



Local students participating in the 'Day-in-the-Life' program sponsored by BNL's Office of Education Programs.

Chapter 6

Natural and Cultural Resources



The Brookhaven National Laboratory (BNL) Natural Resource Management Program (NRMP) 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 maintaining compliance with applicable regulations.

The goals of the program include protecting and monitoring the ecosystems, conducting research, and communicating with personnel and the public on ecological issues. BNL focuses on protecting both Federal and 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 the program. In 2023, deer, vegetation, and soil sampling results were consistent with previous years' results.

The overriding goal of the Cultural Resource Management Program is to ensure that proper stewardship of BNL 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 for research and interpretation. The Cultural Resource Management Plan (CRMP) was updated in 2023 and reporting in this chapter fulfills reporting requirements specified in the CRMP.

6.1

Natural Resource Management Program (NRMP)

The NRMP at BNL promotes stewardship of the natural resources found at the Laboratory and integrates natural resource management and protection with BNL's scientific mission. The NRMP describes the program strategy, elements, and planned activities for managing the various natural resources found on-site. The NRMP is updated every five years, with the most recent update completed in 2021 (BNL 2021).

6.1.1 Identification and Mapping

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

Mapping associated with tracking impacts from the operation of the Long Island Solar Farm (LISF) at BNL continues to use GPS and GIS as tools to analyze changes to wildlife populations and vegetation. In 2020, the Lab secured a contract with an aerial imaging service that provides high-definition images that are updated three times each year. This service allows tracking of visually evident changes in vegetation, hydroperiod, and infrastructure. The service includes aerial imagery dating back to 2014.

A wide variety of vegetation, birds, reptiles, amphibians, and mammals inhabit the BNL site. Through implementation of the NRMP, endangered and threatened species, as well as species of special concern, have been identified as having been resident at BNL during the past 30 years or are expected to be present on-site (see

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

Federal and New York State Threatened & Endangered Species, Species of Special Concern, & Species of Greatest Conservation Need			
Common Name	Scientific Name	Status	BNL Status
Insects			
Comet darter	<i>Anax longipes</i>	SGCN	Confirmed
Frosted elfin	<i>Callophrys iris</i>	T	Likely
New England bluet	<i>Enallagma laterale</i>	SGCN	Likely
Little bluet	<i>Enallagma minusculum</i>	T	Likely
Scarlet bluet	<i>Enallagma pictum</i>	T	Likely
Pine Barrens bluet	<i>Enallagma recurvatum</i>	T	Confirmed
Mottled duskywing	<i>Erynnis martialis</i>	SC	Likely
Persius duskywing	<i>Erynnis persius persius</i>	E	Likely
Pine barrens zanclognatha	<i>Zanclognatha martha</i>	SGCN	Confirmed
Black-bordered lemon moth	<i>Marimatha nigrofimbria</i>	SGCN	Confirmed
Fish			
Banded sunfish	<i>Enneacanthus obesus</i>	T	Confirmed
Swamp darter	<i>Etheostoma fusiforme</i>	T	Confirmed
Amphibians			
Marbled salamander	<i>Ambystoma opacum</i>	SC	Confirmed
Eastern tiger salamander	<i>Ambystoma tigrinum tigrinum</i>	E	Confirmed
Fowler's toad	<i>Bufo fowleri</i>	SGCN	Confirmed
Four-toed salamander	<i>Hemidactylium scutatum</i>	SGCN	Confirmed
Eastern spadefoot toad	<i>Scaphiopus holbrookii</i>	SC	Confirmed
Reptiles			
Worm snake	<i>Carphophis amoenus</i>	SC	Confirmed
Snapping turtle	<i>Chelydra serpentina</i>	SGCN	Confirmed
Spotted turtle	<i>Clemmys guttata</i>	SC	Confirmed
Northern black racer	<i>Coluber constrictor</i>	SGCN	Confirmed
Eastern hognose snake	<i>Heterodon platyrhinos</i>	SC	Confirmed
Stinkpot turtle	<i>Sternotherus odoratus</i>	SGCN	Confirmed
Eastern box turtle	<i>Terrapene carolina</i>	SC	Confirmed
Eastern ribbon snake	<i>Thamnophis sauritus</i>	SGCN	Confirmed
Birds (nesting, transient, or potentially present)			
Cooper's hawk	<i>Accipiter cooperii</i>	SC	Confirmed
Sharp-shinned hawk	<i>Accipiter striatus</i>	SC	Confirmed
Great egret	<i>Ardea alba</i>	SGCN	Confirmed
Whip-poor-will	<i>Caprimulgus vociferus</i>	SC	Confirmed
Northern harrier	<i>Circus cyaneus</i>	T	Confirmed
Black-billed cuckoo	<i>Coccyzus erythrophthalmus</i>	SGCN	Confirmed
Northern bobwhite	<i>Colinus virginianus</i>	SGCN	Confirmed
Prairie warbler	<i>Setophaga discolor</i>	SGCN	Confirmed
Perigrine Falcon	<i>Falco peregrinus</i>	E	Confirmed
Bald Eagle	<i>Haliaeetus leucocephalus</i>	T	Confirmed
Wood thrush	<i>Hylocichla mustelina</i>	SGCN	Confirmed
Red-headed woodpecker	<i>Melanerpes erythrocephalus</i>	SC	Confirmed
Osprey	<i>Pandion haliaetus</i>	SC	Confirmed
Scarlet tanager	<i>Piranga olivacea</i>	SGCN	Confirmed
Glossy ibis	<i>Plegadis falcinellus</i>	SGCN	Confirmed
Brown thrasher	<i>Toxostoma rufum</i>	SGCN	Confirmed
Blue-winged warbler	<i>Vermivora pinus</i>	SGCN	Confirmed

(continued on next page)

Table 6-1). New York State endangered animal species confirmed as currently inhabiting Laboratory property include the eastern tiger salamander (*Ambystoma t. tigrinum*) and the peregrine falcon (*Falco peregrinus*).

Endangered plants that have been confirmed on the BNL site include Engelmann spikerush (*Eleocharis engelmannii*), Ipecac spurge (*Euphorbia ipecacuanhae*), and dwarf huckleberry (*Gaylussacia bigeloviana*). Five other New York State endangered species have been identified at BNL in the past or are possibly present including: Persius duskywing (*Erynnis p. persius*), crested fringed orchid (*Plantathera cristata*), prostrate knotweed (*Polygonum aviculare* ssp. *buxiforme*), bracken fern (*Pteridium aquilinum* var. *pseudocaudatum*), and possum hawk (*Viburnum nudum* var. *nudum*).

Eight threatened species in New York State have been positively identified on-site and three other species are considered likely to be present. Threatened species include: two fish (banded sunfish [*Enneacanthus obesus*] and swamp darter [*Etheostoma fusiforme*]); three plants (stiff-leaved goldenrod [*Oligoneuron rigida*], stargrass [*Aletris farinosa*], and eastern showy aster [*Eurybia spectabilis*]); the northern harrier (*Circus cyaneus*) is periodically seen in the fall; and the bald eagle (*Haliaeetus leucocephalus*) is routinely seen visiting the site.

