PNNL-31853

Pacific Northwest National Laboratory Annual Site Environmental Report for Calendar Year 2020

Final Report

September 2021

JP Duncan
JM Becker
JM Barnett
TW Moon
WC Weaver
LY Renaud
RA Del Mar
MD Ellefson
KD Hand
LE Bisping
JA Stephens
MA Aranda
EA Raney
CJ Duchsherer

U.S. DEPARTMENT OF ENERGY

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

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;
ph: (865) 576-8401
fax: (865) 576-5728
email: reports@adonis.osti.gov

Available to the public from the National Technical Information Service
5301 Shawnee Rd., Alexandria, VA 22312
ph: (800) 553-NTIS (6847)
email: orders@ntis.gov <https://www.ntis.gov/about>
Online ordering: http://www.ntis.gov

PNNL-31853

Pacific Northwest National Laboratory Annual Site Environmental Report for Calendar Year 2020

Final Report

September 2021

JP Duncan
WC Weaver
KD Hand
EA Raney
JM Becker
LY Renaud
LE Bisping
CJ Duchsherer
JM Barnett
RA Del Mar
JA Stephens
TW Moon
MD Ellefson
MA Aranda

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

Pacific Northwest National Laboratory
Richland, Washington 99354

This page intentionally left blank

Pacific Northwest National Laboratory
Annual Site Environmental Report for 2020
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

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

(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	

This page intentionally left blank

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. DOE's Pacific Northwest Site Office is responsible for oversight of PNNL.

PNNL prepares this annual site environmental report to meet the requirements of DOE Order 231.1B, *Environmental, Safety and Health Reporting*, and DOE Order 458.1, *Radiation Protection of the Public and the Environment*, 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 on 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.

In March 2020, PNNL operations were curtailed due to the COVID-19 pandemic; restrictions remained in force for the remainder of the calendar year. PNNL operations impacted by implemented temporary COVID-19 work limitations are indicated, where appropriate.

Compliance with Federal, State, and Local Laws and Regulations in 2020

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 all PNNL projects by means of environmental compliance representatives assigned to assess and assist with each project. PNNL continued to exhibit an excellent compliance record in 2020; 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 not exceeded.

Environmental Sustainability Performance

PNNL's environmental management system (EMS) has been certified to meet the requirements of the International Standards Organization (ISO) 14001 standards since 2002, demonstrating commitment to safe and sustainable operations, and satisfying the requirements of DOE Order 436.1, *Departmental Sustainability*. 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. 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 disciplines including energy and water conservation, waste diversion, alternative fuel use, reduction of greenhouse gas emissions, and sustainable building design in 2020.

Environmental Monitoring and Dose Assessment

PNNL monitors air and water quality to assure compliance with federal, state, and local regulatory requirements and permits.

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. There were no unplanned releases of regulated substances or substances of concern from PNNL facilities in 2020.

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 onsite wastewater treatment plant prior to being discharged to Sequim Bay under a permit issued by the Washington State Department of Ecology. In 2020, there were no unplanned releases of regulated pollutants or contaminated wastewater from PNNL facilities and effluent discharges were within permitted limits.

Radiological Release of Property. PNNL uses the pre-approved guideline limits derived from guidance in DOE Order 458.1, Admin 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 from PNNL in 2020.

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 2020 dose rate estimates for aquatic, terrestrial, and riparian animals and plants for both the PNNL Richland and Sequim Campuses were well below the dose rate limits of DOE Order 458.1, Admin 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 2020, 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 Richland Campus maximum exposed individual (MEI) location was 0.55 km (0.34 mi) south-southeast of the Physical Sciences Facility 3410 Building. The dose to the MEI from site radionuclide air emissions was 1.7×10^{-5} mrem (1.7×10^{-7} mSv). This MEI was also assigned a 3 mrem (0.03 mSv) dose from ambient external dose surveillance results. In 2020, 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 9.0×10^{-5} person-rem (9.0×10^{-7} person-Sv).

The PNNL Sequim Campus MEI location for 2020 was 0.23 km (0.14 mi) west-northwest of the central emission location. The dose to the MEI from site emissions was 3.5×10^{-5} mrem (3.5×10^{-7} mSv). The 80 km (50 mi) collective dose for PNNL Sequim Campus emissions was 3.9×10^{-5} person-rem (3.9×10^{-7} 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 2020.

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. Eleven federally endangered or threatened animal species are known to occur on or near the PNNL Sequim Campus: marbled murrelet, bull trout, Hood Canal summer-run chum salmon, North American green sturgeon, Pacific eulachon, Puget Sound bocaccio, Puget Sound Chinook salmon, Puget Sound steelhead, Puget Sound yelloweye rockfish, island marble butterfly, and Taylor's checkerspot butterfly.

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. Forty-three biological resource reviews were completed in 2020 at the Richland Campus (16), PNNL Sequim Campus (10), and other locations (17). Thirty-six environmental permits for PNNL research activities were acquired.

The PNNL cultural resources program supported 44 projects in 2020; six occurred at the PNNL Sequim Campus, where one undertaking resulted in an Adverse Effect. Resolution of the Adverse Effect has been delayed due to the COVID-19 pandemic. Four new archaeological sites were identified and documented on the PNNL Richland Campus. NHPA Section 110 monitoring was also conducted in 2020; no new impacts were identified.

Groundwater Protection

Prior to April 1, 2020, groundwater under the PNNL Richland Campus was monitored routinely through seven groundwater monitoring wells and four heat pump production wells. After nine years of monitoring for temperature and contaminants in groundwater, the Washington State Department of Ecology determined that further monitoring was no longer necessary. Groundwater monitoring is no longer required for environmental compliance at either the PNNL Richland or Sequim Campuses.

Quality Assurance

Sampling and monitoring activities performed under PNNL's Environmental Management Program in 2020 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. The comprehensive quality assurance programs and plans at PNNL, which include various quality control procedures and method verification, assured reported data were reliable and met all quality control and quality assurance objectives.

This page intentionally left blank

Acknowledgments

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

JP Duncan	Document Coordination, Editing, Background, Executive Summary, Geology, Meteorology, Hydrology, Demographics
JM Becker	Project Management, *National Environmental Policy Act*, Ecology and Biological Resources
WC Weaver	Document review/coordination assistant
JM Barnett	Air Quality, Radiation Protection, Environmental Radiological Monitoring
KD Hand	Biological Resources, Noxious Weed Control
LY Renaud	Cultural and Historic Resources
RA Del Mar	Environmental Management System and Sustainability
LE Bisping	Environmental Radiological Monitoring
EA Raney	Groundwater Protection, Liquid Effluent Monitoring
CJ Duchsherer	Nonradiological Air Emissions
MD Ellefson	Permitting, Regulations, Statutes
MA Aranda	Quality Control and Assurance
JA Stephens	Radiation Protection
TW Moon	Water Quality, Soils, Groundwater Protection, Liquid Effluent Monitoring, DOE Order 458.1 Reporting
MJ Parker	Publication Design
SK Ennor	Copy Editing
SF Snyder	Peer Review

This page intentionally left blank

Acronyms and Abbreviations

ºC	degrees Celsius
ºF	degrees Fahrenheit
µg/L	microgram(s) per liter
µrem/hr	microrem(s) per hour
µSv	microsievert(s)
A	
ac	acre(s)
AFE	alternative fuel vehicle(s)
ALARA	as low as reasonably achievable
AQSS	Acquisition Quality Support Services
ASME	American Society of Mechanical Engineers
ASO	Analytical Support Operations (laboratory)
B	
Battelle	Battelle Memorial Institute
BCAA	Benton Clean Air Agency
BP	Before Present
Bq	becquerel(s)
BSF	Biological Sciences Facility
Btu	British thermal unit(s)
C	
C&D	construction and demolition
CAA	*Clean Air Act*
CBRMP	Cultural and Biological Resources Management Plan
CEQ	Council on Environmental Quality
CERCLA	*Comprehensive Environmental Response, Compensation, and Liability Act of 1980*
CFR	Code of Federal Regulations

Ci	curie(s)
cm	centimeter(s)
CSF	Computational Sciences Facility
CWA	*Clean Water Act*
CY	calendar year
D	
d	day(s)
DoD	U.S. Department of Defense
DOE	U.S. Department of Energy
DOECAP	DOE Consolidated Audit Program
DOE-RL	DOE-Richland Operations Office
DOE-SC	DOE Office of Science
dpm	disintegrations per minute
DQO	data quality objective(s)
E	
ED	effective dose
EDE	effective dose equivalent
EISA	*Energy Independence and Security Act of 2007*
EM	Effluent Management
EMP	Environmental Management Plan
EMS	environmental management system
EMSL	William R. Wiley Environmental Molecular Sciences Laboratory
EO	Executive Order
EPA	U.S. Environmental Protection Agency
EPCRA	*Emergency Planning and Community Right-to-Know Act of 1986*
ERP	Environmental Research Permitting
ESA	*Endangered Species Act of 1973*
ESC	Energy Sciences Center
EV	electric vehicle(s)
F	
FEMA	Federal Emergency Management Agency
FR	Federal Register
FSOAA	*Forest Service Organic Administration Act*
ft	foot (feet)
ft^2	square foot (feet)
ft^3	cubic foot (feet)
FY	fiscal year

G

g	g-force
g	gram(s)
gal	gallon(s)
GBq	gigabecquerel(s)
GEL	General Engineering Laboratories
GHG	greenhouse gas
gpd	gallon(s) per day
gpm	gallon(s) per minute
GSA	General Services Administration
gsf	gross square foot (feet)
Gy	gray(s)

H

ha	hectare(s)
HDI	How Do I….?

I

ILA	industrial, landscaping, and agricultural
in.	inch(es)
ISO	International Organization for Standardization
ISO/IEC	International Organization for Standardization/ International Electrotechnical Commission
IT	information technology

K

kg	kilogram(s) (1,000 grams)
km	kilometer(s)
km^2	square kilometer(s)
kW	kilowatt(s)

L

L	liter(s)
L/min	liter(s) per minute
lb(s)	pound(s)
LNM	Local Notice to Mariners
LSL2	Life Sciences Laboratory 2

M

m	meter(s)
m^2	square meter(s)
m^3	cubic meter(s)
m/s	meter(s) per second

MAPEP	Mixed-Analyte Performance Evaluation Program
MEI	maximum exposed individual
mGy/d	milligray(s) per day
mi	mile(s)
mi^2	square mile(s)
min	minute(s)
MMI	Modified Mercalli Intensity
MMPA	*Marine Mammal Protection Act of 1972*
MoU	Memorandum of Understanding
mph	mile(s) per hour
MRAD	Multi-Media Radiochemistry Proficiency Testing
mrem	millirem
mrem/yr	millirem per year
MSFCMA	*Magnuson–Stevens Fishery Conservation and Management Act*
mSv	millisievert(s)
mSv/yr	millisievert(s) per year
N	
NA	not applicable
NELAP	National Environmental Laboratory Accreditation Program
NEPA	*National Environmental Policy Act of 1969*
NESHAP	National Emission Standards for Hazardous Air Pollutants
NMFS	National Marine Fisheries Service
NPDES	National Pollutant Discharge Elimination System
NQA	nuclear quality assurance
NRHP	National Register of Historic Places
NZERO	net-zero emissions and energy-resilient operations
O	
OAR	Oregon Administrative Rules
ORCAA	Olympic Region Clean Air Agency
OSL	Optically stimulated luminescence
OSLD	Optically stimulated luminescence dosimeter
P	
PATON	permit and/or private aid to navigation
PCB	polychlorinated biphenyl(s)
pCi	picocurie(s)
pCi/L	picocurie(s) per liter
pCi/m^3	picocurie(s) per cubic meter
pCi/mL	picocurie(s) per milliliter

PIC-5	Potential Impact Category 5
PNL	Pacific Northwest Laboratory
PNNL	Pacific Northwest National Laboratory
PNSO	Pacific Northwest Site Office
PSF	Physical Sciences Facility
Q	
QC	quality control
QA	quality assurance
QAP	quality assurance plan
R	
R&D	research and development
RAEL	radioactive air emission license
RCRA	*Resource Conservation and Recovery Act of 1976*
RCW	Revised Code of Washington
REC	Renewable Energy Credit
RESL	Radiological and Environmental Sciences Laboratory
RHA	*Rivers and Harbors Appropriations Act of 1899*
RPL	Radiochemical Processing Laboratory
RCW	Revised Code of Washington
RPL	Radiochemical Processing Laboratory
S	
s	second(s)
SEPA	*State Environmental Policy Act*
SMA	*Shoreline Management Act of 1971*
Sv	sievert(s)
T	
TNI	The NELAC Institute
U	
UESC	Utility Energy Services Contract
UIC	underground injection control
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
W	
WAC	Washington Administrative Code
WDFW	Washington Department of Fish and Wildlife
WDOH	Washington State Department of Health

Y

YOY	year over year
yr	year(s)

Contents

Figures

This page intentionally left blank

Tables

1.0 Introduction

The 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, Admin 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) 2020 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, as well as 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.

In late 2019, a novel coronavirus designated as SARS-CoV-2 was first identified. Commonly known as COVID-19, the virus developed to pandemic proportions in 2020, affecting both work and private lives. As a result, some information presented in this report may be for 2019, if updated data was not available.

1.1 Location

PNNL has facilities on the PNNL Richland Campus in Richland, Washington, and on the PNNL Sequim Campus near Sequim, Washington (Figure 1.1). 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 satellite offices in various other locations, including Seattle, Washington, and Portland, Oregon, as well as at various off-site field locations.

Figure 1.1. PNNL Office Locations

1.1.1 PNNL Richland Campus

The PNNL Richland Campus covers approximately 269 ha (664 ac) and is located in Benton County in southeastern Washington State, 275 km (170 mi) east-northeast of Portland, Oregon, 270 km (170 mi) southeast of Seattle, Washington, and 200 km (125 mi) southwest of Spokane, Washington. It is located at the northern boundary of the City of Richland and south of the DOE-Richland Operations Office's (DOE-RL's) Hanford Site 300 Area (Figure 1.2). Adjacent to the Columbia River, the PNNL Richland Campus encompasses DOE-SC federally owned land, land owned by Battelle, and leased facilities in the Richland area. PNNL also leases facilities located on private land and on the campus of Washington State University–Tri-Cities, located just south of the PNNL Richland Campus.

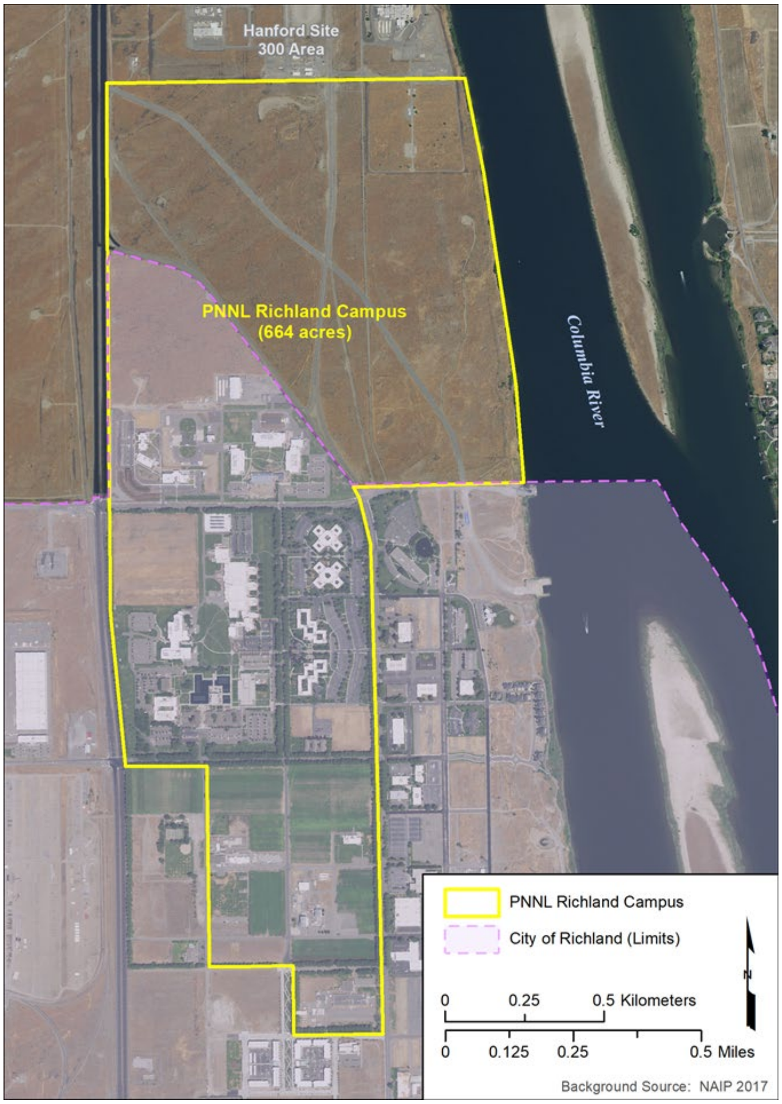


Figure 1.2. PNNL Richland Campus

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, 74 km (46 mi) northwest of Seattle, Washington, and 47 km (29 mi) southwest of Victoria, British Columbia. The PNNL Sequim Campus encompasses 47 ha (117 ac), 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 1.3).

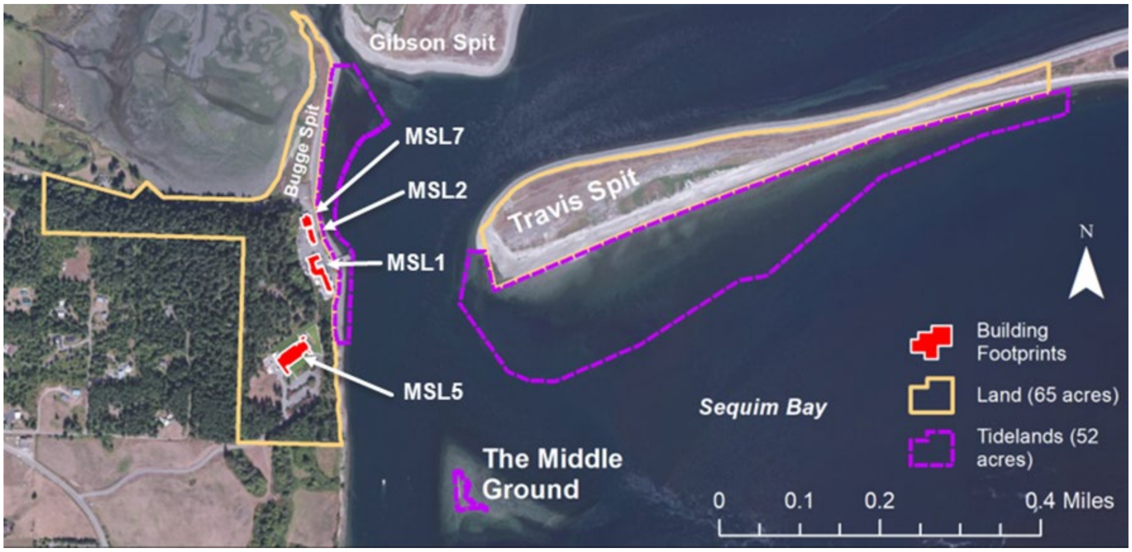


Figure 1.3. PNNL Sequim Campus and Nearby Environment

1.2 Background and Mission

The following sections provide a short synopsis 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 areas including robotics, environmental monitoring, material coatings, veterinary medicine, and the formation of new plastics.

In 1995, PNL 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 for monitoring the Laboratory's compliance with applicable laws, policies, and DOE Orders. Research efforts on the PNNL Richland Campus include the 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 Washington's Puget Sound near the City of Sequim. As part of Battelle's commitment to developing research facilities to benefit the region and serve the environment, the Marine Research Laboratory near Sequim was constructed to provide laboratories 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 Marine and Coastal Research Laboratory operations.

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 PNNL 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^2 (15,000 ft^2) of area, which includes an innovative seawater 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, biofouling/biocorrosion, climate change, 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 located 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.

Demographic information for 2020 was not available from the U.S. Census Bureau at the time of this document's publication; 2019 data were the most recent and are provided. In 2019, an estimated 204,390 people lived in Benton County and 95,222 people lived in adjacent Franklin County, increases of 16.7% and 21.8%, respectively, over 2010 figures (USCB 2021). During 2019, Benton and Franklin Counties accounted for 3.9% of Washington's population. Based on U.S. Census population data, the population within an 80 km (50 mi) radius of the PNNL Richland Campus is estimated to be about 432,700. This population estimate is used to calculate the radiation dose to the general public (see Section 4.2 of this report).

The PNNL Sequim Campus is located in Clallam County, Washington, an area of approximately 4,500 km^2 (1,740 mi^2) on the Olympic Peninsula in the northwestern corner of Washington State. An estimated 77,331 people lived in Clallam County in 2019, an increase of approximately 8.3% over 2010 figures and equivalent to approximately 1% of Washington's population (USCB 2021). The City of Sequim, the nearest population center to the PNNL Sequim Campus, had a population of 7,640 people in 2019 (USCB 2021).

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 composing 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, non-native 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 non-native vegetation.

The PNNL Richland Campus is located 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 1.4. The stratigraphic column for the upper Ringold Formation and the Hanford formation is based on information obtained from the drilling of 11 boreholes within the footprint of the Biological Sciences Facility/Computational Sciences Facility (BSF/CSF) 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 in size 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 are typically more consolidated and less permeable than those in the Hanford formation. The 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.

The general direction of groundwater flow under the PNNL Richland Campus is toward the east-northeast toward the Columbia River (Figure 1.5). 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).

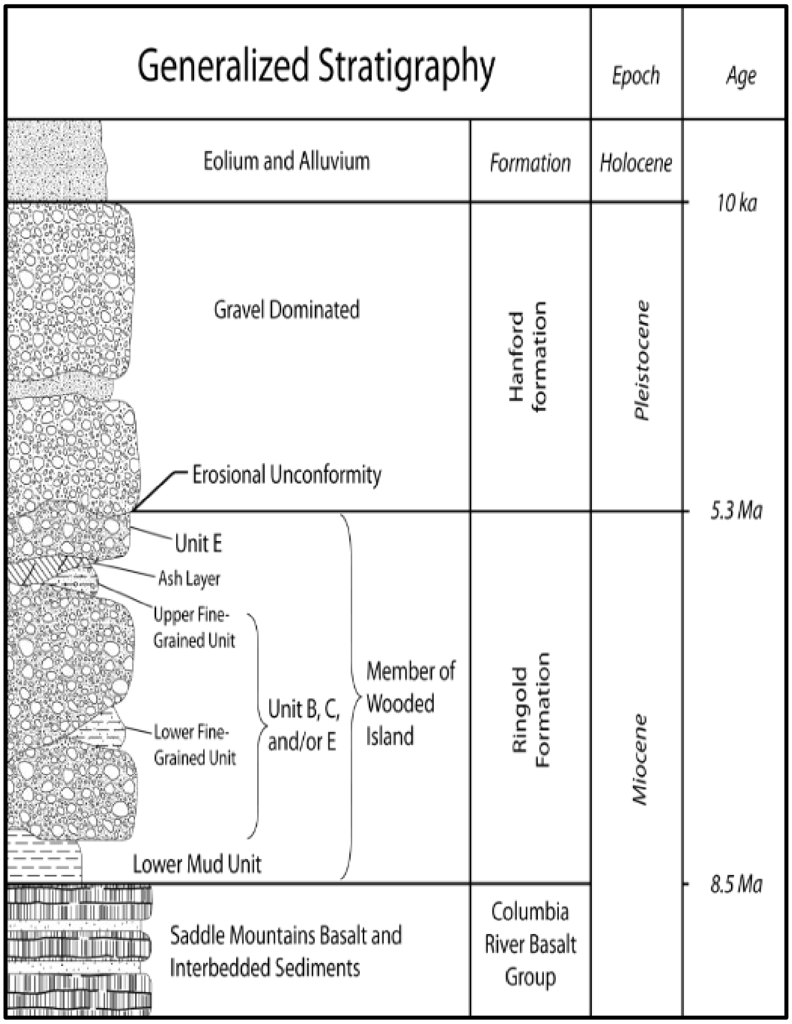


Figure 1.4. Generalized Stratigraphic Column Depicting the Stratigraphy Underlying the PNNL Richland Campus (modified from Reidel et al. 1992; Thorne et al. 1993; Lindsey 1995; Williams et al. 2000; DOE-RL 2002; and Williams et al. 2007)

While large 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 on the Columbia River. The largest flood on record for the Columbia River occurred in 1894 and had an estimated peak discharge of 21,000 m^3/s (742,000 ft^3/s) at the Hanford Site; the largest recent flood took place in 1948 and had an estimated peak discharge of 20,000 m^3/s (700,000 ft^3/s) (Duncan 2007). Exceptionally high runoff during the spring of 1996 resulted in a maximum discharge of nearly 11,750 m^3/s (415,000 ft^3/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 conducted in 1976, the Hanford Site would be unaffected by the probable maximum flood on the Columbia River, a discharge of about 40,000 m^3/s (1.4 million ft^3/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^3/s (570,000 ft^3/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^3/s (440,000 ft^3/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), would be unaffected by a 100-year flood.

