



PNNL-36464

# Pacific Northwest National Laboratory Annual Site Environmental Report for Calendar Year 2023

September 2024

SW Thompson  
SF Snyder  
CA Duberstein  
ES Norris  
JM Barnett  
JL Blake

AT Pitman  
C Counts  
J Haigh  
KM Mendez  
KD Hand  
J Su-Coker

RA Del Mar  
LE Bisping  
TW Moon  
EA Raney  
CJ Duchsherer

RS Wiegman  
SR Horn  
L Dinh  
JA Stephens  
C Ramos

## DISCLAIMER

This report was prepared as an account of work sponsored by an agency of the United States Government. Neither the United States Government nor any agency thereof, nor Battelle Memorial Institute, nor any of their employees, makes **any warranty, express or implied, or assumes any legal liability or responsibility for the accuracy, completeness, or usefulness of any information, apparatus, product, or process disclosed, or represents that its use would not infringe privately owned rights.** Reference herein to any specific commercial product, process, or service by trade name, trademark, manufacturer, or otherwise does not necessarily constitute or imply its endorsement, recommendation, or favoring by the United States Government or any agency thereof, or Battelle Memorial Institute. The views and opinions of authors expressed herein do not necessarily state or reflect those of the United States Government or any agency thereof.

PACIFIC NORTHWEST NATIONAL LABORATORY  
*operated by*  
BATTELLE  
*for the*  
UNITED STATES DEPARTMENT OF ENERGY  
*under Contract DE-AC05-76RL01830*

Printed in the United States of America

Available to DOE and DOE contractors from  
the Office of Scientific and Technical Information,  
P.O. Box 62, Oak Ridge, TN 37831-0062

[www.osti.gov](http://www.osti.gov)  
ph: (865) 576-8401  
fox: (865) 576-5728  
email: [reports@osti.gov](mailto:reports@osti.gov)

Available to the public from the National Technical Information Service  
5301 Shawnee Rd., Alexandria, VA 22312  
ph: (800) 553-NTIS (6847)  
or (703) 605-6000  
email: [info@ntis.gov](mailto:info@ntis.gov)  
Online ordering: <http://www.ntis.gov>

# **Pacific Northwest National Laboratory Annual Site Environmental Report for Calendar Year 2023**

September 2024

SW Thompson	AT Pitman	RA Del Mar	RS Wiegman
SF Snyder	C Counts	LE Bisping	SR Horn
CA Duberstein	J Haigh	TW Moon	L Dinh
ES Norris	KM Mendez	EA Raney	JA Stephens
JM Barnett	KD Hand	CJ Duchsherer	C Ramos
JL Blake	J Su-Coker		

Prepared for  
the U.S. Department of Energy  
under Contract DE-AC05-76RL01830

Pacific Northwest National Laboratory  
Richland, Washington 99354

## Pacific Northwest National Laboratory Annual Site Environmental Report for 2023

### Can We Make This Report More Useful to You?

We want to make this report useful and easy to read. To help us in this effort, please take a few minutes to let us know if the PNNL Annual Site Environmental Report meets your needs. Email us at [pnsomanager@science.doe.gov](mailto:pnsomanager@science.doe.gov), or print this page and mail it to:

Tom McDermott  
Pacific Northwest Site Office, P.O. Box 350 MS K9-42, Richland, WA 99352

### How do you use the information in this report?

- ☐ To learn general information about PNNL
- ☐ To learn about doses from PNNL activities
- ☐ To send to others outside the Tri-Cities area
- ☐ To learn about site compliance
- ☐ Other: \_\_\_\_\_

### Does this report contain:

- ☐ Enough detail
- ☐ Not enough detail
- ☐ Too much detail

### Is the technical content:

- ☐ Too concise
- ☐ Too wordy
- ☐ Uneven
- ☐ Just right

### Is the text easy to understand?

- ☐ Yes
- ☐ No

If no, is it: ☐ Too technical ☐ Too detailed ☐ Other \_\_\_\_\_

### Is the report comprehensive?

- ☐ Yes
- ☐ No

If no, please identify any issues you believe are missing in the Other Comments section below.

### Other Comments:

---



---



---

### What is your affiliation?

- ☐ U.S. DOE
- ☐ Media
- ☐ State Agency
- ☐ Federal Agency
- ☐ Public Interest Group
- ☐ Member of Native American Nation
- ☐ Local Agency
- ☐ Member of the public
- ☐ University
- ☐ Industry



## Executive Summary

Pacific Northwest National Laboratory (PNNL), one of the U.S. Department of Energy (DOE) Office of Science's 10 national laboratories, provides innovative science and technology development in the areas of energy and the environment, fundamental and computational science, and national security. There are three DOE offices within the Richland area. Two are responsible for the Hanford Site, whereas the Pacific Northwest Site Office oversees PNNL.

PNNL prepares an Annual Site Environmental Report to meet the requirements of DOE Order 231.1B, *Environment, Safety and Health Reporting*, and DOE Order 458.1, *Radiation Protection of the Public and the Environment*, thus assuring that the public is informed of any PNNL-Richland campus or PNNL-Sequim campus event that could adversely affect the health and safety of the public, site staff, or the environment.

The report provides a synopsis of ongoing environmental management performance and compliance activities for operations that occur at the PNNL-Richland campus in Richland, Washington, and at the PNNL-Sequim campus near Sequim, Washington. It describes the location of and background for each facility; addresses compliance with applicable DOE, federal, state, and local regulations, and site-specific permits; documents environmental monitoring efforts and their status; presents potential radiation doses to staff and the public in the surrounding areas; and describes DOE-required data quality assurance methods used for data verification.

## Compliance with Federal, State, and Local Laws and Regulations in 2023

PNNL is subject to many federal, state, and local environmental laws, regulations, guidance decrees, DOE requirements, and Executive Orders, as well as numerous site-specific permits. Detailed requirements are integrated into PNNL projects by means of environmental compliance representatives assigned to assess and assist with each project. During 2023, PNNL continued to exhibit an excellent compliance record. Required reports were submitted, necessary reviews and permits for research and support activities were obtained, all sitewide permits were current, and authorized emission and discharge levels were kept within specified limits.

## Environmental Sustainability Performance

PNNL's environmental management system was certified to meet the requirements of the International Standards Organization (ISO) 14001 standards from 2002 through 2023. Since 2023, PNNL has an ISO 14001 conforming program per DOE Order 436.1A. This demonstrates commitment to safe and sustainable operations. The system is integrated into PNNL's Integrated Safety Management Program, which assures that staff are aware of project scope, risks/hazards, and controls available to address the functions, processes, and procedures used to plan and perform work safely. PNNL is dedicated to responsible planning for and management of resources that could be affected by facility operations and exhibited excellent environmental sustainability performance in energy and water conservation, waste diversion, alternative fuel use, reduction of greenhouse gas emissions, and sustainable building design in 2023. Additionally, the PNNL Implementation Plan for Net-Zero Emissions and Energy-Resilient Operations Pilot provides the blueprint to systematically implement this strategy through deep facility retrofits and new construction projects. Along the way, PNNL is using its PNNL-Richland and PNNL-Sequim campuses as living laboratories for testing new technologies and approaches and using the knowledge we gain to shape a model for others. Additionally, PNNL's Campus Master Plan provides the tactical details on project execution to achieve the net-zero emissions vision.

During FY 2023, electrification projects were prioritized based on mission needs. Progress toward net-zero emission buildings continued. By the end of calendar year 2024, PNNL will add over 135,000 gross square feet of net-zero emissions-ready new buildings and electrify over 213,000 gross square feet of existing buildings.

## Environmental Monitoring and Dose Assessment

PNNL monitors air and water quality to assure compliance with federal, state, and local regulatory requirements and permits. Focus areas for monitoring efforts are described below.

### Air Emissions

Airborne emissions from PNNL facilities are monitored to assess the effectiveness of emission treatment and control systems, as well as pollution management practices. The Benton Clean Air Agency implements and enforces most federal and state requirements on the PNNL-Richland campus, and the Olympic Region Clean Air Agency implements and enforces most federal and state requirements at the PNNL-Sequim campus for non-radioactive emissions. For radioactive emissions to air, the Washington Department of Health provides regulatory oversight. There were no unplanned releases of regulated substances or substances of concern from PNNL facilities in 2023.

### Liquid Effluent Monitoring

Liquid effluent discharges from PNNL-Richland campus operations are monitored under permits issued by the City of Richland. Process wastewater from the PNNL-Sequim campus is treated at an on-site wastewater treatment plant prior to being discharged to Sequim Bay under a permit issued by the Washington State Department of Ecology. In 2023, there were no unplanned releases of regulated pollutants or contaminated wastewater from PNNL facilities.

## Drinking Water Monitoring

Drinking water quality at the PNNL-Sequim campus is monitored under a permit issued by the Washington State Department of Health. Drinking water is supplied by an on-site groundwater well and is untreated prior to distribution. In 2023, the PNNL-Sequim campus drinking water system complied with drinking water standards and there were no noncompliance issues.

## Radiological Release of Property

PNNL uses the preapproved guideline limits derived from guidance in DOE Order 458.1, Chg 4, *Radiation Protection of the Public and the Environment*, when releasing property potentially contaminated with residual radioactive material. No property with detectable residual radioactivity above authorized levels was released to the general public from PNNL in 2023.

## Radiation Protection of Biota

PNNL models environmental concentrations for air, soil, sediment, and water to consider impacts on biota from PNNL particulate radioactive releases to ambient air. The 2023 dose rate estimates for aquatic, terrestrial, and riparian animals and plants for both the PNNL-Richland and PNNL-Sequim campuses were well below the dose rate limits of DOE Order 458.1, Chg 4 guidance (1 rad/d [10 mGy/d] for both aquatic animals and terrestrial plants, and less than 0.1 rad/d [1 mGy/d] for both riparian animals and terrestrial animals).

## Environmental Radiological Monitoring

Radioactive particulates in ambient air are monitored using a particulate air-sampling network located at the PNNL-Richland campus. No radiological releases to the environment exceeded permitted limits in 2023, and there was no indication that any PNNL activities increased the ambient air concentrations at the air-sampling locations.

## Public Radiation Dose from All Pathways

The PNNL-Richland campus 2023 maximum exposed individual (MEI) location was 0.74 km (0.46 mi) south-southeast of the Physical Sciences Facility 3410 Building. Dose to the MEI from site radionuclide air emissions was  $2.1 \times 10^{-5}$  mrem ( $2.1 \times 10^{-7}$  mSv). No other pathways contributed to MEI dose. In 2023, within the 80 km (50 mi) radius of the PNNL-Richland campus, the collective dose from radionuclide air emissions that originated from the campus was  $2.4 \times 10^{-4}$  person-rem ( $2.4 \times 10^{-6}$  person-Sv).

The PNNL-Sequim campus MEI location for 2023 was 0.23 km (0.14 mi) west of the central emission location. Dose to the MEI from site emissions was  $5.8 \times 10^{-8}$  mrem ( $5.8 \times 10^{-10}$  mSv). The 80 km (50 mi) collective dose for PNNL-Sequim campus emissions was  $1.6 \times 10^{-7}$  person-rem ( $1.6 \times 10^{-9}$  person-Sv).

The total dose from radioactive air emissions to either the PNNL-Richland campus or PNNL-Sequim campus MEI is well below the federal and state standard of 10 mrem/yr (0.1 mSv/yr). The total dose from all pathways (air emissions, liquid effluent releases, and other pathways) is well below the limit of 100 mrem/yr (1 mSv/yr).

## Environmental Nonradiological Program Information

PNNL nonradiological air emissions are below levels that require stack monitoring; compliance is achieved by conforming to permit conditions. There was no nonradiological air emission permit exceedance or noncompliance occurrence at either the PNNL-Richland campus or PNNL-Sequim campus in 2023.

## Natural and Cultural Resource Management

Protection and management of cultural and biological resources on PNNL lands is implemented through internal cultural and biological resource protection procedures, which are updated annually to reflect relevant changes in applicable laws and regulations and compliance methods. The *Pacific Northwest Site Office Cultural and Biological Resources Management Plan* provides guidance related to protecting and managing biological and cultural resources at PNNL.

Three endangered and threatened fish species—Upper Columbia River spring-run Chinook salmon, Upper Columbia River steelhead, and bull trout—are known to occur or potentially occur in the Columbia River Hanford Reach, adjacent to the PNNL-Richland campus. Ten federally endangered or threatened animal species are known to occur on or near the PNNL-Sequim campus.

1. marbled murrelet
2. bull trout
3. Hood Canal summer-run chum salmon
4. North American green sturgeon
5. Pacific eulachon
6. Puget Sound bocaccio
7. Puget Sound Chinook salmon
8. Puget Sound steelhead
9. Puget Sound yelloweye rockfish
10. Taylor's checkerspot butterfly.

The range of the island marble butterfly has been refined, as this species is no longer found near the PNNL-Sequim campus. Additionally, all of Clallam County, Washington, including the PNNL-Sequim campus, is within the range of the northwestern pond turtle, a species proposed for listing as a threatened species in 2023.

All PNNL projects involving soil or vegetation disturbance or work outdoors are routinely evaluated to determine their potential to affect biological resources prior to implementation. Ninety-three biological resource reviews were completed in 2023 at the PNNL-Richland campus (35), PNNL-Sequim campus (24), and other locations (34). One hundred forty-one environmental permits or authorizations for PNNL research activities were acquired in calendar year 2023.

The PNNL cultural resources program supported 72 projects in 2023—16 occurred at the PNNL-Richland campus, and 20 occurred at the PNNL-Sequim campus. Annual conditions monitoring was also conducted at both campuses in 2023. Minor disturbances were noted during monitoring specified under Section 110 of the National Historic Protection Act of 1966. The issues did not result in adverse impacts to cultural or historic resources.

## **Groundwater Protection**

Groundwater monitoring is no longer required for environmental compliance at either the PNNL-Richland or PNNL-Sequim campus.

## **Quality Assurance**

The comprehensive quality assurance programs and plans at PNNL, which include quality control procedures and method verification, assured reported data were reliable and met all quality control and quality assurance objectives. Sampling and monitoring activities performed under PNNL's Environmental Management Program in 2023 included collecting samples of water, wastewater, radiological air emissions, ambient air, and environmental dosimeters. Chain-of-custody procedures tracked the transfer of samples from points of collection to accredited analytical laboratories.

## Contributors

Compilation of the Pacific Northwest National Laboratory Annual Site Environmental Report involved the collaboration and expertise of numerous staff members at PNNL. Principal contributors and their subject matter specialties included the following:

SW Thompson	Project Leader, Coordination, Editing and Reviewing throughout, Executive Summary, Compiling Introduction, References
SF Snyder	Document Review/Coordination, Demographics, Ambient External Dose Monitoring, Peer Review, Distribution Assist
CA Duberstein, ES Norris	Project Management, <i>National Environmental Policy Act</i> , Environmental Setting and Ecology, Biological Resources
JM Barnett	Air Quality, Radiation Protection of Biota, Environmental Radiological Monitoring and Permits, Assist Non-Radiological Monitoring
JL Blake, AT Pitman, C Counts, J Haigh	Copyediting and Formatting
KM Mendez	Cultural and Historic Resources
KD Hand	Environmental Setting and Ecology, Compliance Summary, Permit List, Biological Resources, Noxious Weed Control
J Su-Coker, RA Del Mar	Environmental Management System and Sustainability
LE Bisping	Environmental Radiological Monitoring
TW Moon	Groundwater Protection, Liquid Effluent Monitoring, DOE Order 458.1 Reporting
EA Raney	Water Quality, Liquid Effluent Monitoring, Contributor Compliance Summary, QA Assist
CJ Duchsherer	Nonradiological Air Emissions, Permit List
RS Wiegman, SR Horn	Permitting, Environmental and Waste Management Regulations, Statutes
L Dinh	Quality Control and Assurance
JA Stephens	Radiation Protection
C Ramos	Distribution

## Acronyms and Abbreviations

°C	degrees Celsius
°F	degrees Fahrenheit
µg/L	microgram per liter
µrem/hr	microrem per hour
µSv	microsievert
325RPL	325 Building Radiochemical Processing Laboratory
<b>A</b>	
ac	acre
AFFF	aqueous film forming foam
AIM	American Innovation and Manufacturing Act
ALARA	as low as reasonably achievable
ANSI/HPS	American National Standards Institute/Health Physics Society
AQSS	Acquisition Quality Support Services
ASME	American Society of Mechanical Engineers
ASO	Analytical Support Operations (laboratory)
<b>B</b>	
BCAA	Benton Clean Air Agency
BP	Before Present
BPA	Bonneville Power Administration
Bq	becquerel
Btu	British thermal unit
<b>C</b>	
CAA	<i>Clean Air Act</i>
CBRMP	Cultural and Biological Resources Management Plan
CCR	California Code of Regulations
CERCLA	<i>Comprehensive Environmental Response, Compensation, and Liability Act of 1980</i>
CFE	Carbon-Free Electricity
CFR	Code of Federal Regulations
Ci	curie
cm	centimeter
CMP	coastal zone management program
CWA	<i>Clean Water Act</i>
CY	calendar year
CZMA	Coastal Zone Management Act of 1972

**D**

d	day
DoD	U.S. Department of Defense
DOE	U.S. Department of Energy
DOE-RL	DOE-Richland Operations Office
DOE-SC	DOE Office of Science
dpm	disintegrations per minute
DQO	data quality objective

**E**

EAC	Energy Attribute Certificates
ECHO	Enforcement & Compliance History Online
EDE	effective dose equivalent
EISA	<i>Energy Independence and Security Act of 2007</i>
EM	Effluent Management
EMP	Environmental Management Plan
EMS	environmental management system
EMSL	William R. Wiley Environmental Molecular Sciences Laboratory
EPA	U.S. Environmental Protection Agency
EPCRA	<i>Emergency Planning and Community Right-to-Know Act of 1986</i>
ERP	Environmental Research Permitting
ESA	<i>Endangered Species Act of 1973</i>
ESC	Energy Sciences Center
EWTPG	Effluent, Waste, and Transportation Programs Group

**F**

FEMA	Federal Emergency Management Agency
FR	Federal Register
FSOAA	<i>Forest Service Organic Administration Act</i>
ft	foot (feet)
ft <sup>2</sup>	square foot (feet)
ft <sup>3</sup>	cubic foot (feet)
FY	fiscal year

**G**

g	g-force
gal	gallon
GBq	gigabecquerel
GEL	General Engineering Laboratories
GLM	General Laws of Massachusetts
gpd	gallon per day

gsf	gross square foot (feet)
GSL	Grid Storage Launchpad
Gy	gray
<b>H</b>	
ha	hectare
HDI	How Do I....?
HFC	hydrofluorocarbon
HEMSF	High-Energy Mission-Specific Facility
HTB	Heat Transfer Building
<b>I</b>	
IEC	International Electrotechnical Commission
in.	inch(es)
ISO	International Organization for Standardization
<b>K</b>	
kg	kilogram (1,000 grams)
km	kilometer
km <sup>2</sup>	square kilometer
kW	kilowatt
<b>L</b>	
L	liter
L/min	liter per minute
LAC	Louisiana Administrative Code
lb.	pound
LEPC	Local Emergency Planning Committee
<b>M</b>	
m	meter
m <sup>2</sup>	square meter
m <sup>3</sup>	cubic meter
m/s	meter per second
MAPEP	Mixed-Analyte Performance Evaluation Program
MBTA	<i>Migratory Bird Treaty Act of 1918</i>
MEI	maximum exposed individual
mGy/d	milligray per day
mi	mile
mi <sup>2</sup>	square mile
min	minute
MMPA	<i>Marine Mammal Protection Act of 1972</i>
mph	miles per hour

MRAD	Multimedia Radiochemistry Proficiency Testing
mrem	millirem
mrem/yr	millirem per year
MSFCMA	<i>Magnuson–Stevens Fishery Conservation and Management Act</i>
mSv	millisievert
mSv/yr	millisievert per year
<b>N</b>	
NA	not applicable
NEPA	<i>National Environmental Policy Act of 1969</i>
NESHAP	National Emission Standards for Hazardous Air Pollutants
NHPA	<i>National Historic Preservation Act of 1966</i>
NMFS	National Marine Fisheries Service
NOAA	National Oceanic and Atmospheric Administration
NPDES	National Pollutant Discharge Elimination System
NQA	nuclear quality assurance
<b>O</b>	
OAR	Oregon Administrative Rules
ORCAA	Olympic Region Clean Air Agency
OSLD	optically stimulated luminescence dosimeter
<b>P</b>	
PCB	polychlorinated biphenyl
pCi	picocurie
pCi/L	picocurie per liter
pCi/m <sup>3</sup>	picocurie per cubic meter
pCi/mL	picocurie per milliliter
PFAS	per- and polyfluoroalkyl substances
PIC-5	Potential Impact Category 5
PNL	Pacific Northwest Laboratory
PNNL	Pacific Northwest National Laboratory
PNSO	Pacific Northwest Site Office
PSF	Physical Sciences Facility
PV	photovoltaic
<b>Q</b>	
QA	quality assurance
QAP	quality assurance plan
QC	quality control
<b>R</b>	
R&D	research and development

RAEL	radioactive air emission license
RCRA	<i>Resource Conservation and Recovery Act of 1976</i>
RCW	Revised Code of Washington
RESL	Radiological and Environmental Sciences Laboratory
RHA	<i>Rivers and Harbors Appropriations Act of 1899</i>
<b>S</b>	
s	second
SDWA	<i>Safe Drinking Water Act of 1974</i>
SEPA	<i>State Environmental Policy Act</i>
SERC	State Emergency Response Commission
SMA	<i>Shoreline Management Act of 1971</i>
Sv	sievert
<b>T</b>	
TSCA	Toxic Substances Control Act
<b>U</b>	
U.S.	United States
USACE	U.S. Army Corps of Engineers
U.S.C.	U.S. Code
USCG	U.S. Coast Guard
USFWS	U.S. Fish and Wildlife Service
<b>W</b>	
WAC	Washington Administrative Code
WDFW	Washington Department of Fish and Wildlife
WDOH	Washington State Department of Health
<b>Y</b>	
yr	year
<b>Z</b>	
ZEV	zero-emission vehicle

## Contents

Executive Summary .....	i
Contributors .....	vi
Acronyms and Abbreviations.....	vii
1.0 Introduction .....	1
1.1 Location .....	2
1.1.1 PNNL-Richland Campus.....	2
1.1.2 PNNL-Sequim Campus .....	4
1.2 Background and Mission.....	4
1.2.1 PNNL-Richland Campus.....	4
1.2.2 PNNL-Sequim Campus .....	5
1.3 Demographics.....	5
1.4 Environmental Setting – PNNL-Richland Campus.....	6
1.4.1 Environmental Locale .....	6
1.4.2 Ecology .....	10
1.5 Environmental Setting – PNNL-Sequim Campus .....	12
1.5.1 Environmental Locale .....	13
1.5.2 Ecology .....	14
1.6 Cultural Setting – PNNL-Richland Campus.....	16
1.6.1 Precontact Period .....	17
1.6.2 Ethnographic Period .....	17
1.6.3 Euro-American Period .....	17
1.6.4 Manhattan Project and Cold War Era .....	18
1.7 Cultural Setting – PNNL-Sequim Campus.....	18
1.7.1 Ethnographic Period .....	19
1.7.2 Historic Period.....	19
2.0 Compliance Summary .....	21
2.1 Sustainability and Environmental Management System.....	28
2.2 Energy Independence and Security Act of 2007 .....	29
2.3 National Environmental Policy Act of 1969.....	29
2.4 Air Quality .....	31
2.4.1 Clean Air Act .....	31
2.4.2 Clean Air Act Amendments of 1990 and the National Emissions Standards for Hazardous Air Pollutants .....	31
2.4.3 Radioactive Emissions .....	32
2.4.4 Air Permits.....	32
2.4.5 Hydrofluorocarbon Phasedown.....	33

2.5	Water Quality and Protection .....	33
2.5.1	Clean Water Act .....	33
2.5.2	Stormwater Management .....	34
2.5.3	Safe Drinking Water Act of 1974.....	35
2.5.4	Emerging Contaminants .....	35
2.6	Environmental Restoration and Waste Management .....	36
2.6.1	Emergency Planning and Community Right-to-Know Act of 1986 .....	36
2.6.2	Tri-Party Agreement .....	39
2.6.3	Comprehensive Environmental Response, Compensation, and Liability Act of 1980 .....	40
2.6.4	Washington State Dangerous Waste/Hazardous Substance Reportable Releases to the Environment .....	40
2.6.5	Resource Conservation and Recovery Act of 1976.....	40
2.6.6	Federal Facility Compliance Act of 1992.....	41
2.6.7	Toxic Substances Control Act.....	42
2.6.8	Federal Insecticide, Fungicide, and Rodenticide Act.....	42
2.7	Natural and Cultural Resources .....	42
2.7.1	Biological Resources and Environmental Permitting .....	43
2.7.2	PNNL Programs .....	50
2.7.3	Cultural Resources .....	55
2.8	Radiation Protection.....	56
2.8.1	DOE Order 458.1, Radiation Protection of the Public and the Environment .....	56
2.8.2	DOE Order 435.1, Radioactive Waste Management.....	57
2.8.3	Atomic Energy Act of 1954 .....	58
2.9	Major Environmental Issues and Actions .....	58
2.9.1	Continuous Release Reporting .....	58
2.9.2	DOE Order 232.2A, Occurrence Reporting and Processing of Operations Information .....	58
2.9.3	Unplanned Releases .....	58
2.10	Summary of Permits .....	59
3.0	Environmental Management System .....	63
3.1	Environmental Operating Experience and Performance Measurement .....	65
3.1.1	Environmental Management System Highlights.....	65
3.1.2	Reducing Energy Use.....	66
3.1.3	Clean and Renewable Energy .....	67
3.1.4	Net-Zero Emissions and Energy Efficient Buildings .....	68
3.1.5	Adaptation and Resilience .....	70

4.0	Environmental Radiological Protection Program and Dose Assessment.....	71
4.1	Radiological Liquid Discharges and Doses .....	71
4.1.1	Annual Report for DOE Order 458.1 .....	72
4.2	Radiological Air Discharges and Doses .....	72
4.2.1	Contributions from PNNL-Richland Campus.....	73
4.2.2	Contributions from PNNL-Sequim Campus.....	74
4.3	Release of Property Having Residual Radioactive Material.....	75
4.3.1	Property Potentially Contaminated on the Surface.....	75
4.3.2	Property Potentially Contaminated in Volume.....	76
4.4	Radiation Protection of Biota.....	77
4.4.1	Radiation Protection of Biota – PNNL-Richland Campus .....	77
4.4.2	Radiation Protection of Biota – PNNL-Sequim Campus.....	78
4.5	Unplanned Radiological Releases .....	79
4.6	Environmental Radiological Monitoring .....	79
4.6.1	Environmental Radiological Monitoring – PNNL-Richland Campus.....	79
4.6.2	Environmental Radiological Monitoring – PNNL-Sequim Campus.....	84
4.7	Public Dose Summary .....	85
4.8	Future Radiological Monitoring.....	85
5.0	Environmental Nonradiological Program Information .....	86
5.1	Liquid Effluent Monitoring.....	86
5.2	Air Effluent .....	87
6.0	Groundwater Protection Program .....	88
7.0	Quality Assurance .....	89
7.1	Environmental Monitoring Program.....	90
7.2	Sample Collection Quality Assurance .....	93
7.3	Quality Assurance Analytical Results.....	93
7.4	Data Management and Calculations .....	96
7.5	Interlaboratory Performance Programs .....	96
8.0	References.....	99
	Appendix A – Plant and Animal Species Found on Undeveloped Upland and Riparian Areas of the PNNL-Richland Campus, 2009–2023 .....	A.1
	Appendix B – Plant and Animal Species Observed On and In the Vicinity of the PNNL- Sequim Campus.....	B.1
	Appendix C – Ambient External Dose Surveillance Results .....	C.1
	Appendix D – Helpful Information.....	D.1
	Appendix E – Glossary.....	E.1

## Figures

Figure 1.	PNNL Office Locations .....	2
Figure 2.	PNNL-Richland Campus .....	3
Figure 3.	PNNL-Sequim Campus and Nearby Environment .....	4
Figure 4.	Generalized Stratigraphic Column Depicting the Stratigraphy Underlying the PNNL-Richland Campus .....	7
Figure 5.	Water Table Elevations (m) .....	8
Figure 6.	Habitat Polygons on the PNNL-Richland Campus .....	11
Figure 7.	Habitat Types at the PNNL-Sequim Campus .....	14
Figure 8.	NEPA Reviews for New Projects in the Electronic Prep and Risk System Conducted Annually at PNNL from CY 2013–2023. ....	30
Figure 9.	Number of Permits/Authorizations Obtained and Used for Research Projects .....	46
Figure 10.	Yellow Starthistle ( <i>Centaurea solstitialis</i> ) in Bloom .....	52
Figure 11.	Field Crew Applying Targeted Herbicides at the PNNL-Richland Campus .....	53
Figure 12.	Areas Treated for Noxious Weeds on the PNNL-Richland Campus in 2023 .....	54
Figure 13.	Number of Cultural Reviews by Location .....	55
Figure 14.	Elements of the As Low As Reasonably Achievable (ALARA) Principle .....	57
Figure 15.	Electricity Usage and Cost Projections .....	67
Figure 16.	PNNL Carbon-Free Electricity Plan .....	68
Figure 17.	PNNL FY 2023 Greenhouse Gas Scope 1 & 2 by Category .....	69
Figure 18.	Air Surveillance Station Locations for the PNNL-Richland Campus .....	80
Figure 19.	Average Daily Ambient External Dose Rates in 2023 for the PNNL-Richland Campus .....	83
Figure 20.	Components Basic to a Comprehensive QA Program (Barnett 2011) .....	90
Figure A.1.	Vegetation Observed on the Undeveloped Upland Portions of the PNNL-Richland Campus in 2023 .....	A.1
Figure B.1.	Typical Vegetation at the PNNL-Sequim Campus .....	B.1
Figure C.1.	2017 Updated Methodology OSL Results .....	C.3
Figure C.2.	2018 Updated Methodology OSL Results .....	C.3
Figure C.3.	2019 Updated Methodology OSL Results .....	C.4
Figure C.4.	2020 Updated Methodology OSL Results .....	C.4
Figure C.5.	2021 Updated Methodology OSL Results .....	C.5
Figure C.6.	2022 Updated Methodology OSL Results .....	C.5
Figure C.7.	Daily Dose Rates by Quarter for PNNL-Richland Campus .....	C.6
Figure D.1.	Radioactivity Units, Curies to Becquerels .....	D.3
Figure D.2.	Radiological Dose Units, Sieverts to Rem .....	D.3

## Tables

Table 1.	Wildlife, Fish, and Plant Species of Conservation Concern Known to Occur or that Potentially Occur near the PNNL-Richland Campus .....	12
Table 2.	Animal Species of Conservation Concern Known to Occur or that Potentially Occur at and in the Vicinity of the PNNL-Sequim Campus .....	16
Table 3.	EPA ECHO Database Listing for PNNL Campuses .....	22
Table 4.	Status of Federal Environmental Laws and Regulations Applicable to PNNL, 2023 .....	23
Table 5.	Status of Washington State Environmental Laws and Regulations Applicable to PNNL, 2023 .....	27
Table 6.	Provisions of the <i>Emergency Planning and Community Right-to-Know Act of 1986</i> .....	38
Table 7.	<i>Emergency Planning and Community Right-to-Know Act of 1986</i> Compliance Reporting, 2023 .....	39
Table 8.	Environmental Research Permits/Authorizations Obtained in 2023 for PNNL Research Activities .....	43
Table 9.	PNNL Air, Liquid, and Hazardous Waste Permits, 2023 .....	61
Table 10.	PNNL FY 2023 Sustainability Goals and Planned Actions .....	66
Table 11.	PNNL-Richland Campus Emissions and Dose Contributions by Radionuclide, 2023 .....	73
Table 12.	PNNL-Sequim Campus Emissions and Dose Contributions, 2023 (Snyder et al. 2024c) .....	74
Table 13.	Preapproved Surface Activity Guideline Limits .....	76
Table 14.	Preapproved Volumetric Release Limits .....	76
Table 15.	Absorbed Biota Dose Rates for the PNNL-Richland Campus, 2023 .....	78
Table 16.	Absorbed Biota Dose Rates for the PNNL-Sequim Campus, 2023 .....	79
Table 17.	Summary of 2023 Air-Sampling Results for the PNNL-Richland Campus (Snyder et al. 2024b) .....	81
Table 18.	Average Hourly Ambient External Dose Rates in 2023 for the PNNL-Richland Campus ( $\mu\text{rem/hr}$ ) .....	83
Table 19.	Radiological Dose Summary for PNNL Locations, 2023 .....	85
Table 20.	PNNL-Sequim Campus NPDES Monitoring Results for Outfall 008, 2023 <sup>(a)</sup> .....	87
Table 21.	PNNL Effluent Management QA Requirements Documents .....	91
Table 22.	QC Terms .....	94
Table 23.	Participating Laboratory MAPEP Performance and Analytes Summaries .....	97
Table A.1.	Plant Species Observed on the Undeveloped Upland Portions of the PNNL-Richland Campus, 2009–2023 .....	A.1
Table A.2.	Bird Species Observed on the Undeveloped Upland Portions of the PNNL-Richland Campus, 2009–2023 .....	A.5
Table A.3.	Mammal Species Observed on the Undeveloped Upland Portions of the PNNL-Richland Campus, 2009–2023 .....	A.6

Table A.4.	Plant Species Observed in the Riparian Area of the PNNL-Richland Campus in 2015 and 2017–2018.....	A.7
Table A.5.	Bird Species Observed in the Riparian Area of the PNNL-Richland Campus in 2015 and 2017–2018.....	A.9
Table A.6.	Mammal Species Observed in the Riparian Area of the PNNL-Richland Campus in 2015 and 2017–2018.....	A.10
Table B.1.	Plant Species Observed on PNNL-Sequim Campus Lands, 2006–2019 .....	B.1
Table B.2.	Bird Species Observed on and in the Vicinity of the PNNL-Sequim Campus Lands, 2010–2021 .....	B.5
Table B.3.	Other Vertebrate Species Observed on PNNL-Sequim Campus Lands, 2013–2015 .....	B.7
Table C.1.	Definitions for Ambient Air External Dose Sampling Data.....	C.1
Table C.2.	Ambient External Dose Surveillance 2023 PNNL-Richland Campus .....	C.1
Table C.3.	2023 PNNL-Richland Campus Ambient External Dose Calculated for ANSI/HPS N13.37-2014 (HPS 2019) 91-d Normalized Quarters .....	C.2
Table D.1.	Names and Symbols for Units of Measure .....	D.1
Table D.2.	Conversion Table .....	D.2
Table D.3.	Names and Symbols for Units of Radioactivity .....	D.2
Table D.4.	Names and Symbols for Units of Radiation Dose or Exposure .....	D.4
Table D.5.	Radionuclides and Their Half-Lives <sup>(a)</sup> .....	D.4



## 1.0 INTRODUCTION

The United States (U.S.) Department of Energy (DOE) requires that all its site facilities develop an annual site environmental report to comply with DOE Order 231.1B, Chg 1, *Environment, Safety and Health Reporting*, and DOE Order 458.1, Chg 4, *Radiation Protection of the Public and the Environment*. DOE is committed to environmental protection, compliance, sustainability, and efforts to assure the validity and accuracy of compliance monitoring data.

This report provides a synopsis of calendar year (CY) 2023 information related to environmental management performance and compliance efforts at Pacific Northwest National Laboratory (PNNL). It summarizes site compliance with federal, state, and local environmental laws, regulations, policies, directives, permits, and orders and provides environmental management performance benchmarks and their status to the public, regulatory agencies, community officials, Native American Tribes, and public interest groups.

PNNL—one of 10 DOE Office of Science (DOE-SC) national laboratories—provides innovative science and technology solutions in energy and the environment, fundamental and computational science, and national security disciplines. Operated by Battelle Memorial Institute (Battelle) under contract to DOE-SC's Pacific Northwest Site Office (PNSO), PNNL performs work for a diverse set of clients, including the National Nuclear Security Administration, U.S. Department of Homeland Security, U.S. Nuclear Regulatory Commission, U.S. Environmental Protection Agency (EPA), DOE Office of Environmental Management, and other federal agencies, state agencies, and private industry. PNSO is responsible for program implementation, acquisition management, and laboratory stewardship at PNNL. Through its oversight role, PNSO manages the safe and efficient operation of PNNL while enabling the pursuit of visionary research and development (R&D) in support of complex national energy and environmental missions.

As part of PNNL's commitment to environmental stewardship, staff members conduct surveillance and monitoring tasks to confirm compliance with established standards and specific permit limits, as well as to provide information regarding any impacts on the environment from operations.

## 1.1 Location

PNNL has facilities on the PNNL-Richland campus in Richland, Washington, and on the PNNL-Sequim campus near Sequim, Washington (Figure 1). Environmental activities at other locations also fall under PNNL's responsibility (e.g., a permitted waste storage and treatment unit on the Hanford Site). In addition, PNNL conducts research at other satellite offices, including Seattle, Washington; Portland, Oregon; and off-site locations, such as College Park, MD. Of these, only Richland and Sequim have laboratory operations with the potential to emit substances. The other locations are business and research offices.



Figure 1. PNNL Office Locations

### 1.1.1 PNNL-Richland Campus

The PNNL-Richland campus covers approximately 269 ha (664 ac) and is in Benton County in southeastern Washington State, 275 km (170 mi) east-northeast of Portland, Oregon; 275 km (170 mi) southeast of Seattle, Washington; and 200 km (125 mi) southwest of Spokane, Washington. It is fully encompassed by the City of Richland boundary as of mid-2022 and is south of the DOE-Richland Operations Office's (DOE-RL's) Hanford Site 300 Area (Figure 2). Adjacent to the Columbia River, the PNNL-Richland campus encompasses land owned by DOE-SC and Battelle. PNNL also leases facilities located on privately owned land and on the campus of Washington State University Tri-Cities, located just south of the PNNL-Richland campus.

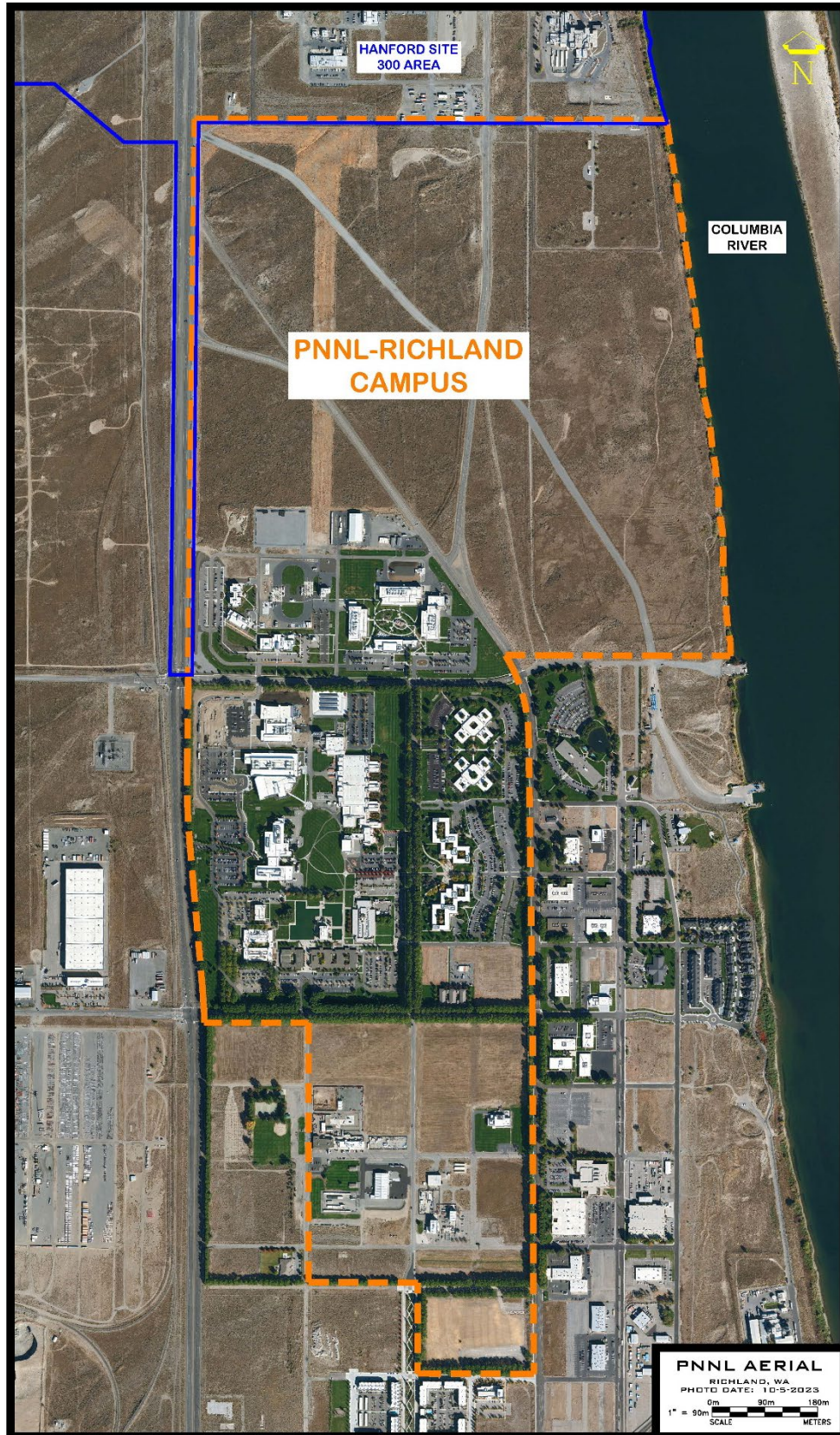


Figure 2. PNNL-Richland Campus

### 1.1.2 PNNL-Sequim Campus

The PNNL-Sequim campus is located at the mouth of Sequim Bay, near the town of Sequim on the northern portion of the Olympic Peninsula in Clallam County, Washington. The campus is 74 km (46 mi) northwest of Seattle, Washington, and 47 km (29 mi) southwest of Victoria, British Columbia. It encompasses an area of 47 ha (117 ac) owned by Battelle Memorial Institute, including the main portion on the west shore of Sequim Bay; most of Travis Spit, which forms the northern boundary of Sequim Bay; and a shoal in the bay called The Middle Ground (Figure 3). A Federal acquisition is underway that will transfer a portion of this land, including the facilities and associated tidelands, to the Department of Energy. A portion of the research pier facility in Sequim Bay resides within aquatic land leased from the Washington Department of Natural Resources.

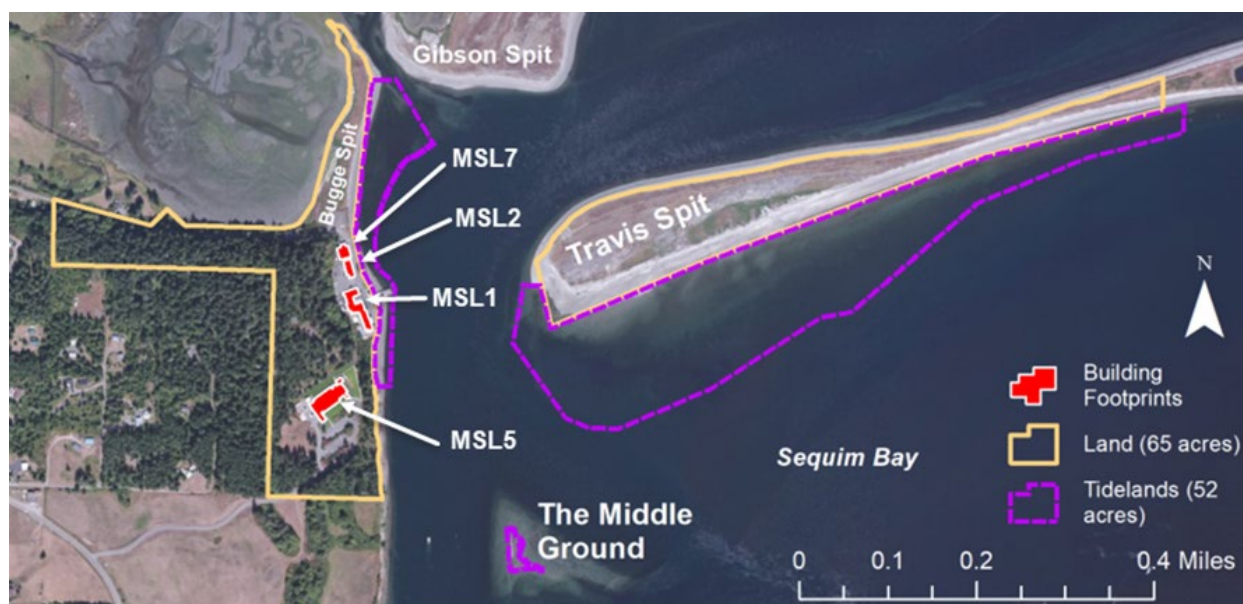


Figure 3. PNNL-Sequim Campus and Nearby Environment

## 1.2 Background and Mission

The following sections provide a summary of the history and mission of PNNL.

### 1.2.1 PNNL-Richland Campus

In January 1965, Battelle was awarded the Pacific Northwest Laboratory (PNL) contract to operate the Hanford Site laboratories. In addition, Battelle invested its own funds to construct facilities to conduct non-Hanford Site research to promote R&D in the Pacific Northwest. In the late 1970s, research expanded to include energy, health, environment, and national security ventures. PNL contributed to robotics, environmental monitoring, material coatings, veterinary medicine, and the formation of new plastics.

In 1995, PNL joined the DOE national laboratory system and was renamed Pacific Northwest National Laboratory. Over the years, PNNL researchers have developed versatile technologies, and received numerous R&D 100 Awards, Federal Laboratory Consortium Awards, innovation awards, and patents for their R&D work and contributions.

PNNL is operated by Battelle for DOE-SC's PNSO, which was established in 2003. PNSO is responsible for overseeing all PNNL activities and monitoring the Laboratory's compliance with applicable laws, policies, and orders. Research efforts on the PNNL-Richland campus include development and analysis of high-performance materials for energy, construction, and transportation technologies and systems; national-security-related radiation detection methodologies, including optics/infrared spectroscopy, electromagnetics/radiography, and acoustics/ultrasonics; systems biology research, which develops comprehensive monitoring programs and performs environmental and biotechnology research; visual analytics technologies; cyber analytics; and critical infrastructure assessment and protection.

### 1.2.2 PNNL-Sequim Campus

In 1967, Battelle acquired acreage on Sequim Bay on the Strait of Juan de Fuca in the Puget Sound, near Sequim, Washington. As part of Battelle's commitment to developing research facilities to benefit the region and serve the environment, the Marine Research Laboratory was constructed to provide facilities for marine-related work involving biology, physiology, histology, chemistry, physics, and engineering. In 1973, the Marine Research Laboratory opened; it was later renamed Marine Research Operations, then Marine Sciences Laboratory. It is now referred to as the PNNL-Sequim campus.

In October 2012, the PNNL operating contract was revised, giving DOE exclusive use of the PNNL-Sequim campus, consolidating operations under PNSO oversight. Currently, researchers at the Sequim campus provide innovative science and technology solutions critical to the nation's energy, environmental, and security future. Capabilities are based on expertise in biotechnology, biogeochemistry, ecosystems science, toxicology, and Earth systems modeling. In addition, a scientific dive team supports in-water research and analysis. The research laboratories encompass more than 1,400 m<sup>2</sup> (15,000 ft<sup>2</sup>) of area, which includes an innovative wastewater treatment system that treats up to 909 L (200 gal) per minute of seawater to remove chemical and biological impurities before returning the water to Sequim Bay. Research efforts include studying algal biofuels, climate change, biofouling/biocorrosion, and environmental monitoring; quantifying the transport, fate, and effects of chemicals in marine environments; predicting and analyzing coastal risks/hazards; and developing detection and signatures against threats.

## 1.3 Demographics

The PNNL-Richland campus is in Benton County, Washington, south of the Hanford Site, in an area that is primarily flat, semi-arid, and restricted from public access. Residents north and east of the Hanford Site generally live on farms or in farming communities. Residents south, southwest, and west of the PNNL-Richland campus live in the urban communities of Richland, Kennewick, Pasco, and West Richland. Richland is the only community adjacent to the PNNL-Richland campus.

Demographic information from the 2020 U.S. Census Bureau indicates an estimated 206,873 people lived in Benton County and 96,749 people lived in adjacent Franklin County (WOFM 2022). During 2023, Benton and Franklin Counties accounted for 4.0% of Washington's population (WOFM 2023). Based on 2020 U.S. Census population data, the population within an 80 km (50 mi) radius of the PNNL-Richland campus is estimated to be about 605,419 (Rose et al. 2023). This population estimate is used to calculate radiation dose to the public (see Section 4.2 of this report).

The PNNL-Sequim campus is in Clallam County, Washington, on the Olympic Peninsula in the northwestern corner of Washington State. An estimated 76,482 people lived in Clallam County in 2020, equivalent to approximately 1% of Washington's population (USCB 2022). The city of Sequim, the nearest population center to the PNNL-Sequim campus, had a population of 8,350 people in 2023 (WOFM 2024). Based on 2020 U.S. Census population data, the population within an 80 km (50 mi) radius of the PNNL-Sequim campus is estimated to be about 2,936,180 (Rose et al. 2023). This population estimate is used to calculate the radiation dose to the public (see Section 4.2 of this report).

## 1.4 Environmental Setting – PNNL-Richland Campus

The land and associated geology, hydrology, seismicity, and meteorology of the PNNL-Richland campus locale, as well as the flora and fauna and land and water habitats of the ecoregion, are described in the following sections.

### 1.4.1 Environmental Locale

The lands containing the PNNL-Richland campus have experienced varying degrees of previous disturbance. Upland areas affected by lower levels of prior disturbance principally support native shrub-steppe vegetation, while more heavily disturbed uplands support more invasive, nonnative vegetation. Other areas have undergone complete habitat conversion and contain facilities bordered by landscaping or xeriscaping. The portion of the Columbia River riparian zone on the PNNL-Richland campus is largely undisturbed and supports both native and nonnative vegetation.

The PNNL-Richland campus is in the Columbia Basin, an intermontane region between the Cascade Range and the Rocky Mountains. The campus lies above a gentle syncline formed by the intersection of the Yakima Fold Belt, a series of anticlinal ridges and synclinal valleys, and the gently west-dipping Palouse Slope, which contains few faults and low-amplitude, long-wavelength folds. The uppermost basalt flow is part of the Ice Harbor Member of the Saddle Mountains Basalt Formation, and the relatively thin overlying sediment layers consist of Ringold Formation and Hanford Formation sediments. These sediment layers are predominantly coarse sandy alluvial deposits mantled by windblown sand. A generalized suprabasalt stratigraphic column showing what underlies the PNNL-Richland campus is shown in Figure 4. The stratigraphic column for the upper Ringold and Hanford Formations is based on information obtained from the drilling of 11 boreholes within the footprint of the Biological Sciences Facility/Computational Sciences Facility on the PNNL-Richland campus (Freedman et al. 2010).

The Hanford Formation, a highly permeable mixture of sand and gravel deposited by Ice Age floods during the late Pleistocene period, comprises unconsolidated sediments that range from boulder-sized gravel to sand, silt, and clay. Late Miocene- to Pliocene-age sediments of the Ringold Formation underlie the Hanford Formation. The Ringold Formation displays lower hydraulic conductivity and is texturally and structurally distinct from the overlying Hanford Formation. Ringold Formation sediments contain sands, gravels, and muds that typically are more consolidated and less permeable than those in the Hanford formation. Basalt underlying the Ringold Formation has a very low vertical hydraulic conductivity and forms an aquitard between the base of the unconfined aquifer and the confined aquifers within the basalt formations.

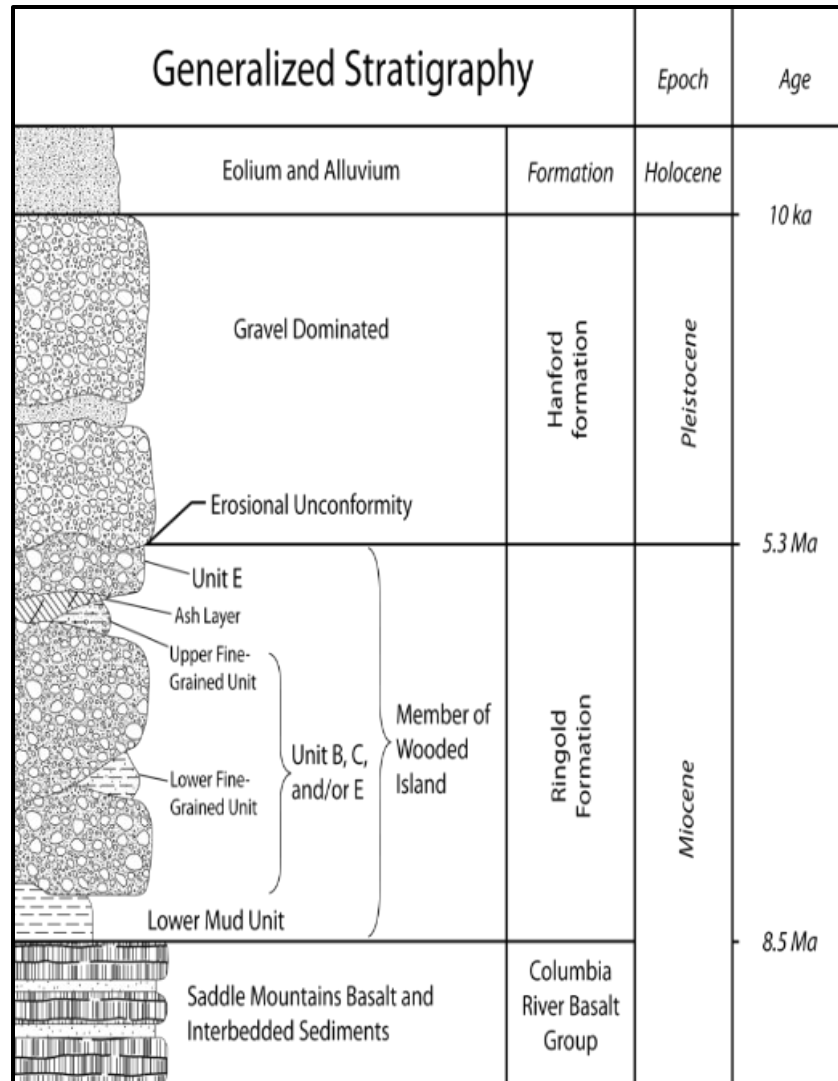


Figure 4. Generalized Stratigraphic Column Depicting the Stratigraphy Underlying the PNNL-Richland Campus (modified from Reidel et al. 1992; Thorne et al. 1993; Lindsey 1995; Williams et al. 2000; DOE-RL 2002; and Williams et al. 2007)

The general direction of groundwater flow under the PNNL-Richland campus is east-northeast toward the Columbia River (Figure 5). The unconfined aquifer beneath the PNNL-Richland campus is predominantly in the Ringold Formation; however, depending on the water table elevation, the aquifer may inundate portions of the Hanford Formation. The vadose zone below the PNNL-Richland campus is about 15 m (49 ft) thick; its thickness generally decreases with proximity to the Columbia River as the ground surface slopes toward the river. This zone consists of unsaturated sediments between the ground surface and the water table, predominantly within the Hanford Formation (Newcomer 2007).

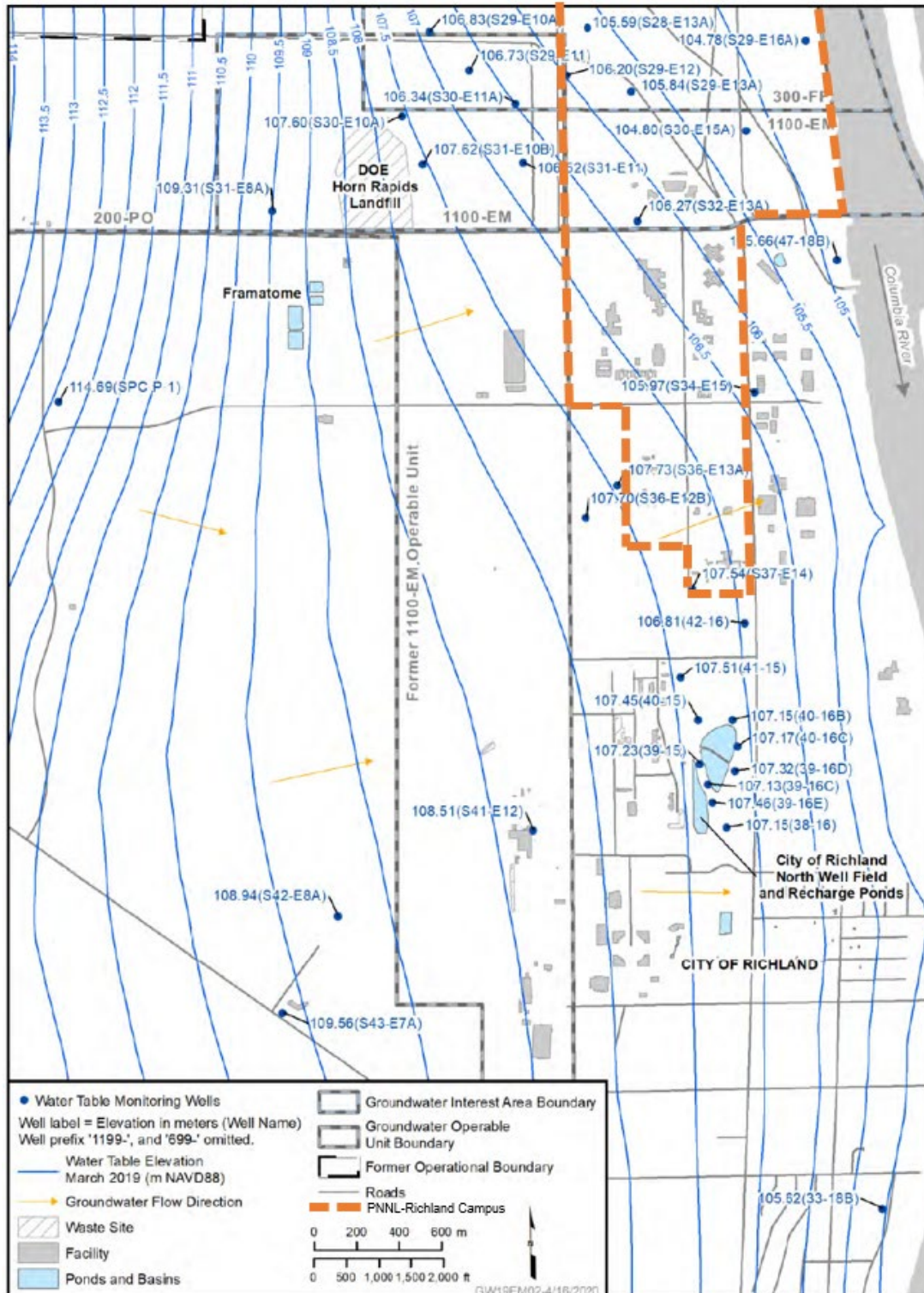


Figure 5. Water Table Elevations (m) (modified from DOE-RL 2020). Groundwater flow direction is normal to the water table contour lines. The approximate PNNL-Richland campus is outlined in orange (northern portion not shown).

