6 Natural and Cultural Resources

The Brookhaven National Laboratory Natural Resource Management Program is designed to protect and manage flora and fauna and the ecosystems in which they exist. The Laboratory's natural resource management strategy is based on 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 2010, 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 prepared a Natural Resource Management Plan (NRMP) (BNL 2003a). This plan describes the program strategy, elements, and planned activities for managing the various resources found on site.

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 of 1969 for construction of the Long Island Solar Farm (LISF) on site. This project encompasses an area of approximately 200 acres and will be 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 further updated with the expected footprint of the LISF during 2010 to meet requirements of the easement agreement between DOE and BP Solar. Construction of the LISF began in late October 2010. The GIS layers are routinely updated through surveys, observa-

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

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

tions, and research to ensure accuracy of the layers.

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. Six New York State threatened species have been positively identified on site and three other species are considered likely to be present. The banded sunfish (*Enneacanthus obesus*), the swamp darter fish (*Etheostoma fusiforme*), the stiff goldenrod plant (*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*) 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 ponds on site. The frosted elfin butterfly (*Callophrys irus*) has been identified as possibly being at BNL, based on historic documentation and the presence of its preferred habitat and host plant (wild lupine). 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 on-site habitats and natural resources. Activities to eliminate or minimize negative effects on sensitive or critical species are either incorpo-

rated 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 4 of 26 ponds were conducted in 2010. The monitoring procedure calls for all ponds that had egg masses during the spring surveys to be surveyed again in June and July to check for the presence of larval salamanders. A PhD candidate and student interns have conducted surveys of tiger salamander ponds, drift fence surveys, and radio telemetry tracking around four ponds on site. The results of these studies have shown the extent of egg mass production, the importance of precipitation as a trigger for metamorphic salamanders leaving ponds, and the extent of movements by both adults and metamorphic tiger salamanders. Work toward a comprehensive understanding of eastern tiger salamander movements and habitat requirements began in 2004, with funding provided to SUNY Binghamton by NYSDEC. Continued research adds to the understanding of the needs of this state-endangered species. Information acquired from all research is entered into a database, and portions of the data are linked to a GIS. These data are used to visualize distributions, track reproductive success, and identify areas for focused management or study.

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 allow it to retain water for longer periods of time, supporting larval development.

6.1.2.2 Other Species

As part of the eastern tiger salamander and herpetological surveys, information is being gathered on other species found on site. Including the tiger salamander, sightings of 26 species of reptiles and amphibians have been recorded over the past several years. 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 (*Rana sylvatica*), gray tree frog (*Hyla versicolor*), bullfrog (*Rana catesbiana*), green frog (*Rana clamitans*), pickerel frog (*Rana palustris*), Fowler's toad (*Bufo woodhousei fowleri*), eastern spadefoot toad (*Scaphiopus holbrooki*), snapping turtle (*Chelydra*

serpentine), painted turtle (*Chrysemys p. picta*), musk turtle (*Sternotherus odoratus*), spotted turtle (*Clemmys guttata*), eastern box turtle (*Terrapene c. carolina*), northern black racer (*Coluber constrictor*), eastern ribbon snake (*Thamnophis s. sauritus*), eastern garter snake (*Thamnophis s. sirtalis*), northern water snake (*Nerodia s. sipedon*), northern ring-necked snake (*Diadophis puctatus edwardsi*), brown snake (*Storeria d. dekayi*), 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 2007, with a population of approximately 4,000 fish. An updated survey is planned for summer 2011 to determine the status and abundance of the banded sunfish.

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 (a new route was established in 2010 in the vicinity of the LISF) in various habitats on site. In 2010, monthly surveys were conducted starting at the end of April and extending through the end of September. These surveys identified 70 songbird species, comparable to the 71 species in 2009 and 70 species during 2008. A total of 114 songbird 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 and the Peconic River. The four transects passing through the various forest types (white pine, moist pine barrens, and dry pine barrens) showed a less diverse bird community. Data are stored in an electronic database that is linked to the Laboratory's GIS.

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.

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.

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 for the Laboratory. In 2007, under a permit from the U.S. Fish & Wildlife Service (FWS), the Laboratory began managing the resident goose population. In the first year, the goose population was estimated at approximately 120 birds and nests were only managed if they posed a health or safety issue;

eggs were oiled-treated in 10 nests, or the nests were removed. At the end of the 2007 nesting season, the goose population reached an estimated 157 birds. Therefore, in 2008, nest management became more aggressive and eggs in 30 nests that were found were treated to prevent development. Even with a more assertive approach to nest management, 15 goslings were hatched and survived. However, with attrition and mortality associated with off-site hunting, the resident population was estimated at 148 birds at the end of 2008. In 2009, the goose population was estimated at 120 birds prior to treating 30 nests. By the end of 2009, the local resident goose population was estimated at 105 birds. Again, in 2010, approximately 30 nests were treated, and 15 goslings produced from untreated nests. However, due to attrition and local off-site hunting, the population had declined to approximately 85 birds by the end of the year.

In 2010, the Laboratory removed the fan house associated with the Brookhaven Graphite Research Reactor (BGRR). This project lasted through the summer. Due to the open nature of the building, two or three pairs of barn swallows (*Hirundo rustica*) established nests within the structure at about the time the last walls and supports were to be demolished. The project was halted in order to consult with FWS and the United States Department of Agriculture–Wildlife Services (USDA-WS). The verbal consultation process resulted in the authorization to go forward with the demolition due to worker and environmental safety issues (i.e., potential collapse of the structure and contamination). The structure was removed without further incident.

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. Biologists from NYSDEC, USDA-WS, and the Wild Turkey Federation banded six turkeys on site prior to the second-year hunt in 2010. Hunting is not currently allowed at the Laboratory. However, turkeys do not limit their movements to BNL and often move great distances. Banding turkeys taken in the hunt provided valuable information on patterns of movement. 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.

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 BNL property, under normal circumstances. This was the approximate density in 1966, when the Laboratory reported an estimate of 267 deer on site (Dwyer 1966). The 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 estimate of 800 deer in 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.

To gain additional information on deer popu-

lations, 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. Deer surveys will likely not be conducted until spring 2012, as the construction of the LISF will conclude by November 2011. Using the current population estimate of 310 animals, the density is approximately 38 animals per square mile.

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 2010, there was only one deer-related collision on site, compared to 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 the National environmental Policy Act (NEPA). The EA process 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 fall of 2011.

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 2010, BNL completed an EA for the proposed LISF and began planning for an EA for 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, 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 Agree-

ment (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 the monitoring 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. Further information on the forest health initiative, as well as other activities of FERN, is available on the FERN website at www.fern-li.org. In 2008, FERN finalized protocols for monitoring wetland health throughout the Pine Barrens. These protocols, when implemented, will provide baseline information on the current health of the wetlands found within the Central Pine Barrens. Implementation is dependent on finding sufficient funding.

Research supported by FERN in 2010 included continued investigation into the microbial world of soils located within the pine barrens and experimental areas at BNL. 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, who have submitted their results for publication. In 2010, the research team completed genetic analysis of the microbes to further refine the microbial community structure. Additional work funded by FERN included an aquatic invertebrate survey of the Carmans River and the development of a DVD documenting the various sampling protocols used within the Open Space Stewardship Program (OSSP) sponsored by the Office of Education at BNL. Information on these projects is provided in Section 6.5.

6.3 MONITORING FLORA AND FAUNA

The Laboratory routinely monitors flora and fauna to determine the effects of past and present Laboratory activities. 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 one-third 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 2010, as in recent years, an on- and off-site deer-sampling program was conducted with the

NYSDEC Wildlife Branch. While most off-site samples are from road-killed deer near the Laboratory, NYSDEC occasionally provides samples from hunters beyond BNL boundaries, yielding control data on deer living 1 mile or more from BNL. In addition, Laboratory employees occasionally inform Laboratory staff of deer that have died in various areas of Long Island. In all, one deer was obtained on site and 11 were from off-site locations, ranging from adjacent to BNL along the William Floyd Parkway, to approximately 10 miles away (Westhampton, New York).

BNL sampling technicians collect the samples and process them for analysis. Samples of meat, 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 at BNL has occurred under the Laboratory's Environmental Restoration (ER) Project. 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 significant 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 2009 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 2006. 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 are greatest.

