL's GIS system. These tools enable resource managers to track changes over time, detect interactions between components of the ecosystem, and identify the locations of management activities on the 5,265-acre property.

A wide variety of vegetation, birds, reptiles, amphibians, and mammals inhabit the BNL site. Through implementation of the NRMP, additional endangered, threatened, and species of special concern have been identified as having been resident at BNL within the past 30 years. The only New York State endangered species confirmed as now inhabiting BNL property is the eastern tiger salamander (*Ambystoma t. tigrinum*). Additionally, the New York State endangered Persius duskywing butterfly (*Erynnis p. persius*) and the crested fringed orchid (*Plantathera cristata*) have been identified on the BNL site in the past. Four New York State threatened species have been positively identified on site and two other species

Figure 6-1. Vegetation Map of BNL.

are considered likely to be present. The banded sunfish (*Enneacanthus obesus*), the swamp darter fish (*Etheostoma fusiforme*), and the stiff goldenrod plant (*Solidago rigida*) have been previously reported (BNL 2000). The northern harrier (*Circus cyaneus*) was seen hunting over open fields in November 2003. 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, stargrass (*Aletris farinosa*) has historically been found and is likely to persist. Several other species that either inhabit the BNL site, visit during migration, or have historically been identified at BNL, are listed as rare, species of special concern, or exploitably vulnerable by New York State (see Table 6-1).

6.1.2 Habitat Protection and Enhancement

BNL has precautions in place to protect on-site habitats 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 may affect habitat (such as road maintenance) are not undertaken until they have been duly evaluated.

6.1.2.1 Eastern Tiger Salamander Efforts

To safeguard eastern tiger salamander breeding areas, a map of these locations is reviewed when new projects are proposed. Distribution of the map is limited, to protect the salamander from exploitation by collectors and the pet trade. The map is updated annually as new information concerning eastern tiger salamanders is generated through research and monitoring. 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

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

Common Name	Scientific Name	State Status
Insects		
Frosted elfin	*Callophrys iris*	T
Mottled duskywing	*Erynnis martialis*	SC
Persius duskywing	*Erynnis persius persius*	E
Fish		
Banded sunfish	*Enneacanthus obesus*	T
Swamp darter	*Etheostoma fusiforme*	T
Amphibians		
Eastern tiger salamander	*Ambystoma tigrinum tigrinum*	E
Marbled salamander	*Ambystoma opacum*	SC
Eastern spadefoot toad	*Scaphiopus holbrooki*	SC
Reptiles		
Spotted turtle	*Clemmys guttata*	SC
Eastern hognose snake	*Heterodon platyrhinos*	SC
Eastern box turtle	*Terrapene carolina*	SC
Worm snake	*Carphophis amoenus*	SC
Birds (nesting or common)		
Cooper's hawk	*Accipiter cooperii*	SC
Grasshopper sparrow	*Ammodramus savannarum*	SC
Whip-poor-will	*Caprimulgus vociferus*	SC
Northern harrier	*Circus cyaneus*	T
Horned lark	*Eremophila alpestris*	SC
Vesper sparrow	*Pooecetes gramineus*	SC
Plants		
Stargrass	*Aletris farinosa*	T
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
Crested fringed orchid	*Plantathera cristata*	E
Long-beaked bald-rush	*Rhynchospora scirpoides*	R
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

maintenance activities near eastern tiger salamander habitats are postponed. BNL environmental protection staff must review any project planned near eastern tiger salamander habitats, and every effort is made to minimize impacts.

Water quality testing is conducted as part of the routine monitoring of recharge basins, as discussed in Chapter 5. In cooperation with the New York State Department of Environmental Conservation (NYSDEC), habitat surveys have been conducted annually since 1999. Biologists conducting egg mass and larval surveys have increased the number of confirmed sites from 17 on-site ponds to 22 ponds that are used by eastern tiger salamanders. The study procedure calls for all ponds that had egg masses during the spring surveys to be surveyed again in June and July to check for the presence of larval salamanders. Egg mass surveys of 26 ponds plus additional flooded depressions at BNL were conducted in 2004. Interns working through the Science Undergraduate Laboratory Intern Program offered by DOE and BNL's Office of Education conducted surveys of tiger salamander ponds and conducted drift fence surveys on three ponds. The results of these studies show the extent of egg mass production, and the importance of precipitation as a trigger for metamorphic salamanders leaving ponds. The success of these surveys has resulted in further interest by NYSDEC and researchers at SUNY Binghamton. Work toward a comprehensive understanding of eastern tiger salamander movements and habitat needs began in 2004 with funding provided to SUNY Binghamton by NYSDEC. Information acquired from all research is entered into a database and portions of the data are linked to a GIS. These data are used to visualize distributions, track reproductive success, and identify areas for focused management or study.

6.1.2.2 Eastern Hognose Snake

In 2003, a radio telemetry study of the eastern hognose snake (*Heterodon platyrhinos*) was initiated. This species of special concern was considered to be very rare on Long Island. Reports of the snake were spotty through 1995, with no reports from Long Island between 1995 and 2001. In 2002, five sightings of this snake occurred at BNL, with photo documentation for two of the sightings. The presence of the snake at BNL raised interest as to the health of the population, and a FWS biologist with the Upton Reserve began looking for the snake in order to conduct radio telemetry studies and determine habitat use. Six snakes were captured by the end of May 2003. Veterinarians from the Wildlife Conservation Society (Bronx Zoo) surgically implanted radio transmitters into five of the snakes. The snakes were held for several days to recover from surgery before being released. The snakes were routinely followed throughout the summer of 2003, and location and habitat data were recorded each time the snakes were found. Early in the project, two snakes could not be located. Information gained from the remaining three snakes provided biologists with a better understanding of this snake's movement and habitat use. It was originally thought that the eastern hognose snake preferred open sandy habitats. Results of the study now suggest that the snake utilizes multiple habitats that include sandy open areas, grassy areas, and forest habitats. During the summer months, additional sightings of eastern hognose snakes occurred. A total of 17 individual snakes were documented in 2003 and permanently identified by implanting a passively induced transponder subcutaneously, just forward of their tails.

In 2004, the radio telemetry program was expanded to eight snakes. During spring 2004, biologists retrieved the three snakes from 2003 and collected five additional snakes. Veterinarians from the Bronx Zoo implanted the transmitters and the snakes were released. An intern tracked snakes throughout the summer and a report was written concerning the snakes' movements and the biological observations that were made. The project will continue for one additional year in 2005, after which results will be published in the scientific literature.

6.1.2.3 Other Species

As part of the eastern tiger salamander and herpetological surveys, information is being gathered on other species. Including the tiger salamander (see Section 6.1.2.1), sightings of

a total of 26 species of reptiles and amphibians were recorded. The species observed include the northern red-back salamander (*Plethodon c. cinereus*), marbled salamander (*Ambystoma opacum*), four-toed salamander (*Hemidactylium scutatum*), red-spotted newt (*Notophthalmus viridescens*), spring peeper (*Pseudacris crucifer*), wood frog (*Rana sylvatica*), gray tree frog (*Hyla versicolor*), bullfrog (*Rana catesbiana*), green frog (*Rana clamitans*), pickerel frog (*Rana palustris*), Fowler's toad (*Bufo woodhousei fowleri*), eastern spadefoot toad (*Scaphiopus holbrooki*), snapping turtle (*Chelydra serpentine*), painted turtle (*Chrysemys p. picta)*, musk turtle (*Sternotherus odoratus*), spotted turtle (*Clemmys guttata*), eastern box turtle (*Terrapene carolina*), eastern hognose snake (*Heterodon platyrhinos*), northern black racer (*Coluber constrictor*), eastern ribbon snake (*Thamnophis s. sauritus*), eastern garter snake (*Thamnophis s. sirtalis*), northern water snake (*Nerodia s. sipedon*), northern ring-necked snake (*Diadophis puctatus edwardsi*), brown snake (*Storeria d. dekayi*), and the northern red-bellied snake (*Storeria occiptiomaculata*). In addition, the eastern worm snake (*Carphophis amoenus*), a species of special concern, was found during summer 2004. This listing indicates that BNL has one of the most diverse herpetofaunal assemblages on Long Island.

Banded sunfish protection efforts include observing whether adequate flow in the Peconic 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. The Peconic River cleanup project was initiated in 2004. Prior to dewatering the on-site portions of the river, an effort was made to capture and relocate banded sunfish. From late April through July, 147 sunfish were captured on site and moved to a protected location. When the off-site portion of the Peconic River cleanup began, an additional 46 sunfish were captured and moved for protection. The sunfish will be re-introduced to the river once sufficient vegetative cover has been established.

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. In 2004, monthly surveys were conducted, starting at the end of March and extending through the end of September. These surveys resulted in the identification of 68 species, compared to 79 during 2003. Two new species were identified during the surveys, and a total of 108 species having been identified during surveys in the past 5 years; 45 of these species were present each year. Variations in the number and species identified may be the result 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. Trends in the data indicate a slight decline in the number of species detected on each transect annually. 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*). BNL's NRMP calls for habitat enhancement. Since 2000, BNL has installed 48 nest boxes around open grassland areas on site to enhance the bluebird population. In 2004, the 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*), black-capped chickadees (*Poecile atricapilla*), and tree swallows (*Tachycineta bicolor*). Bluebirds have consistently produced 19 broods each year for the past 5 years.

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 Turkey

The forested areas of BNL provide good nesting and foraging habitat for wild turkey *(Meleagris gallapavo)*. The on-site population was estimated at 60 to 80 birds in 1999 and had grown to approximately 250 birds by the end of 2001. Due to drought, the population dropped to around 175 birds by the end of 2002. Conditions greatly improved in 2003, and the population was estimated at over 300 birds. Reproduction in 2004 was also successful, and the population at the end of 2004 was estimated to be approximately 500 birds.

In 2004, NYSDEC again requested authorization from BNL to trap and release wild turkey from BNL to other locations on Long Island. In March 2004, twenty-nine turkeys were trapped at BNL and released in the Easthampton area. BNL will continue to monitor the turkey population and cooperate with NYSDEC to ensure the turkeys' success at BNL and at other sites 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 1 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). BNL has been conducting population surveys of the white-tailed deer since 2000, with population estimates ranging from more than 1,900 deer in spring 2001 to a low of 838 during the winter of 2001/2002. In February and March 2004, an aerial infrared survey was conducted of three properties, including Wertheim National Wildlife Refuge (south of BNL), Brookhaven National Laboratory, and Rocky Point Wildlife Area (northwest of BNL). The results indicated a population of 412 deer on site and immediately off site. When a correction for survey accuracy was applied, the on-site population was estimated at 446 animals. This value was much lower than an estimate of 1,302 made at the same time using the existing ground based survey methodology. Because there was a large discrepancy between methods, a review of the ground-based methodology was conducted and the method of estimating was refined. The refined method utilizes the Laboratory's vegetation map and estimates the deer population based on the habitat in which deer are sighted during surveys. The result of this revised method indicated that the deer population was approximately 497, which is considered to be reasonably comparable to the aerial survey results. The next step taken was to apply the new population model to historic survey data. Most of the data resulted in much lower estimates, with ranges from approximately 1,000 deer in 2001 down to less than 500 deer during the autumn of 2004.

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 and browsing damage to ornamental plantings). In 2004, there were 25 deer-related collisions on site, comparable to the 24 collisions documented in 2003. Deer health continues to be affected due to over browsing and lack of food. Deer damage to vegetation around buildings continues to be a problem, but varies depending on the severity of the winter and the availability of browse on the lawns. 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.