While Columbia River floods have occurred in the past, the likelihood of recurrence of large-scale flooding has been reduced by the construction of dams upstream. The largest flood on record for the Columbia River occurred in 1894 and had an estimated peak discharge of 21,000 m<sup>3</sup>/s (742,000 ft<sup>3</sup>/s) at the Hanford Site. The largest recent flood took place in 1948 and had an estimated peak discharge of 20,000 m<sup>3</sup>/s (700,000 ft<sup>3</sup>/s) (Duncan 2007). Exceptionally high runoff during the spring of 1996 resulted in a maximum discharge of nearly 11,750 m<sup>3</sup>/s (415,000 ft<sup>3</sup>/s) (Duncan 2007). The floodplain associated with the 1894 flood has been modeled based on topographic cross-sections of the river; no portion of the PNNL-Richland campus was within this area.

The probable maximum flood has an unspecified but very large return period (generally greater than 500 years). Based on modeling from 1976, the Hanford Site would be unaffected by the probable maximum flood on the Columbia River, a discharge of about 40,000 m<sup>3</sup>/s (1.4 million ft<sup>3</sup>/s) (Duncan 2007). A flood of this magnitude would result in a water-surface elevation of 119 m (390 ft) at the Columbia Generating Station, located about 12 km (7.5 mi) north of the PNNL-Richland campus (Energy Northwest 2011). The standard project flood, a flood that would occur during the combination of the harshest meteorological and hydrological conditions, has an unspecified return period, usually greater than several hundred years (Linsley et al. 1992). The regulated standard project flood used by the U.S. Army Corps of Engineers for the Columbia Generating Station is 16,100 m<sup>3</sup>/s (570,000 ft<sup>3</sup>/s) (Energy Northwest 2011). The 100-year regulated flood discharge for the Columbia River along the northern boundary of the Hanford Site is estimated to be 12,500 m<sup>3</sup>/s (440,000 ft<sup>3</sup>/s) (Duncan 2007); corresponding discharge at the PNNL-Richland campus would be somewhat larger. The Federal Emergency Management Agency (FEMA) floodplain maps extend only to the southern boundary of the PNNL-Richland campus (FEMA 1984). However, FEMA maps suggest that the PNNL-Richland campus, with a ground-surface elevation of about 122 m (400 ft) above mean sea level would be unaffected by a 100-year flood.

The seismicity of the PNNL-Richland campus vicinity is relatively low compared to other regions of the Pacific Northwest, as determined by the rate and magnitude of historical events. The largest known earthquake in the region occurred in 1936 near Milton-Freewater, Oregon, approximately 103 km (64 mi) from the PNNL-Richland campus (Duncan 2007). This earthquake had a Richter magnitude of 5.75 and a maximum Modified Mercalli Intensity of VII (very strong shaking). Susceptibility to liquefaction is rated as very low or low for the entire PNNL-Richland campus (WDNR 2021). The U.S. Geological Survey has identified ash as the only volcanic hazard in the vicinity of the PNNL-Richland campus (WDNR 2021).

The rain-shadow effect of the Cascade Range, west of Yakima, influences the climate at the PNNL-Richland campus. North of the PNNL-Richland campus, the Rocky Mountains and ranges in southern British Columbia protect the region from severe, cold polar air masses moving southward across Canada and the winter storms associated with them. Daily meteorological data are collected at a weather station maintained by the DOE Hanford Site meteorological staff, located just north of the PNNL-Richland campus.

Regional weather in CY 2023 was warm with typical winds and precipitation, based on measurements at the nearby Hanford Site's central monitoring station. Normal regional monthly average temperatures range from a low of -4.3°C (24.2°F) in the winter to a high of 26.5°C (79.7°F) in the summer. The maximum high temperature in 2023 was 44°C (111°F), measured at the central Hanford meteorological station; the minimum was -14°C (7°F). CY 2023 was the fourth consecutive year during which the highest temperature exceeded 43°C (110°F), the longest such streak recorded. The average annual temperature near the PNNL-Richland

campus in 2023 was 13.1°C (55.5°F), which is 0.7°C (1.2°F) above the average of 12°C (54°F). The annual relative humidity near the PNNL-Richland campus generally is highest in the colder months and lowest in the warmer months (DOE 2022c). Precipitation for 2023 was 15.3 cm (6.02 in.), 16% below average (18.2 cm [7.15 in.]) (Snyder et al. 2024b). Regional winds are primarily toward the northwest and south-southeast at the PNNL-Richland campus. Regional average wind speeds in 2023 were typical, averaging about 3.4 m/s (7.7 mph). The maximum regional wind gust recorded during 2023 was a relatively mild 15 m/s (34 mph). Fog has been recorded during every month of the year at the Hanford Meteorology Station; however, fog occurs mostly from November through February. Additional visibility reductions can occur in the form of windblown dust; the region has averaged four dust storms per year for the entire period of record (1945–2020).

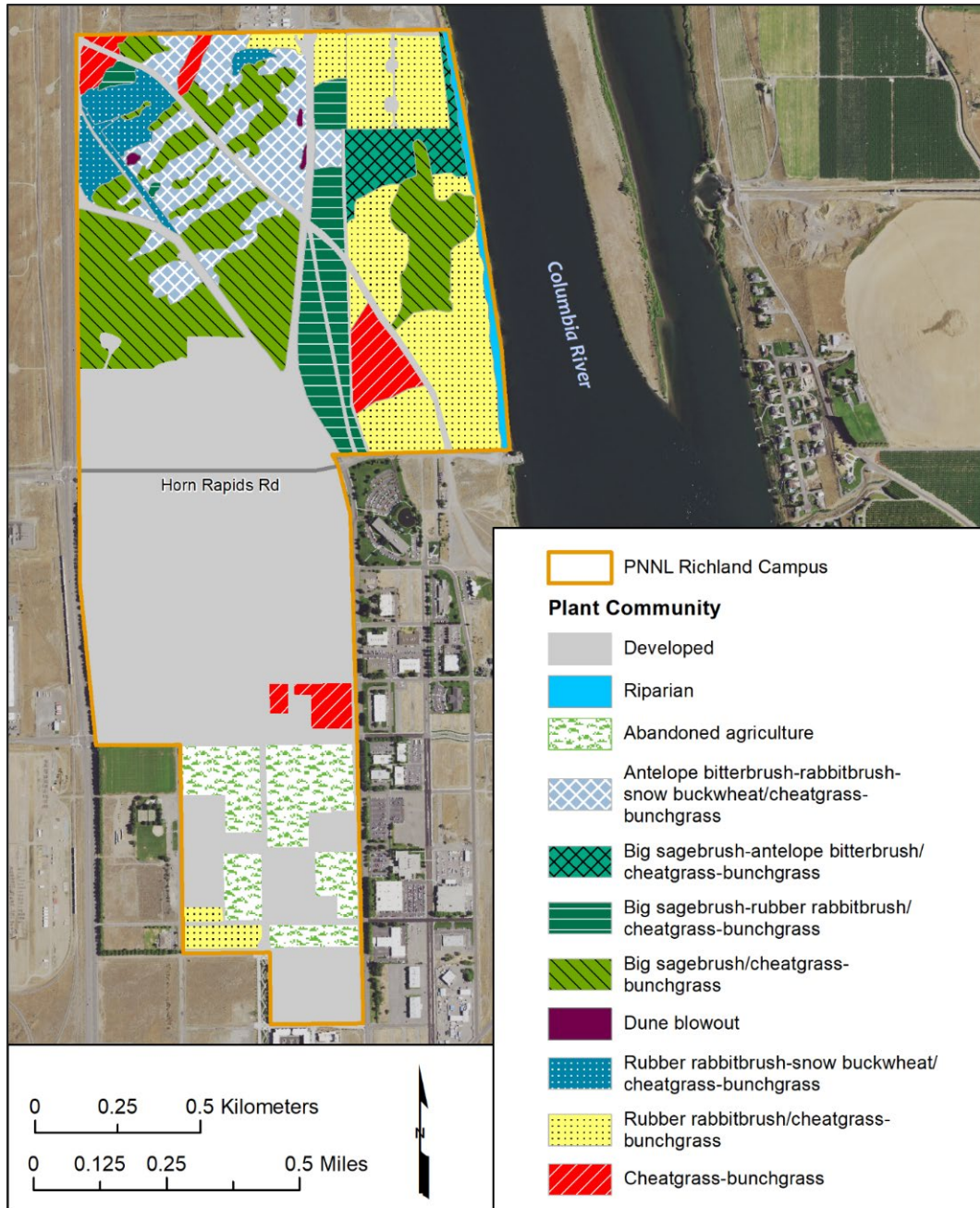
Atmospheric dispersion is a function of wind speed, wind duration and direction, atmospheric stability, and mixing depth. Dispersion conditions are generally good if winds are moderate to strong, the atmosphere is of neutral or unstable stratification, and there is a deep mixing layer. Historically, good dispersion conditions associated with neutral and unstable stratification exist approximately 57% of the time at the Hanford Site during summer (Poston et al. 2011). During winter, moderate to extremely stable stratification exists (approximately 66% of the time).

#### 1.4.2 Ecology

The PNNL-Richland campus is in the lowest and most arid portion of the Columbia Plateau Ecoregion (LandScope Washington 2022; EPA 2013). The portion of the PNNL-Richland campus north of Horn Rapids Road (Figure 6) was previously part of the Hanford Site and has been protected from agricultural use and development since 1943. The southern one-third of this area has been developed, and the remainder is still mostly dominated by native shrub-steppe vegetation and thus retains much of its native biodiversity and community structure.

These areas are dominated by climax shrubs such as big sagebrush (*Artemisia tridentata*) and bitterbrush (*Purshia tridentata*), with a noticeable component of native forbs and perennial bunchgrasses within an introduced annual grass understory. The portion of the PNNL-Richland campus south and just north of Horn Rapids Road has been developed to various extents and consists of a mosaic of buildings surrounded by maintained landscapes, abandoned agricultural fields, and previously disturbed, early successional habitats dominated by introduced annual grasses or subclimax shrubs, such as common rabbitbrush (*Ericameria nauseosa*) (Figure 6). The more mature and undisturbed shrub-steppe communities generally support greater plant species diversity. Approximately 171 plant species, 40 bird species, and 10 mammal species have been observed in upland portions of the PNNL-Richland campus (see species lists in Appendix A). A relatively undisturbed riparian community exists along the Columbia River shoreline north of Horn Rapids Road (Figure 6). This riparian community is limited to a narrow band of multilayered trees, including Siberian elm (*Ulmus pumila*), white mulberry (*Morus alba*), and poplars (*Populus* spp.); shrubs such as coyote willow (*Salix exigua*) and rose (*Rosa woodsii*); and herbaceous and grass species. Species diversity is high in the riparian zone given its relatively small area. Approximately 87 plant species, 29 bird species, and 5 other wildlife species have been observed in the riparian zone of the PNNL-Richland campus (Appendix A).

Priority habitats are those habitat types or elements that have unique or significant value to a diverse assemblage of species. Both the shrub-steppe and riparian habitats are listed by the Washington Department of Fish and Wildlife (WDFW) as priority habitats for the state and are priorities for management and conservation (WDFW 2023).



**Figure 6. Habitat Polygons on the PNNL-Richland Campus**

The Hanford Reach of the Columbia River is adjacent to the eastern edge of the PNNL-Richland campus. This river supports a diverse fish and invertebrate community, including three species listed under the *Endangered Species Act* of 1973 (ESA). The Columbia River is designated as critical habitat for these species under the ESA ([50 CFR 226.212](#); [75 FR 63898](#)). Federally and state-listed wildlife and plant species known to occur or that potentially occur on or near the PNNL-Richland campus were identified using sources from WDFW (2024) and Washington Natural Heritage Program (WNHP 2021) and are listed in Table 1. Of these, the sagebrush sparrow (*Artemisiospiza nevadensis*), loggerhead shrike (*Lanius ludovicianus*), and black-tailed jackrabbit (*Lepus californicus*) have been observed within undeveloped upland portions of the

PNNL-Richland campus (see Appendix A). The American white pelican is common within the Hanford Reach, as well as the Columbia River adjacent to the PNNL-Richland campus.

**Table 1. Wildlife, Fish, and Plant Species of Conservation Concern Known to Occur or that Potentially Occur near the PNNL-Richland Campus**

Common Name	Genus and Species	Federal Status <sup>(a)</sup>	State Status <sup>(b)</sup>
<b>Wildlife</b>			
American white pelican	<i>Pelecanus erythrorhynchos</i>		Sensitive
Black-tailed jackrabbit	<i>Lepus californicus</i>		Candidate
Burrowing owl	<i>Athene cunicularia</i>		Candidate
Loggerhead shrike	<i>Lanius ludovicianus</i>		Candidate
Northern sagebrush lizard	<i>Sceloporus graciosus</i>		Candidate
Sagebrush sparrow	<i>Artemisiospiza nevadensis</i>		Candidate
Desert striped whipsnake	<i>Coluber taeniatus</i>		Candidate
Townsend's ground squirrel	<i>Urocitellus townsendii</i>		Candidate
<b>Fish</b>			
Bull trout	<i>Salvelinus confluentus</i>	Threatened	Candidate
Upper Columbia River spring Chinook salmon	<i>Oncorhynchus tshawytscha</i>	Endangered	
Upper Columbia River steelhead	<i>Oncorhynchus mykiss</i>	Threatened	Candidate
<b>Plants</b>			
Awed halfchaff sedge	<i>Lipocarpa aristulata</i>		Sensitive
Walking spike-rush	<i>Eleocharis rostellata</i>		Sensitive
Large St. Johns-wort	<i>Hypericum majus</i>		Sensitive
Columbian yellowcress	<i>Rorippa columbiae</i>		Threatened
Grand redstem	<i>Ammania robusta</i>		Sensitive
Great Basin gilia	<i>Aliciella leptomeria</i>		Sensitive
Spreading pygmyleaf	<i>Loeflingia squarrosa</i>		Sensitive
Rosy pussypaws	<i>Calyptidium roseum</i>		Sensitive
Suksdorf monkeyflower	<i>Erythranthe suksdorfii</i>		Sensitive

Sources: WDFW (2024) and WNHP (2021)

- (a) Federally threatened species are likely to become an endangered species within the foreseeable future throughout all or a significant portion of their range. Federally endangered species are in danger of extinction within the foreseeable future throughout all or a significant portion of their range (USFWS 2022).
- (b) State candidate animal species are fish and wildlife species that the WDFW will review for possible listing as endangered, threatened, or sensitive (WDFW 2023). State threatened animal species are native to the state of Washington and are likely to become endangered within the foreseeable future throughout a significant portion of their range without cooperative management or removal of threats (WDFW 2023). State threatened plant species are those that are likely to become endangered within the near future in Washington if the factors contributing to their population decline or habitat loss continue. State sensitive plant species are those that are vulnerable or declining and could become endangered or threatened in the state without active management or removal of threats (WNHP 2021).

## 1.5 Environmental Setting – PNNL-Sequim Campus

The land and associated geology, seismicity, and meteorology of the PNNL-Sequim campus, as well as the flora and fauna and land and water habitats of the ecoregion, are described in the following sections.

### 1.5.1 Environmental Locale

The PNNL-Sequim campus is located on Sequim Bay in Puget Sound and consists of forests, sandy beach shoreline, a bluff line, and developed areas with roads and structures, as well as The Middle Ground, a sandy shoal that is frequently submerged, and Travis Spit (Figure 3). Campus facilities include buildings on the shoreline and structures on an approximately 27 m (89 ft) high bluff overlooking Sequim Bay and Puget Sound.

In the vicinity below the PNNL-Sequim campus are Quaternary-age unconsolidated glacial and interglacial deposits to depths greater than 366 m (1,200 ft) (Thomas et al. 1999). The upland portion of the PNNL-Sequim campus has surficial deposits of glacial till 14,500 to 17,500 years old, designated as unstratified, poorly sorted, clayey, sandy silt up to 45.7 m (150 ft) thick, and averaging 9.1 m (30 ft) thick throughout the greater region (Schasse and Logan 1998). Beneath the surficial deposits are undifferentiated deposits from older glacial events and interglacial periods. Water-bearing units of coarse-grained sands and gravels are found in the unconsolidated deposits throughout the region, including in the vicinity of the PNNL-Sequim campus (Thomas et al. 1999). Tertiary-age sedimentary rock (primarily siltstone, sandstone, and mudstone) and volcanic rock (primarily basalt and basalt breccia) are beneath the unconsolidated deposits (Schasse and Logan 1998).

Earthquakes have been recorded in the vicinity of the PNNL-Sequim campus, and seismically active faults are located within 8 km (5 mi); the nearest fault trace is about 3.2 km (2 mi) to the southwest (WDNR 2021). The region is subject to significant seismic hazards, as evidenced by the estimated peak ground acceleration of 3.92 to 7.85 m/s<sup>2</sup> (0.4 to 0.8 g) and 2% probability of exceedance in 50 years (Peterson et al. 2014). Washington State has evaluated several earthquake scenarios, including modeling a magnitude 9.0 earthquake on the Cascadia Subduction Zone. An earthquake of that magnitude would result in a Modified Mercalli Intensity of VII (very strong shaking) in the PNNL-Sequim campus region (WDNR 2013). Susceptibility to liquefaction is rated as very low or low for both the uplands and shoreline areas of the PNNL-Sequim campus, except for Travis Spit and Bugge Spit north of the shoreline parking area, which are rated as moderate to high for liquefaction susceptibility (WDNR 2021). The shoreline area of the PNNL-Sequim campus and Travis Spit are subject to tsunami hazards (inundation) for the Cascadia Subduction Zone scenario (WDNR 2021). Although the glacial deposits at the PNNL-Sequim campus support the near-vertical slopes along the bluff at the site, landslides have been mapped in the region (WDNR 2021), suggesting a potential landslide hazard at the site. No volcanic hazard has been identified in the PNNL-Sequim campus region (WDNR 2021).

Daily meteorological data are collected at an automated weather station near Sequim, Washington, maintained by AgWeatherNet, an affiliate of Washington State University (WSU 2023). The region around the PNNL-Sequim campus is positioned in the rain shadow of the Olympic Mountains, so it generally receives less than 38 cm (15 in.) of rainfall annually despite its coastal location; rainfall in 2023 was 19.9 cm (7.9 in.). Total precipitation in 2023 was about 50% below average with drought conditions predominating from September through November (Snyder et al. 2024c). The region typically experiences cool, wet winters and warm, dry summers. From January 2009 to December 2020, average temperatures ranged from 4.6–14.7°C (40.3–58.5°F). Monthly average temperatures in 2023 ranged from 4.1°C–15°C (39°F–59°F). The annual average temperature in 2023 was 9.9°C (49.8°F). Regional winds are primarily from the west to northwest.

### 1.5.2 Ecology

The PNNL-Sequim campus (Figure 3) lies in the Olympic Rain Shadow subdivision of the Puget Lowland Ecoregion, a north-south depression between the Olympic Peninsula and western slopes of the Cascade Mountains that flank the coastline of Puget Sound (LandScope Washington 2022; EPA 2013). The PNNL-Sequim campus is in one of the driest areas in the region, owing to the rain-shadow effects of the Olympic Mountains. Timber harvesting and cultivation have removed and fragmented the original coniferous forest and prairie-oak woodland (WDFW 2005). Today, the region consists mostly of second-growth coniferous forest and agricultural fields; little of the original forest habitat remains (EPA 2013; LandScope Washington 2022).

The PNNL-Sequim campus includes 26 ha (65 ac) of land and 21 ha (52 ac) of tidelands. Tideland habitat includes shoals, intertidal wetlands, and subtidal wetlands. The Middle Ground (Figure 7) is a 0.18 ha (0.46 ac) sandy shoal that is submerged except during lower tides and does not support vegetation (DOE-PNSO 2022).

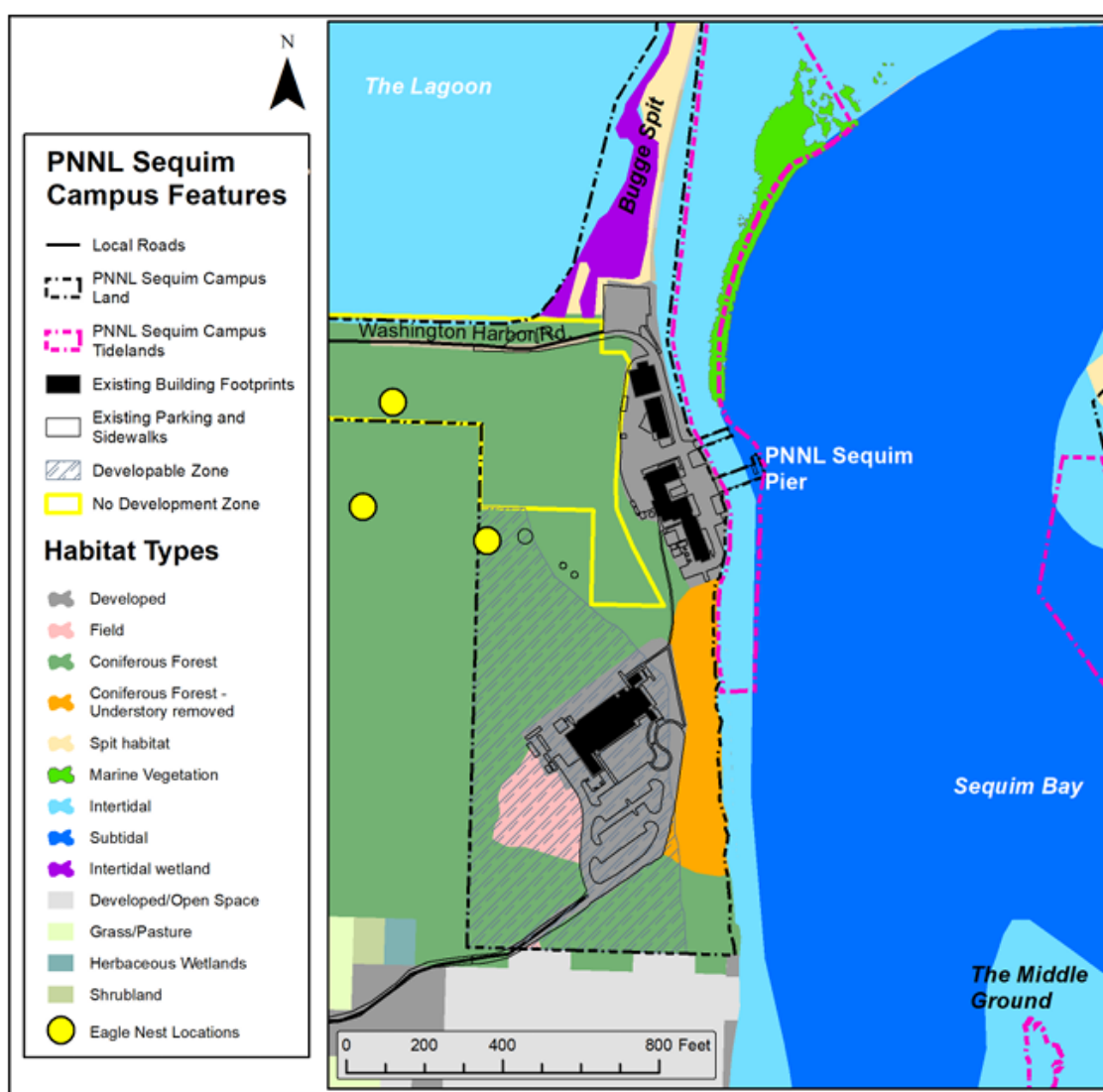


Figure 7. Habitat Types at the PNNL-Sequim Campus

Estuarine intertidal wetlands occur in a narrow band that circumscribes the shoreline of Sequim Bay, while adjacent estuarine subtidal wetlands occur in deeper water and make up the interior portion of Sequim Bay. Seagrass meadows consisting of eelgrass (*Zostera* spp.) occur in intertidal wetlands, labeled marine vegetation in Figure 7 (DOE-PNSO 2022), and serve as forage for birds, snails, and crab species. Some fish species use eelgrass for spawning, while other anadromous and forage fish use eelgrass beds for cover or to find food. Common aquatic species include fish species such as sole (*Parophrys vetulus*), sculpin (*Artedius fenestralis*), Pacific tomcod (*Microgadus proximus*), striped perch (*Embiotoca lateralis*), Pacific herring (*Clupea pallasii*), sand lance (*Ammodytes hexapterus*), and spiny dogfish (*Squalus acanthias*) (DOE-PNSO 2022).

Land habitat includes spits, beaches, and uplands. Travis Spit and Bugge Spit are located slightly above sea level and consist of sediments deposited during higher tides. They support mostly herbaceous vegetation consisting of forbs, including silver bursage (*Ambrosia chamissonis*), common yarrow (*Achillea millefolium*), Puget Sound gumweed (*Grindelia integrifolia*), bare-stemmed biscuitroot (*Lomatium nudicaule*), low glasswort (*Salicornia depressa*), and yellow sand verbena (*Abronia latifolia*); and grasses such as blue wildrye (*Elymus glaucus*) (DOE-PNSO 2022). A sandy beach lies at the base of an approximately 7.6 m (25 ft) high feeder bluff that overlooks Sequim Bay. The beach is maintained by longshore currents that erode the bluff. Beach vegetation is sparse, located mostly above tidal influence at the base and on the face of the bluff, and includes some of the tree and shrub species common in the uplands noted below (DOE-PNSO 2022).

The uplands begin adjacent to and just above the spit and beach habitats, extending west of the facilities, and rising to approximately 46 m (150 ft) above sea level on the ridge above Washington Harbor Road (DOE-PNSO 2022). The uplands support mostly mixed coniferous forest habitat (Figure 7), most of which is mature, naturally regenerated second growth, estimated to be 100–160 years old (DOE-PNSO 2022). The dominant and subdominant canopy species are Douglas fir (*Pseudotsuga menziesii*) and western red cedar (*Thuja plicata*), respectively. Subcanopy tree species include red alder (*Alnus rubra*), bigleaf maple (*Acer macrophyllum*), madrone (*Arbutus menziesii*), grand fir (*Abies grandis*), Indian plum (*Oemleria cerasiformis*), and Rocky Mountain maple (*Acer glabrum*). Characteristic understory flora includes common snowberry (*Symphoricarpos albus*), Saskatoon serviceberry (*Amelanchier alnifolia*), ocean spray (*Holodiscus discolor*), vine maple (*Acer circinatum*), salal (*Gaultheria shallon*), Oregon-grape (*Berberis* spp.), western swordfern (*Polystichum munitum*), rose (*Rosa* spp.), blackcap (*Rubus leucodermis*), and redflower currant (*Ribes sanguineum*) (DOE-PNSO 2022). Approximately 148 plant species, 104 bird species, and 7 other wildlife species have been observed on the PNNL-Sequim campus (see species lists in Appendix B).

The relatively undisturbed nearshore areas of Puget Sound, including the Strait of Juan de Fuca, are listed by the WDFW as priority habitat for the state (WDFW 2023) and, therefore, are considered a priority for management and conservation (Clallam County 2018). Priority habitat zones include shore, intertidal, and subtidal, which include the tidelands, spits, beaches, and feeder bluffs, described previously (Clallam County 2018; WDFW 2023).

The tideland and land habitats provide potential habitat for several federally listed threatened, endangered, and/or candidate species (Table 2) (DOE-PNSO 2022). One avian species of conservation concern, as well as eight fish, three invertebrate, and one turtle species of conservation concern, are known to occur or potentially occur near PNNL-Sequim campus facilities. No plant species of state or federal concern are currently known to occur near the PNNL-Sequim campus. Sequim Bay is designated critical habitat for Puget Sound bocaccio

(*Sebastes paucispinis*) and Puget Sound yelloweye (*Sebastes ruberrimus*) ([79 FR 68042](#)), bull trout (*Salvelinus confluentus*) ([75 FR 63898](#)), and Hood Canal summer-run chum salmon (*Oncorhynchus keta*) ([50 CFR 226.212](#); [70 FR 52630](#)).

**Table 2. Animal Species of Conservation Concern Known to Occur or that Potentially Occur at and in the Vicinity of the PNNL-Sequim Campus**

Common Name	Genus and Species	Federal Status <sup>(a)</sup>	State Status <sup>(b)</sup>
<b>Wildlife</b>			
Marbled murrelet	<i>Brachyramphus marmoratus</i>	Threatened	Endangered
Northwestern pond turtle	<i>Actinemys marmorata</i>	Proposed Threatened	Endangered
<b>Fish</b>			
Bull trout	<i>Salvelinus confluentus</i>	Threatened	Candidate
Hood Canal summer-run chum salmon	<i>Oncorhynchus keta</i>	Threatened	
North American green sturgeon	<i>Acipenser medirostris</i>	Threatened	
Pacific eulachon	<i>Thaleichthys pacificus</i>	Threatened	
Puget Sound bocaccio	<i>Sebastes paucispinis</i>	Endangered	
Puget Sound Chinook salmon	<i>Oncorhynchus tshawytscha</i>	Threatened	
Puget Sound steelhead	<i>Oncorhynchus mykiss</i>	Threatened	
Puget Sound yelloweye rockfish	<i>Sebastes ruberrimus</i>	Threatened	
<b>Invertebrates</b>			
Sunflower sea star	<i>Pycnopodia helianthoides</i>	Proposed Threatened	
Taylor's checkerspot butterfly	<i>Euphydryas editha taylori</i>	Endangered	Endangered
Monarch butterfly	<i>Danaus plexippus</i>	Candidate	Candidate

Source: WDFW (2023)

- (a) Federally threatened species are likely to become an endangered species within the foreseeable future throughout all or a significant portion of their range. Federally endangered species are in danger of extinction within the foreseeable future throughout all or a significant portion of their range (USFWS 2022).
- (b) State candidate animal species are those fish and wildlife species that the WDFW will review for possible listing as endangered, threatened, or sensitive (WDFW 2023). State endangered species are native to the state of Washington and are seriously threatened with extinction throughout all or a significant portion of their range within the state (WDFW 2023).

Several marine mammals, including harbor seal (*Phoca vitulina*), California sea lion (*Zalophus californianus*), Dall's porpoise (*Phocoenoides dalli*), and harbor porpoise (*Phocoena phocoena*), inhabit Sequim Bay (DOE-PNSO 2022). Each of these mammals is considered a priority species by the state, and priority areas comprise haul-outs used by California sea lions and harbor seals, and foraging areas and migration routes used by harbor porpoises and Dall's porpoises. Klapot Point on the southwest tip of Travis Spit (Figure 3), located across the mouth of Sequim Bay from the PNNL-Sequim campus, is a haul-out area for harbor seals (DOE-PNSO 2022). Although rare, killer whales (*Orcinus orca*) have been observed in Sequim Bay.

## 1.6 Cultural Setting – PNNL-Richland Campus

The archaeological record of the Mid-Columbia Basin bears evidence of human occupation for more than 10,000 years. The history of the Mid-Columbia Basin includes four distinct periods of human occupation: the Precontact period, the Ethnographic period, the Euro-American period, and the Manhattan Project period.

### 1.6.1 Precontact Period

Archaeological investigations conducted throughout the Columbia Plateau provide a definitive cultural chronology dating back to the end of the Pleistocene (about 11,000 years before present [BP]). The protected area of the Hanford Site has contributed to extensive archaeological deposits, documenting thousands of years of Precontact human activity throughout the Columbia Plateau. The archaeological record shows a progression from the earliest inhabitants who were mobile, lived in caves or rock shelters, and subsisted primarily by hunting large mammals, to the development of dwellings approximately 4,500 years ago when the inhabitants subsisted on a more diverse diet, to the eventual creation of pit houses and long-house villages and a subsistence centered around riverine resources, especially salmon.

### 1.6.2 Ethnographic Period

The ethnohistoric/ethnographic period began in the late 1700s to the early 1800s at the time of initial American Indian contact with nonnative American settlers in the area and extends to the present day. Ethnohistorically, the Wanapum, Walla Walla, Palus, Nez Perce, Umatilla, Cayuse, and Yakama used land now encompassed by the Hanford Site. The Wanapum band reportedly occupied village sites along the Columbia River from as far north as the Wenatchee River to its confluence with the Snake River. Fishing sites at Priest Rapids and in the vicinity were used by other surrounding groups, including the Yakama, Wallula, Nez Perce, Palus, Columbia, and Spokane (Galm et al. 1981). Residents relied on a pattern of seasonal rounds that included semi-permanent residences in villages along major waterways during the winter months. Subsistence focused on seasonally available plant and animal resources. Documented archaeological sites in the vicinity of the PNNL-Richland campus include fishing and village sites along the shoreline, stone quarrying sites, temporary camps, and plant processing locations (Schroeder and Landreau 2012; Hodges et al. 2003; Smith 1910).

### 1.6.3 Euro-American Period

The Lewis and Clark Expedition of 1805 began the Euro-American exploration and settlement of the region. Explorers sought trade items from Native Americans and trade routes were established. Gold miners, livestock producers, and homesteaders soon followed. By the 1860s, the discovery of gold north and east of the Mid-Columbia region resulted in an influx of miners traveling through the area. Ringold, White Bluffs, and Wahluke were stops along the transportation routes used by miners and the supporting industry. The mining industry created a demand for beef, and the Mid-Columbia Basin was ideal for livestock production. An increase in Euro-American settlement began in eastern Washington in the late 1800s, first by livestock producers then by homesteaders who settled the area and plowed the rangeland to plant crops beginning in the 1880s.

As farming increased, water resources other than rainfall were needed to produce higher crop yields. Many irrigation projects began; most were privately and insufficiently funded. Land speculators



Farmer leading horse-drawn cart

began constructing large-scale irrigation canals to supply water to thousands of acres in the White Bluffs, Hanford, Fruitvale, Vernita, and Richland areas (Sharpe 1999). However, poor economic conditions associated with the Great Depression of the 1930s created economic hardship for residents of the area. The hardship continued until the government took over under the *First War Powers Act of 1941* (50 U.S.C. App. 601 et seq.) (Marceau et al. 2002).

#### 1.6.4 Manhattan Project and Cold War Era

In 1942, the area around Hanford, Washington, was selected by the federal government as one of three principal Manhattan Project sites. Occupying portions of Grant, Franklin, and Benton Counties, the Hanford Site was created to support U.S. plutonium production during World War II. Plutonium production, chemical separation, and R&D focused on process improvements and were the primary activities during the Manhattan Project, as well as during the subsequent Cold War Era.

The Hanford Site underwent a major expansion at the beginning of the Cold War in the late 1940s. The town of North Richland was developed as a construction camp that eventually housed more than 13,000 people in barracks and more than 2,000 trailers. The town had a school, hospital, police and fire services, and entertainment facilities such as a tavern, movie theater, and stores. The town waned in the early 1950s as Hanford construction slowed, but the area continued to be used as Camp Hanford, headquarters for an Army battalion that first operated antiaircraft batteries and eventually Nike missile bases around the Hanford Site. Camp Hanford closed in 1961 after the Nike missiles were decommissioned.

In 1965, the Atomic Energy Commission tried to help diversify the Tri-Cities economy by restructuring the Hanford contracts and requiring new contractors to invest in private ventures and facilities. Battelle Memorial Institute was awarded the research contract to run Pacific Northwest Laboratory (eventually PNNL) in 1965. Battelle purchased 93 ha (230 ac) of former North Richland/Camp Hanford land, and hired the firm of Naramore, Bain, Brady, and Johanson to design the first four buildings of the PNNL-Richland campus. These buildings, along with others that were completed by the early 1970s, are each individually eligible for listing in the National Register of Historic Places and constitute a Historic District.



Battelle Awarded Contract to Operate at Hanford

### 1.7 Cultural Setting – PNNL-Sequim Campus

The archaeological record suggests the presence of northwest coastal populations as early as 10,000 BP (Ackerman et al. 1985). Sites dating to the earliest occupation of the region often contain assemblages of sea mammal bones, as well as evidence of heavy reliance on salmon, herring, and shellfish. The richness of these resources may have supported semisedentary winter occupation of coastal sites as early as 7,000 BP (Cannon 1991).

As the Holocene era progressed and the climate of the region warmed, salmon and the human populations that subsisted on them could move into upland areas and places away from the coasts that were previously inaccessible. As the Canadian Cordilleran glacier retreated, Puget Sound was created, and new interior coastal territories opened (Schalk 1988). By about 5,000 BP, consumption of shellfish began to play a dominant role in regional subsistence patterns. The abundance of shellfish, salmon, and other wild resources in the region formed the basis of an economic and subsistence pattern that was exceptionally stable. This stability allowed for the development of complex hunter/fisher/gatherer societies that persisted into the late 18<sup>th</sup> century (Fagan 2001), as well as a homogeneous regional social system facilitated by widespread regional trade networks (Croes 1989).

### 1.7.1 Ethnographic Period

The PNNL-Sequim campus is located within the Central Coast Salish Culture Area, which includes the southern end of the Strait of Georgia, most of the Strait of Juan de Fuca, the lower Fraser Valley, and other nearby areas. Five traditional languages were spoken throughout the area: Squamish, Halkomelem, Nooksack, Northern Straits, and Klallam (Suttles and Lane 1990a). Klallam speakers lived in the vicinity of the PNNL-Sequim campus. There were 13 Klallam winter villages in the region (Schalk 1988).

Fishing for salmon and other anadromous fish was a major component of the subsistence pattern within the Central Coast Salish Culture Area. In addition to salmon, saltwater fish such as halibut, herring, lingcod, and flounder were caught. Invertebrates such as clams, cockles, mussels, sea urchins, crabs, and barnacles were abundant (Schalk 1988; Suttles and Lane 1990a).

The Klallam-speaking people hunted whales opportunistically (Schalk 1988). Terrestrial game played a relatively small role in the overall subsistence pattern (Schalk 1988), but deer and other mammals were hunted by a small number of specialized hunters. Women gathered at least 40 different edible plants, including sprouts, stems, bulbs, roots, berries, fruits, and nuts.

Most travel in the region was by canoe, and winter village sites were located where canoes could be beached. Villages often consisted of one or more rows of plank houses paralleling the shore. Houses were constructed on a post and beam framework, with plank walls and shed roofs (Suttles and Lane 1990a).

One important aspect of Salish society was the practice of ritual feasts and gift-giving events, known as potlatches, which marked important events or a change in an individual's status (Suttles and Lane 1990a; Fagan 2001). A typical potlatch included members from several or all houses of a village preparing a feast and giving large quantities of accumulated wealth and gifts to guests from neighboring villages. The redistribution of accumulated goods was important for establishing and reinforcing status or fame and as an investment in securing relationships and support networks between villages and neighbors (Suttles and Lane 1990b).

### 1.7.2 Historic Period

The earliest Euro-American settlement in Clallam County and the Sequim area was known as Whiskey Flat, which was located on the cliffs above the Strait of Juan de Fuca in the 1850s (Morgan 1996). By the end of the 19<sup>th</sup> century, the settlement of New Dungeness had grown, and the county courthouse was moved to Port Angeles. At this time, Sequim was a developing

agricultural area. The Sequim Prairie irrigation ditch was completed in 1896, which allowed for expanded farming (Morgan 1996).

Before being chosen as the site of the PNNL-Sequim campus, the location was home to the Bugge Clam Cannery, which had started business on the site in 1905. The cannery eventually expanded to processing salmon and produce, and a creamery was added. The original cannery burned in 1929, but the Bugge family rebuilt and continued to operate the cannery until the land was purchased by Battelle in 1967 (Russell 1971).

In 1967, Battelle began to develop the PNNL-Sequim campus with the intention to "... provide facilities for research projects which require ocean waters or oceanic environments" (Battelle-Northwest 1967). Most of the cannery and outbuildings were removed by the early 1970s for construction of the PNNL-Sequim campus (Brownell 2018).



## 2.0 COMPLIANCE SUMMARY

Operations at PNNL in CY 2023 were conducted to comply with all applicable federal, state, and local environmental laws, regulations, and guidance; presidential Executive Orders; and DOE Orders, directives, policies, and guidance. PNNL endeavors to conduct operations in a manner that is sustainable and protective of the environment.

Per- and polyfluoroalkyl substances (PFAS) and several other persistent contaminants (e.g., perchlorates, 1,4-dioxane) are known to require a comprehensive approach by DOE. In 2021, DOE established a policy (Turk 2021) for addressing these emerging contaminants and, in 2022, issued the *Per- and Polyfluoroalkyl Substances (PFAS) Strategic Roadmap: DOE Commitments to Action 2022-2025* (DOE 2022d).

As part of the roadmap, DOE completed an initial assessment of PFAS chemicals at its sites across the nation (DOE 2022b), including PNNL. In this initial assessment, DOE found that the drinking water system at the PNNL-Sequim campus should be tested for PFAS, and sampling results from the groundwater well in 2023 were found to be nondetectable for PFAS chemicals. The initial assessment also indicated that an aqueous film forming foam (AFFF) fire suppression system had been installed previously at a facility on the PNNL-Richland campus, although the system had been removed and the disposal of the AFFF material completed. In 2023, a below-grade emergency overflow tank that had been connected to this system required removal. Residual liquid in the underground storage tank and soils surrounding the tank were tested and found to contain low concentrations of PFAS chemicals. In 2023, the liquid from the tank was removed and properly disposed of at an off-site treatment facility. A plan for cleaning up the soil around the tank is being developed with technical assistance from the Washington State Department of Ecology. PFAS are addressed further in Sections 2.5.4.

The Enforcement & Compliance History Online (ECHO) database at <https://echo.epa.gov> is the EPA's official record of the current compliance status of a DOE site or specific facilities within the site, except where the Washington State Department of Ecology has been delegated responsibility for a program area. The ECHO-designated locations in Table 3 apply to the PNNL-Richland and PNNL-Sequim campuses.

Table 3. EPA ECHO Database Listing for PNNL Campuses

ECHO Facility Name	Facility Registry Service (FRS) ID	Program Area
Pacific Northwest National Laboratory Stevens	110025329133	RCRA
Pacific Northwest National Laboratory	110006473440	RCRA
Battelle Marine Sciences Laboratory <sup>(a)</sup>	110000828230	Wastewater, RCRA
<sup>(a)</sup> Synonymous with the PNNL-Sequim campus		

The Washington State Department of Ecology has been delegated oversight of the wastewater program area by EPA. A search of the ECHO database for the “Battelle Marine Sciences Lab” indicates noncompliance for “failure to report.” EPA acknowledges that the Washington State Department of Ecology received the reports and that the records are tracked within state agency’s Water Quality Permitting Portal rather than the ECHO database. The Battelle Marine Sciences Lab wastewater and *Resource Conservation and Recovery Act of 1976* (RCRA) program areas comply with applicable regulations. Table 4 and Table 5 summarize PNNL’s compliance with federal and state laws and regulations, respectively, and subsequent sections provide brief descriptions of each statute or regulation.

Table 4. Status of Federal Environmental Laws and Regulations Applicable to PNNL, 2023

Statute/Regulation	2023 Status	Report Section(s)
<b>Air Quality and Protection</b>		
The <i>Clean Air Act</i> (CAA) and its amendments regulate the release of air pollutants from facilities and unmonitored sources through permitting and air-quality restrictions.	PNNL conducted operations under permits issued by the Washington State Department of Health (WDOH), Washington State Department of Ecology, Benton Clean Air Agency (BCAA), and Olympic Region Clean Air Agency (ORCAA). No events were reported for emissions of regulated substances to the air or substances of concern. Radioactive air emissions were more than 100,000 times lower than the regulatory standard of 10 mrem/yr (0.1 mSv/yr) at both the PNNL-Richland campus and PNNL-Sequim campus.	2.4
The hydrofluorocarbon (HFC) phasedown requirements of the American Innovation and Manufacturing (AIM) Act of 2020 seek to reduce HFC consumption and production to 15% of a 2011–2013 baseline by 2036.	PNNL uses HFCs primarily as refrigerants in chillers and other refrigeration appliances. Cleaning solvents used at PNNL also may contain HFCs. Refrigerants and products containing HFCs will be replaced by EPA-approved substitutes as they become available.	2.4.5
<b>Cultural and Historic Resources</b>		
The <i>National Historic Preservation Act of 1966</i> (NHPA) requires the establishment of programs to preserve and protect historical and cultural resources including sites, documents, buildings, artifacts, and records using permits, access restrictions, and other means.	The PNNL cultural resources program completed compliance reviews for 72 projects: 16 on the PNNL-Richland campus, 20 on the PNNL-Sequim campus, 12 on the Hanford site, and 24 at off-site locations.	2.7.3
DOE Policy 141.1, “Department of Energy Management of Cultural Resources.”	PNNL implements this policy to protect and manage cultural resources by identifying impacts of unauthorized public use on prehistoric sites, protecting sensitive sites, and conducting annual monitoring activities. Annual monitoring is conducted by PNNL cultural resources program to document evidence of potential impacts to archaeological, cultural or historic resources. No evidence of impacts that would diminish the historic or archaeological significance of any observed resources was documented in 2023.	2.7, 2.7.2
<b>Energy Independence</b>		
The <i>Energy Independence and Security Act of 2007</i> (EISA) encourages U.S. energy independence and security, while promoting energy efficiency, conservation, and savings.	PNNL evaluates buildings under EISA energy and water evaluation requirements. PNNL also implements stormwater management practices to promote water drainage and reduce runoff.	2.2, 2.5.2
Predominantly, Executive Order 14008 establishes environmental sustainability goals that protect public health and the environment and requirements related to energy and environmental performance with respect to facilities, vehicles, and overall operations.	PNNL prepared the <i>Pacific Northwest National Laboratory FY 2022 Site Sustainability Plan</i> (PNNL 2021), which addressed the goals and requirements of Executive Orders.	2.1, 3.0

Statute/Regulation	2023 Status	Report Section(s)
<b>Environmental Safety and Health Reporting</b>		
DOE Order 231.1B, <i>Environment, Safety, and Health Reporting</i> , requires the gathering, analysis, and reporting of information about environmental safety and health issues.	PNNL monitors and conveys information via reports, emails, <i>myPNNL</i> articles, and staff meetings. This PNNL Annual Site Environmental Report is a requirement of this Order.	1.0
DOE Order 414.1D, <i>Quality Assurance</i> , states the roles and requirements for quality assurance (QA) for work performed by DOE and its contractors.	A PNNL internal document, <i>Quality Assurance Program Description/Quality Management M&amp;O Program Description</i> , describes the Laboratory-level QA program that applies to all work performed by staff at PNNL, conforming to DOE Order 414.1D requirements.	7.0
<b>Hazardous Materials and Waste Management</b>		
The <i>Comprehensive Environmental Response, Compensation, and Liability Act of 1980</i> (CERCLA) provides regulations for the identification, assessment, and remediation of sites contaminated by hazardous materials.	Neither the PNNL-Richland campus nor the PNNL-Sequim campus contains a PNNL CERCLA operable unit. The PNNL-Richland campus is not part of any Hanford CERCLA operable unit and had no continuous releases.	2.6.1, 2.6.2
The <i>Emergency Planning and Community Right-to-Know Act of 1986</i> stipulates the public's right to information about hazardous materials in the community and the establishment of emergency planning procedures.	PNNL submitted two Tier-Two reports, providing information about potential hazards. PNNL was not required to submit a Toxic Release Inventory Report.	2.6.1
The <i>Federal Facility Compliance Act of 1992</i> amends the <i>Resource Conservation and Recovery Act of 1976</i> (RCRA) and CERCLA and establishes new mixed waste reporting requirements.	PNNL provided information as part of the Hanford Site Mixed Waste Land Disposal Restrictions Summary Reports pursuant to Tri-Party Agreement Milestone M-26.	2.6.6
The <i>Federal Insecticide, Fungicide, and Rodenticide Act</i> regulates the storage and use of pesticides.	Licensed staff at PNNL or certified commercial applicators were used to purchase, store, and apply pesticides on the PNNL-Richland campus and PNNL-Sequim campus.	2.6.8
The RCRA requires hazardous waste to be tracked from generation to treatment, storage, or disposal (referred to as cradle-to-grave management).	PNNL is responsible for one RCRA-permitted storage and treatment unit. PNNL generates hazardous waste in six RCRA facilities. A total of three CY 2023 inspections were performed at the PNNL-managed 325 Building Radiochemical Processing Laboratory (325RPL) facility on the Hanford Site and PNNL campuses. One record-keeping violation was found.	2.6.5
The <i>Superfund Amendments and Reauthorization Act of 1986</i> amends and reauthorizes CERCLA.	PNNL-Richland campus areas near the Hanford Site have been evaluated and require no further action. Groundwater near the PNNL-Richland campus is no longer required to be monitored for Hanford Site contaminant migration. No contamination was identified at the PNNL-Sequim campus that would require response under CERCLA or the <i>Superfund Amendments and Reauthorization Act</i> .	2.6.3
The <i>Toxic Substances Control Act (TSCA)</i> requires the control and tracking of regulated hazardous chemicals, primarily polychlorinated biphenyls (PCBs).	PNNL contributed to the 2023 PCB annual document log report for the Hanford Site and 2023 PCB annual report; both were published in 2024 and submitted to the EPA, as required. These reports were not required for PNNL-Richland and PNNL-Sequim campuses for 2023.	2.6.7

Statute/Regulation	2023 Status	Report Section(s)
<b>Radiation Protection</b>		
DOE Order 435.1, <i>Radioactive Waste Management</i> , establishes requirements for managing high-level waste, transuranic waste, low-level waste, and mixed wastes.	PNNL's Radioactive Waste Management Basis report identifies radioactive waste management controls through internal workflows and procedures, which then are implemented by staff at PNNL.	2.8.2, 2.8.3
DOE Order 458.1, <i>Radiation Protection of the Public and the Environment</i> , establishes requirements related to radiation protection of the public and the environment, including estimating radiological dose.	PNNL implements programs to assure that facilities, emissions, effluents, and wastes are protective of the public, workers, and the environment.	2.8, 4.1, 4.2, 4.3, 4.4
The Atomic Energy Act of 1954 encompasses the management of low-level and mixed low-level wastes and radioactive materials.	PNNL's Radiation Protection Management and Operation Program includes safeguarding and monitoring radioactive materials through work controls, dosimetry, bioassay, and safety information.	2.8.3
<b>Water Quality and Protection</b>		
The <i>Clean Water Act</i> (CWA) seeks to maintain and improve surface water quality through criteria and permitting, including point-source discharges to U.S. surface waters and indirect discharges to sewer systems, as well as the discharge of dredged or fill material into U.S. waters and/or wetlands.	PNNL conducted operations under permits issued by the Washington State Department of Ecology and the City of Richland. The PNNL-Sequim campus operated under a National Pollutant Discharge Elimination System (NPDES) permit issued by the Washington State Department of Ecology. Permits were acquired for off-site scientific research studies as applicable.	2.5, 2.7.1, 7.3, 7.5
The <i>Safe Drinking Water Act of 1974</i> (SDWA) establishes standards and requirements for public drinking water systems.	The PNNL-Richland campus receives all drinking water for use in laboratory and nonlaboratory spaces from the City of Richland. The city is responsible for meeting water quality standards under the SDWA. At the PNNL-Sequim campus, drinking water is provided exclusively from an on-site well and PNNL implements the requirements of SDWA as part of the Group A operating permit for this water system.	2.5.2, 2.5.3, 7.3, 7.5
PFAS (Per- and polyfluoroalkyl substances) Emerging Contaminants	PNNL performed testing and analysis for PFAS chemicals as required by DOE and Washington State requirements.	2.5.4
<b>Wildlife and Ecosystems</b>		
The <i>Bald and Golden Eagle Protection Act of 1940</i> provides for the protection of bald and golden eagles.	The U.S. Fish and Wildlife Service (USFWS) short-term eagle incidental take permit acquired for nesting bald eagles at PNNL-Sequim campus. Required monitoring, access restrictions, and reporting completed. Biological resource reviews provided assurance that proposed actions did not adversely affect bald or golden eagles.	2.7.1
The <i>Coastal Zone Management Act of 1972</i> encourages the development of coastal zone management plans to preserve, protect, and enhance natural coastal resources and the wildlife using coastal habitats.	PNNL considers coastal resources and the fish and wildlife that use the associated habitats when evaluating proposed actions.	2.7.1

Statute/Regulation	2023 Status	Report Section(s)
The ESA provides for the protection of threatened and endangered plant and animal species.	No endangered or threatened species were observed during biological field surveys of the PNNL-Richland campus. PNNL evaluates potential impacts to federally listed species and their designated critical habitats for all proposed research or development actions. Consultations with regulatory agencies (USFWS, National Marine Fisheries Service [NMFS]) were completed, as required, whenever proposed actions had the potential to affect ESA-listed resources.	2.7.1
The <i>Forest Service Organic Administration Act of 1897</i> (FSOAA) provides for the protection and administration of U.S. Forest Service lands.	Authorizations under the FSOAA were acquired for off-site research studies, as applicable.	2.7.1
The <i>Magnuson–Stevens Fishery Conservation and Management Act of 1976</i> (MSFCMA) governs marine fisheries management.	PNNL evaluates potential impacts to essential fish habitat from all proposed research or development actions. Consultations with the NMFS were completed, as required, whenever proposed actions had the potential to affect essential fish habitat resources.	2.7.1
The <i>Marine Mammal Protection Act of 1972</i> (MMPA) provides for the protection of all marine mammals.	PNNL evaluates potential impacts to federally protected marine mammal species and their habitats for all proposed research or development actions.	2.7.1
The <i>Migratory Bird Treaty Act of 1918</i> (MBTA) makes it illegal to take, capture, or kill migratory birds or their feathers, nests, or eggs.	PNNL evaluates potential impacts to migratory birds for all proposed R&D activities. Many migratory birds were observed at the lands encompassing the PNNL-Richland and PNNL-Sequim campuses. PNNL biologists resolved 24 inquiries concerning migratory birds.	2.7.1
The <i>National Environmental Policy Act of 1969</i> (NEPA) requires the formulation of an environmental impact statement, environmental assessment, or categorical exclusion for federal projects that have the potential to affect the quality of the human environment.	PNNL environmental compliance representatives and NEPA staff conducted 1,453 NEPA reviews for newly proposed and funded research activities and 55 NEPA reviews for facility modification permits during CY 2023. DOE-PNSO approved three new activity-specific categorical exclusions in 2023 and evaluated and reapproved 13 generic categorical exclusions.	2.3, 7.1
The <i>National Park Service Organic Act of 1916</i> provides for the management of national parks and monuments.	Scientific Research and Collecting Permits and Special Use Permits were acquired for off-site studies, as applicable.	2.7.1
The <i>National Wildlife Refuge System Administration Act of 1966</i> provides administrative and management directives for refuges under the jurisdiction of the USFWS.	Special Use Permits were acquired for off-site research studies, as needed.	2.7.1
The <i>Nonindigenous Aquatic Nuisance Prevention and Control Act of 1990</i> prevents the spread of nonindigenous aquatic nuisance species to non-infested waters.	An aquatic invasive plant and animal species interception program has been developed and implemented by PNNL.	2.7.1.1, 2.7.2.1
The <i>Rivers and Harbors Appropriation Act of 1899</i> (RHA) prohibits obstruction or alteration of navigable waters.	RHA Section 10 permits were obtained for off-site research studies as applicable.	2.7.1

Statute/Regulation	2023 Status	Report Section(s)
Executive Order 11988, <i>Floodplain Management</i> (42 FR 26951), requires federal agencies to evaluate the potential effects of any actions within a floodplain.	Compliance was achieved through the biological resource review process at PNNL.	2.7.1
Executive Order 11990, <i>Protection of Wetlands</i> (42 FR 26961), requires federal agencies to minimize the loss or degradation of wetlands and to preserve and enhance their natural and beneficial values.	Compliance was achieved through the biological resource review process at PNNL.	2.7.1

Table 5. Status of Washington State Environmental Laws and Regulations Applicable to PNNL, 2023

Statute/Regulation	2023 Status	Report Section(s)
The <i>Hazardous Waste Management Act of 1976</i> provides for safe planning, regulation, control, and management of hazardous waste.	PNNL manages hazardous wastes in a safe and responsible manner. Inventories and storage methods are regulated, and reports are submitted as required.	2.6.2
The <i>Shoreline Management Act of 1971</i> establishes guidelines for shoreline use, environmental protection, and public access.	Shoreline Substantial Development Permits or Exemptions were acquired for off-site research studies as applicable.	2.7.1
The <i>Washington Clean Air Act</i> implements and supplements the federal CAA, overseeing state air quality.	PNNL operated under permits issued by the WDOH, Washington State Department of Ecology, BCAA, and ORCAA. No events were reported for emissions of regulated substances or substances of concern to the outside air.	2.4
The <i>Washington Pesticide Application Act</i> provides for the control of pesticide application and use to protect public health and welfare.	Pesticide use and applications were accomplished by licensed staff at PNNL or certified commercial applicators in compliance with regulations.	2.6.8
The <i>Washington Pesticide Control Act</i> establishes guidelines for proper use and control of pesticides.	Pesticide use and applications were accomplished by licensed staff at PNNL or certified commercial applicators in compliance with regulations.	2.6.8
The <i>Washington State Environmental Policy Act</i> (SEPA) requires the identification and analysis of the environmental impacts of state and local decisions, giving agencies the authority to deny a proposal when adverse environmental impacts are identified.	PNNL environmental compliance representatives and staff review research and support activities and complete SEPA checklists as required.	2.3
Washington Administrative Code (WAC) 246–290, “Group A Public Water Supplies,” establishes drinking water State Action Levels and monitoring requirements for five PFAS chemicals in Washington State.	No PFAS monitoring was required or performed for the water supply at the PNNL-Richland campus as the City of Richland is responsible for monitoring for PFAS in drinking water. Initial sampling of the PNNL-Sequim campus drinking water for PFAS was completed in 2023 to meet DOE requirements, and all results were nondetectable.	2.5.3, 2.5.4

## 2.1 Sustainability and Environmental Management System

The DOE-Battelle Prime Contract for management and operation of PNNL (DOE-PNSO 2024) continues to implement applicable sustainability and environmental management system (EMS) requirements from Executive Orders, including associated performance goals, objectives, and systems.

The DOE-Battelle Prime Contract requires developing a Site Sustainability Plan (e.g., PNNL 2023) and maintaining an EMS that conforms to the International Organization for Standardization (ISO) 14001:2015 standards, per DOE Order 436.1A. Prepared and submitted to DOE annually in accordance with DOE Sustainability Performance Division guidance, the Site Sustainability Plan highlights accomplishments and continuous improvement opportunities related to DOE's sustainability goals. Section 3.1 of this report provides a summary of PNNL's Fiscal Year (FY) 2024 Site Sustainability Plan (PNNL 2023) and the EMS.

