Annual Site Environmental Report

2019

Princeton Plasma Physics Laboratory

Operated by Princeton University For the U.S. Department of Energy
Under Contract DE-AC02-09CH11466

PPPL
PRINCETON PLASMA PHYSICS LABORATORY

PPPL - 2021_379

U.S. DEPARTMENT OF ENERGY

Princeton Plasma Physics Laboratory

Annual Site Environmental Report

PPPL–2021_379

For Calendar Year 2019 – Abstract

This report provides the U.S. Department of Energy (DOE) and the public with information on the level of radioactive and non-radioactive pollutants (if any) that are added to the environment as a result of Princeton Plasma Physics Laboratory's (PPPL) operations. The results of PPPL's 2019 environmental surveillance and monitoring program are presented and discussed. The report also summarizes environmental initiatives, assessments, and community involvement programs that were undertaken in 2019.

PPPL has engaged in fusion energy research since 1951. The Laboratory's mission is to develop the scientific knowledge and advanced engineering to enable fusion to power the U.S. and the world, and to developing the understanding of plasmas from the nano- to the astrophysical scale. PPPL's primary experiment, the National Spherical Torus Experiment-Upgrade (NSTX-U) is a collaboration among national laboratories, universities, and national and international research institutions and is a major element in the US Fusion Energy Sciences Program. Its design tests the physics principles of spherical torus (ST) plasmas, playing an important role in the development of smaller, more economical fusion reactors. Due to operational issues, NSTX-U did not operate in 2019. Redesign and recovery efforts are ongoing.

In 2019, PPPL's radiological environmental monitoring program measured tritium in the air at the NSTX-U Stack and at onsite sampling stations. Using highly sensitive air monitors, PPPL is capable of detecting small changes in the ambient levels of tritium. The operation of an in-stack monitor located on D-site is used to demonstrate compliance with the National Emission Standard for Hazardous Air Pollutants (NESHAPs) regulations. Also included in PPPL's radiological environmental monitoring program, are water monitoring – ground, and surface, and waste waters. PPPL's radiological monitoring program characterized the background levels of tritium in the environment and those data are presented in this report.

Ground water monitoring continued under New Jersey Department of Environmental Protection's Site Remediation Program regulations. PPPL monitored for non-radiological contaminants, mainly volatile organic compounds (components of common degreasing solvents). In 2019, PPPL complied with permit limits for surface and sanitary discharges. PPPL was honored with awards for its waste reduction and recycling program, EPEAT-certified electronics purchasing, and energy and water reduction.

Robert S. Sheneman, editor

Prepared for the U.S. Department of Energy
Under Contract DE-AC02-09CH11466

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2019 Annual Site Environmental Report
List of Acronyms

AEA	Atomic Energy Act of 1954
AFV	alternative fuel vehicles
ALARA	as low as reasonably achievable
ARD	America Recycles Day (November 15th)
ASER	Annual Site Environmental Report
B1, B2	Bee Brook 1 (upstream of DSN001) and 2 (downstream of DSN001) (surface water stations)
B-20	biofuel (20%)
BCG	biota concentration guide
Bq	Becquerel
BTU/gsf	British Thermal Unit per gross square feet
°C	Degrees Celsius
C- & D-	C & D-sites of James Forrestal Campus, currently site of PPPL
C1	Canal - surface water monitoring location (Delaware & Raritan Canal)
c-1,2-DCE	cis-1,2-dichloroethylene
C&D	Construction and demolition (waste)
CAA	Clean Air Act
CAS	Coil Assembly and Storage building
CDX-U	Current Drive Experiment – Upgrade (at PPPL)
CEA	classified exception area
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
CEDR	Comprehensive Energy Data Report
CEQ	Council on Environmental Quality
CFR	Code of Federal Regulations
CHP	Combined heat and power
Ci	Curie (3.7 ^{E10} Becquerel)
cm	centimeter
CO	carbon monoxide
CO_2	carbon dioxide (GHG)
CO_{2e}	carbon dioxide equivalent
COD	chemical oxygen demand
COP21	21st Century Conference of Parties (also known as the Paris Accord)
CPO	chlorine-produced oxidants known as total residual chlorine
CWA	Clean Water Act
CXs	categorical exclusions
CY	calendar year
D-D (DD)	deuterium-deuterium
DART	days away, restricted transferred (case rate - Safety statistic)
DATS	differential atmospheric tritium sampler
DESC	Defense Energy Supply Center
DMR	discharge monitoring report
DOE	Department of Energy
DOE-PSO	Department of Energy - Princeton Site Office
DOT	Department of Transportation
DPCC	Discharge Prevention Control and Containment
dpm	disintegrations per minute
D&R	Delaware & Raritan (Canal)
DSN	discharge serial number
E1	surface water monitoring station (NJ American Water Co. potable water source)

E-85	ethanol (85%) fuel
EDE	effective dose equivalent
EHS	extremely hazardous substance
EISA	Energy Independence and Security Act, Section 432
EML	Environmental Monitoring Laboratory (DOE)
EMS	Environmental Management System
EO	Executive Order
EPA	Environmental Protection Agency (US)
EPCRA	Emergency Planning and Community Right to Know Act
EPEAT	Electronic Product Environmental Assessment Tool
EPP	Environmentally Preferred Products
ESD	Environmental Services Division (PPPL)
ES&H	Environment, Safety, and Health
ESHD	Environment, Safety, & Health Directives
ESPC	Energy Savings Performance Contract
^{o}F	Degrees Fahrenheit
FFCA	Federal Facility Compliance Act
FIFRA	Federal Insecticide, Fungicide, and Rodenticide Act
FY	fiscal year (October 1 to September 30)
GGE	Gasoline gallon equivalent
GHGs	greenhouse gases
GP	Guiding principles
GPD	gallons per day
GPP	General plant projects
GSA	General Services Administration
GSF	gross square feet
GSR	green sustainable remediation
HAZMAT	hazardous materials
HP	Health Physics Division of ES&H
HPSB	high performance and sustainable buildings
HT	tritium (elemental)
HTO	tritiated water or tritium oxide
IC25	Inhibition concentration
ILA	Industrial landscaping and agriculture
ISO14001	International Standards Organization 14001 (Environmental Management System – EMS)
ITER	International Thermonuclear Experimental Reactor (France)
JFC	James Forrestal Campus
JET	Joint European Torus facility (United Kingdom)
km	kilometer
kWh	kilowatt hour
LEC	liquid effluent collection (tanks)
LED	Light emitting diode
LEED®	Leadership in Energy and Environmental Design
LEED®-EB	Leadership in Energy and Environmental Design - Existing Buildings
LLW	Low level waste
LSB	Lyman Spitzer Building (Formerly Laboratory Office Building)
LSRP	Licensed Site Remediation Professional
LOI	Letter of Interpretation (Wetlands)

LOTO	lock-out, tag-out (electrical safety)
LSI	lined surface impoundment
LTX	Lithium Tokamak Experiment
M1	Millstone River (surface water station)
MC&A	Material Control & Accountability (nuclear materials)
MEI	Maximally Exposed Individual
MG	Motor Generator (Building)
MGD	Million gallons per day
mg/L	milligram per liter
M&O	Maintenance &Operations
MNA	Monitored Natural Attenuation
mrem	milli roentgen equivalent man (per year)
MRX	Magnetic Reconnection Experiment
MSDS	Material Safety Data Sheet
msl	mean sea level (in feet)
mSv	milliSievert
MT (mt)	metric ton (equivalent to 2,204.6 pounds or 1.10 tons)
MW	monitoring well
Mwh	Megawatt hour
MSW	Municipal solid waste
NBI	Neutral Beam Injector(s)
NCSX	National Compact Stellarator Experiment
NEPA	National Environmental Policy Act
NESHAPs	National Emission Standards for Hazardous Air Pollutants
NHPA	National Historic and Preservation Act
NIST	National Institute of Standards and Technology
NJAC	New Jersey Administrative Code
NJDEP	New Jersey Department of Environmental Protection (prior to 1991 and after July 1994)
NJPDES	New Jersey Pollutant Discharge Elimination System
NOEC	no observable effect concentration
NOVs	Notice of violations
NO_x	nitrogen oxides
NPDES	National Pollutant Discharge Elimination System
NSTX-U	National Spherical Torus Experiment Upgrade
NVLAP	National Voluntary Laboratory Accreditation Program (NIST)
ODS	ozone-depleting substances (Class I and II)
OPEX	Operating expenses (PPPL budget)
ORPS	occurrence reporting and processing system ((DOE accident/incident reporting system)
OSHA	Occupational Safety and Health Agency
P1, P2	Plainsboro 1 (Cranbury Brook) and 2 (Devil's Brook) (surface water stations)
PCs	personal computer(s)
PCBs	polychlorinated biphenyls
PCE	perchloroethylene, tetrachloroethene, or tetrachloroethylene
pCi/L	picoCuries per liter
PE	Professional engineer
PEARL	PPPL Environmental, Analytical, and Radiological Laboratory
PF1A	Poloidal field coil 1A
PFC	Princeton Forrestal Center

PJM	Pennsylvania, Jersey, Maryland (Electric-power grid controllers/operators)
POTW	publicly-owned treatment works
PPA	Power Purchase Agreement
PPPL	Princeton Plasma Physics Laboratory
PSO	Princeton Site Office (DOE)
PSTP	Preliminary Site Treatment Plan
PT	proficiency test (Laboratory certification)
PTE	potential to emit (air emissions)
PUE	Power utilization or usage effectiveness
QA	Quality assurance
RAA	Remedial Alternative Assessment
RASR	Remedial Action Selection Report
RAWP	Remedial Action Work Plan
RCRA	Resource Conservation and Recovery Act
REC	renewable energy credits
redox	oxidation-reduction (potential)
rem	roentgen equivalent man
RESA	Research Equipment Storage and Assembly Building
RI	Remedial Investigation
RWHF	Radiological Waste Handling Facility
SF_6	sulfur hexafluoride (GHG)
SARA	Superfund Amendments and Reauthorization Act of 1986
SBRSA	Stony Brook Regional Sewerage Authority
SDWA	Safe Drinking Water Act
SESC	Soil erosion and sediment control
SO_2	sulfur dioxide
SPCC	Spill Prevention Control and Countermeasure
SWPPP	Stormwater Pollution Prevention Plan
Sv	Sievert
SVOCs	semi-volatile organic compounds
TCE	trichloroethene or trichloroethylene
TFTR	Tokamak Fusion Test Reactor
TPHC	total petroleum hydrocarbons
TRI	Toxic Reduction Inventory (CERCLA)
TSCA	Toxic Substance Control Act
TSS	total suspended solids
TW	test wells
UL-DQS	Underwriters Laboratories-DQS (Germany's first certification body)
UNFCCC	United Nations Framework Convention on Climate Change
VOCs	volatile organic compounds
WCR	Waste Character
μg/L	micrograms per liter

Princeton Plasma Physics Laboratory (PPPL)
Certification of Monitoring Data for
Annual Site Environmental Report for 2019

Contained in the following report are data for radioactivity in the environment collected and analyzed by Princeton Plasma Physics Laboratory's Princeton Environmental, Analytical, and Radiological Laboratory (PEARL). The PEARL is located on-site and is certified for analyzing radiological and non-radiological parameters through the New Jersey Department of Environmental Protection's Laboratory Certification Program, Certification Number 12471. Non-radiological surface and ground water samples are analyzed by NJDEP certified subcontractor laboratories – QC, Inc. and Accutest Laboratory. To the best of our knowledge, these data, as contained in the "Annual Site Environmental Report for 2019," are documented and certified to be correct.

Signed:

Mark Hughes

Digitally signed by Mark Hughes
Date: 2021.01.08 09:31:14 -05'00'

Mark Hughes,
Environmental Compliance Manager
Environmental Services Division

Robert S Sheneman

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Mike Bonkalski
Head
Environment, Safety, & Health Department

Executive Summary

Princeton Plasma Physics Laboratory

Annual Site Environmental Report for

Calendar Year 2019

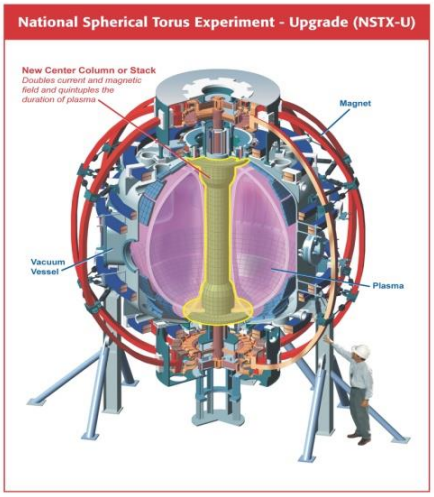
This report presents the results of environmental activities and monitoring programs at the Princeton Plasma Physics Laboratory (PPPL) for Calendar Year 2019. The report provides the U.S. Department of Energy (DOE) and the public with information on the level of radioactive and non-radioactive pollutants, if any, that are released into the environment as a result of PPPL operations. The report also summarizes environmental initiatives, assessments, and programs that were undertaken in 2019. The objective of the Site Environmental Report is to document PPPL's efforts to protect the public's health and the environment through its environmental protection, safety, and health programs.

Since 1951, PPPL has engaged in fusion energy research. Fusion is the reaction that occurs in our sun as well as in other stars. During fusion reactions, the nuclei of hydrogen atoms in a plasma state, i.e. as an ionized gas, fuse or join forming helium atoms and releasing of neutrons and energy. Unlike the sun, PPPL's fusion reactions are magnetically confined within a vessel or reactor under vacuum conditions. The long-range goal of the U.S. Magnetic Fusion Energy Science program is to develop and demonstrate the practical application of fusion power as a safe, alternative energy source replacing power plants that burn fossil fuels. Energy from fusion power plants would boil water for steam that drives electric-generating turbines without the production of greenhouse gases and other air pollutants.

National Spherical Torus Experiment - Upgrade

2019 marked the twenty-first year of the National Spherical Torus Experiment (NSTX). The NSTX upgrade project (NSTX-U) was completed in 2016 at a cost of $94 million. Some of the major upgrades included a redesign of the center stack magnets and an addition of a second neutral

beam box from the former Tokamak Fusion Test Reactor (TFTR). They were in place to begin the operation of the most advanced spherical tokamak in the world.



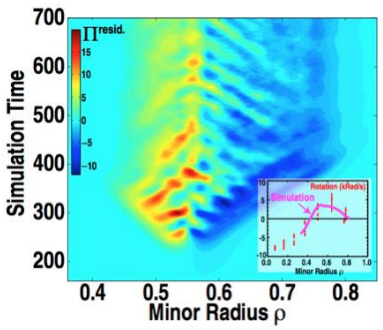
Unfortunately, due to disruptions to NSTX-U caused by events in 2015 and again in 2016, the experiment did not operate for second half of 2016 through 2019. Engineering and quality assurance issues caused the disruptions to a major magnetic coil (poloidal field coil, PF1A) and other smaller components of the experiment. Systemic design verification and validation (DVV) and other reviews were conducted in 2017 and 2018 to identify potential latent system weaknesses. Following completion of the reviews, a corrective action plan was developed to address the identified issues and vetted by independent reviewers. Following appropriate reviews and approval from DOE, the Laboratory is implementing the plan to revitalize NSTX-U and return it to experimental operations.

ITER Cadarache, France

ITER in Latin means "the way" and is the name of the large international fusion experiment located in the Provence-Alpes-Côte-d'Azur region in southeastern France. Construction began in 2007 with a projected First Plasma date for December 2025. When operational ITER will generate 10 times (Q10) the external power delivered to heat the plasma. PPPL, partnering with Oak Ridge National Laboratory, leads the U.S. ITER Project that coordinates U.S. ITER activities - lending to the project design, construction, and technical expertise.

International Collaboration & Other Plasma Physics Research

PPPL scientists and engineers collaborate with researchers from other fusion laboratories in the U.S. and around the world. Our international work supports work on the DIII-D experiment in San Diego, CA, the W-7X device in Germany, JET in the United Kingdom, the KSTAR experiment in South Korea, and the EAST facility in China. In addition, PPPL's researchers study plasma astrophysical phenomena and conduct theoretical plasma physics studies and develop computer models to simulate plasma disruptions and other physical phenomena.



PPPL Maximum Off-site Dose in 2019

When the total maximum off-site dose for 2019 was calculated, PPPL's radiological contribution was a fraction of the 10 milli roentgen equivalent man per year (mrem/year) PPPL objective and the 100-mrem/year DOE limit. Based on the radiological monitoring program data, the dose results for 2019 were:

1. Maximum exposed individual (MEI) dose from all sources—airborne and liquid releases—was 5.43E-03 mrem per year (5.43E-05 person-Sv per year) as shown in Exhibit 5-1.
2. The collective effective dose equivalent for the population living within 80 kilometers was 1.91E-01 person-rem (1.91E-03 person-Sv) as shown in Exhibit 5-1.

Infrastructure and Operation Improvements (IOI) Project

PPPL completed the initial phase of a campus-wide improvement plan which included renovating and modernizing office and storage space in addition to consolidating technical machine shops. The initial project, known as the Infrastructure and Operation Improvements (IOI) Project, is funded by the US DOE's Office of Science. The project began in 2015 with the removal of obsolete equipment and systems in the C-site motor generator (MG) building. The project continued with renovations to office, meeting, technical and storage areas and removal of modular office structures. The project was completed in 2019 when the Research, Storage and Assembly Building (RESA), one of PPPL's primary fabrication shops, was moved into the renovated C-Site MG. The building RESA originally occupied was fitted for racks and converted into a new warehouse for storing equipment.

2019 saw the development and conceptual design of additional campus improvement projects envisioned by PPPL's 10-Year Campus Plan. They include critical infrastructure system improvements, new high-performance computing capabilities, and the construction of a new research and collaboration facility, known as the Princeton Plasma Innovation Center (PPIC). DOE and Princeton University are committed to the comprehensive suite of campus improvements outlined in the Campus Plan.

PPPL Environmental Achievements and Activities in 2019

PPPL won seven national honors for sustainable programs in 2019. The U.S. Environmental Protection Agency (EPA) Region 2 recognized the Laboratory for several environmental programs which include, but are not limited to:

- Reducing paper purchasing by nearly 54 percent
- Reducing water use by 36 percent over two years
- Increasing electronics recycling by 67 percent over two years
- Increasing office recycling and recycling of demolition materials by 77 percent
- Decreasing energy use by nearly 27 percent over two years
- Reducing business travel by 25 percent over two years

PPPL was also recognized for purchasing sustainable electronics, winning an EPEAT Purchaser award. PPPL encourages its employees to practice environmental stewardship principles in their daily lives through their personal purchases and recycling activities as well as at work. Each year, the Laboratory hosts events such as Earth Week in April and America Recycles Day in November

when information on green products and recycling opportunities are provided. PPPL's "Green Team" designs programs and activities to help green PPPL and the whole community.

PPPL has maintained an Environmental Management System (EMS) program certified to the International Organization for Standards (ISO) 14001 Standard since 2012. Registration to the ISO14001 Standard requires annual audits by an independent audit and registration firm. PPPL's EMS was first registered against the 2015 version of ISO14001 in 2016 and completed annual surveillance audits in 2017 and 2018. The recertification audit was delayed until 2020 in order to competitively bid the subcontract for EMS audit and registration services.

The Laboratory continues to promote all aspects of its ES&H program as it has in its fusion research program. Efforts are geared not only to full compliance with applicable local, state, and federal regulations, but also to achieve a level of excellence in ES&H performance. PPPL is an institution that serves other research facilities and the nation by providing valuable information gathered from its fusion research program.

Chapter 1

The DOE PPPL is a Collaborative National Center for plasma and fusion science. Its primary mission is to develop the scientific knowledge and advanced engineering to enable fusion to power the U.S. and the world, and to developing the understanding of plasmas from the nano- to the astrophysical scale. Related missions include developing the science of nanofabrication for U.S. industries of the future, while providing the highest quality of scientific education. Our vision is "To create the innovations which will make fusion power a practical reality."

INTRODUCTION

1.1 Site Mission

PPPL is a Collaborative National Center for plasma and fusion science. It is unique as the only DOE national laboratory devoted to developing the scientific knowledge and advanced engineering to enable fusion to power the U.S. and the world, and to developing the understanding of plasmas from the nano- to the astrophysical scale. Related missions include conducting world-class research along the broad frontier of plasma science, providing the highest quality of scientific education and experimentation, and developing technology transfer and science education programs in the local community and nation-wide.

The National Spherical Torus Experiment Upgrade (NSTX-U) is a collaborative project among 30 U.S. laboratories, including DOE national laboratories, universities, and institutions, and 28 international institutes from 11 countries. Also located at PPPL are smaller experimental devices, the Magnetic Reconnection Experiment (MRX), the Lithium Tokamak Experiment (LTX) and Hall Thruster, which investigate plasma physics phenomena. The next generation magnetic reconnection experiment, the Facility for Laboratory Astrophysical Reconnection Experiments (FLARE) arrived at PPPL in August 2019 and is scheduled to be operational in mid-2022.

As a part of both off and on-site collaborative projects PPPL scientists assist fusion programs within the United States and in Europe and Asia. To further fusion science in 2019, PPPL collaborated with other fusion research laboratories across the globe on experiments including the Joint European Torus (JET) facility located in the United Kingdom, the Korean Superconducting Tokamak Advanced Research (KSTAR) facility located in South Korea, and the International Thermonuclear Experimental Reactor or ITER, which in Latin means "The Way," located in Cadarache, France. PPPL's main fusion experiment, the National Stellarator Tokamak

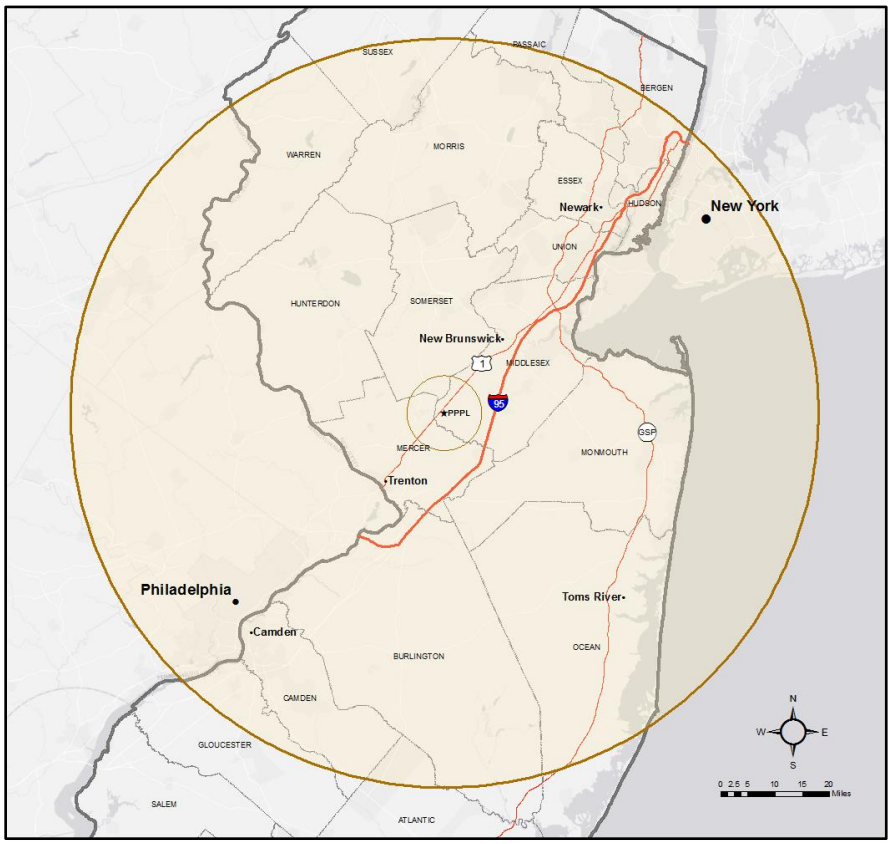
Experiment Upgrade project (NSTX-U), began in 2011 and was completed in May 2016. After a successful inauguration it was taken offline to perform additional renovations, which are projected to be completed in the next few years.

1.2 Site Location

The PPPL site is in the center of a highly urbanized Northeastern region. The closest urban centers are New Brunswick, 14 miles (22.5 km) to the northeast, and Trenton, 12 miles (19 km) to the southwest. Within a 50-mile (80 km) radius are the major urban centers of New York City, Philadelphia, and Newark (Exhibit 1-1).

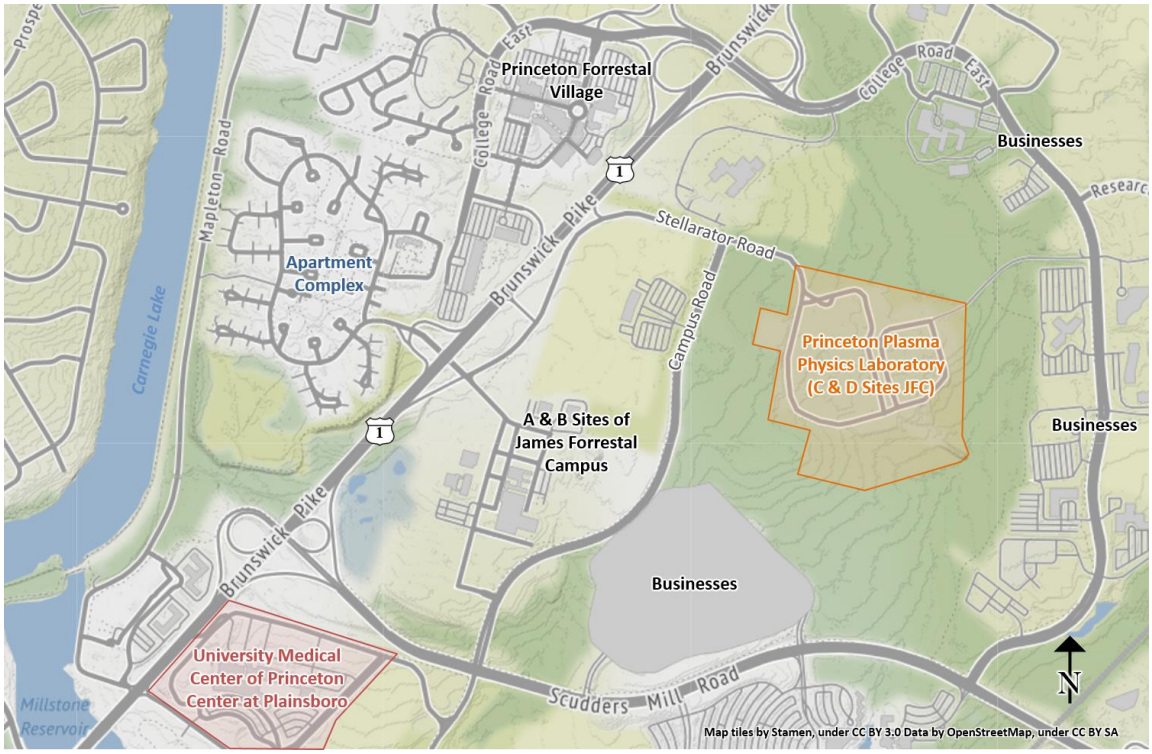
The site is located in Plainsboro Township in Middlesex County (central New Jersey), adjacent to the municipalities of Princeton, Kingston, East and West Windsor, and Cranbury, NJ. The Princeton area continues to experience growth in commercial and residential development along the broader Route 1 corridor near the site. The development of new commercial buildings on Campus Drive, about a mile South-West of PPPL is on ongoing. The Penn Medicine Princeton Medical Center at Plainsboro is located less than 2 miles South-West of PPPL (Exhibit 1-2). Princeton University's main campus is approximately three miles South-West of the site.

Exhibit 1-1. Region Surrounding PPPL (50-mile radius shown)



PPPL, then known as "Project Matterhorn", was first established in small buildings on the A- and B-sites of the James Forrestal Campus (JFC), Princeton University's research center named for Princeton graduate (Class of 1915) and the first U. S. Secretary of Defense, James Vincent Forrestal. Located east of U.S. Route 1 North, PPPL has occupied the C- and D-site location of JFC since 1959 (Exhibit 1-2). The alphabet designation was derived from the names given to the early-model Stellarator plasma fusion devices.

