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 2006, 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 Foundation for Ecological Research in the Northeast conducted a second year of monitoring under the Forest Health Monitoring program established for the Long Island Central Pine Barrens, and planning for freshwater wetlands monitoring was initiated. This work is discussed in greater detail in this chapter.

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. Under the BNL Cultural Resource Management Plan, an archeological survey was completed of a 30-acre area where the proposed National Synchrotron Light Source II is to be placed. Additional details are discussed within this chapter.

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 and issued the Natural Resource Management Plan (NRMP) (BNL 2003a). The NRMP 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 the 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 2005, efforts were initiated to better understand the distribution of deer on site. A model of deer

density was developed (Figure 6-1) using the mapping and spatial analysis tools. This model enables resource managers to track changes in deer density over time, detect interactions between components of the ecosystem, and identify locations for management activities.

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. 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 the site in the past. Five New York State threatened species have been positively identified on site and two other species are considered likely to be present. The banded sunfish (*Enneacanthus obesus*), the swamp darter fish (*Etheostoma fusiforme*), and the stiff goldenrod plant (*Solidago rigida*) have been previously reported (BNL 2000). The northern harrier (*Circus cyaneus*) was seen hunting over open fields in November 2003. In 2005, the Pine Barrens bluet (*Enallagma recurvatum*) damselfly was confirmed at one of the many coastal plain ponds located 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). In addition, stargrass (*Aletris farinosa*) was reconfirmed to exist at BNL. Several other species that inhabit the site, visit during migration, or have historically been identified, are listed as rare, species of special concern, or exploitably vulnerable by New York State (Table 6-1).

6.1.2 Habitat Protection and Enhancement

BNL has precautions in place to protect on-site habitats and natural resources. Activities to eliminate or minimize negative effects on sensitive or critical species are either incorporated into Laboratory procedures or into specific program or

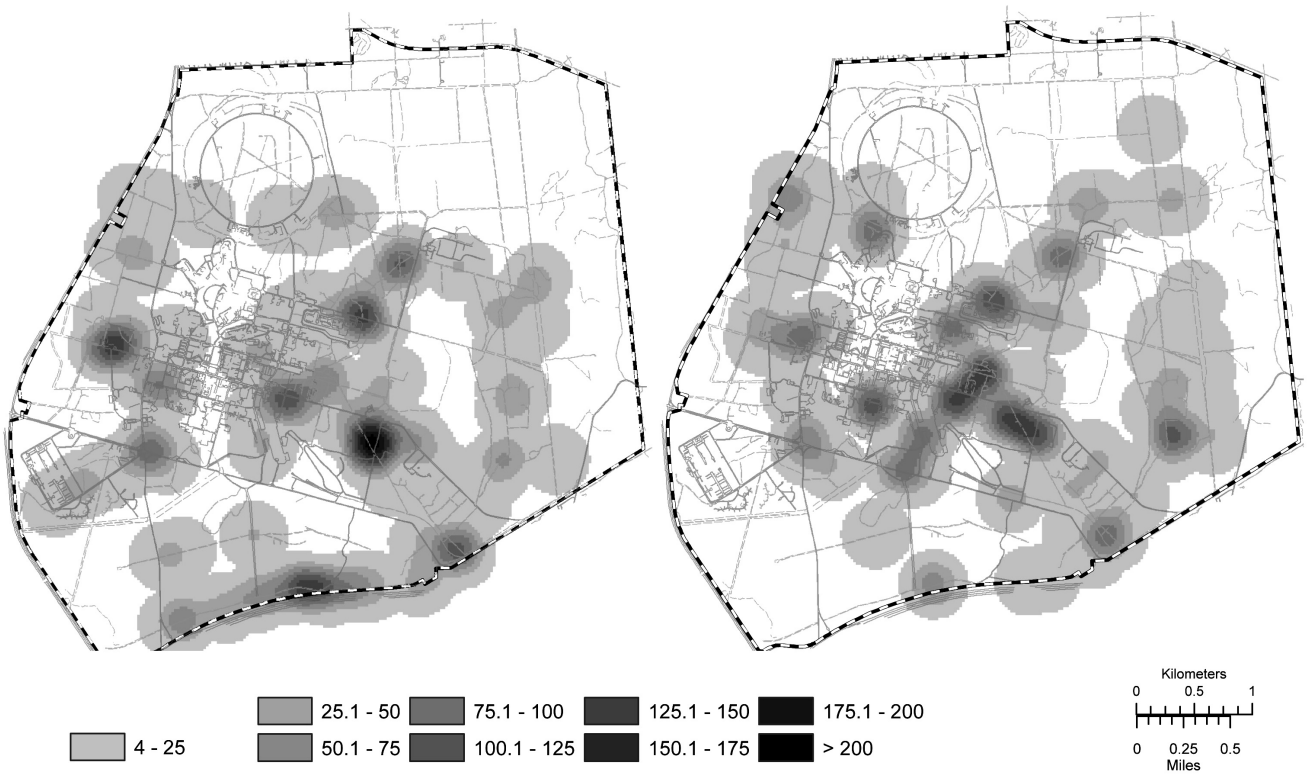


Figure 6-1. Population Density of Deer — Fall 2006.

project plans. Environmental restoration efforts remove pollutant sources that could contaminate habitats. Human access to critical habitats is limited. In some cases, habitats are enhanced to improve survival or increase populations. 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 these locations is reviewed when new projects are proposed. Distribution of the map is limited, to protect the salamander from exploitation by collectors and the pet trade. The map is routinely updated as new information concerning the salamanders is generated through research and monitoring. Other efforts to protect this state endangered species include determining when adult salamanders are migrating toward breeding locations, when metamorphosis has been completed, and when juveniles are migrating after metamorphosis. During these times, construction and maintenance activities near their habitats are postponed. BNL environmental protection staff must review any project planned near eastern tiger salamander habitats, and every effort is made to minimize impacts.

Water quality testing is conducted as part of the routine monitoring of recharge basins, as discussed in Chapter 5. In cooperation with the New York State Department of Environmental Conservation (NYSDEC), habitat surveys have been conducted annually since 1999. Biologists conducting egg mass and larval surveys have increased the number of confirmed sites from 17 on-site ponds to 26 ponds that are used by eastern tiger salamanders. The study procedure calls for all ponds that had egg masses during the spring surveys to be surveyed again in June and July to check for the presence of larval salamanders. Egg mass surveys of 26 ponds plus additional flooded depressions at the Laboratory were conducted in 2006. A PhD candidate and students working through the intern programs offered by DOE and BNL's Office of Education conducted surveys of tiger salamander ponds, drift fence surveys, and radio telemetry tracking

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
Mottled duskywing	*Erynnis martialis*	SC	Likely
Persius duskywing	*Erynnis persius persius*	E	Likely
Pine Barrens Bluet	*Enallagma recurvatum*	T	Confirmed
Fish			
Banded sunfish	*Enniacanthus obesus*	T	Confirmed
Swamp darter	*Etheostoma fusiforme*	T	Confirmed
Amphibians			
Eastern tiger salamander	*Ambystoma tigrinum tigrinum*	E	Confirmed
Marbled salamander	*Ambystoma opacum*	SC	Confirmed
Eastern spadefoot toad	*Scaphiopus holbrookii*	SC	Confirmed
Reptiles			
Spotted turtle	*Clemmys guttata*	SC	Confirmed
Eastern hognose snake	*Heterodon platyrhinos*	SC	Confirmed
Eastern box turtle	*Terrapene carolina*	SC	Confirmed
Worm snake	*Carphophis amoenus*	SC	Confirmed
Birds (nesting, transient, or potentially present)			
Horned lark	*Eremophila alpestris*	SC	Likely
Whip-poor-will	*Caprimulgus vociferus*	SC	Likely
Vesper sparrow	*Pooecetes gramineus*	SC	Likely
Grasshopper sparrow	*Ammodramus savannarum*	SC	Confirmed
Northern harrier	*Circus cyaneus*	T	Confirmed
Cooper's hawk	*Accipiter cooperii*	SC	Confirmed
Osprey	*Pandion haliaetus*	SC	Confirmed
Shap-shinned hawk	*Accipiter striatus*	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 inhabit the BNL site.
E = Endangered
R = Rare
SC = Species of Special Concern
T = Threatened
V = Exploitably Vulnerable

around four ponds. The results of these studies show 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 needs began in 2004, with funding provided to SUNY Binghamton by NYSDEC. Continued research consistently 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.

6.1.2.2 Eastern Box Turtle

A radio telemetry study of the eastern box turtle (*Terrapene carolina*) was initiated in 2006 to investigate the amount of territory overlap between individual turtles. This study was initiated after repeatedly finding turtles with ear infections and the discovery of three sick turtles simultaneously in 2005. Two of the three turtles died and were subsequently necropsied, with tissues sent to a laboratory for virus isolation. Results confirmed the presence of an iridovirus known to affect turtles and amphibians, which was of greater concern, given their endangered status. As the three turtles were found in a primary breeding pond for tiger salamanders, further study was warranted. The radiotelemetry study confirmed significant amounts of overlap within the territories of five turtles outfitted with transmitters. This overlap provides an indication of the likelihood of disease transmission between turtles. Additionally, all five turtles spent some time near the pond and could have released the virus to the water, where it could infect amphibians. The telemetry work is scheduled to continue in 2007.

Associated with the radiotelemetry study was a study to isolate and identify the iridovirus within eastern box turtles found at BNL. Routine transects of various areas of the Laboratory were established and traversed in order to capture eastern box turtles. When a turtle was found, it was given a unique identification mark and samples from the mouth and cloaca were taken using cotton swabs. The samples were later tested for iridovirus. Unfortunately, due to difficulties at the contract analytical laboratory, iridovirus could not be isolated. The study will continue with revisions in 2007 in order to assess the potential for turtles to carry iridovirus and infect other reptiles or amphibians. Revisions will include improved procedures for obtaining swab samples and alterations of lab procedures to improve the genetic analysis of samples.

6.1.2.3 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 (see Section 6.1.2.1), sightings of 26 species of reptiles and amphibians have been recorded over the past several years. The species observed include the northern red-back salamander (*Plethodon c. cinereus*), marbled salamander (*Ambystoma opacum*), four-toed salamander (*Hemidactylium scutatum*), red-spotted newt (*Notophthalmus viridescens*), spring peeper (*Pseudacris crucifer*), wood frog (*Rana sylvatica*), gray tree frog (*Hyla versicolor*), bullfrog (*Rana catesbiana*), green frog (*Rana clamitans*), pickerel frog (*Rana palustris*), Fowler's toad (*Bufo woodhousei fowleri*), eastern spadefoot toad (*Scaphiopus holbrooki*), snapping turtle (*Chelydra serpentine*), painted turtle (*Chrysemys p. picta)*, musk turtle (*Sternotherus odoratus*), spotted turtle (*Clemmys guttata*), eastern box turtle (*Terrapene 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 punctatus edwardsi*), brown snake (*Storeria d. dekayi*), the northern red-bellied snake (*Storeria occiptiomaculata*), and the eastern wormsnake (*Carphophis amoenus*). This listing indicates that BNL has one of the most diverse herpetofaunal assemblages on Long Island.