In 2010, Cs-137 concentrations in deer muscle ("meat") samples were obtained from a single deer taken at BNL with a value of 0.31 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 single on-site sample (0.31 pCi/g wet weight) was 9.6 times lower than the highest level reported in 2009 (2.97 pCi/g wet weight), and is significantly lower than the highest level ever reported (11.74 pCi/g wet weight, in 1996). The 0.31 pCi/g wet weight is also lower than the arithmetic average in 2009, 0.80 pCi/g wet weight.

Cs-137 concentrations in off-site deer meat samples were separated into two groups: samples taken within 1 mile of BNL (nine samples)

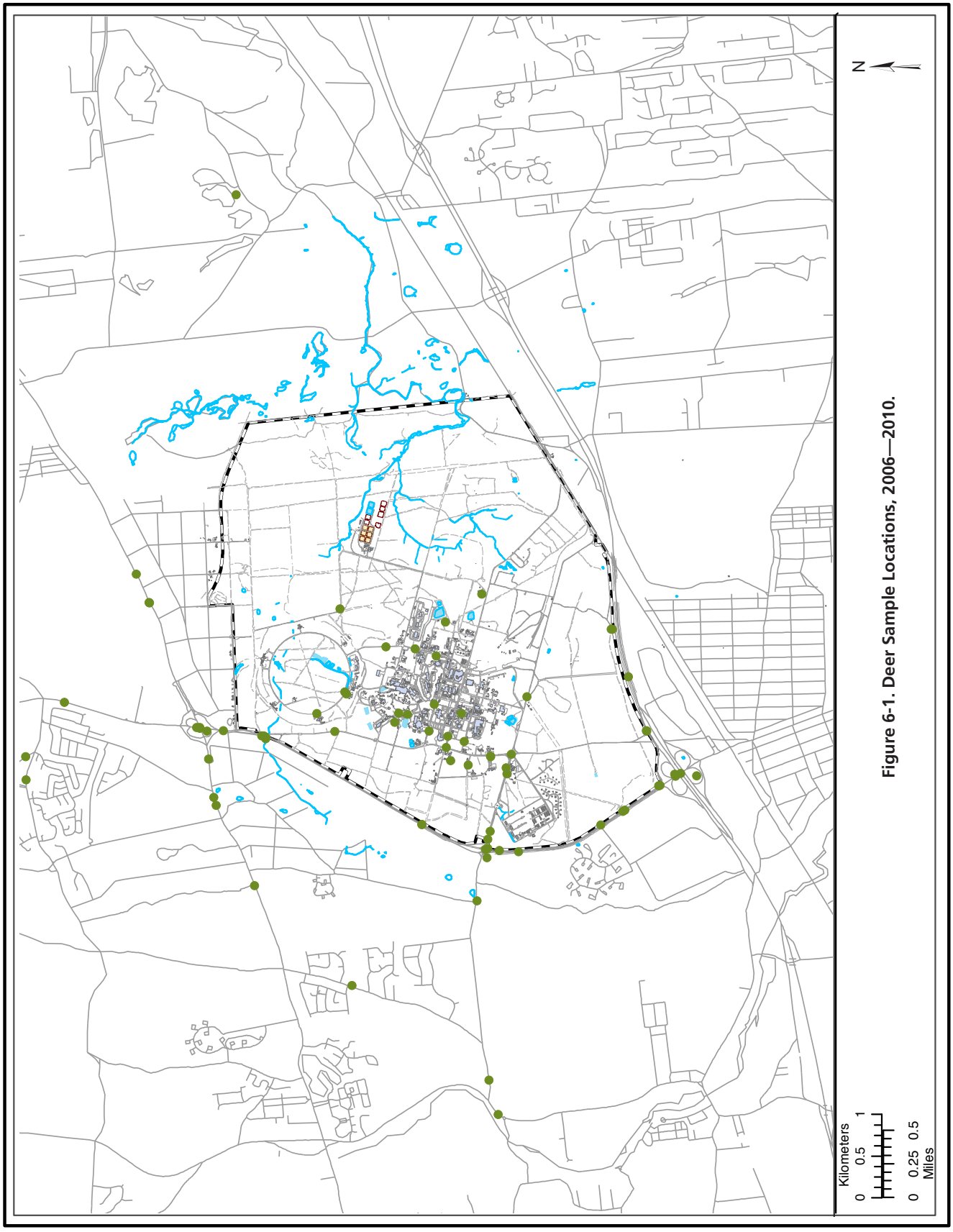


Figure 6-1. Deer Sample Locations, 2006—2010.

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					
Renaissance Rd., N of East 5th	10/16/2010	flesh	3.69 ± 0.42	0.31 ± 0.04	
		liver*	2.08 ± 0.39	0.06 ± 0.03	
		bone			1.76 ± 0.39
Offsite < 1 mile					
Rte. 25 and William Floyd Parkway	10/19/2010	flesh	3.47 ± 0.43	3.38 ± 0.28	
		bone			2.7 ± 0.35
Rte. 25 and William Floyd Parkway (2)	10/19/2010	flesh	3.23 ± 0.39	0.94 ± 0.09	
		liver	2.39 ± 0.31	0.32 ± 0.04	
		bone			1.51 ± 0.30
Longwood Rd. and Smith Rd.	11/3/2010	flesh	3.23 ± 0.38	0.45 ± 0.05	
		liver	2.62 ± 0.34	0.21 ± 0.03	
		bone			1.45 ± 0.28
William Floyd Parkway and BNL North Gate	11/4/2010	flesh	3.3 ± 0.41	0.97 ± 0.09	
		liver	2.29 ± 0.31	0.35 ± 0.04	
		bone			1.55 ± 0.33
William Floyd Parkway and BNL Main Gate	11/16/2010	flesh	3.31 ± 0.39	1.82 ± 0.17	
		bone			1.97 ± 0.35
Offsite > 1 mile					
Wiskey Rd. at Leisure Village	07/1/2010	flesh*	3.68 ± 0.45	0.03 ± 0.01	
		bone			2.64 ± 0.36
Rte. 25 at Calverton Cemetary	10/18/2010	flesh	3.02 ± 0.38	0.83 ± 0.08	
		liver	2.59 ± 0.35	0.42 ± 0.04	
		bone			2.25 ± 0.43
Fresh Pond Rd., 100 yds. S of Sound Ave.	10/19/2010	flesh*	3.65 ± 0.45	0.03 ± 0.01	
		liver*	2.38 ± 0.33	0.01 ± 0.01	
		bone**			0.87 ± 0.26
Fresh Pond Rd., 100 yds. S of Sound Ave. (2)	10/19/2010	flesh*	2.96 ± 0.39	0.02 ± 0.01	
		liver	2.8 ± 0.36	ND	
		bone**			0.79 ± 0.21
Randall Rd., 100 ft. N of Wiskey Rd.	10/21/2010	flesh	3.40 ± 0.42	1.02 ± 0.09	
		liver	2.27 ± 0.32	0.64 ± 0.07	
		bone			1.31 ± 0.26
Tanner Neck, Westhampton, NY	10/26/2010	flesh*	2.97 ± 0.39	0.04 ± 0.01	
		liver*	3.10 ± 0.40	0.02 ± 0.01	
		bone			ND
Averages by Tissue					
Flesh					
All Samples (12)			3.33 ± 1.41	0.82 ± 0.37	
BNL Average (1)			3.69 ± 0.42	0.31 ± 0.04	
< 1 Mile Average (5)			3.31 ± 0.89	1.51 ± 0.35	
BNL + < 1 Mile Average (6)			3.37 ± 0.99	1.31 ± 0.35	

(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)
> 1 Mile Average (6)			3.28 ± 1.01	0.33 ± 0.12	
All Off Site Ssamples Average (11)			3.29 ± 1.35	0.87 ± 0.37	
Liver					
All Samples (9)			2.50 ± 1.03	0.23 ± 0.11	
BNL Average (1)			2.08 ± 0.39	0.06 ± 0.03	
< 1 Mile Average (3)			2.43 ± 0.55	0.29 ± 0.06	
BNL + < 1 Mile Average (4)			2.35 ± 0.68	0.24 ± 0.07	
> 1 Mile Average (5)			2.63 ± 0.78	0.22 ± 0.08	
All Off Site Samples Average (8)			2.56 ± 0.96	0.25 ± 0.10	
Bone					
All Samples (12)					1.58 ± 1.10
BNL Average (1)					1.76 ± 0.39
< 1 Mile Average (5)					1.84 ± 0.72
BNL + < 1 Mile Average (6)					1.82 ± 0.82
> 1 Mile Average (6)					1.33 ± 0.74
All Off Site Samples Average (11)					1.56 ± 1.03

Notes:
All values are shown with a 95% confidence interval.
K-40 occurs naturally in the environment and is presented as a comparison to Cs-137.
All averages are the arithmetic average.
Confidence limits are 2σ (95%) propogated error.