Exhibit 1-2. PPPL James Forrestal Campus (JFC), Plainsboro, NJ



Surrounding the site are lands of preserved and undisturbed areas including upland forest, wetlands, open grassy areas, and a minor stream, Bee Brook, which flows along PPPL's eastern boundary. These areas are designated as open space in the James Forrestal Campus (JFC) site development plan.

D-site is fully surrounded by a chain-linked fence topped with barbed wire for security purposes. Access to D-site is limited to authorized personnel through the use of access card readers. PPPL's Site Protection Division controls access to C-site allowing the public and visitor access following an identification check. Vehicle inspections may occur prior to entrance.

Exhibit 1-3. Aerial View of PPPL

The aerial photo above (Exhibit 1-3) shows the general layout of the facilities at the C-sites and D-sites as viewed from the North; the former TFTR and current NSTX-U Test Cells are located at D-site (on the left side of photo).

1.3 General Environmental Setting

The climate of central New Jersey is classified as mid-latitude, rainy climate with mild winters, hot summers, and no dry season. In 2019 temperatures ranged from 2 degrees to 97 degrees Fahrenheit (°F) (-16.7° Celsius (C) to 36.1° C); the average departure from normal temperature (1981-2010) was minus 4.0° F (-15.6° C) according to NOAA Local Climatological Data. Extreme temperatures typically occur once every five years. Approximately half the year, from late April until mid-October, the days are freeze-free [NOAA].

The typical regional climate is moderately humid with a total average precipitation about 55.4 inches evenly distributed throughout the year. In 2019, the total rainfall for the year was 58.06 inches (147.47cm), or 2.66 inches (6.76cm) above average for the region.

The most recent archaeological survey was conducted in 1978 as part of the TFTR site environmental assessment study. Through historical records reviews, personal interviews, and field investigations, one projectile point and a stone cistern were found. Apparently, the site had limited occupation during prehistoric time and has only in recent times been actively used for farming. No significant archeological resources were identified on-site. There are more significant

examples of prehistoric occupation in areas closer to the Millstone River, which are within two miles of the site [Gr77]. PPPL's original C-Site buildings are now over 50 years old and, thus, are subject to evaluation as historical resources under the National Historic Preservation Act (NHPA).

1.4 Primary Operations and Activities

Several magnetic fusion experiments, including NSTX-U, MRX, and LTX, currently operate at PPPL. NSTX-U is the Laboratory's largest experiment and is located on D-site. The original NSTX experiment produced one million amperes of plasma current, setting a new world record for a spherical torus device. This device was designed to test the physics principles of spherical-shaped plasmas forming a sphere with a hole through its center. Plasma shaping is an important parameter for plasma stability and performance enabling viable fusion power. NSTX ceased operations in 2011 and was partially dismantled for major upgrades and renamed NSTX-U, which were finished in May of 2016. The new machine was operational for two months, until a key magnetic coil failed, when operations were ceased for repairs. NSTX-U, has twice the plasma heating power and magnetic confinement as the original experiment and will be able to extend plasma pulse duration by five times.

LTX continues to explore new paths for plasma energy efficiency and sustainability, after producing its first plasma in 2008. The primary goal of LTX is to investigate the properties of a lithium liquid coating for plasma surfaces or plasma-facing component (PFC). The previous experiment, Current Drive Experiment-Upgrade (CDX-U) held the lithium in a circular tray at the base of the vacuum vessel. The LTX liquid lithium was evaporated and deposited a thin layer inside the vacuum vessel and kept liquid by heater in the shell. LTX-β, an upgrade incorporating new beam line, went online in April 2019.

PPPL's Magnetic Reconnection Experiment (MRX) investigates the explosive process of magnetic reconnection, giving rise to astrophysical events that include auroras, solar flares and geomagnetic storms. The process occurs when the magnetic field lines in plasmas break and violently reconnect. Generating and studying reconnection under controlled laboratory conditions can yield insights into solar outbursts and the formation of stars, and to greater control of experimental fusion reactions.

1.5 Relevant Demographic Information

Using data from the latest American Community Survey, there are an estimate 17.7 million people living within a 50-mile radius of the Laboratory, totaling to 2,258 people per a square mile. The 2019 US Census Bureau Statistics estimates that Middlesex County has a population of 825,062. Adjacent counties have populations of 367,430 (Mercer), 618,795 (Monmouth), 328,934 (Somerset), and 556,341(Union) [US19]. Other information gathered and updated from previous studies, conducted for TFTR, include socioeconomic information [Be87b] and an ecological survey, which were studies describing pre-TFTR conditions [En87].

✵

CHAPTER 2

ENVIRONMENTAL COMPLIANCE SUMMARY AND ENVIRONMENTAL STEWARDSHIP

Princeton Plasma Physics Laboratory's (PPPL) environmental goals are to fully comply with environmental regulations, to conduct our scientific research and operate our facilities in a manner protective of human health and the environment, and to promote sustainable practices wherever possible. In 2019, PPPL has accomplished these goals while operating within its permitted limits as documented in the following chapter. In addition, PPPL promotes good environmental practices through the Earth Day, America Recycle Day, and other activities for its employees.

PPPL initiates actions which enhance and document compliance with its identified compliance obligations and regulatory requirements. Compliance with applicable federal, state, and local environmental statutes or regulations, and Executive or DOE Orders is an important element of PPPL's mission and operations.

2.1 Laws and Regulations

Exhibit 2.1 summarizes the environmental statutes and regulations applicable to PPPL's activities, as well as summarizing the 2019 compliance status and providing the ASER sections where further details are located. The list of "Applicable Environmental Laws and Regulations – 2019 Status" mirrors PPPL's EMS Appendix B, "Summary of Compliance Obligations" [PPPL20a].

2.2 Site Compliance and Environmental Management System (EMS) Assessments

The annual surveillance audit of PPPL's Environmental Management System against the International Standard Organization ISO-14001:2015 was completed in November 2018. Two major non-conformances were identified, and corrective actions were developed to address them. In addition, the independent audit team identified two opportunities for improvement and three best practices during the audit. A follow-up audit in February 2019 addressed all corrective actions from the 2018 audit and extended PPPL's ISO-14001 certificate until February 2020. Further discussion of the EMS program audits follows in Section 2.3 of this chapter [Cum20, ISO15, UL17].

2.3 Environmental Permits

The following Exhibit 2.1 "Applicable Environmental Laws and Regulations –2019 Status" provides information about PPPL's compliance with applicable environmental permits, Federal and State environmental laws, regulation, DOE and Executive Orders.

Exhibit 2-1. Applicable Environmental Laws and Regulations – 2019 Status

Environmental Restoration and Waste Management	2019 Status	ASER section(s)
Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) provides the regulatory framework for identification, assessment, and if needed remediation of contaminated sites – either recent or inactive releases of hazardous waste. (Also see Superfund Act Reauthorization Amendments under NJ Emergency Planning and Community Right-to-Know)	The CERCLA inventory completed in 1993 [Dy93] warranted no further CERCLA actions. During 2019, PPPL had no involvement in CERCLA-mandated clean-up actions. PPPL's on-going New Jersey-regulated groundwater remediation is discussed in Chapters 4 and 6.	*4.3.1 B* *6.5*
Resource Conservation and Recovery Act (RCRA) regulates the generation, storage, treatment, and disposal of hazardous wastes. RCRA also includes underground storage tanks containing petroleum and hazardous substances, universal waste, and recyclable used oil. (NJ-delegated program)	In 2019, PPPL shipped 20.46 tons of combined hazardous, universal and TSCA waste, of which 16.01 tons were recycled. The types of waste are highly variable each year; in 2019, incinerated quantities were classified in several hazard classes [San20a].	*4.2.1 B* *4.2.1 C*
Federal Facility Compliance Act (FFCA) requires the Department of Energy (DOE) to prepare "Site Treatment Plans" for the treatment of mixed waste, which is waste containing both hazardous and radioactive components.	In 1995, PPPL prepared a Preliminary Site Treatment Plan (PSTP). An agreement among the regulators was reached to treat in the original accumulation container any potential mixed waste [PPPL95]. PPPL does not nor does not expect to generate mixed waste in the future.	
National Environmental Policy Act (NEPA) covers how federal actions may impact the environment and an examination of alternatives to those actions	In 2019, PPPL performed NEPA reviews of 19 proposed activities. These activities were determined to be categorical exclusions (CXs) in accordance with the regulations/guidelines of the Council on Environmental Quality (CEQ) [Str20].	
Toxic Substance Control Act (TSCA) governs the manufacture, use, and distribution of regulated chemicals listed.	In 2019, PPPL shipped 1153 pounds of PCB TSCA Hazardous Substances, which consisted of capacitors, ballast and RF filters. Asbestos shipments in 2019 totaled 40 cubic yards [San20a].	*4.2.1A*
Federal Insecticide, Fungicide, and Rodenticide Act (FIFRA) regulate the user and application of insecticides, fungicides, and rodenticides. (NJ-delegated program)	PPPL used limited quantities of pesticides/insecticides, herbicides, and fertilizers. A licensed subcontractor performs the application under the direction of licensed PPPL's Facilities personnel [Kin20].	*Exhibit 4- 11* *4.5.3*

Exhibit 2-1. Applicable Environmental Laws and Regulations – 2019 Status (continued)

Other Environmental Statutes	2019 Status	ASER section(s)
Oil Pollution Prevention provides the regulatory requirements for a Spill Prevention Control and Countermeasure (SPCC) Plan for petroleum containing storage tanks and equipment.	The SPCC plan was reviewed and updated in 2016 [PPPL16a]. PPPL does not meet the threshold quantity of 200,000 gallons of petroleum (excluding transformer oil) for the requirements of a Discharge Prevention Control and Containment (DPCC) plan. PPPL experienced one reportable spill in 2019, which was quickly remediated. [San20b].	*4.3.1*
National Historic Preservation Act (NHPA) and New Jersey Register of Historic Places protect the nation and New Jersey's historical resources through a comprehensive historic preservation policy.	The Delaware & Raritan Canal and the area within 100 yards are designated as National and New Jersey Historic Districts. PPPL's canal pump house is located within this historic district. [PPPL05]. The original C-Site buildings are now over 50 years old and, thus eligible for evaluation under the NHPA.	
EO 11988 Floodplain Management Programs covers the delineation of the 100- and 500-year floodplain and prevention of development within the floodplain zones. (NJ-delegated program)	The 100- and 500-year floodplain levels in the vicinity of PPPL are at 80 and 85 feet above mean sea level (msl), respectively. The majority of the PPPL site is located at approximately 100 ft. above msl. The HAZMAT building is in the flood hazard zone but is protected by concrete dikes [NJDEP84].	
EO 11990 Protection of Wetlands; Wetlands Protection Act governs the activities that are allowable through the permitting system and mitigation requirements. (NJ-delegated program)	In 2015, PPPL and Princeton Forrestal Center received the wetlands delineation from NJDEP. Any regulated activities either in the wetlands or transition areas must receive approve prior to commencement [PPPL15]. No new wetlands or transition area permits were required in 2019.	*4.5.1*
Clean Air Act (CAA) and New Jersey Air Pollution Control Act controls the release of air pollutants through permit and air quality limits and conditions. **National Emission Standards for Hazardous Air Pollutants (NESHAPs)** USEPA regulates the NESHAPs program for tritium (an airborne radionuclide) and boilers (<10 million BTUs). Greenhouse gas (GHG) emissions inventory tracking and reporting are regulated by EPA.	PPPL-DOE maintain air certificates/permits for the regulated equipment: 4 boilers, 3 emergency/standby generators, 1 dust collector, and a fluorescent bulb crusher. Two previous above-ground storage tank permits (< 10,000 gals. fuel oil) were canceled following guidance from an NJDEP inspection. PPPL is designated as a synthetic minor emitter and does not exceed air contaminant thresholds requiring a Title V permit. In 2018, PPPL submitted Subpart JJJJJJ Notification to EPA, it's biennial boiler adjustment [Nem19]. The annual 2019 boiler adjustment results were submitted to NJDEP as required by the permit. Fuel consumption sulfur content for the generators and boilers are recorded; annual boiler emissions calculated [Rog20]. NESHAPs	*4.4*

Exhibit 2-1. Applicable Environmental Laws and Regulations – 2019 Status (continued)

	report for tritium emissions are submitted annually [PPPL20b]. PPPL maintains an inventory for ozone-depleting substances (ODS) [Hug20e].	

Other Environmental Statutes	2019 Status	ASER section(s)
NJ Soil Erosion and Sediment Control (SESC) Plan requires an approval by the Freehold Soil Conservation District for any soil disturbance greater than 5,000 sq. feet.	No projects required soil erosion permits in 2019.	*4.5.2*
NJ Comprehensive Regulated Medical Waste Management governs the proper disposal of medical wastes.	Last report was submitted to NJDEP in 2004. PPPL is no longer required to submit reports but continues to comply with proper disposal of all medical wastes [San20a].	
NJ Endangered Species Act prohibits activities that may harm the existence of listed threatened or endangered species.	No endangered species reported on PPPL or D&R Canal pump house sites. Cooper's hawks and Bald eagles have been sited within 1 mile; other endangered species, like the bog turtle, have been sighted in surrounding towns. [Am98, NJB97, NJDEP97, PPPL05].	
NJ Emergency Planning and Community Right-to-Know Act (EPCRA) and Superfund Amendment Reauthorization Act (SARA Title III), requires for certain toxic chemicals emergency planning information, hazardous chemical inventories, and the reporting of environmental releases to federal, state, and local authorities.	PPPL submitted the required annual chemical inventory reports [PPPL19a].	*4.3.1 C* *Exhibit 4-7* *Exhibit 4-8*
NJ Regulations Governing Laboratory Certification and Environmental Measurements mandate that all required water analyses be performed by certified laboratories.	The PPPL Environmental, Analytical, and Radiological Laboratory (PEARL) maintained NJDEP certification for non-radiological analyze-immediately parameters. PPPL received acceptable for all performance tests for pH and total residual chlorine (chlorine-produced oxidants or CPO) and temperature. In 2019 PPPL used the CPO method to analyze Peracetic Acid (PAA), because their results are proportional. PPPL uses a NJDEP certified subcontract analytical laboratory for most environmental monitoring [PPPL20c].	*7*

Exhibit 2-1 Applicable Environmental Laws and Regulations – 2019 Status (continued)

Water Quality and Protection	2019 Status	ASER section(s)
NJ Safe Drinking Water Act (SDWA) protects the public water supply by criteria standards and monitoring requirements.	PPPL conducts quarterly inspections of the potable water physical cross connection system as required by the NJDEP permit. Potable water is supplied by NJ American Water Company [Con20b].	*4.1.4 A* *Exhibit 4-4*
Stormwater Management and the Energy Independence and Security Act of 2007 (EISA) & **Delaware & Raritan Canal Commission Regulations (Stormwater Water Quality)**	PPPL's Stormwater Pollution Prevention Plan (SWPPP) was revised in 2019, it provides guidance to reduce the impact of PPPL's operations on storm water quality [PPPL19b]. PPPL maintains stormwater best management practices structures such as erosion control procedures, rain gardens, grassed swales, vegetated cover, and a permitted retention basin.	
Clean Water Act (CWA) and NJ Pollution Discharge Elimination System (NJPDES) regulates surface and groundwater (lined surface impoundment, LSI) quality by permit requirements and monitoring point source discharges.	In 2019, PPPL-DOE received from NJDEP the final NJPDES surface water discharge permit [NJDEP19]. PPPL reported two permit limits exceeded at DSN001, the basin outfall. However, one was determined to be a mistake by the analytical laboratory, and one was invalid measurement and/or test results because it is not possible to discern the concentration of individual chemicals when chlorine and PAA are used together. PPPL also monitors sample point DSN003, the D&R Canal pump house backwash filter outfall. PPPL completed its transition to PAA as a substitute for chlorine disinfection for industrial water and this parameter was added to PPPL's discharge monitoring program.	*4.1.1* *Exhibits 4-1, 4-2, 4-3 and 4-5*

Regulatory Program Description	2019 Status	ASER section(s)
NJ Technical Standards for Site Remediation governs the soil/groundwater assessments, remedial investigations, and clean-up actions for sites suspected of hazardous substance contamination.	PPPL began investigation the presence of chlorinated solvent chemicals in groundwater in 1990. Over time, more than 20 monitoring wells were installed on-site to determine the source and extent of groundwater contamination. Quarterly monitoring is conducted at 9 wells and 1 foundation drain sump, and annual monitoring is conducted at 12 wells and 2 sumps in March each year. Monitoring results are reported biennially to NJDEP under a Groundwater Remedial Action Permit. In late 2019, PPPL closed 11 wells from previous investigations that were no longer needed.	*6.5*
Executive Order (E.O.) 11988 – Floodplain Management & **E.O. 11990 – Protection of Wetlands**	See Floodplain Management Program (NJ delegated program) & Wetlands Protection Act (NJ delegated program)	
Migratory Bird Treaty Act DOE's 2013 Memorandum of Understanding and E.O. 13186, Responsibilities of Federal Agencies to Protect Migratory Birds srequires that actions are taken to protect migratory birds and conduct community outreach.	In 2019, PPPL took no migratory birds nor conducted any programs or actions that call for activities such as banding, marking, or scientific collection, taxidermy and/or depredation control.	
DOE Order 231.1B, ***Environment, Safety, and Health Reporting,*** requires the timely collection, analysis, reporting, and distribution of information in ES&H issues.	PPPL ES&H Department monitors and reports environmental, safety and health data and distributes the information *via* lab-wide e-mails, PPPL news articles, at meetings with Laboratory management, supervisors, staff and DOE-PSO. The ES&H Executive Board and its sub-committees meet throughout the year [DOE11c]. PPPL's Annual Site Environmental Report (ASER) is required by this order.	
DOE Order 436.1, ***Departmental Sustainability,*** requires all applicable DOE elements to implement an ISO14001-compliant Environmental Management System and support departmental sustainability goals.	PPPL's Environmental Management System (EMS) was originally developed in 2005 and is reviewed and updated periodically [DOE11a, PPPL16b]. PPPL's EMS is registered to the ISO14001:2015 standard by an independent registrar (UL-DQS) based on annual audits [UL17].	*3*

Exhibit 2-1 Applicable Environmental Laws and Regulations – 2019 Status (continued)

Radiation Protection	2019 Status	ASER section(s)
DOE Order 435.1, Change 1, *Radioactive Waste Management*, provides guidance to ensure that DOE radioactive waste is properly managed to protect workers, the public and the environment.	PPPL maintains a Low-Level Radioactive Waste Program Basis document to meet the requirements of DOE Order 435.1 and enable shipments to the Energy Solutions disposal facility in Clive, UT. This document as approved by DOE in July 2012. [DOE01, PPPL12].	*5.1.3*
DOE Order 458.1, *Radiation Protection*, provides protection of the public and the environment from exposure to radiation from any DOE facility. Operations and its contractors comply with standards and requirements in this Order.	PPPL's policy is to maintain all radiation exposures "As Low as Reasonably Achievable" (ALARA). PPPL implements its radiation protection program as outlined in the Environmental Radiation Protection Program (ERPP) document and the Environmental Monitoring Plan Section 6, "Radiological Monitoring Plan." PPPL's contribution to radiation exposure is well below the DOE and PPPL limits [10CFR835, DOE01, DOE11b, PPPL13a]	*5.1* *Exhibit 5-1*
Atomic Energy Act (AEA) governs plans for the control of radioactive materials	PPPL's "Nuclear Materials Control and Accountability (MC&A) Plan" describes the control and accountability system of nuclear material at PPPL. This plan provides a system of checks and balances to detect, deter and prevent unauthorized use or removal of nuclear material from PPPL [PPPL13a].	*5.2*
Executive Order (EO) 13834, *Efficient Federal Operations* requires all Federal agencies to meet energy and environmental performance statutory requirements in a manner that increases efficiency, optimizes performance, eliminates unnecessary use of resources, and protects the environment.	PPPL reported through DOE Dashboard the FY2019 site sustainable data that addressed the goals, targets and status of EO requirements [PPPL19c].	*3*

CERTIFICATE

This is to certify that

Princeton University
Princeton Plasma Physics Laboratory
100 Stellarator Road
Princeton, NJ 08540
United States of America

has implemented and maintains an **Environmental Management System**.

Scope:
The environmental activities and supporting processes associated with the facilities, experiments, and operations.

Through an audit, documented in a report, it was verified that the management system fulfills the requirements of the following standard:

ISO 14001 : 2015

Certificate registration no. 10008966 UM15
Date of original certification 2012-02-07
Date of certification 2018-01-04
Valid until 2021-01-03

DQS Inc.

Brad McGuire
Managing Director

Accredited Body: DQS Inc., 1130 West Lake Cook Road, Suite 340, Buffalo Grove, IL 60089 USA

Exhibit 2-2. ISO-14001 Certificate

2.4 External Oversight and Assessments

In 2016, the International Organization for Standards (ISO) revised the Environmental Management System Standard as stated on their web site:

ISO 14001:2015 helps an organization achieve the intended outcomes of its environmental management system, which provide value for the environment, the organization itself and interested parties. Consistent with the organization's environmental policy, the intended outcomes of an environmental management system include:

- *enhancement of environmental performance;*
- *fulfilment of compliance obligations;*
- *achievement of environmental objectives.* [ISO15]

In November 2017, the Laboratory's EMS program underwent a comprehensive audit for re-certification issued by DQS-UL for the new ISO-14001 Certificate on January 4, 2018. The annual surveillance audit of PPPL's Environmental Management System against the International Standard Organization ISO-14001:2015 was completed in November 2018. A follow-up audit in February 2019 addressed all corrective actions from the 2018 audit and extended PPPL's ISO-14001 certificate until February 2020.

2.5 Emergency Reporting of Spills and Releases

Under New Jersey regulations, PPPL is required to call the Action Hotline to report any permit limits that are exceeded. One release of petroleum hydrocarbons on pervious and adjacent impervious surfaces required notification to New Jersey's Action Hotline during 2019. During a project to replace fuel tanks, PPPL discovered what appeared to be some mild diesel fuel contamination. A sump beneath the diesel pump may have overflowed with stormwater in the past and that water carried some diesel fuel with it [San20d]. The release was remediated, and documentation was submitted under NJDEP's Site Remediation Regulations.

2.6 Notice of Violations and Penalties

In 2019, there were three instances of permit non-compliances; two permit limit exceedances and one for a sampling error. Both permit exceedances turned out to be analysis errors. One was an error on the part of PPPL's subcontracted analytical laboratory; they received incorrect results of COD due to a bad low-level standard lot. They reanalyzed the samples for COD and the results came back normal. The other reported permit exceedance was for a chlorine

exceedance in our surface water discharge at sample point DSN001, which also turned out to be incorrect. PPPL switched to using potable water for several days, as the canal water system was being repaired, which is pre-treated with Chlorine by the water supplier. PPPL never stopped PAA injection during that time. It is not possible to discern the concentrations between the two chemicals because they use the same analysis method. The NJDEP didn't penalize PPPL for either of these instances.

The third noncompliance, when PPPL did not sample surface water outfalls in September of 2019, PPPL received a Notice of Violation (NOV). The error was a result of a staffing shortage and inadequate task assignment. In response to the NOV, PPPL developed a corrective action plan to prevent other potential incidents.

Exhibit 2-3 Earth Week 2019

2.7 Green and Sustainable Remediation (GSR)

The requirements of E.O. 13834 and DOE's 2019 Sustainability Report and Implementation Plan advocate green and sustainable remediation practices [EO19, DOE19]. Currently, PPPL's remediation program is monitoring ground and surface water for contaminants and does not include treatment or remediation actions (See Ch. 4 and 6).

2.8 Adapting to Climate Change

As a relatively small facility in a temperate climate, PPPL is prepared for local weather events addressed in the DOE vulnerability assessment survey. On-site and nearby severe weather events/risks are identified, and the emergency planning and communication processes adapted to be better able to prepare and respond to climate driven severe weather events.

2.9 Environmental Stewardship

During the annual Earth Week site-wide clean-up, more than 20 PPPL employees took time from their normal tasks to improve the PPPL's environment. Teams patrolled the grounds by removing recyclables and trash that had escaped the dumpsters. In all, 274 pounds of trash and 246 pounds of recyclables were collected from the site.

2.9.1 Earth Week 2019

Celebrating Earth Day at PPPL, on April 19, PPPL employees and members of the public viewed displays on sustainable renovations and projects; vendor participants were PSE&G, Princeton University Transportation Office, Princeton Public Library, office and janitorial supply vendors, PPPL's cafeteria, our sustainable furniture supply vendor, and electronic waste removal company. PPPL employees recycled 650 pounds. of electronics from their homes. Employees also viewed a lunch time documentary called "The Sourlands: A New Jersey Treasure" that describes the importance of the Sourland Mountain Preserve, a 17-mile-long ridge that is the largest forest in Central New Jersey[Dev20].

In 2019, PPPL continued its annual Bike to Work Challenge, which encouraged employees to bike to the laboratory to help reduce the carbon footprint.

Exhibit 2-4 Bike Banner Promoting Cycling

Each year, employees nominate their co-workers for their exceptional efforts to minimize waste, improve energy efficiency, and promote sustainable practices at PPPL. 52 employees received the 2019 PPPL Green Machine Awards for the following projects:

- Alternative commuting for biking or taking the Tiger Transit bus to work and thereby reducing greenhouse gas emissions and lowering PPPL's carbon footprint.
- Organizing a green event by serving single stream and compostable breakfast items at Science on Saturday, contributing to a zero-waste event.
- Construction and demolition waste diversion by recycling demolition waste and placing recycling, trash and recycling in proper bins.
- Preventing waste in the landfill by recycling properly and placing compost, trash and recyclables in the proper bins.
- Lab-wide recycling support by educating the staff about recycling and composting and for sorting recycling and compost from the waste stream, thereby contributing to PPPL's 69 percent office waste recycling rate in fiscal year 2019.

Exhibit 2-5 Earth Week's Green Machine Award Recipients

2.9.2 American Recycles Day at PPPL

Each year PPPL celebrates America Recycles Day (ARD) which is officially every November 15th. In 2019, PPPL's Green Team, volunteers who promote recycling and environmental sustainability within their Departments, gave out "Get Caught Green-Handed" awards to those who correctly composted or carried reusable bags/dishes for their lunch. The Recycled Art Contest inspired the creative talents of employees, who selected the winners – Winners of the America Recycles Day art contest included scooter using recycled materials, "For the Birds", and lamp made out of a blowtorch, along with many other entries.

Exhibit 2-6. America Recycles Day

ARD activities included employee electronics recycling, totaling 1,425 pounds, voluntary pledges to recycle, a clothing drive, and more.

2.9.3 Environmental Awards

In 2019 PPPL received six (6) Federal Green Challenge Awards from the U.S. EPA's Region 2. Here are some of the achievements PPPL attained:

- 53.74% decrease in paper purchasing from previous year

Exhibit 2-7. 2019 US EPA Federal Green Challenge Awards

- 35.89% decrease of water usage over a two-year period
- 67.13% increase in electronics recycling over a two-year period
- 77.38% increase of construction and demolitions materials diversion from a landfill over a two-year period
- 26.87% decrease in energy usage over a two-year period

Chapter 3

The DOE Princeton Plasma Physics Laboratory's Environmental Management System (EMS) program was certified ISO:14001 compliant first in 2011, recertified in 2014. PPPL first certified to the new ISO 14001:2015 standard in 2017. Each year PPPL's EMS is audited by an independent auditing firm and certified to the ISO:14001 standards. PPPL's EMS program is accessible online for employees and the public.