Banded sunfish protection efforts include observing whether adequate flow in the Peconic

River is maintained within areas currently identified as sunfish habitat, ensuring that existing vegetation in their habitat is not disturbed, and evaluating all activities taking place on the river for potential impacts on these habitats. A population estimate of reproductive success of the banded sunfish in a protected pond was scheduled for 2006 after the pond nearly dried in 2005. However, due to cool springtime temperatures, fish reproduction was delayed. An attempt at assessing the population was made, but because the fish were so small, concerns were that studies would damage the population. Plans for the population assessment were rescheduled for 2007. The likelihood of a successful population estimate in 2007 is high because the hydrologic conditions of the pond remained in satisfactory condition in late 2005. Conservative estimates are that the pond held 3,000 fish at that time. If even a portion of the fish survived to successfully breed in 2006, the resulting population should be significant.

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 six permanent bird survey routes in various habitats at BNL. In 2006, monthly surveys were conducted starting at the end of March and extending through the end of September. These surveys identified 70 songbird species, compared to 67 species in 2005 and 68 species during 2004. Two new species were identified during the 2006 surveys. A total of 110 songbird species have been identified during surveys in the past seven 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.

Canada geese (*Branta canadensis*) are a protected species under the Migratory Bird Treaty Act. BNL has a resident, year-round (non migrating) flock of approximately 120 birds that occasionally create problems due to their droppings, choice of nesting areas, and assertive defense of nests and offspring. When questions regarding migratory birds arise, BNL consults NYSDEC, U.S. Fish & Wildlife Services (FWS), and the United States Department of Agriculture – Animal Plant Health Inspection Service – Wildlife Services Division. Because Canada geese have protected status, they were allowed to finish nesting while action plans took shape to prevent their use of the same areas in the future. The Laboratory began looking into control methods in 2006 and will likely begin some form of population management in 2007.

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 56 nest boxes around open grassland areas on site to enhance their population. In 2006, the boxes were monitored approximately every 3 weeks during the breeding season to determine use and nesting success. Thirty-nine bluebird nests were observed. Other birds using the houses included house wrens (*Troglodytes aedon*), black-capped chickadees (*Poecile atricapilla*), tufted titmouse (*Baeolophus bicolor*), and tree swallows (*Tachycineta bicolor*). Bluebirds produced 38 broods in 2006, compared to 19 broods in 2002.

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, is now sufficiently large for NYSDEC to consider establishing a hunting season to maintain the population at a reasonable number.

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). BNL has been conducting population surveys of the white-tailed deer since 2000. In February and March 2004, an aerial infrared survey was conducted of three properties, including Wertheim National Wildlife Refuge (south of BNL), Brookhaven National Laboratory, and Rocky Point Wildlife Area (northwest of BNL). The results indicated a population of 412 deer on site and immediately off site. When a correction for survey accuracy was applied, the on-site population was estimated at 446 animals. This value was much lower than a ground-based estimate of 1,302, made at the same time using the existing methodology. Because there was a large discrepancy between methods, a review of the ground-based methodology was conducted and the method of estimating was refined. The new method uses the Laboratory's vegetation map and estimates the deer population based on the habitat in which deer are sighted during surveys. The result of this revised method indicated that the deer population was approximately 497, which is considered to be reasonably comparable to the aerial survey results. The next step taken was to apply the new population model to historic survey data. Most of the data resulted in a much lower estimate, with ranges from approximately 1,000 deer in 2001 to approximately 400 deer in 2005. The current population estimate is 466 deer, based on surveys conducted in November and December 2006. Note that the current estimate is still higher than the optimal range of 80 to 250 deer on an area the size of BNL.

Deer overpopulation can affect animal and human health (e.g., animal starvation, Lyme disease from deer ticks, collision injuries—both human and animal), species diversity (songbird species reduction due to selective grazing and destruction of habitat by deer), and property values (auto damage and browsing damage to ornamental plantings). In 2006, 10 deer-related collisions occurred on site, compared to six accidents in 2005 and 25 accidents documented in 2004. This downward trend in accidents is attributed to a major effort by BNL Safeguards and Security personnel to enforce the 30-mph speed limit on site. Additional emphasis on vehicle–deer safety is also thought to have helped reduce this type of accident. Deer health continues to be affected due to lack of food. Deer damage to vegetation around buildings continues to be a problem, but varies depending on the severity of the winter and the availability of browse in the lawns.

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

6.1.4 Compliance Assurance and Potential Impact Assessment

The National Environmental Policy Act (NEPA) review process at BNL is key to ensuring that environmental impacts of a proposed action or activity are adequately evaluated

and addressed. 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 Brookhaven 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.

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 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 the 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. FERN established 91 permanent plots over the 2 year period of the monitoring program and is currently analyzing the data. 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, are available on the FERN website, at www.fern-li.org .

The Interagency Agreement that established the Upton Reserve specified the formation of a Technical Advisory Group (TAG), which includes the supervisory biologist for FWS and representatives from NYSDEC, Suffolk County Parks Department, the Central Pine Barrens Joint Policy and Planning Commission, DOE, BNL's Community Advisory Council, Brookhaven Executive Roundtable, Brookhaven Science Associates, and The Nature Conservancy. The TAG's primary responsibility was to develop a comprehensive NRMP for BNL. The TAG also developed criteria for soliciting and reviewing proposals and awarding funds for research that is conducted within the Upton Reserve. While most of the TAG's responsibilities have been met, the Laboratory intends to periodically ask for assistance in reviewing annual reports required under the NRMP, and to support the five-year update of the plan.

Research on oak tree defoliators that was initiated by FWS and the Upton Reserve is continuing at the Laboratory. Much of the oak forest on site and immediately east of BNL has been subject to repeated defoliation by gypsy moth and orange-striped oak moth. This double defoliation, if it occurs year after year, can kill large sections of oak forest. Beginning in 2003, death of tree oaks was documented. Due to continued defoliation, oak mortality is now estimated at greater than 25 percent in many areas in the northeast quadrant of the Laboratory. The amount of defoliation increased in 2006, with a second year of defoliation by a geometrid moth that became established in 2005.

Research supported by FERN in 2006 included an investigation into the microbial world of soils located within the former Gamma Forest. Microbial research carried out by a scientist at Dowling College identified several new species of fungus and bacteria that had not previously

been known. Future work in the area of microbial diversity is expected to identify additional new species across the Pine Barrens.

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

6.3.1 Deer Sampling

White-tailed deer in New York State typically are large, with males weighing, on average, 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 2006, as in recent years, an off-site deer-sampling program was conducted with the NYSDEC Wildlife Branch and FWS. While most off-site samples are from road-killed deer at and near the Laboratory, NYSDEC provides a few samples that result in data on deer that move beyond BNL boundaries, where they can be legally hunted. The samples provide control data on deer living 1 mile or more from BNL. In addition, FWS occasionally informs Laboratory staff of deer that have died in or near the Wertheim National Wildlife Refuge and other FWS properties on Long Island. In all, 11 deer were obtained on site and 13 were from off-site locations, ranging from adjacent to BNL along the William Floyd Parkway, to approximately 3 miles away (Ridge, 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).

6.3.1.1 Cs-137 in White-Tailed Deer

White-tailed deer sampled at the Laboratory contain higher concentrations of Cs-137 than deer from greater than 1 mile off site (BNL 2000), probably 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) Program. All major areas of contaminated soil were remediated in 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 the facility was found and is currently being characterized.

The number of deer taken for sampling steadily increased between 1996 and 2004. However, the numbers of deer taken in 2005 and 2006 were significantly down. As mentioned above, the number of deer killed on-site and available for sampling has decreased, most likely due to increased safety awareness and better enforcement of speed restrictions. 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 taken 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 6-2 shows the location of all deer samples taken within a 5-mile radius of the Laboratory since 2002. 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.

In 2006, Cs-137 concentrations in deer meat samples taken at BNL ranged from nondetectable to 4.27 pCi/g wet weight. The "wet weight" concentration is before a sample is dried for analysis, and is the form most likely to be consumed. Dry weight concentrations are typically higher than wet weight values. The maximum 2006 on-site concentration (4.27 pCi/g wet weight) was eight times higher than the highest level reported in 2005 (0.52 pCi/g wet weight), but is significantly lower than the highest level ever reported (11.74 pCi/g wet weight, in 1996). The arithmetic average concentration in on-site meat samples was 0.82 pCi/g (see Table 6-2).

Cs-137 concentrations in off-site deer meat samples were separated into two groups: samples taken within 1 mile of BNL (nine samples) and samples taken farther away (four samples) (see Table 6-2). Concentrations in meat samples taken within 1 mile ranged from 0.08 to 9.51 pCi/g wet weight, with an average of 2.04 pCi/g wet weight; concentrations in meat taken from greater than 1 mile ranged from 0.79 to 4.00 pCi/g wet weight, with an average of 2.17 pCi/g wet weight. Because deer on site may routinely travel up to 1 mile off site, the average for deer taken both on site and within 1 mile of the Laboratory is also calculated and for 2006 was 1.37 pCi/g wet weight.

Figure 6-3 compares the average values of Cs-137 concentrations in meat samples collected in 2006 from four different location groupings. Although the figure does not show this, 58 percent of all samples taken both on and off site are below 1 pCi/g wet weight (see Table 6-2).

Figure 6-4 presents the nine-year trend of on-site and near off-site Cs-137 averages in deer meat. 2006 sampling is the first year since 2001 that showed a statistically significant increase in Cs-137 concentrations. The unexplained increase was due to a single sample taken off site along the William Floyd Parkway (9.51 pCi/g wet weight). While the sample was high compared to samples taken within the recent past, it was within the historic range of samples taken within the same geographic area. The area was scanned in aerial radiological surveys in 1981 and 1990; no unremediated sources are known to be in the area.