Because the high deer population is a regional problem, BNL is working on the issue with other entities. BNL is represented on a deer advisory panel for the hamlet of Lloyd Harbor. In addition, BNL environmental biologists would like to see a regional approach to deer management in place before attempting large-scale deer management on site. Options for deer management are limited, and most are controversial. A regional approach would benefit the community, land managers, and the health of the deer population.

6.1.4 Compliance Assurance and Potential Impact Assessment

The National Environmental Policy Act (NEPA) review process at BNL is key 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 processes under the Comprehensive Environmental Response, Compensation and Liability Act [CERCLA]) when identifying potential environmental impacts associated with site activities—especially involving physical alterations. As appropriate, stakeholders such as EPA, NYSDEC, Suffolk County Department of Health Services (SCDHS), The Nature Conservancy, the Town of Brookhaven, the Community Advisory Council, and local environmental advocacy groups are involved in reviewing major projects that have the potential for 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 Fish & Wildlife Service, dedicated 530 acres of Laboratory property as an ecological research reserve. The property was designated by DOE 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 2004 can be found at http://www.bnl.gov/esd/reserve/default.htm. The Upton Reserve, on the eastern boundary of BNL (see 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 5-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, these biologists conducted baseline biological survey work, initiated basic research, and funded educational programs in conjunction with BNL, Suffolk County Community College, and Longwood High School. In 2003, grants were awarded and research was initiated involving the Upton Reserve and Stony Brook University, Dowling College, and Rutgers University. In 2004, a contract for developing a database of all known Pine Barrens–related research was undertaken and a contract was initiated to develop plot-based monitoring of Pine Barrens communities. The database will allow better management of research needs and will help resource managers decide what future research to pursue. The plot-based monitoring protocols will be used to determine the current health of the forests on site and will allow detection of changes in the forest through repeated sampling efforts.

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 has been to help develop the comprehensive NRMP for both BNL and the Upton Reserve that replaced the *Wildlife Management Plan* (Naidu 1999). The TAG also has developed criteria for soliciting

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

and reviewing proposals and awarding funds for research to be conducted within the Upton Reserve. Multiple research proposals have been approved over the past few years that have greatly improved the understanding of the ecology of the Pine Barrens.

In the spring of 2003, students from Longwood High School began investigating the gypsy moth (*Lymantria dispar*) population by monitoring gypsy moth 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 be used to assist the U.S. Forest Service in determining potential management activities. 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 results in tree death when it occurs year after year, and large sections of oak forest can be destroyed. This was observed in areas of the BNL site in 2003.Through coordination provided by the Upton Reserve, the U.S. Forest Service surveyed large sections of the Central Pine Barrens and created a map of the defoliation. At the time the map was produced, approximately 4,000 acres of oak forest had been defoliated within the Pine Barrens; approximately 1,600 acres are on the BNL site. An additional 1,000-acre area was estimated to have been defoliated by the time of leaf drop in early October 2003. The surveys, along with monitoring, will document the long-term effects of defoliation on forest health. In 2004, aerial surveys indicated that much of the infestation had concluded and that the affected area was no

longer effected by the defoliation, although a significant number of trees had died.

Additional FWS management activities for the Upton Reserve in 2004 included mapping vernal pools, assisting with bird and deer surveys, conducting educational and outreach activities, coordinating researcher access and training requirements, and conducting radio telemetry work on hognose snakes (*Heterodon platyrhinos*) and spotted turtles (*Clemmys guttata*), as discussed in Section 6.8.

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 soil contaminated with cesium-137 (Cs-137), a radioactive isotope of cesium, was used in some BNL landscaping projects in the past, traces have now been found in deer and in other animals and plants. Most radionuclide tables in this chapter list data for both potassium-40 (K-40), a naturally occurring radioisotope of potassium, and Cs-137. Because K-40 occurs naturally in the environment, it is not uncommon in flora and fauna. It is presented as a comparison to Cs-137 because Cs-137 competes with potassium at a cellular level. General trends indicate that Cs-137 will out-compete potassium when potassium salts are limited in the environment, which is the typical case on Long Island. In general, K-40 values do not receive significant discussion in the scientific literature due to this relationship and the fact that K-40 occurs naturally. The results of the annual sampling conducted under the flora and fauna monitoring program follow.

6.3.1 Deer Sampling

White-tailed deer in New York State typically are large, with males weighing, on average, approximately 150 pounds; females typically weigh one-third less, about 100 pounds. However, white-tailed 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 calculating the potential radiation dose to consumers of deer meat containing Cs-137, because smaller deer do not provide sufficient amounts of venison to support the necessary calculations.

In 2004, as in recent years, an off-site deer-sampling program was conducted with the NYSDEC Wildlife Branch and FWS. While most off-site samples are from road-killed deer at and near BNL, NYSDEC provides additional samples that result in data on deer that move beyond BNL boundaries, where they can be legally hunted, and also provides control data on deer living 1 mile or more from BNL. Also, FWS informs BNL staff of deer that have died in or near the Wertheim National Wildlife Refuge and other FWS properties on Long Island. In all, 25 deer were obtained on site and 18 from off-site locations, ranging from adjacent to BNL along the William Floyd Parkway, to as far away as East Islip, New York.

BNL sampling technicians collect the samples and process them for analysis. A sample of meat, liver, and bone is taken from each deer, when possible. The meat and liver are analyzed for Cs-137, and the bone is analyzed for strontium-90 (Sr-90).

6.3.1.1 Cs-137 in White-Tailed Deer

It has been previously established (BNL 2000) that white-tailed deer sampled on the BNL site contain higher concentrations of Cs-137 than deer from greater than 1 mile off site. This is most likely the result of deer consuming contaminated soil and grazing on vegetation growing in soil where elevated Cs-137 levels are known to exist. Cs-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 Laboratory's Environmental Restoration (ER) Program. All major areas of contaminated lawn soil were remediated in 2000. Some soil contamination is still present in areas that are part of Operable Units (OU) I/VI and V (operable units are explained in Chapter 2). The cleanup of areas covered by the *Record of Decision for Operable Unit I and Radiologically Contaminated Soils* (BNL 1999) 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. A *Record of Decision for the Sewage Treatment Plant*, a part of OU V, was signed in 2001; cleanup there began in 2002 and was completed in 2003. All buildings at the former Hazardous Waste Management Facility were removed in 2003, and the cleanup of the remainder of the facility began in 2004 with completion scheduled for mid 2005.

The number of deer used 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 on site 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 sampled each year has varied because the sampling method depends on vehicle/deer accidents and people reporting dead deer. The number of deer hit by cars can vary 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 2000. Most of the off-site samples are concentrated along the William Floyd Parkway on the western boundary of BNL, whereas the concentration on site is near the front gate area and the constructed portions of BNL. This distribution occurs because people on their way to work see and report dead deer. Vehicle collisions with deer on site occur primarily early or late in the day, when deer are more active.

In 2004, Cs-137 concentrations in deer meat samples taken at BNL ranged from 0.01 to 2.93 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 higher than wet weight values. The maximum 2004 on-site concentration (2.93 pCi/g wet weight) is much lower than the highest level reported in 2003 (5.57 pCi/g wet weight), and is significantly lower than the highest level ever reported (11.74 pCi/g wet weight, in 1996). The arithmetic average concentration in on-site meat samples was 0.68 pCi/g wet weight. The average concentration of all off-site meat samples was 0.65 pCi/g wet weight. Averages for Cs-137 both on and off site were below 1.0 pCi/g wet weight for the first time since the cleanup of landscape soils was completed in 2000.

Cs-137 concentrations in off-site deer meat samples were separated into two groups: samples taken within 1 mile of BNL and samples taken farther away (see Table 6-2). Concentrations in meat samples taken within 1 mile ranged from 0.04 to 2.75 pCi/g wet weight, with an average of 0.92 pCi/g wet weight; concentrations in meat taken from greater than 1 mile ranged from nondetectable to 1.01 pCi/g wet weight, with an average of 0.23 pCi/g wet weight.

Figure 6-4 compares the average values of Cs-137 concentrations in meat samples collected in 2004 from four different location groupings. Although the figure does not show this, more than 70 percent of all samples taken both on and off site are below 1 pCi/g wet weight (see Table 6-2).

Figure 6-5 presents the 5-year trend of on-site and near off-site Cs-137 averages in deer meat. Although there is no statistical difference between the values across the 5 years, there is a statistical difference between values in 2000 (when landscape soils were cleaned up) and values in 2002 and 2004.

In 2003, a seasonal pattern in Cs-137 concentrations in deer meat was noticed. This seasonality was present in earlier years and occurred again in 2004 (see Table 6-2). During the summer of 2004, a student in the Community College Intern program reviewed all data from 2000–2003, analyzed it statistically, and determined that there was a statistical seasonal variation in values for deer both on site as well as far off site (Florendo 2004). This seasonality is likely due to diet and the biological processing of Cs-137. From January through May, deer have a limited food supply—mostly dry vegetation from the previous year's growth (with a fixed concentration of Cs-137 because the plants are dormant), whereas in summer and fall, deer eat more and the vegetation is constantly growing, taking up nutrients—and contaminants—from the soil. In summer and fall, if the deer

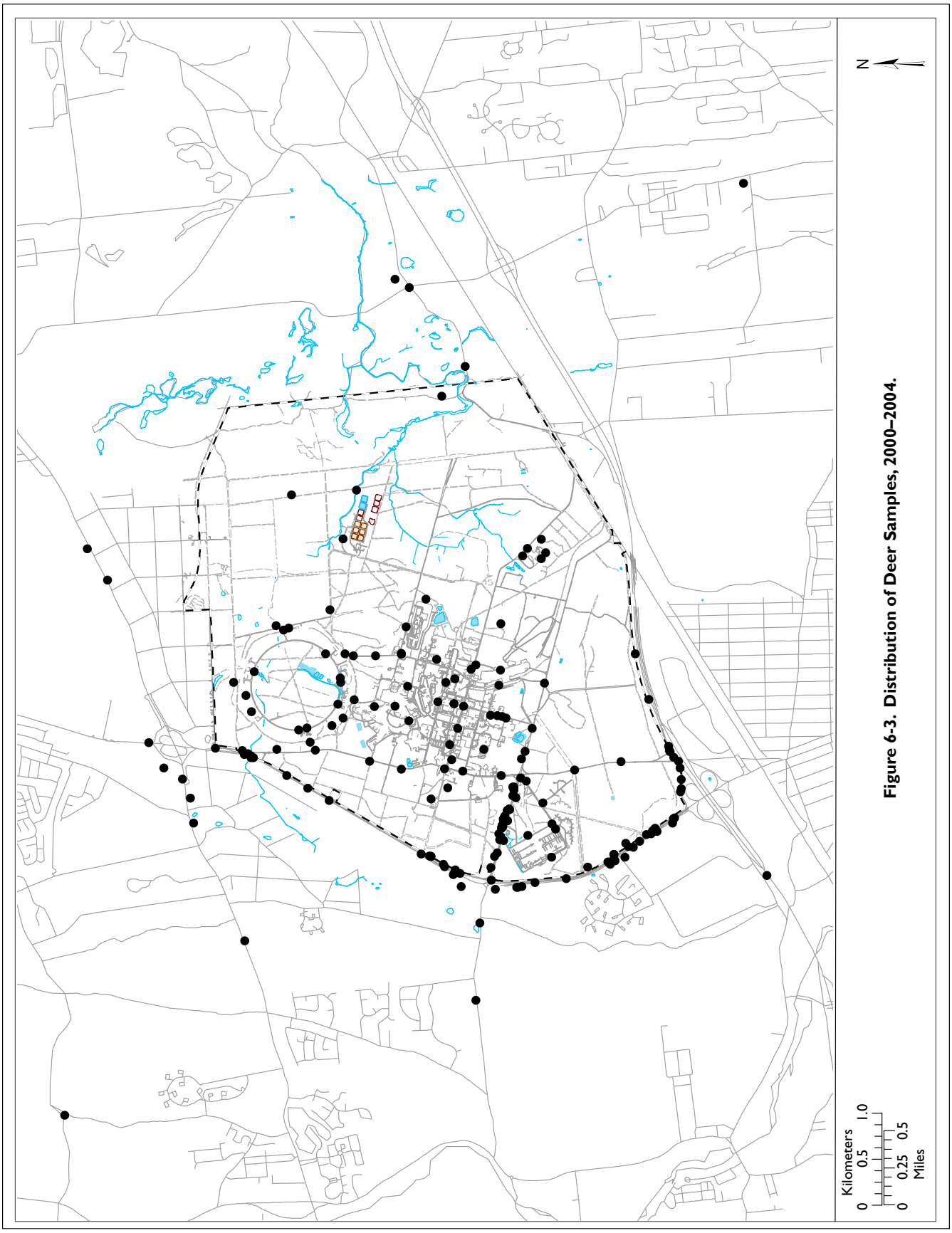

Figure 6-3. Distribution of Deer Samples, 2000–2004.

