Annual Site Environmental Report

PPPL - ****

2016




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

U.S. DEPARTMENT OF
ENERGY

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List of Exhibits in Text

NOTE: ***Data tables are located in Appendix A - 2016 Tables beginning on page 73.***
All tables as noted in the report are located in Appendix A.

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
$\mu g/L$	micrograms per liter

Princeton Plasma Physics Laboratory (PPPL)
Certification of Monitoring Data for
Annual Site Environmental Report for 2016

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 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 2016," are documented and certified to be correct.

Signed:

Virginia L. Finley

Digitally signed by Virginia L. Finley
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Approved:

Jerry D. Levine

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Executive Summary

Princeton Plasma Physics Laboratory

Annual Site Environmental Report for

Calendar Year 2016

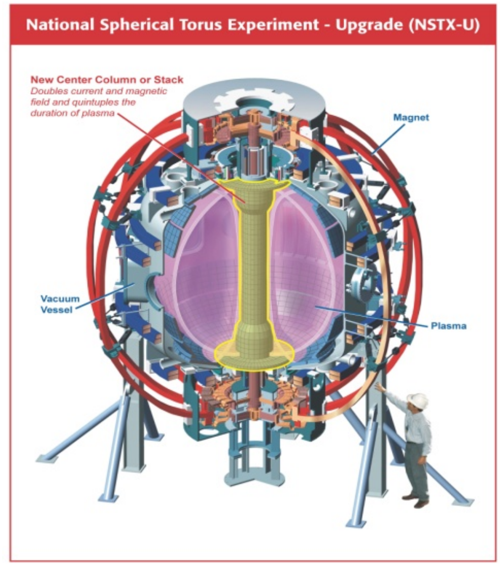
This report presents the results of environmental activities and monitoring programs at the Princeton Plasma Physics Laboratory (PPPL) for Calendar Year 2016. The report provides the U.S. Department of Energy (DOE) and the public with information on the level of radioactive and non-radioactive pollutants, 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 2016. 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.* an ionized gas, fuse or join forming helium atoms thus 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

2016 marked the eighteenth year of the National Spherical Torus Experiment (NSTX). Completed in 2015 at a cost of $94 million, the NSTX upgrade project, 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.

In drawing on the right, the vacuum vessel is spherical in shape; the person standing to the right of the base illustrates the scale of this device. The new center column or stack shown in a yellow outline, are two magnets bound together – one contains vertical copper bars creating a magnetic field up and down the stack. The other is a coil wound around the center that drives a magnetic force or current through the plasma, which produces round-shape plasmas. The new center stack design will increase the field strength to one tesla - or 20,000 times the strength of Earth's magnetic field. The magnetic field generated by the polodial field coils is used to control the plasma shape within the vacuum vessel. For the NSTX research collaborators from 28 U.S. institutions and 11 other countries, the project is a major effort to produce a smaller, more economical fusion reactor that addresses some of fusion's unanswered questions.



The second neutral beam line injects neutral atoms, deuterium (hydrogen isotope with one neutron), into the ionized gas or plasma causing the plasma to heat to temperatures on the order of 100 million degrees. The plasma is also heated by radio-frequency waves and together with the neutral beam injection, allows for greater heat capacity and hotter experimental plasmas.

U.S. Secretary of Energy Moniz Dedicates NSTX-U

On May 20, 2016 in a dedication ceremony, Secretary Ernest Moniz presented a plaque to NSTX-U team. He, U.S. Senator Cory Bookman, U. S. Rep. Bonnie Watson-Coleman, Princeton University President Christopher Eisgruber, and several other officials toured the NSTX-U test cell. The dedication celebrated the completion of a challenging construction project and was believed to be the start of NSTX-U's research activity.

7
Due to disruptions to NSTX-U caused by two minor events in 2015 (2) and three additional events in 2016, the experiment did not operate for second half of 2016. The causes for the disruptions to a major coil (poloidal field coil known as PF1A) and the center stack structure are under investigation. Design verification and validation reviews are underway in 2017.

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 set 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.

PPPL Maximum Off-site Dose in 2016

When the total maximum off-site dose for 2016 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 as measured in mrem/year and person-Sieverts per year (Sv/year) for 2016 were:

1. *Maximum exposed individual (MEI) dose from all sources—airborne and liquid releases—was 4.94×10^{-3} mrem per year (4.94×10^{-5} person-Sv/year).*
   In
2. *The collective effective dose equivalent for the population living within 80 kilometers was 0.104 person-rem (1.04×10^{-3} person-Sv).*

Infrastructure and Operation Improvements (IOI) Project

In 2016, PPPL continued the campus-wide project for improvements to the existing facilities by renovating and modernizing office and storage space and 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. Work began in 2015 with the removal of obsolete equipment and systems in the C-site motor generator (MG) building. A survey of building interiors found legacy polychlorinated biphenyls (PCB) contamination on surfaces, which were either cleaned or removed. The second phase continued into CY2016 with office, meeting, technical and storage area renovations that are expected to be completed in CY2018.

Princeton Plasma Physics Laboratory hosted the 2016 Technology of Fusion Energy (TOFE) conference in Philadelphia.

- The four-day conference sponsored by the American Nuclear Society brought together; about 180 engineers, scientists and students from national laboratories and institutions gathered from across the US and around the world.
- PPPL researchers presented talks and chaired technical sessions on fusion energy, spherical tokamaks, and safety accident analysis.

PPPL Environmental Achievements and Activities in 2016

PPPL encourages its employees to practice environmental stewardship and sustainability 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.

An independent registrar company, UL-DQS, evaluated PPPL's Environmental Management System (EMS) program comparing it with the International Standards Organization or ISO 14001 program in late 2014. This audit concluded that PPPL's EMS program is compliant with the ISO standard, and in 2015, PPPL received ISO recertification. The auditors cited nine strengths and improvement potentials, seven recommendations, and no audit findings. An example of a strength is the clarity and readability of the six page "Summary of Legal and Other Requirements Matrix", Appendix B of PPPL's Environmental Management System Program, that maps the requirements with the lead organization, PPPL's applicable document(s), and the associated compliance assessment [PPPL16b]. An annual surveillance was conducted in January 2016, enabling continued certification to the ISO-14001 standard.

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

Introduction

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, and providing the highest quality of scientific education. Our vision is "To create the innovations which will make fusion power a practical reality".

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 with the primary mission 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 (NSTX) 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 2016, PPPL collaborated with other fusion research laboratories across the globe on the Joint European Torus (JET) facility located in the United Kingdom, the Experimental Advanced Superconducting Tokamak (EAST) reactor in China, 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

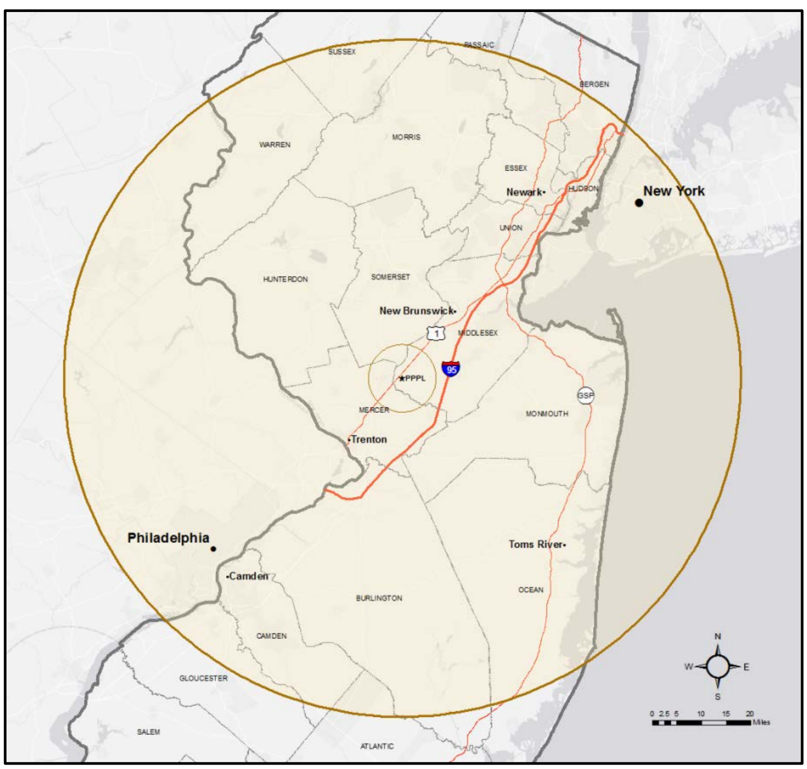
Experiment Upgrade project (NSTX-U), began in 2011 and was completed in early 2016. After running for a few months it was taken offline due to coil operational issues and for necessary technical improvements. The target date for resumption of operations has not been established.

1.2 Site Location

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

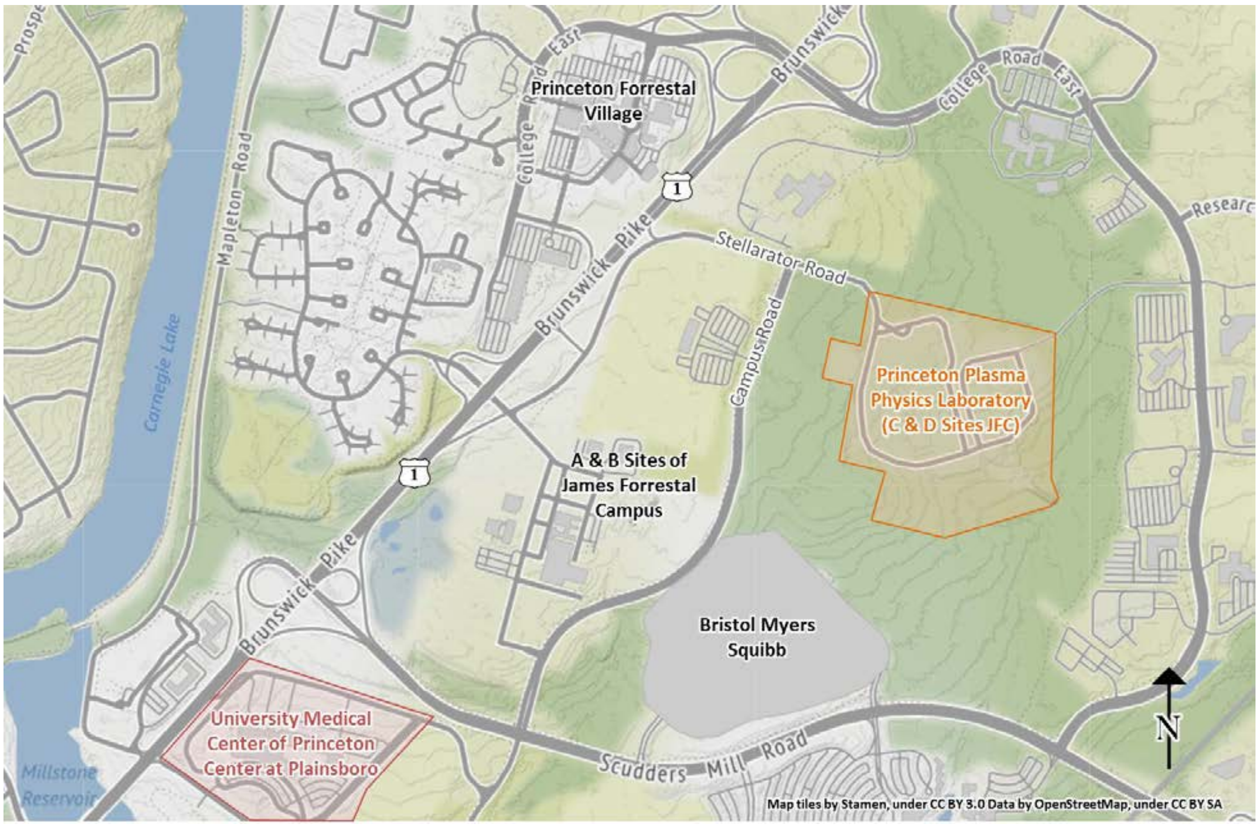
The site is located in Plainsboro Township in Middlesex County (central New Jersey), adjacent to the municipalities of Princeton, Kingston, East and West Windsor, and Cranbury, NJ. The Princeton area continues to experience a sustained growth of new businesses locating along the Route 1 corridor near the site. Recently, new commercial buildings were constructed on Campus Drive, about a mile South-West of PPPL, and development of new buildings is ongoing. Also, the University Medical Center of Princeton Center at Plainsboro is located less than 2 miles Southwest 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 since 1959 (Exhibit 1-2). The alphabet designation was derived from the names given to the Stellarator models, those early plasma fusion devices, as named by Lyman Spitzer, founder of PPPL.

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



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

D-site is fully surrounded by a chain-linked fence topped with barbed wire for security purposes. Access to D-site is limited to authorized personnel through the use of card readers. PPPL's Site Protection Division controls access to C-site allowing the public and visitor access following an identification check. Vehicle inspections 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- and D-sites of JFC as viewed from the North-East; 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 2016 temperatures ranged from 4 degrees to 97 degrees Fahrenheit (°F) (-15.5°Celsius (C) to 37.1° C); the average departure from normal temperature (1981-2010) was plus 2.3° F (+1.28° C) according to NOAA Local Climatological Data [NOAA]. Extreme temperatures typically occur once every five years. Approximately half the year, from late April until mid-October, the days are freeze-free.

The typical regional climate is moderately humid with a total average precipitation about 46 inches (116 cm) evenly distributed throughout the year. In 2016, the Central New Jersey region experienced abnormally dry to severe drought conditions for more than half the year. The total rainfall for the year was 34.8 inches (88.4 cm), or 11.2 inches (28.4 cm) below the average rainfall for central New Jersey.

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, MRX, and LTX, currently operate at PPPL. NSTX is the Laboratory's largest experiment and it is located on D-site. NSTX has produced one million amperes of plasma current, setting a new world record for a spherical torus device. This device is 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 which were finished in May 2016. The machine was operational for two months, until one of the coils failed, resulting in an operational shutdown. The upgraded experiment, known as NSTX-U, will have twice the plasma heating power and magnetic confinement and be able to extent the 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.

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 American community survey, there are 17.7 million people living within a 50 mile radius of the laboratory, totaling to roughly 2,258 people per a square mile. There are just over 100,000 people living within a 5 mile radius. The 2016 US Census Bureau Statistics estimates that Middlesex County has a population of 837,073, a growth of 3.4%. Adjacent counties have populations of 371,023 (Mercer), 625,846 (Monmouth), 333,751 (Somerset), and 555,630 (Union) [US13]. Other information gathered and updated from previous ITER studies include socioeconomic information [Be87b] and an ecological survey, which were studies describing pre-TFTR conditions [En87].

Chapter

2

2016 ENVIRONMENTAL COMPLIANCE SUMMARY and ENVIRONMENTAL STEWARDSHIP

Princeton Plasma Physics Laboratory's (PPPL) environmental goals are to fully comply with environmental regulations, to conduct our scientific research and operate our facilities in a manner protective of human health and the environment, and to promote sustainable practices wherever possible. In 2016, 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.

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 2016 compliance status and providing the ASER sections where further details are located. The list of "Applicable Environmental Laws and Regulations – 2016 Status" conforms to PPPL's Environmental Management System (EMS) Appendix B, "Summary of Legal and Other Requirements" [PPPL16b].

2.2 Site Compliance and Environmental Management System (EMS) Assessments

In 2016, PPPL's Quality Assurance (QA) Division completed and closed an internal environmental audit of PPPL's Environmental Management System (EMS). This audit included follow-up of the findings and recommendations made by UL-DQS's external audits, which is tracked through PPPL's QA Audit Database. In November 2014, UL-DQS, Inc. conducted the triennial certification audit of PPPL's EMS against the International Organization for Standards (ISO) standard 14001:2004 – "Environmental Management Systems – Requirements with guidance for use." The most recent annual surveillance audit was conducted in January 2016 without manor non-conformities [Cu17]. Further discussion of the EMS program audits follow in Section 2.3 of this chapter.

In February 2016, the Department of Energy, the Office of Science - Chicago and Princeton Site Offices (PSO) performed a Program Assessment of PPPL's National Environmental Policy Act (NEPA) program. This external review resulted in no Level 1 or 2 findings; three Level 3 findings were identified. PPPL policy required revisions to include Executive Order (EO 13693). PSO Procedure and Plans were not finalized and signed by the appropriate parties, and the NEPA Quality Plan needed more specifics about continual improvement actions that included training [DOE16].

The Hazardous Material Transportation Safety and Training assessment was performed in 2016 and all corrective actions were completed and closed [Cu17].

2.3 Environmental Permits

The following Exhibit 2.1 "Applicable Environmental Laws and Regulations –2016 Status" provides information about PPPL's compliance with applicable Federal and State environmental laws, regulations, DOE and Executive Orders.