Executive Order 13834 of May 17, 2018, *Efficient Federal Operations* ([83 FR 23771](#)), required that federal agencies meet statutory requirements to increase energy efficiency, improve performance, eliminate resource use when unnecessary, and protect the environment. This Executive Order established goals and requirements for reducing building energy use, implementing energy efficiency measures, reducing potable and nonpotable water consumption, managing stormwater and wastewater, increasing energy and water use efficiency, modernizing buildings to comply with building energy efficiency requirements and sustainable design principles, preventing pollution, diverting waste, and stewarding electronics.

In January 2021, Executive Order 13990, *Protecting Public Health and the Environment and Restoring Science to Tackle the Climate Crisis* ([86 FR 7037](#)), was issued, which directed "... all executive departments and agencies to immediately review, and, as appropriate and consistent with applicable law, take action to address the promulgation of Federal regulations and other actions ... that conflict with ... important national objectives, and to immediately commence work to confront the climate crisis." This Executive Order partially revoked some provisions in Executive Order 13834. Later in January 2021, Executive Order 14008, *Tackling the Climate Crisis at Home and Abroad* ([86 FR 7619](#)), was issued to place the climate crisis at the forefront of foreign policy and national security planning.

Subsequently, in December 2021, Executive Order 14057, *Catalyzing Clean Energy and Industries and Jobs Through Federal Sustainability* ([86 FR 70935](#)), was issued to establish a new, broader federal policy of leading by example "... to achieve a carbon pollution-free electricity sector by 2035 and net-zero emissions economy-wide by not later than 2050." This Executive Order fully revoked Executive Order 13834 and set new federal-level sustainability goals. In FY 2021, PNNL was selected by DOE to participate in its Net-Zero Laboratory pilot. The Net-Zero Laboratory pilot, which also includes Idaho National Laboratory, the National Renewable Energy Laboratory, and the National Energy Technology Laboratory, will bring together new technologies, innovative approaches, and relevant stakeholders to lead the transition to net-zero emissions and decarbonization, and will do so in a way that can be replicated to benefit the entire nation.

At PNNL, our role in Net-Zero Laboratory aligns with our longstanding commitment to sustainability and our initiative to achieve net-zero-emissions and energy-resilient operations on our campuses. This initiative will allow PNNL to leverage our facilities, capabilities, and expertise to advance the transition to net-zero emissions at PNNL and to help pave the way for

others across the nation who are striving to do the same. Our plans are focused on enabling PNNL to achieve net-zero emissions, while optimizing our resources and operations to achieve 24/7 carbon-free energy and mitigate the impacts of utility disruptions. Additional information on PNNL progress toward net-zero emissions and energy-resilient operations are provided in Section 3.0 of this report.

## 2.2 Energy Independence and Security Act of 2007

The EISA (42 U.S.C. § 17001) was enacted “... to move the United States toward greater energy independence and security.” It promotes the production of clean, renewable fuels, R&D of biofuels, improved vehicle technology, energy savings through improved standards including those for appliances and lighting, improved energy savings in buildings and industry, reduction of stormwater runoff, water conservation and protection, development and extension of new technologies (including solar, geothermal, marine and hydrokinetic, and energy storage), carbon capture and sequestration research, and energy transportation and infrastructure provisions. In FY 2023, PNNL completed required evaluation in two buildings that are subject to EISA Section 432 continuous (four-year cycle) comprehensive energy and water requirements.

Whole-building metering for electricity, natural gas, and water have been completed for all DOE-owned buildings, enabling facility system analyses, as needed. Stormwater management practices are implemented to promote water drainage and reduce runoff (see Section 2.5.2 of this report). Also, a 125-kW photovoltaic (PV) array on the PNNL-Richland campus continued operation in 2023, contributing to on-site energy generation and, together with renewable energy certificate purchases, it made up 8.8% of PNNL’s electrical use and 7.7% of its total electric and thermal energy (PNNL 2023).

## 2.3 National Environmental Policy Act of 1969

NEPA (42 U.S.C. § 4321 *et seq.*) was enacted to assure that potential environmental impacts, as well as technical factors and costs, are considered during federal agency decision-making. For the first time since 1978, in July 2020, the Council on Environmental Quality (CEQ) comprehensively updated its regulations for federal agencies to implement NEPA ([85 FR 43304](#)). DOE is in the process of updating its implementing procedures to match changes in CEQ regulations. The goal of the update was to facilitate more efficient, effective, and timely NEPA reviews. The regulations were amended in May 2022 and updated to restore provisions that had been in effect prior to the 2020 update ([87 FR 23453](#)). PNNL’s NEPA Compliance Program supports its compliance with NEPA and SEPA (Revised Code of Washington [\[RCW\] 43.21C](#), as amended). Program activities include preparing sitewide and activity-specific categorical exclusions, environmental assessments, and Washington SEPA checklists. NEPA reviews of PNNL activities are conducted by PNSO. NEPA compliance is verified through assessments conducted by PNNL and PNSO.

PNNL environmental compliance representatives and NEPA experts conducted 1,453 NEPA reviews for newly proposed and funded research activities during CY 2023 for research and support activities. Additionally, 55 facility modification permits were reviewed for NEPA compliance. The number of NEPA reviews conducted annually for new projects within the Electronic Prep and Risk system has increased over the past five years (Figure 8). NEPA experts review projects in Electronic Prep and Risk to verify that potential project environmental impacts were adequately considered, and NEPA (and as appropriate, SEPA) coverage was correctly applied.

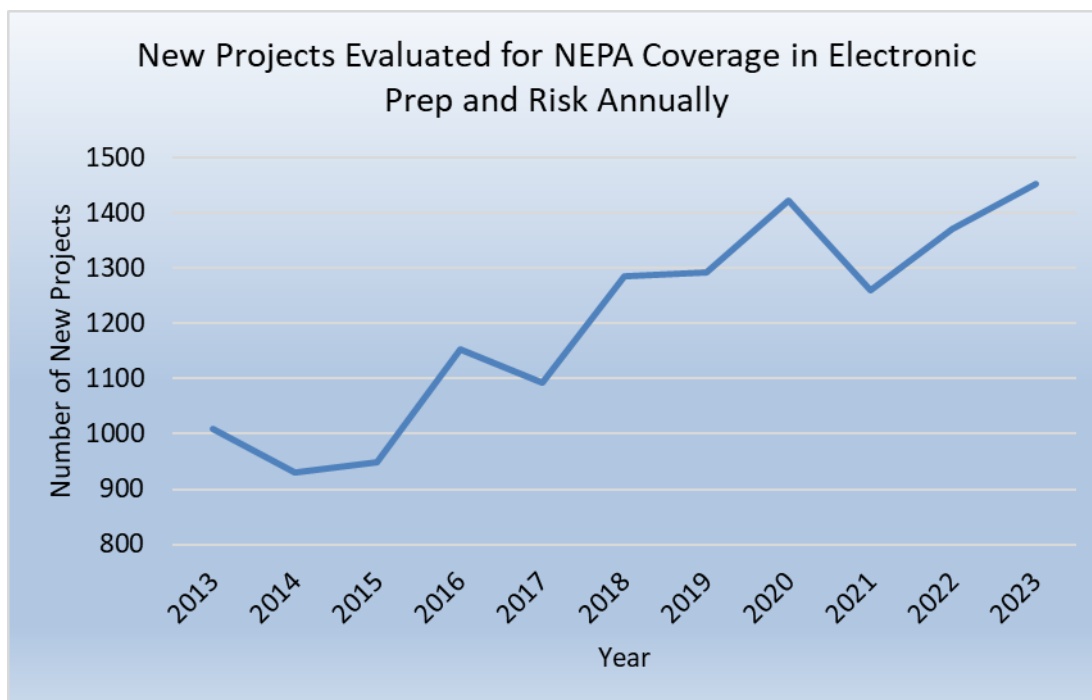


Figure 8. NEPA Reviews for New Projects in the Electronic Prep and Risk System Conducted Annually at PNNL from CY 2013–2023.

In all cases, activities were adequately addressed in previously approved NEPA documentation, including generic categorical exclusions, environmental assessments, environmental impact statements, and supplement analyses.

Categorical exclusions represent an effective and necessary means of addressing activities that 1) clearly fit within a class of actions that DOE has determined do not individually or cumulatively have a significant effect on the environment, 2) do not have extraordinary circumstances that may affect the environment, and 3) are not connected to other actions that may have potentially significant impacts. A single determination for a generic categorical exclusion is allowed for recurring activities undertaken during a specified period of time.

There were no new PNSO-approved generic categorical exclusions in 2023, though numerous reevaluations were finalized. A total of 20 generic categorical exclusions have been approved by PNSO to cover PNNL research and operations activities to date. Generic categorical exclusions are reevaluated every five years by PNSO. In 2023, 13 generic categorical exclusions were reevaluated, and all were approved by PNSO. When projects clearly are within the definition of a categorical exclusion, but a generic categorical exclusion is not applicable, a new project- or activity-specific categorical exclusion is prepared. Three project-specific categorical exclusions were published in CY 2023. A list of all PNSO-approved categorical exclusions is available at <https://science.osti.gov/pns/NEPA-Documents/Categorical-Exclusion-Determinations>.

Potential impacts to the environment from campus development at the PNNL-Richland and PNNL-Sequim campuses are evaluated in Environmental Assessments. Environmental Assessments are prepared for proposed actions that do not fit within the DOE categorical exclusions, and when the decision has been made not to prepare in Environmental Impact

Statement. A list of all PNSO-approved Environmental Assessments is available at <https://science.osti.gov/pnso/NEPA-Documents/PNSO-EA-EIS>.

## 2.4 Air Quality

Federal and state regulations that apply to air quality at the PNNL-Richland campus and PNNL-Sequim campus, and the permits necessary to maintain compliance, are discussed in this section.

### 2.4.1 Clean Air Act

The CAA (42 U.S.C. § 7401 *et seq.*) is administered by the EPA. It regulates air emissions from stationary and mobile sources, both criteria and hazardous air pollutants. It authorized the EPA to establish National Ambient Air Quality Standards for the protection of public health and welfare. Establishment of these pollutant standards was combined with state implementation plans to facilitate attainment of the standards. The *Washington Clean Air Act* ([RCW 70A.15](#)), which implements and supplements the federal law, has been revised periodically to keep pace with changes at the federal level. The Washington State Department of Ecology is responsible for developing most statewide air-quality rules and enforces Title 40 of the *Code of Federal Regulations* (CFR) Part 52 ([40 CFR Part 52](#)), [40 CFR Part 60](#), [40 CFR Part 61](#), [40 CFR Part 63](#), [40 CFR Part 68](#), [40 CFR Part 82](#), and [40 CFR Part 98](#), as well as the state requirements in [WAC 173-400](#), “General Regulations for Air Pollution Sources;” [WAC 173-441](#), “Reporting of Emissions of Greenhouse Gases;” [WAC 173-460](#), “Controls for New Sources of Toxic Air Pollutants;” and [WAC 173-480](#), “Ambient Air Quality Standards and Emission Limits For Radionuclides.”

The BCAA implements and enforces most federal and state requirements on the PNNL-Richland campus through [BCAA Regulation 1](#) (BCAA 2021). Requirements applicable to the PNNL-Richland campus include Article 4, “General Standards for Particulate Matter;” Article 5, “Outdoor Burning;” Article 8, “Asbestos;” Article 9, “Source Registration;” and Article 10, “Fees and Charges.” The ORCAA implements and enforces most federal and state requirements at the PNNL-Sequim campus through [ORCAA Regulations](#) (ORCAA 2023). Requirements applicable to the PNNL-Sequim campus include Regulation 4, “Registration;” Regulation 6, “Required Permits and Notifications;” Regulation 7, “Prohibitions;” and Regulation 8, “Performance Standards.”

### 2.4.2 Clean Air Act Amendments of 1990 and the National Emissions Standards for Hazardous Air Pollutants

Section 112 of the CAA addresses emissions of hazardous air pollutants. The *Clean Air Act Amendments of 1990* Revised Section 112 to require standards for major and certain specific stationary source types. The amendments also revised the National Emissions Standards for Hazardous Air Pollutants (NESHAP) regulations that govern emissions of radionuclides from DOE facilities ([40 CFR Part 61, Subpart H](#)). These regulations address the measurement of point-source emissions but incorporate fugitive emissions for complying with established regulations for radioactive air emissions, including standards, monitoring provisions, and annual reporting requirements. The NESHAP regulations cover all pollutants not regulated by the National Ambient Air Quality Standards that are classified as hazardous. PNNL complies with all NESHAP requirements at both the PNNL-Richland campus and PNNL-Sequim campus.

### 2.4.3 Radioactive Emissions

Federal regulations in [40 CFR Part 61, Subpart H](#), require the measurement and reporting of radionuclides emitted from DOE facilities and the resulting maximum public dose from those emissions. These regulations impose a standard of 10 mrem/yr (0.1 mSv/yr) effective dose equivalent (EDE), which is not to be exceeded. Washington State adopted the [40 CFR Part 61, Subpart H](#), standard in its regulations ([WAC 246-247](#)), “Radiation Protection – Air Emissions,” that require the calculation and reporting of the EDE to the maximum exposed individual (MEI) from point-source emissions and from radon and fugitive source emissions. While the [WAC 246-247](#) receptor location considers whether an individual resides or abides at the evaluated location, an additional assessment is performed for the location that has the maximum off-site nuclide air concentrations, whether or not the reside/abide criterion is met ([WAC 173-480](#)).

On the PNNL-Richland campus, the Physical Sciences Facility (PSF) has the potential to emit radionuclides. PSF<sup>1</sup> radioactive emission point sources at the PNNL-Richland campus are actively ventilated stacks that use electrically powered exhausters and from which emissions are discharged under controlled conditions. PNNL sources are major, minor, and fugitive emissions units. In addition, several sitewide radioactive air permits, commonly called Potential Impact Category 5 (PIC-5) permits (Barnett 2018), were used to assign dose from very low potential emissions sources associated with campus-wide operations. The low-level radioactive sources permitted under PIC-5 include emissions for instrument and operational checks, nondispersible radioactive materials, volumetrically released radioactive materials, and certain facility restoration activities.

Details regarding ambient air, stack emissions monitoring, and PIC-5 permit programs for the PNNL-Richland campus and PNNL-Sequim campus are reported annually. Richland data for 2023 are available in the *PNNL-Richland Campus Radionuclide Air Emissions Report for Calendar Year 2023* (Snyder et al. 2024b). The PNNL-Sequim campus has one sitewide minor fugitive emission unit that has the potential to emit radionuclides. Radioactive air emissions results for Sequim are available in the *PNNL-Sequim Campus Radionuclide Air Emissions Report for Calendar Year 2023* (Snyder et al. 2024c). During CY 2023, the PNNL-Richland campus and PNNL-Sequim campus maintained compliance with state and federal regulations and with issued air emissions permits. Radioactive air emissions were more than 100,000 times lower than the regulatory standard of 10 mrem/yr (0.1 mSv/yr) EDE for the period at each facility.

### 2.4.4 Air Permits

PNNL has several permits that control airborne emissions from facilities within the PNNL-Richland campus boundary. Permits for radioactive air emissions are issued by the WDOH as a Notice of Construction and are incorporated into the Radioactive Air Emissions License (RAEL). For the PNNL-Richland campus, WDOH issued RAEL-005, which was last renewed on January 1, 2021; the renewal cycle for a WDOH RAEL is every five years. Permits for nonradiological air emissions at the PNNL-Richland campus are issued by the BCAA as an Order of Approval; they can cover particulate, volatile organic compound, and toxic air pollutant

---

<sup>1</sup> As a group of research buildings, the PSF is expected to accommodate emerging research over time.

emissions. Current Orders of Approval issued by the BCAA to the PNNL-Richland campus are listed below:

- PNNL Site – William R. Wiley Environmental Molecular Sciences Laboratory (EMSL), PSF Complex, Energy Sciences Center, Life Sciences Laboratory 2 Halogenated Solvent Degreaser Operations, Grid Storage Launchpad (Order of Approval No. 2019-0005, Rev. 2)
- Life Sciences Laboratory 2 Building Operations (Order of Approval No. 2007-0006, Rev. 1)
- Richland North Building Operations (Order of Approval No. 2012-0017)
- Richland North Research (Order of Approval No. 2012-0016).

The PNNL-Sequim campus has two air permits for airborne emissions: RAEL-014 issued effective on January 1, 2023, by the WDOH and a nonradiological regulatory order issued by the ORCAA (Order of Approval 13NOI968).

#### 2.4.5 Hydrofluorocarbon Phasedown

The AIM Act of 2020 ([42 U.S.C. § 7675](#) *et seq.*) seeks to reduce HFC consumption and production to 15% of a 2011–2013 baseline by 2036. PNNL uses HFCs primarily as refrigerants in chillers and other refrigeration appliances. Cleaning solvents that may contain HFCs also are used at PNNL. Refrigerants and products containing HFCs will be replaced with EPA-approved substitutes as they become available. Chemical products containing HFCs are currently tracked in the Chemical Management System. Refrigerants containing HFCs are currently tracked in the Compliance Suite Refrigeration Compliance Management Software™.

### 2.5 Water Quality and Protection

Federal and state regulations that apply to water quality at the PNNL-Richland campus and PNNL-Sequim campus are discussed in this section, which addresses wastewater, stormwater, drinking water, and emerging contaminant regulations and permitting processes.

#### 2.5.1 Clean Water Act

The CWA (33 U.S.C. § 1251 *et seq.*) establishes the basic structure for regulating discharges of pollutants into the waters and wetlands of the United States, as well as quality standards for surface waters. The CWA was enacted in 1948 and was officially named the *Federal Water Pollution Control Act*. Substantially reorganized and expanded with amendments in 1972, it became commonly known as the CWA. Under the CWA, EPA has implemented pollution control programs, such as setting wastewater standards for industry and implementing water quality standards for all contaminants in surface waters. The CWA made it unlawful to discharge any pollutant from a point source into navigable waters unless a permit is obtained. EPA's NPDES permit program controls these point-source discharges. Point sources are discrete conveyances such as pipes or constructed ditches. Industrial, municipal, and other facilities must obtain permits if their discharges go directly to surface waters. The EPA delegated responsibility for the Washington State NPDES permit program to the Washington State Department of Ecology in August 1989.

The Washington State Department of Ecology has issued Permit No. WA0020419 to the City of Richland for discharges from its Publicly Owned Treatment Works to the Columbia River. To make sure it meets its NPDES permit conditions, the City of Richland issues industrial

wastewater discharge permits to industrial users that discharge process wastewater to the City of Richland sanitary sewer system, as codified in Richland Municipal Code Chapter 17.30.

On the PNNL-Richland campus, the discharge of process wastewater to the City of Richland sanitary sewer system is governed by three City of Richland industrial wastewater discharge permits. Permit No. CR-IU001 regulates discharges from facilities on the PNNL-Richland campus and leased facilities, and requires monitoring at one discharge point, Outfall CS-001. Permit No. CR-IU005 regulates discharges from EMSL to Outfall 001. Permit No. CR-IU011 regulates process wastewater discharged from the PSF. All waste streams regulated by these permits are reviewed by staff at PNNL and evaluated for compliance with the applicable permit prior to being discharged.



PNNL Staff Member Collecting Samples by the Columbia River

Process wastewater from PNNL-Sequim campus facilities is discharged to an on-site wastewater treatment system before being discharged to Sequim Bay under the authorization of Washington State Department of Ecology NPDES Permit No. WA0040649. The wastewater treatment system consists of particulate filters, ultraviolet lamps, and granulated activated carbon. All waste streams regulated by this permit are reviewed by staff at PNNL and evaluated for compliance prior to being discharged.

## 2.5.2 Stormwater Management

The CWA (33 U.S.C. § 1251 *et seq.*) also regulates the discharge of stormwater to the surface waters of the United States from point sources. Stormwater discharges from specific industries or industrial categories are governed by general permits or individual permits issued under the NPDES program. Stormwater discharges to the ground through certain types of engineered structures (e.g., dry wells, French drains) are regulated by the SDWA (42 U.S.C. § 300f *et seq.*) under the Underground Injection Control well program. The EPA has delegated responsibility for both of these stormwater programs to the Washington State Department of Ecology.

Stormwater on the PNNL-Richland campus is primarily managed via underground injection control wells and grassy swales. The underground injection control wells are registered with the Washington State Department of Ecology, as required by [WAC 173-218](#), "Underground Injection Control Program." Best management practices, in accordance with the *Stormwater Management Manual for Eastern Washington* (Ecology 2019), are used to minimize pollution in stormwater. These practices include using catch basins to remove solids, storing chemicals inside or under cover, when possible, to prevent contact with stormwater, routinely sweeping and cleaning parking lots, promptly notifying the manager of spills, cleaning up spills, and conducting good housekeeping.

Stormwater at the PNNL-Sequim campus is managed via a stormwater drain system that includes grated catch basins for paved areas and parking lots. The catch basins provide basic treatment for solids removal. In addition, catch basins in the boat storage yard and in the wastewater treatment system area contain multimedia filtration systems for oil control. Stormwater from the beach area drains to outfalls located near the shoreline. Stormwater from the uplands area of the PNNL-Sequim campus drains to an infiltration pond, which is an engineered stormwater collection basin with an overflow trench.

Industrial stormwater discharges from the PNNL-Richland campus and PNNL-Sequim campus are not subject to federal or state NPDES stormwater regulations. However, stormwater management practices that promote water drainage and reduce runoff as outlined under EISA (42 U.S.C. § 17001) Section 438 are considered and implemented as part of PNNL sustainability practices (PNNL 2021). Registration of underground injection control wells for stormwater has been completed, as required by the SDWA and [WAC 173-218](#).

### 2.5.3 Safe Drinking Water Act of 1974

The SDWA (42 U.S.C. § 300f *et seq.*) is the main federal law that assures the quality of drinking water in the United States. Under the SDWA, the EPA establishes primary and secondary standards for drinking water quality and oversees the states, municipalities, and water suppliers who implement those standards. The SDWA was originally passed by Congress to protect public health by regulating the nation's public drinking water supply. The law was amended in 1986 and 1996 and requires many actions to protect drinking water and its sources—rivers, lakes, reservoirs, springs, and groundwater wells.

The SDWA focuses on all waters actually or potentially designated for use as drinking water, whether from aboveground or underground sources. The SDWA authorizes the EPA to establish minimum standards to protect tap water and requires all owners or operators of public water systems to comply with these primary (health-related) standards. The WDOH has been approved to implement these rules for EPA under [WAC 246-290](#) "Group A Public Water Supplies," which also addresses compliance with water quality and implementation of secondary standards. Under the SDWA, EPA also established minimum standards for state programs to protect underground sources of drinking water from endangerment by underground injection of fluids.

The PNNL-Richland campus receives all drinking water from the City of Richland drinking water supply, and the city is responsible for meeting water quality standards under the SDWA.

Water for PNNL-Sequim campus facilities is provided exclusively from an on-site well. PNNL is considered the water purveyor and is responsible for all monitoring and sampling of the drinking water system. All drinking water parameters sampled met compliance requirements.

### 2.5.4 Emerging Contaminants

PFAS are a family of chemicals that are emerging contaminants-of-concern because of their potential adverse health effects and widespread contamination at sites across the nation. PFAS chemicals are used to manufacture stain-resistant, water-resistant, and nonstick products, as well as some cleaning products and engineered coatings, and certain types of firefighting foam. In 2023, the EPA made progress in protecting human health and the environment from PFAS contamination by issuing proposed national drinking water standards for six PFAS chemicals, designating the two most common PFAS chemicals

(i.e., perfluorooctanoic acid [PFOA] and perfluorooctanesulfonic acid [PFOS]) as CERCLA hazardous substances, adding PFAS chemicals to the annual Toxics Release Inventory report requirements under the Emergency Planning and Community Right-to-Know Act, and issuing a final rule requiring reporting for those who manufacture PFAS under TSCA.

In 2021, Washington State passed legislation to monitor certain PFASs in drinking water and establish approved analytical methods for testing for PFASs. Under [WAC 246-290](#), effective January 2023, all public water systems will be required to perform initial sampling for five specific PFAS chemicals.

In 2022, an initial assessment of PNNL properties and activities was conducted to determine if the potential for PFAS contamination exists (DOE 2022b). The assessment identified that there may be some chemicals, products, or pieces of equipment being used at PNNL that contain PFAS, but there are no active fire suppression systems that contain AFFF or other PFAS chemicals. One decommissioned fire suppression system that contained PFAS chemicals was identified. The AFFF and the system and piping were removed and disposed of in 2014 and 2022, respectively. In 2023, a below-grade emergency overflow tank that was previously connected to this system was tested, and residual liquid in the tank was found to have detectable levels of PFAS. Removal of the tank was initiated, and residual liquid in the tank was removed and properly disposed of. Soils surrounding the tank were tested and found to contain low concentrations of PFAS chemicals. A plan for managing the soils surrounding the tank is being developed with technical assistance from the Washington State Department of Ecology. No other PNNL activities or properties were identified to have potential PFAS contamination. Testing of the PNNL-Sequim campus drinking water was completed in 2023, and no detectable levels of PFAS chemicals were found.

## 2.6 Environmental Restoration and Waste Management

This section describes PNNL activities conducted to protect the environment through proper management of waste.

### 2.6.1 Emergency Planning and Community Right-to-Know Act of 1986

The *Emergency Planning and Community Right-to-Know Act of 1986* (EPCRA; 42 U.S.C. § 11001 *et seq.*) requires each state to establish an emergency response commission and local emergency planning committees and develop a process for gathering and distributing information about hazardous chemicals present in local facilities. These local planning committees develop emergency plans for local planning districts. Facilities that produce, use, release, or store toxic or hazardous substances in quantities above threshold levels must submit information about the chemicals to local emergency planning committees.

EPCRA has four major provisions:

1. Emergency planning
2. Emergency release notification
3. Hazardous chemical inventory reporting
4. Toxic chemical release inventory reporting.

Each provision requires reporting when thresholds are exceeded (Table 6).

PNNL EPCRA reporting for the PNNL-Richland campus combines the quantities of chemicals in the Hanford 300 Area facilities that PNNL occupies and those present in on-campus facilities. EPCRA reports for the PNNL-Sequim campus are submitted separately from those for the PNNL-Richland campus because the PNNL-Sequim campus is in a different county (Clallam).

On February 10, 2023, the Annual Tier-Two inventory report for the PNNL-Richland campus was submitted to the Washington State Emergency Response Commission via the [SecureAccessWA](#) website. The completed Tier-Two form then was transmitted via email to the Benton County Emergency Management and the Richland Fire Department. Under the governing regulations, R&D chemicals are exempt from reporting. The report includes facility operations chemical inventories located at PNNL-occupied 300 Area Hanford facilities and facilities on the PNNL-Richland campus (comprising both PNSO and Battelle-owned facilities). This report identified that lead-acid batteries, diesel fuel, and the urea content of fertilizer products stored at PNNL exceeded the reporting threshold.

Using the same process, the Annual Tier-Two inventory report for the PNNL-Sequim campus was submitted to the Washington State Emergency Response Commission on February 2, 2023. The completed Tier-Two form was emailed to Clallam County Emergency Management and Clallam County Fire District 3. As in previous years, this report identifies diesel fuel as the only material that exceeds the reporting threshold at the PNNL-Sequim campus.

Neither the PNNL-Richland campus nor PNNL-Sequim campus was required to submit a Toxic Release Inventory Report for 2023 because no releases of Toxic Release Inventory chemicals exceeded reporting thresholds. Table 7 provides an overview of PNNL reporting under EPCRA for CY 2023.

Table 6. Provisions of the *Emergency Planning and Community Right-to-Know Act of 1986*

Section	CFR Section	Reporting Criteria	Due Date	Agencies Receiving Report
302	40 CFR Part 355: "Emergency Planning"	The presence of an extremely hazardous substance in a quantity equal to or greater than the threshold planning quantity at any one time.	Within 60 days of threshold planning quantity exceedance	SERC; LEPC
302	40 CFR Part 355: "Emergency Planning"	Change occurring at a facility that is relevant to emergency planning.	Within 30 days after the change has occurred	LEPC
304	40 CFR Part 355: "Emergency Release Notification"	Release of an extremely hazardous substance or a CERCLA hazardous substance in a quantity equal to or greater than the reportable quantity.	Initial notification: immediate (within 15 minutes of knowledge of reportable release). Written follow-up within 14 days of the release.	SERC; LEPC
311	40 CFR Part 370: "Reporting Requirements – Material Safety Data Sheet Reporting"	The presence at any one time at a facility of an OSHA hazardous chemical in a quantity equal to or greater than 4,500 kg (10,000 lb.) or an extremely hazardous substance in a quantity equal to or greater than the threshold planning quantity or 230 kg (500 lb.), whichever is less.	Revised list of chemicals due within 3 months of a chemical exceeding a threshold	SERC; LEPC; local fire departments
312	40 CFR Part 370: "Reporting Requirements – Tier-Two Report"	The presence at any one time at a facility of an OSHA hazardous chemical in a quantity equal to or greater than 4,500 kg (10,000 lb.), or an extremely hazardous substance in a quantity equal to or greater than the threshold planning quantity or 230 kg (500 lb.), whichever is less.	Annually by March 1	SERC; LEPC; local fire departments
313	40 CFR Part 372: "Reporting Requirements – Toxic Release Inventory Report"	Manufacture, processing, or use at a facility of any listed Toxic Release Inventory chemical in excess of its threshold amount during a calendar year. Thresholds are 11,300 kg (25,000 lb.) for manufactured or processed chemicals or 4,500 kg (10,000 lb.) for chemicals otherwise used, except for persistent, bio-accumulative, toxic chemicals, which have thresholds of 45 kg (100 lb.) or less.	Annually by July 1	EPA; SERC
CERCLA = <i>Comprehensive Environmental Response, Compensation, and Liability Act of 1980</i> CFR = <i>Code of Federal Regulations</i> EPA = U.S. Environmental Protection Agency LEPC = Local Emergency Planning Committee OSHA = Occupational Safety and Health Administration SERC = State Emergency Response Commission				

Table 7. *Emergency Planning and Community Right-to-Know Act of 1986 Compliance Reporting, 2023*

Section	Description of Reporting	Reporting Status	Notes
302	Emergency planning notifications	Not required	No changes in previously reported inventories of sulfuric acid and no new extremely hazardous substances greater than thresholds.
304	Extremely hazardous substance release notification	Not required	No releases occurred.
311	Safety Data Sheet	Required	No changes in previously reported inventories.
312	Chemical inventory	Required	Tier-Two reports for the PNNL-Richland campus and PNNL-Sequim campus were submitted to the Washington State Department of Ecology, LEPC, and local fire departments in February 2023.
313	Toxic release inventory	Not required	No releases were greater than the reporting threshold requirement.

## 2.6.2 Tri-Party Agreement

The “Hanford Federal Facility Agreement and Consent Order,” also known as the Tri-Party Agreement (Ecology et al. 1989), is an agreement between the Washington State Department of Ecology, EPA, and DOE (the Tri-Party Agreement agencies) to achieve compliance on the Hanford Site with the treatment, storage, and disposal unit regulations and corrective action provisions of the *Comprehensive Environmental Response, Compensation, and Liability Act of 1980* (CERCLA; 42 U.S.C. § 9601 *et seq.*) and RCRA (42 U.S.C. § 6901 *et seq.*, and 42 U.S.C. § 6927(c) *et seq.*). The Tri-Party Agreement is an interagency agreement (also known as a federal facility agreement) under Section 120 of CERCLA, a corrective action order under RCRA, and a consent order under the Washington State *Hazardous Waste Management Act of 1976* (RCW 70.105). The Tri-Party Agreement 1) defines RCRA and CERCLA cleanup commitments, 2) establishes responsibilities, 3) provides a basis for budgeting, and 4) reflects a concerted goal to achieve regulatory compliance and remediation with enforceable milestones.

The Tri-Party Agreement is available on the DOE Hanford Site website.<sup>2</sup> Printed copies, current as of March 26, 2024, are publicly available at DOE’s Public Reading Room, located in the Washington State University–Tri-Cities Consolidated Information Center, 2770 University Drive, Richland, Washington, and at public reading rooms in Seattle and Spokane, Washington, and Portland, Oregon.

Under the Tri-Party Agreement, Hanford waste sites were grouped into “operable units” based on geographic proximity or similarity of waste-disposal history. The Tri-Party Agreement only applies to PNNL facilities operating on the Hanford Site; it does not apply to the PNNL-Richland campus, PNNL-Sequim campus, or other PNNL offices. The PNNL-Richland campus is not part of any active Hanford Site CERCLA operable unit or subject to any cleanup action under the Tri-Party Agreement. PNNL maintains administrative controls like those at adjacent uncontaminated portions of the Hanford Site 300 Area (e.g., access control and groundwater use restrictions). PNNL provides information to DOE-RL and its contractors regarding the facilities it occupies on the Hanford Site to support the preparation of the annual land disposal restrictions report required by the Tri-Party Agreement M-26 milestone series. Some wells on

<sup>2</sup> <http://www.hanford.gov/?page=81>

the PNNL-Richland campus are monitored by Hanford Site contractors as part of the regional groundwater monitoring network. Sampling data are available in the *Hanford Site RCRA Groundwater Monitoring Report for 2023* (DOE-RL 2024b).

### 2.6.3 Comprehensive Environmental Response, Compensation, and Liability Act of 1980

CERCLA was promulgated to address response, compensation, and liability for past releases or potential releases of hazardous substances, pollutants, and contaminants to the environment. CERCLA was amended by the *Superfund Amendments and Reauthorization Act of 1986* (42 U.S.C. § 9601 *et seq.*), which made several important changes and additions, including clarification that federal facilities are subject to the same provisions of CERCLA as any nongovernmental entity. Executive Order 12580 of January 23, 1987, *Superfund Implementation* ([52 FR 2923](#)), directs that DOE, as the lead agency, must conduct CERCLA response actions (i.e., removal and remedial actions). Such actions would be subject to oversight by EPA and/or the Washington State Department of Ecology.

Two Hanford 300 Area operable units,<sup>3</sup> listed on the National Priorities List on November 3, 1989, are located near the PNNL-Richland campus.

A portion of the PNNL-Richland campus located north of Horn Rapids Road was investigated as part of the Hanford 300-FF-2 Operable Unit in the late 1990s. Site characterization efforts found vestiges of petroleum hydrocarbons, irrigation canals, and debris (windblown garbage, porcelain products, battery cores, cans, and glass). After a site evaluation, EPA issued a CERCLA Final Record of Decision (EPA and DOE-RL 2013) that concluded that PNNL-Richland campus areas north of Horn Rapids Road require no further remedial action under CERCLA.

No PNNL-Sequim campus facilities require action under CERCLA guidelines.

### 2.6.4 Washington State Dangerous Waste/Hazardous Substance Reportable Releases to the Environment

Washington State Dangerous Waste Regulations ([WAC 173-303-145](#)) require that spills or nonpermitted discharges of dangerous wastes or hazardous substances to the environment be reported to the Washington State Department of Ecology. This requirement applies to discharges to soil, surface water, groundwater, or air when such discharges threaten human health or the environment, regardless of the quantity of dangerous waste or hazardous substance released.

During CY 2023, no spills or nonpermitted discharges that posed a threat to human health or the environment occurred at PNNL facilities in the 300 Area, on the PNNL-Richland campus, or on the PNNL-Sequim campus. Minor spills were cleaned up immediately and disposed of in accordance with applicable requirements.

### 2.6.5 Resource Conservation and Recovery Act of 1976

RCRA was enacted to protect human health and the environment through cradle-to-grave management of hazardous waste from its generation through treatment, storage, and disposal.

---

<sup>3</sup> Further details regarding Hanford Site CERCLA and CERCLA groundwater sampling program can be found at <https://www.hanford.gov/page.cfm/environmentalsurveillance>.

The Washington State Department of Ecology has the authority to enforce RCRA requirements in the state under [WAC 173-303](#), “Dangerous Waste Regulations.”

PNNL, in cooperation with DOE-RL, operates one RCRA-permitted storage and treatment unit group—the 325 Hazardous Waste Treatment Units (Ecology 2022). This unit group is in 325RPL in the Hanford Site 300 Area and is permitted as part of the Hanford Facility RCRA Permit. The Hanford Facility RCRA Permit expired on September 27, 2004. However, DOE and PNNL continue to operate in compliance with the expired permit until the permit is reissued, as authorized by [WAC 173-303-806\(7\)](#) and the Washington State Department of Ecology. The full documentation of the Hanford RCRA Permit may be viewed at <https://fortress.wa.gov/ecy/nwp/permitting/hdwp/rev/8c/index.html>. PNNL, in coordination with DOE-RL, has been in active negotiations with the Washington State Department of Ecology for renewal of the 325 Hazardous Waste Treatment Units portion of the Hanford Facility RCRA Permit, which would be issued as Revision 9. PNNL and the Washington State Department of Ecology have reached tentative agreement on most of the 325 Hazardous Waste Treatment Units Revision 9 permit sections. It is anticipated that the Revision 9 permit for all Hanford site unit groups (including the 325 Hazardous Waste Treatment Units) will be submitted for public review in late 2024 or 2025.

With the exception of the 325 Hazardous Waste Treatment Units, the PNNL-Richland campus, PNNL-Sequim campus, and PNNL facilities on the Hanford Site operate under the generator requirements of [WAC 173-303](#). During CY 2023, PNNL facilities followed the generator requirements for waste management and shipped nonradioactive waste to off-site facilities for proper disposal.

RCRA also includes requirements for the proper management of underground storage tanks. In CY 2023, Battelle administered two underground storage tanks that store diesel fuel for backup generators on the PNNL-Richland campus that are registered under the WAC-173-360A, Underground Storage Tank regulations—a 20,000-gallon tank and 600-gallon tank. The tanks are routinely monitored, and no problems have been observed. No underground tanks are used at the PNNL-Sequim campus.

The Washington State Department of Ecology performed three RCRA compliance inspections of PNNL-managed facilities during 2023. The inspections covered the 325 Hazardous Waste Treatment Units and generator areas in the 325RPL facility on the Hanford Site, and the generator areas at the PNNL-Richland and PNNL-Sequim facilities. The inspection at the 325 Hazardous Waste Treatment Units identified one violation for failure to record the time of inspection for emergency eyewash and shower weekly inspections. No violations were identified during the inspections at the PNNL-Richland and PNNL-Sequim campus facilities.

### **2.6.6 Federal Facility Compliance Act of 1992**

The Federal Facility Compliance Act of 1992 (42 U.S.C. 6939c and 6961), enacted by Congress on October 6, 1992, amended Section 6001 of RCRA to specify that the United States waives sovereign immunity from civil and administrative fines and penalties for RCRA violations. In addition, RCRA requires the EPA to conduct annual inspections of all federal facilities. Authorized states also are given authority to conduct inspections of federal facilities to enforce compliance with state hazardous waste programs. DOE also is required to provide mixed waste information to EPA and the states under the Federal Facility Compliance Act. PNNL provides this information as part of an annual Hanford Site Mixed Waste Land Disposal Restrictions

Report pursuant to Tri-Party Agreement Milestone M-26. The 2023 report was transmitted to Department of Ecology on April 30, 2024 (DOE-RL 2024a).

### 2.6.7 Toxic Substances Control Act

Requirements of the *Toxic Substances Control Act* (TSCA; 15 U.S.C. § 2601 *et seq.*) that apply to PNNL primarily involve the regulation of PCBs. Federal regulations for PCB use, storage, and disposal are provided in [40 CFR Part 761](#), “Polychlorinated Biphenyls (PCBs) Manufacturing, Processing, Distribution in Commerce, and Use Prohibitions.” PNNL generates very small quantities of waste that is regulated by [40 CFR Part 761](#), and any of these wastes are stored and/or disposed of in accordance with this regulation.

The *2023 Hanford Site Polychlorinated Biphenyl Annual Report* (Weyns 2024a) and the *2023 Hanford Site Polychlorinated Biphenyl Annual Document Log* (Weyns 2024b) were published in 2024. These documents describe the PCB waste management and disposal activities that occur on the Hanford Site, including PNNL activities in the Hanford Site 300 Area. The annual reports are provided to the EPA, as required by 40 CFR 761.180. A PCB log and annual report were not required for either the PNNL-Richland campus or the PNNL-Sequim campus in 2023.

### 2.6.8 Federal Insecticide, Fungicide, and Rodenticide Act

The *Federal Insecticide, Fungicide, and Rodenticide Act* (7 U.S.C. § 136 *et seq.*) is administered by the EPA. Washington State Department of Agriculture rules implementing the requirements of this act include the *Washington Pesticide Control Act* (RCW 15.58), the *Washington Pesticide Application Act* (RCW 17.21), and rules related to general pesticide use codified in WAC 16-228, “General Pesticide Rules.” In 2023, commercial pesticides used at the PNNL-Richland campus and PNNL-Sequim campus were managed in accordance with these rules and applied either by licensed staff at PNNL or by a licensed commercial applicator.

## 2.7 Natural and Cultural Resources

The *Pacific Northwest Site Office Cultural and Biological Resources Management Plan* (CBRMP; DOE-PNSO 2021a) provides guidance related to protecting and managing biological and cultural resources on the PNNL-Richland campus in accordance with applicable laws and regulations. The CBRMP was developed as a requirement of DOE Policy 141.1, “Department of Energy Management of Cultural Resources,” to provide for the protection and management of cultural and biological resources, identify impacts of unauthorized public use on prehistoric sites, identify actions that will protect sensitive sites, and provide details of annual monitoring activities to identify potential impacts. The CBRMP is implemented by application of PNNL’s internal cultural and biological resource protection procedures, which are updated regularly to reflect relevant changes in applicable laws and regulations and compliance methods.

PNNL staff members conduct field research for which environmental permits are required, often at locations throughout the Pacific Northwest and elsewhere in the United States other than the PNNL-Richland campus or PNNL-Sequim campus. The Environmental Research Permitting (ERP) program was established in 2016 to centralize the acquisition of permits and authorizations in compliance with laws and regulations applicable to PNNL research projects. The ERP program also maintains an online, internal PNNL database for environmental permits (the Environmental Permitting Information Center) and tracks reporting requirements on behalf of research projects.

The following sections describe the laws and regulations applicable to 1) the management of biological and cultural resources on the PNNL-Richland campus and 2) the environmental permits required to protect biological and cultural resources that may be affected by research projects conducted on the PNNL-Richland campus, PNNL-Sequim campus, and other research locations.

### 2.7.1 Biological Resources and Environmental Permitting

Several federal and state laws, Executive Orders, regulations, and related memoranda contain requirements for 1) managing biological resources on the PNNL-Richland campus and PNNL-Sequim campus and 2) acquiring the environmental permits or authorizations required to protect biological resources that may be affected by research projects conducted on the PNNL-Richland campus, PNNL-Sequim campus, and other research locations. This section and Table 8 summarize the requirements and catalog PNNL's compliance activities related to biological resources and environmental permitting in 2023. Figure 9 shows the average number of authorizations (permits and biological no effects determinations and/or consultations) in effect for research projects at any given time for years 2017 through 2023 and, within that, the number of new authorizations obtained. Both the numbers of active and newly obtained authorizations have generally increased over the past seven years, though numbers dipped during the COVID-19 pandemic.

**Table 8. Environmental Research Permits/Authorizations Obtained in 2023 for PNNL Research Activities**

Issuer	Authorization Type	Regulatory Driver	Number
Alaska Department of Fish and Game	Fish Habitat Permit	AFA	1
Apache Louisiana Minerals LLC	Access Approval	NA	1
Benton County	Shoreline Substantial Development Permit Exemption	SMA	1
Bureau of Land Management	Access Approval	FLPMA	2
California Coastal Commission	Development Permit Waiver	CCR	1
California Water Board	Notice of Applicability	CCR	1
Clallam County	Shoreline Substantial Development Permit Exemption	SMA	1
Confederated Tribes and Bands of the Yakama Nation	Closed Area Work Permit	NA	8
Danforth Plant Science Center	Access Approval	NA	1
Federal Aviation Administration	Equipment Operational Impact Review	CFR	1
Federal Aviation Administration	Obstruction Evaluation/Airport Airspace Analysis	CFR	4
Fermilab	National Environmental Research Park Research Agreement	NA	1
Igiugig Native Corporation	Access Approval	NA	1
Kansas State University	Access Approval	NA	1
Katama Airpark Commission	Access Approval	NA	1
King County	Shoreline Substantial Development Permit Exemption	SMA	1
Louisiana Department of Wildlife and Fisheries	Scientific Collection Permit	LAC	1
Louisiana Department of Wildlife and Fisheries	Special Use Permit	LAC	2

Issuer	Authorization Type	Regulatory Driver	Number
Louisiana Land and Exploration Company LLC	Access Approval	NA	1
Massachusetts Division of Fisheries and Wildlife	Scientific Collection Permit	GLM	1
Missouri Prairie Foundation	Access Approval	NA	1
Morton Arboretum	Research Documentation	NA	1
National Marine Fisheries Service	Informal Consultation	ESA, MSFCMA	3
National Marine Fisheries Service	Take Authorization under a Biological Opinion	ESA	3
National Park Service	Scientific Research and Collecting Permit	CFR	2
National Park Service	Special Use Permit	CFR	1
NOAA Fisheries	Formal Consultation	ESA	1
Northwest Watershed Research Center	Access Approval	NA	1
Ohio Department of Natural Resources	Research Permit	OAC	1
Oregon Department of Fish and Wildlife	Fish Liberation Report	OAR	2
Oregon Department of Fish and Wildlife	Fish Transport Permit	OAR	1
Oregon Department of Fish and Wildlife	Scientific Taking Permit - Fish	OAR	3
PNNL for DOE-PNSO	No effects Determination	ESA, MMPA, MSFCMA	9
Port of Benton	Temporary Land Use Agreement	NA	3
Premier Tech	Access Approval	NA	1
Private Landowner	Access Approval	NA	6
Qawalangin Tribe of Unalaska	Access Approval	NA	1
Rhode Island Airport Corporation	Access Approval	NA	1
Rhode Island National Guard	Access Approval	NA	1
Rocky Mountain Biological Laboratory	Research Permit	NA	1
Sound Agriculture	Use Permit	NA	1
Town of Nantucket	Access Approval	NA	1
University of Alaska	Access Approval	NA	1
U.S. Army Corps of Engineers	Access Approval	NA	2
U.S. Army Corps of Engineers	Massachusetts General Permit 14 – Scientific Measurement Devices	CWA	1
U.S. Army Corps of Engineers	Nationwide Permit 5 – Scientific Measurement Devices	CWA	4
U.S. Army Corps of Engineers	Programmatic General Permit	CWA, RHA	1
U.S. Army Corps of Engineers	Section 10 Individual Permit – Work in Navigable Waters	RHA	2
U.S. Coast Guard	Local Notice to Mariners	CFR	5
U.S. Department of Agriculture – Agricultural Research Service	Cooperative Agreement	CFR	1
U.S. Department of Agriculture – Animal and Plant Health Inspection Service	Biotechnology Regulatory Service – Permit to Import Genetically Engineered Organisms or Products	PPA	1
U.S. Department of Agriculture – Animal and Plant Health Inspection Service	Plant Protection and Quarantine – Permit to Move Live Plant Pests, Biocontrol Organisms, Federal Noxious Weeds, Soil, and Bees – Importation	PPA	3
U.S. Department of Agriculture – Animal and Plant Health Inspection Service	Plant Protection and Quarantine – Permit to Move Live Plant Pests, Biocontrol Organisms, Federal Noxious Weeds, Soil, and Bees – Interstate Movement	PPA	5

Issuer	Authorization Type	Regulatory Driver	Number
U.S. Department of Agriculture – Animal and Plant Health Inspection Service	Plant Protection and Quarantine – Permit to Receive Soil	PPA	6
U.S. Department of Agriculture – Veterinary Services	Permit for Import and Transport of Controlled Materials, Organisms, and Vectors	CFR	1
U.S. Fish and Wildlife Service	Informal Consultation	ESA	3
U.S. Fish and Wildlife Service	Migratory Bird Incidental Take Permit	MBTA	1
U.S. Fish and Wildlife Service	Special Use Permit	NWRSAA, CFR	1
U.S. Forest Service	Special Use Permit	FSOAA	2
Virginia Institute of Marine Science	Research Permit	NA	1
Washington Department of Ecology	CZMA Negative Determination	CZMA, WAC	1
Washington Department of Fish and Wildlife	Fish Transport Permit	WAC	5
Washington Department of Fish and Wildlife	Hydraulic Project Approval	WAC	2
Washington Department of Fish and Wildlife	Right of Entry	WAC	4
Washington Department of Fish and Wildlife	Scientific Collection Permit	WAC	2
Washington Department of Natural Resources	Aquatic Lands Right of Entry License	WAC	3
Washington Department of Natural Resources	Land Easement	WAC	1
Washington Department of Natural Resources	Research Permit	WAC	1
Washington State Parks	Scientific Research Permit	WAC	1
Washington State University	Access Approval	NA	1
Yakima County	Access Approval	NA	2
<b>Total Environmental Research Permits/Authorizations</b>			<b>141</b>

AFA	=	<i>American Fisheries Act of 1998</i>
CCR	=	California Code of Regulations
CFR	=	Code of Federal Regulations
CZMA	=	<i>Coastal Zone Management Act of 1972</i>
ESA	=	<i>Endangered Species Act of 1973</i>
FLPMA	=	<i>Federal Land Policy and Management Act of 1976</i>
FSOAA	=	<i>Forest Service Organic Administration Act of 1897</i>
GLM	=	General Laws of Massachusetts
LAC	=	Louisiana Administrative Code
MBTA	=	<i>Migratory Bird Treaty Act of 1918</i>
MMPA	=	<i>Marine Mammal Protection Act of 1972</i>
MSFCMA	=	<i>Magnuson–Stevens Fishery Conservation and Management Act</i>
NA	=	not applicable
NOAA	=	National Oceanic and Atmospheric Administration
NWRSAA	=	<i>National Wildlife Refuge System Administration Act of 1966</i>
OAC	=	Ohio Administrative Code
OAR	=	Oregon Administrative Rules
PPA	=	<i>Plant Protection Act</i>
RHA	=	<i>Rivers and Harbors Appropriation Act of 1899</i>
SMA	=	<i>Shoreline Management Act of 1971</i>
WAC	=	Washington Administrative Code

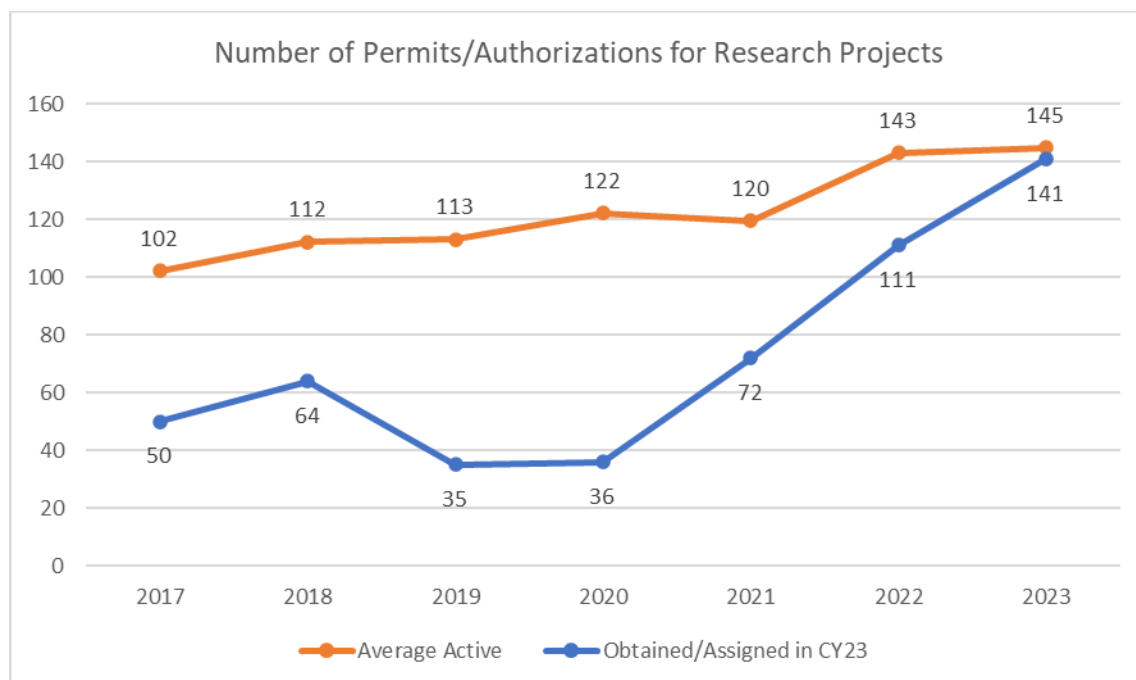


Figure 9. Number of Permits/Authorizations Obtained and Used for Research Projects

### 2.7.1.1 Federal Statutes and Regulations

The ESA (16 U.S.C. § 1531 *et seq.*) contains requirements for the designation and protection of wildlife, fish, plant, and invertebrate species that are in danger of becoming extinct because of natural or manmade factors and the conservation of habitats upon which they depend. Section 7(a)(2) of the ESA requires federal agencies to evaluate actions that they perform, fund, or permit to determine whether they would affect any species listed as endangered or threatened or affect designated critical habitat. Consultation with the USFWS and/or the NMFS is required if the action may affect listed species or critical habitat. The biological resource review process and consultation with USFWS and/or NMFS are the primary means by which PNNL determines whether any listed species or critical habitat may be affected by a proposed action.

The MBTA (16 U.S.C. § 703 *et seq.*) makes it illegal to take, capture, or kill any migratory bird, or to take any part, nest, or egg of any such birds. The MBTA prohibits incidental take and applies enforcement discretion ([86 FR 54642](#)). PNNL projects that have a potential to affect avian species listed under the MBTA use the PNNL biological resource review process, as described in the CBRMP (DOE-PNSO 2021a) and implemented by PNNL's internal biological resource protection procedures to protect migratory birds regardless of intent. In 2023, PNNL biologists resolved 24 inquiries concerning migratory birds on the PNNL-Richland campus and PNNL-Sequim campus and installed deterrents in areas of habitual nesting to avoid potential impacts on active bird nests.

The *Bald and Golden Eagle Protection Act of 1940* (16 U.S.C. § 688 *et seq.*) prohibits anyone without a permit from disturbing, wounding, killing, harassing, or taking bald eagles (*Haliaeetus leucocephalus*) or golden eagles (*Aquila chrysaetos*), alive or dead, including their parts, nests, or eggs. The act also applies to impacts made around previously used nest sites, if upon an eagle's return, normal breeding, feeding, or sheltering habits are influenced negatively. In 2023,

PNNL helped DOE obtain a short-term eagle incidental take permit from the USFWS to allow disturbance of up to three bald eagle nests incidental to PNNL-Sequim campus construction and maintenance activities. This permit required monitoring of eagle activity at previously established nearby nests, restricted certain activities during designated timeframes and nest buffer distances, and subsequent reporting. All activities were completed as required and no nest take resulted from PNNL-Sequim activities. The PNNL biological resource review process provides assurance that all other proposed research or development actions will not adversely affect bald or golden eagles. Mitigation, if needed for other PNNL activities, includes performing work according to the spatial and timing restrictions established for seasonal use locations away from the DOE-Sequim campus, such as nest sites and communal night roosts in applicable jurisdictional management plans for the species.

The MSFCMA (16 U.S.C. § 1801 *et seq.*) is the primary law governing marine fisheries management in the United States. It provides a national program for the conservation and management of U.S. fishery resources to prevent overfishing, rebuild overfished stocks, assure conservation, and facilitate long-term protection of essential fish habitats (waters and substrate necessary to fish for spawning, breeding, feeding, or growth to maturity). Under Section 305(b)(2) of the MSFCMA, federal agencies must consult with the NMFS about any action that might adversely affect essential fish habitat. The PNNL biological resource review process and consultation with NMFS are the primary means by which PNNL determines whether any essential fish habitat may be affected by a proposed action.

The MMPA (16 U.S.C. § 1361 *et seq.*) provides a program for the protection of all marine mammals based on some species or stocks being in danger of extinction or depletion due to human activities. The purpose of the MMPA is to assure actions that may affect marine mammal species or stocks do not cause them to fall below their optimum sustainable population levels. Consultation with the NMFS is required if an action may affect any marine mammal species. The biological resource review process and consultation with NMFS are the primary means by which PNNL determines whether marine mammal species may be affected by a proposed action.

The RHA (33 U.S.C. § 403 *et seq.*) is the oldest federal environmental law in the United States. Section 10 of the act prohibits the creation of any obstruction, excavation, or fill within a navigable waterway without a permit, including but not limited to the building of any wharfs, piers, jetties, or other structures. The CWA (33 U.S.C. § 1251 *et seq.*) regulates the discharge of dredged or fill material into waters of the United States. Authorization for issuing permits under both RHA Section 10 and CWA Section 404 is delegated to the U.S. Army Corps of Engineers (USACE), within the Department of the Army. One of several permit types may be issued depending on the type of use and the project's impacts on navigable waters. The USACE has established a system of Nationwide Permits to streamline permitting certain activities known to have minimal impacts. Nationwide Permits are often used for PNNL research projects. PNNL achieves compliance with these regulations through its ERP program.

The *Nonindigenous Aquatic Nuisance Prevention and Control Act of 1990* (16 U.S.C. § 4701 *et seq.*) provides for the development and execution of environmentally sound control methods that prevent the unintentional introduction and dispersal of nonindigenous aquatic nuisance species into waters of the United States. PNNL has developed and implements an aquatic invasive plant and animal species interception program to comply with this Act. This program is detailed in Section 2.7.2.1 of this report.

Executive Order 11990 of May 24, 1977, “Protection of Wetlands” (42 FR 26961), requires federal agencies to minimize the destruction, loss, or degradation of wetlands on federal lands and to preserve and enhance the natural and beneficial values of wetlands on federal lands. It states that federal agencies should avoid undertaking or assisting in new construction located in wetlands unless the agency finds 1) that there is no practicable alternative to such construction and 2) that the proposed action includes all practicable measures to minimize harm to wetlands that may result from such use. Compliance with Executive Order 11990, as well as the wetland provisions of the CWA (see Section 2.5.1 of this report), is achieved through the biological resource review process at PNNL.

Executive Order 11988 of May 24, 1977, “Floodplain Management” (42 FR 26951), requires federal agencies to evaluate the potential effects of any actions within a floodplain to minimize any direct or indirect impacts on the floodplain’s natural and beneficial values. Potential floodplain impacts are considered through the biological resource review process at PNNL.

Executive Order 13112 of February 3, 1999, “Invasive Species” ([64 FR 6183](#)) and its amendment Executive Order 13751 of December 5, 2016, “Safeguarding the Nation from the Impacts of Invasive Species” ([81 FR 88609](#)), established a National Invasive Species Council to oversee implementation of the executive order and require federal agencies to identify actions that may affect the status of invasive species; prevent introduction of invasive species; detect, respond to, monitor, and control populations of invasive species; provide for restoration of native species and habitats in ecosystems that have been invaded; and conduct research and public outreach to control and prevent the introduction of invasive species. See Section 2.7.2.2 of this report for a description of the PNNL noxious weed control program.

