

Natural and Cultural Resources

The Brookhaven National Laboratory (BNL) Natural Resource Management Program is designed to protect and manage flora and fauna and the ecosystems in which they exist. The Laboratory's natural resource management strategy is based on 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 2020, 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. In 2020, 19 additional buildings were determined to be eligible for listing on the National Register of Historic Places.

6.1 NATURAL RESOURCE MANAGEMENT PROGRAM

The Natural Resource Management Program 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 Natural Resource Management Plan (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 2016 (BNL 2016).

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). 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*).

Table 6-1. Federal and New York State Threatened & Endangered Species, Species of Special Concern, & Species of Greatest Conservation Need.

Federal and New York State Threatened & Endangered Species, Species of Special Concern, & Species of Greatest Conservation Need			
Common Name	Scientific Name	State Status	BNL Status
Insects			
Comet damer	<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
Grasshopper sparrow	<i>Ammodramus savannarum</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
Horned lark	<i>Eremophila alpestris</i>	SC	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

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Endangered plants that have been confirmed on the BNL site include Engelman spikerush (*Eleocharis engelmannii*), Ipecac spurge (*Euphorbia ipecacuanhae*), dwarf huckleberry (*Gaylussacia bigeloviana*), and whorled loosestrife (*Lysimachia quadrifolia*). 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 haw (*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

Table 6-1. Federal and New York State Threatened & Endangered Species, Species of Special Concern, & Species of Greatest Conservation Need (concluded).

Federal and New York State Threatened & Endangered Species, Species of Special Concern, & Species of Greatest Conservation Need			
Common Name	Scientific Name	State Status	BNL Status
Mammals			
Northern long-eared bat	<i>Myotis septentrionalis</i>	FT	Confirmed
Plants			
Small-flowered false foxglove	<i>Agalinis paupercula</i>	R	Confirmed
Stargrass	<i>Aletris farinosa</i>	T	Confirmed
Butterfly weed	<i>Asclepias tuberosa ssp. 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 var. 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>Plantathera cristata</i>	E	Likely
Green fringed orchid	<i>Platanthera lacera</i>	V	Confirmed
Prostate knotweed	<i>Polygonum aviculare ssp. buxiforme</i>	E	Possible
Bracken fern	<i>Pteridium alquilinum var. 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 var. pubescens</i>	V	Confirmed
Possum haw	<i>Viburnum nudum var. 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
 FE=federally endangered
 FT = federally threatened

R = rare
 SC = species of special concern
 SGCN = species of greatest conservation need
 T = threatened
 V = exploitably vulnerable

and host plant, wild lupine (*Lupinus perennis*).

A number of other species that are listed as rare, of special concern, or exploitably vulnerable by New York State either currently inhabit the site, visit during migration, or have been identified historically. BNL has one federally threatened species, the northern long-eared bat (*Myotis septentrionalis*) that is found within the forests of the Lab. The federally endangered rusty-patch bumble bee (*Bombus affinis*) has been removed from the list as no verification of its presence has occurred since a tentative identification of a single individual occurred in 2016.

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 program 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 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 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 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 2020, surveys were not completed due to time constraints and impacts from COVID-19.

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 early 2017 likely resulted in the extirpation of the banded sunfish from the BNL site. The single known habitat held water throughout 2018 and 2019 could likely sustain sunfish. However, a short survey by NYSDEC personnel in 2019 did not find sunfish in the pond. Regionally, NYSDEC determined that only a few populations of banded sunfish survived the drought and they continue to evaluate the need for restoration efforts.

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 2020, monthly surveys were conducted

starting at the end of June and extending through the end of August. Surveys in April and May were suspended due to COVID-19. These surveys identified 65 bird species, compared to the 73 species identified in 2019 and 67 species in 2018. A total of 134 bird species have been identified in surveys in the past 21 years; 59 of these species were present in each of the past 21 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 the eastern edge 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 resulted in significant tree mortality. Bluebirds have been documented within the burned area in 2019 and 2020.

In 2019, a pair of peregrine falcons (*Falco peregrinus*) successfully nested on the stack of

the former High Flux Beam Reactor (HFBR). The pair took over a common raven's nest and successfully raised two chicks. While the nesting is a great success, the nesting was discouraged in 2020 to allow the demolition of the stack which is required under the Record of Decision for the Decontamination and Dismantlement of the HFBR. The falcons had been seen in various locations on site in 2020 but nesting was not documented.