Table 6-2. Radiological Analyses of Deer Tissue (Flesh, Liver, Bone).

Sample Location	Collection Date	Tissue Type	K-40 pCi/g Wet Weight	Cs-137 pCi/g Wet Weight	Sr-90 pCi/g Dry Weight
BNL, On Site					
Bldg. 515, loading dock east	01/06/04	Flesh	3.32 ± 0.33	0.05 ± 0.01	
		Liver	2.66 ± 0.41	0.05 ± 0.02	
		Bone			2.33 ± 0.67
Princeton Ave., just east of main gate	01/26/04	Flesh	3.60 ± 0.33	0.18 ± 0.02	
		Liver*	2.25 ± 0.22	0.04 ± 0.01	
		Bone			2.64 ± 0.50
Bldg. 490, Radiation Facility	02/02/04	Flesh	3.45 ± 0.29	0.07 ± 0.01	
		Liver*	2.28 ± 0.26	0.02 ± 0.01	
		Bone**			1.97 ± 0.44
Inner RHIC Rd. by Bldg. 1005	02/04/04	Liver	2.73 ± 0.42	ND	
		Bone			3.16 ± 0.72
Main gate at guard booth	02/12/04	Flesh	2.65 ± 0.22	0.04 ± 0.01	
		Bone			5.40 ± 0.63
South of the weather tower	02/23/04	Flesh*	3.47 ± 0.28	0.03 ± 0.01	
		Liver	2.63 ± 0.27	ND	
		Bone**			1.73 ± 0.59
South side of Brookhaven Ave., across from Berkner Hall	02/28/04	Flesh	3.51 ± 0.33	0.06 ± 0.01	
		Liver*	2.20 ± 0.20	0.03 ± 0.01	
		Bone			2.61 ± 0.50
Brookhaven Ave., east of the NSLS	03/05/04	Flesh*	2.73 ± 0.22	0.02 ± 0.00	
		Bone			ND
Princeton Ave., east of Main Gate	03/09/04	Flesh*	3.58 ± 0.29	0.04 ± 0.01	
		Bone			1.13 ± 0.28
Princeton Ave., 75 yards east of Main Gate	03/10/04	Flesh*	3.55 ± 0.32	0.11 ± 0.01	
		Liver*	2.34 ± 0.24	0.04 ± 0.01	
		Bone			1.85 ± 0.29
Inner RHIC Rd., Bldg. 1002	03/17/04	Liver	1.63 ± 0.35	ND	
Upton Gas Station	03/23/04	Flesh*	2.86 ± 0.25	0.01 ± 0.00	
		Liver	2.06 ± 0.44	ND	
		Bone			1.51 ± 0.32
Princeton Ave., 200 yards east of guard booth	04/01/04	Flesh*	3.12 ± 0.34	0.06 ± 0.01	
		Liver*	1.93 ± 0.54	0.04 ± 0.03	
		Bone			5.99 ± 0.58
Bldg. 211	04/28/04	Flesh*	4.00 ± 0.25	0.02 ± 0.01	
Bldg. 480, across from HFBR	05/25/04	Flesh*	3.22 ± 0.26	0.02 ± 0.01	
		Liver	2.72 ± 0.34	ND	
		Bone			1.69 ± 0.39
W. Princeton Ave., across from Bldg. 423	09/02/04	Flesh*	3.13 ± 0.46	0.13 ± 0.03	
		Liver*	3.07 ± 0.49	0.11 ± 0.02	
		Bone**			0.97 ± 0.32
Vehicle Monitor	09/10/04	Flesh	3.78 ± 0.30	0.33 ± 0.04	
		Bone			2.84 ± 0.58

(continued on next page)

Table 6-2. Radiological Analyses of Deer Tissue (Flesh, Liver, Bone) *(continued).*

Sample Location	Collection Date	Tissue Type	K-40 pCi/g Wet Weight	Cs-137 pCi/g Wet Weight	Sr-90 pCi/g Dry Weight
Brookhaven Ave. and Rochester Ave.	10/07/04	Flesh*	3.54 ± 0.27	0.06 ± 0.01	
		Liver*	2.36 ± 0.13	0.03 ± 0.00	
		Bone**			0.46 ± 0.21
RHIC outer road, 1008 B	10/18/04	Flesh	3.69 ± 0.31	1.60 ± 0.15	
		Liver	3.05 ± 0.26	0.58 ± 0.06	
		Bone			1.09 ± 0.28
Brookhaven Ave. and Upton Rd.	11/09/04	Flesh	4.00 ± 0.32	2.41 ± 0.25	
		Liver	2.17 ± 0.24	1.33 ± 0.12	
		Bone			2.56 ± 0.26
Yale Rd. and York Lane	11/16/04	Flesh	4.14 ± 0.31	2.02 ± 0.21	
		Liver	4.30 ± 0.45	0.30 ± 0.03	
		Bone			1.38 ± 0.26
Bldg 1008, on top of the berm	11/18/04	Flesh	2.70 ± 0.29	0.43 ± 0.04	
		Liver*	1.07 ± 0.17	0.08 ± 0.01	
		Bone			1.42 ± 0.32
Princeton Ave., 200 ft east of Main Gate guard booth	12/02/04	Flesh	4.01 ± 0.33	2.93 ± 0.31	
		Liver	2.68 ± 0.23	0.39 ± 0.04	
		Bone**			0.61 ± 0.12
Princeton Ave., inbound lane next to Upton Gas Station	12/13/04	Flesh	3.51 ± 0.30	2.87 ± 0.20	
		Liver	1.50 ± 0.18	0.40 ± 0.03	
		Bone			1.30 ± 0.54
Bldg. 412, eastbound W. Princeton Ave.	12/15/04	Flesh	3.82 ± 0.28	2.15 ± 0.18	
		Liver	2.90 ± 0.23	0.47 ± 0.05	
		Bone			1.17 ± 0.40
< 1 Mile from BNL					
William Floyd Pkwy., north of Colonial Pines	01/22/04	Flesh	3.20 ± 0.36	0.04 ± 0.01	
		Bone			2.47 ± 0.61
William Floyd Pkwy. northbound, 1/4 mile north of Whispering Pines	01/30/04	Flesh	3.73 ± 0.30	0.16 ± 0.01	
		Liver*	3.04 ± 0.30	0.03 ± 0.01	
		Bone			4.35 ± 0.69
William Floyd Pkwy., northbound 1/4 mile north of Whispering Pines	03/23/04	Flesh*	3.19 ± 0.35	0.08 ± 0.01	
		Liver	2.08 ± 0.44	ND	
		Bone			4.81 ± 0.46
William Floyd Pkwy., 1/4 mile north of main entrance	05/12/04	Flesh	3.43 ± 0.35	0.21 ± 0.03	
		Liver*	2.78 ± 0.35	0.14 ± 0.02	
		Bone			4.29 ± 0.48
William Floyd Pkwy., 1/4 mile south of main entrance	06/24/04	Flesh*	3.76 ± 0.39	0.11 ± 0.02	
		Bone			3.50 ± 0.56
Long Island Expressway, service road, exit 68 at south gate	10/08/04	Flesh	3.97 ± 0.32	0.48 ± 0.03	
		Liver	2.75 ± 0.15	0.25 ± 0.01	
		Bone			2.26 ± 0.41

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Table 6-2. Radiological Analyses of Deer Tissue (Flesh, Liver, Bone) *(continued).*

Sample Location	Collection Date	Tissue Type	K-40 pCi/g Wet Weight	Cs-137 pCi/g Wet Weight	Sr-90 pCi/g Dry Weight
William Floyd Pkwy. at north gate	10/14/04	Flesh	3.71 ± 0.17	2.75 ± 0.03	
		Liver	1.68 ± 0.15	0.86 ± 0.02	
		Bone		0.34 ± 0.03	1.20 ± 0.23
William Floyd Pkwy., north of Long Island Expressway	10/22/04	Flesh	3.51 ± 0.29		
		Liver*	2.92 ± 0.25	0.09 ± 0.01	
		Bone			3.67 ± 0.48
Rt. 25, east of William Floyd Pkwy.	10/26/04	Flesh	3.61 ± 0.30	1.76 ± 0.12	
		Liver	2.64 ± 0.16	0.99 ± 0.02	
		Bone	3.78 ± 0.36		5.00 ± 0.53
William Floyd Pkwy. at Colonial Pines	11/17/04	Flesh		1.86 ± 0.19	
		Liver	3.40 ± 0.25	0.80 ± 0.07	
		Bone**			0.94 ± 0.21
William Floyd Pkwy. northbound, across from SCWA wells	12/06/04	Flesh	3.89 ± 0.26	2.33 ± 0.23	
> 1 mile from BNL					
Montauk Hwy. in East Moriches	01/22/04	Flesh	3.46 ± 0.35	0.01 ± 0.01	
		Liver	2.58 ± 0.39	ND	
		Bone			3.48 ± 0.67
Old Stump Rd., Yaphank, south of railroad tracks	02/19/04	Flesh	3.99 ± 0.35	0.46 ± 0.05	
		Liver	1.77 ± 0.19	0.06 ± 0.01	
		Bone			2.73 ± 0.45
Rte. 27 Sunrise Hwy., east of Rte. 111 exit	03/16/04	Flesh	2.89 ± 0.34	1.01 ± 0.11	
Rocky Point Rd., north of Whiskey Rd.	04/17/04	Flesh*	3.57 ± 0.32	0.03 ± 0.01	
		Liver*	2.52 ± 0.23	0.01 ± 0.01	
		Bone			3.46 ± 0.47
Bartlett and Rte. 25	06/10/04	Flesh*	3.20 ± 0.30	0.05 ± 0.02	
		Liver	2.96 ± 0.25	ND	
		Bone			1.21 ± 0.24
Corner of Sound Ave. and Fresh Pond Rd.	10/01/04	Flesh	2.51 ± 0.03	ND	
		Liver	4.04 ± 0.52	ND	
		Bone			2.61 ± 0.45
30 ft east of Sound Ave. and Fresh Pond Rd.	10/01/04	Flesh*	4.02 ± 0.48	0.06 ± 0.02	
		Liver*	3.77 ± 0.55	0.0 ± 0.02	
		Bone			1.82 ± 0.35
Averages by Tissue					
Flesh					
Average for all samples			3.5 ± 2.0	0.7 ± 0.7	
BNL on-site average			3.5 ± 1.4	0.7 ± 0.5	
BNL on- and off-site < 1 mile average			3.5 ± 1.8	0.8 ± 0.6	
Off-site average			3.5 ± 1.4	0.7 ± 0.4	
Off-site < 1 mile average			3.6 ± 1.1	0.9 ± 0.3	
Off-site > 1 mile average			3.4 ± 0.9	0.2 ± 0.1	

