Natural and Cultural Resources 6

The Brookhaven National Laboratory Natural Resource Management Program is designed to protect and manage flora and fauna and the ecosystems in which they exist. The Laboratory's natural resource management strategy is based on understanding 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 2011, 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.

The overriding goal of the 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.

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 uses a Natural Resource Management Plan (NRMP) (BNL 2011) to describe the program strategy, elements, and planned activities for managing the various resources found on site. The NRMP was first developed through wide participation with local agencies providing professional input as participants of a Technical Advisory Group. The first iteration of the NRMP was approved in 2003, with recommendations for review and update every 5 years. The current NRMP, approved in 2011, is the result of changes made based on experience and knowledge gained through the implementation of the earlier version and incorporates the principles of adaptive management.

6.1.1 Identification and Mapping

An understanding of an environmental baseline is the foundation of natural resource management planning. BNL uses digital global positioning systems (GPS) and geographic information systems (GIS) to clearly relate various "layers" of geographic information (e.g., vegetation types, soil condition, habitat, forest health, etc.). This is done to gain insight into interrelationships between the biotic systems and physical conditions at the Laboratory.

In 2009, BNL developed an Environmental Assessment (EA) under the National Environmental Policy Act (NEPA) of 1969 for construction of the Long Island Solar Farm (LISF) on site. This project encompasses an area of approximately 200 acres and is one of the Nation's largest solar photovoltaic arrays on DOE property. The GIS and natural resource data were utilized in the development of the EA (DOE 2009). The GIS has been updated with the exact footprint of the LISF since completion of construction in October 2011, and the GIS layers are routinely updated through surveys, observations, and research to ensure accuracy.

A wide variety of vegetation, birds, reptiles, amphibians, and mammals inhabit the site. Through implementation of the NRMP, additional endangered, threatened, and species of special concern have been identified as having been resident at BNL during the past 30 years or are expected to be present on site. The only New York State endangered species confirmed as now inhabiting Laboratory 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 site in the past, but are not currently known to exist here. Six New York State threatened species have been positively identified on site and three other species are considered likely to be present. Fish species, including the banded sunfish (*Enneacanthus obesus*) and swamp darter (*Etheostoma fusiforme*), and plants including the stiff goldenrod (*Solidago rigida*) and stargrass (*Aletris farinose*), have been previously reported (BNL 2000). The northern harrier (*Circus cyaneus*) was seen hunting over open fields in November 2003 and along the Peconic River in October 2010. In 2005, the Pine Barrens bluet (*Enallagma recurvatum*), a damselfly, was confirmed at one of the many coastal plain ponds located on site. Two other threatened damselflies, the little bluet (*Enallagma minisculum*) and the scarlet bluet (*Enallagma pictum*), are likely to be present at one or more of the ponds on site. The frosted elfin (*Callophrys irus*), a butterfly, has been identified as possibly being at BNL, based on historic documentation and the presence of its preferred habitat and host plant, wild lupine (*Lupinus perennis*). A number of other species that are listed as rare, of special concern, or exploitably vulnerable by New York State either currently inhabit the site, visit during migration, or have been identified historically (see Table 6-1).

6.1.2 Habitat Protection and Enhancement

BNL has precautions in place to protect onsite habitats and natural resources. Activities to eliminate or minimize negative effects on sensitive or critical species are either incorporated into Laboratory procedures or into specific program or project plans. Environmental restoration projects 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. Even routine activities such as road maintenance are not performed until they have been duly evaluated and determined to be unlikely to affect habitat.

6.1.2.1 Salamander Protection Efforts

To safeguard eastern tiger salamander breeding areas, a map of the 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 routinely updated as new information concerning the salamanders is generated through research and monitoring. The most recent update extends the buffer area around tiger salamander habitat from 800 feet to 1,000 feet based on guidance from the New York State Department of Environmental Conservation (NYSDEC). Other efforts to protect this state-endangered species include determining when adult salamanders are migrating toward breeding locations, when metamorphosis has been completed, and when juveniles are migrating after metamorphosis. During these times, construction and maintenance activities near their habitats are postponed or closely monitored. 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

NYSDEC, habitat surveys have been routinely conducted since 1999. Biologists conducting egg mass and larval surveys have confirmed 26 on-site ponds that are used by eastern tiger salamanders. Egg mass surveys of 18 of 26 ponds were conducted in 2011. Whenever possible, ponds with documented egg masses from the spring surveys are revisited in June and July to check for the presence of larval salamanders. When new information is obtained, it is entered into the GIS and used to visualize distributions, track reproductive success, and identify areas for focused management or study.

Protection of the eastern tiger salamander was a key component of the EA for the LISF project. The unique shape of the project, in part, came about due to the need to provide sufficient, viable habitat for the tiger salamander within the area to be developed. In 2010, the LISF completed habitat enhancement to improve one of BNL's tiger salamander ponds; the enhancements to the pond are intended to allow it to retain water for longer periods of time to support larval development. The enhanced pond is currently being managed to remove invasive plants that moved into the pond from surrounding areas.

6.1.2.2 Other Species

A number of other species are found at the Laboratory including 25 species of reptiles and amphibians that have been recorded over the past several years, in addition to the tiger salamander. The species 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 (*Lithobates sylvatica*), gray tree frog (*Hyla versicolor*), bullfrog (*Lithobates catesbiana*), green frog (*Lithobates clamitans*), pickerel frog (*Lithobates 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 c. carolina*), northern

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

Common Name	Scientific Name	State Status	BNL Status
Insects			
Frosted elfin	*Callophrys iris*	T	Likely
Little bluet	*Enallagma minusculum*	T	Likely
Scarlet bluet	*Enallagma pictum*	T	Likely
Pine Barrens bluet	*Enallagma recurvatum*	T	Confirmed
Mottled duskywing	*Erynnis martialis*	SC	Likely
Persius duskywing	*Erynnis persius persius*	E	Likely
Fish			
Banded sunfish	*Enniacanthus obesus*	T	Confirmed
Swamp darter	*Etheostoma fusiforme*	T	Confirmed
Amphibians			
Marbled salamander	*Ambystoma opacum*	SC	Confirmed
Eastern tiger salamander	*Ambystoma tigrinum tigrinum*	E	Confirmed
Eastern spadefoot toad	*Scaphiopus holbrookii*	SC	Confirmed
Reptiles			
Worm snake	*Carphophis amoenus*	SC	Confirmed
Spotted turtle	*Clemmys guttata*	SC	Confirmed
Eastern hognose snake	*Heterodon platyrhinos*	SC	Confirmed
Eastern box turtle	*Terrapene carolina*	SC	Confirmed
Birds (nesting, transient, or potentially present)			
Cooper's hawk	*Accipiter cooperii*	SC	Confirmed
Sharp-shinned hawk	*Accipiter striatus*	SC	Confirmed
Grasshopper sparrow	*Ammodramus savannarum*	SC	Confirmed
Whip-poor-will	*Caprimulgus vociferus*	SC	Likely
Northern harrier	*Circus cyaneus*	T	Confirmed
Horned lark	*Eremophila alpestris*	SC	Confirmed
Red-headed woodpecker	*Melanerpes erythrocephalus*	SC	Confirmed
Osprey	*Pandion haliaetus*	SC	Confirmed
Plants			
Stargrass	*Aletris farinosa*	T	Confirmed
Butterfly weed	*Asclepias tuberosa*	V	Confirmed
Spotted wintergreen	*Chimaphila maculata*	V	Confirmed
Flowering dogwood	*Cornus florida*	V	Confirmed
Pink lady's slipper	*Cypripedium acaule*	V	Confirmed
Winterberry	*Ilex verticillata*	V	Confirmed
Sheep laurel	*Kalmia angustifolia*	V	Confirmed
Narrow-leafed bush clover	*Lespedeza augustifolia*	R	Confirmed
Ground pine	*Lycopodium obscurum*	V	Confirmed
Bayberry	*Myrica pensylvanica*	V	Confirmed
Cinnamon fern	*Osmunda cinnamomera*	V	Confirmed
Clayton's fern	*Osmunda claytoniana*	V	Confirmed
Royal fern	*Osmunda regalis*	V	Confirmed
Crested fringed orchid	*Plantathera cristata*	E	Likely
Swamp azalea	*Rhododendron viscosum*	V	Confirmed
Long-beaked bald-rush	*Rhynchospora scirpoides*	R	Confirmed
Stiff goldenrod	*Solidago rigida*	T	Confirmed
New York fern	*Thelypteris novaboracensis*	V	Confirmed
Marsh fern	*Thelypteris palustris*	V	Confirmed
Virginia chain-fern	*Woodwardia virginica*	V	Confirmed

Notes:
* Table information based on 6 NYCRR Part 182, 6 NYCRR Part 193, and BNL survey data. No federally listed threatened or endangered species are known to occur at BNL.

E = Endangered
R = Rare
SC = Species of Special Concern
T = Threatened
V = Exploitably Vulnerable

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*), northern red-bellied snake (*Storeria occiptiomaculata*), and eastern wormsnake (*Carphophis amoenus*). This list 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 their habitat is not disturbed, and evaluating all activities taking place on the river for potential impacts on these habitats. Population estimates are periodically conducted within various waters on site to determine the current health of the banded sunfish. The last estimate was conducted in 2011, with a population of approximately 6,400 fish.

6.1.2.3 Migratory Birds

A total of 216 species of birds have been identified at BNL since 1948; at least 85 species 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 seven permanent bird survey routes in various habitats on site (a new route was established in 2010 in the vicinity of the LISF). In 2011, monthly surveys were conducted starting at the end of April and extending through the end of September. These surveys identified 67 songbird species, comparable to the 70 species in 2010 and 71 species during 2009. A total of 114 bird species have been identified during surveys in the past 11 years; 45 of these species were present each year. Variations in the number and species identified reflect 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 (now the LISF) and the Peconic River. The four transects passing through the various forest types (white pine, moist pine barrens, and dry pine barrens) showed a less diverse bird community. Data are stored in an electronic database.

The Biology Field transect and the new Solar Farm transect will be important in the collection of migratory bird data to assess the effects of the LISF on local bird populations. The LISF is predicted to improve habitat for some migratory birds over time as understory vegetation begins to grow under the arrays and deer are kept out of the area. No known data on the effects of a utility-scale solar array are known within scientific literature. One species, indigo bunting, was absent along the Biology Field transect in 2011. This may be due to disturbance from construction activities at the LISF.

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 includes habitat enhancement for the eastern bluebird. Since 2000, the Laboratory has installed more than 56 nest boxes around open grassland areas on site to enhance their population. Many of these boxes were removed from service in 2010 in preparation for the construction of the LISF. The LISF will create nearly 200 acres of suitable habitat for the eastern blue bird; therefore, additional boxes will be installed around the solar farm beginning in 2012.

Migratory birds occasionally cause safety and health concerns. Birds that typically are of concern include Canada geese (*Branta canadensis*) and several species of migratory birds that occasionally nest on buildings or in construction areas. Over the past several years, the resident Canada goose population began increasing with the potential to reach large numbers that could result in health and safety issues at BNL. In 2007, under a permit from the U.S. Fish & Wildlife Service (FWS), the Laboratory began managing the resident goose population. In 2011, 20 nests were treated, but a number of nests were missed and more than 30 goslings were produced; the overall population climbed to more than 120 individuals, which is approximately the same population when goose nest management began.

In 2011, eastern phoebes, which are migratory birds, began nesting on the cable trays of the LISF during construction. The nesting habits were monitored and it was determined that construction could continue by the careful placement of cabling around individual nests. Cable placement was successful and the nesting birds were able to successfully rear their young.

6.1.3 Population Management

The Laboratory 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 500 birds in 2004. Since 2004, the population appears to have stabilized at approximately 300 birds. The population across Suffolk County, Long Island, was determined to be of sufficient size to support hunting in 2009. The annual hunt (5 days) results in over 100 birds taken annually in Suffolk County, with little or no evidence of effects on the BNL turkey population. Turkey hunting on Long Island has been so successful that the NYSDEC intends to hold a spring youth hunt in 2012.

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 the Laboratory, there are no significant pressures on the population to migrate beyond their typical home range of approximately 1 square mile. Normally, a population density of 10 to 30 deer per square mile is considered an optimum sustainable level for a given area. This would equate to approximately 80 to 250 deer inhabiting the property, under normal circumstances. This was the approximate density in 1966, when BNL reported an estimate of 267 deer on site (Dwyer 1966). The Laboratory has been conducting population surveys of the white-tailed deer since 2000. In 2004, based on results of aerial infrared surveys, BNL adjusted the methods for estimating the deer population. The method utilizes GIS data layers for vegetation to adjust deer counts based on habitat. The deer population increased to an estimated 800 deer by December 2008. In 2009, the deer population increased to an estimated 893 animals in the spring and began declining in the fall. By December 2009, the population estimate was 731. This decrease is, in part, supported by the increased number of car–deer accidents reported on site during October and November of that year.