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

and samples taken farther away (five samples) as shown in Table 6-2. Concentrations in meat samples taken within 1 mile ranged from 0.45 to 3.38 pCi/g wet weight, with an arithmetic average of 1.51 pCi/g wet weight; concentrations in meat taken from greater than 1 mile ranged from non-detectable to 1.02 pCi/g wet weight, with an arithmetic average of 0.33 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 2010, this was 1.31 pCi/g wet weight.

Figure 6-2 compares the average values of Cs-137 concentrations in meat samples collected in 2010 from four different location groupings. Although the figure does not show this, 75 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. Similar in number to the samples taken in 2007, samples from 2010 also indicate a similar range of error. While the average is slightly higher than the 2009 average, it continues to indicate the effectiveness of cleanup actions across the Laboratory; approximately 0.4 pCi lower average than in 2001. 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 2010 (see Table 6-2). Deer sampled from October to December typically have higher Cs-137 values than those 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, 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 three highest values seen in deer in 2010 (0.97, 1.82, and 3.38 pCi/g wet weight) from samples taken in October through November. By January or February, the Cs-137 in their tissues has been eliminated through biological processes. The levels of Cs-137 in deer tissue during June through early August are not well known, as there are few vehicle–deer accidents at this time of year.

When possible, liver samples are taken concurrently with meat samples. Liver generally accumulates Cs-137 at a lower rate than muscle tissue. 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 2010, Cs-137 concentration was estimated at 0.06 pCi/g wet weight in the single sample taken. The off-site Cs-137 concentration in liver ranged from nondetectable to 0.64 pCi/g wet weight, with an arithmetic average for all off-site liver samples of 0.25 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).

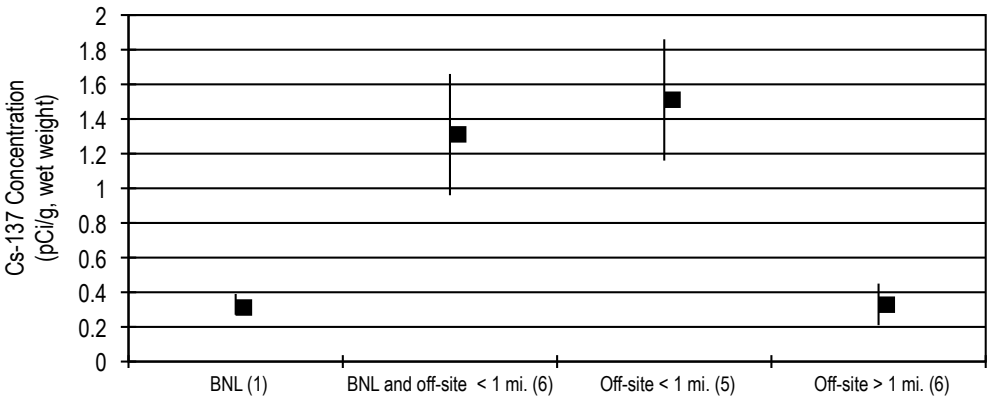
With respect to the health of on-site deer based on their exposure to radionuclides, the International Atomic Energy Agency (IAEA) has concluded that chronic dose rates of 100 millirad per day to even the most radiosensitive species in terrestrial ecosystems are unlikely to cause detrimental effects 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 2010, Sr-90 content was detected at 1.76 pCi/g dry weight in the single on-site sample. Sr-90 in off-site samples ranged from 1.45 to 2.7 pCi/g dry weight in samples taken within 1 mile of BNL, and nondetectable to 2.64 pCi/g dry weight in samples taken more than a mile from BNL. This overlap in values between all samples suggests that Sr-90 is present in the environment at background levels, probably as a result of worldwide fallout from 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.

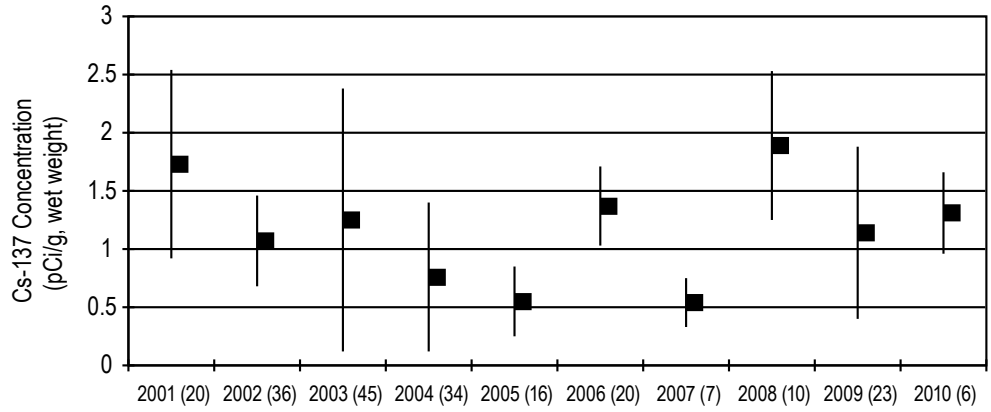
6.3.2 Other Animals Sampled

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 2010, as in 2009, there were no



Notes: Averages are shown for samples collected at BNL, on site and off site within 1 mile, off site but within 1 mile of the boundary, and off site greater than 1 mile from 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, 2010.



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.

samples taken from geese or turkeys. Data taken over the past several years indicate that both species do not readily uptake radionuclides from their diet.

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 2010 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 2010 by the Laboratory, NYSDEC, and through contract labor included brown bullhead (*Ictalurus nebulosus*), chain pickerel (*Esox niger*), largemouth bass (*Micropterus salmoides*), bluegill (*Lepomis macrochirus*), pumpkinseed (*Lepomis gibbosus*), brown trout (*Salmo trutta*), and yellow perch (*Perca flavescens*). 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. Information on the natural radioisotope K-40 is included as a comparison.

Cs-137 was detected at low levels in all but 13 samples from the Peconic River system. The samples with non-detectable amounts were in composite samples of bluegill and pumpkinseed, and larger samples of largemouth bass, yellow perch, chain pickerel, and brown bullhead taken mostly from Swan Pond and Forge Pond. Detectable levels in fish ranged from 0.01 pCi/g wet weight in a chain pickerel from Forge Pond to 0.32 pCi/g wet weight in brown bullhead from the BNL site. This is compared to the highest value of 0.51 pCi/g wet weight in a composite sample of largemouth bass taken from Area C on site in 2009. In 2010, fish taken from Lower Lake on the Carmans River (the non-Peconic control location) had only one measurable value of Cs-137 in a largemouth bass, which was 0.06 pCi/g wet weight.