ENVIRONMENTAL MANAGEMENT SYSTEM

PPPL continues to make progress toward the sustainability goals established by Presidential Executive Orders and DOE Order 436.1 by integrating sustainability goals into its site-wide Environmental Management System (EMS). Since 2005, PPPL has focused on improving the sustainability of Laboratory operations and improving environmental performance. "Sustainable PPPL" is a program that capitalizes on PPPL's existing EMS to move the Laboratory toward more sustainable operations. The EMS includes energy management, water conservation, renewable energy, greenhouse gas management, waste minimization, environmentally preferable purchasing, and facility operation programs to reduce environmental impacts and improve performance [PPPL20a]. PPPL will continue to implement sustainability practices aimed at meeting, or exceeding, the sustainability goals in its EMS, DOE Orders, and Executive Orders [EO15].

The annual surveillance audit of PPPL's Environmental Management System against the International Standard Organization ISO-14001:2015 was completed in November 2018. Two major non-conformances were identified, and corrective actions were developed to address them. In addition, the independent audit team identified two opportunities for improvement and three best practices during the audit. A follow-up audit in February 2019 addressed all corrective actions from the 2018 audit and extended PPPL's ISO-14001 certificate until February 2020.

3.1 DOE Sustainability Goals

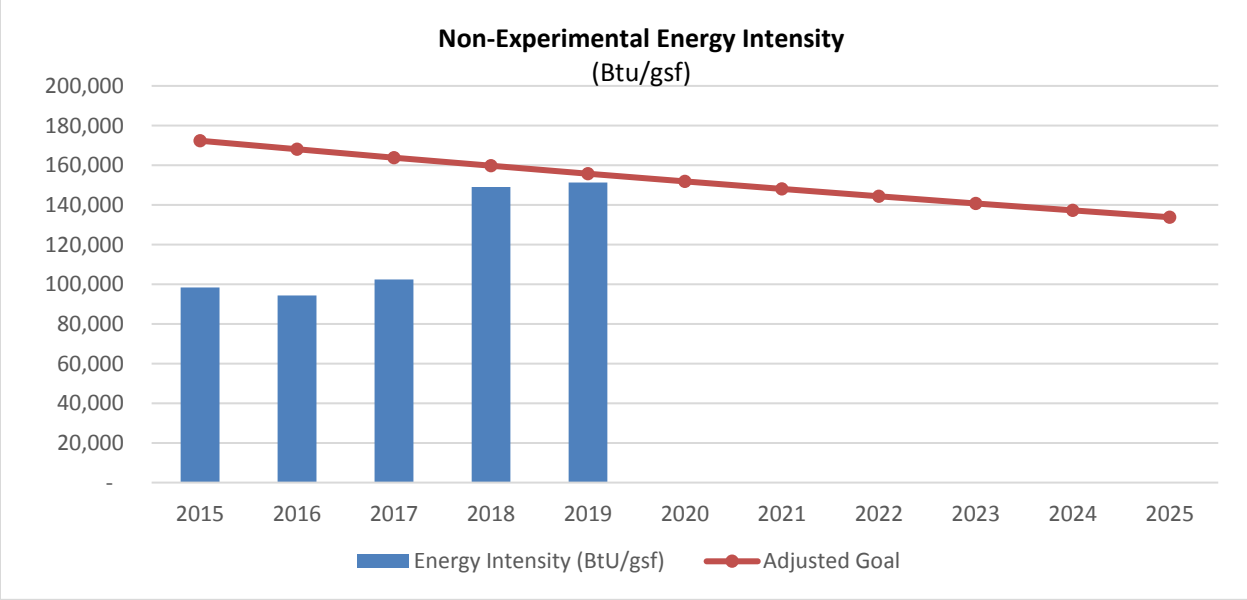
In 2019, PPPL continued to address the energy, water, and environmental management goals from EO 13834, *Efficient Federal Operations* and DOE Order 436.1, *Departmental Sustainability*. PPPL completed its annual sustainability reporting for FY19, which summarized progress and outlined future plans for meeting the departmental sustainability goals under previous EO13514 and

submitted the *DOE Sustainability Dashboard Report* detailing our energy and environmental performance [PPPL19f].

3.1.1 Energy Efficiency

In 2019, PPPL experienced an increase of 1.5% in energy intensity (British Thermal Units per gross square feet, BTU/gsf) for non-experimental energy use when compared to 2018 and 53.7% increase compared to the 2015 baseline year (see Exhibit 3-1). Based on a review of previous measurement and determination between goal-subject building consumption and excluded building consumption, adjustments were made in FY18. This adjustment skewed the site's performance when reviewing energy intensity reporting in FY18 and FY19 versus the FY15 goal baseline. The goal has been adjusted based on PPPL's corrected electricity baseline values. It is important to note that PPPL has not experienced a significant change in gross square footage, nor did we experience a dramatic increase in total energy usage. PPPL's non-experimental buildings still use less than one-half of the energy consumed in 2003. This was achieved through building automation, energy conservation measures, and building system equipment upgrades.

Exhibit 3-1. Annual Non-Experimental Energy Intensity in BTU/gsf [Mor20]
(Green line represents adjusted annual energy intensity goal)



PPPL continues to emphasize energy management as part of its facility operations and to leverage the success in non-experimental energy management to improve experimental efficiency. PPPL continues to carefully manage its central steam and chilled water plant to maximize efficiency and minimize greenhouse gas emissions. PPPL standardized on high-efficiency light-emitting diode (LED) lighting years ago for all office renovations and continues to evaluate and implement other energy efficiency projects where feasible. Finally, PPPL is incorporating energy efficiency and green building practices into its long-term campus improvement plans, which include improvements to critical infrastructure systems, building renovations, and new construction.

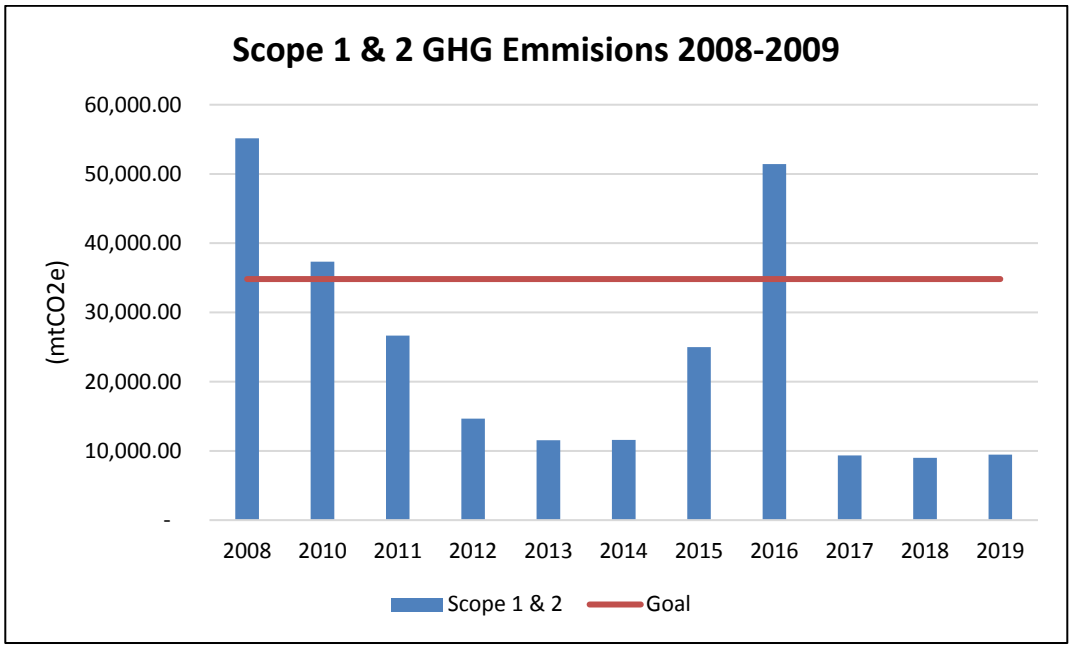
3.1.2 Renewable Energy

PPPL and DOE-PSO have pursued various on-site renewable energy generation projects for as much as 40% of non-experimental energy use over a number of years. The Energy Savings Performance Contract (ESPC) proposal received in FY08 and again in 2018 not successful due to the need for significant up-front investment that PPPL could not gain an endorsement for. PSO and PPPL have also pursued a long-term Power Purchase Agreement (PPA) through the Defense Energy Supply Center (DESC). After more than a year of bidding and negotiations, DESC, PSO, PPPL and the vendor were unable to develop a financially viable project. The ESPC and PPA processes at PPPL identified several significant statutory and management barriers to the cost-effective development of renewable power projects at DOE sites. The planned capital building and infrastructure renovation projects discussed in Section 3.2 will consider inclusion of renewable energy capacity as applicable and practicable. PPPL will continue to purchase renewable energy credits (RECs) to meet its renewable energy commitments and will pursue cost-effective renewable energy project opportunities within the context of the DOE Office of Science's portfolio approach to the departmental sustainability goals. PPPL purchased 3,100 MWh Renewable Energy Credits to offset 19.57% of total electrical energy used in FY2019.

3.1.3 Greenhouse Gas Emissions

Between 2008 and 2019, PPPL reduced its Scope 1 and 2 greenhouse gas (GHG) emissions by 89.3% [Mor20]. This significant reduction in GHG emissions is largely due to the focused efforts to control fugitive losses of sulfur hexafluoride (SF_6) and reduced emissions from on-site combustion of fuel through improved boiler operations, boiler control upgrade projects and the use of natural gas as the primary fuel over fuel oil. Sulfur hexafluoride is a potent GHG that is a highly effective high voltage insulator (see Exhibit 3-2). The peak in GHG emissions seen in 2016 was caused by fugitive SF_6 emissions during NSTX-U experimental power system commissioning and start-up operations. PPPL did not release any SF_6 in 2019 because NSTX-U was not operating.

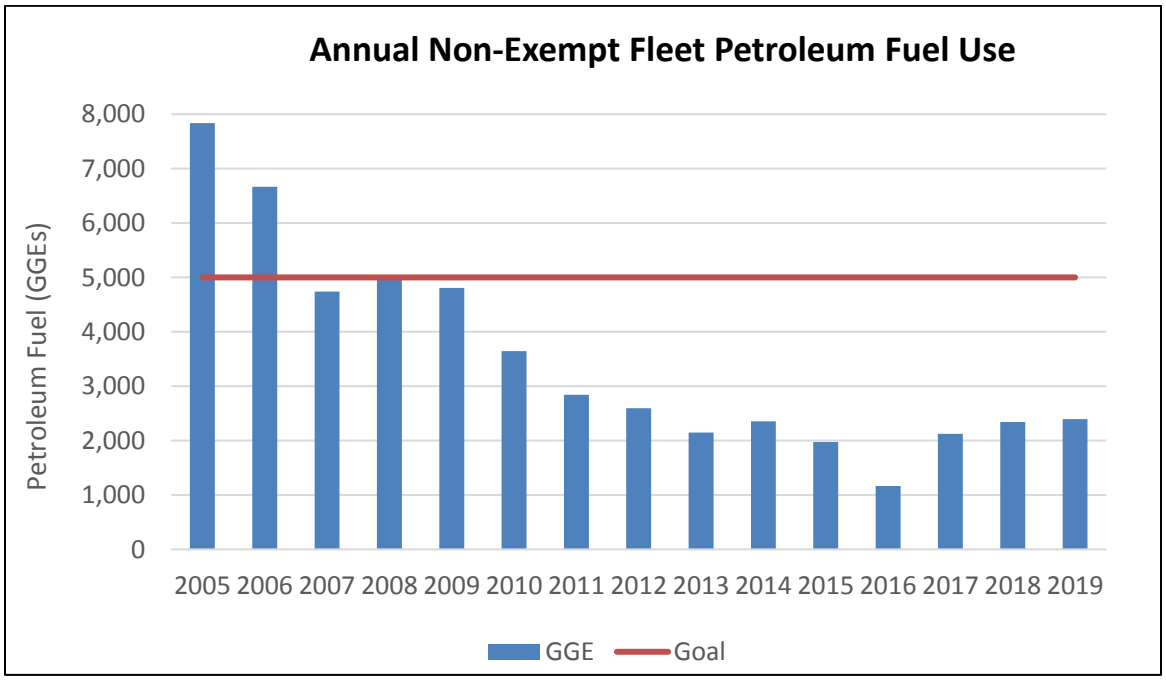
Exhibit 3-2. Summary of PPPL Scope 1 & 2 GHG Emissions between 2008 and 2019 (mtCO2e)



3.1.4 Fleet Management

In 2019, PPPL's fleet petroleum fuel use was 69.4% below 2005 baseline levels (see Exhibit 3-3) exceeding the 20% Federal goal. PPPL continues to exceed the goal for 75% acquisition of alternative fuel vehicles (AFV) for its GSA-leased light-duty vehicles [Mor20, Rai20]. PPPL specifies only AFVs as replacement lease vehicles through the GSA whenever a suitable AFV is available. PPPL's fleet includes gasoline-electric hybrid vehicles, alternative fuel vehicles - Ethanol 85% (E-85) or biodiesel 20% (B20) - and petroleum-fueled (gasoline & diesel) vehicles. In addition to the use of alternative fuels in its covered fleet vehicles, PPPL uses B20 in several pieces of heavy-mobile equipment, including a 15-ton forklift, backhoe, skid steer loader, and various utility vehicles run primarily on B20.

Exhibit 3-3. Annual Non-Exempt Fleet Petroleum Fuel Use between 2005 and 2019



3.1.5 Water Efficiency

PPPL has made significant progress in reducing its use of both potable and non-potable water. In recent years the Laboratory achieved a water use reduction of 5.5% between 2007 and 2019 [Mor20]. In 2019, PPPL used 4.3 Gal/GSF of potable water, a reduction of approximately 40% since 2007, when PPPL was using approximately 7.2 Gal/GSF (see Exhibit 3-4). There was also a small decrease in non-potable water intensity from the 2007 baseline year, dropping just 1.7% (see Exhibit 3-5). The Laboratory also continues to pursue water conservation pilot projects and to identify new opportunities for water conservation and has included the renovation and repair of certain water systems in the planned critical infrastructure upgrade project. Given the reduction in potable water use between 2009 and 2016, significant additional savings may be incremental over a number of years, until the planned critical infrastructure upgrade project.

Exhibit 3-4. PPPL Potable Water Intensity

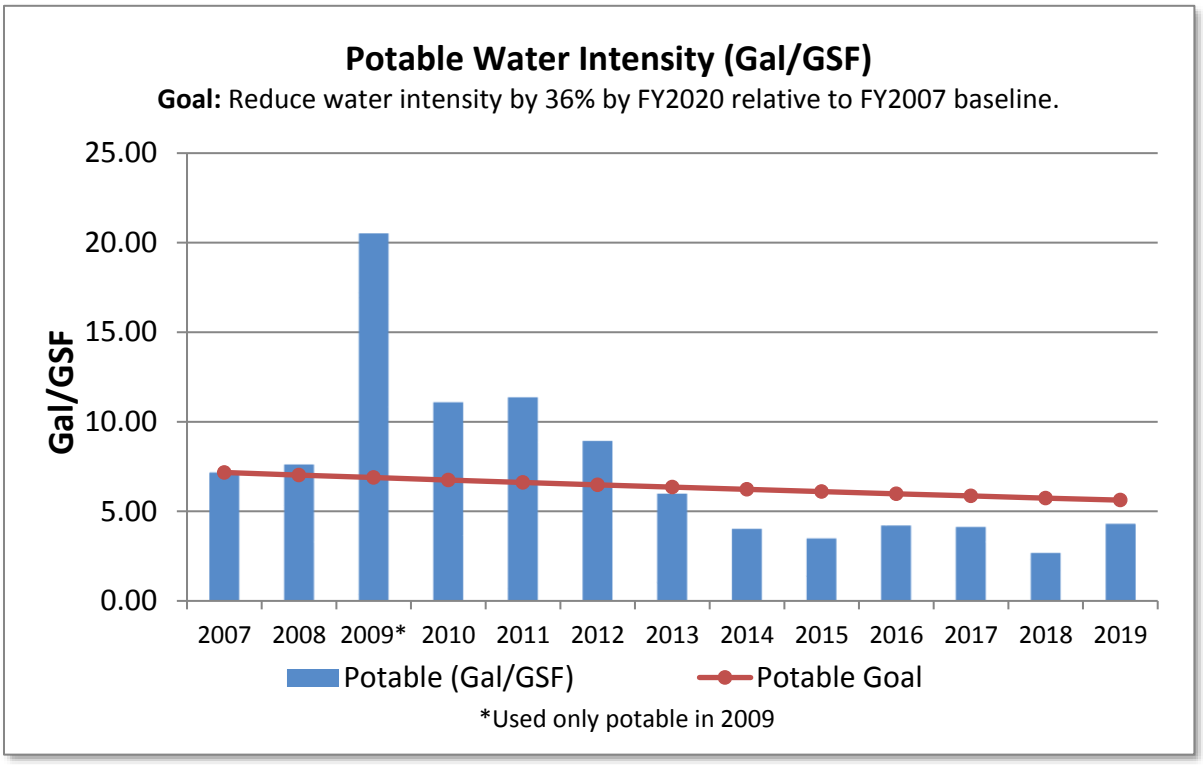
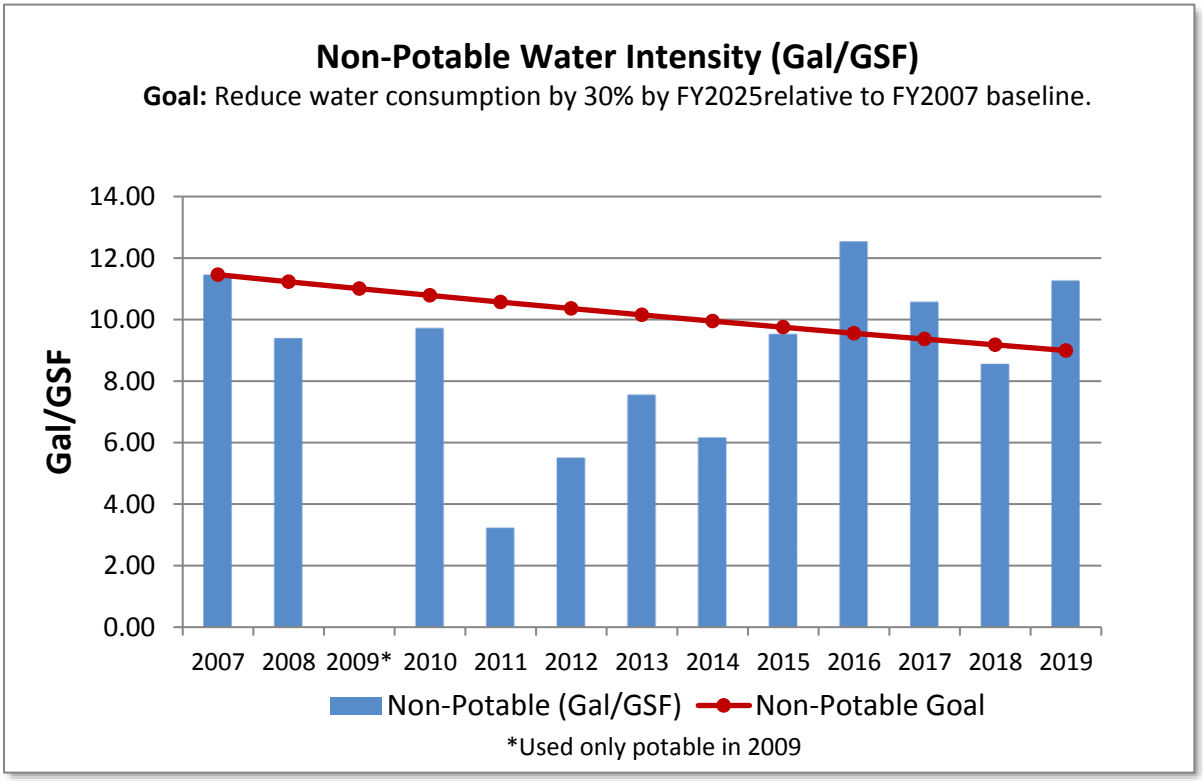


Exhibit 3-5. PPPL Non-Potable Water Intensity



3.2 Energy Efficient "Green" Buildings

The Lyman Spitzer Building (LSB), PPPL's main office building was awarded LEED®-Gold certification by the U.S. Green Building Council in April 2011 for meeting the rigorous Leadership in Energy and Environmental Design – Existing Buildings Operations & Maintenance (LEED®-EBOM) standard. The LSB represents approximately 16% of the current building space and certification of this building to the LEED®-EBOM standard is a major step toward the goal of having at least 15% of non-exempt building space meeting the Federal Guiding Principles for High Performance and Sustainable Buildings.

PPPL continues to prioritize infrastructure projects on those buildings identified with the greatest potential for meeting the Guiding Principles to meet the 15% goal, with a long-term objective of 100% HPSB buildings. ENERGYSTAR® Portfolio Manager is used to document progress in meeting these goals. PPPL and PSO are pursuing funding for a multi-year campus infrastructure investment program which includes renovation to critical infrastructure, renovation and reutilization of existing buildings, and construction of new buildings. These capital projects will be designed to meet or exceed the Federal Guiding Principles or LEED-Gold criteria to the maximum extent practicable. Renovations or other building improvements required to meet the Guiding Principles will be incorporated into PPPL's OPEX and GPP planning process for inclusion in out-year plans. A tabular summary of PPPL's performance against the comprehensive sustainability goals of DOE Order 436.1 is presented in Exhibit 3-6.

3.3 Sustainability Awards

PPPL has demonstrated its commitment to sustainability through its well-established environmental stewardship program. PPPL is often consulted by DOE Laboratories and other organizations for advice and experience in sustainable environmental performance. PPPL was recognized by the Green Purchasing Council with an EPEAT Purchaser Award for its strong commitment to the purchasing of EPEAT-certified electronics. In addition, PPPL is regularly recognized by EPA's WasteWise program for its sustained waste diversion and recycling efforts and by DOE's GreenBuy program for its commitment to environmentally preferable purchasing.

Exhibit 3-6: 2019 DOE Sustainability Goal Summary Table for PPPL

Prior DOE Goal	Current Performance Status	2 Year Performance & Plans	5 Year Performance & Plans	10 Year Performance & Plans
Multiple Categories				
50% Scope 1 & 2 GHG emissions reduction by FY 2025 from a FY 2008 baseline.	**EXCEEDED**	Maintain reductions, increases anticipated with experimental operations	Maintain reductions, increases anticipated with experimental operations	Maintain reductions, incremental improvements as operations allow

Prior DOE Goal	Current Performance Status	2 Year Performance & Plans	5 Year Performance & Plans	10 Year Performance & Plans
25% Scope 3 GHG emissions reduction by FY 2025 from a FY 2008 baseline.	**IN PROGRESS**	Maintain reductions, incremental improvements as operations allow	Maintain reductions, incremental improvements as operations allow	Maintain reductions, incremental improvements as operations allow
Energy Management				
25% energy intensity (Btu per gross square foot) reduction in goal-subject buildings by FY 2025 from a FY 2015 baseline.	**IN PROGRESS**	Maintain reductions, incremental improvements as operations allow	Maintain reductions, incremental improvements, incorporate into Campus Plan	Maintain reductions, incremental improvements, incorporate into Campus Plan
EISA Section 432 continuous (4-year cycle) energy and water evaluations.	**MET**	25% of buildings evaluated each year.	25% of buildings evaluated each year.	25% of buildings evaluated each year.
Meter all individual buildings for electricity, natural gas, steam and water, where cost-effective and appropriate.	**IN PROGRESS**	Additional sub-metering as cost-effective and programmatically appropriate	Additional sub-metering as cost-effective and programmatically appropriate	Current utility configuration doesn't allow building-level metering
Water Management				
36% potable water intensity (Gal per gross square foot) reduction by FY 2025 from a FY 2007 baseline.	**EXCEEDED**	Maintain reductions, incremental improvements as operations allow.	Maintain reductions, incremental improvements, incorporate into Campus Plan.	Maintain reductions, incremental improvements, incorporate into Campus Plan.
30% water consumption (Gal) reduction of industrial, landscaping, and agricultural (ILA) water by FY 2025 from a FY 2010 baseline.	**IN PROGRESS**	Maintain reductions, increases anticipated with experimental operations	Maintain reductions, increases anticipated with experimental operations	Maintain reductions, incremental improvements as operations allow.
Waste Management				
Divert at least 50% of non-hazardous solid waste,	**EXCEEDED**	Maintain performance,	Maintain performance,	Maintain performance,

Prior DOE Goal	Current Performance Status	2 Year Performance & Plans	5 Year Performance & Plans	10 Year Performance & Plans
excluding construction and demolition debris.		incremental improvements.	incremental improvements.	incremental improvements.
Divert at least 50% of construction and demolition materials and debris.	**EXCEEDED**	Maintain performance, incremental improvements.	Maintain performance, incremental improvements.	Maintain performance, incremental improvements.
Fleet Management				
30% reduction in fleet-wide per-mile GHG emissions reduction by FY 2025 from a FY 2014 baseline.	**MET**	Reduce GHG intensity as fleet operations allow.	Reduce GHG intensity as fleet operations allow.	Reduce GHG intensity as fleet operations allow.
20% reduction in petroleum consumption by FY2015 relative to FY2005 baseline; maintain 20% reduction thereafter.	**EXCEEDED**	Maintain with incremental improvements	Maintain with incremental improvements	Maintain with incremental improvements
10% increase in annual alternative fuel consumption by FY 2015 relative to a FY 2005 baseline; maintain 10% increase thereafter.	**EXCEEDED**	Maintain with incremental improvements	Maintain with incremental improvements	Maintain with incremental improvements
75% of light duty vehicle acquisitions must consist of alternative fuel vehicles (AFV).	**MET**	Maintain with incremental improvements	Maintain with incremental improvements	Maintain with incremental improvements
50% of passenger vehicle acquisitions consist of zero emission or plug-in hybrid electric vehicles by FY 2025.	**IN PROGRESS**	Work with GSA to identify opportunities in vehicle lease program.	Limited number of suitable vehicles.	Limited number of suitable vehicles.
Clean & Renewable Energy				
"Clean Energy" requires that the percentage of an agency's total electric and thermal energy accounted for by renewable and alternative energy shall be not less than 25% by FY	**MET** Purchase RECs to meet goal	Continue purchasing RECs and evaluate future funding opportunities	Continue purchasing RECs, incorporate into Campus Plan	Continue purchasing RECs, incorporate into Campus Plan

Prior DOE Goal	Current Performance Status	2 Year Performance & Plans	5 Year Performance & Plans	10 Year Performance & Plans
2025 and each year thereafter.				
"Renewable Electric Energy" requires that renewable electric energy account for not less than 30% of a total agency electric consumption by FY 2025 and each year thereafter.	**MET** Purchase RECs to meet goal	Continue purchasing RECs and evaluate future funding opportunities	Continue purchasing RECs, incorporate into Campus Plan	Continue purchasing RECs, incorporate into Campus Plan
Green Buildings				
At least 17% of existing buildings greater than 5,000 gross square feet to be compliant with the *revised* Guiding Principles for HPSB by FY 2025, with progress to 100% thereafter.	**MET** (square footage)	Include Guiding Principles in facility repairs, renovations & new construction.	Incorporate Guiding Principles into Campus Plan	Incorporate Guiding Principles into Campus Plan
Net Zero Buildings: 1% of the site's existing buildings above 5,000 gross square feet intended to be energy, waste, or water net-zero buildings by FY 2025.	**IN PROGRESS**	Reduce deferred maintenance & improve existing building energy efficiency	Incorporate Net-Zero goal into Campus Plan	Incorporate Net-Zero goal into Campus Plan
Net Zero Buildings: All new buildings (>5,000 GSF) entering the planning process designed to achieve energy net-zero beginning in FY2020.	**IN PROGRESS**	PPIC building design started in FY19	Incorporate Net-Zero goal into Campus Planning	Incorporate Net-Zero goal into Campus Planning
Increase regional and local planning coordination and involvement.	**MET**	Regional planning coordination through Princeton Forrestal Center	Regional planning coordination through Princeton Forrestal Center	Regional planning coordination through Princeton Forrestal Center
Acquisition & Procurement				

Prior DOE Goal	Current Performance Status	2 Year Performance & Plans	5 Year Performance & Plans	10 Year Performance & Plans
Promote sustainable acquisition and procurement to the maximum extent practicable, ensuring BioPreferred and biobased provisions and clauses are included in 95% of applicable contracts.	**MET**	Continue to promote sustainable acquisition goals.	Continue to promote sustainable acquisition goals.	Continue to promote sustainable acquisition goals.
Measures, Funding, & Training				
Annual targets for performance contracting to be implemented in FY 2017 and annually thereafter.	**IN PROGRESS**	Continue to explore opportunities for performance contracting	Continue to explore opportunities for performance contracting	Continue to explore opportunities for performance contracting
Electronic Stewardship				
Purchases – 95% of eligible acquisitions each year are EPEAT-registered products.	**EXCEEDED**	Continue to specify EPEAT default	Continue to specify EPEAT default	Continue to specify EPEAT default
Power management – 100% of eligible PCs, laptops, and monitors have power management enabled.	**IN PROGRESS**	Plans to procure power management software for Macs.	Fully implement power management	Fully implement power management
Automatic duplexing – 100% of eligible computers and imaging equipment have automatic duplexing enabled.	**MET**	Specify purchase of duplex-capable networked printers as older units are retired.	Continue to specify purchase of duplex-capable networked printers as older units are retired.	Continue to specify purchase of duplex-capable networked printers as older units are retired.
End of Life – 100% of used electronics are reused or recycled using environmentally sound disposition options each year.	**MET**	Continue to re-use electronic assets internally & recycle through UNICOR or commercial vendor	Continue to re-use electronic assets internally & recycle through UNICOR or commercial vendor	Continue to re-use electronic assets internally & recycle through UNICOR or commercial vendor

Prior DOE Goal	Current Performance Status	2 Year Performance & Plans	5 Year Performance & Plans	10 Year Performance & Plans
Data Center Efficiency. Establish a power usage effectiveness target in the range of 1.2-1.4 for new data centers and less than 1.5 for existing data centers.	**IN PROGRESS**	Utilize Princeton University high-performance computing resources.	Utilize Princeton University high-performance computing resources.	Incorporate goal into Campus Plan
Organizational Resilience				
Discuss overall integration of climate resilience in emergency response, workforce, and operations procedures and protocols.	Climate resilience and severe weather are integrated into lab-wide EMS, emergency plans, and operational procedures.			