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. In 2020, the nest management program was suspended due to restrictions associated with COVID-19. Prior to the start of nesting, the population was estimated at 105 birds; nesting success resulted in a population of approximately 150 birds by August 2020. In an attempt to get the birds to move into areas where they could be hunted, a team of USDA-Wildlife Services biologists scared geese using a radio-controlled car resulting in their leaving the site. The effort resulted in a slight reduction of geese during the September early hunting season.

6.1.2.4 Bald Eagle

The bald eagle (*Haliaeetus leucocephalus*) has been increasing in population locally on Long Island with at least ten known nest sites on the island. Bald eagles were sighted numerous times in the area of the Sewage Treatment Plant (STP) throughout the year in 2020. 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 added to the list of federally threatened species in 2015. BNL began planning for the eventual listing and put in place actions to minimize the likelihood of impacting this species. The two most likely activities that could impact this bat on the BNL site are building

demolitions and prescribed fires. Inspections for the presence of bats may be conducted through either acoustic or visual surveys prior to demolition. Regardless of the outcome of acoustic monitoring (when conducted), a final internal inspection of the building(s) is conducted approximately 24 hours prior to demolition to verify the absence of bats.

For growing season prescribed fires, acoustic monitoring may be done within the burn unit to determine if there is bat activity. If positive results occur, surveys of the entire burn unit are completed to identify potential roost trees and appropriate protections are put into place to ensure that bats are not impacted by fire. In 2020, two buildings were demolished, and there was no impact to bats. No prescribed fires were conducted in 2020.

6.1.3 Population Management

In addition to controlling resident Canada goose populations described above, the Laboratory also monitors or 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 ideal nesting and foraging habitat for wild turkey (*Meleagris gallopavo*). In 2020, the on-site population continued to range between 350 and 500 birds due to successful nesting. Each year, NYSDEC manages a hunting period during the week of Thanksgiving, and a youth-only hunt in May for several areas across Long Island, which typically results in approximately 100 birds taken.

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 one square mile. Normally, a population density of ten 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 the 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 decreased in 2020 compared to 2019, potentially an indication of decreased population from the 2020 deer harvest as well as fewer employees onsite due to the COVID-19 pandemic.

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 (aka 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 2018. The herd was estimated at 350 at the end of 2019 and a harvest was planned for two separate weekends between February and April 2020.

The first herd reduction conducted in March

2020 resulted in 82 animals being taken. The second reduction was planned for April 2020 but was cancelled due to COVID-19 restrictions. The removal of 82 deer effectively brought the population to approximately 275 animals. With reproduction at approximately 55 percent, the population at the end of 2020 was estimated at approximately 425 deer. Efforts were underway in December 2020 to plan for the next round of population management in 2021.

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 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.

In January 2020, the Department of Energy (DOE) announced the award for construction of the Electron-Ion Collider at BNL. This resulted in the development of an Environmental Evaluation and Notification Form that was submitted to the Brookhaven Site Office and a determination was issued that an Environmental Assessment (EA) would be necessary. The EA was developed and presented to the CAC in September 2020 and was further developed for submission to New York State by year's end.

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.



4 poster™ tick management system

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 will allow for greater levels of research within the Central Pine Barrens and the Upton Reserve.

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 the site. Because soil contaminated with a radioactive isotope of cesium (Cs-137) was used in some BNL landscaping projects in the past, traces of Cs-137 attributable to past practices and worldwide 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. While most off-site samples are the result of car/deer accidents near the Laboratory, samples from deer taken by hunters beyond BNL boundaries or samples from car/deer accidents greater than one mile from BNL have also been made available for analysis. In 1998, a statistical analysis suggested that 40 deer from off site and 25 deer from on site are needed to achieve a statistically sound data set. The number obtained each year has not met this preferred level because sample availability depends on accidents between vehicles and deer and people reporting dead deer. In 2020, a total of 13 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 2016 and 2020. Most of the off-site samples are concentrated along the William Floyd Parkway on the west boundary of BNL, whereas historically most on-site samples are collected near the Laboratory's main entrance gate and the developed portions of the site. This distribution is mainly due to people reporting dead deer on their way to work. Also, vehicle collisions with deer on site occur primarily early or late in the day, when deer are more active and traffic to and from the Lab's Main Gate is greatest.