Exhibit 2-1. Applicable Environmental Laws And Regulations – 2016 Status

Environmental Restoration and Waste Management	2016 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 2016, PPPL had no involvement with CERCLA-mandated clean-up actions. The New Jersey-regulated ground water investigation and remediation project are 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 2016, PPPL shipped 19.22 tons (T) (17.43 metric tons, MT) of hazardous waste of which 4.81 tons (4.36 MT) were recycled (25.1% recycling rate). The types of waste are highly variable each year; in 2016, majority of incinerated quantities came from batteries and fluorescent bulbs [Pue17a]. In 2016,PCB contaminated soil (8.58 T, 7.78 MT) disposed of in landfills caused an increase from 6.51 T (2015) to 19.22 T.	*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 will not 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 2016, PPPL performed NEPA reviews of 25 proposed activities, and the one NEPA review was on-hold due to project delays. Twenty-two of these activities were determined to be categorical exclusions (CXs) in accordance with the regulations/guidelines of the Council on Environmental Quality (CEQ), and two were sent to DOE and approved [Str17].	
Toxic Substance Control Act (TSCA) governs the manufacture, use, and distribution of regulated chemicals listed.	PPPL shipped in 2016, 17,949 pounds of PCB TSCA Hazardous Substances, contaminated soil from the C-site MG building renovations. Five PCB capacitors remain on-site. Asbestos shipments in 2016 were 40 cubic yards [Pue17a].	*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 [Kin17b].	*Exhibit 4- 11* *4.5.3*

Exhibit 2-1. Applicable Environmental Laws and Regulations – 2016 Status (continued)

Other Environmental Statutes	2016 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 no reportable spills in 2016 [Pue17b].	*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].	
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].	
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 [PPPL15f]. 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 its regulated equipment: 4 boilers, 3 emergency/standby generators, 2 dust collectors, 2 above-ground storage tanks (< 10,000 gals. fuel oil) & a fluorescent bulb crusher. PPPL is designated a synthetic minor and does not exceed any air contaminant thresholds requiring a Title V permit. Submitted Subpart JJJJJJ Notice to EPA - biennial boiler adjustment. Annual 2016 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 [Nem17]. NESHAPs report for tritium emissions are submitted annually [PPPL17b]. PPPL maintains an inventory for ozone-depleting substances (ODS)/ greenhouse gas (GHG) emissions [Ger17]	*4.4*

Exhibit 2-1. Applicable Environmental Laws And Regulations – 2016 Status (continued)

Other Environmental Statutes	2016 Status	ASER section(s)
NJ Soil Erosion and Sediment Control (SESC) Plan requires an approval by the Freehold Soil Conservation District for any soil disturbance greater than 5,000 sq. feet.	No activities requiring soil erosion permits were conducted in 2016.	*4. 5.2*
NJ Comprehensive Regulated Medical Waste Management governs the proper disposal of medical wastes.	Last report submitted to NJDEP in 2004; no longer required to submit report, but continues to comply with proper disposal of all medical wastes [Pue17a].	
NJ Endangered Species Act (ESA) 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 [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 [PPPL17a].	*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 tritium, gross beta, pH, total residual chlorine (Chlorine-produced oxidants- CPO) and temperature. NJDEP Office of Quality Assurance conducted an audit in May 2015 [NJDEP15]. PPPL subcontractor analytical laboratory is a NJDEP certified laboratory.	*7*

Exhibit 2-1. Applicable Environmental Laws and Regulations – 2016 Status (continued)

Water Quality and Protection	2016 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 cross connection system as required by the NJDEP permit. Potable water is supplied by NJ American Water Company [Mor17].	*4.1.4 A* *Exhibit 4-4*
Stormwater Management and the Energy Independence and Security Act of 2007 (EISA) **and** **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 [PPPL15e]. 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 [NJDEP13a, PPPL13e]. For 2016, PPPL reported two non-compliances at DSN001 (both were chlorine-produced oxidant (CPO) limit exceedances in June and August), the basin outfall; no permit limits at DSN003, the D&R Canal pump house backwash filter outfall were exceeded in 2016 [Fin17c].	*4.1.1* *Exhibits 4-1, 4-2, 4-3 and 4-5*

Exhibit 2-1. Applicable Environmental Laws And Regulations – 2016 Status (continued)

Regulatory Program Description	2016 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.	In 1990, ground water monitoring of volatile organic compounds (VOCs) began at PPPL. 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 annually to NJDEP [NJDEP13b, PPPL13c].	*6.5*
Executive Order (E.O.) 11988 – Floodplain Management **and** **E.O. 11990 – Protection of Wetlands**	See Floodplain Management Program (NJ delegated program) and Wetlands Protection Act (NJ delegated program)	
Migratory Bird Treaty Act (MBTA) **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 2016, 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) originally was prepared in 2005 and is reviewed and updated annually [DOE11a, PPPL16b, & 17c]. PPPL's EMS is registered to the ISO14001 standard by an independent registrar (UL-DQS) based on annual audits [UL17].	3

Exhibit 2-1. Applicable Environmental Laws and Regulations – 2016 Status (continued)

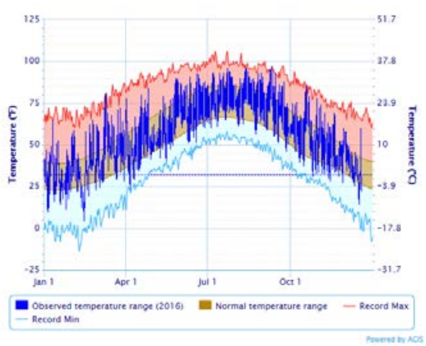
Radiation Protection	2016 Status	ASER section(s)
DOE Order 435.1, Change 1, *Radioactive Waste Management*, provides guidance to ensure that DOE radioactive waste is properly managed to protect workers, the public and the environment.	PPPL maintains a Low-Level Radioactive Waste Program Basis document 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, PPPL15h]	*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 [PPPL13b].	*5.2*

Executive Order (EO) 13693, *Planning for Federal Sustainability in the Next Decade* requires all federal agencies maintain Federal leadership in sustainability and greenhouse gas emission reductions, work to build a clean energy economy, promote building energy conservation, efficiency, and management ,promote use of energy from renewable sources, conserve water, improve waste minimization, purchase sustainable products, implement an environmental management system .	PPPL prepared the 2017 Site Sustainable Plan that addressed the goals, targets and status of EO 13693 requirements [EO15 & PPPL16c & d].	*3*

During the months from March through, November 2016, the New Jersey Department of Environment declared thirty-five (35) days as Unhealthy for Sensitive Groups. NJDEP Bureau of Stationary Sources determines each day the Air Quality and issues an "Daily Air Quality Forecast – Action Days," when ozone, particulates or other air pollutant concentration is above the Air Quality Standards .

1. *In 2016, the spring and fall temperatures were relatively mild while the summer air temperatures were on the high side of normal.*

Daily Temperature Data – Trenton Area, NJ (ThreadEx)



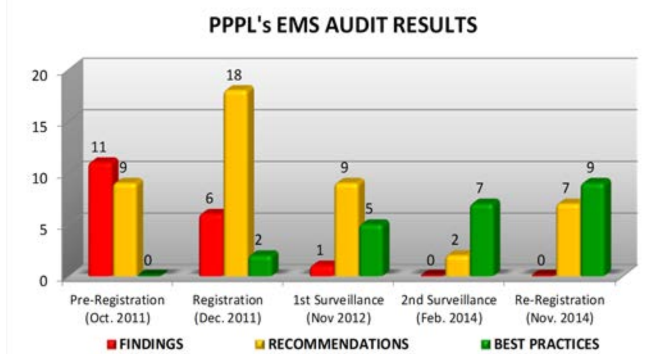
2. *PPPL monitors the NJDEP Daily Air Forecast especially when the weather is hot and humid. Three of PPPL's emergency generators (stand-by) cannot operate for maintenance or testing during a forecast Action Day without penalty.*

2.4 External Oversight and Assessments

In 2016, the International Standards Organization 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]

Exhibit 2.2 EMS Audit Results October 2011 to November 2014



In November 2014, the Laboratory's EMS program underwent a comprehensive audit for re-certification of its program. 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. No releases of hazardous substances or petroleum hydrocarbons on pervious surfaces required notification to New Jersey's Action Hotline during 2016.

2.6 Notice of Violations and Penalties

There were no notices of violations or penalties for environmental occurrences at PPPL during 2016 [Fin17c].

2.7 Green and Sustainable Remediation (GSR)

The requirements of E.O. 13693 and DOE's 2016 Strategic Sustainability Performance Plan incorporate green and sustainable remediation practices [EO15, DOE15]. 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's climate change risks are limited. Our preparedness plans include local and regional severe 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

2.9.1 Earth Week 2016

During the third annual Earth Week site-wide clean-up, twenty 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, 220 pounds of trash, and recyclable or compostable material were collected from the site. Site-wide office clean-ups yielded the recycling of 3,100 pounds [Kin16a].

Celebrating Earth Day at PPPL, "Trees for the Earth. Let's get planting" was the theme of PPPL's 2016 Earth Day/Week box). On April 27, 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,

Exhibit 2.3 PPPL's 2016 Earth Week

EARTH DAY 2016

and electronic waste removal companies. PPPL employees recycled 675 lbs. of electronics from their homes. [Kin16a]

Each year, employees nominate their co-workers for their exceptional efforts to minimize waste, improve energy efficiency, and promote sustainable practices at PPPL. Thirty employees received the 2015 PPPL Green Machine Awards for the following projects:

- Material Services programs have facilitated re-utilization or acquisition of over 3400 items of excess property.
- An employee has the spirit of an environmental steward par excellence.
- An employee rides his bicycle or drives an electric car to PPPL – a truly Green employee."
- An Infrastructure Operations Improvement (IOI) project recycled over 3000 tons of concrete and 58 tons of steel that avoided landfilling of 1836 cubic yards.
- A team of engineers and technicians uupgraded Power-in-a-Box project -a deployable renewable energy source in a portable shipping container equiped with solar panels and awind turbine.

In 2016, PPPL launched the "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 and Green Machine Awardee

Following the Green Machine awards presentations, a mini-movie, "The Story of Stuff," was viewed during lunch time by employees who enjoyed a cupcake or a dirt cup (chocolate pudding with gummy worms).

Exhibit 2-5. PPPL's Earth Week Poster

The 2016 Earth Day colloquium speaker, Dale Jamieson, Professor of Environmental Studies and Philosophy, College of Arts & Sciences, New York University, presented a talk on "Living with Climate Change: the Road from Paris." The 21st Conference of the Parties (COP21) of the United Nations Framework Convention on Climate Change (UNFCCC) (aka the Paris Agreement) met in Paris where an outcome is known to some as "the world's greatest diplomatic success" and to others as "too weak" and "full of false hope." The sustained economic and political behavior of the peoples of the world will be"… the only sure path to making the objectives of the Paris Agreement a reality." (D. Jamieson, 2016)

Exhibit 2-6. Earth Week's Green Machine Recipients

2.9.2 American Recycles Day at PPPL

Each year PPPL celebrates America Recycles Day (ARD, officially November 15th). In 2016, 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 – 1st place "Staying Alive" disco sphere made out of clear recyclable cups, 2nd place Recycling Radio, and 3rd place "Power Plant."

Exhibit 2-7. ARD Electronics Poster

Exhibit 2-8. ARD Art Contest Winners

ARD activities included employee electronics recycling 2,095 pounds, sign-up pledges to recycle more, Terracycle boxes for recycling miscellaneous items, and the collection of clothing (1150 pounds in 2016 *vs*. 360 pounds in 2015) in support of Princeton University’s clothing drive for the Trenton Rescue Mission [Kin16b].

2.9.3 Environmental Awards

This award is the third award the Laboratory received from a Federal Agency. PPPL received a Gold Green Buy award – its fourth such award in six years – from the Department of Energy (DOE) for its Green Purchasing program. Another EPA award, Food Recovery Challenge for Fiscal Year 2015, was given to PPPL for its composting program.

Exhibit 2-9. PPPL Accepting EPA Award

US Environmental Protection Agency

Recognizes PPPL for its outstanding waste management program with its 2016 Federal Green Challenge Regional Award for reducing waste from landfills by recycling 84% in Fiscal Year 2015 and 97% in Fiscal Year 2016

Chapter

3

Environmental Management System

> The DOE Princeton Plasma Physics Laboratory's Environmental Management System (EMS) program was certified ISO:14001 compliant first in 2011 and was recertified again in late 2014. Each year PPPL is audited by an external auditing agency, which certifies our EMS to the ISO:14001 standard. PPPL's EMS program is accessible online for employees and the general public to view.

PPPL has made progress toward the sustainability goals established by Presidential Executive Orders (EO) 13693 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, 16b, & 17c]. PPPL will continue to implement sustainable environmental practices aimed at meeting or exceeding the sustainability goals in its EMS, DOE Orders, and Executive Orders [EO15].

PPPL's annual surveillance audit of its Environmental Management System against the International Standard Organization ISO-14001:2004 was completed in January 2017. No findings were identified, but the auditor identified one opportunity for improvement and seven best practices.

3.1 DOE Sustainability Goals

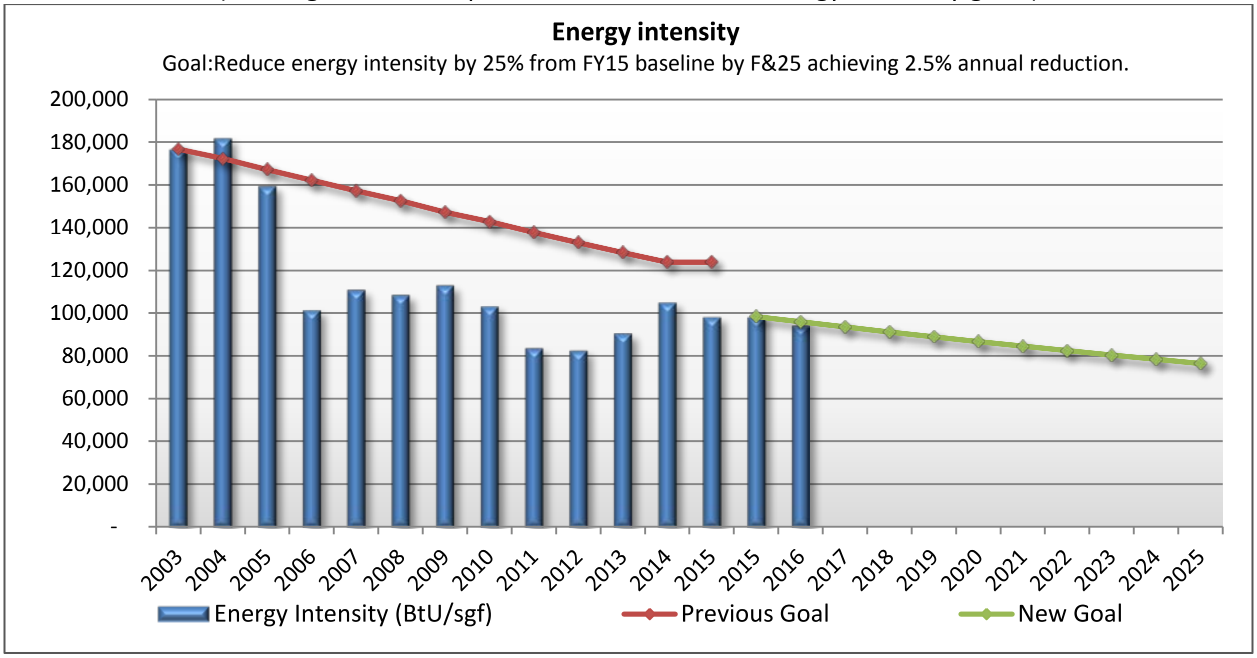
In 2016, PPPL worked to incorporate the new sustainability and greenhouse gas management goals of EO 13693, *Planning for Federal Sustainability in the Next Decade*. PPPL completed its annual *Site Sustainability Plan*, which summarized progress and outlined future plans for meeting the departmental sustainability goals under EO13693, and submitted the *Comprehensive Energy Data Report (CEDR)* and *Site Sustainability Plan* reports detailing our energy and environmental performance [PPPL16c & 16d, respectively].

3.1.1 Energy Efficiency

In 2016, PPPL achieved a reduction of 44.5% in energy intensity (British Thermal Units per gross square feet, BTU/gsf) for non-experimental energy use compared to the 2003 baseline year (see Exhibit 3-1). This value represents a modest decrease from 2014. 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 & green lines represents annual Federal energy efficiency goals)

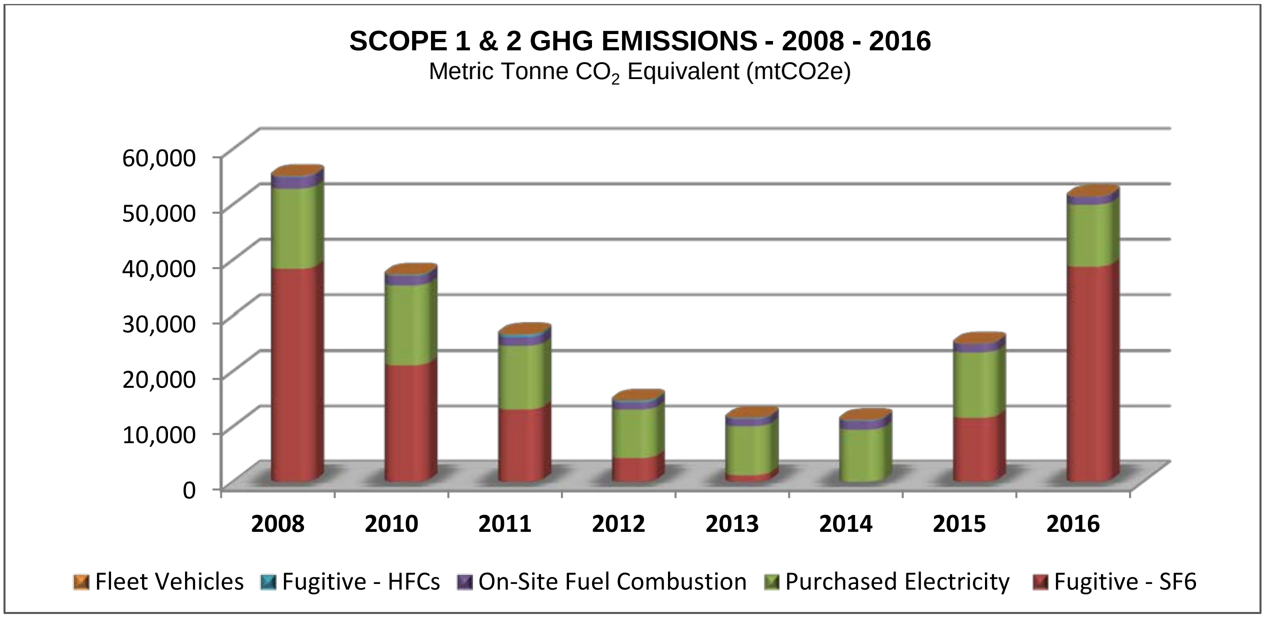


PPPL continues to emphasize energy management as part of its facility operations and to leverage the success in non-experimental energy management to improve experimental efficiency where practicable. For example, PPPL continues to carefully manage its central steam and chilled water plant to maximize efficiency and minimize greenhouse gas emissions. PPPL utilizes high-efficiency light-emitting diode (LED) lighting for office/space renovations and continues to evaluate and implement other energy efficiency projects.