Chapter 4

PPPL's environmental non-radiological monitoring program includes information about PPPL's compliance with New Jersey state environmental rules, regulations and the associated permit requirements. Surface, ground, potable, non-potable water, sanitary and storm waters, air emissions, hazardous materials and waste, land use, and pollution prevention are included in this chapter.

ENVIRONMENTAL NON-RADIOLOGICAL PROGRAM INFORMATION

The following sections briefly describe PPPL's environmental programs required by federal, state, or local agencies as well as with Executive and DOE orders. These programs were developed to comply with the environmental regulations governing PPPL's operations.

4.1 Non-Radiological Water Programs: Environmental Monitoring

4.1.1 New Jersey Pollutant Discharge Elimination System (NJPDES) Program

A. Monthly Discharge Monitoring Reports (DMR)

In compliance with permit requirements of the New Jersey Pollutant Discharge Elimination System (NJPDES) permit, NJ0023922, PPPL and DOE-PSO submitted to NJDEP monthly discharge monitoring reports (DMRs) for Discharge Serial Number (DSN)—DSN001, retention basin outfall, and DSN003, Delaware & Raritan (D&R) Canal pump house filter backwash discharge. See Appendix Tables 16 & 17 for the monitoring data.

In 2019, PPPL received a new NJPDES Discharge to Surface Water (DSW) permit with the effective date of July 1, 2019 and expiration date of June 30, 2024 [NJDEP19]. Prior to July 1, 2019, PPPL operated under the previous permit, with an effective date of October 1, 2013. NJDEP did not issue a new permit prior to the October 1, 2018 permit expiration date, and PPPL continued to operate under the previous permit until the new permit was finalized in 2019.

In 2018 NJDEP informed PPPL that the CPO limits for its NJPDES permit were to be lowered to diminutive levels equivalent to the analytical detection limit. As a result, and with NJDEP's support and encouragement, PPPL decided to use peracidic acid (PAA) as the primary biocide in canal water system and eliminate the routine use of chlorine.

Current NJPDES permit reporting requirements are summarized in Exhibit 4-2. PPPL is required to provide an annual WCR for both DSN001 and DSN003. DSN001 also requires addition semiannual WCR reporting for metals and semi volatile organic compounds (SVOC). DSN003 is still required to complete a full WCR once per permit cycle [NJDEP19]. PPPL's NJPDES compliance summary for 2019 is presented in Exhibit 4-1 below.

There were no permit exceedances in 2019 [Hug20c]. Surface water samples from May 2019 were found to have elevated chemical oxygen demand (COD) that would have warranted an exceedance at DSN001. However, it was discovered that the elevated levels were due to laboratory error. A revised monthly report was submitted to NJDEP to reflect this. In September 2019, PPPL mistakenly overlooked a monthly sampling event and failed to collect the required samples and monitoring data and received a notice of violation from NJDEP. In November 2019, PPPL switched to potable water due to a water tower maintenance project. As per the NJPDES permit, CPO was sampled during this period. The November NJPDES sampling showed elevated CPO that would have warranted an exceedance. However, it was determined that PAA in the system had likely resulted in a false positive for CPO, and it was recorded as an error in the final monthly report.

Exhibit 4-1. 2019 NJPDES Permitted Compliance NJPDES permit NJ0023922

Outfall DSN001							
Parameter (1)	**Frequency**	**Permit Limit**	**# Permit Exceedance**	**# Samples Taken** (4)	**# Compliant Samples**	**Percent Compliance**	**Dates Exceeded**
Chemical Oxygen Demand (COD), mg/L	Monthly	50.0	0	15	15	100%	-
Chlorine Produced Oxidants (CPO), mg/L	Monthly	0.011 Avg. 0.016 Max.	0	22	22	100%	-
Flow, MGD	Monthly	-	0	12	12	100%	-
Petroleum Hydrocarbons (TPHC), mg/L	Monthly	10.0 Avg. 15.0 Max.	0	15	15	100%	--
pH, S. U.	Monthly	>6.0; <9.0	0	22	22	100%	-
Phosphorus, total mg/L (2	Monthly	-	0	15	15	100%	-
Temperature º C	Monthly	30.0	0	22	22	100%	-
Tetrachloroethylene (PCE), µg/L (3)	Monthly	0.703	0	15	15	100%	-
Total Suspended	Monthly	50.0	0	15	15	100%	-

Solids (TSS), mg/L							

Outfall DSN003							
Flow, GPD	Monthly	-	0	11	11	100%	-
Petroleum Hydro-carbons (TPHC), mg/L	Monthly	10.0 Avg. 15.0 Max	0	11	11	100%	-
pH, S. U.	Monthly	>6.0; <9.0	0	11	11	100%	-
Phosphorus, total mg/L (2)	Monthly	-	0	11	11	100%	-
Total Suspended Solids (TSS), mg/L	Quarterly	-	0	11	11	100%	-

Intake C1							
Total Suspended Solids (TSS), mg/L	Quarterly	-	0	11	11	100%	-

NA = Not applicable

Note: All samples reported in quality or concentration on monthly DMR

(1) *Methods for Chemical Analysis of Water and Wastes*, Environmental Monitoring and Support Laboratory, Office of Research and Development, U.S. Environmental Protection Agency, March 1983, EPA-600 4-79-020 [EPA83].

(2) *Phosphorus Evaluation Study will be included in the Raritan Watershed Study.*

(3) *Tetrachloroethylene (PCE) found in the retention basin outfall results from ground water from the building foundation drainage system. Additional basin aeration is expected to keep the discharge concentration of PCE at or below 0.703 µg/L.*

(4) *Number* of samples taken indicates the minimum number of samples required for the current NJPDES permit. Additional samples and duplicates may be taken and reported each CY year.

Exhibit 4-2. NJPDES Reporting Requirements 2019

Parameter	Location	Frequency/Type	Last Completed
Discharge Monitoring Report (DMR)	DSN001, DSN003, C1	Monthly	Monthly 2020
Acute Whole Effluent Toxicity	DSN003	4 – 4.5 Years per Permit	July 2019
Chronic Toxicity (% Effluent) IC25 7 Day *Ceriodaphnia dubia* & *Pimephales promelas*	DSN001	Annual	July 2019
Waste Characterization Report (WCR) – Complete WCR	DSN001	Annual	July 2019
Waste Characterization Report (WCR) – Metals, SVOC, Chloroform	DSN001	Semi Annual	May & July 2019
Waste Characterization Report (WCR) - Metals	DSN003	Annual	May 2019
Waste Characterization Report (WCR) – Complete WCR	DSN003	4 – 4.5 Years per Permit	December 2017

B. Acute Toxicity Study

The Acute Biomonitoring Report for the water flea (*Ceriodaphnia dubia*) was completed on December 5, 2017 for DSN003 [PPPL18]. Samples were collected for the 48-hour acute toxicity

survival test, required to be performed once per permit cycle between 4 to 4.5 years after the effective date of the permit (Exhibit 4-2). The toxicity test with *Ceriodaphnia dubia* resulted in an inhibition concentration (IC25) of >100 percent [PPPL18].

C. Chronic Whole Effluent Toxicity Study

Annual Chronic Whole Effluent Toxicity testing for DSN001 was completed on July 30, 2019 (Exhibit 4-2). In all chronic toxicity tests, *Pimephales promelas* (fathead minnow) survival rate inhibition concentration (IC25), as defined by the NJ Surface Water Quality Standards, was IC25 >100 percent (statistically possible) no observable effect concentration (NOEC) [NJDEP13, PPPL19d].

D. Waste Characterization Report (WCR)

Waste Characterization Reports (WCR) is required by NJPDES Permit for monitoring effluent conditions. DSN001 Semi Annual WCR were completed twice annually on May 10, 2019 and November 19, 2019. The DSN001 Annual WCR was completed on July 25, 2019 [PPPL19e]. DSN003 Annual WCR was completed on May 10, 2019 [PPPL19g]. WCR data can be seen in Appendix Table 25.

4.1.2 Lined Surface Impoundment Permit (LSI)

PPPL complies with NJDEP Ground Water General Permit No. NJ0142051, dated February 26, 2009, and is permitted to operate its retention basin as a Lined Surface Impoundment (LSI) with Program Interest (P.I.) ID#:47029. The LSI Permit operates on a 5-year permit cycle, which was renewed by the NJDEP on May 1, 2019 and will expire on April 30, 2024. The LSI Permit authorizes PPPL to discharge from our lined retention basin outlet to surface water, Bee Brook in Plainsboro, NJ [NJDEP09]. A flow meter measured a total of 103,077,860 gallons annually or 282,405 gallons per day of water that was discharged from the retention basin in 2019 [Hug20a].

Exhibit 4-3. PPPL Retention Basin

Exhibit 4-4. Flow Sensor and Discharge Valve

The LSI permit allows maintenance of liner as necessary. Inspection and repairs are required by the permit with 18 months of a permit renewal. In May 2015, PPPL completed a basin cleaning and inspected and certified the liner by Professional Engineer (PE) from Midstate Engineering Inc. and repairs and maintenance completed by Picone Contracting. Liner inspection was reported to the NJDEP in June 2015. In the interim, the basin operating conditions are inspected weekly and any findings are corrected promptly, following procedure in PPPL's basin operations manual.

Water flowing through the retention basin includes site storm water, groundwater from building foundation drains, non-contact cooling water, and cooling tower and boiler blow down. PPPL operates and maintains all equipment associated with the retention basin including aerators, sonic algae control, oil sensors, oil boom, sump pump and flow meter (Exhibit 4-3). If oil is detected within the basin, an alarm signals Site Protection Communications Center and automatically closes the discharge valve **(**Exhibit 4-4**)**. The ultrasonic flow meter measures flow from the basin is downloaded monthly for NJPDES Discharge Monitoring Report (DMR). The following maintenance activities were conducted in 2019:

- Sump pump maintained
- Two of three oil sensors replaced and calibrated
- BAS delivered flow meter data electronically
- Oil detector controller was replaced.

4.1.3 Ground Water

A. NJPDES Ground Water Program

No ground water monitoring is required by the LSI NJPDES Groundwater permit.

B. Regional Ground Water Monitoring Program

PPPL's Remedial Investigation and Remedial Action Selection Report (RI & RASR) was approved by NJDEP in 2000 [PPPL99b]. The Remedial Action Work Plan (RAWP) was approved NJDEP in June 2000 [PPPL00]. The process of natural attenuation by the indigenous bacteria and other *in-situ* processes are slowly degrading tetrachloroethylene or perchloroethylene (PCE) to its natural products. The de-watering sumps located in the D-site MG and air shaft (formerly TFTR) basements draw ground water radially from the shallow aquifer, controlling ground water flow

and preventing off-site contaminant migration. For details, see Chapter 6, "Site Hydrology, Ground Water, and Drinking Water Protection."

In early 2018, NJDEP issued Groundwater Remedial Action Permit number RAP17001, effective for 30 years, for the ongoing remediation and monitoring programs at PPPL. PPPL has modified its monitoring program to meet conditions of the new permit [NJDEP18]. Additional groundwater information can be found in Chapter 6.

4.1.4 Metered Water

A. Drinking (Potable) Water

Potable water is supplied by the public utility, New Jersey American Water Company. PPPL used approximately 3.81 million gallons in 2019 (Exhibit 4-5) [Con20b]. PPPL uses potable water as a backup resource for non-contact cooling and fire protection.

Exhibit 4-5. PPPL Potable Water Use from NJ American Water Co. [Con20b]

CY	In Million Gallons
2013	4.52
2014	2.74
2015	2.64
2016	3.21
2017	2.99
2018	2.66
2019	3.81

Exhibit 4-6. PPPL Non-Potable Water Use From Delaware & Raritan Canal [Hug20d]

CY	In Million Gallons
2013	5.73
2014	5.14
2015	8.59
2016	10.34
2017	8.89
2018	5.61
2019	7.38

B. Process (Non-potable) Water

Non-potable water from the Delaware & Raritan (D&R) Canal is used for fire protection and process cooling. Non-potable water is pumped from the D&R Canal as authorized through a contract with the New Jersey Water Supply Authority that allows for the withdrawal of up to 150,000 gallons per day (GPD) and an annual limit of 54.75 million gallons [NJWSA12]. PPPL used 7.38 million gallons of non-potable water from the D&R Canal in 2019 (Exhibit 4-6) [Hug20a]. There was a slight increase in D&R Canal water usage in CY 2019.

Located in the canal pump house is a strainer to remove solids from the non-potable water and metering pumps used for the addition of water treatment chemicals like peracetic acid and a

corrosion inhibitor. Discharge serial number DSN003, located at the canal pump house filter-backwash, is a separate discharge point in the NJPDES surface-water permit and is monitored monthly (Appendix Table 17). No treatment chemicals are discharged through DSN003 because the chemicals are added after the canal pumps and strainer backwash. A sampling point upstream of DSN003 (C1) was established to provide baseline data for surface water that is pumped from the D&R Canal for non-potable uses. Appendix Table 11 summarizes the results of water quality analysis at the water intake C1, at the D&R Canal.

C. Surface Water

Surface water is monitored for potential non-radioactive pollutants both on-site and at surface-water discharge pathways upstream and downstream off-site. Other sampling locations—Bee Brook (B1 & B2), New Jersey American Water Company (potable water supplier-E1), Delaware & Raritan Canal (C1), Millstone River (M1), and Cranbury and Devil's Brooks in Plainsboro (P1 & P2) sampling points (Appendix Tables 9-17)—are not required by regulation but are a part of PPPL's environmental surveillance program.

D. Sanitary Sewage

Sanitary sewage is discharged to the Publicly Owned Treatment Works (POTW) operated by South Brunswick Township, which is part of the Stony Brook Regional Sewerage Authority (SBRSA). SBRSA requires quarterly reporting of total volume discharged from the Liquid Effluent Collection (LEC) tanks on D-Site. PPPL continued to collect radioactive Tritium samples and non-radioactive data of analyze immediately parameters pH and temperature (Appendix Table 7). Detailed radiological and discharge quantities for LEC tanks can be found in Chapter 5 "Environmental Radiological Program Information".

For 2019, PPPL estimated a total annual sanitary sewage discharge of 3.79 million gallons to the South Brunswick sewerage treatment plant [Con20b].

4.2 Non-Radiological Waste Programs

4.2.1 Hazardous Waste Programs

A. Toxic Substance Control Act (TSCA)

In CY2019, PPPL shipped 1,153 pounds of PCB waste. All contents were recycled or incinerated in a permitted facility as TSCA Hazardous Waste [San20a].

B. Hazardous Waste

PPPL did not meet the threshold to submit a Biennial Hazardous Waste Generator Report to NJDEP for hazardous waste generated in the last period of CY2019. A description of Resource Conservation and Recovery Act (RCRA) compliance is found in Exhibit 2-1 of this report [San20a].

PPPL continues to evaluate opportunities to remove hazardous materials from the workplace that have the potential to become hazardous wastes by substituting them with non-hazardous materials, which has the added benefit of reducing employee exposure.

C. Recycled Hazardous/Universal Waste

The types and quantities of waste that are recycled each year changes due to the activities varying greatly from year to year as shown in Exhibit 4-7. PPPL's waste shipments can include hazardous, universal, non-hazardous and TSCA regulated waste. PPPL avoids landfilling environmental waste through recycling and incinerating, aligning with PPPL's commitment to sustainability. PPPL's only hazardous/TSCA waste that is landfilled is asbestos waste. In 2019 PPPL disposed of one 40 cubic yard dumpster of asbestos.

Exhibit 4-7. 2019 Waste Shipments [San20a]

Recycled Hazardous Waste	Pounds	Kilograms
Recycled	32,014	14,534
Incinerated	8,915	4,047
Landfilled	*	*
Burial	0	0
Treated	-	-
Total Waste	**40,929**	**18,581**

*Only volume of container is recorded

4.3 Environmental Protection Programs

4.3.1 Release Programs

A. Spill Prevention Control and Countermeasure (SPCC)

PPPL maintains a Spill Prevention Control and Countermeasure Plan (SPCC), which was updated in November 2016. In annual review, Environmental Services updated Section 10 Summary of Past Required Action Items. The SPCC Plan is incorporated as a supplement to the PPPL Emergency Preparedness Plan. In addition to the 5-year major revision as required by the USEPA, PPPL's Environmental Services Division (ESD) completes a review every year to make any minor changes required to the SPCC program [PPPL16a].

B. Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) - Continuous Release Reporting

Under Comprehensive Environmental Recovery, Compensation, and Liability Act, (CERCLA) reporting requirements for the release of listed hazardous substances in quantities equal to or greater than its reportable quantity, the National Response Center is notified, and the facility is required to report annually to EPA. Because PPPL did not release any CERCLA-regulated hazardous substances, no "Continuous Release Reports" were filed with EPA in CY 2019 [Ger20].

C. Superfund Amendments and Reauthorization Act (SARA) Title III Reporting Requirements

NJDEP administers the Superfund Amendments and Reauthorization Act (SARA) Title III, also known as the Emergency Reporting and Community Right-to-Know Act (EPCRA), reporting for

regulated facilities in New Jersey. The modified Tier I form includes SARA Title III and NJDEP-specific reporting requirements. PPPL submitted the SARA Title III Report to NJDEP on February 19, 2019 [PPPL19a]. No changes were reported in PPPL's 2019 EPCRA/SARA.

SARA Title III reports included information about eleven compounds used at PPPL as listed in Exhibits 4-8and 4-9.

PPPL does not exceed threshold amounts for chemicals listed on the Toxic Release Inventory (TRI). PPPL completed the TRI cover page and Laboratory exemptions report for 1996 and submitted these documents to DOE. Since PPPL did not exceed the threshold amounts, no TRI submittal was completed for 2019 [Ger20].

Exhibit 4-8. 2019 Summary of PPPL EPCRA Reporting Requirements

SARA	YES	NO	NOT REQUIRED
EPCRA 302-303: Planning Notification	X		
EPCRA 304: EHS Release Notification		X	
EPCRA 311-312: MSDS/Chemical Inventory	X		
EPCRA 313: TRI Report			Did not exceed threshold

EHS – Extremely hazardous substances (No EHS are on-site at PPPL)
MSDS – Material Safety Data Sheets
TRI – Toxic Release Inventory

Exhibit 4-9. 2019 Hazard Class of Chemicals at PPPL

Compound	Category	Compound	Category
Bromochlorodifluoro-methane (Halon 1211)	Sudden release of pressure & Acute health effects	**Lead**	Chronic health effects
Carbon dioxide	Sudden release of pressure & Reactive	**Nitrogen**	Sudden release of pressure
Diesel Fuel Oil	Fire	**Propane**	Sudden release of pressure
Gasoline	Fire & Chronic Health Hazard	**Petroleum Oil**	Fire
Helium	Sudden release of pressure	**Sulfur Hexafluoride**	Sudden release of pressure
Sulfuric acid	Acute Health Hazard & Reactive		

4.3.2 Environmental Releases

As mentioned in section 2.5, PPPL had one reportable spill of about one quart of diesel fuel in CY2019. Due to New Jersey's no *de minimus* thresholds, all oil released to unpaved surfaces must be reported. PPPL removed the impacted soil and gravel and tested it to ensure adequate cleanup of petroleum hydrocarbons and other pertinent chemicals in accordance with NJDEP Site Remediation Program regulations[San20b].

4.3.3 Pollution Prevention Program

In 2019, PPPL continued to pursue waste minimization and pollution prevention opportunities through active recycling efforts and through the purchasing of recycled-content and other environmentally preferable products (EPP). In FY 2019, PPPL diverted 76.5% of the municipal solid waste through single stream recycling and organic waste composting programs. The DOE goal of 50% recycle versus disposal rate was exceeded by active participation of Laboratory employees. PPPL's FY 2019 rate for recycling of construction materials including wood, concrete, and metal was 70.5% by weight [Kin20a].

In September 2010, PPPL initiated the collection and recycling of food waste from the cafeteria kitchen and waste bins located in the cafeteria and at select locations around the Laboratory. In FY 2019, PPPL composted 114.2 tons of food waste, yard waste, and tree cutting waste. A change in vendor material acceptance led PPPL to limit compostable items in FY 2017 to only food waste and eliminate corn starch and compostable paper products from PPPL waste stream. [Kin20a].

4.4 Non-Radiological Emissions Monitoring Programs

Air Permits

PPPL maintains New Jersey Department of Environmental Protection (NJDEP) air permits/certificates for the equipment as listed in Exhibit 4-9. PPPL is classified as a synthetic-minor facility and does not exceed the Potential to Emit (PTE) limits for any of the Criteria Air Pollutants.

PPPL tracks NJDEP Air Quality Conditions Alerts. Unhealthy conditions are noted, and all generator repairs and maintenance are postponed until normal air quality is reinstated. During those times, the standby (emergency) generators may be used only in an emergency (power outage) or when a voltage reduction issued by Pennsylvania, New Jersey, Maryland Interconnect (PJM) electric-power grid controllers and posted on the PJM internet website under the "emergency procedures" menu.

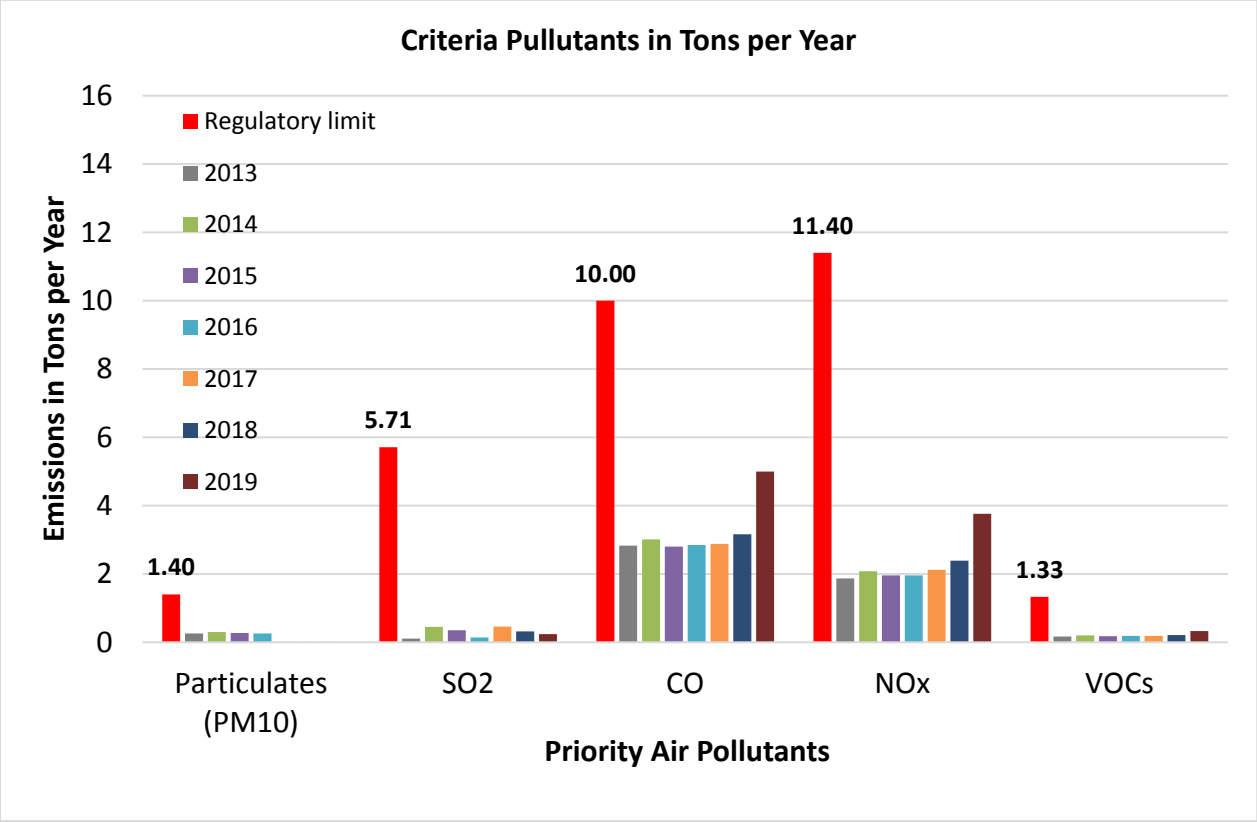
In 2008, NJDEP reduced the regulatory limits for the Criteria air pollutants for operating the boilers; PPPL's operated these four boilers were well below those limits in 2019 (Exhibit 4-10 & Appendix Table 8). With the installation of digital controls and high-efficiency, low nitrogen oxide (NO_x) burners, the NO_x, volatile organic compounds (VOCs), particulates, sulfur dioxide (SO_2), and carbon monoxide (CO) emissions have been further reduced [Rog20].

In late 2017 the NJDEP replaced GP-003 permits for woodworking equipment like dust collectors to GP-016A permits. The new construction permits exempted "Single or multiple pieces of manufacturing and materials handling equipment each with a potential to emit (PTE) less than the reporting threshold for each air contaminant." Because PPPL's dust collector PTE is less than the reporting threshold, the Lab no longer has a general permit for its dust collector.

Exhibit 4-10. PPPL's Air-Permitted Equipment

Type of Air Permit	Qty	Location	Requirements
Storage tanks vents*	2	25,000 gal. No. 2 & 4 oil 15,000 gal. No.1 oil	TANKS – EPA annual emissions based on amount of fuel through-put *Note: Canceled per NJDEP Audit 2/2017
Diesel generators	1 2	D-site generator C-site generator	Annual limit of 200 hours for D-site & 100 hours for C-site of operation excluding emergencies; no testing on NJDEP Air Action Days
Utility boilers	4	Units 2,3,4, & 5 in Facilities	Annual emission testing same quarter each year; annual emission calculations based on hours of operations (Ex.4-12); rolling 12-month calendar total fuel consumed by boiler and fuel type (Table 8). Visual stack checked weekly when operating.
Fluorescent bulb crusher	1	Hazardous Materials Storage Facility	Hours of operations and number of bulbs crushed; air monitoring for mercury during filter changes.