To gain additional information on deer populations, an aerial deer survey was conducted in March 2010 with a count of 226 deer, which when corrected for expected errors, resulted in a population estimate of 310 animals. This survey is very similar to the aerial surveys conducted in February and March 2004. The much lower numbers estimated are due largely to continued poor health and winter mortality. Deer surveys were not conducted in the fall of 2010 due to the start of construction of the LISF, which impedes access to all three survey routes on site and were not fully completed in 2011 due to continued construction. Based on births of fawns during summer 2011, the deer population was roughly estimated to be between 450 and 500 animals (55–61 deer/sq. mi.). This increase in population was evidenced by more car-deer accidents and one bicyclist-deer accident.

Deer overpopulation can affect animal and human health (e.g., animal starvation, Lyme disease from deer ticks, collision injuries to both human and animal), species diversity (songbird species reduction due to selective grazing and destruction of habitat by deer), and property values (collision damage to autos and browsing damage to ornamental plantings). In 2011, there were approximately 10 deer-related collisions on site in addition to the bicyclist-deer accident mentioned above, and a pedestrian-deer accident, compared to one accident in 2010 and 13 accidents in 2009.

Because the high deer population is a regional problem, the Laboratory is working on the issue with other local jurisdictions. As part of this regional approach, an issue and decision paper was prepared for BNL management consideration late in 2007. Options for deer management are limited, and most are controversial. While a single regional approach would benefit the community, land managers, and the health of the deer population, multiple land managing organizations like the Laboratory must begin to implement deer management. In 2008, the BNL Policy Council approved moving forward with deer management planning. Several meetings were held with employees during the spring months, resulting in the development of an employee survey. The survey was sent out to approximately 2,800 individuals; 829 individuals responded. Most respondents believe that deer management is needed, but the survey was unclear on the method of deer management to be used. Several informational sessions were held to further explain the various options available in order to begin moving forward with management. The first step is for BNL to prepare an EA under the requirements of NEPA, which was scheduled to begin in 2009 but was delayed due to the higher priority development of an EA for the LISF and an EA for Enhanced Treatment options at the Laboratory's Sewage Treatment Plant (STP). The current schedule for writing an EA for deer management is the spring of 2012.

6.1.4 Compliance Assurance and Potential Impact Assessment

The NEPA review process at BNL is a key to ensuring that environmental impacts of a proposed action or activity are adequately evaluated and addressed. The Laboratory will continue to use NEPA (or NEPA-like) processes under the Comprehensive Environmental Response, Compensation and Liability Act (CERCLA) Environmental Restoration Program when identifying potential environmental impacts associated with site activities—especially with physical alterations. As appropriate, stakeholders such as EPA, NYSDEC, Suffolk County Department of Health Services (SCDHS), BNL's Community Advisory Council, and the BNL Brookhaven Executive Roundtable are involved in reviewing major projects that have the potential for significant environmental impacts. Formal NEPA reviews are coordinated with the State of New York. As discussed previously, in 2011, BNL completed an EA for the proposed enhanced treatment options at the STP. A summary of NEPA reviews is provided in Chapter 3.

6.2 UPTON ECOLOGICAL AND RESEARCH RESERVE

On November 9, 2000, then-Secretary of Energy Bill Richardson and Susan MacMahon, the Acting Regional Director of Region 5 FWS, 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 was managed by FWS under an Interagency Agreement (DOE–FWS 2000). The Upton Reserve, on the eastern boundary of BNL, 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 a 1994–1995 biological survey of the Laboratory, 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).

A transition from FWS management of the Upton Reserve to management by BNL and the Foundation for Ecological Research in the Northeast (FERN) occurred in 2005. During that year, FERN initiated its first pine barrens–wide monitoring program to assess the health of the various forest types within the Pine Barrens, followed by a continuation of the effort in 2006. FERN established 91 permanent plots over the 2-year period of the monitoring program. One significant finding from that study is the lack of forest regeneration. In virtually every forest type, there is a lack of survival of trees from seedlings through to saplings. This is likely a result of either deer over-abundance or lack of sunlight penetrating to the understory. The Laboratory was able to utilize three of the forest health plots as controls for the establishment of deer exclosures (areas fenced off to prevent entry by deer) to further study the effects of deer on forest ecosystems. Much of FERN's activities have transitioned to providing seed money to initiate research within the pine barrens and other Long Island ecosystems.

Research supported by FERN in 2011 included continued investigation into the microbial world of soils located within the pine barrens and experimental areas on site. Microbial research carried out by a scientist at Dowling College, New York, has identified several new species of fungus and bacteria. Research was conducted in conjunction with a faculty and student team from Southern University at New Orleans, with the results being successfully published in PLosOne, which is an interactive open-access journal for the communication of all peer reviewed scientific and medical research. Information on these projects and others is provided in Section 6.5.

6.3 MONITORING FLORA AND FAUNA

The Laboratory routinely conducts surveillance monitoring of flora and fauna to determine the effects of past and present activities on site. Because soil contaminated with a radioactive isotope of cesium (Cs-137) was used in some BNL landscaping projects in the past, traces have now been found in deer and in other animals and plants. At the cellular level, Cs-137 takes the place of potassium (K), an essential nutrient.

Most radionuclide tables in this chapter list data for both Cs-137 and potassium-40 (K-40), a naturally occurring radioisotope of potassium. Because K-40 is naturally in the environment, it is commonly found in flora and fauna. (In general, K-40 values do not receive significant discussion in the scientific literature because K-40 occurs naturally.) Studies indicate that Cs-137 out-competes K and K-40 when potassium salts are limited in the environment, which is typical on Long Island. 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, about 150 pounds; females typically weigh 1/3 less, approximately 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 2011, as in recent years, an on- and off-site deer-sampling program was conducted. While most off-site samples are from the results of car–deer accidents near the Laboratory, in most years, samples from deer taken by hunters beyond BNL boundaries or samples from car-deer accidents greater than 1 mile from BNL are received. Based on more than a decade of sampling, deer taken from more than one mile from BNL represent background. In all, 12 deer were obtained on site and 5 deer were from off-site locations within one mile of the Laboratory. No deer samples were obtained from areas greater than one mile in 2011. A single hunter-donated sample was provided for analysis during the summer of 2011, but a definitive location and exact date of collection was not provided. The results of this sample are discussed in the text below, but are not presented in Table 6-2 with other analytical data.

BNL sampling technicians collect the samples and process them for analysis. Samples of meat (flesh), liver, and bone are 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). Meat and liver data are reported on a wet weight basis and bone data are reported as dry weight.

6.3.1.1 Cesium-137 in White-Tailed Deer

Based on historic and current data, white-tailed deer sampled at or near the Laboratory contain higher concentrations of Cs-137 than deer from greater than 1 mile off site (BNL 2000), most likely because they graze 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 on site has occurred under the Laboratory's cleanup program. All major areas of contaminated soil were remediated by September 2005. In addition, all buildings at the former Hazardous Waste Management Facility (HWMF) were removed in 2003, and the cleanup of the remainder of the facility was completed by fall 2005. Subsequent to the completion of cleanup at the former HWMF, additional minor contamination outside that facility was found and characterized, and the majority of the contamination was removed in 2009. Further characterization of the area surrounding the former HWMF was performed in late 2009, with a portion of the work completed in 2010 to allow use of the area for the LISF.

The number of deer obtained for sampling steadily increased between 1996 and 2004. However, the numbers of deer obtained from 2005 to 2010 were significantly lower. 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 obtained each year has varied due to the sampling method, which depends on vehicle and deer accidents and people reporting dead deer. The number of deer hit by vehicles varies widely from year to year, depending on the population of deer present near major roadways and the traffic density. Figure 6-1 shows the location of all deer samples taken within a 5-mile radius of the Laboratory since 2007. Most of the off-site samples are concentrated along the William Floyd Parkway on the west boundary of BNL, whereas the concentration on site is near the front gate area and the constructed portions of the Laboratory. This distribution is most likely due to the fact that 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 and traffic to and from the front gate is greatest.

In 2011, Cs-137 concentrations in deer meat (flesh) samples were obtained from 12 deer on site with a range of values from 0.07 pCi/g, wet weight, to 3.08 pCi/g, wet weight, and an arithmetic average of 1.02 pCi/g, wet weight. The wet weight concentration is before a sample is dried for analysis and is the form most likely to be consumed. Dry weight concentrations are typically higher than wet weight values. The highest on-site sample in 2011 (3.08pCi/g, wet weight) was 10 times higher than the single on-site sample reported in 2010 (0.31 pCi/g wet weight). However, it was only one-fourth as much as the highest level ever reported (11.74 pCi/g, wet weight, in 1996).

Cs-137 concentrations in off-site deer meat samples are typically separated into two groups: samples taken within 1 mile of BNL (five samples) and samples taken farther away (no samples in 2011), as shown in Table 6-2. Concentrations in meat samples taken within 1 mile ranged from 0.50 to 4.08 pCi/g, wet weight, with an arithmetic average of 2.25 pCi/g, wet weight. Because deer on site may routinely travel up to 1 mile off site, the arithmetic average for deer taken on site and within 1 mile of the Laboratory is also calculated; for 2011, this was 1.39 pCi/g, wet weight.

Figure 6-2 compares the average values of Cs-137 concentrations in meat samples collected in 2011 from three different location groupings. Although the figure does not show this, 50 percent of all meat samples taken both on and off site are below 1 pCi/g, wet weight (see Table 6-2).

Figure 6-3 presents the 10-year trend of on-site and near off-site Cs-137 averages in deer meat. While similar in number to the samples taken in 2005, samples from 2011 indicate a greater range of error. The average is approximately 2.5 times higher than the 2005 average, but only slightly higher than the 2010 average. Although these sample results continue to indicate the effectiveness of cleanup actions across the Laboratory, the trend is slightly upward from 2002 to 2011 and likely reflects the seasonality of sample acquisition. In 2003, a seasonal pattern in Cs-137 concentrations in deer meat was noticed. This seasonality was present in data from earlier years and occurred again in 2011 (see Table 6-2). Deer sampled from October to December typically have higher Cs-137 values

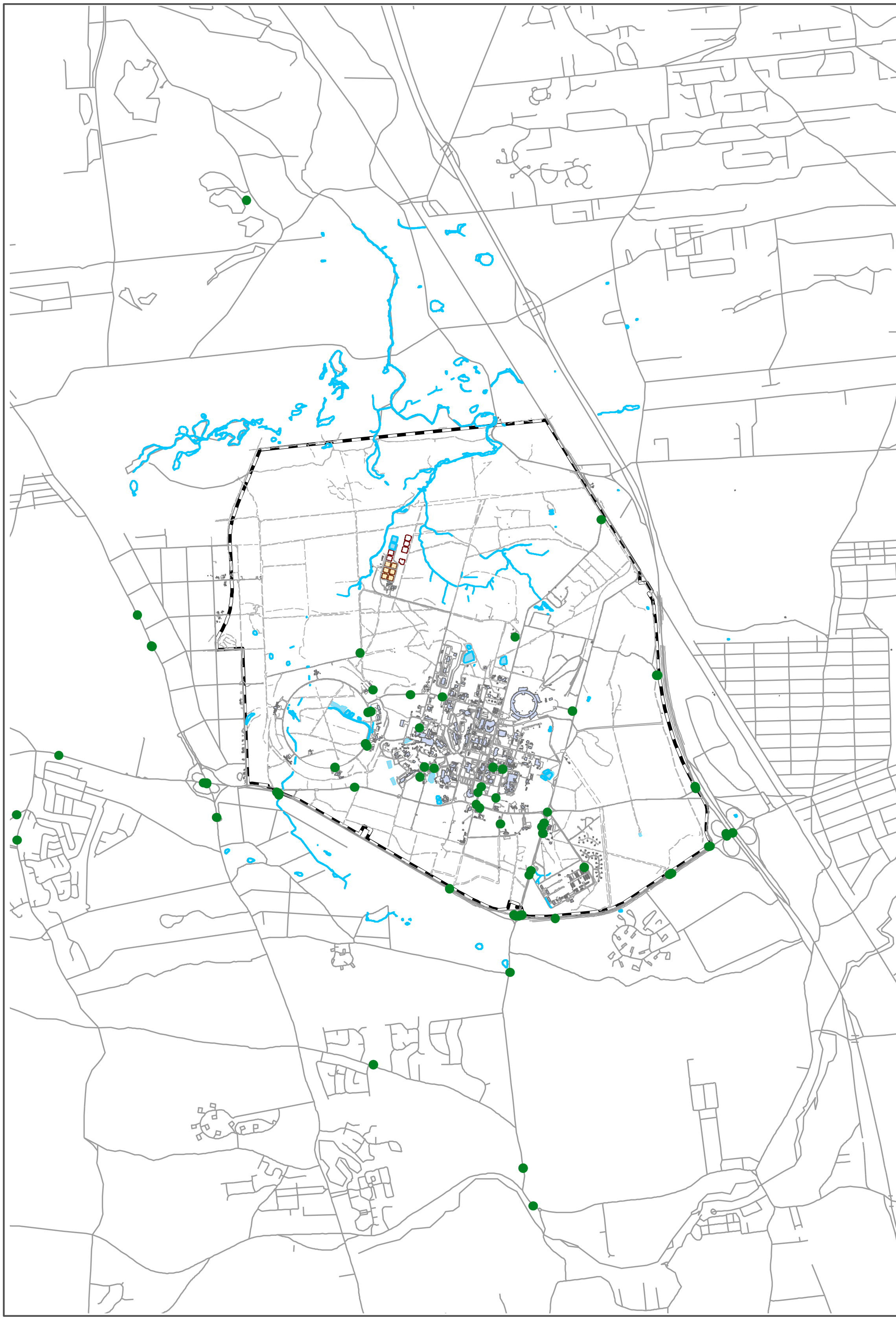


Figure 6-1. Deer Sample Locations, 2006—2011.