Insects listed as threatened include the Pine Barrens bluet (*Enallagma recurvatum*), a damselfly which was confirmed at one of the many coastal plain ponds located on-site. Two other damselflies, the little bluet (*Enallagma minusculum*) and the scarlet bluet (*Enallagma pictum*), are likely to be present at one or more of the ponds on-site. The frosted elfin (*Callophrys irus*), a butterfly, has been historically present on-site due to its preferred habitat and host plant, wild lupine (*Lupinus perennis*),

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

Federal and New York State Threatened & Endangered Species, Species of Special Concern, & Species of Greatest Conservation Need			
Common Name	Scientific Name	Status	BNL Status
Mammals			
Northern long-eared bat*	<i>Myotis septentrionalis</i>	FE	Confirmed
Plants			
Small-flowered false foxglove	<i>Agalinis paupercula</i>	R	Confirmed
Stargrass	<i>Aletris farinosa</i>	T	Confirmed
Butterfly weed	<i>Asclepias tuberosa</i> ssp. <i>interior</i>	V	Confirmed
Spotted wintergreen	<i>Chimaphila maculata</i>	V	Confirmed
Flowering dogwood	<i>Cornus florida</i>	V	Confirmed
Pink lady's slipper	<i>Cypripedium acaule</i>	V	Confirmed
Ground pine	<i>Dendrolycopodium obscurum</i>	V	Confirmed
Round-leaved sundew	<i>Drosera rotundifolia</i> var. <i>rotundifolia</i>	V	Confirmed
Marginal wood fern	<i>Dryopteris marginalis</i>	V	Confirmed
Engelman spikerush	<i>Eleocharis engelmannii</i>	E	Confirmed
Ipecac spurge	<i>Euphorbia ipecacuanhae</i>	E	Confirmed
Eastern showy aster	<i>Eurybia spectabilis</i>	T	Confirmed
Dwarf huckleberry	<i>Gaylussacia bigeloviana</i>	E	Confirmed
Winterberry	<i>Ilex verticillata</i>	V	Confirmed
Sheep laurel	<i>Kalmia angustifolia</i>	V	Confirmed
Narrow-leaved bush clover	<i>Lespedeza angustifolia</i>	R	Confirmed
Wild lupine	<i>Lupinus perennis</i>	R	Confirmed
Whorled loosestrife	<i>Lysimachia quadrifolia</i>	E	Confirmed
Bayberry	<i>Myrica pensylvanica</i>	V	Confirmed
Stiff-leaved goldenrod	<i>Oligoneuron rigida</i>	T	Confirmed
Cinnamon fern	<i>Osmunda cinnamomea</i>	V	Confirmed
Clayton's fern	<i>Osmunda claytoniana</i>	V	Confirmed
Royal fern	<i>Osmunda regalis</i>	V	Confirmed
Crested fringed orchid	<i>Plantanthera cristata</i>	E	Likely
Green fringed orchid	<i>Platanthera lacera</i>	V	Confirmed
Prostate knotweed	<i>Polygonum aviculare</i> ssp. <i>buxiforme</i>	E	Possible
Bracken fern	<i>Pteridium aquilinum</i> var. <i>pseudocaudatum</i>	E	Possible
Swamp azalea	<i>Rhododendron viscosum</i>	V	Confirmed
Long-beaked bald-rush	<i>Rhynchospora scirpoides</i>	R	Confirmed
New York fern	<i>Thelypteris novaboracensis</i>	V	Confirmed
Marsh fern	<i>Thelypteris palustris</i> var. <i>pubescens</i>	V	Confirmed
Possum haw	<i>Viburnum nudum</i> var. <i>nudum</i>	E	Possible
Virginia chain-fern	<i>Woodwardia virginica</i>	V	Confirmed

Notes: Information based on 6 NYCRR Part 182, 6 NYCRR Part 193, and BNL survey data.

E = endangered, T = threatened, SC = species of special concern, R = rare, V = exploitably vulnerable, SGCN = species of greatest conservation need, FT = federally threatened, FE = federally endangered, *NLEB up-listed to federally endangered 03/31/23

however, little lupine remains, and it is therefore unlikely this species can be found on-site.

A number of other species that are listed as rare, of special concern, or exploitably vulnerable by New York State either currently inhabit the site, visit during migration, or have been identified historically. BNL has one federally endangered species, the northern long-eared bat (*Myotis septentrionalis*), that has been found within the forests of the Lab.

6.1.2 Habitat Protection and Enhancement

BNL has administrative processes in place to protect on-site habitats and natural resources. Activities to eliminate or minimize negative effects on endangered, threatened, or sensitive species are either incorporated into Laboratory procedures or into specific programs or project plans. Human access to critical habitats, when necessary, is limited, and habitats are enhanced to improve survival or increase populations. Routine activities, such as road maintenance, are not performed until the planned activities have been evaluated and determined to be unlikely to affect habitat.

6.1.2.1 Salamander Protection Efforts

Many safeguards are in place to protect eastern tiger salamander breeding areas. BNL natural resource staff must review any project planned near eastern tiger salamander habitats and every effort is made to minimize impacts. A map of the breeding areas is reviewed when new projects are proposed. The current map incorporates buffer areas around tiger salamander habitats of 1,000 feet based on guidance from the New York State Department of Environmental



Conservation (NYSDEC). Other efforts to protect this state endangered species include determining when adult salamanders are migrating toward breeding locations, when metamorphosis has been completed, and when juveniles are migrating after metamorphosis.

Water quality testing is conducted as part of the routine monitoring of recharge basins, as discussed in Chapter 5. In cooperation with the NYSDEC, habitat surveys have been routinely conducted since 1999. Biologists conducting egg mass and larval surveys have confirmed that 26 on-site ponds are used by eastern tiger salamanders. In 2023, most ponds were either dry or frozen over and thus could not be surveyed. Only two ponds could be surveyed with documentation of thirty-two egg masses.

6.1.2.2 Banded Sunfish

Banded sunfish protection efforts include observing whether adequate water is present within areas currently identified as sunfish habitat, ensuring that vegetation in their habitat is not disturbed, and evaluating all activities taking place in ponds and the Peconic River on-site for potential impacts on these habitats. Drought conditions that lasted from 2015 through fall 2023 likely resulted in the extirpation of the banded sunfish from the BNL site. The single known habitat held water throughout 2018 and by 2019 the pond had totally dried. A short survey by NYSDEC personnel in 2019 did not find sunfish in the pond. No additional effort has been made regionally with regard to the banded sunfish in 2023.

6.1.2.3 Migratory Birds

A total of 216 species of birds have been identified at BNL since 1948; at least 85 species are known to nest on-site. Some of these nesting birds have shown declines in their populations nationwide over the past 30 years. The Laboratory conducts routine monitoring of songbirds along seven permanent bird survey routes in various habitats on-site.

In 2023, monthly surveys were conducted starting at the end of April and extending through the end of August. These surveys identified 81 bird species which was a significant increase from the 67 species identified in 2022 and 2021. A total of 138 bird species have been identified in surveys in the past 24 years. Variations in the number and species identified during each survey may reflect the time of observation, variations in weather patterns between years, and possible changes in the environment.

