Annual Site Environmental Report

2018

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-2019_191

U.S. DEPARTMENT OF ENERGY

Princeton Plasma Physics Laboratory

Annual Site Environmental Report

PPPL–2019_191

For Calendar Year 2018 – 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 2018 environmental surveillance and monitoring program are presented and discussed. The report also summarizes environmental initiatives, assessments, and community involvement programs that were undertaken in 2018.

PPPL has engaged in fusion energy research since 1951. The vision of the Laboratory is to create innovations to make fusion power a practical reality – a clean, alternative energy source. 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 with several poloidal field coils, NSTX-U did not operate in 2018. Redesign and recovery efforts are ongoing.

In 2018, PPPL's radiological environmental monitoring program measured tritium in the air at the NSTX-U Stack and at on -site sampling stations. Using highly sensitive 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; the 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 chlorinated degreasing solvents). In 2018, PPPL was in compliance with its permit limits for surface and sanitary discharges. PPPL was honored with awards for its waste reduction and recycling program, EPEAT-certified electronics purchasing, and its commitment to DOE's GreenBuy Program .

Robert S. Sheneman, editor

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

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2018 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
^{o}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 2018

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 2018," are documented and certified to be correct.

Signed:

Mark Hughes
Digitally signed by Mark Hughes
Date: 2019.11.08 08:02:00 -05'00'

Mark Hughes,
Environmental Compliance Manager
Environmental Services Division

Robert S Sheneman
Digitally signed by Robert S Sheneman
Date: 2019.11.08 08:28:06 -05'00'

Robert S. Sheneman,
Deputy Head
Environment, Safety, & Health Department

Approved:

Jerry D. Levine
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DN: cn=Jerry D. Levine, o=Princeton Plasma Physics Laboratory, ou=ESH&S Department, email=jlevine@pppl.gov, c=US
Date: 2019.11.08 09:15:15 -05'00'

Jerry D. Levine,
Head
Environment, Safety, & Health Department

Executive Summary

Princeton Plasma Physics Laboratory

Annual Site Environmental Report for

Calendar Year 2018

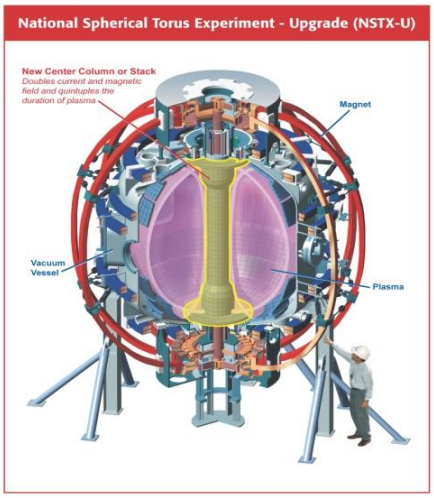
This report presents the results of environmental activities and monitoring programs at the Princeton Plasma Physics Laboratory (PPPL) for Calendar Year 2018. The report provides the U.S. Department of Energy (DOE) and the public with information on the level of radioactive and non-radioactive pollutants, 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 2018. 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, the Princeton Plasma Physics Laboratory 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

2018 marked the twentieth year of the National Spherical Torus Experiment (NSTX). Completed in 2016 at a cost of $94 million, the NSTX upgrade project (NSTX-U), the redesign of the center

stack magnets and the addition of a second neutral beam box from the former Tokamak Fusion Test Reactor (TFTR), were in place to begin the operation of the most advanced spherical tokamak in the world.



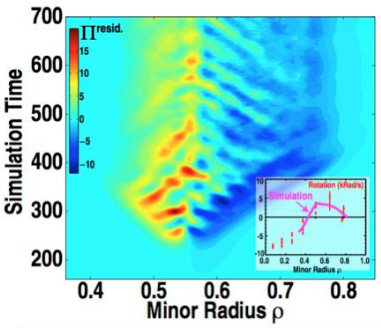
Unfortunately, due to disruptions to NSTX-U caused by events in 2015 and again in 2016, the experiment did not operate for second half of 2016 through 2018. Engineering and quality assurance issues caused the disruptions to a major magnetic coil (poloidal field coil, PF1A) and other smaller components 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. After appropriate reviews and approval from DOE, the Laboratory will implement the plan and begin the revitalization of NSTX-U.

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 in Germany, 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 2018

When the total maximum off-site dose for 2018 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 2018 were:

1. *Maximum exposed individual (MEI) dose from all sources—airborne and liquid releases—was 3.39 x 10^{-3} mrem per year (3.39x 10^{-5} person-Sv per year) in 2017.*
2. *The collective effective dose equivalent for the population living within 80 kilometers was 1.29x10^{-3} person-rem (1.29 x 10^{-5} person-Sv).*

Infrastructure and Operation Improvements (IOI) Project

PPPL finalized its campus-wide plan of actions to improve the existing facilities by renovating and modernizing office and storage space in addition to consolidating technical machine shops. The project, known as the Infrastructure and Operation Improvements (IOI) Project, is funded by the US Department of Energy'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 in 2016 and 2017 with renovations to office, meeting, technical and storage areas. The project was completed in 2018 when the contents of the Research, Storage and Assembly Building (RESA), one of PPPL's primary fabrication shops, was moved to the renovated C-Site MG Building. The RESA building was fitted for racks and converted into a new warehouse for storing equipment.

PPPL Environmental Achievements and Activities in 2018

PPPL won four national honors for sustainable programs in 2018. The U.S. Environmental Protection Agency (EPA) recognized the Laboratory for its waste management program, by diverting 1,042 tons of waste from landfills. The agency awarded PPPL the 2018 Federal Green Challenge Regional Award and Waste Wise Regional Award for reducing waste and achieving a combined recycling rate of 84 percent in Fiscal Year 2017.

Earlier in the year, the U.S. Department of Energy presented Green Buy Award to the Laboratory for its green buying program — the award recognizes PPPL's for continued success in acquiring environmentally preferable products. PPPL was also recognized for purchasing sustainable electronics, winning a 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 PPPL. 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 has contracted with the international auditing firm DQS-UL for these services. PPPL's EMS was audited against the latest version of ISO14001 (2015) in late 2017 and received a new registration certificated in January 2018.

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 Princeton Plasma Physics Laboratory is a Collaborative National Center for plasma and fusion science. Its primary mission is to develop the scientific understanding and the key innovations which will lead to an attractive fusion energy source. Associated missions include conducting world class research along the broad frontier of plasma science and technology, 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

The U.S. Department of Energy's Princeton Plasma Physics Laboratory (PPPL) is a Collaborative National Center for plasma and fusion science. Its primary mission is to develop scientific understandings and key innovations leading to an attractive fusion energy source [PPPL08a]. Related missions include conducting world-class research along the broad frontier of plasma science, providing the highest quality of scientific education and experimentation, and participating in technology transfer and science education projects/programs within the local community and nation-wide.

The National Spherical Torus Experiment Upgrade (NSTX-U) is a collaborative project among 30 U.S. laboratories, including Department of Energy 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.

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 2018, 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

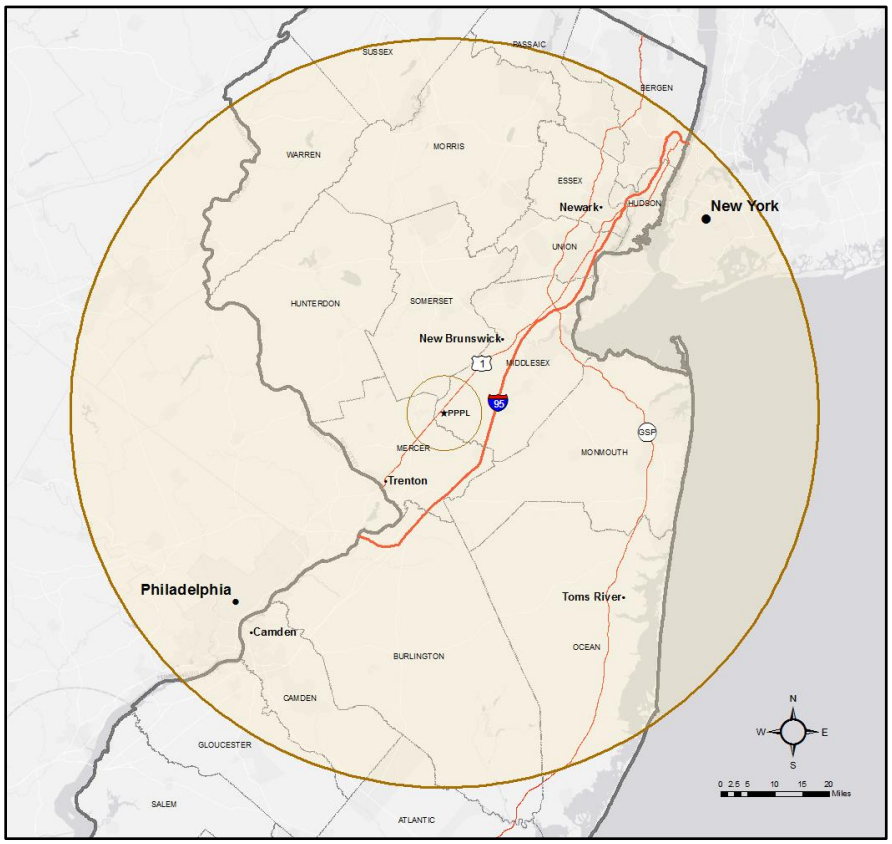
Tokamak Experiment Upgrade project (NSTX-U), began in 2011 and was completed in May 2016. After a successful inauguration it was taken offline to perform additional renovations; the renovations are projected to be completed in the next few years.

1.2 Site Location

The Princeton Plasma Physics Laboratory (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).

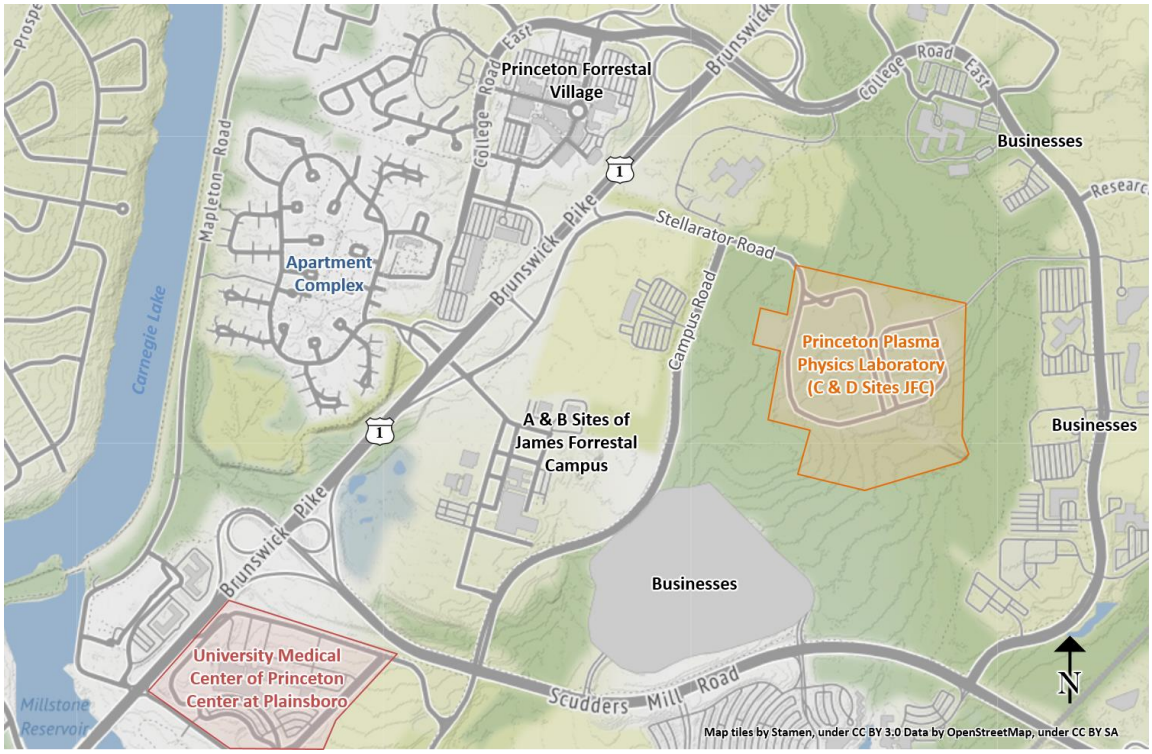
The site is in Plainsboro Township in Middlesex County (central New Jersey), adjacent to the municipalities of Princeton, Kingston, East and West Windsor, and Cranbury, NJ. The Princeton area continues to experience a sustained growth of new businesses located along the Route 1 corridor near the site. 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 on 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 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 Stellarator models, which were early 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 using 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 2018 temperatures ranged from -2 degrees to 98 degrees Fahrenheit (°F) (-18.9° Celsius (C) to 36.6° C); the average departure from normal temperature (1981-2010) was plus 2.5° F (16.39° 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 2018, the total rainfall for the year was 63.24 inches (160.63 cm), or 17.24 inches (43.79 cm) 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].

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 one of the coils 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-B, an upgrade incorporating new beam line, went online April 30, 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 2012- 2017American 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 2018 US Census Bureau Statistics estimates that Middlesex County has a population of 829,685, a growth of 2.4%. Adjacent counties have populations of 369,811 (Mercer), 621,354 (Monmouth), 331,164 (Somerset), and 558,067 (Union) [US18]. 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

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 2018, 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 its Earth Day and America Recycle Day activities for its employees.

ENVIRONMENTAL COMPLIANCE SUMMARY AND ENVIRONMENTAL STEWARDSHIP

PPPL initiates actions which enhance and document compliance with these requirements. Compliance with applicable federal, state, and local environmental statutes or regulations, and Executive or DOE Orders is an important piece of PPPL's primary mission.

2.1 Laws and Regulations

Exhibit 2.1 summarizes the environmental statutes and regulations applicable to PPPL's activities, as well as summarizing the 2018 compliance status and providing the ASER sections where further details are located. The list of "Applicable Environmental Laws and Regulations – 2018 Status" conforms to PPPL's Environmental Management System (EMS) Appendix B, "Summary of Legal and Other Requirements" [PPPL18].

2.2 Site Compliance and Environmental Management System (EMS) Assessments

In 2018, PPPL's Quality Assurance (QA) Department performed an internal environmental audit of PPPL's Environmental Management System (EMS). This audit included ensuring PPPL would meet ISO the 14001:2015 new standard, follow-up of the findings and recommendations made by UL-DQS's 2016 annual surveillance audit, which is tracked through PPPL's internal QA Audit Database. In November 2017, UL-DQS, Inc. conducted the certification audit of PPPL's EMS against the International Organization for Standards (ISO) standard 14001:2015 – "Environmental Management Systems – Requirements with guidance for use" to transition

from the 2004 version of ISO14001. Further discussion of the EMS program audits follows in Section 2.3 of this chapter [Cum19, ISO15, UL17].

2.3 Environmental Permits

The following Exhibit 2.1 "Applicable Environmental Laws and Regulations –2018 Status" provides information about PPPL's compliance with applicable Federal and State environmental laws, regulation, DOE and Executive Orders.

Exhibit 2.1 Applicable Environmental Laws and Regulations – 2018 Status

Environmental Restoration and Waste Management	2018 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 2018, PPPL was not involved with CERCLA-mandated clean-up actions. An on-going New Jersey-regulated ground water remediation project is discussed in ASER 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 2018, PPPL shipped 19.32 tons of combined hazardous, universal and TSCA waste of which 9.49 tons were recycled. The types of waste are highly variable each year; in 2018, incinerated quantities were classified in several hazard classes [San19a].	*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). PPPL does not nor does not expect to generate mixed waste in the future. An agreement among the regulators was reached to treat in the accumulation container any potential mixed waste [PPPL95].	
National Environmental Policy Act (NEPA) covers how federal actions may impact the environment and an examination of alternatives to those actions	In 2018, PPPL performed NEPA reviews of 14 proposed activities. All Fourteen of these activities were determined to be categorical exclusions (CXs) in accordance with the regulations/guidelines of the Council on Environmental Quality (CEQ) [Str19].	
Toxic Substance Control Act (TSCA) governs the manufacture, use, and distribution of regulated chemicals listed.	In 2018, PPPL shipped 535 pounds of PCB TSCA Hazardous Substances, which consisted of either capacitors or filters. Asbestos shipments in 2018 totaled 40 cubic yards [San19a].	*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 certified subcontractor performs the application under the direction of PPPL's Facilities personnel [Kin19b].	*Exhibit 4- 11* *4.5.3*

Exhibit 2.1 Applicable Environmental Laws and Regulations – 2018 Status

Other Environmental Statutes	2018 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 2018 [San19b, San19c].	*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.	Due to the location of the pump house next to the Delaware & Raritan Canal, the Canal and the area within 100 yards are listed on both the federal and state register of historic sites [PPPL05].	
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 floodplains are at 80 and 85 feet above mean sea level (msl), respectively. The majority of the PPPL site is located at 100 ft. above msl; only HAZMAT building is in the flood hazard zone but is protected by 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 [PPPL15b]. No new wetlands or transition area permits were required.	*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, 2 dust collectors and a fluorescent bulb crusher. Two above-ground storage tank permits (< 10,000 gals. fuel oil) were canceled per NJDEP recommendation during an audit. PPPL is designated as a synthetic minor and does not exceed any air contaminant thresholds requiring a Title V permit. Submitted Subpart JJJJJJ Notification to EPA - biennial boiler adjustment. Annual 2018 boiler adjustment results submitted to NJDEP as required by the permit. Fuel consumption sulfur content for the generators and boilers are recorded; annual boiler emissions calculated [Nem19]. NESHAPs report for tritium emissions are submitted annually [PPPL18b]. PPPL maintains an inventory for ozone-depleting substances (ODS) and greenhouse gas (GHG) emissions [Hug19c].	*4.4*

Exhibit 2.1 Applicable Environmental Laws and Regulations – 2018 Status

Other Environmental Statutes	2018 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.	In CY 2017, PPPL obtained a soil erosion permit for the demolition of Modular Building #6, which is part of a major infrastructure project (IOI Project). In 2018 PPPL completed the project and closed the permit. No other projects required a soil erosion permit. [PPPL17].	*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 report but continues to comply with proper disposal of all medical wastes [San19b].	
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-DOE submitted annual chemical inventory reports [Sla19].	*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) continued analyze immediately parameters; PPPL received acceptable for all performance tests for pH, total residual chlorine (Chlorine-produced oxidants- CPO) and temperature. However, transcription errors on two PT tests led the certification to be suspended. PPPL subcontractor analytical laboratory is a NJDEP certified laboratory [PPPL18e].	*7*

Exhibit 2.1 Applicable Environmental Laws and Regulations – 2018 Status

Water Quality and Protection	2018 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 [Con19].	*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 2015 providing guidance to reduce the impact of PPPL's operations on storm water quality [PPPL15c]. PPPL maintains stormwater best management practices structures such as raingardens, grassed swales, vegetated cover and 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 2013, PPPL-DOE received from NJDEP the final NJPDES surface water discharge permit [NJDEP13]. For 2018, PPPL reported no permit limits exceeded at DSN001, the basin outfall and at DSN003, the D&R Canal pump house backwash filter outfall. PPPL completed its transition to Peracetic Acid (PAA) as a substitute for chlorine disinfection for industrial water and will submit a report to the NJDEP for final authorization.	*4.1.1* *Exhibits 4-1, 4-2, 4-3 and 4-5*