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 2020, nine deer were obtained on site, of which eight were

sampled as part of deer reduction efforts, two from off-site locations within one mile of the Laboratory, and two from greater than one mile from the BNL boundary, all except those from deer reduction efforts were from car/deer accidents. The number of offsite samples in 2020 is lower than what has been provided historically largely due to a reduced number of trips by Lab personnel due to reduced staffing levels associated with COVID-19 restrictions. 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.

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. Cesium-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 2020, Cs-137 concentrations in deer meat samples were obtained from nine deer on site with a range of values from 0.02 pCi/g, wet weight, to 0.24 pCi/g, wet weight, and an arithmetic average of 0.06 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 2020 (0.24 pCi/g, wet weight) was roughly equivalent to the highest on-site sample reported in 2019 (0.28 pCi/g, wet weight) and 49

times lower than the highest level ever reported in 1996 (11.74 pCi/g, wet weight).

Cs-137 concentrations in off-site deer meat samples are typically separated into two groups: samples taken within one mile of BNL (two samples) and samples taken farther away (two samples), as shown in Table 6-2. Concentrations in meat samples taken within one mile ranged from 0.03 pCi/g, wet weight, to 0.64 pCi/g, wet weight, with an arithmetic average of 0.33 pCi/g, wet weight. 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 2020, this was 0.11 pCi/g, wet weight. The two deer sampled from greater than one mile from BNL had Cs-137 concentrations of 0.01 pCi/g, wet weight, with an arithmetic average of 0.01 pCi/g, wet weight. Figure 6-2 compares the average values of Cs-137 concentrations in meat samples collected in 2020 from four different location groupings. The off-site location group within one mile of the site was higher than the onsite average due to the highest value in all samples being from a sample taken immediately offsite.

Although not shown on Figure 6-2, Cs-137 concentrations in 11 of the 13 meat samples taken both on and off site were below 0.24 pCi/g, wet weight. Figure 6-3 presents the ten-year trend of on-site and near off-site Cs-137 averages in deer meat. The 2020 average is approximately 33 percent of the 2019 value of 0.34 pCi/g, wet weight, and is the lowest average seen since trending began in 2000. The higher averages shown are reflective of a significant number of samples taken in the fall when Cs-137 levels are typically higher. However, these sample results continue to indicate the effectiveness of cleanup actions across the Laboratory, with the trend being downward from 2011 to 2020 and the ten-year average being 0.59 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