Exhibit 4-11. PPPL's Boiler Emissions from 2012- 2019 vs. Regulatory Limits (Hug20g)



4.5 Land Resources and Conservation

4.5.1 Wetlands Letter of Interpretation (LOI)

PPPL operates under NJDEP Land Use Wetlands LOI. Under permit No. 1218-06-0002.2FWW070001, NJDEP had line verified LOI PPPL's freshwater boundaries in 2008. PPPL's permit was renewed in 2015 and extended until April 1, 2018. PPPL's ES&H Executive Board decided to would allow Wetlands LOI to expire on April 1, 2018. No projects or construction within the 50-foot buffer of PPPL wetlands were planned in the foreseeable future. No construction or alterations to existing vegetation within 50 feet of wetlands can commence without state notification. PPPL's National Environmental Policy Act (NEPA) review process verifies projects do not alter vegetation within 50 feet of wetlands. The freshwater line verifications must be identified on future site development drawings [PPPL15].

4.5.2 Soil Erosion and Landscaping

PPPL maintains an engineering standard for soil erosion and sediment control measures on projects that have soil disturbance below the permit threshold of 5,000 square feet. Projects above 5,000 square feet require soil erosion permits [PPPL14]. Currently there are no projects that require soil erosion and sediment control permit from the Freehold Soil Conservation District (FSCD). However, multiple infrastructure projects in the early planning stages will require permits in the future.

PPPL Stormwater Pollution Prevention Plan encourages the reduction of turf grass areas that required mowing and other maintenance by planting native meadow grasses that can grow tall where practical. Other landscaping improvements, such as rain gardens and tree planting improve the local wildlife habitat and help to minimize stormwater pollution.

4.5.3 Herbicides and Fertilizers

During 2019, PPPL's Facilities & Site Services Division used herbicides, insecticide and fertilizer on campus grounds (Exhibit 4-11). These materials are applied in accordance with state and federal FIFRA regulations. Chemicals are applied by New Jersey-certified applicators. No herbicides or fertilizers are stored on site; therefore, no disposal of these types of regulated chemicals is required by PPPL [Kin20].

Exhibit 4-12. 2019 Fertilizer and Herbicide

Type of Material	Name of Material	Registered EPA No.	Application Qty
Herbicide	Prodiamine	66222-230	189.05 Oz.
Herbicide	Ranger Pro	524-517	1,147.4 Oz.
Insecticide	None	-	-
Fertilizer	None	-	-

4.5.4 Stormwater Pollution Prevention

PPPL's Stormwater Pollution Prevention Plan (SWPPP) was revised in 2019 to provide guidance to reduce the impact of PPPL's operations on stormwater quality [PPPL19b]. As summarized in Exhibit 8 of SWPPP, PPPL reduces stormwater quantity by utilizing best management practices, such as limiting the mowing areas with rain gardens and native grass meadows plantings.

4.6 Safety

PPPL's 2019 performance with respect to worker safety is noted in Exhibit 4-12 [Lev20a].

Exhibit 4-12. 2019 PPPL's Safety Performance

Total OSHA recordable case rate[1]	Days away, restricted transferred (DART) case rate[1]
2.08	0.62
Number of radioactive contaminations (external)	**Number of Safety report OSHA (ORPS) Occurrence confined space, chemical exposure and (LOTO) incidents**
0	0

OSHA – Occupational Safety and Health Administration

[1] Per 200,000 hours worked

Chapter 5

The DOE PPPL's Environmental Radiological program includes information about PPPL's tritium releases to the environment and dose to employees and to the public. This annual dose is calculated using air and water measurements, and in 2019 was 5.43E-03 mrem compared to 310 mrem annual dose from natural sources.

ENVIRONMENTAL RADIOLOGICAL PROGRAM INFORMATION

5.1 Radiological Emissions and Doses

For 2019, the releases of tritium to air and water and the dose to the maximum exposed individual (MEI) are summarized in Exhibit 5-1. The calculated MEI is 5.43E-03 milli-radiation equivalent man (mrem), far below the annual DOE limit of 10 mrem per year [Lev20b]. PPPL's atmospheric releases of Tritium in 2019, totaled at 8.67 curies, as shown in Exhibit 5-2. The Lab measures this data using active and passive stack monitors [Lev20c].

Laboratory policy states that when occupational exposures have the potential to exceed 1,000 mrem (1 rem) per year (10 mSv/y), the PPPL Environment, Safety, and Health (ES&H) Executive Board must approve an exemption. This value (1,000 mrem per year limit) is 20 percent of the DOE legal limit for occupational exposure. In addition, the Laboratory applies the "ALARA" (As Low As Reasonably Achievable) policy to all its operations. This philosophy for control of occupational exposure means that environmental radiation levels for device operation are also very low. The ALARA program goal for maximum individual occupational exposure is less than 100 mrem per year (1.0 mSv/year) above natural background from all operational sources of radiation. The average annual dose to a member of the general population is considered to be about 620 mrem/year with 310 mrem contribution from natural sources and 310 mrem from man-made sources.

- Cosmic radiation - 28 mrem/yr
- Terrestrial sources /earth's crust - 28 mrem/yr
- Food – 40 mrem/yr
- Radon - ~200 mrem/yr
- Medical sources: 310 mrem from medical disgnostics such as x-rays, CAT scans, cancer treatments.

Exhibit 5-1. Summary of 2019 Emissions and Doss from D-Site Operations

Radionuclide & Pathway	Source	Source Term Curies (Bq)	MEI mrem/yr (mSv/yr)	Percent of Total	Collective EDE w/in 80 km in person-rem (person-Sv)
Tritium (air)	D-site stack	HTO – 7.32E+00 (2.71E+11) HT - 1.35E+00 (5.00E+10)	5.34E-03 (5.34E-05)	98.36%	1.91E-01 (1.91E-03)
Tritium (water)	LEC tank	HTO - 4.28E-03 (1.58E+08)	8.56E-05 (8.56E-07)	1.58%	1.17E-04 (1.17E-06)
Tritium Deposition (water)	Surface/ Ground	180.2pCi/L (Multiple) 180.2 pCi/L (Multiple)	3.40E-06 (3.40E-08)	0.06%	4.63E-04 (4.63E-06)
Direct/Scattered neutron & Gamma radiation	NSTX	N/A[3] neutrons	N/A	0	N/A
Argon-41 $(Air)_3$	NSTX	N/A[3]	N/A	0	N/A
Total [Lev20b]			**5.43E-03 (5.43E-05)$_1$**	100%	1.91E-01 (1.91E-03)$_2$

Bq = Bequerel EDE = effective dose equivalent HT = elemental tritium
mSv = milli Sievert mrem = milli radiation equivalent man HTO = tritium oxide NSTX = National Spherical Torus Experiment
Half-life of tritium (HTO & HT) is 12.3 years.

Note:
1. Dose to the MEI occurs at the nearest business which is 351 meters from the D-site stack. Doses assume maximum exposed individual is in continuous occupation at the nearest business; waterborne doses assume that maximum exposed individual uses the ultimate destination of liquid discharges (Millstone River) as sole source of drinking water.
2. Annual limit is 10 mrem/year; background is about 620 mrem/year. (Reference NCRP Report 160, 2009)
3. NSTX was not in operation in 2019, therefore it did not generate any neutrons or Argon-41.

Exhibit 5-2. Radiological Atmospheric Releases for Calendar Year 2019 (Curies)

Tritium	85Kr	Noble Gases (T1/2 <40 days)	Short-Lived Fission and Activation Products (T1/2 <3 hr)	Fission and Activation Products (T1/2 >3 hr)	Total Radio-iodine	Total Radio-strontium	Total Uranium	Plutonium	Other Actinides
8.67+00	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A

5.1.1 Penetrating Radiation

The NSTX-U experiment did not operate during 2019 and did not contribute to the dose totals. Restoration of the experiment includes the production of new magnetic coils and additional upgrades. NSTX-U will produce prompt neutron when experimental operations resume.

5.1.2 Sanitary Sewage

Drainage from D-site sumps in radiological areas is collected in one of the three liquid effluent collection (LEC) tanks. Each tank has a capacity of 15,000 gallons. Prior to release of these tanks to the sanitary sewer and the publicly owned treatment works, *i.e.*, Stony Brook Regional Sewerage Authority (SBRSA), a sample is collected and analyzed for tritium concentration and gross beta. All samples for 2019 showed effluent quantity and concentrations of radionuclides (tritium) to be within allowable limits established in New Jersey regulations (1 Ci/y for all radionuclides), the National Safe Drinking Water regulations (40 CFR 141.66 limit of 20,000 pCi/L) and DOE Order 458.1 (1.9 x 10^6 pCi/liter for tritium) [40CFR141].

As shown in Exhibits 5-3 and 5-4, the total amount of tritium released to the sanitary sewer in 2019 was 4.28E-03 Curies, far less than the allowable 1.0 Curie annual limit. In Appendix A, Table 7, the tritium activity is reported; the gross beta activity ranges from 685 to 2,300 pCi/L.

Exhibit 5-3. Annual Releases to Sanitary System from Liquid Effluent Collection Tanks 2008-2019

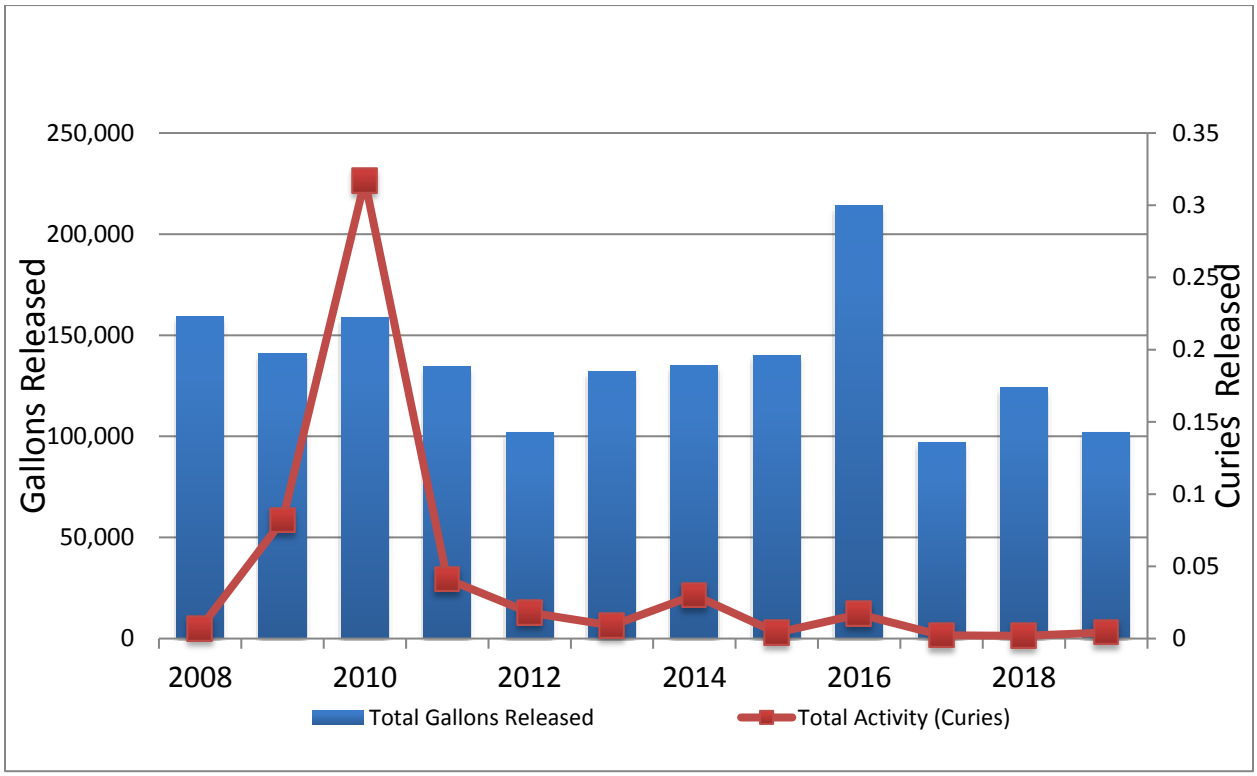


Exhibit 5-4. Total Annual Releases (LEC tanks) to Sanitary System

Calendar Year	Total Gallons Released	Total Activity (Curies)
2008	159,450	0.007
2009	140,850	0.082
2010	158,900	0.317
2011	134,450	0.041
2012	102,000	0.018
2013	132,250	0.009
2014	135,250	0.030
2015	139,950	0.005
2016	213950	0.0169
2017	97200	0.0022
2018	124,150	0.0019
2019	101,775	0.0039

Exhibit 5-5. Total Low-Level Radioactive Waste

Year	Cubic meters (m^3)	Total Activity in Curies (Bq)
2008	3.63	0.08341 (3.086 $x10^9$)
2009	No shipment	No shipment
2010	13.3	6.30270 (2.332 $x10^{11}$)
2011	15.6	0.0351 (1.297$x10^9$)
2012	No shipment	No shipment
2013	34.9	0.357 (1.32$X10^{10}$)
2014	17.1	0.0082 (3.03$x10^8$)
2015	No shipment	No shipment
2016	No shipment	No shipment
2017	17.80	1.23E+01 (4.57E+11)
2018	0.076	1.25E-02 (4.63E+08)
2019	No Shipment	No shipment

5.1.3 Radioactive Waste

In 2019, a small amount of low-level radioactive wastes (LLW) were stored on-site in the Radioactive Waste Handling Facility (RWHF). There was insufficient quantity of LLW to justify the transportation expense for disposal (Exhibit 5-4). PPPL shipped legacy radioactive sources for disposal in 2018. The total activity of the shipment was 1.25E-02 Curies.

Exhibit 5-6. Truck with B-boxes and drums for shipping LLW to Energy Solutions

Most LLW are packaged for shipment and disposal in IP-1 metal containers, refered to as "B-boxes" and 55 gallon steel drums (Exhibit 5-6). PPPL maintains waste profiles for LLW that is shipped off-site for burial. PPPL ships LLW to the Energy Solutions facility in Clive, Utah. PPPL's radioactive waste program is audited triennially to ensure compliance with DOE and DOT requirements. The audit includes employee training, waste characterization, waste packaging, quality control, and records retention.

5.1.4 Airborne Emission - Differential Atmospheric Tritium Samplers (DATS)

PPPL uses differential atmospheric tritium samplers (DATS) to measure elemental (HT) and oxide tritium (HTO) at the D site stack. DATS are similarly used at four environmental sampling stations located on D-site facility boundary trailers (T1 to T4), All of the aforementioned monitoring is performed on a continuous basis.

Tritium (HTO and HT) was released and monitored at the D-site stack (Appendix Table 3). Projected dose equivalent to the MEI from airborne emissions of tritium was 5.34E-03 mrem/year (5.34E-05 mSv/year) in 2019.

5.2 Release of Property Containing Residual Radioactive Material

Release of property containing residual radioactivity material is performed in accordance with PPPL ES&H Directives (ESHD) 5008, Section 10, Subpart L. PPPL has not released real property assets (land, structures, etc.) for public use in the past and has no plans for such releases in the future. Current property release processes focus on personal property items (equipment, materials, etc.). Property cannot be released for unrestricted use unless it is demonstrated that contamination levels on accessible surfaces are less than the values in Appendix D of ES&HD 5008, Section 10, and that prior use does not suggest that contamination levels in inaccessible surfaces exceed surface contamination values in excess of Appendix D. For tritium and tritiated compounds, the removable surface contamination value used for this purpose is 1,000 dpm/100 cm^2. In addition, material is not released if radiation levels above background are detected when performing activation analysis with portable survey instruments per PPPL approved procedure. During 2019, PPPL did not release any property containing residual radioactivity for recycle or reuse.

5.3 Protection of Biota

The highest measured concentrations of tritium in ground water in 2019 was 180.2 pCi/L in the Airshaft sump, in November (Appendix Table 4), and for surface water 180.2 pCi/L at DSN001, also in November (Appendix Table 5). Most of the sample results were below the lower limit of detection. These concentrations are small fractions of the water biota concentration guide (BCG) (for HTO) of 3 $x10^8$ pCi/L for aquatic system evaluations, and the water BCG (for HTO) of 2 x 10^8 pCi/L for terrestrial system evaluations, per DOE Standard STD-1153-2002, "A Graded Approach for Evaluating Radiation Doses to Aquatic and Terrestrial Biota" [Lev20b, DOE11b & 10CFR835]. Because of the very low aquatic concentrations and resulting doses, PPPL does not conduct direct biota monitoring.

5.4 Unplanned Radiological Releases

There were no unplanned radiological releases in 2019.

5.5 Environmental Radiological Monitoring

5.5.1 Waterborne Radioactivity

A. Surface Water

Surface-water samples from nine locations; two on-site locations: DSN001, and E1; and seven off-site locations: B1, B2, C1, DSN003, M1, P1, and P2) are monitored for tritium (Appendix Table 5).

In November 2019, at DSN001, the tritium concentration in water was measured at 180.2 pCi/L. This was the highest tritium concentration for surface water sample(s), most of which were below the lower limit of detection (Appendix Table 5).

PPPL monitors precipitation data using the National Oceanic and Atmospheric Administration (NOAA) climate database. The monthly precipitation amounts for 2019 are shown on Appendix Table 2. In 2019 central New Jersey received total at 58.06 inches of precipitation, which exceeds New Jersey's precipitation average of 46 inches (116.8cm) (Appendix Table 6).

B. Ground Water

Ground water samples are taken from two building foundation sumps: D-Site Airshaft, and D-Site MG sump, which are sampled monthly. The highest concentration of tritium in ground water was found in D-site Airshaft at 180.2 pCi/L in November 2019 (Appendix Table 4). This concentration is well below the state and federal Drinking Water Standard of 20,000 pCi/L

Based on PPPL's environmental monitoring data and the available scientific literature [Jo74, Mu77, Mu82, Mu90], the most likely source of the tritium detected in the on-site ground water samples is from the atmospheric releases of tritium from the D-site stack and the resulting "wash-out" during precipitation. Monitoring of ground water from building foundation sump (dewatering sump for D-site buildings) will continue as on-going atmospheric releases necessitate.

C. Drinking (Potable) Water

Potable water is supplied by the public utility, New Jersey American Water Company. In April 1984, a sampling point at the input to PPPL (E1 location) was established to provide baseline data for water coming onto the site. Radiological analysis of incoming potable water includes gamma spectroscopy and tritium. The tritium concentration at this location for all samples collected in 2019 was below the lower limit of detection (Appendix Table 5).

5.5.2 Foodstuffs, Soil, and Vegetation

PPPL did not monitor foodstuffs, soil, or vegetation for radiological analysis in 2019. In 1996 PPPL's Health Physics (HP) Manager determined that PPPL's tritium releases did not justify foodstuff, soil and vegetation monitoring based on DOE requirements for soil/biota sampling and extensive prior non-detect results in these media. Tritium was not detected in almost all samples collected prior to 1996, and these data were not adding to the understanding of tritium transport in the environment. Greater emphasis was placed on water sampling and monitoring, which produced more relevant results.

Chapter 6

The DOE PPPL's Site Hydrology, Ground Water, and Drinking Water Protection program includes information about PPPL's compliance with the Ground Water Remedial Action Permit issued by the New Jersey Department of Environmental Protection. This permit requires quarterly and annual ground water monitoring that includes testing for volatile organic chemicals and their natural attenuation byproducts.

SITE HYDROLOGY, GROUND WATER, AND DRINKING WATER PROTECTION

6.1 Lower Raritan River Watershed

PPPL is located within the Bee Brook Watershed. Bee Brook is a tributary to the Millstone River, which is part of the Raritan River Watershed (Exhibit 6-1). NJDEP has developed a watershed-based management program for prospective environmental planning and has divided the State of New Jersey into twenty watershed basins.

Locally, the Bee Brook Watershed encompasses approximately 700 acres within the Princeton Forrestal Center and James Forrestal Campus tracts. It begins at College Road East (approximately 1600 feet east of US Route 1), flows south in a wide flood plain, and then discharges into Devil's Brook at the entrance to Mill Pond [Sa80].

6.2 Geology & Topography

PPPL is situated on the eastern edge of the Piedmont Physiographic Province, approximately one-half mile from the western edge of the Atlantic Coastal Plain Province. The site is underlain largely by gently dipping and faulted sedimentary rock of the Newark Basin. The Newark Basin is one of several rift basins that were filled with sedimentary material during the Triassic Period, about 250-200 Ma (million years ago). At PPPL, bedrock is part of the Stockton Formation, which is reportedly more than 500 feet thick and consists of fractured red siltstone and sandstone [Lew87]. Regionally, the formation strikes approximately north 65 degrees east, and dips approximately 8 degrees to the northwest. The occurrence of limited amounts of clean sand near the surface indicates the presence of the Pennsauken Formation. This alluvial material was probably deposited during the Aftonian Interglacial period of the Pleistocene Epoch (approximately 2.6 million to 12,000 years ago).

Exhibit 6-1. Millstone River Watershed Basin

Within 25 miles, there are a number of documented faults; the closest of which is the Hopewell fault located about 8 miles from the site. The Flemington Fault and Ramapo Faults are located within 20 miles. None of these faults are determined to be "active" by the U.S. Geological Survey. This area of the country (eastern central US) is not generally earthquake-prone, despite the occurrence of minor earthquakes that have caused little or no damage.

The Millstone River and its tributaries geographically dominate the region. The well-watered soils of the area have provided a wealth of natural resources including good agricultural lands from prehistoric times to the present. Land use was characterized by several small early centers of historic settlement and dispersed farmland. It has now been developed into light industrial parks, housing and commercial centers [Gr77].

The topography of the site is relatively flat and open with elevations ranging from 110 feet in the northwestern corner to 80 feet above mean sea level (msl) along the southern boundary. The low-

lying topography of the Millstone River drainage reflects the glacial origins of the surface soils; sandy loams with varying percent of clay predominate.

Two soil series are recognized in the immediate vicinity of the site. Each reflects differences in drainage and subsurface water tables. Along the low-lying banks of stream tributaries, Bee Brook, the soils are classified Nixon-Nixon Variant and Fallsington Variant Association and Urban Land [Lew87]. This series is characterized by nearly level to gently sloping upland soils, deep, moderate to well drained, with a loamy subsoil and substratum. The yellowish-white sands contain patches of mottled coloring caused by prolonged wetness. On a regional scale, the water table fluctuates between 5 and 15 feet below the surface in wet periods and can drop below 15 feet during drier months. In the slightly higher elevations (above 70 feet msl), the sandy loams are better drained and belong to the Sassafras series. Extensive historic farmlands and nurseries in the area indicate this soil provides a good environment for agricultural purposes, both today and in the past.

6.3 Biota

An upland forest type with dominant Oak forest characterizes vegetation of the site. Associated with the various oaks are Red Maple, Hickories, Sweetgums, Beech, Scarlet Oak, and Ash. Red, White, and Black Oaks are isolated in the lower poorly drained areas. Along the damp borders of Bee Brook, a bank of Sweetgum, Hickory, Beech, and Red Maple define the watercourse. The forest throughout most of the site has been removed either for farmland during the last century or recently for the construction of new facilities. Grass has replaced much of the open areas.

The under-story of the wooded areas is partially open with isolated patches of shrubs, vines, and saplings occurring mostly in the uplands area. The poorly drained areas have a low ground cover of ferns, grasses, and leaf litter.

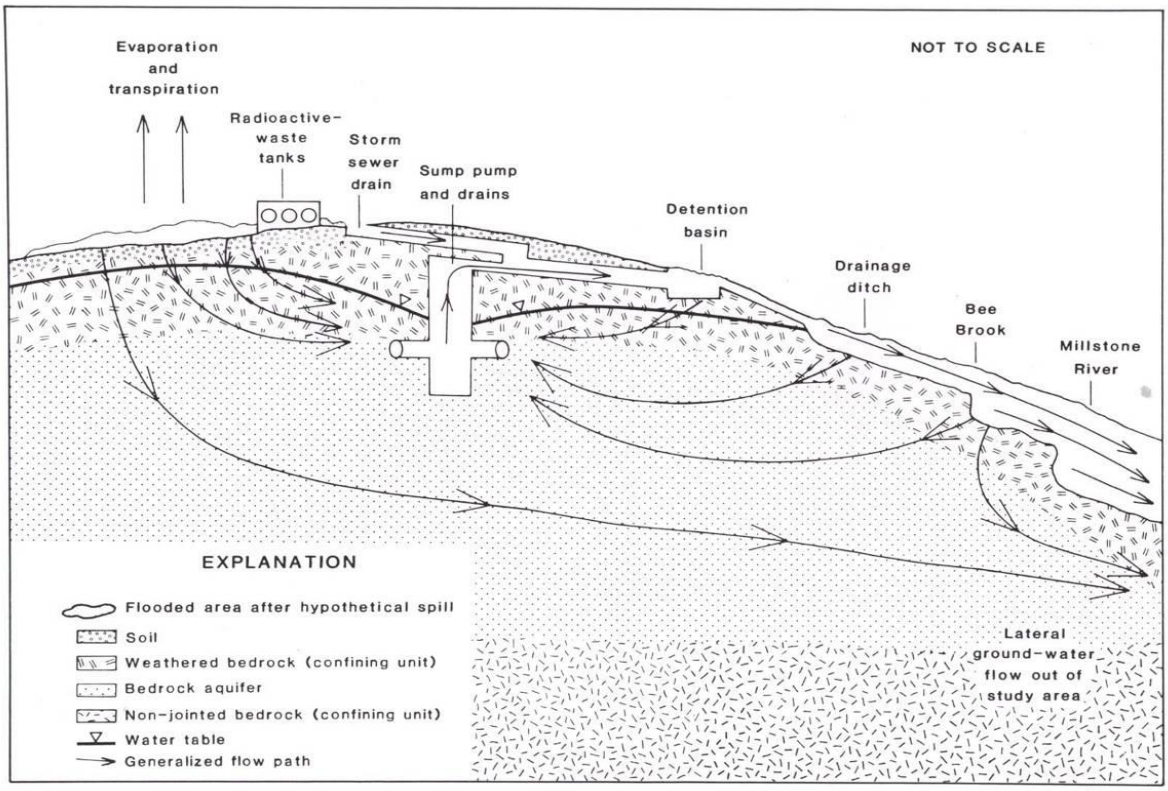
6.4 Flood Plain

All of PPPL's storm water runoff flows to Bee Brook, either directly *via* the retention basin outfall (DSN001) or along the western swale to the wetlands south of the site. Approximately 55% [Hug20f] of the site's total area is covered by impervious surfaces – buildings, roadways and parking lots, and other structures.

The Princeton Forrestal Center Stormwater Management Plan and an agreement with the Delaware and Raritan Canal Commission allows for a maximum impervious coverage of 60% of the developable land. Eighteen acres of PPPL's 88.5-acre site are wetlands, grass, and upland forest resulting in 36.7 acres of natural areas. Gravel, which is semi-impervious, covers approximately 7.97 acres, resulting in an impervious cover (buildings, roadways, sidewalks, etc.) of 28.24 acres (54.18%). PPPL's current site impervious cover is under the D&R Canal and SWPPP's of 60 percent of total developable coverage [PPPL19b & SE96].

In addition to impervious cover limits, the 500-year flood plain elevation (85 ft. above msl) delineates the storm protection corridor designated by Princeton Forrestal Center, which is vital to the flood and water quality control program for both Princeton Forrestal Center and PPPL. This "corridor" is preserved and protected from development by Princeton Forrestal Center in the Site Development Plan [PFC80].

Exhibit 6-2. Generalized Potentiometric Surface of the Bedrock Aquifer at PPPL [Lew87]



The general direction of ground-water flow on the site is from the northwest of PPPL toward the southeast in the direction of Bee and Devil's Brooks. The operation of several building foundation drain sump pumps creates a local and shallow cone of depression radially toward the sumps (Exhibit 6-2).