3.1.2 Renewable Energy

PPPL and DOE-PSO have pursued various on-site renewable energy generation projects for as much as 40% of non-experimental energy use over a number of years. The Energy Savings Performance Contract (ESPC) proposal received in FY08 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. PPPL is pursuing other opportunities for bundled energy efficiency and renewable energy projects through ESPCs and other alternative financing options. We will continue to purchase renewable energy credits (RECs) to meet our 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. In FY2016 PPPL purchased 2,760,000 kWh Renewable Energy Credits to offset 9.6% of total electrical energy used.

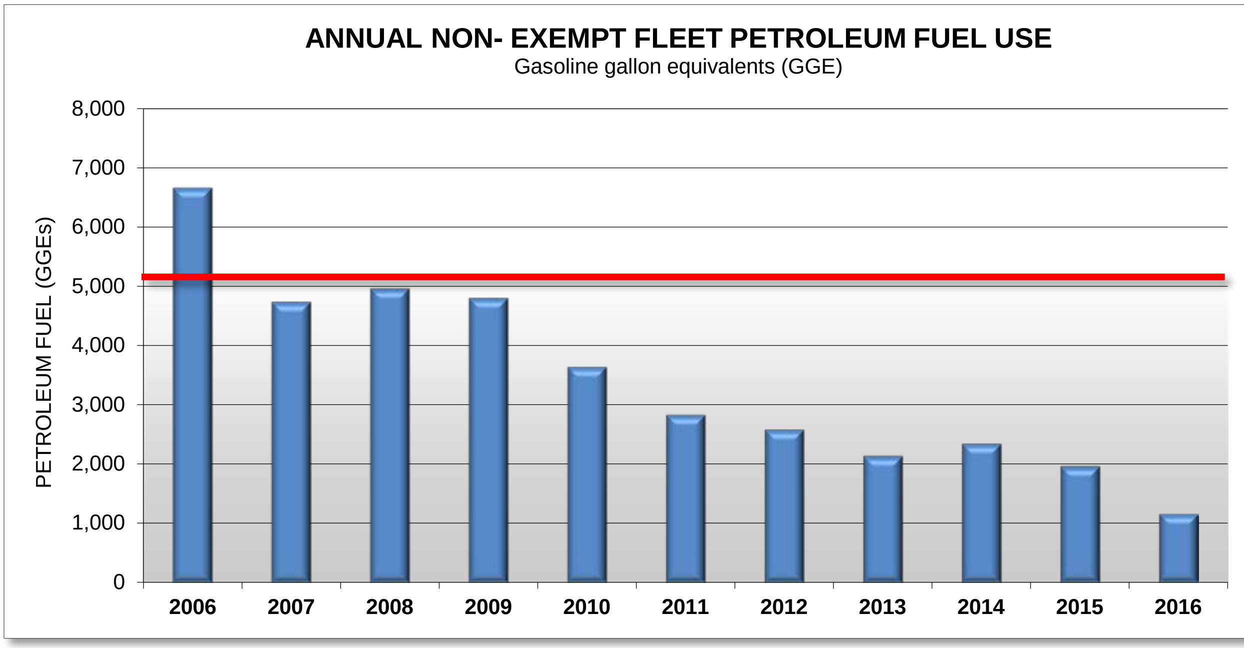
Exhibit 3-2. Summary of PPPL Scope 1 & 2 GHG Emissions between 2008 and 2016 (mtCO2e)



3.1.3 Greenhouse Gas Emissions

Between 2008 and 2015, PPPL made significant reduction is its Scope 1 and 2 greenhouse gas (GHG) emissions. Start-up and commissioning of the NSTX-U experiment in late 2015 and early 2016 resulted in a significant increase in fugitive losses of sulfur hexafluoride (SF_6), a potent GHG that is a highly effective high voltage insulator (see Exhibit 3-2). Future SF_6 losses are expected to be less than 2016, and PPPL is examining low GHG-potential materials that may be substituted for SF_6. PPPL continues to focus on GHG reductions by reducing 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.

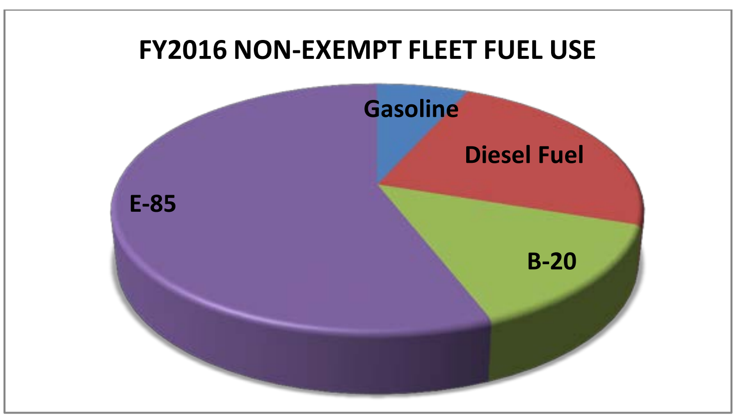
Exhibit 3-3. Annual Non-Exempt Fleet Petroleum Fuel Use between 2005 and 2016
(Red line indicates the Federal energy efficiency goal set for 2020)



3.1.4 Fleet Management

In 2016, PPPL's fleet petroleum fuel use was approximately 85% below 2005 levels (see Exhibit 3-3) and 70% of PPPL's total non-exempt fleet fuel use consisted of the alternative fuels E-85 and B-20 (see Exhibit 3-4).

Exhibit 3-4. FY2016 Non-Exempt Fleet Fuel Use by Type

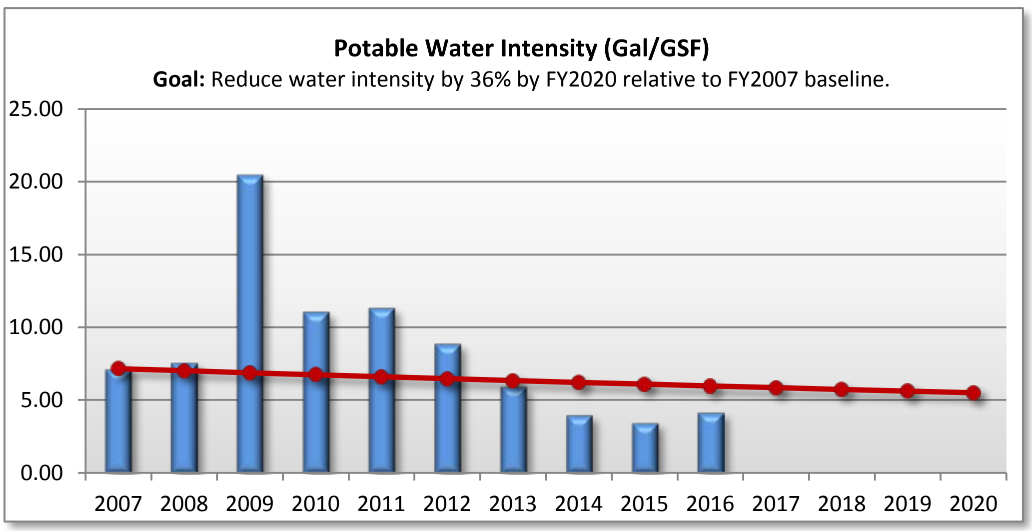


PPPL continues to exceed the goal for 75% acquisition of alternative fuel vehicle (AFV) for light duty vehicles. PPPL specifies only AFVs as replacement lease vehicles through the GSA whenever a suitable AFV is available. PPPL's fleet includes gasoline-electric hybrid vehicles, alternative fuel vehicles - Ethanol 85% (E-85) or biodiesel 20% (B-20) - and petroleum-fueled (gasoline & diesel) vehicles. In addition to the use of alternative fuels in its covered fleet vehicles, PPPL uses B-20 in several pieces of heavy-mobile equipment, including a 15-ton forklift, backhoe, and skid steer loader. PPPL's fleet of diesel utility vehicles runs exclusively on B-20. Following B-20 pilot testing in FY2007 and 2008, PPPL expanded its on-site fleet refueling station to support the storage and dispensing of E-85 and B-20 fuels.

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 approximately 80% between 2000 and 2015 and its water intensity, measured in gallons per square foot of building space annually (see Exhibit 3-5). PPPL currently uses less than 4 gallons of potable water per square foot of building space annually, a reduction of 41% 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 a number of years, as the largest water efficiency opportunities have likely already been addressed.

Exhibit 3-5. 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 building space meet the Guiding Principles for High Performance and Sustainable Buildings. The certification expired in April 2016 and there are no plans to re-certify. All actions taken to achieve are still in place and the building energy consumption is metered and accounted.

Within its overall campus modernization plan, PPPL prioritizes infrastructure projects on those buildings with the greatest potential for meeting the Guiding Principles, 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 are being incorporated into PPPL's operating expenses (PPPL Budget OPEX) and general plant projects (GPP) overall campus modernization plans.

3.3 Sustainability Awards

PPPL has demonstrated its commitment to sustainability through its mature environmental stewardship programs. PPPL is often consulted by DOE Laboratories and other organizations for advice and experience in sustainable environmental performance. PPPL has recognized by the Green Purchasing Council with the 3-Star EPEAT Purchaser Award for the past three years, representing our strong commitment to purchasing of EPEAT-certified electronics. We have also received awards from the DOE GreenBuy program and Federal Green Challenge.

Exhibit 3-6. 2016 DOE Sustainability Goal Summary Table for PPPL

SSPP Goal #	DOE Goal	Performance Status through FY 2016	Planned Actions & Contribution	Risk of Non-attainment
Goal 1: Greenhouse Gas (GHG) Emission Reduction				
1.1	50% Scope 1 & 2 GHG reduction by FY 2025 from a FY 2008 baseline (2016 target: 22%)	**IN PROGESS** FY16 GHGs down 6% from baseline	Renewed emphasis on SF_6 management and overall energy efficiency	Moderate
1.2	25% Scope 3 GHG reduction by FY 2025 from a FY 2008 baseline (2016 target: 7%)	**IN PROGESS** FY16 GHGs up 18% from baseline	Focus on telework and employee commuting; continue to emphasize energy efficiency and business travel	Moderate to high. Ongoing international research emphasis & employee growth put upward pressure on Scope 3 GHGs
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	**ON TARGET** Met FY16 target	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** 100% of covered buildings had Type 1 audit in FY15	25% of buildings will be evaluated in 2017	NA
2.3	Meter all individual buildings for electricity, natural gas, steam and water, where cost-effective and appropriate	**MET**	Additional sub-metering as cost-effective and programmatically appropriate	Moderate. Current utility configuration doesn't allow building-level metering.
2.4	At least 17% (by building count or gross square feet) of existing buildings greater than 5,000 gsf are compliant with the Guiding Principles (GPs) of HPSB by FY 2025, with progress to 100% thereafter	**MET** Using gross square feet (GSF) option	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

Exhibit 3-6. 2015 DOE Sustainability Goal Summary Table for PPPL

SSPP Goal #	DOE Goal	Performance Status through FY 2016	Planned Actions & Contribution	Risk of Non-attainment
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.	**NONE**	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	**NONE**	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: Percentage of an agency's total electric & thermal energy accounted for by renew-able and alternative energy shall be not: < 10% in FY 2016-2017, working towards 25% by FY 2025 (2017 target: 10%).	**ON TARGET**	Continue purchasing RECs and evaluate ESPC/PPA opportunities	Moderate.
3.2	"Renewable Electric Energy" Renewable electric energy account for not less than 10% of a total agency electric consumption in FY16-17, working towards 30% of total agency electric consumption by FY 2025. (2017 target: 10%)	**MET** Purchased RECs to meet goal.	Continue purchasing RECs and evaluate ESPC/PPA opportunities	NA
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 (2016 target: 18%)	**EXCEEDED**	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 (2016 target: 12%)	**IN PROGRESS** Exceeded goal in FY11-14. FY16 water use exceeded goal level	Mission-critical operational use of industrial water caused increase in FY16. Will continue to seek and maximize opportunities to reduce industrial water use.	Moderate. Additional water conservation opportunities are limited.

Exhibit 3-6. 2016 DOE Sustainability Goal Summary Table for PPPL

SSPP Goal #	DOE Goal	Performance Status through FY 2016	Planned Actions & Contribution	Risk of Non-attainment
Goal 5: Fleet Management				
5.1	30% reduction in fleet-wide per-mile greenhouse gas emissions reduction by FY 2025 from FY14 baseline. (2016 target: 3%)	**EXCEEDED** FY16 total fleet GHG intensity down 55% from baseline	Continue to manage fleet composition and emphasize alternative fuel use.	Low. Dashboard data not accurate.
5.2	20% reduction in annual petroleum consumption by FY2015 relative to a FY05 baseline; maintain 20% reduction thereafter. (2016 target: 20%)	**EXCEEDED**	Continue to manage fleet composition and emphasize alternative fuel use.	NA
5.3	10% increase in annual alternative fuel consumption by FY15 relative to a FY05 baseline; maintain 10% increase thereafter. (2016 target: 10%)	**EXCEEDED**	Continue to manage fleet composition and emphasize alternative fuel use.	NA
5.4	75% of light duty vehicle acquisitions must consist of alternative fuel vehicles (AFV). (2016 target: 75%)	**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. (2016 target: 4%)	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 BioPreferred and biobased provisions and clauses are included in 95% of applicable contracts.	**MET**	Continue to integrate sustainable acquisition information into applicable contracting documents.	NA
Goal 7: Pollution Prevention & Waste Reduction				
7.1	Divert at least 50% of non-hazardous solid waste, excluding construction and demolition debris.	**EXCEEDED** FY16MSW recycling rate was 69%%	Continue existing programs and expand as appropriate.	NA

Exhibit 3-6. 2015 DOE Sustainability Goal Summary Table for PPPL

SSPP Goal #	DOE Goal	Performance Status through FY 2016	Planned Actions & Contribution	Risk of Non-attainment
7.2	Divert at least 50% of construction and demolition materials and debris.	**EXCEEDED** FY16 C&D recycling rate was 97.1%	Continue existing programs and expand as appropriate.	NA
Goal 8: Energy Performance Contracts				
8.1	Annual targets for performance contracting to be implemented in FY2017 and annually thereafter as part of the planning of section	**ON TARGET**	Currently investigating combined heat & power (CHP) opportunity and DOE AFFECT program.	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	**MET** All eligible printers default to duplex	Specify purchase of duplex-capable networked printers as older units are retired.	NA
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
2.7	Data Center Efficiency - Power Usage Effectiveness (PUE) target in the range of 1.2-1.4 for new data centers and less than 1.5 for existing data centers	**IN PROGRESS** Data center PUE for FY16 was 1.57	Reviewing near-term options to improve cooling efficiency. Evaluating potential GPP project to replace existing HVAC with chilled water cooling.	Moderate. Evaluate opportunities to include data center in potential ESPC
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).		

Exhibit 3-6. 2016 DOE Sustainability Goal Summary Table for PPPL

SSPP Goal #	DOE Goal	Performance Status through FY 2016	Planned Actions & Contribution	Risk of Non-attainment
10.2	Update emergency response procedures and protocols to account for projected climate change, including extreme weather events.	Existing Emergency Plan includes various weather-related emergencies. Plan is tested and exercised during major weather events.		
10.3	Ensure workforce protocols and policies reflect projected human health and safety impacts of climate change.	Existing emergency procedures address weather-related risks. Continue to revise and update emergency procedures as necessary.		
10.4	Ensure site/lab management demonstrates commitment to adaptation efforts through internal communications and 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

Environmental Non-Radiological Program Information

The DOE Princeton Plasma Physics Laboratory's Environmental Non-Radiological program includes information about PPPL's compliance with New Jersey state and Federal 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 .

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

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 2008, NJDEP issued a *Final Surface Water Minor Modification Permit Action* report. Key changes to the permit included eliminating loading requirements, additions to the annual and semi-annual Waste Characterization Reports (WCR), and the addition of *Ceriodaphnia dubia* (water flea) to the DSN001 Chronic Toxicity test requirements [NJDEP13a].