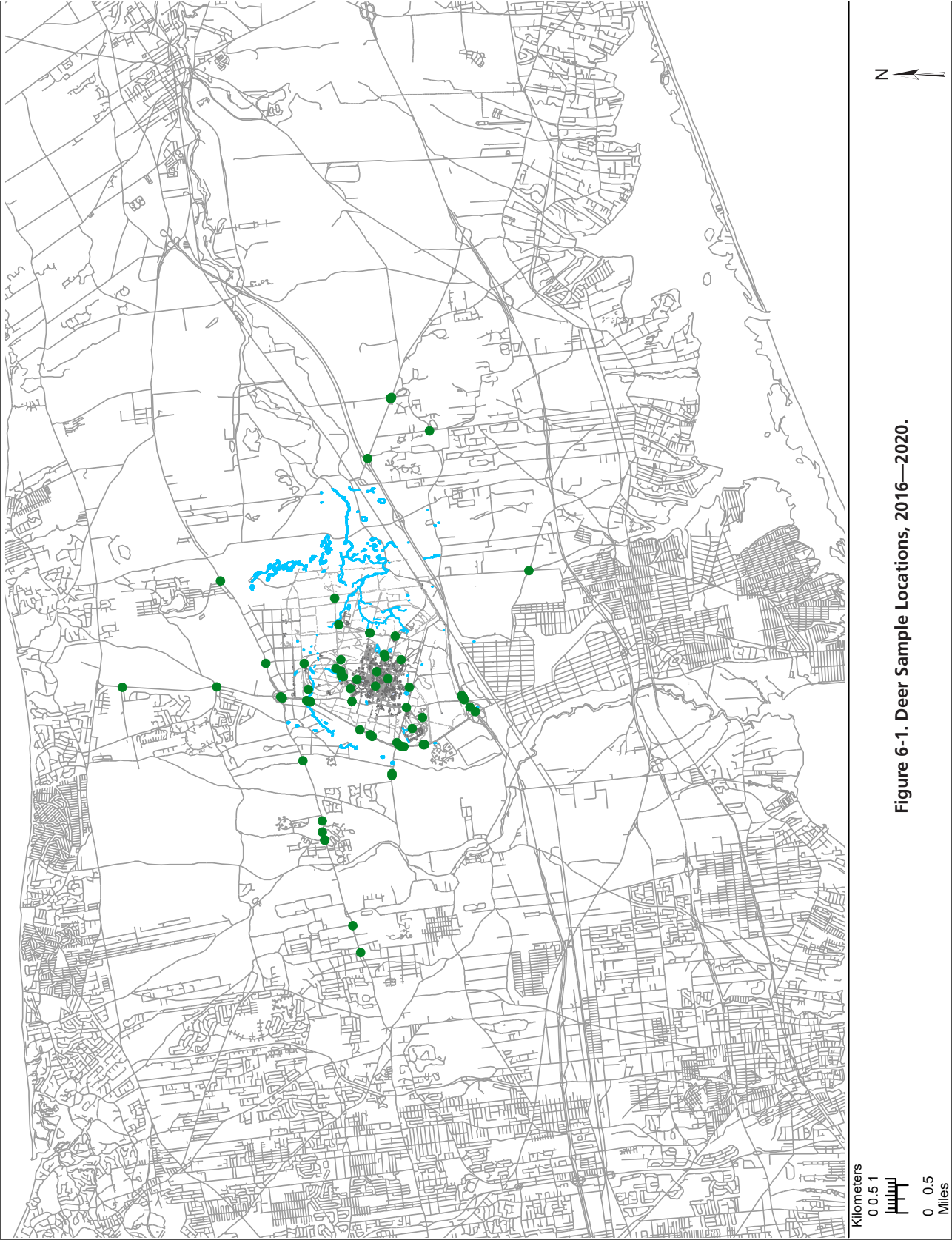


Figure 6-1. Deer Sample Locations, 2016—2020.

Table 6-2. Radiological Analyses of Deer Tissue (2020).

Sample Location	Collection Date	Tissue	K-40 pCi/g (Wet Weight)	Cs-137 pCi/g (Wet Weight)
BNL				
Forest Path 100yd west of East Firebreak	3/1/20	flesh	3.21±0.23	0.24±0.02
		liver	1.51±0.24	0.04±0.02
Cull Sample 1 Cornell Water Tower	3/6/20	flesh	2.87±0.37	0.02±0.02
		liver	1.89±0.20	ND
Cull Sample 2 1st St. and Forest Path	3/7/20	flesh	2.88±0.33	0.10±0.02
		liver	2.35±0.23	0.04±0.01
Cull Sample 3 Balloon Launch Facility	3/7/20	flesh	2.58±0.39	0.06±0.02
		liver	1.71±0.14	0.01±0.01
Cull Sample 4 Rochester & Weaver Rd.	3/7/20	flesh	2.89±0.35	0.03±0.02
		liver	1.96±0.19	0.01±0.01
Cull Sample 5 Basin HT-E	3/8/20	flesh	3.16±0.40	0.03±0.02
		liver	2.16±0.22	ND
Cull Sample 6 Bldg. 528	3/8/20	flesh	2.51±0.28	0.02±0.01
		liver*	2.20±0.17	0.01±0.01
Cull Sample 7 Former Cottage Area	3/9/20	flesh	2.62±0.28	0.06±0.01
		liver	2.52±0.18	0.01±0.01
Cull Sample 8 Upton & W 5th Ave.	3/9/20	flesh	2.62±0.33	0.03±0.02
		liver	2.40±0.15	0.01±0.01
< 1 Mile from BNL				
South Gate - LIE Service Rd.	4/1/20	flesh	2.99±0.10	0.64±0.01
		liver	1.74±0.16	0.10±0.01
WFPKY 1/2 mile south of Main Gate	11/1/20	flesh	2.99±0.18	0.03±0.01
		liver	2.03±0.20	0.02±0.01
> 1 Mile from BNL				
Middle Island, NY near Artist Lake west	2/4/20	flesh	3.64±0.22	0.01±0.01
Middle Island, NY near Artist Lake east	2/4/20	flesh*	3.36±0.19	0.01±0.00
		liver	2.60±0.20	ND
Averages by Tissue				
Flesh Averages				
All Samples (13)			2.95±1.06	0.10±0.05
BNL Average (9)			2.82±0.99	0.06±0.05
< 1 Mile Average (2)			2.99±0.21	0.33±0.01
BNL + < 1 Mile Average (11)			2.85±1.02	0.11±0.05
> 1 Mile Average (2)			3.50±0.29	0.01±0.01
Cull Average (8)			2.77±0.97	0.04±0.05
Liver Averages				
All Samples (12)			2.09±0.67	0.02±0.03
BNL Average (9)			2.08±0.58	0.02±0.03
< 1 Mile Average (2)			1.89±0.26	0.06±0.01
BNL + < 1 Mile Average (11)			2.04±0.64	0.02±0.03
> 1 Mile Average (1)			2.60±0.20	0.01±0.01
Cull Average (8)			2.15±0.53	0.01±0.02

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.