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Table 6-2. Radiological Analyses of Deer Tissue (Flesh, Liver, Bone) *(concluded).*

Sample Location	Collection Date	Tissue Type	K-40 pCi/g Wet Weight	Cs-137 pCi/g Wet Weight	Sr-90 pCi/g Dry Weight
Liver					
Average for all samples			2.6 ± 1.9	0.2 ± 0.2	
BNL on-site average			2.4 ± 1.4	0.2 ± 0.2	
BNL on- and off-site < 1 mile average			2.5 ± 1.6	0.3 ± 0.2	
Off-site average			2.8 ± 1.2	0.2 ± 0.1	
Off-site < 1 mile average			2.7 ± 0.8	0.4 ± 0.1	
Off-site > 1 mile average			2.9 ± 0.9	0.0 ± 0.0	
Bone					
Average for all samples					2.4 ± 2.9
BNL on-site average					2.0 ± 2.1
BNL on- and off-site < 1 mile avg.					2.4 ± 2.6
Off-site average					3.0 ± 1.9
Off-site < 1 mile average					3.2 ± 1.5
Off-site > 1 mile average					2.6 ± 1.1

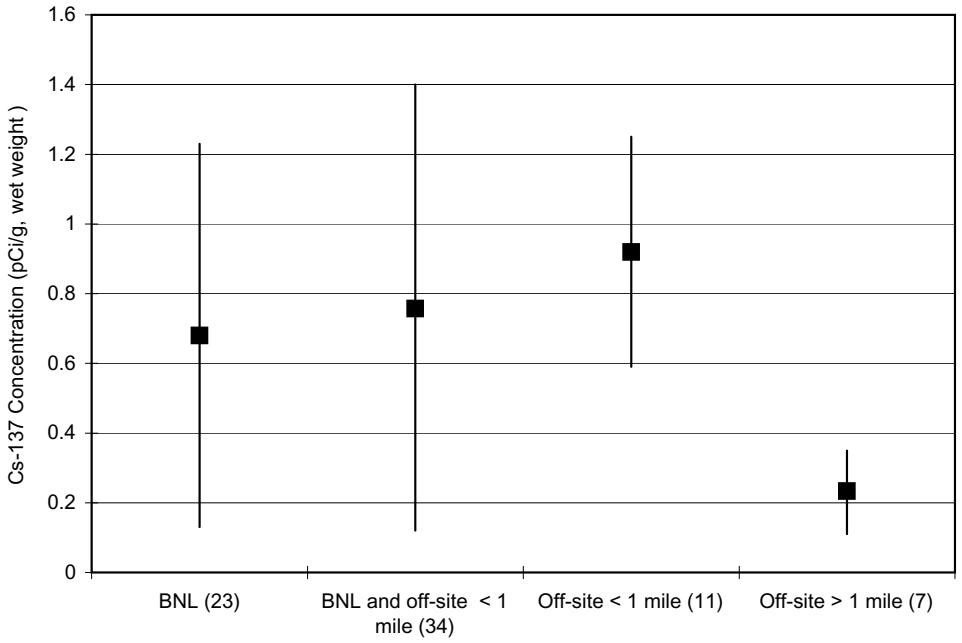
Notes:
All values are presented with a 95% confidence interval.
Potassium-40 (K-40) occurs naturally in the environment and is presented as a comparison to Cs-137.
All averages are the arithmetic average and utilize estimated values for ND. Confidence limits are 2σ (95%) propogated error.
HFBR = High Flux Beam Reactor
ND = Not Detected
NSLS = National Synchrotron Light Source
RHIC = Relativistic Heavy Ion Collider
SCWA = Suffolk County Water Authority
* The cesium-137 (Cs-137) concentration was reported as an estimated value by the analytical laboratory.
** The strontium-90 (Sr-90) concentration was reported as an estimated value by the analytical laboratory.

feed on vegetation growing in soil containing Cs-137, they are then likely to obtain a continuous supply, which is incorporated in their tissues. By January or February, the Cs-137 in their tissues has been eliminated through biological processes. The levels of Cs-137 in deer tissue during June through early August are not well known, as there are few vehicle–deer accidents at this time of year.

When possible, liver samples are taken concurrently with meat samples. Liver generally accumulates Cs-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 can be considered questionable and should be confirmed). In liver samples collected on site in 2004, the range of Cs-137 concentration was from nondetectable to 1.33 pCi/g wet weight, with an average of 0.20 pCi/g wet weight. The off-site Cs-137 concentration in liver ranged from nondetectable to 0.99 pCi/g wet weight, with an average for all off-site liver samples being 0.2 pCi/g wet weight.

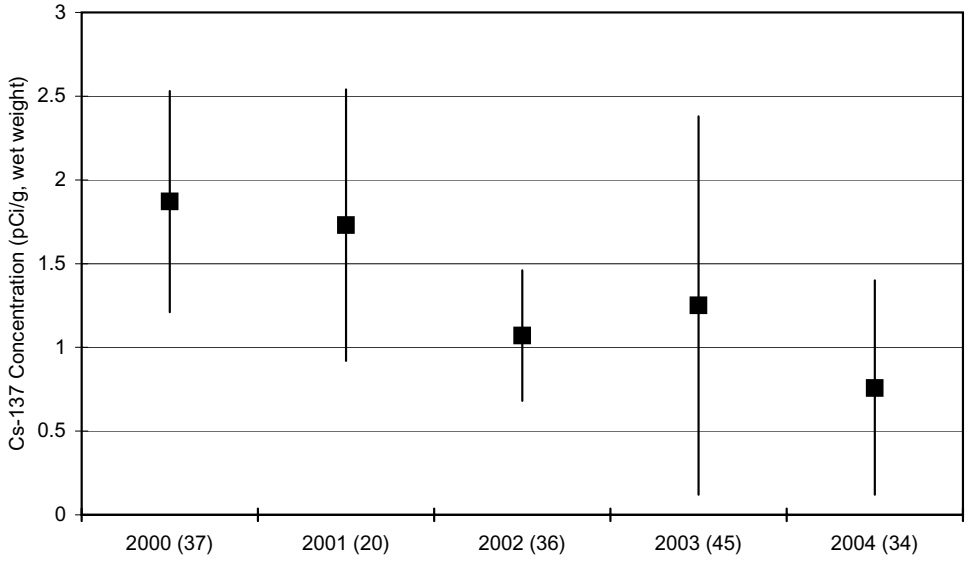
The potential radiological dose resulting from deer meat consumption is discussed in Chapter 8. Although hunting is restricted on site, the New York State Department of Health (NYSDOH) has formally considered the potential public health risk associated with elevated Cs-137 levels in on-site deer and has determined that no formal health advisories are warranted (NYSDOH 1999). This report can 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 contain-



Notes:
Averages are shown for samples collected at BNL, on site and off site within 1-mile, off site but within 1-mile, and off site greater than 1-mile.
Numbers in parentheses indicate the number of samples in that data set.
All values are presented with a 95% confidence interval.

Figure 6-4. Comparison of Cs-137 Average Concentrations in Deer, 2004.



Notes:
Averages are shown for samples collected at BNL, and within 1-mile.
Numbers in parentheses indicate the number of samples in that data set.
All values are presented with a 95% confidence interval.

Figure 6-5. Five-Year Cs-137 Concentration Trends in Deer Meat at BNL and Within 1 Mile of BNL, 2000 to 2004.

ing a uniform distribution of Cs-137 within muscle tissue at the highest levels observed to date (11.74 pCi/g wet weight, reported in 1996) would carry a total body burden (total amount in body) 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 Cs-137 found in their tissues, although the general health of the herd is not optimal because of overpopulation.

6.3.1.2 Strontium-90 in Deer Bone

BNL began testing deer bones for Sr-90 content in 2000. In 2004, Sr-90 content in deer bone ranged from nondetectable to 5.99 pCi/g dry weight in on-site samples. Sr-90 in off-site samples ranged from 0.94 to 5.00 pCi/g dry weight in samples taken within 1 mile of BNL, and 1.21 to 3.48 pCi/g dry weight in samples taken from locations greater than a mile from BNL. This overlap in values between all samples suggests that Sr-90 is present in the environment at background levels, probably as a result of worldwide fallout from historic nuclear weapons testing. Sr-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 Sr-90 in bone to develop baseline information on this radionuclide and its presence in white-tailed deer.

6.3.2 Small Mammal Sampling

BNL continued small mammal sampling in 2004. 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 analytical laboratory for dissection and analysis. The meat was separated from the bone and tested for gamma-emitting radionuclides and the bone was tested for Sr-90. Results of the analyses are presented in Table 6-3. Cs-137 in off-site samples ranged from nondetectable to 1.70 pCi/g dry weight. On-site samples contained Cs-137 ranging from 0.33 to 12.40 pCi/g dry weight. Sr-90 values ranged from nondetectable to 0.21 pCi/g dry weight in off-site squirrels. On-site squirrels had Sr-90 values ranging from nondetectable to 0.86 pCi/g dry weight. Small mammals will continue to be sampled to obtain additional information about their usefulness in environmental surveillance.

6.3.3 Other Animals Sampled

Occasionally, other animals of interest are found dead along the roads of BNL and the immediate vicinity. Wild turkey is prevalent at BNL and has a mixed diet, eating mostly insects in the spring and summer and acorns during the fall and winter. In 2004, two turkeys were hit by cars at BNL and one was hit by a car along the William Floyd Parkway. The on-site turkeys had Cs-137 concentrations of 0.01 and 0.04 pCi/g wet weight. This is comparable to the 0.04 pCi/g wet weight value seen in a turkey sampled on site in 2002. The turkey from off site had a Cs-137 concentration of 0.11 pCi/g wet weight.

Two Canada geese hit by cars on site were sampled during 2004. Geese typically graze on the lawns around the Laboratory, but are less selective in feeding compared to deer. Cs-137 was found in concentrations between nondetectable and 0.02 pCi/g wet weight. This is comparable to the far off-site values found in deer meat and suggests that Canada geese do not have significant uptake of Cs-137.

Sr-90 in bone taken from the on-site turkeys was nondetectable in one and 0.46 pCi/g dry weight in the other. The off-site turkey had a Sr-90 value of 0.77 pCi/g dry weight. The two geese taken on site had Sr-90 values of 0.47 and 0.77 pCi/g. Sr-90 values in turkey and geese are comparable to values seen in squirrels on site.

6.3.4 Fish Sampling

In collaboration with the NYSDEC Fisheries Division, BNL maintains an ongoing pro-

Table 6-3. Radiological Analyses of Small Mammals (Squirrels), Turkeys, and Geese.