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 0.32 pCi/g wet weight. Largemouth bass from the Peconic River showed Cs-137 levels of 0.16 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 2010 (see Figure 5-4 for a trend of Cs-137 discharges). 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 will be tracked and modifications to future sampling events will be made, as necessary, to ensure long-term health of the on-site fish populations. Successful sampling of sufficiently large fish for analysis in 2008 through 2010 indicated that populations are maintaining

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

Location/Species	K-40 (pCi/g)	Cs-137 (pCi/g)
BNL, On Site		
Area A		
Bluegill	NR	0.13 ± 0.05
Pumpkinseed	NR	0.24 ± 0.09
Pumpkinseed	NR	0.24 ± 0.05
Pumpkinseed	NR	0.22 ± 0.07
Chain Pickerel	NR	0.17 ± 0.06
Chain Pickerel	NR	0.12 ± 0.07
Brown Bullhead	NR	0.25 ± 0.07
Brown Bullhead (composite)	NR	0.24 ± 0.06
Brown Bullhead (composite)	NR	0.20 ± 0.04
Area C		
Brown Bullhead	NR	0.22 ± 0.07
Brown Bullhead	NR	0.32 ± 0.08
Brown Bullhead	NR	0.18 ± 0.07
Area D		
Bluegill (composite)	NR	0.09 ± 0.04
Pumpkinseed (composite)	NR	0.09 ± 0.04
Largemouth Bass	NR	0.16 ± 0.05
Largemouth Bass	NR	0.13 ± 0.08
Brown Bullhead	NR	0.20 ± 0.05
Brown Bullhead	NR	0.18 ± 0.06
Brown Bullhead	NR	0.07 ± 0.06
Brown Bullhead	NR	0.15 ± 0.05
Brown Bullhead	NR	0.22 ± 0.07
Brown Bullhead	NR	0.12 ± 0.04
Brown Bullhead	NR	0.08 ± 0.05
Brown Bullhead (composite)	NR	0.13 ± 0.05
Brown Bullhead (composite)	NR	0.13 ± 0.04
Schultz Road		
Brown Bullead (composite)	NR	0.11 ± 0.04
Manor Road		
Brown Bullhead	NR	0.14 ± 0.06

(continued)

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

Location/Species	K-40 (pCi/g)	Cs-137 (pCi/g)
Brown Bullhead	NR	0.08 ± 0.05
Brown Bullhead	NR	0.10 ± 0.05
Brown Bullhead	NR	0.12 ± 0.06
Brown Bullhead (composite)	NR	0.11 ± 0.05
Brown Bullhead (composite)	NR	0.08 ± 0.07
Brown Bullhead (composite)	NR	0.03 ± 0.04
Brown Bullhead (composite)	NR	0.12 ± 0.05
Brown Bullhead (composite)	NR	0.07 ± 0.05
Donahue's Pond		
Bluegill	2.74 ± 0.69	0.1 ± 0.04
Bluegill	3.23 ± 0.88	0.05 ± 0.04
Bluegill	2.65 ± 0.66	0.05 ± 0.03
Bluegill	3.43 ± 1.04	0.05 ± 0.04
Bluegill	2.99 ± 0.76	0.02 ± 0.02
Bluegill	2.62 ± 0.82	0.12 ± 0.05
Bluegill	2.78 ± 0.72	0.08 ± 0.05
Bluegill	2.1 ± 0.72	0.06 ± 0.04
Pumpkinseed	3.08 ± 0.66	0.04 ± 0.03
Pumpkinseed	3.46 ± 1.07	0.09 ± 0.04
Pumpkinseed (composite)	2.86 ± 0.84	0.05 ± 0.04
Pumpkinseed (composite)	2.27 ± 0.71	0.03 ± 0.03
Pumpkinseed (composite)	2.68 ± 0.72	0.08 ± 0.05
Pumpkinseed (composite)	3.4 ± 1.14	0.06 ± 0.05
Largemouth Bass	3.83 ± 0.84	0.04 ± 0.03
Largemouth Bass	3.33 ± 0.73	0.13 ± 0.05
Largemouth Bass	2.89 ± 0.76	0.11 ± 0.04
Chain Pickerel	3.71 ± 0.71	0.1 ± 0.04
Brown Bullhead	3.56 ± 0.85	0.06 ± 0.04
Brown Bullhead	4.29 ± 0.76	0.05 ± 0.04
Brown Bullhead	3.96 ± 0.76	0.06 ± 0.04
Brown Bullhead	3.49 ± 0.7	0.06 ± 0.03
Brown Bullhead	4.1 ± 0.71	0.08 ± 0.03
Brown Bullhead	3.79 ± 0.74	0.1 ± 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 (pCi/g)	Cs-137 (pCi/g)
Brown Bullhead	3.91 ± 0.69	0.06 ± 0.03
Brown Bullhead	3.35 ± 0.79	0.08 ± 0.04
Brown Bullhead	4.18 ± 0.71	0.07 ± 0.05
Brown Bullhead	4.89 ± 0.74	0.07 ± 0.04
Forge Pond		
Bluegill (composite)*	3.31 ± 0.69	0.05 ± 0.04
Bluegill (composite)*	3.45 ± 0.76	0.10 ± 0.04
Pumpkinseed (composite)*	2.26 ± 0.76	0.06 ± 0.04
Pumpkinseed (composite)	2.31 ± 0.60	ND
Largemouth Bass*	3.43 ± 0.7	0.11 ± 0.03
Largemouth Bass*	3.07 ± 0.93	0.07 ± 0.05
Largemouth Bass*	2.69 ± 1.11	0.06 ± 0.06
Largemouth Bass*	2.91 ± 0.81	0.09 ± 0.04
Largemouth Bass*	2.89 ± 0.78	0.09 ± 0.04
Yellow Perch*	2.65 ± 0.81	0.09 ± 0.06
Yellow Perch*	3.73 ± 0.87	0.09 ± 0.05
Yellow Perch*	3.25 ± 0.8	0.10 ± 0.05
Yellow Perch*	3.51 ± 0.76	0.15 ± 0.05
Chain Pickerel*	3.55 ± 0.77	0.01 ± 0.04
Brown Bullhead*	3.82 ± 0.68	0.07 ± 0.04
Swan Pond (Peconic River control location)		
Bluegill (composite)*	2.60 ± 0.61	0.05 ± 0.04
Bluegill (composite)	2.75 ± 0.74	ND
Bluegill (composite)	2.72 ± 1.03	ND
Pumpkinseed (composite)	2.89 ± 0.87	ND
Pumpkinseed (composite)	3.33 ± 0.71	ND
Pumpkinseed (composite)	2.95 ± 0.74	ND
Pumpkinseed (composite)*	2.74 ± 0.60	0.06 ± 0.03
Largemouth Bass*	2.81 ± 0.71	0.07 ± 0.04
Largemouth Bass*	3.06 ± 0.78	0.09 ± 0.04
Largemouth Bass*	3.57 ± 0.87	0.06 ± 0.05
Largemouth Bass	2.97 ± 0.80	ND
Yellow Perch*	2.86 ± 1.02	0.12 ± 0.06
Yellow Perch	3.67 ± 0.96	ND
Yellow Perch*	3.28 ± 0.88	0.11 ± 0.05
Yellow Perch*	3.52 ± 1.06	0.10 ± 0.06
Yellow Perch	1.94 ± 0.56	ND
Chain Pickerel	3.08 ± 1.09	ND
Brown Bullhead	3.93 ± 0.78	0.23 ± 0.05
Brown Bullhead*	3.41 ± 0.68	0.04 ± 0.03
Brown Bullhead*	3.65 ± 0.59	0.06 ± 0.03
Brown Bullhead*	3.85 ± 0.86	0.09 ± 0.04
Brown Bullhead	3.28 ± 0.70	ND
Brown Bullhead	2.86 ± 0.89	ND
Brown Bullhead	4.02 ± 0.76	ND
Brown Bullhead*	3.24 ± 0.75	0.06 ± 0.03
Lower Lake, Carmans River		
Largemouth Bass	3.57 ± 0.67	ND
Largemouth Bass*	3.74 ± 0.62	0.06 ± 0.03
Largemouth Bass	3.58 ± 0.61	ND
Largemouth Bass	3.60 ± 0.68	ND
Largemouth Bass	3.57 ± 0.82	ND
Brown Trout	3.74 ± 0.74	ND
Brown Trout	4.04 ± 0.73	ND
Brown Trout	3.79 ± 0.70	ND
Brown Trout (composite)	3.25 ± 0.74	ND
Brown Trout (composite)	3.65 ± 0.75	ND
Brown Bullhead	3.69 ± 0.71	ND
Brown Bullhead	2.81 ± 0.59	ND
Brown Bullhead	3.93 ± 0.66	ND
Brown Bullhead	3.79 ± 0.70	ND
Brown Bullhead	3.94 ± 0.70	ND

(continued)

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

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.

themselves and can support annual sampling.