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					
National Synchrotron Light Source II, South Gate	06/06/11	flesh	3.37 ± 0.38	0.14 ± 0.02	
		liver	2.18 ± 0.25	0.04 ± 0.01	
		bone			2.36 ± 0.70
Long Island Solar Farm, Area 2	07/27/11	flesh	2.86 ± 0.31	0.97 ± 0.08	
		liver	2.28 ± 0.28	0.70 ± 0.06	
		bone*			1.96 ± 0.32
Bldg. 1004, Outer Ring Road	08/01/11	flesh	3.30 ± 0.36	0.64 ± 0.06	
		liver	2.74 ± 0.31	0.18 ± 0.02	
		bone*			1.83 ± 0.27
Main Gate	08/08/11	flesh	2.72 ± 0.27	0.93 ± 0.08	
		liver	2.41 ± 0.41	0.21 ± 0.04	
		bone			4.79 ± 0.67
Bldg. 912B	08/08/11	flesh	3.150 ± 0.32	0.07 ± 0.01	
		liver	2.32 ± 0.26	0.29 ± 0.01	
		bone			2.58 ± 0.57
Bldg. 422	09/29/11	flesh	3.42 ± 0.41	0.98 ± 0.09	
		liver	2.08 ± 0.43	0.62 ± 0.07	
		bone			2.63 ± 1.14
West Princeton Ave. at Motorpool	11/14/11	flesh	3.20 ± 0.30	3.08 ± 0.27	
		liver	2.09 ± 0.25	1.14 ± 0.09	
		bone			2.55 ± 0.75
RHIC 1005	11/21/11	flesh	3.30 ± 0.39	2.84 ± 0.24	
RHIC 1005 (deer 2)	11/21/11	flesh	1.95 ± 0.38	0.35 ± 0.05	
		bone			2.33 ± 0.76
Yale and York Rds.	11/28/11	flesh	3.55 ± 0.36	1.10 ± 0.10	
		liver	2.38 ± 0.38	0.22 ± 0.04	
		bone			ND
Bldg. 438	12/14/11	flesh	3.01 ± 0.29	1.02 ± 0.09	
		liver	2.63 ± 0.25	0.21 ± 0.02	
		bone			2.1 ± 1.24
Bldg. 462	12/29/11	flesh	3.33 ± 0.31	0.18 ± 0.02	
		liver	1.89 ± 0.23	0.02 ± 0.01	
		bone			ND
Offsite < 1 mile					
William Floyd Parkway and BNL Main Gate	01/05/11	flesh	3.64 ± 0.52	2.39 ± 0.12	
		bone			ND
William Floyd Parkway and BNL Main Gate	02/11/11	flesh	2.91 ± 0.43	0.50 ± 0.06	
		bone			ND
South Gate, Long Island Expressway Service Rd.	10/11/11	flesh	3.16 ± 0.44	4.08 ± 0.34	
		liver	2.35 ± 0.30	1.39 ± 0.13	
		bone			2.57 ± 0.70
William Floyd Parkway and North Gate	12/01/11	flesh	3.35 ± 0.39	2.38 ± 0.20	
		liver	2.58 ± 0.30	0.75 ± 0.07	
		bone			ND

(continued on next page)

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

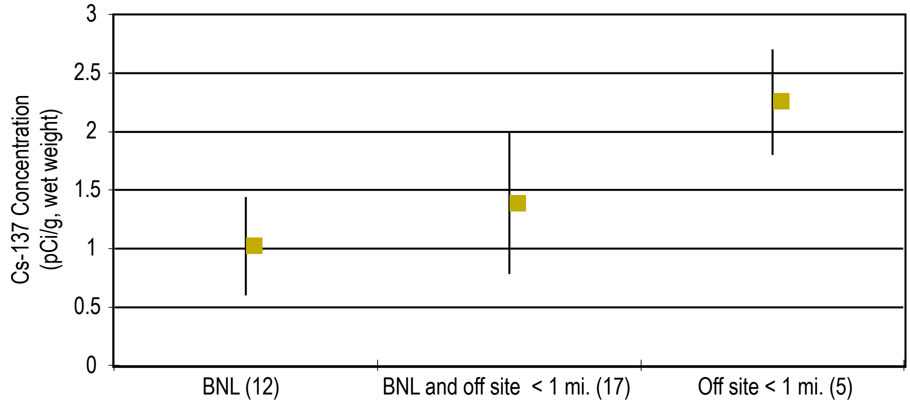
Sample Location	Collection Date	Tissue Type	K-40 pCi/g (Wet Weight)	Cs-137 pCi/g (Wet Weight)	Sr-90 pCi/g (Dry Weight)
William Floyd Parkway and BNL Main Gate	12/20/11	flesh	2.86 ± 0.27	1.91 ± 0.16	
		liver	2.43 ± 0.26	0.43 ± 0.04	
		bone			2.74 ± 1.28
Averages by Tissue					
Flesh					
All Samples (17)			3.12 ± 1.51	1.39 ± 0.61	
BNL Average (12)			3.09 ± 1.18	1.02 ± 0.42	
< 1 Mile Average (5)			3.18 ± 0.94	2.25 ± 0.45	
Liver					
All Samples (13)			2.31 ± 1.08	0.50 ± 0.21	
BNL Average (10)			2.26 ± 0.96	0.38 ± 0.14	
< 1 Mile Average (3)			2.45 ± 0.49	0.86 ± 0.15	
Bone					
All Samples (16)					1.96 ± 3.22
BNL Average (11)					2.16 ± 2.46
< 1 Mile Average (5)					1.53 ± 2.08
BNL + < 1 Mile Average (16)					1.96 ± 3.22

Notes:
All values are shown with a 95% confidence interval.
Samples were not taken from >1 mile from BNL.
K-40 occurs naturally in the environment and is presented as a comparison to Cs-137.
All averages are the arithmetic average.
Confidence limits are 2σ (95%) propogated error.

Cs-137 = cesium-137
K-40 = potassium-40
ND = Non-detected
Sr-90 = strontium-90
* = estimated value for Sr-90

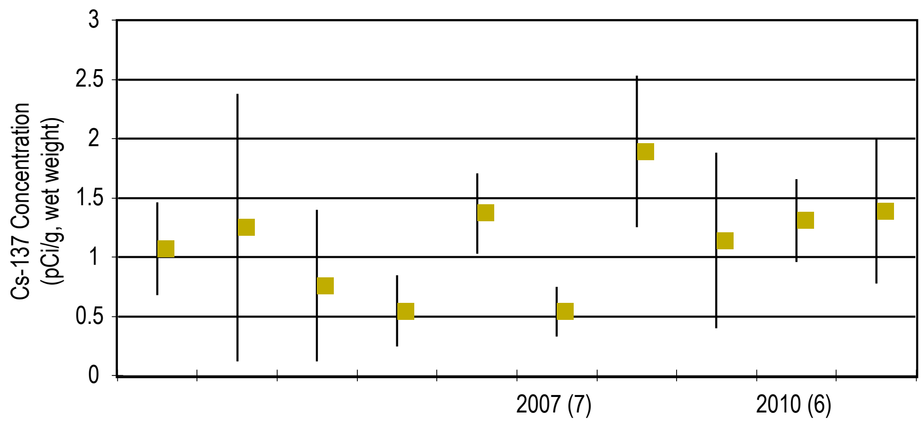
than samples obtained in the spring and summer. During the summer of 2004, a student in the Community College Intern Program reviewed all data from 2000–2003, analyzed the data statistically, and determined that there was a statistical seasonal variation in values for deer both on site as well as far 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 plants are dormant). In the summer and fall (July through mid-December), deer eat more and the vegetation is constantly growing, taking up nutrients and contaminants from the soil. In summer and fall, deer feeding on vegetation growing in soil containing Cs-137 are more likely to obtain a continuous supply, which is incorporated into their tissues. This increased concentration of Cs-137 in tissues is evidenced by the four highest values seen in deer in 2011 (2.38, 2.39, 2.84, and 4.08 pCi/g, wet weight) from samples taken in January and then October through November respectively. By late-January to February, the Cs-137 in their tissues had 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.

As mentioned in Section 6.3.1 above, BNL received a request in 2011 from a local hunter to analyze deer meat taken locally. The sample was estimated to be taken early in November 2011, thereby making an accurate analysis



Notes: Averages are shown for samples collected at BNL, on site and off site within 1 mile, and off site but within 1 mile of the boundary.
Numbers in parentheses indicate the number of samples in that data set.
All values are presented with a 95% confidence interval.
Cs-137 = Cesium-137

Figure 6-2. Comparison of Cs-137 Average Concentrations in Deer Meat, 2011.



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.
Cs-137 = cesium-137

Figure 6-3. Ten-Year Trend of Cs-137 Concentrations in Deer Meat.

questionable. The analytical data indicated that the Cs-137 content was less than 0.01 pCi/g, wet weight, and the K-40 content was 2.63 pCi/g, wet weight, indicating that the analysis was within the range of values seen historically. The data was provided to the individual, allowing them to make an informed decision as to whether or not to consume other meat from the same deer.

When possible, liver samples are taken concurrently with meat samples. Liver generally accumulates Cs-137 at a lower rate than muscle tissue. The typically lower values in liver allow the results to be used 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 2011, Cs-137 concentration ranged from 0.02 to 1.14 pCi/g, wet weight, with an average of 0.38 pCi/g, wet weight. The off-site Cs-137 concentration in liver ranged from 0.43 to 1.39 pCi/g, wet weight, with an arithmetic average for all off-site liver samples of 0.86 pCi/g, wet weight.

The potential radiological dose resulting from deer meat consumption is discussed in Chapter 8. The New York State Department of Health (NYSDOH) has formally considered the potential public health risk associated with elevated Cs-137 levels in on-site deer and determined that neither hunting restrictions nor formal health advisories are warranted (NYSDOH 1999).

With respect to the health of on-site deer based on their exposure to radionuclides, the International Atomic Energy Agency (IAEA) has concluded that chronic dose rates of 100 millirad per day to even the most radiosensitive species in terrestrial ecosystems are unlikely to cause detrimental effects in animal populations (IAEA 1992). A deer containing a uniform distribution of 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 amount of approximately 0.2 µCi. That animal would receive an absorbed dose of approximately 3 millirad per day, which is only 3 percent of the threshold evaluated by IAEA. The deer observed and sampled on site appear to have no health effects from the level of Cs-137 found in their tissues.

6.3.1.2 Strontium-90 in Deer Bone

BNL began testing deer bones for Sr-90 content in 2000. In 2011, Sr-90 content ranged from non-detectable to 4.79pCi/g, dry weight, in samples taken on site. Sr-90 in off-site samples taken within one mile of BNL ranged from non-detectable to 2.74 pCi/g, dry weight. There is significant overlap across all values, which suggests that Sr-90 is present in the environment at background levels, probably as a result of worldwide fallout from 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. The Laboratory will continue to test for Sr-90 in bone to maintain baseline information on this radionuclide and its presence in local white-tailed deer.