Changes to PPPL's reporting requirements are noted in Exhibit 4-2. Under the current NJPDES permit effective October 2013, PPPL is required to provide an annual WCR for both DSN001 and DSN003. DSN001 also requires addition semiannual WCR reporting for particular metals and semi volatile organic compounds (SVOC). DSN003 is still required to complete a full WCR once per permit cycle [PPPL13a].

PPPL NJPDES compliance summary for CY2016 is presented in Exhibit 4-1 below. All permit exceedance were reported to NJDEP within the allowable time frame.

Exhibit 4-1. 2016 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	2	23	21	93.8%	6/2016 8/2016
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	16	16	100%	-
Phosphorus, total mg/L (2	Monthly	-	0	16	16	100%	-
Temperature º C	Monthly	30.0	0	16	16	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 2016

Parameter	Location	Frequency/Type	Last Completed
Discharge Monitoring Report (DMR)	DSN001, DSN003, C1	Monthly	Monthly 2016
Acute Whole Effluent Toxicity	DSN003	4 – 4.5 Years per Permit	Due Nov 2017
Chronic Toxicity (% Effluent) IC25 7 Day *Ceriodaphnia dubia* & *Pimephales promelas*	DSN001	Annual	None due in 2016
Waste Characterization Report (WCR) – Complete WCR	DSN001	Annual	None due in 2016
Waste Characterization Report (WCR) – Metals, SVOC, Chloroform	DSN001	Semi Annual	May 2, 2016 & November 11, 2016
Waste Characterization Report (WCR) - Metals	DSN003	Annual	May 3, 2016
Waste Characterization Report (WCR) – Complete WCR	DSN003	4 – 4.5 Years per Permit	Due Nov 2017

B. Acute Toxicity Study

The Acute Biomonitoring Report for the water flea (*Ceriodaphnia dubia*) was completed on March 20, 2010 for DSN003. Samples were collected for the 48-hour acute toxicity survival test, required to be performed between 4 to 4.5 years after the effective date of the permit (Exhibit 4-2). The next permitted sampling is scheduled for November 2017. The toxicity test with *Ceriodaphnia dubia* (water flea) resulted in an inhibition concentration (IC25) of >100 percent [PPPL10].

C. Chronic Whole Effluent Toxicity Study

Annual Chronic Whole Effluent toxicity testing for DSN001 was completed on November 16, 2015 (Exhibit 4-2). No Annual Chronic Whole Effluent toxicity testing for DSN001 was completed for 2016 but will take place in the first quarter of 2017, per the permit schedule. 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) [NJDEP13a, PPPL15c].

D. Waste Characterization Report (WCR)

Waste Characterization Reports (WCR) is required by NJPDES Permit for monitoring effluent conditions. Semi Annual WCR were completed twice annually in May 2, 2016 and November 11, 2016 at DSN001 (Appendix Table 25). PPPL completed DSN001 Annual WCR twice due to permit cycles not correlating with calendar years and were completed on June 7, 2015 and November 9, 2015 [PPPL15d]. As there were two DSN001 Annual WCR completed in 2015, there were no requirements for 2016. DSN003 was completed annually on May 3, 2016 [PPPL16e]. 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 [NJDEP09]. LSI Permit operates on a 5-year permit cycle, expiring on February 28, 2014. 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]. An estimated total of 97.6 million gallons annually or 262,976 gallons per day of water was discharged from the retention basin in 2016 [Fin17a].

Exhibit 4-3. PPPL Retention Basin, Flow Sensor, Discharge Gate

LSI permit requires inspection and maintenance of liner every three years. In May 2015, PPPL completed its annual 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; next inspection is due in spring 2018. In the interim, the basin condition will be monitored until its next inspection.

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 PPPL's Security Communications Center and automatically closes the discharge valve. Officers are dispatched to investigate all alarms at the retention basin. The ultrasonic flow meter measures flow from the basin; the data are downloaded monthly for NJPDES Discharge Monitoring Report (DMR). The following maintenance activities were conducted in 2016:

- Sump pump maintained and oil sensors replaced and calibrated.
- Calibrated the retention basin flow meter via certified outside vendor.
- Building automation system (BAS) delivers flow meter data electronically.

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 August 2013, NJDEP issued Groundwater Remedial Action Permit number 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 [PPPL13c]. Additional groundwater information can be found in Chapter 6.

4.1.4 Metered Water

A. Drinking (Potable) Water

Potable water is supplied by the public utility, New Jersey American Water Company. PPPL used approximately 3.21 million gallons in 2016 (Exhibits 4-4 & 4-5) [Mor17]. PPPL uses potable water as a backup resource for fire protection.

Exhibit 4-4. PPPL Potable Water Use from NJ American Water Co. [Mor17]

CY	In Million Gallons
2006	12.85
2007	3.78
2008	7.41
2009	15.57
2010	7.65
2011	8.54
2012	6.75
2013	4.52
2014	2.74
2015	2.64
2016	3.21

Exhibit 4-5. PPPL Non-Potable Water Use From Delaware & Raritan Canal [Fin17a]

CY	In Million Gallons
2006	7.90
2007	8.71
2008	7.15
2009	0.00
2010	7.35
2011	2.47
2012	4.19
2013	5.73
2014	5.14
2015	8.59
2016	10.34

B. Process (Non-potable) Water

Delaware & Raritan (D&R) Canal non-potable water is used for fire protection and process cooling *via* Physical Cross-Connection Permit 0826-WPC110001. 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 gpd and an annual limit of 54.75 million gallons [NJWSA12]. PPPL used 10.34 million gallons of non-potable water from the D&R Canal in 2016 [Fin17a].

Filtration to remove solids and the addition of chlorine and a corrosion inhibitor are the primary water treatment at the canal pump house. 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). A sampling point (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 9-15)—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 during 2016 (Appendix Table 7). Detailed radiological and discharge quantities for LEC tanks can be found in Chapter 5 "Environmental Radiological Program Information".

For 2016, PPPL estimated a total annual sanitary sewage discharge of 2.75 million gallons to the South Brunswick sewerage treatment plant [Mor17].

4.2 Non-Radiological Waste Programs

4.2.1 Hazardous Waste Programs

A. Toxic Substance Control Act (TSCA)

In CY2016, PPPL shipped 17,949 pounds of PCB waste. All contents were landfilled, recycled or incinerated in a permitted facility as TSCA Hazardous Waste [Pue17a].

B. Hazardous Waste

PPPL did not meet the threshold to submit a Biennial Hazardous Waste Generator Report to NJDEP for waste generated in CY2016. A description of Resource Conservation and Recovery Act (RCRA) compliance is found in Exhibit 2-1 of this report [Pue17a]. 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 on-site activities, which can vary 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, shows PPPL's commitment to sustainability. PPPL's only hazardous waste that is currently landfilled is asbestos. In 2016, PPPL had one 40 cubic yard dumpsters [Pue17a].

Exhibit 4-6. 2016 Waste Shipments [Pue16a]

Recycled Hazardous Waste	Pounds	Other
Recycled	9,610	-
Incinerated	11,664	-
Landfilled	17,159	40CY Dumpsters
Treated		1,778 G
Total Waste	**38,433**	**40 CY Dumpsters**

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 & Pue17b].

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 2016 [PPPL17a & Sla17].

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 [PPPL17a]. No changes were reported in PPPL's 2016 EPCRA/SARA.

SARA Title III reports included information about eleven compounds used at PPPL as listed in Exhibits 4-7and 4-8.

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 2017 [PPPL17a].

Exhibit 4-7. 2015 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			X = 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 4-8. 2015 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

PPPL reported no oil or chemical spills in CY2016. Due to New Jersey's no *de minimus* thresholds, all oil released to unpaved surfaces must be reported. If spills occur, PPPL removes the dirt and tests the soil to ensure adequate cleanup of petroleum hydrocarbons and any other chemicals [Pue17b].

4.3.3 Pollution Prevention Program

In 2015, 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 FY2016, PPPL diverted 69.0% of the municipal solid waste through single stream recycling and organic waste composting programs, exceeding DOE and EO13514 goal of 50%. This is accomplished by active participation of Laboratory employees, and the diligent attention of the custodial and other staff. PPPL's FY 2016 rate for recycling of construction materials (wood, concrete, and metal) was 97.9% by weight [Kin17a].

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 FY2016, PPPL composted 19.03 tons of food waste. A change in vendor material acceptable has led PPPL to limit compostable items in FY 2016 to only food waste and eliminate corn starch and compostable paper products from our waste stream. [Kin17a].

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, Jersey, Maryland Interconnect (PJM – electric-power grid controllers) and posted on the PJM internet website under the "emergency procedures" menu.

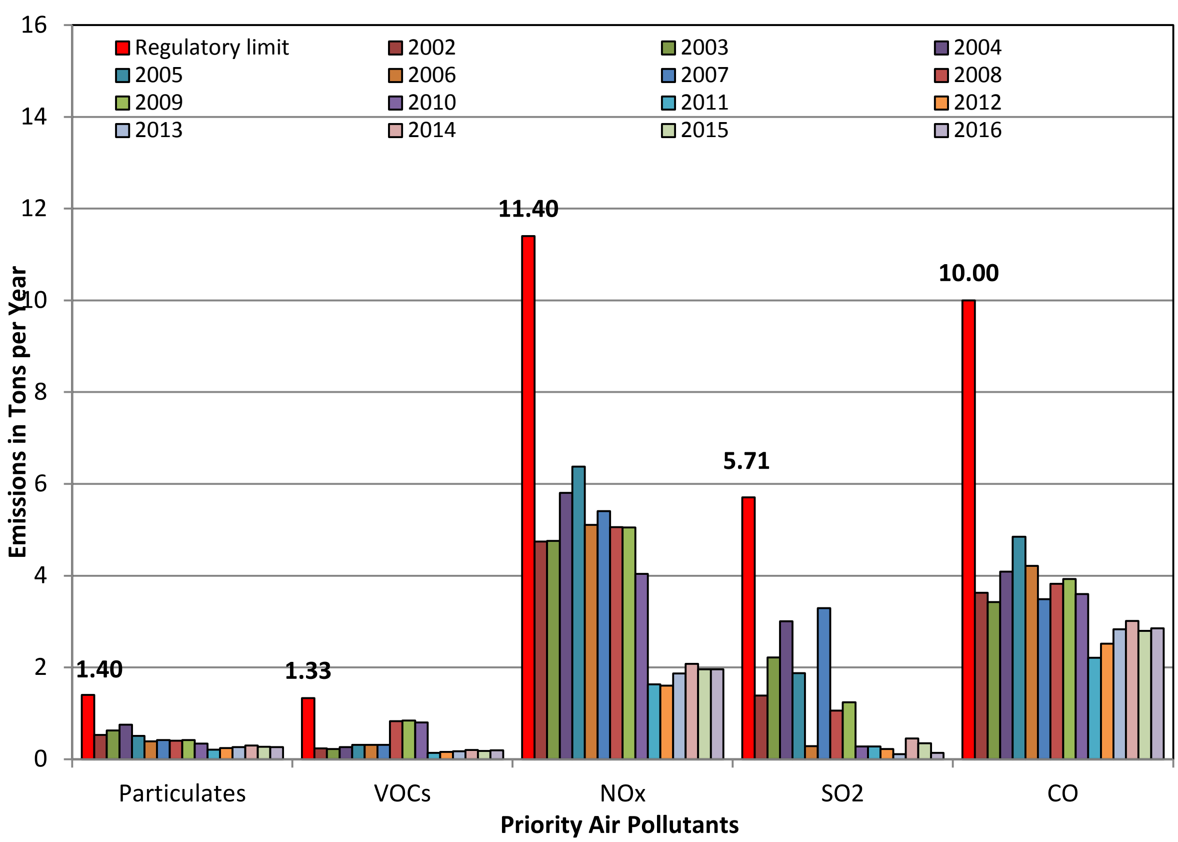
In 2008, NJDEP reduced the regulatory limits for the Criteria air pollutants for operating the boilers; PPPL's operated these four boilers were well below those limits in 2016 (Exhibit 4-10 & Appendix Table 8). With the installation of digital controls and high-efficiency, lower nitrogen oxide (NO_x) burners, the NO_x , volatile organic compounds (VOCs), particulates, sulfur dioxide (SO_2), and carbon monoxide (CO) emissions are being further reduced [Nem17].

Exhibit 4-9. PPPL's Air-Permitted Equipment

Type of Air Permit	Qty	Location	Requirements
Dust collectors	2	Facilities Woodworking shop C-Site MG Annex	Operate at 99% efficiency General Permit July 2011 (Facilities out of commission since 12/2014)
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
Diesel generators	1 2	D-site generator C-site generator	Annual Limi200of 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 4-10. PPPL's Boiler Emissions from 2002- 2016 vs. Regulatory Limits (Fin17b)

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 1st, 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 System process verifies projects do not alter vegetation within 50 feet of wetlands. Freshwater line verifications must be present on all future site development drawings [PPPL15f].

4.5.2. Soil Erosion and Landscaping

In 2015, PPPL has an open Soil Erosion Permit obtained through the Freehold Soil Conservation District. Permit No. 2014-0657 for PPPL's C-Site and D-Site Chilled Water Line was issued on 11/26/2014 and expires on 5/26/2018. Draft internal soil erosion and sediment control guidelines were for inclusion in PPPL's Engineering Standards [PPPL14a].

PPPL continued to reduce the grassed acreage that required mowing and other maintenance by planting native meadow grasses that are allowed to grow tall through PPPL's Storm water Pollution Prevention Plan [PPPL15g].

4.5.3 Herbicides and Fertilizers

During 2016, 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 certified applicators. No herbicides or fertilizers are stored on site; therefore, no disposal of these types of regulated chemicals is required by PPPL [Kin17b].

Exhibit 4-11. 2016 Fertilizer and Herbicide

Type of Material	Name of Material	Registered EPA No.	2016 Applied
Herbicide	Trimec Bentgrass Broadleaf	2217-529	261.36 Oz.
Herbicide	Quali-pro Prodiamine 4L	66222-230	96.71 Oz.
Herbicide	Roundup ProMax	524-579	828.8 Oz.
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 [PPPL15g]. 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 2016 performance with respect to worker safety is noted in Exhibit 4-12 [Lev17a].

Exhibit 4-12. 2016 PPPL's Safety Performance

Total OSHA recordable case rate[1]	Days away, restricted transferred (DART) case rate[1]
0.96	0.19
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

4.7 Fire Protection Management and Planning

PPPL manages the site using subcontractor landscapers and arborists, who remove unwanted vegetation and dead or dying trees either using powered equipment or by hand. No controlled burning has occurred on this property in 2016 or in the distant past.

4.8 Recreational Hunting & Fishing

Though PPPL is surrounded by woods and has a population of wild turkeys, deer, ground hogs and other animals, no hunting or fishing is allowed on site. PPPL's boundaries are posted no trespassing.

Chapter

5

Environmental Radiological Program Information

The DOE Princeton Plasma Physics Laboratory's Environmental Radiological program includes information about PPPL's tritium releases to the environment and as measured by dose to employees and to the public. This annual dose is calculated using air and water measurements and is 0.0049 mrem for 2016 compared to 310 mrem from natural sources.

5.1 Radiological Emissions and Doses

For 2016, the releases of tritium in air and water and the dose to the maximum exposed individual (MEI) are summarized in Exhibit 5-1. The calculated MEI is less than 0.005 milli-radiation equivalent man (mrem), far below the annual limit of 10 mrem per year [Lev17b, Rul17].

Laboratory policy states that when occupational exposures have the potential to exceed 1,000 mrem (1 rem) per year (10 milli Sievert per year, 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 2016Emissions and Doses 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 – 2.91 (1.08e11) HT - 1.67 (6.2e10)	2.1e-3 (2.1e-5)	43	0.1 (1.0e-3)
Tritium (water)	LEC tank	HTO – 1.69e-2 (6.3e8)	2.1e-4 (2.1e-6)	4	4.6e-4 (4.6e-6)
Tritium (water)	Surface Ground	1400 pCi/L (P-2) 270 pCi/L (D-MG)	2.63e-3 (2.63e-5)	53	3.60e-3 (3.60e-5)
Direct/Scattered neutron & Gamma Radiation	NSTX	1.15×10^{16} D-D neutrons	2.89e-6 (2.89e-8)	0	N/A
Argon-41 (Air)	NSTX	1.01×10^{-4} (3.7e6)	8.90e-7 (8.90e-9)	0	2.16e-6 (2.16e-8)
Total [Lev16b & Rul16]			**4.94e-3** **(4.94e-5)**	100	1.04e-1 (1.04e-3)

Bq = Bequerel
EDE = effective dose equivalent
HT = elemental tritium
DD =deuterium-deuterium
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. [NCRP Report 160, 2009)]

5.1.1 Penetrating Radiation

With the upgrade project completed in 2015, the NSTX-U reactor conducted experiments during the first 6 months of 2016 and generated neutrons though at a very low amount that did not contribute significantly to the dose totals. The upgrade project includes installation of a new center stack, new magnetic coils, additional diagnostic instruments, and a second neutral beam for heating.