Executive Order 13186 of January 10, 2001, “Responsibilities of Federal Agencies to Protect Migratory Birds” ([66 FR 3853](#)), requires agencies to avoid or minimize the adverse impact of their actions on migratory birds and to assure that environmental analyses under NEPA evaluate the effects of proposed federal actions on such species. A Memorandum of Understanding between DOE and USFWS regarding implementation of Executive Order 11386, identifies specific areas in which enhanced collaboration between DOE and USFWS will substantially contribute to the conservation and management of migratory birds and their habitats (DOE and USFWS 2013). Compliance with the order and memorandum of understanding is assured by PNNL’s biological resource review process, as described in the CBRMP (DOE-PNSO 2021a), and implemented by PNNL’s internal biological resource protection procedures.

The CZMA (16 U.S.C. § 1451 *et seq.*) includes the establishment of a National Coastal Zone Management Program administered by the National Oceanic and Atmospheric Administration (NOAA) Office of Ocean and Coastal Resource Management. Most coastal and Great Lakes states have a federally approved coastal zone management program (CMP) to preserve, protect, develop, and, where possible, restore or enhance valuable natural coastal resources such as wetlands, floodplains, estuaries, beaches, dunes, barrier islands, and coral reefs, as well as the fish and wildlife using those habitats. Federally funded research performed by PNNL that may affect natural resources of the coastal zone must be consistent with the policies of the applicable coastal state’s federally approved CMP. The *Coastal Zone Act Reauthorization Amendments of 1990* include Section 6217, which calls upon states that have a federally approved CMP to develop coastal nonpoint pollution control programs to improve, safeguard, and restore the quality of coastal waters. Section 6217 is administered jointly by the EPA and NOAA. PNNL maintains compliance with the federal consistency provisions and Section 6217 of this CZMA through its ERP program.

The U.S. Coast Guard (USCG) administers 33 CFR Part 66, *Navigation and Navigable Waters*, “Private Aids to Navigation.” For the safe navigation of watercraft, installation of a fixed structure or floating object in any navigable water of the United States requires review by the USCG to determine whether a private aid to navigation permit is necessary. Each USCG district also publishes a *Local Notice to Mariners* weekly, which provides information about the location of structures to facilitate navigational safety in marine or riverine environments. Permits and *Local Notices to Mariners* allow research projects to be carried out in navigable waters without posing undue hazards to watercraft. PNNL maintains compliance with these regulations through its ERP program.

The *Forest Service Organic Administration Act of 1897* (formally titled the *Sundry Civil Appropriations Act of 1897*, but commonly called the *Forest Service Organic Act*) specified the purpose for establishing forest reserves and their administration and protection. The U.S. Forest Service, within the U.S. Department of Agriculture, administers the use of national forests, including for scientific research, under 36 CFR Part 251. Uses such as scientific research and specimen collection are deemed “special uses” and require a permit. PNNL maintains compliance with these regulations through its ERP program.

The *National Park Service Organic Act of 1916* established the National Park Service to oversee management of national parks and monuments. The National Park Service, within the U.S. Department of the Interior, administers the use of such lands under Chapter 1 of 36 CFR, which governs parks, forests, and public property. A Scientific Research and Collecting Permit is required for activities pertaining to natural resources that involve fieldwork, specimen collection, or that may potentially disturb resources or visitors. PNNL maintains compliance with these regulations through its ERP program.

The *National Wildlife Refuge System Administration Act of 1966* formally established the National Wildlife Refuge System and provided administration and management directives under the jurisdiction of the USFWS. The USFWS, in accordance with 50 CFR, issues permits for uses, including scientific research, deemed compatible with the purposes of specific refuge areas. PNNL maintains compliance with these regulations through its ERP program.

### 2.7.1.2 State Statutes and Regulations

PNNL conducts research at locations throughout the United States and must comply with applicable state and local statutes, regulations, and directives at those sites. Washington and Oregon are the principal states in which PNNL conducts research, although work also was undertaken in several other states in 2023. Applicable rulings under which work was conducted are summarized in the following paragraphs.

The Washington State *Shoreline Management Act of 1971* ([RCW 90.58](#), as amended) establishes policy for shoreline use and environmental protection along shorelines that include rivers and streams with a mean annual flow greater than 0.6 m<sup>3</sup>/s (21 ft<sup>3</sup>/s), which includes the Columbia River in Benton and Franklin Counties. The shoreline jurisdiction extends 61 m (200 ft) landward of these waters and includes associated wetlands, floodways, and up to 61 m (200 ft) of floodway-contiguous floodplains. The act requires that shoreline uses be consistent with the control of pollution and protection of natural resources, including the land, vegetation, wildlife, water, and aquatic life from adverse effects. County Shoreline Master Programs (Ecology 2021) implement the policies of the Washington State *Shoreline Management Act of 1971* and establish a shoreline-specific combined comprehensive plan, zoning ordinance, and

development permit system. PNNL maintains compliance with the act by meeting the provisions of County Shoreline Master Plans through PNNL's ERP program.

Several chapters and sections of the WAC govern activities that affect fish and wildlife or their habitat, aquatic lands, and excavation activities in Washington State. [WAC 220-200-150](#) requires a Scientific Collection Permit from the WDFW for the collection of fish, shellfish, wildlife, or nests of birds for research purposes, as well as a Fish Transport Permit for transporting fish or the viable eggs/gametes of fish into or through Washington. [WAC 220-660](#) requires a Hydraulic Project Approval from the WDFW for construction or projects that will use, divert, obstruct, or change the natural flow or bed of any waters in the state (see RCW 77.55). [WAC 332-30](#) governs the use of state-owned aquatic lands and outlines necessary use authorizations from the Washington State Department of Natural Resources. [WAC 296-155-655](#) requires that utility companies or landowners be contacted prior to excavation activities, resulting in the issuance of an Excavation Permit. PNNL maintains compliance with these regulations through its ERP program.

PNNL regularly conducts research activities in Oregon and must comply with state regulations involving fish and wildlife or their habitat, and aquatic lands as governed by the Oregon Administrative Rules (OARs). OAR 635-007 and OAR 635-043 direct the administration of Scientific Taking Permits for fish and for wildlife, respectively, under the jurisdiction of the Oregon Department of Fish and Wildlife. OAR 141-082 governs the use of state-owned submerged land, and OAR 141-089 governs removal/fill activities within waters of the state under the jurisdiction of the Oregon Department of State Lands. PNNL maintains compliance with these regulations for research activities through its ERP program.

Research conducted in Alaska is done under permits issued by the Alaska Department of Fish and Game as required by the Alaska State Anadromous Fish Act ([AS 16.05.871](#)).

Research conducted in California must comply with state regulations in place to protect coastal resources. The California Code of Regulations requires a permit from the California Coastal Commission (CCR, Title 14, Section 13050.5) for certain research activities or deployments within the coastal zone.

Scientific collections and research conducted in Louisiana are authorized by permits issued through the Louisiana Department of Wildlife and Fisheries under the Louisiana Administrative Code (LAC, Title 76, Part I).

Scientific collections conducted in Massachusetts are done under permits issued by the Massachusetts Division of Fisheries and Wildlife as required under the General Laws of Massachusetts (GLM, Part I, Title XIX, Chapter 131).

For research conducted in Ohio on natural areas and preserves, a permit issued by the Ohio Department of Natural Resources is required under the Ohio Administrative Code (Rule 1501:17-3-02).

## **2.7.2 PNNL Programs**

Programs and activities performed to assure compliance with the preceding biological resource and environmental statutes and drivers are discussed in this section.

PNSO prepared the CBRMP (DOE-PNSO 2021a) in response to the direction and guidance provided in DOE Policy 141.1, “Department of Energy Management of Cultural Resources,” related to protecting and managing cultural and biological resources. The plan provides direction regarding the requirements for annual surveys and monitoring for species of concern, review of project activities for environmental impacts, and identification and control of invasive species. The CBRMP is implemented by application of PNNL’s internal cultural and biological resource protection procedures.

As stipulated in the CBRMP (DOE-PNSO 2021a), projects involving soil or vegetation disturbance, tagging and tracking of fish, placement of research equipment and sensors in the environment, and myriad other outdoor research activities are routinely evaluated to determine their potential to affect biological resources prior to implementation. Ninety-eight biological resource reviews were completed for PNNL projects in CY 2023—34 on the PNNL-Richland campus, 28 at the PNNL-Sequim campus, and 36 at other locations.

Potential project impacts were evaluated for plant or animal species protected under the ESA, species proposed or candidates for such protection, and species of concern; species listed by the state of Washington and elsewhere as threatened, endangered, sensitive, candidate, or monitor; State priority habitats where the action is proposed; marine mammals protected by the MMPA; commercial fish and their essential habitats protected under the *Magnuson-Stevens Fishery Conservation and Management Act*; and bird species protected under the *Migratory Bird Treaty Act* and *Bald and Golden Eagle Protection Act*. Federal- and state-listed species on the PNNL-Richland campus and PNNL-Sequim campus are listed in Table 1 and Table 2, respectively. No projects violated related federal or state laws, regulations, or conservation priority guidance.

Staff ecologists performed pedestrian and visual reconnaissance surveys of biological resources found on the undeveloped portions of the PNNL-Richland campus in 2021, except for the riparian zone adjacent to the Columbia River, with the most recent survey occurring from May through August 2018. The primary objective of the field surveys was to determine the occurrence of the plant and animal species and habitats of concern for project-specific biological resource reviews. Lists of plant and animal species identified on the undeveloped portions of the PNNL-Richland campus from 2009 to 2021, and at the PNNL-Sequim campus from 2006 to 2021, and their status are provided in Appendix A and Appendix B, Table A.1 through Table B.3, respectively.

### 2.7.2.1 Aquatic Invasive Species Interception

Several nonnative invasive aquatic species identified by the WDFW (2001) are of concern for boaters in Washington State, including staff at PNNL operating research watercraft, and are addressed by PNNL’s Aquatic Invasive Species Interception Program. These include some “Prohibited Level 1 Species” and “Prohibited Level 3 Species” listed by the state of Washington ([WAC 220-640-030](#) and [WAC 220-640-050](#), respectively). Prohibited Level 1 and Level 3 species are considered to pose either a high (Level 1) or moderate to high (Level 3) invasive risk and are either a priority (Level 1) or may be appropriate (Level 3) for prevention (RCW 77.135.030). Prohibited Level 1 species include zebra mussels (*Dreissena polymorpha*) and quagga mussels (*D. rostriformis bugensis*). Prohibited Level 3 species include New Zealand mud snail (*Potamopyrgus antipodarum*) and all other Dreissenid mussel species. PNNL’s Aquatic Invasive Species Interception Program also includes several invasive or potentially invasive tunicate species (e.g., club tunicate [*Styela clava*]), identified by WDFW (Pleus et al. 2008), and aquatic plant species such as Eurasian water milfoil (*Myriophyllum spicatum*), a

Class B noxious weed ([WAC 16-750-011](#)). Class B noxious weeds are species designated for control where they are not yet widespread, to prevent new infestations (WNWCB 2021).

PNNL's Aquatic Invasive Species Interception Program prevents the conveyance and dispersal of the species listed above. Water bodies are researched beforehand during the PNNL biological resource review process to determine if there are known invasive species present and if there are any specific state requirements and control programs. In addition, the boat manifest details invasive species known to exist in the body of water where the launch is planned. Watercraft, equipment, and trailers recovered from infested water bodies are self-inspected, decontaminated, and quarantined according to protocols specific to the type or types of infestation: aquatic weed, tunicate, and/or New Zealand mud snail and Dreissenid mussel (Elwell and Phillips 2016). The boat operator is responsible for meeting PNNL invasive species-specific requirements, completing a PNNL Watercraft and Trailer Self-Inspection Form, where applicable, and submitting the inspection form to the boat custodian. Boat custodians notify subsequent boat operators of watercraft condition and status relative to completion of decontamination and quarantine requirements prior to launch.

### 2.7.2.2 Noxious Weed Control

Several nonnative plant species listed in the state noxious weed list “Class B” or “Class C” noxious weeds (as classified by the state of Washington, [WAC 16-750-011](#) and [WAC 16-750-015](#), respectively) have been identified on the PNNL-Richland campus (Larson and Downs 2009; Thompson et al. 2023; see Appendix A, Table A.1). Class B noxious weeds are species designated for control where they are not yet widespread to prevent new infestations (WNWCB 2021). On the PNNL-Richland campus, Class B species include the following:

- Broadleaf (perennial) pepperweed (*Lepidium latifolium*)
- Burning-bush (kochia) (*Bassia [Kochia] scoparia*)
- Cotton (Scotch) thistle (*Onopordum acanthium*)
- Diffuse knapweed (*Centaurea diffusa*)
- Puncturevine (*Tribulus terrestris*)
- Rush skeletonweed (*Chondrilla juncea*)
- Russian knapweed (*Rhaponticum [Acroptilon] repens*)
- Yellow starthistle (*Centaurea solstitialis*).



Figure 10. Yellow Starthistle (*Centaurea solstitialis*) in Bloom

Rush skeletonweed occurs throughout areas of natural vegetation on the PNNL-Richland campus and is most prevalent in previously disturbed areas or along road edges. It spreads by seed and by root, forming dense stands if left unchecked. Diffuse knapweed occurs sporadically throughout areas of natural vegetation and reproduces primarily by seed. Russian knapweed reproduces by seed and roots; it can form dense stands where water is adequate. Yellow starthistle (see Figure 10) is an annual or biennial plant that reproduces by seed; scattered, relatively small patches occur throughout undeveloped areas of the site. Cotton thistle was first identified on the PNNL-Richland campus in 2016. It reproduces by seed. Broadleaf pepperweed, a perennial that spreads by seed and root, occurs in seasonally moist areas (e.g., low areas or near the river). Burning-bush and puncturevine are annual plants typically found along road edges.

Class C noxious weeds are already widespread, and control is determined on a case-by-case basis at the county level (WNWCB 2021). These species are not typically targeted for control on the PNNL-Richland campus. Known Class C species on the PNNL-Richland campus are as follows:

- Baby's breath (*Gypsophila paniculata*)
- Field bindweed (*Convolvulus arvensis*)
- Longspine sandbur (*Cenchrus longispinus*)
- Common groundsel (*Senecio vulgaris*)
- Common St. Johnswort (*Hypericum perforatum*)
- Creeping (Canada) thistle (*Cirsium arvense*)
- Heart-podded hoarycress (*Lepidium draba*)
- Himalayan blackberry (*Rubus bifrons*)
- Reed canarygrass (*Phalaris arundinacea*)
- Russian olive (*Elaeagnus angustifolia*)
- Tree of heaven (*Ailanthus altissima*).

PNNL has carried out a noxious weed control program on the PNNL-Richland campus since 2010. Certified Facilities and Operations staff, in coordination with staff ecologists, use hand-spraying methods (spot application of herbicide to individual weeds within a surveyed/traversed area) to control populations of Class B noxious weeds in upland areas of natural vegetation. The hand-spraying method (see Figure 11) facilitates avoidance of nontarget (i.e., native) species. The herbicide Milestone™ is generally used (along with water conditioner, drift control agent, surfactant, and blue visibility dye). In addition, hand-pulling or chopping is used opportunistically on species for which mechanical control is effective (e.g., annual or biennial plants with limited occurrence such as yellow starthistle and cotton thistle).

Areas treated in 2023 are shown in Figure 12. In 2023, the primary weed species targeted for herbicide applications were rush skeletonweed and Russian knapweed. Herbicide applications were conducted on four days between April 26 and May 11, 2023. In addition, mechanical control of yellow starthistle and cotton thistle was conducted when those species were observed outside of the spray period.



Figure 11. Field Crew Applying Targeted Herbicides at the PNNL-Richland Campus

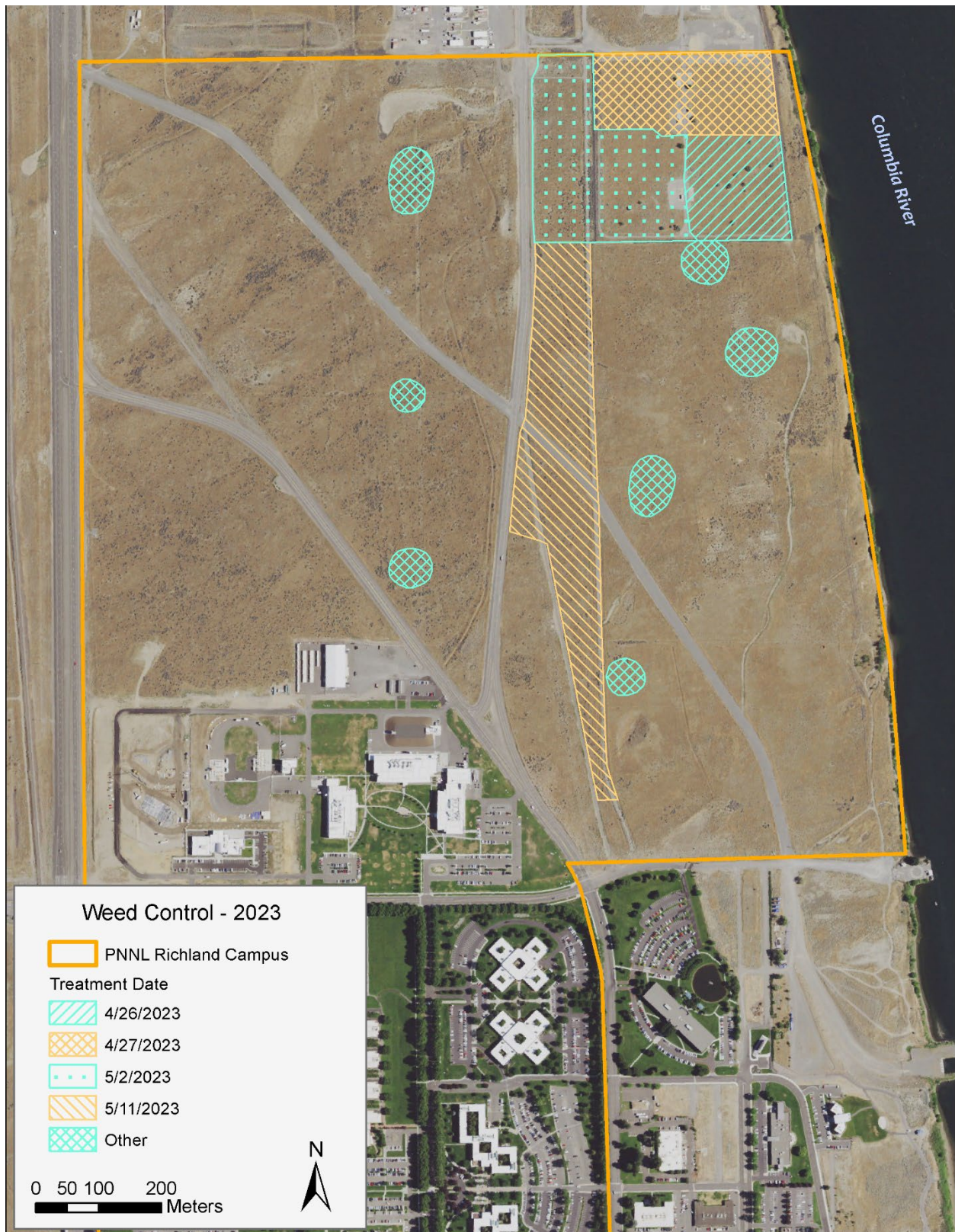


Figure 12. Areas Treated for Noxious Weeds on the PNNL-Richland Campus in 2023

### 2.7.3 Cultural Resources

Cultural resources at PNNL represent thousands of years of human land use. Several federal laws, regulations, and Executive Orders provide the framework for protection of cultural resources on the PNNL-Richland and PNNL-Sequim campuses and off-site field projects. Most work completed by the cultural resources program at PNNL focuses on compliance with Section 106 of the NHPA (54 USC § 306108). The NHPA requires federal agencies to consider the effects of their project on any district, site, building, structure, or object that may be eligible for inclusion in the National Register of Historic Places to avoid, minimize, or mitigate these impacts. This section summarizes PNNL's compliance activities in 2023.

#### 2.7.3.1 Project Review

The PNNL cultural resources program supported 72 projects by performing compliance reviews. A breakdown of reviews by location is shown in Figure 13. Of the 72 reviews completed, 16 (22%) were conducted for projects at the PNNL-Richland campus, 20 (28%) were conducted for projects at the PNNL-Sequim campus, 12 (17%) were conducted for projects on the Hanford Site, and 24 (33%) were conducted for projects deployed at off-site locations across 14 states. Of the 72 cultural reviews conducted, 20 (28%) were completed in accordance with provisions of memoranda of agreement for the PNNL-Richland or PNNL-Sequim campuses (DOE-PNSO 2018, DOE-PNSO 2021b) or the Richland Campus Programmatic Agreement.

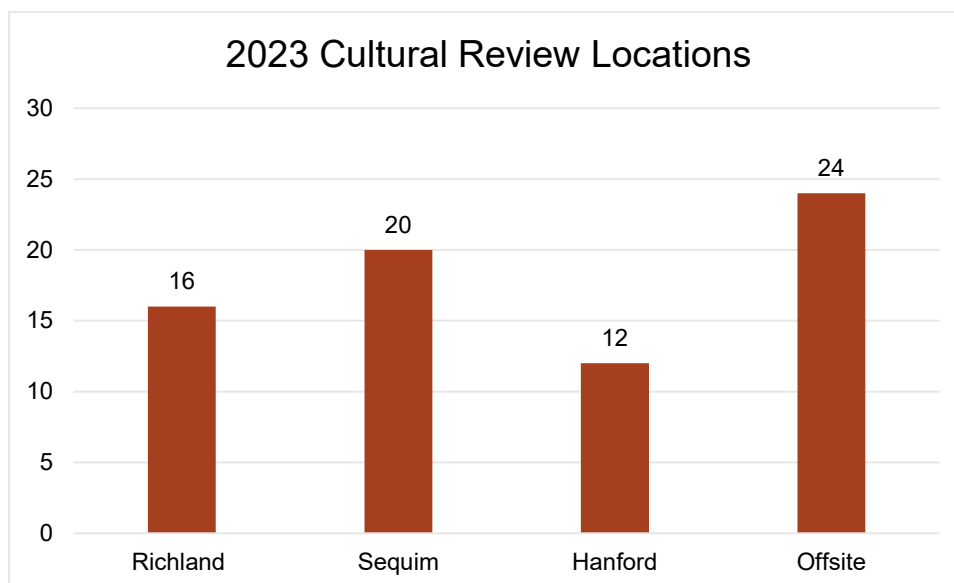


Figure 13. Number of Cultural Reviews by Location

The PNNL cultural resources program continues to consult with Plateau Tribes (i.e., the Confederated Tribes of the Colville Reservation, Confederated Tribes of the Umatilla Indian Reservation, Confederated Tribes and Bands of the Yakama Nation, the Nez Perce, and the Wanapum) for undertakings on the PNNL-Richland campus. For undertakings on the PNNL-Sequim campus, consultation is directed at the Peninsula Tribes (i.e., the Hoh Indian Tribe, Jamestown S'Klallam Tribe, Lower Elwha Klallam Tribe, the Lummi Nation, Makah Indian Tribe of the Makah Indian Reservation, Port Gamble S'Klallam Tribe, and the Quileute Nation). The Confederated Tribes of Warm Springs of Oregon also are consulted regularly. Cultural reviews

require consultation with the State Historic Preservation Officer for the state in which the project will take place. In 2023, cultural reviews were conducted for projects in 14 states.

### **2.7.3.2 Conditions Monitoring**

Archaeological and historic resources at the PNNL-Richland and PNNL-Sequim campuses have the potential to be impacted by both natural and human caused disturbances. Annual conditions monitoring is conducted by PNNL cultural resources program to document evidence of any such disturbances and make management recommendations to minimize, rectify, or avoid impacts. Conditions monitoring fulfills certain obligations under Section 110 of the NHPA and the Archaeological Resources Protection Act.

Annual conditions monitoring was conducted on the PNNL-Richland campus in November 2023 and on the PNNL-Sequim campus in July 2023. Monitoring was conducted by the PNNL cultural resources staff and Tribal cultural resources staff. Monitoring personnel inspected all relevant resources to assess conditions and document potential changes to the site caused by human or natural impacts. In addition, information was collected and added to file records to update the current knowledge of the sites.

None of the annual condition monitoring activities identified impacts that would diminish the historic or archaeological significance of any observed resources. In general, sensitive archaeological remains appear to be free from unauthorized access, looting, or damage from human activities. Evidence of some nominal disturbances from erosion or animal activities were observed for resources at both the PNNL-Richland and PNNL-Sequim campuses. Monitoring of historic architectural resources at the PNNL-Richland campus identified wear, disrepair, or damage to some architectural elements. These areas will continue to be monitored and, if they are found to diminish the historic character or integrity of the historic architectural resources, corrective actions may be developed. Annual conditions monitoring of archaeological and historic resources at the PNNL-Richland and PNNL-Sequim campuses will continue to be performed to make sure these non-renewable resources are protected.

## **2.8 Radiation Protection**

PNNL is subject to radiation protection statutes and regulations that are designed to protect the health and safety of the workforce, the public, and the environment.

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

During the reporting period of this annual site environmental report, PNNL was working under the requirements of DOE Order 458.1, Chg 4 (September 2020). Section 2.d (“As Low As Reasonably Achievable [ALARA]”), Section 2.g (“Control and Management of Radionuclides from DOE Activities in Liquid Discharges”), and Section 2.k (“Release and Clearance of Property”) of DOE Order 458.1 were incorporated into PNNL’s contract with PNSO in July 2011 and were fully implemented on September 1, 2012. PNNL’s contract was revised in March 2021 to replace DOE Order 458.1, Chg 3, with DOE Order 458.1, Chg 4.

Section 2.d of DOE Order 458.1 requires each contractor to establish an environmental ALARA process to control and manage radiological activities so that doses to the public and releases to the environment are kept ALARA (Figure 14). The ALARA process must be applied to the design or modification of facilities and to the conduct of radiological work activities.

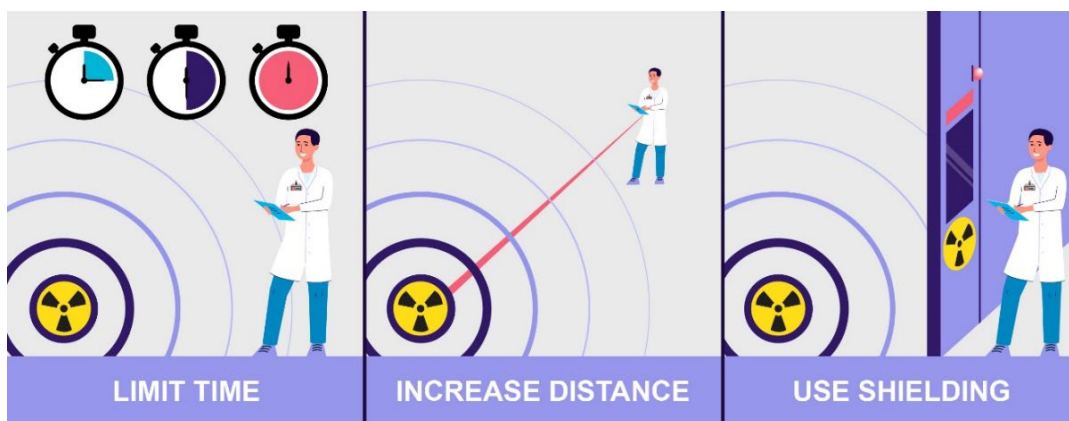


Figure 14. Elements of the As Low As Reasonably Achievable (ALARA) Principle

Section 2.g of DOE Order 458.1 requires each contractor to establish and implement procedures and practices related to control and management of radionuclides from DOE activities in liquid discharges. A description of how PNNL complies with the liquid discharge requirements in Section 2.g of DOE Order 458.1 is found in Section 4.1 of this report.

Section 2.k of DOE Order 458.1 provides the requirements with which each contractor must comply when releasing property that potentially contains residual radioactivity. Dose constraints for the public are established based on the type of property (i.e., personal property and real property). Requirements for releasing property based on process knowledge, radiological surveys, or a combination of both are provided. The process of obtaining preapproved release limits and activity-specific release limits for releasing property is also described in the Order. The public is required to be notified annually of property released from contractor facilities.

PNNL radiation protection procedures implement Sections 2.d and 2.k of DOE Order 458.1. Procedures include guidance on the environmental ALARA program, use of process knowledge and historical knowledge when releasing property, preparation and approval of requests for authorized limits, and preparation of an annual site environmental report. A description of PNNL programs that implement these sections of the Order is found in Section 4.3 of this report.

No property with detectable residual radioactivity above guideline limits was released in 2023.

## 2.8.2 DOE Order 435.1, Radioactive Waste Management

The purpose of DOE Order 435.1 is to establish requirements for assuring that DOE radioactive waste is managed in a manner that is protective of workers, public health and safety, and the environment. The Order takes a cradle-to-grave approach to managing waste and includes requirements for waste generation, storage, treatment, disposal, and post-closure monitoring of facilities.

Radioactive waste shall be managed such that the requirements of other DOE Orders, standards, and regulations are met, including the following:

- 10 CFR Part 835, “Occupational Radiation Protection”
- DOE Order 440.1B, Chg 4 (Admin Chg), *Worker Protection Program for DOE (Including the National Nuclear Security Administration) Federal Employees*
- DOE Order 458.1, Chg 4 (Ltd Chg), *Radiation Protection of the Public and the Environment*.

DOE Order 435.1 establishes requirements for the management of high-level waste, transuranic waste, and low-level waste. It also pertains to mixed waste (i.e., high-level waste, transuranic waste, or low-level waste that also contain chemically hazardous constituents).

PNNL's Radioactive Waste Management Basis (Ellefson 2023) identifies the hazards associated with radioactive waste management at PNNL along with their potential impacts. Controls for protection of the public, workers, and environment also are presented. Controls are implemented through internal PNNL workflows and waste management procedures.

### **2.8.3 Atomic Energy Act of 1954**

The *Atomic Energy Act of 1954* (42 U.S.C. § 2011 *et seq.*) was passed to assure the proper management of radioactive materials. Through the act, DOE regulates the control of radioactive materials under its authority, including the treatment, storage, and disposal of low-level radioactive waste from its operations and establishes radiation protection standards for itself and its contractors. Accordingly, DOE promulgated a series of regulations (e.g., 10 CFR Part 820, 10 CFR Part 830, and 10 CFR Part 835) and directives (e.g., DOE Order 435.1 and DOE Order 458.1) to protect public health and the environment from potential risks associated with radioactive materials. PNNL complies with the Act through its Radiation Protection Management and Operation Program and Radioactive Waste Management Basis.

## **2.9 Major Environmental Issues and Actions**

Releases of radioactive and regulated materials to the environment are reported to DOE and other federal, state, and/or local agencies as required by law. The specific agencies notified depend on the type and amount of material released and the location of each release event. This section describes any releases to the environment that occurred at PNNL during CY 2023.

### **2.9.1 Continuous Release Reporting**

A continuous release is a hazardous release exceeding reporting thresholds under CERCLA regulations (40 CFR Part 302.8) that is "continuous" and "stable in quantity and rate" for which reduced reporting requirements apply. There were no continuous releases on the PNNL-Richland campus or the PNNL-Sequim campus in 2023.

### **2.9.2 DOE Order 232.2A, Occurrence Reporting and Processing of Operations Information**

DOE Order 232.2A requires reporting of incidents that could adversely affect the public or workers, the environment, or the mission that occur at DOE sites and/or during DOE operations. Significant releases of radiological or hazardous substances above established regulatory limits requiring regulatory agency notification (Section 2.9.3) and receipt of formal or informal regulator correspondence alleging violations (Section 2.6) must be reported to DOE through the reporting system. PNNL reports all incidents to DOE as required.

### **2.9.3 Unplanned Releases**

No environmentally significant releases occurred at PNNL in 2023.

## 2.10 Summary of Permits

Table 9 summarizes air, liquid, and hazardous waste permits for the PNNL-Richland and PNNL-Sequim campuses during CY 2023. Project-specific permits also are acquired but are not reflected in the table because they are usually of limited term and scope.

Table 9 PNNL Air, Liquid, and Hazardous Waste Permits, 2023

Issuer	Permit #	Location(s) Regulated	Activity(ies) Regulated	Expiration Date <sup>(a)</sup>
<b>Air Emissions</b>				
Washington State Department of Health	FF-01 <sup>(b)</sup>	PNNL-occupied locations on the Hanford Site	Radioactive air emissions	10/20/2027
Washington State Department of Health	RAEL-005	PNNL-Richland campus	Radioactive air emissions	1/1/2026
Washington State Department of Health	RAEL-014	PNNL-Sequim campus	Radioactive air emissions	1/1/2028
Washington State Department of Ecology	00-05-006, Renewal 3	PNNL-occupied locations on the Hanford Site	Radioactive and nonradioactive air emissions	8/1/2024
Benton Clean Air Agency	Order 2019-0005, Rev. 2	PNNL Site – EMSL, Physical Sciences Facility Complex, Energy Sciences Center, Life Sciences Laboratory II Halogenated Solvent Degreaser, Grid Storage Launchpad	Nonradioactive air emissions	None
Benton Clean Air Agency	Order 2012-0017	PNNL-Richland Campus – Building Operations	Nonradioactive air emissions	None
Benton Clean Air Agency	Order 2012-0016	PNNL-Richland Campus – R&D Pilot-Scale Processes and Field Experiments	Nonradioactive air emissions	None
Benton Clean Air Agency	Order 2007-0006, Rev. 1	Life Sciences Laboratory II – Building Operations	Nonradioactive air emissions	None
Washington State Department of Ecology	Order 02NWP-001	300 Area Standby Generators (Radiochemical Processing Laboratory & 331 Buildings)	Nonradioactive air emissions	None
Washington State Department of Ecology	Order 97NM-138	200/300 Area Boilers (331, 325, & 318 Buildings)	Nonradioactive air emissions	None
Olympic Region Clean Air Agency	Order of Approval 13NOI968	PNNL-Sequim Campus Standby Generators	Nonradioactive air emissions	None
<b>Liquid Effluents<sup>(c)</sup></b>				
City of Richland	CR-IU001	PNNL-Richland campus	Liquid effluent discharges to city sewer	8/15/2025
City of Richland	CR-IU005	W.R. Wiley Environmental and Molecular Sciences Laboratory	Liquid effluent discharges to city sewer	1/15/2027
City of Richland	CR-IU011	Physical Sciences Facility (buildings north of Horn Rapids Road)	Liquid effluent discharges to city sewer	12/15/2028
Washington State Department of Ecology	WA0040649 <sup>(a)</sup>	PNNL-Sequim campus	Treated liquid effluent discharges to Sequim Bay	11/30/2022

Issuer	Permit #	Location(s) Regulated	Activity(ies) Regulated	Expiration Date <sup>(a)</sup>
<b>Hazardous Waste</b>				
Washington State Department of Ecology	WA7890008967	325 Hazardous Waste Treatment Units (located in the 300 Area)	Treatment and storage of dangerous waste (primarily mixed waste)	9/27/2004 <sup>(d)</sup>
<p><sup>(a)</sup> Expired permits generally remain in force while renewal applications are processed by the issuing agency.</p> <p><sup>(b)</sup> Permit is issued to DOE-Richland Operations Office (DOE-RL) and/or its contractor(s). PNNL is obligated to comply with this permit through an operating agreement between the DOE-RL and PNSO.</p> <p><sup>(c)</sup> PNNL also conducts activities in leased facilities that have wastewater permits issued to the owner. These permits are not listed here, but compliance-related impacts from PNNL activities are included in this report.</p> <p><sup>(d)</sup> Refer to Section 2.6 for a discussion on the status of the renewal of this permit.</p>				



## 3.0 ENVIRONMENTAL MANAGEMENT SYSTEM

PNNL has a mature, robust EMS that was certified to meet the requirements of ISO 14001 standard from 2002 through 2022. Beginning 2023, PNNL opted for a conforming program per DOE Order 436.1. On January 6, 2023, PNNL received a letter from DOE-SC declaring the EMS to be in full conformance with ISO 14001. On February 6, 2024, the DOE-SC letter was updated to document PNNL's continuous conformance.

The EMS is integrated into PNNL's Integrated Safety Management Program, which assures that staff are aware of project scope, risks/hazards, and controls available to address functions, processes, and procedures used to plan and perform work safely. The outcome of the integration is the accomplishment of PNNL missions while protecting the worker, the public, and the environment.

Management at PNNL periodically assesses environmental performance from a programmatic perspective to determine whether issues require attention and to facilitate the identification and communication of best management practices. PNNL management also routinely evaluates progress on key environmental improvement projects.

The EMS program is audited annually to verify that it is operating as intended and in conformance with ISO 14001 standards. These audits are performed by staff outside the control of the EMS (typically led by non-PNNL staff from other national laboratories) to assure independence and objectivity. The results of the 2023 audit showed that PNNL continues to meet the requirements of the ISO 14001 standard. In addition, the 2023 EMS performance data submitted to the Federal Facilities Environmental Stewardship & Compliance Assistance Center received a "Green" score for the EMS performance metrics listed below.

- Environmental aspects were identified or reevaluated using an established procedure and updated as appropriate.
- Measurable environmental goals, objectives, and targets were identified, reviewed, and updated as appropriate.
- Operational controls were documented to address significant environmental aspects consistent with objectives, and targets were fully implemented.

- Environmental training procedures were established to assure that training requirements for individual competence and responsibility were identified, carried out, monitored, tracked, recorded, and refreshed as appropriate to maintain competence. EMS requirements were included in all appropriate contracts, and contractors fulfilled defined roles and specified responsibilities.
- EMS audit/evaluation procedures were established, audits were conducted, and nonconformities were addressed or corrected.
- Senior leadership review of the EMS was conducted, and management responded to recommendations for continual improvement.

PNNL examines its operations to determine which categories of environmental impacts (referred to as “aspects” in the ISO 14001 standards) have the greatest potential to occur and, therefore, require consideration and control through the EMS process. Annual environmental aspect and impact analyses, including risk analyses and work evaluations, are performed to assure regulatory requirements and any concerns of the public or other interested parties are addressed. The 11 most significant aspects and the EMS controls used to minimize the potential impacts of each aspect are described below:

1. *Chemical Use and Storage.* As a research laboratory, PNNL has many buildings in which chemical materials are used and/or stored for research operations and maintenance activities. Controls used to avoid potential hazards include training, inventory control procedures, approvals prior to requisitioning, and work procedures for chemical material use, as well as adequate safety requirements. Amounts of chemicals stored in PNNL facilities are maintained below Building Fire Code Limits. PNNL has implemented a “ChemAgain” program that redistributes surplus chemicals internally to reduce chemical waste. PNNL actively seeks to keep chemical inventories at a minimum by evaluating continued need for materials when staff leave PNNL and during project closeouts.
2. *Biological Material Use and Storage.* As a research laboratory, PNNL has many buildings in which biological materials are used and/or stored for research activities. Controls used to avoid potential hazards include training, work controls and procedures for biological material use, and adequate safety requirements.
3. *Regulated Waste Generation.* The use of chemical and radioactive materials creates waste streams that may be regulated as dangerous waste, radioactive waste, or both dangerous and radioactive (mixed) waste. Wastes within these categories are subject to the regulations of the Washington State Department of Ecology (for dangerous and mixed waste) and DOE (for radioactive and mixed waste). In addition to the controls imposed by these requirements, PNNL seeks to reduce generated wastes. Projects are regularly reviewed and procedures are scrutinized to minimize the production of regulated wastes. Any generated waste may be treated to be made less hazardous or nonhazardous for proper disposal.
4. *Radioactive Material Use and Storage.* Research at PNNL may involve the use of radioactive materials, all of which are labeled and controlled. Controls include restricting access to radiation areas, implementing special training requirements for staff requiring access, performing routine inventories, and restricting the amounts and locations where radioactive materials can be used to within permitted levels.

5. *Emissions to Air.* Potential air emissions are evaluated and permits are obtained when required. Active controls for the management of chemicals, radioactive materials, and regulated wastes seek to minimize PNNL air emissions. Sources of air emissions include boilers, diesel generators, vehicle exhaust, R&D activities, and facility and grounds maintenance and operations.
6. *Effluents to Water.* PNNL seeks to minimize liquid discharges to the environment. Discharges include laboratory wastewater to sewer systems and stormwater to underground injection control wells in parking lots, which are regulated by state and local permits and/or regulations. Discharges are evaluated to assure they conform to regulations and permits.
7. *Energy Use.* Using energy judiciously is a prime objective at PNNL. Energy reduction goals are established and activities to reduce energy consumption are implemented.
8. *Solid Waste Generation.* The use of office products, electronics, and equipment, along with construction, demolition, and normal maintenance activities, create nonregulated solid waste streams. Reduction or elimination of environmental hazards, conservation of environmental resources, and maximization of operational sustainability are achieved through the incorporation of electronic stewardship practices, reuse of materials, and operation of recycling programs.
9. *Fuel Usage.* PNNL seeks to minimize the use of petroleum-based fuels by purchasing vehicles that use alternative fuels, such as ethanol-85, and by acquiring high-fuel-efficiency vehicles, including hybrid and all-electric vehicles. PNNL also has acquired electric vehicles for on-campus transportation and has installed solar-powered electric vehicle charging stations across the PNNL-Richland campus. In addition, PNNL was instrumental in obtaining the first biofuel service station in Richland, Washington, and, when appropriate, uses biodiesel to fuel generators.
10. *Physical Interaction with the Environment.* Some PNNL projects are performed outdoors in direct contact with the environment. These projects include facility construction, maintenance, and modifications, as well as occasional R&D activities. Work proposed to be performed outdoors is reviewed to minimize potential impacts and assure the protection of workers, the public, and environmental resources.
11. *Water Use.* PNNL recognizes the value of water in the eastern Washington environment. PNNL maintains water use reduction goals and implements actions to reduce water consumption.

The benefits of implementing a well-performing EMS include enabling upfront planning to incorporate sustainability and pollution prevention opportunities, early identification of environmental requirements to avoid project delays, high-level integration with existing programs to improve efficiency, reduced operational costs, and enhanced public recognition as a “good neighbor.”

### **3.1 Environmental Operating Experience and Performance Measurement**

#### **3.1.1 Environmental Management System Highlights**

In FY 2023, PNNL actively pursued excellence in meeting DOE’s sustainability goals as delineated in [86 FR 70935](#), Executive Order 14057, Catalyzing Clean Energy Industries and Jobs Through Federal Sustainability, and DOE Order 436.1A, Department Sustainability.

From pioneering sustainable operational practices to achieving scientific breakthroughs with an environmental focus, PNNL actively supports DOE in realizing its sustainability objectives. These objectives include achieving carbon-pollution-free electricity, constructing net-zero-emission buildings, enhancing energy efficiency, promoting zero-emission vehicles, and advancing climate adaptation and resilience.

PNNL maintained its stride toward sustainability excellence in FY 2023. Key achievements and efforts to advance DOE's sustainability goals are emphasized in Sections 3.1.2 through 3.1.5.

Table 10 summarizes PNNL's performance status, planned actions, and contribution toward DOE's goals in energy management, clean and renewable energy, efficiency and conservation measures, and adaptation and resilience (PNNL 2023).

**Table 10. PNNL FY 2023 Sustainability Goals and Planned Actions**

Prior DOE Goal	Current Performance Status	Planned Actions & Contribution	Overall Risk of Non-Attainment
<b>Energy Management</b>			
Reduce energy intensity (Btu per gross square foot [gsf]) in goal subject buildings by 50% by the end of FY 2030.	2.0% increase versus last year due to the new Energy Sciences Center (ESC) becoming operational, a warmer summer, and additional on-site staff.	PNNL will continue implementing electrification projects and cost-effective energy conservation measures.	Medium Risk
<b>Clean &amp; Renewable Energy</b>			
Achieve 100% carbon-free electricity (CFE) on a net annual basis by 2030, including 50% 24/7 carbon pollution-free electricity.	PNNL's combined CFE is 86%, using the CFE factor as reported by EPA for the Bonneville Power Administration (BPA) balancing authority region plus the energy attribute certificates (EACs).	PNNL will pursue the feasibility of additional on-site clean and renewable energy systems (see Clean and Renewable Energy section for additional details).	Medium Risk
<b>Investment: Improvement Measures, Workforce, &amp; Community</b>			
Implement life-cycle cost-effective efficiency and conservation measures with appropriated funds and/or performance contracts.	In FY 2022, PNNL partnered with Cascade Natural Gas Corporation to explore potential energy savings projects for funding under a Utility Energy Service Contract. However, this project was suspended in FY 2023, primarily due to higher interest rates and project scope.	PNNL will continue to explore opportunities to implement energy conservation projects under performance contracts.	Low Risk
Implement climate adaptation and resilience measures.	Completed the Vulnerability Assessment and Resiliency Plan in September 2022. The feasibility review of solutions is in progress. Completed a wildland and fire assessment for the PNNL-Sequim campus.	PNNL will continue to evaluate the feasibility of the proposed resilience solutions, which are provided in the Vulnerability Assessment and Resiliency Plan.	Low Risk

### 3.1.2 Reducing Energy Use

Leveraging the DOE Federal Energy Management Program (FEMP) 50001 Ready Energy Management System framework, PNNL has significantly improved its capabilities in identifying, monitoring, tracking, and enhancing energy conservation measures. Recognition from DOE's 50001 Ready program for the third consecutive year in early 2024 underscores the effectiveness of PNNL's Energy Management System at its PNNL-Richland and PNNL-Sequim campuses.

In FY 2023, PNNL's energy intensity for "goal subject" buildings was 187,800 British thermal units (Btu)/gsf, a 2.0% increase over last year. The major contributor to the increase in energy use is the start-up of two new facilities: ESC and Heat Transfer Building (HTB). The local weather also contributed to this observation. In FY 2023, PNNL experienced a warmer summer compared to FY 2022. In addition, PNNL continues to add staff back to the campus, as well as grow in head count. By the end of FY 2023, PNNL expanded from nearly 5,000 to over 6,000 staff, with just over 4,000 staff on-site at least 40% of their time. The increased use of PNNL facilities by on-site occupants is also a factor in the increasing energy use as plug loads increase and occupied spaces drive heating and cooling loads.

Figure 15 shows the total base and high-energy mission-specific facility (HEMSF) electricity use in FY 2023 in MWh and associated costs from FY 2021 through FY 2023, as well as the projection through FY 2030, assuming the successful implementation of planned electrification projects.

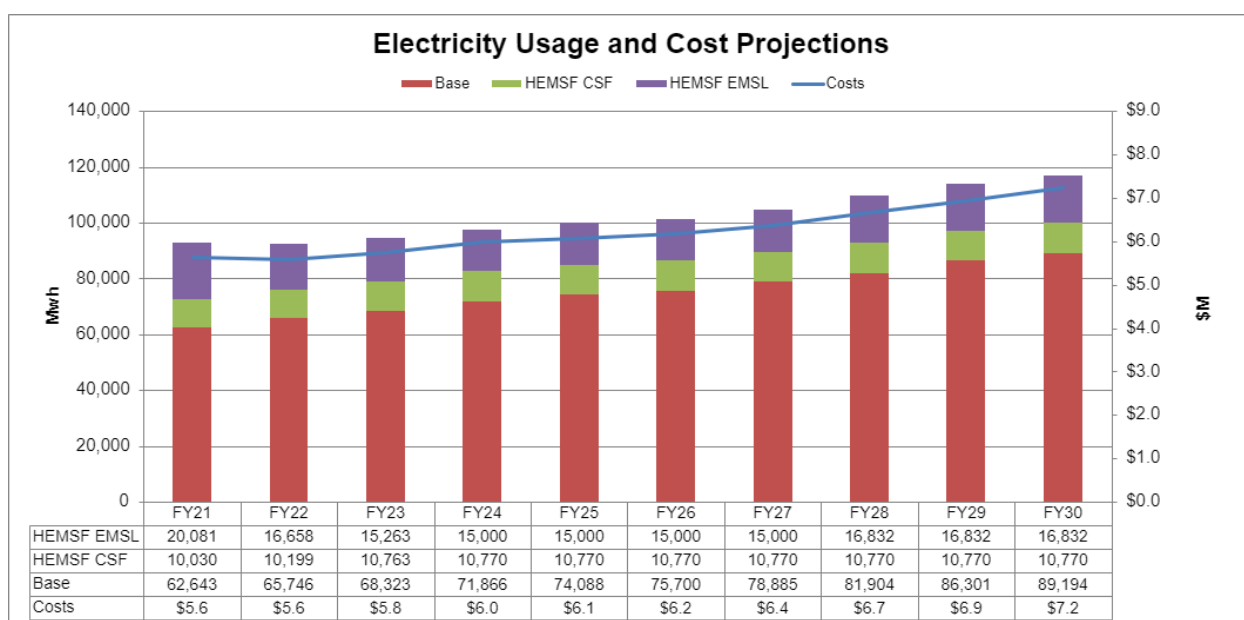


Figure 15. Electricity Usage and Cost Projections

### 3.1.3 Clean and Renewable Energy

PNNL is on track to meet the 100% CFE goal. In FY 2023, PNNL procured 7,600 MWh of EACs. The combination of EACs and PNNL's on-site renewables made up 8.8% of its electrical use, or 7.7% of its total electric and thermal energy.

Currently, PNNL purchases utilities from local providers, Richland Energy Services and Cascade Natural Gas Corporation, for electricity and natural gas, respectively. The PNNL-Sequim campus has utility providers local to the Sequim area, namely Clallam County Public Utility District for electricity. Clallam County Public Utility District is also a BPA Tier 1 customer and has essentially the same resource mix as the PNNL-Richland campus.

To set CFE performance targets, as shown in Figure 16, PNNL is applying a 78% grid-supplied CFE from FY 2023 through FY 2030, based on the 2021 published fuel mix data from the BPA balancing authority region. It should be noted that the 2023 CFE data from the City of

Richland attested report contains nearly 90% clean and renewable power sources, such as hydroelectric and nuclear.

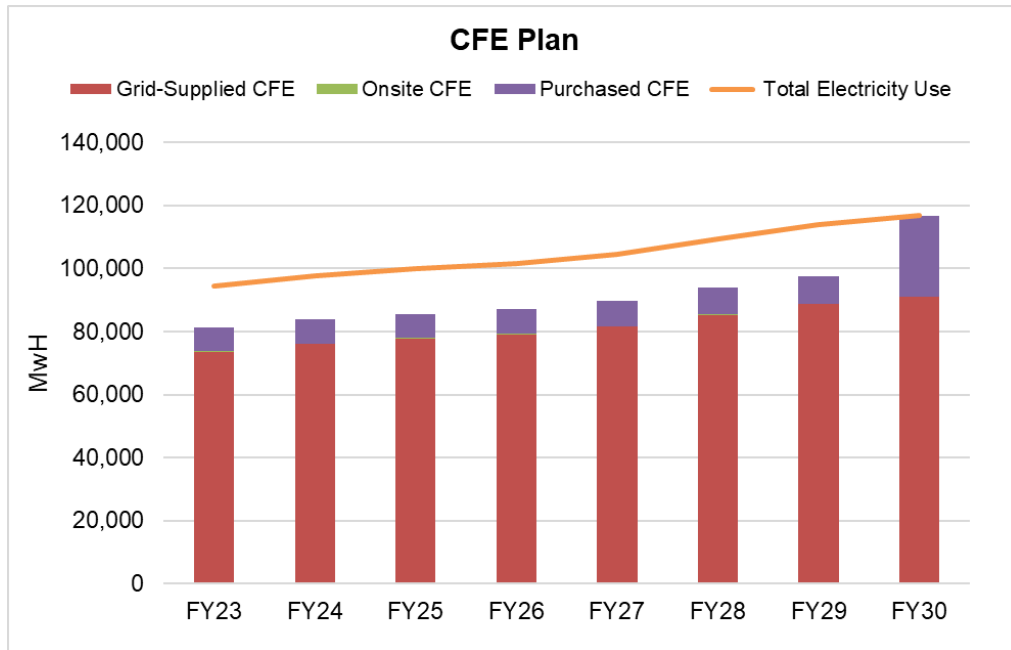


Figure 16. PNNL Carbon-Free Electricity Plan

Given the existing clean power supplies and the addition of Washington State’s Clean Energy Transformation Act, a 100% total CFE is projected with the procurement of additional EACs in FY 2030.

### 3.1.4 Net-Zero Emissions and Energy Efficient Buildings

Throughout FY 2023, PNNL has advanced toward its objective of achieving net-zero emissions. Notably, FY 2023 saw the completion of the net-zero-emissions-ready South Campus Warehouse, equipped with air source heat pumps and backup electric heating. PNNL is on track to finalize three additional net-zero-emissions-ready facilities—the Grid Storage Launchpad (GSL), the Advanced Secure Communication Building, and the 300 Area Office Building—in CY 2024 or early 2025. PNNL’s greenhouse gas emissions by category are illustrated in Figure 17.

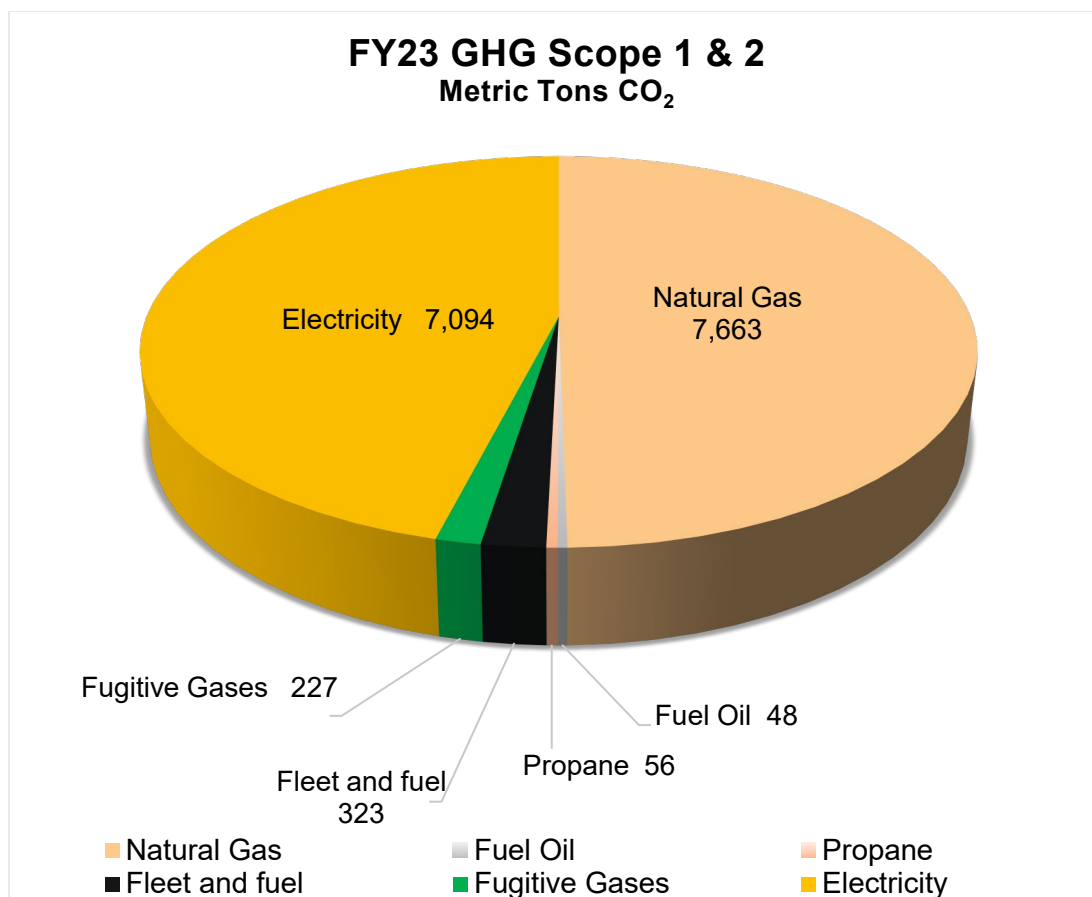


Figure 17. PNNL FY 2023 Greenhouse Gas Scope 1 & 2 by Category

Efforts to electrify existing infrastructure included the significant renovation of Building 550 (Testing and Analysis Laboratory), where PNNL phased out a natural-gas-fired heating system in favor of backup electric boilers with the installation of air source heat pumps.

By the conclusion of CY 2024, PNNL anticipates expanding its inventory of net-zero-emissions-ready buildings by over 135,000 gsf and will have electrified more than 213,000 gsf of its existing building stock, underscoring the proactive approach to sustainability and emissions reduction.

Although PNNL is committed to the net-zero emissions goals, the ability to accelerate electrification efforts across the PNNL-Richland campus has been constrained by insufficient regional and local electrical capacity to satisfy the near- and long-term demands; this subsequently will lead to a delay in PNNL's implementation timeline. Current projections indicate that PNNL's consumption will exceed the remaining available reserve power capacity in the next three to five years, thus affecting PNNL's ability to transition to net-zero emissions. Planned facility projects focused on electrification and increased efficiency are being prioritized; other facilities and infrastructure missions may be readjusted to align with the available power.

Near-term solutions being considered and evaluated to address the available power deficiency include on-site renewable generation (solar PV), energy/thermal storage, and implementation of energy-efficient projects. PNNL has initiated an effort with the local utility to explore the benefits that on-site generation and energy storage would have on the regional electrical capacity,

including consideration of how the Long-Duration Energy Storage project, which is being funded by the DOE Office of Clean Energy Demonstration, could support energy storage needs that could benefit the local utility.

PNNL also made progress toward the zero-emission vehicle (ZEV) fleet goal, with 80% of light-duty vehicle acquisitions ordered as ZEVs. PNNL has added additional on-site charging stations to accommodate the growing numbers of fleet ZEVs, as well as personal electric vehicles. Currently, PNNL has 26 level-2 stations and has installed three additional stations as part of the GSL construction project. At PNNL, all new construction projects are required to provide charging stations for at least 2% of the planned building occupants. Electrical infrastructure will be provided for up to 10% of the parking spaces for future expansion.

### 3.1.5 Adaptation and Resilience

Resilience planning is an iterative and continuous process. During FY 2022, PNNL completed two key resilience planning processes—resiliency planning using the Technical Resilience Navigator tool and the Vulnerability Assessment and Resilience Plan, which identified PNNL top climate risks and provided the blueprint to mitigate those risks and strengthen resilient operations.

Central to this plan was implementation of energy district energy systems as one of the solutions to elevate resilient operations. In FY 2023, PNNL began operation of its first district energy system. The ESC features an energy reducing design that captures and uses waste heat from EMSL supercomputer and research equipment via the creation of the HTB. When operation is fully optimized, the combined features of the ESC's mechanical systems and HTB potentially reduce ESC's carbon footprint by 2 million pounds of CO<sub>2</sub> equivalent per year and energy savings of approximately 14,500 million British thermal units (MMBtu) per year. This system will be expanded with connections to the GSL in early 2024.