The three most diverse transects on-site are by the LISF, the Peconic River, and through the eastern forested portion of the BNL property. The transects passing through the various forest types on-site (e.g., white pine, pine oak forest, and red maple-mesic heath forest) showed a less diverse bird community. Bird survey data are stored in an electronic database for future reference and study. Little data on the effects of a large, utility scale solar array such as the LISF are present within scientific literature. To assess the effects of the LISF on local bird populations, the collection of migratory bird data in both the Biology Field and Solar Farm transects is important. The LISF vegetation and the way it is managed may play a key role as habitat for migratory birds. The eastern bluebird (*Sialia sialis*) has been identified as a declining species of migratory birds in North America. This is due to loss of habitat and nest site competition from European starlings (*Sturnus vulgaris*) and house sparrows (*Passer domesticus*). BNL's NRMP includes habitat enhancement for the eastern bluebird.

Since 2000, the Laboratory has installed more than 60 nest boxes around open grassland areas on-site to enhance their population. The LISF created nearly 200 acres of suitable habitat for the eastern blue bird. Forty boxes were installed around the northern-most portions of the LISF and are routinely used by bluebirds, house wrens, and tree swallows. Bluebirds have also benefited from natural nesting habitat resulting from the 2012 wildland fire that led to significant tree mortality. Bluebirds have been documented annually within the burned area since 2019.

Migratory birds occasionally cause safety and health concerns, particularly Canada geese (*Branta canadensis*) and several species of migratory birds that occasionally nest on buildings or in construction areas on-site. To control the goose population, the Laboratory manages nesting through egg oiling under an annual permit from the U.S. Fish & Wildlife Service.

The population was estimated at approximately 48 birds in spring 2023 going into nesting season. With successful nest management and continued reductions from early and regular hunting seasons, the number of geese on-site at the end of 2023 was around four dozen.

6.1.2.4 Bald Eagle

The bald eagle (*Haliaeetus leucocephalus*) has been increasing in population locally on Long Island with more than a dozen known nest sites on Long Island. In 2023, bald eagles were sighted numerous times in the area of the Sewage Treatment Plant (STP), the cell tower, and near the National Weather Service offices. As the eagle population increases on Long Island, the potential for them to nest on the BNL site will increase as well.

6.1.2.5 Northern Long-eared Bat

As discussed in Section 6.1.1, the northern long-eared bat was federally listed as endangered in 2023. The activities most likely to impact this bat on the BNL site are building demolitions, any project involving tree clearing, and forest management activities such as prescribed fires, mechanical treatments, and forest thinning. Inspections for the presence of bats in buildings are typically conducted via visual surveys approximately 24 hours prior to demolition to verify the absence of bats. In 2023, two buildings were demolished, and there was no impact to bats.

In 2023 four projects required formal consultation with the U.S. Fish & Wildlife Service because they involved tree removal and resulted in the issuance of a Biological Opinion and Statement of Incidental Take.

Two prescribed fires were conducted in 2023 for a total of 37 acres burned and 23 acres were mechanically treated during the dormant season. Acoustic surveys did not yield any northern long-eared bat detections in these areas. The need to continue bat monitoring will likely increase in the future as the little brown bat (*Myotis lucifugus*) and tri-colored bat (*Perimyotis subflavus*) have also been petitioned for listing.

6.1.3 Population Management

6.1.3.1 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 one 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 optimal circumstances. This was the approximate density in 1966, when BNL reported an estimate of 267 deer on-site (Dwyer 1966). The Laboratory has been conducting routine population surveys of white-tailed deer since 2000.

Deer overpopulation can affect animal and human health (e.g., animal starvation, Lyme disease from deer ticks, and collision injuries to both humans and animals), species diversity (e.g., songbird species reduction due to selective grazing and destruction of habitat by deer), and property damage (e.g., collision damage to autos and browsing damage to ornamental plantings). Deer-related collisions on-site continued to be low in

2023, presumably due to deer harvest as well as more employees working remotely.

High deer populations are a regional problem, and the Laboratory is just one area on Long Island with such an issue. Multiple east end towns are now managing deer populations either through culls (also known as deer harvests), hunting, or sterilization programs. Under BNL's permit for deployment of the 4-Poster™ tick management system issued by NYSDEC, the Laboratory is required to implement a deer management program. BNL has been implementing deer management since 2015 and conducting herd reductions annually since 2019.



4-poster™ tick management system.

In 2023, the herd was estimated at approximately 350 individuals at the beginning of the year and a harvest was planned for two separate weekends in March 2023. A total of 106 animals were taken which effectively brought the population to approximately 244 animals and barely succeeded in meeting the reduction goals of getting below 250 deer. With a reproductive rate at approximately 60 percent, however, the population at the end of 2023 was expected to be back up to nearly 400 individuals.

6.1.4 Compliance Assurance and Potential Impact Assessment

The National Environmental Policy Act (NEPA) review process at BNL ensures that environmental impacts of a proposed action or activity are adequately evaluated and addressed. The Laboratory uses NEPA reviews when identifying potential environmental impacts associated with site activities, especially projects that may result in physical alterations to the landscape and structures. As appropriate, stakeholders such as the Environmental Protection Agency (EPA), NYSDEC, Suffolk County Department of Health Services (SCDHS), BNL's Community Advisory Council (CAC), and the Brookhaven Executive Roundtable are involved in reviewing major projects that have the potential for significant environmental impacts. Formal NEPA reviews are coordinated with the State of New York. An Environmental Assessment for the proposed modification of building 870 to create the Clinical Alpha-Radionuclide Production facility was started in 2023. See Chapter 3, Section 3.3 for more information.

6.2

Upton Ecological and Research Reserve

The Upton Ecological and Research Reserve (Upton Reserve) consists of 530 acres located on the eastern boundary of the BNL site. The reserve has been designated as an area for the protection of sensitive habitats and a place where researchers can study local ecosystems. The Upton Reserve is home to a wide variety of flora and fauna. It contains wetlands and is largely within the core preservation area of the Long Island Central Pine Barrens. Based on information from a 1994-1995 biological survey of the Laboratory, experts believe the reserve is home to more than 200 plant species and at least 162 species of mammals, birds, fish, reptiles, and amphibians (LMS 1995).

The Upton Reserve is managed by BNL which also coordinates research projects that occur within the reserve and the larger Pine Barrens. After successfully establishing a Memorandum of Understanding (MOU) with the State University of New York's School of Environmental Science and Forestry (SUNY-ESF), efforts to revisit the 2005-2006 forest health monitoring program resulted in the completion of monitoring during summer 2020 (see education programs below). The MOU with SUNY-ESF allows for greater levels of research within the Central

Pine Barrens and the Upton Reserve. In 2023, a PhD student working with the Department of Sustainable Resources Management at SUNY-ESF began collecting data looking at the effects of fire on tick populations which is expected to continue through 2025.

6.3

Monitoring Flora and Fauna

The Laboratory routinely conducts surveillance monitoring of flora and fauna to determine the effects of past and present activities on-site. Because soil contaminated with a radioactive isotope of cesium (Cs-137) was mistakenly used in some BNL landscaping projects in the past, traces of Cs-137 attributable to past practices and world-wide fallout from above-ground nuclear bomb testing can be found in deer and other animals and plants. At the cellular level, Cs-137 takes the place of potassium (K), an essential nutrient. Most tables in this chapter listing Cs-137 also list analytical results for potassium-40 (K-40), a naturally occurring radioisotope of potassium that is commonly found in flora and fauna. Studies indicate that Cs-137 out-competes potassium when potassium salts are limited in the environment, which is typical on Long Island. Including K-40 in tables allows for a comparison with Cs-137 levels and is used, in part, to determine the accuracy of analytical results. The results of the annual sampling conducted under the flora and fauna monitoring program are described in the following sections.