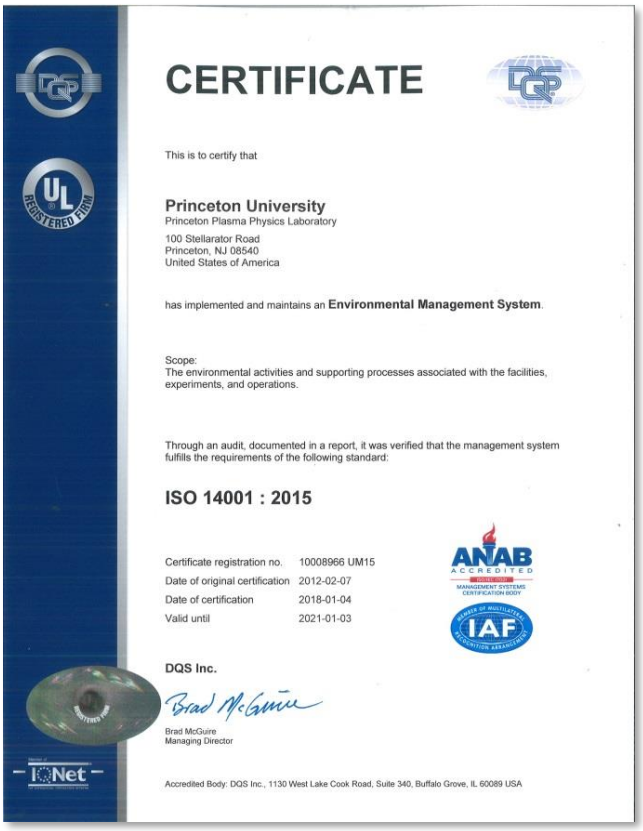
Exhibit 2.1 Applicable Environmental Laws and Regulations – 2018 Status

Regulatory Program Description	2018 Status	ASER section(s)
NJ Technical Standards for Site Remediation governs the soil/ground water assessments, remedial investigations, and clean-up actions for sites suspected of hazardous substance contamination.	PPPL began investigation the presence of chlorinated solvent chemicals in ground water in 1990. Over time, more than 20 monitoring wells were installed on-site to determine contamination source and extent of the plume. Quarterly sampling of 9 wells and 1 sump is collected, and annual sampling of 12 wells, 2 sumps and 1 surface water site is collected in March with the results reported biennially to NJDEP under a Ground Water Remedial Action Permit.	*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 states that actions are taken to protect migratory birds and conduct community outreach.	In 2018, 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/reports on environmental, safety and health data and distributes the information *via* lab-wide e-mails, PPPL news articles, at weekly Laboratory Management, DOE-Site Office, and staff meetings and at periodic ES&H Executive Board/sub-committees/Lab-wide meetings [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, & 16c]. 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 – 2018 Status

Radiation Protection	2018 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. Approval was granted 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 discussed in 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, PPPL13]	*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 prevent/detect unauthorized use or removal of nuclear material from PPPL [PPPL13].	*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 FY2018 site sustainable data that addressed the goals, targets and status of EO requirements [PPPL16c & PPPL18c].	*3*

Exhibit 2-2. ISO 14001:2015 Certificate



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

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. In January 2017, PPPL's EMS program was audited its annual audit/assessment by a third party [UL17]. The specifics of PPPL's EMS program are detailed in Chapter 3.

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 2018. A 5-gallon bucket of hydraulic oil fell off a truck and onto asphalt which ran into the adjacent dirt. The Spill was immediately cleaned, and the impacted soil was excavated and properly disposed [San19c].

2.6 Notice of Violations and Penalties

PPPL received a lab certification suspension warning letter from NJDEP Office of quality assurance for not properly completing two separate tests. Although both tests passed based on analysis results, each one had transcription errors, which does not conform to NJAC 7:18 regulations dictating reporting to be free of transcription errors.

There were no penalties or Notices of Violations (NOVs) for environmental occurrences at PPPL during 2018.

2.7 Green and Sustainable Remediation (GSR)

The requirements of E.O. 13834 and DOE's 2018 Sustainability Report and Implementation Plan advocate green and sustainable remediation practices [EO19, DOE18]. 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 prepared and able to respond. [PPPL16c]

2.9 Environmental Stewardship

During the fourth annual Earth Week site-wide clean-up, twenty-five plus employees took two-hours from their normal tasks to improve the PPPL's environment. Four teams patrolled the grounds by removing recyclables and trash that had escaped the dumpsters. In all, 480 pounds of trash, and recyclable or compostable material were collected from the site.

2.9.2 American Recycles Day at PPPL

Celebrating Earth Day at PPPL, on April 25, PPPL employees and members of the public viewed displays on sustainable renovations and projects; vendor participants were Mercer County Improvement Authority, and PPPL's subcontractors for landscaping, office and janitorial supply, cafeteria, sustainable furniture supply, and electronic waste removal companies. PPPL employees recycled 1,175 lbs. of electronics from their homes. Employees also participate in decorating their own mason jars to prevent use of disposable water cups [Dev19].

Exhibit 2-3. Earth Week 2018

In 2018, PPPL continued May "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 2018 PPPL Green Machine Awards for the following projects:

- Participating in the Lab-wide trailer cleanup imitative
- Recycling 95 percent of all construction debris on the IOI project
- Recovering and recycling old refrigerants and oil from abandoned, replaced and repaired equipment to comply with the new U.S. Environmental Protection Agency Clean Air Act regulations
- Implementing a chlorine alternative in treated water to comply with DOE regulations
- Reducing waste at colloquia and other events
- Providing staff with information and requesting proper bins to ensure paper from moves during the IOI project is recycled, resulting in nearly 23 tons of paper being recycled
- Finding a way to recycle filters from water coolers through Terracycle
- Participating in the annual Earth Day cleanup for multiple years
- Recycling, reusing and sorting PPPL's trash and reusing catering equipment, thereby contributing to more than 12 tons of food being composted
- Recycling used mineral oil totaling 9,830 gallons and diverting waste while earning the Laboratory more than $3,000:

Exhibit 2-5 Earth Week's Recycling Challenge Recipients

2.9.2 American Recycles Day at PPPL

Each year PPPL celebrated America Recycles Day (ARD, officially November 15th). In 2018, PPPL's Green Team, volunteers who promote recycling within their Departments, gave out "Get 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 Time for a Drink display, second prize for wreath made of recycled bottles, third place for her metal robot, and many others. PPPL also held its first annual inter-departmental recycling contest. This contest judged how well each department or area diverts waste from landfill based on the accuracy of the waste in each been (i.e. no recyclables in trash). It proved to be a very informative way to garner employee attention in recycling efforts.

Exhibit 2-6. America Recycles Day

ARD activities included employee electronics recycling, totaling 1,600 pounds and voluntary pledges to recycle more.

2.9.3 Environmental Awards

PPPL was awarded four environmental awards in 2018 including:

- 2018 US DOE Federal Green Buy Award
- 2018 EPEAT Purchaser Award, Gold
- 2018 US EPA Waste Wise Award Regional Award
- 2018 US EPA Federal Green Challenge Regional Award

Exhibit 2-7. 2018 US DOE Federal Green Buy Award

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 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 general public to view.

ENVIRONMENTAL MANAGEMENT SYSTEM

PPPL has made steady 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 [PPPL15a]. PPPL will continue to proactively implement sustainability practices aimed at meeting, or exceeding, the sustainability goals in its EMS, DOE Orders, and Executive Orders [EO19].

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.

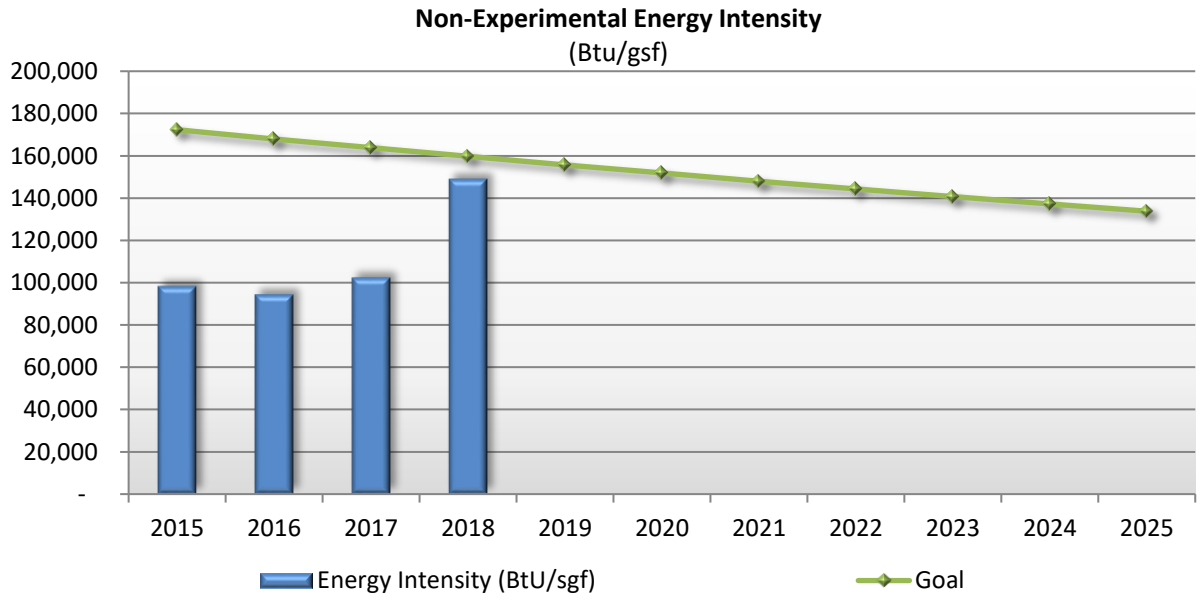
3.1 DOE Sustainability Goals

In 2018, PPPL continued to address the energy, water, and environmental management goals from previous Executive Orders and the new EO 13834, *Efficient Federal Operations*. PPPL completed its annual sustainability reporting for FY18, which summarized progress and outlined future plans to meet departmental sustainability goals under previous EO13514 and submitted the *DOE Sustainability Dashboard Report* instead of the annual *Site Sustainability Plan* detailing our energy and environmental performance [PPPL18h].

3.1.1 Energy Efficiency

In 2018, PPPL achieved an increase of 51.4% in energy intensity (British Thermal Units per gross square feet, BTU/GSF) for non-experimental energy use compared to the 2015 baseline year (see Exhibit 3-1). This value represents a substantial increase from 2015. A modified process was used to calculate energy intensity, which explains the spike [Mor19]. Construction-related energy use to support the IOI infrastructure project was a significant factor in this increase. 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 equipment upgrades.

Exhibit 3-1. Annual Non-Experimental Energy Intensity in BTU/GSF
(Red line represents annual Federal energy efficiency 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 has standardized on high-efficiency light-emitting diode (LED) lighting for all office renovations and continues to evaluate and implement other energy efficiency projects. Finally, PPPL is incorporating energy efficiency and green building practices into its long-term campus improvement plans.

3.1.2 Renewable Energy

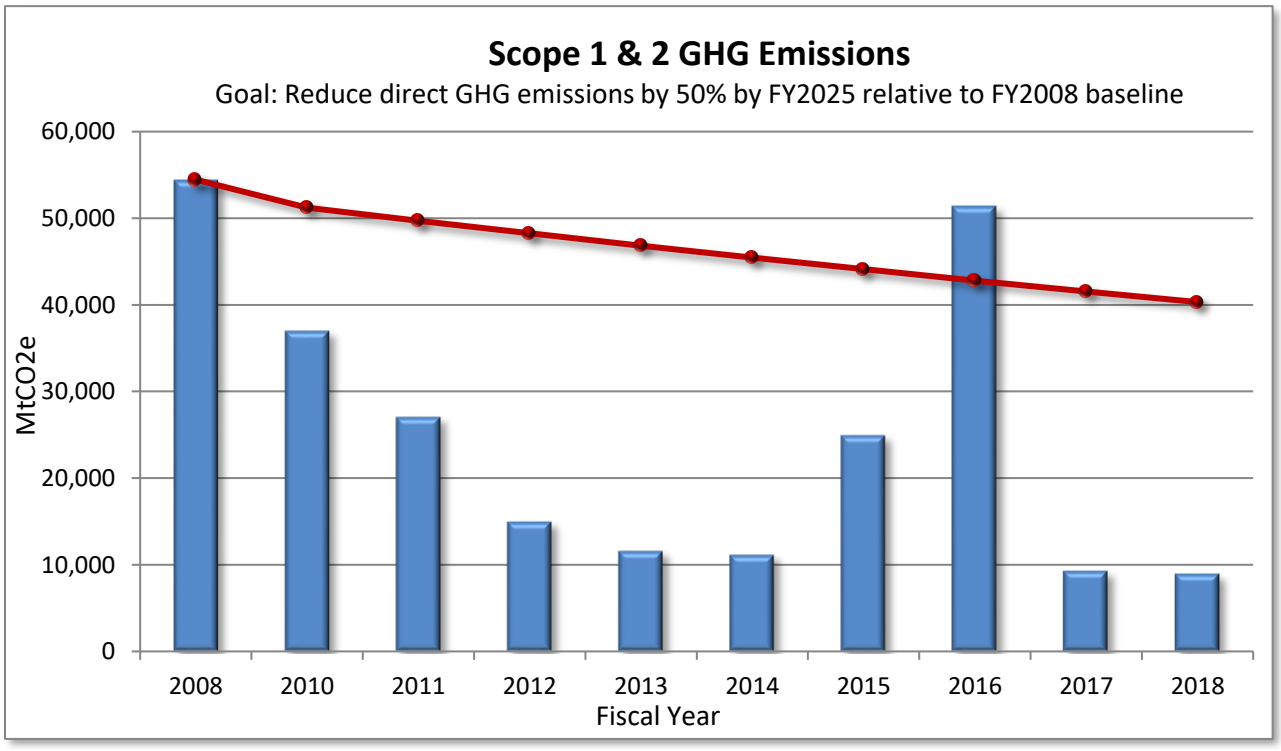
PPPL and DOE-PSO have pursued various on-site renewable energy generation projects for as much as 40% of non-experimental energy use over several years. The Energy Savings Performance Contract (ESPC) proposal received in FY08 was not successful due to the need for significant up-front investment by DOE. PSO and PPPL then 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. 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 4,000 MWh Renewable Energy Credits to offset 19.57% of total electrical energy used in FY2018.

3.1.3 Greenhouse Gas Emissions

Between 2008 and 2018, PPPL reduced its Scope 1 and 2 greenhouse gas (GHG) emissions by 80.15%. 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.

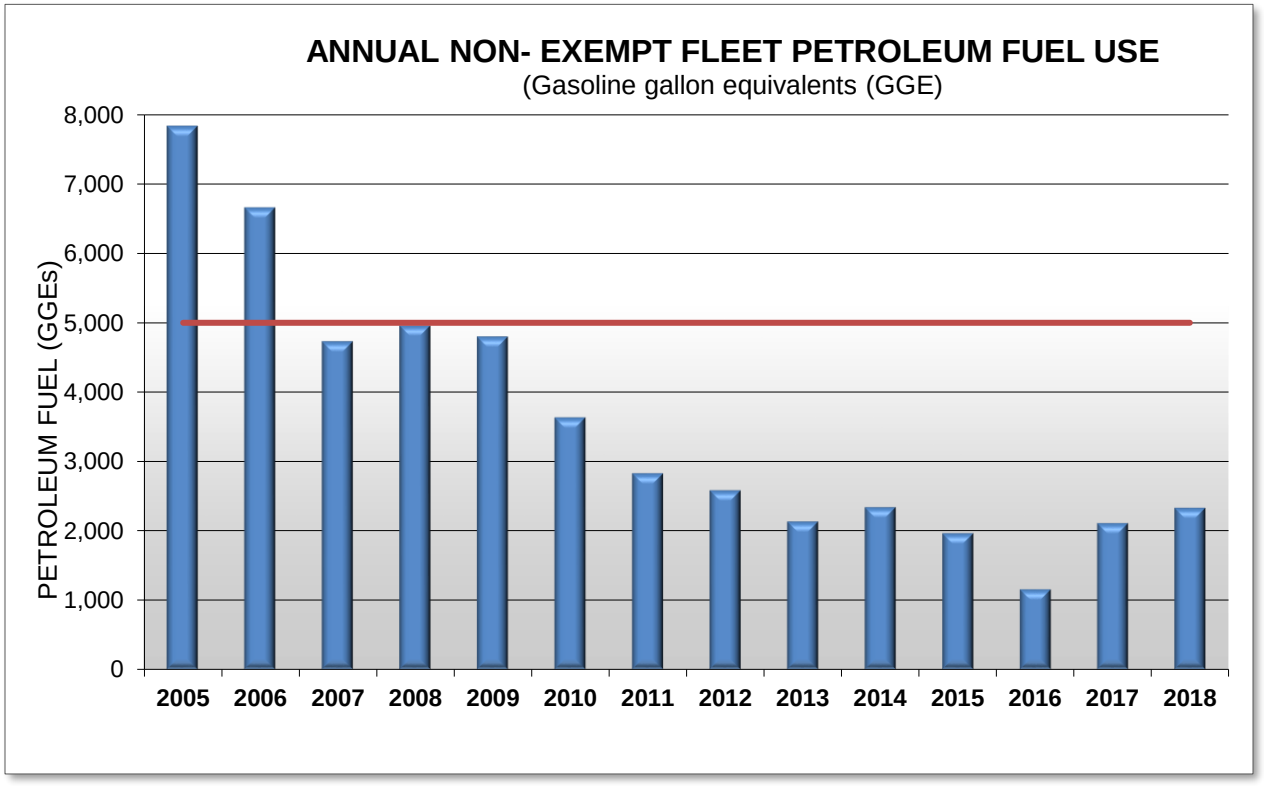
Exhibit 3-2. Summary of PPPL Scope 1 & 2 GHG Emissions between 2008 and 2018 (mtCO2e)



3.1.4 Fleet Management

In 2018, PPPL's fleet petroleum fuel use was 70.1% 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 vehicle (AFV) for light duty vehicles. 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.