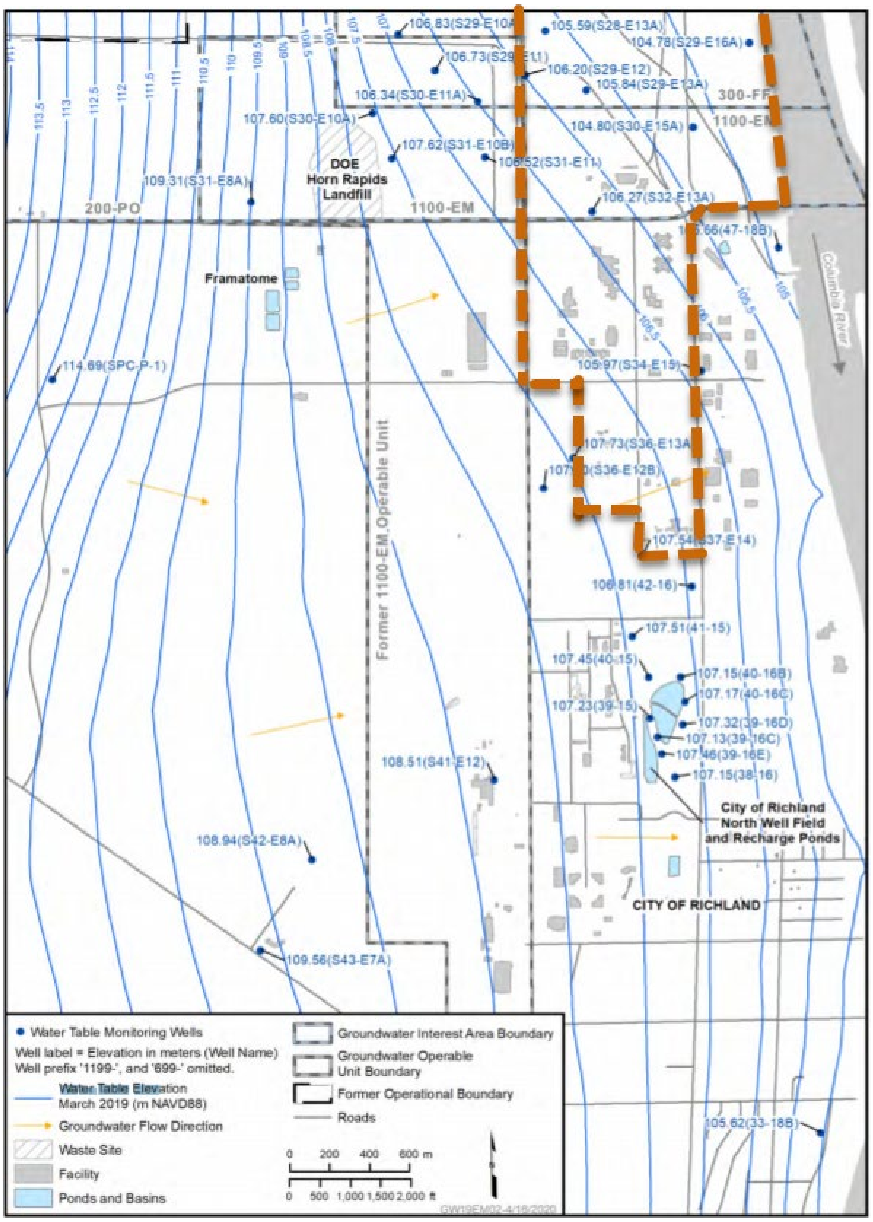


Figure 1.5. Water Table Elevations (m) in April 2020 (modified from DOE-RL 2020b). Groundwater flow direction is normal to the water table contour lines. The approximate PNNL Richland Campus is outlined in orange (northern portion not shown).

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 (MMI) 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 an automated weather station maintained by AgWeatherNet on the campus of Washington State University–Tri-Cities (WSU 2021a), located just south of the PNNL Richland Campus. Normal monthly average temperatures range from a low of –2.9°C (26.7°F) in February to a high of 24.7°C (76.4°F) in August. The maximum high temperature in 2020 was 42.9°C (109.3°F); the minimum was -11.4°C (11.5°F). The average annual temperature near the PNNL Richland Campus in 2020 was 13.3°C (55.9°F), -1.1°C (2.0°F) above average 12.2°C (53.9°F). The annual relative humidity near the PNNL Richland Campus was 57.8% in 2020; humidity was highest in December, when it averaged approximately 86.3%, and lowest during July, when it averaged 38.7% (WSU 2021a). Precipitation for 2020 was 14.8 cm (5.82 in.), 81% below average (18.1 cm [7.14 in.]).

Regional winds are primarily from the south and southwest at the PNNL Richland Campus. Monthly average wind speeds in 2020 were lowest during September, averaging about 1.4 m/s (3.2 mph), and highest in January and March, averaging about 2.5 m/s (5.7 mph). The maximum wind gust recorded during 2020 was 26.4 m/s (59 mph); the maximum for the period of record (2001–2020) was 27.7 m/s (62 mph) (WSU 2021a).

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. 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).

Fog has been recorded during every month of the year at the Hanford Meteorology Station; however, fog occurs mostly from November through February. In 2020, there were 39 days of fog. 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). Three dust storms occurred in 2020; visibility was 0.4 km (0.25 mi) September 7, and approximately 1.6 km (1 mi) on May 2 and November 8 due to blowing dust (DOE 2021).

During September 2020, the entire region was inundated with smoky conditions due to wildfires. Visibilities at the Hanford Meteorology Station on the Hanford Site were below three-quarters of a mile on eight consecutive days (September 11–18), and only one-quarter mile on September 11 (DOE 2021).

1.4.2 Ecology

The PNNL Richland Campus is located in the lowest and most arid portion of the Columbia Plateau Ecoregion (LandScope Washington 2021; EPA 2013). The portion of the PNNL Richland Campus north of Horn Rapids Road (Figure 1.6) was previously part of the Hanford Site, and has been protected from agricultural use and development since 1943. It is still mostly dominated by native shrub-steppe vegetation, and thus retains much of its native biodiversity and community structure (Figure 1.6). These areas are dominated by climax shrubs such as big sagebrush (*Artemisia tridentata*) and bitterbrush (*Purshia tridentata*), with a noticeable component of native perennial bunchgrasses within an introduced annual grass understory. The portion of the PNNL Richland Campus south of Horn Rapids Road has been developed to various extents and consists of a mosaic of 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 1.6). The more mature and undisturbed shrub-steppe communities generally support greater plant species diversity. Approximately 170 plant species, 40 bird species, and 9 other wildlife 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 1.6). The 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 considered to be priorities for management and conservation (WDFW 2021a).

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* (ESA) (Table 1.1). The Columbia River is designated as critical habitat for these species under the ESA (50 CFR 226.212; 75 FR 63898).

Federal 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 (2021b) and Washington Natural Heritage Program (WNHP 2019) and are listed in Table 1.1. Of these, the American white pelican (*Pelecanus erythrorhynchos*), sagebrush sparrow (*Artemisiospiza nevadensis*), loggerhead shrike (*Lanius ludovicianus*), and black-tailed jackrabbit (*Lepus californicus*) have been observed on the upland portions of the PNNL Richland Campus (see Appendix A).

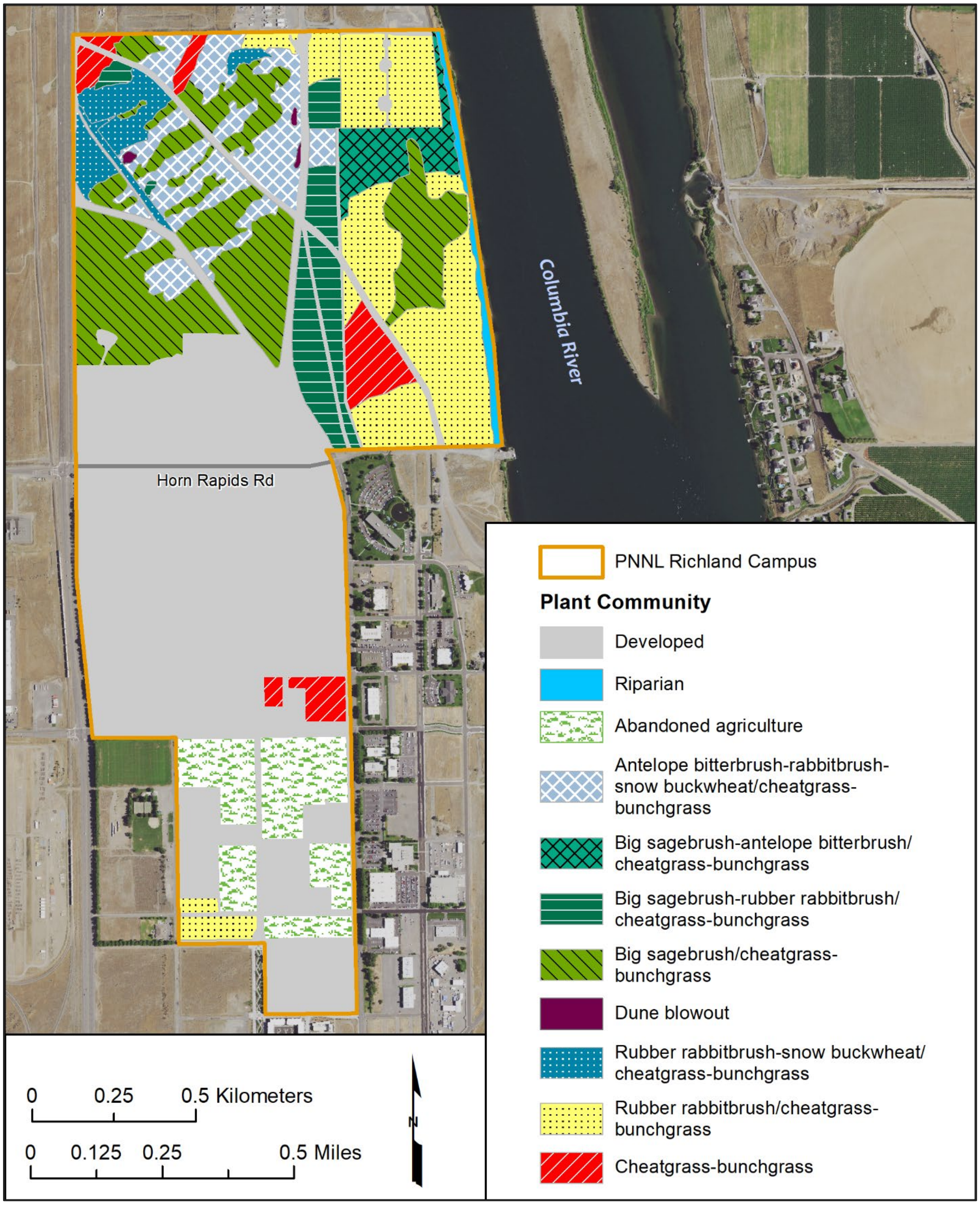


Figure 1.6. Habitat Polygons on the PNNL Richland Campus

Table 1.1. 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[(a)]	State Status[(b)]
Wildlife			
American white pelican	*Pelecanus erythrorhynchos*		Threatened
Black-tailed jackrabbit	*Lepus californicus*		Candidate
Burrowing owl	*Athene cunicularia*		Candidate
Loggerhead shrike	*Lanius ludovicianus*		Candidate
Northern sagebrush lizard	*Sceloporus graciosus*		Candidate
Sagebrush sparrow	*Artemisiospiza nevadensis*		Candidate
Striped whipsnake	*Masticophis taeniatus*		Candidate
Townsend ground squirrel	*Urocitellus townsendii*		Candidate
Fish			
Bull trout	*Salvelinus confluentus*	Threatened	Candidate
Upper Columbia River spring Chinook salmon	*Oncorhynchus tshawytscha*	Endangered	Candidate
Upper Columbia River steelhead	*Oncorhynchus mykiss*	Threatened	Candidate
Plants			
Awned halfchaff sedge	*Lipocarpha aristulata*		Threatened
Beaked spike-rush	*Eleocharis rostellata*		Sensitive
Canadian St. Johnswort	*Hypericum majus*		Sensitive
Columbian yellowcress	*Rorippa columbiae*		Threatened
Grand redstem	*Ammania robusta*		Threatened
Great Basin gilia	*Aliciella leptomeria*		Threatened
Loeflingia	*Loeflingia squarrosa*		Threatened
Lowland toothcup	*Rotala ramosior*		Sensitive
Rosy pussypaws	*Calyptridium roseum*		Threatened
Suksdorf monkeyflower	*Erythranthe suksdorfii*		Sensitive

Sources: WDFW (2021b) and WNHP (2019)

(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 2021).

(b) State candidate animal species are those fish and wildlife species that the Washington Department of Fish and Wildlife will review for possible listing as endangered, threatened, or sensitive (WDFW 2021b). 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 within the state without cooperative management or removal of threats (WDFW 2021b). 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 2019).

1.5 Environmental Setting – PNNL Sequim Campus Vicinity

The land and associated geology, seismicity, and meteorology of the PNNL Sequim Campus locale, 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 submerged except during low tide, and Travis Spit (Figure 1.3). PNNL Sequim Campus facilities include buildings on the shoreline, as well as structures on an approximately 27 m (89 ft) high bluff overlooking the ocean.

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 site (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^2 (0.4 to 0.8 *g*) and a two-percent 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 MMI 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, with the exception of 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, a number of 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 2021b). 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 2020 was 49.9 cm (19.63 in.). The region experiences cool, wet winters and warm, dry summers; average monthly temperatures in 2020 ranged from 0.6°C to 22.9°C (33.1°F to 73.3°F). From January 2009 to December 2020, average temperatures ranged from 4.6°C to 14.7°C (40.3°F to 58.5°F). The annual average temperature in 2020 was 10.2°C (50.3°F); the maximum temperature was 30.3°C (86.5°F) and the minimum temperature was -5.28°C (22.5°F). The lowest temperature for the period of record was -17.9°C (-0.3°F); the highest was 33.1°C (91.6°F). The annual relative humidity at the PNNL Sequim Campus was 84.3% in 2020; humidity was highest during fall, when it averaged approximately 86.7%, and lowest during spring, when it averaged 80.1%. Regional winds are primarily from the northwest. Wind speed averaged 1.3 m/s (3.0 mph) in 2020; peak wind speed, 13.9 m/s (31.1 mph), occurred in November (WSU 2021b).

1.5.2 Ecology

The PNNL Sequim Campus (Figure 1.3) 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 2021; EPA 2013). The PNNL Sequim Campus is located 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 (WWF 2021). Today, the region consists mostly of second-growth coniferous forest and agricultural fields; little of the original forest habitat remains (EPA 2013; LandScope Washington 2021).

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 1.7) is a sandy shoal, which is submerged except during lower tides, and does not support vegetation (DOE-PNSO 2020). 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 (Figure 1.7). Seagrass meadows consisting of eelgrass (*Zostera* spp.) occur in intertidal wetlands (labeled marine vegetation in Figure 1.7) (DOE-PNSO 2020) 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 (*Paraphrys vetulus*), sculpin (*Artedius fenestralis*), Pacific tomcod (*Mircogadus proximus*), striped perch (*Embiotca lateralis*), Pacific herring (*Clupea pallasii*), sand lance (*Ammodytes hexapterus*), and spiny dogfish (*Squalus acanthias*) (DOE-PNSO 2020).

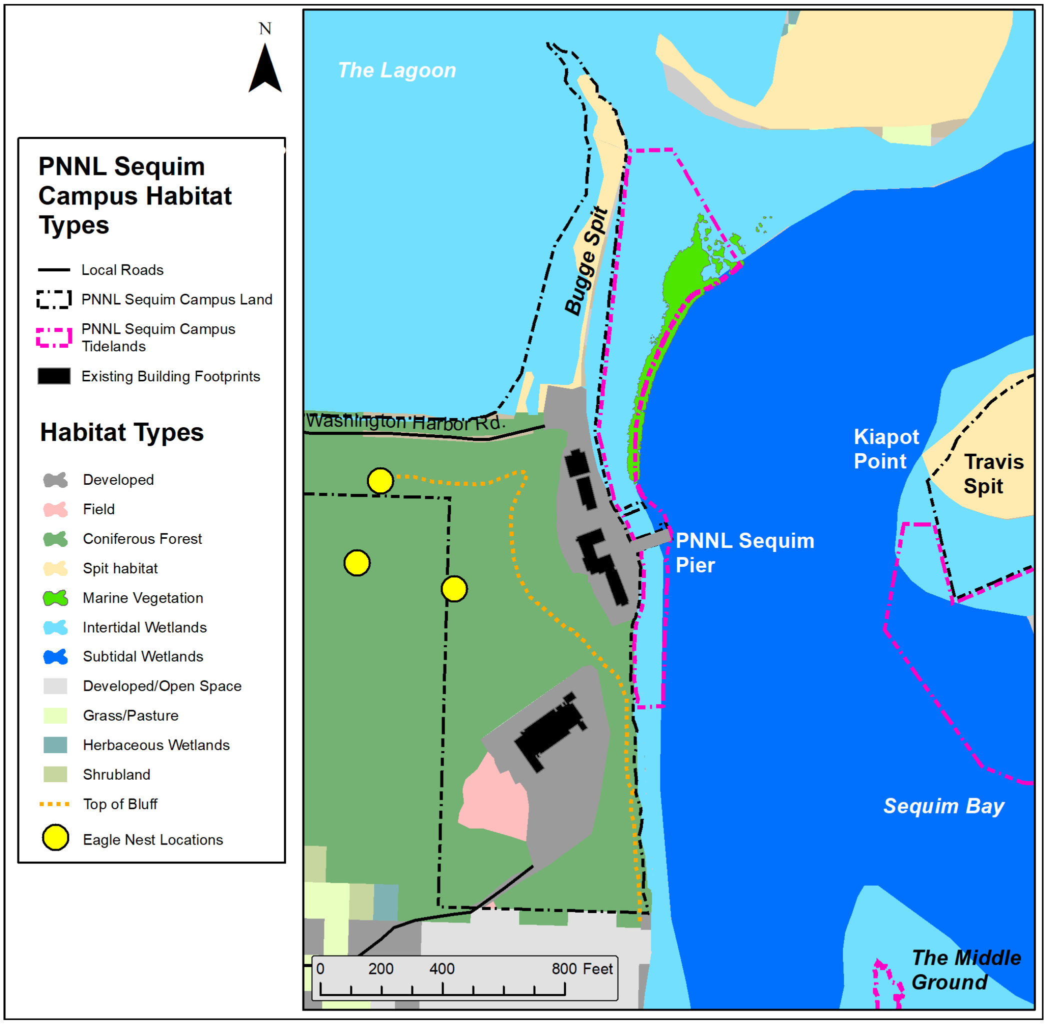


Figure 1.7. Habitat Types at the PNNL Sequim Campus

Land habitat includes spits, beaches, and uplands. Travis Spit and Bugge Spit (Figure 1.7) 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 2020). A sandy beach lies at the base of an approximately 7.6 m (25 ft) high feeder bluff that overlooks Sequim Bay (Figure 1.7). 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 2020).

The uplands begin adjacent to and just above the spit and beach habitats, extending west of the facilities, and rising to approximately 45.7 m (150 ft) above sea level on the ridge above Washington Harbor Road (Figure 1.7) (DOE-PNSO 2020). The uplands support mostly mixed coniferous forest habitat (Figure 1.7), most of which is mature, naturally regenerated second growth, estimated to be 100−160 years old (DOE-PNSO 2020). 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 (*Symphoricarpus 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 2020). Approximately 148 plant species, 102 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 2021a) and, therefore, are considered to be a priority for management and conservation (Clallam County 2017). Priority habitat zones include shore, intertidal, and subtidal, which include the tidelands, spits, beaches, and feeder bluffs, described previously (Clallam County 2017; WDFW 2021a).

The tideland and land habitats provide potential habitat for several federally listed threatened, endangered, and/or candidate species (Table 1.2) (DOE-PNSO 2020). Two avian species of conservation concern are known to occur or potentially occur near PNNL Sequim Campus facilities, as well as eight aquatic and three invertebrate species of conservation concern (Table 1.2). No plant species of state or federal concern are currently known to occur near the PNNL Sequim Campus (Table 1.2). Sequim Bay is designated critical habitat for Puget Sound bocaccio (*Sebastes paucispinis*) and Puget Sound yelloweye (*Sebastes ruberrimus*) (79 FR 68041), bull trout (*Salvelinus confluentus*) (75 FR 63898), and Hood Canal summer-run chum salmon (*Oncorhynchus keta*) (50 CFR 226.212; 70 FR 52630) (Table 1.2).

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 2020). Each of these mammals is considered a priority species by the state, and priority areas comprise haulouts used by California sea lions and harbor seals, and foraging areas and migration routes used by harbor porpoises and Dall's porpoises. Kiapot Point on the southwest tip of Travis Spit, located across the mouth of Sequim Bay from the PNNL Sequim Campus (Figure 1.7), is a haulout area for harbor seals (DOE-PNSO 2020). Although rare, killer whales (*Orcinus orca*) have been observed in Sequim Bay (DOE-PNSO 2020).

Table 1.2. 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(a)	State Status(b)
Wildlife			
Marbled murrelet	*Brachyramphus marmoratus*	Threatened	Endangered
Fish			
bull trout	*Salvelinus confluentus*	Threatened	Candidate
Hood Canal summer-run chum salmon	*Oncorhynchus keta*	Threatened	Candidate
North American green sturgeon	*Acipenser medirostris*	Threatened	
Pacific eulachon	*Thaleichthys pacificus*	Threatened	Candidate
Puget Sound bocaccio	*Sebastes paucispinis*	Endangered	Candidate
Puget Sound Chinook salmon	*Oncorhynchus tshawytscha*	Threatened	Candidate
Puget Sound steelhead	*Oncorhynchus mykiss*	Threatened	
Puget Sound yelloweye rockfish	*Sebastes ruberrimus*	Threatened	Candidate
Invertebrates			
Island marble butterfly	*Euchloe ausonides insulanus*	Endangered	Endangered
Sand-verbena moth	*Copablepharon fuscum*		Candidate
Taylor's checkerspot butterfly	*Euphydryas editha taylori*	Endangered	Endangered

Source: WDFW (2021b)

(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 2021). Federal candidate species are those for which the U.S. Fish and Wildlife Service has sufficient information about biological vulnerability and threat(s) to support issuance of a proposed rule to list the species, but issuance of the proposed rule is precluded (81 FR 87246).

(b) State candidate animal species are those fish and wildlife species that the Washington Department of Fish and Wildlife will review for possible listing as endangered, threatened, or sensitive (WDFW 2021b). 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 2021b).

1.6 Cultural Setting – PNNL Richland Campus

The archaeological record of the Mid-Columbia Basin bears evidence of more than 10,000 years of human occupation. 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 non-Native American settlers in the area and extends to the present day. Ethnohistorically, the Walla Walla, Palouse, Nez Perce, Umatilla, Wanapum, 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 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 local residents. The hardship continued until the government took over the area under the *First War Powers Act of 1941* (50 U.S.C. App. 601 *et seq.*) (Marceau et al. 2003).

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 the three principal Manhattan Project sites. Occupying portions of Grant, Franklin, and Benton Counties, the Hanford Site was created to support the United States' plutonium-production effort 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 the subsequent Cold War Era.


IT'S BATTELLE!
- To Operate Laboratories At Hanford
Offer Described As Outstanding; Objectives Met
Reactions
Tri-City Growth Seen
Chance Seen As Challenge
Tri-City Herald

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 service, 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 anti-aircraft 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 the Pacific Northwest Laboratory (eventually PNNL) in 1966. 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 now each individually eligible for listing on the National Register of Historic Places (NRHP) and constitute a Historic District.

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 semi-sedentary 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 up (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 18th 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 Frasier 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 this 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 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 nineteenth century, the settlement of New Dungeness had grown, and the county courthouse was moved to Port Angeles. At this time, the Sequim area was a developing agricultural area. The Sequim Prairie irrigation ditch was completed in 1896, which allowed for expanded farming in the area (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 the construction of the PNNL Sequim Campus (Brownell 2018).

2.0 Compliance Summary

Operations at PNNL in CY 2020 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 sustainable manner that is protective of the environment. Table 2.1 and Table 2.2 summarize PNNL's compliance with federal and state laws and regulations, respectively, and subsequent sections provide brief descriptions of each statute or regulation.

PNNL operations were curtailed due to the COVID-19 pandemic starting in March 2020 and remained in effect for the remainder of the calendar year. Teleworking was maximized and the health and safety of all onsite and offsite staff were tracked. PNNL operations impacted by the temporary COVID-19 requirements are indicated, where appropriate.

2.1 Sustainability and Environmental Management System

The DOE-Battelle Prime Contract for the management and operation of PNNL (DOE-PNSO 2021) incorporates applicable requirements from DOE Order 436.1, *Departmental Sustainability*, including associated performance goals, objectives, and systems. This Order and related Executive Orders are briefly discussed in the following sections.

2.1.1 DOE Order 436.1, Departmental Sustainability

DOE Order 436.1 was approved on May 2, 2011. The purpose of this Order is to

> "…1) ensure the Department carries out its missions in a sustainable manner that addresses national energy security and global environmental challenges, and advances sustainable, efficient and reliable energy for the future,
>
> 2) institute wholesale cultural change to factor sustainability and greenhouse gas (GHG) reductions into all DOE corporate management decisions, and
>
> 3) ensure DOE achieves the sustainability goals established in its Strategic Sustainability Performance Plan pursuant to applicable laws, regulations and Executive Orders (EO[s]), related performance scorecards, and sustainability initiatives…."

PNNL has incorporated these requirements by modifying the DOE-Battelle Prime Contract to include the development of a site sustainability plan (e.g., PNNL 2020), incorporation of sustainable acquisition requirements into applicable processes, and the development of an environmental management system (EMS) that is certified to meet the requirements of International Organization for Standardization (ISO) 14001:2015 standards.

The PNNL FY 2021 Site Sustainability Plan (PNNL 2020) identifies the status and accomplishments of sustainability projects related to DOE's sustainability goals. Prepared and submitted to DOE annually, the sustainability plan includes Pollution Prevention Program activities, accomplishments, and continuous improvement opportunities. Section 3.0 of this report provides further information concerning PNNL's EMS and the status of PNNL's sustainability goals.