5.1.2 Sanitary Sewage

Drainage from D-site sumps in radiological areas is collected in the 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 2016 showed effluent quantity and concentrations of radionuclides (tritium) to be within allowable limits established in New Jersey regulations (1 Curies per year, Ci/y for all radionuclides), the National Safe Drinking Water regulations (40 CFR 141.66 limit of 20,000 pico Curies per year, pCi/L) and DOE Order 5400.5 (2×10^6 pCi/liter for tritium) [40CFR141].

As shown in Exhibits 5-2 and 5-3, the 2016 total amount of tritium released to the sanitary sewer was 0.0169 Curies, less than the allowable 1.0-Curie per year limit. In Appendix Table 7, the tritium activity is reported; the gross beta activity ranges from 113 to 197,000 pCi/L.

Exhibit 5-2. Annual Releases to Sanitary System from Liquid Effluent Collection Tanks 2000-2015

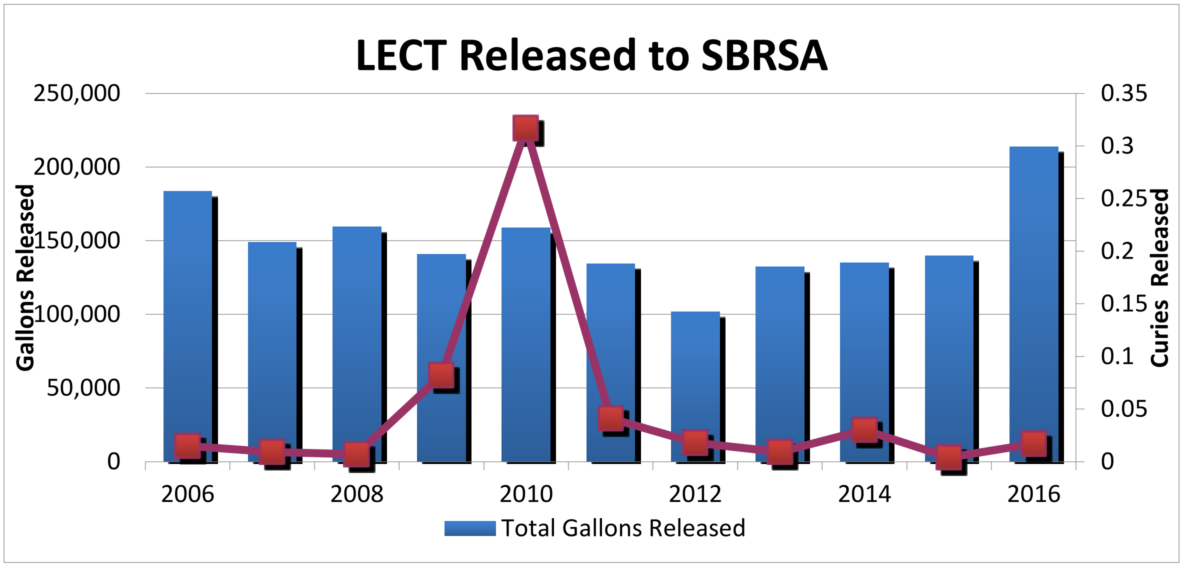


Exhibit 5-3.
Total Annual Releases (LEC tanks) to Sanitary System from 2001 to 2016

Calendar Year	Total Gallons Released	Total Activity (Curies)
2001	150,150	0.103
2002	190,200	0.453
2003	217,320	0.032
2004	223,650	0.041
2005	247,950	0.044
2006	183,657	0.015
2007	149,100	0.009
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	213,950	0.002

Exhibit 5-4.
Total Low-Level Radioactive Waste from 2001-2016

Year	Cubic meters (m^3) or Kilograms (kg)	Total Activity in Curies (Bq)
2001	565 m^3	1,288.43 (4.77×10^{13})
2002	858,568 kgs	4,950.14 (1.83×10^{14})
2003	8,208 kgs	0.03 (1.11×10^{9})
2004	4,467 kgs	0.0202 (7.48×10^{8})
2005	30.29m^3	0.01997 (7.39×10^{8})
2006	11.12m3	2.3543 (8.71 x 1010)
2007	8.6 m3	0.09285 (3.44 x109)
2008	3.63 m3	0.08341 (3.09 x109)
2009	No Shipment	No Shipment
2010	13.3	6.30270 (2.33×10^{11})
2011	15.6 m^3	0.0351 (1.30×10^{9})
2012	No shipment	No shipment
2013	34.9m^3	0.357 (1.32×10^{10})
2014	17.1	0.0082 (3.03×10^{8})
2015	No shipment	No shipment
2016	No shipment	No shipment

5.1.3 Radioactive Waste

Exhibit 5-5. B-box with Liner in RWHF for Shipping Radioactive Waste to Clive

In 2016, 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 waste to justify the transportation expense for disposal (Exhibit 5-4).

PPPL did not ship radioactive waste for disposal in 2016. Wastes are packaged for shipment and disposal in metal containers, refered to as "B-boxes" and drums (Exhibit 5-5). PPPL maintains waste profiles for LLW that is shipped off-site for burial. PPPL ships radioactive waste to the Energy Solutions facility in Clive, Utah. PPPL's radioactive waste program is audited periodically to ensure compliance with burial facility and DOT requirements. The audit includes employee training, waste characterization, waste packaging, quality control, and records retention.

5.1.4 Airborne Emission - Differential Atmospheric Tritium Samplers (DATS)

PPPL uses differential atmospheric tritium 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 0.0021 mrem/year (2.1e-5 mSv/year) in 2016 (Exhibit 5-1).

5.2 Release of Property Containing Residual Radioactive Material

Release of property containing residual radioactivity material is performed in accordance with PPPL ES&H Directives (ESHD) 5008, Section 10, Subpart L. PPPL has not released real property assets (land, Structures, etc.) for public use in the past and has no plans for such releases in the future. Current property release processes focus on person property items (equipment, materials, etc.). Property cannot be released foe 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 cm^2 . In addition, material is not released if radiation levels above background are detected when performing activation analysis per PPPL approved procedure. During 2016, 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 2016, was 270 pCi/L D-MG sump, in July (Appendix Table 4) and for surface water 1400 pCi/L at P2, and E1 (Appendix Table 5). 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" [Lev17a & 17b]. Because of these low doses, PPPL does not conduct direct biota monitoring.

5.4 Unplanned Releases

There were no unplanned radiological releases in 2016.

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 February 2016 the tritium concentration at location P-2 was 1400 pCi/L. This concentration of 1400 pCi/L was the highest for surface water sample(s) (Appendix Table 5).

In April 1988, PPPL began on-site precipitation measurements as part of its environmental surveillance program. On a weekly basis, precipitation is measured by an on-site rain gauge. The 2016 weekly precipitation amounts are shown on Appendix Table 2. Based on the average rainfall, a comparison of dry or wet years shows that 2016 was below the average rainfall total at 34.8 inches (88.4 cm), an 11.2 inches (28.5 cm) deficit from New Jersey's expected average of 46 inches (116.8cm) (Appendix Table 6).

B. Ground Water

Ground water samples are taken from five locations, two building foundation sumps: D-Site Airshaft, and D-Site MG are sampled monthly, and three on-site wells are sampled quarterly. The highest concentration of tritium in ground water was found in the D-site MG sump at 270 pCi/L in February 2016 (Appendix Table 4). These tritium concentrations are well below the Drinking Water Standard of 20,000 pCi/L. The three on-site wells used to monitor for tritium in the ground water (TW-1, TW-5, TW-8) were tested for tritium in 2016 and all were below the lowest level of detection (Appendix Table 4).

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 wells and the 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 2016, tritium concentration at this location was 180 pCi/L in February (Appendix Table 5).

5.5.2 Foodstuffs, Soil, and Vegetation

There were no foodstuffs, soil, or vegetation samples gathered for analysis in 2016. 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

Site Hydrology, Ground Water, and Drinking Water Protection

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 NJ Department of Environmental Protection. This permit requires quarterly and annual ground water monitoring that includes testing for volatile organic compounds and natural attenuation products.

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 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 [Gr 77].

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 1.5 and 2.5 feet below the surface in wet periods and drops below 5 feet during drier months.

In the slightly higher elevations (above 70 feet msl), the sandy loams are better drained and belong to the Sassafras series. Extensive historic farmlands and nurseries in the area indicate this soil provides a good environment for agricultural purposes, both today and in the past.

6.3 Biota

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

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

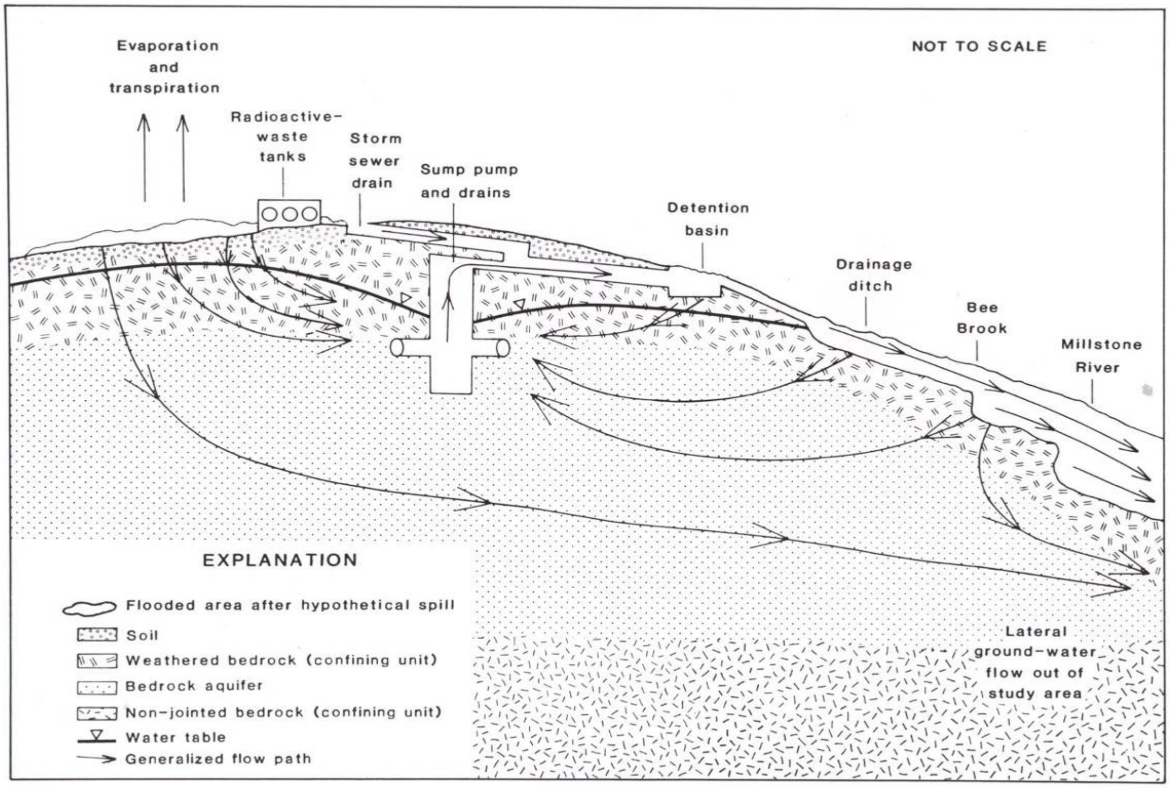
6.4 Flood Plain

All of PPPL's storm water runoff flows to Bee Brook, either directly *via* the retention basin (DSN001) or along the western swale to the wetlands south of the site. Approximately 45% of the site's total area is covered by impervious surfaces – buildings, roadways and parking lots, and storage trailers.

PPPL's Stormwater Management Plan allows for a maximum impervious coverage of 60% of the developable land. Eighteen acres of PPPL's 88.5-acre site are wetlands, 14.5 acres grass, and 18.4 acres upland forest. Gravel, which is semi-impervious, covers approximately 11.1 acres, resulting in an impervious cover (buildings, roadways, sidewalks, etc.) of 26.5 acres. PPPL's current site impervious cover is well under SWPPP's Best Management Practice of 60 percent of total developable coverage [PPPL15g & SE96].

Also, the 500-year flood plain elevation (85 ft. above msl) delineates the storm protection corridor, which is vital to the flood and water quality control program for PPPL as well as the Princeton Forrestal Center site. 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 August 2013, NJDEP issued

Groundwater Remedial Action Permit number RAP13001, effective on August 27, 2013 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 [NJDEP13b].

Exhibit 6-3. 2016 Monitoring Wells

	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	3
Sampling Rounds Completed	4	3

Exhibit 6-4. 2016 Groundwater Contamination

Ranges of Results for Positive Detections		
	2016 Wells	**2016 Sumps**
Tritium (pCi/L)	ND	ND – 270.3
PCE (μg/L)	ND – 87	ND – 54
TCE (μg/L)	ND – 24.3	ND – 5
1,4 Dioxane (μg/L)	ND – 0.723	ND-0.115

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 either a compressed gas (carbon dioxide) cylinders or from a gasoline–powered air compressor 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 parameters sampled can be seen in Exhibit 6-6.

Ground water monitoring results show that tetrachloroethylene, trichloroethylene (PCE, TCE), 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.

Limited ground water sampling for 1,4 dioxane was conducted in June, September and December 2016. The results are summarized in Appendix Figure 1 and 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 Standards of 0.4 µg/L with the exception of monitoring wells MW-13S and MW-9 in September 2016. The maximum 1,4 dioxane concentration detected was 0.723 µg/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 1,4dioxane sampling through September 2017. In addition to the wells sampled previously, PPPL will be analyzing 1,4dioxane in monitoring wells MW-5S and MW-5I to confirm horizontal delineation to the north. After the September 2017 sampling event the data will be reevaluated to determine if further monitoring or modification of the CEA and permit are needed.

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, NJDEP13b & PPPL13c].

Exhibit 6-5.Well Monitoring Set-up

Exhibit 6-6. Groundwater Parameters

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

6.5.3 Remedial Action Work Plan (RAWP)

Following a site-wide RI/RAA study and remedy selection process, PPPL prepared and submitted a Remedial Action Work Plan (RAWP) outlining continual operation of the ground water extraction system and a long-term monitoring program [Sh00]. 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, Sh 10-13].

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 2013, with submittal of a Biennial Remedial Action and Ground Water Classification Exception Area Recertification Report [PPPL13d].

General RAWP activities monitored:

- 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.

RAWP 2016 activities include:

- NJDEP issued PPPL's Groundwater Remedial Action Permit No. RAP13001, effective for 30 years starting August 27, 2013.
- Quarterly and Annual sampling JM Sorge subcontractor sampled March, June, September, and December.
- Annual sampling will be conducted with VOC + library search and monitored natural attenuation (MNA) parameters in March 2016
- 1,4 Dioxane sampled at select wells June, September, December 2016
- Annual Remedial Action Progress Reports to NJDEP were discontinued in 2016; data, graphs and charts are compiled annually.
- *Remedial Action Biennial Certification for Ground Water* submitted to NJDEP in 2015, next report not due until 2017.
- Bladder pumps and monitoring well casings were refurbished as necessary.
- Groundwater monitoring equipment repairs.

6.5.4 Monitored Natural Attenuation

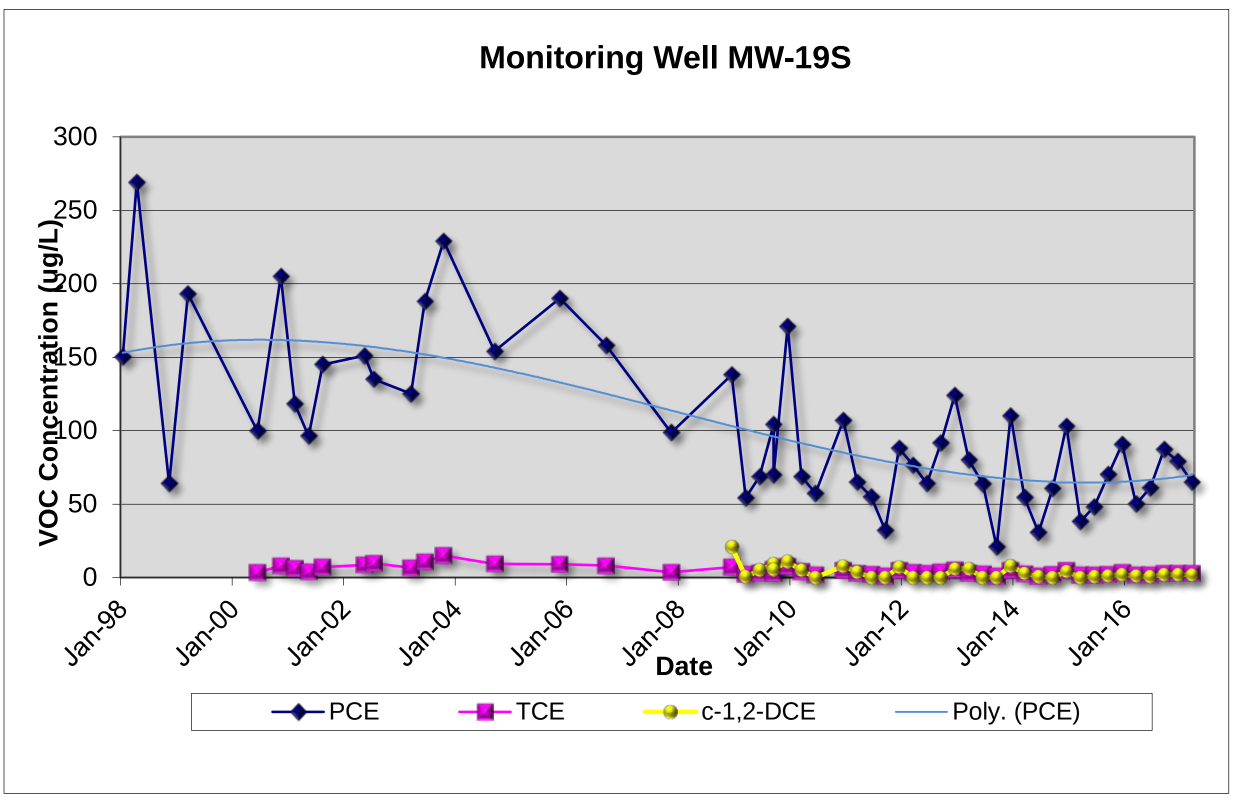
Examination of analytical data and water level measurements during the Remedial Investigation and the beginning of the Remedial Action indicated an inverse relationship between ground water level and VOC concentration (particularly PCE). Periods of higher water level generally corresponded with lower 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 [PPPL13d, Sh06,07, 08, 09 & 10-13].