6.3.1 Deer Sampling

White-tailed deer in New York State are typically large, with males weighing on average approximately 150 pounds; females typically weigh approximately 100 pounds. However, white-tailed deer on Long Island tend to be much smaller, weighing an average of 80 pounds. The meat available for consumption from local deer ranges from 20 to 40 pounds per animal. Samples of meat and liver are taken from each deer, when possible, and are analyzed for Cs-137. Data are reported on a wet-weight basis, as that is the form most likely used for consumption.

Since 1996, BNL has routinely collected deer samples from on- and off-site areas. Most off-site samples are the result of car/deer accidents. The number of samples obtained each year varies depending on accidents between vehicles and deer and people reporting dead deer available for retrieval. In 2023, a total of 20 deer were taken both on and off the BNL site. Figure 6-1 shows the location of all deer samples taken within a five-mile radius of the Laboratory between 2018 and 2023. Most of the off-site samples are concentrated along Route 25 just north of BNL, whereas historically most on-site samples are collected near the Laboratory's main entrance gate and the developed portions of the site. The distribution of deer samples onsite is becoming more uniform across the site due to obtaining samples during annual deer population reduction efforts. Historically, samples tended to be from near the front gate due to collisions with cars entering or leaving the site.

Based on more than two decades of sampling, deer taken from more than one mile from BNL are used for comparison with populations on and near the Laboratory that could acquire Cs-137 from a BNL source.

In 2023, thirteen deer were obtained on-site, of which ten were sampled as part of deer reduction efforts; four deer were taken from off-site less than a mile from BNL, and three deer were taken greater than a mile from BNL, although only the liver was able to be sampled from one of those individuals. The seven off-site deer and three of the on-site deer were due to deer/vehicle collisions. The analytical results of deer sampling are shown in Table 6-2. The samples taken as part of deer population reductions serve a dual purpose to provide data for surveillance and to determine the safe release of meat for consumption. Every tenth deer taken was sampled for Cs-137 content in both meat and liver.

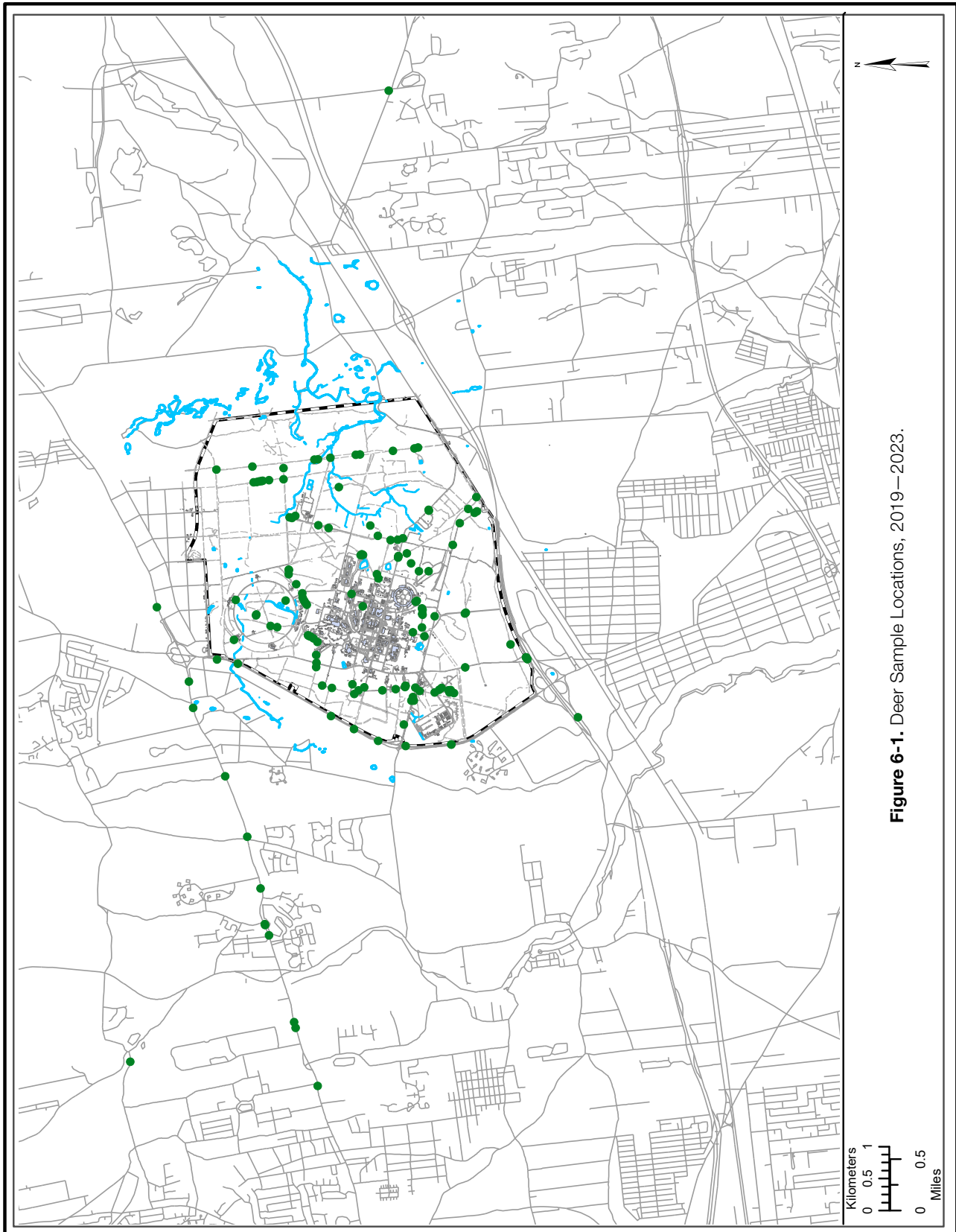


Figure 6-1. Deer Sample Locations, 2019–2023.

6.3.1.1 Cesium-137 in White-Tailed Deer

Based on historic and current data, white-tailed deer sampled at or near the Laboratory contain higher concentrations of Cs-137 than deer from greater than one mile off-site. This is most likely because the deer graze on vegetation growing in soil where elevated Cs-137 levels are known to exist. Cs-137 in soil can be transferred to above-ground plant matter via root uptake, where it then becomes available to browsing and grazing animals or is consumed directly with soil while the animal is grazing.

Remediation of contaminated soil areas on-site occurred under the Laboratory's Comprehensive Environmental Response, Compensation & Liability Act (CERCLA) program, with all major areas of contaminated soil being remediated by September 2005.

In 2023, Cs-137 concentrations in deer meat samples were obtained from 13 deer on-site with a range of values from non-detect to 0.21 pCi/g, wet weight, and an arithmetic average of 0.08 pCi/g, wet weight, as shown in Table 6-2. The wet weight concentration is before a sample is dried for analysis and is the form most likely to be consumed. Dry weight concentrations are typically higher than wet weight values. The highest on-site sample in 2023 (0.21 pCi/g, wet weight) was roughly 85 percent lower than the highest on-site sample reported in 2022 (1.40 pCi/g, wet weight) and 56 times lower than the highest level ever reported in 1996 (11.74 pCi/g, wet weight). Higher values in deer are usually seen during the fall months immediately after plants stop growing and uptake ceases. By January, cesium has usually been excreted.