Location	Collection Date	Species	K-40	Cs-137 pCi/g, Dry Weight[3]	Sr-90
BNL					
Trailer-533	04/09/04	Squirrel	13.1 ± 2.8	1.55 ± 0.28	ND
Trailer-533	08/18/04	Squirrel[1]	14.6 ± 1.9	5.68 ± 0.46	0.62 ± 0.26
Trailer-533	09/14/04	Squirrel[1]	11.5 ± 1.3	3.51 ± 0.27	0.69 ± 0.24
Upton St. and Bell Ave.	04/22/04	Squirrel	13.4 ± 3.8	0.33 ± 0.26	0.32 ± 0.33
Upton St. and Bell Ave.	08/20/04	Squirrel[1]	12.4 ± 1.5	7.26 ± 0.55	0.85 ± 0.23
Bldg. 569	09/17/04	Squirrel	11.2 ± 1.3	7.41 ± 0.55	ND
Bldg. 569	10/15/04	Squirrel[1]	11.9 ± 1.4	12.40 ± 0.97	0.86 ± 0.20
BERA Softball Fields	03/04/04	Turkey[2,3]	3.5 ± 0.3	0.04 ± 0.01	ND
Lawrence Ave. and Rutherford St.	05/10/04	Turkey[1,2,3]	3.7 ± 0.5	0.01 ± 0.01	0.46 ± 0.14
East of Bldg. 488	04/13/04	Goose[1,3]	3.8 ± 0.3	ND	0.77 ± 0.19
Bldg. 479	05/26/04	Goose[1,2,3]	3.9 ± 0.3	0.02 ± 0.02	0.47 ± 0.18
Off Site					
Mastic Beach	03/02/04	Squirrel	13.2 ± 2.7	ND	ND
Flanders	09/03/04	Squirrel[1]	8.6 ± 1.3	1.70 ± 0.19	0.21 ± 0.10
William Floyd Parkway	09/10/04	Turkey[1,2,3]	2.7 ± 0.3	0.11 ± 0.02	0.77 ± 0.27

Notes:
All values are presented with a 95% confidence interval.
Potassium-40 (K-40) occurs naturally in the environment and is presented as a comparison to Cs-137.
[1] = The cesium-137 (Cs-137) concentration was reported as an estimated value by the analytical laboratory.
[2] = The strontium-90 (Sr-90) concentration was reported as an estimated value by the analytical laboratory.
[3] = Cs-137 values for turkeys and geese are presented as pCi/g wet weight.
ND = Not Detected

gram 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. Population surveys over the past three years indicate that population levels on site are still insufficient to conduct full-scale annual sampling and analysis. However, in 2004, the Peconic River cleanup project began with dewatering of the on-site portion of the river as an early step. This provided an opportunity to collect several composite samples of chain pickerel and pumpkinseed. After the cleanup project is completed, the suspension of on-site fish sampling will resume until fish populations have recovered.

Off-site fish 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 2004, various species of fish were collected off site from Swan Pond, Donahue's Pond, Forge Pond, and Lower Lake on the Carmans River (see Figure 5-8 for sampling stations). Swan Pond is a semi-control location on the Peconic River system (a tributary of the Peconic not connected to the BNL branch) and Lower Lake on the Carmans River is the non-Peconic control site. As part of pre-cleanup operations, several fish from Donahue's Pond were sampled and analyzed for mercury. Analyses of these fish were conducted on edible portions only (fillets). Sampling is carried out in cooperation with NYSDEC and through a contract with Cold Spring Harbor Fish Hatchery and

Museum. Seventy-two samples were taken, representing seven species of fish.

6.3.4.1 Radiological Analysis of Fish

The species collected for radiological analyses in 2004 by BNL and through contract labor included brown bullhead (*Ictalurus nebulosus*), chain pickerel (*Esox niger*), largemouth bass (*Micropterus salmoides*), bluegill (*Lepomis macrochirus*), pumpkinseed (*Lepomis gibbosus*), golden shiner (*Notemigonus crysoleucas*), and yellow perch (*Perca flavescens*). 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 dry weight concentrations.

Cs-137 was detected at low levels in all samples from the Peconic River system, ranging from 0.08 pCi/g dry weight in chain pickerel from Donahue's Pond, to 1.05 pCi/g dry weight in pumpkinseed from BNL. In 2004, fish taken from Lower Lake on the Carmans River (the non-Peconic control location) showed estimated levels of Cs-137 ranging from below the minimum detection limit (MDL) in largemouth bass to 0.20 pCi/g dry weight in golden shiners.

Sr-90 is readily deposited in bone. In 2004, BNL continued the testing for Sr-90 that was initiated in 2000. Values ranged from nondetectable to 1.58 pCi/g dry weight. Because fish were analyzed for whole-body content, values for Sr-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 portion of the sample used for analysis. BNL will continue to test for Sr-90 in off-site samples in order to build baseline values for future comparisons.

Some Cs-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). Cs-137 concentrations in bullhead collected at all locations along the Peconic River had values less than 0.80 pCi/g dry weight, whereas values for bullhead at Lower Lake on the Carmans River had 0.07 pCi/g dry weight. Comparison of pumpkinseed shows levels of Cs-137 on site to be 1.05 pCi/g dry weight compared to 0.08 pCi/g dry weight in fish from Lower Lake on the Carmans River. Levels of Cs-137 in all fish species appear to be declining, compared with 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. Concentrations continue to decline over time through natural decay and remedial activities. Cs-137 has a half-life of 30 years. No Cs-137 was released from the STP to the Peconic River in 2003 or 2004 (see Figure 5-5 for a trend of Cs-137 discharges). Additionally, the cleanup of both on-site and off-site portions of the river in 2004 removed small quantities of Cs-137 in the sediment that was co-located with mercury. Removal of this contamination should result in further decreases in Cs-137 levels in fish.

6.3.4.2 Fish Population Assessment

As mentioned above, BNL suspended fish sampling on site in 2001 because prior fish sampling had depleted the population and limited the remaining fish to smaller sizes. Because the cleanup of the Peconic River was initiated in April 2004, a population assessment was not conducted. However, a number of fish were retrieved and moved to suitable portions of the river in order for them to survive. These rescued fish included 218 brown bullhead, 193 banded sunfish (mentioned previously), 34 pumpkinseed, 32 chain pickerel, 4 creek chubsuckers, 3 golden shiners, and 15 unidentified minnows. These numbers are comparable to the numbers seen in previous years and continue to reflect lack of fish large enough to warrant sampling.

Table 6-4. Radiological Analyses of Fish from the Peconic River System and Carmans River, Lower Lake Control Location.

Species	K-40	Cs-137 pCi/g, Dry Weight	Sr-90
BNL, On Site			
Chain pickerel[1]	11.8 ± 1.3	0.64 ± 0.08	0.8 ± 0.4
Chain pickerel	13.2 ± 1.8	0.55 ± 0.10	ND
Chain pickerel[1]	11.2 ± 1.4	0.61 ± 0.10	0.7 ± 0.3
Pumpkinseed	11.8 ± 1.7	1.05 ± 0.15	ND
Manor Road (HB)			
Brown bullhead[1]	9.6 ± 1.2	0.25 ± 0.05	0.7 ± 0.3
Pumpkinseed	12.0 ± 1.4	0.33 ± 0.06	ND
Donahue's Pond			
Chain pickerel	NR	0.17 ± 0.03	NT
Chain pickerel	NR	0.20 ± 0.03	NT
Chain pickerel	NR	0.16 ± 0.03	NT
Chain pickerel	NR	0.18 ± 0.04	NT
Chain pickerel	NR	0.16 ± 0.05	NT
Chain pickerel	NR	0.18 ± 0.04	NT
Chain pickerel	NR	0.16 ± 0.04	NT
Chain pickerel	NR	0.22 ± 0.04	NT
Chain pickerel	NR	0.17 ± 0.07	NT
Chain pickerel	NR	0.18 ± 0.04	NT
Chain pickerel	NR	0.12 ± 0.04	NT
Chain pickerel	NR	0.16 ± 0.04	NT
Chain pickerel	NR	0.16 ± 0.04	NT
Chain pickerel	NR	0.14 ± 0.04	NT
Chain pickerel	NR	0.15 ± 0.04	NT
Chain pickerel	NR	0.10 ± 0.04	NT
Chain pickerel	NR	0.20 ± 0.07	NT
Chain pickerel	NR	0.17 ± 0.04	NT
Chain pickerel	NR	0.16 ± 0.05	NT
Chain pickerel	NR	0.08 ± 0.07	NT
Brown bullhead	NR	0.43 ± 0.12	NT
Brown bullhead	NR	0.41 ± 0.17	NT
Brown bullhead	NR	0.61 ± 0.13	NT
Brown bullhead	NR	0.42 ± 0.15	NT
Brown bullhead	NR	0.36 ± 0.11	NT
Brown bullhead	NR	0.55 ± 0.13	NT
Brown bullhead	NR	0.57 ± 0.21	NT
Brown bullhead	NR	0.53 ± 0.15	NT
Brown bullhead	NR	0.41 ± 0.11	NT
Brown bullhead	NR	0.43 ± 0.11	NT
Brown bullhead	NR	0.64 ± 0.71	NT
Donahue's Pond *(continued)*			
Brown bullhead	NR	0.44 ± 0.32	NT
Brown bullhead	NR	0.61 ± 0.16	NT
Brown bullhead	NR	0.40 ± 0.10	NT
Brown bullhead	NR	0.67 ± 0.20	NT
Brown bullhead	NR	0.39 ± 0.13	NT
Brown bullhead	NR	0.40 ± 0.10	NT
Brown bullhead	NR	0.80 ± 0.16	NT
Brown bullhead	NR	0.54 ± 0.30	NT
Forge Pond			
Bluegill	8.8 ± 0.8	0.22 ± 0.04	ND
Bluegill	8.2 ± 0.8	0.18 ± 0.03	ND
Bluegill	8.5 ± 0.9	0.21 ± 0.05	ND
Pumpkinseed[2]	9.2 ± 0.7	0.18 ± 0.04	ND
Chain pickerel	11.1 ± 0.7	0.35 ± 0.03	ND
Chain pickerel	10.9 ± 1.0	0.43 ± 0.05	ND
Chain pickerel	10.1 ± 1.8	0.37 ± 0.09	ND
Largemouth bass	10.1 ± 0.9	0.34 ± 0.05	ND
Largemouth bass	7.7 ± 0.8	0.26 ± 0.04	ND
Largemouth bass[1]	10.2 ± 0.9	0.44 ± 0.05	0.6 ± 0.3
Golden shiner	9.7 ± 0.9	0.11 ± 0.03	ND
Golden shiner[2]	9.5 ± 0.9	0.12 ± 0.03	1.0 ± 0.4
Yellow perch	10.8 ± 0.9	0.32 ± 0.04	ND
Brown bullhead	11.4 ± 1.2	0.43 ± 0.09	ND
Swan Pond			
Bluegill[2]	7.1 ± 1.1	0.20 ± 0.06	1.4 ± 0.4
Bluegill[2]	8.3 ± 1.0	0.17 ± 0.05	1.6 ± 0.4
Pumpkinseed[2]	9.6 ± 1.4	0.18 ± 0.12	1.0 ± 0.4
Yellow perch[1]	9.5 ± 1.2	0.39 ± 0.06	0.5 ± 0.3
Yellow perch[1]	8.3 ± 1.2	0.38 ± 0.07	0.8 ± 0.3
Largemouth bass	11.2 ± 0.8	0.41 ± 0.05	1.1 ± 0.4
Largemouth bass[1]	9.1 ± 1.7	0.41 ± 0 11	1.0 ± 0.4
Chain pickerel	9.8 ± 1.3	0.38 ± 0 07	ND
Lower Lake, Carmans River			
Largemouth bass	10.7 ± 1.6	ND	ND
Brown bullhead	12.5 ± 1.4	0.07 ± 0.04	ND
Bluegill[1,2]	10.6 ± 1.2	0.06 ± 0.04	0.6 ± 0.3
Bluegill	8.7 ± 1.2	0.08 ± 0.04	ND
Pumpkinseed	11.5 ± 1.5	0.08 ± 0.05	ND
Golden shiner	7.5 ± 2.2	0.20 ± 0.10	ND

Notes:
All values are presented with a 95% confidence interval.
Potassium-40 (K-40) occurs naturally in the environment and is presented as a comparison to Cs-137.
Fish taken from Donahue's Pond as part of the OU V project were tested as fillets. Samples were not analyzed for K-40 and Sr-90.
See Figure 5-8 for sampling stations.
ND = Not Detected
NR = Not Reported by analytical laboratory
NT = Not Tested
[1] = The cesium-137 (Cs-137) concentration was reported as an estimated value for by the analytical laboratory.
[2] = The strontium-90 (Sr-90) concentration was reported as an estimated value by the analytical laboratory.