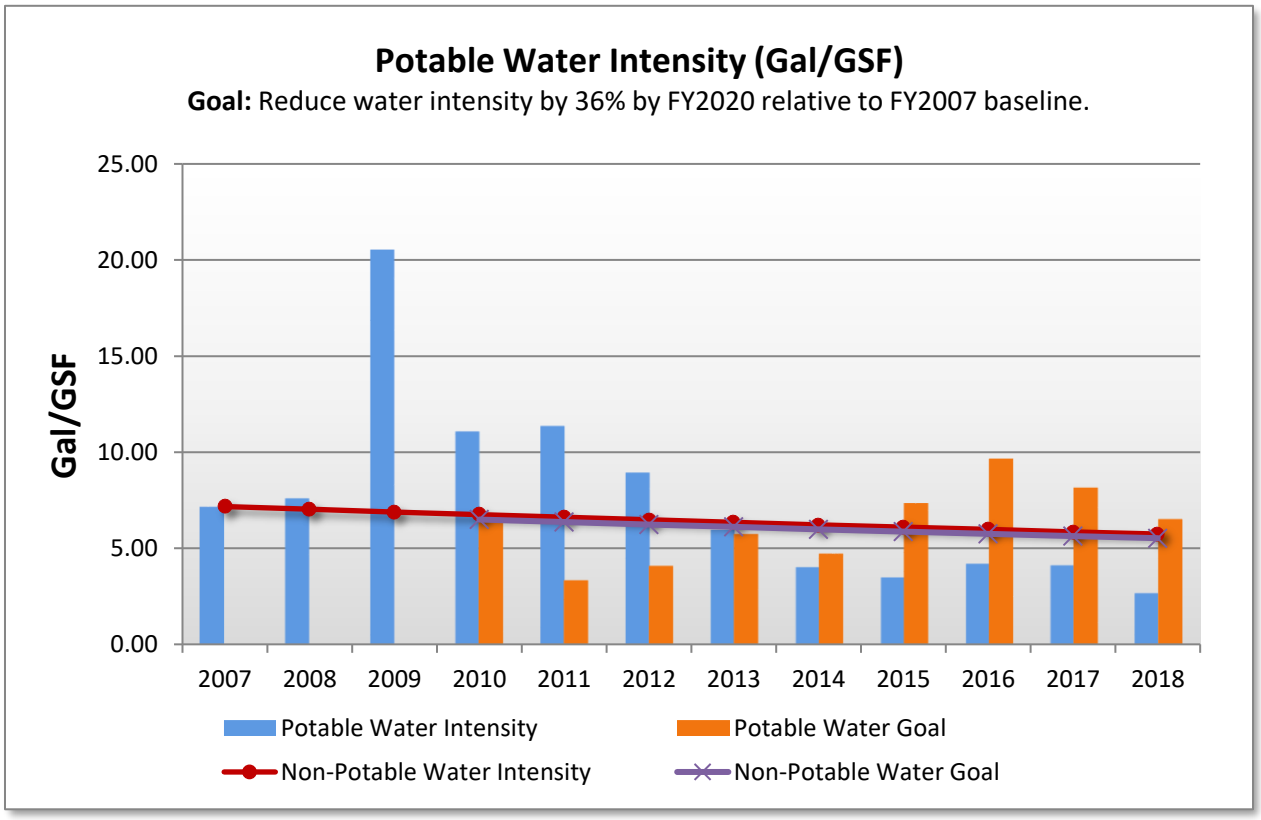
Exhibit 3-3. Annual Non-Exempt Fleet Petroleum Fuel Use between 2005 and 2018



3.1.5 Water Efficiency

PPPL has made significant progress in reducing its use of both potable and non-potable water in recent years achieving an overall water use reduction of 26.6% between 2007 and 2018 and its water intensity, measured in gallons per square foot of building space annually (see Exhibit 3-4). PPPL currently uses less than 3 gallons of potable water per square foot of building space annually, a reduction of approximately 30% since 2007. The Laboratory also continues to pursue water conservation pilot projects and to identify new opportunities for water conservation. Given the reductions already achieved additional savings may be incremental over several years, as the largest water efficiency opportunities have likely already been addressed.

Exhibit 3-4. PPPL 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 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. 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 3-5: 2018 DOE Sustainability Goal Summary Table for PPPL

SSPP Goal #	DOE Goal	Performance Status through FY 2018	Planned Actions & Contribution	Risk of Non-attainment
Goal 1: Greenhouse Gas Reduction				
1.1	50% Scope 1 & 2 GHG reduction by FY 2025 from a FY 2008 baseline (2017 target: 23%)	**EXCEEDED** Scope 1 & 2 GHGs down 77% in FY18	Renewed emphasis on SF6 management and overall energy efficiency	Low to Moderate
1.2	25% Scope 3 GHG reduction by FY 2025 from a FY 2008 baseline (2017 target: 10%)	**IN PROGRESS** Scope 3 GHGs down 10.1% in FY18.	Focus on telework and employee commuting; continue to emphasize energy efficiency and business travel.	Moderate. Ongoing international research emphasis
Goal 2: Sustainable Buildings				
2.1	25% energy intensity (Btu per gross square foot) reduction in goal-subject buildings, achieving 2.5% reductions annually, by FY 2025 from a FY 2015 baseline	**IN PROGRESS**	Continue to focus on energy efficiency and building energy performance	Moderate. Limited funding available for ECMs
2.2	EISA Section 432 energy and water evaluations	**MET**	25% of buildings will be evaluated in 2016	NA
2.3	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	Moderate. Current utility configuration doesn't allow building-level metering.

SSPP Goal #	DOE Goal	Performance Status through FY 2018	Planned Actions & Contribution	Risk of Non-attainment
2.4	At least 15% (by building count or gross square feet) of existing buildings greater than 5,000 gross square feet (GSF) are compliant with the Guiding Principles (GPs) of HPSB by FY 2025, with progress to 100% thereafter	**MET** (building footprint) **IN PROGRESS** (building count)	Plan to continue HPSB Guiding Principles on additional facilities in conjunction with facility repairs & renovations.	Moderate. LEED-Gold certification of LSB due to renewal. Limited funding available for ECMs
2.5	Efforts to increase regional and local planning coordination and involvement	**MET**	Continue to coordinate with Princeton Forrestal Center.	NA
2.6a	Net Zero Buildings: 1% of the site's existing buildings above 5,000 GSF intended to be energy, waste, or water net-zero buildings by FY 2025.	**IN PROGRESS**	Evaluating existing buildings to identify opportunities and strategies to address this goal	High. Critical infrastructure needs may not allow sufficient funds in the near term.
2.6b	Net Zero Buildings: All new building entering planning process designed to achieve energy net-zero beginning in FY2020	**IN PROGRESS**	Evaluating existing buildings to identify opportunities and strategies to address this goal	High. Critical infrastructure needs may not allow sufficient funds in the near term.
Goal 3: Clean & Renewable Energy				
3.1	"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: 10% in FY 2016-2017, working towards 25% by FY 2025	New Goal **ON TARGET**	Continue purchasing RECs and evaluate ESPC/PPA opportunities	Moderate.
3.2	"Renewable Electric Energy" requires that renewable electric energy account for not less than 10% of a total agency electricity consumption in FY16-17, working towards 30% of total agency electricity consumption by FY 2025	**MET** Purchased RECs to meet goal.	Continue purchasing RECs and evaluate ESPC/PPA opportunities	NA

SSPP Goal #	DOE Goal	Performance Status through FY 2018	Planned Actions & Contribution	Risk of Non-attainment
Goal 4: Water Use Efficiency and Management				
4.1	36% potable water intensity (Gal per gross square foot) reduction by FY 2025 from a FY 2007 baseline	**EXCEEDED** FY15 goal **MET** new goal	Continue to identify water conservation opportunities. Maintain previous savings.	NA
4.2	30% water consumption (Gal) reduction of industrial, landscaping, and agricultural (ILA) water by FY 2025 from a FY 2010 baseline	**IN PROGRESS** Exceeded goal for previous 4 years. FY15 water use exceeded goal level	Mission-critical operational use of industrial water caused FY15 increase. Will continue to seek and maximize opportunities to reduce industrial water use.	Moderate. Additional water conservation opportunities are limited.
Goal 5: Fleet Management				
5.1	20% reduction in annual petroleum consumption by FY2015 relative to a FY05 baseline; maintain 20% reduction thereafter.	**EXCEEDED**	Continue to manage fleet composition and emphasize alternative fuel use.	NA
5.2	10% increase in annual alternative fuel consumption by FY15 relative to a FY05 baseline; maintain 10% increase thereafter	**EXCEEDED**	Continue to manage fleet composition and emphasize alternative fuel use.	NA
5.3	30% reduction in fleet-wide per-mile greenhouse gas emissions reduction by FY 2025 from a FY14 baseline	New Goal. Note: FY15 fleet GHG intensity is down 49.2% from FY08.	Continue to manage fleet composition and emphasize alternative fuel use.	Low.
5.4	75% of light duty vehicle acquisitions must consist of alternative fuel vehicles (AFV)	**MET**	Continue to emphasize AFV and alternative fuel use.	NA
5.5	50% of passenger vehicle acquisitions consist of zero emission or plug-in hybrid electric vehicles by FY 2025	New Goal	Work with GSA to identify opportunities in vehicle lease program. Limited number of passenger vehicles.	NA
Goal 6: Sustainable Acquisition				
6.1	Promote sustainable acquisition and procurement to the maximum extent practicable, ensuring Bio Preferred and bio-	**MET**	Continue to integrate sustainable acquisition information into	NA

SSPP Goal #	DOE Goal	Performance Status through FY 2018	Planned Actions & Contribution	Risk of Non-attainment
	based provisions and clauses are included in 95% of applicable contracts		applicable contracting documents.	
Goal 7: Pollution Prevention & Waste Reduction				
7.1	Divert at least 50% of non-hazardous solid waste, excluding construction and demolition debris	**EXCEEDED** FY15 MSW recycling rate was 74.1%	Continue existing programs and expand as appropriate.	NA
7.2	Divert at least 50% of construction and demolition materials and debris	**EXCEEDED** FY15 C&D recycling rate was 85.8%	Continue existing programs and expand as appropriate.	NA
Goal 8: Energy Performance Contracts				
8.1	Annual targets for performance contracting to be implemented in FY 2017 and annually thereafter as part of the planning of section	**ON TARGET**	Currently investigation new ESPC/PPA opportunities.	NA
Goal 9: Electronic Stewardship				
9.1	Purchases – 95% of eligible acquisitions each year are EPEAT-registered products	**EXCEEDED**	EPEAT products specified as default	NA
9.2	Power management – 100% of eligible PCs, laptops, and monitors have power management enabled	**IN PROGRESS** for desktops & laptops **MET** for monitors	Plans to procure power management software for Macs.	Moderate.
9.3	Automatic duplexing – 100% of eligible computers and imaging equipment have automatic duplexing enabled	**IN PROGRESS**	Specify purchase of duplex-capable networked printers as older units are retired.	Moderate. De-pendent on operational funds for replacement & upgrades.
9.4	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	NA
Goal 10: Climate Change Resilience				
10.1	Update policies to incentivize planning for and addressing the impacts of climate change.	DOE GHG and climate adaptation goals are integrated into lab-wide ISO-14001 certified environmental management system (EMS).		
10.2	Update emergency response procedures/protocols for climate change, including extreme weather events.	Existing Emergency Plan includes various weather-related emergencies. Plan is tested and exercised during major weather events.		

SSPP Goal #	DOE Goal	Performance Status through FY 2018	Planned Actions & Contribution	Risk of Non-attainment
10.3	Ensure workforce protocols and policies reflect projected human health and safety impacts of climate change.	Existing ES&H directives address weather-related risks. Continue to revise and update ES&H directives as necessary.		
10.4	Ensure site/lab management demonstrates commitment to adaptation efforts through internal communications/policies.	DOE GHG and climate adaptation goals are integrated into lab-wide ISO-14001 certified environmental management system (EMS).		
10.5	Ensure that site/lab climate adaptation and resilience policies and programs reflect best available current climate change science, updated as necessary.	Continue to participate in state and regional climate change initiatives. Monitor developments in climate science and update policies and programs as necessary.		

Chapter 4

The DOE Princeton Plasma Physics Laboratory's Environmental Non-Radiological 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 stormwater, air emissions, hazardous materials and waste, and land use, 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 data.

In 2013, PPPL received the final NJPDES permit with the effective date of October 1, 2013. In February of 2008 NJDEP issued a *Final Surface Water Minor Modification Permit Action* report. Key changes to the permit included eliminating loading requirements and quarterly monitoring for DSN001, additional annual and semi-annual Waste Characterization Reports from DSN001 and DSN003 as well as addition annual [NJDEP13]. A new permit was not issued by NJDEP prior to the October 1, 2018 permit expiration date. PPPL continued to operate under the previous permit until a new one is finalized.

Changes to PPPL's reporting requirements are noted in Exhibit 4-2. Operating under the previous NJPDES permit, 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 [PPPL18g, 18i]. For CY2018, PPPL NJPDES compliance summary is presented in Exhibit 4-1 below. There were no permit exceedances in 2018. In 2018 NJDEP informed PPPL that the COD limits were to be lowered to diminutive levels. As a result, and with NJDEPs support, PPPL decided to use Peracetic Acid (PAA) as the primary biocide in canal water system.

Exhibit 4-1. 2018 NJPDES Permitted Compliance NJPDES permit NJ0023922

Outfall DSN001							
Parameter (1)	**Frequency**	**Permit Limit**	**# Permit Excee-dance**	**# Samples Taken (4)**	**# Compliant Samples**	**Percent Compliance**	**Dates Exceeded**
Chemical Oxygen Demand (COD), mg/L	Monthly	50.0	0	16	16	100%	-
Chlorine Produced Oxidants (CPO), mg/L	Monthly	0.1	0	24	24	100%	-
Flow, MGD	Monthly	-	0	12	12	100%	-
Petroleum Hydrocarbons (TPHC), mg/L	Monthly	10.0 Avg. 15.0 Max.	0	16	16	100%	--
pH, S. U.	Monthly	>6.0; <9.0	0	24	24	100%	-
Phosphorus, total mg/L (2	Monthly	-	0	16	16	100%	-
Temperature º C	Monthly	30.0	0	24	24	100%	-
Tetrachloroethylene (PCE), µg/L (3)	Monthly	0.703	0	16	16	100%	-
Total Suspended Solids (TSS), mg/L	Monthly	50.0	0	16	16	100%	-

Outfall DSN003							
Chlorine Produced Oxidants (CPO), mg/L	Monthly	>0.1	0	15	15	100%	-
Flow, GPD	Monthly	-	0	12	12	100%	-
Petroleum Hydro-carbons (TPHC), mg/L	Monthly	10.0 Avg. 15.0 Max	0	12	12	100%	-
pH, S. U.	Monthly	>6.0; <9.0	0	12	12	100%	-
Phosphorus, total mg/L (2)	Monthly	-	0	12	12	100%	-
Total Suspended Solids (TSS), mg/L	Quarterly	50.0	0	12	12	100%	-

Intake C1							
Total Suspended Solids (TSS), mg/L	Quarterly	-	0	12	12	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 2018

Parameter	Location	Frequency/Type	Last Completed
Discharge Monitoring Report (DMR)	DSN001, DSN003, C1	Monthly	Monthly 2018
Acute Whole Effluent Toxicity	DSN003	4 – 4.5 Years per Permit	November 2017
Chronic Toxicity (% Effluent) IC25 7 Day *Ceriodaphnia dubia* & *Pimephales promelas*	DSN001	Annual	April 2018
Waste Characterization Report (WCR) – Complete WCR	DSN001	Annual	April 2018
Waste Characterization Report (WCR) – Metals, SVOC, Chloroform	DSN001	Semi Annual	April & November 2018
Waste Characterization Report (WCR) - Metals	DSN003	Annual	December 2018
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. 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 [PPPL18j].

C. Chronic Whole Effluent Toxicity Study

Annual Chronic Whole Effluent Toxicity testing for DSN001 was completed on April 6, 2018 (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, PPPL18f].

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 in April 4, 2018 and November 7, 2018. PPPL completed DSN001 Annual WCR was completed on April 4, 2018

[PPPL18g]. DSN003 Annual WCR was completed annually on May 3, 2018 [PPPL18i]. 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 and is permitted to operate Lined Surface Impoundment (LSI) Program Interest (P.I.) ID#:47029 dated February 26, 2009. The LSI Permit operates on a 5-year permit cycle, expiring on February 28, 2019. PPPL will operate under the previous permit until NJDEP issues a new permit. 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 94,314,326 gallons annually or 258,395 gallons per day of water that was discharged from the retention basin in 2018 [Hug19a].

Exhibit 4-3. PPPL Retention Basin

Exhibit 4-4. Flow Sensor and Discharge Valve

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 in concurrence with PPPL's basin 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 2018:

- Sump pump maintained, and oil sensors replaced and calibrated.
- BAS delivered flow meter data electronically.

- Oil detector controller was equipped with a new main board.
- Two oil detectors were 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 degradation 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 2.66 million gallons in 2018 (Exhibits 4-4 & 4-5) [Con19]. 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. [Con19]

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

Exhibit 4-6. PPPL Non-Potable Water Use From Delaware & Raritan Canal [Hug19a]

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

B. Process (Non-potable) Water

Delaware & Raritan (D&R) Canal non-potable water 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 5.61

million gallons of non-potable water from the D&R Canal in 2018 (Exhibit 4-6) [Hug19a]. A significant decrease in D&R Canal water usage in CY 2018 can be credited to fixing a leak in the chilled water system piping in August 2017.

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 pump. 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 2018, PPPL estimated a total annual sanitary sewage discharge of 2.66 million gallons to the South Brunswick sewerage treatment plant [Con19].

4.2 Non-Radiological Waste Programs

4.2.1 Hazardous Waste Programs

A. Toxic Substance Control Act (TSCA)

In CY2018, PPPL shipped 535 pounds of PCB waste. All contents were recycled or incinerated in a permitted facility as TSCA Hazardous Waste [San19a].

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 CY2018. A description of Resource Conservation and Recovery Act (RCRA) compliance is found in Exhibit 2-1 of this report [San19a].

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 that 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 4-6. PPPL's waste shipments can include hazardous, universal, non-hazardous and TSCA regulated waste. PPPL's avoids landfilling environmental waste through recycling and incinerating, showing PPPL's commitment to sustainability. PPPL's only hazardous/TSCA waste that is landfilled is asbestos waste. In 2018 PPPL had one 40 cubic yard dumpster. PPPL also had one radioactive waste shipment totaling 34.08 pounds that was sent to a burial facility [San19a].

Exhibit 4-7. 2018 Waste Shipments [San19a]

Recycled Hazardous Waste	Pounds	Kilograms
Recycled	18,989	8,632
Incinerated	19,660	8,936
Landfilled	*	*
Burial	34	15
Treated	-	-
Total Waste	**38,683**	**17,583**

*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 [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 has not released any CERCLA-regulated hazardous substances, no "Continuous Release Reports" have been filed with EPA in CY 2018 [Sla19].

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 EPA Region II. The modified Tier I form includes SARA Title III and NJDEP-specific reporting requirements. PPPL submitted the SARA Title III Report to NJDEP prior to the March 1st deadline [PPPL18a]. No changes were reported in PPPL's 2018 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 2018 [Sla19].

Exhibit 4-8. 2018 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. 2018 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 less than three gallons of hydraulic oil in CY2018. Due to New Jersey's no *de minimus* thresholds, all oil released to unpaved surfaces must be reported. PPPL removed the impacted dirt and tests sit to ensure adequate cleanup of petroleum hydrocarbons and any other chemicals [San19b].

4.3.3 Pollution Prevention Program

In 2018, 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 2018, PPPL diverted 69.6% of the municipal solid waste through single stream recycling and organic waste composting programs. The DOE goal of 50% recycle versus disposal rate was met and accomplished by active participation of Laboratory employees. PPPL's FY 2018 rate for recycling of construction materials including wood, concrete, and metal was 88.8% by weight [Kin19a].

In September 2010, PPPL initiated the collection and recycling of food waste from the cafeteria kitchen and the trash bins located in the cafeteria and select locations around the laboratory. In FY 2018, PPPL composted 10.6 tons of food waste. A change in vendor material acceptable has 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. [Kin19a].

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 2018 (Exhibit 4-10 & Appendix Table 8). With the installation of digital controls and high-efficiency, lower nitrogen oxide (NO_x) burners, the NO_x, volatile organic compounds (VOCs), particulates, sulfur dioxide (SO_2), and carbon monoxide (CO) emissions are being further reduced [Nem19].