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

ND = not detected

Table 6-3. Radiological analysis of grassy vegetation and associated soils.

Location/Matrix	K-40 pCi/g±95% C.I.	Cs-137 pCi/g±95% C.I.
1st St. west side, S. of East 5th Ave.		
Vegetation	3.08±1.08	ND
Soil	4.69±1.03	ND
1st St. west side, N. of East 5th Ave.		
Vegetation*	1.81±0.74	0.12±0.05
Soil	5.17±0.97	0.34±0.08
Firebreak N. of NOAA, W. of 1st St.		
Vegetation	4.97±0.80	ND
Soil*	8.64±1.14	0.20±0.06
N. side of South Firebreak E. of RR Spur		
Vegetation	3.69±0.78	ND
Soil*	7.35±1.00	0.13±0.05
West end of Brookhaven Ave.		
Vegetation*	2.99±0.59	0.04±0.04
Soil	6.36±0.79	0.22±0.04
West end of 5th Ave.		
Vegetation	1.47±0.45	ND
Soil*	5.10±1.00	0.17±0.06
West end of Middle Path		
Vegetation	2.28±0.61	ND
Soil	4.80±0.92	ND
East end of Middle Path		
Vegetation	1.82±0.85	ND
Soil*	5.65±0.93	0.09±0.06
Glass holes area		
Vegetation	0.80±0.60	ND
Soil	7.68±0.89	0.77±0.08
West of Canal leading to Basin HS		
Vegetation	4.20±0.46	ND
Soil	5.56±0.70	ND
NYSDEC Game Farm (Control)		
Vegetation	3.39±0.87	ND
Soil	5.06±0.81	ND

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

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

Table 6-4. Precipitation Monitoring (Mercury).

Location/Period	Mercury ng/L
P4	
1/8/20	5.75
4/8/20	7.86
7/22/20	6.31
10/14/20	4.57
S5	
1/8/20	4.76
4/8/20	7.04
7/22/20	8.37
10/14/20	5.53

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.

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 2020, Cs-137 concentrations ranged from non-detectable to 0.04 pCi/g, wet weight, with an average of 0.02 pCi/g, wet weight. The near off-site Cs-137 concentration in liver ranged from 0.02 pCi/g, wet weight, to 0.10 pCi/g, wet weight, with an arithmetic average for off-site liver samples within one mile of 0.06 pCi/g, wet weight. The single liver sample from deer taken greater than one mile from BNL was non-detectable for Cs-137. The potential radiological dose resulting from deer meat consumption is discussed in Chapter 8.

