



U. S. Department of Energy
Princeton Plasma Physics Laboratory
Environmental Radiation Protection Program

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1.0 Introduction

DOE Order 458.1, *Radiation Protection of the Public and the Environment*, requires that each site have an Environmental Radiation Protection Program (ERPP) that complies with the applicable requirements of the Order. The purpose of this document is to outline the plans, procedures and other documents used by the Princeton Plasma Physics Laboratory (PPPL) to implement the requirements of DOE Order 458.1 and other radiation protection programs. The major elements of the Order applicable to PPPL are addressed in the sections that follow. More details of the policies, plans, procedures and other documents applicable to each requirement are provided in Appendix A, ERPP Implementation Matrix. This matrix provides evidence of the depth and breadth of the implementing documents supporting the ERPP. Updates to the Appendix A matrix and changes to individual policies and procedures do not require DOE approval.

The U.S. Department of Energy's Princeton Plasma Physics Laboratory (PPPL) is a collaborative national center for plasma and fusion science. PPPL is dedicated to developing fusion as a clean and abundant source of energy and to advancing the frontiers of plasma science. The Laboratory pursues these goals through experiments and computer simulations of the behavior of plasma, the hot, electrically-charged gas that fuels fusion reactions and has a wide range of practical applications. As a plasma science and fusion energy research facility with limited radioactive materials, many of the requirements in DOE Order 458.1 are not applicable to PPPL. Therefore, a graded approach has been used in preparing this Environmental Radiation Protection Plan (ERPP). For any determination of a requirement of the Order that is not relevant to PPPL, the basis for that determination is documented.

PPPL advances the coupled fields of fusion energy and plasma physics research and, with collaborators, is developing the scientific understanding and key innovations needed to realize fusion as an energy source for the world. 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, such as the Magnetic Reconnection Experiment (MRX), the Lithium Tokamak Experiment (LTX) and Hall Thruster, which investigate plasma physics phenomena. PPPL also conducts theoretical plasma physics research and mathematical simulation of plasma physics phenomena as well as advancing graduate education in plasma physics.

2.0 Background & Site Description

PPPL is located on Princeton University's James Forrestal Campus in Plainsboro Township, Middlesex County (central New Jersey), adjacent to the municipalities of Princeton, Kingston,

East and West Windsor, and Cranbury, NJ. It occupies approximately 88.5 acres in the areas known as “C- and D-Sites.” PPPL has operated on the current site since 1959. 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). Princeton University's main campus is approximately three miles west of the site, primarily located within the Borough of Princeton.

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.

The climate of central New Jersey is classified as mid-latitude, rainy climate with mild winters, hot summers, and no dry season. Temperatures may range from below zero to above 100 degrees Fahrenheit (°F) (-17.8°Celsius (C) to 37.8° C); extreme temperatures typically occur once every five years. Approximately half the year, from late April until mid-October, the days are freeze-free. Normally, the climate is moderately humid with a total average precipitation about 46 inches (116 cm) evenly distributed throughout the year.

3.0 Exposure Limits

PPPL is committed to the principle of maintaining worker, public and environmental radiation exposure As Low As Reasonably Achievable (ALARA). PPPL limits radiation doses to members of the public to less than all applicable dose limits. DOE O 458.1, *Radiation Protection of the Public and the Environment*, establishes dose limits for members of the public of 100 mrem per year total effective dose, as well as equivalent doses of 1,500 mrem/year to the lens of the eye and 5,000 mrem/year to the skin or extremities. To ensure that dose to the public does not exceed the applicable dose limit, PPPL has established an administrative dose limit (experimental design objective) of 10 mrem/year from all exposure pathways. In addition to the total dose limit, PPPL’s ES&H Directives (ESH5008) includes the following limits (mrem/year):

PATHWAY	LEGAL LIMIT	ADMINISTRATIVE LIMIT
All Pathways	100	10*
Air**	10	---
Drinking Water***	4	---

* NSTX design objective

** NESHAPS requirement (40 CFR 61 Subpart H)

*** 40 CFR 141

--- No established limit

Additional details regarding dose limits and monitoring can be found in ESH5008, Section 10, *Radiation Safety* and the PPPL *ALARA Plan*.

4.0 Environmental Monitoring

PPPL's Environmental Monitoring Plan (EMP) outlines the radiological and non-radiological environmental monitoring and surveillance that are conducted to demonstrate compliance with legal and regulatory requirements of applicable federal, state, and local agencies; demonstrate adherence to U.S. Department of Energy's (DOE) environmental protection policies; and document PPPL's environmental monitoring programs.