Cs-137 concentrations in off-site deer meat samples are typically separated into two groups: samples taken within one mile of BNL (four samples in 2023) and samples taken farther away (two samples in 2023) shown in Table 6-2. Concentrations in meat samples taken within one mile of the Lab ranged from 0.04 pCi/g to 0.24 pCi/g, wet weight, with an arithmetic average of 0.14 pCi/g. Because deer on-site may routinely travel up to one mile off-site, the arithmetic average for deer taken on-site and within one mile of the Laboratory is also calculated; for 2023, this average of 17 samples was 0.09 pCi/g. Deer taken greater than one mile from the Lab ranged from 0.06 to 0.08 pCi/g, wet weight, with the arithmetic average being 0.07 pCi/g, wet weight. The deer with the highest value of Cs-137, 0.24 pCi/g, wet weight, was in a deer taken less than a mile from the Laboratory.



Deer visiting a 4-poster™ device.

Table 6-2. Radiological Analysis of Deer Tissue (2023).

Location	Date	Distance Miles	Organ	K-40 pCi/g (Wet Weight)	Cs-137 pCi/g (Wet Weight)
BNL					
East side of Renaissance Rd	1/4/23	0	flesh	2.73±0.26	0.21±0.02
			liver	2.12±0.15	0.04±0.01
Bldg. 830 Renaissance Rd	1/19/23	0	flesh	2.75±0.28	0.05±0.01
			liver	2.36±0.28	N2
BNL Cull Sample 1, Brookhaven Center	3/4/23	0	flesh	2.36±0.29	N2
			liver	2.36±0.30	0.01±0.01
BNL Cull Sample 2, RHIC Center	3/4/23	0	flesh	2.36±0.31	0.03±0.01
			liver	2.36±0.32	ND
BNL Cull Sample 3, East Princeton at RR	3/5/23	0	flesh	2.36±0.33	ND
			liver	2.36±0.34	ND
BNL Cull Sample 4, HO Basin East	3/5/23	0	flesh	2.36±0.35	0.08±0.03
			liver	2.36±0.36	0.03±0.01
BNL Cull Sample 5, East Princeton at Powerline	3/6/23	0	flesh	2.36±0.37	ND
			liver	2.36±0.38	0.01±0.00
BNL Cull Sample 6, North end of Stump Dump	3/6/23	0	flesh	2.36±0.39	0.17±0.03
			liver	2.36±0.40	0.04±0.01
BNL Cull Sample 7, Weaver Rd. Pond	3/24/23	0	flesh	2.36±0.41	N2
			liver	2.36±0.42	ND
BNL Cull Sample 8, RHIC Tank Farm	3/25/23	0	flesh	2.36±0.43	N2
			liver	2.36±0.44	ND
BNL Cull Sample 9, South Side NSLS-II	3/26/23	0	flesh	2.36±0.45	N2
			liver	2.36±0.46	N2
BNL Cull Sample 10, Ball Fields	3/27/23	0	flesh	2.36±0.47	0.06±0.02
			liver	2.36±0.48	0.02±0.01
East Princeton near Solar Farm	6/29/23	0	flesh	2.36±0.49	0.17±0.04
			liver	2.36±0.50	0.13±0.04
< 1 Mile from BNL					
LIE Shoulder exit 68 eastbound	6/10/23	< 1 mile	flesh	3.15±0.38	0.04±0.02
			liver	2.84±0.17	0.02±0.01
South Gate Offsite	7/6/23	< 1 mile	flesh	3.01±0.43	0.09±0.03
			liver	2.32±0.35	0.06±0.02
1/4 mile north of main gate entrance	10/16/23	< 1 mile	flesh	3.55±0.22	0.24±0.02
			liver	2.84±0.21	0.09±0.01
1/4 mile west of WFP on Rt. 25	12/7/23	< 1 mile	flesh	3.07±0.34	0.19±0.02
			liver	2.69±0.35	0.04±0.02
> 1 Mile from BNL					
Rt. 25 West of Artist Lake	3/28/23		liver	1.93±0.16	ND
Rt. 25 just west of All Island Car Wash M.I.	6/5/23	> 1 mile	flesh	3.50±0.39	0.08±0.02
			liver	2.79±0.20	N2
Rt. 25 and Wading River Hollow Rd	6/13/23	> 1 mile	flesh	3.19±0.35	0.06±0.02
			liver	2.48±0.30	ND
Flesh Averages					
All Samples (19)				2.95±0.45	0.09±0.03
BNL Average (13)				2.81±0.48	0.08±0.03
< 1 Mile Average (4)				3.20±0.35	0.14±0.02
BNL + < 1 Mile Average (17)				2.90±0.46	0.09±0.03
> 1 Mile Average (2)				3.35±0.37	0.07±0.02
Cull Average (10)				2.64±0.50	0.06±0.03
Liver Averages					
All Samples (20)				2.48±0.25	0.03±0.01
BNL Average (13)				2.44±0.24	0.03±0.01
< 1 Mile Average (4)				2.67±0.28	0.05±0.02
BNL + < 1 Mile Average (17)				2.49±0.25	0.03±0.02
> 1 Mile Average (3)				2.49±0.23	0.01±0.01
Cull Average (10)				2.31±0.18	0.01±0.01

Notes: All values are shown with a 95% confidence interval
 K-40 Occurs naturally in the environment and is presented as a comparison to Cs-137

All averages are the arithmetic average with confidence limits using a 2 sigma (95%) propagated error.

ND=non-detect

N2=data not useable based on laboratory qualifiers



Figure 6-2 compares the average values of Cs-137 concentrations in meat samples collected in 2023 from on-site, within one mile, combined on-site and within one mile, greater than one mile, and deer taken from culling. Figure 6-3 presents the ten-year trend of on-site and near off-site Cs-137 averages in deer meat. The 2023 average (0.09 pCi/g) is lower than the 2022 value of 0.30 pCi/g, wet weight, and is significantly lower than the ten-year average. The higher averages shown for 2017 and 2018 are reflective of a significant number of samples taken in the fall when Cs-137 levels are typically higher. These sample results continue to indicate the effectiveness of cleanup actions across the Laboratory, with the overall trend being downward from 2013 to 2023, and the ten-year average being 0.44 pCi/g.

The effectiveness of the BNL soil cleanup program and the reduction of Cs-137 in deer meat was evaluated by Rispoli, et al. (2014). The average Cs-137 content was shown to be statistically lower than before cleanup. Samples taken at distances greater than one mile from the BNL site were shown to remain consistent before and after cleanup, while the on-site and near off-site values were shown to decline. In 2017, while preparing for monitoring associated with the reduction of the deer population, the ten-year average for on-site deer samples was calculated to be 1.0 pCi/g, wet weight, and this value was used to establish an administrative release criterion for deer meat made available for donation. When possible, liver samples are taken concurrently with meat samples. The liver generally accumulates Cs-137 at a lower rate than muscle tissue. The typically lower values in liver allow the results to be used as a validity check for meat values (i.e., if liver values are higher than meat values, results can be considered questionable and should be confirmed).