6.3.4.3 Nonradiological Analysis of Fish

In 1997, under the OU V remediation project, the BNL ER Program sampled and analyzed fish from the Peconic River for metals, pesticides, and PCBs. The contaminant levels found were not considered by NYSDEC to have a health impact on fish or humans, but DOE directed that sampling and analyses should be done annually. This analysis was conducted on site in 1999 and 2000; analysis in 2001 and 2002 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; therefore, 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 6-5 shows the concentrations of metals in fish for 2004. None of the metal concentrations were considered capable of affecting the health of the consumers of such fish, according to NYSDEC. Because the values for arsenic, beryllium, cobalt, silver, thallium, and vanadium were near or less than the MDL for the analytical procedure, they were not included in Table 6-5. Other metals tested but not included in the table include aluminum, antimony, cadmium, and silver because the majority of the values reported were less than MDL and those values that were reported were just above MDL and were not considered to be indicative of a health risk.

Mercury is a metal of concern due to its known health effects. Mercury was found in on-site fish at levels of 0.73 mg/kg or lower and 0.68 mg/kg or lower in off-site fish from the Peconic River. Both values are less than the 1.0 mg/kg consumption standard set by the U.S. Food and Drug Administration.

Table 6-6 shows the concentrations of DDT and its breakdown products that were found in low levels in both on- and off-site fish sampled in 2004. In addition to those pesticides shown in Table 6-6, the pesticide Aldrin was found in a single bluegill at 0.011 mg/kg; Chlordane was found in two yellow perch from Forge Pond at levels of 0.037 and 0.204 mg/kg and in a pumpkinseed taken from Lower Lake on the Carmans River at 0.032 mg/kg; and Dieldrin was detected in a composite sample of pumpkinseed taken on site at BNL at 0.021 mg/kg. These levels of pesticides detected do not exceed any standards that may constitute a health impact to the consumers of such fish and thus are not considered harmful. DDT was commonly used on Long Island before 1970. Chlordane was also commonly used across Long Island and is found occasionally in fish samples. Dieldrin is a breakdown product of Aldrin, which was commonly used to treat soil insects in crops (termites in potatoes). Of the pesticides detected, only DDT and its breakdown products remain at significantly measurable levels in the environment.

PCBs were found at levels above the method detection limit in two samples taken on site at BNL and in one sample taken off site, at Swan Pond. Aroclor-1254 was found in a sample of pumpkinseed and chain pickerel taken from an area of the Peconic River located near the east firebreak on BNL. Values were 0.137 mg/kg and 0.049 mg/kg, respectively. A sample of largemouth bass taken from Swan Pond had a concentration of 0.027 mg/kg of Aroclor-1260. Historically, PCBs have been found in both fish and sediment on site at BNL and periodically at other locations in the Peconic River. The cleanup of the Peconic River (to be completed in 2005) is expected to remove the majority of PCBs within the sediments.

6.3.5 Aquatic Sampling

6.3.5.1 Radiological Analysis

Annual sampling of sediment, vegetation, and freshwater in the Peconic River and a control location on the Carmans River was conducted in 2004. (On-site portions of the Peconic River were not sampled because the river cleanup project was underway.) See Chapter 5 for a

Table 6-5. Metals Analyses of Fish from the Peconic River System and Carmans River, Lower Lake Control Location.

Location/Species	Barium	Chromium	Copper	Iron	Lead	Manganese	Mercury	Selenium	Zinc
	mg/kg								
BNL, On Site									
Chain pickerel	1.96	0.34	1.39	18.0	<MDL	9.22	0.39	0.54	59.9
Chain pickerel	1.19	0.22	2.44	32.8	0.331	2.48	0.23	0.53	53.6
Chain pickerel	0.25	<MDL	1.61	61.9	<MDL	0.89	0.26	1.12	109
Pumpkinseed	4.79	0.68	1.43	33.5	<MDL	2.36	0.73	0.45	26.6
Manor Road (HB)									
Brown bullhead	2.00	0.16	1.25	43.6	<MDL	2.00	0.18	0.54	14.7
Pumpkinseed	2.49	0.84	0.71	21.1	<MDL	29.60	0.30	0.25	64.4
Donahue's Pond[1]									
Chain pickerel	<MDL	<MDL	<MDL	2.0	<MDL	0.39	0.44	0.67	6.65
Chain pickerel	<MDL	<MDL	0.21	3.4	<MDL	0.27	0.51	0.71	6.72
Chain pickerel	<MDL	<MDL	0.25	4.2	<MDL	0.49	0.57	0.41	9.22
Chain pickerel	0.12	<MDL	0.30	4.4	<MDL	0.72	0.63	0.64	11.2
Chain pickerel	<MDL	<MDL	0.29	3.3	<MDL	0.27	0.53	0.50	11.6
Chain pickerel	0.07	<MDL	0.36	9.3	<MDL	0.65	0.51	0.49	19.4
Chain pickerel	<MDL	0.17	0.72	8.5	<MDL	0.18	0.44	0.72	11
Chain pickerel	<MDL	<MDL	0.25	3.0	<MDL	0.33	0.59	0.58	8.96
Chain pickerel	<MDL	<MDL	0.29	5.4	<MDL	0.18	0.36	0.46	11.4
Chain pickerel	0.25	0.18	0.33	8.0	<MDL	2.31	0.43	0.54	45.9
Chain pickerel	<MDL	<MDL	0.30	3.6	<MDL	0.15	0.36	0.59	10.4
Chain pickerel	<MDL	<MDL	0.26	2.1	<MDL	0.20	0.58	0.68	7.35
Chain pickerel	<MDL	<MDL	<MDL	3.9	<MDL	0.14	0.35	0.86	9.48
Chain pickerel	<MDL	<MDL	0.50	5.4	<MDL	0.53	0.55	0.72	20.7
Chain pickerel	<MDL	<MDL	0.28	4.6	<MDL	0.21	0.39	0.81	12.3
Chain pickerel	0.12	<MDL	0.60	13.7	<MDL	1.06	0.29	0.71	30.6
Chain pickerel	<MDL	0.20	0.34	4.2	<MDL	0.51	0.47	0.59	9.6
Chain pickerel	<MDL	0.16	0.62	5.1	<MDL	0.31	0.44	0.71	16.1
Chain pickerel	<MDL	<MDL	0.30	3.0	<MDL	0.24	0.41	0.47	12.3
Chain pickerel	<MDL	<MDL	0.41	3.9	<MDL	0.23	0.68	0.71	7.06
Brown bullhead	0.19	<MDL	0.36	14.9	<MDL	0.30	0.13	0.68	7.03
Brown bullhead	0.16	<MDL	<MDL	5.4	<MDL	0.27	0.17	0.52	5.15
Brown bullhead	0.12	<MDL	0.27	8.5	<MDL	0.27	0.18	0.42	6.76
Brown bullhead	0.17	<MDL	<MDL	11.9	<MDL	0.25	0.14	0.84	7.52
Brown bullhead	0.14	<MDL	<MDL	6.5	<MDL	0.21	0.17	0.57	3.91
Brown bullhead	0.15	0.21	<MDL	9.0	<MDL	0.18	0.34	0.76	6.07
Brown bullhead	0.19	0.16	<MDL	10.7	<MDL	0.21	0.18	0.92	7.22
Brown bullhead	0.19	0.16	<MDL	8.7	<MDL	0.22	0.20	0.58	5.6
Brown bullhead	0.22	<MDL	<MDL	8.1	<MDL	0.18	0.19	0.54	6.44
Brown bullhead	0.24	<MDL	<MDL	17.8	<MDL	0.27	0.22	0.89	6.33
Brown bullhead	0.18	<MDL	<MDL	4.6	<MDL	0.23	0.14	0.58	6.09
Brown bullhead	0.28	<MDL	<MDL	8.2	<MDL	0.37	0.17	0.85	6.55

(continued on next page)

Table 6-5. Metals Analyses of Fish from the Peconic River System and Carmans River, Lower Lake Control Location *(concluded).*

Location/Species	Barium	Chromium	Copper	Iron	Lead	Manganese	Mercury	Selenium	Zinc
	mg/kg								
Brown bullhead	0.40	<MDL	0.23	9.3	<MDL	0.26	0.18	0.89	7.44
Brown bullhead	0.21	<MDL	<MDL	8.7	<MDL	0.25	0.14	0.75	6.81
Brown bullhead	0.18	<MDL	<MDL	8.1	<MDL	0.24	0.30	0.67	7.63
Brown bullhead	0.27	<MDL	<MDL	8.1	<MDL	0.21	0.14	0.46	6.15
Brown bullhead	0.18	0.16	0.25	8.4	<MDL	0.30	0.29	0.63	6.52
Brown bullhead	0.20	<MDL	<MDL	7.3	<MDL	0.25	0.13	0.65	6.88
Forge Pond									
Bluegill	2.55	0.37	0.80	29.7	<MDL	9.32	0.09	0.16	24.2
Bluegill	1.54	0.29	0.62	19.9	0.4	6.93	0.09	0.73	15
Bluegill	1.67	0.30	0.36	13.4	<MDL	7.50	0.24	0.16	17.7
Pumpkinseed	1.96	0.32	0.64	76.0	<MDL	14.90	0.09	0.19	22.9
Chain pickerel	<MDL	0.22	<MDL	2.7	<MDL	0.15	0.16	0.38	4.69
Chain pickerel	<MDL	<MDL	<MDL	1.8	<MDL	0.16	0.26	0.48	7.39
Chain pickerel	0.48	0.22	0.35	11.0	<MDL	4.34	0.26	0.17	45.2
Largemouth bass	<MDL	<MDL	0.35	2.5	<MDL	<MDL	0.23	0.16	4.57
Largemouth bass	0.41	0.16	0.29	38.8	<MDL	1.03	0.23	0.25	8.61
Largemouth bass	<MDL	<MDL	<MDL	2.3	<MDL	<MDL	0.12	0.16	4.8
Golden shiner	20.90	0.40	0.50	39.8	<MDL	17.60	0.07	0.37	22.5
Golden shiner	12.00	0.64	0.58	46.1	<MDL	24.20	0.10	0.34	26.7
Yellow perch	0.21	<MDL	0.49	10.7	<MDL	1.95	0.06	0.16	6.99
Brown bullhead	0.17	<MDL	0.60	10.9	<MDL	0.35	0.20	0.31	7.63
Swan Pond									
Bluegill	5.68	0.54	1.79	81.4	0.618	61.60	0.05	0.33	42.3
Bluegill	7.48	0.91	0.60	30.3	<MDL	33.00	0.07	0.74	45.6
Pumpkinseed	5.63	1.06	0.30	8.4	<MDL	25.10	0.04	0.90	34.8
Yellow perch	3.27	0.46	0.70	16.3	<MDL	48.50	0.01	0.77	23.2
Yellow perch	2.48	0.35	0.89	13.7	<MDL	28.80	0.03	0.81	18.5
Largemouth bass	1.18	0.40	0.30	12.7	<MDL	14.30	0.12	0.30	20.6
Largemouth bass	0.77	0.27	0.30	9.7	<MDL	11.20	0.12	0.38	15.8
Chain pickerel	0.18	<MDL	0.33	8.0	<MDL	6.85	0.16	0.26	41.9
Lower Lake, Carmans River									
Largemouth bass	0.10	<MDL	0.23	3.4	<MDL	0.54	0.18	0.24	6.03
Brown bullhead	0.16	<MDL	0.27	8.0	<MDL	0.41	0.04	0.16	5.21
Bluegill	0.54	<MDL	0.26	9.1	<MDL	3.67	0.08	0.86	11.7
Bluegill	2.05	0.22	0.47	18.2	0.30	8.24	0.01	0.50	18.9
Pumpkinseed	2.43	0.47	0.55	30.0	0.45	16.90	0.04	0.16	33.3
Golden shiner	15	0.19	0.54	24.7	0.43	61.30	0.03	0.16	20.4