Table 2.1. Status of Federal Environmental Laws and Regulations Applicable to PNNL, 2020

Statute/Regulation	2020 Status	Report Section(s)
Air Quality and Protection		
The *Clean Air Act* 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, Washington State Department of Ecology, Benton Clean Air Agency, and Olympic Region Clean Air Agency. No events were reported for emissions of regulated substances to the air or substances of concern. Radioactive air emissions were more than 10,000 times lower than the regulatory standard of 10 mrem/yr (0.1 mSv/yr) at both the PNNL Richland Campus and the PNNL-Sequim Campus.	2.4.1, 2.4.2
Cultural and Historic Resources		
The *National Historic Preservation Act of 1966* (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 supported 44 projects. Six of the 44 projects were undertakings at PNNL's Sequim Campus. One undertaking resulted in an Adverse Effect; consultation to resolve the Adverse Effect has been delayed due to the COVID-19 pandemic. Four new archaeological sites were identified and documented on the PNNL Richland Campus. NHPA Section 110 monitoring was also conducted; no new impacts were identified.	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.	2.7, 2.7.2
Energy Independence		
The *Energy Independence and Security Act of 2007* (EISA) encourages United States 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, 3.1

Statute/Regulation	2020 Status	Report Section(s)
DOE Order 436.1, *Departmental Sustainability*, establishes implementation requirements that include the preparation of a site sustainability plan and an environmental management system (EMS).	PNNL has developed and implements a site sustainability plan that incorporates the annual status and strategy for achieving the goals and objectives of DOE Order 436.1. PNNL has a fully integrated EMS that is certified to meet International Organization for Standardization (ISO) 14001:2015 standards.	2.1.1, 3.0
Executive Order 13834, "Efficient Federal Operations" (83 FR 23771) establishes goals and requirements related to energy and environmental performance with respect to facilities, vehicles, and overall operations.	PNNL produced the *Pacific Northwest National Laboratory FY 2020 Site Sustainability Plan* (PNNL 2020), which focuses on the goals and requirements of Executive Order 13834.	2.1.2, 3.0
Environmental Safety and Health Reporting		
DOE Order 231.1B, *Environment, Safety, and Health Reporting*, requires the gathering, analysis, and reporting of information about environmental safety and health issues.	PNNL monitors and conveys information via reports, emails, *LabWeb News* articles, and staff meetings. The PNNL Annual Site Environmental Report is a requirement of this Order.	1.0
DOE Order 414.1D, *Quality Assurance*, states the roles and requirements for providing quality assurance (QA) for work performed by DOE and its contractors.	A PNNL internal 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 staff, conforming to DOE Order 414.1D requirements.	7.0
Hazardous Materials and Waste Management		
The *Comprehensive Environmental Response, Compensation, and Liability Act of 1980* (CERCLA) provides regulations for the identification, assessment, and remediation of sites contaminated by hazardous materials.	Neither the Richland Campus nor the 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.	2.6.2
The *Emergency Planning and Community Right-to-Know Act of 1986* 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.	2.6.8

Statute/Regulation	2020 Status	Report Section(s)
The *Federal Facility Compliance Act of 1992* amends the *Resource Conservation and Recovery Act of 1976* (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.	2.6.5
The *Federal Insecticide, Fungicide, and Rodenticide Act* regulates the storage and use of pesticides.	Licensed PNNL staff or certified commercial applicators were used to purchase, store, and apply pesticides on the PNNL Richland Campus and PNNL Sequim Campus.	2.6.7
The *Resource Conservation and Recovery Act of 1976* (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 eight RCRA facilities (EPA Site ID#s). No facilities were inspected in 2020 due to COVID-19 access restrictions.	2.6.4
The *Superfund Amendments and Reauthorization Act of 1986* 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 monitored for Hanford Site contaminant migration. No contamination was identified at the PNNL Sequim Campus that would require response under CERCLA or the *Superfund Amendments and Reauthorization Act*.	2.6.2
The *Toxic Substances Control Act* requires the control and tracking of regulated hazardous chemicals, primarily polychlorinated biphenyls (PCBs).	PNNL contributed to the 2020 PCB annual document log report for the Hanford Site and 2020 PCB annual report; both were published in 2021 and submitted to the U.S. Environmental Protection Agency as required.	2.6.6
Radiation Protection		
DOE Order 435.1, *Radioactive Waste Management*, establishes requirements for managing high-level waste, transuranic waste, low-level waste, and mixed wastes.	PNNL's Radioactive Waste Management Basis Program identifies and implements radioactive waste-management controls through internal workflows and procedures.	2.8.2, 2.8.3

Statute/Regulation	2020 Status	Report Section(s)
DOE Order 458.1, *Radiation Protection of the Public and the Environment*, 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.	2.8.1, 2.8.2, 2.8.3, 4.1, 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
Water Quality and Protection		
The *Clean Water Act* seeks to maintain and improve surface water quality through criteria and permitting, including point-source discharges to United States 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. Three Nationwide Permits were acquired for off-site scientific research studies.	2.5.1, 2.7.1, 7.3, 7.4
The *Safe Drinking Water Act of 1974* 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 *Safe Drinking Water Act of 1974*. At the PNNL Sequim Campus, water is provided exclusively from on-site wells and PNNL is considered the water purveyor.	2.5.2, 2.5.3, 7.4
Wildlife and Ecosystems		
The *Bald and Golden Eagle Protection Act* provides for the protection of bald and golden eagles.	Biological resource reviews provided assurance that proposed actions did not adversely affect bald or golden eagles.	2.7.1
The *Coastal Zone Management Act of 1972* 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. No federal consistency determinations were acquired by PNNL.	2.7.1

Statute/Regulation	2020 Status	Report Section(s)
The *Endangered Species Act of 1973* (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. Four ESA authorizations were acquired, and five no-effect determinations were made or acquired for off-site scientific research studies.	2.7.1
The *Forest Service Organic Administration Act of 1897* (FSOAA) provides for the protection and administration of U.S. Forest Service lands.	One authorization under the FSOAA was acquired in 2020 for an off-site scientific research study.	2.7.1
The *Magnuson–Stevens Fishery Conservation and Management Act* governs marine fisheries management.	Two essential fish habitat authorizations were acquired, and two no-effect determinations were made for off-site scientific research studies.	2.7.1
The *Marine Mammal Protection Act of 1972* provides for the protection of all marine mammals.	One *Marine Mammal Protection Act* no-effect determination was made for off-site scientific research studies.	2.7.1
The *Migratory Bird Treaty Act* makes it illegal to take, capture, or kill migratory birds or their feathers, nests, or eggs.	A number of migratory birds were observed during the biological field survey of the PNNL Richland Campus and the lands encompassing the PNNL Sequim Campus. PNNL biologists resolved 10 inquiries concerning migratory birds on the PNNL Richland Campus and PNNL Sequim Campus.	2.7.1
The *National Environmental Policy Act of 1969* (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 1,855 NEPA reviews during CY 2020 for research and support activities. The U.S. Department of Energy (DOE)-Pacific Northwest Site Office approved four activity-specific categorical exclusions in 2020.	2.3
The *National Park Service Organic Act* provides for the management of national parks and monuments.	No scientific research and collecting permits were acquired for off-site studies.	2.7.1

Statute/Regulation	2020 Status	Report Section(s)
The *National Wildlife Refuge System Administration Act of 1966* provides administrative and management directives for refuges under the jurisdiction of the U.S. Fish and Wildlife Service.	One special use permit was acquired for an off-site scientific research study.	2.7.1
The *Nonindigenous Aquatic Nuisance Prevention and Control Act of 1990* 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
The *Rivers and Harbors Appropriation Act of 1899* prohibits obstruction or alteration of navigable waters.	No Section 10 permits were acquired for off-site scientific research.	2.7.1
Executive Order 11988, "Floodplain Management" (42 FR 26951), requires federal agencies to evaluate the potential effects of any actions within a floodplain.	No activities were performed that required a floodplain evaluation.	2.7.1
Executive Order 11990, "Protection of Wetlands" (42 FR 26961), requires federal agencies to minimize the loss or degradation of wetlands and to preserve and enhance their natural and beneficial values.	No off-site activities were performed that required wetland evaluations.	2.7.1

Table 2.2. Status of Washington State Environmental Laws and Regulations Applicable to PNNL, 2020

Statute/Regulation	2020 Status	Report Section(s)
The *Hazardous Waste Management Act of 1976* 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.	2.6.1
The *Shoreline Management Act of 1971* establishes guidelines for shoreline use, environmental protection, and public access.	No Shoreline Substantial Development Permits and two Exemptions were obtained for off-site scientific research studies.	2.7.1
The *Washington Clean Air Act* implements and supplements the federal *Clean Air Act*, overseeing state air quality.	PNNL operated under permits issued by the Washington State Department of Health, Washington State Department of Ecology, Benton Clean Air Agency, and Olympic Region Clean Air Agency. No events were reported for emissions of regulated substances or substances of concern to the outside air.	2.4.1
The *Washington Pesticide Application Act* provides for the control of pesticide application and use to protect public health and welfare.	Licensed PNNL staff or certified commercial applicators are used to apply pesticides.	2.6.7
The *Washington Pesticide Control Act* establishes guidelines for proper use and control of pesticides.	Licensed PNNL staff or certified commercial applicators are used to apply pesticides.	2.6.7
The Washington *State Environmental Policy Act* (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, completing SEPA checklists as required.	2.3

2.1.2 Executive Order 13834, "Efficient Federal Operations"

Executive Order 13834 of May 17, 2018, (83 FR 23771) requires that federal agencies meet statutory requirements to increase energy efficiency, improve performance, eliminate resource use when unnecessary, and protect the environment. The Order revokes Executive Order 13693 of March 19, 2015 (80 FR 15871), "Planning for Federal Sustainability in the Next Decade," which established goals and requirements in the areas of greenhouse gas reduction and promoted sustainable buildings, clean and renewable energy, water-use efficiency and management, fleet management, sustainable acquisition, pollution prevention and waste reduction, energy performance contracts, and electronic stewardship.

Executive Order 13834 (83 FR 23771) establishes goals and requirements for reducing building energy use, implementing energy efficiency measures, reducing potable and non-potable 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. PNNL has developed detailed plans and milestones for achieving energy efficiency objectives and goals as directed by Executive Order 13834; details are available in Section 3.0 of this report.

2.2 *Energy Independence and Security Act of 2007*

The *Energy Independence and Security Act of 2007* (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, the reduction of stormwater runoff, water conservation and protection, the 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 fiscal year (FY) 2020, PNNL completed an evaluation of four buildings subject to EISA Section 432 continuous (4-year cycle) comprehensive energy and water requirements. To date, approximately 52% of buildings (45% by total square footage) have met the criteria for DOE Federal Energy Management Program Guiding Principles for high-performance sustainable buildings, far exceeding the 2025 goal of 17% (PNNL 2020).

Whole-building metering for electricity, natural gas, and water have been completed for all viable 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 array continued operation in 2020, contributing to on-site energy generation and, together with a solar water heater, additional small photovoltaic arrays on monitoring stations, and renewable energy certificate purchases, it offset 32% of PNNL's electrical use and 24% of its total electric and thermal energy (PNNL 2020).

2.3 National Environmental Policy Act of 1969

The *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). The update modernizes and clarifies the regulations to facilitate more efficient, effective, and timely NEPA reviews. The PNNL NEPA Compliance Program supports Laboratory compliance with NEPA and the Washington *State Environmental Policy Act* (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 staff conducted 1,855 NEPA reviews during CY 2020 for research and support activities (1,526 Electronic Prep and Risk System reviews, 305 William R. Wiley Environmental Molecular Sciences Laboratory [EMSL] user proposals, and 24 facility-modification permits). NEPA staff reviewed Electronic Prep and Risk reviews to verify that potential project environmental impacts were adequately considered, and NEPA (and as appropriate, SEPA) coverage was correctly applied. In nearly every case, activities were adequately addressed in previously approved NEPA documentation, including generic categorical exclusions, environmental assessments, environmental impact statements, and supplement analyses. When there was no adequate previously approved documentation, PNNL staff prepared additional NEPA documentation, such as project-specific categorical exclusions, for approval by DOE.

A draft environmental assessment for future development of the PNNL Sequim Campus was published by PNSO during 2020. Stakeholder comments have been received and dispositioned. Finalization of the environmental assessment is pending completion of federal agency consultations.

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 time period.

There were four new PNSO-approved generic categorical exclusions in 2020. A total of 20 generic categorical exclusions have been approved by PNSO to cover PNNL research and operations activities to date. When projects clearly are within the definition of a categorical exclusion, but a generic categorical exclusion is not applicable, a project- or activity-specific categorical exclusion is prepared. There were no activity-specific PNSO-approved categorical exclusions in 2020. A list of all PNSO-approved categorical exclusions is available at https://science.osti.gov/pnso/NEPA-Documents/Categorical-Exclusion-Determinations.

2.4 Air Quality

Federal 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 *Clean Air Act* (42 U.S.C. § 7401 *et seq.*) is administered by EPA. It regulates air emissions from stationary and mobile sources, both criteria and hazardous air pollutants. The Act authorized EPA to establish National Ambient Air Quality Standards for the protection of public health and welfare. The establishment of these pollutant standards was combined with state implementation plans to facilitate attainment of the standards. The *Washington Clean Air Act* (Revised Code of Washington [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* 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, WAC 173-441, WAC 173-460, and WAC 173-480.

The Benton Clean Air Agency (BCAA) implements and enforces most federal and state requirements on the PNNL Richland Campus through BCAA Regulation 1 (BCAA 2020). 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 Olympic Region Clean Air Agency (ORCAA) implements and enforces most federal and state requirements at the PNNL Sequim Campus through ORCAA Regulations (ORCAA 2020). Requirements applicable to the PNNL Sequim Campus include Regulation 4, "Registration;" Regulation 6, "Required Permits;" 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 *Clean Air Act* 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 with regard to 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 the 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) 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.[1] 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. The sources are major, minor, and fugitive emissions units. In addition, several PNNL Richland Campus 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 Campus data for 2020 are available in the *PNNL Richland Campus Radionuclide Air Emissions Report for Calendar Year 2020* (Snyder et al. 2021a). The PNNL Sequim Campus has one site-wide minor fugitive emission unit that has the potential to emit radionuclides. Radioactive air emissions results for the PNNL Sequim Campus are available in the *PNNL Sequim Campus Radionuclide Air Emissions Report for Calendar Year 2020* (Snyder et al. 2021b). During CY 2020, the PNNL Richland Campus and PNNL Sequim Campus maintained compliance with state and federal regulations and with issued air emissions permits, as described below. In particular, radioactive air emissions were more than 10,000 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 Washington State Department of Health (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 June 17, 2015; the renewal cycle for a WDOH RAEL is every 5 years. The RAEL-005 renewal application was submitted to WDOH in a timely manner, and WDOH allowed permit continuance until the renewal was issued, effective January 1, 2021. 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 emissions. The current Orders of Approval issued by the BCAA to the PNNL Richland Campus are listed below:

[1] As a group of research buildings, the PSF expects to accommodate emerging research over time.

- PNNL Site – EMSL, PSF Complex, Energy Sciences Center (ESC), Life Sciences Laboratory 2 (LSL2) Halogenated Solvent Degreaser Operations (Order of Approval No. 2019-0005, Revision 1)
- LSL2 Building Operations (Order of Approval No. 2007-0006, Revision 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, 2018, by the WDOH and a nonradiological regulatory order issued by the ORCAA (Order of Approval 13NOI968).

2.5 Water Quality and Protection

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

2.5.1 *Clean Water Act*

The *Clean Water Act* (33 U.S.C. § 1251 *et seq.*) establishes the basic structure for regulating discharges of pollutants into the waters of the United States, as well as quality standards for surface waters. The basis of the *Clean Water Act* 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 *Clean Water Act*. Under the *Clean Water Act*, 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 *Clean Water Act* made it unlawful to discharge any pollutant from a point source into navigable waters unless a permit is obtained. EPA's National Pollutant Discharge Elimination System (NPDES) permit program controls these point-source discharges. Point sources are discrete conveyances such as pipes or manmade ditches. Industrial, municipal, and other facilities must obtain permits if their discharges go directly to surface waters. 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 assure that 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. Industrial wastewater discharge permit 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 CR-IU005 regulates discharges from EMSL to Outfall 001. Permit CR-IU011 regulates process wastewater discharged from PSF. All process wastewater from PSF is monitored at a single compliance point (Outfall PS-001). All waste streams regulated by these permits are reviewed by PNNL staff and evaluated for compliance with the applicable permit prior to being discharged.

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

2.5.2 Stormwater Management

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. Best management practices are used to minimize pollution in stormwater. These practices include 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 drain boxes for paved areas and a trench that drains to an infiltration pond. Drain boxes provide simple oil separation through the use of a submerged discharge outlet. In addition, separate drain boxes in the boat storage yard and in the wastewater treatment system area contain multimedia filtration systems (sedimentation chamber, oil adsorbent, and granular activated carbon adsorbent). The infiltration pond is an engineered stormwater collection basin with an overflow trench.

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 Section 438 are considered and implemented as part of PNNL sustainability practices (PNNL 2020). The registrations of underground injection control wells for stormwater have been completed as required by *Safe Drinking Water Act of 1974*.

2.5.3 *Safe Drinking Water Act of 1974*

The *Safe Drinking Water Act of 1974* (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 Act, EPA sets primary and secondary standards for drinking water quality and oversees the states, localities, and water suppliers who implement those standards. The *Safe Drinking Water Act of 1974* 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 Act focuses on all waters actually or potentially designated for use as drinking water, whether from aboveground or underground sources. The Act authorizes 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. State governments, which can be approved to implement these rules for EPA, also encourage attainment of secondary standards.[1] Under the *Safe Drinking Water Act of 1974*, 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 for uses in laboratory and nonlaboratory spaces from the City of Richland drinking water supply and is not subject to the *Safe Drinking Water Act of 1974*.

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 distribution system. All drinking water parameters sampled met compliance requirements.

As described in Section 6.0 of this report, the BSF/CSF buildings use groundwater for heating and cooling. Water is withdrawn from production wells and discharged to the ground via underground injection control wells. The registrations of underground injection control wells for injection of ground-source heat pump return flow water have been completed as required by the *Safe Drinking Water Act of 1974*.

2.5.4 Emerging Contaminants

Per- and polyfluoroalkyl substances (PFAS) are a family of chemicals that are emerging contaminants of concern due to their potential adverse health effects and widespread contamination at sites across the United States. PFAS chemicals are used to manufacture stain-resistant, water-resistant, and non-stick products, as well as some cleaning products and engineered coatings, and certain types of firefighting foam. There are currently no enforceable federal standards for PFAS chemicals, but Washington State has passed legislation to restrict the use of PFAS in food packaging and to ban the new sale and distribution of PFAS-based firefighting foams. Washington State is also developing legislation to monitor certain PFAS chemicals in drinking water, create cleanup standards for groundwater contamination, and establish approved analytical methods for testing for PFAS. A review of PNNL properties and activities was conducted to determine if the potential for PFAS contamination exists. One decommissioned fire suppression system that contained PFAS chemicals was identified and there is no recorded activation of the system. No other PNNL activities or properties were identified to have potential PFAS contamination. Currently, no monitoring or testing for PFAS chemicals has occurred or been required for PNNL facilities.

2.6 Environmental Restoration and Waste Management

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

---

[1] Secondary standards are established to give operators of public water systems guidance about removing contaminants that may cause the water to appear cloudy or colored, or to taste or smell bad, even though the water is actually safe to drink.

2.6.1 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 the *Resource Conservation and Recovery Act of 1976* (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 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 at http://www.hanford.gov/?page=81. Printed copies of the Tri-Party Agreement, which is current as of April 14, 2021, 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 Hanford Site CERCLA operable unit or subject to any cleanup action under the Tri-Party Agreement. PNNL maintains administrative controls similar to 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 with regard to 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 located on 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 2020* (DOE-RL 2021c).

2.6.2 *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, 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 china, 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.

Groundwater under the northern portion of the PNNL Richland Campus is routinely monitored for contaminants migrating from Hanford Site contamination plumes, as well as nitrates migrating from off-site locations. See Section 6.0 of this report for further information concerning groundwater monitoring on the PNNL Richland Campus.

No PNNL Sequim Campus facilities require action under CERCLA guidelines.

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

The Washington State Dangerous Waste Regulations (WAC 173-303-145) require that spills or non-permitted 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 the dangerous waste or hazardous substance released.

During CY 2020, no spills or non-permitted discharges that posed a threat to human health or the environment occurred at PNNL facilities in the 300 Area, the PNNL Richland Campus, or PNNL Sequim Campus. Minor spills were cleaned up immediately and disposed of in accordance with applicable requirements.

2.6.4 *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. 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. This unit group is located in the Radiochemical Processing Laboratory in the Hanford 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 Hanford RCRA Permit may be viewed at https://fortress.wa.gov/ecy/nwp/permitting/hdwp/rev/8c/index.html.

With the exception of the 325 Hazardous Waste Treatment Units, the PNNL Richland Campus and PNNL Sequim Campus facilities operate under the generator requirements of WAC 173-303. During CY 2020, PNNL facilities followed the generator requirements for waste management and shipped nonradioactive waste to off-site facilities for proper disposal.

RCRA and WAC 173-360A also include requirements for the proper management of underground storage tanks. In CY 2020, Battelle administered two underground storage tanks for the storage of diesel fuel for backup generators on the PNNL Richland Campus in Richland—a 20,000-gallon tank and 600-gallon tank. The tanks are routinely monitored, and no problems were observed. No underground tanks are used at the PNNL Sequim Campus.

The Washington State Department of Ecology did not perform any RCRA compliance inspections at PNNL in 2020 due to COVID-19 access restrictions.

2.6.5 *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 EPA to conduct annual inspections of all federal facilities. Authorized states are also given authority to conduct inspections of federal facilities to enforce compliance with state hazardous waste programs. A portion of the Act also requires DOE to provide mixed waste information to EPA and the states. 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. Submission of the 2020 report has been delayed until late FY 2021, after the publication date of this report, pending resolution of Washington Department of Ecology comments on the 2019 report (DOE-RL 2020a).

2.6.6 Toxic Substances Control Act

Requirements of the *Toxic Substances Control Act* (15 U.S.C. § 2601 *et seq.*) that apply to PNNL primarily involve the regulation of polychlorinated biphenyls (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 regulated by 40 CFR Part 761, which are stored and/or disposed of in accordance with this regulation.

The *2020 Hanford Site Polychlorinated Biphenyl Annual Document Log* (DOE-RL 2021a) and the *2020 Hanford Site Polychlorinated Biphenyl Annual Report* (DOE-RL 2021b) were produced in 2021 and describe the PCB waste-management and disposal activities that occur on the Hanford Site, including PNNL activities in the 300 Area. The Annual Report is provided to EPA as required by 40 CFR 761.180. The PNNL Richland campus did not generate enough waste to require reporting in 2020. The PNNL Sequim Campus did not generate PCB waste in 2020.

2.6.7 Federal Insecticide, Fungicide, and Rodenticide Act

The *Federal Insecticide, Fungicide, and Rodenticide Act* (7 U.S.C. § 136 *et seq.*) is administered by EPA. Washington State Department of Agriculture rules implementing the Act requirements 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 2020, commercial pesticides used at the PNNL Richland Campus and PNNL Sequim Campus were managed in accordance with these rules and applied either by licensed PNNL staff or by a licensed commercial applicator.

2.6.8 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 emergency 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: emergency planning, emergency release notification, hazardous chemical inventory reporting, and toxic chemical release inventory reporting. Each provision requires reporting when thresholds are exceeded (Table 2.3).

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 former is located in a different county (Clallam).

Table 2.3. 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 lbs) or an extremely hazardous substance in a quantity equal to or greater than the threshold planning quantity or 230 kg (500 lbs), 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 lbs), or an extremely hazardous substance in a quantity equal to or greater than the threshold planning quantity or 230 kg (500 lbs), 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 the course of a calendar year. Thresholds are 11,300 kg (25,000 lbs) for manufactured or processed chemicals or 4,500 kg (10,000 lbs) for chemicals otherwise used, except for persistent, bio-accumulative, toxic chemicals, which have thresholds of 45 kg (100 lbs) or less.	Annually by July 1.	EPA; SERC

CERCLA = *Comprehensive Environmental Response, Compensation, and Liability Act of 1980*;
CFR = *Code of Federal Regulations*;
EPA = U.S. Environmental Protection Agency; LEPC = Local Emergency Planning Committee; OSHA = Occupational Safety and Health Administration;
SERC = State Emergency Response Commission.

The Annual Tier Two inventory report for calendar year 2020 for the PNNL Richland Campus was submitted on February 22, 2021, to the Washington State Emergency Response Commission, Benton County Emergency Management, and the Richland Fire Department via the SecureAccessWA website. Under the governing regulations, R&D chemicals are exempt from reporting. The report includes 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 lead-acid batteries, diesel fuel, and the urea content of fertilizer products stored at PNNL in excess of 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, Clallam County Emergency Management, and the Clallam County Fire District 3 on February 23, 2021. Similar to previous years, this report identifies diesel fuel as the only material in excess of 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 2020, because no releases of Toxic Release Inventory chemicals occurred in excess of reporting thresholds.

Table 2.4 provides an overview of PNNL reporting under EPCRA for CY 2020.

Table 2.4. *Emergency Planning and Community Right-to-Know Act of 1986* Compliance Reporting, 2020

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 managed in excess of thresholds.
304	Extremely hazardous substance release notification	Not required	No releases occurred.
311	Material Safety Data Sheet	Yes	No changes in previously reported inventories.
312	Chemical inventory	Yes	The CY 2020 Tier Two reports for the PNNL Richland Campus and PNNL Sequim Campus were submitted to the Washington State Department of Ecology, the LEPC, and local fire departments in February 2021.
313	Toxic release inventory	Not required	No releases were greater than the reporting threshold requirement.