Ground water is pumped from the sumps into the retention basin, which flows into Bee Brook. Bee Brook is hydraulically connected with ground water; during flooding stages, the brook recharges ground water and during low-flow periods, ground water discharges to the brook.

6.5 Groundwater Monitoring

6.5.1 Monitoring Wells

PPPL installed a total of 46 wells to monitor ground-water quality under various regulatory programs (Exhibit 6-3), although many wells have since been decommissioned. PPPL has 32 active monitoring

wells for environmental monitoring and surveillance purposes. Remedial Investigation and Remedial Alternatives Analysis (RI/RAA) studies were conducted to delineate soil and ground water contamination and identify a suitable remedy for ground water contamination under the New Jersey Site Remediation Program [PPPL99a & b]. A Remedial Action Work Plan (RAWP) was approved by NJDEP in 2000. Ground water monitoring continues as part of the selected remedy [PPPL00]. PPPL completed the transition from NJDEP oversight to the Licensed Site Remediation Professional (LSRP) program in May 2012. In early 2018, NJDEP issued a revised Groundwater Remedial Action Permit number RAP17001 to replace RAP13001, effective for 30 years, for the ongoing remediation and monitoring programs at PPPL. PPPL revised its groundwater monitoring program to meet conditions of the new permit [NJDEP18].

Exhibit 6-3. Summary of Monitoring Wells at PPPL

	Remedial Action Monitoring Well (MW)	Environmental Surveillance (TW)
Active Wells Monitored On-Site	22	10
Active Wells Monitored Off-Site	0	0
Number of Wells Sampled	15	0
Sampling Rounds Completed	4	0

Exhibit 6-4. Summary of Groundwater Contamination

Historical Range of Results for Positive Detections		
	Wells	**Sumps**
Tritium (pCi/L)	N/A	<Bkg
PCE (µg/L)	ND – 97.4	2.0 – 32.4
TCE (µg/L)	ND – 11.4	1.9 – 3.1
1,4 Dioxane (µg/L)	ND – 0.69	ND - 0.173

Note: ND- Not Detected;
Bkg- Background radiation naturally present

6.5.2 Sampling Events

In support of the approved ground water remedial action, PPPL monitors the groundwater wells quarterly in March, June, September and December. The type of equipment used by PPPL to sample the ground water is shown in Exhibits 6-5. Gas from a compressed gas (carbon dioxide) cylinder is pumped down into the well via a Teflon-lined polyethylene tube into the dedicated bladder pump. The air pushes the water up through the exit tube and water flows through a chamber containing instruments to measure pH, conductivity, dissolved oxygen, temperature, and turbidity. Discharged water flows into a bucket that measures the volume discharged. A water level gauge is used to determine the rate of water recharging back into the well to ensure the sample will be representative of the groundwater. Groundwater monitoring parameters are listed in Exhibit 6-6.

Ground water monitoring results show that tetrachloroethylene (PCE), trichloroethylene (TCE), 1-4-dioxane, and their natural degradation products are present in a number of shallow and intermediate-

depth wells on C-Site (Exhibit 6-4). These VOCs are commonly contained in industrial solvents or metal degreasing agents. The source of these chemicals was identified as a former waste storage area known as the PPPL Annex Building.

PPPL's Groundwater Remedial Action Permit requires quarterly sampling for a targeted list of chlorinated VOCs and 1,4-Dioxane. Ground water monitoring results are summarized in Appendix A and Figure 1, which show that PCE, TCE and 1,4 dioxane are present in ground water south of the CAS/RESA building. Results for 1,4 dioxane are generally below the NJDEP Ground Water Quality Standard of 0.4 ug/L, with the exception of monitoring wells MW-19S and MW-13S. The maximum 1,4-dioxane concentration detected in 2019 was 0.620 ug/L. Typically the highest chlorinated contaminant concentrations are detected during the September sampling event, which is consistent with the 1,4 dioxane data.

Foundation dewatering sumps located on D-site influence ground water flow across the site (Exhibits 6-8). The sumps create a significant cone of depression drawing ground water toward them. Under natural conditions, ground water flow is to the south-southeast toward Bee Brook; however, because of building foundation drains on D-Site, ground water beneath the site is drawn radially toward the D site sumps [EPA99, NJDEP18].

Exhibit 6-5. Well Monitoring Equipment

Exhibit 6-6. Groundwater Monitoring Parameters

Frequency	Analytical Parameter	Analytical Method
Monthly	Tritium	
Quarterly (Mar., Jun., Sept., Dec.)	Chlorinated Volatile Organics (VOCs)	EPA-624
	1,4-Dioxane	SW 846/8270 D
Annual (Mar.)	Nitrate & Nitrite	EPA-300.0
	Chloride	EPA-300.0
	Sulfate	EPA-300.0
	Alkalinity	SM 2320B
	Manganese	EPA-200.8 Rev. 5
	Ferrous Iron (Fe^{+2})	SM20/3500FEB
	Dissolved Methane	RSK-175
	Sulfide	SM 5310C
	Total Organic Carbon (TOC)	EPA 906.0

6.5.3 Remedial Action Work Plan (RAWP)

Following a site-wide RI/RAA study and remedy selection process, PPPL prepared and submitted a Remedial Action Work Plan outlining continual operation of the ground water extraction system and a long-term monitoring program [PPPL00]. The RAWP was approved by NJDEP 2000 and was implemented until the Ground Water Remedial Action Permit (GWRAP) was issued in August 2013 [HLA97, HLA98, Sh 10-03]. A revised GWRAP was issued by NJDEP in January 2018.

In January 2002, an Aquifer Classification Exception Area (CEA) Designation was submitted to NJDEP. The CEA designation identifies specific areas where state-wide Ground Water Quality Standards are not met and will not be met for some time. The CEAs was granted for a specific area of an aquifer to address specific VOCs in the shallow (<60 feet deep) aquifer. The CEA request was approved by NJDEP in August 2002. NJDEP site remediation regulations require long-term remedies to be certified biennially. The ground water remedy and CEA were recertified most recently in 2019, with submittal of a Remedial Action Protectiveness and Recertification Report.

Long-term ground water monitoring confirms the following conditions:

- Comparision of analytical data and water level measurements indicates an inverse relationship between ground water level and VOC concentration.
- Natural attenuation (anaerobic biodegradation) occurs in the wetlands adjacent to CAS/RESA.
- Contaminated ground water is captured by building sumps and is not migrating off-site.

Ground water remedial action activities in 2019 included:

- Quarterly and annual sampling JM Sorge subcontractor sampled March, June, September, and December.
- Annual sampling for chlorinated VOC + library search and monitored natural attenuation (MNA) parameters was conducted in March 2019.
- 1,4 Dioxane sampled at all wells quarterly.
- *Remedial Action Biennial Certification for Ground Water* submitted to NJDEP in 2019; the next report is due in 2021.
- Groundwater monitoring equipment and monitoring wells repaired as necessary.

6.5.4 Monitored Natural Attenuation

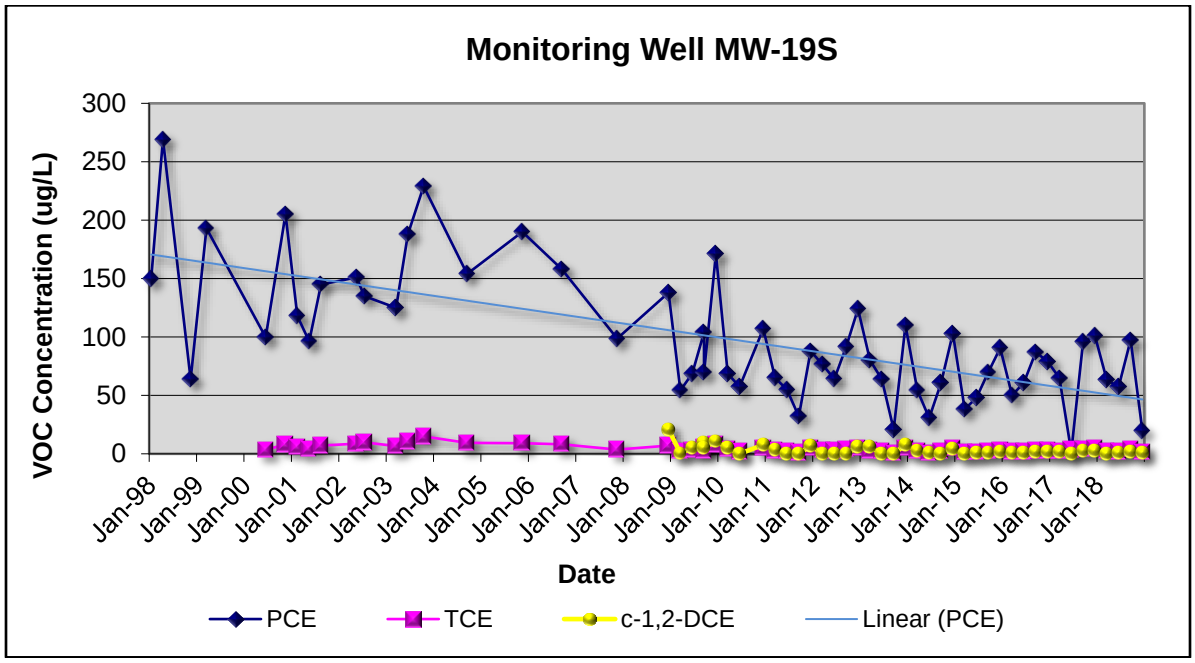
Examination of analytical data and water level measurements during the Remedial Investigation and the beginning of the Remedial Action indicated an inverse relationship between ground water level and VOC concentration (particularly PCE). Periods of higher water level generally corresponded with lower PCE results. Conversely, higher PCE results are generally coincident with period of lower ground water elevation (Appendix Tables 18-21).

Natural attenuation processes are active as evidenced by presence of degradation compounds in ground water down gradient of source area (Appendix Tables 18-21). PCE is sequentially degraded into trichloroethylene (TCE) and cis-1,2-dichloroethlyene (c-1,2-DCE) (Exhibit 6-7). The presence of c-1,2-DCE, dissolved methane, reduced dissolved oxygen levels and negative oxidation-reduction potential (redox) values provide definitive evidence of on-going biological degradation of chlorinated ethenes [Sh00-13].

Exhibit 6-7. Typical PCE Degradation Pathway

Review and examination of the analytical results indicate that contaminant concentrations, particularly PCE, are generally decreasing and are below the levels documented at the beginning to the Remedial Investigation. Seasonal fluctuations in VOC concentrations were seen in data collected during the RI and during the first two years of remedial action monitoring. These data generally showed peak VOC concentration during the late fall/winter months (Appendix Figure 1 and 2, Exhibits 6-8). The time-trend graph shown in Exhibit 6-8 also includes a second-order polynomial regression line fitted to PCE concentrations. This trend line shows an overall downward trend in contaminant concentration with a significant decrease since early 2007. Spring and summer concentrations are generally lower than fall and winter.

Exhibit 6-8. PCE Concentration vs. Time at MW-19S (1998-2019)[Hug20h]



6.6 Drinking Water Protection

PPPL and the surrounding area do not rely on on-site or shallow supply wells for potable water. All potable water in the immediate area of the Laboratory is provided by New Jersey American Water Company. New Jersey American Water Company is supplied by a variety of sources, including surface water intakes and deep supply wells located throughout its service area. The nearest wells supplying water to New Jersey American are located approximately 2 miles south-southwest of the

Laboratory near the Millstone River. As discussed above, ground water contaminated with PCE and other organic chemicals is captured by the building foundation drains and is not migrating offsite.

Chapter 7

As required by DOE Order 450.1, Environmental Protection Program and DOE Order 414.1D, Quality Assurance, PPPL has established a Quality Assurance/Quality Control (QA/QC) Program to ensure that the accuracy, precision, and reliability of environmental monitoring data are consistent.

QUALITY ASSURANCE

7.1 PEARL Lab Certification

In 2019, analyses of environmental samples for "analyze-immediately" non-radiological parameters were conducted by SGS/Accutest Laboratories, NJDEP ID Number 12129, from January to June. In July, PPPL on-site analytical laboratory certification was reinstated following a six-month suspension due to transcription errors on the NJDEP mandated proficiency test (PT). From July to December, PPPL's on-site analytical laboratory performed the "analyze-immediately" non-radiological parameters on-site (Exhibits 7-1 & 7-2).

Exhibit 7-1. PEARL Chlorine Standard Check for Accuracy

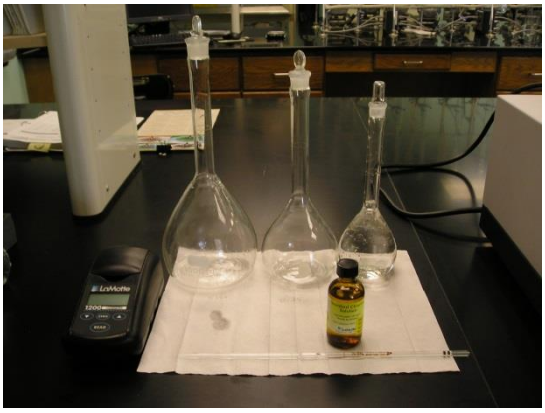


Exhibit 7-2. Distilling Samples for Tritium Analysis Performed at PEARL

The Princeton Environmental Analytical Radiological Laboratory (PEARL) procedures follow the DOE's Environmental Measurements Laboratory's *EML HASL-300 Manual* [Vo82], *EPA's Methods and Guidance for Analysis of Water* [EPA99], *and Standard Methods of Water and Wastewater Analysis* [SM12] that are nationally recognized standards.

Beginning in 1984, PPPL participated in a NJDEP radiological testing certification program initially through the USEPA QA program. In March 1986, EPA/Las Vegas and NJDEP reviewed PPPL's procedures and inspected its facilities. The Laboratory became certified for tritium analysis in urine (bioassays) and water. In 2001, USEPA turned the QA program over to the states; NJDEP chose a contractor laboratory, ERA, to supply the radiological proficiency tests. As of October 2013, NJDEP is no longer administrating PT Sample Contracts, requiring individual sites to obtain their own approved PT Sample Providers to obtain PT samples.

7.1.1 Radiological Parameters

In response to an on-site NJDEP Office of Quality Assurance (OQA) Audit, all PEARL radiological parameters including tritium and gamma spectroscopy certifications were dropped as of August 14, 2015. As a best management practice, PPPL participates in a National Institute for Standards and Technology's (NIST) National Voluntary Laboratory Accreditation Program (NVLAP) accredited radiochemistry quality control testing program. Cesium, cobalt and zinc use a gamma spectroscopy technique while tritium uses a distillation and liquid scintillation method as seen in Appendix Table 24 (Exhibit 7-3).

Exhibit 7-3. 2019 Internal Radiological Parameters

Parameter	Approved Method
Cesium 134/137*	SM 7120
Cobalt 60*	SM 7120
Zinc 65*	SM 7120
Tritium*	EPA 906.0

*Dropped NJDEP laboratory certification for parameters as of 8/14/2015

7.1.2 Non-Radiological Parameters

For non-radiological parameters, PPPL participates in NJDEP Laboratory Certification program (NJ ID #12471) (Exhibit 7-4). A requirement of the certification program is to analyze within the acceptance range the quality control and proficiency test samples that are purchased from outside laboratory suppliers. These PT samples are provided as blind samples for analysis; the test results are submitted prior to the end of the study; in some cases, the PT samples are purchased as a lone study in which PPPL can submit and receive study results immediately. Results are supplied to PPPL and NJDEP to confirm a laboratories' ability to correctly analyze those parameters being tested [PPPL20c]. In Appendix Table 24, the non-radiological proficiency testing (PT) results show that all PEARL's May and December 2019 results were in the acceptable range for pH and residual chlorine [Hug20i].

PPPL followed its internal procedures, EM-OP-49— "Methods for Measuring Analyze Immediately Parameters," EM-OP-31— "Surface Water Sampling Procedure," and EM-OP-38— "Ground Water Sampling Procedures." These procedures provide detailed descriptions of all NJPDES permit-required sampling and analytical methods for collection of samples, analyses of

these samples, and quality assurance/quality control requirements. Chain-of-custody forms are required for all samples; holding times are closely checked to ensure that analyses are performed within established holding times and that the data is valid; trip blanks are required for all volatile organic compound analyses.

Exhibit 7-4. 2019 NJDEP Non-Radiological Certified Parameters
NJDEP Laboratory Number 12471

Parameter	Approved Method
Chlorine	SM 4500-Cl G
pH	SM 4500-H B
Temperature	SM 2550 B

7.2 Subcontractor Labs

Subcontractor laboratories used by PPPL are certified by NJDEP and participate in the state's QA program; the subcontractor laboratories must also follow their own internal quality assurance plans. SGS/Accutest Laboratories were used for environmental laboratory analysis. Starting in 2017, PPPL environmental samples switched to SGS/Accutest NJDEP Laboratory ID Number 12129. American Aquatics was also used as a subcontractor laboratory for acute and chronic toxicity, NJDEP Laboratory is PA682. Lower tier subcontractors are sometimes used when SGS/Accutest is not certified by the NJDEP to analyze certain parameters. When this happens SGS/Accutest confirms with PPPL that the lower tier laboratory is NJDEP certified to perform the analysis for that parameter.

PPPL's groundwater monitoring subcontractor JM Sorge, Inc. has a NJDEP ID 18012 state laboratory certifications for groundwater analyze immediately parameters. Precision Testing Laboratories, Inc. is used to analyze the majority of hazardous waste sampling analysis NJDEP Laboratory ID 15005.

7.3 Internal QA/QC

7.3.1 Internal Audit

PPPL's Quality Assurance program provides a variety of internal audits annually. The audits are completed with a member of QA and a subject matter expert. The following is a list of audits dealing with the environmental issues or environmental management [Cum20].

In 2019, PPPL participated in the following environmental internal audits:

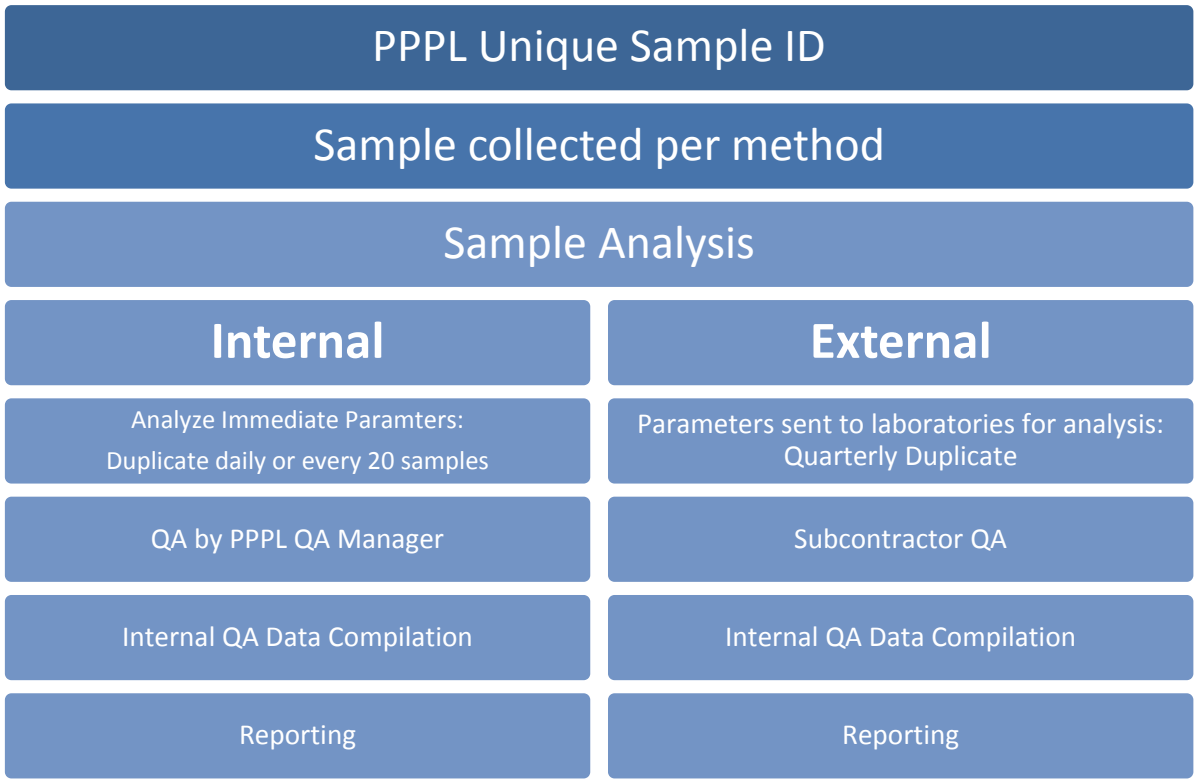
- Hazardous Material Transportation Safety Program Audit

7.3.2 Internal QA Check

PPPL's PEARL ensures QA/QC through EM-QA-02 "Quality Assurance/Quality Control Plan for Analyze Immediately Parameters." PPPL internal procedures include the following:

- NIST thermometers are replaced with new NIST-certificatied long stem thermometers quarterly.
- Chlorine field meters and secondary standards are calibrated at least quarterly by chlorine standard concentrations; Quarterly chlorine calibration curves are generated.
- Duplicate samples of chlorine, pH and temperature will be conducted daily or every 20 samples.
- Duplicate samples for NJPDES permit monitoring are submitted to the external laboratory quarterly.

PPPL's internal Quality Assurnace process for laboratory samples is as follows:



7.3.3 Calibrations

PPPL calibrates all equipment per equipment manual and following EM-OP-49 and EM-QA-02 procedures. Calibrations are recorded in the respective lab calibration log and reported to Head QA Officer for review.

PPPL's Environmental QA procedures following for calibration prior to sampling. The chlorine field meter is verified by using calibrated Secondary Standards. pH meters are calibrated with a 3-point standard calibration, and verified by checking the pH to the 7.01 standard.

7.3.4 Chemicals

Analytical laboratory chemical inventories are performed quarterly to ensure proper storage, expiration and quantity checks for chemical reagents, standrads, etc. Chemical name, stock number, lot number, date received, date opened and expiration date are checked to ensure chemical quality for calibration. Expired chemicals are removed from service and processed through the labwide hazardous waste management program.

7.4 External QA/QC

PPPL's external audits can be completed by a variety of different sources. Local, state and federal entities such as US DOE or NJDEP may request an on-site audit or inspection at any time. As reviewed in Chapter 3, PPPL's EMS requires ISO Registrar Audits for Registration and Surveillance Audits. All corrective action were tracked and completed using PPPL's internal by the QA Division [Cum20].

One external audits/inspections were performed for Environmental QA/QC in 2019:

- New Jersey Environmental Laboratory Certification Program (ELCP) Audit
- Pre-registration Transition Audit, ISO14001:2015

Chapter 8

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CHAPTER 9

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APPENDIX A

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Table 1. PPPL NSTX-U Radiological Limits and Design Objectives

CONDITION			PUBLIC EXPOSURE[b]		OCCUPATIONAL EXPOSURE	
		P, Probability Of Occurrence In A Year	REGULATORY LIMIT (rem/year)	DESIGN OBJECTIVE (rem/year)	REGULATORY LIMIT (rem/year)	DESIGN OBJECTIVE (rem/year)
ROUTINE OPERATION Dose equivalent to an individual from routine operations (rem per year, unless otherwise indicated)	NORMAL OPERATIONS	P~1	0.1 Total, 0.01[c] Airborne, 0.004 Drinking Water	0.01 Total	5	1
	ANTICIPATED EVENTS	$(1 > P \geq 10^{-2})$	0.5 Total (including normal operation)	0.05 per event		
ACCIDENTS Dose equivalent to an individual from an accidental release (rem per event)	UNLIKELY EVENTS	$10^{-2} > P \geq 10^{-4}$	2.5	0.5	Emergency Exposure Situation: 5 to >25 depending on activity (property protection or lifesaving; see ESHD 5008, Section10.1302[PPPL13b])	
	EXTREMELY UNLIKELY EVENTS	$10^{-4} > P \geq 10^{-6}$	25	5[d]		
	INCREDIBLE EVENTS	$10^{-6} > P$	NA	NA		

P = Probability of occurrence in a year.

[a] All operations must be planned to incorporate radiation safety guidelines, practices and procedures included in PPPL ESHD 5008, Section 10.

[b] Evaluated at PPPL site boundary.

[c] Compliance with this limit is to be determined by calculating the highest effective dose equivalent to any member of the public at any offsite point where there is a residence, school, business or office

[d] For design basis accidents (DBAs), i.e., postulated accidents or natural forces and resulting conditions for which the confinement structure, systems, components and equipment must meet their functional goals, the design objective is 0.5 rem.

(e) See PPPL ESHD-5008, Section 10, Chapter 10.1302 for emergency personnel exposure limits.