6.3.3.3 Nonradiological Analysis of Fish

In 1997, under BNL's Environmental Restoration Program Operable Unit (OU) V Remediation Project, fish from the Peconic River on site were analyzed for metals, pesticides, and PCBs. From 2002 through 2006, analysis was limited to off-site fish. The timing of sampling has varied from year to year, as well as the sample preparation (whole-body, tissue separation, composite sampling). In 1997, sampling was performed during April through May; in 1999, sampling was performed during September through December. From 2000 through 2006, sampling was performed from July through August. Additionally, there has been a wide variation in fish size; therefore, samples have had to be composite whole-body to obtain significant mass for analysis. These variables make the comparisons from year to year difficult, as there can be significant seasonal variations in feeding, energy consumption, and incorporation of nutrients into various tissues. Beginning in 2005, all fish of sufficient size were analyzed as edible portions (fillets). Smaller fish, such as golden shiners, were 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 2010 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 arsenic, beryllium, cadmium, cobalt, silver,

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								
Bluegill	< MDL	< MDL	< MDL	< MDL	< MDL	< MDL	0.188	12
Bluegill	0.445	< MDL	< MDL	< MDL	< MDL	1.07	0.149	8.95
Bluegill	0.705	< MDL	< MDL	< MDL	< MDL	1.51	0.192	15.1
Pumpkinseed (composite)	0.143	< MDL	< MDL	< MDL	0.115	0.209	0.129	9.11
Pumpkinseed (composite)	0.186	< MDL	< MDL	< MDL	< MDL	< MDL	0.163	8.17
Pumpkinseed (composite)	0.522	< MDL	< MDL	< MDL	< MDL	0.545	0.064	10
Pumpkinseed (composite)	0.81	0.205	< MDL	< MDL	< MDL	0.976	0.17	13.8
Largemouth Bass	< MDL	< MDL	0.442	< MDL	< MDL	0.307	0.348	7.31
Largemouth Bass	0.108	< MDL	< MDL	< MDL	< MDL	0.232	0.452	5.18
Largemouth Bass	0.462	0.156	< MDL	< MDL	0.098	3.35	0.96	7.32
Chain Pickerel	0.249	< MDL	0.672	< MDL	< MDL	0.422	0.131	7.68
Brown Bullhead	0.184	< MDL	1.14	< MDL	< MDL	0.278	0.146	6.93
Brown Bullhead	0.229	< MDL	1.48	7.88	< MDL	0.213	0.086	6.47
Brown Bullhead	0.291	< MDL	1.39	< MDL	< MDL	0.399	0.024	7.01
Brown Bullhead	0.325	< MDL	< MDL	< MDL	< MDL	0.22	0.072	6.82
Brown Bullhead	0.212	< MDL	< MDL	< MDL	< MDL	0.229	0.048	5.07
Brown Bullhead	0.256	< MDL	1.09	9.68	< MDL	0.178	0.151	7.51
Brown Bullhead	0.282	< MDL	2.29	< MDL	< MDL	0.197	0.042	6.39
Brown Bullhead	0.334	< MDL	2.36	7.31	< MDL	0.344	0.107	7.35

(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							
Brown Bullhead	0.674	< MDL	3.6	8.63	< MDL	0.257	0.065	8.8
Brown Bullhead	0.41	< MDL	0.35	8.01	< MDL	< MDL	0.04	5.89
Forge Pond								
Bluegill (composite)	0.159	< MDL	< MDL	< MDL	< MDL	0.335	0.043	6.46
Bluegill (composite)	0.214	< MDL	< MDL	< MDL	< MDL	0.661	0.057	6.71
Pumpkinseed (composite)	0.242	< MDL	< MDL	< MDL	< MDL	0.456	0.116	9.52
Pumpkinseed (composite)	< MDL	< MDL	< MDL	< MDL	< MDL	0.274	0.133	7.82
Yellow Perch	< MDL	< MDL	< MDL	< MDL	< MDL	0.386	0.078	6.48
Yellow Perch	< MDL	< MDL	< MDL	< MDL	< MDL	0.258	0.108	6.3
Yellow Perch	< MDL	< MDL	< MDL	< MDL	< MDL	0.291	0.067	5.81
Yellow Perch	< MDL	< MDL	< MDL	< MDL	< MDL	0.245	0.065	5.72
Chain Pickerel	< MDL	< MDL	< MDL	< MDL	< MDL	0.188	0.292	0.527
Brown Bullhead	0.279	< MDL	0.422	< MDL	< MDL	0.266	0.070	4.15
Largemouth Bass	0.259	0.162	< MDL	< MDL	< MDL	1.000	0.220	23.1
Largemouth Bass	< MDL	< MDL	< MDL	< MDL	< MDL	0.410	0.147	4.84
Largemouth Bass	< MDL	< MDL	< MDL	< MDL	< MDL	0.386	0.149	5.77
Largemouth Bass	< MDL	< MDL	< MDL	< MDL	< MDL	0.239	0.174	5.13
Largemouth Bass	< MDL	< MDL	< MDL	< MDL	< MDL	0.358	0.147	4.85
Swan Pond (Peconic River control location)								
Bluegill (composite)	< MDL	< MDL	< MDL	< MDL	< MDL	0.209	0.058	5.84
Bluegill (composite)	< MDL	< MDL	< MDL	< MDL	< MDL	0.525	0.054	5.88
Bluegill (composite)	< MDL	< MDL	< MDL	< MDL	< MDL	0.726	0.049	6.24
Pumpkinseed (composite)	0.373	< MDL	< MDL	< MDL	< MDL	1.530	0.040	8.21
Pumpkinseed (composite)	< MDL	< MDL	< MDL	< MDL	< MDL	0.300	0.032	7.91
Pumpkinseed (composite)	< MDL	< MDL	< MDL	< MDL	< MDL	0.531	0.016	8.32
Pumpkinseed (composite)	< MDL	< MDL	< MDL	< MDL	< MDL	0.283	0.007	8.37
Largemouth Bass	< MDL	< MDL	< MDL	< MDL	< MDL	0.426	0.544	4.62
Largemouth Bass	< MDL	< MDL	< MDL	< MDL	< MDL	0.783	0.206	7.27
Largemouth Bass	< MDL	< MDL	< MDL	< MDL	< MDL	0.435	0.079	6.09
Largemouth Bass	0.21	< MDL	< MDL	< MDL	< MDL	1.930	0.080	7.24
Yellow Perch	< MDL	< MDL	< MDL	< MDL	< MDL	0.693	0.107	7.5
Yellow Perch	0.147	< MDL	< MDL	< MDL	< MDL	1.430	0.111	5.92
Yellow Perch	< MDL	< MDL	< MDL	< MDL	< MDL	0.721	0.053	5.78
Yellow Perch	0.0967	< MDL	< MDL	< MDL	< MDL	0.971	0.029	6.17
Yellow Perch	< MDL	< MDL	< MDL	< MDL	< MDL	0.560	0.049	5.98
Chain Pickerel	0.291	< MDL	< MDL	< MDL	< MDL	3.850	0.073	10.6
Brown Bullhead	< MDL	< MDL	< MDL	71.9	< MDL	0.249	0.157	3.97
Brown Bullhead	0.223	< MDL	< MDL	< MDL	< MDL	0.571	0.024	4.87
Brown Bullhead	0.279	< MDL	< MDL	< MDL	< MDL	0.270	0.006	5.63

(continued on next page)