CY = calendar year
LEPC = Local Emergency Planning Committee
PNNL = Pacific Northwest National Laboratory.

2.7 Natural and Cultural Resources

The Pacific Northwest Site Office Cultural and Biological Resources Management Plan (CBRMP; DOE-PNSO 2015) 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 conducts 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

A number of federal and state laws, Executive Orders, regulations, and related memoranda contain requirements for (1) managing biological and cultural resources on the PNNL Richland Campus and PNNL Sequim Campus, and (2) acquiring 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. This section and Table 2.5 summarize the requirements and catalog PNNL's compliance activities related to biological resources in 2020.

2.7.1.1 Federal Statutes and Regulations

The *Endangered Species Act* (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. Under Section 7(a)(2) of the Act, federal agencies are required 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 U.S. Fish and Wildlife Service (USFWS) and/or the National Marine Fisheries Service (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.

Table 2.5. Environmental Research Permits Obtained in 2020 for PNNL Research Activities

Issuer and Permit Type	Regulatory Driver	Number of Permits
Alaska Department of Fish and Game		
Fish Habitat Permit	AFA	1
Alaska Department of Natural Resources		
Land Use Permit	AS	1
Clallam County		
Shoreline Substantial Development Permit Exemption	SMA	1
Franklin County		
Shoreline Substantial Development Permit Exemption	SMA	1
Hancock Forest Management		
Access Permit	NA	1
Hanford Fire Department		
Fire Permit	NA	1
Mission Support Alliance		
Hanford Site Access Permit	NA	1
Hanford Site Excavation Permit	WAC	1
National Marine Fisheries Service / NOAA Fisheries		
Determination of Take Authorization (Willamette Biological Opinion)	ESA	1
Informal Consultation (ESA Section 7/MSFCMA Essential Fish Habitat)	ESA, MSFCMA	1
No Effects Determination	ESA, MSFCMA	1
Oregon Department of Fish and Wildlife		
Scientific Taking Permit – Fish	OAR	3
PNNL for DOE-PNSO		
No Effects Determination	ESA, MMPA, MSFCMA	5
U.S. Army Corps of Engineers		
Access Permit	RHA	1
Nationwide Permit 5 – Scientific Measurement Devices	RHA, CWA	3
U.S. Coast Guard		
Local Notice to Mariners	CFR	1
Private Aids to Navigation Permit	CFR	1
U.S. Fish and Wildlife Service		
Informal Consultation (ESA Section 7)	ESA	1
Special Use Permit	NWRSAA, CFR	1
U.S. Forest Service		
Special Use Permit	FSOAA	1
Washington Department of Fish and Wildlife		
Fish Transport Permit	WAC	2
Hydraulic Project Approval	WAC	1
Right of Entry	WAC	1
Scientific Collection Permit	WAC	2
Washington Department of Natural Resources		
Aquatic Lands Right of Entry License	WAC	2
Total		36

AFA = *American Fisheries Act of 1998*; AS = Alaska Statutes; CFR = *Code of Federal Regulations*; CWA = *Clean Water Act*; ESA = *Endangered Species Act of 1973*; FSOAA = *Forest Service Organic Administration Act of 1897*; MMPA = *Marine Mammal Protection Act of 1972*; MSFCMA = *Magnuson–Stevens Fishery Conservation and Management Act*; NWRSAA = *National Wildlife Refuge System Administration Act of 1966*; OAR = Oregon Administrative Rules; RHA = *Rivers and Harbors Appropriation Act of 1899*; SMA = *Shoreline Management Act of 1971*; WAC = Washington Administrative Code. NA = not applicable.

The *Migratory Bird Treaty Act* (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. A Department of the Interior Office of the Solicitor Memorandum (M-37050, issued in December 2017 [DOI 2017]) and a subsequent explanatory Memorandum (issued in June 2018 [DOI 2018]) clarified that an active nest of a migratory bird may be destroyed while conducting any activity where the intent of the action is not to kill migratory birds or destroy their nests or contents (incidental take). PNNL projects that have a potential to affect avian species listed under the Act use the PNNL biological resource review process, as described in the CBRMP (DOE-PNSO 2015) and implemented by PNNL's internal biological resource protection procedures to protect migratory birds regardless of intent. In 2020, PNNL biologists resolved 10 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* (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. The PNNL biological resource review process provides assurance that a proposed action will not adversely affect bald or golden eagles. Mitigation includes performing work according to the spatial and timing restrictions established for seasonal use locations, such as nest sites and communal night roosts in applicable jurisdictional management plans for the species.

The *Magnuson–Stevens Fishery Conservation and Management Act* (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 in order 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 Act, 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 *Marine Mammal Protection Act* of 1972 (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 Act is to assure that 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 *Rivers and Harbors Appropriation Act of 1899* (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. Authorization for issuing permits under both RHA Section 10 and *Clean Water Act* Section 404 (Section 2.5.1) 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 acquired for PNNL research projects. PNNL obtains Department of the Army permits from USACE for each project, as applicable, as part of 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. The Order states that federal agencies should avoid undertaking or providing assistance for 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 this Order, as well as the wetland provisions of the *Clean Water Act* (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 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 (MoU) between DOE and the USFWS regarding implementation of Executive Order 11386, identifies specific areas in which enhanced collaboration between DOE and the USFWS will substantially contribute to the conservation and management of migratory birds and their habitats (DOE and USFWS 2013). Compliance with the Order and MoU are assured by PNNL's biological resource review process as described in the CBRMP (DOE-PNSO 2015) and implemented by PNNL's internal biological resource protection procedures.

The *Coastal Zone Management Act of 1972* (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 EPA and NOAA. PNNL maintains compliance with the federal consistency provisions and Section 6217 of this Act 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, the 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 permit and/or private aid to navigation (a buoy, light, or day beacon owned and maintained by a private organization or individual [PATON]) is necessary. The USCG also publishes the *Local Notice to Mariners* (LNM) weekly, which provides information about the location of structures to facilitate navigational safety in marine environments. Permits, PATONs, and LNMs allow research projects to be located in navigable waters without posing undue hazard 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 collecting are deemed "special uses" and require a permit. PNNL maintains compliance with these regulations through its ERP program.

The *National Park Service Organic Act* established the National Park Service in 1916 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.

The *Columbia River Gorge National Scenic Area Act* (16 U.S.C. § 544 *et seq.*) was enacted to protect and enhance the scenic, recreational, and natural resources and to support the economy of the Columbia River Gorge. The Act is implemented through a Gorge Management Plan (CRGC and USFS 2016), overseen by the U.S. Forest Service and an Oregon-Washington bi-state Columbia River Gorge Commission. The U.S. Forest Service conducts consistency reviews for proposed projects that are to be located within designated management areas. PNNL maintains compliance with this Act through its ERP program.

2.7.1.2 State Statutes and Regulations

PNNL conducts research at locations throughout the Northwest and must also comply with applicable state and local statutes, regulations, and directives at those sites. Principal relevant rulings 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^3/s (21 ft^3/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 (SMPs) (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 SMPs through PNNL's ERP program.

Several chapters and sections of the Washington Administrative Code (WAC) govern activities that affect fish and wildlife or their habitat, aquatic lands, and excavation activities in the state of Washington. 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 the state of 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 that PNNL undertakes in the state of Alaska must comply with state regulations in place to protect fish and wildlife and their habitat. The *Alaska State Anadromous Fish Act* (Alaska Statute [AS] 16.05.871) requires a permit from the Alaska Department of Fish and Game for any activities that alter or affect the natural flow or bed of specified waterbodies. The Alaska Department of Natural Resources (AS 38.05.005 – Public Land – Division of Lands) is responsible for managing most state-owned land and issues permits for uses including scientific research.

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 the following paragraphs.

PNSO prepared the CBRMP (DOE-PNSO 2015) 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 2015), projects involving soil or vegetation disturbance or work outdoors are routinely evaluated to determine their potential to affect biological resources prior to implementation. Forty-three biological resource reviews were completed for PNNL projects in CY 2020—16 on the Richland Campus, 10 at the PNNL Sequim Campus, and 17 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 as threatened, endangered, sensitive, candidate, or monitor; Washington State priority habitats; and bird species protected under the *Migratory Bird Treaty Act* and *Bald and Golden Eagle Protection Act*. Federally and state-listed species on the PNNL Richland Campus and PNNL Sequim Campus are listed in Table 1.1 and Table 1.2, 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 from May through June 2020, except for the riparian zone adjacent to the Columbia River. 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 2020, and at the PNNL Sequim Campus from 2006 to 2020 and their status are provided in Appendix A and Appendix B, respectively.

2.7.2.1 Aquatic Invasive Species Interception

Several non-native invasive aquatic species identified by the WDFW (2001) are of concern for boaters in Washington State, including PNNL staff operating research watercraft, and are addressed by PNNL's Aquatic Invasive Species Interception Program. These include some Prohibited Level 1 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 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 non-native plant species listed as 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; Duncan et al. 2020; see Appendix A). 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:

- broadleaf pepperweed (*Lepidium latifolium*),
- burning-bush (*Bassia [Kochia] scoparia*),
- cotton [Scotch] thistle (*Onopordum acanthium*),
- diffuse knapweed (*Centaurea diffusa*),
- puncturevine (*Tribulus terrestris*),
- rush skeletonweed (*Chondrilla juncea*),
- Russian knapweed (*Rhaponticum* [*Acroptilon*] *repens*), and
- yellow starthistle (*Centaurea solstitialis*).

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 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:

- baby’s-breath (*Gypsophila paniculata*),
- bindweed (*Convolvulus arvensis*),
- bur-grass (*Cenchrus longispinus*),
- common groundsel (*Senecio vulgaris*),
- common St. John’s-wort (*Hypericum perforatum*),
- creeping [Canada] thistle (*Cirsium arvense*),
- heart-podded hoarycress (*Lepidium draba*),
- Himalayan blackberry (*Rubus bifrons*),
- reed canarygrass (*Phalaris arundinacea*),
- Russian olive (*Elaeagnus angustifolia*), and
- 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 facilitates avoidance of non-target (i.e., native) species. The Milestone™ herbicide generally used (along with water conditioner, drift control agent, surfactant, and blue visibility dye). Hand-pulling or chopping is used opportunistically for those species for which mechanical control is effective (e.g., annual or biennial plants with limited occurrence such as yellow starthistle and cotton thistle).

Because of the COVID-19 pandemic and resultant work restrictions during the spring and summer of 2020, control efforts in 2020 were limited to mid-summer mechanical control of yellow starthistle and cotton thistle (Figure 2.1). No herbicide applications were made in the natural vegetation areas of the PNNL Richland Campus in 2020.

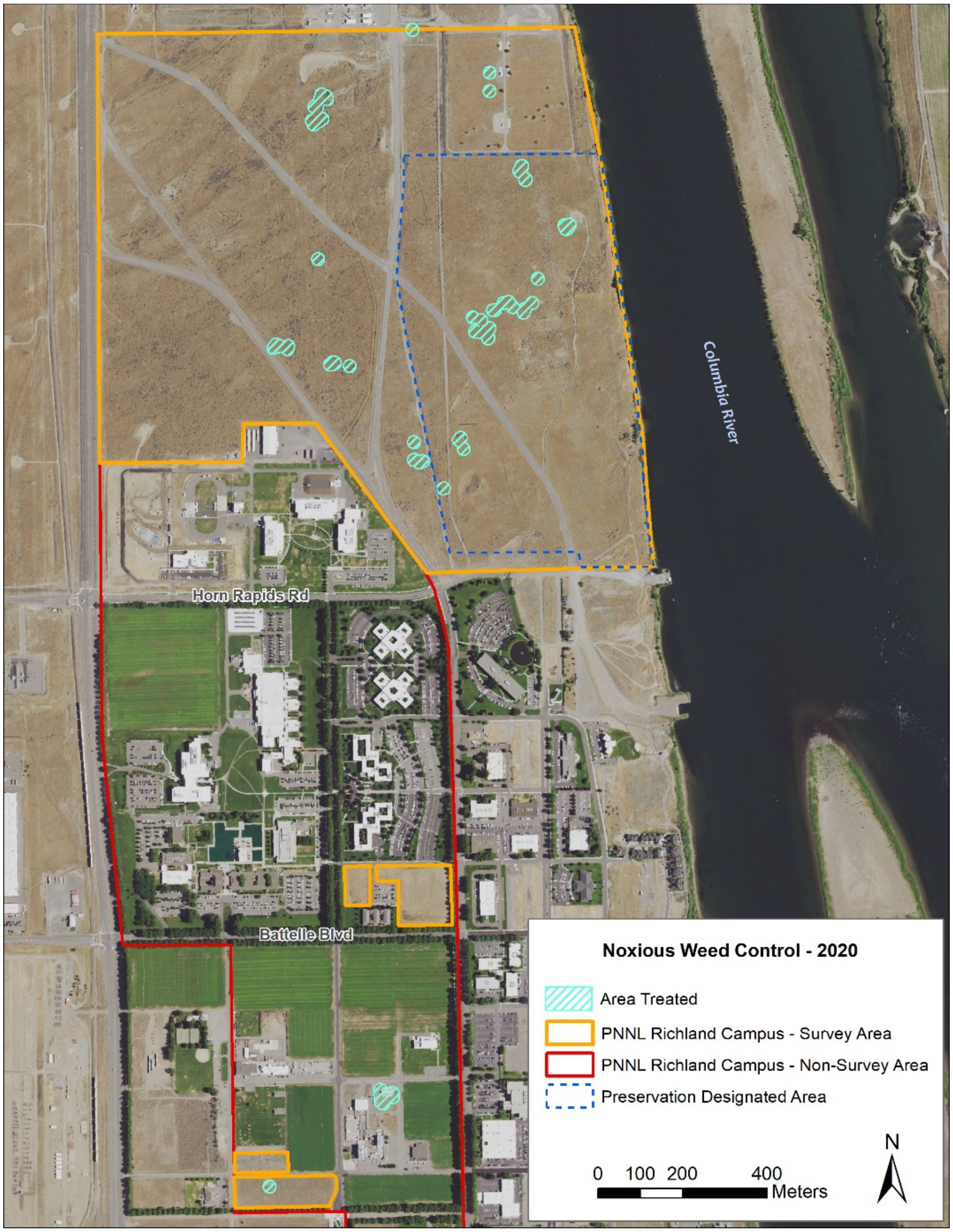


Figure 2.1. Areas Treated for Noxious Weeds on the PNNL Richland Campus in 2020

2.7.3 Cultural Resources

The cultural resources at PNNL represent thousands of years of human land use. A number of federal laws, regulations, and Executive Orders provide the framework for protection of cultural resources on the PNNL Richland and Sequim Campuses. Most of the work completed by the cultural resources program at PNNL is focused on Section 106 compliance, as required by the *National Historic Preservation Act of 1966* (NHPA). The NHPA requires federal agencies to consider the effect of their project on any district, site, building, structure, or object that may be eligible for inclusion in the NRHP in order to avoid, minimize, or mitigate these impacts. This section summarizes PNNL's compliance activities in 2020.

The PNNL cultural resources program supported 44 projects by performing surveys or verifying results from previous surveys in 2020. Six of the 44 projects were activities exempt under existing agreement documents. On the Richland Campus, four archaeological sites were identified and added to PNSO's inventory. These findings were reported to the Washington State Department of Archaeology and Historic Preservation and described in an annual report to consulting tribes.

Six of the 44 projects were undertakings at PNNL's Sequim Campus. One undertaking resulted in an Adverse Effect. Consultation to resolve the Adverse Effect was put on hold due to the COVID-19 pandemic.

The PNNL cultural resources program continues to consult with the Plateau tribes (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, including 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 are also regularly consulted.

2.7.3.1 NHPA Section 110 Activities

PNNL's cultural resources program performs annual site condition monitoring to comply with NHPA Section 110. Annual site condition monitoring also enables PNNL cultural resources staff to determine if the integrity of known resources has been compromised in any way.

Annual Section 110 monitoring was conducted on the PNNL Richland Campus during the first quarter of FY 2020. Monitoring was conducted by the PNNL cultural resources staff and Tribal cultural resources staff. Photographs and field notes were taken at set points for each archaeological site to assess the site condition and identify potential changes to the site caused by human or natural causes. In addition, information was collected and added to file records to update the current knowledge of the sites.

No previously unrecorded impacts at any of the sites monitored were identified during the FY 2020 monitoring trip. Previously noted manmade disturbances were no longer visible because vegetation has completely covered them. Animals have increasingly used the area, as noted by the significant increase in game trails, animal droppings, burrowing, tracks, and other activities. Overall, there was larger vegetation growth throughout.

For the first time, PNNL's Richland Campus historic district was included in the Section 110 monitoring. The district comprises six buildings—four that were part of the original Battelle campus and two facilities completed in the 1970s. A visual inspection of the six buildings that make up the district was done to assess current conditions. Some deterioration was noted along with shattered and fractured exterior windows on two of the facilities. Historic properties will continue to be monitored annually.

2.8 Radiation Protection

PNNL is subject to radiation protection statutes and regulations that are designed to protect the health and safety of the public, the workforce, 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 Admin Chg 3 (January 2013) and Admin 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.

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 2.2). The ALARA process must be applied to the design or modification of facilities and to the conduct of radiological work activities.

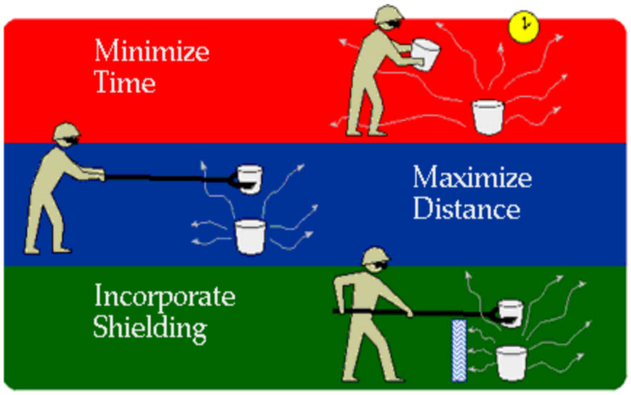


Figure 2.2. Elements of the As Low As Reasonably Achievable (ALARA) Principle

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 pre-approved 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, the use of process knowledge and historical knowledge when releasing property, the preparation and approval of requests for authorized limits, and the 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 2020.

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 3, *Worker Protection Program for DOE (Including the National Nuclear Security Administration) Federal Employees*
- DOE Order 458.1, Admin Chg 4, *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 covers mixed waste (i.e., high-level waste, transuranic waste, or low-level waste that also contain chemically hazardous constituents). DOE Order 435.1 (approved in 1999) superseded a previous set of requirements (DOE Order 5820.2A, dated September 26, 1988) for managing radioactive waste. DOE Order 435.1, Chg 1, approved in 2001, includes minor revisions to the original Order and was formally certified again in 2007.

PNNL's Radioactive Waste Management Basis Program identifies the hazards associated with radioactive waste management at PNNL along with their potential impacts. Controls for the protection of the public, workers, and environment are also 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 promulgated 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, Chg 1 [Section 2.8.2] and DOE Order 458.1, Admin Chg 4 [Section 2.8.1]) to protect public health and the environment from potential risks associated with radioactive materials. PNNL complies with the *Atomic Energy Act of 1954* through its Radiation Protection Management and Operation Program and Radioactive Waste Management Basis Program.

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 2020.

2.9.1 Continuous Release Reporting

A continuous release is a hazardous release exceeding reporting thresholds under CERCLA regulations (40 CFR 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 PNNL Sequim Campus in 2020.

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

DOE Order 232.2A requires the 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. Releases requiring regulatory agency notification (Section 2.9.3) and receipt of formal or informal regulator correspondence alleging violations (Section 2.6) are required to 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 2020.

2.10 Summary of Permits

Table 2.6 summarizes air, liquid, and hazardous waste permits for the PNNL Richland Campus and PNNL Sequim Campus during 2020. Project-specific permits are also acquired but are not reflected in the table because they are usually of limited term and scope.

Table 2.6. PNNL Air, Liquid, and Hazardous Waste Permits, 2020

Issuer	Permit #	Location(s) Regulated	Activity(ies) Regulated	Expiration Date[a]
Air Emissions				
Washington State Department of Health	FF-01[b]	PNNL-occupied locations on the Hanford Site	Radioactive air emissions	10/20/2022
Washington State Department of Health	RAEL-005	PNNL Richland Campus	Radioactive air emissions	6/17/2020
Washington State Department of Health	RAEL-014	PNNL Sequim Campus	Radioactive air emissions	1/1/2023
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. 1	PNNL Site – W.R. Wiley Environmental and Molecular Sciences Laboratory, Physical Sciences Facility Complex, Energy Sciences Center, Life Sciences Laboratory II Halogenated Solvent Degreaser	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
Olympic Region Clean Air Agency	Order of Approval 13NOI968	PNNL Sequim Campus Standby Generators	Nonradioactive air emissions	None

Issuer	Permit #	Location(s) Regulated	Activity(ies) Regulated	Expiration Date[a]
Liquid Effluents[c]				
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	8/21/2022
City of Richland	CR-IU011	Physical Sciences Facility (buildings north of Horn Rapids Road)	Liquid effluent discharges to city sewer	3/9/2023
City of Richland	CR-IU010[b]	PNNL-occupied locations on the Hanford Site	Liquid effluent discharges to city sewer	11/30/2021
Washington State Department of Ecology	ST 4511[b]	PNNL-occupied locations in the Hanford Site 300 Area	Discharge of wastewater from maintenance, construction, and hydro testing activities; allows for cooling water, condensate, and industrial stormwater discharges to ground	12/31/2019
Washington State Department of Ecology	ST-9274	Biological Sciences Facility and Computational Sciences Facility	Reinjection of well water used in ground-source heat pump	6/6/2020[d]
Washington State Department of Ecology	WA0040649	PNNL Sequim Campus	Treated liquid effluent discharges to Sequim Bay	11/30/2022
Washington State Department of Ecology	WA0026859	PNNL Scientific Focus Area Tracer Injection Project	Tracer injection into water sampling tubes to study the interaction of groundwater and surface water along the Columbia River shoreline	5/31/2023
Hazardous Waste				
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

(a) Expired permits generally remain in force while renewal applications are processed by the issuing agency.
(b) Permit is issued to DOE-Richland Operations Office and/or its contractor(s); PNNL is obligated to comply with these permits through an operating agreement between the DOE-Richland Operations Office and the Pacific Northwest Site Office.
(c) 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.
(d) Washington State Department of Ecology cancelled this permit April 1, 2020, as the wells met the nonendangerment standard as defined in WAC 173-218-080.

This page intentionally left blank

3.0 Environmental Management System

PNNL has a mature, robust EMS that has been certified to meet the requirements of ISO 14001 standards since 2002. 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.

In early 2020, PNNL successfully renewed its ISO 14001:2015 Certificate of Registration through 2023 (Figure 3.1). The EMS program is audited annually to verify that it is operating as intended and in conformance with ISO 14001 standards. The 2020 audit had to be performed virtually due to site access restrictions imposed by the COVID-19 pandemic. The results of the 2020 audit showed that PNNL continues to meet the requirements of the ISO 14001 standard, despite the disruptions and workplace access challenges imposed by the pandemic. In addition, the 2020 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 re-evaluated 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

Certificate of Registration

This certifies that the Environmental Management System of

Battelle - Pacific Northwest Division

Pacific Northwest National Laboratory
902 Battelle Boulevard
Mail Stop J2-25
Richland, Washington, 99354, United States

has been assessed by NSF-ISR and found to be in conformance to the following standard(s):

ISO 14001:2015

Scope of Registration:
Pacific Northwest National Laboratory, operated by Battelle for the U.S. Department of Energy: Research and development activities and associated facilities operations.

Certificate Number: 6Z781-EM10
Certificate Issue Date: 17-JAN-2020
Registration Date: 26-JAN-2020
Expiration Date *: 25-JAN-2023

Tom Chestnut,
Sr Vice President - ISR,
NSF-ISR, Ltd.

Page 1 of 4

NSF International Strategic Registrations
789 North Dixboro Road, Ann Arbor, Michigan 48105 | (888) NSF-9000 | www.nsf-isr.org

Authorized Registration and /or Accreditation Marks. This certificate is property of NSF-ISR and must be returned upon request.
*Company is audited for conformance at regular intervals. To verify registrations call (888) NSF-9000 or visit our web site at www.nsf-isr.org

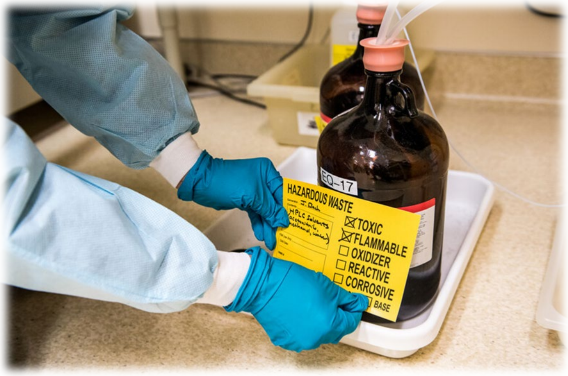
Figure 3.1. Certificate of Registration for PNNL Conformance with ISO 14001:2015 Standard

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. PNNL performs annual environmental aspect and impact analyses, including risk analyses and work evaluations, 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 as follows:

- Chemical Use and Storage. As a research laboratory, PNNL has many buildings in which chemicals/biological 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/biological material use, as well as adequate safety requirements. PNNL implements a "ChemAgain" program, which redistributes surplus chemicals internally in an effort to reduce PNNL's chemical waste.



- 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 and work procedures for biological material use and adequate safety requirements.
- 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.
- Radioactive Material Use and Storage. Research at PNNL may involve the use of radioactive materials. All radioactive materials are labeled and controlled. Controls include restricted access to radiation areas, special training requirements for staff requiring access, and restricting the amount and location of where radioactive materials can be used to within permitted levels.
- 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.
- Effluents to Water. PNNL seeks to minimize liquid discharges to the environment. Discharges include laboratory drain water to sewer systems and stormwater to dry 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.