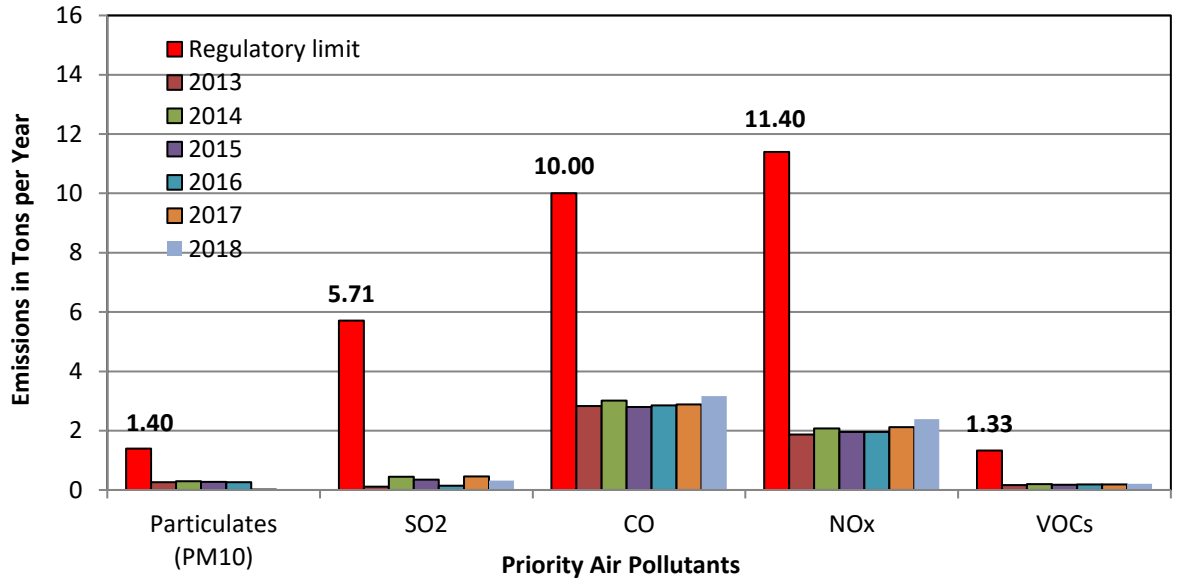
In late 2017 the NJDEP replaced GP-003 permits for woodworking equipment like dust collectors to GP-016A permits. The new construction permits exempted "Single or multiple pieces of manufacturing and materials handling equipment each with a potential to emit (PTE) less than the reporting threshold for 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- 2018 vs. Regulatory Limits [Hug19e]

Criteria Pollutants in Tons per Year



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. 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 present on all future site development drawings [PPPL15b].

4.5.2. Soil Erosion and Landscaping

In 2017, PPPL obtained a Soil Erosion Permit obtained through the Freehold Soil Conservation District. Permit No. 2017-0530 for the demolition of Modular Building #6 (MOD VI) was issued on 8/18/2017 and it was closed out in 2018 when the project was completed [PPPL17]. PPPL also maintains soil erosion and sediment control engineering standard for projects that have soil disturbance below the permit threshold of 5,000 square feet, above 5,000 square feet, and above 1 acre. [PPPL14a].

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 2018, PPPL's Facilities 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 [Kin19b].

Exhibit 4-12. 2018 Fertilizer and Herbicide

Type of Material	Name of Material	Registered EPA No.	Application Qty
Herbicide	Quali-pro Prodiamine 4L	66222-230	96.71 Oz.
Herbicide	Roundup ProMax	524-579	568.13 Oz.
Insecticide	Up-star Gold	70506-24	10 gallons
Insecticide	The End Wasp, Bee Killer	11694-109	As needed
Fertilizer	None	-	-

4.5.4 Stormwater Pollution Prevention

PPPL's Stormwater Pollution Prevention Plan (SWPPP) was revised in 2015 to provide guidance to reduce the impact of PPPL's operations on stormwater quality [PPPL15c]. 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 2018 performance with respect to worker safety is noted in Exhibit 4-12 [Lev19a].

Exhibit 4-13. 2018 PPPL's Safety Performance

Total OSHA recordable case rate[1]	Days away, restricted transferred (DART) case rate[1]
0.99	0.20
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 Princeton Plasma Physics Laboratory'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 2018 was 3.39E-03 mrem compared to 310 mrem annual dose from natural sources.

ENVIRONMENTAL RADIOLOGICAL PROGRAM INFORMATION

5.1 Radiological Emissions and Doses

For 2018, 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 3.39E-03 milli-radiation equivalent man (mrem), far below the annual limit of 10 mrem per year [Lev19b, Hug19].

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. From all operational sources of radiation, the ALARA goal for maximum individual occupational exposure was less than 100 mrem per year (1.0 mSv/year) above natural background at PPPL. 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 2018 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 – 4.35E+00 (1.61E+11) HT - 1.48E+00 (5.49E+10)	3.18E-03 (3.18E-05)	93.81	1.28E-01 (1.28E-03)
Tritium (water)	LEC tank	HTO - 1.89E-03 (6.99E+07)	3.78E-05 (3.78E-07)	1.12	5.18E-05 (5.18E-07)
Tritium Deposition (water)	Surface Ground	90.1 pCi/L (Multiple) 135 pCi/L (Multiple)	1.69E-04 (1.69E-06)	5.00	2.32E-04 (2.32E-06)
Direct/Scattered neutron & Gamma radiation	NSTX	N/A[3] neutrons	N/A	0	N/A
Argon-41 (Air)	NSTX	N/A[3]	N/A	0	N/A
Total [Lev19b,Hug19]			**3.39E-03 (3.39E-05)**	100	1.29E-01 (1.29E-03)

Bq = Becquerel 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 2018, therefore it did not generate any neutrons or Argon-41.

Exhibit 5-2. Radiological Atmospheric Releases for Calendar Year 2018 (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
5.83E+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 reactor was down for repairs for all of 2018 and did not contribute to the dose totals. The repairs include production of new magnetic coils and additional upgrades. This will result in increased neutron production when NSTX-U resumes scheduled operations.

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 system 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 2018 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 2018 was 0.0019 Curies, far less than the allowable 1.0-Curie per year limit. In Appendix A, Table 7, the tritium activity is reported; the gross beta activity ranges from 1,350 to 13,900pCi/L.

Exhibit 5-3. Annual Releases to Sanitary System from Liquid Effluent Collection Tanks 2008-2018

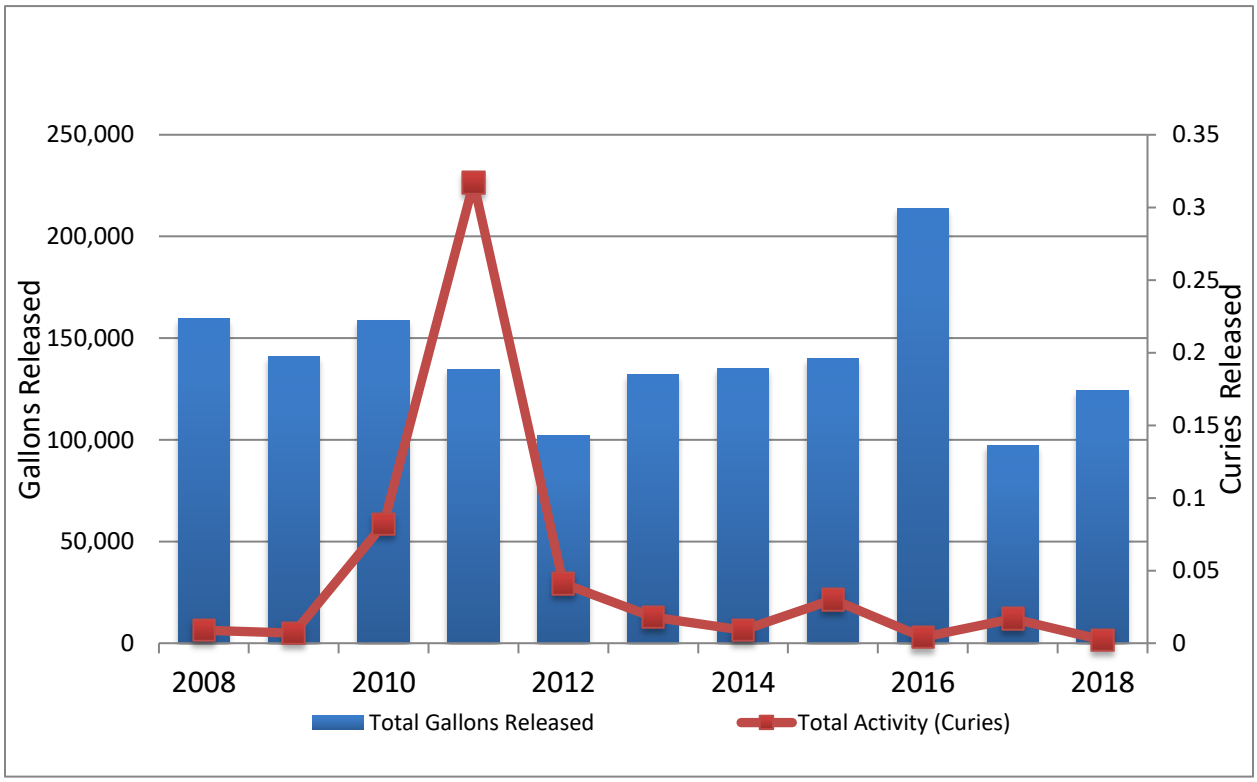


Exhibit 5-4. Total Annual Releases (LEC tanks) to Sanitary System

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

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 E+9)
2009	No Shipment	No Shipment
2010	13.3	6.30270 (2.332 E+11)
2011	15.6	0.0351 (1.297 E+9)
2012	No shipment	No shipment
2013	34.9	0.357 (1.32 E+10)
2014	17.1	0.0082 (3.03 E+8)
2015	No shipment	No shipment
2016	No shipment	No shipment
2017	17.80	1.23E+01 (4.57 E+11)
2018	0.076	1.25E-02 (4.63 E+08)

5.1.3 Radioactive Waste

In 2018, a small amount of low-level radioactive wastes (LLW) were stored on-site in the Radioactive Waste Handling Facility (RWHF). There was not a sufficient quantity of LLW to justify the transportation expense for disposal (Exhibit 5-4). PPPL shipped 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 periodically to ensure compliance with 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 sampler (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 3.18E-03 mrem/year (3.18E-05 mSv/year) in 2018.

5.2 Release of Property Containing Residual Radioactive Material

Release of property containing residual radioactivity material is performed in accordance with Appendix D of 10CFR835. 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 person 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 value used for this purpose is 1,000 dpm/100 cm2 . In addition, material is not released if radiation levels above background are detected when performing activation analysis per PPPL approved procedure. During 2018, PPPL did not release any property containing radioactive material for recycle or reuse.

5.3 Protection of Biota

The highest measured concentrations of tritium in ground water in 2018, was 135 pCi/L in both sumps, in July (Appendix Table 4) and for surface water 90.1 pCi/L at C1, E1, and DSN-003 (Appendix Table 5). Most of the other 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" [Lev19b, DOE11b & 10CFR835]. Because of these low concentrations and potential doses, PPPL does not conduct direct biota monitoring.

5.4 Unplanned Radiological Releases

There were no unplanned radiological releases in 2018.

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) have been analyzed for tritium (Appendix Table 5).

In March 2018, at DSN003, the tritium concentration in water was measured at 135 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 weekly precipitation amounts for 2018 are shown on Appendix Table 2. Based on the average rainfall, a comparison of dry or wet years shows that 2018 was well above the average rainfall total at 65.01 inches, which exceeded New Jersey's expected 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 in both sumps at 135 pCi/L (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, formerly Elizabethtown 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 has included gamma spectroscopy and tritium-concentration determination. In 2018, tritium concentration at this location was below the lower limit of detection (Appendix Table 5).

5.5.2 Foodstuffs, Soil, and Vegetation

There were no foodstuffs, soil, or vegetation samples gathered for analysis in 2018. In 1996, the Health Physics (HP) Manager reviewed the requirement for soil/biota sampling. At that time, a decision was made to discontinue the sampling program. Tritium was not detected in almost all samples 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 Princeton Plasma Physics Laboratory'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 supporting 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 industrial parks, housing developments, apartment complexes and shopping 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

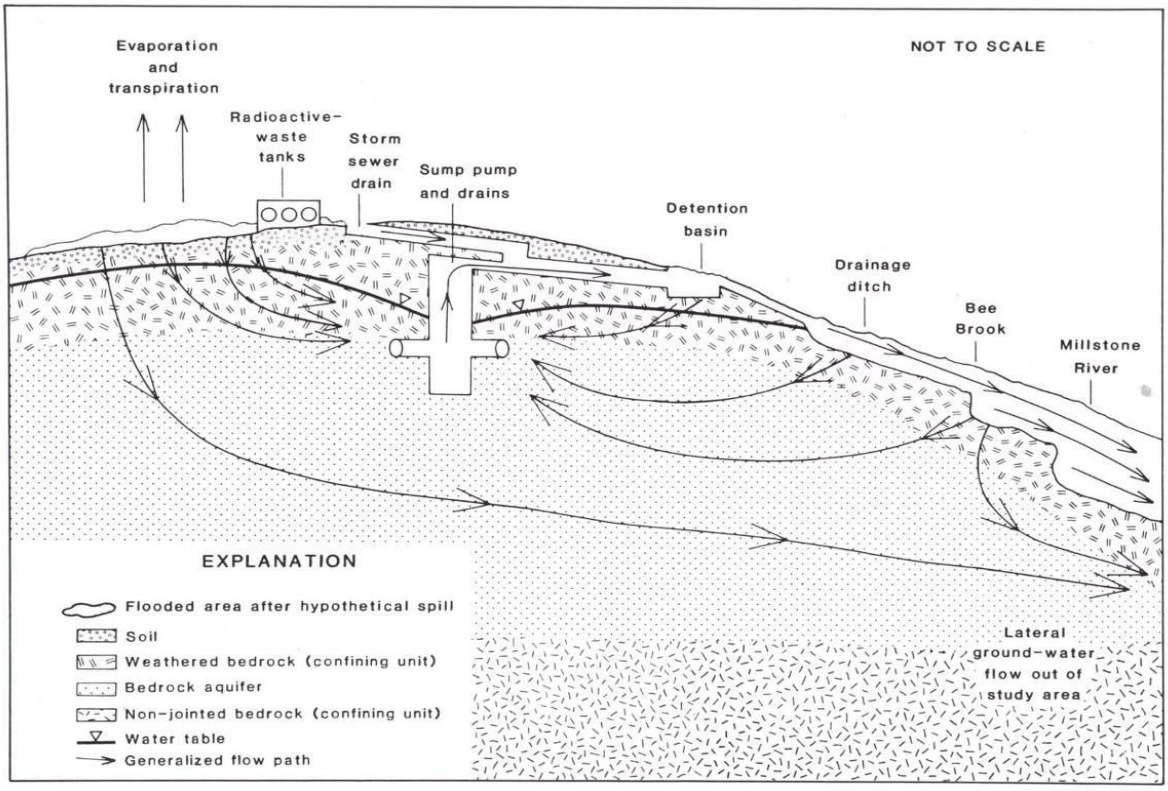
All PPPL's storm water runoff flows to Bee Brook, either directly *via* the retention basin outfall (DSN001) or along the western swale to the wetlands south of the site. Approximately 55% [Hug19f] of the site's total area is covered by impervious surfaces – buildings, roadways and parking lots, and other structures.

PPPL's 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 biota. 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 [PPPL15c & SE96].

Also, 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 has 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 shallow 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 new state-mandated 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 has modified it 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

Ranges 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, trichloroethylene (PCE, 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 has been 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 1,4 dioxane is present in ground water south of the CAS/RESA building. All results have been below the NJDEP Ground Water Quality Standard of 0.4 ug/L, except for monitoring well MW-19S. The maximum 1,4-dioxane concentration detected was 0.693 ug/L. Typically the highest chlorinated contaminant concentrations are detected during the September sampling event, which is consistent with the 1,4 dioxane data. Based on the existing data PPPL will continue 1,4-dioxane sampling in 2018. In addition to the wells sampled previously, PPPL will be analyzing 1,4-dioxane in monitoring wells MW-5S and MW-5I to confirm horizontal delineation to the north.

Foundation de-watering 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 Set-up

Exhibit 6-6. Groundwater Monitoring Parameters

Frequency	Analytical Parameter	Analytical Method
Monthly	Tritium	
Quarterly	March, June 2018: Volatile Organic Compounds (VOC) + Library Search	EPA-624
	Sept., December 2018: Chlorinated Volatile	
Quarterly	Organics (VOCs)	SW 846/8270 D
Annual	1,4-Dioxane	EPA-300.0
Annual	Nitrate & Nitrite	EPA-300.0
Annual	Chloride	EPA-300.0
Annual	Sulfate	SM 2320B
Annual	Alkalinity	EPA-200.8 Rev. 5
Annual	Manganese	SM20/3500FEB
Annual	Ferrous Iron (Fe^{+2})	RSK-175
Annual	Dissolved Methane	SM 5310C
Annual	Sulfide	EPA 906.0
	Total Organic Carbon (TOC)	

6.5.3 Ground Water Remedial Action

Following a site-wide RI/RAA study and remedy selection process, PPPL prepared and submitted a Remedial Action Work Plan (RAWP) outlining continual operation of the ground water extraction system and a long-term monitoring program [PPPL00]. The RAWP was submitted to NJDEP in May 2000, which was implemented until the Ground Water Remedial Action permit was issued in August 2013 [HLA97, HLA98, Sh10-03] and revised 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. The CEA was recertified in 2017, with submittal of a Biennial Remedial Action and Ground Water Classification Exception Area Recertification Report.

Long-term ground water monitoring confirms the following conditions:

- Examination 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 2018 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 2018.
- 1,4 Dioxane sampled at all wells quarterly.
- *Remedial Action Biennial Certification for Ground Water* submitted to NJDEP in 2017; the next report is due in 2019.
- 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).

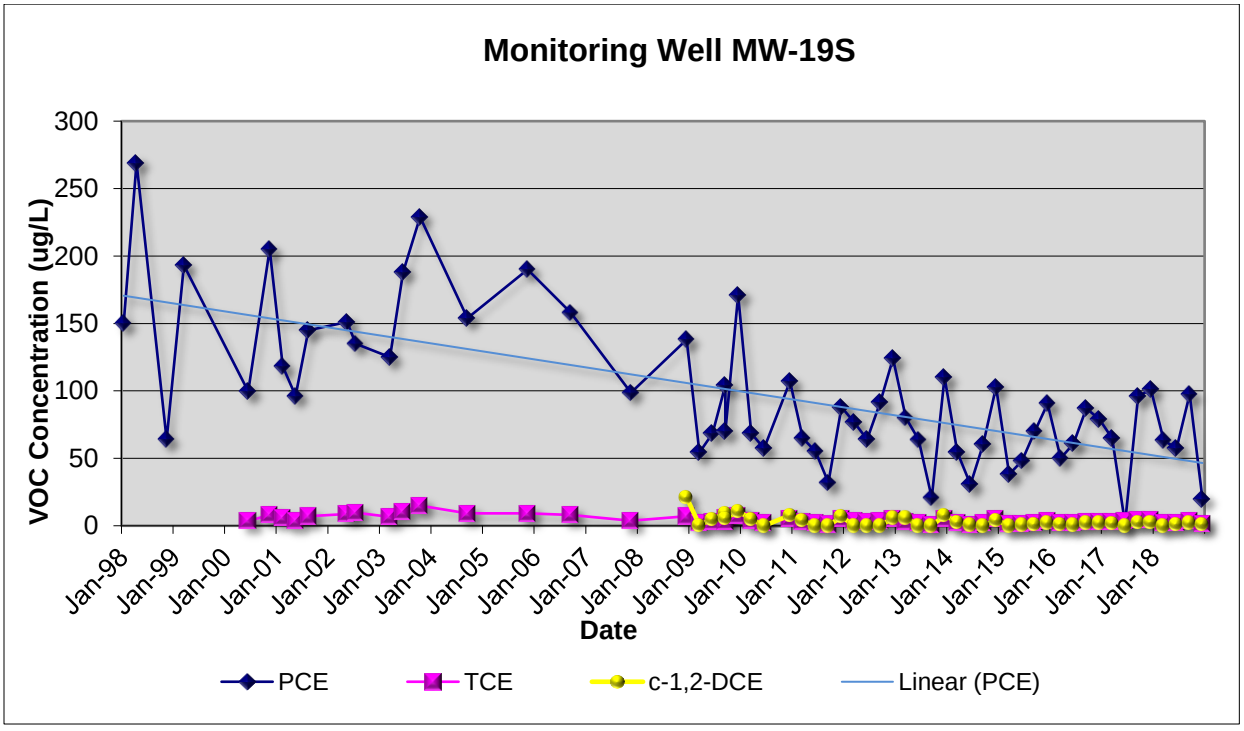
Natural attenuation processes are active as evidenced by presence of degradation compounds in ground water down gradient of source area (Appendix Tables 18-21). PCE is sequentially degraded into trichloroethylene (TCE) and cis-1,2-dichloroethlyene (c-1,2-DCE) (Exhibit 6-7). The presence of c-1,2-DCE, dissolved methane, reduced dissolved oxygen levels and negative oxidation-reduction potential (redox) values provide definitive evidence of on-going biological degradation of chlorinated ethenes [PPPL18, Sh10-13].