Additionally, PNNL completed a wildland and fire assessment for the PNNL-Sequim campus. To elevate resiliency to wildland fire, PNNL removed trees and shrubs that were deemed vulnerable to a wildland fire and risk to the campus, developed a maintenance plan for pruning and removal, and removed parking areas along the shoreline hillside.



## 4.0 ENVIRONMENTAL RADIOLOGICAL PROTECTION PROGRAM & DOSE ASSESSMENT

This section describes the environmental monitoring programs for radiological constituents and the associated estimated dose assessments for the PNNL-Richland and PNNL-Sequim campuses. Reported doses are calculated rather than measured, so they represent potential or estimated doses.

### 4.1 Radiological Liquid Discharges and Doses

PNNL prohibits the discharge of liquid waste streams that contain radiological material to sanitary sewer systems, the ground, or surface water. Wastewater in PNNL facilities is expected to be free of radioactive materials but may have the potential for contamination in the event of a failure of an engineered barrier or administrative control. In facilities in which wastewater generated in radiologically controlled areas has the potential to become contaminated, it is discharged to retention tanks. After each retention tank is filled, it is isolated and its contents are analyzed for radiological components. The results of the analyses are compared to screening limits in [WAC 246-221-190](#), "Disposal by Release into Sanitary Sewerage Systems." If the analytical results indicate that the concentrations of radiological components in the wastewater are below the WAC screening limit, the wastewater is released to the City of Richland's sanitary sewer system. If the analytical results indicate that the concentrations of radiological components in the wastewater are above the WAC screening limit, the wastewater is transported to a waste treatment facility. These wastes may be transferred to a permitted waste treatment facility that is authorized to receive radiological material. Further evaluation is then performed to determine the source of the radiological component in the discharge.

If a waste stream is identified as containing very low levels of radioactive material, a request to authorize the discharge of this waste stream to the sewer system would be submitted to the City of Richland. The City of Richland can authorize the discharge of individual waste streams that contain very low levels of radiological material to the sewer system, as appropriate. As described in Section 4.1.1, there is currently only one authorized discharge of a liquid waste stream potentially containing radiological material to the City of Richland sanitary sewer.

### 4.1.1 Annual Report for DOE Order 458.1

This report has been prepared in accordance with DOE Order 458.1 (DOE CRD 458.1, Section [2][g][8][a][7]), which requires that the contractor prepare and provide a report that describes and summarizes discharges of liquids potentially containing radionuclides from DOE activities into nonfederally owned sanitary sewers. PNNL has one waste stream that has the potential for containing radionuclides that is approved for discharge to the City of Richland's sanitary sewer system. This waste stream is associated with fume hood washdown operations in the PSF.

On November 2, 2010, the City of Richland authorized the release of "... very low levels of volumetrically released radioactive material." These volumetrically released radioactive materials can be handled without concern for measurable contamination and without radiological postings or labeling pursuant to 10 CFR Part 835.

The total amount of radioactive material used in each fume hood is very small. Each washdown is estimated to be 190 L (50 gal). The worst-case concentration of radioactivity in each washdown is estimated to be  $7.1 \times 10^{-7}$  pCi/L. In 2023, the fume hoods were washed down an estimated total of 15 times. The screening criteria, as referenced in the City of Richland's Industrial Wastewater Discharge Permit CR-IU011 for PSF, are based on [WAC 246-221-190](#), Appendix A, Table III. The screening limits for each washdown are 20 pCi/L for gross alpha activity and 100 pCi/L for beta/gamma activity. If all activity in each washdown is conservatively presumed to be alpha activity, the concentration of radioactive material is more than a million times less than these WAC screening limits. This affirms that the washdowns are negligible in terms of the screening limits for discharge to the City of Richland's sewer systems.

## 4.2 Radiological Air Discharges and Doses

The federal regulatory standard for a maximum dose to any member of the public is 10 mrem/yr (0.1 mSv/yr) EDE. The standard is set forth in [40 CFR Part 61, Subpart H](#), and applies to radionuclide air emissions other than radon from DOE facilities.

Washington State has adopted the federal dose standard of 10 mrem/yr (0.1 mSv/yr) EDE in [WAC 246-247-040\(1\)](#). In addition to the maximum dose attributable to radionuclides emitted from point sources, [WAC 246-247-060\(6\)](#) requires that the dose to the MEI include doses attributable to fugitive emissions, radon, and nonroutine events.

Radionuclide air emissions are routinely sampled and tracked at the PNNL-Richland campus and routinely tracked at the PNNL-Sequim campus. Regulatory compliance reporting and monitoring results are reported in an annual air emission report for each location (Snyder et al. 2024b, 2024c). CY 2023 data are summarized in the following sections.



3410 Building Filtered Exhaust Stack

### 4.2.1 Contributions from PNNL-Richland Campus

Operations are registered with the state of Washington under RAEL-005. For CY 2023, the PNNL-Richland campus MEI location was 0.74 km (0.46 mi) south-southeast of PSF relative to the 3410 Building. Table 11 lists the relative contributions of each nuclide to the MEI dose. There were no unplanned releases from the PNNL-Richland campus in CY 2023.

Table 11. PNNL-Richland Campus Emissions and Dose Contributions by Radionuclide, 2023

Radionuclide <sup>(a)</sup>	Releases (Ci)	Campus MEI Dose (mrem EDE)	Percent of EDE
Gross Alpha <sup>(b)</sup>	$1.4 \times 10^{-7}$	$6.3 \times 10^{-6}$	31%
Gross Beta <sup>(c)</sup>	$1.5 \times 10^{-6}$	$6.2 \times 10^{-6}$	30%
Hydrogen-3 (tritium)	$2.0 \times 10^{-5}$	$3.9 \times 10^{-9}$	<1%
Aluminum-26	$1.6 \times 10^{-8}$	$2.7 \times 10^{-7}$	1%
Manganese-54	$3.7 \times 10^{-10}$	$1.9 \times 10^{-10}$	<1%
Cobalt-60	$4.2 \times 10^{-8}$	$1.2 \times 10^{-7}$	1%
Zinc-65	$1.3 \times 10^{-10}$	$1.8 \times 10^{-10}$	<1%
Bromine-82	$1.3 \times 10^{-8}$	$1.5 \times 10^{-10}$	<1%
Rubidium-83	$5.9 \times 10^{-9}$	$1.0 \times 10^{-9}$	<1%
Yttrium-88	$6.2 \times 10^{-10}$	$3.5 \times 10^{-10}$	<1%
Cadmium-109	$1.4 \times 10^{-9}$	$1.4 \times 10^{-10}$	<1%
Cesium-137	$3.2 \times 10^{-10}$	$4.2 \times 10^{-9}$	<1%
Cerium-141	$2.8 \times 10^{-8}$	$1.5 \times 10^{-10}$	<1%
Lead-210	$1.3 \times 10^{-9}$	$2.1 \times 10^{-8}$	<1%
Radon-220	$2.6 \times 10^{-3}$	$4.0 \times 10^{-7}$	2%
Radon-222	$1.5 \times 10^{-7}$	$4.0 \times 10^{-10}$	<1%
Thorium-229	$2.2 \times 10^{-8}$	$1.4 \times 10^{-6}$	7%
Thorium-232	$3.0 \times 10^{-12}$	$3.5 \times 10^{-10}$	<1%
Uranium-233/234	$1.1 \times 10^{-7}$	$4.2 \times 10^{-7}$	2%
Uranium-235	$1.7 \times 10^{-11}$	$2.0 \times 10^{-10}$	<1%
Plutonium-238	$9.3 \times 10^{-9}$	$3.7 \times 10^{-7}$	2%
Plutonium-239/240	$4.4 \times 10^{-8}$	$1.9 \times 10^{-6}$	9%
Americium-241	$7.5 \times 10^{-9}$	$3.0 \times 10^{-7}$	1%
Americium-243	$6.9 \times 10^{-11}$	$2.6 \times 10^{-9}$	<1%
Curium-243/244	$3.5 \times 10^{-8}$	$9.6 \times 10^{-7}$	5%
All other nuclides	$1.6 \times 10^{-7}$	$4.8 \times 10^{-10}$	<1%
PIC-5 emissions – VRRM	NA	$9.4 \times 10^{-7(e)}$	4%
PIC-5 emissions – NDRM	NA	$6.6 \times 10^{-8(e)}$	<1%
PIC-5 emissions – Facilities Restoration <sup>(e)</sup>	NA	$8.4 \times 10^{-7(e)}$	0%
PIC-5 emissions – SOIC <sup>(e)</sup>	NA	0	0%
<b>Total<sup>(f)</sup></b>	<b><math>2.6 \times 10^{-3}</math> Ci</b>	<b><math>2.1 \times 10^{-5}</math></b>	<b>100%</b>

(a) Release information available in Snyder et al. (2024b).

(b) Gross alpha from PSF emission units sampling assumed to be Pu-239.

(c) Gross beta from PSF emission units sampling assumed to be Cs-137.

(d) Dose includes progeny isotope Rn-222.

(e) The PIC-5 emission doses are assigned based on permit value. The SOIC emission source was not implemented in 2023.

(f) Totals may not add up to value indicated due to rounding.

NA = not applicable

NDRM = nondispersible radioactive material

PIC-5 = Potential Impact Category-5

SOIC = sources for instrument/operational checks

VRRM = volumetrically released radioactive material

To convert Ci to GBq, multiply Ci by 37. To convert mrem to mSv, multiply mrem by 0.01.

Emissions were determined from both sampling and, for nonsampled emissions, using the 40 CFR Part 61, Appendix D method. The CAP88-PC Version 4.0 code was used for estimating dose. The MEI dose of  $2.1 \times 10^{-5}$  mrem ( $2.1 \times 10^{-7}$  mSv) effective dose<sup>4</sup> is more than 100,000 times smaller than the 10 mrem/yr [WAC 246-247](#) compliance standard. This dose is many orders of magnitude below the average annual individual background dose of 310 mrem (3.1 mSv) from natural terrestrial and cosmic radiation and inhalation of naturally occurring radon (NCRP 2009). In 2023, modeling was done to determine the location of the maximum off-site radioactive material air concentration. A  $2.1 \times 10^{-5}$  mrem ( $2.1 \times 10^{-7}$  mSv) effective dose was estimated for the maximum off-site radioactive material air concentration location at 0.74 km (0.46 mi) south-southeast relative to the 3410 Building (i.e., the same location as the MEI for 2023).

The regional collective dose from the PNNL-Richland campus air emissions in CY 2023 also was estimated using CAP88-PC Version 4.0. Estimates of population exposure to radionuclide air emissions consider site-specific meteorology and population distributions. The population consists of approximately 605,000 people residing within an 80 km (50 mi) radius of the PNNL-Richland campus (Rose et al. 2023). Pathways evaluated for population exposure include inhalation, air submersion, ground shine, and consumption of food. The CY 2023 total collective dose from radionuclide air emissions estimated from nuclides that originated from the PNNL-Richland campus was  $2.4 \times 10^{-4}$  person-rem ( $2.4 \times 10^{-6}$  person-Sv).

#### 4.2.2 Contributions from PNNL-Sequim Campus

PNNL-Sequim campus operations for the sitewide minor, fugitive, nonpoint source emission unit is registered with the state of Washington under RAEL-014. For CY 2023, the PNNL-Sequim campus MEI location was 0.23 km (0.14 mi) west of a central PNNL-Sequim campus emission location (coordinates: 48.078, -123.047). This emission location is central to all operations areas at the PNNL-Sequim campus (Figure 3). Radiological operations at the PNNL-Sequim campus emit very low levels of radioactive materials. Table 12 lists the relative contributions to the MEI dose. The 40 CFR Part 61, Appendix D method was used to determine the routine emissions from the PNNL-Sequim campus in CY 2023, which are summarized as gross alpha and gross beta emissions. There were no unplanned emissions or radon emissions from the site during the year. The COMPLY Code (a computerized screening tool for evaluating radiation exposure from atmospheric releases of radionuclides) Version 1.7.1 (Level 4) was used for estimating dose (EPA 1989).

Table 12. PNNL-Sequim Campus Emissions and Dose Contributions, 2023 (Snyder et al. 2024c)

Radionuclide	Releases <sup>(a)</sup> (Ci)	Dose to MEI (mrem EDE)	Percent of EDE
Gross Alpha (as americium-241)	$6.8 \times 10^{-14}$	$2.0 \times 10^{-10}$	0.3%
Gross Beta (as cesium-137)	$5.0 \times 10^{-10}$	$5.8 \times 10^{-8}$	99.7%
<b>Total</b>	<b><math>5.0 \times 10^{-10}</math></b>	<b><math>5.8 \times 10^{-8}</math></b>	<b>100%</b>

<sup>(a)</sup> Emissions based on 40 CFR Part 61, Appendix D methods.

To convert Ci to GBq, multiply Ci by 37; to convert from mrem to mSv, multiply mrem by 0.01.

<sup>4</sup> The EDE and effective dose units can be considered equivalent for the purposes of this report and reflect the units calculated by the software used.

The dose to the PNNL-Sequim campus MEI was  $5.8 \times 10^{-8}$  mrem ( $5.8 \times 10^{-10}$  mSv) EDE. This dose is many orders of magnitude below the average annual individual background dose from natural terrestrial and cosmic radiation and inhalation of naturally occurring radon of 310 mrem (3.1 mSv) (NCRP 2009). In 2023, modeling was done to determine the location of the maximum off-site radioactive material air concentration near the PNNL-Sequim campus. The maximum modeled air concentration location results in a  $3.8 \times 10^{-7}$  mrem ( $3.8 \times 10^{-9}$  mSv) effective dose at a boundary location 0.08 km (262 ft) west of the central PNNL-Sequim campus location; it is forest area on Battelle-owned land.

Collective dose was determined for the estimated 2.94 million people who live within 80 km (50 mi) of the PNNL-Sequim campus; about 456,000 of them reside in Canada (Rose et al. 2023). Victoria, British Columbia, is the only major Canadian city within 80 km (50 mi) and is more than 32 km (20 mi) away. The maximum collective dose was determined assuming the total CY 2023 PNNL-Sequim campus curies released were dispersed in the single direction that results in the maximum collective dose. This direction was determined to be toward the west, which only contains U.S. populations. The MEI dose was multiplied by a population-weighted air concentration for a collective dose of  $1.6 \times 10^{-7}$  person-rem ( $1.6 \times 10^{-9}$  person-Sv). If the release were dispersed only to the maximum Canadian sector (north-northwest), the maximum estimated Canadian collective dose would be  $3.0 \times 10^{-8}$  person-rem ( $3.0 \times 10^{-10}$  person-Sv).

### 4.3 Release of Property Having Residual Radioactive Material

Principal requirements for the release of DOE property having residual radioactivity are set forth in DOE Order 458.1, Chg 4, *Radiation Protection of the Public and the Environment*. These requirements are designed to assure the following:

- Property is evaluated, radiologically characterized and, where appropriate, decontaminated before it is released.
- The level of residual radioactivity in property to be released is as near background levels as is reasonably practicable, as determined using DOE's ALARA process requirements, and it meets DOE-authorized limits.
- All property releases are certified, verified, documented, and reported; public participation needs are addressed; and processes are in place to appropriately maintain records.

Property as defined in DOE Order 458.1 consists of real property (i.e., land and structures), personal property, and materials and equipment. PNNL has two paths for releasing property to the public: (1) preapproved surface contamination guidelines for releasing property potentially contaminated on the surface; and (2) preapproved volumetric release limits for small-volume research samples. A summary of the two release paths is provided in the following sections. No property with detectable residual radioactivity above DOE-authorized levels was released from PNNL during CY 2023.

#### 4.3.1 Property Potentially Contaminated on the Surface

PNNL uses the previously approved surface activity guideline limits (Table 13) derived from guidance in DOE Order 458.1 when releasing property potentially contaminated on the surface. As part of research activities conducted in PNNL facilities, PNNL releases hundreds of items of personal property annually for excess to the general public, including office equipment, office furniture, labware, and research equipment. The PNNL Radiation Protection organization has a documented process for releasing items based on process knowledge, radiological surveys, or

a combination of both. No property with detectable residual radioactivity above the preapproved surface activity guidelines was released from PNNL during CY 2023.

**Table 13. Preapproved Surface Activity Guideline Limits**

Radionuclides	Allowable Total Residual Surface Contamination Limits (dpm/100 cm <sup>2</sup> )		
	Removable	Average	Maximum
Uranium-natural, uranium-235, uranium-238, and associated decay products	1,000	5,000	15,000
Transuranic elements, <sup>(a)</sup> radium-226, radium-228, thorium-230, thorium-228, protactinium-231, actinium-227, iodine-125, iodine-129	20	100	300
Natural thorium, thorium-232, strontium-90, radium-223, radium-224, uranium-232, iodine-126, iodine-131, iodine-133	200	1,000	3,000
Beta/gamma-emitters (nuclides with decay modes other than alpha emission or spontaneous fission) except strontium-90 and others noted above	1,000	5,000	15,000
Select hard-to-detect radionuclides (carbon-14, iron-55, nickel-59, nickel-63, selenium-79, technetium-99, palladium-107, and europium-155)	10,000	50,000	150,000
Tritium organic compounds, surfaces contaminated with tritium gas, tritiated water vapor, and metal tritide aerosols	10,000	NA	NA

<sup>(a)</sup> All transuranic elements except plutonium-241, which is treated as a beta/gamma-emitter.  
dpm = disintegrations per minute  
NA = not applicable

### 4.3.2 Property Potentially Contaminated in Volume

PNNL uses preapproved volumetric release limits when releasing small-volume research samples and wastewater potentially contaminated in volume (Table 14). DOE approved these release limits in response to an authorized limits request submitted by PNNL in 2000 and 2007 (DOE-RL 2001; DOE-PNSO 2007). During CY 2023, PNNL released hundreds of liquid research samples with a total volume on the order of 19 L (5 gal), using the preapproved release limits in Table 14. Generally, the liquid samples were not released to the public but were handled without radiological controls in PNNL facilities. When disposed of, the samples were treated as radioactive waste.

**Table 14. Preapproved Volumetric Release Limits**

Radionuclide Groups	Volumetric Release Limit (pCi/mL)
Transuranic elements, iodine-125, iodine-129, radium-226, actinium-227, radium-228, thorium-228, thorium-230, protactinium-231, polonium-208, polonium-209, polonium-210	1
Natural thorium, thorium-232	3
Strontium-90, iodine-126, iodine-131, iodine-133, radium-223, radium-224, uranium-232	9
Natural uranium, uranium-233, uranium-235, uranium-238	30
Beta/gamma-emitters (radionuclides with decay modes other than alpha emission or spontaneous fission) except strontium-90 and others noted in the rows above	45
Tritium	450

## 4.4 Radiation Protection of Biota

DOE Order 458.1 directs that DOE sites establish procedures and practices to protect biota, while DOE-STD-1153-2019, *A Graded Approach for Evaluating Radiation Doses to Aquatic and Terrestrial Biota* (DOE 2019), provides a graded approach for evaluating the doses to biota. PNNL has adopted dose rate limits of 1 rad/d (10 mGy/d) for aquatic animals and terrestrial plants and 0.1 rad/d (1 mGy/d) for riparian and terrestrial animals for the demonstration of the protection of biota (DOE 2019, DOE Order 458.1). These limits are applied similarly at the PNNL-Richland campus and the PNNL-Sequim campus.

### 4.4.1 Radiation Protection of Biota – PNNL-Richland Campus

Environmental media pathways were evaluated for the PNNL-Richland campus following the data quality objectives (DQOs) process in support of radiological emissions monitoring (Snyder et al. 2024a). Potential media exposure pathways, such as air, soil, water, and food, were considered in conjunction with both gaseous and particulate radioactive contamination of the air pathway. The DQO process determined that only the air pathway necessitates monitoring, because there are no radiological emissions via liquid pathways or directly to contaminated land areas. It also determined that the extremely small amounts of emissions would be impossible to differentiate from background levels in nearby locations, such as the Columbia River, and from food sources. While these measures are used primarily to demonstrate protection of the public, they also adequately demonstrate protection of biota. Therefore, biota monitoring for radionuclides both near and far from the PNNL-Richland campus is not conducted.

Routine operations were conducted on the PNNL-Richland campus during CY 2023—there were no unplanned radiological emissions. The resultant absorbed dose (external and internal) rates were less than the DOE criteria of 1 rad/d (10 mGy/d) for both aquatic animals and terrestrial plants, and less than 0.1 rad/d (1 mGy/d) for both riparian animals and terrestrial animals (Table 15). The dose rates are based on the PNNL-reported total particulate radionuclide emissions for CY 2023 (Snyder et al. 2024b). Calculations are based on conservative assumptions that all the particulate radioactive material is concentrated into either 2,500 m<sup>3</sup> (8.8 × 10<sup>4</sup> ft<sup>3</sup>) of contaminated water, equivalent to the volume of an Olympic swimming pool, or 50 m<sup>2</sup> (538 ft<sup>2</sup>) of contaminated soil or sediment, with a soil density of 224 kg/m<sup>2</sup> (14 lb/ft<sup>2</sup>) to a depth of 15 cm (6 in.), equivalent to a representative garden area (Napier 2006). For comparison, an average of 5.04 × 10<sup>3</sup> m<sup>3</sup>/s (1.78 × 10<sup>5</sup> ft<sup>3</sup>/s) of Columbia River water flows below Priest Rapids Dam (USGS 2024) and past the PNNL-Richland campus on a daily basis, and the PNNL-Richland campus occupies approximately 3.1 × 10<sup>6</sup> m<sup>2</sup> (3.3 × 10<sup>7</sup> ft<sup>2</sup>) of area.

Doses to terrestrial plants and terrestrial animals are assumed to be from contaminated soil, while doses to aquatic animals are assumed to be from contaminated water and doses to riparian animals are assumed to be from contaminated sediment. The dose coefficients were determined using RESRAD-BIOTA V1.8 Level 2 (available from Argonne National Laboratory).



Canada Goose (*Branta canadensis*) on the PNNL-Richland Campus

The resulting water and soil concentrations are very conservative and are used for basic screening and calculating the contrast to adopted biota dose rate limits.

**Table 15. Absorbed Biota Dose Rates for the PNNL-Richland Campus, 2023**

	Particulate Emissions <sup>(a)</sup> (Bq/yr)	Terrestrial Animal to Contaminated Soil <sup>(b)</sup> (mGy/d)	Terrestrial Plant to Contaminated Soil <sup>(b)</sup> (mGy/d)	Aquatic Animals to Contaminated Water <sup>(c)</sup> (mGy/d)	Riparian Animal to Contaminated Sediment <sup>(b)</sup> (mGy/d)
Totals	$8.1 \times 10^5$	$6.9 \times 10^{-3}$	$1.1 \times 10^{-3}$	$6.7 \times 10^{-2}$	$6.5 \times 10^{-3}$
Dose Limit mGy/d	-	1	10	10	1

(a) Total particulate emissions determined from Snyder et al. (2024b).

(b) The terrestrial animals may include deer, bee, earthworm, and rat. The terrestrial plants may include pine tree and wild grass. The riparian animals may include duck and frog. The contaminated soil area is 50 m<sup>2</sup> (538 ft<sup>2</sup>) to a depth of 15 cm (6 in.) (Napier 2006).

(c) The aquatic animals may include trout, bass, and salmon and steelhead. The contaminated water volume is 2,500 m<sup>3</sup> ( $8.8 \times 10^4$  ft<sup>3</sup>).

Conversion factors: 1 Ci =  $3.7 \times 10^{10}$  Bq; 1 Gy = 100 rad.

#### 4.4.2 Radiation Protection of Biota – PNNL-Sequim Campus

Environmental media pathways were evaluated during the development of PNNL-Sequim campus DQOs in support of radiological emissions monitoring. Potential media exposure pathways, such as air, soil, water, and food, were considered in conjunction with potential releases of radioactive contamination to the air pathway.

The DQO process determined that, because of the low probability of potential air emissions and the absence of radiological emissions via liquid pathways or directly to land areas, no environmental sampling would be required. Because emission levels at the PNNL-Sequim campus are very low, it would be impossible to differentiate actual emissions from background levels in nearby locations such as Sequim Bay and those from food sources (Snyder et al. 2019). Reported emissions from the PNNL-Sequim campus are conservatively estimated because neither environmental surveillance nor stack sampling are required. These conservatively estimated emissions are also adequate to demonstrate protection of the public and of biota; therefore, biota monitoring for radionuclides, both near to and far from the PNNL-Sequim campus, is not conducted.

Routine operations were conducted at PNNL-Sequim campus facilities during CY 2023—there were no unplanned radiological emissions. The resultant absorbed dose (external and internal) rates were less than the DOE criteria of 1 rad/d (10 mGy/d) for both aquatic animals and terrestrial plants, and 0.1 rad/d (1 mGy/d) for both riparian and terrestrial animals (Table 16). These conservative dose rates are well below dose rate limits, which are based on the PNNL-reported total particulate radionuclide emissions for CY 2023 (Snyder et al. 2024c). Conservative assumptions are that the particulate radioactive material is concentrated into either 2,500 m<sup>3</sup> ( $8.8 \times 10^4$  ft<sup>3</sup>) of contaminated water, equivalent to the volume of an Olympic swimming pool, or 50 m<sup>2</sup> (538 ft<sup>2</sup>) of contaminated soil or sediment, with a soil density of 224 kg/m<sup>2</sup> (14 lb/ft<sup>2</sup>) to a depth of 15 cm (6 in.), equivalent to a representative garden area (Napier 2006). For comparison, Sequim Bay contains an approximate  $1.32 \times 10^8$  m<sup>3</sup> ( $4.66 \times 10^9$  ft<sup>3</sup>) of seawater with continuous tidal flow past Travis Spit, and the PNNL-Sequim campus developed land occupies approximately  $3 \times 10^4$  m<sup>2</sup> ( $3.2 \times 10^5$  ft<sup>2</sup>) of area.

Table 16. Absorbed Biota Dose Rates for the PNNL-Sequim Campus, 2023

	Particulate Emissions <sup>(a)</sup> (Bq/yr)	Terrestrial Animal to Contaminated Soil <sup>(b)</sup> (mGy/d)	Terrestrial Plant to Contaminated Soil <sup>(b)</sup> (mGy/d)	Aquatic Animals to Contaminated Water <sup>(c)</sup> (mGy/d)	Riparian Animal to Contaminated Sediment <sup>(b)</sup> (mGy/d)
Totals	$1.9 \times 10^1$	$2.1 \times 10^{-6}$	$2.0 \times 10^{-7}$	$2.0 \times 10^{-6}$	$1.1 \times 10^{-6}$
Dose Limit mGy/d	–	1	10	10	1

<sup>(a)</sup> Total particulate emissions determined from Snyder et al. (2024c).

<sup>(b)</sup> The terrestrial animals may include deer, bee, earthworm, and rat. The terrestrial plants may include pine tree and wild grass. The riparian animals may include duck and frog. The contaminated soil area is 50 m<sup>2</sup> (538 ft<sup>2</sup>) to a depth of 15 cm (6 in.) (Napier 2006).

<sup>(c)</sup> The aquatic animals may include crab, shrimp, and saltwater fish. The contaminated water volume is 2,500 m<sup>3</sup> ( $8.8 \times 10^4$  ft<sup>3</sup>).

Conversion factors: 1 Ci =  $3.7 \times 10^{10}$  Bq; 1 Gy = 100 rad

Doses to terrestrial plants and terrestrial animals are assumed to be from contaminated soil, while doses to aquatic animals are assumed to be from contaminated water and doses to riparian animals are assumed to be from contaminated sediment. The dose coefficients were determined using RESRAD-BIOTA V1.8 Level 2. The resulting water and soil concentrations are very conservative and are used for basic screening and calculating the contrast to adopted biota dose rate limits.

## 4.5 Unplanned Radiological Releases

No radiological releases to the environment exceeded permitted limits at the PNNL-Richland campus or PNNL-Sequim campus in 2023. There were no unplanned releases reported at either the PNNL-Richland campus or PNNL-Sequim campus via air effluent in 2023 (Snyder et al. 2024b, 2024c), nor were there any unplanned release events via liquid effluents or to soil.

## 4.6 Environmental Radiological Monitoring

The DOE Handbook, *Environmental Radiological Effluent Monitoring and Environmental Surveillance*, provides information about basic program implementation requirements and activities (DOE-HDBK-1216-2015; DOE 2022a). In addition, the WDOH may require an operator of any emission unit to conduct ambient air monitoring or other testing, as necessary, to demonstrate compliance with the [WAC 246-247](#) standard; such requirements for a program would be included in the operator's license. This section summarizes environmental radiological monitoring activities conducted by PNNL for both the PNNL-Richland campus and PNNL-Sequim campus.

### 4.6.1 Environmental Radiological Monitoring – PNNL-Richland Campus

A particulate air-sampling (environmental surveillance) network was established in 2010 to monitor radioactive particulates in ambient air near the PNNL-Richland campus as stipulated by WDOH in RAEL-005. As a result of changes in DOE-permitted operations in 2012, the air-sampling network was reevaluated (Barnett et al. 2012b). In 2017, the PNNL-Richland campus boundary was expanded by 35 ha (85.6 ac) to the north, necessitating that the particulate air-sampling network again be evaluated (Snyder et al. 2017). Starting in 2023, the north area of the campus began to undergo development and Snyder et al. (2024a) documents the impacts to and the optimization of the ambient air surveillance network stations. The current

PNNL-Richland campus particulate air-sampling network consists of four campus samplers (PNL-1, PNL-2, PNL-3, and PNL-4), one background sampler (PNL-5), and co-located ambient external dose monitors. Air surveillance station locations for the PNNL-Richland campus are shown in Figure 18.

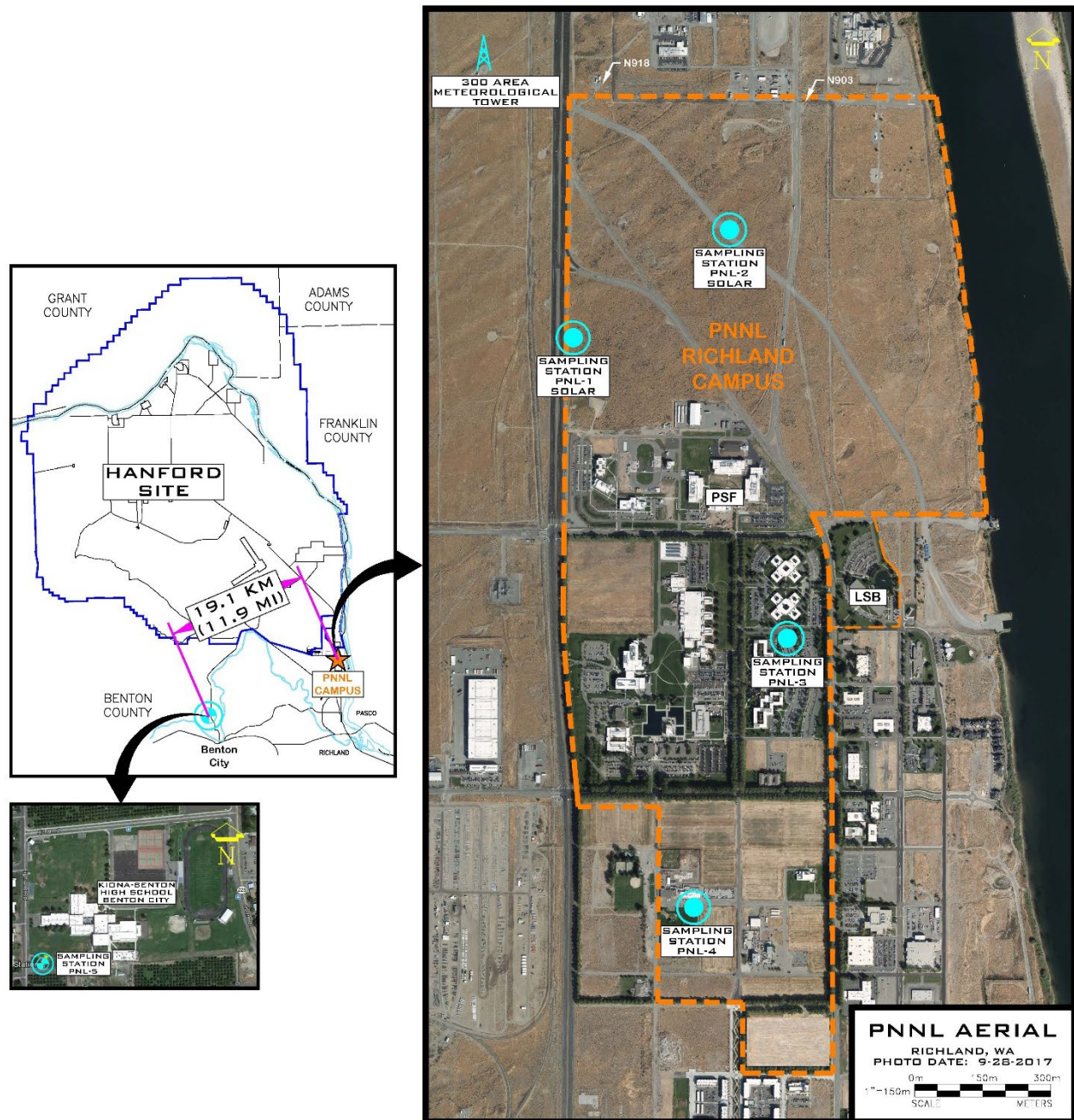


Figure 18. Air Surveillance Station Locations for the PNNL-Richland Campus

#### 4.6.1.1 Environmental Air Surveillance – PNNL-Richland Campus

During CY 2023, air samples were collected at all sampling stations and included sampling and analysis for airborne particulate radionuclides. Two-week particulate air samples are routinely analyzed for gross alpha and beta activity. These gross analyses would indicate potential unexpected increases in emissions. Semiannually, filters are composited for specific radionuclide analysis. There were no significant impacts to the annual composite results or network station operational frequency for CY 2023. The required composite analyses include cobalt-60, uranium-233/234,<sup>5</sup> plutonium-238 and plutonium-239/240, americium-241 and americium-243, and curium-243/244.<sup>6</sup> See Snyder et al. (2024b) for additional details regarding environmental air surveillance in CY 2023.

No PNNL activities resulted in increased ambient air concentrations at the air-sampling locations in CY 2023 (Table 17). The gross alpha and beta results were comparable to background levels. These nuclide-specific results were less than the 40 CFR Part 61, Appendix E, Table 2 values, and there was no indication of elevated levels of monitored particulate radionuclides near the PNNL-Richland campus. The lack of overall detectable concentrations supports the results of stack effluent monitoring and demonstrates that emissions from the PNNL-Richland campus are low and have minimal potential for dose to members of the public.

Table 17. Summary of 2023 Air-Sampling Results for the PNNL-Richland Campus (Snyder et al. 2024b)

Nuclide	Location <sup>(a)</sup>	No. of Samples Analyzed	No. of Detections	Value $\pm$ Error (pCi/m <sup>3</sup> ) <sup>(b)</sup>		
Gross Alpha	PNL-1	27	22	$8.4 \times 10^{-4}$	$\pm$	$2.7 \times 10^{-3}$
	PNL-2	27	21	$8.9 \times 10^{-4}$	$\pm$	$3.0 \times 10^{-3}$
	PNL-3	26	18	$7.8 \times 10^{-4}$	$\pm$	$2.3 \times 10^{-3}$
	PNL-4	26	23	$8.0 \times 10^{-4}$	$\pm$	$2.5 \times 10^{-3}$
	PNL-5	26	22	$9.1 \times 10^{-4}$	$\pm$	$2.5 \times 10^{-3}$
Gross Beta	PNL-1	27	27	$1.7 \times 10^{-2}$	$\pm$	$8.4 \times 10^{-3}$
	PNL-2	27	27	$1.7 \times 10^{-2}$	$\pm$	$8.8 \times 10^{-3}$
	PNL-3	26	26	$1.6 \times 10^{-2}$	$\pm$	$7.3 \times 10^{-3}$
	PNL-4	26	26	$1.7 \times 10^{-2}$	$\pm$	$7.9 \times 10^{-3}$
	PNL-5	26	26	$1.5 \times 10^{-2}$	$\pm$	$7.2 \times 10^{-3}$
Co-60 <sup>(c)</sup>	PNL-1	2	0	$1.3 \times 10^{-6}$	$\pm$	$9.0 \times 10^{-5}$
	PNL-2	2	0	$3.5 \times 10^{-7}$	$\pm$	$9.1 \times 10^{-5}$
	PNL-3	2	0	$1.3 \times 10^{-5}$	$\pm$	$1.1 \times 10^{-4}$
	PNL-4	2	0	$5.3 \times 10^{-5}$	$\pm$	$1.4 \times 10^{-4}$
	PNL-5	2	0	$3.7 \times 10^{-5}$	$\pm$	$1.0 \times 10^{-4}$
Cs-137 <sup>(c)</sup>	PNL-1	2	0	$-3.0 \times 10^{-5}$	$\pm$	$1.4 \times 10^{-4}$
	PNL-2	2	0	$3.9 \times 10^{-5}$	$\pm$	$1.4 \times 10^{-4}$
	PNL-3	2	0	$7.2 \times 10^{-6}$	$\pm$	$6.7 \times 10^{-5}$
	PNL-4	2	0	$2.8 \times 10^{-5}$	$\pm$	$8.7 \times 10^{-5}$
	PNL-5	2	0	$3.8 \times 10^{-6}$	$\pm$	$1.8 \times 10^{-4}$

<sup>5</sup> Only uranium-233 is required, but it is reported as uranium-233/234 because the naturally occurring uranium-234 emission peak overlaps with uranium-233.

<sup>6</sup> Only curium-244 is required, but it is reported as curium-243/244 because the curium-243 emission peak overlaps with curium-244.

Nuclide	Location <sup>(a)</sup>	No. of Samples Analyzed	No. of Detections	Value $\pm$ Error (pCi/m <sup>3</sup> ) <sup>(b)</sup>	
U-233/234 <sup>(c)</sup>	PNL-1	2	2	$4.2 \times 10^{-5}$	$\pm 2.7 \times 10^{-5}$
	PNL-2	2	1	$3.3 \times 10^{-5}$	$\pm 2.6 \times 10^{-5}$
	PNL-3	2	2	$5.0 \times 10^{-5}$	$\pm 2.6 \times 10^{-5}$
	PNL-4	2	2	$4.5 \times 10^{-5}$	$\pm 2.5 \times 10^{-5}$
	PNL-5	2	2	$4.1 \times 10^{-5}$	$\pm 3.3 \times 10^{-5}$
Pu-238 <sup>(c)</sup>	PNL-1	2	0	$7.6 \times 10^{-6}$	$\pm 1.4 \times 10^{-5}$
	PNL-2	2	1	$2.8 \times 10^{-5}$	$\pm 2.3 \times 10^{-5}$
	PNL-3	2	1	$5.1 \times 10^{-5}$	$\pm 2.5 \times 10^{-5}$
	PNL-4	2	1	$1.4 \times 10^{-5}$	$\pm 1.8 \times 10^{-5}$
	PNL-5	2	0	$1.4 \times 10^{-5}$	$\pm 1.9 \times 10^{-5}$
Pu-239/240 <sup>(c)</sup>	PNL-1	2	1	$9.9 \times 10^{-6}$	$\pm 1.5 \times 10^{-5}$
	PNL-2	2	1	$1.7 \times 10^{-5}$	$\pm 2.1 \times 10^{-5}$
	PNL-3	2	1	$6.1 \times 10^{-5}$	$\pm 2.8 \times 10^{-5}$
	PNL-4	2	1	$4.9 \times 10^{-5}$	$\pm 2.8 \times 10^{-5}$
	PNL-5	2	1	$2.0 \times 10^{-5}$	$\pm 2.6 \times 10^{-5}$
Am-241 <sup>(c)</sup>	PNL-1	2	0	$2.6 \times 10^{-6}$	$\pm 1.9 \times 10^{-5}$
	PNL-2	2	1	$1.7 \times 10^{-5}$	$\pm 1.9 \times 10^{-5}$
	PNL-3	2	1	$2.8 \times 10^{-5}$	$\pm 2.0 \times 10^{-5}$
	PNL-4	2	1	$2.2 \times 10^{-5}$	$\pm 2.2 \times 10^{-5}$
	PNL-5	2	0	$1.6 \times 10^{-5}$	$\pm 3.2 \times 10^{-5}$
Am-243 <sup>(c)</sup>	PNL-1	2	0	$4.2 \times 10^{-5}$	$\pm 9.4 \times 10^{-5}$
	PNL-2	2	0	$1.6 \times 10^{-5}$	$\pm 9.4 \times 10^{-5}$
	PNL-3	2	0	$3.4 \times 10^{-5}$	$\pm 8.7 \times 10^{-5}$
	PNL-4	2	0	$3.5 \times 10^{-6}$	$\pm 1.6 \times 10^{-5}$
	PNL-5	2	0	$2.5 \times 10^{-5}$	$\pm 6.5 \times 10^{-5}$
Cm-243/244 <sup>(c)</sup>	PNL-1	2	0	$7.8 \times 10^{-6}$	$\pm 2.6 \times 10^{-5}$
	PNL-2	2	0	$2.4 \times 10^{-6}$	$\pm 2.2 \times 10^{-5}$
	PNL-3	2	0	$4.5 \times 10^{-6}$	$\pm 2.3 \times 10^{-5}$
	PNL-4	2	0	$-3.1 \times 10^{-6}$	$\pm 1.8 \times 10^{-5}$
	PNL-5	2	0	$1.3 \times 10^{-5}$	$\pm 3.4 \times 10^{-5}$

To convert pCi/m<sup>3</sup> to Bq/m<sup>3</sup>, multiply pCi/m<sup>3</sup> by 0.037.

<sup>(a)</sup> Refer to Figure 18 for PNL-1, PNL-2, PNL-3, PNL-4, and PNL-5 locations.

<sup>(b)</sup> Value is the average of samples collected throughout the year, with no background (PNL-5) results subtracted.

<sup>(c)</sup> Semiannual composite analyses.

#### 4.6.1.2 Ambient External Dose Monitoring – PNNL-Richland Campus

Ambient levels of external dose from gamma, beta, and X-ray sources were monitored quarterly at the five particulate air monitoring stations during 2023. The external dose monitoring program establishes baseline ambient external dose levels at the perimeter particulate sampling stations and the background (PNL-5) station. No current PNNL-Richland campus radioactive air emissions include significant quantities of external dose contributors, nor had PNNL transported high external dose sources on campus roads in 2023.

Ambient external dose monitoring is done with aluminum oxide dosimeters read by optically stimulated luminescence, using the Landauer<sup>7</sup> InLight® System. The system has a 5 mrem (50 µSv) minimum detection level with two sigma uncertainty of 12% for each measurement period. Additional QA information regarding dosimeters is found in Section 7.3.

Optically stimulated luminescence dosimeter (OSLD) results for the 2023 monitoring periods are presented in Appendix C. After adjusting for control dosimeter results, daily and hourly reported results were determined and used to evaluate dose rates by the number of days monitored each quarter. Daily average dose rates and total 2023 annual background are provided in Figure 19. Hourly average dose rates are provided in Table 18, with no uncertainties indicated. Background values at PNL-5 are not subtracted from the PNL-1 through PNL-4 values in the figure and table data.

Appendix C also includes results of a reassessment of all prior ambient dosimeter results. A new statistical method was developed to consider dosimeter uncertainty and whether critical station (PNL-1 through PNL-4) results are determined to be above PNL-5 background. This new method was applied to all prior years of OSLD ambient external dose monitoring results.

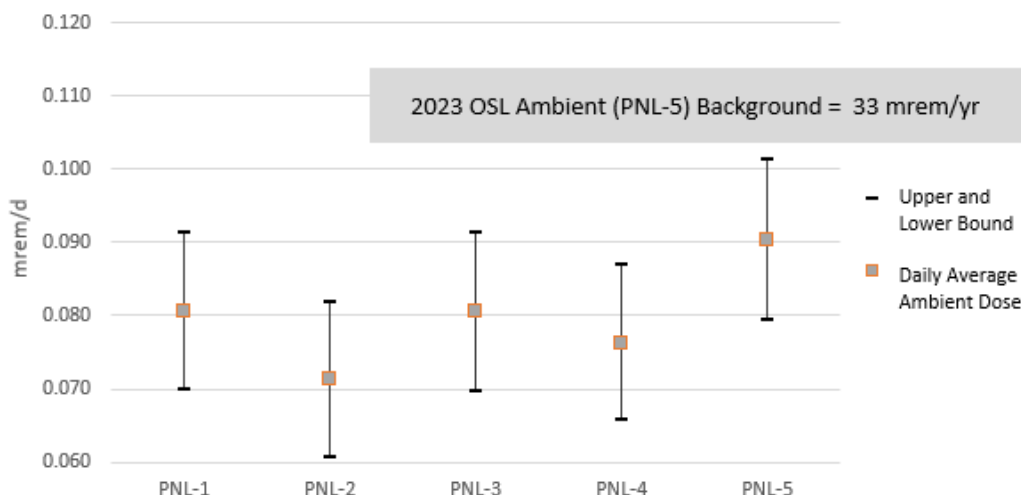


Figure 19. Average Daily Ambient External Dose Rates in 2023 for the PNNL-Richland Campus

Table 18. Average Hourly Ambient External Dose Rates in 2023 for the PNNL-Richland Campus (µrem/hr)

2023 Quarter	PNL-1	PNL-2	PNL-3	PNL-4	PNL-5 <sup>(a)</sup>
First (Q1)	2.5	3.0	5.0	2.0	2.0
Second (Q2)	4.3	3.4	2.6	3.4	4.7
Third (Q3)	2.5	3.0	3.0	4.0	5.5
Fourth (Q4)	4.3	2.6	3.0	3.4	3.0
<b>Average annual (µrem/hr)</b>	<b>3.4</b>	<b>3.0</b>	<b>3.4</b>	<b>3.2</b>	<b>3.8</b>

<sup>(a)</sup> PNL-5 is the background station. No background values were subtracted from PNNL-Richland campus perimeter stations (PNL-1 through PNL-4) results.

To convert µrem/hr to µSv/hr, multiply mrem by 0.01.

<sup>7</sup> Landauer, 2 Science Rd, Glenwood, Illinois 60425-1586. Accessed at <https://www.landauer.com>.

CY 2023 annual dose rates at each campus monitoring location are within or below the PNL-5 background ( $33.0 \pm 4.0$  mrem/yr [ $330 \pm 40$   $\mu$ Sv/yr] with normalized 91-day quarters). The 2023 normalized results at all stations would be expected to range from 28.9–37.0 mrem/yr (289–370  $\mu$ Sv/yr), based on PNL-5 background measurements. For this seventh year of ambient external dose monitoring, the PNNL-Richland campus measurements remained similar to previous regional average background levels from 2017–2022 (29–40 mrem [290–400  $\mu$ Sv]).

In addition to the boundary and background station ambient external dose monitoring discussed above, the PNNL Radiation Protection organization performs external dose rate surveys and direct contamination surveys of the ground within 6 m (20 ft) of PNNL buildings that contain radiological areas. For CY 2023, survey results were at background levels ( $< 20$   $\mu$ rem/hr [ $< 0.2$   $\mu$ Sv/hr]) in areas that could be occupied by the public. For roof areas not accessible by the public, similar measurements were made, and all were found to be at background levels.

#### 4.6.2 Environmental Radiological Monitoring – PNNL-Sequim Campus

Emissions at the PNNL-Sequim campus are low, the radionuclide inventory is relatively small, and radiological impact estimates are well below regulatory limits, even when highly over-estimated assumptions are applied (Snyder et al. 2019; Barnett et al. 2012a). The emissions at the PNNL-Sequim campus have historically met requirements for dose limit compliance based on estimates derived using the COMPLY Code (EPA 1989). COMPLY is applicable to sites that have low levels of releases (i.e., releases that result in an MEI dose below the minor emissions unit limit of 0.1 mrem/yr [1  $\mu$ Sv/yr]) (Snyder et al. 2019; Barnett et al. 2012a). At this time, there are no data available for particulate radionuclide air sampling for baseline background or co-located ambient external dose monitoring.

The PNNL Radiation Protection organization performs external dose rate surveys at MSL-1 and MSL-5 exterior door locations, as well as direct contamination surveys of the ground within 6 m (20 ft) of these building perimeters. For CY 2023, survey results were at background levels ( $< 20$   $\mu$ R/hr [approximately  $< 0.2$   $\mu$ Sv/hr]) in areas that could be occupied by the public. For roof areas not accessible by the public, similar measurements were made, and all were found to be at background levels.



Bird's-eye View of MSL at PNNL-Sequim

## 4.7 Public Dose Summary

The total public dose includes air, water, and other contributions from facility operations. DOE limits the all-pathway public dose limit to 100 mrem/yr (1,000  $\mu$ Sv/yr) in DOE Order 458.1 (DOE CRD 458.1, Section 2.b.1). Components of the total public dose can include contributions from the radiological air emissions pathway, which is limited to 10 mrem/yr (100  $\mu$ Sv/yr) under [40 CFR Part 61, Subpart H](#). Radiological liquid effluents for community water systems are limited to 4 mrem/yr (40  $\mu$ Sv/yr) beta/gamma under [40 CFR 141.26](#). Other dose pathways may be addressed through environmental surveillance activities (e.g., ambient air monitoring, environmental dosimetry, biota [such as native plant and wildlife] surveys, and farm product surveys [such as local milk, produce, and meat]) (DOE 2015). The 100 mrem (1,000  $\mu$ Sv/yr) public dose limit is about one-third of the typical background exposure of 310 mrem/yr (3,100  $\mu$ Sv/yr) (NCRP 2009).

In 2023, the radiological public dose was assigned from the air pathway (i.e., resulting from permitted operations on the PNNL-Richland campus and the PNNL-Sequim campus). The radiological dose summary to the public by pathway and total is provided in Table 19.

Table 19. Radiological Dose Summary for PNNL Locations, 2023

Dose Source	PNNL-Richland Campus		PNNL-Sequim Campus	
	MEI Dose (mrem/yr)	Collective Dose (person-rem/yr)	MEI Dose (mrem/yr)	Collective Dose (person-rem/yr)
Air Pathway	$2.1 \times 10^{-5}$	$2.4 \times 10^{-4}$	$5.8 \times 10^{-8}$	$1.6 \times 10^{-7}$
Water Pathway	0	0	0	0
Other Pathway	0	NA	NA	NA
Total Dose	$2.1 \times 10^{-5}$	$2.4 \times 10^{-4}$	$5.8 \times 10^{-8}$	$1.6 \times 10^{-7}$
All-Pathways Dose Limit	100	NA	100	NA
Natural Background Radiation	310	$1.9 \times 10^{+5}$	310	$9.1 \times 10^{+5}$

NA = not applicable

To convert Ci to GBq, multiply Ci by 37. To convert mrem to mSv, multiply mrem by 0.01.

## 4.8 Future Radiological Monitoring

The PNNL-Sequim campus RAEL-014 was renewed with an effective date of January 1, 2023. The RAEL-014 single PNNL-Sequim campus sitewide minor, fugitive, nonpoint source emission unit has no specific building units. A reevaluation of the PNNL-Sequim campus for environmental surveillance began in 2018 and concluded in CY 2019. While operations under the RAEL-014, Renewal 1, do not require emission unit sampling, monitoring, or ambient surveillance, the revised DQO (Snyder et al. 2019) recommended baseline radioactive air background surveillance be performed because no baseline radioactive air background data are available for the PNNL-Sequim campus or surrounding area. Determinations of site radiation background for ambient external environmental dose and for particulate gross alpha and beta in air were recommended. DQO results further recommended the sampling be performed at an on-site location; on-site sampling is acceptable because of the historical and continued minimal radiological operations at the PNNL-Sequim campus (Snyder et al. 2019). Ambient external environmental dose surveillance is expected to commence in 2024, while implementation planning of baseline radioactive air particulates background surveillance at the PNNL-Sequim campus will coincide with future land decisions.



## 5.0 ENVIRONMENTAL NONRADIOLOGICAL PROGRAM INFORMATION

The Effluent, Waste, and Transportation Programs Group (EWTPG) within the PNNL Environmental Protection and Regulatory Programs Division establishes or provides reference to already established discharge limits for toxic and radiological effluents to air and water. Specific effluent management services include establishing monitoring and sampling programs to characterize effluents from PNNL facilities, including those at the PNNL-Sequim campus, verifying compliance with effluent standards and controls, assisting facility operations, and monitoring compliance with air and wastewater permits.

EWTPG provides the interface between regulatory agencies and PNNL to prepare and submit required environmental permitting documentation, and reports spills and releases to regulatory agencies. A detailed description of the responsibilities assigned to the group and interactions with other PNNL organizations is provided in the internal *Pacific Northwest National Laboratory Effluent Management Quality Assurance Plan* (Barnett 2024). The ALARA principle is applied to effluent activities to minimize potential effects of emissions on the public and the environment.

### 5.1 Liquid Effluent Monitoring

Wastewater from the PNNL-Richland campus is discharged directly to the City of Richland's Publicly Owned Treatment Works. Wastewater discharges are regulated by the City of Richland under three industrial wastewater discharge permits (see Table 9). Waste streams regulated by these permits are reviewed by staff at PNNL and evaluated relative to compliance with the applicable permit prior to their discharge. Sampling, monitoring, and reporting of the wastewater discharges to the City of Richland's system are done as required in accordance with the permits.

Process wastewater from the PNNL-Sequim campus is discharged to an on-site treatment plant and then directly discharged to Sequim Bay under the authorization of Washington State Department of Ecology NPDES Permit No. WA0040649. This permit identifies effluent limitations and monitoring requirements for this facility. Monitoring data required by the NPDES permit for 2023 are listed in Table 20. All parameters met the NPDES permit effluent limitations. There were no regulated discharges from Outfall 007 during this time period.

Table 20 PNNL-Sequim Campus NPDES Monitoring Results for Outfall 008, 2023<sup>(a)</sup>

Parameter	Total Samples	Quantity Found Below Method Reporting Limit	Method Reporting Limit <sup>(b)</sup>	Maximum Value
Maximum flow (gpd)	NA	NA	NA	85,700.00
Copper (µg/L)	12	10	1.00	5.10
Lead (µg/L)	12	10	0.20	0.48
Zinc (µg/L)	12	12	20.00	< 20.00
pH <sup>(c)</sup>	12	12	NA	7.90

<sup>(a)</sup> There were no regulated discharges from Outfall 007 during this time period.

<sup>(b)</sup> The highest Method Reporting Limit reported for all months is listed.

<sup>(c)</sup> The current permit specifies pH limits of 6–9 standard units.

gpd = gallons per day

mg/L = milligrams per liter

NA = not applicable

µg/L = micrograms per liter

## 5.2 Air Effluent

While PNNL is not a large source of nonradiological air emissions, past and present emissions include greenhouse gases (e.g., tons of carbon dioxide-equivalent emissions), ozone-depleting substances (primarily refrigerants), hazardous air pollutants, and criteria air pollutants. The air effluent program does not monitor any stacks for nonradiological constituents, and compliance is assured by complying with regulatory standards for equipment and permit conditions.

Complying typically involves activities such as using clean fuels and monitoring fuel use, adhering to required operating hours for boilers and diesel engines, and following maintenance and operating requirements. Permit applications contain emission estimates based on vendor data (e.g., emission rate/hour), so monitoring of run time or fuel use is an acceptable method of determining permit compliance. In addition, reviews of research and facility construction/renovation projects are conducted to maintain compliance with all applicable requirements.



## 6.0 GROUNDWATER PROTECTION PROGRAM

PNNL-Richland and PNNL-Sequim campuses do not currently have any Washington State Department of Ecology requirements to monitor groundwater. PNNL is not required to have a Groundwater Protection Program.



## 7.0 QUALITY ASSURANCE

The PNNL QA Program is based on the requirements defined in DOE Order 414.1D, *Quality Assurance*, and [10 CFR Part 830](#), *Energy/Nuclear Safety Management, Subpart A*, “Quality Assurance Requirements.” PNNL has chosen to implement the following American Society of Mechanical Engineers (ASME) consensus standards in a graded approach:

- ASME NQA-1-2000, *Quality Assurance Requirements for Nuclear Facility Applications*, Part I, “Requirements for Quality Assurance Programs for Nuclear Facilities” (ASME 2001)
- ASME NQA-1-2000, Part II, Subpart 2.7, “Quality Assurance Requirements for Computer Software for Nuclear Facility Applications,” including problem reporting and corrective actions (ASME 2001)
- ASME NQA-1-2000, Part IV, Subpart 4.2, “Guidance on Graded Application of Quality Assurance (QA) for Nuclear-Related Research and Development” (ASME 2001).

An internal PNNL document, *Quality Assurance Program Description/Quality Management M&O Program Description*, describes the Laboratory-level QA program that applies to all work performed by PNNL. Laboratory-level procedures for implementing the QA requirements described in the standards identified above are deployed through PNNL’s web-based “How Do I...?” (HDI) system, a standards-based informational system for managing and deploying requirements and procedures to staff at PNNL.

To demonstrate compliance with the requirements, it is essential to implement a robust QA program capable of passing external audits. The basic components of a QA program depicted in Figure 20 may include various quality supporting documents, procedures, training, and assessments (Barnett 2011).



Figure 20. Components Basic to a Comprehensive QA Program (Barnett 2011)

## 7.1 Environmental Monitoring Program

Environmental sampling and monitoring were performed under PNNL's Environmental Management Program. These activities included sampling of water, wastewater, radiological air emissions, ambient air, and environmental dosimeters. Sampling is conducted by the EWTPG (formerly, the Effluent Management [EM] Group) or its delegates under the *Pacific Northwest National Laboratory Effluent Management Quality Assurance Plan*, EM-QA-01 (Barnett 2024).

The EM Quality Assurance Plan (QAP) has been developed to demonstrate how the EWTPG is meeting QA requirements specified in environmental regulations and permits; assist EM staff in identifying applicable requirements and procedures (i.e., workflows, work controls, or process lifecycles) that are delivered through the HDI standards-based management system; and to document the integration of quality into EM processes and activities. For further information about the quality requirements mentioned in this section, refer to the documents listed in Table 21.

The EM QAP addresses the requirements in DOE Order 414.1D and the guidance in EPA QA/R-5 (EPA 2001). The EM QAP is written in the same format as the DOE Order 414.1D, so that identical requirement sections align. Sections 1–10 of the document discuss each of the 10 criteria in the DOE Order and the applicable EM procedures and processes to meet the criteria.

The related quality requirements documents were approved by the PNNL QA organization that monitors compliance. Work performed through contracts or statements of work, including sample analyses, must meet the U.S. governmental agencies, state, and local regulations, as well as other technical and guidance regulations specified by the PNNL program or the project-specific procedure. Potential suppliers of items and services that could have an impact on quality (e.g., analytical services, calibration services, reference standard material providers) were closely evaluated before contracts were awarded.



Staff Member Maintaining an Air Sampling Station

PNNL’s Contracts and Acquisitions Department directly supports and follows DOE’s socioeconomic objectives. Acquisition Quality Support Services (AQSS), as an integral part of Contracts, provides staff to support acquisition activities. This service model appoints matrixed AQSS professionals to provide independent oversight while making sure that internal and external requirements are met.