- Energy Use. Using energy judiciously is a prime objective at PNNL. Energy reduction goals are established and activities to reduce energy consumption are implemented.

- 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.
- 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 has also acquired electric vehicles for on-campus transportation and has installed solar-powered electric vehicle charging stations across the Richland Campus. In addition, PNNL was instrumental in obtaining the first biofuel service station in Richland, Washington, and when appropriate, uses bio-diesel to fuel generators.
- 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.
- 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

From innovative best practices in sustainable operations to environmentally focused scientific breakthroughs, PNNL is committed to making the world a better place to live for many generations to come. In FY 2020, despite the unprecedented disruptions and challenges of the ongoing COVID-19 pandemic, staff at PNNL have remained productive. Key accomplishments and initiatives in advancing PNNL sustainability are highlighted in the following sections. Select sustainability goals, PNNL's FY 2020 performance status, and planned actions are detailed in Table 3.1.

Table 3.1. Select PNNL Sustainability Goals through FY 2020 and Planned Actions

DOE Goal	Current Performance Status	Planned Actions & Contribution
Energy Management		
30% energy intensity (Btu per gross square foot) reduction in goal-subject buildings by FY 2015 from a FY 2003 baseline and 1.0% (year over year [YOY]), thereafter.	Current Performance: 5% reduction versus FY 2019.	PNNL plans to build three new buildings and modernize several existing buildings and infrastructure. New buildings will have highly innovative heating and cooling systems.
EISA Section 432 continuous (4-year cycle) energy and water evaluations.	Compliant with EISA Section 432 requirements. Recently completed buildings are EMSL, BSF, CSF, and the Physical Sciences Laboratory.	PNNL will continue to complete EISA evaluations, as required.
Meter all individual buildings for electricity, natural gas, steam, and water where cost effective and appropriate.	All individual buildings are metered for electricity, natural gas, steam, water, and chilled water where cost effective and appropriate.	PNNL will continue implementing metering for applicable buildings. Metering progress is documented in internal PNNL documents.
Water Management		
20% potable water intensity (gal per gross square foot) reduction by FY 2015 from a FY 2007 baseline and 0.5% YOY thereafter.	Current Performance: 64.6% reduction from FY 2007 baseline with a 10% decrease in water use intensity versus FY 2019 usage.	PNNL will continue to reduce potable water intensity as much as possible. Over one quarter of the potable water is used for cooling towers.
Non-potable freshwater consumption (gal) reduction of industrial, landscaping, and agricultural (ILA) uses. YOY reduction; no set target.	Current Performance: 31% increase YOY.	Hot dry windy summer in FY 2020 increased landscaping needs. Trending shows possible impact due to climate change. New buildings will impact ILA water use.
Waste Management		
Reduce at least 50% of nonhazardous solid waste, excluding construction and demolition debris, sent to treatment and disposal facilities.	Diverted 55% through recycling.	Continue to implement and improve recycling programs and assess opportunities for further waste reduction.

DOE Goal	Current Performance Status	Planned Actions & Contribution
Reduce construction and demolition materials and debris sent to treatment and disposal facilities. YOY reduction; no set target.	Diverted 70% through recycling.	Continue to monitor construction and demolition recycling performance and raise awareness of waste diversion requirements.
Fleet Management		
20% reduction in annual petroleum consumption by FY 2015 relative to a FY 2005 baseline; 2.0 % YOY thereafter.	No information available for 2020.	Education will continue for vehicle custodians regarding the importance of avoiding extra idling time, speed control, combining trips with other staff members when feasible, as COVID-19 restrictions permit.
10% increase in annual alternative fuel consumption by FY 2015 relative to a FY 2005 baseline; maintain 10% increase thereafter.	No information available for 2020.	Continue periodic checks on the local availability for alternative fuels. As older vehicles are replaced, PNNL will continue to work with the General Services Administration (GSA) to determine if alternative fuel vehicles (AFVs) or electric vehicles (EVs) are replacement options.
75% of light-duty vehicle acquisitions must consist of AFVs.	Limitations of GSA available options resulted in PNNL achieving 25% AFVs in FY 2020.	PNNL will continue to work closely with GSA to assure that all applicable PNNL vehicle orders are for AFVs, when available.
Clean & Renewable Energy		
"Renewable Electric Energy" requires that renewable electric energy account for not less than 7.5% of a total agency electric consumption by FY 2013 and each year thereafter.	Current Performance: 32% of electricity consumption is renewable, slightly exceeding the interim target of 30.5% for FY 2020.	Renewable Energy Credit (REC) purchases will be adjusted to meet new interim targets. PNNL will evaluate the feasibility of renewable energy systems.
Continue to increase non-electric thermal usage. YOY increase; no set target but an indicator in the Office of Management and Budget scorecard.	Current Performance: 24% of total electricity and thermal energy is renewable.	REC purchases will be adjusted to meet new interim targets.

DOE Goal	Current Performance Status	Planned Actions & Contribution
Sustainable Buildings		
At least 15% (by count) of owned existing buildings to be compliant with the *revised* Guiding Principles for Sustainable Buildings by FY 2021, with annual progress thereafter.	Current Performance: 52%.	All new construction will meet the Guiding Principles.
Acquisition & Procurement		
Promote sustainable acquisition and procurement to the maximum extent practicable, ensuring BioPreferred and bio-based provisions and clauses are included in all applicable contracts.	Current Performance: 100% of eligible contracts contain the sustainable acquisition clause.	Continue sustainable acquisition.
Measures, Funding, & Training		
Site set annual targets for sustainability investment with appropriated funds and/or financed contracts for implementation.	PNNL partnered with Cascade Natural Gas to explore potential energy saving projects for funding under a Utility Energy Services Contract (UESC).	Implement approved energy saving projects under a UESC.
Electronic Stewardship		
End of Life: 100% of used electronics are reused or recycled using environmentally sound disposition options each year.	Current Performance: 100%.	Continue to reuse and recycle electronics.
Data Center Efficiency: Establish a power usage effectiveness target for new and existing data centers; discuss efforts to meet targets.	The normalized (weighted by information technology [IT] load) power usage effectiveness at PNNL is 1.30 for FY 2020	Continued server and storage improvements along with removal of older devices has garnered a 19% decrease in overall IT load.
Organizational Resilience		
Integration of climate resilience in emergency response, workforce, and operations procedures and protocols.	Currently conducting a pilot study to identify improvement opportunities in energy/water resilience using the Federal Energy Management Program Technical Resilience Navigator (TRN) tool.	Leverage the TRN pilot study to improve integration of energy/water resilience in emergency response, workforce, and operations procedures and protocols.

3.1.1 Reducing Energy Use

In March 2020, PNNL moved into curtailed operation to combat the COVID-19 pandemic and transitioned over 90 percent of PNNL's nearly 5,000 staff to telework status. Since then, facility operations have been modified to increase air flow to deliver maximum fresh air into applicable buildings, following guidance from the Centers for Disease Control and Prevention. However, reduced plug loads due to staff teleworking in FY 2020 enabled PNNL to achieve an overall reduction in energy intensity of approximately 5 percent compared to FY 2019 (172,864 British thermal units [Btu]/gross square foot [gsf] vs.165,500 Btu/gsf) and a reduction of 1 percent from the FY 2015 baseline (167,612 Btu/gsf). Figure 3.2 provides PNNL's actual electricity consumption from FY 2016 through FY 2020.

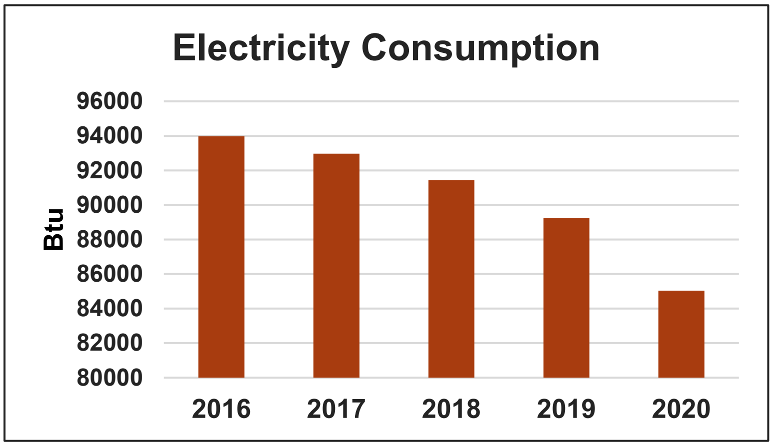


Figure 3.2. Electricity Consumption

3.1.2 Reducing Water Use Intensity

By the end of FY 2020, PNNL reduced its water intensity by 64.6 percent compared to the FY 2007 baseline (2,724 L/m^2 [66.85 gal/ft^2] vs. 963.2 L/m^2 [23.64 gal/ft^2]). Potable water usage in FY 2020 was 201 million L (53.1 million gal), an 8.9 percent year-over-year (YOY) usage reduction compared to the revised FY 2019 potable water usage 221 million L (58.3 million gal). This accomplishment was achieved primarily due to water conservation and efficiency efforts. Potable water usage from FY 2016 through FY 2020 is provided in Figure 3.3.

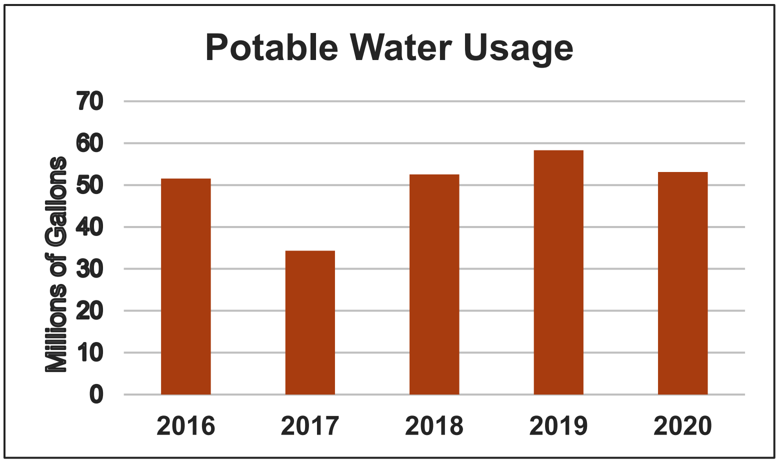


Figure 3.3. Potable Water Usage

3.1.3 Sustainable Buildings

Currently, 11 of 21 applicable PNNL buildings (517,841 gsf of a total 1,149,480 gsf) are compliant with the Guiding Principles (GPs) issued by the CEQ (2020). This is 52 percent by building count, or 45 percent by total square footage.

PNNL has committed making all new construction, major renovations, and building alterations greater than 10,000 gsf comply with the GPs. PNNL started construction on the Energy Sciences Center (ESC) project in early CY 2020. This facility will co-locate chemists, materials scientists, and computational scientists to advance catalysis and material syntheses for energy applications. The ESC building will be compliant with the 2016 GPs and will be equipped with controls and sensors enabling Smart Labs operations.

In addition, PNNL began designing the Grid Storage Launchpad (GSL) Facility, that will consolidate and enhance the grid energy storage research capabilities. This building will also be designed to meet 2016 GP requirements.

In FY 2021, PNNL will begin the development of a Laboratory-wide initiative that will result in net-zero emissions and energy-resilient operations (NZERO). Future PNNL facilities and infrastructure investments will be in accordance with NZERO objectives.

3.1.4 Solid Waste Management

In FY 2020, PNNL generated 302 tonnes (333 tons) of nonhazardous waste and diverted 365 tonnes (402 tons) (i.e., 55%) of nonhazardous sanitary waste by recycling and composting it. This success is attributed to innovative program communication and infrastructure/process improvements as highlighted in the following paragraphs.

Recycling at PNNL became easier with “single-stream recycling,” launched in late FY 2016. Prior to single-stream recycling, routine recyclables were separated into several different bins; the intention was to improve the recycling culture with zero-sort recycling.

A nitrile glove recycling program was initiated in FY 2015 to divert this high-volume, hard-to-recycle waste stream from laboratory spaces. More than 227 kg (500 lbs) of gloves were collected during FY 2020; the program was also expanded to include additional PNNL laboratory spaces, and shipping practices were expanded to improve the ability to support point-source generation of nitrile gloves for recycling.

Because of the pandemic, recycling pickup was suspended for approximately three months. However, despite the pandemic, PNNL remained committed to good recycling practices, and continued to facilitate single-stream recycling and nitrile glove recycling.

In FY 2020, PNNL conducted a Pollution Prevention (P2) program assessment of a pilot program to collect laboratory glassware for recycling. The assessment confirmed that the glass recycling program has been successful and identified opportunities for improvement that should allow the program to expand into new labs during FY 2021. The Sustainable Acquisitions Program was also evaluated in FY 2020; the assessment determined that sustainable acquisitions can be increased via better access to training and clear communication regarding program requirements for staff who purchase items.

Figure 3.4 presents PNNL’s solid waste diversion history since FY 2017 and projections for the next five years.

Figure 3.4. Municipal Solid Waste Diversion, 2017–2020, with Estimates through 2025

3.1.5 Construction Waste Management

PNNL has a wide variety of construction and demolition (C&D) work activities, from large construction projects to smaller activities. Reuse and recycling strategies are integrated with project planning, enabling continued success in C&D waste diversion. During FY 2020, PNNL generated 81.6 tonnes (90 tons) of construction and demolition wastes, diverting 70% (57.2 tonnes [63 tons]) through recycling or reuse. PNNL's construction waste diversion history since FY 2017 and projections for the next five years are provided in Figure 3.5.

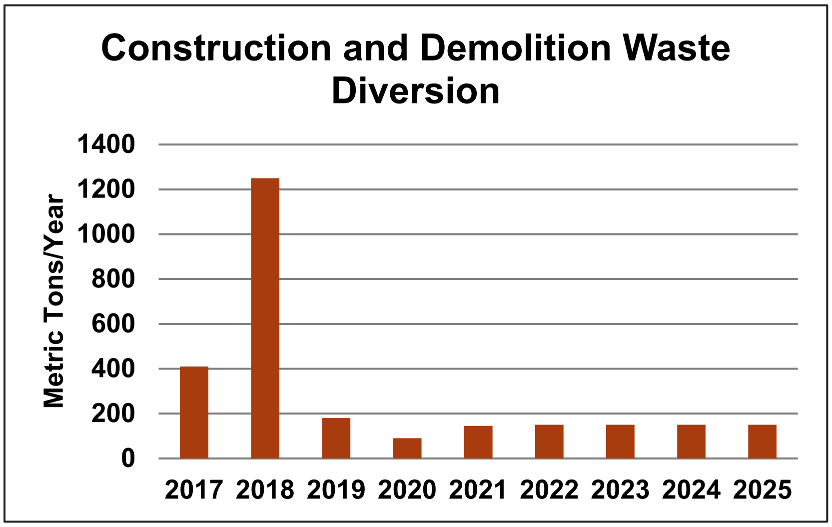


Figure 3.5. Diverted Construction and Demolition Waste, 2017–2020, with Estimates through 2025

3.1.6 DOE's 50001 Ready Cohort Initiative

In FY 2020, PNNL signed an agreement to support the DOE's 50001 Ready Cohort initiative, an ISO 50001-based energy management system. This system, when implemented fully, will improve PNNL's ability to continually identify, monitor, track, and improve energy conservation measures. PNNL is positioned to obtain the 50001 Ready recognition from DOE by the end of 2021 or early 2022.

3.1.7 Better Building Smart Labs Accelerator Partner

PNNL participates in DOE's Better Building Smart Labs Accelerator Partner Program. In FY 2019, PNNL developed a Smart Labs evaluation tool to help with consistent review and qualifying of buildings and laboratory spaces as "Smart Labs." Through 2020, PNNL has qualified one building and 40 laboratory spaces using the PNNL Smart Labs checklist. In FY 2021, PNNL plans to align the Smart Labs evaluation process with the EISA (*Energy Independence and Security Act*) commissioning/retro-commissioning requirements as a continuous improvement effort.

3.2 Site Resiliency

Site resilience planning is an iterative process at PNNL, and is revisited as external hazards and threats, site missions and priorities, and local systems and conditions change. During FY 2015, PNNL developed a *Climate Resilience Action Plan*, which examined climate-driven hazards and their potential to affect various PNNL systems, including human, natural, and infrastructure (PNNL 2015). DOE's Federal Energy Management Program (FEMP) Technical Resilience Navigator (TRN) provides a systematic approach to examining resilience needs and goals, assessing on-site energy and water systems, evaluating risk, identifying resilience gaps, and developing and prioritizing solutions to resolve those gaps.

In FY 2020, PNNL was selected by FEMP to pilot its TRN tool to determine the effectiveness of the methodologies and provide lessons learned/improvement opportunities. The TRN tool gives PNNL the opportunity to examine in greater detail, risk to PNNL operations from energy and water systems conditions, operations, procedures, and plans, identifying potential opportunities for improvements in PNNL's energy and water resilience. Upon completion, PNNL will share lessons learned with other DOE offices and sites to help others enhance resilience at their own facilities.

PNNL initiated the TRN planning process and assessment of baseline conditions in FY 2020 and will continue using them into FY 2021. Specific actions included the following:

1. Establish a resilience planning team and engaging stakeholders.
2. Collect and review existing policies and plans, such as the Climate Resilience Action Plan (PNNL 2015), that could affect or intersect with resilience planning efforts.
3. Define the scope of the resilience assessment and identify resilience priorities for the Richland Campus.
4. Identify critical functions with senior management.
5. Collect and review sources of information used to establish the site's critical loads and their energy and water requirements, as well as the baseline conditions of those systems.
6. Establish energy and water requirements for critical loads.
7. Establish baseline conditions of energy and water systems that enable critical loads.

In FY 2021, PNNL will use the baseline assessment to establish risk to critical missions from potential disruptions in critical energy and water utilities. PNNL will use that risk analysis to inform the development technological, operational, and institutional/policy solutions.

3.2.1 Risks to Mission, Operations, and People

The FY 2015 Climate Resilience Action Plan (PNNL 2015) established potential impacts from current and changing climate exposures on PNNL's core systems, considering the current levels of preparedness. Higher priority areas (Table 3.2) are the focus of PNNL's near-term climate resilience planning actions, and they represent a starting point for PNNL's FY 2021 TRN pilot resilience planning effort.

Table 3.2. Potential Climate Exposures and Impacts on Core Systems

Climate Exposure/Core System	High Temperatures	Intense Precipitation	Wildfire	Drought	Storms and Winds	Ice Storms
Buildings	Higher	Higher	Medium	Medium	Medium	Medium
Energy	Higher	Lower	Lower	Medium	Medium	Lower
IT Services	Medium	Medium	Lower	Lower	Medium	Lower
Worker, Safety, & Health	Lower	Lower	Medium	Lower	Lower	Lower
Water Resources & Infrastructure	Lower	Lower	Lower	Lower	Lower	Lower
Transportation	Lower	Lower	Lower	Lower	Lower	Lower

The two climate exposures of highest concern to PNNL's Richland Campus operations are the projected increase in the number of high-temperature days and the intense precipitation events that are experienced each year. Of particular concern is how these climate exposures could affect the Laboratory's building infrastructure and energy systems. For example, an increased number of high-temperature days in the decades ahead could raise costs and decrease reliability, as building exteriors and HVAC systems degrade at a faster rate, energy use increases as cooling systems work harder, and facility maintenance costs increase due to the added stress on systems. An increase in the number of intense precipitation events could lead to flood damage to roofs and damage to ground-level and below-grade facilities. A specific concern is the flood risk to a below-grade data center on the Richland campus.

PNNL's current measures to help strengthen resilience in the face of high-priority climate exposure are provided in Table 3.3. PNNL will identify additional potential solutions to enhance Richland Campus energy and water resilience as a part of the TRN pilot in FY 2021. The TRN pilot team meets regularly to discuss progress toward understanding the current campus resilience posture. The Sustainability Program team members responsible for resilience planning consult with internal subject matter experts, as warranted.

The Climate Resilience Action Plan (PNNL 2015) provides information about climate exposures and core system vulnerabilities rated medium or low priority.

Table 3.3. Measures to Address High-Priority Climate Exposure and Impacts on PNNL Systems

Managing High Temperature Impacts
Preventive maintenance plans are reviewed annually
Cool roofs are the design default
Use of light-colored materials for roofs and hard-paved areas is maximized
Building orientation and window glazing are optimized
Energy escalation rates will reflect risk in facility design and operations planning
Equipment life cycle cost is tracked. Premature equipment failures due to climate are reviewed during annual assessments
PNNL has the ability to reduce power load if needed through its building control system
Continuous commissioning and facility-tuning for *Energy Independence and Security Act* “covered facilities” are implemented
All space temperatures are monitored
Managing Intense Precipitation Impacts
Preventive maintenance procedures include cleaning roof drains
Preventive maintenance measures associated with building drainage are addressed
Five-year condition assessments will be conducted, including drainage system integrity
Preventive maintenance procedures include cleaning catch basins/storm drains

3.2.2 Emergency Response Procedures

PNNL has Emergency Management and Business Continuity Plans that address most hazards that could result from long-term climate variability and change. These plans use an all-hazards-based approach, including response processes that are flexible and adaptable to a multitude of scenarios, and are considered sufficient to address any threats and hazards. In addition, Emergency Preparedness hazards surveys are conducted on a triennial basis, covering a multitude of natural phenomena events (e.g., flood, wildfire, earthquake).

Changes in PNNL’s operating structure based on COVID-19 lessons learned are being leveraged in the TRN pilot and will inform planned updates to PNNL Emergency Management and Business Continuity Plans.

4.0 Environmental Radiological Protection Program and Dose Assessment

This section describes the environmental monitoring programs for radiological constituents and the associated estimated dose assessments for the PNNL Richland and Sequim Campuses. Reported doses are calculated rather than measured, so they represent potential or estimated, rather than actual, 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 and discharged to a treatment facility authorized or permitted to receive radiological material. Further evaluation is then performed to determine the source of the radiological component in the discharge.

The City of Richland may authorize the discharge of individual waste streams that contain radiological material to the sewer system. As described in Section 4.1.1, there is currently only one authorized discharge of a liquid waste stream 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 (4)(g)(8)(a)(7), which requires that the contractor prepare and provide a report that describes and summarizes discharges of liquids containing radionuclides from DOE activities into non-federally 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 (Physical Sciences Facility).

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 7.1×10^{-7} pCi/L.

In 2020, the fume hoods were washed down an estimated total of 39 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. 2021a, 2021b). CY 2020 data are summarized in the following sections.

4.2.1 Radiological Air Discharges and Doses – PNNL Richland Campus

Operations are registered with the state of Washington under RAEL–005. For CY 2020, the PNNL Richland Campus MEI location was 0.55 km (0.34 mi) south-southeast of the PSF 3410 Building. Table 4.1 lists the relative contributions of each nuclide to the MEI dose.

There were no nonroutine emissions from the PNNL Richland Campus in CY 2020. Emissions were determined from both sampling and, for non-sampled emissions, by the 40 CFR Part 61, Appendix D method. The CAP88-PC Version 4.0 code was used for estimating dose. The MEI dose of 1.7×10^{-5} mrem (1.7×10^{-7} mSv) effective dose[1] 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 2020, modeling was done to determine the location of the maximum off-site radioactive material air concentration. An effective dose of 2.1×10^{-5} mrem (2.1×10^{-7} mSv) was estimated for the maximum off-site radioactive material air concentration location at 0.72 km (0.45 mi) northwest (i.e., PNL-1 ambient air surveillance station) of the 3410 Building.

---

[1] 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.

Table 4.1. PNNL Richland Campus Emissions and Dose Contributions by Radionuclide, 2020 (Snyder et al. 2021a)

Radionuclide[a]	Releases (Ci)	Campus MEI Dose (mrem EDE)	Percent of Total EDE
Hydrogen-3 (tritium)	1.2×10^{-4}	1.1×10^{-8}	<1%
Aluminum-26	3.5×10^{-8}	3.7×10^{-7}	2%
Manganese-54	1.3×10^{-8}	8.0×10^{-9}	<1%
Cobalt-60	8.3×10^{-9}	2.0×10^{-8}	<1%
Zinc-65	1.4×10^{-8}	2.3×10^{-8}	<1%
Rubidium-83	1.4×10^{-6}	3.6×10^{-7}	2%
Strontium-85	2.8×10^{-8}	2.6×10^{-9}	<1%
Strontium-90	9.6×10^{-8}	1.9×10^{-7}	1%
Yttrium-88	1.6×10^{-8}	1.1×10^{-8}	<1%
Cadmium-109	3.8×10^{-8}	4.4×10^{-9}	<1%
Iodine-125	1.0×10^{-8}	3.1×10^{-8}	<1%
Xenon-133	6.1×10^{-5}	1.8×10^{-9}	<1%
Cesium-137[b]	1.1×10^{-6}	2.8×10^{-6}	17%
Lead-210	4.3×10^{-8}	8.7×10^{-7}	5%
Polonium-210	3.2×10^{-9}	5.1×10^{-8}	<1%
Radon-222	5.0×10^{-6}	1.3×10^{-8}	<1%
Radium-226[c]	8.7×10^{-9}	6.2×10^{-7}	4%
Uranium-232	1.3×10^{-10}	7.5×10^{-9}	<1%
Uranium-233/234	5.1×10^{-7}	5.7×10^{-6}	34%
Plutonium-238	9.3×10^{-9}	2.2×10^{-7}	1%
Plutonium-239/240[d]	1.3×10^{-7}	3.5×10^{-6}	21%
Americium-241	8.3×10^{-9}	7.6×10^{-7}	5%
Americium-243	4.8×10^{-10}	1.1×10^{-8}	<1%
Curium-243/244	1.1×10^{-9}	1.8×10^{-8}	<1%
All other nuclides	2.3×10^{-6}	8.5×10^{-9}	<1%
PIC-5 emissions – VRRM	NA	9.4×10^{-7}[e]	6%
PIC-5 emissions – NDRM	NA	6.6×10^{-8}[e]	<1%
PIC-5 emissions – Facilities Restoration[e]	NA	0	0%
PIC-5 emissions – SOIC[e]	NA	0	0%
Total[f]	1.9×10^{-4}	1.7×10^{-5}	100%

(a) Release information available in Snyder et al. (2021a).
(b) Gross beta from PSF emission unit sampling assumed to be Cs-137. Also, calculated Cs-137 release based on 40 CFR Part 61, Appendix D (1989) methods.
(c) Dose includes progeny isotope Rn-222.
(d) Gross alpha from PSF emission unit sampling assumed to be Pu-239. Also includes Pu-239 and Pu-240 based on 40 CFR Part 61, Appendix D (1989) methods.
(e) The PIC-5 emission doses are assigned based on permit value. The SOIC and Facilities Restoration emission sources were not implemented in 2020. The SOIC PIC-5 permit has been alternatively referred to as the Low-level Sources PIC-5 permit.
(f) Totals may not add up to value indicated due to rounding.
NA = not applicable.
NDRM = non-dispersible radioactive material
PIC-5 = Potential Impact Category
PSF = Physical Sciences Facility
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.