In 2003, a seasonal pattern in Cs-137 concentrations in deer meat was noticed. This seasonality was present in earlier years and occurred again in 2006 (see Table 6-2). During the summer of 2004, a student in the Community College Intern Program reviewed all data from 2000–2003, analyzed it statistically, and determined that there was a statistical seasonal variation in values for deer both on site as well as far off site (Florendo 2004). This seasonality is likely due to diet and the biological processing of Cs-137. From January through May, deer have a limited food supply—mostly dry vegetation from the previous year's growth (with a fixed concentration of Cs-137 because 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 2006 (3.06, 4.00, and 9.51 pCi/g wet weight) from samples taken in October and November. By January or February, the Cs-137 in their tissues

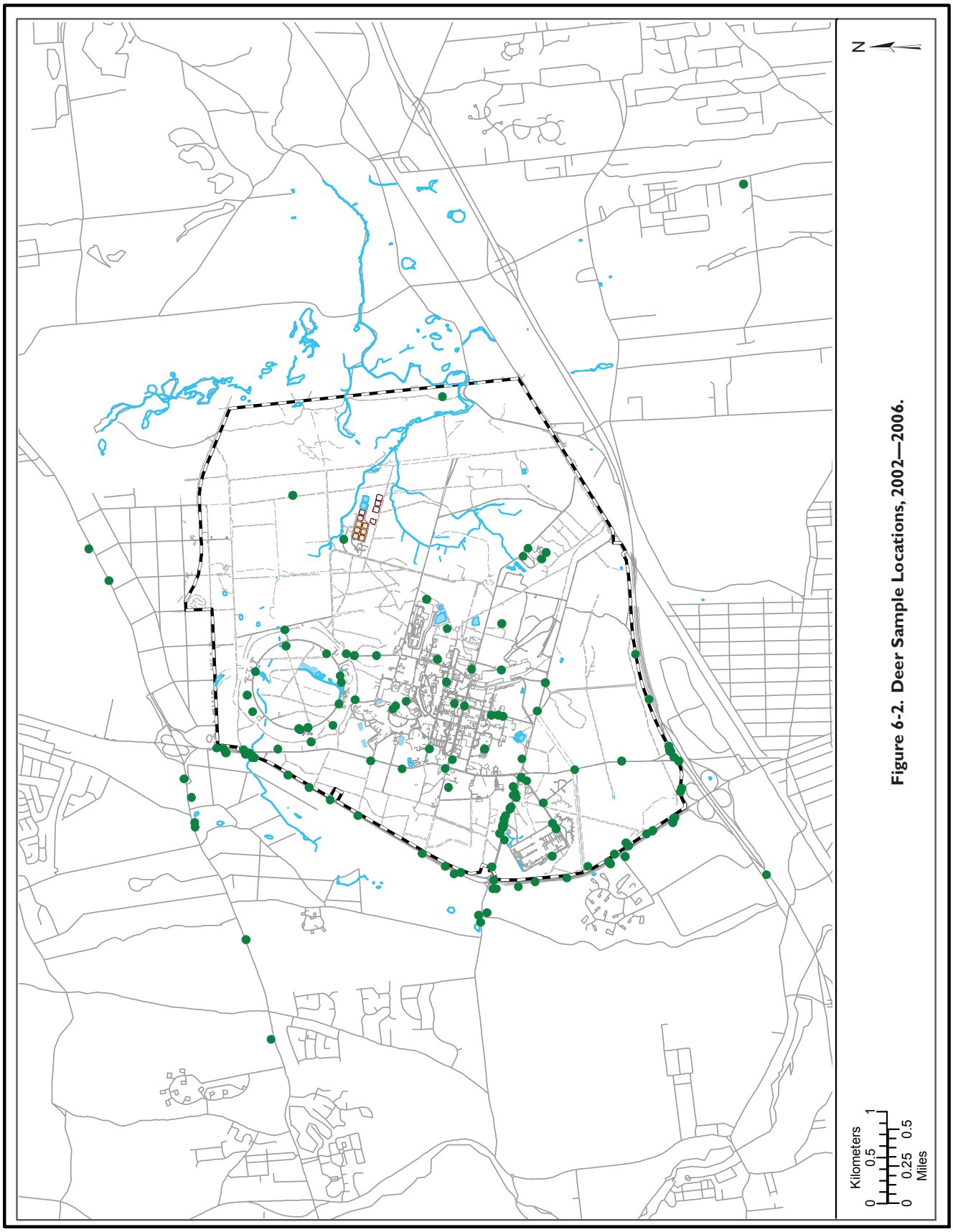


Figure 6-2. Deer Sample Locations, 2002—2006.

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					
North of Cafeteria	01/06/06	Flesh	3.07 ± 0.37	ND	
		Liver	2.14 ± 0.33	ND	
		Bone			1.53 ± 0.18
Princeton Ave.	02/01/06	Flesh	4.05 ± 0.50	0.41 ± 0.04	
		Liver*	2.29 ± 0.35	0.13 ± 0.02	
		Bone			1.83 ± 0.24
Bldg. 650 Sump	03/14/06	Flesh*	2.60 ± 0.35	0.07 ± 0.02	
		Liver*	2.37 ± 0.37	0.08 ± 0.02	
		Bone			2.36 ± 0.23
Upton Rd. and Bldg. 50	03/29/06	Flesh	3.87 ± 0.55	ND	
		Liver	3.24 ± 0.70	ND	
		Bone			2.19 ± 0.28
Bldg. 750, East Side	04/06/06	Flesh	3.62 ± 0.49	ND	
		Liver	2.74 ± 0.51	ND	
		Bone			2.42 ± 0.23
North Gate	05/02/06	Flesh	3.90 ± 0.59	0.27 ± 0.04	
		Bone			2.69 ± 0.24
Cornell Ave. and Rutherford Drive	09/16/06	Flesh	3.28 ± 0.54	0.28 ± 0.04	
		Liver*	2.47 ± 0.60	0.11 ± 0.03	
		Bone**			0.61 ± 0.21
Back of Paint Shop, Bldg. 244	10/23/06	Flesh	3.87 ± 0.42	4.27 ± 0.10	
		Liver	2.47 ± 0.35	1.18 ± 0.06	
		Bone			1.61 ± 0.27
Inbound lane of Main Gate	11/01/06	Flesh	3.31 ± 0.40	2.00 ± 0.17	
		Bone			5.27 ± 0.48
Inbound lane of Main Gate	11/27/06	Flesh	4.12 ± 0.54	1.04 ± 0.09	
		Bone			1.43 ± 0.29
Upton Rd., across from Bldg. 50	12/11/06	Flesh	3.41 ± 0.55	0.64 ± 0.07	
		Liver*	2.61 ± 0.37	0.10 ± 0.02	
		Bone**			0.94 ± 0.21
< 1 Mile from BNL					
William Floyd Pkwy., south of main gate	01/20/06	Flesh	3.92 ± 0.32	0.27 ± 0.02	
		Liver*	2.99 ± 0.47	0.04 ± 0.02	
		Bone			3.32 ± 0.33
Rte. 25, Ridge	07/20/06	Flesh	4.25 ± 0.56	0.08 ± 0.02	
		Bone			2.53 ± 0.25
Rte. 25 and William Floyd Pkwy.	08/11/06	Flesh	3.75 ± 0.44	1.59 ± 0.07	
		Bone			1.01 ± 0.14
William Floyd Pkwy., south of main gate	10/13/06	Flesh	3.47 ± 0.40	1.86 ± 0.06	

(continued on next page)

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

Sample Location	Collection Date	Tissue Type	K-40 pCi/g Wet Weight	Cs-137 pCi/g Wet Weight	Sr-90 pCi/g Dry Weight
William Floyd Pkwy. and Long Island Expressway	10/25/06	Flesh	3.76 ± 0.44	9.51 ± 0.16	
		Liver	2.47 ± 0.39	2.67 ± 0.09	
		Bone			2.35 ± 0.49
William Floyd Pkwy., southbound 1/4 mile north of Long Island Expressway ramp	10/31/06	Flesh	3.39 ± 0.41	0.56 ± 0.04	
		Liver*	3.30 ± 0.57	0.10 ± 0.04	
		Bone**			0.75 ± 0.20
Long Island Expressway, 1 mile east of of William Floyd Pkwy.	11/07/06	Flesh	3.27 ± 0.38	1.85 ± 0.13	
		Bone			2.89 ± 0.38
William Floyd Pkwy. and Rte. 25	11/13/06	Flesh	3.25 ± 0.38	0.61 ± 0.04	
		Bone			2.66 ± 0.37
William Floyd Pkwy. at Colonial Pine light	11/16/06	Flesh	3.99 ± 0.40	2.02 ± 0.07	
> 1 Mile from BNL					
100' east of McDonald's Restaurant, Rte. 25	01/27/06	Flesh	2.96 ± 0.43	0.79 ± 0.06	
		Liver*	3.08 ± 0.47	0.17 ± 0.03	
		Bone			2.15 ± 0.22
Smith Rd., Ridge	11/01/06	Flesh	3.22 ± 0.47	4.00 ± 0.39	
		Liver	1.43 ± 0.25	1.03 ± 0.10	
		Bone			3.89 ± 0.44
William Floyd Pkwy., 1 mile north of Whiskey Road	11/08/06	Flesh	3.30 ± 0.43	3.06 ± 0.09	
		Liver	2.57 ± 0.30	0.62 ± 0.06	
		Bone			2.62 ± 0.37
Woodlot Rd. and Rte. 25	11/27/06	Flesh	3.38 ± 0.34	0.85 ± 0.04	
		Liver	2.82 ± 0.39	0.22 ± 0.03	
		Bone			1.99 ± 0.32
Averages by Tissue					
Flesh					
Average for all samples (24)			3.54 ± 2.21	1.50 ± 0.53	
BNL on-site average (11)			3.55 ± 1.61	0.82 ± 0.24	
BNL on- and off-site < 1 mile average (20)			3.61 ± 2.05	1.37 ± 0.34	
Off-site average (13)			3.53 ± 1.51	2.08 ± 0.47	
Off-site < 1 mile average (9)			3.67 ± 1.26	2.04 ± 0.25	
Off-site > 1 mile average (4)			3.22 ± 0.84	2.17 ± 0.41	
Liver					
Average for all samples (15)			2.60 ± 2.05	0.45 ± 0.24	
BNL on-site average (8)			2.54 ± 1.32	0.20 ± 0.08	
BNL on- and off-site < 1 mile average (11)			2.64 ± 1.56	0.40 ± 0.13	
Off-site average (7)			2.67 ± 1.11	0.69 ± 0.16	

(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
Off-site < 1 mile average (3)			2.92 ± 0.84	0.94 ± 0.10	
Off-site > 1 mile average (4)			2.48 ± 0.72	0.51 ± 0.12	
Bone					
Average for all samples (21)					2.29 ± 1.41
BNL on-site average (10)					2.19 ± 0.87
BNL on- and off-site < 1 mile average (17)					2.20 ± 1.23
Off-site average (11)					2.38 ± 1.11
Off-site < 1 mile average (7)					2.22 ± 0.86
Off-site > 1 mile average (4)					2.66 ± 0.69

Notes:
All values are shown with a 95% confidence interval.
K-40 occurs naturally in the environment and is presented as a comparison to cesium-137 (Cs-137).
All averages are the arithmetic average and utilize estimated values for ND. Confidence limits are 2σ sigma (95%) propogated error.
Cs-137 = cesium-137
K-40 = potassium-40
ND = Not Detected
Sr-90 - strontium-90
* = estimated value for Cs-137
** = estimated value for Sr-90

has been eliminated through biological processes. The levels of Cs-137 in deer tissue during June through early August are not well known, as there are few vehicle–deer accidents at this time of year.