Table 2. Annual Precipitation Data for 2019 [Hug20b]

Month	Montgomery Twp. 2.3 S, NJ US US1NJSM0022
January	4.99
February	3.16
March	3.95
April	4.56
May	7.79
June	6.28
July	7.91
August	2.8
September	1.19
October	6.36
November	2.25
December	6.82
Total	**58.06**
Monthly Average	**4.84**

Table 3. D– Site Tritium Stack Releases in Curies in 2019

Week Beginning	HTO (Ci)	HT (Ci)	Weekly Total (Ci)
1/2/19	0.27800	0.01870	0.29670
1/9/19	0.23300	0.01050	0.24350
1/16/19	0.02890	0.00086	0.02976
1/23/19	0.02820	0.00088	0.02908
1/30/19	0.02760	0.00096	0.02856
2/6/19	0.06910	0.00256	0.07166
2/13/19	0.02900	0.00077	0.02977
2/20/19	0.02520	0.00091	0.02611
2/27/19	0.02710	0.00116	0.02826
3/6/19	0.02570	0.00229	0.02799
3/13/19	0.02480	0.00066	0.02546
3/20/19	0.02730	0.00082	0.02812
3/27/19	0.02610	0.00110	0.02720
4/3/19	0.02770	0.28800	0.31570
4/10/19	0.29700	0.00597	0.30297
4/17/19	0.29600	0.87800	1.17400
4/24/19	0.27300	0.00519	0.27819
5/1/19	0.27000	0.00546	0.27546
5/8/19	0.32300	0.00923	0.33223
5/15/19	0.32300	0.00751	0.33051
5/22/19	0.30600	0.00789	0.31389
5/29/19	0.29800	0.00685	0.30485
6/5/19	0.28300	0.00774	0.29074
6/12/19	0.34200	0.00897	0.35097
6/19/19	0.35100	0.00972	0.36072
6/26/19	0.35500	0.01190	0.36690
7/3/19	0.32000	0.00860	0.32860
7/10/19	0.36800	0.00812	0.37612
7/17/19	0.33500	0.00076	0.33576
7/24/19	0.03170	0.00069	0.03239
7/31/19	0.03520	0.00064	0.03584
8/7/19	0.03260	0.00056	0.03316
8/14/19	0.58600	0.01050	0.59650
8/21/19	0.29500	0.00197	0.29697
8/28/19	0.27200	0.00177	0.27377
9/4/19	0.00016	0.00064	0.00080
9/11/19	0.00016	0.00106	0.00122
9/18/19	0.00197	0.00828	0.01025
9/25/19	0.03080	0.00079	0.03159
10/2/19	0.02850	0.00031	0.02881
10/9/19	0.02930	0.00044	0.02974
10/16/19	0.02650	0.00047	0.02697
10/23/19	0.08160	0.00170	0.08330
10/30/19	0.02440	0.00041	0.02481
11/6/19	0.02530	0.00079	0.02609
11/13/19	0.02120	0.00063	0.02183
11/20/19	0.03120	0.00054	0.03174
11/27/19	0.02920	0.00104	0.03024
12/4/19	0.00000	0.00017	0.00017
12/11/19	0.02730	0.00059	0.02789
12/18/19	0.02830	0.00150	0.02980
12/24/19*	0.06080	0.00160	0.06240
TOTALS	**7.31689**	**1.34917**	**8.66606**

Table 4. Ground Water Tritium Concentrations for 2019 (in picoCuries/Liter)

Month	D-Site MG Sump	D-Site Airshaft Sump
January	*	*
February	*	*
March	*	*
April	*	*
May	*	*
June	*	*
July	*	*
August	*	*
September	*	*
October	1.35E+02	1.35E+02
November	*	1.802E+02
December	*	*

Sumps are taken monthly

*All sample dates not listed or shown without a number, are below LLD and background

Table 5. Surface Water Tritium Concentrations for 2019 (in picoCuries/liter)

Month	Bee Brook (B1)	Bee Brook (B2)	Basin (DSN001)	Basin Duplicate (DSN004)	D&R Canal (C1)	D&R Canal (DSN003)	E1	M1	P1	P2
January			*		*	*				
February	*	*	*	*	*	*	*	*	*	*
March			*		*	*				
April			*		*	*				
May	*	*	*	*	*	*	*	*	*	*
June			*		*	*				
July			*		*	*				
August	9.01E+01	9.01E+01	*	*	*	*	*	9.01E+01	*	*
September			*		*	*				
October			1.35E+02		1.35E+02	1.35E+02				
November	*	1.802E+02	*	1.802E+02	*	*	*	*	*	*
December			9.01E+01		9.01E+01	1.35E+02	9.01E+01	1.35E+02	1.35E+02	9.01E+01

Sample locations B1, B2, DSN004, E1, M1, P1, and P2 are taken quarterly

Sample locations DSN001, DSN003, and C1 are taken monthly

* All sample dates not listed or shown without a number, were below the LLD and background

Table 6. Annual Range of Tritium Concentration at PPPL in Precipitation from 1985 to 2019

Year	Tritium Range picoCuries/Liter	Precipitation In Inches	Difference from Middlesex County Avg. Precipitation of 46.5 inches/year
1985	40 to 160		
1986	40 to 140		
1987	26 to 144		
1988	34 to 105		
1989	7 to 90	55.4	+8.8
1990	14 to 94	50.3	+3.8
1991	10 to 154	45.1	-1.5
1992	10 to 838	41.9	-4.6
1993	25 to 145	42.7	-3.8
1994	32 to 1,130	51.3	+4.8
1995	<19 to 2,561	35.6	-10.9
1996	<100 to 21,140	61.0	+14.5
1997	131 to 61,660	42.0	-4.5
1998	<108 to 26,450	42.9	-3.6
1999	<58 to 7,817	47.3(38.7 w/out Floyd)	+0.8(-7.8)
2000	<31 to 3,617	38.7	-7.8
2001	153 to 14,830	32.8	-13.7
2002	24 to 3,921	47.9	+1.4
2003	9 to 1,126	54.7	+8.2
2004	27 to 427	40.5	-6.0
2005	<37 to 623	48.4	+1.9
2006	9 to 3,600	48.1	+1.6
2007	<93 to 1,440	49.1	+2.6
2008	<103 to 1,212	48.2	+1.7
2009	< Bkg to 375	47.1	+1.6
2010	<105 to 469	40.8	-5.7
2011	<109 to 269	65.1	+18.6
2012	3 to 182	38.9	-7.6
2013	<Bkg to 1331	43.25	-3.25
2014	<Bkg to 216	45.06	-1.44
2015	<Bkg to 901	39.8	- 6.7
2016	<Bkg to 1396	34.82	-11.7
2017	*	41.38	-5.13
2018	*	65.01	+18.51
2019	*	58.36	+11.86

* PPPL stopped monitoring tritium concentration in rainwater because NSTX wasn't operating
Bkg = Background

Table 7. Liquid Effluent Collection Tank Release Data for 2019

Release Date	Gallons Released	Tritium Sample LLD (pCi/L)	Tritium Sample Activity (pCi/L)	Total Tritium Tank Activity (Ci)
1/25/2019	12,750	2.92E+02	8.24E+03	3.98E-04
6/4/2019	12,675	4.17E+02	1.30E+04	6.22E-04
7/2/2019	12,750	4.29E+02	1.51E+04	7.30E-04
7/11/2019	12,750	3.72E+02	1.09E+04	5.24E-04
8/13/2019	12,750	3.01E+02	8.51E+03	4.11E-04
8/26/2019	12,750	4.05E+02	9.05E+03	4.37E-04
9/16/2019	12,750	3.54E+02	4.28E+03	2.07E-04
10/30/2019	12,600	3.05E+02	1.12E+04	5.33E-04
Total	**101,775Gal.**			**3.86E-03**

Table 8. Total Fuel Consumption by Fuel Type from 2012 to 2019

Year	Natural Gas (mmcf)	Fuel Oil # 2 (kgals.)
2012	0.201	4.8
2013	0.262	5.0
2014	0.267	18.5
2015	0.209	12.8
2016	0.233	4.86
2017	0.244	0.1
2018	0.142	11.03
2019	0.148	0.1
Permit limit	**2.176**	**251**

* Note: No. 2 Fuel oil consumption first began December 2004.
No. 4 Fuel oil no longer burned after December 2004.
mmcf = millions of cubic feet
kgals. = thousands of gallons

Table 9. Surface Water Analysis for Bee Brook, B1, in 2019

Location B1 = Bee Brook upstream of PPPL basin discharge

B1						
Parameters	**Units**		**February**	**May**	**June**	**July**
			2019	**2019**	**2019**	**2019**
Chemical Oxygen Demand, COD	mg/L		41.60	32.4*		
Total Phosphorus	mg/L	<	0.027	0.095	0.100	0.071
Total Suspended Solids, TSS	mg/L	<	3.3	8.00		
Field Parameters						
pH	SU		6.38	6.62		
Oxidation-Reduction Potential, ORP	mV					
Temperature	° C		2.3	13.2		

B1								
Parameters	**Units**		**August**	**September**	**October**		**Nov.**	**Dec.**
			2019	**2019**	**2019**		**2019**	**2019**
Chemical Oxygen Demand, COD	mg/L	<	11.00			<	18.9	
Total Phosphorus	mg/L		0.062		0.570	<	0.045	0.058
Total Suspended Solids, TSS	mg/L		11.00				22.00	
Field Parameters								
pH	SU		6.65				8.06	
Oxidation-Reduction Potential, ORP	mV		15.3				-64.8	
Temperature	° C		20.8				7.4	

* From analytical lab revised report

Blank indicates no measurement NL = No limit

Table 10. Surface Water Analysis for Bee Brook, B2, in 2019

Location B2 = Bee Brook downstream of PPPL basin discharge

B2									
Parameters	**Units**		**February**		**May**		**June**		**July**
			2019		**2019**		**2019**		**2019**
Chemical Oxygen Demand, COD	mg/L	<	11.1	<	18.9*				
Total Phosphorus	mg/L	<	0.027		0.068		0.180		0.055
Total Suspended Solids, TSS	mg/L	<	2.3		5.00				
Field Parameters									
pH	SU		6.80		6.96				
Oxidation-Reduction Potential, ORP	mV								
Temperature	° C		4.1		14.0				

B2									
Parameters	**Units**		**August**	**September**	**October**		**Nov.**		**Dec.**
			2019	**2019**	**2019**		**2019**		**2019**
Chemical Oxygen Demand, COD	mg/L	<	11.00			<	18.9		
Total Phosphorus	mg/L		0.062		0.570	<	0.045		0.058
Total Suspended Solids, TSS	mg/L		11.00				22.00		
Field Parameters									
pH	SU		6.65				8.06		
Oxidation-Reduction Potential, ORP	mV		15.3				-64.8		
Temperature	° C		20.8				7.4		

* From analytical lab revised report

Blank indicates no measurement NL = No limit

Table 11. Surface Water Analysis for Delaware & Raritan Canal, C1, in 2019

Location C1 = Delaware & Raritan Canal State Park at Mapleton Avenue, Plainsboro midway on pedestrian bridge

C1													
Parameters	**Units**	**January**		**Feb.**		**March**		**April**		**May**		**June**	
		2019		**2019**		**2019**		**2019**		**2019**		**2019**	
Chemical Oxygen Demand, COD	mg/L	22.20	<	11.00	<	13.9	<	11.00	<	11.00*	<	16.2	
Phosphorus, total	mg/L	< 0.049	<	0.027	<	0.037	<	0.029		0.059		0.096	
Total Suspended Solids, TSS	mg/L	8.00	<	3.7 B	<	2.1 B	<	2.2		22.70		6.40	
Field Parameters													
pH	SU	6.74		7.15		6.86		7.41		6.67		7.07	
Oxidation-Reduction Potential, ORP	mV												
Temperature	° C	5.40		2.0		3.3		14.1		17.6		22.3	

C1													
Parameters	**Units**	**July**		**Aug.**		**Sept.**		**Oct.**		**Nov.**		**Dec.**	
		2019		**2019**		**2019**		**2019**		**2019**		**2019**	
Chemical Oxygen Demand, COD	mg/L	25.00	<	11.00		<		11.00	<	11.00	<	16.20	
Phosphorus, total	mg/L	0.085		0.089				0.051	<	0.049		0.095	
Total Suspended Solids, TSS	mg/L	4.00	<	3.20		<		3.80		4.00		6.30	
Field Parameters													
pH	SU	6.83		6.96				6.88		7.07		7.04	
Oxidation-Reduction Potential, ORP	mV	8.90						-5.9		-15.5		-12.5	
Temperature	° C	25.50		23.3				22.2		6.0		4.1	

* From analytical lab revised report

Blank indicates no measurement NL = No limit

Table 12. Surface Water Analysis for NJ American Water, E1, in 2019

Location E1 = NJ American Water (potable) collected at Main Gate Security Booth

E1								
Parameters	**Units**	**February**	**May**	**August**	**Nov.**
		2019	**2019**	**2019**	**2019**
Chemical Oxygen Demand, COD	mg/L	< 11.00	< 11.00*	< 11.00	< 11.00
Total Phosphorus	mg/L	0.310	0.220	0.330	0.440
Total Suspended Solids, TSS	mg/L	< 1.50	< 1.50	< 1.5	< 1.5
Field Parameters					
pH	SU	7.05	6.80	6.70	6.63
Oxidation-Reduction Potential, ORP	mV			12.5	7.0
Temperature	° C	9.3	16.1	23.1	15.5

* From analytical lab revised report

Blank indicates no measurement NL = No limit

Table 13. Surface Water Analysis for Millstone River, M1, in 2019

Location M1 = Millstone River at Delaware & Raritan Canal State Park at Mapleton Road

M1								
Parameters	**Units**	**February**	**May**	**August**	**Nov.**
		2019	**2019**	**2019**	**2019**
Chemical Oxygen Demand, COD	mg/L	< 11.1	< 18.9*	< 11.00	< 11.00
Total Phosphorus	mg/L	< 0.047	0.083	0.051	0.059
Total Suspended Solids, TSS	mg/L	5.20	8.50	4.60	15.00
Field Parameters					
pH	SU	7.12	6.62	6.75	7.01
Oxidation-Reduction Potential, ORP	mV			9.5	-12.6
Temperature	° C	2.7	17.4	23.1	7.5

* From analytical lab revised report

Blank indicates no measurement NL = No limit

Table 14. Surface Water Analysis for Cranbury Brook (Plainsboro), P1, in 2019

Location P1 = Cranbury Brook at George Davison Road, Plainsboro mid-span on bridge southbound

P1											
Parameters	**Units**		**February**		**May**		**August**		**Nov.**		
			2019		**2019**		**2019**		**2019**		
Chemical Oxygen Demand, COD	mg/L	<	< 11	<	16.2*	<	11.00	<	13.58		
Total Phosphorus	mg/L	<	< 0.027		0.070	<	0.027	<	0.037		
Total Suspended Solids, TSS	mg/L	<	< 2.7		10.80	<	3.3		4.20		
Field Parameters											
pH	SU		7.14		6.31		6.63		6.69		
Oxidation-Reduction Potential, ORP	mV						16.1		4.1		
Temperature	° C		2.3		16.8		22.1		7.3		

* From analytical lab revised report

Blank indicates no measurement NL = No limit

Table 15. Surface Water Analysis for Devil's Brook (Plainsboro), P2, in 2019

Location P2 = Devil's Brook at Schalks Road overpass, adjacent to Amtrak railroad tracks

P2											
Parameters	**Units**		**February**		**May**		**August**		**Nov.**		
			2019		**2019**		**2019**		**2019**		
Chemical Oxygen Demand, COD	mg/L	<	11.1		35.1*	<	15.4	<	13.5		
Total Phosphorus	mg/L	<	0.027		0.070	<	0.027	<	0.029		
Total Suspended Solids, TSS	mg/L		8.40	<	3.6	<	3.3	<	1.5		
Field Parameters											
pH	SU		7.83		6.15		6.62		7.1		
Oxidation-Reduction Potential, ORP	mV						16.8		-17.3		
Temperature	° C		2.5		16.3		20.5		7.3		

* From analytical lab revised report

Blank indicates no measurement NL = No limit

Table 16. DSN001 – Retention Basin Outfall Surface Water Analysis (NJPDES NJ0023922) in 2019

DSN001																							
Parameters	**Units**	**Permit Limit**	**January**			**Feb.**			**March**			**April**			**May**			**June**		
			2019			**2019**			**2019**			**2019**			**2019**			**2019**		
Chemical Oxygen Demand, COD	mg/L	50.0	<	11.00		<	13.9		<	11.00		<	11.00		<	11.00*		<	11.00	
Phosphorus, total	mg/L		<	0.049			0.079			0.068			0.057		<	0.027			0.069	
Tetrachloroethylene, PCE	ug/L	0.703	<	0.52		<	ND (0.40)		<	ND (0.40)		<	ND (0.57)		<	ND (0.18)		<	ND (0.33)	
Total Petroleum Hydrocarbon, TPHC	mg/L	15 Max 10 Avg	<	0.86		<	0.86		<	0.86		<	1.0		<	0.86		<	0.90	
Total Suspended Solids, TSS	mg/L	50.0	<	2.90		<	1.8		<	1.8			9.50		<	1.8			3.2	
Field Parameters																				
pH (Max) (Min)	SU	>6; <9		6.89			7.12			6.89			7.59			7.27			7.35	
Oxidation-Reduction Potential, ORP, Max	mV																			
Temperature (Max/Average)	° C	30		10.2			2.7			8.8			15.9			15.4			18.4	

DSN001																							
Parameters	**Units**	**Permit Limit**	**July**			**August**			**Sept.**			**Oct.**			**Nov.**			**Dec.**		
			2019			**2019**			**2019**			**2019**			**2019**			**2019**		
Chemical Oxygen Demand, COD	mg/L	50.0		22.50		<	11.00 U					<	13.50		<	11.00		<	11.00	
Phosphorus, total	mg/L			0.096			0.091						0.340			0.130			0.110	
Tetrachloroethylene, PCE	ug/L	0.703		0.59			0.44					<	ND (0.41)		<	ND (0.42)		<	0.90	
Total Petroleum Hydrocarbon, TPHC	mg/L	15 Max 10 Avg	<	1.7 B		<	0.86 U					<	1.50		<	0.86		<	0.86	
Total Suspended Solids, TSS	mg/L	50.0	<	2.5 B		<	2.0 B					<	1.50			7.00			4.00	
Field Parameters																				
pH (Max) (Min)	SU	>6; <9		7.31 7.26			7.300 7.04						6.85			6.65 6.61			6.09 6.07	
Oxidation-Reduction Potential, ORP, Max	mV			-15.5									-7.2			8.2			37.2	
Temperature (Max/Average)	° C	30		20.3			19.9						21.6			9.3			6.7	

* From analytical lab revised report

Blank indicates no measurement NL = No limit

Table 17. D&R Canal Pump House – DSN003

Monthly Surface Water Analysis (NJPDES NJ0023922) in 2019

DSN003																							
Parameters	**Units**	**Permit Limit**		**January 2019**			**Feb. 2019**			**March 2019**			**April 2019**			**May 2019**			**June 2019**				
Chemical Oxygen Demand, COD	mg/L	50	<	13.90	<	<	11.00	<	<	19.4	<	<	11.00	<	<	11.00*	<	<	11.00				
Phosphorus, total	mg/L			0.062	<		.027			0.074	<		0.029			0.074			0.110				
Total Petroleum Hydrocarbon, TPHC	mg/L	15 Max 10 Avg	<	0.86	<	<	0.86	<	<	0.86	<	<	0.86	<	<	0.86 U	<	<	0.86				
Total Suspended Solids, TSS	mg/L			5.80			4.20			12.30	<		3.0 B			4.6			5.80				
Field Parameters																							
pH (Min) (Max)	SU	>6; <9		6.86			7.13			7.17			7.12			6.74			6.87				
Oxidation-Reduction Potential, ORP (Max)	mV																						
Temperature (Max)	° C	30 Max		19.80			4.10			5.50			14.70			17.90			22.00				

DSN003																							
Parameters	**Units**	**Permit Limit**		**July 2019**			**Aug. 2019**			**Sept. 2019**			**Oct. 2019**			**Nov. 2019**			**Dec. 2019**				
Chemical Oxygen Demand, COD	mg/L	50	<	11.00	<	<	11.00				<	<	11.00	<	<	11.00	<	<	13.50				
Phosphorus, total	mg/L			0.100	<		0.027						0.095			0.057			0.100				
Total Petroleum Hydrocarbon, TPHC	mg/L	15 Max 10 Avg	<	1.2 B	<	<	0.86				<	<	1.00	<	<	1.4 B	<	<	0.86				
Total Suspended Solids, TSS	mg/L			5.00	<		3.9 B				<		3.70	<		2.4B			6.80				
Field Parameters																							
pH (Min) (Max)	SU	>6; <9		6.91			6.93 6.79						6.77 6.76			7.13			6.5 6.52				
Oxidation-Reduction Potential, ORP (Max)	mV			4.60			-1.00						-0.10			18.90			14.6				
Temperature (Max)	° C	30 Max		26.80			23.30						21.60			9.40			9.10				

* From analytical lab revised report

Blank indicates no measurement NL = No limit

Table 18. Summary of Ground Water Sampling Results – March 2019

Target Chlorinated Volatile Organic Compounds (VOC), Monitored Natural Attenuation (MNA)

Well No.		MW-3S	MW-5I	MW-5S	MW-9S	MW-12S	MW-13S	MW-13I	MW-17	MW-18	MW-19S	MW-19I	NJ Ground Water Standard
PPPL Sample No.		19-129	19-130	19-131	19-132	19-133	19-135	19-134	19-136	19-137	19-139	19-138	
Lab Sample No.		JC84403-1	JC84257-1	JC84257-2	JC84309-2	JC84529-2	JC84257-4	JC8457-3	JC84309-3	JC84309-4	JC84529-4	JC84529-3	
Target Volatile Organic Compounds (ug/L)													
Tetrachloroethylene		<0.90	<0.90	<0.90	**7.0**	<0.90	**11.6**	**8.8**	**5.2**	<0.90	**54.6**	<0.90	1
Trichloroethylene		<0.53	**1.7**	<0.53	**6.9**	<0.53	**2.4**	<0.53	0.73 J	<0.53	**1.8**	<0.53	1
c-1,2-Dichloroethylene		<0.51	4.9	<0.51	3.6	<0.51	8.2	<0.51	<0.51	<0.51	1	<0.51	70
1,1,1-Trichloroethane		<0.54	<0.54	<0.54	<0.54	<0.54	<0.54	<0.54	<0.54	<0.54	<0.54	<0.54	30
1,1-Dichloroethylene		<0.59	<0.59	<0.59	<0.59	<0.59	<0.59	<0.59	<0.59	<0.59	<0.59	<0.59	1
Vinyl Chloride		<0.79	<0.79	<0.79	<0.79	<0.79	<0.79	<0.79	<0.79	<0.79	<0.79	<0.79	1
Target Semi-Volatile Organic Compounds (ug/L)													
1,4-Dioxane		0.0648 J	0.0734 J	<0.046	0.136	<0.046	0.272	0.188	0.0890 J	<0.046	**0.401**	<0.049	0.4
Natural Attenuation Indicators													
Manganese	mg/L	**1220**	**629**	<15	<15	<15	**4020**	23.8	**249**	**244**	**89.3**	<15	0.05
Alkalinity	mg/L	195	142	41.1	94.4	59.4	34.5	12	80.2	<5.0	12.2	21.3	–
Nitrate as N	mg/L	0.12	<0.11	1.3	<0.11	1.8	<0.11	0.2	<0.11	<0.11	0.26	**1.3**	1
Nitrite	mg/L	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010
Sulfate	mg/L	22.3	23.8	12.4	13.1	14.7	15.9	14	12.2	18.9	**36.2**	**7.3**	7
Sulfide	mg/L	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	–
Total Organic Carbon	mg/L	13.2	<1.0	<1.0	2.6	1.1	1.5	<1.0	<1.0	1.2	1.5	<1.0	–
Ferrous Iron	mg/L	<0.20	<0.2	<0.20	<0.20	<0.20	0.85	<0.20	<0.20	<0.20	<0.20	<0.20	–
Dissolved Methane	mg/L	40.5	5.1	<0.060	0.15	<0.060	17.1	<0.060	<0.060	<0.060	<0.060	<0.60	–
Dissolved Oxygen	mg/L	0.00	5.35	NA	0	2.18	9.75	7.41	0.00	0.00	3.55	2.57	–
pH	Std. Units	6.02	7.23	NA	6.14	6.26	5.67	6.69	6.34	4.87	4.5	5.07	–
Redox Potential	mVe	96	-88	NA	197	160	108	152	125	250	329	272	–

NOTES:

J - Estimated, concentration listed greater than the MDL but lower than the lowest standard.

N - Indicates presumptive evidence of the compound's presence.

ND - Analyte Not Detected

NA - Not Analyzed

Ground water quality standards as published in N.J.A.C. 7:9-6.9.

— - Compound-specific Ground Water Quality Standard not published.

* MW-26S is duplicate sample from well MW-13S.

Table 18 cont. Summary of Ground Water Sampling Results – March 2019

Target Chlorinated Volatile Organic Compounds (VOC), Monitored Natural Attenuation (MNA)

Well No.		MW-22S	MW-23	MW-24	MW-25S	MW-26S*	D-SITE BASEMENT	D-SITE AIR SHAFT	TRIP BLANK	TRIP BLANK	TRIP BLANK	NJ Ground
PPPL Sample No.		19-140	19-141	19-142	19-143	19-144	19-145	19-146	19-147	19-147	19-147	Water
Lab Sample No.		JC84403-02	JC84403-4	JC84403-3	JC84309-5	JC84257-6	JC84529-5	JC84529-6	JC84257-6	JC84309-1	JC84403-1	Standard
Tetrachloroethylene		<0.90	<0.90	<0.90	<0.90	**13.2**	**1.7**	**14.8**	<0.90	<0.90	<0.90	1
Trichloroethylene		<0.53	<0.53	<0.53	<0.53	**2.7**	**<0.53**	**1.6**	<0.53	<0.53	<0.53	1
c-1,2-Dichloroethylene		<0.51	<0.51	<0.51	0.88 J	9.3	<0.51	0.91 J	<0.51	<0.51	<0.51	70
1,1,1-Trichloroethane		<0.54	<0.54	<0.54	<0.54	<0.54	<0.54	<0.54	<0.54	<0.54	<0.54	30
1,1-Dichloroethylene		<0.59	<0.59	<0.59	<0.59	<0.59	<0.59	<0.59	<0.59	<0.59	<0.59	1
Vinyl Chloride		<0.79	<0.79	<0.79	<0.79	<0.79	<0.79	<0.79	<0.79	<0.79	<0.79	1
Target Semi-Volatile Organic Compounds (ug/L)												
1,4-Dioxane		<0.049	<0.049	<0.048	0.133	0.26	<0.046	0.0895 J	NA	NA	NA	0.4
Manganese	mg/L	**51.6**	**99.4**	<15	**4530**	**4130**	**175**	**71500**	NA	NA	NA	0.05
Alkalinity	mg/L	<5.0	<5.0	13.2	123	17.3	120	100	NA	NA	NA	–
Nitrate as N	mg/L	0.53	<0.11	<0.11	<0.11	<0.11	0.89	0.5	NA	NA	NA	10
Nitrite	mg/L	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	0.028	NA	NA	NA	1
Sulfate	mg/L	19.3	43.3	15.2	24	13.6	19.3	30.2	NA	NA	NA	250
Sulfide	mg/L	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	NA	NA	NA	–
Total Organic Carbon	mg/L	<1.0	1.7	<1.0	1.3	1.5	1.2	1.2	NA	NA	NA	–
Ferrous Iron	mg/L	<0.20	<0.20	<0.20	0.35	0.96	<0.20	<0.2	NA	NA	NA	–
Dissolved Methane	mg/L	<0.060	0.13	<0.060	1.7	9.5	<0.060	2.5	NA	NA	NA	–
Dissolved Oxygen	mg/L	5.65	3.4	4.05	0.0	NA	NA	NA	NA	NA	NA	–
pH	Std. Units	4.76	4.51	5.31	6.37	NA	NA	NA	NA	NA	NA	–
Redox Potential	mVe	290	375	285	29	NA	NA	NA	NA	NA	NA	–

NOTES:
J - Estimated, concentration listed greater than the MDL but lower than the lowest standard.
N - Indicates presumptive evidence of the compound's presence.
ND - Analyte Not Detected
NA - Not Analyzed
Ground water quality standards as published in N.J.A.C. 7:9-6.9.
— - Compound-specific Ground Water Quality Standard not published.
* MW-26S is duplicate sample from well MW-13S.

Table 19. Summary of Ground Water Sampling Results –June 2019

Target Chlorinated Volatile Organic Compounds (VOC), Monitored Natural Attenuation (MNA)

Well No.		MW-3S	MW-5I	MW-5S	MW-9S	MW-13S	MW-18	MW-17	MW-19S	MW-25S	MG BASEMENT	MW-26S *	Trip Blank
PPPL Sample No.		19-188	19-189	19-190	19-191	19-192	19-194	19-193	19-195	19-196	19-198	19-197	19-199
Lab Sample No.		JC90316-6	JC90124-4	JC90124-3	JC90124-2	JC90316-4	JC90252-2	JC90252-3	JC90124-5	JC90316-3	JC90316-2	JC90316-5	JC90124
Target Volatile Organic Compounds (ug/L)													
Tetrachloroethylene		<0.33	<0.19	<0.19	**19.9**	**12.7**	<0.33	**4.3**	**92.1**	<0.33	**13.7**	**14.4**	<0.19
Trichloroethylene		<0.53	**1.7**	<0.53	**12.9**	**2.4**	<0.53	0.82 J	**2.5**	<0.53	**1.5**	**2.7**	<0.53
c-1,2-Dichloroethylene		<0.51	6.1	<0.51	8.4	9.5	<0.51	<0.51	1	1.1	0.82 J	10	<0.51
1,1,1-Trichloroethane		<0.54	<0.54	<0.54	<0.54	<0.54	<0.54	<0.54	<0.54	<0.54	<0.54	<0.54	<0.54
1,1-Dichloroethylene		<0.59	<0.59	<0.59	<0.59	<0.59	<0.59	<0.59	<0.59	<0.59	<0.59	<0.59	<0.59
Vinyl Chloride		<0.79	<0.79	<0.79	<0.79	<0.79	<0.79	<0.79	<0.79	<0.79	<0.79	<0.79	<0.79
Target Semi-Volatile Organic Compounds (ug/L)													
1,4-Dioxane		<0.047	0.095 B	<0.046	**0.569 B**	0.265	<0.049	0.0884 J	**0.546 B**	0.116	<0.047	0.235	NA
Natural Attenuation Indicators													
Dissolved Oxygen	mg/L	1.86	2.25	NA	0.30	0.00	7.15	0.47	2.63	0.00	NA	0.00	NA
pH	Std. Units	5.99	7.25	NA	6.01	5.53	5.32	6.47	4.54	6.53	NA	5.53	NA
Redox Potential	mVe	19	-62	NA	159	76	190	74	329	19	NA	76	NA

.NOTES:

B Analyte found in associated method blank.
J Estimated, concentration listed greater than the MDL but lower than the lowest standard.
***** MW-26S is duplicate sample from well MW-13S.
Ground water quality standards as published in N.J.A.C. 7:9C [NJDEP18a].
-- Compound-specific Ground Water Quality Standard not published.