The regional collective dose from PNNL's Richland Campus air emissions in CY 2020 was also 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 432,700 people residing within an 80 km (50 mi) radius of the Hanford Site 300 Area (Hamilton and Snyder 2011), with one adjustment to add 640 residents in the sector that accounts for the two phases of apartment units constructed and occupied adjacent to the southern PNNL Richland Campus boundary. The close proximity of the Hanford Site 300 Area and relatively rural region within 80 km (50 mi) of the PNNL Richland Campus permits the Hanford Site 300 Area 80 km (50 mi) population estimate to be applicable. Pathways evaluated for population exposure include inhalation, air submersion, ground shine, and consumption of food. The CY 2020 total collective dose from radionuclide air emissions estimated from nuclides that originated from the PNNL Richland Campus was 9.0×10^{-5} person-rem (9.0×10^{-7} person-Sv).

4.2.2 Radiological Air Discharges and Doses – 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 2020, the PNNL Sequim Campus MEI location was 0.23 km (0.14 mi) west-northwest 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 1.3). Radiological operations at the PNNL Sequim Campus emit very low levels of radioactive materials. Table 4.2 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 2020 and 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 (Level 4) was used for estimating dose (EPA 1989).

Table 4.2. PNNL Sequim Campus Emissions and Dose Contributions, 2020 (Snyder et al. 2021b)

Radionuclide	Releases[a] (Ci)	Dose to MEI (mrem EDE)	Percent of Total EDE (Percent)
Gross Alpha (as Americium-241)	1.6×10^{-8}	3.3×10^{-5}	93
Gross Beta (as Cesium-137)	3.0×10^{-8}	2.4×10^{-6}	7
Total	4.6×10^{-8}	3.5×10^{-5}	100

(a) 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.

The dose to the PNNL Sequim Campus MEI was 3.5×10^{-5} mrem (3.5×10^{-7} 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 2020, 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 was 4.0×10^{-4} mrem (4.0×10^{-6} mSv) effective dose where no members of the public routinely inhabit the shore, at the boundary location 0.13 km (0.08 mi) east of the central PNNL Sequim Campus location.

Collective dose was determined for the estimated 2.35 million people who live within 80 km (50 mi) of the PNNL Sequim Campus; about 362,000 of them reside in Canada (Zuljevic et al. 2016). Victoria, British Columbia, is the only major Canadian city within 80 km (50 mi) of the PNNL Sequim Campus and is more than 32 km (20 mi) away. The maximum collective dose was determined assuming the total CY 2020 PNNL Sequim Campus curies released were dispersed in a single direction, resulting 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 3.9×10^{-5} person-rem (3.9×10^{-7} person-Sv). If the release were dispersed only to the maximum Canadian sector (north-northwest), the maximum estimated Canadian collective dose would be 1.6×10^{-5} person-rem (1.6×10^{-7} 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, Admin 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 appropriately 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) pre-approved surface contamination guidelines for releasing property potentially contaminated on the surface, and (2) pre-approved volumetric release limits for releasing 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 2020.

4.3.1 Property Potentially Contaminated on the Surface

PNNL uses the previously approved surface activity guideline limits (Table 4.3) 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 pre-approved surface activity guidelines was released from PNNL during CY 2020.

Table 4.3. Pre-Approved Surface Activity Guideline Limits

Radionuclides	Allowable Total Residual Surface Contamination Limits (dpm/100 cm^2)		
		Total	
	Removable	Average	Maximum
Uranium-natural, uranium-235, uranium-238, and associated decay products	1,000	5,000	15,000
Transuranic elements,[(a)] 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

(a) 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 pre-approved volumetric release limits when releasing small-volume research samples and wastewater potentially contaminated in volume (Table 4.4). 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 2020, PNNL released hundreds of liquid research samples with a total volume on the order of 58 L (15 gal), using the pre-approved release limits in Table 4.4. 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 4.4. Pre-Approved 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 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-STD-1153-2019, DOE Order 458.1 Admin Chg 4). 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 during the development of the PNNL Richland Campus data quality objectives (DQOs) in support of radiological emissions monitoring (Snyder et al. 2017). 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 amount 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 2020—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 4.5). The dose rates are based on the PNNL-reported total particulate radionuclide emissions for CY 2020 (Snyder et al. 2021a). Calculations are based on conservative assumptions that all the particulate radioactive material is concentrated into either 2,500 m^3 (8.8 x 10^4 ft^3) of contaminated water (equivalent to the volume of an Olympic swimming pool) or 50 m^2 (538 ft^2) of contaminated soil or sediment, with a soil density of 224 kg/m^2 (14 lbs/ft^2) to a depth of 15 cm (6 in.) (equivalent to a representative garden area) (Napier 2006). For comparison, an average of 3.34 x 10^3 m^3/s (1.18 x 10^5 ft^3/s) of Columbia River water flows below Priest Rapids Dam (USGS 2021) and past the PNNL Campus on a daily basis, and the PNNL Richland Campus occupies approximately 3.1 x 10^6 m^2 (3.34 x 10^7 ft^2) 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 from contaminated sediment. The dose coefficients were determined using RESRAD-BIOTA V1.8, Level 2 (available from Argonne National Laboratory). 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 4.5. Absorbed Biota Dose Rates for the PNNL Richland Campus, 2020

	Particulate Emissions[(a)] (Bq/yr)	Terrestrial Animal to Contaminated Soil[(b)] (mGy/d)	Terrestrial Plant to Contaminated Soil[(c)] (mGy/d)	Aquatic Animals to Contaminated Water[(d)] (mGy/d)	Riparian Animal to Contaminated Sediment[(e)] (mGy/d)
Totals	4.6 × 10^6	1.7 × 10^{-2}	2.0 × 10^{-3}	7.9 × 10^{-2}	1.1 × 10^{-2}

(a) Total particulate emissions determined from Snyder et al. (2021a).
(b) The terrestrial animal dose limit is 1 mGy/d; and may include deer, bee, earthworm, and rat. The contaminated soil area is 50 m^2 (538 ft^2) to a depth of 15 cm (6 in.) (Napier 2006).
(c) The terrestrial plant dose limit is 10 mGy/d; and may include pine tree and wild grass. The contaminated soil area is 50 m^2 (538 ft^2) to a depth of 15 cm (6 in.) (Napier 2006).
(d) The aquatic animal dose limit is 10 mGy/d; and may include crab, trout, and flatfish. The contaminated water volume is 2,500 m^3 (8.8 x 10^4 ft^3).
(e) The riparian animal dose limit is 1 mGy/d; and may include duck and frog. The contaminated sediment area is assumed for 50 m^2 (538 ft^2) to a depth of 15 cm (6 in.).
Conversion factors: 1 Ci = 3.7 × 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 is 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 2020—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 4.6). These conservative dose rates are well below dose rate limits, which are based on the PNNL-reported total particulate radionuclide emissions for CY 2020 (Snyder et al. 2021b). Conservative assumptions are that all the particulate radioactive material is concentrated into either 2,500 m^3 (8.8 x 10^4 ft^3) of contaminated water (equivalent to the volume of an Olympic swimming pool) or 50 m^2 (538 ft^2) of contaminated soil or sediment, with a soil density of 224 kg/m^2 (14 lbs/ft^2) 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 x 10^8 m^3 (4.66 x 10^9 ft^3) of seawater with continuous tidal flow past Travis Spit, and the PNNL Sequim Campus developed land occupies approximately 3 x 10^4 m^2 (3.2 x 10^5 ft^2) 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 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.

Table 4.6. Absorbed Biota Dose Rates for the PNNL Sequim Campus, 2020

	Particulate Emissions[(a)] (Bq/yr)	Terrestrial Animal to Contaminated Soil[(b)] (mGy/d)	Terrestrial Plant to Contaminated Soil[(c)] (mGy/d)	Aquatic Animals to Contaminated Water[(d)] (mGy/d)	Riparian Animal to Contaminated Sediment[(e)] (mGy/d)
Totals	1.7×10^3	1.6×10^{-4}	6.2×10^{-5}	6.4×10^{-3}	4.3×10^{-4}

(a) Total particulate emissions determined from Snyder et al. (2021b).
(b) The terrestrial animal dose limit is 1 mGy/d; and may include deer, bee, earthworm, and rat. The contaminated soil area is 50 m^2 (538 ft^2) to a depth of 15 cm (6 in.) (Napier 2006).
(c) The terrestrial plant dose limit is 10 mGy/d; and may include pine tree and wild grass. The contaminated soil area is 50 m^2 (538 ft^2) to a depth of 15 cm (6 in.) (Napier 2006).
(d) The aquatic animal dose limit is 10 mGy/d; and may include crab, trout, and flatfish. The contaminated water volume is 2,500 m^3 (8.8×10^4 ft^3).
(e) The riparian animal dose limit is 1 mGy/d; and may include duck and frog. The contaminated sediment area is assumed for 50 m^2 (538 ft^2) to a depth of 15 cm (6 in.).
Conversion factors: 1 Ci = 3.7×10^{10} Bq; 1 Gy = 100 rad

4.5 Unplanned Radiological Releases

No radiological releases to the environment exceeded permitted limits at the PNNL Richland Campus or PNNL Sequim Campus in 2020. There were no unplanned releases reported at either the PNNL Richland Campus or PNNL Sequim Campus in 2020 (Snyder et al. 2021a, 2021b), 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 2015). 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. The environmental radiological monitoring activities conducted by PNNL for both the PNNL Richland Campus and PNNL Sequim Campus are included in this report.

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 re-evaluated (Barnett et al. 2012b). In 2017, the PNNL Richland Campus boundary was expanded by 35 ha (85.6 ac) to the north, necessitating the particulate air-sampling network again be evaluated (Snyder et al. 2017). The current PNNL Richland Campus particulate air-sampling network consists of four campus samplers—PNL-1, PNL-2, PNL-3, and PNL-4—and one background sampler—PNL-5 (Figure 4.1)—and co-located ambient external dose monitors.

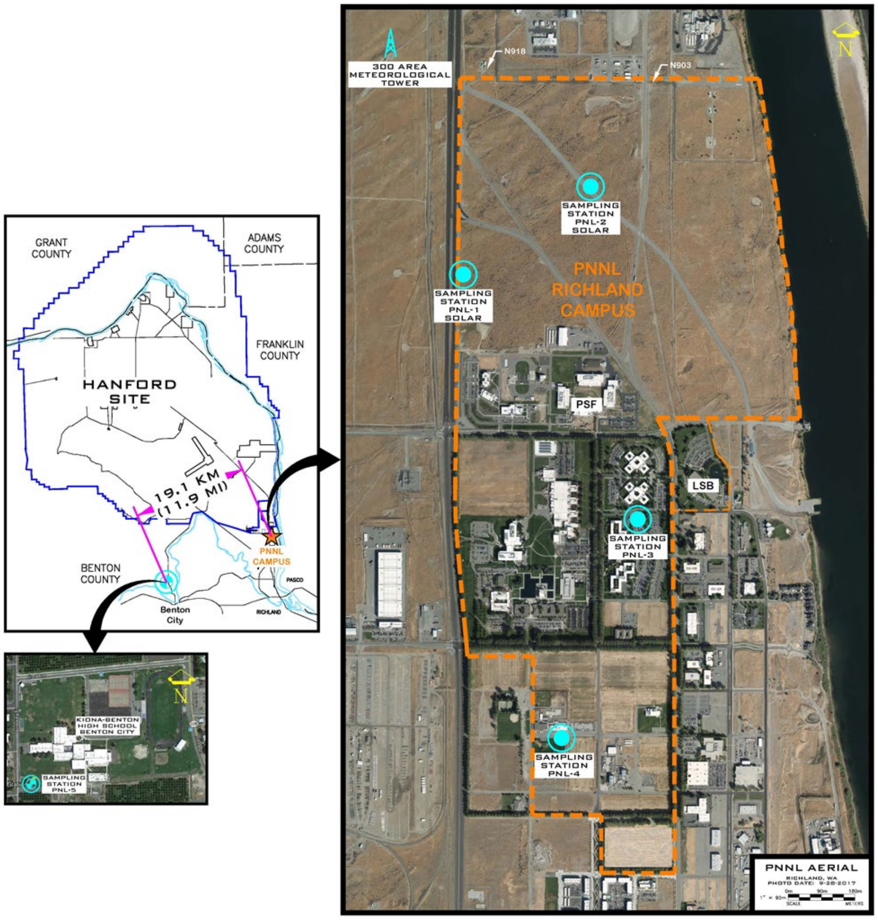


Figure 4.1. Air Surveillance Station Locations for the PNNL Richland Campus (based on Snyder et al. 2021a)

4.6.1.1 Environmental Air Surveillance – PNNL Richland Campus

During CY 2020, 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 gross beta activity. These gross analyses indicate potential unexpected increases in emissions. Semi-annually, filters are composited for specific radionuclide analysis. The required composite analyses include cobalt-60, uranium-233,[1] plutonium-238 and plutonium-239/240, americium-241 and americium-243, and curium-244.[2]

No PNNL activities resulted in increased ambient air concentrations at the air-sampling locations in CY 2020 (Table 4.7). The gross alpha and gross 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.

---

[1] 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.
[2] Only curium-244 is required, but it is reported as curium-243/244 because the curium-243 emission peak overlaps with curium-244.

Table 4.7. Summary of 2020 Air-Sampling Results for the PNNL Richland Campus (Snyder et al. 2021a)

Nuclide	Location(a)	No. of Samples Analyzed	No. of Detections	Value ± 2σ Error (pCi/m³)(b)
Gross alpha	PNL-1	26	25	$9.8 \times 10^{-4} \pm 2.5 \times 10^{-3}$
	PNL-2	26	20	$7.6 \times 10^{-4} \pm 2.1 \times 10^{-3}$
	PNL-3	26	24	$6.7 \times 10^{-4} \pm 1.8 \times 10^{-3}$
	PNL-4	26	22	$6.5 \times 10^{-4} \pm 1.7 \times 10^{-3}$
	PNL-5	25	22	$6.3 \times 10^{-4} \pm 1.5 \times 10^{-3}$
Gross beta	PNL-1	26	26	$1.6 \times 10^{-2} \pm 6.2 \times 10^{-3}$
	PNL-2	26	26	$1.5 \times 10^{-2} \pm 5.8 \times 10^{-3}$
	PNL-3	26	26	$1.5 \times 10^{-2} \pm 6.1 \times 10^{-3}$
	PNL-4	26	26	$1.4 \times 10^{-2} \pm 5.6 \times 10^{-3}$
	PNL-5	25	25	$1.3 \times 10^{-2} \pm 5.0 \times 10^{-3}$
Cobalt-60	PNL-1	2	0	$8.4 \times 10^{-6} \pm 1.1 \times 10^{-4}$
	PNL-2	2	0	$1.6 \times 10^{-5} \pm 1.1 \times 10^{-4}$
	PNL-3	2	0	$3.9 \times 10^{-5} \pm 1.1 \times 10^{-4}$
	PNL-4	2	0	$7.5 \times 10^{-6} \pm 1.0 \times 10^{-4}$
	PNL-5	2	0	$2.3 \times 10^{-5} \pm 1.0 \times 10^{-4}$
Cesium-137	PNL-1	2	0	$4.0 \times 10^{-6} \pm 1.1 \times 10^{-4}$
	PNL-2	2	0	$2.0 \times 10^{-5} \pm 8.9 \times 10^{-5}$
	PNL-3	2	0	$4.0 \times 10^{-5} \pm 9.8 \times 10^{-5}$
	PNL-4	2	0	$1.4 \times 10^{-5} \pm 8.6 \times 10^{-5}$
	PNL-5	2	0	$5.3 \times 10^{-6} \pm 1.0 \times 10^{-4}$
Uranium-233/234	PNL-1	2	1	$3.0 \times 10^{-5} \pm 3.2 \times 10^{-5}$
	PNL-2	2	2	$5.8 \times 10^{-5} \pm 3.2 \times 10^{-5}$
	PNL-3	2	2	$5.1 \times 10^{-5} \pm 2.8 \times 10^{-5}$
	PNL-4	2	2	$5.8 \times 10^{-5} \pm 3.0 \times 10^{-5}$
	PNL-5	2	2	$5.1 \times 10^{-5} \pm 3.2 \times 10^{-5}$
Plutonium-238	PNL-1	2	0	$3.2 \times 10^{-6} \pm 1.3 \times 10^{-5}$
	PNL-2	2	0	$3.8 \times 10^{-7} \pm 1.2 \times 10^{-5}$
	PNL-3	2	0	$2.8 \times 10^{-6} \pm 7.1 \times 10^{-6}$
	PNL-4	2	0	$4.5 \times 10^{-6} \pm 1.2 \times 10^{-5}$
	PNL-5	2	0	$4.8 \times 10^{-7} \pm 8.5 \times 10^{-6}$
Plutonium-239/240	PNL-1	2	0	$3.5 \times 10^{-7} \pm 1.0 \times 10^{-5}$
	PNL-2	2	0	$1.2 \times 10^{-6} \pm 1.1 \times 10^{-5}$
	PNL-3	2	0	$3.9 \times 10^{-7} \pm 6.5 \times 10^{-6}$
	PNL-4	2	0	$-3.0 \times 10^{-6} \pm 7.4 \times 10^{-6}$
	PNL-5	2	0	$-1.8 \times 10^{-6} \pm 7.3 \times 10^{-6}$
Americium-241	PNL-1	2	0	$-9.7 \times 10^{-7} \pm 2.5 \times 10^{-5}$
	PNL-2	2	0	$7.9 \times 10^{-6} \pm 2.1 \times 10^{-5}$
	PNL-3	2	0	$8.2 \times 10^{-6} \pm 1.9 \times 10^{-5}$
	PNL-4	2	0	$1.1 \times 10^{-5} \pm 2.2 \times 10^{-5}$
	PNL-5	2	0	$4.6 \times 10^{-6} \pm 1.2 \times 10^{-5}$
Americium-243	PNL-1	2	0	$1.1 \times 10^{-5} \pm 3.6 \times 10^{-5}$
	PNL-2	2	0	$1.8 \times 10^{-6} \pm 4.3 \times 10^{-5}$
	PNL-3	2	0	$3.6 \times 10^{-6} \pm 3.5 \times 10^{-5}$
	PNL-4	2	0	$-3.5 \times 10^{-6} \pm 2.7 \times 10^{-5}$
	PNL-5	2	0	$2.0 \times 10^{-5} \pm 2.9 \times 10^{-5}$
Curium-243/244	PNL-1	2	0	$-4.3 \times 10^{-6} \pm 1.8 \times 10^{-5}$
	PNL-2	2	0	$5.0 \times 10^{-6} \pm 1.7 \times 10^{-5}$
	PNL-3	2	0	$2.5 \times 10^{-6} \pm 2.1 \times 10^{-5}$
	PNL-4	2	0	$-3.4 \times 10^{-6} \pm 2.4 \times 10^{-5}$
	PNL-5	2	0	$6.6 \times 10^{-7} \pm 1.1 \times 10^{-5}$

(a) Refer to Figure 4.1 for PNL-1, PNL-2, PNL-3, PNL-4, and PNL-5 locations.
(b) The value is the average of samples collected throughout the year.
To convert pCi/m³ to Bq/m³, multiply pCi by 0.037.

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 2020. 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 has PNNL transported high external dose sources on campus roads in 2020.

Ambient external dose monitoring is done with aluminum oxide dosimeters read by optically stimulated luminescence, using the Landauer[1] InLight® System. The system has a 5 mrem (50 µSv) minimum detection level with one sigma uncertainty of 12% for each measurement period. In addition, two control dosimeters are used, one to measure exposure during field deployment/retrieval activities and the second to measure exposure during shipment to and from the vendor.

Optically stimulated luminescence dosimeter (OSLD) results for the 2020 monitoring periods are presented in Appendix C. After adjusting for control dosimeter results, daily and hourly reported results were determined to evaluate dose rates by the number of days monitored each quarter. Daily average dose rates and total 2020 annual background are provided in Figure 4.2. Hourly average dose rates are provided in Table 4.8. Background values at PNL-5 are not subtracted from the PNL-1 through PNL-4 values in the figure and table data.

CY 2020 annual dose rates at each campus monitoring location are less than the PNL-5 background (32 mrem/yr [320 µSv/yr] with normalized 91-day quarters), with the exception of PNL-3. The 2020 dosimeter results at all stations would be expected to have ranged from 27.8–35.4 mrem (278–354 µSv), based on PNL-5 background measurements. The PNL-3 annual result of 38.1 mrem (381 µSv) is outside of this range and is largely a consequence of an elevated third-quarter result. No third-quarter elevated Richland Campus releases to air or material transports in the vicinity of the air monitoring station are known. During this third quarter, significant wind and regional wildfire events resulted in an air quality index at unhealthy to hazardous levels. While all air monitoring stations would have been equally affected, it was a noteworthy event with airborne (particulate) impacts during this quarter. The PNL-3 result was elevated for the year relative to the PNL-5 background. No known PNNL Richland Campus cause was indicated, and PNL-3 annual dose remained within the range of previous regional average background levels from 2017–2019 (34–40 mrem [340–400 µSv]).

As a conservative measure, dose assigned as an "Other Pathway" to the MEI member of the public is based on the PNL-3 results. The value is a conservative assignment for two reasons. First, PNL-3 is an on-site location, whereas the MEI is off-site. PNL-3 is the sampling location closest to the air emissions MEI. Second, no PNNL Richland Campus sources were identified for this above-background elevated result from ambient external dose sampling. However, based on the PNL-3 result, the MEI is assigned an "Other Pathway" dose of 3 mrem/yr (30 µSv/yr), which is the dose beyond the 2020 maximum uncertainty value of background.

In addition to the boundary and background station ambient external dose monitoring discussed above, the PNNL Radiation Protection organization performs semi-annual 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 2020, survey results were at background levels in areas that could be occupied by the public.

[1] Landauer, 2 Science Rd, Glenwood, Illinois 60425-1586. Accessed at https://www.landauer.com.

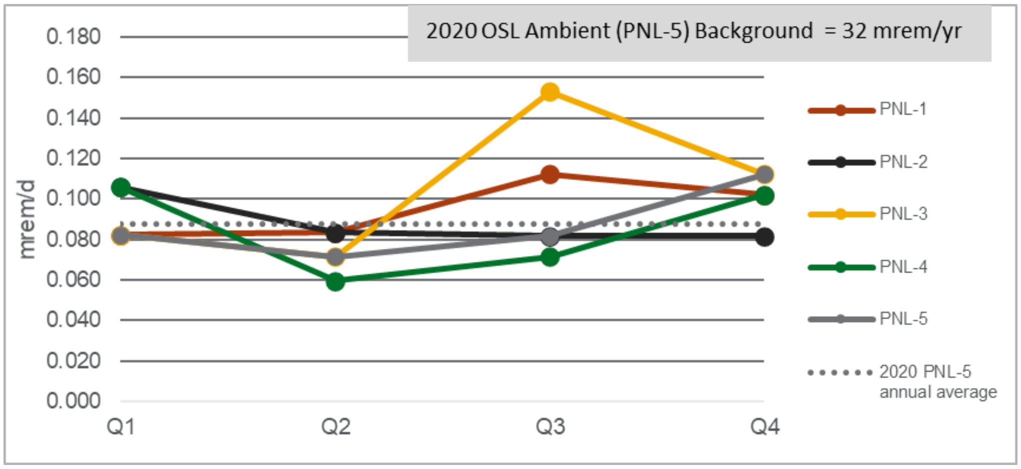


Figure 4.2. Average Daily Ambient External Dose Rates at Each PNNL Richland Campus Sampling Location for Each Calendar Quarter in 2020

Table 4.8. Average Hourly Ambient External Dose Rates at Each PNNL Richland Campus Sampling Location (µrem/hr)

2020 Quarter	PNL-1	PNL-2	PNL-3	PNL-4	PNL-5[(a)]
Q1	3.4	4.4	3.4	4.4	3.4
Q2	3.5	3.5	3.0	2.5	3.0
Q3	4.7	3.4	6.4	3.0	3.4
Q4	4.3	3.4	4.7	4.3	4.7
Average annual (µrem/hr)	4.0	3.7	4.4	3.5	3.6

(a) 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 mrem to mSv, multiply mrem by 0.01.

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-estimating assumptions are applied (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 µSv/yr]) (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 semi-annual external dose rate surveys at MSL-5 exterior door locations. For CY 2020, survey results were at background levels in areas that could be occupied by the public.