Table 21. PNNL Effluent Management QA Requirements Documents

Document Titles
<i>Effluent Management Quality Assurance Plan (EM-QA-01)</i>
<i>Quality Requirements for Air Chemical Emissions Management</i>
<i>Quality Requirements for Facility Effluent Management Planning</i>
<i>Quality Requirements for Industrial Wastewater Discharge Permit Sampling and Monitoring for the PNNL Campus (CR-IU001), Environmental Molecular Sciences Laboratory (CR-IU005), Physical Sciences Facility (CR-IU011), and 300 Area (CR-IU010)</i>
<i>Quality Requirements for PNNL-Sequim Campus Sampling and Monitoring to National Pollutant Discharge Elimination System Permit WA0040649</i>
<i>Quality Requirements for Radioactive Air Emissions Sampling and Monitoring</i>
<i>Quality Requirements for Radioactive Air Environmental Surveillance Monitoring</i>
<i>Quality Requirements for Environmental Dose Assessment</i>

Radiological environmental air monitoring activities were determined using the DQO process described in *EPA Guidance on Systematic Planning Using the Data Quality Objectives Process* (EPA 2006) for operations on the PNNL-Richland campus (Snyder et al. 2017) and PNNL-Sequim campus (Snyder et al. 2019). The DQO process provides a standard working tool for

project managers and planners to develop DQOs for determining the type, quantity, and quality of data needed to reach defensible decisions or make credible estimates. Snyder et al. (2017, 2024a) determined and documented the environmental sampling and monitoring requirements necessary to comply with applicable regulations at the PNNL-Richland campus. As determined in the DQO process for the PNNL-Richland campus, PNNL has established an environmental surveillance program that samples particulate radionuclides in ambient air at strategic locations. The Environmental Management Plan (EMP; Snyder et al. 2020) with its attachments—*Sampling and Analysis Plan*, *Data Management Plan*, and *Dose Assessment Guidance*—documents the environmental radioactive air monitoring program.

PNNL-Richland Campus radioactive air emissions are permitted under RAEL-005, which was issued by the WDOH. PNNL-owned facilities in the 300 Area are also subject to the Hanford Site Air Operating Permit. Regulatory standards/bodies include NESHAP ([40 CFR Part 61, Subpart H](#) and [WAC 246-247](#)), [WAC 173-480](#), and Facility Use Agreements. Radiological air emissions are monitored by several different means, including the analysis of air filters; calculations of potential releases that are based on radioactive inventory using 40 CFR Part 61, Appendix D, calculations; and using the recorded releases documented in the PNNL Radioactive Gas Inventory database.

Environmental air surveillance and ambient external dose surveillance were performed at the five particulate air monitoring stations associated with the PNNL-Richland campus. The environmental air surveillance meets the requirements of the RAEL-005. The program also collects baseline ambient external dose levels at the perimeter and background sampling stations (Appendix C); the PNNL-Richland campus currently has no significant quantities of external dose contributors. Dose monitoring is done using aluminum oxide dosimeters read by optically stimulated luminescence.

Potential PNNL-Sequim campus radioactive air emissions are permitted under the current RAEL and compliance is demonstrated through calculated emission rates using 40 CFR Part 61, Appendix D, calculations. The renewed PNNL-Sequim campus license (RAEL-014, Renewal 2) approved in September 2022 went into effect on January 1, 2023, and is renewed every 5 years. This RAEL provides a permit for PNNL-Sequim campus radioactive air emissions as a single sitewide emission unit. The PNNL-Sequim campus DQO (Snyder et al. 2019) notes radioactive air emissions from operations at the campus do not require emission unit sampling or monitoring, or ambient surveillance under the RAEL-014, Renewal 1 nor Renewal 2. Snyder et al. (2019) recommended that baseline radioactive air background surveillance be performed. No baseline radioactive air background data are currently available for the PNNL-Sequim campus or for the local area. Determination of site radiation background for ambient external dose and for particulate gross alpha and gross beta in air is, therefore, recommended. It is suggested that this sampling be performed at on-site locations. Sampling is acceptable at on-site locations because of the historical and continued minimal radiological operations at the PNNL-Sequim campus.

Wastewater sampling and monitoring at the PNNL-Richland campus are performed to meet requirements in permits issued by the City of Richland for discharges to the sewer. At the PNNL-Sequim campus, water and wastewater sampling and monitoring are performed to comply with NPDES and Group A Drinking Water permits. QA requirements for these activities have been integrated into the EM QAP (Barnett 2024) and related QA documents (see Table 21), and include specific requirements such as sampling locations, quality objective criteria, analytical methods, and detection limits.

In lieu of monitoring, chemical air emissions are managed by complying with PNNL's air permits. Permits for nonradiological air emissions are issued by the BCAA for the PNNL-Richland campus and the ORCAA for the PNNL-Sequim campus. Applicable regulatory statutes include the CAA and NEPA. PNNL limits its chemical air emissions primarily by limiting the hours of operation, using ultralow sulfur diesel fuel when operating on diesel, and operating and maintaining PNNL combustion units (e.g., backup generators, boilers, water heaters) as described in the notice of construction application and in accordance with the manufacturer's emission-related instructions. Each research project or Facilities and Infrastructure Operations activity that has the potential to generate nonradiological air emissions is subject to an air emissions review to identify the compliance actions and administrative controls necessary to assure compliance with existing air permits.

## 7.2 Sample Collection Quality Assurance

Samples are collected by PNNL personnel trained to conduct environmental sampling according to approved and documented procedures. These procedures are based on standards, regulatory requirements, and guidance produced by NESHAP, EPA, WAC, WDOH, and the American National Standards Institute/Health Physics Society (ANSI/HPS). Sampling protocols include use of appropriate sampling methods and equipment, a defined sampling frequency, specified sampling locations, and procedures for sample handling (which may include storage, packaging, and shipping) to maintain sample integrity. Chain-of-custody processes are used to track the transfer of samples from the point of collection to the analytical laboratory. Requests for sample analysis are also a means of sample tracking and provide specific instructions for completing analyses of specific samples. QA program requirements in terms of sample receipt, handling, control, and identification of samples are integrated into the statement of work for subcontracted analytical laboratories.

Typically, samples are collected then analyzed in a laboratory. However, some water and wastewater samples are required to be analyzed in the field at the time of sample collection because of short holding time limits. These analyses (e.g., pH, temperature, and conductivity) are completed by staff at both the PNNL-Richland and PNNL-Sequim campuses using portable calibrated equipment (e.g., pH probe), approved standards, and controlled procedures based on EPA-approved methods or methods specified by the applicable regulatory agency.

## 7.3 Quality Assurance Analytical Results

Analyses are performed according to a statement of work or contract, which describes the activities necessary to assure that the analytical results are of high and verifiable quality. These activities include calibration and performance testing of analytical methods and equipment; implementing a QA program; maintaining analytical and support equipment and facilities; handling, protecting, and analyzing samples; checking data traceability, validity, and quality; recording all analytical data; participating in the analysis of performance evaluation programs; and communicating and reporting to the EWTPG. Each analytical data package is validated prior to using and reporting the data. Data packages include the analytical results of quality control (QC) samples/analysis, which help determine the adequacy of the entire analysis. These QA requirements, which are disseminated to subcontractors, may include the analyses of laboratory method blanks to evaluate sources of contamination, laboratory duplicates to evaluate method precision, laboratory control samples/blank spike samples, and sometimes matrix spikes and/or surrogates to assess accuracy. A description of these QC terms is

provided in Table 22. For cases where identified quality issues result in invalid data, the issues are documented and corrective actions are taken.

Table 22. QC Terms

QC Type	Description
Laboratory method blank	Control sample containing no analyte of interest; used to monitor for bias or contamination introduced during processing and analysis in the laboratory.
Duplicate	Field Duplicate: An additional sample collected as closely as possible to the same time and location, to measure sources of error from field sampling activities when compared to laboratory duplicate precision results. (PNNL does not sample field duplicates.)  Laboratory Duplicate: An additional aliquot or split sample from the same sample that is analyzed by the laboratory to measure analytical precision.
Matrix spike or surrogate samples	An aliquot of actual sample spiked with a known concentration of target analytes and processed in the same manner as the sample; used to determine the extent to which matrix bias or interferences affect the results when compared to a blank spike result. Instead of target analytes, surrogate analytes can be used. The surrogates are similar compounds that behave analytically like the target analyte in the specific analytical process.
Blank spike or reagent spike samples	A known concentration of target analytes added to the sample matrix prior to analysis. Blank or reagent spike samples are used to determine the accuracy associated with measuring a specific analyte by a specific method.
Laboratory control samples	A certified reference material or a prepared sample (created from an analyte-free sample matrix spiked with a known amount of analyte), which is carried through the preparation and analysis procedures to measure possible sources of preparation and measurement error.

The following laboratories conducted the analyses of environmental samples (i.e., stack air emissions, ambient air, water, wastewater, and environmental dosimeters) from the PNNL-Richland campus and PNNL-Sequim campus during 2023:

- Radiological air emission filter samples were analyzed by PNNL's Analytical Support Operations (ASO) laboratory located on the Hanford Site in the 325RPL Building.
- Ambient air filter samples were analyzed for radioactivity by General Engineering Laboratories (GEL), LLC, Charleston, South Carolina.
- Environmental dosimeters were read using optically stimulated luminescence technology by Landauer®, Glenwood, Illinois.

Water and wastewater samples were analyzed by the following organizations:

- ALS Environmental, Kelso, Washington
- Benton-Franklin Health District Laboratory, Kennewick, Washington
- Spectra Laboratories, Poulsbo, Washington.

Information about each laboratory is summarized below.

The ASO laboratory analyzed all airborne filter samples for radioactivity according to criteria in their statements of work and contracts. Analytical activities included use of daily calibration and verification QC samples (e.g., blanks, spiked samples, and sample duplicate pairs) and precision and accuracy targets that require the analysis method to meet quality performance limits. A blank and an instrument control sample were measured against known standards for each batch of routine samples analyzed for alpha and beta activity. In addition, a spiked sample and a blank were included with each batch of composite analysis samples and were analyzed for specific isotopes in addition to alpha and beta activity to assure QC. ASO's QAP, ASO-QAP-001, Rev. 11 (PNNL 2017), is guided by Nuclear Quality Assurance standard ASME NQA-1-

2000 requirements (ASME 2001), which direct the facility staff and management to maintain a high level of analytical testing rigor, giving special attention to radiological safety and environmental protection. ASO performs assessments that address analytical instrument maintenance, checking data traceability and validity, undergoing independent DOE performance testing, and communicating results to the client. Any corrective actions are addressed by the ASO quality engineer and laboratory management.

Landauer provided dosimetry services for ambient air external dose monitoring. Services included providing an aluminum oxide dosimeter in a waterproof pouch at the frequency requested by PNNL, reading the exposed dosimeter using optically stimulated luminescence technology, and providing dose results for the deployment period. Landauer provided two control dosimeters per shipment: the first to measure exposure during field deployment/retrieval activities and the second to measure exposure during shipment to and from the vendor. Control or background values were not subtracted from the PNNL-Richland campus value in Landauer-reported results, but these values are subtracted when dosimeter results are evaluated for reporting. The environmental dosimeter external dose reporting information is expected to follow the ANSI/HPS Standard N13.37-2014, Environmental Dosimetry—Criteria for System Design and Implementation (HPS 2019).

GEL analyzed all particulate air filters for radioactivity according to criteria in their statement of work. The analytical activities included use of calibration and verification QC samples (e.g., blanks, spiked samples, and sample duplicate pairs) with precision and accuracy targets that require that the analysis method meets quality performance QC limits. A blank sample was analyzed for each analytical batch analyzed for alpha and beta activity. In addition, each analytical batch reporting composite result included a blank, a duplicate, and a laboratory control sample. The integrity and validity of analytical test results are maintained by GEL through the implementation of an internal QC program, while meeting the requirements of 40 CFR Part 61 and the U.S. Department of Defense (DoD)/DOE Consolidated Quality Systems Manual 5.4 for Environmental Laboratories (DoD and DOE 2021).

ALS Environmental, Benton-Franklin Health District Laboratory, and Spectra Laboratories analyzed all water and wastewater samples from the PNNL-Richland and PNNL-Sequim campuses during 2023. All analytical laboratories are accredited by the Washington State Department of Ecology for the analysis of water and wastewater samples. To receive accreditation, a laboratory must implement a QAP, perform periodic proficiency testing, and undergo periodic inspection by the Washington State Department of Ecology to assure that it is operating within regulatory and QA requirements. Each time a laboratory is selected to perform analyses for PNNL, the PNNL AQSS Group evaluates whether the laboratory is either accredited or currently listed on PNNL's Evaluated Supplier List. ALS Environmental is also accredited by the National Environmental Laboratory Accreditation Conference Institute, which requires adherence to a uniform and robust laboratory program that has been implemented consistently nationwide. All wastewater and drinking water analyses are performed using approved CWA or SDWA methods specified by EPA in "Guidelines Establishing Test Procedures for the Analysis of Pollutants" (40 CFR Part 136) and "National Primary Drinking Water Regulations" (40 CFR Part 141). QA/QC requirements in the contract with PNNL for wastewater analyses include the measurement or assessment of sample accuracy, precision, reliability, representativeness, completeness, and comparability. Measurements are reviewed for each analytical data package to verify that the data are valid. Analytical methods, method detection limits, holding times, sample containers, and sample preservation laboratory activities must meet regulatory requirements and are verified for each sample collected.

## 7.4 Data Management and Calculations

QA is integrated into data management processes and calculations through the EM QAP and related QA documents, the EMP Data Management Plan, and staff procedures; parameters for dose calculations are documented as a component of the EMP. Software QA processes are used to verify the accuracy of databases used for analytical results.

Procedures identify the process for developing, testing, maintaining, and using spreadsheets to perform calculations that support or relate to a regulatory compliance, permit, or safety requirement; procedures also contain the basis for parameters and methods used in estimating environmental releases, as well as checklists used to verify and validate analytical results. For 2023, the processes for managing data and calculations were followed.

## 7.5 Interlaboratory Performance Programs

The biannual Mixed-Analyte Performance Evaluation Program (MAPEP) is a performance testing program managed by the Radiological and Environmental Sciences Laboratory (RESL) at Idaho National Laboratory. RESL is a government-owned and -operated DOE laboratory facility that provides unbiased technical DOE oversight to assure the quality and stability of analytical chemistry, radiation calibrations, and measurements. As a laboratory accredited by ISO/IEC (International Organization for Standardization/International Electrotechnical Commission) 17043, RESL complies with the requirements of DOE Order 414.1D, *Quality Assurance*; ISO 9001:2015, *Quality Management Systems – Requirements*; and ISO/IEC 17025:2017, *General Requirements for the Competence of Testing and Calibration Laboratories*. Each year, the MAPEP provides samples of environmental media for assessing air filters, water, soil, and vegetation, which contain specific amounts of one or more radionuclides unknown to the participating laboratory. After analysis, the results are evaluated against a stated reference value and acceptance range. For 2023, two studies—MAPEP-48 and MAPEP-49—were issued to participating laboratories; results are provided below.

GEL participated in both MAPEP-48 and MAPEP-49 performance evaluation studies, as well as Multimedia Radiochemistry Proficiency Testing (MRAD)-38 and MRAD-39 studies in 2023. MRAD is provided by ERA-Waters Corporation, which is also accredited to ISO 9001:2015 and ISO/IEC 17025:2017. For MAPEP-48, radiological filter results for gross alpha, gross beta, select gamma, and alpha spectroscopy results were all acceptable. For MAPEP-49, radiological filter results for gross beta, select gamma, and alpha spectroscopy results were acceptable or acceptable with warning (Zn-65 only); however, gross alpha was unacceptable with GEL issuing a Corrective Action Report. For both MRAD-38 and MRAD-39, radiological filter results for gross alpha, gross beta, select gamma, and select alpha spectroscopy sample results were all acceptable. The DOE Consolidated Audit Program Accreditation Body contractual auditing organization American Association for Laboratory Accreditation (A2LA) performed the analyte performance assessment per the requirements of the program for 2023. GEL maintained laboratory accreditation, which provides added confidence in the data reported by the laboratory. The latest certification, Certificate Number 2567.01, was originally authorized in June 2021, and prior to expiring on June 30, 2023, was reauthorized in June 2023 and expires in June 2025. GEL also maintained Laboratory Accreditation through the State of Washington for 2023 (Certificate Number: C780-22a, which expires November 25, 2023).

In 2023, the ASO 325RPL at PNNL participated in MAPEP-48 and MAPEP-49 testing studies. Table 23 shows the analytes of interest for reporting purposes, as well as ASO's proficiency

performance for the corresponding constituents. For MAPEP-48 and MAPEP-49, all submitted results were acceptable; however, Co-60 (MAPEP-48 only) and Pu-238 were unacceptable, with ASO issuing a Corrective Action. It should be noted that ASO's internal requirement is to have one acceptable result for the year, which is why there are certain instances of nonreporting. Any instance of a nonacceptable result or consecutive nonreporting is captured in a corrective action/occurrence report.

In addition to participating in performance testing, it should be noted that, on a periodic basis, the ASO laboratory is audited relative to requirements of the Hanford Analytical Services Quality Assurance Requirements Document (HASQARD) (DOE-RL 2014) to remain on the Hanford Evaluated Suppliers List; the most recent audit was performed in October 2021. ASO was also audited by PNNL's internal audit program using the HASQARD standard in November 2022.

**Table 23. Participating Laboratory MAPEP Performance and Analytes Summaries**

Analytes of Interest (Hanford and PNNL) <sup>(a)</sup>	ASO						GEL					
	MAPEP-49 (Aug 2023)	MAPEP-48 (Mar 2023)	MAPEP-47 (Aug 2022)	MAPEP-46 (Mar 2022)	MAPEP-45 (Aug 2021)	MAPEP-44 (Mar 2021)	MAPEP-49 (Aug 2023)	MAPEP-48 (Mar 2023)	MAPEP-47 (Aug 2022)	MAPEP-46 (Mar 2022)	MAPEP-45 (Aug 2021)	MAPEP-44 (Mar 2021)
Gross Alpha	NR	A	NR	A	N	NR	N	A	A	A	N	A
Gross Beta	NR	A	NR	A	A	NR	A	A	A	A	A	A
Am-241	A	A	NR	NR	A	NR	A	A	A	A	A	A
Co-60	N	A	NRPR	A	A	A	A	A	A	A	A	A
Cs-137	A	A	NRPR	A	A	A	A	A	A	A	A	A
Pu-238	N	N	A	NR	ND	NR	ND	A	A	A	A	A
Pu-239/240	A	A	A	NR	A	NR	A	A	A	A	A	A
Sr-90	A	NR	A	NRPR	A	A	A	A	A	A	W	A
U-233/234	NR	A	A	N	A	NR	A	A	A	A	A	A

A = Acceptable; N = Not Acceptable; W = Acceptable with Warning; NR = Not Reported; ND = Not Detected; NRPR = Not Reported Previously Reported

<sup>(a)</sup> MAPEP does not include analytes of interest Al-26, Am-243, Cm-243/244, Pu-241, and Th-229 for Proficiency Testing.

Note: ASO also reports select MAPEP filter analytes that are not target Hanford/PNNL analytes of interest: Co-57, Mn-54, U-234, U-238, and Zinc-65.

The requirements for interlaboratory performance do not apply to dosimetry.

Participation in interlaboratory performance programs for the analysis of water and wastewater samples is not required pursuant to permits issued under the SDWA or CWA. PNNL considers the following standards in review of commercial analytical laboratories for use: ISO/IEC Standard 17025 and Standard 17043. ISO/IEC 17025 provides guidance for testing and calibration laboratories. Standard 17043 provides the general requirements for proficiency testing. ALS Environmental (Kelso, Washington), Benton-Franklin Health District Laboratory (Kennewick, Washington), and Spectra Laboratories (Poulsbo, Washington) are evaluated suppliers and use an ISO/IEC 17043 accredited proficiency testing company.

ALS Environmental is an accredited laboratory ([WAC 173-50](#)) certified by the Washington State Department of Ecology. The laboratory's certification (Accreditation ID: C544-23b) was updated July 9, 2023, and expires July 8, 2024, at which time the scope of their accreditation will be reevaluated. ALS also was accredited by Perry Johnson Laboratory Accreditation, Inc., as being certified to the ISO/IEC 17025:2017 standard, the DoD Environmental Laboratory Accreditation Program for ISO/IEC 17025:2017, and the DoD Quality Systems Manual Version 5.4 on July 11, 2022; this accreditation expires July 11, 2024. Spectra Labs and the Benton-Franklin Health District Laboratory are also accredited by the Washington State Department of Ecology to [WAC 173-50](#) and [WAC 246-290](#) criteria. These accreditations are renewed annually. Spectra Labs

accreditation (Accreditation ID: C594-23a) was revised September 28, 2023, and expires September 27, 2024, and the Benton-Franklin Health District accreditation (Accreditation ID: H408-23) was revised August 24, 2023, and expires August 23, 2024.

## References

- [10 CFR Part 820](#). "Procedural Rules for DOE Nuclear Activities." *Code of Federal Regulations*, U.S. Department of Energy, Washington, DC.
- [10 CFR Part 830](#). "Nuclear Safety Management." *Code of Federal Regulations*, U.S. Department of Energy, Washington, DC.
- [10 CFR Part 830, Subpart A](#). "Quality Assurance Requirements." *Code of Federal Regulations*, U.S. Department of Energy, Washington, DC.
- [10 CFR Part 835](#). "Occupational Radiation Protection." *Code of Federal Regulations*, U.S. Department of Energy, Washington, DC.
- [10 CFR Part 1021, Appendix D](#). "Classes of Actions that Normally Require EISs." *Code of Federal Regulations*, U.S. Department of Energy, Washington, DC.
- [33 CFR Part 66](#). "Private Aids to Navigation." *Code of Federal Regulations*, U.S. Coast Guard, Washington, DC.
- [36 CFR](#). "Parks, Forests, and Public Property." *Code of Federal Regulations*. U.S. Forest Service. Washington, DC.
- [36 CFR Part 251](#). "Land Uses." *Code of Federal Regulations*, U.S. Forest Service. Washington, DC.
- [40 CFR Part 52](#). "Approval and Promulgation of Implementation Plans." *Code of Federal Regulations*, U.S. Environmental Protection Agency, Washington, DC.
- [40 CFR Part 60](#). "Standards of Performance for New Stationary Sources." *Code of Federal Regulations*, U.S. Environmental Protection Agency, Washington, DC.
- [40 CFR Part 61](#). "Protection of the Environment/National Emission Standards for Hazardous Air Pollutants (NESHAP)." *Code of Federal Regulations*, U.S. Environmental Protection Agency, Washington, DC.
- [40 CFR Part 61, Appendix D](#). "Methods for Estimating Radionuclide Emissions." *Code of Federal Regulations*, U.S. Environmental Protection Agency, Washington, DC.
- [40 CFR Part 61, Appendix E](#). "Compliance Procedures Methods for Determining Compliance with Subpart I." *Code of Federal Regulations*, U.S. Environmental Protection Agency, Washington, DC.
- [40 CFR Part 61, Subpart H](#). "National Emission Standards for Emissions of Radionuclides Other Than Radon From Department of Energy Facilities." *Code of Federal Regulations*, U.S. Environmental Protection Agency, Washington, DC.
- [40 CFR Part 63](#). "National Emissions Standards for Hazardous Air Pollutants for Source Categories." *Code of Federal Regulations*, U.S. Environmental Protection Agency, Washington, DC.
- [40 CFR Part 68](#). "Chemical Accident Prevention Provisions." *Code of Federal Regulations*, U.S. Environmental Protection Agency, Washington, DC.
- [40 CFR Part 82](#). "Protection of Stratospheric Ozone." *Code of Federal Regulations*, U.S. Environmental Protection Agency, Washington, DC.
- [40 CFR Part 98](#). "Mandatory Greenhouse Gas Reporting." *Code of Federal Regulations*, U.S. Environmental Protection Agency, Washington, DC.
- [40 CFR Part 136](#). "Guidelines Establishing Test Procedures for the Analysis of Pollutants." *Code of Federal Regulations*, U.S. Environmental Protection Agency, Washington, DC.
- [40 CFR Part 141](#). "National Primary Drinking Water Regulations." *Code of Federal Regulations*, U.S. Environmental Protection Agency, Washington, DC.

[40 CFR Part 302.8](#). “Continuous Releases.” *Code of Federal Regulations*, U.S. Environmental Protection Agency, Washington, DC.

[40 CFR Part 355](#). “Emergency Planning and Notification.” *Code of Federal Regulations*, U.S. Environmental Protection Agency, Washington, DC.

[40 CFR Part 370](#). “Hazardous Chemical Reporting: Community Right-To-Know.” *Code of Federal Regulations*, U.S. Environmental Protection Agency, Washington, DC.

[40 CFR Part 372](#). “Toxic Chemical Release Reporting: Community Right-To-Know.” *Code of Federal Regulations*, U.S. Environmental Protection Agency, Washington, DC.

[40 CFR Part 761](#). “Polychlorinated Biphenyls (PCBs) Manufacturing, Processing, Distribution in Commerce, and Use Prohibitions.” *Code of Federal Regulations*, U.S. Environmental Protection Agency, Washington, DC.

[50 CFR](#). “Wildlife and Fisheries.” *Code of Federal Regulations*, U.S. Fish and Wildlife Service and National Marine Fisheries Service, Washington, DC.

[50 CFR 226.212](#). “Critical habitat for 15 Distinct Population Segments (DPSs) of Salmon and Steelhead (*Oncorhynchus* spp.) in Washington, Oregon and Idaho.” *Code of Federal Regulations*, U.S. Fish and Wildlife Service and National Marine Fisheries Service, Washington, DC.

[42 FR 26951](#). May 25, 1977. Executive Order 11988 of May 24, 1977: “Floodplain Management.” *Federal Register*, Office of the President, Washington, DC.

[42 FR 26961](#). May 25, 1977. Executive Order 11990 of May 24, 1977: “Protection of Wetlands.” *Federal Register*, Office of the President, Washington, DC.

[52 FR 2923](#). January 29, 1987. Executive Order 12580 of January 23, 1987: “Superfund Implementation.” *Federal Register*, Office of the President, Washington, DC.

[64 FR 6183](#). February 8, 1999. Executive Order 13112 of February 3, 1999: “Invasive Species.” *Federal Register*, Office of the President, Washington, DC.

[66 FR 3853](#). January 17, 2001. Executive Order 13186 of January 10, 2001: “Responsibilities of Federal Agencies to Protect Migratory Birds.” *Federal Register*, Office of the President, Washington, DC.

[70 FR 52630](#). September 2, 2005. “Endangered and Threatened Species; Designation of Critical Habitat for 12 Evolutionarily Significant Units of West Coast Salmon and Steelhead in Washington, Oregon, and Idaho; Final Rule.” *Federal Register*, National Oceanic and Atmospheric Administration, Washington, DC.

[75 FR 63898](#). October 18, 2010. “Endangered and Threatened Wildlife and Plants; Revised Designation of Critical Habitat for Bull Trout in the Coterminous United States.” Final Rule, *Federal Register*, Fish and Wildlife Service, Washington, DC.

[79 FR 68042](#). November 13, 2014. “Endangered and Threatened Species; Designation of Critical Habitat for the Puget Sound/Georgia Basin Distinct Population Segments of Yelloweye Rockfish, Canary Rockfish and Bocaccio.” Final Rule, *Federal Register*, National Marine Fisheries Service, Washington, DC.

[81 FR 88609](#). December 8, 2016. Executive Order 13751 of December 5, 2016: “Safeguarding the Nation from the Impacts of Invasive Species.” *Federal Register*, Office of the President, Washington, DC.

[83 FR 23771](#). May 22, 2018. Executive Order 13834 of May 17, 2018, “Efficient Federal Operations.” *Federal Register*, Office of the President, Washington, DC.

[85 FR 43304](#). July 16, 2020. “Update to the Regulations Implementing the Procedural Provisions of the National Environmental Policy Act.” Final Rule, *Federal Register*, Council on Environmental Quality, Washington, DC.

[86 FR 7037](#). January 20, 2021. Executive Order 13990 of January 20, 2021, “Protecting Public Health and the Environment and Restoring Science to Tackle the Climate Crisis.” Final Rule, *Federal Register*, Presidential Documents, Washington, DC.

[86 FR 7619](#). February 1, 2021. Executive Order 14008 of January 27, 2021, “Tackling the Climate Crisis at Home and Abroad.” *Federal Register*, Office of the President, Washington, DC.

[86 FR 54642](#). October 4, 2021. Regulations Governing Take of Migratory Birds; Revocation of Provisions. U.S. Fish and Wildlife Service, Washington, DC.

[86 FR 70935](#) of December 13, 2021. “Executive Order 14057 of December 13, 2021, “Catalyzing Clean Energy and Industries and Jobs Through Federal Sustainability” Final Rule, *Federal Register*, Office of the President, Washington, DC.

[87 FR 23453](#). May 20, 2022. “National Environmental Policy Act Implementing Regulations Revisions.” Final Rule, *Federal Register*, Council on Environmental Quality, Washington, DC.

Ackerman R, KC Reid, JD Gallison, and ME Roe. 1985. *Archaeology of Heceta Island: A Survey of 16 Timber Harvest Units in the Tongass National Forest, Southern Alaska*. Center for Northwest Archaeology, Washington State University, Pullman, WA.

American Innovation and Manufacturing (AIM) Act. Section 103 of HR 133 Consolidated Appropriations Act of 2021. Accessed July 1, 2022, at <https://www.epa.gov/climate-hfcs-reduction/aim-act>.

[AS 16.05.871](#). 2023 “Alaska State Anadromous Fish Act.” *Alaska Statutes*, Juneau, AK.

ASME (American Society of Mechanical Engineers). 2001. *Quality Assurance Requirements for Nuclear Facility Applications*. ASME NQA-1-2000, New York, NY.

*Atomic Energy Act of 1954*. Chapter 724, 60 Stat. 755, 42 U.S.C. § 2011 *et seq.* Accessed June 30, 2022, at <https://www.gpo.gov/fdsys/pkg/USCODE-2015-title42/pdf/USCODE-2015-title42-chap23-divsnA.pdf>.

*Bald and Golden Eagle Protection Act*. Public Law 87-884, as amended, 16 U.S.C. § 688 *et seq.* Accessed June 30, 2022, at <https://www.fws.gov/birds/policies-and-regulations/laws-legislations/bald-and-golden-eagle-protection-act.php>.

Barnett JM. 2011. *Concepts for Environmental Radioactive Air Sampling and Monitoring*. In: EO Ekundayo, ed., *Environmental Monitoring*, ISBN 979-953-307-295-0. Rejeka, Croatia: InTech; 263-282. DOI: 10.5772/28533. Accessed June 15, 2023, at <http://www.intechopen.com/books/environmental-monitoring/concepts-for-environmental-radioactive-air-sampling-and-monitoring>.

Barnett JM. 2018. *Pacific Northwest National Laboratory Potential Impact Categories for Radiological Air Emission Monitoring*. PNNL-19904, Revision 5, Pacific Northwest National Laboratory, Richland, WA. Accessed June 30, 2022, at [https://www.pnnl.gov/main/publications/external/technical\\_reports/PNNL-19904Rev.5.pdf](https://www.pnnl.gov/main/publications/external/technical_reports/PNNL-19904Rev.5.pdf).

Barnett JM. 2024. *Pacific Northwest National Laboratory Effluent Management Quality Assurance Plan*. EM-QA-01, Revision 12, Pacific Northwest National Laboratory, Richland, WA.

Barnett JM, KM Meier, SF Snyder, EJ Antonio, BG Fritz, and TM Poston. 2012a. *Data Quality Objectives Supporting Radiological Air Emissions Monitoring for the Marine Sciences Laboratory, Sequim Site*. PNNL-22111, Pacific Northwest National Laboratory, Richland, WA. Accessed June 30, 2022, at [http://www.pnnl.gov/main/publications/external/technical\\_reports/PNNL-22111.pdf](http://www.pnnl.gov/main/publications/external/technical_reports/PNNL-22111.pdf).

Barnett JM, KM Meier, SF Snyder, BG Fritz, TM Poston, and EJ Antonio. 2012b. *Data Quality Objectives Supporting Radiological Air Emissions Monitoring for the PNNL Site*. PNNL-19427, Revision 1, Pacific Northwest National Laboratory, Richland, WA. Accessed June 30, 2022, at [http://www.pnnl.gov/main/publications/external/technical\\_reports/PNNL-19427rev1.pdf](http://www.pnnl.gov/main/publications/external/technical_reports/PNNL-19427rev1.pdf).

Battelle-Northwest. 1967. “Architect Selected for Sequim.” *Staff Bulletin*, Volume IV, Number 2, May 22, 1967. Richland, WA.

BCAA (Benton Clean Air Agency). 2021. “Regulation 1 of the Benton Clean Air Agency.” Kennewick, WA. Accessed July 1, 2024, at <https://bentoncleanair.org/air-quality/regulation-fees>.

Brownell D. 2018. *A Glimpse of Sxʷčkwíyən, A S'Klallam Village at Washington Harbor*. Blyn, WA.

- Cannon A. 1991. *The Economic Prehistory of Namu*. Archaeology Press, Simon Fraser University, Burnaby, BC.
- CCR (California Code of Regulations). 2020. "Permit Jurisdiction," [14 CCR § 13050.5](#). Sacramento, CA.
- CEQ (Council on Environmental Quality). 2020. *Guiding Principles for Sustainable Federal Buildings and Associated Instructions*. Washington, DC. Accessed June 30, 2022, at [https://www.sustainability.gov/pdfs/guiding\\_principles\\_for\\_sustainable\\_federal\\_buildings.pdf](https://www.sustainability.gov/pdfs/guiding_principles_for_sustainable_federal_buildings.pdf).
- Clallam County. 2018. "Shoreline Master Program (SMP) Maps, Exhibit A: Draft Clallam County Shoreline Environmental Designation Maps, 03 Sequim Bay North, Gibson & Travis Spit Vicinity." Accessed at <https://www.clallamcountywa.gov/DocumentCenter/View/5805/03-Sequim-Bay-North-Gibson-and-Travis-Spit-Vicinity-PDF>.
- Clean Air Act*. Public Law 88-206, as amended, 42 U.S.C. § 7401 *et seq.* Accessed June 30, 2022, at <http://www.epa.gov/air/caa/>.
- Clean Air Act Amendments of 1990*. Public Law 101-549, as amended, 42 U.S.C. § 7401 *et seq.* Accessed June 30, 2022, at <https://www.epa.gov/clean-air-act-overview/clean-air-act-highlights-1990-amendments>.
- Clean Water Act*. Public Law 95-217, as amended, 33 U.S.C. § 1251 *et seq.* Accessed June 30, 2023, at <https://www.epa.gov/laws-regulations/summary-clean-water-act>.
- Coastal Zone Management Act of 1972*. Public Law 89-454, Title III, as amended, 16 U.S.C. § 1451 *et seq.*
- Coastal Zone Act Reauthorization Amendments of 1990*. Public Law 101-508, Title VI, Subtitle C § 6201 *et seq.*, 104 Stat. 1388–299.
- Comprehensive Environmental Response, Compensation, and Liability Act of 1980* (CERCLA). Public Law 96-510, as amended, 42 U.S.C. § 9601 *et seq.* Accessed June 30, 2022, at <https://www.gpo.gov/fdsys/pkg/USCODE-2015-title42/pdf/USCODE-2015-title42-chap103.pdf>.
- Croes D. 1989. "Prehistoric Ethnicity on the Northwest Coast of North America: An Evaluation of Style in Basketry and Lithics." *Journal of Anthropological Archaeology* 8:101–130.
- DoD and DOE (U.S. Department of Defense and U.S. Department of Energy). 2021. *DoD/DOE Consolidated Quality Systems Manual for Environmental Laboratories*. DoD Quality Systems Manual Version 5.4, Washington, DC. Accessed July 2, 2024, at <https://www.denix.osd.mil/edqw/denix-files/sites/43/2021/10/QSM-Version-5.4-FINAL.pdf>.
- DOE (U.S. Department of Energy). 2019. *A Graded Approach for Evaluating Radiation Doses to Aquatic and Terrestrial Biota*. DOE-STD-1153-2019, U.S. Department of Energy, Washington, DC. Accessed June 30, 2022, at <https://www.standards.doe.gov/standards-documents/1100/1153-astd-2019/@images/file>.
- DOE (U.S. Department of Energy). 2022a. *Environmental Radiological Effluent Monitoring and Environmental Surveillance*. DOE-HDBK-1216-2015 Chg Notice 1 (Reaffirmed 2022), U.S. Department of Energy, Washington, DC. Accessed April 4, 2023, at <https://www.standards.doe.gov/standards-documents/1200/1216-hdbk-2015-cn1-2022-reaff-2022>.
- DOE (U.S. Department of Energy). 2022b. *Initial Assessment of Per- and Polyfluoroalkyl Substances at Department of Energy Sites*. U.S. Department of Energy, Washington, DC. Accessed June 6, 2024, at <https://www.energy.gov/sites/default/files/2022-11/DOE%20Initial%20PFAS%20Assessment%20-508.pdf>.
- DOE (U.S. Department of Energy). 2022c. "Met and Climate Data Summary Products." Richland, WA. Accessed June 30, 2022, at <http://www.hanford.gov/page.cfm/MetandClimateDataSummary>.
- DOE (U.S. Department of Energy). 2022d. *PFAS Strategic Roadmap: DOE Commitments to Action 2022-2025*. U.S. Department of Energy, Washington, DC. Accessed June 6, 2024, at <https://www.energy.gov/sites/default/files/2022-08/DOE%20PFAS%20Roadmap%20August%202022.pdf>.

DOE and USFWS (U.S. Department of Energy and U.S. Fish and Wildlife Service). 2013. Memorandum of Understanding between the United States Department of Energy and the United States Fish and Wildlife Service Regarding Implementation of Executive Order 13186, "Responsibilities of Federal Agencies to Protect Migratory Birds." Washington, DC. Accessed June 30, 2022, at <http://energy.gov/sites/prod/files/2013/10/f3/Final%20DOE-FWS%20Migratory%20Bird%20MOU.pdf>.

DOE Order 231.1B, Admin Chg 1. 2012. *Environment, Safety and Health Reporting*. U.S. Department of Energy, Washington, DC. Accessed June 30, 2022, at <https://www.directives.doe.gov/directives-documents/200-series/0231.1-BOrder-b-admchg1/@@download/file>.

DOE Order 232.2A Chg 1 (MinChg). 2019. *Occurrence Reporting and Processing of Operations Information*. U.S. Department of Energy, Washington, DC. Accessed June 30, 2022, at <https://www.directives.doe.gov/directives-documents/200-series/0232.2-BOrder-a-chg1-minchg>.

DOE Order 414.1D Admin Chg 2 (LtdChg). 2020. *Quality Assurance*. U.S. Department of Energy, Washington, DC. Accessed June 30, 2022, at <https://www.directives.doe.gov/directives-documents/400-series/0414.1-BOrder-d-chg2-ltdchg>.

DOE Order 435.1, Chg 2 (AdminChg). 2021. *Radioactive Waste Management*. U.S. Department of Energy, Washington, DC. Accessed July 2, 2024, at <https://www.directives.doe.gov/directives-documents/400-series/0435.1-BOrder-chg2-AdminChg>.

DOE Order 436.1. 2011. *Departmental Sustainability*. U.S. Department of Energy, Washington, DC. Accessed July 1, 2024, at <https://www.directives.doe.gov/directives-documents/400-series/0436.1-BOrder>.

DOE Order 436.1A. 2023. *Departmental Sustainability*. U.S. Department of Energy, Washington, DC. Accessed July 1, 2024, at <https://www.directives.doe.gov/directives-documents/400-series/0436.1-BOrder-a>.

DOE Order 440.1B, Chg 3. 2020. *Worker Protection Program for DOE (Including the National Nuclear Security Administration) Federal Employees*. U.S. Department of Energy, Washington, DC. Accessed June 30, 2022, at <https://www.directives.doe.gov/directives-documents/400-series/0440.1-BOrder-b-chg3-ltdchg>.

DOE Order 458.1 Chg 4 (LtdChg). 2021. *Radiation Protection of the Public and the Environment*. U.S. Department of Energy, Office of Health, Safety and Security, Washington, DC. Accessed June 7, 2022, at <https://www.directives.doe.gov/directives-documents/400-series/0458.1-border-chg4-ltdchg>.

DOE-PNSO (U.S. Department of Energy Pacific Northwest Site Office). 2007. Memorandum from RM Kilbury to M Kluse, dated June 18, 2007, regarding "Approval of Application for Authorized Limits for the Release of Small Volume Laboratory Liquid Samples from Radiological Control." Richland, WA.

DOE-PNSO (U.S. Department of Energy Pacific Northwest Site Office). 2018. "Memorandum of Agreement Between the U.S. Department of Energy Pacific Northwest Site Office, The Washington State Historic Preservation Officer, the Confederated Tribes and Bands of the Yakama Nation, the Confederated Tribes of the Umatilla Indian Reservation, the Nez Perce Tribe, and the Wanapum Band, Regarding the Adverse Effect of the Pacific Northwest National Laboratory Richland Campus Future Development on the Yakama Nation Traditional Cultural Property, the Wanapum Band Traditional Cultural Property, and the Preservation Designated Area (45BN1426)." Richland, WA.

DOE-PNSO (U.S. Department of Energy Pacific Northwest Site Office). 2021a. *Pacific Northwest Site Office Cultural and Biological Resources Management Plan*. PNSO-PLAN-09, Revision 4. Richland, WA.

DOE-PNSO (U.S. Department of Energy Pacific Northwest Site Office). 2021b "Memorandum of Agreement Among the U.S. Department of Energy Pacific Northwest Site Office, the Washington State Historic Preservation Officer, and The Jamestown S'Klallam Tribe, Regarding the Adverse Effect of the Pacific Northwest National Laboratory Sequim Campus Future Development." Richland, WA.

DOE-PNSO (U.S. Department of Energy Pacific Northwest Site Office). 2022. *Pacific Northwest National Laboratory-Sequim Campus Future Development*. DOE/EA-2130, Environmental Assessment, Richland, WA. Accessed June 4, 2024, at [https://science.osti.gov/-/media/ssp/pdf/nepa-documents/ea-eis/pnso/2023/Final\\_Signed\\_PNNL\\_Sequim\\_Campus\\_Future\\_Development\\_EA\\_and\\_FONSI\\_12-27-2022.pdf](https://science.osti.gov/-/media/ssp/pdf/nepa-documents/ea-eis/pnso/2023/Final_Signed_PNNL_Sequim_Campus_Future_Development_EA_and_FONSI_12-27-2022.pdf).

DOE-PNSO (U.S. Department of Energy Pacific Northwest Site Office). 2024. "DOE-Battelle Prime Contract for the Management and Operation of Pacific Northwest National Laboratory, DE-AC05-76RL01830." Richland, WA. Accessed June 18, 2024, at <http://doeprimecontract.pnnl.gov/>.

DOE Policy 141.1. 2011. "Department of Energy Management of Cultural Resources." U.S. Department of Energy, Washington, DC. Accessed June 30, 2022, at <https://www.directives.doe.gov/directives-documents/100-series/0141.1-APolicy/@images/file>.

DOE-RL (U.S. Department of Energy Richland Operations Office). 2001. Memorandum from JK Erickson to LJ Powell, dated February 21, 2001, regarding "Approval of Application for Authorized Limits for the Release of Small Volume Laboratory Liquid Samples from Radiological Control." Richland, WA.

DOE-RL (U.S. Department of Energy Richland Operations Office). 2002. *Standardized Stratigraphic Nomenclature for the Post-Ringold-Formation Sediments Within the Central Pasco Basin*. DOE/RL-2002-39, Revision 0, Richland, WA. Accessed June 30, 2022, at <https://pdw.hanford.gov/document/0081471H>.

DOE-RL (U.S. Department of Energy Richland Operations Office). 2014. Hanford Analytical Services Quality Assurance Requirements Document. DOE/RL-96-68, Revision 4, Richland, WA.

DOE-RL (U.S. Department of Energy Richland Operations Office). 2020. *Hanford Site Groundwater Monitoring Report for 2019*. DOE/RL-2019-66, Revision 0, Richland, WA. Accessed June 30, 2022, at [https://www.hanford.gov/files.cfm/DOE-RL-2019-66\\_R0\\_Clean.pdf](https://www.hanford.gov/files.cfm/DOE-RL-2019-66_R0_Clean.pdf).

DOE-RL (U.S. Department of Energy Richland Operations Office). 2024a. *Calendar Year 2023 Hanford Land Disposal Summary Report*, DOE/RL-2024-15, Revision 0, Richland, WA. Accessed May 21, 2024.

DOE-RL (U.S. Department of Energy Richland Operations Office). 2024b. *Hanford Site RCRA Groundwater Monitoring Report for 2023*. DOE/RL-2023-53, Revision 0, Richland, WA. Accessed May 23, 2024, at [https://www.hanford.gov/files.cfm/DOE-RL-2023-53\\_R0\\_Combined\\_clean.pdf](https://www.hanford.gov/files.cfm/DOE-RL-2023-53_R0_Combined_clean.pdf).

Duncan JP, ed. 2007. *Hanford Site National Environmental Policy Act (NEPA) Characterization*. PNL-6415, Revision 18. Pacific Northwest National Laboratory, Richland, WA. Accessed June 30, 2022, at [http://www.pnnl.gov/main/publications/external/technical\\_reports/PNNL-6415Rev18.pdf](http://www.pnnl.gov/main/publications/external/technical_reports/PNNL-6415Rev18.pdf).

Duncan JP, JM Becker, JM Barnett, TW Moon, WC Weaver, KD Hand, LY Renaud, RA Del Mar, MD Ellefson, LE Bisping, JA Stephens, MA Aranda, EA Raney, CJ Duchsherer. 2021. *Pacific Northwest National Laboratory Annual Site Environmental Report for Calendar Year 2020*, PNNL-31853, Pacific Northwest National Laboratory Richland, WA. Accessed May 23, 2024, at [https://science.osti.gov/-/media/pnso/pdf/resources/ATT\\_PNNL\\_ASER\\_CY20.pdf](https://science.osti.gov/-/media/pnso/pdf/resources/ATT_PNNL_ASER_CY20.pdf).

Ecology (Washington State Department of Ecology). 2019. *Stormwater Management Manual for Eastern Washington*. Olympia, WA. Accessed July 9, 2024, at <https://fortress.wa.gov/ecy/ezshare/wq/Permits/Flare/2019SWMMEW/2019SWMMEW.htm>.

Ecology (Washington State Department of Ecology). 2021. "Shoreline Master Programs." Olympia, WA. Accessed May 31, 2022, at <https://ecology.wa.gov/Water-Shorelines/Shoreline-coastal-management/Shoreline-coastal-planning/Shoreline-Master-Programs>.

Ecology (Washington State Department of Ecology). 2022. 325 Hazardous Waste Treatment Units Operating Unit Group 5 (OUG-5), Olympia, WA. Accessed June 7, 2022, at [https://fortress.wa.gov/ecy/nwp/permitting/hdwp/rev/8c/325-HWTU/325\\_HWTU.html](https://fortress.wa.gov/ecy/nwp/permitting/hdwp/rev/8c/325-HWTU/325_HWTU.html).

Ecology, EPA, and DOE (Washington State Department of Ecology, U.S. Environmental Protection Agency, and U.S. Department of Energy). 1989. *Hanford Federal Facility Agreement and Consent Order*. Document No. 89-10, as amended, Washington State Department of Ecology, U.S. Environmental Protection Agency, and U.S. Department of Energy, Olympia, WA. Accessed June 30, 2022, at <http://www.hanford.gov/?page=81>.

Ellefson MD. 2023. *Radioactive Waste Management Basis, Revision 7*. Pacific Northwest National Laboratory, Richland, WA.

Elwell LC and S Phillips, editors. 2016. *Uniform Minimum Protocols and Standards for Watercraft Inspection and Decontamination Programs for Dreissenid Mussels in the Western United States (UMPS III)*. Pacific States Marine Fisheries Commission, Portland, OR. Accessed July 29, 2022, at <https://invasivemusselcollaborative.net/wp-content/uploads/2018/11/UMPS-III-7-14-2016.pdf>.

*Emergency Planning and Community Right-to-Know Act of 1986*. Public Law 99-499, as amended, 42 U.S.C. 11001 *et seq.* Accessed June 30, 2022, at <http://www.gpo.gov/fdsys/pkg/USCODE-2010-title42/html/USCODE-2010-title42-chap116.htm>.

*Endangered Species Act of 1973*. Public Law 100-478, as amended, 16 U.S.C. § 1531 *et seq.* Accessed June 30, 2022, at <https://www.gpo.gov/fdsys/pkg/USCODE-2015-title16/pdf/USCODE-2015-title16-chap35.pdf>.

*Energy Independence and Security Act of 2007 (EISA)*. Public Law 110-140, 121 Stat. 1492, 42 U.S.C. § 17001.

Energy Northwest. 2011. "Site Characteristics." Chapter 2 in *Columbia Generating Station Final Safety Analysis Report*. Amendment 61, Richland, WA. Accessed June 30, 2022, at <https://adamswebsearch2.nrc.gov/webSearch2/main.jsp?AccessionNumber=ML12011A153>.

EPA (U.S. Environmental Protection Agency). 1989. *User's Guide for the COMPLY Code*. EPA 520/1-89-003, Revision 2, (Applicable to COMPLY v1.7.1 [2017]) Office of Radiation and Indoor Air, Washington, DC. Accessed May 21, 2024, <https://www.epa.gov/radiation/users-guide-comply-code-revision-2>.

EPA (U.S. Environmental Protection Agency). 2001. *EPA Requirements for Quality Assurance Project Plans*. EPA QA/R-5, EPA/240/B-01/003, Washington, DC. Accessed June 30, 2023, at [https://www.epa.gov/sites/production/files/2016-06/documents/r5-final\\_0.pdf](https://www.epa.gov/sites/production/files/2016-06/documents/r5-final_0.pdf).

EPA (U.S. Environmental Protection Agency). 2006. *Guidance on Systematic Planning Using the Data Quality Objective Process (EPA QA/G-4)*. EPA/240/B-06/001, Office of Environmental Information, Washington, DC. Accessed June 30, 2022, at <https://www.epa.gov/quality/guidance-systematic-planning-using-data-quality-objectives-process-epa-qag-4>.

EPA (U.S. Environmental Protection Agency). 2013. *Primary Distinguishing Characteristics of Level III Ecoregions of the Continental United States (September 2013)*. Washington, DC. Accessed June 30, 2022, at [https://gaftp.epa.gov/EPADDataCommons/ORD/Ecoregions/us/Eco\\_Level\\_III\\_descriptions.doc](https://gaftp.epa.gov/EPADDataCommons/ORD/Ecoregions/us/Eco_Level_III_descriptions.doc).

EPA and DOE-RL (U.S. Environmental Protection Agency and U.S. Department of Energy Richland Operations Office). 2013. *Hanford Site 300 Area Record of Decision for 300-FF-2 and 300-FF-5, and Record of Decision Amendment for 300-FF-1*. Accessed June 30, 2022, at <https://pdw.hanford.gov/document/0087180?>.

Fagan BM. 2001. *Ancient North America: The Archaeology of a Continent*. Thames & Hudson, New York, New York.

*Federal Facility Compliance Act of 1992*. Public Law 102-386, as amended, 106 Stat. 1505 *et seq.*, 42 U.S.C. 6939c and 6961. Accessed June 30, 2022, at [http://www.labtrain.noaa.gov/ppguide/ffpp\\_55.htm](http://www.labtrain.noaa.gov/ppguide/ffpp_55.htm).

*Federal Insecticide, Fungicide, and Rodenticide Act*. 1975. Public Law 94-51, as amended, 7 U.S.C. § 136 *et seq.* Accessed June 30, 2022, at <https://www.gpo.gov/fdsys/pkg/USCODE-2014-title7/pdf/USCODE-2014-title7-chap6-subchapII.pdf>.

*Federal Water Pollution Control Act*. 1948. Public Law 92-500, 86 Stat. 816 *et seq.*, 33 U.S.C. § 1251 *et seq.* (Also see *Clean Water Act*.)

FEMA (Federal Emergency Management Administration). 1984. "Flood Insurance Rate Map, City of Richland, WA, Benton County, Community-Panel Number 5355330010E, March 1, 1984." Washington, DC. Accessed June 30, 2022, at <https://msc.fema.gov/portal>.

*First War Powers Act of 1941*. 55 Stat. 838, Ch. 593, 50 U.S.C. App. 601 *et seq.*

*Forest Service Organic Administration Act of 1897*. 16 U.S.C. § § 473-478, 479-482, and 551, as amended.

Freedman VL, RD Mackley, SR Waichler, JA Horner, TW Moon, DR Newcomer, DJ DeSmet, KA Lindsey, and JJ Porcello. 2010. *Hydrogeologic Evaluation of a Ground-Source Cooling System at the BSF/CSF on the Battelle Campus: Final Report*. PNNL-18463, Pacific Northwest National Laboratory, Richland, WA. Accessed June 30, 2022, at [http://www.pnnl.gov/main/publications/external/technical\\_reports/PNNL-18463final.pdf](http://www.pnnl.gov/main/publications/external/technical_reports/PNNL-18463final.pdf).

Galm JR, GD Hartmann, RA Masten, and GO Stephenson. 1981. *A Cultural Resources Overview of the Bonneville Power Administration's Mid-Columbia Project, Central Washington*. Eastern Washington University, Cheney, WA.

[GLM, Part I, Title XIX, Chapter 131](#). 2024. "Administration of the Government – Agriculture and Conservation – Inland Fisheries and Game and Other Natural Resources." *General Laws of Massachusetts*, Boston, MA.

*Hazardous Waste Management Act of 1976*. RCW 70.105, as amended. *Revised Code of Washington*, Olympia, WA. Accessed June 30, 2022, at <http://apps.leg.wa.gov/rcw/default.aspx?cite=70.105>.

Hodges CM, C Miss, and J Shea. 2003. *Cultural resources survey for the Desert Claim Wind Power Project, Kittitas County, Washington*. Seattle, WA: Northwest Archaeological Associates. Report on file at the Department of Archaeology and Historic Preservation, Olympia, WA.

HPS (Health Physics Society). 2019. *Environmental Dosimetry – Criteria for System Design and Implementation*. ANSI/HPS N13.37-2014 (R2019), Herndon, VA.

ISO 9001:2015. 2015. *Quality Management Systems – Requirements*. International Organization for Standardization, Geneva, Switzerland.

ISO 14001:2015. 2015. *Environmental Management Systems – Requirements with Guidance for Use*. International Organization for Standardization, Geneva, Switzerland.

ISO/IEC 17025:2017. 2017. *General Requirements for the Competence of Testing and Calibration Laboratories*. International Organization for Standardization/International Electrotechnical Commission, Geneva, Switzerland.

ISO/IEC 17043:2010. 2010. *Conformity Assessment – General Requirements for Proficiency Testing*. International Organization for Standardization/International Electrotechnical Commission, Geneva, Switzerland.

[LAC, Title 76, Part I](#). 2024. "Wildlife and Fisheries." *Louisiana Administrative Code*, Baton Rouge, LA.

LandScope Washington. 2022. "Ecoregions in Washington." Accessed June 30, 2022, at [http://www.landscape.org/washington/natural\\_geography/ecoregions](http://www.landscape.org/washington/natural_geography/ecoregions).

Larson KB and JL Downs. 2009. *2009 Baseline Ecological Survey: Pacific Northwest National Laboratory Site*. PNNL-18939, Pacific Northwest National Laboratory, Richland, WA.

Lindsey KA. 1995. *Miocene- to Pliocene-Aged Suprabasalt Sediments of the Hanford Site, South-Central Washington*. BHI-00184, Bechtel Hanford, Inc., Richland, WA.

Linsley RK, JB Franzini, DL Freyberg, and G Tchobanoglous. 1992. *Water Resources Engineering*. McGraw-Hill Publishing Company, New York, NY.

*Magnuson–Stevens Fishery Conservation and Management Act*. 1976. 90 Stat. 331, as amended, 16 U.S.C. § 1801 *et seq.* Accessed June 30, 2022, at <https://www.fisheries.noaa.gov/resource/document/magnuson-stevens-fishery-conservation-and-management-act>.

Marceau TE, DW Harvey, DC Stapp, SD Cannon, CA Conway, DH DeFord, BJ Freer, MS Gerber, JK Keeting, CF Noonan, and G Weisskopf. 2002. *Hanford Site Historic District History of the Plutonium Production Facilities 1943–1990*. DOE-RL-97-1047, U.S. Department of Energy, Richland Operations Office, Richland, WA. Accessed June 30, 2022, at <https://pdw.hanford.gov/document/0081396H?>.

*Marine Mammal Protection Act of 1972*. 86 Stat. 1027, as amended, 16 U.S.C. § 1361 *et seq.* Accessed July 1, 2022, at [USCODE-2017-title16-chap31-subchapl-sec1361.pdf \(govinfo.gov\)](https://www.govinfo.gov/content/pkg/USCODE-2017-title16-chap31-subchapl-sec1361/pdf/USCODE-2017-title16-chap31-subchapl-sec1361.pdf).

*Migratory Bird Treaty Act*. 1918. 40 Stat. 755, as amended, 16 U.S.C. § 703 *et seq.* Accessed June 30, 2022, at <http://www.fws.gov/laws/lawsdigest/migtrea.html>.

Morgan V. 1996. *Results of Cultural Resources Survey and Testing for the Washington State Department of Transportation's Planned SR 101 Sequim Bypass Project, Clallam County, Washington*, NADB#1344078. Archaeological and Historical Services, Eastern Washington University, Cheney, WA.

Napier B. 2006. *Alternative Conceptual Models for Assessing Food Chain Pathways in Biosphere Models*. NUREG/CR-6910, U.S. Nuclear Regulatory Commission, Office of Nuclear Regulatory Research, Washington, DC. Accessed June 30, 2022, at <https://www.nrc.gov/docs/ML0622/ML062210427.pdf>.

*National Environmental Policy Act of 1969 (NEPA)*. Public Law 91-190, as amended, 42 U.S.C. § 4321 *et seq.* Accessed July 9, 2024, at <https://www.govinfo.gov/content/pkg/COMPS-10352/pdf/COMPS-10352.pdf>.

*National Historic Preservation Act of 1966 (NHPA)*. Public Law 89-665, as amended, 54 U.S.C. § 300101 *et seq.* Accessed July 9, 2024, at <https://www.achp.gov/sites/default/files/2018-06/nhpa.pdf>.

*National Park Service Organic Act*. 16 U.S.C. § 1, 2, 3, and 4. Accessed June 30, 2022, at <https://www.nps.gov/grba/learn/management/organic-act-of-1916.htm>.