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	0.29	< MDL	< MDL	< MDL	< MDL	0.564	0.054	5.25
Brown Bullhead	0.143	< MDL	< MDL	< MDL	< MDL	0.646	0.004	3.85
Brown Bullhead	0.2	< MDL	< MDL	< MDL	< MDL	0.617	0.003	5.22
Brown Bullhead	0.2	< MDL	< MDL	< MDL	< MDL	0.542	0.008	4.32
Brown Bullhead	0.268	< MDL	< MDL	< MDL	< MDL	1.180	0.006	9.81
Lower Lake, Carmans River (control location)								
Largemouth Bass	0.122	0.998	0.534	11.2	< MDL	0.183	0.218	10.3
Largemouth Bass	< MDL	< MDL	0.304	< MDL	< MDL	0.188	0.466	4.15
Largemouth Bass	< MDL	0.152	0.351	< MDL	< MDL	0.245	0.134	3.58
Largemouth Bass	0.114	< MDL	0.397	< MDL	< MDL	0.363	0.118	5.16
Largemouth Bass (composite)	0.139	< MDL	< MDL	< MDL	< MDL	0.478	0.077	5.38
Brown Trout	< MDL	< MDL	0.479	< MDL	< MDL	< MDL	0.007	3.85
Brown Trout	< MDL	< MDL	0.507	< MDL	< MDL	< MDL	0.006	4.62
Brown Trout	< MDL	< MDL	0.468	< MDL	< MDL	< MDL	0.007	4.25
Brown Trout (composite)	< MDL	< MDL	0.469	< MDL	< MDL	< MDL	0.006	3.76
Brown Trout (composite)	< MDL	< MDL	0.51	34.5	< MDL	0.224	0.006	4.14
Brown Bullhead	0.218	0.148	0.396	7.47	< MDL	0.31	0.061	4.06
Brown Bullhead	0.131	< MDL	0.599	< MDL	< MDL	0.249	0.032	3.84
Brown Bullhead	0.187	< MDL	0.436	9.05	< MDL	0.392	0.033	4.42
Brown Bullhead	0.222	< MDL	0.393	< MDL	< MDL	0.388	0.045	4.53
Brown Bullhead	0.13	< MDL	0.436	< MDL	0.457	0.307	0.014	4.26

Notes:
See Figure 5-8 for sampling locations.
All fish were analyzed as edible portions (fillets).
MDL = Minimum Detection Limit

thallium, selenium, and vanadium were near or less than the minimum detection level (MDL) for the analytical procedure, they were not included in Table 6-4. Other metals tested but not included in the table include aluminum, antimony, and nickel, as most values reported for these metals were less than the MDL. Values that were above the MDL are discussed below. 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.

Values for metals not shown in Table 6-4 because they were at or near MDL were as follows: antimony was found in a composite sample of bluegill from the Swan Pond at a level of 1.12 mg/kg; arsenic was found in Lower Lake fish ranging from 0.19 to 0.97 mg/kg; beryllium, cadmium, cobalt, nickel, silver, thallium, and vanadium were not detected in any fish; and selenium was detected in a largemouth bass (0.44 mg/kg) and two yellow perch (0.45 and 0.46 mg/kg) from Forge Pond. 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.

Due to its known health effects, mercury is the metal of highest concern. Surveillance monitoring data is provided for Donahue's

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

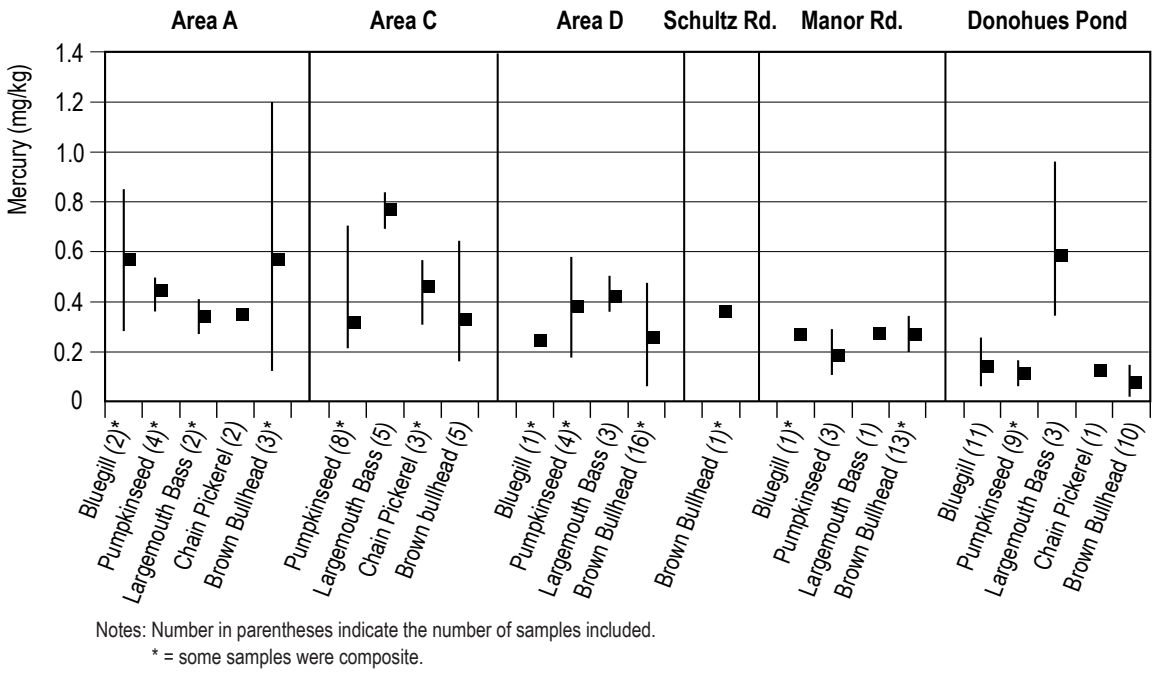
Location/Species (number)	Mercury mg/kg Min	Max	Avg
BNL, On Site			
Area A			
Bluegill (2)*	0.289	0.854	0.572
Pumpkinseed (4)*	0.367	0.500	0.446
Largemouth Bass (2)*	0.276	0.410	0.343
Chain Pickerel (2)	0.351	0.356	0.354
Brown Bullhead (3)*	0.124	1.200	0.569
Area C			
Pumpkinseed (8)*	0.212	0.709	0.319
Largemouth Bass (2)	0.696	0.839	0.768
Chain Pickerel (3)*	0.315	0.569	0.462
Brown Bullhead (5)	0.163	0.648	0.330
Area D			
Bluegill (1)*	0.243	0.243	0.243
Pumpkinseed (4)*	0.182	0.584	0.387
Largemouth Bass (3)	0.362	0.503	0.417
Brown Bullhead (16)*	0.063	0.473	0.253
Schultz Road			
Brown Bullhead (1)*	0.363	0.363	0.363
Manor Road			
Bluegill (1)*	0.266	0.266	0.266
Pumpkinseed (3)	0.107	0.293	0.186
Largemouth Bass (1)	0.278	0.278	0.278
Brown Bullhead (13)*	0.202	0.348	0.262
Donahue's Pond			
Bluegill (11)	0.069	0.256	0.141
Pumpkinseed (9)*	0.064	0.170	0.118
Largemouth Bass (3)	0.348	0.960	0.587
Chain Pickerel (1)	0.131	0.131	0.131
Brown Bullhead (10)	0.024	0.151	0.078

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 2010 Peconic River Monitoring Report.

Pond, Forge Pond, Swan Pond, and Lower Lake on the Carmans River. During 2010, mercury ranged from 0.02 mg/kg in brown bullhead to 0.96 mg/kg in a largemouth bass at Donahue's Pond; from 0.43 mg/kg in a composite bluegill sample to 0.292 mg/kg in a chain pickerel at Forge Pond; from 0.003 mg/kg in brown bullhead to 0.544 mg/kg in a largemouth bass at Swan Pond; and from 0.006 mg/kg in brown trout to 0.466 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. Mercury values in Area A of the Peconic River (area nearest to the STP outfall) ranged from 0.12 mg/kg in brown bullhead to 1.2 mg/kg, also in brown bullhead. At Area C, mercury ranged from 0.163 mg/kg in a brown bullhead to 0.839 mg/kg in a largemouth bass. Fish taken from Area D near the boundary of the Laboratory had mercury content ranging from 0.063 mg/kg in brown bullhead to 0.584 mg/kg in a pumpkinseed. A single sample was obtained at Schultz Road (a composite bullhead sample) with a value of 0.363 mg/kg. At Manor Road, mercury content ranged from 0.107 mg/kg in pumpkinseed to 0.348 mg/kg in brown bullhead. The last location sampled as a part of the Peconic River Cleanup monitoring was Donahue's Pond, where mercury content in fish ranged from 0.024 mg/kg in brown bullhead to 0.96 mg/kg in a largemouth bass. In general, from the rough data presented, a trend of decreasing mercury content going downstream from BNL's STP is evident. A more detailed review of the data is covered in the Annual Report on Peconic River Sampling for 2010 (BNL 2011).