The EMP addresses five media monitored for radiological and non-radiological parameters: meteorology, air, surface water, ground water and wastewater. The EMP is implemented under operational procedures of the Environmental Services (ESD) and Health Physics (HP) Divisions. PPPL's radiological environmental monitoring programs provide confirmation that release of radioactive material at or beyond PPPL's site boundary will be within applicable regulations and are maintained As Low As Reasonably Achievable (ALARA).

Radiological effluents from current and anticipated activities include tritium (tritiated water or tritium oxide - HTO and elemental tritium - HT). Monitoring of airborne effluents complies with the National Emissions Standards for Hazardous Air Pollutants (NESHAPs) regulations in 40 CFR 61, Subpart H, airborne radioactive emissions. Environmental monitoring is conducted to evaluate potentially effected environmental media and exposure pathways. The radiological environmental surveillance program includes precipitation, air, surface water, and ground water monitoring.

5.0 Air Emissions

PPPL operations are managed to maintain radiological and non-radiological air emissions below applicable limits. Monitoring of airborne effluents complies with the National Emissions Standards for Hazardous Air Pollutants (NESHAPs) regulations in 40 CFR 61, Subpart H, airborne radioactive emissions. Air samples from continuous differential atmospheric tritium samplers (DATS) located on the D-site exhaust stack are analyzed weekly to monitor the airborne tritium releases. Air samples are prepared and analyzed for HT and HTO in accordance with PPPL Environmental, Analytical, and Radiological Laboratory (PEARL) procedures HP-RL-19, TFTR Passive Stack Monitoring System Air Sampling. Annually, a NESHAPS report is submitted through DOE to the US Environmental Protection Agency, Region II. PPPL uses the COMPLY code to verify compliance with 40 CFR 61.

6.0 Wastewater

Radiological wastewater is collected in the Liquid Effluent Collection Tank (LECT) system for monitoring prior to discharge to the Stony Brook Regional Sewerage Authority. There is no direct surface or subsurface discharge of radiological wastewater from the site. The management of radiological wastewater is outlined in the Environmental Monitoring Plan, Section 6.0, *Radiological Monitoring*, and controlled by operational procedures of the Engineering and ESH&S Departments. An annual total discharge limit of 1 Curie per year (Ci/yr) for tritium in wastewater discharged to the sanitary sewer, with an additional per-discharge concentration limit of 2×10^6 pico-curies per liter (pCi/L), are based on NJDEP and DOE requirements. Occupational and airborne contamination controls implemented through PPPL's ALARA program indirectly control the generation of radiological wastewater by controlling the contamination source terms resulting in discharges that are significantly below administrative and regulatory limits.

7.0 Direct Radiation

The NSTX experiment generates neutron and gamma radiation during plasma operations, which is a potential source of radiation exposure to the public and environment. The number of neutrons generated during NSTX operations is limited to ensure that any such exposure, when added to all other exposure pathways (air, water), will meet the administrative limit in Section 3.0 above. Neutron and gamma radiation are monitored during NSTX operations using instrumentation located at four D-Site boundary trailers. Potential dose to the public is calculated from the actual number of neutrons generated during NSTX experimental operations using models developed for the TFTR experiment (and extrapolated to NSTX) and documented in the TFTR Final Safety Analysis Report (Section 4.9).

8.0 Radioactive Waste

DOE Order 458.1 addresses waste management and disposal at DOE sites. PPPL's low-level waste is packaged and shipped off-site for disposal; thus, many of the requirements in Order 458.1 are not applicable to PPPL. PPPL's radioactive waste management program is outlined in the *Low-Level Radioactive Waste Management Program Basis Document* and implemented under applicable operating procedures.

9.0 Drinking Water & Ground Water Protection

PPPL does not operate an on-site potable water supply system. Potable water is supplied by the New Jersey American Water Company, which is served by numerous surface water and ground water sources throughout central New Jersey. As noted in Section 6, there are no direct radiological wastewater discharges at PPPL. Occupational and airborne contamination controls implemented through PPPL's ALARA program indirectly control radiological environmental releases by controlling the contamination source terms. Precipitation and ground water monitoring are conducted to evaluate the airborne release pathway and subsequent percolation of precipitation to ground water. The protection of drinking water and ground water is achieved through the implementation of PPPL's ALARA, NEPA and Radiation Protection programs and the activities and administrative limits discussed in Sections 3, 5 and 6 (above). These programs address potential occupational and environmental exposure scenarios and are supplemented by operational procedures. It should be noted that the foundation drainage system on D-Site creates a significant cone of depression in the site-wide water table, causing radial ground water flow toward the building sumps. Water from the sumps is discharged to the surface water at a permitted outfall location, which is monitored as part of PPPL's environmental surveillance program.