Exhibit 6-7: Typical PCE Degradation Pathway

Review and examination of the analytical results indicate that contaminant concentrations, particularly PCE, are generally decreasing and are below the levels documented at the beginning to the Remedial Investigation. Seasonal fluctuations in VOC concentrations were seen in data collected during the RI and during the first two years of remedial action monitoring. These data generally showed peak VOC concentration during the late fall/winter months (Appendix Figure 1 and 2, Exhibits 6-8). The time-trend graph shown in Exhibit 6-7 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 [PPPL13d].

Exhibit 6-8: PCE Concentration vs. Time at MW-19S (1998-2016)



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

Quality Assurance

The DOE Princeton Plasma Physics Laboratory's As required by DOE Order *450.1,* Environmental Protection Program and DOE O 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.

7.1 PEARL Lab Certification

In 2016, analyses of environmental samples for analyze immediately non radiological parameters were conducted by PPPL's on-site analytical laboratory (Exhibits 7-1 & 7-2).

Exhibit 7-1. PEARL Chlorine Standard Check for Accuracy

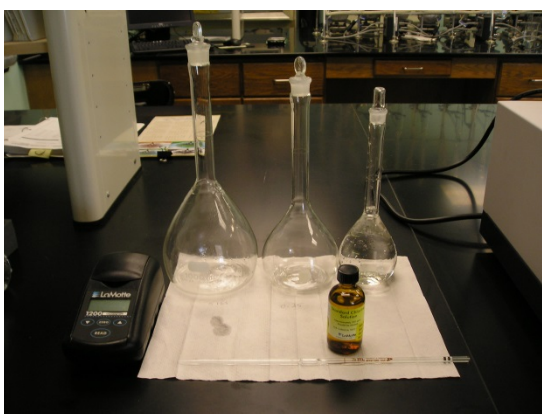


Exhibit 7-2. Distilling Samples for Tritium Analysis Performed at PEARL

The PPPL Environmental Analytical and 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.

PPPL's PEARL participated in a NJDEP Office of Quality Assurance (OQA) Audit on May 20-21, 2015 for both radiological and non-radiological parameters. PPPL responded to NJDEP's onsite audit report dated May 29th, 2015. PPPL's response to NJDEP Corrective Action Plan (CAP) included dropping all of PPPL's PEARL radiological parameters including tritium and gamma spectroscopy certifications [PPPL15e & i].

7.1.1. Radiological Parameters

In response to PPPL's on site NJDEP 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 will continue to maintain in a National Institute for Standards and Technology's (NIST) National Voluntary Laboratory Accreditation Program (NVLAP) accredited radiochemistry quality control testing program annually in 2016. 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) [PPPL15e & i].

Exhibit 7-3. 2016 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 analyses conducted for compliance purposes, 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 laboratory's ability to correctly analyze those parameters being tested. In Appendix Table 24, the non-radiological proficiency testing (PT) results show that all PEARL's results were in the acceptable range.

Exhibit 7-4. 2016 NJDEP Non-Radiological Certified Parameters

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. Eurofins/QC Laboratories and SGS/Accutest Laboratories were used for environmental laboratory analysis. PPPL groundwater subcontractor JM Sorge has NJDEP state laboratory certifications for analyze immediately parameters. Precision Testing is used to analyze the majority of hazardous waste sampling analysis.

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.

In 2016, PPPL participated in the following environmental internal audits:

- Hazardous Waste and Transportation Safety Program
- ISO-14001 Environmental Management System Audit
- NEPA-National Environmental Policy Act Program Assessment

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 has revised internal QA procedures to comply with NJDEP corrective actions.

- NIST Temperature calibrations are conducted quarterly, or replaced with new NIST certification long stem thermometer.
- 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.

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 Head QA Officer for review.

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

7.3.4 Chemicals

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 [UL17].

There was one external audit performed for Environmental QA/QC in 2016:

- Environmental Management System (EMS) UL-DQS ISO -14001:2004

Chapter

8

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Chapter

9

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Appendix

A

TABLES for 2016

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)
<u>ROUTINE OPERATION</u> 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		
<u>ACCIDENTS</u> 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)	
	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 2016

START DATE	WEEK	INCHES	CUM. INCHES	MONTHLY TOTAL	
5-Jan-16	1	0.1600	0.1600		
12-Jan-16	2	1.5600	1.7200		
19-Jan-16	3	0.1200	1.8400		
26-Jan-16	4	1.4500	3.2900	3.2900	JANUARY
2-Feb-16	5	0.0600	3.35		
9-Feb-16	6	0.9000	4.2500		
16-Feb-16	7	1.0400	5.2900		
23-Feb-16	8	0.3300	5.6200		
1-Mar-16	9	1.5800	7.2000	3.9100	FEBRUARY
8-Mar-16	10	0.3300	7.5300		
15-Mar-16	11	0.8500	8.3800		
22-Mar-16	12	0.0100	8.3900		
29-Mar-16	13	0.4200	8.8100	1.6100	MARCH
5-Apr-16	14	0.3100	9.1200		
12-Apr-16	15	0.5800	9.7000		
19-Apr-16	16	0.0000	9.7000		
26-Apr-16	17	0.7900	10.4900	1.6800	APRIL
3-May-16	18	1.2100	11.7000		
10-May-16	19	0.6700	12.3700		
17-May-16	20	0.2800	12.6500		
24-May-16	21	0.7100	13.3600		
31-May-16	22	0.6800	14.0400	3.5500	MAY
7-Jun-16	23	0.3700	14.4100		
14-Jun-16	24	0.6700	15.0800		
21-Jun-16	25	0.0500	15.1300		
28-Jun-16	26	0.9800	16.1100	2.0700	JUNE
5-Jul-16	27	0.9100	17.0200		
12-Jul-16	28	2.3200	19.3400		
19-Jul-16	29	0.8200	20.1600		
26-Jul-16	30	1.8700	22.0300		
2-Aug-16	31	1.5900	23.6200	7.5100	JULY
9-Aug-16	32	0.4200	24.0400		
16-Aug-16	33	0.3900	24.4300		
23-Aug-16	34	0.3700	24.8000		
30-Aug-16	35	0.0000	24.8000	1.1800	AUGUST
6-Sep-16	36	0.3000	25.1000		
13-Sep-16	37	0.1000	25.2000		
20-Sep-16	38	1.3300	26.5300		
27-Sep-16	38	0.0600	26.5900	1.7900	SEPTEMBER
4-Oct-16	39	0.6500	27.2400		
11-Oct-16	40	0.7800	28.0200		
18-Oct-16	41	0.0000	28.0200		
25-Oct-16	42	0.3000	28.3200		
1-Nov-16	44	0.9500	29.2700	2.6800	OCTOBER
8-Nov-16	45	0.1900	29.4600		
15-Nov-16	46	0.2300	29.6900		
22-Nov-16	47	0.2400	29.9300		
29-Nov-16	48	1.2900	31.2200	1.9500	NOVEMBER
6-Dec-16	49	1.2300	32.4500		
13-Dec-16	50	1.3000	33.7500		
20-Dec-16	51	0.3700	34.1200		
27-Dec-16	52	0.4600	34.5800		
3-Jan-17	53	0.5400	35.1200	3.9000	DECEMBER

Table 3. D– Site Tritium Stack Releases in Curies in 2016

Week Ending	HTO (Ci)	HT (Ci)	Weekly Total (Ci)	Annual Total (Ci)
1/7/2016	0.0234	0.00923	0.03263	0.03263
1/13/2016	0.0297	0.00302	0.03272	0.06535
1/20/2016	0.0279	0.00304	0.03094	0.09629
1/27/2016	0.0304	0.0988	0.1292	0.22549
2/3/2016	0.0309	0.147	0.1779	0.40339
2/10/2016	0.0256	0.00422	0.02982	0.43321
2/17/2016	0.0316	0.00375	0.03535	0.46856
2/24/2016	0.0372	0.00346	0.04066	0.50922
3/2/2016	0.308	0.429	0.737	1.24622
3/9/2016	0.0405	0.129	0.1695	1.41572
3/16/2016	0.0309	0.0227	0.0536	1.46932
3/23/2016	0.0356	0.0036	0.0392	1.50852
3/30/2016	0.0375	0.201	0.2385	1.74702
4/6/2016	0.0345	0.0709	0.1054	1.85242
4/13/2016	0.0274	0.00603	0.03343	1.88585
4/20/2016	0.0327	0.00876	0.04146	1.92731
4/27/2016	0.036	0.00371	0.03971	1.96702
5/4/2016	0.0388	0.00718	0.04598	2.013
5/11/2016	0.0373	0.129	0.1663	2.1793
5/18/2016	0.0425	0.00482	0.04732	2.22662
5/25/2016	0.047	0.00143	0.04843	2.27505
6/1/2016	0.0362	0.00246	0.03866	2.31371
6/8/2016	0.0331	0.0274	0.0605	2.37421
6/15/2016	0.0339	0.00171	0.03561	2.40982
6/22/2016	0.0354	0.125	0.1604	2.57022
6/29/2016	0.031	0.00207	0.03307	2.60329
7/6/2016	0.0494	0.00475	0.05415	2.65744
7/13/2016	0.0544	0.0255	0.0799	2.73734
7/20/2016	0.0502	0.098	0.1482	2.88554
7/27/2016	0.0485	0.0157	0.0642	2.94974
8/3/2016	0.035	0.00356	0.03856	2.9883
8/10/2016	0.0368	0.00161	0.03841	3.02671
8/17/2016	0.0332	0.00113	0.03433	3.06104
8/24/16	0.508	0.0139	0.5219	3.58294
8/31/2016	0.115	0.00126	0.11626	3.6992
9/7/2016	0.0318	0.0059	0.0377	3.7369
9/14/16	0.0618	0.0327	0.0945	3.8314
9/21/2016	0.062	0.0019	0.0639	3.8953
9/28/2016	0.0463	0.00213	0.04843	3.94373
10/5/2016	0.0355	0.00049	0.03599	3.97972
10/12/2016	0.148	0.00254	0.15054	4.13026
10/19/2016	0.0524	0.00108	0.05348	4.18374
10/26/2016	0.0515	0.00141	0.05291	4.23665
11/2/2016	0.0551	0.00165	0.05675	4.2934
11/9/2016	0.0429	0.00134	0.04424	4.33764
11/16/2016	0.0416	0.00127	0.04287	4.38051
11/23/2016	0.0353	0.00105	0.03635	4.41686
11/30/2016	0.0358	0.00082	0.03662	4.45348
12/7/2016	0.0253	0.00117	0.02647	4.47995
12/14/2016	0.0317	0.00101	0.03271	4.51266
12/21/17	0.068	0.00256	0.07056	4.58322
Total	**2.9105**	**1.67272**	**4.58322**	**4.58322**

Table 4. Ground Water Tritium Concentrations for 2016 (in picoCuries/Liter)

Quarter	Well TW-1	Well TW-5
2	*	*
3	*	*
4	*	*

Month	D-Site MG Sump	D-Site Airshaft Sump
January	*	*
February	270.3	*
March	*	*
April	*	*
May	*	*
June	*	*
July	*	*
August	*	*
September	*	*
October	*	*
November	*	*
December	*	*

TW wells are sampled quarterly and 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 2016 (in picoCuries/liter)

Month	Bee Brook (B1)	Bee Brook (B2)	Basin (DSN001)	Basin Dup (DSN004)	D&R Canal (C1)	D&R Canal (DSN003)	E1	M1	P1	P2
January			*		*	*				
February	*	*	*	*	*	*	180.2	*	*	1396
March			*		*	*				
April			*		*	*				
May	*	*	*	*	*	*	*	*	*	*
June			*		*	*				
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 2016

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

Table 7. Liquid Effluent Collection Tank Release Data for 2016

Release Date	Gallons Released	Tritium Sample LLD (pCi/L)	Tritium Sample Activity (pCi/L)	Total Tritium Tank Activity (Ci)
1/21/2016	12,650	506	7,340	3.52E-04
5/9/2016	12,750	4.49E+02	4.46E+03	2.15E-04
5/20/2016	12,750	5.35E+02	2.48E+03	1.20E-04
6/3/2016	12,750	2.82E+02	1.17E+03	5.65E-05
6/15/2016	12,750	1.22E+02	1.49E+03	7.17E-05
6/21/2016	12,000	3.38E+02	2.39E+03	1.08E-04
6/28/2016	10,800	4.12E+02	3.06E+03	1.25E-04
7/13/2016	12,750	3.55E+02	2.39E+03	1.15E-04
7/20/2016	12,750	4.24E+02	3.15E+03	1.52E-04
7/28/2016	12,750	2.66E+02	9.01E+02	4.35E-05
8/3/2016	12,750	2.71E+02	1.13E+02	5.43E-05
8/9/2016	12,750	3.64E+02	1.16E+04	5.61E-04
8/16/2016	12,750	3.48E+02	4.95E+03	2.39E-04
8/23/2016	12,750	3.13E+02	1.97E+05	9.51E-03
8/30/2016	12,750	2.92E+02	5.60E+04	2.70E-03
9/9/2016	12,750	4.57E+02	4.00E+02	1.93E-03
10/11/2016	12,750	4.98E+02	1.22E-04	5.89E-04
Total	**213,950**			**0.0169**

Table 8. Total Fuel Consumption by Fuel Type from 2000 to 2016

Year	*Natural Gas (mmcf)*	*Fuel Oil # 2 or Fuel Oil # 4 (kgals.)*
2000	0.387	42.6
2001	0.367	43
2002	0.331	33.8
2003	0.290	61.9
2004*	0.373	62.3
2005	0.427	32.7
2006	0.319	3.8
2007	0.248	49.6
2008	0.271	41
Permit limit	**0.886**	**227**
2009	0.275	33.6
2010	0.267	17.5
2011	0.230	8.0
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
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 2016

Location B1 = Bee Brook upstream of PPPL basin discharge

B1							
Parameters	**Units**	**February**	**May**		**August**		**Nov.**
Chemical Oxygen Demand, COD	mg/L	21.00	24.00	J	31.70		51.90
Phosphorus, total	mg/L	0.018	0.039	<	0.050	J	0.097
Total Suspended Solids, TSS	mg/L	2.00	4.00	J	1.04	J	2.86
Field Parameters							
pH	SU	6.73	6.96		6.38		6.02
Oxidation-Reduction Potential, ORP	mV	10.8	1.4		27.0		53.9
Temperature	^{o}C	1.9	10.3		20.5		9.2

Blank indicates no measurement *NL = no limit*

Table 10. Surface Water Analysis for Bee Brook, B2, in 2016

Location B2 = Bee Brook downstream of PPPL basin discharge

B2							
Parameters	**Units**	**February**	**May**		**August**		**Nov.**
Chemical Oxygen Demand, COD	mg/L	15.00	24.00	J	29.40	J	29.00
Phosphorus, total	mg/L	0.029	0.020		0.170	J	0.079
Total Suspended Solids, TSS	mg/L	5.00	5.00	J	1.78	J	2.14
Field Parameters							
pH	SU	6.77	6.78		6.55		7.02
Oxidation-Reduction Potential, ORP	mV	8.8	10.6		17.8		-1.5
Temperature	^{o}C	6.0	11.1		21.0		10.0

Blank indicates no measurement *NL = no limit*

Table 11. Surface Water Analysis for Delaware & Raritan Canal, C1, in 2016

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

C1								
Parameters	**Units**		**January**	**Feb.**	**March**	**April**	**May**	**June**
Chemical Oxygen Demand, COD	mg/L	<	4.70	12.00	15.00	14.00	12.00	12.00
Phosphorus, total	mg/L		0.03	0.031	0.058	0.064	0.053	0.232
Total Suspended Solids, TSS	mg/L		2.00	3.00	11.00	3.00	4.00	5.00
Field Parameters								
pH	SU		7.38	7.09	7.00	7.07	7.19	6.59
Oxidation-Reduction Potential, ORP	mV		-21.70	-7.8	-3.8	-5.1	-10.9	17.2
Temperature	°C		2.60	1.9	7.9	11.2	13.6	26.5