Exhibit 6-7. Typical PCE Degradation Pathway

Typical Degradation Pathway of PCE to Ethene

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 results are generally lower.

Exhibit 6-8. PCE Concentration vs. Time at MW-19S (1998-2018)



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 2018, analyses of environmental samples for "analyze-immediately" non-radiological parameters were conducted by PPPL's on-site analytical laboratory from January to November (Exhibits 7-1 & 7-2). In December PPPL learned its laboratory certification was going to be suspended due to transcription errors on its NJDEP mandated proficiency test (PT), that were conducted in April and November. In December, SGS/Accutest Laboratories, NJDEP ID Number 12129, performed the "analyze-immediately" non-radiological parameters on-site. PPPL will submit a request to reinstate the certification once the six-month suspension has ended.

Exhibit 7-1. PEARL Chlorine Standard Check for Accuracy

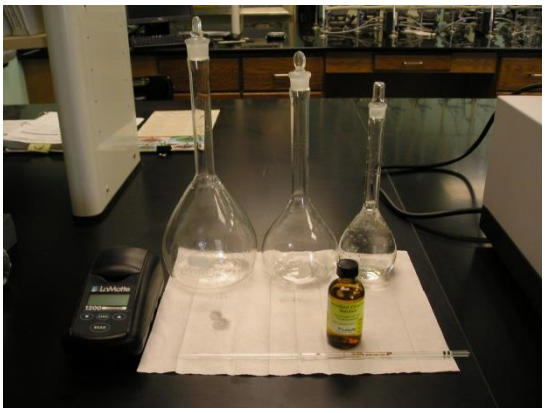


Exhibit 7-2. Distilling Samples for Tritium Analysis Performed at PEARL

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 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 continued in a National Institute for Standards and Technology's (NIST) National Voluntary Laboratory Accreditation Program (NVLAP) accredited radiochemistry quality control testing program in 2018. 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. 2017 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 (QC) and proficiency test (PT) 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. Results are supplied to PPPL and NJDEP to confirm a laboratories' ability to correctly analyze those parameters being tested [PPPL18e].

In Appendix Table 24, the non-radiological proficiency testing (PT) results show that all PEARL's April and November 2018 results were in the acceptable range for pH and residual chlorine.

Exhibit 7-4. 2017 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

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.

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 Aquiatics was also used as a subcontractor laboratory for acute and chronic toxicity, NJDEP Laboratory is PA682.

PPPL's groundwater 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 [Cum19].

In 2018, PPPL participated in the following environmental internal audits:

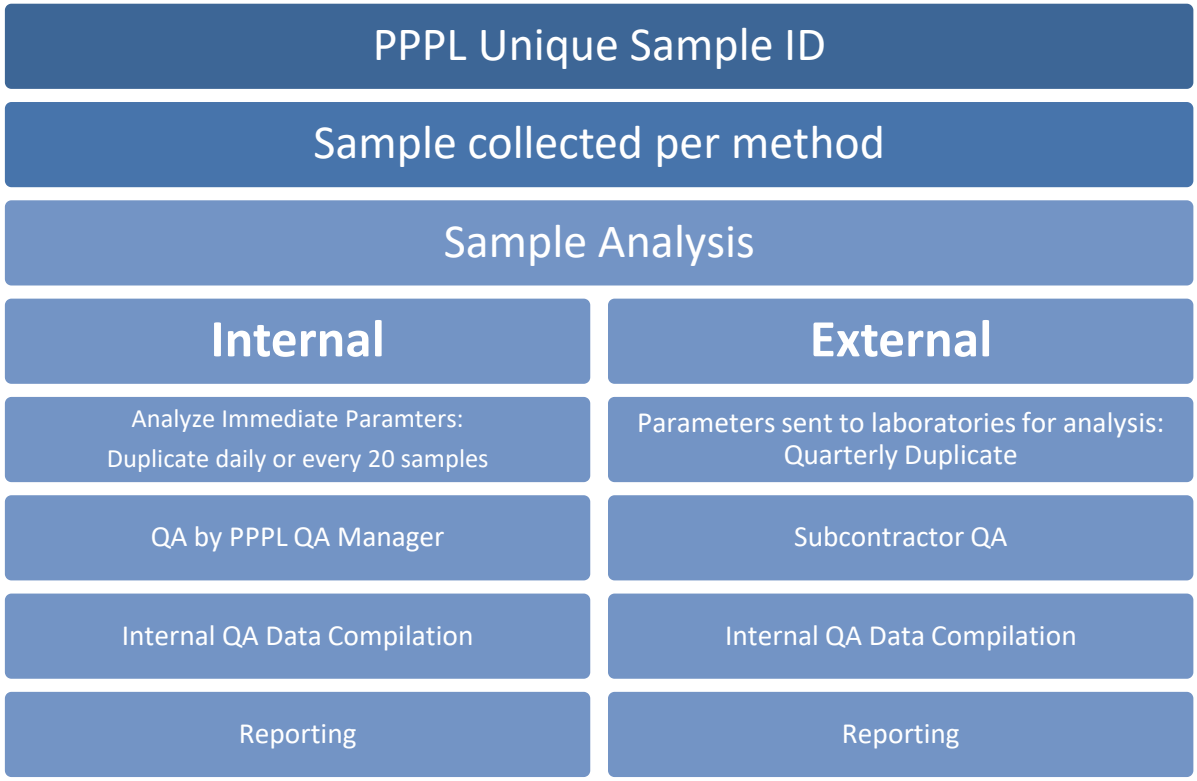
- Radioactive Waste Management Surveillance Audit

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-certified thermometers are replaced with new NIST-certified 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 Assurance 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 lab calibration log and reported to the PEARL 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

Chemical inventories are performed quarterly to insure proper storage, expiration and quantity checks. Chemical name, stock number, lot number, date received, date opened and expiration date are all checked to ensure chemical quality for calibration. Expired chemicals are removed from service and processed through our lab wide Hazardous Waste ID tag 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 [Cum19].

One external audits/inspections were performed for Environmental QA/QC in 2018:

- Re-certification Audit of Environmental Management System (EMS) UL-DQS, ISO14001:2015

Chapter 8

REFERENCES

10CFR835 Title 10, Code of Federal Register, Part 835, *Occupational Radiation Protection, Appendix D – Surface Radioactivity Values.*

40CFR141 Title 40, Code of Federal Register, Part 141.66, *National Primary Drinking Water Regulations, Maximum contaminant levels for radionuclides*.

Am98 Amy S. Greene Environmental Consultants, Inc., 1998, *Baseline Ecological Evaluation Princeton Plasma Physics Laboratory, Plainsboro Township, Middlesex County, New Jersey*.

Be87b Bentz, L. K., and Bender, D. S., 1987, *Socioeconomic Information, Plainsboro Area, New Jersey: Supplementary Documentation for an Environmental Assessment for the CIT at PPPL*, EGG-EP-7752, INEL, Idaho Falls, Idaho.

Cum19 Cummings, C., 2019, *2018 PPPL Audits*, personal communications.

Con19 Conklin, J., 2019, *2018 Water Data for Potable and Non-Potable Sources and Sanitary Wastes,* personal communication.

Dev19 DeVoe, J., 2019, *2018 American Recycles Day and Earth Week 2018 data*, personal communication.

DOE01 Department of Energy Order 435.1, 2001, *Radioactive Waste Management*.

DOE11a Department of Energy Order 436.1, 2011, *Department Sustainability*.

DOE11b Department of Energy Order 458.1, 2011, *Radiation Protection of the Public and the Environment*.

DOE11c Department of Energy Order 231.1B, *Environment, Safety, and Health Reporting.*

DOE15 Department of Energy, 2015, *Strategic Sustainability Performance Plan.*

DOE16 Department of Energy, 2016, Princeton Site Office, *NEPA Program Assessment*.

Dy93 Dynamac Corporation, August 1993, *CERCLA Inventory Report*, prepared for Princeton Plasma Physics Laboratory.

En87 Envirosphere Company, 1987, *Ecological Survey of Compact Ignition Tokamak Site and Surroundings at Princeton University's Forrestal Campus*, Envirosphere Company, Division of Ebasco, Report to INEL for the CIT.

EO19 Executive Order 13834, 2019, *Efficient Federal Operations.*

EPA83 Environmental Protection Agency, Office of Research and Development, Environmental Monitoring and Support, March 1983, *Methods for Chemical Analysis of Water and Waste*, EPA 600-U-79-020.

EPA99 Environmental Protection Agency, Office of Water, June 1999, *Methods and Guidance for Analysis of Water*, EPA 821-C-99-004.

Gr77 Grossman, J. W., 1977, *Archaeological and Historical Survey of the Proposed Tokamak Fusion Test Reactor*, Rutgers University.

HLA 97 Harding Lawson Associates, March 28, 1997, *Remedial Investigation/Remedial Action Report Phase I and II, Princeton University Plasma Physics Laboratory, James Forrestal Campus, Plainsboro, New Jersey*.

HLA98 Harding Lawson Associates, September 25, 1998, Remedial Investigation/Remedial Action Report Addendum, Phase 3 Activities, Princeton Plasma Physics Laboratory, James Forrestal Campus, Plainsboro, New Jersey, 17 volumes.

Hug19 Hughes, M., 2019, *2018 Effective Dose Equivalent Calculations for PPPL Operations*, personal communication.

Hug19a Hughes, M., 2019, *2018 Total Flow Discharged from DSN001, Basin Outfall,* personal communication.

Hug19c Hughes, M., 2019, *2018 Ozone-Depleting Substances Inventory Update*, personal communication.

Hug19e Hughes, M., 2019, *2018 PPPL Boiler Emission Calculations for Criteria Air Pollutants,* personal communication.

Hug19f Hughes, M., 2019, *2018 Impervious vs. Pervius Surfaces Calculations*, personal communication.

ISO15 International Standards Organization, 2015, ISO14001-15, *Environmental Management Systems (EMS).*

Jo74 Jordan, C. F., Stewart, M., and Kline, J., 1974, *Tritium Movement in Soils: The Importance of Exchange and High Initial Dispersion*, Health Physics 27: 37-43.

Kin19a King, M., 2019, *2018 Solid Waste Data*, worksheet.

Kin19b King, M., 2019, *2018 PPPL Fertilizer, Pesticide, and Herbicide Report*, personal communication.

Lev19a Levine, J., 2019, *2018 Safety Statistics*, personal communication.

Lev19b Levine, J., 2019, *2018 Tritium Environmental Data and D Site Stack Tritium Release Data*, personal communication.

Lew87 Lewis, J. C. and Spitz, F. J., 1987, *Hydrogeology, Ground-Water Quality, and The Possible Effects of a Hypothetical Radioactive-Water Spill, Plainsboro Township, New Jersey*,

U.S. Geological Survey Water-Resources Investigations Report 87-4092, West Trenton, NJ.

Mor19 Morrison, K., 2019, *2018 Energy Intensity Calculation*, personal communication.

Mu77 Murphy, C. E., Jr., Watts, J. R., and Corey, J. C., 1977, *Environmental Tritium Transport from Atmospheric Release of Molecular Tritium*, Health Physics 33:325-331.

Mu82 Murphy, C. E., Jr., Sweet, C. W., and Fallon, R. D., 1982, *Tritium Transport Around Nuclear Facilities*, Nuclear Safety 23:667-685.

Mu90 Murphy, C. E., Jr., 1990, *The Transport, Dispersion, and Cycling of Tritium in the Environment*, Savannah River Site Report, WSRC-RP-90-462, UC702, 70 pp.

NCRP09 National Council on Radiation Protection and Measurements, 2009, *Ionizing Radiation Exposure of the Population of the United States*.

Nem19 Nemeth, J. 2019, *2018 Boiler Stack Efficiency Test Results* and *Subpart JJJJJJ form submittal*.

NJB97 NJ Breeding Bird Atlas Report, 1997, *A New Jersey Breeding Bird Atlas Data Base Inquiry for Plainsboro Township, Middlesex County, New Jersey,* Cape May Bird Observatory (Letter), January 13, 1998.

NJDEP84 NJ Department of Environmental Protection, December 1984, *Bee Brook - Delineation of Floodway and Flood Hazard Area*.

NJDEP97 New Jersey Department of Environmental Protection, Natural Heritage Program, 1997, *A Natural Heritage Data Base Inquiry for Plainsboro Township, Middlesex County, New Jersey*, NJDEP Natural Heritage Program (Letter), NHP file No. 97-4007435.

NJDEP09 New Jersey Department of Environmental Protection, 2009, NJPDES *Ground Water General Permit No. NJ0142051 (Lined Surface Impoundment)*

NJDEP13 New Jersey Department of Environmental Protection, 2013, *Final Surface Water Permit, New Jersey Pollutant Discharge Elimination System (NJPDES), NJ0023922*.

NJDEP18 New Jersey Department of Environmental Protection, 2018, NJPDES *Ground Water Remedial Monitoring Permit, RAP170001.*

NJDEP18a New Jersey Department of Environmental Protection, 2018, *New Jersey Administrative Code (N.J.A.C) 7:9c.*

NJWSA12 New Jersey Water Supply Authority, 2012, *Withdrawal Agreement of Water from the Delaware & Raritan Canal.*

NOAA http://www.weather.gov/phi/localclimate.html

PFC80 Princeton Forrestal Center, 1980, *Storm Water Management Plan Phase I*, prepared by Sasaki Associates, Inc.

PPPL95 Princeton Plasma Physics Laboratory, March 1995, *Proposed Site Treatment Plan [PSTP] for Princeton Plasma Physics Laboratory [PPPL].*

PPPL99a Princeton Plasma Physics Laboratory. 1999, *Phase IV Remedial Investigation Report.*

PPPL99b Princeton Plasma Physics Laboratory. 1999, *Remedial Action Selection Report.*

PPPL00 Princeton Plasma Physics Laboratory, 2000, *Remedial Action Work Plan.*

PPPL05 Princeton Plasma Physics Laboratory, August 2005, *Cultural Resource Management Plan*.

PPPL08a Princeton Plasma Physics Laboratory, January 22, 2008, *Laboratory Mission*, O-001, TCR R-1-002, Rev. 4.

PPPL12 Princeton Plasma Physics Laboratory, 2012, *Low-Level Radioactive Waste Program Basis Document.*

PPPL13 Princeton Plasma Physics Laboratory, 2013, *Nuclear Materials Control and Accountability (MC&A) Plan, HP-PP-06. Rev.8*.

PPPL13a Princeton Plasma Physics Laboratory, 2013, *Environmental, Safety and Health Directives (ESHD) 5008, Section 10, rev. 5*

PPPL14a Princeton Plasma Physics Laboratory, 2014, *Excavation Soil Erosion and Sediment Control, ES-MECH-013 Rev. 0*

PPPL15a Princeton Plasma Physics Laboratory, 2015, *Environmental Management System Description, Revision 5.*

PPPL15b Princeton Plasma Physics Laboratory, 2015, *Letter of Interpretation (LOI) Wetlands Delineation.*

PPPL15c Princeton Plasma Physics Laboratory, 2015, *Storm Water Pollution Prevention Plan*.

PPPL16a Princeton Plasma Physics Laboratory, 2016, *Spill Prevention Countermeasure and Control Plan (SPCC Plan).*

PPPL16b Princeton Plasma Physics Laboratory, 2016, *Appendix A, Summary of Environmental Aspects and Impacts by Facility, Rev. 5.*

PPPL16c Princeton Plasma Physics Laboratory, December 2016, *DOE Order 13693 PPPL Site Sustainable Plan.*

PPPL17 Princeton Plasma Physics Laboratory, 2017, *Freehold Soil Conservation District, Soil Erosion Permit 2017-0530 PPPL Mod 6 Demolition*

PPPL18 Princeton Plasma Physics Laboratory, 2018, *Appendix B, Summary of PPPL EMS Legal and Other Requirements, Rev. 10.*

PPPL18a Princeton Plasma Physics Laboratory, 2018, *SARA Title III Annual Report for 2018.*

PPPL 18b Princeton Plasma Physics Laboratory, 2018, *NESHAPs Annual Report for Tritium Emissions 2018.*

PPPL18c Princeton Plasma Physics Laboratory, 2018, *Appendix C, Summary of PPPL EMS Objectives and Targets.*

PPPL18e Princeton Plasma Physics Laboratory, 2018, *NJDEP Laboratory Certification ID 12471*

PPPL18f Princeton Plasma Physics Laboratory, 2018, *Chronic Toxicity Bio-monitoring Tests for DSN001 Report.*

PPPL18g Princeton Plasma Physics Laboratory, 2018, *NJPDES Waste Characterization Report for DSN001.*

PPPL18h Princeton Plasma Physics Laboratory, 2019, *PPPL 2018 DOE Sustainability Dashboard.*

PPPL18i Princeton Plasma Physics Laboratory, 2018, *NJPDES Waste Characterization Report for DSN003.*

PPPL18j Princeton Plasma Physics Laboratory, 2018, *Acute Toxicity Bio-monitoring Tests for DSN003 Report.*

Sa80 Sasaki Associates, February 1980, *Princeton Forrestal Center, Storm Water Management Plan for Bee Brook Watershed*, prepared for Delaware & Raritan Canal Commission.

San19a Sandt, T., 2019, *2018 Hazardous, TSCA, and Medical Waste Data,* personal communication.

San19b Sandt, T., 2019, *2018 Spill Release Number of Incidents,* personal communication.

San19c Sandt, T., 2019, *2018 GreenLee Spill Report*, personal communication.

SE96 Smith Environmental Technologies, Corp., February 29, 1996, *Final Site-Wide Storm Water Management Plan, Princeton Plasma Physics Laboratory, James Forrestal Campus, Plainsboro Township, Middlesex County, New Jersey*.

Sh10-13 Sheneman, R., 2010-2013, *Princeton Plasma Physics Laboratory -- Remedial Action Monitoring Report*.

Sla19 Slavin, W., 2019, 2018 *No continuous releases*, person communication.

SM12 American Public Health Association, American Water Works Association, and Water Environment Federation, 2012 (22nd edition),*Standard Methods for the Examination of Water and Wastewater*.

Str19 Strauss, D., 2019, *NEPA Statistics for 2018*, personal communication.

UL17 UL-DQS, Inc., 2017, *Certification Report ISO 14001:2015 Evaluation of PPPL's International Standard Organization (ISO) – Environmental Management System."*

US18 US Census Bureau, *American FactFinder 2018 population estimates,* http://factfinder.census.gov.

Vo82 Volchok, H. L., and de Planque, G., 1982, *EML Procedures Manual HASL 300*, Department of Energy, Environmental Measurements Laboratory, 376 Hudson St., NY, NY 10014.