4.7 Public Dose Pathway 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 µSv/yr) in DOE Order 458.1, Section 4.b.1 (DOE 2020). Components of the total public dose can include contributions from the radiological air emissions pathway, which is limited to 10 mrem/yr (100 µSv/yr) under 40 CFR Part 61, Subpart H. Radiological liquid effluents for community water systems are limited to 4 mrem/yr (40 μSv/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 [e.g., native plant and wildlife] surveys, and farm product surveys [e.g., local milk, produce, and meat]; DOE 2015). The 100 mrem (1,000 μSv/yr) public dose limit is about one-third of the typical background exposure of 310 mrem/yr (3,100 μSv/yr) (NCRP 2009).

Prior to 2020, the only radiological public dose pathway was from the air pathway (i.e., resulting from permitted operations on the PNNL Richland Campus and the PNNL Sequim Campus). The PNNL Richland Campus ambient environmental dosimetry indicated a result in 2020 that was above background at the sampling station (i.e., PNL-3) nearest to the air emissions MEI. As a conservative measure, this above-background result was assigned as an "Other Pathway" for 2020. The radiological dose summary to the public by pathway and total is provided in Table 4.9.

Table 4.9. Radiological Dose Summary for PNNL Locations

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	1.7E-05	9.0E-05	3.5E-05	3.9E-05
Water Pathway	0	0	0	0
Other Pathway[(a)]	3	NA	NA	NA
Total Dose	**3**	**9.0E-05**	**3.5E-05**	**3.9E-05**
All-Pathways Dose Limit	100	NA	100	NA
Natural Background Radiation	310	1.3E+05	310	7.3E+05

(a) Direct external exposure based on maximum ambient environmental dose result.

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, 2018. The renewal resulted in a single PNNL Sequim Campus sitewide minor, fugitive, nonpoint source emission unit, thereby eliminating specific building emission units and reducing the permit complexity. A re-evaluation 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 or monitoring or ambient surveillance, the revised DQO recommended baseline radioactive air background surveillance be performed because no baseline radioactive air background data are currently 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 gross beta in air were recommended. RAEL-014, Renewal 1 further recommended 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 (Snyder et al. 2019). Implementation planning at the PNNL Sequim Campus is ongoing but has suffered delays due to the onset of and ongoing COVID-19 pandemic.

5.0 Environmental Nonradiological Program Information

The Effluent, Waste, and Transportation Programs Group 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 water permits.

The Effluent, Waste, and Transportation Programs Group 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* (Ballinger and Beus 2016). The ALARA principle is applied to effluent activities to minimize the 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. All waste streams regulated by these permits are reviewed by PNNL staff and evaluated relative to compliance with the applicable permit prior to their discharge. Sampling and monitoring of these waste streams are done in accordance with the permits, and the results are reported as required to the City of Richland.

Process wastewater from the PNNL Sequim Campus is discharged to an on-site wastewater 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 2020 are listed in Table 5.1. One grab sample was taken each month from Outfall 008 and analyzed for the parameters identified in Table 5.1. All parameters met the NPDES permit effluent limitations. There were no regulated discharges from Outfall 007 during this time period.

Table 5.1. PNNL Sequim Campus 2020 NPDES Monitoring Results for Outfall 008[a]

Parameter	Total Samples	Quantity Found Below Method Reporting Limit	Method Reporting Limit[b]	Maximum Value
Maximum flow (gpd)	NA	NA	NA	31,100
Chlorine, total residual (µg/L)	12	12	50	<50
Antimony (µg/L)	2	2	0.5	<0.5
Arsenic (µg/L)	2	2	5	<5
Beryllium (µg/L)	2	2	0.2	<0.2
Cadmium (µg/L)	2	0	0.2	0.28
Chromium (µg/L)	2	2	2	<2
Copper (µg/L)	12	1	1.0	51.3
Lead (µg/L)	12	3	0.2	2.04
Mercury (µg/L)	2	2	0.2	<0.2
Nickel (µg/L)	2	0	2	8.0
Selenium (µg/L)	2	2	10	<10
Silver (µg/L)	2	1	0.2	0.26
Thallium (µg/L)	2	1	0.2	0.61
Zinc (µg/L)	12	4	20	65
pH[c]	12	NA	NA	7.6

(a) There were no regulated discharges from Outfall 007 during this time period.
(b) The highest Method Reporting Limit reported for all months is listed.
(c) pH limits of 6–9 standard units are specified in the current permit.
gpd = gallons per day
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 GHGs (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 adhering to 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

Prior to April 1, 2020, groundwater under the PNNL Richland Campus was monitored routinely through seven groundwater monitoring wells. Monitoring of the groundwater under the PNNL Richland Campus was initiated under the direction of the Washington State Department of Ecology through temporary State Waste Discharge Permit ST-9274 for the BSF/CSF ground-source heat pump. The BSF/CSF uses a novel technology for heating and cooling the buildings that relies on a ground-source heat pump. Water is pumped from four extraction wells, passed through a non-contact heat exchanger, and returned to the aquifer through four underground injection control (UIC) wells. The Washington State Department of Ecology required registration of the UIC wells, which was completed in 2010. In February 2011, the Washington State Department of Ecology issued a water right for the nonconsumptive use of groundwater for the ground-source heat pump, allowing the withdrawal and use of groundwater by the four extraction wells at flow rates up to 7,200 L/min (1,900 gpm) and requiring injection of the water back to the aquifer.

Because the water is re-injected back into the ground, the Washington State Department of Ecology issued temporary State Waste Discharge Permit ST-9274 to have the groundwater monitored for temperature changes and potential influence on pollutants from underground contamination plumes. After nine years of monitoring for temperature and contaminants in groundwater, the Washington State Department of Ecology determined that the Class V UIC wells associated with the BSF/CSF ground-source heat pump met the nonendangerment standard as defined in WAC 173-218-080. Class V UIC wells that meet the nonendangerment standard are considered rule authorized to operate, eliminating the requirement for a State Waste Discharge Permit (WAC 173-218-100). This determination was supported by the report, *Heat Transport from the PNNL BSF/CSF Ground Source Heat Pump System* (Yabusaki et al. 2019), which documented that groundwater temperature at the injection wells was significantly attenuated in the flow path to within 1.5°C (2.7°F) of ambient groundwater temperatures as it approached the Columbia River. The temperature at the monitoring well closest to the Columbia River has reached steady state and the groundwater from the ground-source heat pump system entering the Columbia River would be expected to have negligible impact from the thermal plume. The Washington State Department of Ecology cancelled Permit ST-9274 on April 1, 2020.

This page intentionally left blank

7.0 Quality Assurance

The PNNL Quality Assurance (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 PNNL staff.

7.1 Environmental Monitoring Program

Environmental sampling and monitoring activities 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 Effluent, Waste, and Transportation Programs Group (formerly, the Effluent Management [EM] Group) or its delegates under the *Pacific Northwest National Laboratory Effluent Management Quality Assurance Plan*, EM-QA-01 (Ballinger and Beus 2016). The EM Quality Assurance Plan (QAP) has been developed to demonstrate how the Effluent, Waste, and Transportation Programs Group is meeting QA requirements specified in environmental regulations and permits; assist EM staff in identifying applicable requirements and procedures (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 7.1.

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.

Table 7.1. PNNL Effluent Management Quality Assurance Requirements Documents

Document Title
Effluent Management Quality Assurance Plan (EM-QA-01)
Quality Requirements for Air Chemical Emissions Management
Quality Requirements for Biological Sciences Facility/Computational Sciences Facility (BSF/CSF) Ground Source Heat Pump Monitoring to State Waste Discharge Permit ST-9274
Quality Requirements for Facility Effluent Management Planning
Quality Requirements for Industrial Wastewater Discharge Permit Sampling and Monitoring for the PNNL Campus (CR-IU001), Environmental Molecular Sciences Laboratory (CR-IU005), and Physical Sciences Facility (CR-IU011)
Quality Requirements for Marine Sciences Laboratory Monitoring to National Pollutant Discharge Elimination System Permit WA 0040649
Quality Requirements for Radionuclide Air Emissions Sampling and Monitoring
Quality Requirements for Radionuclide Air Environmental Surveillance Monitoring

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.

Radiological environmental air monitoring activities were determined using the DQO (Data Quality Objective) 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) determined and documented the environmental sampling and monitoring requirements necessary to comply with applicable regulations at PNNL's Richland Campus. As determined in the DQO process for the Richland Campus, PNNL has established an environmental surveillance program that samples particulate radionuclides in ambient air at strategic locations. The Environmental Radiological Air Monitoring Plan (EMP) (Snyder et al. 2020) with its attachments—the *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 *National Emissions Standards for Hazardous Air Pollutants* (NESHAP) (40 CFR Part 61, Subpart H and WAC 246-247), "Radiation Protection – Air Emissions," WAC 173-480 "Ambient Air Quality Standards and Emission Limits For Radionuclides," and Facility Use Agreements. Radiological air emissions are monitored by several different means, including the analysis of air filters, calculations of potential releases 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, because 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 1) became effective on January 1, 2018, and is renewed every five 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. 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.

Water and 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 and by the Washington State Department of Ecology for discharges to the ground. At the PNNL Sequim Campus, water and wastewater sampling and monitoring are performed to comply with NPDES (National Pollutant Discharge Elimination System) and Group A Drinking Water permits. QA requirements for these activities have been integrated into the EM QAP (Ballinger and Beus 2016) and related QA documents (see Table 7.1), and include specific requirements such as sampling locations, quality objective criteria, analytical methods, and detection limits.

Chemical air emission monitoring is performed by complying with PNNL's air permits. Permits for nonradiological air emissions are issued by the BCAA (Benton Clean Air Agency) for the PNNL Richland Campus and the ORCAA (Olympic Region Clean Air Agency) for the PNNL Sequim Campus. Applicable regulatory statutes include the *Clean Air Act* and NEPA. PNNL limits its chemical air emissions primarily by limiting the hours of operation, using ultra-low 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 Operation activity that has the potential for generating 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, WAC, EPA, 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 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 Effluent, Waste, and Transportation Programs Group. 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 7.2. For cases where identified quality issues result in invalid data, the issues are documented, and corrective actions are taken.

Table 7.2. Quality Control Terms

Quality Control 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 did 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 2020:

- Radiological air emission filter samples were analyzed by PNNL's Analytical Support Operations (ASO) laboratory in the Radiochemical Processing Laboratory (RPL).
- 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
  - ALS Environmental, Kelso, Washington;
  - Benton-Franklin Health District Laboratory, Kennewick, Washington;
  - an in-house PNNL Sequim Campus accredited laboratory; and
  - Spectra Laboratories, Port Orchard, Washington.

Information about each laboratory is summarized below:

- The ASO laboratory analyzed all airborne filter samples for radioactivity according to the criteria in their statements of work and contracts. The 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. The QC sample results indicated that the sample batches had no measurable contamination from sample preparation activities. 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 ambient air filters for radioactivity according to the criteria in their contracted 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 for Environmental Laboratories (DoD and DOE 2019).

- ALS Environmental, the Benton-Franklin Health District Laboratory, Spectra Laboratories, and an in-house laboratory on the PNNL Sequim Campus analyzed all water and wastewater samples from the PNNL Richland and Sequim Campuses during 2020. 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 be periodically inspected 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 lab is either accredited or currently listed on PNNL's Evaluated Supplier List. ALS Environmental and the in-house laboratory on the PNNL Sequim Campus are also accredited by the National Environmental Laboratory Accreditation Conference Institute (TNI), 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 *Clean Water Act* or *Safe Drinking Water Act* 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 Inter-Laboratory Performance Programs

The bi-annual 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 filter, 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 2020, MAPEP studies 42 and 43 were issued to participating laboratories; results are as follows:

- GEL participated in both MAPEP 42 and 43 performance evaluation studies as well as Multi-Media Radiochemistry Proficiency Testing (MRAD) studies 32 and 33 in 2020. MRAD is provided by ERA-Waters Corporation, which is also accredited to ISO 9001:2015 and ISO/IEC 17025:2017. For the MAPEP studies, radiological filter results for gross alpha and beta samples were acceptable for all studies; select gamma and alpha spectroscopy results were acceptable as well, for methods used to analyze and report PNNL radiological filter samples. For the MRAD studies, radiological filter results for gross alpha, beta, gamma, and select alpha spectroscopy samples were acceptable. For MRAD-32, GEL reported U-238 and U-Total (Mass) by two methods; the HASL 300 Method U-02 (28th Ed 1997) was deemed acceptable, but the ASTM C1345-08 (Mod 2008) method was not acceptable. GEL uses the HASL 300 Method U-02 to analyze and report PNNL radiological air filters, so this is a non-issue for radiological air monitoring for PNNL. The DOE Consolidated Audit Program (DOECAP) Accreditation Body contractual auditing organization A2LA (American Association for Laboratory Accreditation) performed the analyte performance assessment per the requirements of the DOECAP for 2019. GEL maintained laboratory accreditation, which provides added confidence in the data reported by the laboratory. The latest certification, Certificate Number 2567.01, was authorized in July 2019, and expires on June 30, 2021. GEL also maintained TNI National Environmental Laboratory Accreditation Program (NELAP) 2009 accreditation for 2020 with the state of Washington (Certificate Number: C780-20a, which expires November 25, 2021).
- In 2020, the ASO RPL at PNNL participated in MAPEP 42 and 43 testing studies. As mentioned in last year's ASER, strontium was not reported for MAPEP-19-RdF41; however, it was analyzed and reported for MAPEP-20-Rd42 with an acceptable result. Strontium-90 was the only constituent RPL reported for MAPEP-42 radiological filter analysis. Results for the other radiological filter constituents were not reported, but all of the constituents not reported were all acceptable for the previous two studies (MAPEP-40 and MAPEP-41) in 2019. All of the constituents were reported for MAPEP-43 radiological filter analysis with the exception of Co-57 and Sr-90. Co-57 was not reported

due to a false positive result. Sr-90 was not reported due to quality control issues. Both issues were documented in internal discrepancy reports. Co-57 and Sr-90 were analyzed and submitted for MAPEP-44 on April 28, 2021, and the laboratory received acceptable results for both constituents. In addition to participating in performance testing, it should be noted that on a periodic basis, the ASO laboratory is audited relative to the requirements of the Hanford Analytical Services Quality Assurance Requirements Document (HASQARD), DOE/RL-96-68, so that it can remain on the Hanford Evaluated Suppliers List.

The requirements for inter-laboratory performance do not apply to dosimetry.

Participation in inter-laboratory performance programs for the analysis of water and wastewater samples is not required pursuant to permits issued under the *Safe Drinking Water Act* or the *Clean Water Act*. PNNL considers the following standards in their 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, an in-house laboratory on the PNNL Sequim Campus, and Spectra Laboratories (Port Orchard, 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 as a testing laboratory through July 8, 2021, at which time the scope of their accreditation will be re-evaluated. ALS was also accredited by Perry Johnson Laboratory Accreditation, Inc., as being certified to the ISO/IEC 17025:2017 standard, the U.S. DoD Environmental Laboratory Accreditation Program for ISO/IEC 17025:2017, and the DoD Quality Systems Manual Version 5.3 on July 10, 2020; this accreditation expires on June 10, 2022. Spectra Labs and the Benton-Franklin Health District Laboratory are also accredited by the Washington State Department of Ecology to WAC 173-50 ("Accreditation of Environmental Laboratories") and WAC 246-290 ("Group A Public Water Supplies") criteria. These accreditations are renewed annually; Spectra Labs accreditation expires October 23, 2021 and the Benton-Franklin Health District accreditation expires August 23, 2021. The in-house laboratory on the PNNL Sequim Campus is nationally accredited by the New Jersey Department of Environmental Protection to perform certain analytical methods with TNI requirements until June 30, 2021, and with guidance from EPA QA/R-5, *EPA Quality Requirements for Quality Assurance Project Plans* (EPA 2001). The PNNL Sequim Campus maintained its accreditation with Washington State Department of Ecology, which is applicable until October 23, 2021. Implementation of the policies and requirements are specified in the *PNNL Marine Sciences Laboratory Quality Assurance Management Plan* (PNNL 2016), and detailed methodologies and practices are further defined in project standard operating procedures and project management documents.

7.5 Data Management and Calculations

Quality assurance 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 2020, the processes for managing data and calculations were followed.

This page intentionally left blank

8.0 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. "Designation, Reportable Quantities, and Notification." *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.

36 FR 8921. May 15, 1971. Executive Order 11593 of May 13, 1971: "Protection and Enhancement of the Cultural Environment." *Federal Register*, Office of the President, 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 the Bull Trout." Final Rule, *Federal Register*, Fish and Wildlife Service, Washington, DC.

79 FR 68041. 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.

80 FR 15871. March 25, 2015. Executive Order 13693 of March 19, 2015: "Planning for Federal Sustainability in the Next Decade." *Federal Register*, Office of the President, Washington, DC.

81 FR 87246. December 2, 2016. "Endangered and Threatened Wildlife and Plants; Review of Native Species that are Candidates for Listing as Endangered or Threatened; Annual Notification of Findings on Resubmitted Petitions; Annual Description of Progress on Listing Actions." *Federal Register*, Fish and Wildlife 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.

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.

Alaska State Anadromous Fish Act. Alaska Statute 16.05.871, "Protection of Fish and Game."

Alaska Statute 38.05.005. Title 38, *Public Land*, Chapter 38.05, "Alaska Land Act," Section 38.05.005, *Division of Lands*.

American Fisheries Act of 1998. Public Law 105–277; 16 U.S.C. 1851 note.

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 July 6, 2021, 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 July 6, 2021, at https://www.fws.gov/birds/policies-and-regulations/laws-legislations/bald-and-golden-eagle-protection-act.php.

Ballinger MY and CP Beus. 2016. *Pacific Northwest National Laboratory Effluent Management Quality Assurance Plan*. EM-QA-01, Revision 10, U.S. Department of Energy, Richland, WA.

Barnett JM. 2018. *Pacific Northwest National Laboratory Potential Impact Categories for Radiological Air Emission Monitoring*. PNNL-19904, Revision 5, Richland, WA. Accessed July 6, 2021, at https://www.pnnl.gov/main/publications/external/technical_reports/PNNL-19904Rev.5.pdf.

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 July 6, 2021, at 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 July 6, 2021, at 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). 2020. "Regulation 1 of the Benton Clean Air Agency." Kennewick, WA. Accessed July 2, 2021, at http://bentoncleanair.org/about-us/regulation-i.

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

Cannon A. 1991. *The Economic Prehistory of Namu*. Archaeology Press, Simon Fraser University, Burnaby, BC.

CEQ (Council on Environmental Quality). 2020. *Guiding Principles for Sustainable Federal Buildings and Associated Instructions*. Washington, DC. Accessed May 27, 2021, at https://www.sustainability.gov/pdfs/guiding_principles_for_sustainable_federal_buildings.pdf.

Clallam County. 2017. "Shoreline Master Program (SMP) Maps, Exhibit A: Draft Clallam County Shoreline Environmental Designation Maps, 03 Sequim Bay North, Gibson & Travis Spit Vicinity." Accessed July 6, 2021, at http://www.clallam.net/LandUse/SEDmaps_Jun2017.html.

Clean Air Act. Public Law 88-206, as amended, 42 U.S.C. § 7401 *et seq*. Accessed July 6, 2021, 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 July 6, 2021, 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 July 6, 2021, at http://www2.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.

Columbia River Gorge National Scenic Area Act. Public Law 99-663, as amended, 16 U.S.C. § 544 *et seq*.

Comprehensive Environmental Response, Compensation, and Liability Act of 1980 (CERCLA). Public Law 96-510, as amended, 42 U.S.C. § 9601 *et seq*. Accessed July 6, 2021, at https://www.gpo.gov/fdsys/pkg/USCODE-2015-title42/pdf/USCODE-2015-title42-chap103.pdf.

CRGC and USFS (Columbia River Gorge Commission and U.S. Forest Service). 2016. *Management Plan for the Columbia River Gorge National Scenic Area*. White Salmon, WA. Accessed July 6, 2021, at http://www.gorgecommission.org/images/uploads/amendments/Management_Plan_(as_revised_through_2016).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). 2019. *DoD/DOE Consolidated Quality Systems Manual for Environmental Laboratories*. DoD Quality Systems Manual Version 5.1 and DOE Quality Systems for Analytical Services Version 3.1, Washington, DC. Accessed July 6, 2021, at https://denix.osd.mil/edqw/documents/manuals/qsm-version-5-3-final/.

DOE (U.S. Department of Energy). 2015. *Environmental Radiological Effluent Monitoring and Environmental Surveillance*. DOE-HDBK-1216-2015, U.S. Department of Energy, Washington, DC. Accessed July 6, 2021, at https://www.standards.doe.gov/standards-documents/1200/1216-bhdbk-2015/@@images/file.

DOE (U.S. Department of Energy). 2021. "Met and Climate Data Summary Products." Richland, WA. Accessed June 24, 2021, at http://www.hanford.gov/page.cfm/MetandClimateDataSummary.

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 July 6, 2021, 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 July 6, 2021, at https://www.directives.doe.gov/directives-documents/200-series/0231.1-BOrder-b-admchg1/@@download/file.

DOE Order 232.2A. 2017. *Occurrence Reporting and Processing of Operations Information*. U.S. Department of Energy, Washington, DC. Accessed July 6, 2021, at https://www.directives.doe.gov/directives-documents/200-series/0232.2-BOrder-A.

DOE Order 414.1D Admin Chg 1. 2013. *Quality Assurance*. U.S. Department of Energy, Washington, DC. Accessed July 6, 2021, at https://www.directives.doe.gov/directives-documents/400-series/0414.1-BOrder-d-admchg1.

DOE Order 435.1. 1999. *Radioactive Waste Management*. U.S. Department of Energy, Washington, DC. Accessed July 6, 2021, at https://www.directives.doe.gov/directives-documents/400-series/0435.1-BOrder.

DOE Order 435.1, Chg 1. 2001. *Radioactive Waste Management.* U.S. Department of Energy, Washington, DC. Accessed July 6, 2021, at https://www.directives.doe.gov/directives-documents/400-series/0435.1-BOrder-chg1.

DOE Order 436.1. 2011. *Departmental Sustainability*. U.S. Department of Energy, Washington, DC. Accessed July 6, 2021, at https://www.directives.doe.gov/directives/0436.1-BOrder/view.

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 July 6, 2021, at https://www.directives.doe.gov/directives-documents/400-series/0440.1-BOrder-b.

DOE Order 458.1. 2011. *Radiation Protection of the Public and the Environment.* U.S. Department of Energy, Office of Health, Safety and Security, Washington, DC. Accessed June 16, 2021, at https://www.directives.doe.gov/directives-documents/400-series/0458.1-BOrder.

DOE Order 458.1 Admin Chg 3. 2013. *Radiation Protection of the Public and the Environment.* U.S. Department of Energy, Office of Health, Safety and Security, Washington, DC. Accessed June 16, 2021, at https://www.directives.doe.gov/directives-documents/400-series/0458-1-border-admc3.

DOE Order 458.1 Admin Chg 4 (LtdChg). 2020. *Radiation Protection of the Public and the Environment.* U.S. Department of Energy, Office of Health, Safety and Security, Washington, DC. Accessed June 16, 2021, at https://www.directives.doe.gov/directives-documents/400-series/0458.1-border-chg4-ltdchg.

DOE Order 5820.2A. 1988. *Radioactive Waste Management.* U.S. Department of Energy, Washington, DC. Accessed July 6, 2021, at https://www.directives.doe.gov/directives-documents/5800-series/5820.2-BOrder-a.

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). 2015. *Pacific Northwest Site Office Cultural and Biological Resources Management Plan*. PNSO-PLAN-09, Richland, WA.

DOE-PNSO (U.S. Department of Energy Pacific Northwest Site Office). 2020. *Pacific Northwest National Laboratory Sequim Campus Future Development*. DOE/EA-2130, Draft Environmental Assessment, Richland, WA. Accessed July 6, 2021, at https://www.energy.gov/sites/prod/files/2020/04/f73/draft-ea-2130-pnnl-sequim-campus-2020-04.pdf.

DOE-PNSO (U.S. Department of Energy Pacific Northwest Site Office). 2021. "DOE-Battelle Prime Contract for the Management and Operation of Pacific Northwest National Laboratory, DE-AC05-76RL01830." Richland, WA. Accessed July 6, 2021, at http://doeprimecontract.pnnl.gov/.

DOE Policy 141.1. 2001. "Department of Energy Management of Cultural Resources." U.S. Department of Energy, Washington, DC. Accessed July 6, 2021, 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 July 6, 2021, at https://pdw.hanford.gov/arpir/index.cfm/viewDoc?accession=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). 2020a. *Calendar Year 2019 Hanford Site Mixed Waste Land Disposal Restrictions Full Report*. DOE/RL-2020-09, Revision 0, Richland, WA.

DOE-RL (U.S. Department of Energy Richland Operations Office). 2020b. *Hanford Site Groundwater Monitoring Report for 2019*. DOE/RL-2019-66, Revision 0, Richland, WA. Accessed June 30, 2021, at https://www.hanford.gov/files.cfm/DOE-RL-2019-66_R0_Clean.pdf.

DOE-RL (U.S. Department of Energy Richland Operations Office). 2021a. *2020 Hanford Site Polychlorinated Biphenyl Annual Document Log.* DOE/RL-2021-19, Revision 0, Richland, WA. Accessed July 6, 2021, at https://pdw.hanford.gov/document/AR-02509.

DOE-RL (U.S. Department of Energy Richland Operations Office). 2021b. *2020 Hanford Site Polychlorinated Biphenyl Annual Report*. DOE/RL-2021-18, Revision 0, Richland, WA. Accessed July 6, 2021, at https://pdw.hanford.gov/document/AR-02509.