C1													
Parameters	**Units**		**July**		**Aug.**		**Sept.**		**Oct.**		**Nov.**		**Dec.**
Chemical Oxygen Demand, COD	mg/L	J	26.50	J	22.50	J	15.60	J	45.80	J	13.00	J	24.40
Phosphorus, total	mg/L	J	0.08	J	0.057	J	0.069	J	0.083	J	0.090	J	0.075
Total Suspended Solids, TSS	mg/L	J	2.80	J	1.93	J	1.94		6.60	J	2.71	J	2.24
Field Parameters													
pH	SU		7.49		6.51		7.39		7.06		6.72		6.67
Oxidation-Reduction Potential, ORP	mV		-32.70		20.9		-56.1		-3.3		16.5		17.7
Temperature	°C		25.40		26.8		26.8		18.4		13.3		7.3

Blank indicates no measurement *NL = no limit*

Table 12. Surface Water Analysis for Elizabethtown Water, E1, in 2016

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

E1									
Parameters	**Units**		**February**		**May**		**August**		**Nov.**
Chemical Oxygen Demand, COD	mg/L	J	6.00		12.00	J	13.30	J	15.20
Phosphorus, total	mg/L		0.311		1.160		0.960		0.470
Total Suspended Solids, TSS	mg/L		3.00		2.00	<	1.00	<	1.00
Field Parameters									
pH	SU		6.61		6.96		7.01		6.62
Oxidation-Reduction Potential, ORP	mV		18.1		1.1		-6.6		21.2
Temperature	°C		13.8		15.3		23.8		18.8

Blank indicates no measurement *NL = no limit*

Table 13. Surface Water Analysis for Millstone River, M1, in 2016

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

Parameters	Units	February	May		August		Nov.
Chemical Oxygen Demand, COD	mg/L	13.00	22.00	J	40.90	J	33.60
Phosphorus, total	mg/L	0.058	0.089	J	0.072		0.110
Total Suspended Solids, TSS	mg/L	8.00	7.00		7.11		10.70
Field Parameters							
pH	SU	7.16	7.19		6.83		6.5
Oxidation-Reduction Potential, ORP	mV	-11.6	11.2		3.4		14.5
Temperature	°C	5.6	13.0		26.5		14.2

Blank indicates no measurement *NL = no limit*

Table 14. Surface Water Analysis for Cranbury Brook (Plainsboro), P1, in 2016

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

Parameters	Units	February	May		August		Nov.
Chemical Oxygen Demand, COD	mg/L	17.00	18.00	J	29.40	J	15.20
Phosphorus, total	mg/L	0.042	0.047	<	0.050	J	0.059
Total Suspended Solids, TSS	mg/L	12.00	8.00		4.63		4.29
Field Parameters							
pH	SU	7.11	7.23		7.05		6.31
Oxidation-Reduction Potential, ORP	mV	-9.2	-13.4		-8.7		12.1
Temperature	°C	6.7	12.8		26.6		11.9

Blank indicates no measurement *NL = no limit*

Table 15. Surface Water Analysis for Devil's Brook (Plainsboro), P2, in 2016

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

Parameters	Units	February	May		August		Nov.
Chemical Oxygen Demand, COD	mg/L	25.00	41.00		70.90	J	24.40
Phosphorus, total	mg/L	0.037	0.097	<	0.050	J	0.075
Total Suspended Solids, TSS	mg/L	4.00	8.00	J	7.50		5.71
Field Parameters							
pH	SU	8.22	7.14		7.70		6.29
Oxidation-Reduction Potential, ORP	mV	-68.6	-8.2		23.9		11.9
Temperature	°C	6.1	11.7		24.5		11.4

Blank indicates no measurement *NL = no limit*

Table 16. DSN001 – Retention Basin Outfall Surface Water Analysis (NJPDES NJ0023922) in 2016

DSN001														
Parameters	**Units**	**Permit Limit**		**January**		**Feb.**		**March**		**April**		**May**		**June**
Chemical Oxygen Demand,	mg/L	50.0	<	4.70	J	7.00	J	5.00	J	7.00		12.00		10.00
Phosphorus, total	mg/L	NL		0.061		0.034		0.529		0.093		0.047		0.111
Tetrachloroethylene, PCE	µg/L	0.703	J	0.37	J	0.49	<	0.5	J	0.50	<	0.50	<	0.50
Total Petroleum Hydrocarbon, TPHC	mg/L	15 Max 10 Avg	<	1.89	<	1.89	<	1.89	<	1.89	<	1.89	<	1.89
Total Suspended Solids, TSS	mg/L	50.0	<	2.00		2.00		3.00		5.00		4.00		4.00
Field Parameters														
Chlorine Produced Oxidants, CPO	mg/L	0.1		0.020		0.040		0.040		0.080		0.030		0.150
						0.035		0.040		0.055		0.020		0.090
pH	SU	>6; <9		6.75		6.63		6.51		6.44		6.56		6.25
						6.59		6.49		6.39		6.51		6.16
Oxidation-Reduction Potential,	mV	NL		11.3		18.7		23.9		31.7		25.1		40.1
Temperature (Max)	°C	30		7.7		10.9		13.8		11.3		13.8		20.2

DSN001														
Parameters	**Units**	**Permit Limit**		**July**		**August**		**Sept.**		**Oct.**		**Nov.**		**Dec.**
Chemical Oxygen Demand,	mg/L	50.0	J	19.60	J	17.90	J	27.10	J	13.60	J	13.00	J	22.10
Phosphorus, total	mg/L	NL	<	0.050		0.290		0.26	<	0.050	J	0.067	<	0.050
Tetrachloroethylene, PCE	µg/L	0.703	<	0.50	<	0.50	<	0.50	<	0.50	<	0.50	<	0.50
Total Petroleum Hydrocarbon,	mg/L	15	<	1.40	<	1.40	<	1.40	<	1.40	<	1.40	<	1.40
Total Suspended Solids, TSS	mg/L	50.0	J	2.40	<	1.00		3.85	<	3.00		4.86	<	1.00
Field Parameters														
Chlorine Produced Oxidants,	mg/L	0.1		0.000		0.140		0.000		0.030		0.090		0.060
				0.000		0.093		0.000		0.015		0.080		0.040
pH	SU	>6; <9		6.44		6.28		8.59		8.01		7.57		7.23
				6.40		6.22		8.57		7.94		7.46		7.06
Oxidation-Reduction	mV	NL		27.1		35.5		-		-52.8		-31.8		-13.0
Temperature (Max)	°C	30		22.9		20.5		23.1		18.8		12.8		12.6

Blank indicates no measurement *NL = no limit*

Table 17. D&R Canal Pump House – DSN003

Monthly Surface Water Analysis (NJPDES NJ0023922) in 2016

DSN003								
Parameters	**Units**	**Permit Limit**	**January**	**Feb.**	**March**	**April**	**May**	**June**
Chemical Oxygen Demand,	mg/L	50	10.00	11.00	10.00	10.00	16.00	14.00
Phosphorus, total	mg/L	NL	0.034	0.045	0.236	0.026	0.058	0.226
Total Petroleum	mg/L	15	< 1.89	< 1.89	< 1.89	< 1.89	< 1.89	< 1.89
Total Suspended Solids, TSS	mg/L	NL	2.00	3.00	9.00	4.00	3.00	6.00
Field Parameters								
Chlorine Produced Oxidants,	mg/L	0.1	0.02 0.015	0.00	0.03	0.01	0.00 0.00	0.03
pH	SU	>6;<9	7.11 7.07	6.74	6.90	7.12	6.95 6.94	6.50
Oxidation-Reduction	mV	NL	-5.70	10.50	1.5	-7.90	-	22.40
Temperature (Max)	°C	30	3.10	2.60	7.20	12.50	13.90	27.10

DSN003								
Parameters	**Units**	**Permit Limit**	**July**	**Aug.**	**Sept.**	**Oct.**	**Nov.**	**Dec.**
Chemical Oxygen Demand,	mg/L	50	J 17.30	J 24.80	J 15.60	J 15.90	< 12.80	J 33.60
Phosphorus, total	mg/L	NL	J 0.092	0.110	J 0.064	J 0.097	J 0.098	J 0.097
Total Petroleum Hydrocarbon,	mg/L	15	< 1.40	< 1.40	< 1.40	< 1.40	< 1.40	< 1.40
Total Suspended Solids, TSS	mg/L	NL	J 4.40	4.15	J 1.64	J 5.60	5.71	3.28
Field Parameters								
Chlorine Produced Oxidants,	mg/L	0.1	0.010	0.040	0.010 0.005	0.020	0.000	0.040
pH	SU	>6;<9	6.77	6.68	7.38	7.06	6.70	6.14
Oxidation-Reduction	mV	NL	7.00	23.40	-	-2.80	16.20	46.90
Temperature (Max)	°C	30	26.00	25.50	27.50	18.80	14.10	9.00

Blank indicates no measurement *NL = no limit*

Table 18. Summary of Ground Water Sampling Results – March 2016
Target Chlorinated Volatile Organic Compounds (VOC)

Well No.		MW-3S	MW-5I	MW-5S	MW-9S	MW-12S	MW-13S	MW-13I	MW-17	MW-18	MW-19S	MW-19I	MW-22S	NJ Ground Standard
Target Volatile Organic Compounds (µg/L)														
Tetrachloroethylene		<0.500	<0.500	0.5 J	2	<0.500	13	15	13	<0.500	50	<0.500	<0.500	1
Trichloroethylene		<0.500	2	<0.500	2	<0.500	7	0.6 J	1	<0.500	2	<0.500	<0.500	1
c-1,2-Dichloroethylene		<0.500	5	<0.500	0.6 J	<0.500	10	0.7 J	<0.500	<0.500	1	<0.500	<0.500	70
t-1,2-Dichloroethylene		<0.500	<0.500	<0.500	<0.500	<0.500	<0.500	<0.500	<0.500	<0.500	<0.500	<0.500	<0.500	30
1,1,1-Trichloroethane		<0.500	<0.500	<0.500	<0.500	<0.500	<0.500	<0.500	<0.500	<0.500	<0.500	<0.500	<0.500	1
1,1-Dichloroethylene		<0.500	<0.500	<0.500	<0.500	<0.500	<0.500	0.8 J	<0.500	<0.500	<0.500	<0.500	<0.500	70
Chloroform		<0.500	<0.500	<0.500	<0.500	<0.500	<0.500	<0.500	<0.500	<0.500	<0.500	<0.500	<0.500	1
Vinyl Chloride		<0.500	<0.500	0.5 J	2	<0.500	13	15	13	<0.500	50	<0.500	<0.500	1
Tentatively Identified Compounds (µg/L)														
Unknown		ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	–
Natural Attenuation Indicators														
Chloride	mg/L	9.15	665	139	6.65	167	81.6	15.2	14.5	20.7	6.4	72.2	225	250,000
Manganese	mg/L	0.293	0.854	0.0091	0.0054	0.0019 J	0.353	0.0151	0.107	0.228	0.048	0.0047	0.0813	50
Alkalinity	mg/L	142	106	12.6	62.7	67.7	53. 9	113	42.1	9.53	15.1	30.3	2.38	–
Nitrate as N	mg/L	0.165 J	1.55	<0.0283	0.0872 J	2.67	0.140 J	0.166 J	0.0626 J	<0.0283	0.162	1.18	1.32	10,000
Nitrite	mg/L	0.0151 J	0.128	0.0126 J	0.0159 J	0.0115 J	0.0879	0.0124 J	0.199	0.0130 J	0.00840 J	0.00860 J	<0.00650	1,000
Sulfide	mg/L	<0.00650	<0.00650	<0.00650	<0.00650	<0.00650	<0.00650	<0.00650	<0.00650	<0.00650	0.0450 J	<0.00650	<0.00650	–
Sulfate	mg/L	12	1.18	1.27	4.77	1.5	2.27	1.25	3.34	1.75	2.67	1.41	1.43	–
Total Organic Carbon	mg/L	<0.20	0.26	<0.20	<0.20	<0.20	0.41	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	300
Ferrous Iron	mg/L	<0.11	0.31	0.31	<0.11	0.33	<0.11	<0.11	<0.11	<0.11	0.18	<0.11	<0.11	–
Dissolved Methane	µg/L	<0.23	<0.23	<0.23	<0.23	<0.23	<0.23	<0.23	<0.23	<0.23	<0.23	<0.23	<0.23	–
Dissolved Oxygen	mg/L	<0.31	<0.31	<0.31	<0.31	<0.31	<0.31	<0.31	<0.31	<0.31	<0.31	<0.31	<0.31	–
pH	std. units	2.81	0.01	NA	0.5	4.69	7.12	3.97	0.0	1.90	4.36	3.70	8.09	–
Redox Potential	mVe	5.07	6.20	NA	5.27	5.69	5.24	6.1	5.11	4.18	4.08	4.41	4.03	–

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

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

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

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

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

NA - Field parameters not collected due to low water level in well or equipment malfunction

Table 18 cont. Summary of Ground Water Sampling Results –March 2016

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

Well No.		MW-23	MW-24	MW-25S	MW-26S*	Basin Outflow	D-MG Sump	D-SITE AIR SHAFT	TB-1 3/23	TB-2 3/24	TB-3 3/25	TB-4 3/26	NJ Ground
Target Volatile Organic Compounds (µg/L)													**Standard**
Tetrachloroethylene		<0.500	<0.500	<0.500	15	<0.500	30	2.0	<0.500	<0.500	<0.500	<0.500	1
Trichloroethylene		<0.500	<0.500	<0.500	<0.500	<0.500	3.0	<0.500	<0.500	<0.500	<0.500	<0.500	1
c-1,2-Dichloroethylene		<0.500	<0.500	1	0.6 J	<0.500	2	<0.500	<0.500	<0.500	<0.500	<0.500	70
t-1,2-Dichloroethylene		<0.500	<0.500	<0.500	<0.500	<0.500	<0.500	<0.500	<0.500	<0.500	<0.500	<0.500	30
1,1,1-Trichloroethane		<0.500	<0.500	<0.500	<0.500	<0.500	<0.500	<0.500	<0.500	<0.500	<0.500	<0.500	1
1,1-Dichloroethylene		<0.500	0.6 J	<0.500	0.8 J	<0.500	<0.500	<0.500	<0.500	<0.500	<0.500	<0.500	70
Chloroform		<0.500	<0.500	<0.500	<0.500	<0.500	<0.500	<0.500	<0.500	<0.500	<0.500	<0.500	1
Vinyl Chloride		<0.500	<0.500	<0.500	15	<0.500	30	2.0	<0.500	<0.500	<0.500	<0.500	1
Tentatively Identified Compounds (µg/L)													
Unknown		ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	--
Natural Attenuation Indicators													
Chloride	mg/L	6.47	5.94	93.8	15.2	196	203	158	NA	NA	NA	NA	250,000
Manganese	mg/L	0.0502	0.0076	5.82	0.0166	0.111	1.12	0.905	NA	NA	NA	NA	50
Alkalinity	mg/L	2.15	8.99	81.3	112	81.9	73.9	93.4	NA	NA	NA	NA	–
Nitrate as N	mg/L	0.142	0.0848 J	<0.0283	0.162 J	1.17	1.46	1.62	NA	NA	NA	NA	10,000
Nitrite	mg/L	0.00800 J	<0.00650	<0.00650 J	0.0127 J	0.0128 J	NA	NA	NA	NA	NA	NA	1,000
Sulfide	mg/L	<0.00650	<0.00650	<0.00650	<0.00650	<0.00650	<0.00650	<0.00650	NA	NA	NA	NA	–
Sulfate	mg/L	2.17	1.42	3.33	1.23	2.23	1.85	1.26	NA	NA	NA	NA	–
Total Organic Carbon	mg/L	<0.20	<0.20	<0.20	<0.20	<0.20	0.5	<0.20	NA	NA	NA	NA	300
Ferrous Iron	mg/L	<0.11	0.25	<0.11	<0.11	0.45	NA	NA	NA	<0.11	0.3	<0.11	–
Dissolved Methane	µg/L	<0.23	<0.23	<0.23	<0.23	<0.23	NA	NA	NA	<0.23	<0.23	<0.23	–
Dissolved Oxygen	mg/L	<0.31	<0.31	<0.31	<0.31	<0.31	NA	NA	NA	<0.31	<0.31	<0.31	–
pH	std. units	NA	7.90	0.0	NA	NA	NA	NA	NA	NA	NA	NA	–
Redox Potential	mVe	NA	4.27	5.80	NA	NA	NA	NA	NA	NA	NA	NA	–

NOTES: B - Contaminant also detected in blank
J - Estimated, concentration listed greater than the MDL but lower than the lowest standard.
N - Indicates presumptive evidence of the compound's presence.
NA - Not Analyzed

-- Compound-specific Ground Water Quality Standard not published.
* MW-26 is duplicate sample from well MW-13S.
Ground water quality standards as published in N.J.A.C. 7:9-6.9.