CHAPTER 9

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APPENDIX A

2018 ASER TABLES & MAPS

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[PPPL13a])	
	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 2018

	PRINCETON 2.3 E, NJ US US1NJMC0044	PLAINSBORO TWP 1.8 ESE, NJ US US1NJMD0069	TRENTON 2.8 WNW, NJ US US1NJMC0042
January	2.59	2.12	2.13
February	6.71	6.85	6.58
March	3.87	3.84	2.1
April	4.49	3.9	3.23
May	7.88	9.08	7.78
June	3.77	3.96	4.18
July	6.41	6.32	6.60
August	3.59	3.04	3.13
September	8.1	8.66	4.26
October	3.2	4.18	5.80
November	8.89	8.86	7.97
December	5.51	5.55	4.60
Total	**65.01**	**66.36**	**58.36**
Average	**63.24**		

Table 3. D– Site Tritium Stack Releases in Curies in 2018

Week Beginning	HTO (Ci)	HT (Ci)	Weekly Total (Ci)
1/3/18	0.02840	0.00134	0.02974
1/10/18	0.03420	0.00110	0.03530
1/17/18	0.03410	0.00098	0.03508
1/24/18	0.03320	0.00093	0.03413
1/31/18	0.02850	0.00085	0.02935
2/7/18	0.03250	0.00110	0.03360
2/14/18	0.03120	0.00105	0.03225
2/21/18	0.03170	0.00073	0.03243
2/28/18	0.06260	0.00214	0.06474
3/7/18	0.01480	0.20900	0.22380
3/14/18	0.03370	0.00117	0.03487
3/22/18	0.02540	0.06680	0.09220
3/28/18	0.03300	0.00116	0.03416
4/4/18	0.02710	0.10700	0.13410
4/11/18	0.02880	0.00112	0.02992
4/18/18	0.02530	0.11000	0.13530
4/25/18	0.02990	0.00104	0.03094
5/2/18	0.03380	0.12900	0.16280
5/9/18	0.03020	0.00132	0.03152
5/16/18	0.03780	0.09880	0.13660
5/23/18	0.03780	0.00111	0.03891
5/30/18	0.03420	0.09450	0.12870
6/6/18	0.02830	0.00080	0.02910
6/13/18	0.02960	0.08690	0.11650
6/20/18	0.02960	0.00095	0.03055
6/27/18	0.02800	0.00105	0.02905
7/5/18	0.02830	0.00084	0.02914
7/11/18	0.03760	0.00115	0.03875
7/18/18	0.04080	0.00122	0.04202
7/25/18	0.04040	0.00088	0.04128
8/1/18	0.02890	0.00084	0.02974
8/8/18	0.03230	0.00069	0.03299
8/15/18	0.00341	0.00011	0.00352
8/22/18	0.03400	0.00088	0.03488
8/29/18	0.03300	0.00079	0.03379
9/5/18	0.03110	0.00057	0.03167
9/12/18	0.02980	0.00069	0.03049
9/19/18	0.03240	0.00075	0.03315
9/26/18	0.03140	0.00031	0.03171
10/3/18	0.03200	0.00046	0.03246
10/10/18	0.00435	0.00101	0.00536
10/17/18	0.28600	0.00427	0.29027
10/24/18	0.26100	0.00747	0.26847
10/31/18	0.25500	0.00501	0.26001
11/7/18	0.23400	0.00899	0.24299
11/14/18	0.45400	0.01100	0.46500
11/21/18	0.27400	0.00779	0.28179
11/28/18	0.02260	0.44800	0.47060
12/5/18	0.22400	0.00809	0.23209
12/12/18	0.26800	0.01940	0.28740
12/19/18	0.80900	0.02940	0.83840
Total (Ci)	**4.35106**	**1.48255**	**5.83361**

Table 4. Ground Water Tritium Concentrations for 2018 (in picoCuries/Liter)

Month	D-Site MG Sump	D-Site Airshaft Sump
January	*	*
February	9.01E+01	1.35E+02
March	1.35E+02	1.35E+02
April	*	*
May	1.35E+02	*
June	*	9.01E+01
July	*	*
August	*	*
September	*	*
October	*	*
November	*	*
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 2018 (in picoCuries/liter)

Month	Bee Brook (B1)	Bee Brook (B2)	Basin (DSN001)	Basin Dup (DSN 004)	D&R Canal (C1)	D&R Canal (DSN003)	E1	M1	P1	P2
January			*		*	*				
February	*	*	*	*	9.01E+01	*	*	9.01E+01	9.01E+01	9.01E+01
March			9.01E+01		9.01E+01	1.35E+02				
April			*		*	*				
May	*	*	*	*	*	*	*	*	*	*
June			9.01E+01		9.01E+01	9.01E+01				
July			*		*	*				
August	*	*	*	*	*	*	*	*	*	*
September			*		*	*				
October			*		*	*				
November	*	*	*	*	*	*	*	*	*	*
December			*		*	*				

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 2018

Year	Tritium Range picoCuries/Liter	Precipitation In Inches	Difference from Middlesex County Avg. Precipitation of 46.5 inches/yr
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
2018	*	41.37	-5.13
2018	*	58.36	+11.86

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

Table 7. Liquid Effluent Collection Tank Release Data for 2018

Release Date	Gallons Released	Tritium Sample LLD (pCi/L)	Tritium Sample Activity (pCi/L)	Total Tritium Tank Activity (Ci)
1/29/2018	12,000	3.07E+02	3.83E+03	1.74E-04
6/11/2018	12,700	2.93E+02	1.39E+04	6.70E-04
7/10/2018	12,300	2.91E+02	9.19E+03	4.28E-04
7/18/2018	12,750	3.48E+02	2.84E+03	1.37E-04
7/24/2018	12,450	1.99E+02	1.49E+03	7.00E-05
8/15/2018	12,750	3.10E+02	1.80E+03	8.70E-05
8/23/2018	12,600	3.17E+02	1.85E+03	8.81E-05
9/12/2018	12,000	3.32E+02	1.35E+03	6.14E-05
9/26/2018	12,000	2.98E+02	1.98E+03	9.79E-05
10/12/2018	12,600	3.15E+02	1.71E+03	8.16E-05
Total	**124,150 Gal.**			**0.0019 Ci 0.19% Limit**

Table 8. Total Fuel Consumption by Fuel Type from 2012 to 2018

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
2018	0.244	0.1
2018	0.142	11.032
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 2018

Location B1 = Bee Brook upstream of PPPL basin discharge

B1							
Parameters	**Units**	**February**		**May**	**August**	**Nov.**
		2018		**2018**	**2018**	**2018**
Chemical Oxygen Demand, COD	mg/L	25.60	<	7.60		73.60
Phosphorus, total	mg/L	< 0.043	<	0.034		0.110
Total Suspended Solids, TSS	mg/L	< 2.20	<	1.40		6.70
Field Parameters						
pH	SU	8.40		6.44	6.31	6.57
Oxidation-Reduction Potential, ORP	mV	-83.1		33.2	38.7	22.3
Temperature	o C	0.1		17.2	26.7	11.5

Blank indicates no measurement *NL = no limit*

Table 10. Surface Water Analysis for Bee Brook, B2, in 2018

Location B2 = Bee Brook downstream of PPPL basin discharge

B2							
Parameters	**Units**	**February**		**May**	**August**	**Nov.**
		2018		**2018**	**2018**	**2018**
Chemical Oxygen Demand, COD	mg/L	< 15.40	<	10.20		57.90
Phosphorus, total	mg/L	0.065		0.210		
Total Organic Carbon, TOC	mg/L					0.110
Total Suspended Solids, TSS	mg/L	< 3.60	<	3.80		12.80
Field Parameters						
pH	SU	8.33		6.96	7.52	6.49
Oxidation-Reduction Potential, ORP	mV	-80.0		3.7	-30.7	26.9
Temperature	o C	1.5		18.2	25.4	12.0

Blank indicates no measurement *NL = no limit*

Table 11. Surface Water Analysis for Delaware & Raritan Canal, C1, in 2018

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

C1												
Parameters	**Units**	**January**		**Feb.**		**March**		**April**		**May**		**June**
		2018		**2018**		**2018**		**2018**		**2018**		**2018**
Chemical Oxygen Demand, COD	mg/L	30.40	<	10.30	<	13.00	<	7.60	<	6.30	<	15.00
Phosphorus, total	mg/L	0.15		0.070	<	0.034	<	0.034	<	0.034	<	0.034
Total Suspended Solids, TSS	mg/L	8.20		7.20	<	1.80	<	1.90	<	3.70		7.70
Field Parameters												
pH	SU	6.76		10.06		8.07		6.72		6.91		6.50
Oxidation-Reduction Potential, ORP	mV	19.40		-169.3		-85.1		16.9		6.9		31.3
Temperature	o C	1.00		1.6		4.5		8.9		20.4		20.9

C1												
Parameters	**Units**	**July**		**Aug.**		**Sept.**		**Oct.**		**Nov.**		**Dec.**
		2018		**2018**		**2018**		**2018**		**2018**		**2018**
Chemical Oxygen Demand, COD	mg/L	<	6.30		38.00		18.20	<	12.80		31.60	11.40
Phosphorus, total	mg/L		0.10		0.076		0.074	<	0.047		0.180	0.034
Total Suspended Solids, TSS	mg/L		8.40		5.40	<	3.70		5.20		9.30	5.00
Field Parameters												
pH	SU		6.93		6.59		6.45		6.54		6.60	6.71
Oxidation-Reduction Potential, ORP	mV		6.90		22.5		31.1		25.6		20.9	
Temperature	o C		26.20		27.0		27.0		19.7		13.1	4.1

Blank indicates no measurement *NL = no limit*

Table 12. Surface Water Analysis for NJ American Water, E1, in 2018

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

E1									
Parameters	**Units**	**February**		**May**		**August**		**Nov.**	
		2018		**2018**		**2018**		**2018**	
Chemical Oxygen Demand, COD	mg/L	<	0.22	<	6.30		<17.7	<	11.00
Phosphorus, total	mg/L	<	0.220		0.210		0.320		0.420
Total Suspended Solids, TSS	mg/L	<	0.57	<	0.57	<	1.50	<	1.50
Field Parameters									
pH	SU		8.82		6.64		6.15		7.03
Oxidation-Reduction Potential, ORP	mV		-107.4		21.6		48.2		-2.9
Temperature	o C		9.2		14.9		29.2		15.0

Blank indicates no measurement *NL = no limit*

Table 13. Surface Water Analysis for Millstone River, M1, in 2018

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

M1									
Parameters	**Units**	**February**		**May**		**August**		**Nov.**	
		2018		**2018**		**2018**		**2018**	
Chemical Oxygen Demand, COD	mg/L	<	6.30	<	12.70	<	11.00		21.00
Phosphorus, total	mg/L		0.090	<	0.040		0.097		0.110
Total Organic Carbon, TOC	mg/L								
Total Suspended Solids, TSS	mg/L		20.30		6.60		16.80		12.60
Field Parameters									
pH	SU		8.29		6.52		6.15		6.49
Oxidation-Reduction Potential, ORP	mV		-78.1		29.1		48.2		26.7
Temperature	o C		1.7		24.1		29.2		13.0

Blank indicates no measurement *NL = no limit*

Table 14. Surface Water Analysis for Cranbury Brook (Plainsboro), P1, in 2018

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

P1								
Parameters	**Units**	**February**		**May**		**August**		**Nov.**
		2018		**2018**		**2018**		**2018**
Chemical Oxygen Demand, COD	mg/L	20.50	<	10.20	<	11.00		44.70
Phosphorus, total	mg/L	< 0.043	<	0.042	<	0.029		0.430
Total Organic Carbon, TOC	mg/L							
Total Suspended Solids, TSS	mg/L	5.30		6.00	<	2.40		8.80
Field Parameters								
pH	SU	10.11		5.98		6.08		6.41
Oxidation-Reduction Potential, ORP	mV	-171.4		60.3		52.4		30.9
Temperature	o C	1.1		21.0		27.0		13.4

Blank indicates no measurement *NL = no limit*

Table 15. Surface Water Analysis for Devil's Brook (Plainsboro), P2, in 2018

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

P2								
Parameters	**Units**	**February**		**May**		**August**		**Nov.**
		2018		**2018**		**2018**		**2018**
Chemical Oxygen Demand, COD	mg/L	< 12.80		30.50	<	11.00		26.30
Phosphorus, total	mg/L	1.100	<	0.034		0.088		0.087
Total Organic Carbon, TOC	mg/L							
Total Suspended Solids, TSS	mg/L	41.50		8.00		8.80		11.20
Field Parameters								
pH	SU	9.68		6.15		6.21		6.59
Oxidation-Reduction Potential, ORP	mV	-149.4		50.5		44.6		21.4
Temperature	o C	1.6		21.9		27.2		13.5

Blank indicates no measurement *NL = no limit*

Table 16. DSN001 – Retention Basin Outfall Surface Water Analysis (NJPDES NJ0023922) in 2018

DSN001																							
Parameters	**Units**	**January**			**Feb.**			**March**			**April**			**May**			**June**						
		2018			**2018**			**2018**			**2018**			**2018**			**2018**						
Chemical Oxygen Demand, COD	mg/L	<	6.30		<	6.30		<	13.00		<	15.20		<	6.30		<	7.50					
Phosphorus, total	mg/L		0.041		<	0.034		<	0.034		<	0.034			0.350		<	0.034					
Tetrachloroethylene, PCE	ug/L	<	0.50		J	0.58		J	0.54		<	0.50		<	0.50		<	0.50					
Total Petroleum Hydrocarbon, TPHC	mg/L	<	0.89		<	0.86		<	1.30		<	0.88		<	1.80		<	0.88					
Total Suspended Solids, TSS	mg/L		0.80		<	2.70		<	1.70			4.30		<	2.70		<	3.100					
Field Parameters																							
pH (Max) (Min)	SU		6.65 6.60			7.57 7.29			6.56 6.55			7.00 6.92			7.26 7.21			7.08 7.03				
Oxidation-Reduction Potential, ORP, Max	mV		12.0			-26.5			20.6			5.9			19.1			1.2					
Temperature (Max)	o C		3.4			5.8			12			11.8			16.6			16					
Temperature (Average)						5.5			12			11.75			16.55			15.95					

DSN001																							
Parameters	**Units**	**July**			**August**			**Sept.**			**Oct.**			**Nov.**			**Dec.**						
		2018			**2018**			**2018**			**2018**			**2018**			**2018**						
Chemical Oxygen Demand, COD	mg/L	<	6.30			38.00		<	15.60		<	12.80		<	11.00		<	11.00					
Phosphorus, total	mg/L		0.070			0.430			0.21		<	0.030			0.062			0.079					
Tetrachloroethylene, PCE	ug/L	<	0.80 0.37 0.25		<	0.25		<	0.28		<	0.37		<	0.33		<	0.41					
Total Petroleum Hydrocarbon, TPHC	mg/L		<6.3		<	0.86		<	1.40		<	1.00		<	0.86		<	0.86					
Total Suspended Solids, TSS	mg/L		<4.00			4.10			12.50		<	3.20		<	2.80		<	1.50					
Field Parameters																							
pH (Max) (Min)	SU		8.42 8.31			8.420 8.41			8.150			7.31 7.35			6.84 6.81			7.21 7.21					
Oxidation-Reduction Potential, ORP, Max	mV		-74.6			-82.0			-67.0			-20.6			9.3								
Temperature (Max)	o C		23.4			23.0			24.1			18.4			14.9			7.2					
Temperature (Average)			23.35			22.5			24.1			18.4			14.9			7.2					

Blank indicates no measurement *NL = no limit*

Table 17. D&R Canal Pump House – DSN003

Monthly Surface Water Analysis (NJPDES NJ0023922) in 2018

DSN003												
Parameters	**Units**	**Permit Limit**	**January 2018**	**Feb. 2018**	**March 2018**	**April 2018**	**May 2018**	**June 2018**
Chemical Oxygen Demand, COD	mg/L	50	< 10.30	< 10.30	< 13.00	< 6.30	< 12.40	< 12.50
Phosphorus, total	mg/L		0.059	< 0.041	0.057	< 0.034	0.220	< 0.034
Total Petroleum Hydrocarbon, TPHC	mg/L	15 Max 10 Avg	< 0.95	< 0.86	< 1.40	< 0.83	< 2.00	< 0.89
Total Suspended Solids, TSS	mg/L		1.50	7.80	5.20	6.60	4.40	8.70
Field Parameters								
pH (Max)	SU	>6; <9	8.18	8.24	8.05	6.08	6.79	6.66
pH (Min)			8.13					
Oxidation-Reduction Potential, ORP (Max)	mV		-69.40	75.70	-58.3	53.40	13.60	22.30
Temperature (Max)	o C	30 Max	3.9	2.7	11.0	8.5	18.4	20.7

DSN003												
Parameters	**Units**	**Permit Limit**	**July 2018**	**Aug. 2018**	**Sept. 2018**	**Oct. 2018**	**Nov. 2018**	**Dec. 2018**
Chemical Oxygen Demand, COD	mg/L	50	< 8.20	35.40	< 11.00	25.60	< 13.20	11.00
Phosphorus, total	mg/L		0.220	0.084	0.060	0.072	0.100	0.055
Total Petroleum Hydrocarbon, TPHC	mg/L	15 Max 10 Avg	< 1.90	< 0.91	< 0.86	< 1.30	< 0.86	1.50
Total Suspended Solids, TSS	mg/L		5.40	4.90	< 3.70	4.60	6.00	4.60
Field Parameters								
pH (Max)	SU	>6; <9	6.94	6.44	7.01	6.61	6.49	6.55
pH (Min)			6.90		6.91	6.60		
Oxidation-Reduction Potential, ORP (Max)	mV		8.50	31.30	4.40	27.50	26.90	
Temperature (Max)	o C	30 Max	25.4	26.4	26.7	20.1	13.9	15.4

Blank indicates no measurement *NL = no limit*

Table 18. Summary of Ground Water Sampling Results – March 2018

Target Chlorinated Volatile Organic Compounds (VOC)

Sample Location:	MW-25	Trip Blank	MW-3S	MW-13S	MW-26S	MW-13I	MW-17	MW-18	Basin Outfall	MW-5S	MW-19I
Sample ID:	**18-142**	**18-147**	**18-128**	**18-133**	**18-143**	**18-134**	**18-135**	**18-136**	**18-144**	**18-129**	**18-138**
Target Volatile Organic Compounds (ug/L)											
Chloroethane	<0.59	<0.59	<0.59	<0.59	<0.59	<0.59	<0.59	<0.59	<0.59	<0.59 [a]	<0.59
1,1-Dichloroethane	<0.21	<0.21	<0.21	<0.21	<0.21	<0.21	<0.21	<0.21	<0.21	<0.21	<0.21
1,2-Dichloroethane	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20
1,1-Dichloroethene	<0.47	<0.47	<0.47	<0.47	<0.47	<0.47	<0.47	<0.47	<0.47	<0.47	<0.47
cis-1,2-Dichloroethene	0.80 J	<0.50	<0.50	8.40	8.50	0.51 J	<0.50	<0.50	<0.50	<0.50	<0.50
trans-1,2-Dichloroethene	<0.40	<0.40	<0.40	<0.40	<0.40	<0.40	<0.40	<0.40	<0.40	<0.40	<0.40
1,1,1,2-Tetrachloroethane	<0.19	<0.19	<0.19	<0.19	<0.19	<0.19	<0.19	<0.19	<0.19	<0.19	<0.19
1,1,2,2-Tetrachloroethane	<0.17	<0.17	<0.17	<0.17	<0.17	<0.17	<0.17	<0.17	<0.17	<0.17	<0.17
Tetrachloroethene	<0.50	<0.50	<0.50	12.60	12.70	14.00	8.40	<0.50	<0.50	<0.50	<0.50
1,1,1-Trichloroethane	<0.25	<0.25	<0.25	<0.25	<0.25	0.39 J	<0.25	<0.25	<0.25	<0.25	<0.25
Trichloroethene	<0.27	<0.27	<0.27	4.90	5.10	0.30 J	0.87 J	<0.27	<0.27	<0.27	<0.27
Vinyl chloride	<0.62	<0.62	<0.62	<0.62	<0.62	<0.62	<0.62	<0.62	<0.62	<0.62 [a]	<0.62
Target Semi-Volatile Organic Compound (ug/L)											
1,4-Dioxane	0.13	-	0.15	0.32	0.35	0.34	0.16	<0.046	<0.047	<0.049	<0.054
GC Volatiles (RSK-175)											
Methane	0.41	-	23.90	9.60	4.80	<0.036	<0.036	<0.036	1.40	<0.036	<0.036
Ethane	<0.036	-	<0.036	<0.036	<0.036	<0.036	<0.036	<0.036	<0.036	<0.036	<0.036
Ethene	<0.035	-	<0.035	<0.035	<0.035	<0.035	<0.035	<0.035	<0.035	<0.035	<0.035
Metals Analysis											
Manganese	9330.00	-	780.00	997.00	1790.00	21.40	130.00	205.00	118.00	26.20	<15
General Chemistry											
Alkalinity, Total as CaCO3	98.5 [b]	-	149 [b]	43.6 [b]	43.1 [b]	118 [b]	58.9 [b]	8.1 [c]	78.7 [b]	41.6 [b]	10.2 [c]
Iron, Ferrous	<0.20 [d]	-	1.6 [d]	2.5 [d]	3.8 [d]	<0.20 [d]	<0.20 [d]	<0.20 [d]	<0.20 [d]	<0.20 [d]	<0.20 [d]
Nitrogen, Nitrate	0.11 [e]	-	0.11 [e]	<0.11 [e]	<0.11 [e]	<0.11 [e]	<0.11 [e]	<0.11 [e]	2.1 [e]	1.1 [e]	1.0 [e]
Nitrogen, Nitrate + Nitrite	0.11	-	0.11	<0.10	<0.10	<0.10	<0.10	<0.10	2.10	1.10	1.00
Nitrogen, Nitrite	<0.010	-	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010
Sulfate	23.30	-	24.80	15.50	15.40	18.50	15.40	21.30	20.00	8.70	6.30
Sulfide	<2.0	-	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0
Total Organic Carbon	2.20	-	12.30	1.50	1.40	<1.0	1.70	1.80	2.10	<1.0	<1.0
Natural Attenuation Indicators											
Dissolved Oxygen	0.00		0.00	9.76		0.00	6.20				
pH	6.36		6.00	5.70		6.84	6.13				
Redox Potential	37.00		101.00	117.00		131.00	157.00				

Footnotes:

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

a - This compound in BS is outside in-house QC limits bias high.