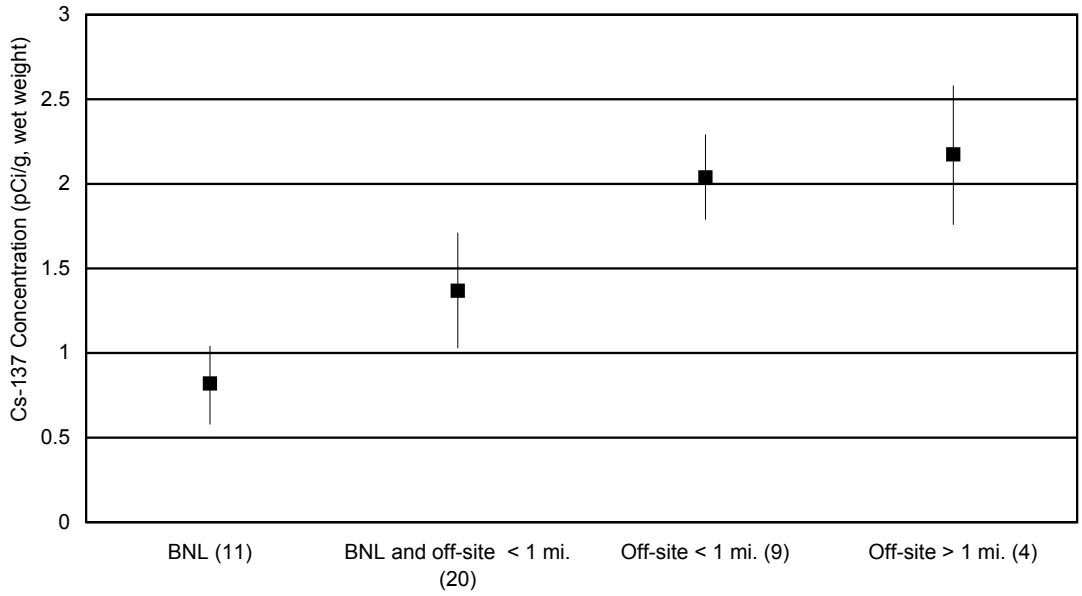
When possible, liver samples are taken concurrently with meat samples. Liver generally accumulates Cs-137 at a lower rate than muscle tissue (meat). The typically lower values in liver allow the results to be used as a validity check for meat values (i.e., if liver values are higher than meat values, results can be considered questionable and should be confirmed). In liver samples collected on site in 2006, Cs-137 concentrations ranged from nondetectable to 1.18 pCi/g wet weight, with an average of 0.20 pCi/g wet weight. The off-site Cs-137 concentration in liver ranged from 0.04 to 2.67 pCi/g wet weight, with an average for all off-site liver samples of 0.69 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 about 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 the IAEA. The deer observed and sampled on site appear to have no health effects from the level of Cs-137 found in their tissues.

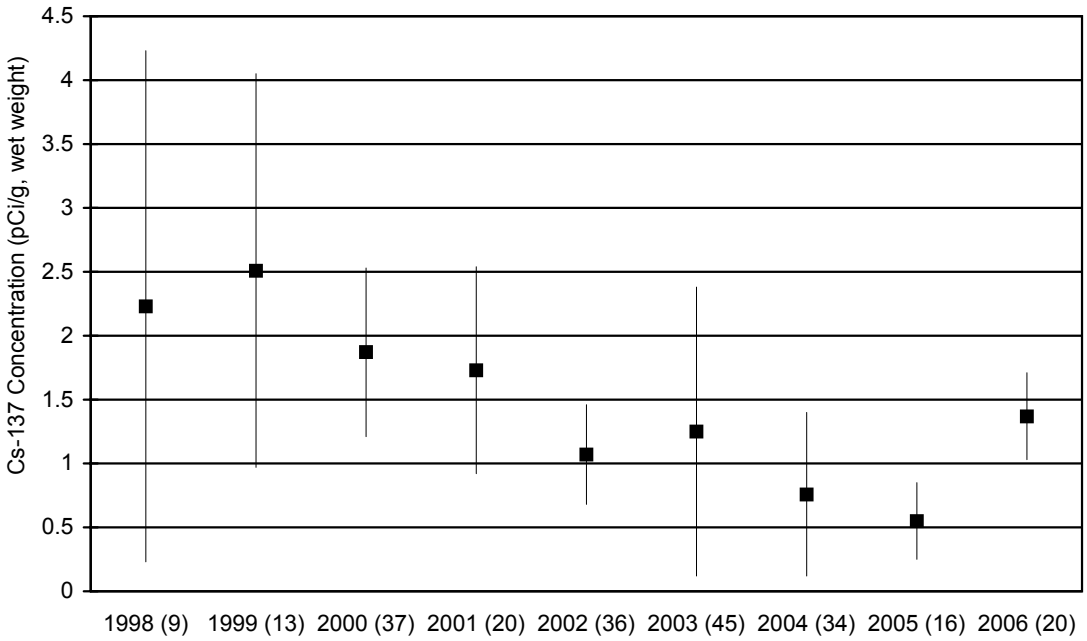
6.3.1.2 Strontium-90 in Deer Bone

BNL began testing deer bones for Sr-90 content in 2000, and continued this analysis in 2006. Sr-90 content ranged from 0.61 to 5.27 pCi/g dry weight in on-site samples. Sr-90 in off-site samples ranged from 0.75 to 3.32 pCi/g



Notes: Averages are shown for samples collected at BNL, on site and off site within 1-mile, off site but within a 1-mile radius, and off site greater than a 1-mile radius.
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. Comparison of Cs-137 Average Concentrations in Deer, 2006.



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

Figure 6-4. Trend of Cs-137 Concentrations in Deer Meat at BNL and Within 1 Mile of BNL, 1998 – 2006.

dry weight in samples taken within 1 mile of BNL, and 1.99 to 3.89 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. BNL will continue to test for Sr-90 in bone to develop baseline information on this radionuclide and its presence in white-tailed deer.

6.3.2 Small Mammal Sampling

BNL continued small mammal sampling in 2006. The original goal of this sampling was to determine the suitability of small mammals, primarily squirrels, as a surrogate for deer sampling. Squirrels are usually readily trapped and tend to eat similar food as deer, but have a much more restricted range and therefore can indicate areas where low levels of contamination may be present. Squirrels were sent to an off-site contract analytical laboratory for dissection and analysis. Meat was separated from the bone and tested for gamma-emitting radionuclides, and the bone was tested for Sr-90. Results of the analyses are presented in Table 6-3. No off-site samples were obtained in 2006. On-site samples contained Cs-137 ranging from 0.12 to 0.86 pCi/g dry weight. Sr-90 values ranged from nondetectable to 0.99 pCi/g dry weight in on-site squirrels. While squirrels appear to be suitable for looking at localized areas, monitoring deer is more appropriate for the larger BNL area. Therefore, continued sampling of small mammals will be assessed and potentially removed from surveillance monitoring.

6.3.3 Other Animals Sampled

Occasionally, other animals such as wild turkey or Canada geese are found dead along the roads of the Laboratory and the immediate vicinity due to road mortality and are tested. In 2006, a single goose was sampled (see Table 6-3). Muscle from the goose was analyzed for Cs-137 content, with a value reported at nondetectable levels.

6.3.4 Fish Sampling

In collaboration with the NYSDEC Fisheries Division, BNL maintains an ongoing program for collecting and analyzing fish from the Peconic River and surrounding freshwater bodies. Annual on-site sampling has depleted the number of large fish. To obtain a sample large enough to complete all analyses desired, multiple small fish would be needed. The Laboratory suspended most on-site sampling in 2001, and population surveys continue to indicate that population levels on site are still insufficient to conduct full-

Table 6-3. Radiological Analyses of Small Mammals (Squirrels) and Other Animals.

			Cs-137	K-40	Sr-90
Location	Sample Date	Species	pCi/g, Dry Weight		
BNL					
Bldg. 729	07/12/06	Squirrel	0.86 ± 0.09	13.1 ± 1.34	ND
IPE	06/28/06	Squirrel*	0.34 ± 0.07	9.11 ± 1.15	0.18 ± 0.07
Bldg. 729	03/08/06	Squirrel	0.12 ± 0.05	11.24 ± 1.17	0.99 ± 0.16
Rutherford Dr.	03/24/06	Goose**	ND	3.51 ± 0.69	ND

Notes:
* Values for Sr-90 concentration was reported as an estimated value by the contract analytical laboratory.
** Values reported for geese are wet weight, except for Sr-90.
K-40 occurs naturally in the environment and is presented as a comparison to Cs-137.
All values are presented with a 95% confidence interval.
Cs-137 = cesium-137
IPE = Industrial Park East
K-40 = potassium-40
Sr-90 = strontium-90

scale annual sampling and analysis. On-site fish were sampled in 2004 when the river was dewatered for the Peconic River cleanup project. Flow was returned to the river in the spring of 2005, but the area experienced drought conditions toward the end of the summer. Natural flow to the river resumed after heavy rains in October 2005. Four fish were sampled on site in 2006 near gauging station HQ, adjacent to North Street. However, due to the size of the fish, not all requested analyses could be obtained. One reason for the lack of fish population growth is likely due to low levels of dissolved oxygen within slow-moving stretches of the Peconic River. Low dissolved oxygen levels during summer months force fish to move to other locations where oxygen is more abundant. The on-site population of fish will be reassessed in 2007, and samples will be taken if the fish populations have sufficiently recovered. BNL is assessing the need to move fish sampling to either earlier or later in the year, to periods when dissolved oxygen levels are higher and will support the presence of fish.

As in the past, off-site fish sampling continued in 2006. All samples were analyzed for edible (fillet) content of each of the analytes reported. In 2006, various species of fish were collected off site from Swan Pond, Donahue's Pond, Forge Pond, Manor 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 Cold Spring Harbor Fish Hatchery and Museum. Eighty-five samples were taken, representing eight species of fish.

6.3.4.1 Radiological Analysis of Fish

The species collected for radiological analysis in 2006 by the Laboratory and through contract labor included brown bullhead (*Ictalurus nebulosus*), chain pickerel (*Esox niger*), largemouth bass (*Micropterus salmoides*), bluegill (*Lepomis macrochirus*), golden shiner (*Notemigonus crysoleucas*), brown trout (*Salmo trutta*), and black crappie (*Pomoxis nigromaculatus*). Gamma spectroscopy analysis was performed on all samples. Table 6-4 presents specific information on the sampling location, species collected, and analytical results. All sample results are presented as wet weight concentrations. Because Sr-90 is deposited only in bone, and only fillets were tested, no Sr-90 data is presented. Information on the natural radioisotope K-40 is included as a comparison.

Cs-137 was detected at low levels in all samples from the Peconic River system, ranging from nondectable levels in golden shiners, chain pickerel, and largemouth bass, to 0.38 pCi/g wet weight in chain pickerel from Donahue's Pond. In 2006, all fish taken from Lower Lake on the Carmans River (the non-Peconic control location) had estimated levels of Cs-137 below the minimum detection limit (MDL) and are shown in Table 6-4 as ND (nondetectable).