*National Wildlife Refuge System Administration Act of 1966*. 16 U.S.C. § 668dd-668ee. Accessed July 6, 2021, at [USCODE-2017-title16-chap5A-subchapl-sec668dd.pdf \(govinfo.gov\)](https://www.govinfo.gov/content/pkg/USCODE-2017-title16-chap5A-subchapl-sec668dd/pdf/USCODE-2017-title16-chap5A-subchapl-sec668dd.pdf).

NCRP (National Council on Radiation Protection and Measurements). 2009. *Ionizing Radiation Exposure of the Population of the United States*. NCRP Report 160, Bethesda, MD.

Newcomer DR. 2007. *Groundwater Monitoring at the 1100-EM-1 Operable Unit*. PNNL-16528, Pacific Northwest National Laboratory, Richland, WA. Accessed June 30, 2022, at [http://www.pnnl.gov/main/publications/external/technical\\_reports/PNNL-16528.pdf](http://www.pnnl.gov/main/publications/external/technical_reports/PNNL-16528.pdf).

*Nonindigenous Aquatic Nuisance Prevention and Control Act of 1990*. Public Law 101-646, as amended, 16 U.S.C. § 4701 *et seq.*

OAC (Ohio Administrative Code). 2024. Preservation of property; exceptions. Rule 1501:17-3-02. Accessed June 13, 2024, at <https://codes.ohio.gov/ohio-administrative-code/rule-1501:17-3-02>. Columbus, OH.

[OAR 141-082](#). “Rules Governing the Management of, and Issuing of Leases, Licenses and Registrations for Structures on, and Uses of State-Owned Submerged and Submersible Land.” *Oregon Administrative Rules*, Salem, OR.

[OAR 141-089](#). “Administrative Rules Governing the Issuance and Enforcement of General Authorizations within the Waters of this State.” *Oregon Administrative Rules*, Salem, OR.

[OAR 635-007](#). “Fish Management and Hatchery Operations.” *Oregon Administrative Rules*, Salem, OR.

[OAR 635-043](#). “Miscellaneous Permits and Records.” *Oregon Administrative Rules*, Salem, OR.

ORCAA (Olympic Region Clean Air Agency). 2023. *Regulations of the Olympic Region Clean Air Agency, Clallam, Grays Harbor, Jefferson, Mason, Pacific, and Thurston Counties*. Olympia, WA. Accessed June 9, 2022, at <https://www.orcaa.org/about/air-quality-regulations>.

Peterson MD, MP Moschetti, PM Powers, CS Mueller, KM Haller, AD Frankel, Y Zeng, S Rezaeian, SC Harmsen, OS Boyd, N Field, R Chen, KS Rukstales, N Luco, RL Wheeler, RA Williams, and AH

- Olsen. 2014. *Documentation for the 2014 Update of the United States National Seismic Hazard Maps*. Open-File Report 2014–1091, U.S. Geological Survey, Reston, VA.
- Pleus A, L LeClair, J Schultz, and G Lambert. 2008. *2007-09 Tunicate Management Plan*. Washington State Department of Fish and Wildlife Aquatic Invasive Species Unit. In coordination with the Tunicate Response Advisory Committee, Olympia, WA. Accessed June 30, 2022, at <https://wdfw.wa.gov/sites/default/files/publications/00806/wdfw00806.pdf>.
- PNNL (Pacific Northwest National Laboratory). 2017. *Analytical Support Operations (ASO) Quality Assurance Plan*. ASO-QAP-001, Revision 11, Richland, WA.
- PNNL (Pacific Northwest National Laboratory). 2023. *Pacific Northwest National Laboratory FY 2024 Site Sustainability Plan*. Richland, WA.
- Poston TM, JP Duncan, and RL Dirkes. 2011. *Hanford Site Environmental Report for Calendar Year 2010*. PNNL-20548, Pacific Northwest National Laboratory, Richland, WA. Accessed June 30, 2022, at [http://www.pnnl.gov/main/publications/external/technical\\_reports/PNNL-20548.pdf](http://www.pnnl.gov/main/publications/external/technical_reports/PNNL-20548.pdf).
- [RCW 77.55](#), as amended. “Construction Projects in State Waters.” *Revised Code of Washington*, Olympia, WA.
- [RCW 77.135](#), as amended. “Invasive Species.” *Revised Code of Washington*, Olympia, WA.
- Reidel SP, KA Lindsey, and KR Fecht. 1992. *Field Trip Guide to the Hanford Site*. WHC-MR-0391, Westinghouse Hanford Company, Richland, WA. Accessed June 30, 2022, at <http://pbadupws.nrc.gov/docs/ML0901/ML090120386.pdf>.
- Resource Conservation and Recovery Act of 1976 (RCRA)*. Public Law 94-580, as amended, 42 U.S.C. § 6901 *et seq.* and 42 U.S.C. § 6927(c) *et seq.* Accessed June 30, 2022, at <https://www.epa.gov/laws-regulations/summary-resource-conservation-and-recovery-act>.
- Richland Municipal Code 17.30. Title 17, *Sewers*, Chapter 30, “Richland Pretreatment Act.” Last updated June 4, 2019, Richland, WA. Accessed June 30, 2023, at <http://www.codepublishing.com/WA/Richland/html/Richland17/Richland1730.html>.
- Rivers and Harbors Appropriation Act of 1899*. Ch. 425, 30 Stat. 1121 *et seq.*, 33 U.S.C. § 403 *et seq.*
- Rose SA, JD Tagestad, and SF Snyder. 2023. *Pacific Northwest National Laboratory Regional Populations – 2020 Census, Richland Campus and Sequim Campus*. PNNL-25305, Rev. 1, Pacific Northwest National Laboratory, Richland, WA.
- Russell J. 1971. *Jimmy Come Lately – History of Clallam County*. Clallam County Historical Society, Port Angeles, WA.
- Safe Drinking Water Act of 1974*. Public Law 93-523, as amended, 42 U.S.C. § 300f *et seq.* Accessed June 30, 2023, at <http://www.gpo.gov/fdsys/pkg/USCODE-2013-title42/pdf/USCODE-2013-title42-chap6A-subchapXII.pdf>.
- Schalk RF. 1988. *The Evolution and Diversification of Native Land Use Systems on the Olympic Peninsula*. Institute for Environmental Studies, University of Washington, Seattle, WA.
- Schasse HW and RL Logan. 1998. *Geologic Map of the Sequim 7.5-Minute Quadrangle, Clallam County, Washington*. Open File Report 98-7, Washington Department of Natural Resources, Olympia, WA.
- Schroeder WD and C Landreau. 2012. *Archaeological Survey and Inventory of A CRP 601/Road Safety Program Road Project (Phase III), Franklin County, Washington*. Report on file with the Washington State Department of Archaeology and Historic Preservation, Olympia, WA.
- Sharpe J. 1999. *Pre-Hanford Agricultural History: 1900–1943*. BHI-01326, Revision 0, Bechtel Hanford, Inc., Richland, WA.
- Shoreline Management Act of 1971*. RCW 90.58, as amended. *Revised Code of Washington*, Olympia, WA. Accessed June 30, 2022, at <http://app.leg.wa.gov/rcw/default.aspx?cite=90.58>.

- Smith HI. 1910. "The Archaeology of the Yakima Valley." *Anthropological Papers of the American Museum of Natural History VI (1)*. American Museum of Natural History, New York, NY.
- Snyder SF and SK Cooley. 2024. EMP Attachment 3, Dose Assessment Guidance. PNNL-20919-3, Rev. 3, Pacific Northwest National Laboratory, Richland, Washington.
- Snyder SF, JM Barnett, KM Meier, and LE Bisping. 2019. *Data Quality Objectives Supporting Radiological Air Emissions Monitoring for the Marine Sciences Laboratory, Sequim Site*. PNNL-22111, Revision 1, Pacific Northwest National Laboratory, Richland, WA.
- Snyder SF, LE Bisping, TR Hay, JM Barnett, LN Dinh, and MC Klein. 2024a. *Data Quality Objectives Supporting Radiological Air Emissions Monitoring for the PNNL-Richland Campus*. PNNL-19427, Revision 3, Pacific Northwest National Laboratory, Richland, WA. Accessed May 24, 2024, at <https://doi.org/10.2172/2326089>.
- Snyder SF, LE Bisping, SG Ramos, LN Dinh, and JM Barnett. 2024b. *PNNL-Richland Campus Radionuclide Air Emissions Report for Calendar Year 2023*. PNNL-20436-14, Pacific Northwest National Laboratory, Richland, WA. <https://science.osti.gov/pnso/Resources>.
- Snyder SF, LN Dinh, and JM Barnett. 2024c. *PNNL-Sequim Campus Radionuclide Air Emissions Report for Calendar Year 2023*. PNNL-22342-12, Pacific Northwest National Laboratory, Richland, WA. <https://science.osti.gov/pnso/Resources>.
- Snyder SF, KM Meier, JM Barnett, and LE Bisping. 2020. *Environmental Radiological Air Monitoring Plan, PNNL Operations in Washington*. PNNL-20919, Revision 1, Pacific Northwest National Laboratory, Richland, WA.
- Snyder SF, DGL Moleta, KM Meier, and JM Barnett. 2017. *Data Quality Objectives Supporting Radiological Air Emissions Monitoring for the PNNL-Richland Campus*. PNNL-19427, Revision 2, Pacific Northwest National Laboratory, Richland, WA. Accessed May 24, 2024, at <https://doi.org/10.2172/1415711>.
- State Environmental Policy Act (SEPA). RCW 43.21C, as amended. *Revised Code of Washington*, Olympia, WA. <http://app.leg.wa.gov/RCW/default.aspx?cite=43.21C>.
- Superfund Amendments and Reauthorization Act of 1986. Public Law 99-499, as amended, 42 U.S.C. § 9601 et seq.
- Suttles W and B Lane. 1990a. "Central Coast Salish." In *Handbook of North American Indians: Northwest Coast*. Volume 7, Smithsonian Institution, Washington, DC.
- Suttles W and B Lane. 1990b. "Southern Coast Salish." In *Handbook of North American Indians: Northwest Coast*. Volume 7, Smithsonian Institution, Washington, DC.
- Thomas BE, LA Goodman, and TD Olsen. 1999. Hydrogeologic Assessment of the Sequim-Dungeness Area, Clallam County, Washington. Water Resources Investigation Report 99-4048, U.S. Geological Survey, Tacoma, WA. Accessed June 30, 2022, at <https://pubs.er.usgs.gov/publication/wri994048>.
- Thompson SW, SF Snyder, JM Becker, ES Norris, JM Barnett, KD Hand, EA Raney, TW Moon, CJ Duchsherer, JL Haigh, J Su-Coker, RA Del Mar, LE Bisping, LY Renaud, MD Ellefson, JA Stephens, and MA Aranda. 2023. *Pacific Northwest National Laboratory Annual Site Environmental Report for Calendar Year 2022*. PNNL-34638, Pacific Northwest National Laboratory, Richland, WA. Accessed May 22, 2024, at <https://www.pnnl.gov/pnnl-annual-site-environmental-report>.
- Thorne PD, MA Chamness, FA Spane, Jr., VR Vermeul, and WD Webber. 1993. *Three-Dimensional Conceptual Model for the Hanford Site Unconfined Aquifer System, FY 93 Status Report*. PNL-8971, Pacific Northwest Laboratory, Richland, WA.
- Toxic Substances Control Act. 1976. Public Law 94-469, as amended, 15 U.S.C. § 2601 et seq. Accessed June 30, 2022, at <https://www.gpo.gov/fdsys/pkg/USCODE-2014-title15/pdf/USCODE-2014-title15-chap53.pdf>.

Turk D. 2021. September 16, 2021, Memorandum from DOE Deputy Secretary, David Turk, Addressing Per- and Polyfluoroalkyl Substances at the Department of Energy, Washington, DC. Accessed June 17, 2022, at <https://www.energy.gov/ehss/articles/exec-2021-004118-distribution-memo-s2-turk-addressing-and-polyfluoroalkyl-substances>.

USCB (U.S. Census Bureau). 2022. American Community Survey 5-year Estimates Subject Table, Sequim City and Clallam County, Washington. Washington, DC. Accessed May 25, 2022, at <https://data.census.gov/cedsci/table?q=United%20States>.

USFWS (U.S. Fish and Wildlife Service). 2022. "Endangered Species: Glossary." Washington, DC. Accessed June 16, 2022, at <https://digitalmedia.fws.gov/digital/collection/document/id/1798/>.

USGS (U.S. Geological Survey). 2024. "National Water Information System: USGS 12472800 Columbia River Below Priest Rapids Dam, WA." Washington, DC. Accessed June 30, 2022, at [https://waterdata.usgs.gov/nwis/uv?site\\_no=12472800](https://waterdata.usgs.gov/nwis/uv?site_no=12472800).

[WAC 16-228](#). 2019. "General Pesticide Rules." *Washington Administrative Code*, Olympia, WA.

[WAC 16-750-011](#). 2023. "State Noxious Weed List—Class B Noxious Weeds." *Washington Administrative Code*, Olympia, WA.

[WAC 16-750-015](#). 2023. "State Noxious Weed List—Class C Noxious Weeds." *Washington Administrative Code*, Olympia, WA.

[WAC 173-50](#). 2010. "Accreditation of Environmental Laboratories." *Washington Administrative Code*, Olympia, WA.

[WAC 173-218](#). 2008. "Underground Injection Control Program." *Washington Administrative Code*, Olympia, WA.

[WAC 173-303](#). 2020. "Dangerous Waste Regulations." *Washington Administrative Code*, Olympia, WA.

[WAC 173-303-145](#). 2019. "Dangerous Waste Regulations—Spills and Discharges into the Environment." *Washington Administrative Code*, Olympia, WA.

[WAC 173-303-806](#). 2020. "Dangerous Waste Regulations—Final Facility Permits." *Washington Administrative Code*, Olympia, WA.

[WAC 173-360A](#). 2018. "Underground Storage Tank Regulations." *Washington Administrative Code*, Olympia, WA.

[WAC 173-400](#). 2021. "General Regulations for Air Pollution Sources." *Washington Administrative Code*, Olympia, WA.

[WAC 173-441](#). 2016. "Reporting of Emissions of Greenhouse Gases." *Washington Administrative Code*, Olympia, WA.

[WAC 173-460](#). 2019. "Controls for New Sources of Toxic Air Pollutants." *Washington Administrative Code*, Olympia, WA.

[WAC 173-480](#). 2007. "Ambient Air Quality Standards and Emission Limits for Radionuclides." *Washington Administrative Code*, Olympia, WA.

[WAC 220-200-150](#). 2019. "Scientific Collection Permits." *Washington Administrative Code*, Olympia, WA.

[WAC 220-640-030](#). 2019. "Prohibited Level 1 Species." *Washington Administrative Code*, Olympia, WA.

[WAC 220-640-050](#). 2019. "Prohibited Level 3 Species." *Washington Administrative Code*, Olympia, WA.

[WAC 220-660](#). 2021. "Hydraulic Code Rules." *Washington Administrative Code*, Olympia, WA.

[WAC 246-221-190](#). 2003. "Disposal by Release into Sanitary Sewerage Systems." *Washington Administrative Code*, Olympia, WA.

[WAC 246-247](#). 2021. "Radiation Protection—Air Emissions." *Washington Administrative Code*, Olympia, WA.

- [WAC 246-290](#). 2019. "Group A Public Water Supplies." *Washington Administrative Code*, Olympia, WA.
- [WAC 296-155-655](#). 2021. "Safety Standards for Construction Work, Part N – Excavation, Trenching, and Shoring." *Washington Administrative Code*, Olympia, WA.
- [WAC 332-30](#). 2015. "Aquatic Land Management." *Washington Administrative Code*, Olympia, WA.
- Washington Clean Air Act*. RCW 70A.15, as amended. *Revised Code of Washington*. Olympia, WA. Accessed June 30, 2022, at <https://app.leg.wa.gov/RCW/default.aspx?cite=70A.15&full=true>.
- Washington Pesticide Application Act*. RCW 17.21, as amended. *Revised Code of Washington*. Olympia, WA. Accessed June 30, 2022, at <http://apps.leg.wa.gov/rcw/default.aspx?cite=17.21>.
- Washington Pesticide Control Act*. RCW 15.58, as amended. *Revised Code of Washington*. Olympia, WA. Accessed June 30, 2022, at <http://apps.leg.wa.gov/rcw/default.aspx?cite=15.58>.
- WDFW (Washington Department of Fish and Wildlife). 2001. *Washington State Aquatic Nuisance Species Management Plan*. Olympia, WA. Accessed June 30, 2022, at <https://wdfw.wa.gov/sites/default/files/publications/00105/wdfw00105.pdf>.
- WDFW (Washington Department of Fish and Wildlife). 2005. Volume I, Chapter 6, Washington's Ecoregional Conservation Strategy, Washington's Comprehensive Wildlife Conservation Strategy, Accessed June 21, 2022, at <https://wdfw.wa.gov/publications/00727#:~:text=Guiding%20principles%20for%20Washington's%20CWC,S,local%20governments%2C%20and%20non%2Dgovernmental>.
- WDFW (Washington Department of Fish and Wildlife). 2023. *Priority Habitats and Species List*. Olympia, WA. Accessed June 30, 2022, at <https://wdfw.wa.gov/sites/default/files/publications/00165/wdfw00165.pdf>.
- WDFW (Washington Department of Fish and Wildlife). 2024. "Threatened and Endangered Species." Revised March 2024. Olympia, WA. June 30, 2022, at <https://wdfw.wa.gov/sites/default/files/2024-03/wa-state-listed-and-candidate-species-list.pdf>.
- WDNR (Washington Department of Natural Resources). 2013. "Modeling a Magnitude 9.0 Earthquake on the Cascadia Subduction Zone off the Pacific Coast." Olympia, WA. Accessed June 30, 2022, at [http://www.dnr.wa.gov/Publications/ger\\_seismic\\_scenario\\_cascadia.pdf](http://www.dnr.wa.gov/Publications/ger_seismic_scenario_cascadia.pdf).
- WDNR (Washington Department of Natural Resources). 2021. "Natural Resources Geologic Information Portal Maps of Active Faults and Earthquakes, Liquefaction Susceptibility, Tsunami Hazard, Landslides, and Volcano Hazards." Olympia, WA. Accessed June 30, 2022, at <https://geologyportal.dnr.wa.gov>.
- Weyns, D. 2024a. *2023 Hanford Site Polychlorinated Biphenyl Annual Report*. DOE/RL-2024-16, Revision 0. U.S. Department of Energy Richland Operations Office, Richland, WA. Accessed July 9, 2024, at <https://pdw.hanford.gov/document/AR-29888>.
- Weyns, D. 2024b. *2023 Hanford Site Polychlorinated Biphenyl Annual Document Log*. DOE/RL-2024-17, Revision 0. U.S. Department of Energy Richland Operations Office, Richland, WA. Accessed July 9, 2024, at <https://pdw.hanford.gov/document/AR-29963>.
- Williams BA, BN Bjornstad, R Schalla, and WD Webber. 2000. *Revised Hydrogeology for the Suprabasalt Aquifer System, 200-East Area and Vicinity, Hanford Site, Washington*. PNNL-12261, Pacific Northwest National Laboratory, Richland, WA. Accessed June 30, 2022, at [http://www.pnnl.gov/main/publications/external/technical\\_reports/PNNL-12261.PDF](http://www.pnnl.gov/main/publications/external/technical_reports/PNNL-12261.PDF).
- Williams BA, CF Brown, W Um, MJ Nimmons, RE Peterson, BN Bjornstad, DC Lanigan, RJ Serne, FA Spane, and ML Rockhold. 2007. *Limited Field Investigation Report for Uranium Contamination in the 300-FF-5 Operable Unit at the 300 Area, Hanford Site, Washington*. PNNL-16435, Pacific Northwest National Laboratory, Richland, WA. Accessed June 30, 2022, at [http://www.pnnl.gov/main/publications/external/technical\\_reports/PNNL-16435.pdf](http://www.pnnl.gov/main/publications/external/technical_reports/PNNL-16435.pdf).
- WNHP (Washington Natural Heritage Program). 2021. *2021 Washington Vascular Plant Species of Conservation Concern*. WNHP Report Number 2021-04, Olympia, WA. Accessed June 17, 2022, at [https://www.dnr.wa.gov/publications/amp\\_nh\\_vascular\\_ets.pdf?zp5o7v1](https://www.dnr.wa.gov/publications/amp_nh_vascular_ets.pdf?zp5o7v1).

WNWCB (Washington Noxious Weed Control Board). 2021. "The Three Classes of Noxious Weeds." Olympia, WA. Accessed June 30, 2022, at <https://www.nwcb.wa.gov/classes-of-noxious-weeds>.

WOFM (Washington Office of Financial Management). 2022. Washington Data and Research, County and City Data, Olympia, WA. Accessed June 29, 2022, at [https://ofm.wa.gov/washington-data-research/county-and-city-data for Benton and Franklin](https://ofm.wa.gov/washington-data-research/county-and-city-data-for-Benton-and-Franklin).

WOFM (Washington Office of Financial Management). 2023. Washington Data and Research, 2023 State of Washington, Population Trends, Olympia, WA. Accessed July 1, 2023, at June 29, 2022, at [https://ofm.wa.gov/sites/default/files/public/dataresearch/pop/april1/ofm\\_april1\\_poptrends.pdf](https://ofm.wa.gov/sites/default/files/public/dataresearch/pop/april1/ofm_april1_poptrends.pdf).

WOFM (Washington Office of Financial Management). 2024. Washington Data and Research, April 1, 2024 Population of Cities, Towns, and Counties Used for the Allocation of Selected State Revenues, Olympia, WA. Accessed July 1, 2024, at [https://ofm.wa.gov/sites/default/files/public/dataresearch/pop/april1/ofm\\_april1\\_population\\_final.pdf](https://ofm.wa.gov/sites/default/files/public/dataresearch/pop/april1/ofm_april1_population_final.pdf).

WSU (Washington State University). 2023. "AgWeatherNet Data for Sequim, Clallam County, Washington." Data provided by personal communication from <https://weather.wsu.edu/?p=88650&desktop>.

## Appendix A – Plant and Animal Species Found on Undeveloped Upland and Riparian Areas of the PNNL-Richland Campus, 2009–2023



Figure A.1. Vegetation Observed on the Undeveloped Upland Portions of the PNNL-Richland Campus in 2023

Table A.1. Plant Species Observed on the Undeveloped Upland Portions of the PNNL-Richland Campus, 2009–2023

Species Name <sup>(a)</sup>	Common Name <sup>(a)</sup>	State Status	Federal Status	Noxious Weed Class [2022] <sup>(b)</sup>
<i>Achillea millefolium</i>	Common yarrow			
<i>Achnatherum hymenoides</i>	Indian ricegrass			
<i>Agoseris glauca</i>	Pale agoseris			
<i>Agoseris grandiflora</i>	Large-flowered agoseris			
<i>Agoseris heterophylla</i>	Annual agoseris			
<i>Agropyron cristatum</i>	Crested wheatgrass			
<i>Ailanthus altissima</i>	Tree of heaven			C
<i>Allium schoenoprasum</i>	Chives			
<i>Amaranthus albus</i>	White pigweed			
<i>Ambrosia acanthicarpa</i>	Bur ragweed			
<i>Amsinckia lycopsoides</i>	Tarweed fiddleneck			
<i>Amsinckia tessellata</i>	Tessellate fiddleneck			
<i>Aphyllon corymbosum</i>	Flat-topped broomrape			
<i>Artemisia campestris</i>	Pacific sagewort			
<i>Artemisia dracunculus</i>	Tarragon			

Species Name <sup>(a)</sup>	Common Name <sup>(a)</sup>	State Status	Federal Status	Noxious Weed Class [2022] <sup>(b)</sup>
<i>Artemisia ludoviciana</i>	Prairie sage			
<i>Artemisia tridentata</i>	Big sagebrush			
<i>Asclepias speciosa</i>	Showy milkweed			
<i>Asparagus officinalis</i>	Garden asparagus			
<i>Astragalus caricinus</i>	Buckwheat milkvetch			
<i>Avena sativa</i>	Cultivated oats			
<i>Balsamorhiza careyana</i>	Carey's balsamroot			
<i>Bassia scoparia</i>	Burning-bush			B
<i>Bromus tectorum</i>	Cheatgrass			
<i>Calochortus macrocarpus</i>	Sagebrush mariposa lily			
<i>Camissonia parvula</i>	Small desert primrose			
<i>Capsella bursa-pastoris</i>	Shepherd's purse			
<i>Carex douglasii</i>	Douglas's sedge			
<i>Cenchrus longispinus</i>	Bur-grass			C
<i>Centaurea diffusa</i>	Diffuse knapweed			B
<i>Centaurea solstitialis</i>	Yellow starthistle			B
<i>Cerastium fontanum</i>	Common mouse-ear			
<i>Chaenactis douglasii</i>	Hoary false yarrow			
<i>Chamaesyce serpyllifolia</i>	Thymeleaf sandmat			
<i>Chenopodium album</i>	White goosefoot			
<i>Chenopodium leptophyllum</i>	Slimleaf goosefoot			
<i>Chondrilla juncea</i>	Skeletonweed			B
<i>Chorisporea tenella</i>	Chorisporea			
<i>Chrysothamnus viscidiflorus</i>	Green rabbitbrush			
<i>Cichorium intybus</i>	Chicory			
<i>Cirsium arvense</i>	Canada thistle			C
<i>Clematis ligusticifolia</i>	Western clematis			
<i>Comandra umbellata</i>	Bastard toadflax			
<i>Convolvulus arvensis</i>	Bindweed			C
<i>Conyza canadensis</i>	Canadian horseweed			
<i>Coreopsis tinctoria</i>	Columbia coreopsis			
<i>Crepis atriobarba</i>	Slender hawksbeard			
<i>Cryptantha flaccida</i>	Weak-stemmed cryptantha			
<i>Cryptantha fendleri</i>	Fendler's cryptantha			
<i>Cryptantha pterocarya</i>	Winged cryptantha			
<i>Cymopterus terebinthinus</i>	Turpentine spring parsley			
<i>Cynodon dactylon</i>	Cynodon			
<i>Dalea ornata</i>	Western prairie-clover			
<i>Delphinium nuttallianum</i>	Upland larkspur			
<i>Descurainia pinnata</i>	Western tansymustard			
<i>Descurainia sophia</i>	Flixweed			
<i>Dieteria canescens</i>	Hoary-aster			
<i>Draba nemorosa</i>	Woodland draba			
<i>Draba verna</i>	Spring Whitlow-grass			

Species Name <sup>(a)</sup>	Common Name <sup>(a)</sup>	State Status	Federal Status	Noxious Weed Class [2022] <sup>(b)</sup>
<i>Elaeagnus angustifolia</i>	Russian olive			C
<i>Eleocharis sp.</i>	Spike-rush			
<i>Elymus elymoides</i>	Bottlebrush squirreltail			
<i>Elymus lanceolatus</i>	Thickspike wheatgrass			
<i>Elymus violaceus</i>	Alaska wheatgrass			
<i>Epilobium brachycarpum</i>	Tall annual willow-herb			
<i>Equisetum sp.</i>	Horsetail			
<i>Ericameria nauseosa</i>	Common rabbitbrush			
<i>Erigeron filifolius</i>	Thread-leaf fleabane			
<i>Eriogonum niveum</i>	Snow buckwheat			
<i>Eriogonum vimineum</i>	Broom buckwheat			
<i>Erodium cicutarium</i>	Redstem stork's bill			
<i>Erysimum asperum</i>	Wallflower			
<i>Euphorbia glyptosperma</i>	Ribseed sandmat			
<i>Euphorbia serpyllifolia</i>	Thymeleaf spurge			
<i>Fallopia convolvulus</i>	Climbing bindweed			
<i>Fritillaria pudica</i>	Yellow bell			
<i>Galium aparine</i>	Cleavers			
<i>Gaillardia aristata</i>	Blanket-flower			
<i>Gilia minutiflora</i>	Small-flowered gilia			
<i>Gilia sinuata</i>	Rosy gilia			
<i>Gratiola neglecta</i>	Common American hedge-hyssop			
<i>Grayia spinosa</i>	Hopsage			
<i>Greeneocharis circumscissa</i>	Matted cryptantha			
<i>Grindelia hirsutula</i>	Hairy gumweed			
<i>Gypsophila paniculata</i>	Baby's-breath			C
<i>Hesperostipa comata</i>	Needle-and-thread			
<i>Holosteum umbellatum</i>	Jagged chickweed			
<i>Hordeum jubatum</i>	Foxtail barley			
<i>Hymenopappus filifolius</i>	Hymenopappus			
<i>Hypericum perforatum</i>	Common St. John's-wort			C
<i>Iris missouriensis</i>	Rocky mountain			
<i>Juniperus scopulorum</i>	Rocky Mountain juniper			
<i>Koeleria macrantha</i>	Junegrass			
<i>Lactuca serriola</i>	Prickly lettuce			
<i>Ladeania lanceolata</i>	Lance-leaf scurf-pea			
<i>Lagophylla rammosissima</i>	Hareleaf			
<i>Lamium amplexicaule</i>	Common dead-nettle			
<i>Layia glandulosa</i>	Tidytips			
<i>Lepidium draba</i>	Heart-podded hoarycress			C
<i>Lepidium densiflorum</i>	Common pepperweed			
<i>Lepidium latifolium</i>	Broadleaf pepperweed			B
<i>Lepidium perfoliatum</i>	Clasping pepperweed			
<i>Leymus cinereus</i>	Great Basin wildrye			

Species Name <sup>(a)</sup>	Common Name <sup>(a)</sup>	State Status	Federal Status	Noxious Weed Class [2022] <sup>(b)</sup>
<i>Linanthus pungens</i>	Granite prickly-phlox			
<i>Logfia gallica</i>	Daggerleaf cottonrose			
<i>Lomatium macrocarpum</i>	Bigseed biscuitroot			
<i>Malus pumila</i>	Cultivated apple			
<i>Malva neglecta</i>	Common mallow			
<i>Marrubium vulgare</i>	Horehound			
<i>Medicago lupulina</i>	Black medick			
<i>Medicago sativa</i>	Alfalfa			
<i>Melilotus officinalis</i>	Common yellow sweet-clover			
<i>Mentha arvensis</i>	Mint			
<i>Mentzelia albicaulis</i>	Small-flowered mentzelia			
<i>Microsteris gracilis</i>	Microsteris			
<i>Morus alba</i>	White mulberry			
<i>Narcissus pseudonarcissus</i>	Common daffodil			
<i>Oenothera pallida</i>	Pale evening primrose			
<i>Onopordum acanthium</i>	Cotton thistle			B
<i>Opuntia polyacantha</i>	Starvation pricklypear			
<i>Parthenocissus vitacea</i>	Virginia creeper			
<i>Phacelia hastata</i>	Silverleaf phacelia			
<i>Phacelia linearis</i>	Thread-leaf phacelia			
<i>Phlox longifolia</i>	Longleaf phlox			
<i>Plantago lanceolata</i>	English plantain			
<i>Plantago patagonica</i>	Indian-wheat			
<i>Plectritis macrocera</i>	Longhorn plectritis			
<i>Poa bulbosa</i>	Bulbous bluegrass			
<i>Poa pratensis</i>	Kentucky bluegrass			
<i>Poa secunda</i>	Sandberg's bluegrass			
<i>Polemonium micranthum</i>	Annual Jacob's ladder			
<i>Polygonum aviculare</i>	Doorweed			
<i>Prunus virginiana</i>	Chokecherry			
<i>Pseudognaphalium stramineum</i>	Cottonbatting plant			
<i>Pseudoroegneria spicata</i>	Bluebunch wheatgrass			
<i>Purshia tridentata</i>	Bitterbrush			
<i>Rhaponticum repens</i>	Hardheads (Russian knapweed)			B
<i>Ribes aureum</i>	Golden currant			
<i>Robinia pseudoacacia</i>	Black locust			
<i>Rosa woodsii</i>	Rose			
<i>Rubus bifrons</i>	Himalayan blackberry			C
<i>Rumex salicifolius</i>	Willow dock			
<i>Rumex venosus</i>	Veiny dock			
<i>Salix exigua</i>	Coyote willow			
<i>Salsola tragus</i>	Russian thistle			
<i>Senecio vulgaris</i>	Common groundsel			C
<i>Setaria pumila</i>	Foxtail			

Species Name <sup>(a)</sup>	Common Name <sup>(a)</sup>	State Status	Federal Status	Noxious Weed Class [2022] <sup>(b)</sup>
<i>Sisymbrium altissimum</i>	Tall tumbledmustard			
<i>Sisymbrium loeselii</i>	Loesel tumbledmustard			
<i>Solidago lepida</i>	Western Canada goldenrod			
<i>Solanum dulcamara</i>	Climbing nightshade			
<i>Solanum triflorum</i>	Cut-leaved nightshade			
<i>Sonchus arvensis</i>	Sow-thistle			
<i>Sphaeralcea munroana</i>	Munro's globemallow			
<i>Sporobolus cryptandrus</i>	Sand dropseed			
<i>Stephanomeria paniculata</i>	Stiff-branched wirelettuce			
<i>Taraxacum officinale</i>	Common dandelion			
<i>Toxicoscordion venenosum</i>	Meadow death-camas			
<i>Thinopyrum intermedium</i>	Intermediate wheatgrass			
<i>Tragopogon dubius</i>	Yellow salsify			
<i>Tribulus terrestris</i>	Puncturevine			B
<i>Trifolium repens</i>	White clover			
<i>Triteleia grandiflora</i>	Large-flowered triteleia			
<i>Ulmus pumila</i>	Siberian elm			
<i>Ulmus americana</i>	American elm			
<i>Verbascum thapsus</i>	Common mullein			
<i>Verbena bracteata</i>	Bracted verbena			
<i>Veronica arvensis</i>	Common speedwell			
<i>Veronica peregrina</i>	Purslane speedwell			
<i>Vulpia microstachys</i>	Small fescue			
<i>Vulpia octoflora</i>	Six-weeks fescue			

(a) Nomenclature according to Hitchcock, CL and A Cronquist. 2018. *Flora of the Pacific Northwest: An Illustrated Manual, 2<sup>nd</sup> Edition*. Edited by DE Giblin, BS Legler, PF Zika, and RG Olmstead. University of Washington Press, Seattle, WA. 936pp.

(b) Noxious Weed Class: B = Prevent spread and contain or reduce existing populations; C = Weeds widespread, control methods available but not normally required.

**Table A.2. Bird Species Observed on the Undeveloped Upland Portions of the PNNL-Richland Campus, 2009–2023**

Species Name	Common Name	State Status[2021]	Federal Status
<i>Agelaius phoeniceus</i>	Red-winged blackbird		
<i>Artemisiospiza nevadensis</i>	Sagebrush sparrow	Candidate	
<i>Anas platyrhynchos</i>	Mallard		
<i>Asio flammeus</i>	Short-eared owl		
<i>Branta canadensis</i>	Canada goose		
<i>Buteo jamaicensis</i>	Red-tailed hawk		
<i>Buteo swainsoni</i>	Swainson's hawk		
<i>Callipepla californica</i>	California quail		
<i>Carpodacus mexicanus</i>	House finch		
<i>Carduelis tristis</i>	American goldfinch		
<i>Charadrius vociferus</i>	Killdeer		

Species Name	Common Name	State Status[2021]	Federal Status
<i>Chordeiles minor</i>	Common nighthawk		
<i>Chondestes grammacus</i>	Lark sparrow		
<i>Circus cyaneus</i>	Northern harrier		
<i>Colaptes auratus</i>	Northern flicker		
<i>Columbus livia</i>	Rock pigeon		
<i>Corvus brachyrhynchos</i>	American crow		
<i>Corvus corax</i>	Common raven		
<i>Eremophila alpestris</i>	Horned lark		
<i>Euphagus cyanocephalus</i>	Brewer's blackbird		
<i>Haliaeetus leucocephalus</i>	Bald eagle		
<i>Hirundo pyrrhonota</i>	Cliff swallow		
<i>Hirundo rustica</i>	Barn swallow		
<i>Icterus bullockii</i>	Bullock's oriole		
<i>Lanius ludovicianus</i>	Loggerhead shrike	Candidate	
<i>Numenius americanus</i>	Long-billed curlew		
<i>Pandion haliaetus</i>	Osprey		
<i>Passer domesticus</i>	House sparrow		
<i>Phasianus colchicus</i>	Ring-necked pheasant		
<i>Pica</i>	Black-billed magpie		
<i>Riparia</i>	Bank swallow		
<i>Sayornis saya</i>	Say's phoebe		
<i>Sturnella neglecta</i>	Western meadowlark		
<i>Sturnus vulgaris</i>	European starling		
<i>Tachycineta thalassina</i>	Violet-green swallow		
<i>Turdus migratorius</i>	American robin		
<i>Tyrannus tyrannus</i>	Eastern kingbird		
<i>Tyrannus verticalis</i>	Western kingbird		
<i>Zenaidura macroura</i>	Mourning dove		
<i>Zonotrichia leucophrys</i>	White-crowned sparrow		

Table A.3. Mammal Species Observed on the Undeveloped Upland Portions of the PNNL-Richland Campus, 2009–2023

Species Name	Common Name	State Status (2021)	Federal Status
<i>Canis latrans</i>	Coyote		
<i>Castor canadensis</i>	Beaver		
<i>Cervus elaphus</i>	Elk		
<i>Erithizon dorsatum</i>	Porcupine		
<i>Lepus californicus</i>	Black-tailed jackrabbit	Candidate	
<i>Odocoileus hemionus</i>	Mule deer		
<i>Perognathus parvus</i>	Great Basin pocket mouse		
<i>Sylvilagus nutalli</i>	Mountain cottontail		
<i>Taxidea taxus</i>	Badger		
<i>Thomomys talpoides</i>	Northern pocket gopher		

Table A.4. Plant Species Observed in the Riparian Area of the PNNL-Richland Campus in 2015 and 2017–2018

Species Name <sup>(a)</sup>	Common Name <sup>(a)</sup>	State Status	Federal Status	Noxious Weed Class [2022] <sup>(b)</sup>
<i>Achillea millefolium</i>	Common yarrow			
<i>Achnatherum hymenoides</i>	Indian ricegrass			
<i>Agropyron cristatum</i>	Crested wheatgrass			
<i>Ailanthus altissima</i>	Tree of heaven			C
<i>Allium schoenoprasum</i>	Chives			
<i>Ambrosia acanthicarpa</i>	Bur ragweed			
<i>Amsinckia lycopsoides</i>	Tarweed fiddleneck			
<i>Apocynum cannabinum</i>	Clasping-leaved dogbane			
<i>Artemisia campestris</i>	Pacific sagewort			
<i>Artemisia dracunculus</i>	Tarragon			
<i>Artemisia ludoviciana</i>	Prairie sage			
<i>Artemisia tridentata</i>	Big sagebrush			
<i>Asclepias speciosa</i>	Showy milkweed			
<i>Asparagus officinalis</i>	Garden asparagus			
<i>Bromus tectorum</i>	Cheatgrass			
<i>Centaurea diffusa</i>	Diffuse knapweed			B
<i>Chondrilla juncea</i>	Skeletonweed			B
<i>Chrysothamnus viscidiflorus</i>	Green rabbitbrush			
<i>Cirsium arvense</i>	Creeping thistle			C
<i>Clematis ligusticifolia</i>	Western clematis			
<i>Convolvulus arvensis</i>	Bind weed			C
<i>Conyza canadensis</i>	Canadian horseweed			
<i>Coreopsis tinctoria</i>	Columbia coreopsis			
<i>Descurainia pinnata</i>	Western tansymustard			
<i>Descurainia sophia</i>	Flixweed			
<i>Dieteria canescens</i>	Hoary-aster			
<i>Eleocharis palustris</i>	Common spike-rush			
<i>Elymus lanceolatus</i>	Thickspike wheatgrass			
<i>Equisetum sp.</i>	Horsetail			
<i>Ericameria nauseosa</i>	Rubber rabbitbrush			
<i>Eriogonum niveum</i>	Snow buckwheat			
<i>Eriogonum sp.</i>	Buckwheat			
<i>Euphorbia glyptosperma</i>	Ribseed sandmat			
<i>Euphorbia serpyllifolia</i>	Thymeleaf sandmat			
<i>Gaillardia aristata</i>	Blanket-flower			
<i>Galium sp.</i>	Bedstraw			
<i>Hesperostipa comata</i>	Needle-and-thread			
<i>Holosteum umbellatum</i>	Jagged chickweed			
<i>Hypericum perforatum</i>	Common St. John's-wort			C
<i>Iris missouriensis</i>	Rocky Mountain iris			
<i>Lactuca serriola</i>	Prickly lettuce			

Species Name <sup>(a)</sup>	Common Name <sup>(a)</sup>	State Status	Federal Status	Noxious Weed Class [2022] <sup>(b)</sup>
<i>Ladearia lanceolata</i>	Lance-leaf scurf-pea			
<i>Lepidium densiflorum</i>	Common pepperweed			
<i>Lepidium draba</i>	Heart-podded hoarycress			C
<i>Lepidium perfoliatum</i>	Clasping pepperweed			
<i>Leymus cinereus</i>	Great Basin wildrye			
<i>Logfia gallica</i>	Daggerleaf cottonrose			
<i>Acmispon americanus</i>	Spanish-clover			
<i>Lupinus sericeus</i>	Silky lupine			
<i>Medicago sativa</i>	Alfalfa			
<i>Melilotus officinalis</i>	Common yellow sweet clover			
<i>Mentha piperita</i>	Mint			
<i>Morus alba</i>	White mulberry			
<i>Oenothera pallida</i>	Pale evening primrose			
<i>Parthenocissus vitacea</i>	Virginia creeper			
<i>Phalaris arundinacea</i>	Reed canarygrass			C
<i>Plantago lanceolata</i>	English plantain			
<i>Plantago patagonica</i>	Indian-wheat			
<i>Poa bulbosa</i>	Bulbous bluegrass			
<i>Poa compressa</i>	Canada bluegrass			
<i>Poa secunda</i>	Sandberg's bluegrass			
<i>Prunus virginiana</i>	Chokecherry			
<i>Purshia tridentata</i>	Antelope-brush			
<i>Rhaponticum repens</i>	Hardheads (Russian knapweed)			B
<i>Rhus glabra</i>	Smooth sumac			
<i>Ribes aureum</i>	Golden currant			
<i>Robinia pseudoacacia</i>	Black locust			
<i>Rosa woodsii</i>	Rose			
<i>Rubus bifrons</i>	Himalayan blackberry			C
<i>Rumex crispus</i>	Curly dock			
<i>Rumex patientia</i>	Patience dock			
<i>Rumex salicifolius</i>	Willow dock			
<i>Rumex venosus</i>	Veiny dock			
<i>Salix exigua</i>	Coyote willow			
<i>Salsola tragus</i>	Russian thistle			
<i>Sisymbrium altissimum</i>	Tall tumbled mustard			
<i>Solidago lepida</i>	Western Canada goldenrod			
<i>Solanum dulcamara</i>	Climbing nightshade			
<i>Sphaeralcea munroana</i>	Munro's globemallow			
<i>Sporobolus cryptandrus</i>	Sand dropseed			
<i>Stephanomeria paniculata</i>	Stiff-branched wirelettuce			
<i>Taraxacum officinale</i>	Common dandelion			
<i>Tragopogon dubius</i>	Yellow salsify			
<i>Ulmus americana</i>	American elm			

Species Name <sup>(a)</sup>	Common Name <sup>(a)</sup>	State Status	Federal Status	Noxious Weed Class [2022] <sup>(b)</sup>
<i>Verbascum thapsus</i>	Common mullein			
<i>Vicia cracca</i>	Bird vetch			
<i>Xanthium strumarium</i>	Common cocklebur			

<sup>(a)</sup> Nomenclature according to Hitchcock, CL and A Cronquist. 2018. *Flora of the Pacific Northwest: An Illustrated Manual, 2nd Edition*. Edited by DE Giblin, BS Legler, PF Zika, and RG Olmstead. University of Washington Press, Seattle, WA. 936pp.

<sup>(b)</sup> Noxious Weed Class B = Prevent spread and contain or reduce existing populations;  
Noxious Weed Class C = Weeds widespread, control methods available but not normally required.

Field surveys in the riparian zone have not been conducted since 2018.

**Table A.5. Bird Species Observed in the Riparian Area of the PNNL-Richland Campus in 2015 and 2017–2018**

Species Name	Common Name	State Status	Federal Status
<i>Actitis macularius</i>	Spotted sandpiper		
<i>Agelaius phoeniceus</i>	Red-winged blackbird		
<i>Anas platyrhynchos</i>	Mallard		
<i>Ardea herodias</i>	Great blue heron		
<i>Branta canadensis</i>	Canada goose		
<i>Bubo virginianus</i>	Great-horned owl		
<i>Calidris bairdii</i>	Baird's sandpiper		
<i>Calidris mauri</i>	Western sandpiper		
<i>Callipepla californica</i>	California quail		
<i>Ardea alba</i>	Great egret		
<i>Columba livia</i>	Rock pigeon		
<i>Corvus corax</i>	Common raven		
<i>Icterus bullockii</i>	Bullock's oriole		
<i>Larus californicus</i>	California gull		
<i>Megaceryle alcyon</i>	Belted kingfisher		
<i>Melospiza lincolni</i>	Lincoln's sparrow		
<i>Melospiza melodia</i>	Song sparrow		
<i>Mergus merganser</i>	Common merganser		
<i>Nycticorax nycticorax</i>	Black-crowned night heron		
<i>Pandion haliaetus</i>	Osprey		
<i>Pelecanus erythrorhynchos</i>	American white pelican	Sensitive	
<i>Phalacrocorax auritus</i>	Double-crested cormorant		
<i>Pica</i>	Black-billed magpie		
<i>Riparia</i>	Bank swallow		
<i>Sturnus vulgaris</i>	European starling		
<i>Tyrannus</i>	Eastern kingbird		
<i>Tyrannus verticalis</i>	Western kingbird		
<i>Turdus migratorius</i>	American robin		
<i>Zenaida macroura</i>	Mourning dove		

Field surveys in the riparian zone have not been conducted since 2018.

Table A.6. Mammal Species Observed in the Riparian Area of the PNNL-Richland Campus in 2015 and 2017–2018

Species Name	Common Name	State Status	Federal Status
<i>Canis latrans</i>	Coyote		
<i>Castor canadensis</i>	American beaver		
<i>Erithizon dorsatum</i>	Porcupine		
<i>Odocoileus hemionus</i>	Mule deer		
<i>Sciurus niger</i>	Eastern fox squirrel		
Field surveys in the riparian zone have not been conducted since 2018.			

## Appendix B – Plant and Animal Species Observed On and In the Vicinity of the PNNL-Sequim Campus

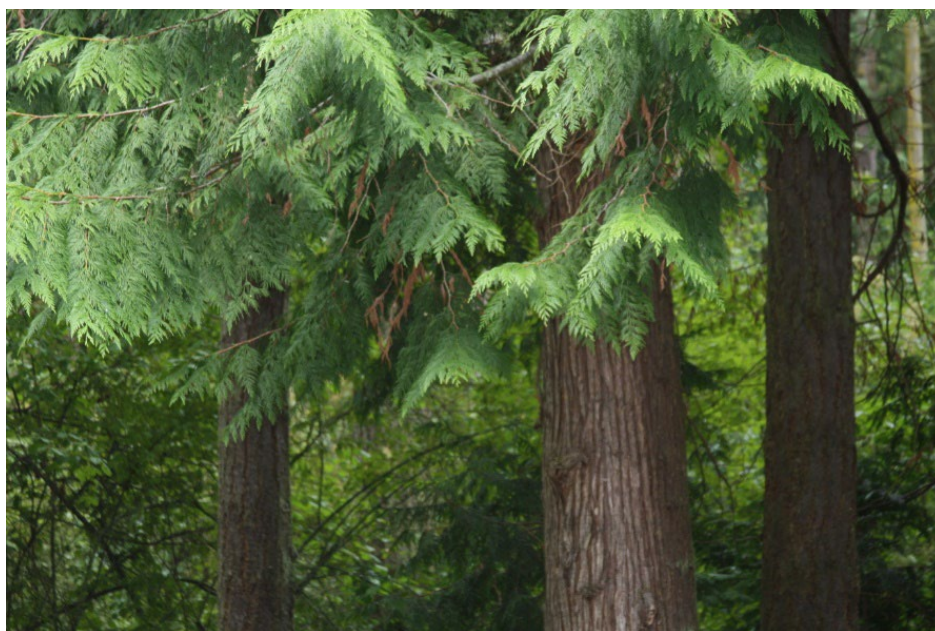


Figure B.1. Typical Vegetation at the PNNL-Sequim Campus

Biological resource surveys were last conducted in CY 2019 at the PNNL-Sequim campus.

Table B.1. Plant Species Observed on PNNL-Sequim Campus Lands, 2006–2019

Species Name <sup>(a)</sup>	Common Name <sup>(a)</sup>	State Status	Federal Status	Noxious Weed Class <sup>(b)</sup>
<i>Abies grandis</i>	Grand fir			
<i>Abronia latifolia</i>	Yellow sand verbena			
<i>Acer circinatum</i>	Vine maple			
<i>Acer glabrum</i>	Rocky Mountain maple			
<i>Acer macrophyllum</i>	Bigleaf maple			
<i>Achillea millefolium</i>	Common yarrow			
<i>Agropyron repens</i>	Quackgrass			
<i>Alnus rubra</i>	Red alder			
<i>Ambrosia chamissonis</i>	Silver bursage			
<i>Amelanchier alnifolia</i>	Saskatoon serviceberry			
<i>Anaphalis margaritacea</i>	Pearly-everlasting			
<i>Arbutus menziesii</i>	Madrone			
<i>Arctostaphylos uva-ursi</i>	Kinnikinnick			
<i>Artemisia suksdorfii</i>	Suksdorf's sagebrush			
<i>Atriplex patula</i>	Spear orache			
<i>Avena</i> sp.	Oat			
<i>Bellis perennis</i>	Daisy			
<i>Berberis aquifolium</i>	Shining Oregon-grape			
<i>Berberis nervosa</i>	Dull Oregon-grape			

Species Name <sup>(a)</sup>	Common Name <sup>(a)</sup>	State Status	Federal Status	Noxious Weed Class <sup>(b)</sup>
<i>Brassica rapa</i>	Field mustard			
<i>Cakile edentula</i>	American searocket			
<i>Calystegia soldanella</i>	Beach morning-glory			
<i>Capsella bursa-pastoris</i>	Shepherd's-purse			
<i>Carex sp.</i>	Sedge			
<i>Castilleja hispida</i>	Harsh Indian-paintbrush			
<i>Cerastium arvense</i>	Field chickweed			
<i>Chamaenerion angustifolium</i>	Fireweed			
<i>Chenopodium album</i>	White goosefoot			
<i>Cirsium arvense</i>	Creeping thistle			C
<i>Cirsium remotifolium</i>	Pacific fringed thistle			
<i>Cirsium vulgare</i>	Bull thistle			
<i>Claytonia perfoliata</i>	Miner's lettuce			
<i>Collinsia parviflora</i>	Small-flowered blue-eyed Mary			
<i>Conium maculatum</i>	Poison-hemlock			B
<i>Convolvulus arvensis</i>	Small bindweed			
<i>Cornus stolonifera</i>	Red-osier dogwood			
<i>Corylus cornuta var. californica</i>	Beaked hazelnut			
<i>Crataegus douglasii</i>	Douglas's hawthorne			
<i>Crataegus monogyna</i>	1-seed hawthorn			C
<i>Crepis capillaris</i>	Smooth hawksbeard			
<i>Cuscuta pacifica</i>	Pacific salt marsh dodder			
<i>Cytisus scoparius</i>	Scot's broom			B
<i>Dactylis glomerata</i>	Orchard-grass			
<i>Danthonia intermedia</i>	Timber oatgrass			
<i>Delphinium sp.</i>	Larkspur			
<i>Deschampsia caespitosa</i>	Tufted hairgrass			
<i>Dipsacus sylvestris</i>	Teasel			C
<i>Distichlis spicata</i>	Saltgrass			
<i>Draba verna</i>	Whitlow-grass			
<i>Elymus glaucus</i>	Blue wildrye			
<i>Elymus mollis</i>	American dunegrass			
<i>Epilobium ciliatum</i>	Common willow-herb			
<i>Epilobium minutum</i>	Small-flowered willow-herb			
<i>Equisetum arvense</i>	Common horsetail			
<i>Equisetum hyemale</i>	Common scouring-rush			
<i>Erodium cicutarium</i>	Redstem stork's bill			
<i>Eschscholzia californica</i>	Poppy			
<i>Fragaria virginiana</i>	Mountain strawberry			
<i>Fritillaria affinis</i>	Checker lily			
<i>Galium aparine</i>	Stickywilly			
<i>Galium triflorum</i>	Sweetscented bedstraw			
<i>Gaultheria shallon</i>	Salal			
<i>Geranium molle</i>	Dovefoot geranium			
<i>Glehnia leiocarpa</i>	Glehnia			

Species Name <sup>(a)</sup>	Common Name <sup>(a)</sup>	State Status	Federal Status	Noxious Weed Class <sup>(b)</sup>
<i>Grindelia integrifolia</i>	Puget Sound gumweed			
<i>Hedera helix</i>	English ivy			
<i>Heracleum maximum</i>	Common cow-parsnip			
<i>Hieraceum sp.</i>	Hawkweed			
<i>Holodiscus discolor</i>	Oceanspray			
<i>Hordeum brachyanterum</i>	Meadow barley			
<i>Hypericum scouleri</i>	Western St. John's-wort			
<i>Hypochaeris radicata</i>	Hairy cat's ear			C
<i>Ilex aquifolium</i>	Holly			M
<i>Juncus sp.</i>	Rush			
<i>Lathyrus japonicus</i>	Sea peavine			
<i>Lathyrus polyphyllus</i>	Leafy peavine			
<i>Lepidium densiflorum</i>	Common pepperweed			
<i>Leucanthemum vulgare</i>	Oxeye-daisy			C
<i>Linnaea borealis</i>	Twinflower			
<i>Lomatium nudicaule</i>	Bare-stemmed biscuitroot			
<i>Lonicera ciliosa</i>	Orange honeysuckle			
<i>Lonicera hispidula</i>	California honeysuckle			
<i>Lupinus sp.</i>	Lupine			
<i>Lysichiton americanus</i>	Skunk cabbage			
<i>Lysimachia latifolia</i>	Western starflower			
<i>Maianthemum dilatatum</i>	False lily-of-the-valley			
<i>Maianthemum racemosum ssp. amplexicaule</i>	Large false Solomon's seal			
<i>Malus fusca</i>	Oregon crabapple			
<i>Matricaria discoidea</i>	Pineapple weed			
<i>Medicago lupulina</i>	Black medick			
<i>Mycelis muralis</i>	Mycelis			
<i>Myosotis laxa</i>	Small-flowered forget-me-not			
<i>Oemleria cerasiformis</i>	Indian plum			
<i>Osmorhiza berteroi</i>	Sweet-cicely			
<i>Petasites frigidus</i>	Sweet coltsfoot			
<i>Physocarpus capitatus</i>	Pacific ninebark			
<i>Plantago lanceolata</i>	English plantain			
<i>Plantago major</i>	Common plantain			
<i>Plantago maritima</i>	Sea tongue			
<i>Plectritis congesta</i>	Sea blush			
<i>Polygonum paronychia</i>	Black knotweed			
<i>Polystichum munitum</i>	Western swordfern			
<i>Populus trichocarpa</i>	Black cottonwood			
<i>Potentilla anserina</i>	Cinquefoil			
<i>Prunella vulgaris</i>	Self-heal			
<i>Prunus emarginata</i>	Bitter cherry			
<i>Prunus laurocerasus</i>	Cherry laurel			
<i>Pseudotsuga menziesii</i>	Douglas fir			

Species Name <sup>(a)</sup>	Common Name <sup>(a)</sup>	State Status	Federal Status	Noxious Weed Class <sup>(b)</sup>
<i>Pteridium aquilinum</i>	Bracken fern			
<i>Ranunculus repens</i>	Creeping buttercup			
<i>Ranunculus uncinatus</i>	Little buttercup			
<i>Ribes divaricatum</i>	Straggly gooseberry			
<i>Ribes sanguineum</i>	Redflower currant			
<i>Rosa gymnocarpa</i>	Little wild rose			
<i>Rosa nutkana</i>	Nootka rose			
<i>Rubus bifrons</i>	Himalayan blackberry			C
<i>Rubus leucodermis</i>	Blackcap			
<i>Rubus nutkanus</i>	Thimbleberry			
<i>Rubus ursinus</i>	Pacific blackberry			
<i>Rumex acetosella</i>	Sheep sorrel			
<i>Rumex crispus</i>	Curly dock			
<i>Rumex occidentalis</i>	Western dock			
<i>Salicornia depressa</i>	Low glasswort			
<i>Salix sitchensis</i>	Sitka willow			
<i>Sambucus racemosa</i>	Red elderberry			
<i>Senecio vulgaris</i>	Old-man-in-the-spring			
<i>Senecio sylvaticus</i>	Wood groundsel			
<i>Sonchus asper</i>	Prickly sow-thistle			
<i>Spiraea douglasii</i>	Spirea			
<i>Stellaria media</i>	Common chickweed			
<i>Struthiopteris spicant</i>	Hard fern			
<i>Symphoricarpos albus</i>	Common snowberry			
<i>Taraxacum officinale</i>	Common dandelion			
<i>Tellima grandiflora</i>	Fringecup			
<i>Thuja plicata</i>	Western red cedar			
<i>Tolmiea menziesii</i>	Youth-on-age			
<i>Tragopogon dubius</i>	Yellow salsify			
<i>Trifolium dubium</i>	Suckling clover			
<i>Trifolium pratense</i>	Red clover			
<i>Trifolium repens</i>	White clover			
<i>Triglochin maritima</i>	Seaside arrow-grass			
<i>Triphysaria pusilla</i>	Dwarf owl-clover			
<i>Tsuga heterophylla</i>	Western hemlock			
<i>Urtica dioica</i>	Stinging nettle			
<i>Vicia americana</i>	American vetch			
<i>Vicia cracca</i>	Bird vetch			
<i>Vicia nigricans</i>	Giant vetch			
<i>Vicia sativa</i>	Common vetch			

<sup>(a)</sup> Nomenclature according to Hitchcock, CL and A Cronquist. 2018. *Flora of the Pacific Northwest: An Illustrated Manual, 2nd Edition*. Edited by DE Giblin, BS Legler, PF Zika, and RG Olmstead. University of Washington Press, Seattle, WA. 936pp.

<sup>(b)</sup> Noxious Weed Class: B = Prevent spread and contain or reduce existing populations; C = Weeds widespread, control methods available but not normally required; M = Monitor list.