* 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 18 cont. Summary of Ground Water Sampling Results – March 2018

Target Chlorinated Volatile Organic Compounds (VOC)

Sample Location:	MW-19S	MW-22S	MW-24	D-Site MG Sump	D-Site Airshaft Sump	Trip Blank	MW-12S	MW-5I	MW-9S	MW-23S	TRIP BLANK
Sample ID:	**18-137**	**18-139**	**18-141**	**18-145**	**18-146**	**18-147**	**18-132**	**18-130**	**18-131**	**18-140**	**18-147**
Target Volatile Organic Compounds (ug/L)											
Chloroethane	<0.59 [a]	<0.59 [a]	<0.59 [a]	<0.59	<0.59	<0.59	<0.59	<0.59	<0.59	<0.59	<0.59
1,1-Dichloroethane	<0.21	<0.21	<0.21	<0.21	<0.21	<0.21	<0.21	0.32 J	<0.21	<0.21	<0.21
1,2-Dichloroethane	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20
1,1-Dichloroethene	<0.47	<0.47	<0.47	<0.47	<0.47	<0.47	<0.47	<0.47	<0.47	<0.47	<0.47
cis-1,2-Dichloroethene	1.6	<0.50	<0.50	4.1	<0.50	<0.50	<0.50	5.3	2	<0.50	<0.50
trans-1,2-Dichloroethene	<0.40	<0.40	<0.40	<0.40	<0.40	<0.40	<0.40	<0.40	<0.40	<0.40	<0.40
1,1,1,2-Tetrachloroethane	<0.19	<0.19	<0.19	<0.19	<0.19	<0.19	<0.19	<0.19	<0.19	<0.19	<0.19
1,1,2,2-Tetrachloroethane	<0.17	<0.17	<0.17	<0.17	<0.17	<0.17	<0.17	<0.17	<0.17	<0.17	<0.17
Tetrachloroethene	63.2	<0.50	<0.50	11.6	2	<0.50	<0.50	<0.50	6	<0.50	<0.50
1,1,1-Trichloroethane	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25
Trichloroethene	2.5	<0.27	<0.27	1.9	<0.27	<0.27	<0.27	2.2	4.9	<0.27	<0.27
Vinyl chloride	<0.62 [a]	<0.62 [a]	<0.62 [a]	<0.62	<0.62	<0.62	<0.62	<0.62	<0.62	<0.62	<0.62
Target Semi-Volatile Organic Compound (ug/L)											
1,4-Dioxane	0.587	<0.049	<0.049	0.0996 J	<0.049	-	<0.049	0.148	0.0804 J	<0.049	--
GC Volatiles (RSK-175)											
Methane	0.47	<0.036	<0.036	14.7	0.16	-	<0.036	1.1	<0.036	<0.036	--
Ethane	<0.036	<0.036	<0.036	<0.036	<0.036	-	<0.036	<0.036	<0.036	<0.036	--
Ethene	<0.035	<0.035	<0.035	<0.035	<0.035	-	<0.035	<0.035	<0.035	<0.035	--
Metals Analysis											
Manganese	83.5	75.1	<15	88200 [f]	1310	-	<15	831	<15	78	--
General Chemistry											
Alkalinity, Total as CaCO3	7.1 [c]	<5.0 [g]	12.2 [c]	134 [b]	100 [b]	-	51.8 [b]	148 [b]	190 [b]	<5.0 [c]	--
Iron, Ferrous	<0.20 [d]	<0.20 [d]	<0.20 [d]	<0.20 [d]	<0.20 [d]	-	<0.20 [d]	<0.20 [d]	<0.20 [d]	<0.20 [d]	--
Nitrogen, Nitrate	0.22 [e]	0.47 [e]	<0.11 [e]	0.17 [e]	0.59 [e]	-	1.6 [e]	<0.11 [e]	<0.11 [e]	<0.11 [e]	--
Nitrogen, Nitrate + Nitrite	0.22	0.47	<0.10	0.17	0.59	-	1.6	<0.10	<0.10	<0.10	--
Nitrogen, Nitrite	<0.010	<0.010	<0.010	<0.010	<0.010	-	<0.010	<0.010	<0.010	<0.010	--
Sulfate	46.1	20.3	16.4	18.5	18.7	-	13.6	31.7	10.8	58	--
Sulfide	<2.0	<2.0	<2.0	<2.0	<2.0	-	<2.0	<2.0	<2.0	<2.0	--
Total Organic Carbon	2	<1.0	<1.0	5.0 [h]	<1.0	-	1.4	1.3	3.3	2.1	--
Natural Attenuation Indicators											
Dissolved Oxygen							5.15	0.00			
pH							6.02	6.99			
Redox Potential							178.00	-48.00			

Footnotes:

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

a - This compound in BS is outside in-house QC limits bias high.

* 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 19. Summary of Ground Water Sampling Results –June 2018

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

Sample Location:	MW-5I	MW-5S	MW-13S	MW-26S	Trip Blank	MW-18	MW-17	MW-25S	Trip Blank	Trip Blank	D-Site MG Sump	MW-9S	MW-3S	MW-19S
Sample ID:					**18-240**	**18-235**	**18-234**	**18-237**	**18-240**	**18-240**	**18-239**	**18-232**	**18-229**	**18-236**
Target Volatile Organic Compounds (ug/L)														
Chloroethane	<0.59	<0.59	<0.59	<0.59	<0.59	<0.59	<0.59	<0.59	<0.59	<0.59	<0.59 [a]	<0.59	<0.59	<0.59
1,1-Dichloroethane	0.25 J	<0.21	<0.21	<0.21	<0.21	<0.21	<0.21	<0.21	<0.21	<0.21	<0.21	<0.21	<0.21	<0.21
1,2-Dichloroethane	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20
1,1-Dichloroethene	<0.47	<0.47	<0.47	<0.47	<0.47	<0.47	<0.47	<0.47	<0.47	<0.47	0.56 J	<0.47	<0.47	<0.47
cis-1,2-Dichloroethene	5.30	<0.50	12.00	13.20	<0.50	<0.50	<0.50	1.30	<0.50	<0.50	1.90	2.90	<0.50	1.10
trans-1,2-Dichloroethene	<0.40	<0.40	<0.40	<0.40	<0.40	<0.40	<0.40	<0.40	<0.40	<0.40	<0.40	<0.40	<0.40	<0.40
1,1,1,2-Tetrachloroethane	<0.19	<0.19	<0.19	<0.19	<0.19	<0.19	<0.19	<0.19	<0.19	<0.19	<0.19	<0.19	<0.19	<0.19
1,1,2,2-Tetrachloroethane	<0.17	<0.17	<0.17	<0.17	<0.17	<0.17	<0.17	<0.17	<0.17	<0.17	<0.17	<0.17	<0.17	<0.17
Tetrachloroethene	<0.50	0.76 J	16.50	17.50	<0.50	<0.50	6.90	<0.50	<0.50	<0.50	29.00	24.50	<0.50	57.30
1,1,1-Trichloroethane	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25	<0.25
Trichloroethene	2.10	<0.27	3.80	4.20	<0.27	<0.27	0.88 J	0.53 J	<0.27	<0.27	3.10	6.50	<0.27	2.10
Vinyl chloride	<0.62	<0.62	0.68 J	0.75 J	<0.62	<0.62	<0.62	<0.62	<0.62	<0.62	<0.62	<0.62	<0.62	<0.62
Target Semi-Volatile Organic Compound (ug/L)														
1,4-Dioxane	0.125	0.0563 J	0.302	0.266	-	<0.049	0.141	0.102	-	-	0.104	0.24	0.0842 J	0.272
Natural Attenuation Indicators														
Dissolved Oxygen														
pH														
Redox Potential														

Footnotes:

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

a - This compound in BS is outside in-house QC limits bias high.

* 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 2018

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

Sample Location:	MW-25S	MW-18	MW-17	Trip Blank	Trip Blank	D-Site MG Sump	MW-5S	MW-5I	MW-13S	MW-26S	Trip Blank	MW-3S	MW-9S	MW-19S
Sample ID:	**18-309**	**18-307**	**18-306**	**18-312**	**18-312**	**18-311**	**18-302**	**18-303**	**18-305**	**18-310**	**18-312**	**18-301**	**18-304**	**18-308**
Target Volatile Organic Compounds (ug/L)														
Chloroethane	<0.73	<0.73	<0.73	<0.73	<0.73	<0.73	<0.73	<0.73	<0.73	<0.73	<0.73	<0.73	<0.73	<0.73
1,1-Dichloroethane	<0.57	<0.57	<0.57	<0.57	<0.57	<0.57	<0.57	<0.57	<0.57	<0.57	<0.57	<0.57	<0.57	<0.57
1,2-Dichloroethane	<0.60	<0.60	<0.60	<0.60	<0.60	<0.60	<0.60	<0.60	<0.60	<0.60	<0.60	<0.60	<0.60	<0.60
1,1-Dichloroethene	<0.59	<0.59	<0.59	<0.59	<0.59	<0.59	<0.59	<0.59	<0.59	<0.59	<0.59	<0.59	<0.59	<0.59
cis-1,2-Dichloroethene	1.90	<0.51	<0.51	<0.51	<0.51	2.20	<0.51	4.70	11.50	12.10	<0.51	<0.51	0.63 J	2.00
trans-1,2-Dichloroethene	<0.54	<0.54	<0.54	<0.54	<0.54	<0.54	<0.54	<0.54	<0.54	<0.54	<0.54	<0.54	<0.54	<0.54
1,1,1,2-Tetrachloroethane	<0.60	<0.60	<0.60	<0.60	<0.60	<0.60	<0.60	<0.60	<0.60	<0.60	<0.60	<0.60	<0.60	<0.60
1,1,2,2-Tetrachloroethane	<0.65	<0.65	<0.65	<0.65	<0.65	<0.65	<0.65	<0.65	<0.65	<0.65	<0.65	<0.65	<0.65	<0.65
Tetrachloroethene	<0.90	<0.90	24.90	<0.90	<0.90	32.40	<0.90	<0.90	13.40	13.60	<0.90	<0.90	22.10	97.40
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	<0.54	<0.54
Trichloroethene	0.66 J	0.60 J	2.00	<0.53	<0.53	3.10	<0.53	2.10	3.80	4.00	<0.53	<0.53	1.90	4.00
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	<0.79	<0.79
Target Semi-Volatile Organic Compound (ug/L)														
1,4-Dioxane	<0.046 [a]	<0.046 [a]	0.232 [a]	-	-	0.173	<0.049	0.0921 J	0.142	0.352	-	<0.047	0.234	0.693
Natural Attenuation Indicators														
Dissolved Oxygen														
pH														
Redox Potential														

Footnotes:

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

a - This compound in BS is outside in-house QC limits bias high.

* 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 21. Summary of Ground Water Sampling Results –December 2018

Target Chlorinated Volatile Organic Compounds (VOC)

Client Sample ID:	Trip Blank	MW-5S	MW-5I	MW-13S	MW-26S	Trip Blank	MW-18	MW-17	MW-25S	Trip Blank	MW-3S	MW-9S	MW-19S	D-Site MG Sump
Sample ID:	**19-71**	**19-62**	**19-61**	**19-64**	**19-69**	**19-71**	**19-66**	**19-65**	**19-68**	**19-71**	**19-60**	**19-63**	**19-67**	**19-70**
Target Volatile Organic Compounds (ug/L)														
Chloroethane	<0.73	<0.73	<0.73	<0.73	<0.73	<0.73	<0.73	<0.73	<0.73	<0.73	<0.73	<0.73	<0.73	<0.73
1,1-Dichloroethane	<0.57	<0.57	<0.57	<0.57	<0.57	<0.57	<0.57	<0.57	<0.57	<0.57	<0.57	<0.57	<0.57	<0.57
1,2-Dichloroethane	<0.60	<0.60	<0.60	<0.60	<0.60	<0.60	<0.60	<0.60	<0.60	<0.60	<0.60	<0.60	<0.60	<0.60
1,1-Dichloroethene	<0.59	<0.59	<0.59	<0.59	<0.59	<0.59	<0.59	<0.59	<0.59	<0.59	<0.59	<0.59	<0.59	<0.59
cis-1,2-Dichloroethene	<0.51	<0.51	4.50	10.80	11.10	<0.51	<0.51	<0.51	1.40	<0.51	<0.51	5.40	1.40	1.00
trans-1,2-Dichloroethene	<0.54	<0.54	<0.54	<0.54	<0.54	<0.54	<0.54	<0.54	<0.54	<0.54	<0.54	<0.54	<0.54	<0.54
1,1,1,2-Tetrachloroethane	<0.60	<0.60	<0.60	<0.60	<0.60	<0.60	<0.60	<0.60	<0.60	<0.60	<0.60	<0.60	<0.60	<0.60
1,1,2,2-Tetrachloroethane	<0.65 [a]	<0.65 [a]	<0.65 [a]	<0.65 [a]	<0.65 [a]	<0.65	<0.65	<0.65	<0.65	<0.65	<0.65	<0.65	<0.65	<0.65
Tetrachloroethene	<0.90	1.40	<0.90	15.90	15.70	<0.90	<0.90	7.50	<0.90	<0.90	<0.90	17.00	80.60	19.80
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	<0.54	<0.54
Trichloroethene	<0.53	<0.53	1.90	3.50	3.40	<0.53	<0.53	1.10	<0.53	<0.53	<0.53	11.40	2.90	1.90
Vinyl chloride	<0.79	<0.79	<0.79	0.91 J	0.90 J	<0.79	<0.79	<0.79	<0.79	<0.79	<0.79	<0.79	<0.79	<0.79
Target Semi-Volatile Organic Compound (ug/L)														
1,4-Dioxane	--	<0.049	0.0915 J	0.37	0.323	--	<0.046	<0.048	<0.047	--	0.0746 J	0.208	0.562	0.0979 J
Natural Attenuation Indicators														
Dissolved Oxygen														
pH														
Redox Potential														

Footnotes:

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

a - This compound in BS is outside in-house QC limits bias high.

* 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 22. Summary of Groundwater Sampling Results – D-Site MG Sump, 2018

Parameters	Units	January	Feb.	March	April	May	June	July	August	Sept.	Oct.	Nov.	Dec.
Chemical Oxygen Demand, COD	mg/L	< 15.40			< 6.30				25.30		< 11.00		
Phosphorus, total	mg/L	0.065	4.200	< 0.034	< 0.790	2.200	0.210	0.490	1.800	1.700		1.600	5.600
Total Suspended Solids, TSS	mg/L		3800.00			540.00			493.00			2390.00	

Blank indicates no measurement *NA = not applicable* *NL = no limit*

Table 23. Summary of Groundwater Sampling Results – D-Site Airshaft Sump, 2018

Parameters	Units	Jan.	Feb.	March	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
Chemical Oxygen Demand, COD	mg/L	< 10.30			< 6.30				38.00		< 13.20		
Phosphorus, total	mg/L	< 0.034	0.094	< 0.034	< 0.097	< 0.034	< 0.034	< 0.045	< 0.041	0.053		0.120	< 0.027
Total Suspended Solids, TSS	mg/L		23.00		< 0.57				< 1.50			22.70	

Blank indicates no measurement *NA = not applicable* *NL = no limit*

Table 24. Quality Assurance Data for Radiological and Non-Radiological Samples for 2018

Laboratory, Program and Parameter	Units	Reported Value	Actual Value	Acceptance Range	Acceptable Not Acceptable
ERA Co. **April 2018 RAD-109, Proficiency Test**					
Barium-133	pCi/L	94.0	91.5	77.1 - 101.0	Acceptable
Cesium-134	pCi/L	74.20	75.9	62.0 - 83.5	Acceptable
Cesium-137	pCi/L	127.78	123.0	111 – 138	Acceptable
Cobalt-60	pCi/L	66.02	64.3	57.9 – 73.2	Acceptable
Zinc-65	pCi/L	96.92	86.7	78.0 – 104.0	Acceptable
Tritium	pCi/L	17690.09	17200.0	15000.0 – 18900.0	Acceptable
ERA Co. **October 2018 RAD-111, Proficiency Test**					
Barium-133	pCi/L	16.12	16.3	11.9 – 19.4	Acceptable
Cesium-134	pCi/L	90.64	93.0	76.4 – 102.0	Acceptable
Cesium-137	pCi/L	245.6	235.0	212.0 – 260.0	Acceptable
Cobalt-60	pCi/L	83.41	80.7	72.6 – 91.1	Acceptable
Zinc-65	pCi/L	362.6	336.0	302.0 – 382.0	Acceptable
Tritium	pCi/L	2891.89	2870.0	2410.0 – 3170.0	Acceptable
Phenova **April 2018 WP-0318**					
pH	S.U.	6.33	6.28	6.08 – 6.48	Acceptable*
Residual Chlorine	mg/L	2.08	2.56	1.88 – 2.98	Acceptable*
Phenova **April 2018 WP-0318**					
pH	S.U.	6.65	6.58	6.38 – 6.78	Acceptable*
Residual Chlorine	mg/L	0.68	0.737	0.554 – 0.902	Acceptable*