Table 20. Summary of Ground Water Sampling Results –September 2019

Target Chlorinated Volatile Organic Compounds (VOC), Monitored Natural Attenuation (MNA)

Well No.		MW-3S	MW-5I	MW-5S	MW-9S	MW-13S	MW-18	MW-17	MW-19S	MW-25S	MG BASEMENT	MW-26S *	Trip Blank
PPPL Sample No.		19-280	19-275	19-276	19-281	19-277	19-273	19-272	19-195	19-274	19-279	19-278	19-283
Lab Sample No.		JC95233-1	JC95120-1	JC95120-2	JC95167-2	JC95120-3	JC95233-5	JC95233-4	JC90124-5	JC95167-1	JC95233-2	JC95120-4	JC95120
Target Volatile Organic Compounds (ug/L)													
Tetrachloroethylene		<0.90	<0.90	0.94	**19.2**	**12.4**	<0.90	**20.8**	**86.7**	<0.90	**30**	**12.6**	<0.90
Trichloroethylene		<0.53	0.83	<0.53	**5.1**	**2.5**	<0.53	**3.9**	**2.6**	<0.53	**3.9**	**2.7**	<0.53
c-1,2-Dichloroethylene		<0.51	2.5	<0.51	2.9	9.8	<0.51	0.73	0.97	2.3	3	10.1	<0.51
1,1,1-Trichloroethane		<0.54	<0.54	<0.54	<0.54	<0.54	<0.54	<0.54	<0.54	<0.54	<0.54	<0.54	<0.54
1,1-Dichloroethylene		<0.59	<0.59	<0.59	<0.59	<0.59	<0.59	<0.59	<0.59	<0.59	<0.59	<0.59	<0.59
Vinyl Chloride		<0.79	<0.79	<0.79	<0.79	<0.79	<0.79	<0.79	<0.79	<0.79	<0.79	<0.79	<0.79
Target Semi-Volatile Organic Compounds (ug/L)													
1,4-Dioxane		0.0604	0.0548	<0.046	0.302	0.256	0.0752	0.218	0.373	0.0934	0.144	0.24	NA
Natural Attenuation Indicators													
Dissolved Oxygen	mg/L	0.34	0.33	NA	0.26	8.78	0.33	0.58	2.16	0.25	NA	8.78	NA
pH	Std. Units	6.09	7.25	NA	5.81	5.66	5.44	5.54	4.95	6.39	NA	5.66	NA
Redox Potential	mVe	103	9	NA	293	118	212	250	419	61	NA	118	NA

NOTES:

B Analyte found in associated method blank.

J Estimated, concentration listed greater than the MDL but lower than the lowest standard.

***** MW-26S is duplicate sample from well MW-13S.

Ground water quality standards as published in N.J.A.C. 7:9C.

-- Compound-specific Ground Water Quality Standard not published

Table 21. Summary of Ground Water Sampling Results –December 2019

Target Chlorinated Volatile Organic Compounds (VOC)

Well No.		MW-3S	MW-5I	MW-5S	MW-9S	MW-13S	MW-18	MW-17	MW-19S	MW-25S	MG BASEMENT	MW-26S *	
PPPL Sample No.		20-40	20-41	20-42	20-43	20-44	20-46	20-45	20-47	20-48	20-50	20-49	2
Lab Sample No.		JD240-5	JD240-3	JD240-2	JD240-4	JC99961-5	JC99961-3	JC99961-4	JD240-6	JC99961-2	JC99961-7	JC99961-6	JC9
Target Volatile Organic Compounds (ug/L)													
Tetrachloroethylene		<0.90	<0.90	<0.90	**6.4**	**11.2**	<0.90	**18.7**	**87.3**	<0.90	**20.5**	**10.2**	<
Trichloroethylene		<0.53	**1.2**	<0.53	<0.53	**3**	<0.53	**4.1**	**2.6**	<0.53	**2.1**	**2.9**	<
c-1,2-Dichloroethylene		<0.51	4.6	<0.51	<0.51	10	<0.51	<0.51	0.98	2.3	1.4	10.2	<
1,1,1-Trichloroethane		<0.54	<0.54	<0.54	<0.54	<0.54	<0.54	<0.54	<0.54	<0.54	<0.54	<0.54	<
1,1-Dichloroethylene		<0.59	<0.59	<0.59	<0.59	<0.59	<0.59	<0.59	<0.59	<0.59	<0.59	<0.59	<
Vinyl Chloride		<0.79	<0.79	<0.79	<0.79	<0.79	<0.79	<0.79	<0.79	<0.79	<0.79	<0.79	<
Target Semi-Volatile Organic Compounds (ug/L)													
1,4-Dioxane		<0.049	<0.048	<0.048	<0.049	0.321	0.146	0.233	**0.620**	0.109	0.118	0.34	
Natural Attenuation Indicators													
Dissolved Oxygen	mg/L	0.00	0.00	NA	0.00	7.13	0.56	0.00	0	0.00	NA	7.13	
pH	Std. Units	6.04	7.21	NA	5.85	6.05	5.56	5.6	4.54	6.60	NA	6.05	
Redox Potential	mVe	146	-76	NA	142	35	191	130	290	15	NA	35	

NOTES:

B Analyte found in associated method blank.

J Estimated, concentration listed greater than the MDL but lower than the lowest standard.

***** MW-26S is duplicate sample from well MW-13S.

Ground water quality standards as published in N.J.A.C. 7:9C.

-- Compound-specific Ground Water Quality Standard not published

Table 22. Summary of Groundwater Sampling Results – D-Site MG Sump, 2019

Parameters	Units	January	Feb.	March	April	May	June	July	August	Sept.	Oct.	Nov.	Dec.
Chemical Oxygen Demand, COD	mg/L		< 11 U			24.3*			23.00			29.70	
Phosphorus, total	mg/L	3.80	8.10	9.60	3.900	15.900	23.50	16.00	19.00		0.98	< 0.027 U	12.400
Total Suspended Solids, TSS	mg/L		4370.00			8660.00			9860.00			12600.00	

* From analytical lab revised report

Blank indicates no measurement

Table 23. Summary of Groundwater Sampling Results – D-Site Airshaft Sump, 2019

Parameters	Units	Jan.	Feb.	March	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
Chemical Oxygen Demand, COD	mg/L		< 11.00			< 11.00*			< 11.00			< 11.00	
Phosphorus, total	mg/L	0.15	< 0.027	< 0.027	0.430	< 0.027	0.06	0.06	< 0.035		0.200	< 0.031	0.064
Total Suspended Solids, TSS	mg/L		< 1.5			67.70			< 1.50			159.00	

* From analytical lab revised report

Blank indicates no measurement

Table 24. Quality Assurance Data for Radiological and Non-Radiological Samples for 2019

Laboratory, Program and Parameter	Units	Reported Value	Actual Value	Acceptance Range	Acceptable Not Acceptable
ERA Co. **May 2019 RAD-117, Proficiency Test**					
Barium-133	pCi/L	22.56	24.1	18.6 – 27.8	Acceptable
Cesium-134	pCi/L	13.03	12.1	8.39 – 14.4	Acceptable
Cesium-137	pCi/L	37.22	33.1	28.8 – 39.4	Acceptable
Cobalt-60	pCi/L	13.39	11.5	8.67 – 15.5	Acceptable
Zinc-65	pCi/L	88.07	89.2	80.3 – 107	Acceptable
Tritium	pCi/L	21,726.13	21,400	18,700 – 23,500	Acceptable
ERA Co. **November 2019 RAD-119, Proficiency Test**					
Barium-133	pCi/L	58.77	43.8	35.7 – 48.8	Not Acceptable*
Cesium-134	pCi/L	72.14	55.9	45.2 – 61.5	Not Acceptable*
Cesium-137	pCi/L	105.1	78.7	70.8 – 89.2	Not Acceptable*
Cobalt-60	pCi/L	71.25	53.4	48.1 – 61.3	Not Acceptable*
Zinc-65	pCi/L	49.88	34.0	28.5 – 43.1	Not Acceptable*
Tritium	pCi/L	23,682.88	23,400	20,500 – 25,700	Not Acceptable*
Phenova **May 2019 R24460**					
pH	S.U.	6.22	6.22	6.02 – 6.42	Acceptable
Residual Chlorine	mg/L	0.769	0.69	0.577 – 0.938	Acceptable

***** Laboratory processing error

Table 25. Waste Characterization Report (WCR) Surface Water Sampling 2019

No limits exceeded, only parameters listed above non-detect

Laboratory Parameter	Reported Value (mg/L)
DSN 001 Semi Annual	May
Barium	<193
Beryllium	-
Copper	-
Lead	-
Manganese	148
Nickel	<3.5
Selenium	-
Thallium	-
Zinc	<18.3
Solids, Total Dissolved	330
Total Organic Carbon	1.3
DSN001 Annual	July
beta-BHC	0.010 ug/L
DSN003 Annual	May
Barium	<44.1
Zinc	<7.7
Nitrogen, Ammonia	<0.15
Solids, Total Dissolved	114
Total Organic Carbon	5.1

Figure 1. 1,4 Dioxane, PCE, TCE Distribution for Groundwater Wells 2019

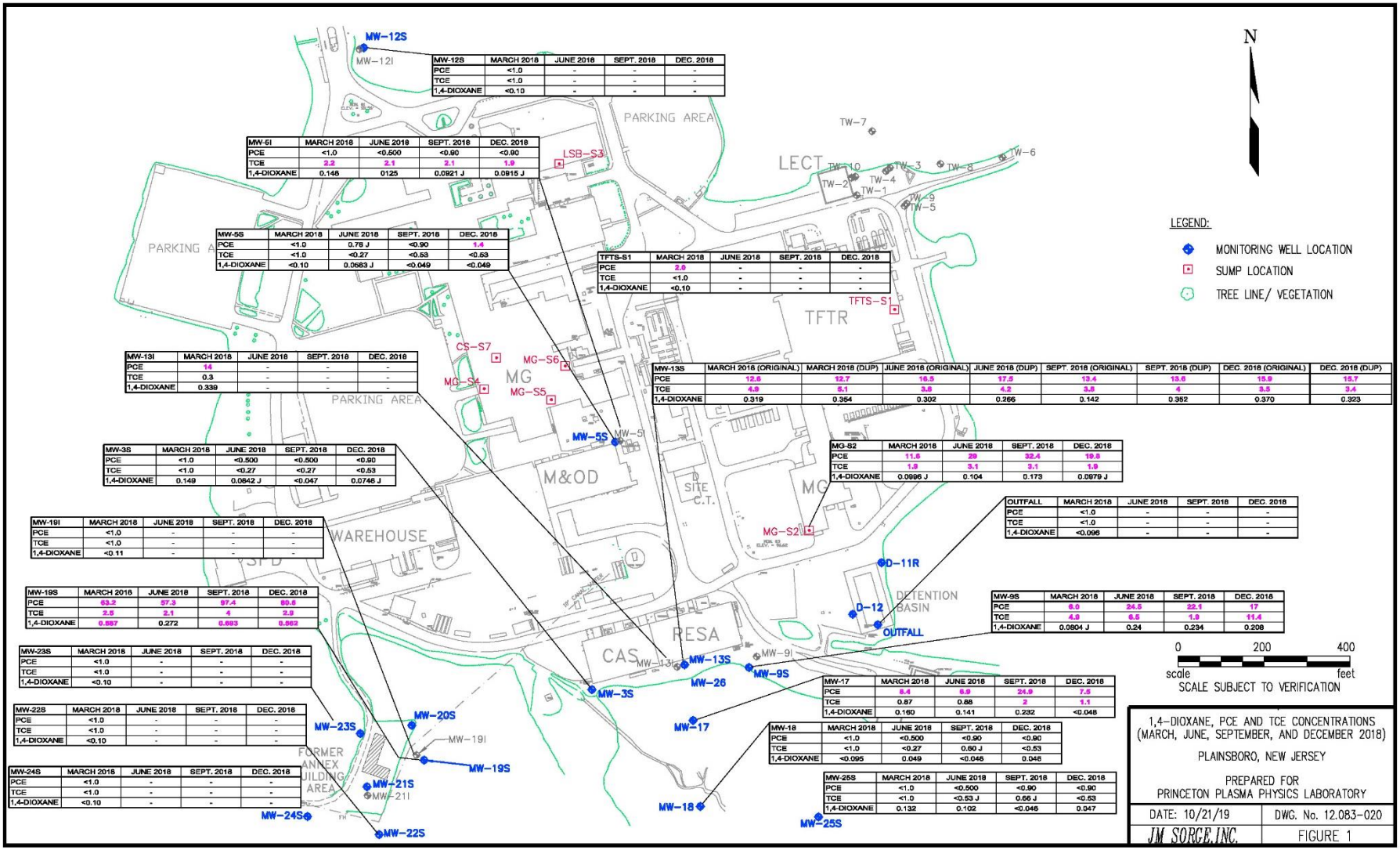


Figure 2. Potentiometric Surface Contours Shallow Groundwater Wells Annual Sampling Event- March 2019

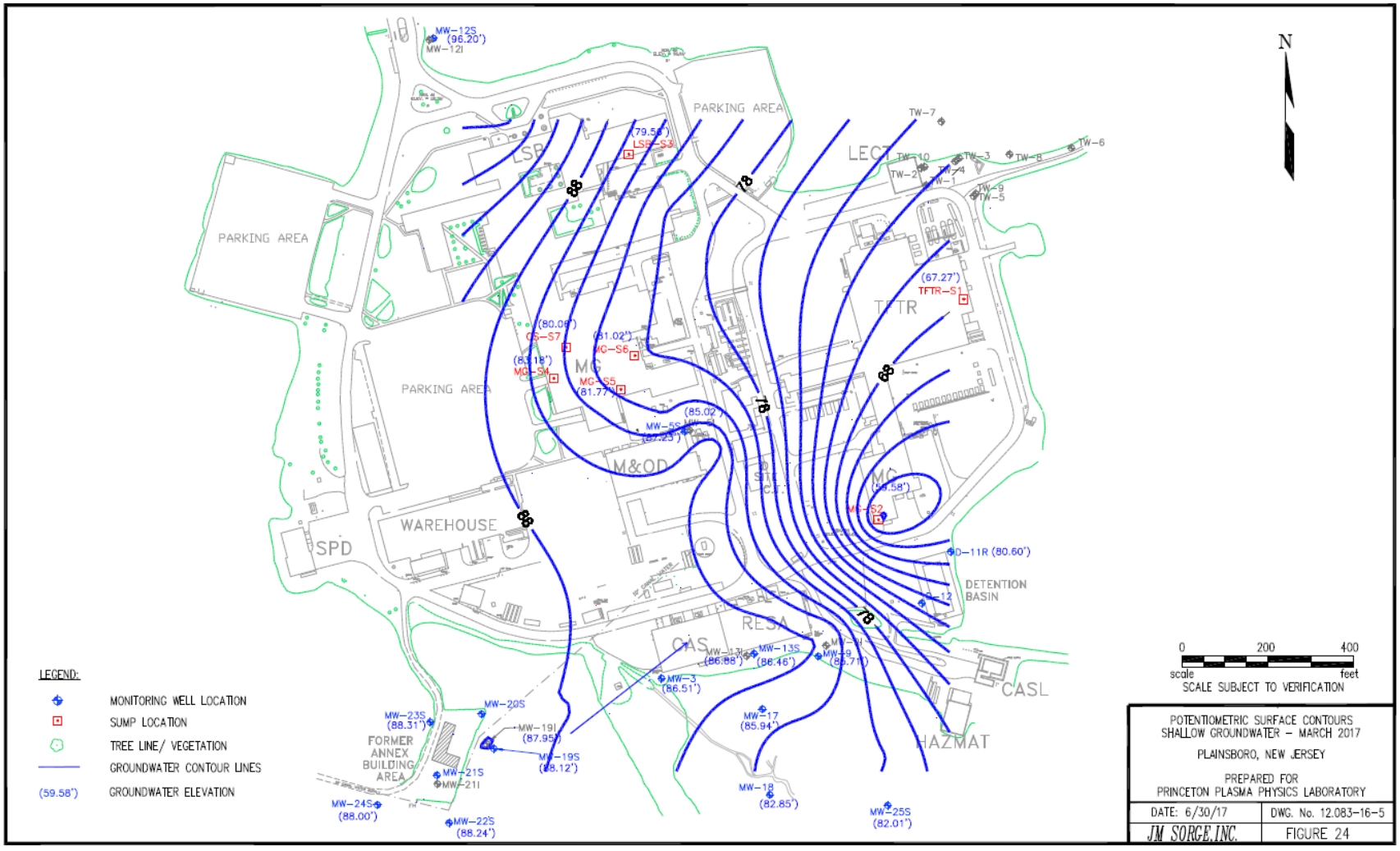


Figure 3. PPPL On Site Sampling Location Map

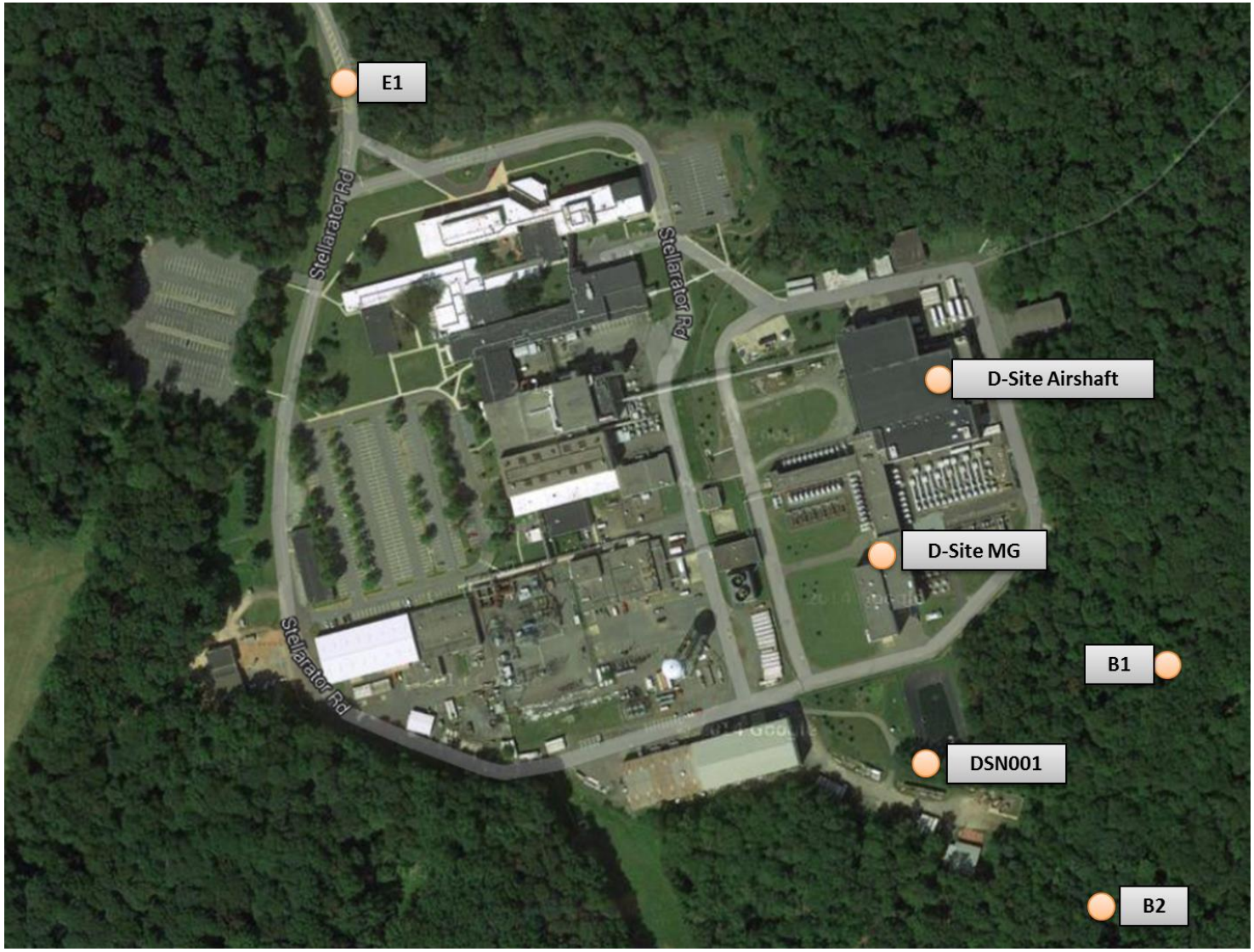


Figure 4. PPPL Off Site Sampling Location Map

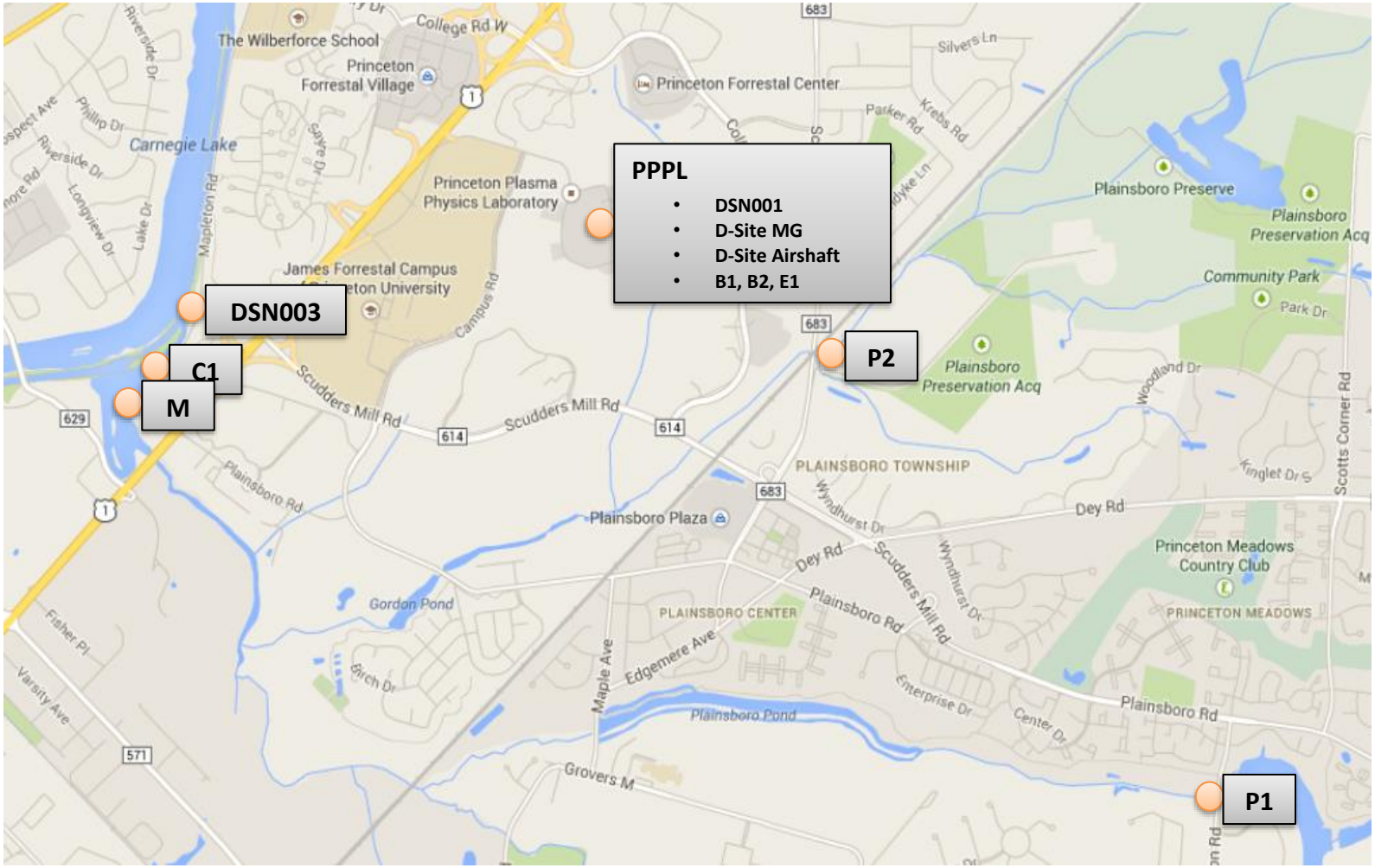
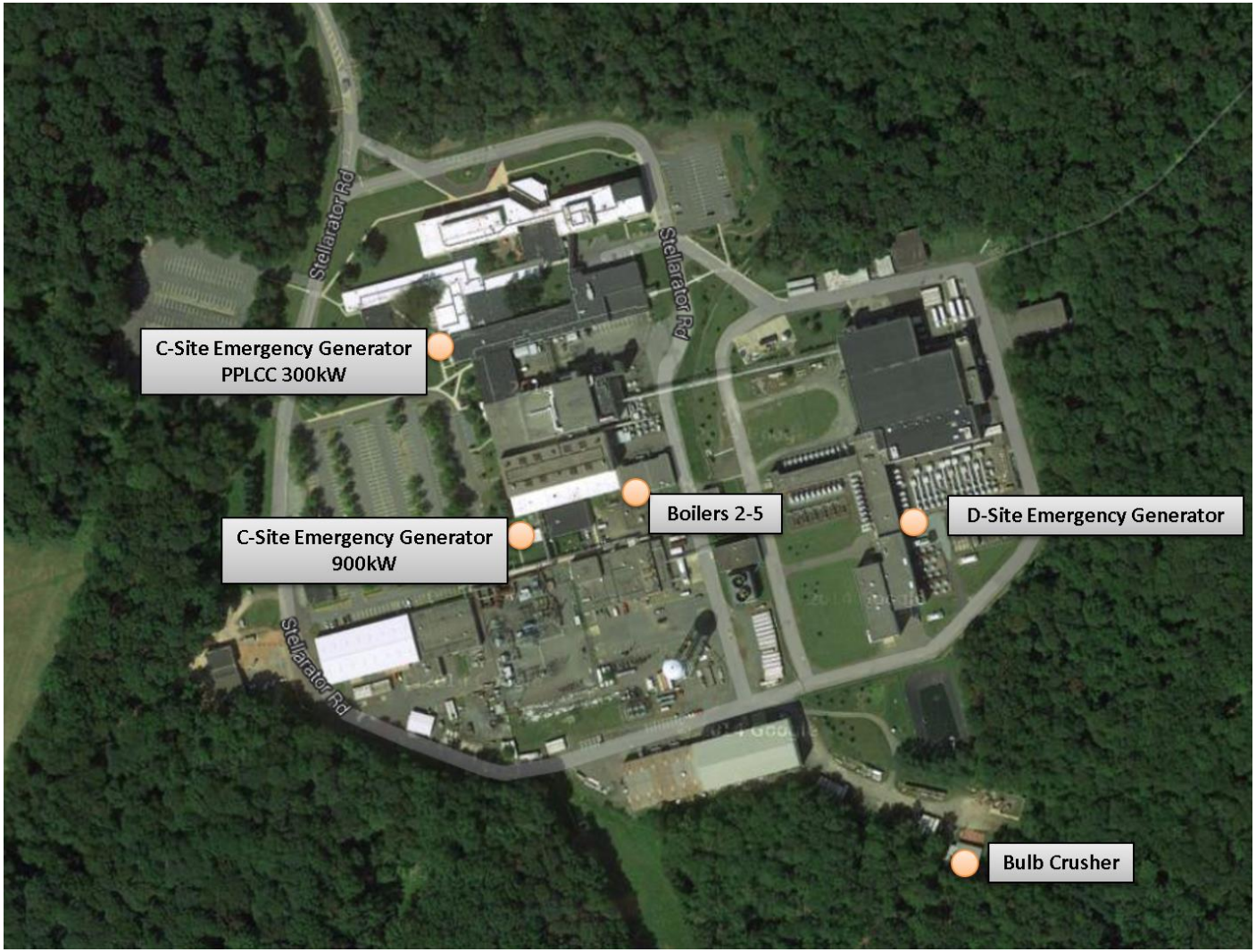


Figure 5. PPPL Air Permitted Equipment Location Map



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