10.0 Protection of Biota

The primary pathway for biota exposure from PPPL's radiological release is via the aquatic pathway. PPPL's environmental monitoring program has consistently documented aquatic releases that are a small fraction of the water biota concentration guide (BCG) (for HTO) of 3×10^8 pCi/L for aquatic system evaluations, and the water BCG for HTO of 2×10^8 pCi/L for terrestrial system evaluations, per DOE Standard STD-1153-2002, *A Graded Approach for Evaluating Radiation Doses to Aquatic and Terrestrial Biota*. PPPL does not monitor soil, vegetation and foodstuffs. 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.

11.0 Release and Clearance of Material

Section 2.k of DOE Order 458.1 requires a program to document the release and clearance of material and (personal) property that could contain residual radioactivity. PPPL's radiological clearance and release program is summarized in ESHD 5008, Section 10, Radiation Safety.

Subpart L identifies the removable surface contamination limit of 1,000 disintegrations per minute (dpm) per 100 square centimeters (cm²) of surface area for unrestricted release from the PPPL site. It is the policy of PPPL not to free-release any material from control that is known or suspected to contain DOE radioactive material above this approved level.

12.0 Records Retention and Reporting

Records retention and reporting is addressed by lab-wide procedure GEN-023, *Records Management*, as well as the PPPL *Radiation Protection Program*, ESHD5008, Section 10, *Radiation Safety*, the *ES&H/IS Records Inventory and Schedule*, and specific plans and procedures.

APPENDIX A

DOE Order 458.1, *Radiation Protection of Public and the Environment*

Environmental Radiation Protection Program (ERPP) Implementation Matrix

[Documents referenced in this matrix are not DOE-approved. Changes to the documents, therefore, do not require DOE approval].

APPENDIX A
Environmental Radiological Protection Program (ERPP)
DOE Order 458.1, Radiation Protection of Public and the Environment

CRD Requirement	Description	Applicable Document(s)
2. SPECIFIC REQUIREMENTS		
2.a - Environmental Radiological Protection Program	The contractor conducting radiological activities must develop and implement a documented program which addresses compliance with the Specific Requirements in this CRD that are relevant to the particular activities being conducted.	P-002, Environmental Stewardship; P-027, Radiological ALARA; P-015, Records Management; P-089, Moratorium on the Release of Surplus and Scrap Materials; ESHD 5008, Section 10, Radiation Safety; PPPL Radiation Protection Program; Environmental Monitoring Plan; PPPL ALARA Plan; PPPL Radioactive Waste Management Basis Document; ES&H/IS Records Inventory and Schedule; ESH-014, NEPA Review; OP-AD-09, D-Site Work Permits; OP-AD-77, Operating and Maintenance of Tritium Contaminated Systems; OP-AD-115, Movement of Radioactive/Contaminated Material To/From D-site; applicable Health Physics (HP) Division Procedures; applicable Environmental Services Division (ESD) Procedures; Annual Site Environmental Reports; Radionuclides Air Emissions Annual Reports
2.b - Public Dose Limit	The contractor must establish and implement procedures and practices to address applicable elements related to the public dose limit.	P-027, Radiological ALARA; ESHD 5008, Section 10, Radiation Safety (Subparts C & P); PPPL ALARA Plan (Sections 7, 8 & 13); PPPL Radiation Protection Program (Subpart C); ESH-014, NEPA Review
2.c - Temporary Dose Limits (TED)	If special circumstances could affect a DOE radiological activity in such a manner that the potential dose to a member of the public could exceed a TED of 100 mrem (1 mSv) in a year the contractor must submit a request for specific authorization for a temporary public dose limit higher than 100 mrem (1 mSv) in a year to the responsible Field Element Manager.	P-027, Radiological ALARA; ESHD5008, Section 10, Radiation Safety (Subparts C, N & P); PPPL ALARA Plan (Sections 7, 8 & 13); PPPL Radiation Protection Program (Subparts C & N); ESH-014, NEPA Review
2.d - As Low As Reasonably Achievable (ALARA)	An ALARA process must be implemented to optimize control and management of radiological activities so that doses to members of the public (both individual and collective) and releases to the environment are kept as low as reasonably achievable	P-027, Radiological ALARA; PPPL ALARA Plan (Sections 7, 8 & 13); PPPL Radiation Protection Plan (Subpart B); Health Physics Division Procedures
2.e - Demonstrating Compliance with the Public Dose Limit	The contractor must establish and implement procedures and practices to demonstrate compliance with the public dose limit.	ESH5008, Section 10 (Subparts E & P), Radiation Safety; ESH-014, NEPA Review; PPPL ALARA Plan (Sections 8 & 13); PPPL Radiation Protection Program (Subpart E); Environmental Monitoring Plan (Sections 2 and 6); HP Division Procedures; Annual Site Environmental Reports (Chapter 5); Radionuclides Air Emissions (NESHAPS) Annual Reports