***** Passed Phenova PT Test, however failed by NJDEP OQA due to transcription errors in the submission

Table 25. Waste Characterization Report (WCR) Surface Water Sampling 2018

No limits exceeded, only parameters listed above non-detect

Laboratory Parameter	Reported Value (mg/L)	
DSN001		
Semi Annual	April	November
Barium	292	-
Beryllium	-	-
Copper	-	-
Lead	-	-
Manganese	133	45.1
Nickel	-	-
Selenium	-	-
Thallium	-	-
Zinc	63.3	27.2
DSN001 Annual	April	
4,4'-DDT a	0.024ug/L	
Alpha-BHC	0.014 ug/L	
DSN003		
Annual		
No parameters detected, May 2018		

Figure 1. 1,4 Dioxane, PCE, TCE Distribution for Groundwater Wells 2018

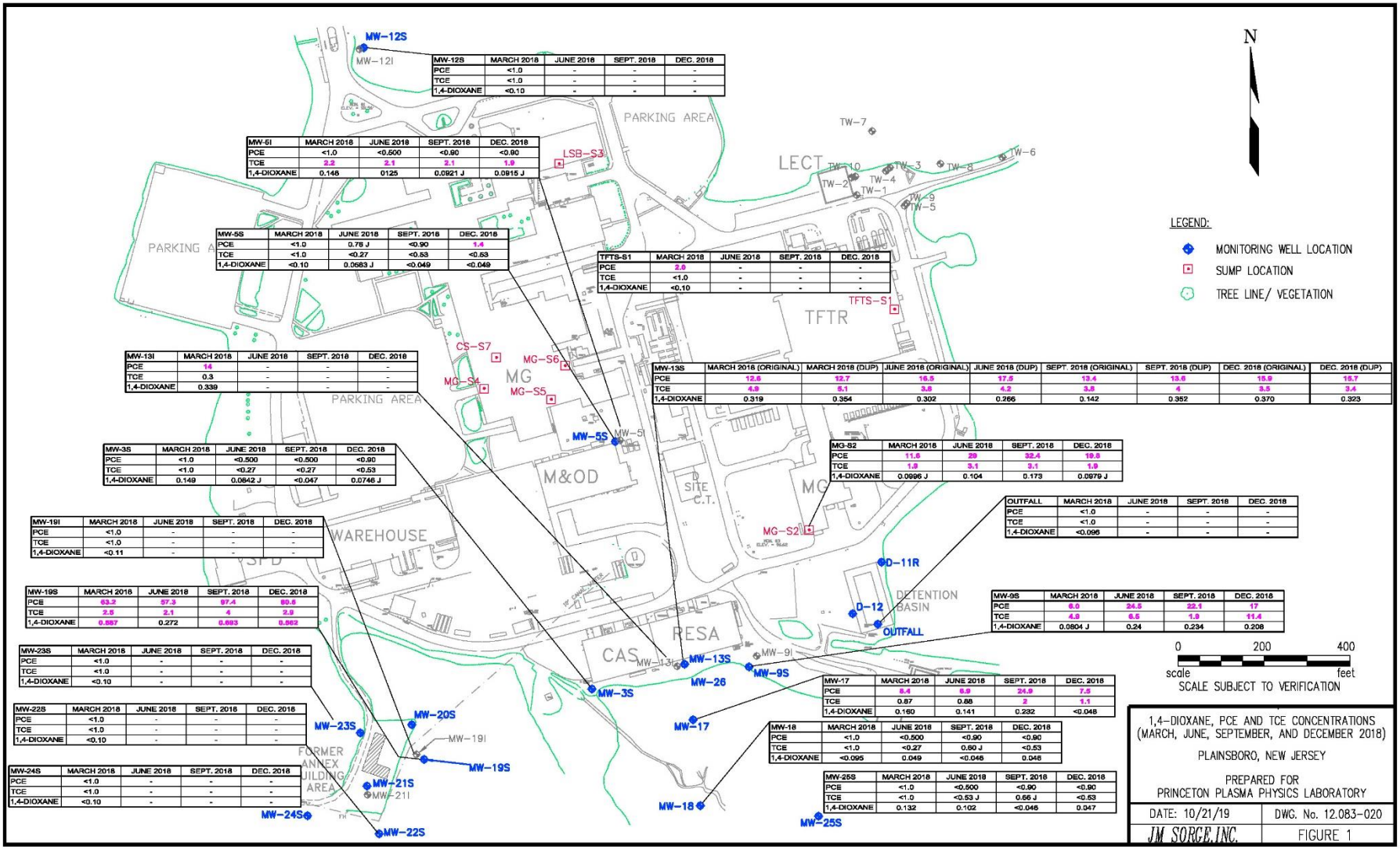


Figure 2. Potentiometric Surface Contours Shallow Groundwater Wells 2018

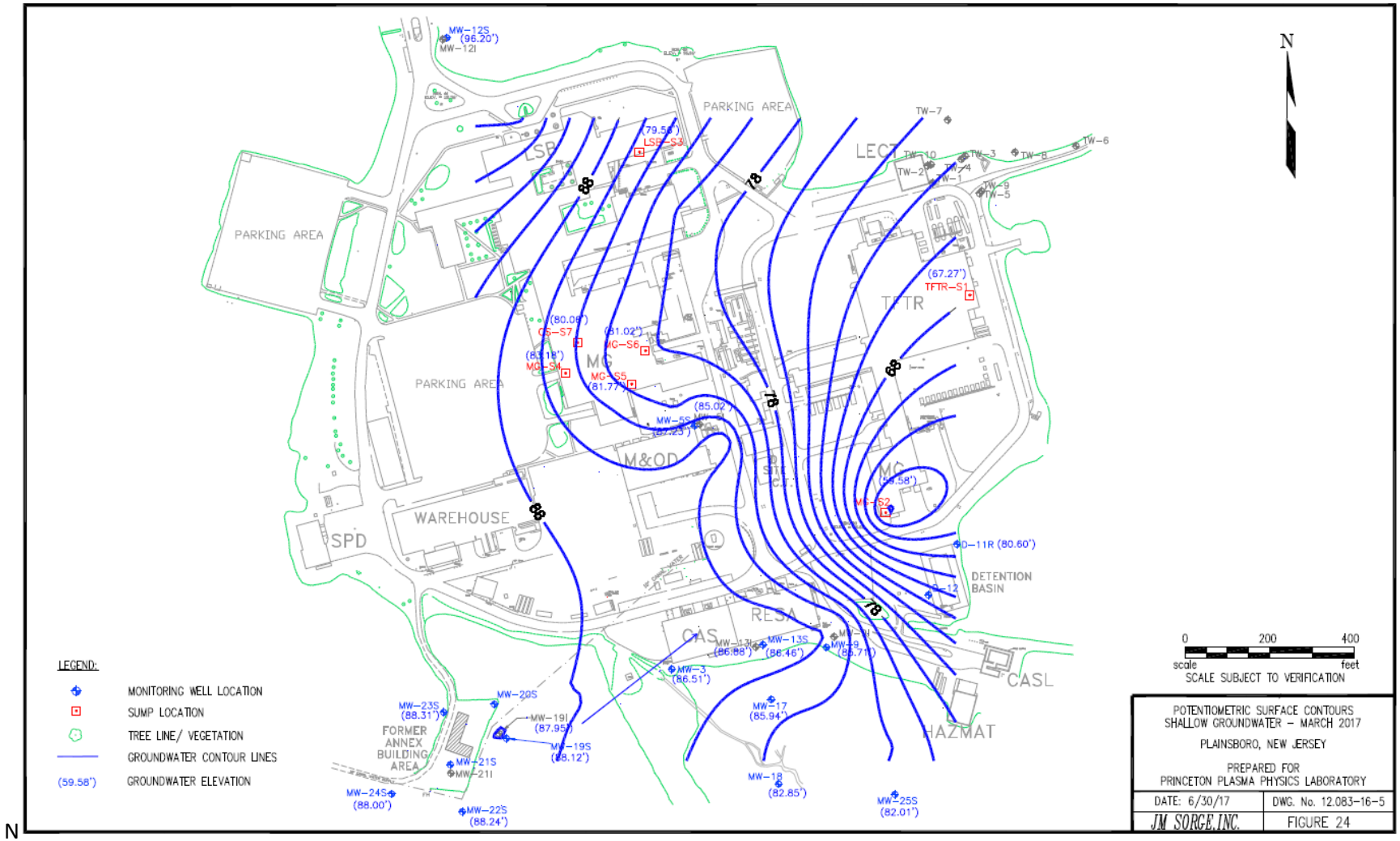


Figure 3. PPPL On Site Sampling Location Map

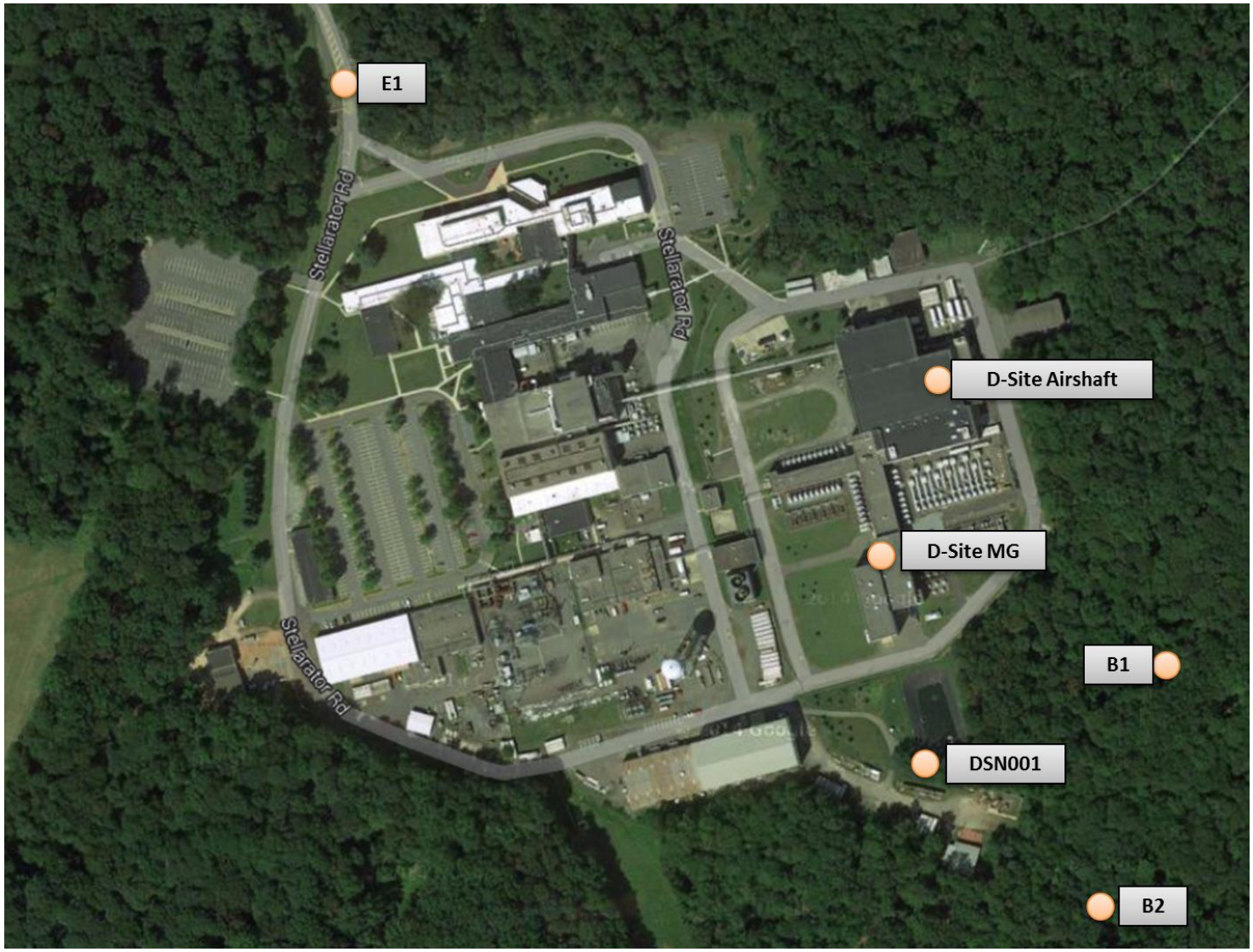


Figure 4. PPPL Off Site Sampling Location Map

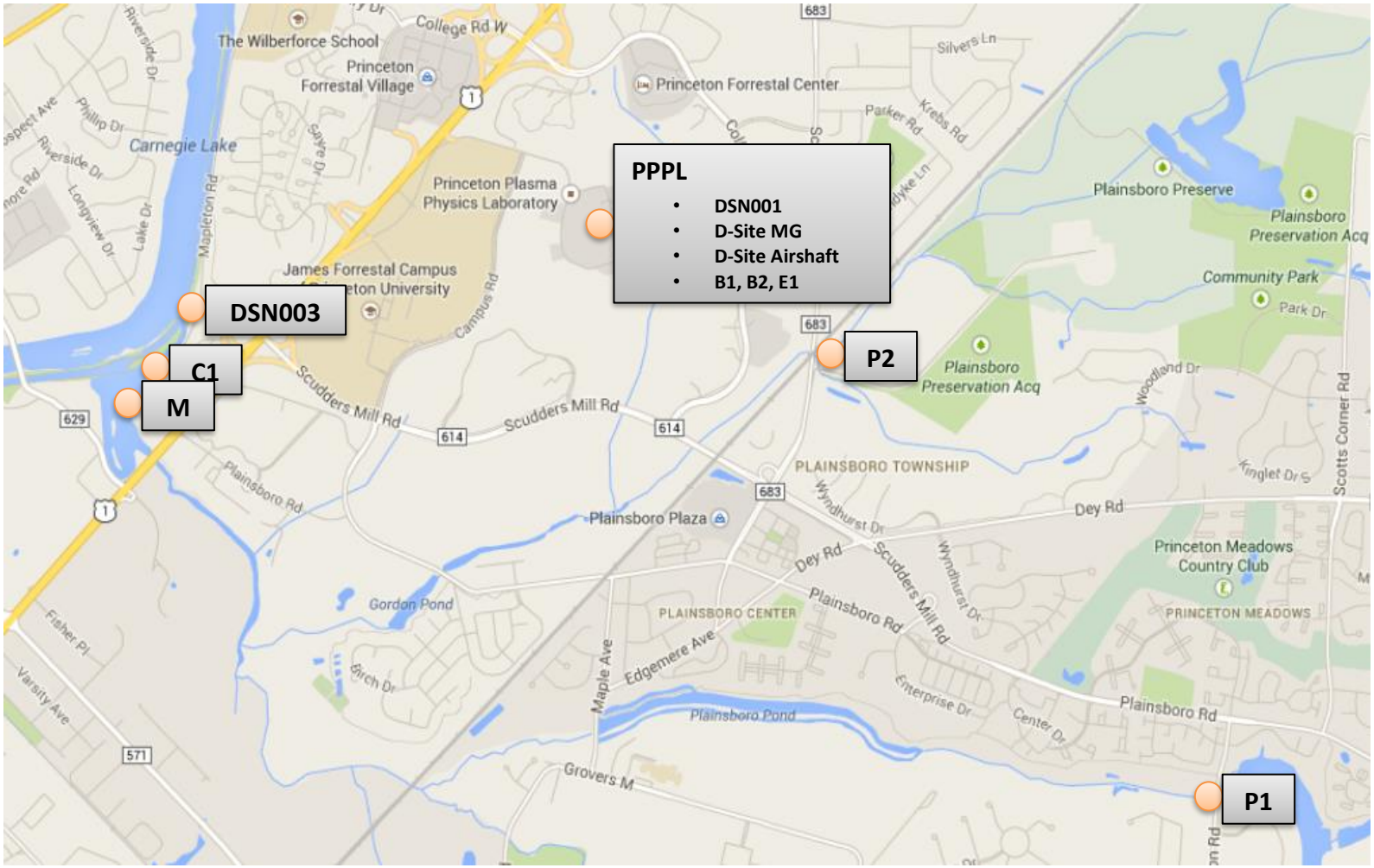
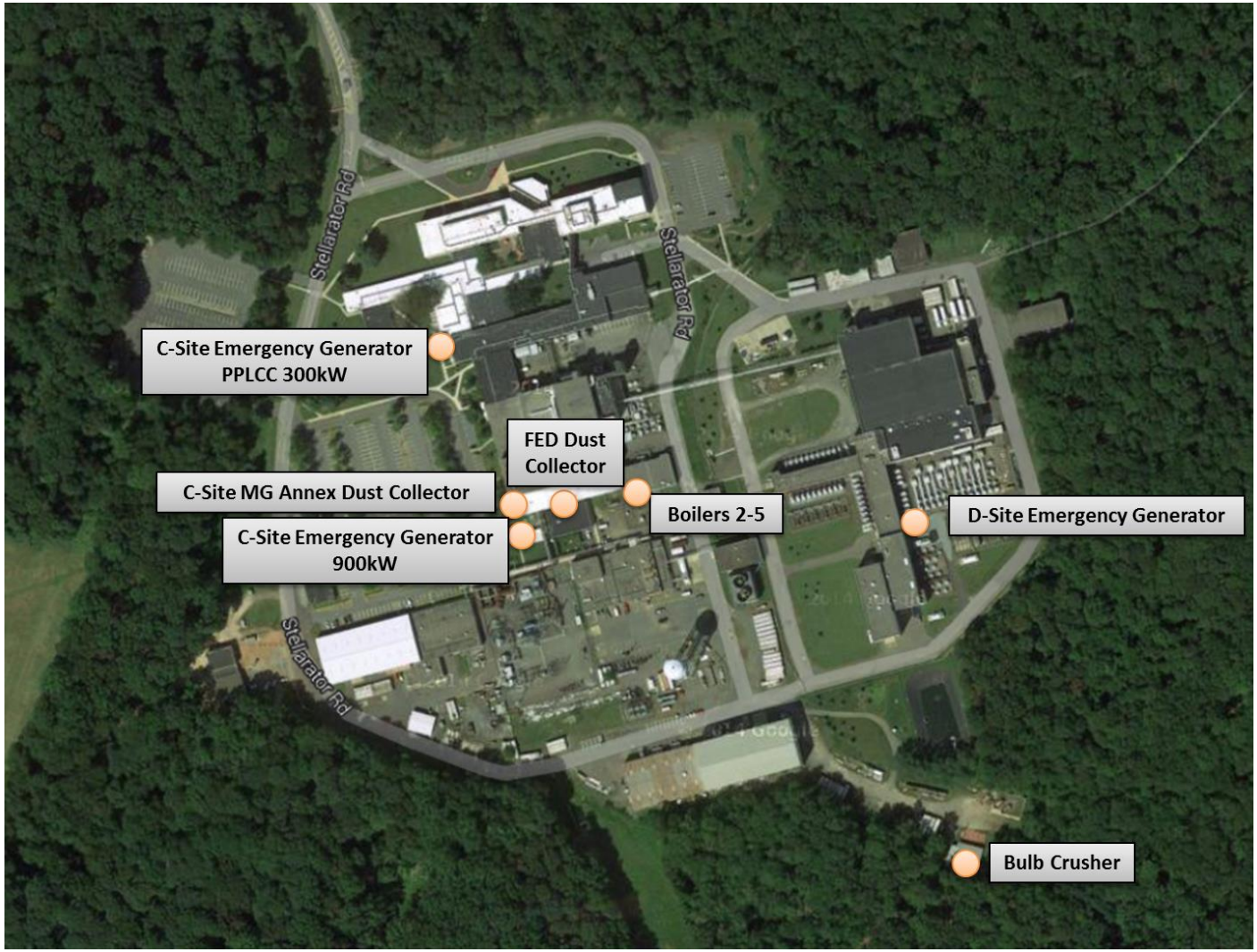


Figure 5. PPPL Air Permitted Equipment Location Map



APPENDIX B

REPORT DISTRIBUTION LIST

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