Notes:
See Figure 5-8 for sampling locations.
MDL = Minimum Detection Limit
[1] = Fish from Donahue's Pond were analyzed as fillets; all others were analyzed whole body.

Table 6-6. Pesticide Analysis of Fish from the Peconic River System and Carmans River, Lower Lake Control Location.

Location / Species	4,4'-DDD (µg/kg)	4,4'-DDE (µg/kg)	4,4'-DDT (µg/kg)
BNL, On Site			
Chain pickerel	< MDL	8.7*	8.9*
Pumpkinseed	5.5	17.7	37.8
Chain pickerel	< MDL	4.7*	9*
Unknown	8.6	20.1	15.1
Manor Road (HB)			
Brown bullhead	25.6	36.4	5.5*
Pumpkinseed	10.4	41.4	11.4
Donahue's Pond[1]			
Chain pickerel	15.7	35.8	10.5
Chain pickerel	9.0	23.5	9.3
Chain pickerel	16.3	45.8	11.3
Chain pickerel	11.0	31.8	12.9
Chain pickerel	12.8	17.2	9.2
Chain pickerel	< MDL	4.6	< MDL
Chain pickerel	6.0	13.0	9.3
Chain pickerel	4.3	6.1	< MDL
Chain pickerel	4.3	6.1	< MDL
Chain pickerel	12.8	34.7	10.0
Chain pickerel	4.8	7.8	< MDL
Chain pickerel	< MDL	< MDL	< MDL
Chain pickerel	< MDL	4.4	9.1
Chain pickerel	< MDL	4.7	< MDL
Chain pickerel	6.5	11.2	18.9
Chain pickerel	8.2	17.3	< MDL
Chain pickerel	18.6	23.3	34.5
Chain pickerel	42.4	124	19.3
Chain pickerel	4.9	6.7	< MDL
Chain pickerel	7.1	13.0	9.0
Brown bullhead	4.7	5.8	20.1
Brown bullhead	< MDL	4.86*	38.2
Brown bullhead	2.62*	6.4	10.6
Brown bullhead	3.06*	2.93*	< MDL
Brown bullhead	< MDL	1.52*	< MDL
Brown bullhead	2.7*	2.11*	< MDL
Brown bullhead	< MDL	1.04*	< MDL
Brown bullhead	3.83*	5.3	7.8
Brown bullhead	< MDL	1.74*	7.2
Brown bullhead	4.1	7.0	9.1
Brown bullhead	< MDL	0.78*	5.8
Donahue's Pond[1] *(continued)*			
Brown bullhead	3.91*	3.39*	42.2
Brown bullhead	2.37*	3.32*	< MDL
Brown bullhead	2.96*	2.68*	< MDL
Brown bullhead	2.54*	2.12*	< MDL
Brown bullhead	2.77*	1.99*	< MDL
Brown bullhead	2.23*	1.8*	< MDL
Brown bullhead	< MDL	1.77*	< MDL
Forge Pond			
Bluegill	9.2	19.5	4.8*
Bluegill	5.6	19.9	3.9*
Bluegill	12.1	29.7	6.1*
Pumpkinseed	7.5	27.8	5.5*
Chain pickerel	< MDL	23.7	4*
Chain pickerel	6.9	24.6	5.5*
Chain pickerel	< MDL	7.6*	< MDL
Largemouth bass	10.5	42.3	6.8*
Largemouth bass	< MDL	12.9	< MDL
Largemouth bass	9.4	40.4	6.8*
Golden shiner	< MDL	4*	< MDL
Golden shiner	6.9	8*	2.5*
Yellow perch	82.6	230	23.8*
Brown bullhead	12.0	27.1	4.1*
Swan Pond			
Bluegill	< MDL	< MDL	9.9
Bluegill	< MDL	7.2*	2.0
Pumpkinseed	< MDL	19.3	< MDL
Yellow perch	6.1	21.3	0.59*
Yellow perch	35.6	130	9*
Largemouth bass	< MDL	21.4	2.6*
Largemouth bass	< MDL	22.1	< MDL
Chain pickerel	< MDL	10.9	< MDL
Lower Lake, Carmans River			
Largemouth bass	8.9	41.2	10.1
Brown bullhead	10.0	44.1	5.2*
Bluegill	6.2	22.7	< MDL
Bluegill	6.0	23.3	< MDL
Pumpkinseed	10.9	52.2	6.4*
Goldenshiner	10.7	38.8	< MDL

Notes:
See Figure 5-8 for sampling locations.
MDL = Minimum Detection Limit
* The reported concentration was estimated by the analytical laboratory.
[1] = Fish from Donahue's Pond were analyzed as fillets; all others as whole body.

discussion of water quality and monitoring, and Figure 5-8 for sampling stations. Table 6-7 summarizes the radiological data. Low levels of Cs-137 were documented in sediments at all locations, except Forge Pond. Aquatic vegetation taken from off-site locations did not have detectable levels of Cs-137.

6.3.5.2 Metals in Aquatic Samples

Metals analyses (Table 6-8) were conducted on aquatic vegetation and sediments from the Peconic River and Carmans River. 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 SCDHS. Vegetation results are compared to soil cleanup standards because metals in vegetation may accumulate via uptake from sediment. In general, metals are seen in vegetation at levels lower than in associated sediment.

Off site, levels of arsenic, cadmium, chromium, and nickel were higher than the SCDHS cleanup objectives in sediment at Swan Pond, and chromium was higher than the cleanup objectives at the Lower Lake on the Carmans River sampling location. No other metals were above cleanup objectives in either sediment or vegetation.

6.3.5.3 Pesticides and PCBs in Aquatic Samples

Pesticides and PCBs are reported in Table 6-9 for only those samples with detectable levels. Sediments from Swan Pond contained low levels of the DDT breakdown products DDE and DDD. A water sample from Swan Pond contained very low levels of DDE. Sediments taken at station HC on the Peconic River (see Figure 5-8 in Chapter 5) contained low levels of alpha-BHC, Lindane, Heptachlor, DDT, and the PCB Aroclor-1254. The water sample from station HC had detectable levels of DDT. As mentioned above, DDT was one of the pesticides used widely in the 1950s and 1960s, and residual amounts are still detected. Finally, in a vegetation sample from Lower Lake on the Carmans River, a low level of the PCB Aroclor-1254 was detected.

6.3.6 Vegetation Sampling

6.3.6.1 Garden Vegetables

On-site sampling of garden vegetables continued in 2004. Samples of zucchini, cucumber, tomato, pepper, and eggplant were analyzed for Cs-137 content. Samples of both tomatoes and peppers had a Cs-137 value of 0.01 pCi/g wet weight, and the soil sample taken concurrently from the garden had a Cs-137 value of 0.18 pCi/g dry weight. Sampling of off-site farm vegetation was discontinued in 2003 because historical data have consistently indicated the absence of BNL-related radionuclides in off-site vegetation. Periodic confirmatory sampling (approximately every 5 years) will be conducted off site to obtain data on farm vegetables.

6.3.6.2 Grassy Plants

In 2003, grassy vegetation sampling was converted to a graded approach and was linked to other sampling programs. As an example of this approach, vegetation sampling would be conducted only if routine air sampling indicated that radionuclides had been released and deposited on soil and vegetation. Periodic confirmatory sampling of grassy vegetation will be conducted approximately every 5 years.

6.4 SOIL SAMPLING

Soil sampling uses the same graded approach as that used for grassy vegetation sampling and was taken out of the basic monitoring protocols in 2003. Confirmatory soil sampling will be conducted periodically.

6.5 BASIN SEDIMENTS

A new 5-year testing cycle for basin sediment samples was established in 2003. 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). The next round of basin sampling will occur in 2008.

6.6 CHRONIC TOXICITY TESTS, SEWAGE TREATMENT PLANT

Under the SPDES discharge permit, BNL was not required to conduct chronic toxicity testing for the STP effluent in 2004 because of

Table 6-7. Radiological Analyses of Aquatic Vegetation and Sediment from the Peconic River System and Carmans River, Lower Lake Control Location.

Location/Sample Type	K-40	Cs-137
	pCi/g Dry Weight	
Forge Pond		
Lily Pad	25.10 ± 9.01*	ND
Sediment	1.45 ± 0.39	ND
Swan Pond		
Lily Pad	NR	ND
Sediment	NR	0.46 ± 0.16**
HC		
Vegetation	39.30 ± 6.43*	ND
Sediment	1.75 ± 0.22	0.03 ± 0.01**
Lower Lake, Carmans River		
Vegetation	1.65 ± 0.44	ND
Sediment	0.27 ± 0.08*	0.02 ± 0.01**

Notes:
All values are presented with 95% confidence interval.
See Figure 5-8 for sampling locations.
ND = Not detected
NR = Not reported
* The potassium-40 (K-40) concentration was reported as an estimated value by the analytical laboratory.
** The cesium-137 (Cs-137) concentration was reported as an estimated value by the analytical laboratory.

favorable results in 2003. Chronic toxicity testing will resume in 2005 under the requirements of the SPDES discharge permit.

6.7 RADIOLOGICAL MONITORING OF PRECIPITATION

As part of the BNL Environmental Monitoring Program, precipitation samples were collected quarterly at air monitoring Stations P4 and S5 (see Figure 4-4 for station locations), and were analyzed for radiological content. Four samples were taken from each of these two stations in 2004. Gross alpha activity measurements above the MDL were found in the first quarterly samples taken at Stations P4 and S5. The value at P4 was 1.03 pCi/L, and the estimated value from the sample at S5 was 1.41 pCi/L. Both of these values are within the range of historic values

Table 6-8. Metals Analyses of Aquatic Vegetation and Sediment from the Peconic River System and Carmans River, Lower Lake Control Location.