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 on fish collected on site. A single fish sample (pumpkinseed composite sample)



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).

taken from within Area A tested positive for Aroclor 1254 with a value of 22.5 µg/kg. Historically, PCBs have been found in both fish and sediment at BNL and periodically at other locations in the Peconic River. The cleanup of the Peconic River that was completed in 2005 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 2010. (See Chapter 5 for a discussion on water quality and monitoring, and Figure 5-8 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 vegetation samples in 2010 and were 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. Most of 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

Table 6-6. Radiological Analyses of Aquatic Vegetation and Sediment 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	4.05 ± 0.94	ND
Aquatic vegetation	3.38 ± 0.74	ND
Aquatic vegetation	4.43 ± 0.83	ND
Aquatic vegetation	3.80 ± 0.78	ND
Donahue's Pond		
Aquatic vegetation	2.99 ± 0.4	0.04 ± 0.02
Sediment	2.97 ± 0.81	0.52 ± 0.11
Water	ND	ND
Forge Pond		
Aquatic vegetation	2.7 ± 0.32	0.30 ± 0.02
Sediment*	2.25 ± 0.29	0.06 ± 0.02
Swan Pond (Peconic River control location)		
Aquatic vegetation	2.12 ± 0.31	0.02 ± 0.01
Sediment	2.65 ± 1.08	0.54 ± 0.11
Lower Lake, Carmans River (control location)		
Aquatic vegetation	2.17 ± 0.25	0.01 ± 0.01
Sediment	2.42 ± 0.42	0.13 ± 0.02

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

action levels or 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, and Lower Lake (7.48, 6.12, and 3.51 mg/kg, respectively). Cadmium was found in sediments at Donahue's Pond (1.27 mg/kg) and at Swan Pond (3.8 mg/kg). Chromium was found above cleanup objectives of 10 mg/kg in sediment at Swan Pond. Mercury and nickel were just above SCDHS cleanup objectives of 0.1 and 13 mg/kg, respectively, at Swan Pond.

6.3.4.3 Pesticides and PCBs in Aquatic Samples

Pesticides and PCBs analyses of aquatic samples were discontinued in 2008, corresponding to the discontinuance of this sampling in fish. DDT and its breakdown products have been the primary pesticide observed in sediments due to its long persistence in the environment. BNL may periodically analyze aquatic sediments to track the continued degradation of this pesticide in the environment.

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 small areas were cleaned up between November 2010 and February 2011 (see Section 6.3.5.4).

A summary of the 2010 sediment, surface water, and fish sampling results is described below. Detailed information on 2010 sampling results can be found in the Final 2010 Peconic River Monitoring Report (BNL, 2011).

6.3.5.1 Sediment Sampling

Sediment was sampled in May 2010 at 15 Peconic River routine sampling stations on site and 15 routine sampling stations off site. Twenty-nine of the 30 annual sediment samples collected in 2010 met the mercury cleanup goal of 2.0 mg/kg. The PR-SS-33 sample had a mercury concentration of 4.7 mg/kg. Five supplemental samples were then collected within the 80–100 square-foot area surrounding the 2010 PR-SS-33 sample location. All five supplemental samples were substantially lower than the cleanup goal and ranged between non-detect at 0.05 mg/kg and 1.5 mg/kg, with an average of 0.61 mg/kg. No further action is required in this area.

Table 6-7. Metals Analysis of Aquatic Vegetation and Sediment from the Peconic River System and Carmans River, 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	1.22	812	< MDL	< MDL	1.68	48.6	0.21	9.27	0.0321	0.208	0.133	< MDL	5.86
Aquatic vegetation	23.8	4.27	1280	0.184	0.156	1.47	199	0.24	34.1	0.00509	0.478	0.18	0.199	7.34
Aquatic vegetation	13.6	3.62	772	< MDL	0.339	2.31	108	0.183	45	0.00544	0.815	0.183	0.21	16.6
Aquatic vegetation	26.9	4.8	1270	0.159	< MDL	2.29	156	0.174	33	0.00556	0.495	0.207	0.146	13.9
Donahue's Pond														
Aquatic vegetation	18.8	41.1	3520	0.145	0.524	< MDL	270	0.36	242	< MDL	0.146	< MDL	0.231	12.7
Sediment	3250	57.7	2090	10.3	7.06	14.5	8460	35.6	153	0.239	6.68	1.02	30.3	120
Water (ug/L)	119	13.5	3060	< MDL	< MDL	< MDL	2140	0.7	107	0.08	< MDL	< MDL	< MDL	3.54
Forge Pond														
Aquatic vegetation	6.9	19.9	2470	< MDL	< MDL	< MDL	65.5	0.13	64.1	< MDL	< MDL	< MDL	< MDL	4.51
Sediment	312	11.2	164	0.658	0.206	0.458	479	3.38	15.7	< MDL	0.268	< MDL	0.806	3.37
Swan Pond (Peconic River control location)														
Aquatic vegetation	8.7	30.5	3820	0.245	< MDL	< MDL	39.2	0.1	488	< MDL	< MDL	< MDL	0.137	6.59
Sediment	6880	155	8140	22.3	8.91	54.3	16500	269	2780	0.341	24.7	1.61	46	266
Lower Lake, Carmans River (control location)														
Aquatic vegetation	25.4	30.2	1300	0.184	< MDL	0.668	109	0.3	106	< MDL	0.221	< MDL	0.0976	9.49
Sediment	1190	30.8	1350	6.91	1.76	5.11	3780	33.4	203	0.0406	2.84	< MDL	7.01	35
SCDHS														
Action Levels	N/A	N/A	N/A	100	N/A	500	N/A	400	N/A	2	1000	100	N/A	N/A
Cleanup Objectives	N/A	N/A	N/A	10	N/A	25	N/A	100	N/A	0.1	13	5	N/A	N/A

Notes:
MDL = Minimum Detection Limit
N/A = not applicable
SCDHS = Suffolk County Department of Health Services

6.3.5.2 Water Column Sampling

Surface water was analyzed in June and July 2010 for total mercury and methyl mercury at 22 and 18 of the 22 Peconic River sampling stations, respectively. A sample of the treated STP effluent at one reference station on the Connetquot River was also collected. Four stations could not be sampled in July due to low water table levels. The total mercury concentrations in the June (75.1 ng/L) and July (69.1 ng/L, maximum) STP effluent samples were the lowest since 2006. The 2010 total mercury concentrations generally trended downwards, with fluctuations at increasing distance downstream from the STP until reaching concentrations of 3.1 ng/L to 4.7 ng/L at sample stations east of the cranberry bogs.

Methyl mercury was not detected in either the June or July 2010 STP effluent samples. Between the station downstream of the STP and the BNL boundary, the June methyl mercury concentrations fluctuated between 3.76 ng/L and 6.74 ng/L, and the July samples fluctuated between 1.84 and 2.61 ng/L. The methyl mercury values from downstream of the BNL boundary to the station west of the cranberry bogs fluctuated between 1.7 ng/L and 4.3 ng/L. Between the station east of the cranberry bogs and downstream of Connecticut Avenue, the June methyl mercury concentrations fluctuated between 0.655 ng/L and 1.37 ng/L, and the July sample results fluctuated between 0.5 and 0.685 ng/L.

6.3.5.3 Fish Sampling

In 2010, 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 108 fish samples (composites and individual fish) was 0.28 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, four fish samples were analyzed for seven PCB isomers, for a total of 28 PCB analyses. All 28 of the PCB analyses had concentrations less than the detection limit. The average Cs-137 activity for the 62 fish samples analyzed in 2010 was 0.11 pCi/g.

6.3.5.4 Remedial Actions

BSA/DOE recommended to EPA, NYSDEC, and SCDHS that a 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) totals 0.39 acres. The work was completed between November 2010 and February 2011, with an average 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 will be re-planted with native Peconic River plants transplanted from previously remediated sections of the river.