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 0.21 pCi/g wet weight; values for brown bullhead at the control location had nondetectable levels of Cs-137. Largemouth bass from the Peconic River showed Cs-137 levels of 0.19 pCi/g wet weight or less; Cs-137 was nondetetable in largemouth bass from the control location. Levels of Cs-137 in all fish species appear to be declining, compared with historic values.

Though it is clear from discharge records and sediment sampling that past BNL operations have contributed to anthropogenic (human-caused) radionuclide levels in the Peconic River system, most of these radionuclides 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 Sewage Treatment Plant (STP) to the Peconic River between 2003 and 2006 (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

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

Species	K-40 (pCi/g, wet weight)	Cs-137 (pCi/g, wet weight)
BNL, On Site		
No Radiological Analysis in 2006 due to poor sample size.		
Manor Road		
Brown bullhead	3.56 ± 0.93	0.21 ± 0.07
Donahue's Pond		
Chain pickerel 1	3.46 ± 1.08	0.33 ± 0.08
Chain pickerel 2	3.89 ± 1.18	0.23 ± 0.08
Chain pickerel 3	3.74 ± 1.14	0.38 ± 0.11
Chain pickerel 4	4.45 ± 0.90	0.36 ± 0.06
Chain pickerel 5	4.29 ± 1.35	0.21 ± 0.08
Bluegill*	2.92 ± 0.95	0.16 ± 0.06
Brown bullhead*	3.72 ± 1.05	0.14 ± 0.06
Golden shiner*	4.39 ± 1.13	0.12 ± 0.08
Forge Pond		
Black crappie*	2.71 ± 0.93	0.13 ± 0.05
Bluegill*	3.93 ± 1.49	0.18 ± 0.08
Largemouth bass 1*	3.65 ± 1.37	0.19 ± 0.18
Largemouth bass 2	2.80 ± 1.48	ND
Largemouth bass 3	2.29 ± 1.76	ND
Chain pickerel 1*	3.74 ± 0.99	0.16 ± 0.08
Chain pickerel 2	3.98 ± 1.02	ND
Chain pickerel 3	2.68 ± 1.38	ND
Chain pickerel 4*	3.64 ± 1.64	0.11 ± 0.05
Chain pickerel 5*	3.23 ± 0.99	0.11 ± 0.05
Golden shiner	3.05 ± 0.85	ND
Swan Pond		
Brown bullhead 1		
Largemouth bass	3.34 ± 1.04	0.11 ± 0.08
Chain pickerel	3.76 ± 1.20	ND
Golden shiner	3.75 ± 1.14	ND
Lower Lake, Carmans River (control location)		
Largemouth bass	3.25 ± 1.26	ND
Brown bullhead	3.08 ± 1.15	ND
Brown trout	3.49 ± 0.94	ND

Notes:
All samples analyzed as edible portions (fillets) except samples of golden shiner, which were analyzed as whole body composite samples.
K-40 occurs naturally in the environment and is presented as a comparison to Cs-137.
Cs-137 = cesium-137
K-40 = potassium-40
ND = Not Detected
* = estimated value for Cs-137 based on analytical laboratory qualifiers

approximately 88 percent of Cs-137 in the sediment that was co-located with mercury. Removal of this contamination should result in further decreases in Cs-137 levels in fish.

6.3.4.2 Fish Population Assessment

As mentioned earlier, BNL suspended fish sampling on site in 2001 because prior fish sampling had depleted the population and limited the remaining fish to smaller sizes. Attempts to capture and sample fish in 2006 were made during routine fish sampling. Due to low dissolved oxygen levels, only a few fish were caught. Low oxygen levels tend to force fish to either migrate to waters with higher oxygen content or result in death. Since there were no documented fish "die-offs," biologists assume that fish have moved away from areas of low oxygen located on site. Therefore, no additional attempts were made to assess on-site fish populations.

6.3.4.3 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. Since 2002, analysis has been limited to off-site fish. The timing of sampling has varied from year to year, as well as the sample preparation (whole-body, tissue separation, composite sampling). In 1997, sampling was performed during April through May; in 1999, sampling was performed during September through December. Since 2000, sampling has been 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.

Table 6-5 shows the 2006 concentration of metals in fish. According to NYSDEC, none of the metal concentrations were considered

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

Location/Species	Barium	Chromium	Copper	Iron	Manganese	Mercury	Zinc
	mg/kg						
BNL, On site							
Largemouth bass	<MDL	0.128	<MDL	2.05	<MDL	0.458	4.75
Brown bullhead	0.132	0.372	0.292	9.4	0.238	0.2	5.09
Chain pickerel	<MDL	0.145	0.387	10.3	<MDL	0.386	9.96
Chain pickerel	0.199	0.196	0.353	7.46	0.777	0.624	14
Manor Road							
Brown bullhead 1	<MDL	0.13	<MDL	4.23	<MDL	0.776	4.14
Brown bullhead 2	<MDL	<MDL	0.445	4.1	<MDL	0.341	3.57
Brown bullhead 3	0.178	<MDL	<MDL	4.72	0.255	0.625	4.33
Brown bullhead 4	<MDL	0.114	<MDL	3.1	<MDL	0.398	3.51
Brown bullhead 5	0.113	<MDL	<MDL	5.76	<MDL	0.341	5.66
Donahue's Pond							
Bluegill 1	0.352	0.218	<MDL	3.16	0.81	0.123	5.72
Bluegill 2	<MDL	0.213	<MDL	2.3	0.23	0.060	5.3
Bluegill 3	<MDL	0.211	<MDL	2.5	0.465	0.088	6.39
Bluegill 4	<MDL	0.171	<MDL	3.68	0.255	0.141	4.82
Bluegill 5	<MDL	0.19	<MDL	2.49	<MDL	0.16	6.03
Brown bullhead 1	0.125	0.213	<MDL	4.85	0.235	0.111	3.96
Brown bullhead 2	0.211	0.188	0.568	9.27	0.204	0.138	4.62
Brown bullhead 3	<MDL	0.198	<MDL	5.42	<MDL	0.112	3.69
Brown bullhead 4	<MDL	0.221	<MDL	6	<MDL	0.113	3.64
Brown bullhead 5	0.100	0.193	<MDL	9.51	0.27	0.131	5.31
Chain pickerel 1	<MDL	0.198	<MDL	3.46	<MDL	0.431	5.66
Chain pickerel 2	0.332	0.28	<MDL	4.76	2.52	0.278	9.21
Chain pickerel 3	0.449	0.23	<MDL	2.52	1.23	0.488	5.76
Chain pickerel 4	<MDL	0.339	<MDL	4.24	0.352	0.252	8.95
Chain pickerel 5	<MDL	0.313	<MDL	3.44	<MDL	0.119	5.17
Golden shiner 1	0.385	0.307	<MDL	4.3	0.88	0.242	4.93
Golden shiner 2	0.349	0.248	<MDL	11.2	0.847	0.407	4.9
Golden shiner 3	0.104	0.263	<MDL	6.84	0.246	0.396	6.12
Golden shiner 4	0.127	0.285	<MDL	5.31	0.277	0.404	5.68
Golden shiner 5	0.241	0.283	<MDL	21.8	0.77	0.273	6.31
Forge Pond							
Black crappie 1	<MDL	<MDL	<MDL	<MDL	<MDL	0.422	4.46
Black crappie 2	<MDL	<MDL	<MDL	<MDL	<MDL	0.221	6.09
Black crappie 3	<MDL	<MDL	<MDL	<MDL	<MDL	0.174	3.66
Black crappie 4	<MDL	<MDL	<MDL	<MDL	<MDL	0.173	4.14
Black crappie 5	<MDL	<MDL	<MDL	<MDL	<MDL	0.185	4.61
Bluegill 1	0.604	<MDL	<MDL	7.14	1620	0.35	7.83

(continued on next page)

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

Location/Species	Barium	Chromium	Copper	Iron	Manganese	Mercury	Zinc
	mg/kg						
Forge Pond *(continued)*							
Bluegill 2	<MDL	<MDL	<MDL	<MDL	916	0.133	5.03
Bluegill 3	5.41	0.487	<MDL	6.67	39.7	0.123	17.4
Bluegill 4	0.369	<MDL	<MDL	<MDL	0.834	0.332	8.96
Bluegill 5	0.926	<MDL	<MDL	3.94	3.54	0.181	6.88
Largemouth bass 1	<MDL	0.269	<MDL	<MDL	0.486	0.147	5.93
Largemouth bass 2	<MDL	<MDL	<MDL	3.81	<MDL	0.285	3.31
Largemouth bass 3	<MDL	<MDL	<MDL	<MDL	<MDL	0.181	4.33
Chain pickerel 1	<MDL	<MDL	<MDL	3.43	1.47	0.347	7.08
Chain pickerel 2	<MDL	<MDL	<MDL	<MDL	<MDL	0.123	7.58
Chain pickerel 3	<MDL	<MDL	<MDL	16	0.843	0.257	4.05
Chain pickerel 4	<MDL	<MDL	<MDL	<MDL	0.976	0.209	5.75
Chain pickerel 5	<MDL	<MDL	<MDL	<MDL	<MDL	0.16	7.66
Golden shiner 1	0.188	0.137	<MDL	9.3	0.374	0.129	6.57
Golden shiner 2	0.586	0.109	<MDL	<MDL	0.992	0.086	9.91
Golden shiner 3	0.767	0.118	<MDL	5.07	3.77	0.057	10.4
Golden shiner 4	1.09	0.099	<MDL	5.97	4.32	0.122	8.26
Golden shiner 5	0.458	<MDL	<MDL	2.43	1.26	0.105	8.39
Swan Pond							
Bluegill 1	0.614	0.471	<MDL	4.06	3.33	0.042	8
Bluegill 2	<MDL	0.172	<MDL	2.27	3.57	0.041	6.17
Bluegill 3	<MDL	0.115	<MDL	2.69	0.619	0.246	7.23
Bluegill 4	<MDL	0.134	<MDL	2.12	1.73	0.025	5.61
Bluegill 5	<MDL	0.117	<MDL	<MDL	0.253	0.036	5.25
Brown bullhead 1	0.174	0.123	0.288	5.57	0.887	0.039	4.29
Largemouth bass 1	<MDL	0.121	<MDL	2.65	<MDL	0.203	4.43
Largemouth bass 2	<MDL	0.132	<MDL	<MDL	<MDL	0.139	3.96
Largemouth bass 3	<MDL	0.132	1.64	3.51	0.237	0.115	4.34
Largemouth bass 4	<MDL	0.205	<MDL	<MDL	0.408	0.169	4.49
Largemouth bass 5	<MDL	0.113	<MDL	1.92	<MDL	0.121	5
Chain pickerel 1	<MDL	0.141	<MDL	2.11	0.386	0.053	7.23
Chain pickerel 2	<MDL	0.159	<MDL	3.28	0.434	0.082	5.62
Chain pickerel 3	<MDL	0.204	<MDL	4.36	0.876	0.11	11.4
Golden shiner 1	1.03	0.565	383	8.9	6.68	0.023	12.7
Golden shiner 2	0.411	0.133	<MDL	3.27	0.465	0.030	6.49
Golden shiner 3	2.17	0.158	<MDL	6.21	21.7	0.041	11.4
Golden shiner 4	0.264	0.107	<MDL	4.58	2.38	0.045	7.4
Golden shiner 5	0.677	0.114	0.349	2.93	1.24	0.049	8.74