6.3.2 Other Animals Sampled

When other animals, such as wild turkey or Canada geese, are found dead along the roads of BNL and the immediate vicinity due to road mortality, they are tested for Cs-137 and Sr-90 content in bone, when possible. In 2011, a single turkey was found dead from avian pox near BNL's Relativistic Heavy Ion Collider and a sample of the breast meat was sent for radiological analysis. The sample resulted in an estimated Cs-137 content of 0.07 pCi/g, wet weight. The K-40 content was 3.52 pCi/g, wet weight, which is within the range of variation seen for K-40 in biological samples from Long Island.

6.3.3 Fish Sampling

In collaboration with the NYSDEC Fisheries Division, BNL maintains an ongoing program for collecting and analyzing fish from the Peconic River and surrounding freshwater bodies. Large areas of open water on site resulting from the cleanup of the Peconic River have resulted in sufficient habitat to support larger fish. During past sampling activities, numerous schools of fry of bass and sunfish were noticed. While low-dissolved oxygen levels continue to be a problem for fish, the deeper pools provide areas of cooler, more highly oxygenated water for long-term survival. Fish were sampled early in 2011 to take advantage of periods when dissolved oxygen levels are higher, supporting the presence of fish.

All samples were analyzed for edible (fillet) content of each of the analytes reported. Various species of fish were also collected off site from Swan Pond, Donahue's Pond, Forge Pond, Manor Road, Schultz Road, 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. Sampling is carried out in cooperation with NYSDEC and through a contract with the Cold Spring Harbor Fish Hatchery and Museum. Sampling is also separated into samples taken as part of the routine surveillance monitoring program and those taken as part of the post cleanup monitoring for the Peconic River Cleanup project (primarily for mercury analysis).

6.3.3.1 Radiological Analysis of Fish

The species collected for radiological analysis in 2011 by BNL, NYSDEC, and through contract labor included brown bullhead (*Ictalurus nebulosus*), chain pickerel (*Esox niger*), largemouth bass (*Micropterus salmoides*), black crappie (*Pomoxis nigromaculatus*), bluegill (*Lepomis macrochirus*), pumpkinseed (*Lepomis gibbosus*), yellow perch (*Perca flavescens*), and a single carp or Koi (*Cyprinus carpio*). Gamma spectroscopy analysis was performed on all samples. When fish were not of sufficient mass to conduct all non-radiological and radiological analyses, samples of the same species were composited to gain sufficient volume for radiological analysis. Table 6-3 presents specific information on the sampling location, species collected, and analytical results. All sample results are presented as wet weight concentrations, and information on the natural radioisotope K-40 is included as a comparison.

Cs-137 was measured at levels ranging from non-detected to 0.78 pCi/g, wet weight, from the Peconic River system, and all samples from the Carmans River were non-detectable levels. Detectable levels in fish ranged from 0.06 pCi/g, wet weight, in a brown bullhead taken at Schultz Road to 0.78 pCi/g, wet weight, in a composite sample of bluegill taken from Forge Pond. This is compared to the highest recent value of 0.51 pCi/g, wet weight, in a composite sample of largemouth bass taken from Area C on site in 2009.

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). Cs-137 concentrations in brown bullhead collected at all locations along the Peconic River had values less than 0.26 pCi/g, wet weight. Largemouth bass, the top predator from the Peconic River, showed Cs-137 levels of 0.34 pCi/g, wet weight, or less. Levels of Cs-137 in all fish species appear to be declining, compared to historic values.

Though it is clear from discharge records and sediment sampling that past BNL operations have contributed to anthropogenic (human-caused) radionuclide levels in the Peconic River system, most of these radionuclides were released between the late 1950s and early 1970s. Concentrations continue to decline over time through natural decay. Cs-137 has a half-life of 30 years. No Cs-137 was released from the BNL STP to the Peconic River between 2003 and 2011. Additionally, the cleanup of both on- and off-site portions of the Peconic River in 2004 and 2005 removed approximately 88 percent of Cs-137 in the sediment that was co-located with mercury. Removal of this contamination is expected to result in further decreases in Cs-137 levels in fish.

6.3.3.2 Fish Population Assessment

BNL suspended fish sampling on site in 2001 because prior fish sampling had depleted the population and limited the remaining fish to smaller sizes. Sampling resumed in 2007 when multiple schools of small fish were observed throughout the on-site portions of the river. The relative sizes of fish caught during annual sampling events are tracked and modifications to future sampling events made, as necessary, to ensure long-term health of the on-site fish populations. Successful sampling of sufficiently large fish for analysis from 2008 through 2011 indicated that populations are maintaining themselves and can support annual sampling.

6.3.3.3 Non-radiological Analysis of Fish

Beginning in 2005, all fish of sufficient size have been analyzed as edible portions (fillets). Smaller fish, such as golden shiners, have been composited for whole-body analysis. In 2007, fish sampling was moved to the spring months, when possible, to lessen the effect of low oxygen levels on fish distributions. All samples for the Peconic River post-cleanup monitoring were obtained between April and mid-June, and general surveillance samples were obtained by early September.

Table 6-4 shows the 2011 concentrations of metals in fish taken for surveillance monitoring within the Peconic River and Lower Lake on the Carmans River. Due to the fact that values for aluminum, antimony, arsenic, beryllium, cadmium, cobalt, silver, selenium, thallium,

Table 6-3. Radiological Analysis of Fish from the Peconic River System and Carmans River, Lower Lake.

Location/Species	K-40	Cs-137
	pCi/g	
BNL, On Site		
Area A		
Pumpkinseed (composite)*	NR	0.36 ± 0.08
Pumpkinseed (composite)*	NR	0.51 ± 0.12
Pumpkinseed (composite)*	NR	0.18 ± 0.08
Chain Pickerel (composite)*	NR	0.38 ± 0.07
Chain Pickerel (composite)*	NR	0.28 ± 0.07
Chain Pickerel (composite)*	NR	0.14 ± 0.09
Brown Bullhead (composite)*	NR	0.26 ± 0.05
Brown Bullhead (composite)*	NR	0.25 ± 0.1
Brown Bullhead (composite)*	NR	0.22 ± 0.06
Area C		
Bluegill (composite)*	2.84 ± 1	0.25 ± 0.1
Bluegill (composite)*	NR	0.16 ± 0.06
Bluegill (composite)*	2.79 ± 0.85	0.15 ± 0.08
Bluegill (composite)*	2.61 ± 0.78	0.19 ± 0.05
Pumpkinseed (composite)*	2.31 ± 0.8	0.22 ± 0.07
Pumpkinseed (composite)*	2.83 ± 0.76	0.2 ± 0.06
Pumpkinseed (composite)*	3.45 ± 1.12	0.13 ± 0.08
Largemouth Bass*	3.41 ± 0.84	0.34 ± 0.06
Brown Bullhead (composite)*	3.26 ± 0.7	0.25 ± 0.05
Brown Bullhead*	4.27 ± 0.92	0.25 ± 0.06
Brown Bullhead*	3.67 ± 1.16	0.2 ± 0.07
Area D		
Bluegill *	NR	0.18 ± 0.06
Bluegill*	NR	0.14 ± 0.06
Bluegill (composite)*	NR	0.19 ± 0.08
Bluegill (composite)*	NR	0.18 ± 0.06
Pumpkinseed (composite)*	NR	0.14 ± 0.06
Pumpkinseed (composite)*	NR	0.16 ± 0.05
Pumpkinseed (composite)*	NR	0.18 ± 0.05
Pumpkinseed (composite)*	NR	0.16 ± 0.05
Pumpkinseed (composite)*	NR	0.18 ± 0.05
Pumpkinseed (composite)*	NR	0.13 ± 0.04
Pumpkinseed (composite)*	NR	0.18 ± 0.05

(continued)

Table 6-3. Radiological Analysis of Fish from the Peconic River System and Carmans River, Lower Lake *(continued).*

Location/Species	K-40	Cs-137
	pCi/g	
Pumpkinseed (composite)*	NR	0.15 ± 0.05
Black Crappie*	NR	0.21 ± 0.05
Black Crappie (composite)*	NR	0.18 ± 0.1
Largemouth Bass*	NR	0.18 ± 0.04
Largemouth Bass*	NR	0.24 ± 0.05
Brown Bullhead (composite)*	NR	0.24 ± 0.04
Brown Bullhead (composite)*	NR	0.22 ± 0.04
Brown Bullhead (composite)*	NR	0.18 ± 0.04
Brown Bullhead (composite)*	NR	0.18 ± 0.03
Brown Bullhead (composite)*	NR	0.2 ± 0.04
Brown Bullhead (composite)*	NR	0.22 ± 0.05
Brown Bullhead (composite)*	NR	0.19 ± 0.04
Brown Bullhead (composite)*	NR	0.2 ± 0.04
Brown Bullhead (composite)*	NR	0.18 ± 0.04
Brown Bullhead (composite)*	NR	0.15 ± 0.07
Brown Bullhead (composite)*	NR	0.13 ± 0.06
Brown Bullhead*	NR	0.19 ± 0.06
Brown Bullhead (composite)*	NR	0.13 ± 0.08
Schultz Road		
Largemouth Bass*	NR	0.13 ± 0.04
Largemouth Bass*	NR	0.1 ± 0.06
Chain Pickerel*	NR	0.19 ± 0.06
Chain Pickerel*	NR	0.12 ± 0.1
Brown Bullhead*	NR	0.06 ± 0.04
Manor Road		
Chain Pickerel*	NR	0.19 ± 0.1
Brown Bullhead	2.67 ± 1.02	ND
Brown Bullhead*	3.23 ± 0.91	0.09 ± 0.05
Brown Bullhead*	3.19 ± 0.91	0.15 ± 0.05
Brown Bullhead*	3.31 ± 1.01	0.15 ± 0.07
Brown Bullhead*	2.84 ± 1.37	0.17 ± 0.1
Brown Bullhead*	2.56 ± 0.8	0.16 ± 0.05
Brown Bullhead*	3.72 ± 0.87	0.07 ± 0.06
Brown Bullhead*	2.87 ± 1.08	0.15 ± 0.05
Brown Bullhead*	4.89 ± 1.13	0.11 ± 0.05
Brown Bullhead (composite)*	3.65 ± 0.66	0.14 ± 0.04

(continued)

Table 6-3. Radiological Analysis of Fish from the Peconic River System and Carmans River, Lower Lake *(continued)*.

Location/Species	K-40	Cs-137
	pCi/g	
Brown Bullhead (composite)*	3.25 ± 0.77	0.09 ± 0.03
Brown Bullhead (composite)*	3.58 ± 0.97	0.12 ± 0.05
Brown Bullhead (composite)*	3.84 ± 0.72	0.16 ± 0.04
Brown Bullhead (composite)*	3.64 ± 1.09	0.12 ± 0.07
Donahue's Pond		
Bluegill (composite)	3.13 ± 1.58	ND
Bluegill (composite)*	2.82 ± 1.53	0.23 ± 0.09
Bluegill (composite)	3.27 ± 1.06	ND
Bluegill (composite)	2.39 ± 0.99	ND
Bluegill (composite)*	4.45 ± 1.19	0.12 ± 0.05
Pumpkinseed		ND
Largemouth Bass*	2.26 ± 0.43	0.08 ± 0.02
Chain Pickerel*	2.77 ± 0.42	0.07 ± 0.02
Brown Bullhead*	3.11 ± 1.26	0.17 ± 0.09
Brown Bullhead*	3.75 ± 0.96	0.1 ± 0.07
Brown Bullhead	2.38 ± 1.32	ND
Brown Bullhead*	3.28 ± 0.93	0.16 ± 0.05
Brown Bullhead	2.31 ± 1.16	ND
Brown Bullhead	3.6 ± 1.35	ND
Brown Bullhead*	2.81 ± 0.98	0.12 ± 0.05
Brown Bullhead	2.58 ± 1.22	ND
Brown Bullhead	3.34 ± 1.54	ND
Brown Bullhead	3.97 ± 1.02	ND
Forge Pond		
Bluegill	3.35 ± 1.34	ND
Bluegill	2.53 ± 1.35	ND
Bluegill*	2.63 ± 1.25	0.78 ± 0.05
Bluegill	3.69 ± 1.22	ND
Bluegill	3.62 ± 1.68	ND
Largemouth Bass*	3.26 ± 1.45	0.11 ± 0.12
Largemouth Bass*	3.61 ± 1.86	0.13 ± 0.11
Largemouth Bass	3.61 ± 1.38	ND
Largemouth Bass	4.18 ± 1.2	ND
Largemouth Bass	4.24 ± 1.37	ND
Yellow Perch*	3.7 ± 1.59	0.19 ± 0.09
Yellow Perch*	2.99 ± 1.80	0.19 ± 0.14

(continued)

Table 6-3. Radiological Analysis of Fish from the Peconic River System and Carmans River, Lower Lake *(continued)*.