In liver samples collected on-site in 2023, Cs-137 concentrations ranged from non-detect to 0.13 pCi/g, wet weight, with an average of 0.03 pCi/g, wet weight. Cs-137 in liver samples collected less than one mile from site ranged from 0.02 pCi/g to 0.09 pCi/g and averaged 0.05 pCi/g, wet weight. Cs-137 concentrations in liver samples taken from deer greater than one mile from site were determined to be non-detect. 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 risks associated with elevated Cs-137 levels in on-site deer and determined that neither hunting restrictions nor formal health advisories are warranted (NYSDOH 1999).

As mentioned above, BNL has established an administrative release criterion of 1.0 pCi/g, wet weight, for meat from deer removed from the Laboratory and donated for consumption. A total of 106 deer were taken during population reductions in 2023. Meat samples were obtained from every tenth deer. Samples were sent for analysis and are included in Table 6-2.

The results ranged from non-detect to 0.17 pCi/g, wet weight, with the arithmetic average being 0.06 pCi/g, wet weight. Since all samples were well below the 1.0 pCi/g, wet weight administrative limit, all 1,788 pounds of meat were donated to Island Harvest Food Pantry and to a local wildlife rehabilitator. With respect to the health of on-site deer based on their exposure to radionuclides, the International Atomic Energy Agency (IAEA) has concluded that chronic dose rates of 100 millirad per day to even the most radiosensitive species in terrestrial ecosystems are unlikely to cause detrimental effects in animal populations (IAEA 1992). A deer containing a uniform distribution of Cs-137 within muscle tissue at the highest levels observed to date (11.74 pCi/g, wet weight, reported in 1996) would carry a total amount of approximately 0.2 μ Ci. That animal would receive an absorbed dose of approximately 3 millirad per day, which is only three percent of the IAEA threshold. The deer observed and sampled on-site appear to have no health effects from the level of Cs-137 found in their tissues.

Figure 6-2. Comparison of Cs-137 average values in deer flesh for onsite, near off-site, on-site + near off-site, off-site greater than 1 mile from the Laboratory, and from deer population reductions (cull). Ten year average of on-site and near off-site deer flesh samples is 0.44 pCi/g, wet weight.

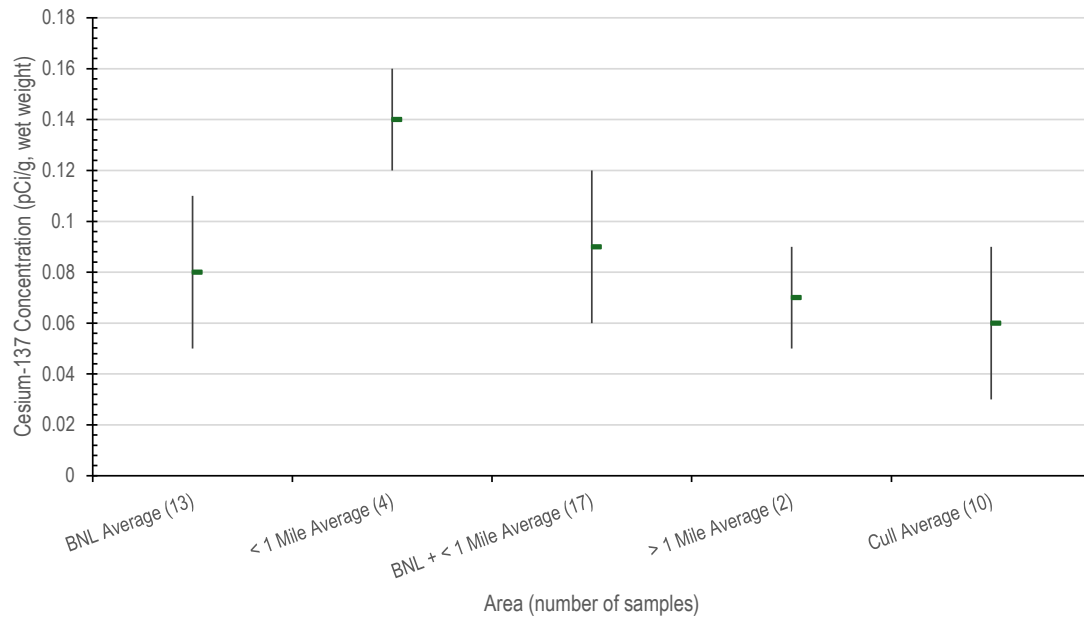
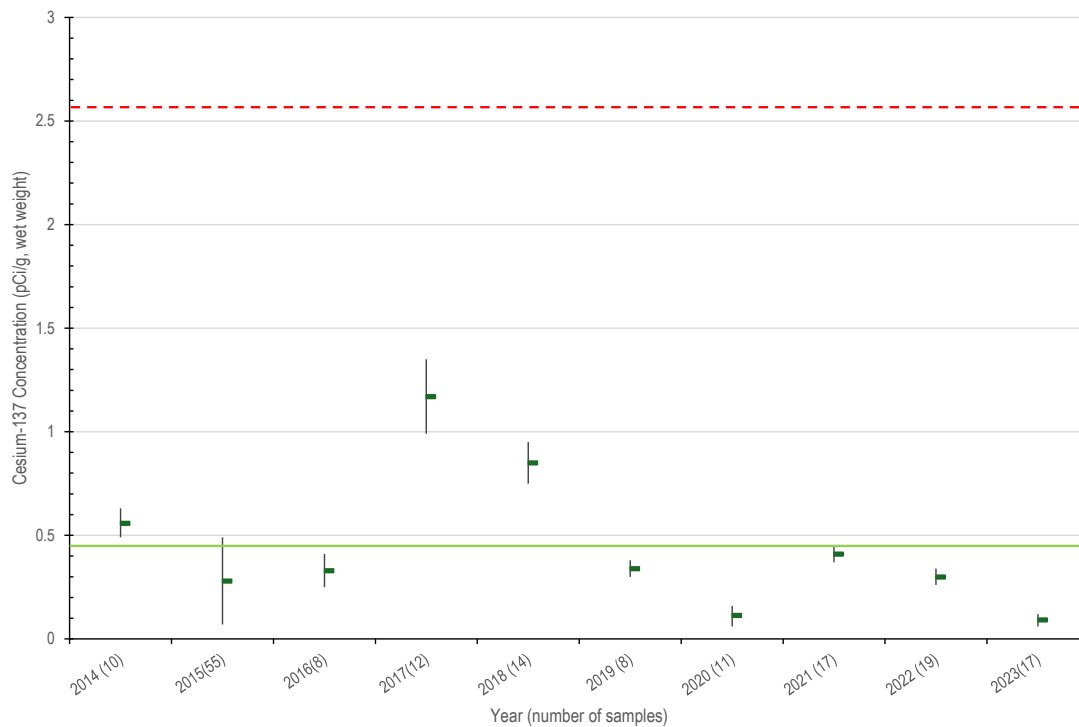


Figure 6-3. Ten year trend in Cs-137 in deer flesh for samples taken at BNL and within 1 mile of the Laboratory. Average before clean-up (dashed line) 2.57 pCi/g wet weight. Ten year average (solid line) 0.44 pCi/g wet weight.