6.3.6 Vegetation Sampling

6.3.6.1 Farm and Garden Vegetables

On-site sampling of garden vegetables was completed in 2010. The data on garden vegetables are presented in Table 6-8. Samples of zucchini, cucumber, tomato, pepper, and egg plant 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 (0.13 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 2010. Vegetation was sampled from 10 locations around the Laboratory, 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 0.18 pCi/g wet weight, which is consistent with past sampling efforts. Grassy vegetation

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

Location/Sample	K-40	Cs-137
	pCi/g	
BNL Garden		
Green Pepper	1.95 ± 0.20	ND
Cucumber	1.77 ± 0.13	ND
Tomato	2.63 ± 0.24	ND
Corn	2.79 ± 0.23	ND
Zuchini	1.70 ± 0.15	ND
Soil	6.24 ± 0.61	0.23 ± 0.03
BNL Grassy Vegetation and Soils		
Firebreak, West of Upton Rd. North		
Vegetation*	4.80 ± 0.96	0.10 ± 0.06
Soil	7.57 ± 0.81	0.22 ± 0.03
Firebreak, North of Bldg. 51		
Vegetation	4.34 ± 1.05	ND
Soil*	4.41 ± 0.50	0.04 ± 0.02
Firebreak, Northwest of Bldg. 51		
Vegetation*	3.01 ± 0.92	0.18 ± 0.07
Soil	5.71 ± 0.72	0.29 ± 0.04
West End of Brookhaven Ave.		
Vegetation	2.80 ± 1.51	0.08 ± 0.12
Soil*	7.22 ± 0.82	0.08 ± 0.03
Firebreak West of Bldg. 619		
Vegetation	3.18 ± 1.38	ND
Soil*	7.82 ± 0.76	0.14 ± 0.02
Firebreak, North of Front Gate		
Vegetation	1.69 ± 0.64	ND
Soil*	3.97 ± 0.46	0.05 ± 0.02
Firebreak, Southwest of Apartments		
Vegetation	1.59 ± 0.59	ND
Soil	9.23 ± 0.91	0.37 ± 0.04
End of Force, Main Firebreak		
Vegetation	1.64 ± 0.61	ND
Soil*	4.36 ± 0.52	0.04 ± 0.02
Southwest Corner, BNL		
Vegetation*	5.44 ± 0.77	0.05 ± 0.03
Soil*	8.39 ± 0.86	0.08 ± 0.02
Middle Road, East of Treatment System		
Vegetation	2.96 ± 0.87	ND
Soil*	9.21 ± 1.01	0.11 ± 0.03

Notes:
Vegetation results are reported as wet weight values.
Soils results are reported as dry weight values.
* = estimated values for Cs-137 based on analytical laboratory qualifiers.
K-40 = Potassium-40
Cs-137 = Cesium-137

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 2010. Soil samples were analyzed for Cs-137 and the data are presented in Table 6-8. Cs-137 content in soils ranged from estimated value of 0.04 pCi/g to 0.37 pCi/g. These values are consistent with past soil analysis and are indicative of background levels 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 this testing are discussed in Chapter 3, Section 3.6.1.1. Testing will continue in 2011.

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 were analyzed for radiological content and total mercury (see Table 6-9). Five samples were taken from each of these two stations in 2010. Gross alpha activity measurements were above the

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

Location/ Period	Be-7	Gross Alpha	Gross Beta	Mercury
	pCi/L			ng/L
P4				
1st Quarter	ND	ND	2.90 ± 0.79*	5.13
2nd Quarter	NT	NT	NT	11.8
2nd Quarter	ND	1.10 ± 0.62*	2.79 ± 0.88*	4.43
3rd Quarter	ND	ND	5.3 ± 1.1	12.3
4th Quarter	ND	ND	1.33 ± 0.6	8.03
S5				
1st Quarter	174 ± 64	0.89 ± 0.65*	3.44 ± 0.86*	5.1
2nd Quarter	NT	NT	NT	13
2nd Quarter	ND	ND	ND	8.19
3rd Quarter	ND	1.07 ± 0.62	3.58 ± 0.94	14.2
4th Quarter	ND	ND	1.15 ± 0.64	6.27

Notes:
* = estimated values based on laboratory qualifiers.
Method detection limit for mercury is 0.2 ng/L.
NT = not tested
ND = not detected
P4 = precipitaion sampler near BNL Apartments area.
S5 = precipitation sampler near BNL Sewage Treatment Plant.

MDL at P4 in the second quarter of 2010 (estimated at 1.10 pCi/L) and at S5 in the first (estimated at 0.89 pCi/L) and third quarters (1.07 pCi/L).

Gross beta activity was measured in samples for three of the four quarters at S5 and in all quarters at P4 in 2010. In general, radioactivity in precipitation comes from naturally occurring radionuclides in dust and from activation products that result from solar radiation. Location P4 had a maximum gross beta activity level of 5.3 pCi/L, with an average of 3.08 pCi/L. Location S5 had a maximum gross beta activity level of 3.58 pCi/L, with an average of 2.72 pCi/L. Gross beta activity values were within the range of values historically observed at these two locations. Beryllium-7 (Be-7) was detected at 174 pCi/L at station S5 in the first quarter sample. Be-7 is produced in the atmosphere by cosmic radiation and is periodically found in precipitation.

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 precipitation samples in each quarter and at both sampling stations. Mercury ranged from 4.43 ng/L at station P4 in the second quarter to 14.2 ng/L at station S5 during the third quarter of 2010.

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 2010, the Environmental Protection Division (EPD) and FERN hosted 16 interns and one faculty member. Interns consisted of one high school intern, 11 undergraduate interns, and five school teachers during the summer. Two of the undergraduate interns worked with a faculty member from Southern University at New Orleans (SUNO), as part of the Faculty and Student Teams (FaST) Program. The FaST team worked on soil microbial studies of Pine Barrens soils. Undergraduate interns worked on insect follivory, pollinator distribution surveys in the area of the LISF, flying squirrel radio-telemetry surveys, quantification of soil nitrogen using the NSLS, soil chemistry of soils within the LISF, and vegetation surveys within the LISF. The high school student intern worked on flying squirrel genetics with one of the teachers. Teachers in the DOE Academies Creating Teacher Scientists (ACTS) program worked on air monitoring for heavy metals, tiger beetles, and coastal plain pond monitoring. A limited discussion concerning each project is presented below, and associated papers and posters are available at www.bnl.gov/esd/wildlife/research.asp.

Various work with insects was conducted in 2010, including a mapping study of tiger beetles conducted by a group of teachers. This work provided interesting information on distribution of these predatory beetles that will allow BNL

the ability to better manage their habitats. Other insect work involved a cooperative study with Dowling College, New York, on interactions between insects and plants within the pine barrens. A third study involved assessing the insect pollinators utilizing both lawns and forest habitats within the footprint of the LISF to determine effects of this facility on this group of insects.

Work associated with the LISF involved establishing permanent vegetation transects both in and outside of the LISF footprint. Initial baseline information was taken for comparison with future work to be done after construction is complete in 2012. Soils data were also collected at multiple locations throughout the LISF to look at the potential impacts on soils due the alteration of moisture regimes caused by the arrays. Soil was analyzed for metals content and pH to be compared to data that will be collected after the array goes into operation.

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.

Small mammal work continued in 2010 with the establishment of radio-telemetry surveys on southern flying squirrels and genetic research on this cryptic species. Radio-telemetry provided indication of home range based on surveys from what appeared to be several siblings from the same brood. Genetic studies on southern flying squirrels are beginning to indicate variations between Long Island populations and those found elsewhere throughout their range. Both genetic and radio-telemetry studies are expected to continue in 2011.

Members of EPD and other BNL 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, the Laboratory hosted the Fifteenth Annual Pine Barrens Research Forum for ecosystems researchers to share and discuss their results. In addition, BNL and FERN participated in the Second 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 fire fighters in the methods of wildland fire suppression, prescribed fire, and fire analysis. BNL has developed and is implementing a Wildland Fire Management Plan. While plans were prepared for conducting a prescribed fire during the Academy, the conditions did not meet the requirements of the prescription. Post-fire monitoring on previous fires, conducted in 2007, 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 being 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 BNL trenches are examples of the few surviving WWI earthworks in the United States. No significant work was required under the Cultural Resource Management Program in 2010.

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