Location/Species	K-40	Cs-137
	pCi/g	
Chain Pickerel*	2.81 ± 1.05	0.16 ± 0.08
Chain Pickerel*	4.01 ± 1.27	0.17 ± 0.09
Chain Pickerel	3.32 ± 1.82	ND
Chain Pickerel*	3.48 ± 1.23	0.17 ± 0.05
Brown Bullhead	3.28 ± 1.78	ND
Swan Pond (Peconic River control location)		
Largemouth Bass	3.95 ± 1.25	ND
Largemouth Bass	4.24 ± 1.56	ND
Largemouth Bass	2.87 ± 1.2	ND
Largemouth Bass	4.1 ± 1.08	ND
Largemouth Bass	4.05 ± 1.61	ND
Yellow Perch	3.75 ± 1.22	ND
Yellow Perch	3.37 ± 1.39	ND
Yellow Perch	4.89 ± 1.64	ND
Yellow Perch*	2.63 ± 1.14	0.12 ± 0.05
Yellow Perch	3.12 ± 1.47	ND
Yellow Perch	2.11 ± 2.11	ND
Brown Bullhead	2.81 ± 1.39	ND
Brown Bullhead	3.65 ± 1.05	ND
Brown Bullhead	3.69 ± 1.43	ND
Brown Bullhead	3.82 ± 1.2	ND
Brown Bullhead	2.3 ± 1.0	ND
Lower Lake, Carmans River		
Koi	3.1 ± 1.06	ND
Bluegill	2.73 ± 1.4	ND
Bluegill	3.37 ± 1.14	ND
Bluegill	2.32 ± 0.98	ND
Bluegill	3.11 ± 1.28	ND
Bluegill	2.49 ± 1.1	ND
Bluegill	2.25 ± 1.23	ND
Largemouth Bass	3.51 ± 1.11	ND
Largemouth Bass	2.87 ± 1.34	ND
Largemouth Bass	3.33 ± 1.44	ND
Brown Bullhead	4.22 ± 1.12	ND
Brown Bullhead	2.59 ± 1.66	ND
Brown Bullhead	3.47 ± 1.1	ND

(continued)

Table 6-3. Radiological Analysis of Fish from the Peconic River System and Carmans River, Lower Lake *(concluded).*

Location/Species	K-40	Cs-137
	pCi/g	
Brown Bullhead	3.38 ± 1.12	ND
Brown Bullhead	2.83 ± 1.40	ND
Brown Bullhead	3.18 ± 1.29	ND

Notes:
All samples analyzed as edible portions (fillets).
K-40 occurs naturally in the environment and is presented as a comparison to Cs-137.
Cs-137 = cesium-137
K-40 = potassium-40
* = estimated value for Cs-137 based on analytical laboratory qualifiers.
ND = not detected, based on analytical laboratory qualifiiers.
NR = data not reported by analytical laboratory.

and vanadium were near or less than the minimum detection level (MDL) for the analytical procedure, they were not included in Table 6-4. Additionally, metals common to biological process including calcium, magnesium, potassium, and sodium are also not presented in Table 6-4. Nickel is the only other metal tested but not included in the table, as most values reported for this metal were less than the MDL. Nickel values that were above the MDL and without laboratory qualifiers were as follows: a single brown bullhead taken from Swan Pond measured 0.465 mg/kg and a yellow perch from the same location measured 0.601 mg/kg. These reported values and those presented in Table 6-4, excluding mercury, are not considered to pose any health risks to humans or other animals that may consume fish. Fish taken on site are important to the post-cleanup monitoring program; they are analyzed for mercury and the data are presented in Table 6-5.

Due to its known health effects, mercury is the metal of highest concern. Surveillance monitoring data is provided in Table 6-4 for Donahue's Pond, Forge Pond, Swan Pond, and Lower Lake on the Carmans River. Dur-

Table 6-4. Surveillance Monitoring Metals Analysis of Fish from the Peconic River System and Carmans River, Lower Lake.

Location/Species	Barium	Chromium	Copper	Iron	Lead	Manganese	Mercury	Zinc
	mg/kg							
Donahue's Pond								
Brown Bullhead	0.205	< MDL	< MDL	< MDL	< MDL	0.196	0.087	4.76
Brown Bullhead	0.366	< MDL	0.373	10.4	< MDL	0.218	0.057	5.45
Brown Bullhead	0.324	< MDL	0.398	< MDL	< MDL	0.205	0.058	6.69
Brown Bullhead	0.203	< MDL	0.363	< MDL	< MDL	< MDL	0.161	4.77
Brown Bullhead	0.437	< MDL	0.483	7.84	< MDL	0.213	0.074	6.37
Brown Bullhead	0.382	< MDL	0.359	9.02	< MDL	< MDL	0.066	7.93
Brown Bullhead	0.383	< MDL	< MDL	9.35	< MDL	0.206	0.091	6.27
Brown Bullhead	0.453	< MDL	0.342	7.61	< MDL	0.263	0.051	5.76
Brown Bullhead	0.601	< MDL	0.387	< MDL	< MDL	0.262	0.051	5.57
Brown Bullhead	0.285	< MDL	0.5	10.2	< MDL	0.279	0.054	8.36
Bluegill (composite)	0.126	< MDL	< MDL	< MDL	0.183	0.318	0.112	12.2
Bluegill (composite)	< MDL	< MDL	< MDL	< MDL	< MDL	< MDL	0.103	11.3
Bluegill (composite)	0.101	0.432	< MDL	< MDL	< MDL	0.245	0.094	7.46
Bluegill (composite)	0.194	< MDL	< MDL	< MDL	< MDL	0.485	0.062	9.06
Bluegill (composite)	0.455	< MDL	0.47	< MDL	< MDL	1.58	0.07	16.8
Pumpkinseed	NT	NT	NT	NT	NT	NT	0.157	NT
Chain Pickerel	0.102	< MDL	< MDL	< MDL	< MDL	1.06	0.1	6.17
Largemouth Bass	0.136	0.148	0.301	< MDL	< MDL	0.32	0.174	5.29

(continued on next page)

Table 6-4. Surveillance Monitoring Metals Analysis of Fish from the Peconic River System and Carmans River, Lower Lake *(continued).*

Location/Species	Barium	Chromium	Copper	Iron	Lead	Manganese	Mercury	Zinc
	mg/kg							
Forge Pond								
Chain Pickerel	0.112	< MDL	< MDL	< MDL	< MDL	0.239	0.235	5.65
Chain Pickerel	< MDL	< MDL	< MDL	< MDL	< MDL	< MDL	0.289	4.28
Chain Pickerel	< MDL	< MDL	< MDL	< MDL	< MDL	0.215	0.251	7.1
Chain Pickerel	< MDL	< MDL	< MDL	< MDL	< MDL	0.242	0.872	6.33
Largemouth Bass	< MDL	< MDL	< MDL	< MDL	< MDL	< MDL	0.167	4.45
Largemouth Bass	< MDL	< MDL	< MDL	< MDL	< MDL	0.179	0.169	4.15
Largemouth Bass	0.095	< MDL	< MDL	< MDL	< MDL	< MDL	0.121	6.27
Largemouth Bass	0.169	< MDL	< MDL	< MDL	< MDL	< MDL	0.0996	6.84
Largemouth Bass	< MDL	0.346	< MDL	< MDL	< MDL	< MDL	0.0908	9.43
Yellow Perch	< MDL	0.171	< MDL	< MDL	< MDL	0.201	0.0824	6.17
Yellow Perch	< MDL	< MDL	< MDL	< MDL	< MDL	< MDL	0.104	5.84
Brown Bullhead	0.293	< MDL	< MDL	12.1	< MDL	< MDL	0.137	5.29
Bluegill	0.104	< MDL	< MDL	< MDL	< MDL	< MDL	0.212	10.1
Bluegill	< MDL	< MDL	< MDL	< MDL	< MDL	0.203	0.219	7.42
Bluegill	< MDL	< MDL	< MDL	< MDL	< MDL	0.23	0.0567	6.33
Bluegill	0.258	< MDL	< MDL	< MDL	< MDL	0.449	0.109	8.16
Bluegill	0.335	< MDL	< MDL	< MDL	< MDL	0.548	0.0776	9.27
Swan Pond (Peconic River control location)								
Brown Bullhead	0.348	< MDL	0.348	< MDL	< MDL	0.492	< MDL	5.45
Brown Bullhead	0.468	< MDL	0.314	< MDL	< MDL	0.623	< MDL	5.3
Brown Bullhead	0.397	< MDL	0.328	< MDL	< MDL	0.29	< MDL	4.47
Brown Bullhead	0.507	< MDL	0.367	< MDL	< MDL	0.515	< MDL	6.59
Brown Bullhead	0.297	< MDL	< MDL	< MDL	< MDL	0.441	0.016	6.51
Largemouth Bass	< MDL	< MDL	< MDL	< MDL	< MDL	0.314	0.0988	8.49
Largemouth Bass	0.128	< MDL	< MDL	< MDL	< MDL	0.463	0.101	6.1
Largemouth Bass	< MDL	0.207	< MDL	< MDL	< MDL	0.39	0.0601	5.04
Largemouth Bass	< MDL	< MDL	< MDL	< MDL	< MDL	0.4	0.151	5.75
Largemouth Bass	< MDL	< MDL	0.346	< MDL	< MDL	0.325	0.0721	6.56
Yellow Perch	< MDL	< MDL	< MDL	< MDL	< MDL	0.598	0.0221	6.25
Yellow Perch	0.231	< MDL	< MDL	< MDL	< MDL	2.23	0.0531	8.39
Yellow Perch	< MDL	< MDL	< MDL	< MDL	< MDL	0.445	0.0107	6.83
Yellow Perch	< MDL	< MDL	< MDL	< MDL	< MDL	0.751	0.0129	6.27
Yellow Perch	0.124	< MDL	< MDL	< MDL	< MDL	1.31	0.0131	12.5
Yellow Perch	0.236	0.813	0.432	41.8	< MDL	1.47	0.0115	7.52
Lower Lake, Carmans River (control location)								
Koi	< MDL	< MDL	< MDL	< MDL	< MDL	< MDL	0.0652	18.6
Brown Bullhead	0.132	0.149	< MDL	< MDL	< MDL	0.239	0.0722	4.25
Brown Bullhead	0.574	< MDL	0.719	10.5	< MDL	0.205	0.0686	5.28

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Table 6-4. Surveillance Monitoring Metals Analysis of Fish from the Peconic River System and Carmans River, Lower Lake *(concluded).*

Location/Species	Barium	Chromium	Copper	Iron	Lead	Manganese	Mercury	Zinc
	mg/kg							
Brown Bullhead	0.421	0.143	< MDL	< MDL	< MDL	0.177	0.0445	5.8
Brown Bullhead	0.162	0.139	0.35	< MDL	< MDL	0.218	0.0152	8.91
Brown Bullhead	0.13	0.153	< MDL	< MDL	< MDL	< MDL	0.0215	5.36
Brown Bullhead	0.128	< MDL	< MDL	< MDL	< MDL	< MDL	0.0207	4.72
Largemouth Bass	< MDL	< MDL	< MDL	< MDL	< MDL	< MDL	0.136	5.55
Largemouth Bass	< MDL	< MDL	< MDL	< MDL	< MDL	< MDL	0.101	6.21
Largemouth Bass	< MDL	< MDL	0.35	< MDL	< MDL	0.179	0.0478	8.73
Bluegill	0.301	0.223	< MDL	< MDL	< MDL	0.724	0.0966	8.83
Bluegill	< MDL	0.353	< MDL	< MDL	< MDL	0.185	0.0391	7.16
Bluegill	< MDL	< MDL	< MDL	< MDL	< MDL	0.423	0.0433	7.15
Bluegill	0.15	0.148	< MDL	< MDL	< MDL	0.441	0.0548	7.04
Bluegill	< MDL	< MDL	< MDL	< MDL	< MDL	0.197	0.0268	5.93
Bluegill	< MDL	0.154	< MDL	< MDL	< MDL	< MDL	0.0332	5.52

Notes:
See Figure 5-8 for sampling locations.
All fish were analyzed as edible portions (fillets).
MDL = Minimum Detection Limit
NT = Not tested

ing 2011, mercury ranged from 0.051mg/kg in brown bullhead to 0.174 mg/kg in a largemouth bass at Donahue's Pond; from 0.057 mg/kg in a composite bluegill sample to 0.872 mg/kg in a chain pickerel at Forge Pond; from less than the minimum detection level in brown bullhead to 0.151 mg/kg in a largemouth bass at Swan Pond; and from 0.015 mg/kg in brown bullheads to 0.136 mg/kg in a largemouth bass from Lower Lake on the Carmans River.