6.3.2 Fish Sampling

BNL maintains an ongoing program for collecting and analyzing fish from the Peconic River and surrounding freshwater bodies. Monitoring of the river has been conducted under the environmental surveillance program and the CERCLA post-cleanup program. Surveillance monitoring had occurred during even-numbered years and post-cleanup monitoring occurred in odd-numbered years. However, with the discontinuance of discharges from the STP to the Peconic River in September 2014 and current lack of flow off-site, the objectives for the fish monitoring program have changed to reflect the current intermittent presence of water in the on-site portions of the river. Fish are now only sampled under the surveillance program when there is enough water to support a sufficient population of fish that can be sampled without harm to their population and that are of sufficient size for analysis.

Based upon the 2016 CERCLA Five-Year Review of the effectiveness of the environmental cleanup and the final supplemental cleanup of a small area within the river during 2017, the Laboratory has discontinued fish monitoring under the CERCLA program. The fish population supported sampling in 2023. However, no individual fish were large enough to meet all of the analysis requirements requested of the analytical laboratory and were therefore sent with several fish making up composite whole-body samples. Two samples were sent for analysis and analyzed for Cs-137, polychlorinated biphenyls (PCBs), and mercury. Both samples were below detection limits for Cs-137 and mercury, and had detections for the PCBs Aroclor-1254 (14.6 and 28 ug/kg) and Aroclor-1260 in one sample with estimated value of 11.2 ug/kg. Both Aroclor-1254 and 1260 were historically used at BNL and known to be present at low levels within Peconic River sediments.

6.3.2.1 Fish Population Assessment

The relative sizes of fish caught during annual sampling events are tracked and modifications to future sampling events are made, as necessary, to ensure long-term health of the on-site fish populations. Successful sampling of sufficiently large fish for analysis from 2008 through 2015, even with low water levels in the on-site portion of the Peconic River, indicated that fish populations could maintain themselves. However, the combination of discontinuing STP discharges to the Peconic River results in high variability in the presence of water and flow sufficient enough to reach off-site portions of the river. In 2019, water levels began to recede, resulting in water being retained only in deeper open water areas. There was no documented off-site flow in 2023.

For fish populations to survive and flourish, water levels must be substantial enough to allow migration of fish and maintain their presence for an extended period to replenish populations. As mentioned above, new criteria for the collection of fish samples have been developed. These criteria will guide the environmental monitoring approach for fish in the future. To determine if enough fish are present to support sampling, population assessments are conducted. In 2023, a population assessment was conducted at the end of May and resulted in the capture of nine pumpkinseed sunfish. The largest fish caught had a length of one hundred and one millimeters, or a little over four inches.

Table 6-3. Radiological Analysis of Grassy Vegetation and Soils (2023).

Location/ Matrix	K-40 pCi/g±95% C.I.	Cs-137 pCi/g±95% C.I.
No-mow Area East of NSLS II		
Vegetation	5.04±1.04	ND
Soil*	7.23±0.95	0.17±0.06
South Boundary at Rail Spur		
Vegetation	4.76±0.97	ND
Soil*	8.13±1.16	0.16±0.06
P7 Area East of LISF		
Vegetation	4.71±0.72	ND
Soil	8.32±1.09	N2
STP New Ponds		
Vegetation	3.20±0.58	ND
Soil	2.94±0.74	ND
STP Old Filter Beds		
Vegetation	1.85±0.61	N2
Soil*	3.05±0.53	0.18±0.05
East Fire Break North of Forest Path		
Vegetation	1.86±0.67	ND
Soil	3.86±0.91	N2
Pond North of North Fire Break		
Vegetation	2.37±0.62	0.70±0.08
Soil	2.36±0.64	0.23±0.05
RHIC Pond Area		
Vegetation	1.88±0.90	ND
Soil	14.9±1.64	ND
RHIC Ring North of Canal		
Vegetation	2.15±0.99	ND
Soil	3.03±0.84	N2
Northeast of HT-E South of RHIC Berm		
Vegetation	4.64±0.77	ND
Soil	4.28±1.60	ND
4th Ave. near AGS Well		
Vegetation	6.18±0.93	ND
Soil	5.88±1.25	ND
South End of Stump Dump Area		
Vegetation	6.15±0.77	ND
Soil	6.79±1.01	N2
NYSDEC Check Station (Control)		
Vegetation	5.06±1.20	ND
Soil	4.45±1.27	0.20±0.09

Notes: All values are shown with a 95% confidence interval.

Radiological values for soils are on a 'dry weight' basis.

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

N2 = data qualified as Not Useable, indistinguishable from background.

* = estimated value for Cs-137 based on laboratory qualifiers.

6.3.3 Vegetation Sampling

6.3.3.1 Grassy Plants and Soil

During 2023, grassy vegetation samples were collected from twelve locations around the Laboratory (Figure 6-4) and a control location at the NYSDEC hunter check station in Ridge, New York. All samples were analyzed for Cs-137 (see Table 6-3). Eleven vegetation samples were undetected or indistinguishable from background for Cs-137 and the remaining sample had a Cs-137 level of 0.70 pCi/g, dry weight. Eight soil samples were undetected or levels of Cs-137 indistinguishable from background. The remaining four samples had Cs-137 levels ranging from 0.16 to 0.23 pCi/g, dry weight.

All values were consistent with historic monitoring and knowledge of cleanup areas. Monitoring results for grassy vegetation and soils were utilized for the annual dose to biota analysis reported in Chapter 8.

6.4

Other Monitoring

6.4.1 Basin Sediments

A five-year cycle for the collection of recharge basin sediment samples was established in 2003. There are 11 recharge basins that receive water discharges that are permitted under the Laboratory's State Pollutant Discharge Elimination System (SPDES) permit (see Figure 5-3 for outfall locations).

The 11 basins were sampled in 2022, and the results were published in the 2022 Site Environmental Report. The next round of basin sediment sampling based on the five-year schedule will occur in 2027.