(continued on next page)

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

Location/Species	Barium	Chromium	Copper	Iron	Manganese	Mercury	Zinc
	mg/kg						
Lower Lake, Carmans River (control location)							
Largemouth bass 1	0.289	0.154	<MDL	6.74	0.57	0.094	5.02
Largemouth bass 2	0.143	0.128	<MDL	1.88	<MDL	0.093	4.47
Brown bullhead 1	0.24	0.215	<MDL	6.04	0.258	0.034	5.56
Brown bullhead 2	0.362	0.142	<MDL	5.9	0.559	0.013	5.7
Brown bullhead 3	0.272	0.16	<MDL	9.93	0.888	0.012	5.55
Brown bullhead 4	0.36	0.13	<MDL	4.44	0.249	0.018	4.08
Brown bullhead 5	0.345	0.123	<MDL	3.99	0.484	0.010	4.19
Brown trout 1	0.196	0.147	<MDL	4.58	0.591	0.010	6.37
Brown trout 2	<MDL	0.114	0.409	2.31	<MDL	0.006	4.78
Bluegill 1	0.295	0.415	<MDL	3.83	0.529	0.031	6.2
Bluegill 2	<MDL	0.115	<MDL	<MDL	0.27	0.029	6.24
Bluegill 3	<MDL	0.115	<MDL	<MDL	<MDL	0.023	5.59
Bluegill 4	<MDL	0.116	<MDL	<MDL	<MDL	0.018	6.25
Bluegill 5	0.579	0.121	<MDL	<MDL	3.07	0.040	7.97

Notes:
See Figure 5-8 for sampling locations.
All fish were analyzed as edible portions (fillets) except golden shiners, which were analyzed as whole body-composite samples.
MDL = Minimum Detection Limit

capable of affecting the health of consumers of such fish. Due to the fact that values for arsenic, beryllium, cadmium, cobalt, silver, thallium, selenium, and vanadium were near or less than the MDL for the analytical procedure, they were not included in Table 6-5. Other metals tested but not included in the table include aluminum, antimony, lead, and nickel, as most values reported for these metals were less than the MDL. Values that were above the MDL are discussed below.

Due to its known health effects, mercury is the metal of highest concern. Mercury in on-site Peconic River samples ranged from 0.46 mg/kg to 0.62 mg/kg. Off-site Peconic River samples ranged from 0.02 mg/kg in bluegill and golden shiner to 0.78 mg/kg in a brown bullhead taken from the Manor Road area. The highest mercury value in the control location on the Carmans River was 0.09 mg/kg. All mercury values were less than the 1.0 mg/kg consumption standard set by the U.S. Food and Drug Administration.

Values for metals not shown in Table 6-5 because they were at or near MDL were as follows: antimony was found in a various species in levels between 0.40 and 1.7 mg/kg throughout the Peconic River; arsenic was found in three fish samples between 0.46 mg/kg in the Peconic River and 0.56 mg/kg in trout from the Carmans River; cadmium was found at 0.33 mg/kg in bluegill taken at Forge Pond; lead was found in a brown bullhead and golden shiners from Donahue's Pond at levels of 0.11 and 0.15 mg/kg, respectively; nickel was recorded in fish in Peconic River fish at levels between 0.01 and 0.22 mg/kg; selenium was found in two bluegills taken from the Carmans River at 0.49 and 0.56 mg/kg; and silver was found in a chain pickerel from Donahue's Pond at 0.29 mg/kg. These reported values and those presented in Table 6-5 are not considered to pose any health risks to humans or other animals that might consume fish.

Table 6-6 shows the results of pesticide and PCB analyses in fish. Only samples and compounds with detectable results are presented. Concentrations of DDE and DDD, which are breakdown products of the pesticide DDT, were found in low levels in both on- and off-site fish

Table 6-6. Pesticide and PCB Analyses of Fish from the Peconic River System and Carmans River, Lower Lake.

Location/Species	4,4'-DDE	4,4'-DDD	4,4'-DDT	Aroclor-1242	Aroclor-1254	Aroclor-1260
	µg/kg					
Donahue's Pond						
Bluegill 3	<MDL	<MDL	<MDL	48.6	37.5	13.9*
Bluegill 5	<MDL	<MDL	6.15*	<MDL	<MDL	<MDL
Brown bullhead 1	3.49*	<MDL	<MDL	<MDL	<MDL	<MDL
Brown bullhead 2	3.59*	<MDL	<MDL	<MDL	<MDL	<MDL
Brown bullhead 3	10.7	4.21*	<MDL	<MDL	<MDL	<MDL
Brown bullhead 4	<MDL	<MDL	<MDL	51.2	26.8	11.3*
Chain pickerel 1	17.9	<MDL	<MDL	<MDL	<MDL	<MDL
Chain pickerel 5	<MDL	<MDL	<MDL	91.3	52.4	23.3
Forge Pond						
Bluegill 2	15.2	<MDL	<MDL	<MDL	<MDL	<MDL
Swan Pond						
Largemouth bass 5	<MDL	<MDL	<MDL	<MDL	17.3*	<MDL
Chain pickerel 3	2.61*	<MDL	<MDL	<MDL	<MDL	<MDL
Golden shiner 1	15.7	<MDL	<MDL	<MDL	<MDL	<MDL
Golden shiner 2	13.4	<MDL	<MDL	<MDL	308	<MDL
Golden shiner 3	12.9	<MDL	<MDL	<MDL	<MDL	<MDL
Lower Lake, Carmans River (control location)						
Brown bullhead 3	22.6	12.4	11.1	<MDL	<MDL	<MDL

Notes:
Only locations with samples showing detectable levels of pesticides and PCBs are presented.
All fish analyzed as edible portions (fillets) except for golden shiner, which were analyzed as whole body-composite samples.
MDL = Minimum Detection Limit
PCB = Polychlorinated biphenyls

sampled in 2006. DDT was reported for only two samples: the larger amount was from the control location outside BNL influence, and the other was a low concentration estimated by the contract analytical laboratory. The levels of pesticides detected did not exceed any established health standards for the consumers of such fish and thus are not considered harmful. DDT was commonly used on Long Island before 1970.

PCBs were found at levels above the MDL in three fish samples taken from Donahue's Pond and one sample taken from Swan Pond. Aroclor-1242 ranged from 48.6 µg/kg in bluegill to 91.3 µg/kg in chain pickerel taken from Donahue's Pond. Aroclor-1254 ranged from an estimated value of 17.3 µg/kg in a largemouth bass taken in Swan Pond to 308 µg/kg in a golden shiner from Swan Pond. Aroclor-1260 ranged from and estimated 11.3 µg/kg in a brown bullhead to 23.3 µg/kg in a chain pickerel, both from Donahue's Pond. 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.

6.3.5 Aquatic Sampling

6.3.5.1 Radiological Analysis

Annual sampling of sediment, vegetation, and

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

Location /Sample type	K-40	Cs-137
	pCi/g Dry Sediment	
Donahue's Pond		
Sediment**	2.58 ± 0.67	0.31 ± 0.06
Vegetation*	1.04 ± 0.18	0.03 ± 0.01
Forge Pond		
Sediment**	2.42 ± 0.76	0.29 ± 0.06
Lilypad*	2.75 ± 0.36	0.03 ± 0.02
Swan Pond		
Sediment**	3.86 ± 1.11	ND
Lilypad	3.74 ± 0.53	ND
Lower Lake, Carmans River (control location)		
Sediment**	1.68 ± 1.02	ND
Vegetation	1.82 ± 0.63	ND

Notes:
Cs-137 = cesium-137
K-40 = potassium-40
ND = Not detected
* Cs-137 values estimated based on contract analytical laboratory qualifiers.
** Sediment values reported in pCi/g dry weight.

freshwater in the Peconic River and a control location on the Carmans River was conducted in 2006. See Chapter 5 for a discussion on water quality and monitoring, and Figure 5-8 for 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.

Table 6-7 summarizes the radiological data. Low levels of Cs-137 were documented in sediments and vegetation at Donahue's and Forge Ponds, while samples taken at Swan Pond and Lower Lake on the Carmans River lacked detectable levels.

6.3.5.2 Metals in Aquatic Samples

Metals analyses (Table 6-8) were conducted on aquatic vegetation and sediments from the Peconic River and Carmans River. Most of the data indicate metals at background levels. The standard used for comparison of sediments is the soil cleanup objectives for heavy metals supported by SCDHS. Vegetation results are compared to soil cleanup standards, because metals in vegetation may accumulate via uptake from sediment. In general, metals are seen in vegetation at levels lower than in associated sediment.

Off site, levels of arsenic were detected in sediments at Forge pond at 764 mg/kg (not shown in Table 6-8). Additionally, lead was found above SCDHS action levels at Swan Pond and Forge Pond. No other metals were found above action levels or cleanup objectives in off-site portions of the Peconic River or Lower Lake on the Carmans River.

6.3.5.3 Pesticides and PCBs in Aquatic Samples

Pesticides and PCBs were found in only three aquatic samples taken in 2006 during routine surveillance; therefore, no table is necessary for reporting. Aroclor-1254 and Aroclor-1260 were detected in lilypads taken from Forge Pond at 27.8 and 9.9 µg/kg, respectively. The 9.9 µg/kg value is an estimated value based on laboratory qualifiers. Aroclor-1254 was detected at an estimated level of 9.70 µg/kg in sediments taken from Swan Pond. The pesticide DDT and one of its breakdown products, DDE, were found in sediments from Donahue's Pond at levels of 90.1 and 59.7 µg/kg, respectively. The value for DDE (59.7 µg/kg) was an estimated value based on laboratory qualifiers. In general, DDT and its breakdown products appear to be slowly declining. Routine vegetation and sediment samples were not taken from on-site portions of the Peconic River, due to extensive post-cleanup monitoring associated with cleanup efforts.