The post cleanup monitoring data for mercury analysis in fish is presented in Table 6-5 and is shown as a range of results by species and area sampled, to reduce the size of the table. The data is presented graphically in Figure 6-4. Data are typically compared to the EPA mercury water criterion of 0.3 mg/kg. Mercury values in Area A of the Peconic River (area nearest to the STP outfall) ranged from 0.155 mg/kg in brown bullhead to 0.895 mg/kg in chain pickerel, with an overall average for the area being 0.495 mg/kg. At Area C, mercury ranged from 0.129 mg/kg in brown bullhead to 1.52 mg/kg in a largemouth bass and averaged, for all samples from the area, 0.37 mg/kg. Fish taken from Area D near the boundary of the Laboratory had mercury content ranging from 0.094 mg/kg in brown bullhead to 0.962 mg/kg in a large mouth bass, with the average being 0.295 mg/kg. At Shultz Road, mercury content ranged from 0.055 mg/kg in a brown bullhead to 0.416 mg/kg in a chain pickerel and averaged 0.283 mg/kg. Mercury content in fish taken from the Manor Road location ranged from 0.104 mg/kg in brown bullhead to 0.582 mg/kg in a chain pickerel, averaging 0.303 mg/kg. The last location sampled as a part of the Peconic River Cleanup monitoring was Donahue's Pond, where mercury content in fish ranged from 0.051 mg/kg in brown bullhead to 0.174 mg/kg in a largemouth bass, with the average being 0.092 mg/kg. In general and from the data presented, a trend of decreasing mercury content going downstream from BNL's STP is evident. The overall average of mercury content in edible portions of fish collected from the Peconic River system in 2011 was 0.307 mg/kg, which compares closely to the EPA water criterion of

Table 6-5. Mercury Analysis of Fish from the Peconic River System Post Cleanup Monitoring.

Location/Species (number)	Mercury mg/kg Min	Max	Avg
BNL, On Site			
Area A			
Pumpkinseed (6)	0.248	0.871	0.559
Largemouth Bass (3)	0.421	0.43	0.425
Chain Pickerel (4)	0.241	0.895	0.574
Brown Bullhead (5)	0.155	0.676	0.397
Area C			
Bluegill (5)	0.209	0.443	0.297
Pumpkinseed (7)	0.332	0.482	0.399
Largemouth Bass (2)	0.464	1.52	0.992
Chain Pickerel (2)	0.209	0.4	0.305
Brown Bullhead (6)	0.129	0.287	0.212
Area D			
Bluegill (6)	0.18	0.506	0.292
Pumpkinseed (9)	0.215	0.498	0.341
Black Crappie (4)	0.134	0.581	0.257
Largemouth Bass (3)	0.256	0.962	0.661
Chain Pickerel (4)	0.187	0.629	0.344
Brown Bullhead (18)	0.094	0.433	0.208
Schultz Road			
Pumpkinseed (1)	0.163	0.163	0.163
Largemouth Bass (2)	0.372	0.387	0.38
Chain Pickerel (2)	0.305	0.416	0.361
Brown Bullhead (1)	0.055	0.055	0.055
Manor Road			
Chain Pickerel (1)	0.582	0.582	0.582
Brown Bullhead (14)	0.104	0.408	0.283
Donahue's Pond			
Bluegill (5)	0.062	0.112	0.088
Pumpkinseed (1)	0.157	0.157	0.157
Largemouth Bass (2)	0.134	0.174	0.154
Chain Pickerel (1)	0.1	0.1	0.1
Brown Bullhead (10)	0.051	0.161	0.075

Notes:
Area letter designation refers to Peconic River cleanup areas on site.
* = one or more samples in the average were composite samples.
All samples were analyzed as edible portions (fillets), including composite samples.
Full data sets are available in the 2011 Peconic River Monitoring Report.

0.3 mg/kg. A more detailed review of the data is covered in the Annual Report on Peconic River Sampling for 2011 (BNL 2012).

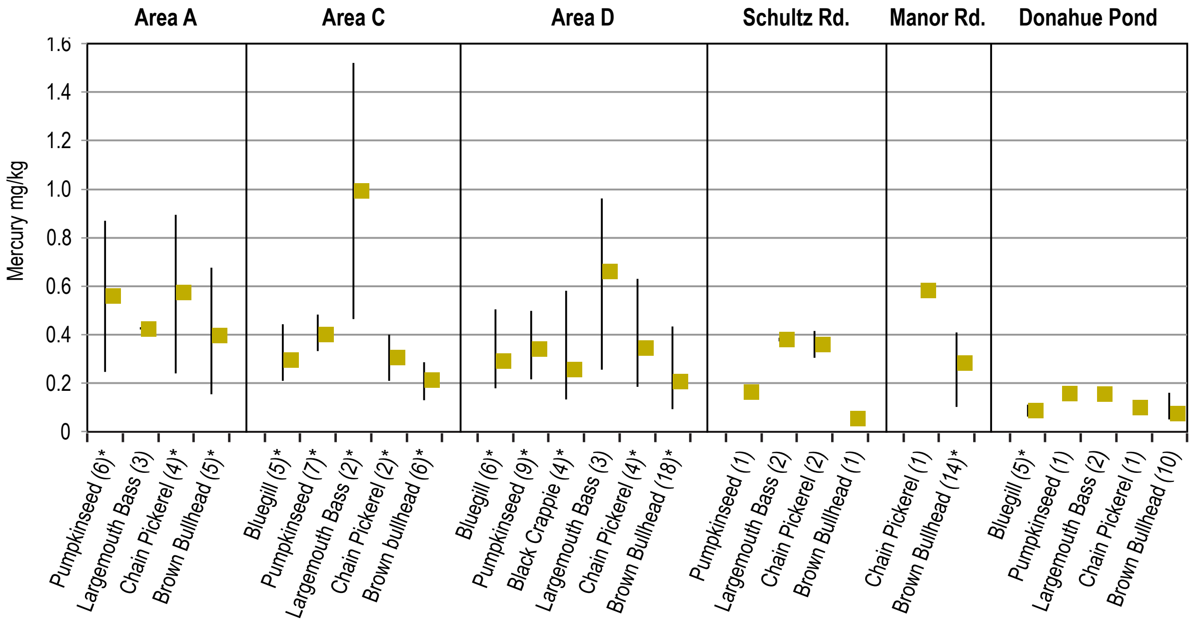
Pesticide analyses in fish were discontinued in 2008, since several years of sampling detected pesticides in only a few fish far off site. PCB analyses in fish was also discontinued from surveillance monitoring, but continued to be completed for fish collected on site. Three composite samples of brown bullhead taken on Site from Area D along North Street contained PCBs. Aroclor 1254 was found in each of the three samples at the following concentrations: 14.3 µg/kg, 18.4 µg/kg, and 22.2 µg/kg, respectively. The fish sample containing 22.2 µg/kg of Aroclor 1254 also contained 10.4 µg/kg of Aroclor 1260. These values are significantly lower than the highest value of 52.4 ug/kg of Aroclor 1254 and 23.3 ug/kg of Aroclor 1260 measured in a chain pickerel from Donahue's Pond during the last year (2008) of routine surveillance monitoring for PCBs. The cleanup of the Peconic River that was completed in 2005 and the supplemental cleanup completed in 2011 removed most PCBs within the sediments. Although BNL has discontinued most pesticide and PCB monitoring, the Laboratory may periodically test for PCBs and pesticides in fish to verify the presence/absence in fish tissue.

6.3.4 Aquatic Sampling

6.3.4.1 Radiological Analysis

Annual sampling of sediment and vegetation in the Peconic River and a control location on the Carmans River was conducted in 2011. (See Chapter 5 for a discussion on water quality and monitoring, and Figure 5-7 for the locations of sampling stations. Additionally, refer to Section 6.3.6 for a discussion of sediment and water analysis related to monitoring post-cleanup of the Peconic River.) Because significant numbers of samples are now taken under this monitoring program, fewer samples are being taken through routine surveillance monitoring to reduce duplication of effort and lessen the impact on the fish populations.

Table 6-6 summarizes the radiological data. Cs-137 was not detected in any on-site aquatic



Notes: Number in parentheses indicate the number of samples included.
* = some samples were composite.

Figure 6-4. Peconic River Post Cleanup Mercury Distribution in Fish Species (Minimum, Maximum, and Average Values).

vegetation samples in 2011 and was detected at levels near the detection level at off-site locations. As in the past, low levels of Cs-137 were detected in sediments at Swan Pond, Forge Pond, and Lower Lake on the Carmans River.

6.3.4.2 Metals in Aquatic Samples

Metals analyses, as shown in Table 6-7, were conducted on aquatic vegetation and sediments from the Peconic River and Lower Lake on the Carmans River. The data indicate metals at background levels. The standard used for comparison of sediments is the SCDHS soil cleanup objectives for heavy metals. 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.

Other metals analyzed for, but not listed in Table 6-7, include antimony, arsenic, beryllium, cadmium, magnesium, potassium, selenium, sodium, and thallium. In general, levels of these metals are either below detection limits, below cleanup objectives, or, like sodium, are common in the environment. Arsenic was detected below the SCDHS cleanup objectives of 7.5 mg/kg in sediments at Donahue's Pond, Swan Pond, Forge Pond, and Lower Lake (1.03, 5.11, 0.36, and 3.38 mg/kg, respectively). Cadmium was found in sediments at Swan Pond (1.06 mg/kg) and at Lower Lake (0.89 mg/kg). Chromium was found above cleanup objectives of 20 mg/kg in sediment at Lower Lake.

6.3.5 Peconic River Post-Cleanup Monitoring

Approximately 20 acres of sediment from the Peconic River were remediated in 2004 and 2005 to remove mercury and associated contaminants from the river. BNL/DOE must ensure that the cleanup provides adequate protection of human health and the environment by monitoring the sediment, surface water, and fish for 5 years (2006–2010). The mercury concentrations from this monitoring identified approximately 0.39 acres in three small areas (the PR-WC-06, PR-SS-15, and sediment trap areas) with mercury concentrations greater than the cleanup goal of 2.0 mg/kg. The three areas were cleaned up between November 2010 and February 2011 (see Section 6.3.5.4).

A summary of the 2011 sediment, surface

Table 6-6. Radiological Analysis of Aquatic Vegetation, Sediment, and Water from the Peconic River System and Carmans River, Lower Lake.

Location/Sample Type	K-40 (pCi/g)	Cs-137 (pCi/g)
BNL, On Site		
Aquatic vegetation	3.52 ± 0.73	ND
Aquatic vegetation	3.13 ± 0.66	ND
Aquatic vegetation	2.44 ± 0.86	ND
Aquatic vegetation	1.11 ± 0.67	ND
Donahue's Pond		
Aquatic vegetation	2.65 ± 0.48	0.04 ± 0.02
Sediment	3.32 ± 0.68	ND
Water	ND	ND
Forge Pond		
Aquatic vegetation	1.24 ± 0.20	0.02 ± 0.01
Sediment *	2.58 ± 0.46	0.12 ± 0.04
Swan Pond (Peconic River control location)		
Aquatic vegetation	1.31 ± 0.18	0.02 ± 0.01
Sediment	2.47 ± 1.66	0.83 ± 0.18
Lower Lake, Carmans River (control location)		
Aquatic vegetation	1.64 ± 0.21	ND
Sediment	1.40 ± 0.83	0.16 ± 0.06

Notes:
Cs-137 = cesium-137
K-40 = potassium-40
ND = not detected based on analytical laboratory qualifiers.
Aquatic vegetation values are reported as dry weight.
Sediment values are reported as dry weight.
* = estimated value for Cs-137 based on analytical laboratory qualifiers.

water, and fish sampling result follows. Detailed information on 2011 sampling results can be found in the Final 2011 Peconic River Monitoring Report (BNL 2012). During the Five-Year Review process in 2011, all data and accomplishments related to the Peconic River cleanup and subsequent monitoring were summarized and reviewed. BNL recommended to the various regulatory agencies that reduced monitoring should take place beginning in 2012 and all future reporting of post-cleanup monitoring results would be within the Site Environmental Reports. The proposed reduced monitoring recommendations are summarized in the sections below.