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CRD Requirement	Description	Applicable Document(s)
2.f - Airborne Radioactive Effluents	The contractor must establish and implement procedures and practices related to airborne radioactive effluents so that radiological activities are conducted in a manner such that the release of radioactive material to the atmosphere will: (1) Be evaluated using the ALARA process.	ESH5008, Section 10, Radiation Safety (Subparts C, K & L); PPPL ALARA Plan (Sections 13 & 14); PPPL Radiation Protection Program (Subparts C, K & L); ESH-014, NEPA Review; Environmental Monitoring Plan (Section 6); HP Division Procedures; OP-AD-09, D-Site Work Permits; OP-AD-77, Operating and Maintenance of Tritium Contaminated Systems; Annual Site Environmental Reports (Chapter 5); Radionuclides Air Emissions (NESHAPS) Annual Reports
2.g - Control and Management of Radionuclides from DOE Activities in Liquid Discharges	The contractor must establish and implement procedures and practices related to control and management of radionuclides from DOE activities in liquid discharges.	ESH5008, Section 10, Radiation Safety (Subparts C, K & L); PPPL Radiation Protection Program (Subparts C, K & L); ESH-014, NEPA Review; PPPL ALARA Plan (Sections 13 & 14); Environmental Monitoring Plan (Section 6); HP Division PEARL Procedures; OP-AD-09, D-Site Work Permits; OP-AD-77, Operating and Maintenance of Tritium Contaminated Systems; OP-G-49, Liquid Effluent Collection Tank Monitoring
2.h - Radioactive Waste and Spent Nuclear Fuel	The contractor must establish and implement procedures and practices to ensure that management, storage and disposal of radioactive waste and spent nuclear fuel address the following elements: (3) Management, storage and disposal of low-level radioactive waste must be conducted in a manner such that exposure to members of the public to radiation from radioactive waste complies with ALARA process requirements, and does not exceed a TED of 25 mrem (0.25 mSv) in a year from all exposure pathways and radiation sources associated with the waste, except for transportation and radon and its decay products.	P-014, Waste Minimization; ESH5008, Section 10, Radiation Safety (Subpart L); PPPL Radiation Protection Program (Subpart L); ESH-014, NEPA Review; PPPL Radioactive Waste Management Basis Document; OP-AD-115, Movement of Radioactive/Contaminated Material To/From D-site; ESD Radioactive Waste Management Procedures
2.i - Protection of Drinking Water and Ground Water	The contractor must establish and implement procedures and practices to ensure that DOE sites provide a level of radiation protection for persons consuming water from a drinking water system operated by DOE, directly or through a DOE contractor... The contractor must protect ground water from radiological contamination to ensure compliance with dose limits in the Specific Requirements in this CRD and consistent with ALARA process requirements.	N/A (No DOE-owned potable water supply system) PPPL ALARA Plan; PPPL Radiation Protection Program (Subparts K & L); ESH-014, NEPA Review; ESHD 5008, Section 10 (Subparts K, L & P), Radiation Safety; OP-AD-09, D-Site Work Permits; OP-AD-77, Operating and Maintenance of Tritium Contaminated Systems
2.j - Protection of Biota	The contractor must establish and implement procedures and practices to ensure that biota are protected.	Environmental Monitoring Plan (Section 6); Annual Site Environmental Reports (Chapter 5)

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CRD Requirement	Description	Applicable Document(s)
2.k - Release and Clearance of Property	The contractor must establish and implement procedures and practices to ensure that release or clearance of property with the potential to contain residual radioactive material must be conducted in accordance with DOE direction and in accordance with the requirements in paragraph 2.k. of the Specific Requirements in this CRD.	P-089, Moratorium on the Release of Surplus and Scrap Materials; ESHD5008, Section 10 (Subpart L), Radiation Safety; ESH-014, NEPA Review; OP-AD-115, Movement of Radioactive/Contaminated Material To/From D-site; MC-004, Acquisition and Disposal of Excess Government Property; HP Division Procedures; ESD Radioactive Waste Management Procedures
2.l - Records, Retention and Reporting Requirements	The contractor must establish and implement recordkeeping, retention and reporting procedures and practices to ensure that the following elements are addressed...	GEN-023, Records Management; ESHD5008, Section 10 (Subpart H); PPPL ALARA Plan (Section 15); PPPL Radiation Protection Program (Subpart H); ES&H/IS Records Inventory and Schedule; EM-OP-15, Waste Management Records; HP Records Procedure; Annual Site Environmental Reports (Chapter 5)