6.3.6 Peconic River Post-Cleanup Monitoring

Sediment from the Peconic River was remediated in 2004 and 2005 to remove mercury and associated contaminants from the river. The cleanup of sections of the river on site focused on sediment in known depositional areas. The goal of the cleanup was to reduce the average mercury concentrations on site to less than

Table 6-8. Metals Analyses 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	Vanadium	Zinc
							mg/kg						
Donahue's Pond													
Sediment	1960	15.9	1470	3.53	0.986	45.5	2330	4.1	76.3	0.005	2.74	5.79	21
Vegetation	406	34.3	351	0.974	0.651	1.63	1050	2.6	622	0.019	0.543	1.44	30
Forge Pond													
Sediment	1270	8.47	113	1.59	0.266	1.46	2450	3090	13.4	0.011	0.594	2.3	9.2
Lilypad	<MDL	6.19	711	0.138	<MDL	<MDL	33.3	<MDL	38.6	0.003	0.108	<MDL	5.64
Swan Pond													
Sediment	3390	17.7	691	4.66	<MDL	0.517	498	3890	244	0.009	0.583	4.43	4.17
Lilypad	<MDL	17.8	1970	0.136	<MDL	<MDL	18.2	<MDL	95.6	0.004	0.134	<MDL	3.11
Lower Lake, Carmans River (control location)													
Sediment	1130	9.97	305	3.68	0.796	2.28	1990	0.75	34.3	0.34	1.68	3.03	9.68
Vegetation	248	52.2	1130	1.67	0.436	1.44	1020	6.3	912	0.011	1.48	1.05	9.19

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

1 mg/kg, with an overall goal to reduce mercury concentrations in the remediated areas, both on site and off site, to less than 2 mg/kg. Onsite remediation efforts resulted in a 96 percent reduction in average mercury concentrations in river sediments, from approximately 4.6 mg/kg to 0.2 mg/kg (Envirocon, 2005).

Cleanup of off-site locations focused on a more stringent cleanup target that would allow the greatest flexibility for use as County parkland or for potential development. Sediment was removed from ponded areas where methylation leading to bioaccumulation is most likely to occur, as well as other areas containing higher concentrations of contamination east of the BNL property line to Connecticut Avenue. The cleanup goal was to reduce mercury concentrations within the sediment to less than 0.75 mg/kg, with an overall goal of mercury concentrations to less than 2 mg/kg following the cleanup. Off-site remediation efforts resulted in a 95 percent reduction in average mercury concentrations in river sediments downstream of the BNL property line, from approximately 1.8 mg/kg to 0.09 mg/kg, excluding the Manor Road area, which had an 83 percent reduction, from 1.08 mg/kg to 0.19 mg/kg (Envirocon, 2005).

The Laboratory and DOE are committed to a multi-year post-cleanup sampling of sediment, surface water, fish, and wetland restoration. Sampling results for 2006 are summarized below. Detailed information on 2006 sampling results can be found in the 2006 Peconic River Monitoring Report (BNL, 2007).

6.3.6.1 Sediment Sampling

Sediment was sampled in June at 16 Peconic River sampling stations on site and 14 sampling stations off site. Ninety-three percent of samples analyzed for mercury met the cleanup goal of 2.0 mg/kg. Two samples exceeded the 2.0 mg/kg goal and another sample was close to the goal. The sample results were shared with NYSDEC, EPA, and SCDHS. In August 2006, five additional sediment samples were taken from the three stations where concentrations had been higher than 2.0 mg/kg. The August sample results were substantially lower than those obtained in

June, although several of the samples surrounding each of the three stations still exceeded 2.0 mg/kg. Additional sampling procedures to characterize the nature and extent of contamination were prepared for implementation in 2007.

6.3.6.2 Water Column Sampling

Surface water was analyzed for total mercury and methylmercury at 20 Peconic River sampling stations and one reference station on the Connetquot River (see Figure 6-5). Samples were taken in both June and August. Concentrations of total mercury were generally less than the 2005 concentrations upstream of Schultz Road, but generally greater than the 2004 mercury concentrations downstream of Schultz Road. In each of the sampling events, the mercury concentration increased from upstream of the Sewage Treatment Plant (STP) outfall to downstream of the STP outfall, then generally decreased continuing downstream from the STP. August samples were generally greater than the June 2006 levels upstream of Schultz Road, with concentrations less than the June concentrations downstream of Schultz Road. In August, low water levels prevented samples from being taken at stations both upstream and downstream of the east boundary off site. Effluent from the STP is a potential low-level mercury source that may contribute to the elevation of mercury concentrations in the Peconic River surface water between stations PR-WC-12 (upstream of the STP outfall) and PR-WC-11 (downstream of the STP outfall). Additional surface water monitoring of the STP effluent will be conducted to evaluate its potential contribution of mercury, methylmercury, and total suspended solids (TSS) to mercury concentrations in the Peconic River.

6.3.6.3 Fish Sampling

In 2006, fish were collected from three sampling stations; Area D near North Street, the Manor Road area, and Donahue's Pond. Comparing 1997 and 2006 data indicated that the average mercury concentrations in fish were very similar at the BNL site boundary at North Street (0.36 mg/kg and 0.42 mg/kg, respectively). At Manor Road, the 2006 concentration (0.50 mg/kg) was higher than the 1997 concentration (0.32 mg/kg). At Donahue's Pond, the 2006 mercury concentrations in fish tissue were substantially lower (0.22 mg/kg) than in 1997 (0.32 mg/kg). The average concentration of mercury in all fish caught at North Street, Manor Road, and Donahue's Pond was 0.3 mg/kg. The EPA criterion for methyl mercury concentration in fish tissue is 0.3 mg/kg.

The average PCB concentration in fish in 2006 for all three locations was below the detection limit; this was a substantial improvement over the 1997 concentration of PCBs found in fish. All 2006 samples analyzed for cesium-137 were also substantially lower than values found in fish in 1997.

6.3.6.4 Wetland Sampling

The wetland monitoring results for 2006 are summarized in Section 5 of the 2006 Peconic River Monitoring Report (BNL, 2007) and detailed in Attachment B of that report. BNL's success at meeting the DEC permit equivalency conditions detailed in the On-Site Peconic River Restoration Program Permit Equivalency Application (Louis Berger, 2004a) and the Off-Site Peconic River Restoration Program Permit Equivalency Application (Louis Berger, 2004b) are discussed below.

As of September 2006, the Laboratory met and exceeded the DEC Equivalency Permit requirements for "cover" growth in on-site marshy areas. A target percent cover of 65 percent in the low marsh was achieved, with an overall average for all 64 transects of 92 percent. No low marsh cleanup area had less than 79 percent cover, and percent cover of invasive species was less than the permit limit of 10 percent in any one wetland restoration. This was achieved with an average percent cover (for permit-specified invasive wetlands plants) of less than 1 percent across all cleanup areas.

In 2007, DEC will tour the Peconic River wetlands and evaluate whether the Permit Equivalency conditions have been met there. Monitoring of invasive species will continue until 2008, at which time DEC will evaluate whether BNL has met the Permit Equivalency requirement for less than 10 percent cover by invasive species in any one remediated area.

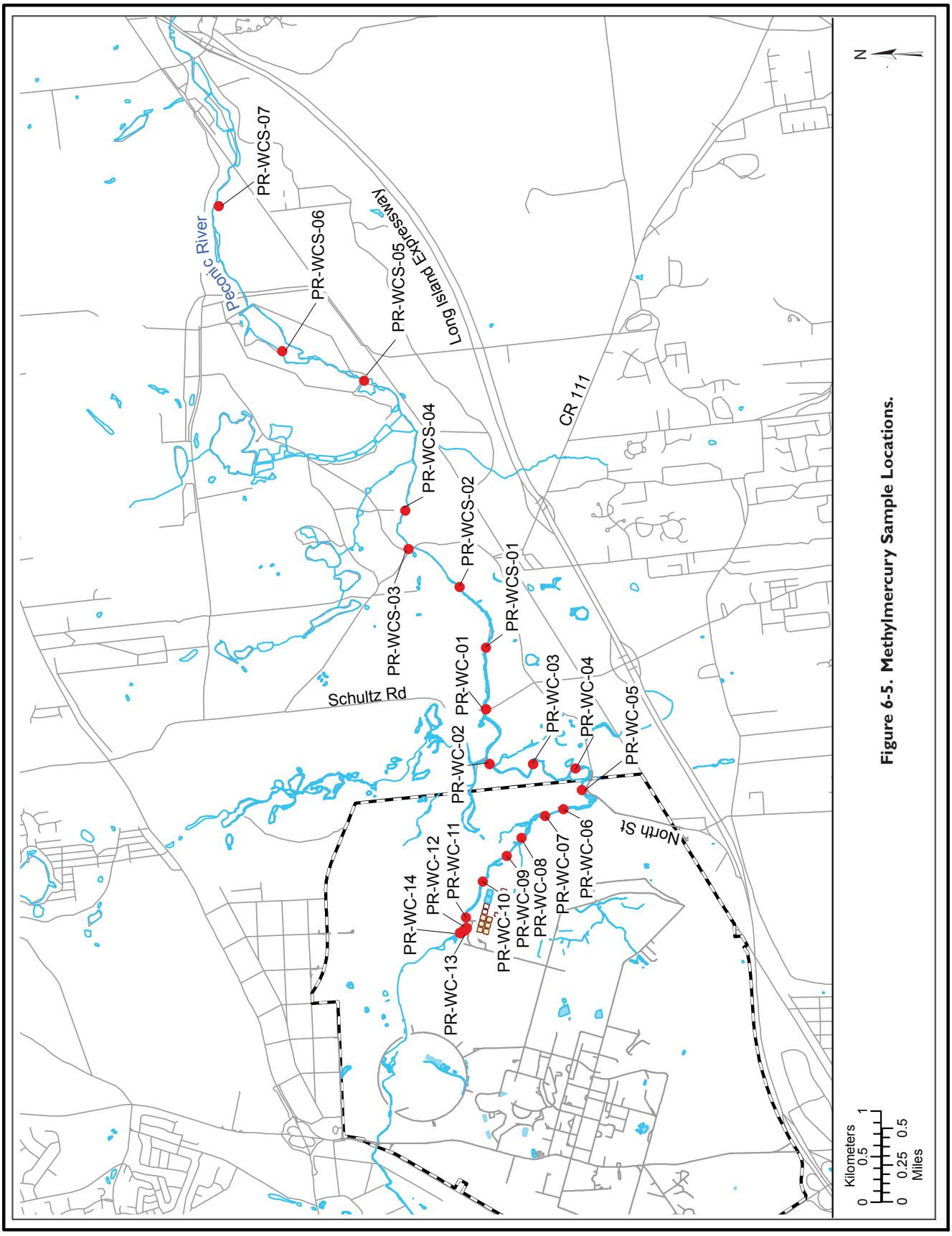


Figure 6-5. Methylmercury Sample Locations.

6.3.7 Vegetation Sampling

6.3.7.1 Garden Vegetables

On-site sampling of garden vegetables continued in 2006. Samples of zucchini, cucumber, tomato, pepper, and eggplant were analyzed for Cs-137 content. The radionuclide was not detected in any vegetable sample, but was detected in soils at very low levels (0.23 pCi/g). Sampling of off-site farm vegetation was discontinued in 2003 because historical data have consistently indicated the absence of BNL-related radionuclides in off-site vegetation. Periodic confirmatory sampling (approximately every five years) will be conducted off site to obtain data on farm vegetables.