6.3.5.1 Sediment Sampling

Sediment was sampled in May 2011 at 15 Peconic River routine sampling stations on site and 15 routine sampling stations off site, and at three new locations associated with the supplemental cleanup areas. Thirty-one of the 33 annual sediment samples collected in 2011 met the mercury cleanup goal of 2.0 mg/kg. A sample taken at PR-SS-38 had a value of 2.7 mg/kg and a sample taken at PR-SS-10 had a value of 2.5 mg/kg. During the Five-Year review, a recommendation was made to and approved by the regulators to reduce sampling from 33 sampling locations to just the locations associated with the three supplemental cleanup areas, with results presented in the annual BNL Site Environmental Report.

6.3.5.2 Water Column Sampling

Surface water was analyzed in June and August 2011 for total mercury and methyl mercury at 14 and 13 of the 22 Peconic River sampling stations, respectively. A sample of the treated STP effluent and at one reference station on the Connetquot River was also collected during each round of sampling. Eight stations could not be sampled in June and nine stations could not be sampled in August due to low water table levels. The total mercury concentrations in the June (47 ng/L) and August (53.1 ng/L, maximum) STP effluent samples were the lowest since 2006. The 2011 total mercury concentrations generally trended downwards, with fluctuations at increasing distance downstream from the STP until reaching concentrations of 1.5 ng/L to 3.8 ng/L at sampling stations east of the cranberry bogs.

Methyl mercury was not detected in either the June or July 2011 STP effluent samples. Between the station downstream of the STP and the BNL boundary, the June methyl mercury concentrations fluctuated between 0.11 ng/L and 3.0 ng/L, and the August samples fluctuated between 0.31 ng/L and 0.88 ng/L. The methyl mercury values from downstream of the BNL boundary to the station west of the cranberry bogs fluctuated between 0.66 ng/L and 0.92 ng/L in June and between 0.35 ng/L and 1.2 ng/L in August. Between the station

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

Location/ Sample Type	Aluminum	Barium	Calcium	Chromium	Cobalt	Copper	Iron	Lead	Manganese	Mercury	Nickel	Silver	Vanadium	Zinc
	mg/kg													
BNL, On Site														
Aquatic vegetation	< MDL	3.52	857	0.245	< MDL	1.73	27.1	< MDL	27.2	0.0071	0.194	< MDL	< MDL	5.13
Aquatic vegetation	< MDL	5.9	1220	0.167	< MDL	2.85	34.7	< MDL	38.9	0.0067	0.277	< MDL	< MDL	6.97
Aquatic vegetation	15.4	2.52	1070	0.149	< MDL	2.6	39.3	0.16	17.1	0.0123	0.308	0.163	< MDL	6.95
Aquatic vegetation	13.3	9.8	1730	0.153	< MDL	2.13	42.8	< MDL	31.3	0.0066	0.274	0.338	< MDL	12.6
Donahue's Pond														
Aquatic vegetation	10.8	12.9	929	0.158	0.142	0.575	47	0.15	59.1	< MDL	< MDL	0.098	< MDL	7.93
Sediment	782	17.9	682	2.36	0.815	1.55	1430	14.4	22.8	< MDL	0.799	< MDL	4.91	7.3
Water (µg/L)	73.8	10.4	2740	< MDL	< MDL	< MDL	611	1.34	34.8	< MDL	< MDL	< MDL	< MDL	< MDL
Forge Pond														
Aquatic vegetation	< MDL	16.6	1960	< MDL	< MDL	0.326	32.8	< MDL	16.2	< MDL	< MDL	< MDL	< MDL	3.62
Sediment	2210	14.9	289	2.63	0.4	2.03	1290	9.46	25	< MDL	1.22	< MDL	3.85	9.8
Swan Pond (Peconic River control location)														
Aquatic vegetation	< MDL	5.19	2350	0.15	< MDL	0.583	22.8	< MDL	70.6	< MDL	0.187	< MDL	< MDL	5.2
Sediment	< MDL	68.5	5630	15.1	2.16	12.6	3670	57.5	1950	0.0405	8.24	< MDL	20.4	63.3
Lower Lake, Carmans River (control location)														
Aquatic vegetation	< MDL	54.1	2340	0.161	< MDL	< MDL	52.8	< MDL	104	< MDL	0.161	< MDL	< MDL	3.89
Sediment	3990	157	8250	26.5	5.54	12.1	11300	45.5	1240	0.119	9.25	< MDL	18.5	113
SCDHS														
Action Levels	SNS	4000	N/A	100	N/A	8500	N/A	2000	N/A	3.7	650	50	N/A	N/A
Cleanup Objectives	SNS	820	N/A	20	N/A	1700	N/A	450	N/A	0.7	130	10	N/A	N/A

Notes:
MDL = Method Detection Limit
N/A = not applicable
SCDHS = Suffolk County Department of Health Services
SNS = Standard Not Specified

east of the cranberry bogs and downstream of Connecticut Avenue, the June methyl mercury concentrations fluctuated between 0.41 ng/L and 1.6 ng/L, and the August sample results fluctuated between 0.21ng/L and 0.42 ng/L. The 2011 Five-Year Review recommended reducing water column sampling from 33 sampling locations to 15 locations between Pr-WC-15 and PR-WC-02 and also PR-WCS-04. Water quality parameters taken between mercury and methyl mercury sampling rounds will be eliminated. All reporting will be within the annual BNL Site Environmental Report.

6.3.5.3 Fish Sampling

In 2011, fish were collected from the Peconic River at Area A downstream of the STP, Area C, Area D near North Street, the Schultz Road and Manor Road areas, and Donahue's Pond. Two feeding guilds were represented: bottom feeders (brown bullheads) and top carnivores (largemouth bass and pickerel, supplemented by bluegills and pumpkinseeds). The average mercury concentration for all 124 fish samples (composites and individual fish) was 0.307 mg/kg, which is significantly lower than the average pre-cleanup (1996 and 2001) fish mercury concentration (0.58 mg/kg). The EPA criterion for methyl mercury concentration in fish tissue is 0.3 mg/kg. For PCBs, 14 fish samples were analyzed for 7 PCB isomers, for a total of 98 PCB analyses. PCB analyses results are presented in section 6.3.3.3 above. The average Cs-137 activity for the 87 fish samples analyzed in 2011 was 0.17 pCi/g. The 2011 Five-Year Review recommended that fish sampling be conducted every other year, with the next round of post cleanup fish monitoring being conducted in 2013. All reporting will be within the annual BNL Site Environmental Report.

6.3.5.4 Remedial Actions

BSA/DOE recommended to EPA, NYSDEC, and SCDHS that the sediment trap be removed from the Peconic River as required by a Record of Decision, and that three small sections of the river with elevated sediment mercury concentrations be remediated. The total area of the three areas (PR-WC-06, Sediment Trap, and PR-SS-15) was 0.39 acres. The work was completed between November 2010 and February 2011, with an average post-cleanup mercury concentration of 0.27mg/kg on site and 0.16 mg/kg off site, relative to cleanup goals of 1.0 mg/kg on site and 0.75 mg/kg off site. The cleaned up wetlands were re-planted with native Peconic River plants transplanted from previously remediated sections of the river. The restoration will be tracked until proven to be successful.

6.3.6 Vegetation Sampling

6.3.6.1 Farm and Garden Vegetables

On-site sampling of garden vegetables was conducted in 2011. The data on garden vegetables are presented in Table 6-8. Samples of string beans, zucchini, cucumber, tomato, and corn were analyzed for Cs-137 content. Cs-137 was not detected in any vegetables sampled from the on-site garden, but was detected in soils at a very low level (0.10 pCi/g). This value for Cs-137 in soil is consistent with background levels resulting from worldwide fallout from historic above-ground nuclear testing.

6.3.6.2 Grassy Plants

Grassy vegetation sampling around the Laboratory was conducted in 2011. Vegetation was sampled from 10 locations around the Laboratory (see Figure 6-5), primarily along the firebreaks located on the western portion of the site. All samples were analyzed for Cs-137 content. Data are presented in Table 6-8. The grassy vegetation samples had levels of Cs-137 ranging from non-detectable to 0.49 pCi/g, wet weight, which is consistent with past sampling efforts. Grassy vegetation sampling is utilized for the annual dose to biota analysis reported in Chapter 8.

6.4 OTHER MONITORING

6.4.1 Soil Sampling

Soil sampling was conducted at the same 10 locations where grassy vegetation was sampled in 2011. Soil samples were analyzed for Cs-137 and the data are presented in Table 6-8. Cs-137 content in soils ranged from 0.07 pCi/g to 0.41 pCi/g. These values are consistent with past soil analysis and are indicative of background levels

Table 6-8. Radiological Analysis of Garden Vegetables, Grassy Vegetation, and Associated Soils.

Location/Sample	K-40	Cs-137
	pCi/g	
BNL Garden		
String Beans	4.20 ± 0.36	ND
Zucchini	2.28 ± 0.22	ND
Cucumber	1.69 ± 0.15	ND
Tomato	2.10 ± 0.18	ND
Corn	2.63 ± 0.24	ND
Soil	4.12 ± 0.51	0.10 ± 0.03
BNL Grassy Vegetation and Soils		
Upton Road, North Gate		
Vegetation	6.30 ± 0.81	ND
Soil	6.07 ± 0.64	0.10 ± 0.02
Upton Road, across from Building 1008		
Vegetation	3.89 ± 0.70	ND
Soil	6.45 ± 0.67	0.22 ± 0.03
HT-E Sampling Station		
Vegetation	3.23 ± 0.70	ND
Soil	6.03 ± 0.61	0.14 ± 0.02
Lawn at Nasa Space Radiation Laboratory		
Vegetation	3.26 ± 0.48	ND
Soil	5.49 ± 0.57	0.09 ± 0.02
Weaver Road, at HS Canal		
Vegetation	5.52 ± 0.74	ND
Soil	5.66 ± 0.63	0.07 ± 0.01
Fire Scar Road, South of Princeton Avenue		
Vegetation	5.00 ± 0.62	0.49 ± 0.06
Soil	3.95 ± 0.42	0.17 ± 0.03
HS Basin		
Vegetation	4.79 ± 0.60	ND
Soil	6.09 ± 0.61	ND
650 Sump Area		
Vegetation	3.35 ± 0.63	ND
Soil	6.25 ± 0.68	0.08 ± 0.02
South Treatment Plant Path		
Vegetation	5.83 ± 0.87	0.07 ± 0.03
Soil	3.45 ± 0.39	0.41 ± 0.04
East End, Old Sewage Treatment Plant Beds		
Vegetation	3.70 ± 0.54	0.05 ± 0.02
Soil	4.33 ± 0.48	0.36 ± 0.03

Notes:
Vegetation results are reported as wet weight values.
Soils results are reported as dry weight values.
See Figure 6-5 for sample location.
K-40 = Potassium-40
Cs-137 = Cesium-137

resulting from worldwide fallout from historic above-ground nuclear testing.

6.4.2 Basin Sediments

A 5-year testing cycle for basin sediment samples was established in 2003. Basin sediments were sampled in 2007 and results were presented in the 2007 Site Environmental Report. In 2007, at basins HO and HT-E, initial results of sampling identified several compounds above SCDHS action levels. Suffolk County was notified and a co-sampling event was conducted with BNL and Suffolk County's participation. Both sets of results indicated that no issue existed, suggesting an error in the original sample results. Under the 5-year cycle for basin sediments, the next sampling will occur in 2012.

6.4.3 Chronic Toxicity Tests

Under BNL's SPDES discharge permit, the Laboratory conducted chronic toxicity testing of STP effluents. The results of the chronic toxicity tests are discussed in Chapter 3, Section 3.6.1.1. Testing will continue in 2012.

6.4.4 Radiological and Mercury 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 4-3 for station locations), and additional samples were taken on each rainfall event after the April 2011 tsunami that caused the compromise of the Fukushima Daiichi nuclear power plants. Samples were analyzed for radiological content and total mercury (see Table 6-9). No radionuclides attributable to the power plant failures were detected. A total of six samples were taken from each of these two stations in 2011 and tested for radiological parameters. Gross alpha activity measurements were above the MDL at both P4 and S5 in the first and second quarters of 2011.

Gross beta activity was measured in samples for each of the four quarters at P4 and the first two and last quarters at S5 in 2011. In general, radioactivity in precipitation comes from naturally occurring radionuclides in dust and from activation products that result from solar radiation.