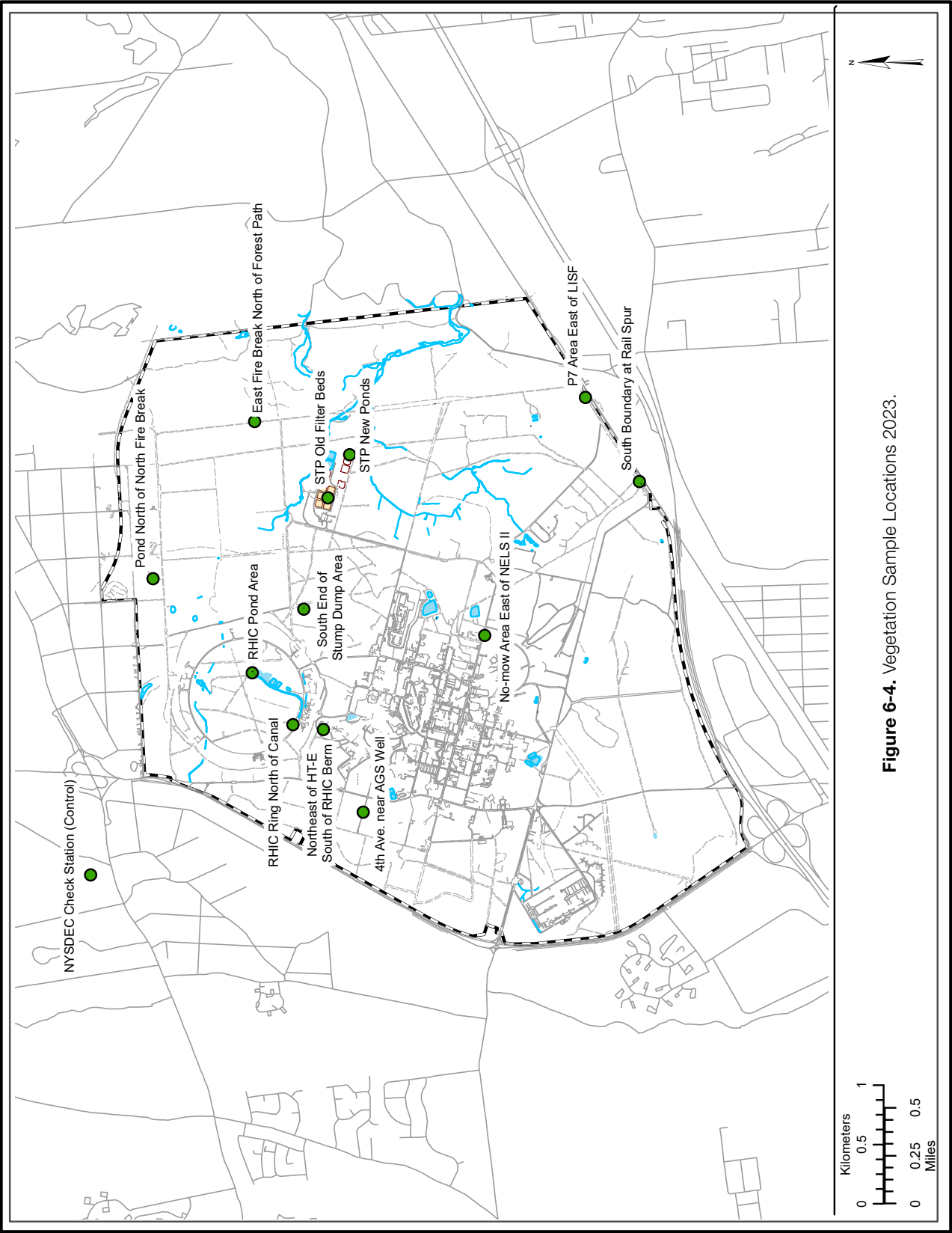


Figure 6-4. Vegetation Sample Locations 2023.



6.4.2 Precipitation Monitoring for Mercury

During 2023, precipitation samples were collected quarterly at air monitoring Stations P4 and S5 (Figure 4-2 for station locations). The samples were analyzed for total mercury (Table 6-4) using low-level mercury analysis.

Mercury concentrations in precipitation have been measured at BNL since 2007. Analysis of mercury in precipitation is conducted to document mercury deposition that is attributable to off-site sources. This information has been used as a comparison to Peconic River monitoring data and aids in understanding the distribution of mercury within the Peconic River watershed. Mercury was detected in all the precipitation samples collected at both sampling stations. Mercury ranged from 1.35 ng/L at station S5 in July 2023 to 13.5 ng/L at station P4 in April 2023. The 13.5 ng/L concentration is three times lower than the highest value of 45.1 ng/L, recorded in 2017.

Table 6-4. Precipitation Monitoring (Mercury).

Location/Period	Mercury ng/L
P4	
1/5/23	9.43
4/3/23	13.5
7/12/23	3.41
10/24/23	5.94
S5	
1/5/23	4.59
4/3/23	11.3
7/12/23	1.35
10/24/23	5.2

Notes: Method detection limit for mercury is 0.2 ng/L.

P4 = precipitation sampler near BNL Apartment area.
S5 = precipitation sampler near BNL Sewage Treatment Plant.

6.5

Educational Programs

BNL sponsors a variety of educational and outreach activities involving natural resources. These programs are designed to help participants understand the ecosystem, foster an interest in science, and provide a meaningful experience for interns in preparation for further studies or a career. Wildlife programs are conducted at the Laboratory in collaboration with the Department of Energy (DOE), local agencies, colleges, and high schools. Ecological research is also conducted on-site to routinely update the natural resource inventory records, gain a better understanding of the ecosystem, and guide management planning.

In FY23, five interns completed projects during the summer. Projects included fire effects on bat species diversity, camera trapping, and small mammal trapping for comparison to previous work conducted in 2014.

BNL participates in, coordinates, or hosts activities that support ecological education on Long Island. In 2023, the following programs were completed, or involved participation:

- Long Island Natural History Conference
- Participation in the Pine Barrens Discovery Day
- Open Space Stewardship Symposium (150 students, 40 posters)
- New York Wildfire & Incident Management Academy

The Day in the Life of a River program ran from September 22 to November 3, 2023. The Day in the Life of a River Program is a place-based educational experience where students and teachers collaborate with environmental professionals to collect scientific information capturing a snapshot of the health of the Long Island rivers and creeks. The Day in the Life of a River is a collaboration between the Central Pine Barrens Commission, the NYSDEC, and BNL, and supported by experts from the US Geological Survey, the Town of Brookhaven, Trout Unlimited, New York State Parks, and others. Approximately 2,000 students and teachers across 27 elementary, middle, and 11 high schools participated in the collection of environmental sample data and conducted real time scientific analyses for eleven rivers across Long Island.

6.6

Cultural Resource Activities

The BNL Cultural Resource Management Program ensures that the Laboratory fully complies with numerous cultural resource regulations. The CRMP for Brookhaven National Laboratory (BNL 2023) was updated in 2023 and guides the management for all the Laboratory's historical resources. BNL's cultural resources include buildings and structures, World War I (WWI) earthwork features, the Camp Upton Historical Collection, scientific equipment, photo/audio/video archives, and institutional records. As various cultural resources are identified, plans for their long-term stewardship are developed and implemented. Achieving these goals will ensure that the contributions BNL and the site have made to local and national history and culture are documented and available for interpretation.

In 2023, the Lab and DOE completed negotiations establishing a Memorandum of Agreement (MOA) for the demolition of the obsolete 1940s era water tower. The recordation report for the water tower was prepared for transmittal toward the end of the year. To begin meeting the requirements outlined in several MOAs, a committee was established to develop kiosks that will highlight several aspects of history of the BNL site including the current Apartment Area and site of the newest building under construction, the Science User Support Center (SUSC); the removal of the 1960s era efficiency apartments; the World War I (WWI) and II hospital area (current apartment area); Camp Upton and the 1917 approaches to Camp Upton; the Brookhaven Medical Research Reactor and Medical Department; and the 1940s era water tower. The majority of the kiosks will be placed in the vicinity of the SUSC once construction is completed. Other kiosks will be placed at Building 490 to highlight the importance of the Brookhaven Medical Research Reactor which was the first reactor designed specifically for medical research, and the importance of the Medical Complex in developing medical research including medical isotope production, Positron Emission Tomography (PET imaging), cancer research, and research into Parkinson's disease. Kiosk design establishes a basic style for future efforts.

Additionally, an intern participating in the Science Undergraduate Laboratory Internship program conducted historical research on the Medical Department including development of imaging techniques such as the PET imaging mentioned above, as well as the importance of the medical isotope program that continues to this day.

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