Table B.2. Bird Species Observed on and in the Vicinity of the PNNL-Sequim Campus Lands, 2010–2021

Species Name	Common Name	State Status	Federal Status
<i>Accipiter cooperii</i>	Cooper's hawk		
<i>Agelaius phoeniceus</i>	Red-winged blackbird		
<i>Accipiter striatus</i>	Sharp-shinned hawk		
<i>Aechmophorus occidentalis</i>	Western grebe	Candidate	
<i>Agelaius phoeniceus</i>	Red-winged blackbird		
<i>Anas platyrhynchos</i>	Mallard		
<i>Anthus rubescens</i>	American pipit		
<i>Ardea herodias</i>	Great blue heron		
<i>Aythya marila</i>	Greater scaup		
<i>Branta bernicla</i>	Brandt		
<i>Branta canadensis</i>	Canada goose		
<i>Bubo virginianus</i>	Great-horned owl		
<i>Bucephala albeola</i>	Bufflehead		
<i>Bucephala clangula</i>	Common goldeneye		
<i>Buteo jamaicensis</i>	Red-tailed hawk		
<i>Calidris alpina</i>	Dunlin		
<i>Callipepla californica</i>	California quail		
<i>Calypte anna</i>	Anna's hummingbird		
<i>Cardellina pusilla</i>	Wilson's warbler		
<i>Cathartes aura</i>	Turkey vulture		
<i>Catharus ustulatus</i>	Swainson's thrush		
<i>Catharus guttatus</i>	Hermit thrush		
<i>Cephus columba</i>	Pigeon guillemot		
<i>Cerorhinca monocerata</i>	Rhinoceros auklet		
<i>Certhia americana</i>	Brown creeper		
<i>Charadrius vociferus</i>	Killdeer		
<i>Circus hudsonius</i>	Northern harrier		
<i>Cistothorus palustris</i>	Marsh wren		
<i>Coccothraustes vespertinus</i>	Evening grosbeak		
<i>Clangula hyemalis</i>	Long-tailed duck		
<i>Colaptes auratus</i>	Northern flicker		
<i>Columba livia</i>	Rock dove (pigeon)		
<i>Contopus cooperi</i>	Olive-sided flycatcher		
<i>Corvus brachyrhynchos</i>	American crow		
<i>Corvus corax</i>	Common raven		
<i>Cyanocitta stelleri</i>	Steller's jay		
<i>Dryobates pubescens</i>	Downy woodpecker		
<i>Dryobates villosus</i>	Hairy woodpecker		
<i>Empidonax difficilis</i>	Pacific-slope flycatcher		
<i>Empidonax hammondi</i>	Hammond's flycatcher		
<i>Euphagus cyanocephalus</i>	Brewer's blackbird		
<i>Falco peregrinus</i>	Peregrine falcon		
<i>Haematopus bachmani</i>	Black oystercatcher		
<i>Haemorhous mexicanus</i>	House finch		

Species Name	Common Name	State Status	Federal Status
<i>Haliaeetus leucocephalus</i>	Bald eagle		
<i>Hirundo rustica</i>	Barn swallow		
<i>Histrionicus histrionicus</i>	Harlequin duck		
<i>Hydroprogne caspia</i>	Caspian tern		
<i>Ixoreus naevius</i>	Varied thrush		
<i>Junco hyemalis</i>	Dark-eyed junco		
<i>Larus glaucescens</i>	Glaucus-winged gull		
<i>Larus glaucescens</i> x <i>L. occidentalis</i>	Olympic gull		
<i>Larus occidentalis</i>	Western gull		
<i>Leiothlypis celata</i>	Orange-crowned warbler		
<i>Lophodytes cucullatus</i>	Hooded merganser		
<i>Megaceryle alcyon</i>	Belted kingfisher		
<i>Melanitta deglandi</i>	White-winged scoter		
<i>Melospiza lincolni</i>	Lincoln's sparrow		
<i>Melospiza melodia</i>	Song sparrow		
<i>Mergus merganser</i>	Common merganser		
<i>Mergus serrator</i>	Red-breasted merganser		
<i>Molothrus ater</i>	Brown-headed cowbird		
<i>Passerculus sandwichensis</i>	Savannah sparrow		
<i>Passerella iliaca</i>	Fox sparrow		
<i>Patagioenas fasciata</i>	Band-tailed pigeon		
<i>Petrochelidon pyrrhonota</i>	Cliff swallow		
<i>Phalacrocorax auritus</i>	Double-crested cormorant		
<i>Phalacrocorax pelagicus</i>	Pelagic cormorant		
<i>Phalacrocorax penicillatus</i>	Brant's cormorant		
<i>Pheucticus melanocephalus</i>	Black-headed grosbeak		
<i>Pipilo maculatus</i>	Spotted towhee		
<i>Piranga ludoviciana</i>	Western tanager		
<i>Podiceps nigricollis</i>	Eared grebe		
<i>Podilymbus podiceps</i>	Pied-billed grebe		
<i>Poecile atricapillus</i>	Black-capped chickadee		
<i>Poecile rufescens</i>	Chestnut-backed chickadee		
<i>Progne subis</i>	Purple martin		
<i>Psaltiriparus minimus</i>	Bushtit		
<i>Regulus calendula</i>	Ruby-crowned kinglet		
<i>Regulus satrapa</i>	Golden-crowned kinglet		
<i>Selasphorus rufus</i>	Rufous hummingbird		
<i>Setophaga coronata</i>	Yellow-rumped warbler		
<i>Setophaga petechia</i>	Yellow warbler		
<i>Setophaga townsendi</i>	Townsend's warbler		
<i>Sitta canadensis</i>	Red-breasted nuthatch		
<i>Sphyrapicus ruber</i>	Red-breasted sapsucker		
<i>Spinus pinus</i>	Pine siskin		
<i>Spinus tristis</i>	American goldfinch		
<i>Stelgidopteryx serripennis</i>	Northern rough-winged swallow		
<i>Sterna caspia</i>	Caspian tern		
<i>Strix varia</i>	Barred owl		

Species Name	Common Name	State Status	Federal Status
<i>Sturnus vulgaris</i>	European starling		
<i>Tachycineta bicolor</i>	Tree swallow		
<i>Tachycineta thalassina</i>	Violet-green swallow		
<i>Thryomanes bewickii</i>	Bewick's wren		
<i>Troglodytes pacificus</i>	Pacific wren		
<i>Turdus migratorius</i>	American robin		
<i>Zenaida macroura</i>	Mourning dove		
<i>Zonotrichia leucophrys</i>	White-crowned sparrow		

Table B.3. Other Vertebrate Species Observed on PNNL-Sequim Campus Lands, 2013–2015

Species Name	Common Name	State Status	Federal Status
<i>Anaxyrus boreas</i>	Western toad		
<i>Canis latrans</i>	Coyote		
<i>Odocoileus hemionus</i>	Black-tailed deer		
<i>Rana aurora</i>	Northern red-legged frog		
<i>Sorex</i> sp.	Shrew		
<i>Tamiasciurus douglasii</i>	Douglas squirrel		
<i>Taricha granulosa</i>	Rough-skinned newt		

## Appendix C – Ambient External Dose Surveillance Results

Ambient levels of external dose from beta, gamma, and X-ray sources are monitored on a quarterly basis at the five particulate air monitoring stations associated with the PNNL-Richland campus. No ambient external dose surveillance is yet conducted at the PNNL-Sequim campus.

### C.1 Ambient External Dose Surveillance Results CY 2023

The program establishes baseline ambient external dose levels at four PNNL-Richland campus stations and at the background (PNL-5) station. Definitions for the ambient air external dose sampling are in Table C.1; dose surveillance results are in Table C.2; and normalized quarterly external dose results are in Table C.3.

Table C.1. Definitions for Ambient Air External Dose Sampling Data

Column Heading	Data Type/Format	Content
Location ID	Text	Location of monitoring station: PNNL-Richland campus Monitoring stations – PNL-1, PNL-2, PNL-3, PNL-4. Background Location – PNL-5 PNL-T – to measure exposure during field deployment/retrieval PNL-Control – to measure exposure during shipment to and from vendor (value is NOT subtracted from the monitoring station data shown in Table C.2)
Field Sample ID	Number (#####)	Unique identifier assigned to a sample (typically six-digit number but characters allowed).
Parameter Name	Text	Code assigned to analytical parameter: Optically Stimulated Luminescence Dosimeter-Gross Exposure (OSLD-GE).
Start Date	Date (DD-MMM-YYYY)	Date when dosimeter sampling started.
Sample Date	Date (DD-MMM-YYYY)	Date when dosimeter sampling ended.
Quarter	Text (Q#)	Calendar quarter when the dosimeter was deployed.
Result	Integer number	Gross dose (no control value subtracted) result as reported by the vendor.
Units	Text	Units associated with the value reported in the Result field, millirem (mrem).

Table C.2. Ambient External Dose Surveillance 2023 PNNL-Richland Campus

Location ID	Field Sample ID	Parameter Name	Start Date	Sample Date	Quarter	Result (mrem)
PNL-1	230001	OSLD-GE	12/28/2022	3/22/2023	Q1	25
PNL-2	230002	OSLD-GE	12/28/2022	3/22/2023	Q1	26
PNL-3	230003	OSLD-GE	12/28/2022	3/22/2023	Q1	30
PNL-4	230004	OSLD-GE	12/28/2022	3/22/2023	Q1	24
PNL-5	230005	OSLD-GE	12/28/2022	3/22/2023	Q1	24
PNL-T	230007	OSLD-GE	12/28/2022	3/22/2023	Q1	18
PNL-CONTROL	230006	OSLD-GE	12/28/2022	3/22/2023	Q1	20
PNL-1	230008	OSLD-GE	3/22/2023	6/28/2023	Q2	26
PNL-2	230009	OSLD-GE	3/22/2023	6/28/2023	Q2	24
PNL-3	230010	OSLD-GE	3/22/2023	6/28/2023	Q2	22
PNL-4	230011	OSLD-GE	3/22/2023	6/28/2023	Q2	24
PNL-5	230012	OSLD-GE	3/22/2023	6/28/2023	Q2	27

Location ID	Field Sample ID	Parameter Name	Start Date	Sample Date	Quarter	Result (mrem)
PNL-T	230014	OSLD-GE	3/22/2023	6/28/2023	Q2	14
PNL-CONTROL	230013	OSLD-GE	3/22/2023	6/28/2023	Q2	16
PNL-1	230015	OSLD-GE	6/28/2023	9/20/2023	Q3	22
PNL-2	230016	OSLD-GE	6/28/2023	9/20/2023	Q3	23
PNL-3	230017	OSLD-GE	6/28/2023	9/20/2023	Q3	23
PNL-4	230018	OSLD-GE	6/28/2023	9/20/2023	Q3	25
PNL-5	230019	OSLD-GE	6/28/2023	9/20/2023	Q3	28
PNL-T	230021	OSLD-GE	6/28/2023	9/20/2023	Q3	17
PNL-CONTROL	230020	OSLD-GE	6/28/2023	9/20/2023	Q3	14
PNL-1	230022	OSLD-GE	9/20/2023	12/27/2023	Q4	33
PNL-2	230023	OSLD-GE	9/20/2023	12/27/2023	Q4	29
PNL-3	230024	OSLD-GE	9/20/2023	12/27/2023	Q4	30
PNL-4	230025	OSLD-GE	9/20/2023	12/27/2023	Q4	31
PNL-5	230026	OSLD-GE	9/20/2023	12/27/2023	Q4	30
PNL-T	230028	OSLD-GE	9/20/2023	12/27/2023	Q4	23
PNL-CONTROL	230027	OSLD-GE	9/20/2023	12/27/2023	Q4	20

Table C.3. 2023 PNNL-Richland Campus Ambient External Dose Calculated for ANSI/HPS N13.37-2014 (HPS 2019) 91-d Normalized Quarters

2023 91-d Normalized Quarter Dose	PNL-1	PNL-2	PNL-3	PNL-4	PNL-5 <sup>(a)</sup>
Normalized Q1 (mrem/Q)	5.42	6.50	10.83	4.33	4.33
Normalized Q2 (mrem/Q)	9.29	7.43	5.57	7.43	10.21
Normalized Q3 (mrem/Q)	5.42	6.50	6.50	8.67	11.92
Normalized Q4 (mrem/Q)	9.29	5.57	6.50	7.43	6.50
<b>Total (mrem/yr)</b>	<b>29.4</b>	<b>26.0</b>	<b>29.4</b>	<b>27.9</b>	<b>33.0</b>

<sup>(a)</sup> PNL-5 is the background station. No background values were subtracted from listed campus perimeter stations (PNL-1 through PNL-4) results.

## C.2 Updated Presentation of OSL 2017–2022 Data

PNNL-Richland campus OSL ambient external dose results were evaluated in an updated manner (Snyder and Cooley 2024). This method was developed to incorporate known dosimeter uncertainty and accommodate both the low dose results reported using ANSI N13.37 methods and the lack of control dosimeter storage vessel dose information. Due to the lack of storage vessel dose, the results do not indicate actual ambient external dose levels but do indicate whether the critical station doses are above or below the background station dose. Ambient external dose is reported to one standard deviation.

The updated methodology was used to reevaluate all prior OSL results. Background at PNL-5 ranged between  $29 \pm 4.5$  mrem/yr and  $40 \pm 4.8$  mrem/yr from 2017 through 2022.

### C.2.1 2017 OSL Results

The updated methodology reconfirms that critical station (PNL-1 through PNL-4) results were all below background (PNL-5) with 95% confidence.

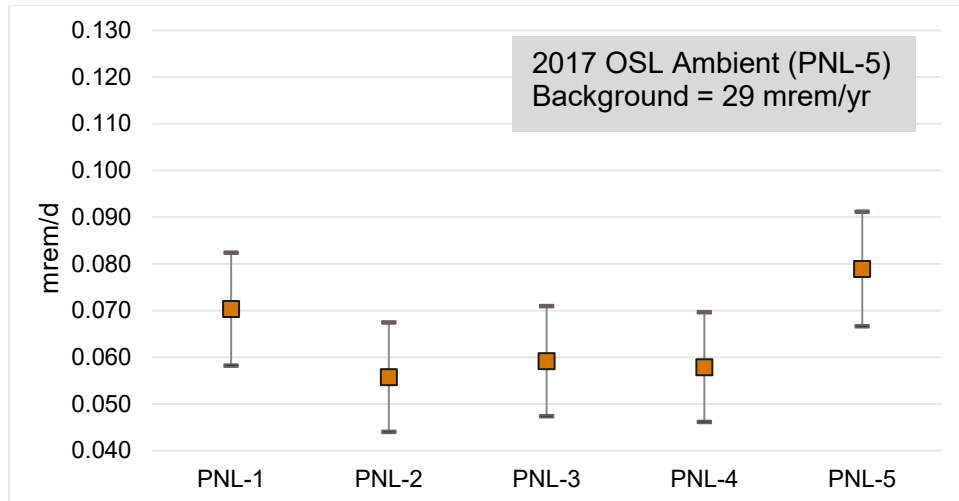


Figure C.1. 2017 Updated Methodology OSL Results

### C.2.2 2018 OSL Results

The updated methodology reconfirms that critical station (PNL-1 through PNL-4) results were all below background (PNL-5) with 95% confidence.

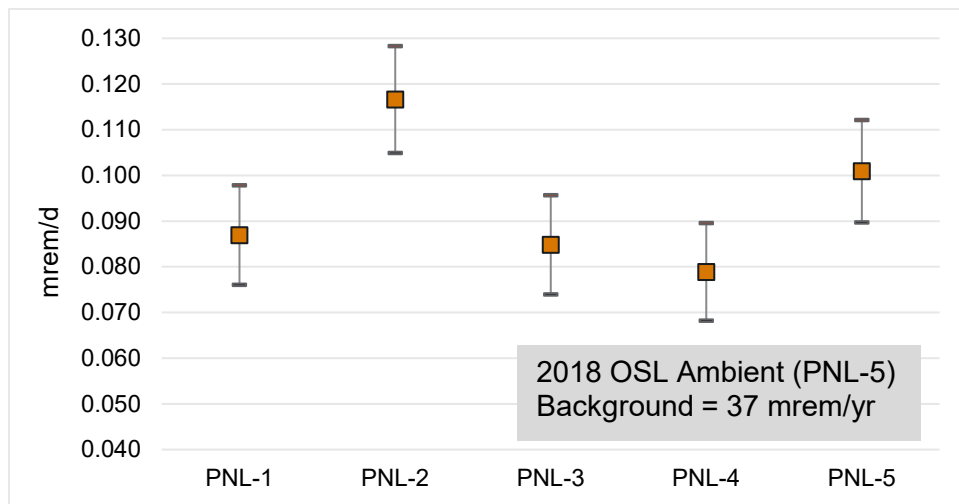


Figure C.2. 2018 Updated Methodology OSL Results

### C.2.3 2019 OSL Results

The updated methodology reconfirms that critical station (PNL-1 through PNL-4) results were all below background (PNL-5) with 95% confidence.

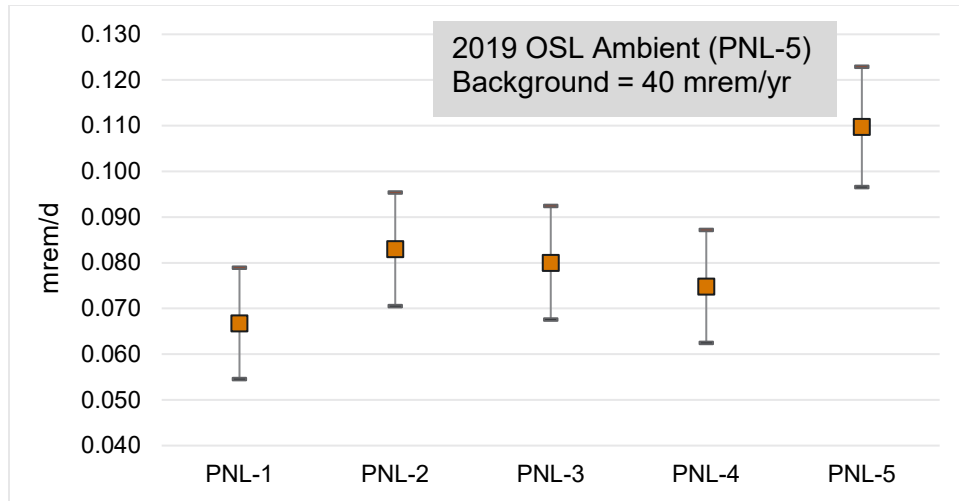


Figure C.3. 2019 Updated Methodology OSL Results

#### C.2.4 2020 OSL Results

The updated methodology indicates that critical station (PNL-1 through PNL-4) results were all below background (PNL-5), with 95% confidence. As a conservative assumption, the 2020 ASER (Duncan et al. 2021) had indicated an MEI external dose assignment of 3 mrem based on OSL ambient dosimeter results at the station nearest the MEI location, PNL-3. Under the updated methodology, no external ambient dose would be assigned because the PNL-3 results are within background at a 95% confidence level. The updated MEI dose for 2020 would result only from radioactive air effluent,  $1.7 \times 10^{-5}$  mrem ( $1.7 \times 10^{-7}$  mSv).

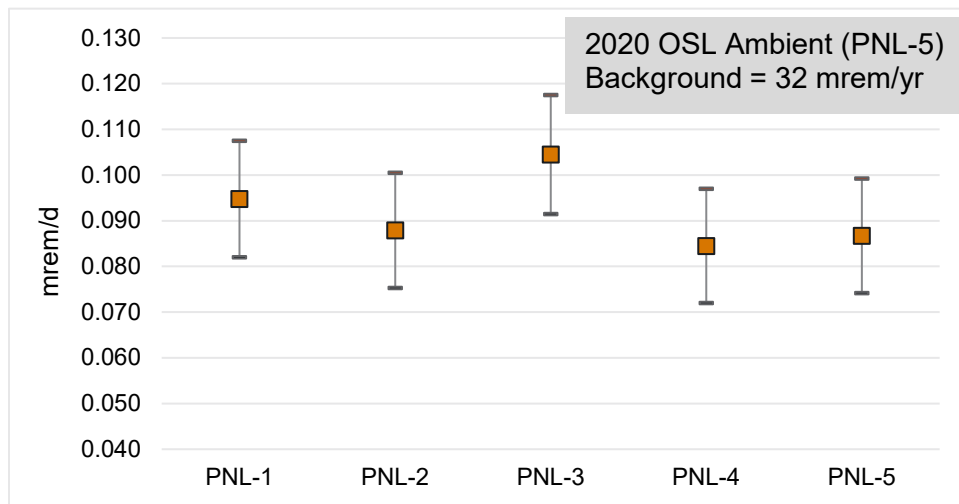


Figure C.4. 2020 Updated Methodology OSL Results

#### C.2.5 2021 OSL Results

The updated methodology reconfirms that critical station (PNL-1 through PNL-4) results were all below background (PNL-5) with 95% confidence.

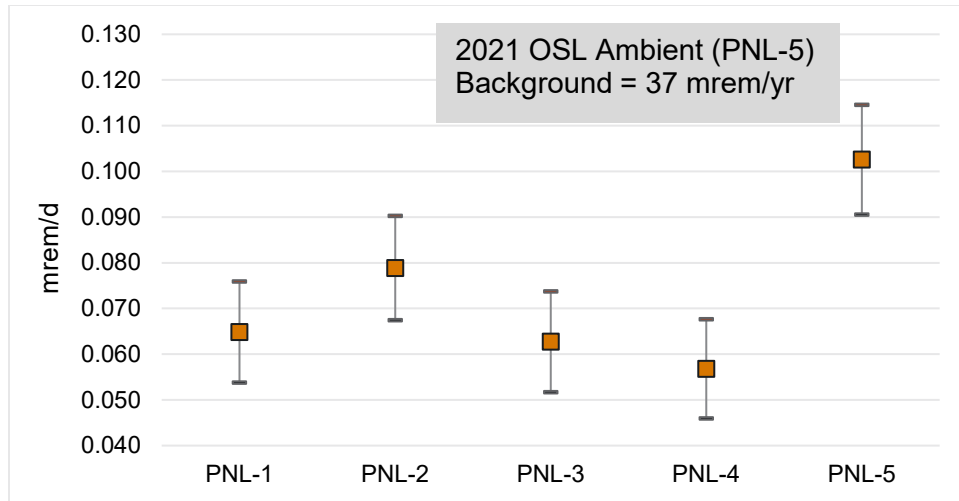


Figure C.5. 2021 Updated Methodology OSL Results

### C.2.6 2022 OSL Results

The updated methodology reconfirms that critical station (PNL-1 through PNL-4) results were all below background (PNL-5) with 95% confidence.

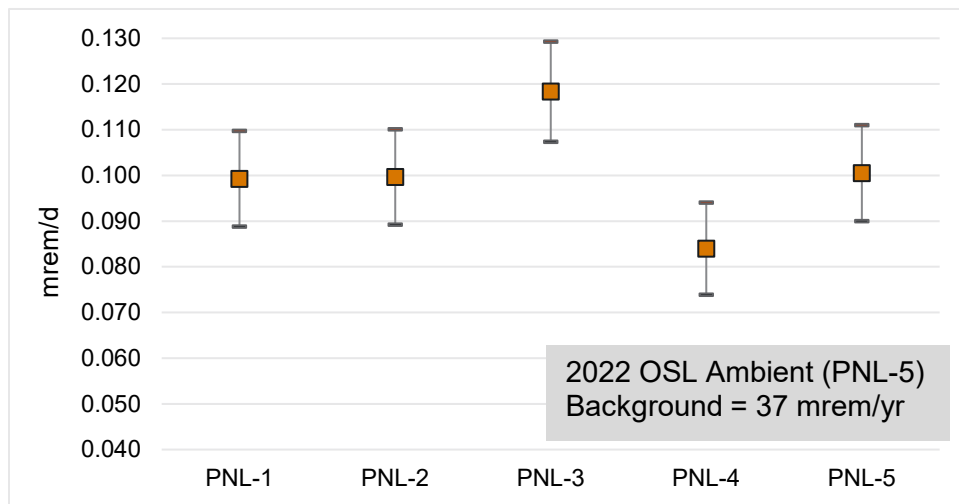


Figure C.6. 2022 Updated Methodology OSL Results

### C.2.7 Quarterly Daily Dose Rate Graphics

PNNL-Richland campus daily dose rates by quarter for the critical stations and background station are indicated in the figures below. The annual background average daily dose rate for each year from 2017–2022 is also indicated.

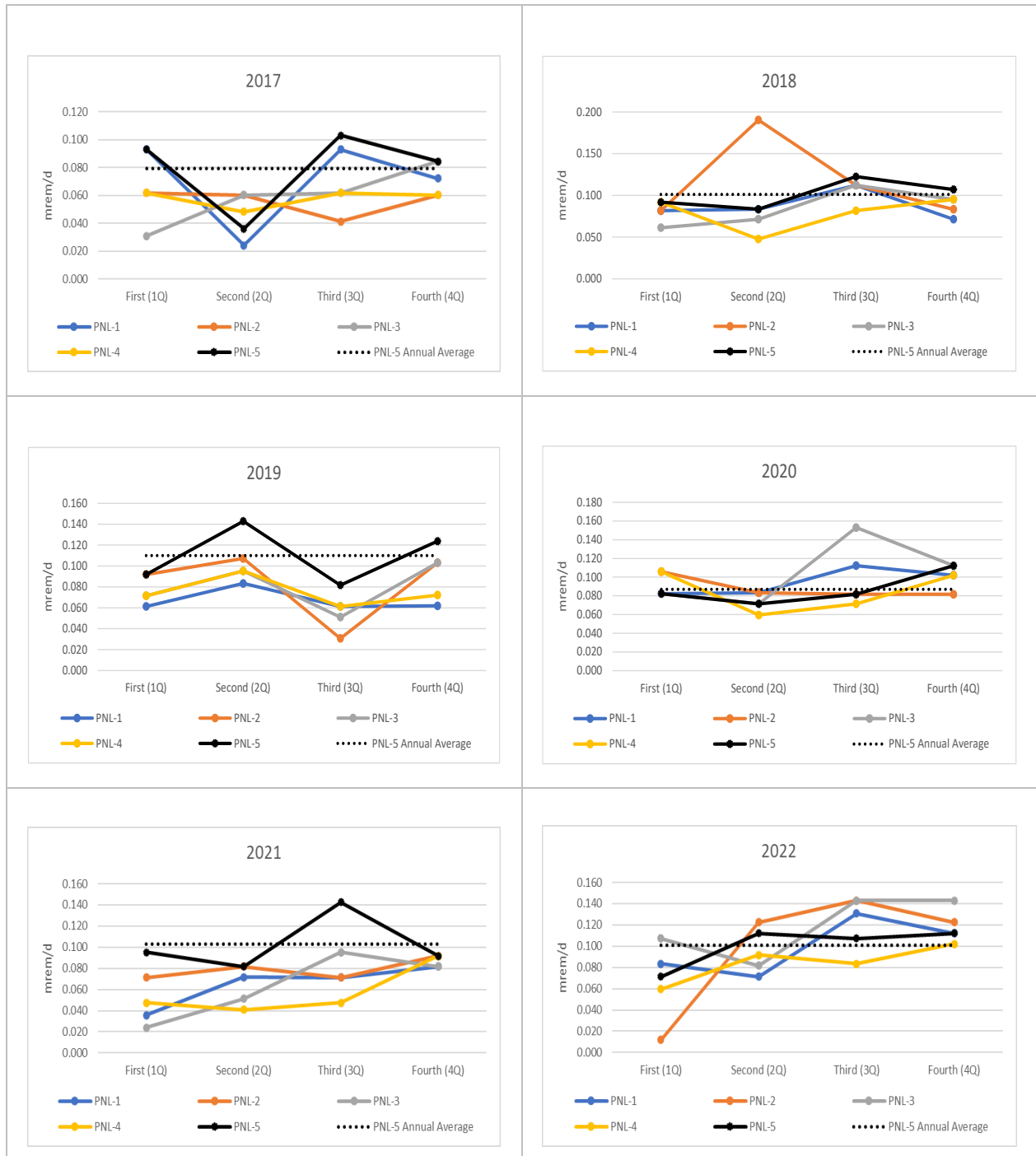


Figure C.7. Daily Dose Rates by Quarter for PNNL-Richland Campus

## Appendix D – Helpful Information

The information in this appendix is provided to assist readers in understanding this report. Included here is information about scientific notation, units of measurement, radioactivity units, radiological dose units, chemical and elemental nomenclature, and greater than or less than symbols. Definitions of technical terms are provided in Appendix E.

### D.1 Scientific Notation

Scientific notation is used to express very large or very small numbers. For example, the number 1 billion can be written as 1,000,000,000 or, by using scientific or E notation, written as  $1 \times 10^9$  or 1.0E+09. Translating from scientific notation to a more traditional number requires moving the decimal point either left or right from its current location. If the value given is  $2.0 \times 10^3$  (or 2.0E+03), the decimal point should be moved three places to the right, so that the number would then read 2,000. If the value given is  $2.0 \times 10^{-5}$  (or 2.0E-05), the decimal point should be moved five places to the left, so that the result would be 0.00002.

### D.2 Units of Measurement

The primary units of measurement used in this report follow the International System of Units and are metric, but U.S. standard measurements are also provided. Table D.1 summarizes and defines the terms and corresponding symbols (metric and non-metric). A conversion table is provided in Table D.2.

Table D.1. Names and Symbols for Units of Measure

Symbol	Name	Symbol	Name
<b>Concentration</b>		<b>Area</b>	
ppb	parts per billion	ha	hectare(s) ( $1 \times 10^4 \text{ m}^2$ )
ppm	parts per million	km <sup>2</sup>	square kilometer(s)
ppmv	parts per million by volume	mi <sup>2</sup>	square mile(s)
<b>Length</b>		ft <sup>2</sup>	square foot (feet)
cm	centimeter(s) ( $1 \times 10^{-2} \text{ m}$ )	<b>Mass</b>	
ft	foot (feet)	g	gram(s)
in.	inch(es)	kg	kilogram(s) ( $1 \times 10^3 \text{ g}$ )
km	kilometer(s) ( $1 \times 10^3 \text{ m}$ )	mg	milligram(s) ( $1 \times 10^{-3} \text{ g}$ )
m	meter(s)	μg	microgram(s) ( $1 \times 10^{-6} \text{ g}$ )
mi	mile(s)	lb	pound(s)
mm	millimeter(s) ( $1 \times 10^{-3} \text{ m}$ )	<b>Time</b>	
μm	micrometer(s) ( $1 \times 10^{-6} \text{ m}$ )	d	day(s)
<b>Rate</b>		hr	hour(s)
cfs (or ft <sup>3</sup> /sec)	cubic feet per second	min	minute(s)
cpm	counts per minute	sec	second(s)
gpm	gallon(s) per minute	yr	year(s)
mph	mile(s) per hour	<b>Volume</b>	
mR/hr	milliroentgen(s) per hour	cm <sup>3</sup>	cubic centimeter(s)
mrem/d	millirem per day	ft <sup>3</sup>	cubic foot (feet)
mrem/yr	millirem per year	gal	gallon(s)
μrem/hr	microrem per hour	L	liter(s)
<b>Temperature</b>		m <sup>3</sup>	cubic meter(s)
°C	degrees Celsius	mL	milliliter(s) ( $1 \times 10^{-3} \text{ L}$ )
°F	degrees Fahrenheit	yd <sup>3</sup>	cubic yard(s)

Table D.2. Conversion Table

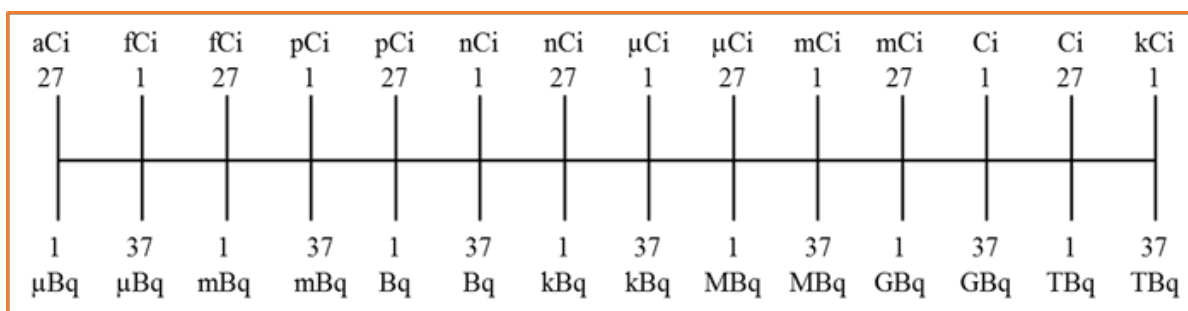
Multiply	By	To Obtain	Multiply	By	To Obtain
cm	0.394	in.	in.	2.54	cm
m	3.28	ft	ft	0.305	m
km	0.621	mi	mi	1.61	km
kg	2.205	lb	lb	0.454	kg
L	0.2642	gal	gal	3.785	L
m <sup>2</sup>	10.76	ft <sup>2</sup>	ft <sup>2</sup>	0.093	m <sup>2</sup>
ha	2.47	acres	acre	0.405	ha
km <sup>2</sup>	0.386	mi <sup>2</sup>	mi <sup>2</sup>	2.59	km <sup>2</sup>
m <sup>3</sup>	35.31	ft <sup>3</sup>	ft <sup>3</sup>	0.0283	m <sup>3</sup>
m <sup>3</sup>	1.308	yd <sup>3</sup>	yd <sup>3</sup>	0.7646	m <sup>3</sup>
pCi	1,000	nCi	nCi	0.001	pCi
μCi/mL	10 <sup>9</sup>	pCi/L	pCi/L	10 <sup>-9</sup>	μCi/mL
Ci/m <sup>3</sup>	10 <sup>12</sup>	pCi/m <sup>3</sup>	pCi/m <sup>3</sup>	10 <sup>-12</sup>	Ci/m <sup>3</sup>
mCi/cm <sup>3</sup>	10 <sup>15</sup>	pCi/m <sup>3</sup>	pCi/m <sup>3</sup>	10 <sup>-15</sup>	mCi/cm <sup>3</sup>
nCi/m <sup>2</sup>	1.0	mCi/km <sup>2</sup>	mCi/km <sup>2</sup>	1.0	nCi/m <sup>2</sup>
Ci	$3.7 \times 10^{10}$	Bq	Bq	$2.7 \times 10^{-11}$	Ci
pCi	0.037	Bq	Bq	27	pCi
rad	0.01	Gy	Gy	100	rad
rem	0.01	Sv	Sv	100	rem
ppm	1,000	ppb	ppb	0.001	ppm
°C	(°C × 9/5) + 32	°F	°F	(°F - 32) ÷ 9/5	°C
oz	28.349	g	g	0.035	oz
ton	0.9078	tonne	tonne	1.1	ton

### D.3 Radioactivity Units

Much of this report deals with levels of radioactivity in various environmental media. Radioactivity in this report is usually discussed in units of curies (Ci), with conversions to becquerels (Bq), the International System of Units measure (Table D.3). The curie is the basic unit used to describe the amount of activity present, and activities are generally expressed in terms of curies per mass or volume (e.g., picocuries per liter). One curie is equivalent to 37 billion disintegrations per second or is a quantity of any radionuclide that decays at the rate of 37 billion disintegrations per second. One becquerel is equivalent to one disintegration per second. Nuclear disintegrations produce spontaneous emissions of alpha or beta particles, gamma radiation, or combinations of these. Figure D.1 includes selected conversions from curies to becquerels.

Table D.3. Names and Symbols for Units of Radioactivity

Symbol	Name	Symbol	Name
Ci	curie	Bq	becquerel
mCi	millicurie (1 × 10 <sup>-3</sup> Ci)	kBq	kilobecquerel (1 × 10 <sup>3</sup> Bq)
μCi	microcurie (1 × 10 <sup>-6</sup> Ci)	mBq	millibecquerel (1 × 10 <sup>-3</sup> Bq)
nCi	nanocurie (1 × 10 <sup>-9</sup> Ci)	MBq	megabecquerel (1 × 10 <sup>6</sup> Bq)
pCi	picocurie (1 × 10 <sup>-12</sup> Ci)	GBq	gigabecquerel (1 × 10 <sup>9</sup> Bq)
fCi	femtocurie (1 × 10 <sup>-15</sup> Ci)	TBq	terabecquerel (1 × 10 <sup>12</sup> Bq)
aCi	attocurie (1 × 10 <sup>-18</sup> Ci)		



### Figure D.1. Radioactivity Units, Curies to Becquerels

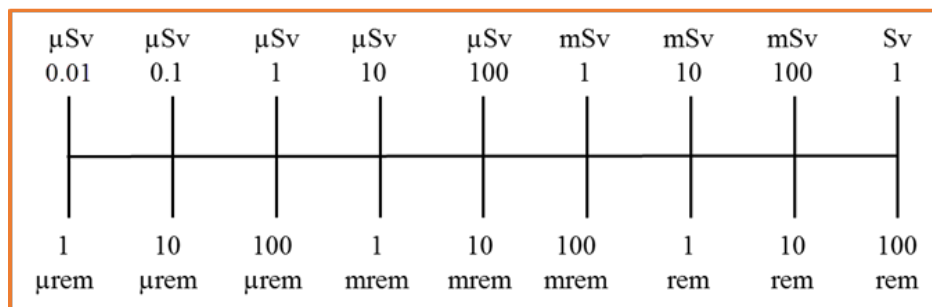
## D.4 Radiological Dose Units

Radiological dose in this report is usually written in terms of EDE and reported numerically in units of millirem (mrem), with the metric units millisievert (mSv) or microsievert ( $\mu\text{Sv}$ ) following in parentheses or footnoted. The EDE and effective dose units can be considered equivalent for the purposes of this report and reflect the units calculated by the software used.

Millirem (millisievert) is a unit of measurement that relates a given amount of absorbed radiation energy to its biological effectiveness or risk (to humans). For perspective, a dose of 1 mrem (0.01 mSv) would have a biological effect roughly the same as that received from 1 day's exposure to natural background radiation. An acute (short-term) dose to the whole body of 100 rem (1 Sv) would likely cause temporary radiation sickness in some exposed individuals. An acute dose of over 500 rem (5 Sv) would soon result in death in approximately 50% of those exposed. Exposure to lower amounts of radiation (10 mrem [100  $\mu$ Sv] or less) produces no immediate observable effects, but long-term (delayed) effects are possible. The average person in the United States receives an annual dose from exposure to naturally produced radiation of approximately 300 mrem (3 mSv). Medical and dental x-rays and air travel add to this total. Figure D.2 includes selected conversions from rem to sievert.

Also used in this report is the term rad, with the corresponding International System of Units, gray (Gy), in parentheses or footnoted. The rad (gray) is a measure of the energy absorbed by any material, whereas a rem relates to both the amount of radiation energy absorbed by humans and its consequence. The gray can be converted to rad by multiplying by 100. The conversions in Figure D.2 can also be used to convert grays to rads, substituting Gy for Sv and substituting rad for rem in Figure D.2.

The names and symbols for units of radiation dose used in this report are listed in Table D.4.



### Figure D.2. Radiological Dose Units, Sieverts to Rem

Table D.4. Names and Symbols for Units of Radiation Dose or Exposure

Symbol	Name
mrاد	millirad ( $1 \times 10^{-3}$ rad)
mrem	millirem ( $1 \times 10^{-3}$ rem)
μrem	microrem ( $1 \times 10^{-6}$ rem)
Sv	sievert (= 100 rem)
mSv	millisievert ( $1 \times 10^{-3}$ Sv)
μSv	microsievert ( $1 \times 10^{-6}$ Sv)
Gy	gray (= 100 rad)
mGy	milligray ( $1 \times 10^{-3}$ Gy)

Additional information about radiation and dose terminology can be found in Appendix E. A list of the radionuclides that may be discussed in this report, their symbols, and their half-lives are included in Table D.5.

Table D.5. Radionuclides and Their Half-Lives<sup>(a)</sup>

Symbol	Radionuclide	Half-Life	Symbol	Radionuclide	Half-Life
<sup>3</sup> H	tritium	12.32 yr	<sup>140</sup> Ba	barium-140	12.7527 d
<sup>7</sup> Be	beryllium-7	53.22 d	<sup>152</sup> Eu	europium-152	13.517 yr
<sup>14</sup> C	carbon-14	5,700 yr	<sup>154</sup> Eu	europium-154	8.601 yr
<sup>24</sup> Na	sodium-24	14.997 h	<sup>155</sup> Eu	europium-155	4.753 yr
<sup>40</sup> K	potassium-40	$1.248 \times 10^9$ yr	<sup>177</sup> Lu	lutetium-177	6.647 d
<sup>26</sup> Al	aluminum-26	$7.17 \times 10^5$ yr	<sup>208</sup> Po	polonium-208	2.898 yr
<sup>39</sup> Ar	argon-39	269 yr	<sup>210</sup> Pb	lead-210	22.20 yr
<sup>51</sup> Cr	chromium-51	27.7025 d	<sup>212</sup> Pb	lead-212	10.64 h
<sup>54</sup> Mn	manganese-54	312.2 d	<sup>220</sup> Rn	radon-220	55.6 sec
<sup>55</sup> Fe	iron-55	2.744 yr	<sup>222</sup> Rn	radon-222	3.8235 d
<sup>59</sup> Fe	iron-59	44.495 d	<sup>226</sup> Ra	radium-226	1600 yr
<sup>59</sup> Ni	nickel-59	$7.6 \times 10^4$ yr	<sup>228</sup> Ra	radium-228	5.75 yr
<sup>57</sup> Co	cobalt-57	271.7 d	<sup>228</sup> Th	thorium-228	1.9125 yr
<sup>60</sup> Co	cobalt-60	5.275 yr	<sup>229</sup> Th	thorium-229	7932 yr
<sup>63</sup> Ni	nickel-63	101.2 yr	<sup>230</sup> Th	thorium-230	$7.54 \times 10^4$ yr
<sup>65</sup> Zn	zinc-65	243.9 d	<sup>232</sup> Th	thorium-232	$1.40 \times 10^{10}$ yr
<sup>82</sup> Br	bromine-82	35.282 h	U or uranium	natural uranium	$\sim 4.5 \times 10^9$ <sup>(b)</sup> yr
<sup>83m</sup> Kr	krypton-83m	1.83 h	<sup>232</sup> U	uranium-232	68.9 yr
<sup>85</sup> Kr	krypton-85	10.739 yr	<sup>233</sup> U	uranium-233	$1.592 \times 10^5$ yr
<sup>89</sup> Sr	strontium-89	50.563 d	<sup>234</sup> U	uranium-234	$2.455 \times 10^5$ yr
<sup>90</sup> Sr	strontium-90	28.9 yr	<sup>235</sup> U	uranium-235	$7.04 \times 10^8$ yr
<sup>88</sup> Y	yttrium-88	106.63 d	<sup>238</sup> U	uranium-238	$4.468 \times 10^9$ yr
<sup>90</sup> Y	yttrium-90	64.053 h	<sup>236</sup> Np	neptunium-236	$1.53 \times 10^5$ yr
<sup>95</sup> Zr	zirconium-95	64.032 d	<sup>237</sup> Np	neptunium-237	$2.144 \times 10^6$ yr
<sup>99</sup> Tc	technetium-99	$2.111 \times 10^5$ yr	<sup>238</sup> Pu	plutonium-238	87.7 yr
<sup>103</sup> Ru	ruthenium-103	39.247 d	<sup>239</sup> Pu	plutonium-239	$2.411 \times 10^4$ yr
<sup>106</sup> Ru	ruthenium-106	371.8 d	<sup>240</sup> Pu	plutonium-240	$6.561 \times 10^3$ yr
<sup>109</sup> Cd	cadmium-109	461.4 d	<sup>241</sup> Pu	plutonium-241	14.329 yr
<sup>113</sup> Sn	tin-113	115.09 d	<sup>242</sup> Pu	plutonium-242	$3.75 \times 10^5$ yr

Symbol	Radionuclide	Half-Life	Symbol	Radionuclide	Half-Life
<sup>125</sup> Sb	antimony-125	2.75856 yr	<sup>244</sup> Pu	plutonium-244	8.0 × 10 <sup>7</sup> yr
<sup>129</sup> I	iodine-129	1.57 × 10 <sup>7</sup> yr	<sup>241</sup> Am	americium-241	432.6 yr
<sup>131</sup> I	iodine-131	8.0252 d	<sup>243</sup> Am	americium-243	7,364 yr
<sup>132</sup> I	iodine-132	2.295 h	<sup>243</sup> Cm	curium-243	29.1 yr
<sup>133</sup> Xe	xenon-133	5.2475 d	<sup>244</sup> Cm	curium-244	18.1 yr
<sup>134</sup> Cs	cesium-134	2.0652 yr	<sup>245</sup> Cm	curium-245	8,423 yr
<sup>137</sup> Cs	cesium-137	30.08 yr	<sup>250</sup> Cf	californium-250	13.08 yr
<sup>137m</sup> Ba	barium-137m	2.552 min	<sup>252</sup> Cf	californium-252	2.645 yr

(a) From NuDat 3.0 at <https://www.nndc.bnl.gov/nudat3/>

(b) Natural uranium is a mixture dominated by uranium-238.

## Appendix E – Glossary

This glossary contains selected words and phrases used in this report that may not be familiar to readers. Words appearing in italic type within a definition are also defined in this glossary.

**alpha particle** – A positively charged particle composed of two protons and two neutrons ejected spontaneously from the nuclei of some *radionuclides* during radioactive decay. It has a low penetrating power and short range. The most energetic alpha particle will generally fail to penetrate the skin but is hazardous when introduced into the body.

**aquifer** – Underground sediment or rock that stores and/or transmits water.

**background radiation** – *Radiation* in the natural environment, including cosmic rays from space and *radiation* from naturally occurring radioactive elements in the air, in the earth, and in human bodies. It also includes *radiation* from global fallout from historical atmospheric nuclear weapons testing. In the United States, the average person receives approximately 300 *millirem* (3 mSv) of background radiation per year.

**becquerel (Bq)** – Unit of activity or amount of a radioactive substance (also *radioactivity*) equal to one nuclear transformation per second (1 Bq = 1 disintegration per second). Another unit of *radioactivity*, the *curie*, is related to the becquerel: 1 Ci =  $3.7 \times 10^{10}$  Bq.

**beta particle** – A negatively charged particle (essentially an electron) released from a nucleus during radioactive *decay*. At high enough intensities, some beta particles may cause skin burns and may be harmful if they enter the body. Beta particles are easily stopped by a thin sheet of metal or plastic.

**Categorical Exclusion** – A class of actions that DOE has determined are not likely to have significant environmental impacts under normal circumstances and for which an environmental assessment or environmental impact statement is not normally needed. These are listed at [10 CFR Part 1021, Appendix D](#).

**collective dose** – Sum of the total EDE for individuals composing a defined population. Collective dose units are *person-rem* or person-sievert.

**composite sample** – Sample formed by combining discrete samples taken at different times or from different locations.

**confined aquifer** – An *aquifer* bounded above and below by less permeable layers. *Groundwater* in the confined aquifer is under a pressure greater than atmospheric pressure.

**curie (Ci)** – A unit of *radioactivity* equal to 37 billion ( $3.7 \times 10^{10}$ ) nuclear transformations per second (*becquerels*).

**decay** – The decrease in the amount of any radioactive material (disintegration) with the passage of time. See *radioactivity*.

**decay product** – The atomic nucleus or nuclei that are left after radioactive transformation of a radioactive material. Decay products may be radioactive or nonradioactive (stable). They are informally referred to as daughter products or progeny. See *radioactivity*.

**dispersion** – Process whereby *effluents* or *emissions* are spread or mixed when they are transported by *groundwater*, surface water, or air.

**dose rate** – The rate at which a dose is delivered over time (e.g., *millirem* per hour [mrem/h]).

**effective dose equivalent (EDE)** – Dose unit qualifier to indicate whole body risk from ionizing radiation exposure. Calculated as the sum of critical human-tissue doses weighted for total health risk. Total health risk includes the risk of fatal and non-fatal cancers, severe hereditary effects, and lifespan.

**effluent** – Liquid material released from a facility.

**effluent monitoring** – Sampling or measuring specific liquid *effluent* streams for the presence of pollutants.

**emission** – Gaseous stream released from a facility.

**essential fish habitat** – Waters and substrate necessary to fish for spawning, breeding, feeding or growth to maturity.

**exposure** – The interaction of an organism with a physical agent (e.g., *radiation*) or a chemical agent (e.g., arsenic) of interest. Also used as a term for quantifying x- and *gamma-radiation* fields.

**fission** – The splitting or breaking apart of a nucleus into at least two other nuclei, accompanied by the release of a relatively large amount of energy.

**gamma radiation** – High-energy electromagnetic *radiation* (photons) originating in the nucleus of decaying *radionuclides*. Gamma radiation is substantially more penetrating than *alpha* or *beta emissions*, but comparatively the energy is not as readily absorbed.

**grab sample** – A short-duration sample (e.g., air, water, and soil) that is grabbed from the collection site.

**gray (Gy)** – Unit of absorbed dose in the International System of Units equal to the absorption of 1 joule per kilogram. The common unit of absorbed dose, the *rad*, is equal to 0.01 Gy.

**groundwater** – Subsurface water that is in the pores of sand and gravel or in the cracks of fractured rock.

**high-level waste** – Highly radioactive waste material resulting from the reprocessing of spent nuclear fuel, including liquid waste produced directly from reprocessing and any solid material derived from such liquid waste that contains *fission* products and other *radioisotopes* in sufficient concentrations to require permanent isolation.

**isotopes** – *Nuclides* of the same chemical element with the same number of protons but a different number of neutrons.

**low-level waste** – Radioactive waste that is not high-level radioactive waste, spent nuclear fuel, *transuranic waste*, byproduct material, or naturally occurring radioactive material.

**maximum exposed individual** – A hypothetical member of the public residing near the PNNL-Richland campus or PNNL-Sequim campus who, by virtue of location and living habits, would reasonably receive the highest possible *radiation* dose from radioactive materials originating from the site.

**method reporting limit** – The lowest amount of analyte in a sample that can be quantitatively determined with the stated acceptable precision and accuracy under controlled laboratory conditions.

**millirem** – A unit of *radiation dose* that is equal to one one-thousandth (1/1000) of a *rem*.

**minimum detectable activity** – The smallest amount or concentration of a chemical or radioactive material that can be reliably detected in a sample.

**mitigation** – Prevention or reduction of expected *risks* to workers, the public, or the environment.

**mixed waste** – A U.S. Environmental Protection Agency or state-designated dangerous, extremely hazardous, or acutely hazardous waste that contains both a nonradioactive hazardous component and a radioactive component.

**monitoring** – As defined in DOE Order 458.1, Admin Chg 4, the collection and analysis of samples or measurements of liquid *effluent* and gaseous *emissions* for purposes of characterizing and quantifying contaminants, assessing *radiation exposure* to the public, and demonstrating compliance with regulatory standards.

**nuclide** – A particular combination of neutrons and protons. A *radionuclide* is a radioactive nuclide.

**operable unit** – A discrete area for which an incremental step can be taken toward comprehensively addressing site problems. The cleanup of a site can be divided into a number of operable units, depending on the complexity of the problems associated with the site.

**outfall** – End of a drain or pipe that carries wastewater or other *effluent* into a ditch, pond, or river.

**person-rem or person-sievert (person-Sv)** – Unit of *collective dose*. 1 person-rem = 0.01 person-Sv.

**plutonium** – A heavy, radioactive, metallic element of several possible *isotopes*. One important *isotope* is plutonium-239, which is produced after a specific neutron reaction with uranium-238. Routine analysis cannot distinguish between the plutonium-239 and plutonium-240 *isotopes*; hence, the term plutonium-239/240 is used in this report to indicate the presence of one or both of these *isotopes* in the analytical results.

**PNNL-Richland Campus** – Includes a mix of federal and private land and facility ownership north of Richland, Washington.

**PNNL-Sequim Campus** – Consists of DOE-contracted facilities near Sequim, Washington.

**quality assurance** – Actions that provide confidence that an item or process meets or exceeds a user's requirements and expectations.

**quality control** – All actions necessary to control and verify that the features and characteristics of a material, process, product, or service meet specified requirements. QC is an element of *quality assurance*.

**rad** – The unit of absorbed dose. 1 rad = 0.01 gray (Gy).

**radiation** – The energy emitted in the form of photons or energetic *alpha* and *beta particles* subsequent to radioactive decay. For this report, radiation refers to ionizing types of radiation; not radiowaves, microwaves, radiant light, or other types of non-ionizing radiation.

**radioactivity** – Property possessed by *radioisotopes* emitting *radiation* (such as *alpha* or *beta particles*, or high-energy photons) spontaneously in their *decay* process; also, the *radiation* emitted.

**radionuclide** – An atom that has a particular number of protons (Z), a particular number of neutrons (A), and a particular atomic weight ( $N = Z + A$ ) that happens to emit *radiation*. Carbon-14 is a radionuclide but carbon-12, which is not radioactive, is referred to simply as a *nuclide*.

**rem** – The unit of EDE. 1 rem = 0.01 sievert (Sv).

**remediation** – Reduction (or cleanup) of known *risks* to the public and environment to an agreed-upon level.

**risk** – The probability that a detrimental health effect will occur.

**shrub-steppe** – A drought-resistant shrub and grassland ecosystem.

**sievert (Sv)** – The unit of EDE and its variants in the International System of Units. The common unit for EDE and its variants, the *rem*, is equal to 0.01 Sv.

**surveillance** – As defined in DOE Order 458.1, Admin Chg 4, the collection and analysis of samples of air, water, soil, foodstuffs, biota, and other media, and the measurement of external radiation for purposes of demonstrating compliance with applicable standards, assessing exposures to the public, and assessing effects, if any, on the local environment.

**transuranic element** – An element with an atomic number greater than 92 (92 is the atomic number of uranium).

**transuranic waste** – Waste containing more than 100 nanocuries ( $10^{-9}$  *curies*) per gram of alpha-emitting transuranic isotopes that have half-lives longer than 20 years.

**tritium** – The heaviest radioactive isotope of hydrogen (hydrogen-3); it has a 12.3-year half-life.

**unconfined aquifer** – An *aquifer* containing groundwater that is not confined above by relatively impermeable rocks. The pressure at the top of the unconfined aquifer is equal to that of the atmosphere. At the Hanford Site, the unconfined aquifer is the uppermost aquifer and is most susceptible to contamination from site operations.

**vadose zone** – Underground area from the ground surface to the top of the *water table* or *aquifer*.

**volatile organic compounds** – Lightweight organic compounds that vaporize easily; they are used in solvents and degreasing compounds as raw materials.

**water table** – The top of the *unconfined aquifer*.

## Distribution

<b>Federal Offices / DOE</b>	
DOE Headquarters	DOE Office of Science Pacific Northwest Site Office
RT Carver	JK Turner, Manager
CM Lobos	AT Morris, Deputy Site Manager
BA Moore	TM McDermott
MJ Silverman	
U Song	<b>DOE-Richland Operations</b>
M Stewart	M Kamal
OR Center for Risk Analysis	KE Lutz
	BR Trimberger
<b>Hanford Mission Integration Solutions</b>	BJ Zelen
JW Cammann	<b>Washington River Protection Solutions</b>
DD Teel	TG Beam
<b>Central Plateau Cleanup Company</b>	SG McKinney
JA Lerch	KA Peterson
<b>Tribes</b>	
<b>Confederated Tribes of the Umatilla Indian Reservation</b>	Hoh Tribe
G Burke, Board of Trustees Chair	D Hollum, Tribal Chair
<b>Jamestown S'Klallam Tribe</b>	Lower Elwha Klallam Tribe
WR Allen, Chair	FG Charles, Chair
L. Greninger, Vice Chair	
<b>Lummi Nation</b>	Makah Tribe
A Hillaire, Chair	TJ Greene, Sr, Chair
<b>Nez Perce Tribe</b>	Port Gamble S'Klallam Tribe
SF. Wheeler, Chair	A Caldera, Chair
<b>Quileute Nation</b>	Wanapum Tribe
D Woodruff, Jr. Chair	C Buck, Leader
<b>Yakama Nation</b>	
G Lewis, Chair	R Longoria
<b>Federal Senators and Representatives</b>	
M Cantwell (via R Evans and A Ronen)	D Kilmer (via Marie Fiori and A Roper)
P Murray (via R Crowley and J Edwards)	D Newhouse (via O Babine and A Stubbs)
<b>Washington State Governor</b>	
J Inslee (via L Jasmin III)	
<b>Washington State Senators and Representatives</b>	
S Rude (16 <sup>th</sup> Leg District)	P Dozier (16 <sup>th</sup> Leg District)
M Klicker (16 <sup>th</sup> Leg District)	S Tharinger (Clallam)
M Chapman (Clallam)	K Van De Wege (Clallam)
<b>Washington State Offices</b>	
<b>Washington State Department of Health</b>	
CD Mathey	GR Priddy
AJ Abelman	TA Rogers
SD Berven	CN Sanders
CA Kennedy	RJ Utley
S McDonald	

Washington State Department of Ecology			
K Baldwin		M. Williams	
A Boyd			
Regional Offices			
EPA Region 10			
D Bray		KD Pepple	
JM McCauley			
Benton Clean Air Agency		Olympic Region Clean Air Agency	
J Lyle		R Moody	
T Thompson			
Benton-Franklin Council of Governments		North Olympic Development Council	
M Holt		K Affeld	
County Offices			
Benton and Franklin Counties			
M Gonzalez		J MacPherson	
M Holt			
Clallam County Health & Human Services		Clallam County	
J Oppelt		R Johnson	
Clallam County Department of Community Dev't		M French	
B Emery		M Ozias	
City Offices			
City of Richland		City of Sequim	
J Amundson		M Huish	
City of Pasco		City of West Richland	
A Lincoln		B Gerry	
City of Kennewick			
G Crawford			
Ports			
Port of Kennewick		Port of Pasco	
TA Arntzen		R Hayden	
John Wayne Marina (Sequim)		Port of Benton	
P Jarkiewicz, Harbormaster		D Howard	
Libraries			
Richland Public Library		DOE Public Reading Room (printed copy)	
Mid-Columbia Libraries		North Olympic Library – Sequim Branch	
Pacific Northwest National Laboratory			
EJ Antonio	CJ Duchsherer	JL Mendez	AJ Schoch
JM Barnett	WL Duffy	KM Mendez	JL Shimek
JE Bewick	JW Duling	AL Miracle	SF Snyder
LE Bisping	DL Edwards	TW Moon	JA Stephens
I Bociu	SU Fies	HL Newsome	MJ Stephenson
TW Buckendorf	BG Fritz	MR Peterson	DM Storms
JW Cook	KD Hand	SG Ramos	J Su-Coker
EG Damberg	TR Hay	EA Raney	SW Thompson
TR Daves	TE Herron	JP Rishel	DJ Warren
RA Del Mar	JR Holland	TO Robertson	GM Wellsfry
LN Dinh	SR Horn	JM Robinson	RS Wiegman
CA Dissing	RT Jeters	EA Rosso	D Zimmerman
CA Duberstein	MC Klein	AM Sachs	

# **Pacific Northwest National Laboratory**

902 Battelle Boulevard  
P.O. Box 999  
Richland, WA 99354

1-888-375-PNNL (7665)

***[www.pnnl.gov](http://www.pnnl.gov)***