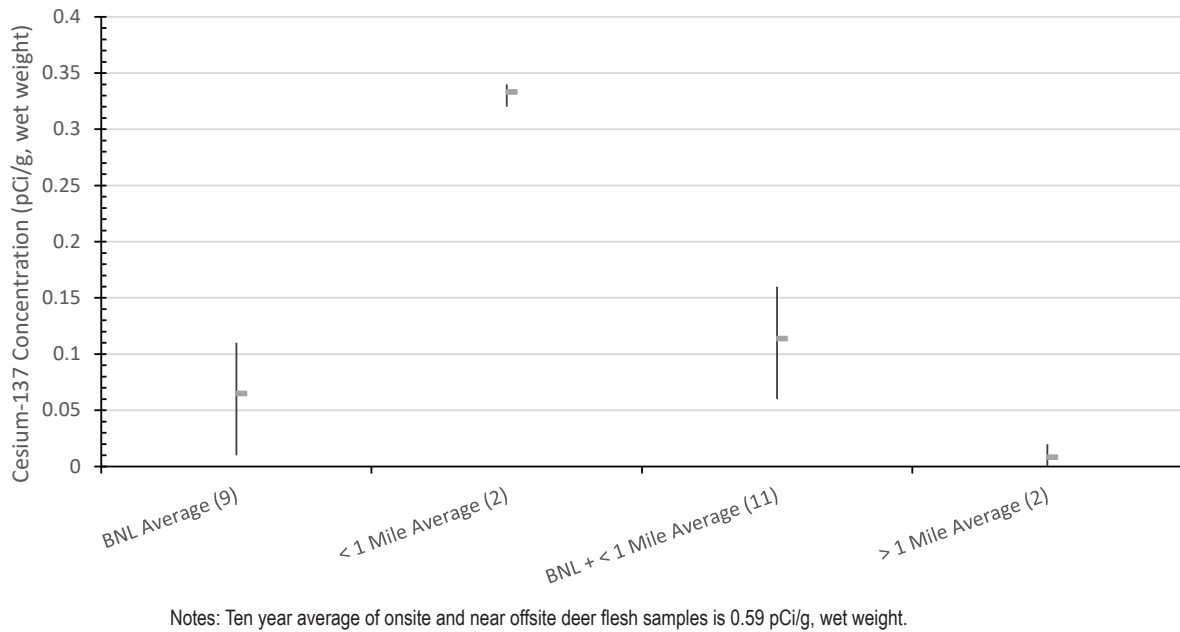


Figure 6-2. Comparison of Cs-137 values in deer flesh for onsite, offsite within 1 mile, onsite and near offsite, and offsite greater than 1 mile from the Laboratory.

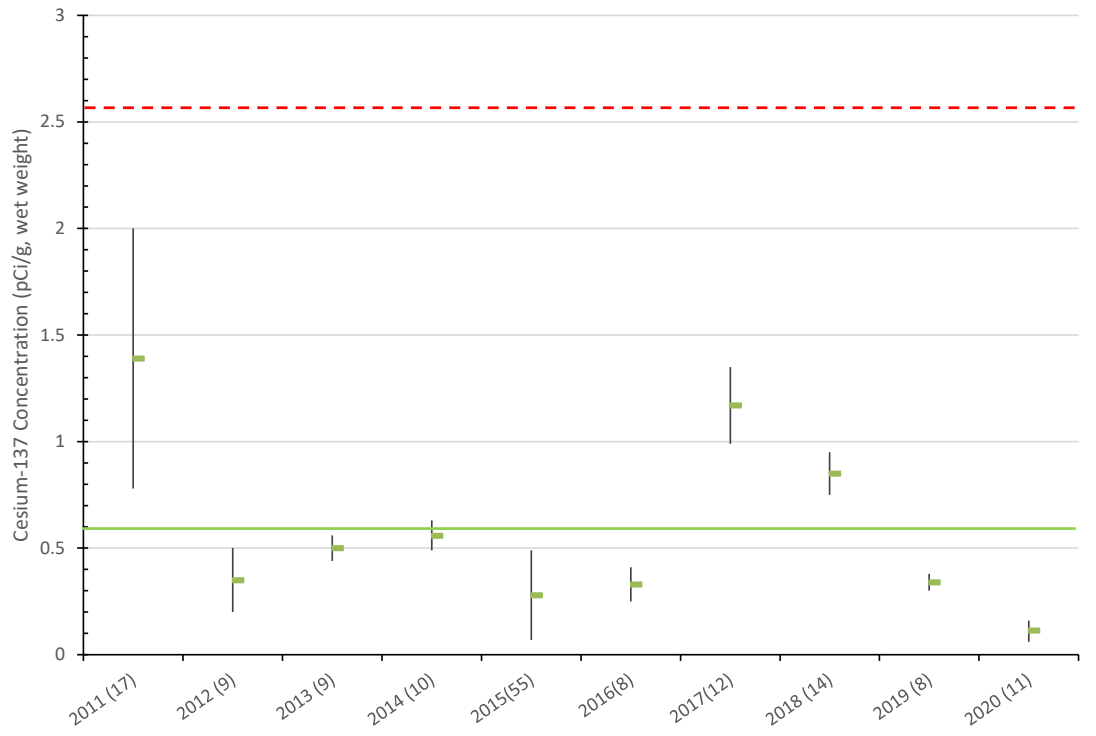


Figure 6-3. Ten year trend in Cs-137 in deer flesh for samples taken at BNL and within 1 mile of the Laboratory. Ten-year average is 0.59 pCi/g (solid line).

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 82 deer were taken during population reductions in 2020. Meat samples were obtained from every tenth deer and were sent for analysis and as mentioned above were included in Table 6-2. The results ranged from 0.02 pCi/g, wet weight, to 0.10 pCi/g, wet weight, with the arithmetic average being 0.04 pCi/g, wet weight. Since all samples were well below the 1.0 pCi/g, wet weight administrative limit, all 1,521 pounds of meat were donated to Island Harvest Food Pantry.