Location/ Sample Type	Arsenic	Barium	Cadmium	Chromium	Copper	Iron	Lead	Manganese	Mercury	Nickel	Vanadium	Zinc
	mg/kg											
Forge Pond												
Lily Pad	< MDL	26.8	0.14	0.17	0.41	93	< MDL	50	0.001	0.186	< MDL	4.01
Sediment	0.40	7.23	0.28	1.19	0.90	756	1.8	9.4	0.023	0.557	1.18	6.01
Swan Pond												
Lily Pad	0.32	15.2	< MDL	< MDL	0.27	17	< MDL	74.2	0.004	0.22	< MDL	2.1
Sediment	8.70	110	2.20	19.00	23.90	5660	81.7	3340	0.200	15.4	30.7	152
HC												
Vegetation	< MDL	4.93	< MDL	0.16	0.82	88	< MDL	94.4	0.035	0.262	< MDL	5.92
Sediment	1.23	2.49	0.09	2.10	3.50	3130	12.5	10.4	0.007	0.259	6.5	2.18
Lower Lake, Carmans River												
Vegetation	< MDL	63.5	< MDL	0.16	< MDL	36	< MDL	47.8	0.004	0.668	< MDL	4.5
Sediment	5.28	140	0.90	28.90	7.61	9790	35.2	1220	0.122	5.150	18.1	40

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

Table 6-9. Pesticide and PCB Analyses of Aquatic Vegetation, Water, and Sediment from the Peconic River System and Carmans River, Lower Lake Control Location.

Location/ Sample Type	Alpha-BHC	Lindane	Heptachlor	4,4'-DDE	4,4'-DDD	4,4'-DDT	Aroclor-1254
	µg/kg						
Forge Pond							
Lily Pad	< MDL	< MDL	< MDL	< MDL	< MDL	< MDL	< MDL
Water (µg/L)	< MDL	< MDL	< MDL	< MDL	< MDL	< MDL	< MDL
Sediment	< MDL	< MDL	< MDL	< MDL	< MDL	< MDL	< MDL
Swan Pond							
Lily Pad	< MDL	< MDL	< MDL	< MDL	< MDL	< MDL	< MDL
Water (µg/L)	< MDL	< MDL	< MDL	0.008*	< MDL	< MDL	< MDL
Sediment	< MDL	< MDL	< MDL	69.2*	66	< MDL	< MDL
HC							
Vegetation	< MDL	< MDL	< MDL	< MDL	< MDL	< MDL	< MDL
Water (µg/L)	< MDL	< MDL	< MDL	< MDL	< MDL	0.036*	< MDL
Sediment	0.208*	0.161*	0.178*	< MDL	< MDL	0.630*	109
Lower Lake, Carmans River							
Vegetation	< MDL	< MDL	< MDL	< MDL	< MDL	< MDL	8.9*
Sediment	< MDL	< MDL	< MDL	< MDL	< MDL	< MDL	< MDL

Notes:
Water values are reported in µg/L.
See Figure 5-8 for sampling locations.
MDL = Minimum Detection Limit
*The concentration was reported as an estimated value by the analytical laboratory.

reported for gross alpha activity and are considered to be background.

Gross beta activity was measured in three samples from Station P4 (all quarters but the third), and in all four samples from Station S5. 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 5.8 pCi/L, with an average of 3.50 pCi/L. Location S5 had a maximum gross beta activity level of 6.6 pCi/L, with an average of 3.89 pCi/L. Gross beta activity values were within the range of values historically observed at these two locations. No radionuclide-specific analyses indicated values above method detection limits.

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 resource inventory, gain a better understanding of the ecosystem, and guide management planning.

In 2003, the Environmental and Waste Management Services Division (EWMSD) hosted seven student interns and two high school teachers during the summer. Interns worked on a variety of subjects, including surveys of dragonflies and damselflies, radio telemetry of turtles and snakes, and analyzing the water chemistry of coastal plain ponds. A limited discussion concerning each project is presented below. These research efforts can be viewed at http://www.bnl.gov/esd/reserve/Posters_and_Presentations.htm.

An intern from the Community College of Rhode Island continued work on the identification and distribution of dragonflies and damselflies (Order *Odonata*) that was started in 2003. These aquatic insects are common around the ponds and the Peconic River on site. The dis-

tribution of aquatic invertebrates may be useful for monitoring the health of aquatic systems. In addition, results from the Odonate surveys are expected to supplement a planned statewide survey of these insects in the near future. The number of species identified by the intern increased from 30 to 46 and detailed information on the distribution of each species across most of the Laboratory site was developed. This project is planned for continued work over the next several years.

Two other interns from the Community College of Rhode Island also worked on projects. One revisited and mapped the distribution of aquatic plants associated with the restoration of the Area D pilot study project associated with the Peconic River. This project provided information on the rapid spread of invasive grasses in the area and will benefit the future management of the river. Additionally, this intern was responsible for most of the transfer of wildlife from the river site, especially banded sunfish, prior to and during the on-site Peconic River cleanup project. The third intern worked on the comparison of species richness and recruitment at three ponds on site.

An intern from North Carolina State University conducted radio telemetry tracking of the eastern hognose snake (*Heterodon platyrhinos*). The biologist for the Upton Reserve started this project in 2003 and continued to oversee it. The project has greatly increased the understanding of the habitat needs of this locally rare snake and its vulnerability to predation and accidental death from vehicles. This project will be continued in the summer of 2005.

The fifth intern, from the University of Massachusetts at Amherst, conducted radio telemetry studies on captive-reared spotted turtles (*Clemmys guttata*). Several turtles were hatched at the Cold Spring Harbor Fish Hatchery and Museum, then outfitted with transmitters and released at BNL. The intern followed the tagged turtles, documenting their movements and use of habitat. The information gained may be helpful in determining the efficacy of captive rearing and release of this species as a means to improve the population levels. This project also is scheduled to continue in 2005.

The sixth intern, from the University of Hull in the United Kingdom, conducted research on the emergence of metamorphic salamanders and their dependence on rainfall. This study was a followup of research conducted near two ponds in 2001 using "cover boards" (sheets of wood placed on the ground as attractive habitat). The present research utilized drift fences around three ponds and correlated the emergence of eastern tiger salamanders and marbled salamanders with rainfall. This research is helpful in planning future trapping that will be necessary as part of a doctoral research project scheduled to begin in the spring of 2005.

A seventh intern, from the Los Angeles Mission College in California, conducted a statistical review and analysis of seasonal patterns in Cs-137 uptake in white-tailed deer. This work, as mentioned in Section 6.3.1.1, was important as it showed a definite seasonal pattern in Cs-137 levels in deer.

Two teachers working under a new DOE Office of Education Program called Laboratory Science Teacher Professional Development (LSTPD), conducted water quality surveys of many of the ponds on site. During this process, the two teachers developed skills and lesson plans that can be introduced into their classrooms. They are planning to share their work with fellow teachers to create interactive classroom activities. This 3-year program will continue in 2005 and 2006. The work this team conducted has also provided needed understanding about the water chemistry in several key coastal plain ponds that are habitat to a diversity of wildlife.

In addition to hosting interns, members of EWMSD and other BNL departments volunteered as speakers for schools and civic groups and provided on-site ecology tours. EWMSD also hosted events in association with Earth Day and provided activities to educate Laboratory employees and the general public on the environment and conservation during a Summer Sunday event in July. In October, BNL hosted the Ninth Annual Pine Barrens Research Forum, 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, using the Incident Command System of wildfire management.

BNL has been working over the past few years to develop and implement a *Wildland Fire Management Plan*. In late 2003, the plan was completed and approved, and a fire plan was written for the first prescribed fire at BNL. Once the prescribed fire plan was approved, BNL began educating its neighbors and preparing for implementation of the plan. In October 2004, the first prescribed fire at BNL was conducted. This fire treated approximately 7 acres to improve germination and recruitment of oak seedlings. It also reduced fine-textured forest fuels that tend to increase the severity of wildfires. Pre-fire monitoring was conducted before the fire was started, and post-fire monitoring indicated the fire was conducted properly for its intended purpose. Additional post-fire monitoring will be conducted in the spring and early summer of 2005 to see if the fire was beneficial for oak seedling recruitment. Future fires are planned for BNL and will be conducted as part of the annual Wildland Fire Academy.

6.9 CULTURAL RESOURCE ACTIVITIES

The BNL Cultural Resource Management (CRM) Program ensures that the Laboratory fully complies with the numerous cultural resource regulations. BNL submitted a draft BNL *Cultural Resource Management Plan* to DOE in December 2003, which outlines the management of all of BNL's cultural resources. Along with achieving compliance with applicable regulations, one of the major goals of the CRM program is to fully assess both known and potential cultural resources. The range of BNL cultural resources includes: buildings and structures, World War I earthwork features, the Camp Upton Historical Collection, scientific equipment, photo/audio/video 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 site have made to U.S. history and culture are documented and available for interpretation.

BNL has three structures/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. The BNL trenches may be the only surviving examples of World War I earthworks in the United States.

In 2004, BNL contracted with a qualified outside organization to survey and evaluate the architectural significance of Berkner Hall (Building 488), the Chemistry Building (Building 555), and other structures. The project included inspecting Brookhaven Center (Building 30, circa 1930s), Building 120 (former WW II barracks), the BGRR and laboratory (Buildings 701–703), the HFBR (Building 750), and the Medical Hot Laboratory (Building 801). The goal of the project was to identify key architectural features and assist BNL to develop management strategies for the future treatment of these structures.

The evaluation concluded that Berkner Hall and the Chemistry Building are architecturally significant resources that appear to be eligible for listing on the National Register of Historic Places. Berkner Hall is an excellent example of Expressionist-style architecture as it was applied to public buildings in the mid-twentieth century, and is representative of the work of the noted architectural firm of Urbahn Architects, an important U.S. architectural and engineering firm. Berkner Hall also possesses significance as an example of precast concrete slab construction and engineering. The Chemistry Building is a significant example of the conceptual work of Marcel Breuer, a major figure in twentieth-century architecture who developed the conceptual design of the building (PAL 2004).

Another contracted project performed in 2004 was the archeological evaluation of two sites believed to date to the 1800s. The sites are known as the Weeks Campbell site and the W.J. Weeks House site (Figure 6-6). The purpose of the site evaluations was to delineate the horizontal and

a

b

c

d

a. Foundation/cellar hole at Weeks Campbell Archeological Site (circa late 1800's).
b. Brickwork uncovered at Weeks Campbell Archeological Site (circa late 1800's).
c. Locust wood fence post identified at W. J. Weeks House Site (circa 1830's).
d. Foundation wall stone – W. J. Weeks House Site (circa 1830's).

Figure 6-6. Archeological Sites Surveyed in 2004.

vertical boundaries of cultural deposits, and to obtain information on the structure, function, cultural/historical context, significance, and integrity of each site. This information will be used to evaluate the sites' potential eligibility for the National Register of Historic Places, and includes recommendations for site protection.

The archeological site evaluations consisted of both archival research and field investigations. The main occupation of the Weeks Campbell site was determined to be late nineteenth–early twentieth century. This site has a relatively high degree of integrity, with several surface and subsurface features (agricultural landscape markers, the brick walkway, and most important to archeologists, the foundation/cellar hole). The archeologists dated the W.J. Weeks House site to the mid- to late-nineteenth century, and recommended protective measures to prevent potential site looting and disturbance. As a result, fencing was erected and warning signs were posted around the perimeter. Both sites may be eligible for listing on the National Register (Merwin and Manfra 2005).

Another goal of the CRM program is to formalize an oral history program for the Laboratory. In 2004, Robert Crease, BNL Historian, conducted four video interviews that included a long-time employee of the Chemistry Department and three individuals associated with the early development and construction of the National Synchrotron Light Source.

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