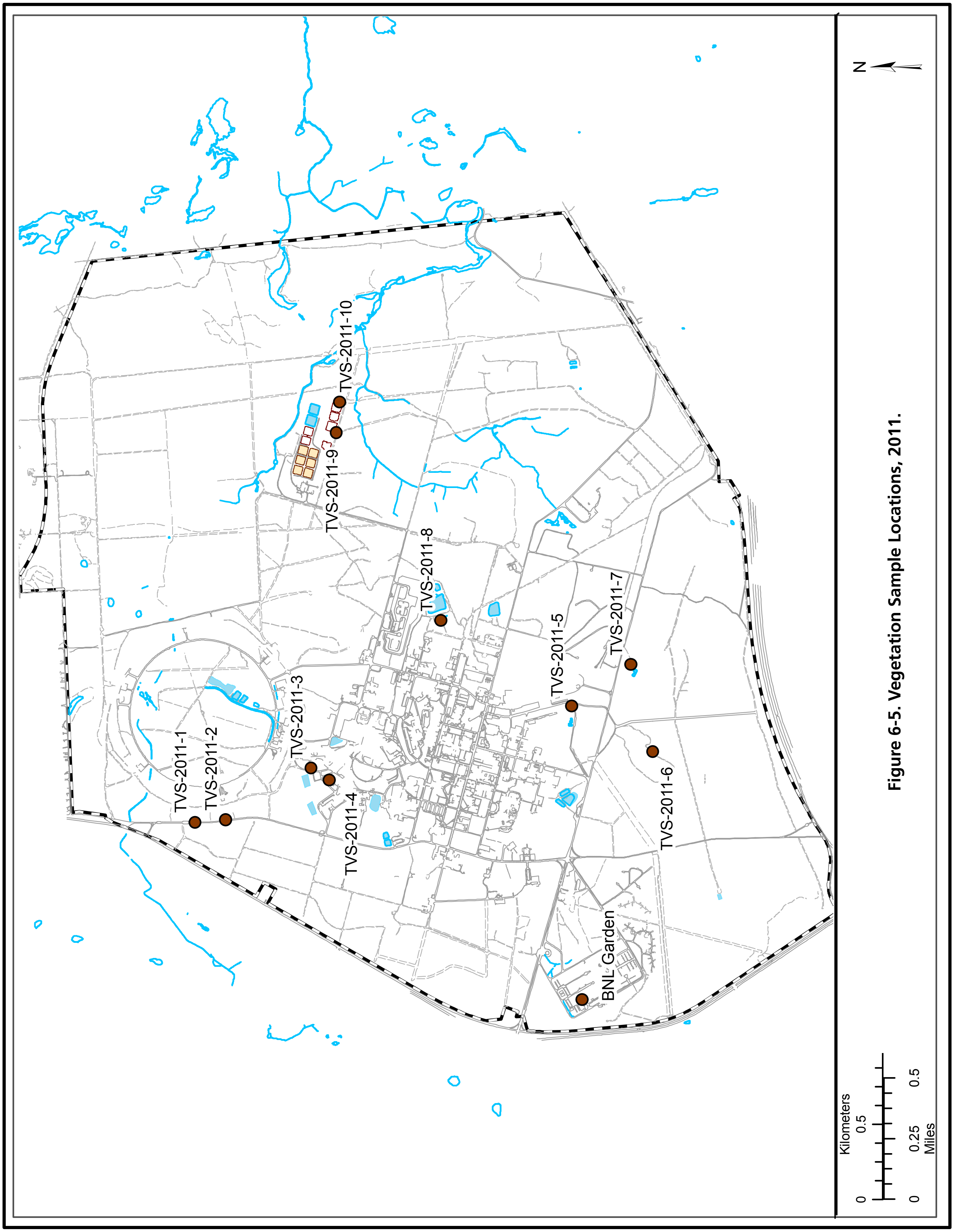


Figure 6-5. Vegetation Sample Locations, 2011.

Location P4 had a maximum gross beta activity level of 5.1 pCi/L. Location S5 had a maximum gross beta activity level of 4.23 pCi/L. Gross beta activity values were within the range of values historically observed at these two locations. Beryllium-7 (Be-7) was not detected at either P4 or S5 in 2011. Sr-90 was measured at 0.36 pCi/L at station S5 during August 2011.

Analysis of mercury in precipitation is completed to document the range of mercury deposition that occurs on site. This information is compared to Peconic River monitoring data and aids in understanding the sources of mercury within the Peconic River. Mercury was detected in 14 precipitation samples and at both sampling stations. Mercury ranged from 2.1 ng/L at station P4 in August to 10.8 ng/L at station S5 in June.

Table 6-9. Precipitation Monitoring (Radiological and Mercury).

Location/ Period	Be-7	Gross Alpha	Gross Beta	Sr-90	Mercury
	pCi/L				ng/L
P4					
01/18/11	–	–	–	–	3.74
01/31/11	ND	1.94 ± 0.79	5.1 ± 1.0	–	–
04/05/11	–	–	–	–	6.01
04/29/11	ND	ND	2.58 ± 0.85	ND	–
05/18/11	–	–	–	–	3.19
05/27/11	ND	1.82 ± 0.77	3.92 ± 0.99	ND	–
06/13/11	–	–	–	–	5.86
06/30/11	ND	ND	3.47 ± 0.91	–	–
07/19/11	–	–	–	–	4.9
08/08/11	–	–	–	–	2.1
08/31/11	ND	ND	ND	ND	–
10/04/11	–	–	–	–	5.86
10/31/11	ND	ND	1.91 ± 0.75	–	–
S5					
01/18/11	–	–	–	–	3.91
01/31/11	ND	3.5 ± 1.0	4.23 ± 0.92	–	–
04/05/11	–	–	–	–	3.83
04/29/11	ND	ND	3.24 ± 0.89	ND	–
05/18/11	–	–	–	–	5.21
05/27/11	ND	0.72 ± 0.53	2.96 ± 0.88	ND	–
06/13/11	–	–	–	–	10.8
06/30/11	ND	ND	ND	–	–
07/19/11	–	–	–	–	8.4
08/08/11	–	–	–	–	2.9
08/31/11	ND	ND	1.75 ± 0.81	0.36 ± 0.19	–
10/04/11	–	–	–	–	7.41
10/31/11	ND	ND	2.04 ± 0.77	–	–

Notes:
– = parameter not tested on date.
Method detection limit for mercury is 0.2 ng/L.
Be-7 = beryllium-7
ND = not detected
P4 = precipitaion sampler near BNL Apartment area.
S5 = precipitation sampler near BNL Sewage Treatment Plant.
Sr-90 = strontium-90

6.5 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 the Laboratory 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 2011, the Environmental Protection Division (EPD) and FERN hosted 26 interns and three faculty members. Interns consisted of two high school students, 19 undergraduate students, and 5 school teachers during the summer. Four of the undergraduate interns worked with a faculty member from Southern University at New Orleans (SUNO) and a faculty member from Dowling College, as part of the Faculty and Student Teams (FaST) Program.

The FaST team worked on soil microbial studies of Pine Barrens soils. Two interns from Southern University at Baton Rouge worked with a visiting professor on banded sunfish genetics, also as part of the FaST program. Undergraduate interns worked on box turtle home range determination and resource use, flying squirrel radio-telemetry surveys and genetics, acoustic surveys of bats, quantification of soil nitrogen using the National Synchrotron Light Source, sustainability of the LISF, and establishing deer exclosures. The high school students worked on static acoustic bat surveys and banded sunfish genetics. Teachers in the DOE Academies Creating Teacher Scientists (ACTS) program worked on various ecological questions of interest for their classroom presentations. A limited discussion concerning each project is presented below and associated papers and posters are available at www.bnl.gov/esd/wildlife/research.asp.

Work associated with the LISF involved tracking six eastern box turtles outfitted with transmitters to determine home range sizes, which will serve as a basis for comparison with additional turtles to be captured within the LISF in 2012 to determine use of the LISF by turtles. The work also looked at the effects of weather on turtle movements and multiple other factors (vegetative cover, roads, food source, and proximity to structures).

Work on soil microbes continued in cooperation with a microbiologist at Dowling College and a faculty and student team from SUNO. Interns from SUNO worked on isolating novel microbes from pine barrens soils, as well as looking at nitrogen compounds in local soils in an attempt to determine why pine barrens soils are lacking in nitrogen. This work resulted in publication of results in the online peer reviewed journal PLoSOne.

Small mammal work continued in 2011 with students using radio-telemetry surveys on southern flying squirrels and additional genetic research on this cryptic species. Radio-telemetry provided an indication of home range based on surveys in both 2010 and 2011 on 15 collared squirrels. The data also improved understanding between family group movements (2010) and multiple collared adults (2011). Both genetic and radio-telemetry studies are expected to continue in 2012.

The FaST group from Southern University at Baton Rouge completed a population survey of banded sunfish in Zeke's Pond located on the BNL site. This was compared to a previous population assessment and indicated a stable population of approximately 6,000 fish. The team, along with a high school intern, also began working on a genetic analysis of banded sunfish on Long Island by isolating and replicating DNA strands for later sequencing. Genetic data is expected to be used, in part, with the development of a recovery plan for this state threatened species.

Work associated with the establishment of three permanent deer exclosures allowed students to look at changes over the past 6 years in forest health. Deer exclosure plots were paired with forest health plots established by FERN in 2005 and 2006. Data from the new exclosures were compared to newly acquired plot data and historic plot data from forest health plots. Comparison indicated subtle variations in understory composition over the 6-year period when the original plots were established.

In early March 2011, an individual bat was found on the ground outside a building at BNL. The bat appeared to have discoloration on the fur around its muzzle, which triggered a call to NYSDEC to report a possible incidence of white-nose syndrome. White-nose syndrome is a recently identified fungal infection impacting bats throughout the northeast and Midwest. The bat turned out to be a northern long-eared bat (*Myotis septentrionalis*) and was the first recorded incidence of white-nose syndrome on Long Island. This event resulted in BNL working with NYSDEC to establish permanent acoustical survey routes on Long Island. Two interns conducted multiple surveys on the routes and analyzed the data for habitat use and species identification. A high school intern used the same acoustic recording technology to record and analyze bat call data at a public park in Nassau County.

Members of EPD and other Laboratory departments volunteered as speakers for schools and civic groups and provided on-site ecology tours. EPD also hosted several environmental events in association with Earth Day. In October, BNL hosted the Sixteenth Annual Pine Barrens Research Forum for ecosystems researchers to share and discuss their results. In addition, BNL and FERN participated in the Third Annual Pine Barrens Discovery Day held on the Suffolk County Community College Campus in Riverhead, New York.

The Laboratory also hosted the annual New York Wildfire & Incident Management Academy, offered by NYSDEC and the Central Pine Barrens Commission. Using the Incident Command System of wildfire management, this academy trains firefighters in the methods of wildland fire suppression, prescribed fire, and fire analysis. BNL has developed and is implementing a Wildland Fire Management Plan. A prescribed fire was successfully implemented during the Academy. Post-fire monitoring on this and previous fires, indicated that prescribed fires have been somewhat effective at opening up the understory to allow forest regeneration. BNL intends to continue the use of prescribed fire for fuel and forest management in the future and is working with NYSDEC to prepare additional prescriptions for a larger portion of the northern and eastern sections of the Laboratory property.

6.6 CULTURAL RESOURCE ACTIVITIES

The BNL Cultural Resource Management (CRM) Program ensures that the Laboratory fully complies with the numerous cultural resource regulations. The Cultural Resource Management Plan for Brookhaven National Laboratory (BNL, 2005) guides the management of all of BNL's historical 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 the Laboratory's cultural resources includes buildings and structures, World War I (WWI) 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 are developed and implemented. Achieving these goals will ensure that the contributions BNL and the site have made to our history and culture are documented and available for interpretation.

The Laboratory has three structures or sites that have been determined to be eligible for listing on the National Register of Historic Places: the Brookhaven Graphite Research Reactor (BGRR) complex, the High Flux Beam Reactor (HFBR) complex, and the WWI training trenches associated with Camp Upton. The trenches are examples of the few surviving WWI earthworks in the United States.

In 2011, documents associated with both the BGRR and HFBR were sent to archives as the clean-up of both facilities was coming to a close. Changes in the final status of the BGRR and HFBR will necessitate minor revision of BNL's Cultural Resource Management Plan in 2012. In addition, a loan request from the Long Island Museum located in Stony Brook, New York, came in late in 2011 looking for materials for display focused on Long Island in the 1950s. BNL will begin reviewing the request for processing early in 2012.

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