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.

6.3.2 Other Animals Sampled

When other animals, such as wild turkey or Canada geese, are found dead along the roads of BNL and the immediate vicinity due to road mortality, they are tested for Cs-137. No other animals were sampled in 2020.

6.3.3 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. However, when conditions allow, fish sampling will be conducted under the surveillance program for radionuclide, mercury, and PCB content. Analysis for radionuclides supports calculation for a dose to biota and dose to the maximally exposed off site individual. Due to lack of water and fish within the on-site portions of the Peconic River, no fish were sampled in 2020.

6.3.3.1 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 offsite portions of the river. In 2019, water levels began to recede, resulting in water being retained only in deeper open water areas and levels continued to recede in 2020. There was no documented offsite flow in 2020.

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 2020, a population assessment was conducted at the end of July and resulted in the capture of 51 fish composed of creek chubsucker, large-mouth bass, and bluegill sunfish. The largest fish caught had a length of 80 mm, or a little over three inches. The average length of fish was 19 mm. Since there were no fish of significant size, no samples were taken.

6.3.4 Vegetation Sampling

6.3.4.1 Grassy Plants and Soil

During 2020, grassy vegetation samples were collected from ten locations around the Laboratory (Figure 6-4) and a control location at the NYS-DEC hunter check station in Ridge, New York. All samples were analyzed for Cs-137 (see Table 6-3). Cs-137 content in vegetation ranged from non-detectable to 0.12 pCi/g, wet weight. Soil samples had Cs-137 levels ranging from non-detect to 0.77 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.



2019 Forest Health Monitoring Team

6.4 PRECIPITATION MONITORING

6.4.1 Mercury Monitoring of Precipitation

During 2020, 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 4.57 ng/L at station P4 in October to 8.37 ng/L at station S5 in July. The 8.37 ng/L concentration is 5.2 times lower than the highest value of 45.1 ng/L, recorded in 2017.

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, 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 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 2020, due to COVID-19 restrictions, all internships were required to be conducted virtually. Due to the nature of the natural resources program, the Environmental Protection Division hosted a single intern during summer of 2020 who worked to perfect Artificial Intelligence software for sorting photos taken as part of the 4-Poster™ project for tick management.

The Forest Health Monitoring project that started in 2019 continued through collaborative efforts between SUNY-ESF in Syracuse, BNL, and the Long Island Central Pine Barrens Joint Planning and Policy Commission (Commission).