6.3.7.2 Grassy Plants

In 2003, grassy vegetation sampling was converted to a graded approach and was linked to other sampling programs. As an example of this approach, vegetation sampling would be conducted only if routine air sampling indicated that radionuclides had been released and deposited on soil and vegetation. Periodic confirmatory sampling of grassy vegetation will be conducted approximately every five years. Grassy vegetation will be sampled on site in 2007.

As part of post-cleanup monitoring for the former Hazardous Waste Management Facility, five terrestrial and two aquatic vegetation samples were acquired. Cs-137 was detected at an estimated value of 0.14 pCi/g dry weight in one of the aquatic vegetation samples. It was not detected in any of the other six samples.

6.4 OTHER MONITORING

6.4.1 Soil Sampling

Soil sampling uses the same graded approach as that used for grassy vegetation sampling and was removed from the basic monitoring protocols in 2003. Confirmatory soil sampling will be conducted every five years. Confirmatory soil sampling will be conducted on site in 2007, in association with vegetation sampling.

6.4.2 Basin Sediments

A five-year testing cycle for basin sediment samples was established in 2003. There are 14 basins associated with outfalls that receive discharges permitted under the State Pollutant Discharge Elimination System (SPDES) permit (see Figure 5-6 for outfall locations). The next round of basin sampling will occur in 2007 in order to stagger periodic five-year sampling.

6.4.3 Chronic Toxicity Tests

Under the SPDES discharge permit, BNL conducted chronic toxicity testing of the STP effluents. Results of this testing are discussed in Chapter 3, Section 3.6.1.1. Testing will continue in 2007.

6.4.4 Radiological Monitoring of Precipitation

As part of the BNL Environmental Monitoring Program, precipitation samples were collected quarterly at air monitoring Stations P4 and S5 (see Figure 4-3 for station locations), and were analyzed for radiological content. Four samples were taken from each of these two stations in 2006. Gross alpha activity measurements above the MDL at 0.91 pCi/L were detected at the S5 station in the fourth quarter sample only.

Gross beta activity was measured in samples in all four quarters from both stations. 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 4.5 pCi/L, with an average of 3.6 pCi/L. Location S5 had a maximum gross beta activity level of 4.9 pCi/L, with an average of 3.9 pCi/L. Gross beta activity values were within the range of values historically observed at these two locations. No radionuclide-specific analyses indicated values above MDL.

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 BNL in collaboration with DOE, local agencies, colleges, and high schools. Ecological research is also conducted on site to update the current natural resource inventory, gain a better understanding of the ecosystem, and guide management planning.

In 2006, the Environmental and Waste Management Services Division (EWMSD) and FERN hosted a total of 24 interns and two faculty members. Interns consisted of one high school intern, 13 undergraduate interns, and four school teachers during the summer. FERN also hosted six undergraduate interns for their Forest Health Monitoring Program. Seven of the undergraduate interns worked with faculty members from North Carolina Agricultural and Technical University and Southern University at New Orleans, as part of the Faculty and Student Teams Program. Interns worked on a variety of projects: surveying dragonflies and damselflies, radio tracking turtles, analyzing the water chemistry of coastal plain ponds, investigating turtle and amphibian diseases, investigating the loss of the southern leopard frog on Long Island, genetics of resident gray and red fox at BNL, effects of insect damage on chlorophyll production in oak trees, and studying various ecological aspects of forest health. Teachers also participated in preparing and carrying out a week-long workshop in environmental monitoring under a new program, the Open Space Stewardship Program, which is managed by the BNL Office of Education Programs. A limited discussion concerning each project is presented below.

An intern in the Community College Internship (CCI) program continued work on the identification and distribution of dragonflies and damselflies (Order *Odonata*) that was started in 2003 and expanded the project to study the feasibility of using simple mark-recapture techniques for determining population estimates of dragonflies. These aquatic insects are common around the ponds and Peconic River on site. The distribution of aquatic invertebrates may be useful for monitoring the health of aquatic systems. In addition, results from the Odonate surveys will supplement the New York State Odonate Atlas. The intern increased the number of species identified from 55 to 60. The state atlas project will continue for another year, as will the Laboratory's surveys for Odonates.

In 2005, three eastern box turtles were found in one of BNL's many ponds. All three turtles had a fairly common infection of the ear. The turtles were taken to a wildlife rehabilitator for treatment and care. Two of the turtles subsequently died of their infections and their tissues were sent for analysis. In the analysis, an iridovirus implicated in amphibian declines was isolated. This resulted in a summer intern project in which samples from eastern box turtles were taken for virus identification and a radio telemetry study was conducted to look at range overlap. Range overlap is important to determine the potential for infected turtles to encounter non-infected turtles and transmit the virus. The study was conducted by an intern from Maine and provided indication of significant territorial overlap between individual turtles within a given area. This poses a potential problem if any of the turtles is carrying a virus.

In the Science Undergraduate Laboratory Intern (SULI) program, two interns from Wesleyan College and the University of Maryland looked at the distribution of the southern leopard frog and chytrid fungus on Long Island. The southern leopard frog has had precipitous population declines, and the focus was to attempt to find existing populations of this frog and to document whether or not chytrid fungus is present in other frog species across Long Island. Unfortunately, there were no southern leopard frogs found in any of the water bodies investigated, and no clear connection as to what may have caused the loss of this species on Long Island.

The two Faculty and Student Teams (FaST) conducted tests of four on-site ponds and the upper reaches of the Peconic River to look at chemical differences of soil and sediments as it relates to water quality variations among ponds and different portions of the Peconic River. Documentation of differences between various ponds on site is used to understand their use by various amphibian species, especially the endangered eastern tiger salamander. Differences in the various areas of the Peconic River is important in understanding the dynamics of this system and the potential effects of acid rain on the greater Pine Barrens ecosystem.

Associated with this study was a continuing effort by three teachers in the Lab Science Teacher Professional Development (LSTPD) program. This project involves obtaining water quality data from all ponds on site. In 2006,

the teachers continued working with the FaST teams to use GPS and GIS to enhance their data. They also developed a week-long workshop under the Open Space Stewardship Program (OSSP) called "Gaining Research Experience in the Environment (GREEN) Institute," where they shared their expertise with approximately 20 teachers participating in OSSP so they could discuss the program within their home schools. The OSSP is expected to grow throughout Suffolk County to foster a sense of stewardship in students and to gather much-needed environmental data on numerous open space parcels throughout the county.

A fourth teacher working in the LSTPD program studied the effects of insect damage on leaves and the production of chlorophyll. This study helps ecologists understand the impacts of insect defoliators that have repeatedly been infesting oak trees at BNL. Insect defoliation has resulted in high tree mortality in hundreds of acres of oak forest in the Central Pine Barrens.

A student from the University of Rhode Island worked on a project to isolate genetic material from fox droppings. This non-invasive genetic technique is being utilized to look at the interrelatedness of numerous fox families living on site, and to try to distinguish between red and gray fox. The gray fox is known to live on site, but is rarely seen. Once thought to be extirpated from Long Island, a gray fox that had been struck by a car was found on site in 2005. Using non-invasive genetics techniques may also allow researchers to estimate population size and distribution of these two species.

Tiger salamanders continue to be a topic for research at the Laboratory. In 2006, a student from the Community College of Rhode Island spent the spring and summer months at BNL looking at various characteristics of ponds and vernal pools. The pond characteristics were compared to juvenile recruitment of metamorphic tiger salamanders. The work is part of a larger project being carried out as a dissertation project by a graduate student from Binghamton University.

As part of the tiger salamander research, a high school student completed a project on the distribution of small mammals around one of the more productive tiger salamander ponds, due to documentation of a relatively high mortality in tiger salamanders that appears to be related to small mammals. The documentation of small mammals around the pond can be compared to the use of small mammal burrows by tiger salamanders, perhaps increasing an understanding of the relationship and the resulting mortality.

FERN hosted six summer students who conducted Forest Health Monitoring in the Long Island Central Pine Barrens. The students were able to establish an additional 41 permanent monitoring plots throughout the pine barrens, gather data, analyze it, and produce five separate projects. Their scientific posters, forest health monitoring protocols, and the associated database are available on the FERN website at www.fern-li.org . The various projects dealt with different aspects of forest health or the ability to gather accurate information. Students evaluated differences in leaf litter among forest types, differences in understory composition and age class structure of the various forest types, differences in soil pH among different forest types, differences in snag (dead limb) density among forest types, and effects of overstory canopy on understory density. The final report on this project is expected to provide significant information resulting in recommendations for forest management throughout the Pine Barrens.

Members of EWMSD and other BNL departments volunteered as speakers for schools and civic groups and provided on-site ecology tours. EWMSD also hosted several environmental events in association with Earth Day. In October, BNL hosted the Eleventh Annual Pine Barrens Research Forum for ecosystems researchers to share and discuss their results.

The Laboratory also hosted the annual Wildland Fire 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. In October 2006, a second

prescribed fire was conducted on site. This fire treated approximately 15 acres to improve germination and recruitment of oak seedlings. It also reduced fine-textured forest fuels that tend to increase the severity of wildfires. Pre-fire monitoring was conducted before the fire was started, and post-fire monitoring indicated the fire was conducted properly for its intended purpose. Additional post-fire monitoring in 2007 will be conducted to determine the effectiveness of the fire in promoting oak recruitment. The Laboratory intends to continue the use of prescribed fire for fuel and forest management in the future, and is working with NYSDEC and The Nature Conservancy to prepare additional prescriptions for a larger portion of the northern and eastern sections of the BNL 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 (CRMP) for Brookhaven National Laboratory (BNL, 2005), which guides the management of all of BNL's historical resources, was approved by DOE in March 2005. 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, archives of photos, audio, and video, and institutional records. As various cultural resources are identified, plans for their long-term stewardship are developed and implemented. Achieving these goals ensures 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 complex, the High Flux Beam Reactor 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.

Compliance activities performed in 2006 included completing a National Historic Preservation Act (NHPA) Section 106 review of the remaining Camp Upton–era buildings at BNL. The review determined that none of the structures were eligible for listing on the National Register. An NHPA Section 106 Determination of Effects was performed to address decommissioning of the High Flux Beam Reactor (HFBR). The decommissioning action was determined to have "Adverse Effects" for its historical status, as defined by the NHPA regulations. Therefore, the Laboratory and DOE will be entering into consultation with the New York State Historic Preservations Officer (SHPO) to discuss ways of mitigating the adverse effects to this historic resource.

In accordance with the guidelines prescribed in the BNL CRMP, an archaeological survey of the proposed site of NSLS-II was performed in December 2006. A total of 356 shovel test pits were dug over the 24-acre area. Based on the results of the survey, no further archaeological investigations were recommended (Merwin and Manfra 2007).

Cultural resource management concepts were strengthened by integrating specific strategies into the Laboratory's maintenance planning and scheduling programs.

Outreach activities consisted of providing presentations on Laboratory cultural resources and tours of the WWI trenches to several small groups, and participating in local fairs. An article featuring BNL cultural resources was published in the DOE newsletter 'Partners In Preservation', April 2006 edition.

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