Table 19 Summary of Ground Water Sampling Results –June 2016
Target Chlorinated Volatile Organic Compounds (VOC), Monitored Natural Attenuation (MNA)

Well No.		MW-3S	MW-5I	MW-9S	MW-13S	MW-17	MW-18	MW-19S	MW-25	D-MG Sump	MW-26 *	TB	NJ Ground
Target Volatile Organic Compounds (µg/L)													
Tetrachloroethylene		<0.500	<0.500	26	19	21	<0.500	61	<0.500	42	19	<0.500	1
Trichloroethylene		<0.500	2	2	7	3	<0.500	2	0.5 J	4	7	<0.500	1
c-1,2-Dichloroethylene		<0.210	<0.500	5	0.7 J	11	<0.500	<0.500	0.6 J	2	3	<0.500	70
1,1,1-Trichloroethane		<0.500	<0.500	<0.500	<0.500	<0.500	<0.500	<0.500	<0.500	<0.500	<0.500	<0.500	30
1,1-Dichloroethylene		<0.500	<0.500	<0.500	0.5 J	<0.500	<0.500	<0.500	<0.500	0.9 J	<0.500	<0.500	1
Chloroform		<0.500	<0.500	2	<0.500	1	0.9 J	<0.500	<0.500	<0.500	<0.500	<0.500	70
Vinyl Chloride		<0.500	<0.500	<0.500	<0.500	<0.500	<0.500	<0.500	<0.500	<0.500	<0.500	<0.500	1
1,4-Dioxane		NA	NA	0.351	0.349	NA	NA	NA	NA	NA	0.320	NA	0.4
1,1,2-Trichloro-1,2,2-Trifluoroethane		<0.500	<0.500	10 J	47	<0.500	<0.500	<0.500	<0.500	<0.500	49	<0.500	--
Tentatively Identified Compounds (µg/L)													
Unknown		ND	ND	17 J	64 J	ND	ND	8 J	ND	ND	ND	1300 J	100/500
1,2-Dichloro-1,1,2-Trifluoroethane		ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Natural Attenuation Indicators													
Dissolved Oxygen	mg/L	0	0	0	3.58	0	0	0	0	NA	3.58	NA	—
pH	5.94	7.18	5.85	5.76	5.67	5.53	5.45	6.47	NA	5.76	NA	NA	—
Redox Potential	mVe	139	-63	184	81	162	192	184	-14	NA	81	NA	—

NOTES:

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

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

ND - Analyte Not Detected

NA - Analyte Not Analyzed For

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

— Compound-specific Ground Water Quality Standard not published.

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

**MW5S not sampled due to low water levels

Table 20. Summary of Ground Water Sampling Results –September 2016

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

Well No.		MW-3S	MW-5S	MW-5I	MW-9S	MW-13S	MW-17	MW-18	MW-19S	MW-25	D-MG Sump	MW-26 *	TB	NJ Ground
Target Volatile Organic Compounds (µg/L)														
Tetrachloroethylene		<0.500	0.8 J	<0.500	28	18	22	0.5 J	87	<0.500	54	18	<0.500	1
Trichloroethylene		<0.500	<0.500	2	2	7	2	0.5 J	3	<0.500	5	7	<0.500	1
c-1,2-Dichloroethylene		<0.210	<0.500	<0.500	4	0.5 J	11	1	<0.500	2	2	3	11	70
1,1,1-Trichloroethane		<0.500	<0.500	<0.500	<0.500	<0.500	<0.500	<0.500	<0.500	<0.500	<0.500	<0.500	<0.500	30
1,1-Dichloroethylene		<0.500	<0.500	<0.500	<0.500	<0.500	<0.500	<0.500	<0.500	<0.500	1 J	<0.500	<0.500	1
Chloroform		<0.500	<0.500	<0.500	2	<0.500	0.7 J	<0.500	<0.500	<0.500	<0.500	<0.500	<0.500	70
Vinyl Chloride		<0.500	<0.500	<0.500	<0.500	<0.500	<0.500	<0.500	<0.500	<0.500	<0.500	<0.500	<0.500	1
1,4-Dioxane		NA	NA	NA	0.723	0.566	NA	NA	NA	NA	NA	0.528	NA	0.4
1,1,2-Trichloro-1,2,2-Trifluoroethane		<2.0	<2.0	<2.0	8 J	40	<2.0	<2.0	<2.0	<0.500	<0.500	39	<0.500	--
Tentatively Identified Compounds (µg/L)														
Unknown		ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
1,2-Dichloro-1,1,2-Trifluoroethane		ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Natural Attenuation Indicators														
Dissolved Oxygen	mg/L	0	NA	0	0	72.7	0	0	1.56	0	NA	72.7	NA	—
pH	5.18	NA	6.79	5.13	5.3	4.56	4.22	3.92	5.7	NA	5.3	NA	NA	—
Redox Potential	mVe	274	NA	-63	207	84	216	220	336	50	NA	84	NA	—

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

Table 21. Summary of Ground Water Sampling Results –December 2016

Target Chlorinated Volatile Organic Compounds (VOC)

Well No.		MW-3S	MW-5S	MW-5I	MW-9S	MW-13S	MW-17	MW-18	MW-19S	MW-25S	D-MG Sump	MW-26S *	TB	NJ Ground
Target Volatile Organic Compounds (µg/L)														
Tetrachloroethylene		<0.500	<0.500	<0.500	7	13	14	0.6 J	79	<0.500	26	12	<0.500	1
Trichloroethylene		<0.500	<0.500	2	1	7	4	0.6 J	3	0.8 J	3	6	<0.500	1
c-1,2-Dichloroethylene		<0.180	<0.500	<0.500	4	<0.500	14	0.5 J	<0.500	2	2	2	<0.500	70
1,1,1-Trichloroethane		<0.500	<0.500	<0.500	<0.500	<0.500	<0.500	<0.500	<0.500	<0.500	<0.500	<0.500	<0.500	30
1,1-Dichloroethylene		<0.500	<0.500	<0.500	<0.500	<0.500	<0.500	<0.500	<0.500	<0.500	0.6 J	<0.500	<0.500	1
Chloroform		<0.500	<0.500	<0.500	2	<0.500	0.5 J	<0.500	<0.500	<0.500	<0.500	<0.500	<0.500	70
Vinyl Chloride		<0.500	<0.500	<0.500	<0.500	1	<0.500	<0.500	<0.500	<0.500	<0.500	1	<0.500	1
1,4-Dioxane		<0.049	NA	NA	0.202	0.315	0.245	0.249	<0.049	<0.049	0.115	0.300	NA	0.4
1,1,2-Trichloro-1,2,2-Trifluoroethane		<2.0	<2.0	<2.0	<2.0	50	<2.0	<2.0	<2.0	<2.0	<2.0	47	<0.500	--
Tentatively Identified Compounds (µg/L)														
Unknown		ND	ND	ND	5 J	ND	7 J	12 J	ND	16 J	ND	ND	ND	--
1,2-dichloro-1,1,2-trifluoro-ethane		–	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	--
Natural Attenuation Indicators														
Dissolved Oxygen	mg/L	ND	ND	ND	5 J	ND	7 J	12 J	ND	16 J	ND	ND	ND	—
pH	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	NA	—
Redox Potential	mVe	102	NA	-17	208	62	162	164	189	23	NA	62	ND	—

NOTES:

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

Table 22. Summary of Groundwater Sampling Results – D-Site MG Sump, 2016

D Site MG													
Parameters	**Units**	**January**	**Feb.**	**March**	**April**	**May**	**June**	**July**	**August**	**Sept.**	**Oct.**	**Nov.**	**Dec.**
		2016	**2016**	**2016**	**2016**	**2016**	**2016**	**2016**	**2016**	**2016**	**2016**	**2016**	**2016**
Chemical Oxygen Demand, COD	mg/L		< 4.70		0.11	89.00			J 22.50			J 24.40	
Phosphorus, Total	mg/L	0.08	0.047	0.047		0.061	0.352	0.17	< 0.050	< 0.050	< 0.050	0.140	< 0.050
Total Suspended Solids, TSS	mg/L		20.00			3470.00			11.50			20.70	

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

Table 23. Summary of Groundwater Sampling Results – D-Site Airshaft Sump, 2016

D Site Airshaft													
Parameters	**Units**	**January**	**Feb.**	**March**	**April**	**May**	**June**	**July**	**August**	**Sept.**	**Oct.**	**Nov.**	**Dec.**
		2016	**2016**	**2016**	**2016**	**2016**	**2016**	**2016**	**2016**	**2016**	**2016**	**2016**	**2016**
Chemical Oxygen Demand, COD	mg/L		< 4.70			J 7.00			< 12.80			J 13.00	
Phosphorus, total	mg/L	0.03	0.029	0.037	0.069	0.072	0.089	< 0.05	< 0.05	< 0.050	< 0.05	< 0.099	< 0.050
Total Suspended Solids, TSS	mg/L		<2.00			2.00			< 1.00			< 1.00	

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

Table 24. Quality Assurance Data for Radiological and Non-Radiological Samples for 2016

Laboratory, Program and Parameter	Units	Reported Value	Actual Value	Acceptance Range	Acceptable Not Acceptable
ERA Co. April 2016 RAD-109, Proficiency Test					
Barium-133	pCi/L	49.81	49.7	40.8 - 55.1	Acceptable
Cesium-134	pCi/L	88.96	90.1	74.0 – 99.1	Acceptable
Cesium-137	pCi/L	212.2	206	185 - 228	Acceptable
Cobalt-60	pCi/L	55.64	54.7	49.2 – 62.7	Acceptable
Zinc-65	pCi/L	59.46	53.8	47.2 – 65.9	Acceptable
Tritium	pCi/L	7212.61	6850	5920 - 7540	Acceptable
Phenova					
April 2015 WP-0316					
pH	S.U.	9.48	9.625	9.28 - 9.68	Acceptable
Residual Chlorine	mg/L	1.89	2.21	1.39 – 2.22	Acceptable

Table 25. Waste Characterization Report (WCR) Surface Water Sampling 2016

No limits exceeded, only parameters listed above non-detect

Laboratory Parameter	Reported Value (mg/L)	
DSN001		
Semi Annual	May	November
Barium	0.188	0.131
Copper	0.0047	-
Manganese	0.0806	0.0765
Zinc	0.0317	0.0218
Annual		
DSN001 not required to complete Annual WCR in 2016		
DSN003		
Annual	May	
Barium	0.0442	
Zinc	0.0106	

Figure 1. 1,4 Dioxane PCE Distribution for Shallow Groundwater Wells Annual Sampling Event March 2017

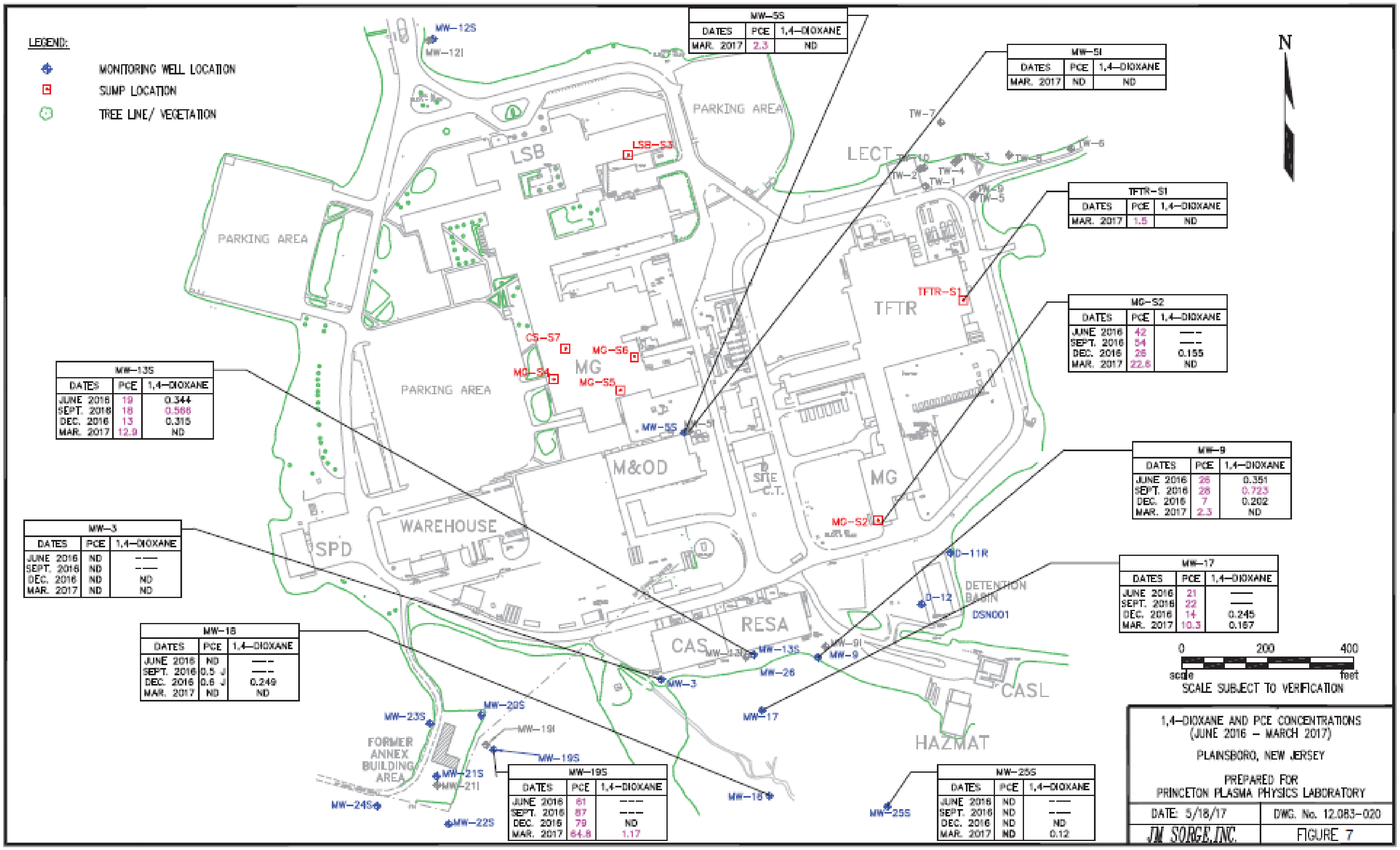
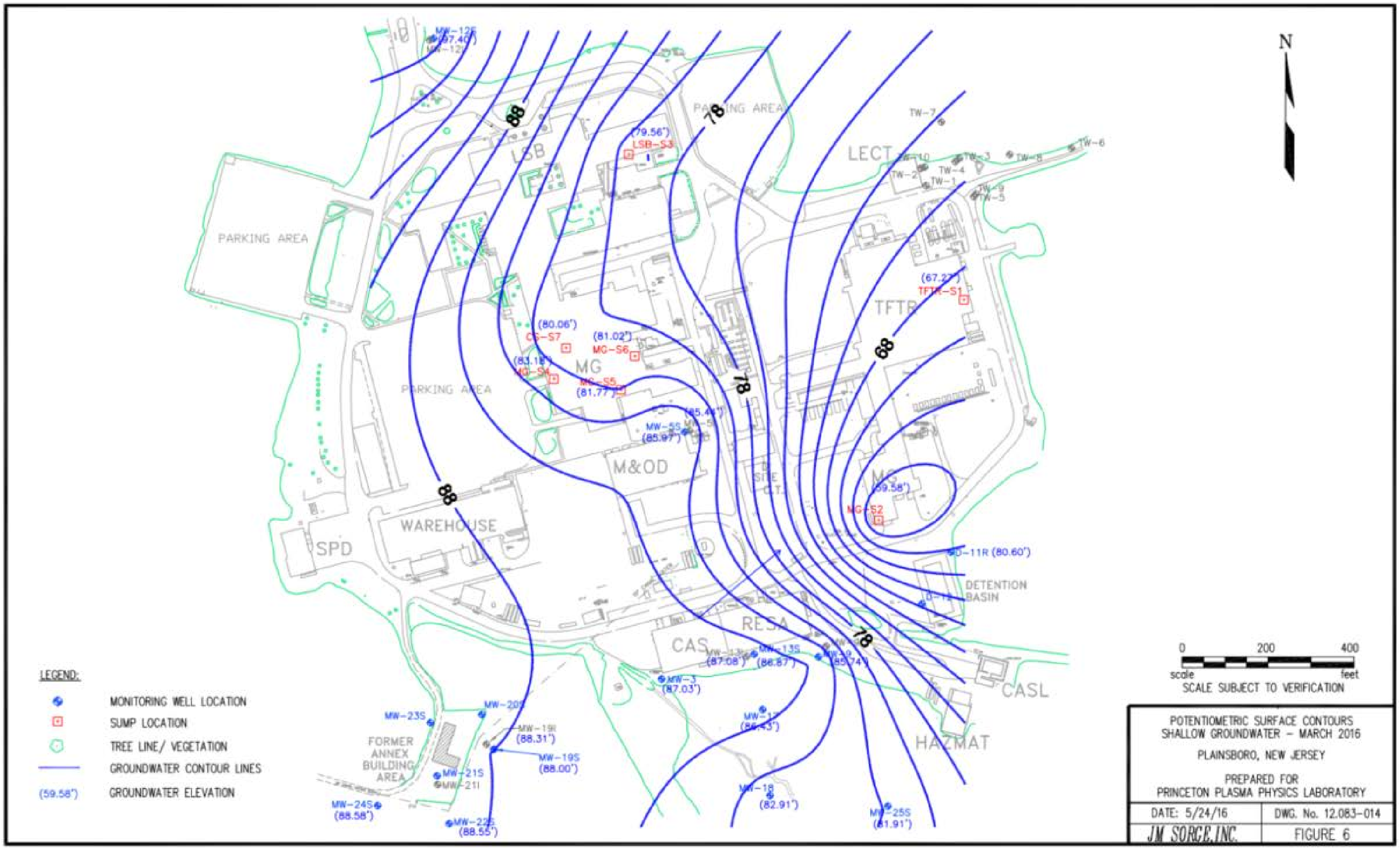


Figure 2. Potentiometric Surface Contours Shallow Groundwater Wells Annual Sampling Event- March 2017



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