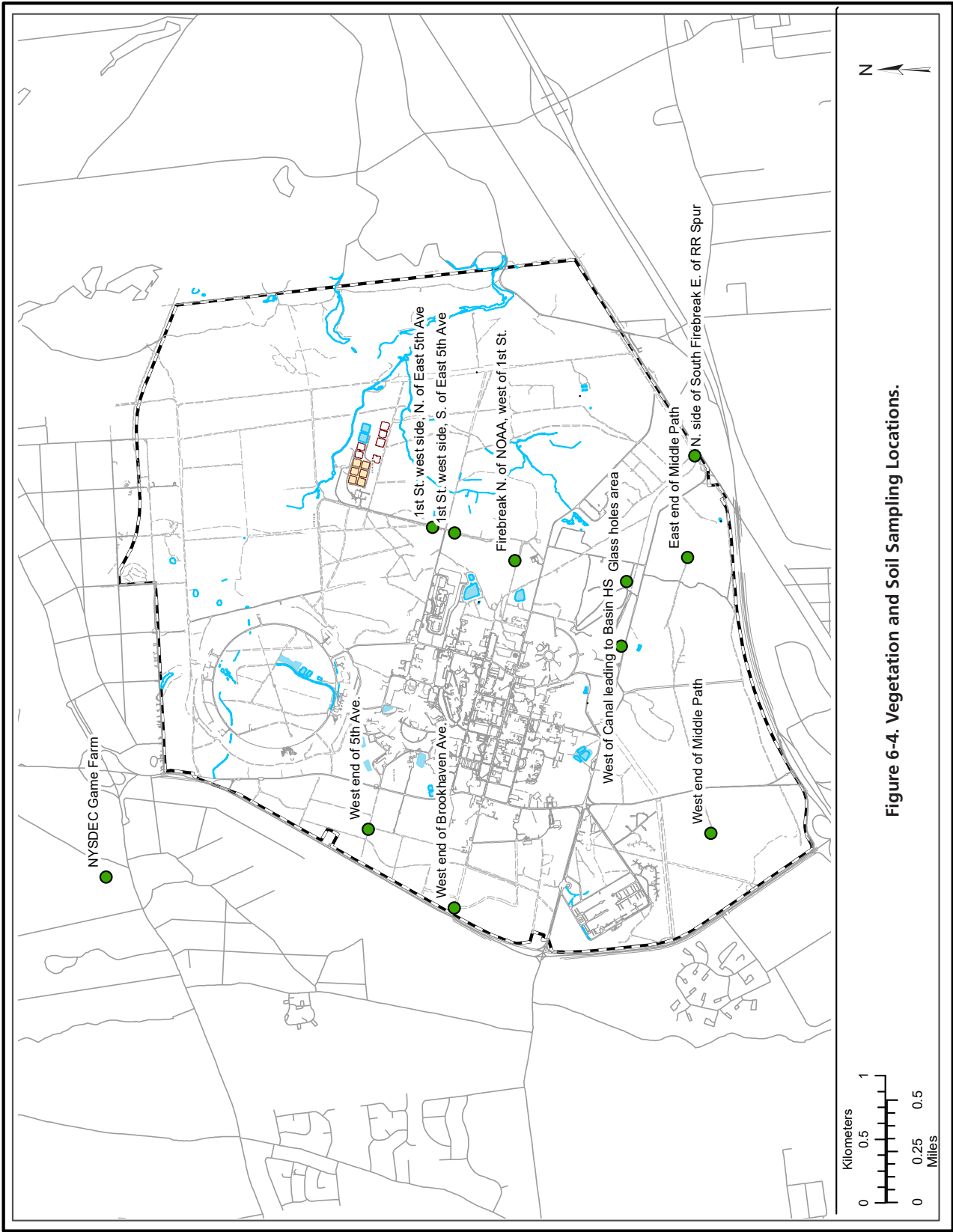


Figure 6-4. Vegetation and Soil Sampling Locations.

CHAPTER 6: NATURAL AND CULTURAL RESOURCES

Because the Commission did not have the same restrictions, they were able to advertise for summer help and a few of the interns originally destined for BNL were hired and managed by Johanna Lumbsden, a SUNY-ESF Ph.D. candidate. The team was able to complete the second half of the forest health monitoring started in 2019, including the addition of new plots to gather data related to fire history. This research effort will result in several publications and award of a Ph.D. degree.

In a normal year, BNL participates in, coordinates, or hosts activities that support ecological education on Long Island. In 2020, due to restrictions associated with COVID-19, the following programs were cancelled:

- Long Island Natural History Conference
- Participation in the Pine Barrens Discovery Day
- A Day in the Life of the Rivers (student/teacher involvement in monitoring 11 Long Island rivers)
- Open Space Stewardship Program (which involves 2,500 students from 30 schools)
- NY Wildfire & Incident Management Academy

6.6 CULTURAL RESOURCE ACTIVITIES

The BNL Cultural Resource Management (CRM) Program ensures that the Laboratory fully complies with numerous cultural resource regulations. The Cultural Resource Management Plan for Brookhaven National Laboratory (BNL 2013) 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 2019, the Laboratory contracted with Hartgen Archeological Associates to conduct historical architectural reviews of buildings that had recently reached 50 years of age. The contract continued into early 2020 with three reports covering the



Building 490 former Medical Complex



World War II water tower

Alternating Gradient Synchrotron (AGS) complex, Medical Complex, and several other buildings. The reports provided determinations of eligibility for the Medical Complex (Buildings 490 and 491), Buildings 820, 820A, 820B, 830, 902, and the WWII water tower, and several buildings combined within the AGS complex, including Buildings 901, 901A, 911, 912, 913, 913A through E, and 930. Several buildings were determined to not meet criteria for consideration. The reports were to be submitted to the NYSHPO in 2021.

BNL continued to negotiate an MOU with the NYSHPO on the 1960s-era apartments and came to a resolution for mitigation of their demolition. The MOU accepted all work up to the MOU including the Section 106 review and Recordation of the Structures. The final piece of the MOU addressed the development of interpretive kiosks that would describe the Apartment Complex area's history from WWI to present. Several of the initial kiosks would be placed as part of the Science User's Support Center with the remaining ones placed within the Discovery Park area as it develops. At least one of the kiosks must specifically highlight the 1960s-era apartments.

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