DOE-RL (U.S. Department of Energy Richland Operations Office). 2021c. *Hanford Site RCRA Groundwater Monitoring Report for 2020*. DOE/RL-2020-59, Revision 0, Richland, WA. Accessed June 30, 2021, at https://www.hanford.gov/files.cfm/DOE-RL-2020-59-Rev_00.pdf.

DOE-STD-1153-2019. 2019. *A Graded Approach for Evaluating Radiation Doses to Aquatic and Terrestrial Biota*. U.S. Department of Energy, Washington, DC. Accessed June 17, 2021, at https://www.standards.doe.gov/standards-documents/1100/1153-astd-2019/@@images/file.

DOI (U.S. Department of the Interior). 2017. Memorandum to the Assistant Secretary for Fish and Wildlife and Parks, dated December 22, 2017, regarding "The Migratory Bird Act Does Not Prohibit Incidental Take." Solicitor's Opinion M-37050, DOI Office of the Solicitor, Washington, DC. Accessed July 6, 2021, at https://www.doi.gov/sites/doi.gov/files/uploads/m-37050.pdf.

DOI (U.S. Department of the Interior). 2018. Memorandum from Assistant Director, Migratory Birds, to Region Directors, dated June 14, 2018, regarding "Destruction and Relocation of Migratory Bird Nest Contents." Washington, DC.

Duncan JP, ed. 2007. *Hanford Site National Environmental Policy Act (NEPA) Characterization*. PNL-6415, Revision 18. Pacific Northwest National Laboratory, Richland, WA. Accessed July 6, 2021, at http://www.pnnl.gov/main/publications/external/technical_reports/PNNL-6415Rev18.pdf.

Duncan JP, MR Sackschewsky, JM Becker, JM Barnett, TW Moon, JA Stephens, MD Ellefson, LY Renaud, RA Del Mar, EA Raney, SA Adams, KD Hand, LE Bisping, and CJ Duchsherer. 2020. *Pacific Northwest National Laboratory Annual Site Environmental Report for Calendar Year 2019*. PNNL-30262, Pacific Northwest National Laboratory, Richland, WA. Accessed May 24, 2021, at https://www.pnnl.gov/pnnl-annual-site-environmental-report.

Ecology (Washington State Department of Ecology). 2021. "Shoreline Master Programs." Olympia, WA. Accessed July 2, 2021, at https://ecology.wa.gov/Water-Shorelines/Shoreline-coastal-management/Shoreline-coastal-planning/Shoreline-Master-Programs.

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 July 6, 2021, at http://www.hanford.gov/?page=81.

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 June 15, 2021, 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 July 6, 2021, 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 July 6, 2021, 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 July 6, 2021, 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, Office of Radiation and Indoor Air, Washington, DC. Accessed July 6, 2021, at https://www.epa.gov/sites/production/files/2015-05/documents/520-1-89-003.pdf.

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 July 6, 2021, at 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 July 6, 2021, 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 July 6, 2021, at https://www.epa.gov/eco-research/level-iii-and-iv-ecoregions-continental-united-states.

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 July 6, 2021, at http://pdw.hanford.gov/arpir/index.cfm/viewDoc?accession=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 July 6, 2021, at 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 July 6, 2021, 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 July 6, 2021, 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 July 6, 2021, at 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.

Hamilton EL and SF Snyder. 2011. *Hanford Site Regional Population—2010 Census*. PNNL-20631, Pacific Northwest National Laboratory, Richland, WA. Accessed July 6, 2021, at http://www.pnnl.gov/main/publications/external/technical_reports/PNNL-20631.pdf.

Hazardous Waste Management Act of 1976. RCW 70.105, as amended. *Revised Code of Washington*, Olympia, WA. Accessed July 6, 2021, 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.

LandScope Washington. 2021. "Ecoregions in Washington." Accessed May 27, 2021, at http://www.landscope.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 July 6, 2021, 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. 2003. *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 July 6, 2021, at https://pdw.hanford.gov/arpir/index.cfm/viewDoc?accession=0081396H.

Marine Mammal Protection Act of 1972. 86 Stat. 1027, as amended, 16 U.S.C. § 1361 *et seq*. Accessed July 6, 2021, at http://www.fws.gov/laws/lawsdigest/MARMAM.HTML.

Migratory Bird Treaty Act. 1918. 40 Stat. 755, as amended, 16 U.S.C. § 703 *et seq*. Accessed July 6, 2021, 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 July 6, 2021, 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 June 7, 2021, at http://energy.gov/sites/prod/files/nepapub/nepa_documents/RedDont/Req-NEPA.pdf.

National Historic Preservation Act of 1966 (NHPA). Public Law 89-665, as amended, 54 U.S.C. § 300101 *et seq*. Accessed July 6, 2021, at https://www.nps.gov/training/nrs/references/ref_docs/NHPA.pdf.

National Park Service Organic Act. 16 U.S.C. § 1, 2, 3, and 4. Accessed July 6, 2021, 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 https://www.fws.gov/laws/lawsdigest/nwrsact.html.

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 July 6, 2021, at 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*.

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). 2020. *Regulations of the Olympic Region Clean Air Agency, Clallam, Grays Harbor, Jefferson, Mason, Pacific, and Thurston Counties*. Olympia, WA. Accessed July 2, 2021 at https://www.orcaa.org/wp-content/uploads/2020/01/ORCAA-Regulations-January-2020.pdf.

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 July 6, 2021, at https://wdfw.wa.gov/sites/default/files/publications/00806/wdfw00806.pdf.

PNNL (Pacific Northwest National Laboratory). 2015. *Climate Resilience Action Plan for Pacific Northwest National Laboratory*. PNNL-24671, Richland, WA. Accessed May 28, 2021, at https://sustainable.pnnl.gov/docs/PNNL_CRP_Results.pdf.

PNNL (Pacific Northwest National Laboratory). 2016. *PNNL Marine Sciences Laboratory Quality Assurance Management Plan (QAMP)*. Sequim, WA.

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). 2020. *Pacific Northwest National Laboratory FY 2021 Site Sustainability Plan*. Richland, WA. Accessed May 28, 2021, at https://sustainable.pnnl.gov/docs/2021Sustainability_Plan.pdf.

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 July 6, 2021, at http://www.pnnl.gov/main/publications/external/technical_reports/PNNL-20548.pdf.

RAEL-005. "Radioactive Air Emissions License for the Department of Energy Office of Science Pacific Northwest National Laboratory Site." Issued by State of Washington Department of Health, Office of Radiation Protection, Radioactive Air Emissions, Olympia, WA. Effective June 17, 2015 through June 17, 2020.

RAEL-014. "Radioactive Air Emissions License for the Pacific Northwest National Laboratory Marine Sciences Laboratory." Issued by State of Washington Department of Health, Office of Radiation Protection, Radioactive Air Emissions, Olympia, WA. Effective October 1, 2017 through January 1, 2023.

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 July 6, 2021, 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 July 6, 2021, at http://www2.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 July 6, 2021, 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*.

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 July 6, 2021, 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 July 6, 2021, 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, 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 July 6, 2021, at http://www.pnnl.gov/main/publications/external/technical_reports/PNNL-19427Rev2.pdf.

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, 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, JM Barnett, and LE Bisping. 2021a. *PNNL Richland Campus Radionuclide Air Emissions Report for Calendar Year 2020*. PNNL-20436-11, Pacific Northwest National Laboratory, Richland, WA.

Snyder SF, JP Rishel, and JM Barnett. 2021b. *PNNL Sequim Campus Radionuclide Air Emissions Report for Calendar Year 2020*. PNNL-22342-9, Pacific Northwest National Laboratory, Richland, WA.

State Environmental Policy Act (SEPA). RCW 43.21C, as amended. *Revised Code of Washington*, Olympia, WA.

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 July 6, 2021, at https://pubs.er.usgs.gov/publication/wri994048.

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 July 6, 2021, at https://www.gpo.gov/fdsys/pkg/USCODE-2014-title15/pdf/USCODE-2014-title15-chap53.pdf.

USCB (U.S. Census Bureau). 2021. "Quick Facts: Sequim City and Clallam, Benton, and Franklin County, Washington." Washington, DC. Accessed June 30, 2021, at https://www.census.gov/quickfacts/fact/table/sequimcitywashington,clallamcountywashington,WA,franklincountywashington,bentoncountywashington,US/PST045219#PST045219.

USFWS (U.S. Fish and Wildlife Service). 2021. "Endangered Species: Glossary." Washington, DC. Accessed May 27, 2021, at http://www.fws.gov/midwest/endangered/glossary/.

USGS (U.S. Geological Survey). 2021. "National Water Information System: USGS 12472800 Columbia River Below Priest Rapids Dam, WA." Washington, DC. Accessed August 3, 2021, at 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. 2020. "State Noxious Weed List—Class B Noxious Weeds." *Washington Administrative Code*, Olympia, WA.

WAC 16-750-015. 2020. "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 173-218-080. 2008. "The Nonendangerment Standard for UIC Wells." *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. 2018. "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. 2019. "Radiation Protection—Air Emissions." *Washington Administrative Code*, Olympia, WA.

WAC 246-247-040(1). 2019. "Radiation Protection—Air Emissions; General Standards." *Washington Administrative Code*, Olympia, WA.

WAC 246-247-060(6). 2019. "Radiation Protection—Air Emissions; Applications, Registration and Licensing." *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 10, 2021, 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 July 6, 2021, 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 July 6, 2021, 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 July 6, 2021, at https://wdfw.wa.gov/sites/default/files/publications/00105/wdfw00105.pdf.

WDFW (Washington Department of Fish and Wildlife). 2021a. "Priority Habitats and Species List." Olympia, WA. Accessed May 27, 2021, at https://wdfw.wa.gov/sites/default/files/publications/00165/wdfw00165.pdf.

WDFW (Washington Department of Fish and Wildlife). 2021b. "Threatened and Endangered Species." Olympia, WA. Accessed May 27, 2021, at https://wdfw.wa.gov/species-habitats/at-risk/listed.

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 May 27, 2021, at 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 May 27, 2021, at https://geologyportal.dnr.wa.gov.

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 July 6, 2021, at 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 July 6, 2021, at http://www.pnnl.gov/main/publications/external/technical_reports/PNNL-16435.pdf.

WNHP (Washington Natural Heritage Program). 2019. *2019 Washington Vascular Plant Species of Special Concern*. Natural Heritage Report 2019-04, Olympia, WA. Accessed July 6, 2021, at 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 15, 2021, at https://www.nwcb.wa.gov/classes-of-noxious-weeds.

WSU (Washington State University). 2021a. "AgWeatherNet Yearly Data for Richland, Benton County, Washington." Data provided by personal communication from https://weather.wsu.edu/?p=93250.

WSU (Washington State University). 2021b. "AgWeatherNet Yearly Data for Sequim, Clallam County, Washington." Data provided by personal communication from https://weather.wsu.edu/?p=93250.

WWF (World Wildlife Fund). 2021. "Puget Lowland Forests." Accessed May 27, 2021, at http://worldwildlife.org/ecoregions/na0524.

Yabusaki SB, ZF Zhang, SR Waichler, and TW Moon. 2019. *Heat Transport from the PNNL BSF/CSF Ground Source Heat Pump System*. PNNL-28913, Richland, WA. Accessed June 3, 2021, at https://apps.ecology.wa.gov/paris/FacilitySummary.aspx?FacilityId=24734.

Zuljevic N, TE Seiple, and SF Snyder. 2016. *Battelle Land–Sequim Regional Population*. PNNL-25305, Pacific Northwest National Laboratory, Richland, WA.

Appendix A

Plant and Animal Species Found on Undeveloped Upland and Riparian Areas of the PNNL Richland Campus, 2009–2020

This page intentionally left blank

Appendix A

Plant and Animal Species Observed on Undeveloped Upland and Riparian Areas of the PNNL Richland Campus, 2009–2020

Table A.1. Plant Species Observed on the Undeveloped Upland Portions of the PNNL Richland Campus, 2009–2020

Species Name[a]	Common Name[a]	State Status	Federal Status	Noxious Weed Class[b]
Achillea millefolium	common yarrow			
Achnatherum hymenoides	Indian ricegrass			
Agoseris glauca	pale agoseris			
Agoseris grandiflora	large-flowered agoseris			
Agoseris heterophylla	annual agoseris			
Agropyron cristatum	crested wheatgrass			
Ailanthus altissima	tree-of-heaven			C
Allium schoenoprasum	chives			
Amaranthus albus	white pigweed			
Ambrosia acanthicarpa	bur ragweed			
Amsinckia lycopsoides	tarweed fiddleneck			
Amsinckia tessellata	tessellate fiddleneck			
Aphyllon corymbosum	flat-topped broomrape			
Artemisia campestris	Pacific sagewort			
Artemisia dracunculus	tarragon			
Artemisia ludoviciana	prairie sage			
Artemisia tridentata	big sagebrush			
Asclepias speciosa	showy milkweed			
Asparagus officinalis	garden asparagus			
Astragalus caricinus	buckwheat milkvetch			
Avena sativa	cultivated oats			
Balsamorhiza careyana	Carey's balsamroot			
Bassia scoparia	burning-bush			B
Bromus tectorum	cheatgrass			
Calochortus macrocarpus	sagebrush mariposa lily			
Camissonia parvula	small desertprimrose			
Capsella bursa-pastoris	shepherd's purse			
Carex douglasii	Douglas's sedge			
Cenchrus longispinus	bur-grass			C
Centaurea diffusa	diffuse knapweed			B
Centaurea solstitialis	yellow starthistle			B
Cerastium fontanum	common mouse-ear			
Chaenactis douglasii	hoary false yarrow			
Chamaesyce serpyllifolia	thymeleaf sandmat			

Species Name[a]	Common Name[a]	State Status	Federal Status	Noxious Weed Class[b]
Chenopodium album	white goosefoot			
Chenopodium leptophyllum	slimleaf goosefoot			
Chondrilla juncea	skeletonweed			B
Chorispora tenella	chorispora			
Chrysothamnus viscidiflorus	green rabbitbrush			
Cichorium intybus	chicory			
Cirsium arvense	Canada thistle			C
Clematis ligusticifolia	western clematis			
Comandra umbellata	bastard toadflax			
Convolvulus arvensis	bindweed			C
Conyza canadensis	Canadian horseweed			
Coreopsis tinctoria	Columbia coreopsis			
Crepis atribarba	slender hawksbeard			
Cryptantha flaccida	weak-stemmed cryptantha			
Cryptantha fendleri	Fendler's cryptantha			
Cryptantha pterocarya	winged cryptantha			
Cymopterus terebinthinus	turpentine spring parsley			
Cynodon dactylon	cynodon			
Dalea ornata	western prairie-clover			
Delphinium nuttallianum	upland larkspur			
Descurainia pinnata	western tansymustard			
Descurainia sophia	flixweed			
Dieteria canescens	hoary-aster			
Draba nemorosa	woodland draba			
Draba verna	spring Whitlow-grass			
Elaeagnus angustifolia	Russian olive			C
Eleocharis sp.	spike-rush			
Elymus elymoides	bottlebrush squirreltail			
Elymus lanceolatus	thickspike wheatgrass			
Elymus violaceus	Alaska wheatgrass			
Epilobium brachycarpum	tall annual willow-herb			
Equisetum sp.	horsetail			
Ericameria nauseosa	common rabbitbrush			
Erigeron filifolius	thread-leaf fleabane			
Eriogonum niveum	snow buckwheat			
Eriogonum vimineum	broom buckwheat			
Erodium cicutarium	redstem stork's bill			
Erysimum asperum	wallflower			
Euphorbia glyptosperma	ribseed sandmat			
Euphorbia serpillifolia	thymeleaf spurge			
Fallopia convolvulus	climbing bindweed			
Fritillaria pudica	yellow bell			
Galium aparine	cleavers			

Species Name[a]	Common Name[a]	State Status	Federal Status	Noxious Weed Class[b]
Gaillardia aristata	blanket-flower			
Gilia sinuata	rosy gilia			
Gratiola neglecta	common American hedge-hyssop			
Grayia spinosa	hopsage			
Greeneocharis circumscissa	matted cryptantha			
Grindelia hirsutula	hairy gumweed			
Gypsophila paniculata	baby's-breath			C
Hesperostipa comata	needle-and-thread			
Holosteum umbellatum	jagged chickweed			
Hordeum jubatum	foxtail barley			
Hymenopappus filifolius	hymenopappus			
Hypericum perforatum	common St. John's-wort			C
Iris missouriensis	Rocky Mountain			
Juniperus scopulorum	Rocky Mountain juniper			
Koeleria macrantha	junegrass			
Lactuca serriola	prickly lettuce			
Ladeania lanceolata	lance-leaf scurf-pea			
Lagophylla rammosissima	hareleaf			
Lamium amplexicaule	common dead-nettle			
Layia glandulosa	tidytips			
Lepidium draba	heart-podded hoarycress			C
Lepidium densiflorum	common pepperweed			
Lepidium latifolium	broadleaf pepperweed			B
Lepidium perfoliatum	clasping pepperweed			
Leymus cinereus	Great Basin wildrye			
Linanthus pungens	granite prickly-phlox			
Logfia gallica	daggerleaf cottonrose			
Lomatium macrocarpum	bigseed biscuitroot			
Malus pumila	cultivated apple			
Malva neglecta	common mallow			
Marrubium vulgare	horehound			
Medicago lupulina	black medick			
Medicago sativa	alfalfa			
Melilotus officianalis	common yellow sweet-clover			
Mentha arvensis	mint			
Mentzelia albicaulis	small-flowered mentzelia			
Microsteris gracilis	microsteris			
Morus alba	white mulberry			
Narcissus pseudonarcissus	common daffodil			
Oenothera pallida	pale evening primrose			
Onopordum acanthium	cotton thistle			B
Opuntia polyacantha	starvation pricklypear			
Parthenocissus vitacea	Virginia creeper			

Species Name[a]	Common Name[a]	State Status	Federal Status	Noxious Weed Class[b]
Phacelia hastata	silverleaf phacelia			
Phacelia linearis	thread-leaf phacelia			
Phlox longifolia	longleaf phlox			
Plantago lanceolata	English plantain			
Plantago patigonica	Indian-wheat			
Plectritis macrocera	longhorn plectritis			
Poa bulbosa	bulbous bluegrass			
Poa pratensis	Kentucky bluegrass			
Poa secunda	Sandberg's bluegrass			
Polemonium micranthum	annual Jacob's ladder			
Polygonum aviculare	doorweed			
Prunus virginiana	chokecherry			
Pseudognaphalium stramineum	cottonbatting plant			
Pseudoroegneria spicata	bluebunch wheatgrass			
Purshia tridentata	bitterbrush			
Rhaponticum repens	hardheads (Russian knapweed)			B
Ribes aureum	golden currant			
Robinia pseudoacacia	black locust			
Rosa woodsii	rose			
Rubus bifrons	Himalayan blackberry			C
Rumex salicifolius	willow dock			
Rumex venosus	veiny dock			
Salix exigua	coyote willow			
Salsola tragus	Russian thistle			
Senecio vulgaris	common groundsel			C
Setaria pumila	foxtail			
Sisymbrium altissimum	tall tumblemustard			
Sisymbrium loeselii	Loesel tumblemustard			
Solidago lepida	western Canada goldenrod			
Solanum dulcamara	climbing nightshade			
Solanum triflorum	cut-leaved nightshade			
Sonchus arvensis	sow-thistle			
Sphaeralcea munroana	Munro's globemallow			
Sporobolus cryptandrus	sand dropseed			
Stephanomeria paniculata	stiff-branched wirelettuce			
Taraxacum officinale	common dandelion			
Toxicoscordion venenosum	meadow death-camas			
Thinopyrum intermedium	intermediate wheatgrass			
Tragopogon dubius	yellow salsify			
Tribulus terrestris	puncturevine			B
Trifolium repens	white clover			
Triteleia grandiflora	large-flowered triteleia			
Ulmus pumila	Siberian elm			

Species Name[a]	Common Name[a]	State Status	Federal Status	Noxious Weed Class[b]
Ulmus americana	American elm			
Verbascum thapsus	common mullein			
Verbena bracteata	bracted verbena			
Veronica arvensis	common speedwell			
Veronica peregrina	purslane speedwell			
Vulpia microstachys	small fescue			
Vulpia octoflora	six-weeks fescue			

(a) 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.
(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, 2009–2020

Species Name	Common Name	State Status	Federal Status
Agelaius phoeniceus	red-winged blackbird		
Artemisiospiza nevadensis	sagebrush sparrow	Candidate	
Anas platyrhynchos	mallard		
Asio flammeus	short-eared owl		
Branta canadensis	Canada goose		
Buteo jamaicensis	red-tailed hawk		
Buteo swainsoni	Swainson's hawk		
Callipepla californica	California quail		
Carpodacus mexicanus	house finch		
Carduelis tristis	American goldfinch		
Charadrius vociferus	killdeer		
Chordeiles minor	common nighthawk		
Chondestes grammacus	lark sparrow		
Circus cyaneus	northern harrier		
Colaptes auratus	northern flicker		
Columbus livia	rock pigeon		
Corvus brachyrhynchos	American crow		
Corvus corax	common raven		
Eremophila alpestris	horned lark		
Euphagus cyanocephalus	Brewer's blackbird		
Haliaeetus leucocephalus	bald eagle		
Hirundo pyrrhonota	cliff swallow		
Hirundo rustica	barn swallow		
Icterus bullockii	Bullock's oriole		
Lanius ludovicianus	loggerhead shrike	Candidate	

Species Name	Common Name	State Status	Federal Status
Numenius americanus	long-billed curlew		
Pandion haliaetus	osprey		
Passer domesticus	house sparrow		
Phasianus colchicus	ring-necked pheasant		
Pica pica	black-billed magpie		
Riparia riparia	bank swallow		
Sayornis saya	Say's phoebe		
Sturnella neglecta	western meadowlark		
Sturnus vulgaris	European starling		
Tachycineta thalassina	violet-green swallow		
Turdus migratorius	American robin		
Tyrannus	eastern kingbird		
Tyrannus verticalis	western kingbird		
Zenaida macroura	mourning dove		
Zonotrichia leucophrys	white-crowned sparrow		

Table A.3. Mammal Species Observed on the Undeveloped Upland Portions of the PNNL Richland Campus, 2009–2020

Species Name	Common Name	State Status	Federal Status
Canis latrans	coyote		
Castor canadensis	beaver		
Erithizon dorsatum	porcupine		
Lepus californicus	black-tailed jackrabbit	Candidate	
Odocoileus hemionus	mule deer		
Perognathus parvus	Great Basin pocket mouse		
Sylvilagus nutalli	mountain cottontail		
Taxidea taxus	badger		
Thomomys talpoides	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[(a)]	Common Name[(a)]	State Status	Federal Status	Noxious Weed Class[(b)]
Achillea millefolium	common yarrow			
Achnatherum hymenoides	Indian ricegrass			
Agropyron cristatum	crested wheatgrass			
Ailanthus altissima	tree-of-heaven			C
Allium schoenoprasum	chives			
Ambrosia acanthicarpa	bur ragweed			
Amsinckia lycopsoides	tarweed fiddleneck			
Apocynum cannabinum	clasping-leaved dogbane			
Artemisia campestris	Pacific sagewort			

Species Name[(a)]	Common Name[(a)]	State Status	Federal Status	Noxious Weed Class[(b)]
Artemisia dracunculus	tarragon			
Artemisia ludoviciana	prairie sage			
Artemisia tridentata	big sagebrush			
Asclepias speciosa	showy milkweed			
Asparagus officinalis	garden asparagus			
Bromus tectorum	cheatgrass			
Centaurea diffusa	diffuse knapweed			B
Chondrilla juncea	skeletonweed			B
Chrysothamnus viscidiflorus	green rabbitbrush			
Cirsium arvense	creeping thistle			C
Clematis ligusticifolia	western clematis			
Convolvulus arvensis	bind weed			C
Conyza canadensis	Canadian horseweed			
Coreopsis tinctoria	Columbia coreopsis			
Descurainia pinnata	western tansymustard			
Descurainia sophia	flixweed			
Dieteria canescens	hoary-aster			
Eleocharis palustris	common spike-rush			
Elymus lanceolatus	thickspike wheatgrass			
Equisetum sp.	horsetail			
Ericameria nauseosa	rubber rabbitbrush			
Eriogonum niveum	snow buckwheat			
Eriogonum sp.	buckwheat			
Euphorbia glyptosperma	ribseed sandmat			
Euphorbia serpillifolia	thymeleaf sandmat			
Gaillardia aristata	blanket-flower			
Galium sp.	bedstraw			
Hesperostipa comata	needle-and-thread			
Holosteum umbellatum	jagged chickweed			
Hypericum perforatum	common St. John's-wort			C
Iris missouriensis	Rocky Mountain iris			
Lactuca serriola	prickly lettuce			
Ladeania lanceolata	lance-leaf scurf-pea			
Lepidium densiflorum	common pepperweed			
Lepidium draba	heart-podded hoarycress			C
Lepidium perfoliatum	clasping pepperweed			
Leymus cinereus	Great Basin wildrye			
Logfia gallica	daggerleaf cottonrose			
Acmispon americanus	Spanish-clover			
Lupinus sericeus	silky lupine			
Medicago sativa	alfalfa			
Melilotus officinalis	common yellow sweet-clover			
Mentha piperita	mint			
Morus alba	white mulberry			

Species Name[a]	Common Name[a]	State Status	Federal Status	Noxious Weed Class[b]
Oenothera pallida	pale evening primrose			
Parthenocissus vitacea	Virginia creeper			
Phalaris arundinacea	reed canarygrass			C
Plantago lanceolata	English plantain			
Plantago patigonica	Indian-wheat			
Poa bulbosa	bulbous bluegrass			
Poa compressa	Canada bluegrass			
Poa secunda	Sandberg's bluegrass			
Prunus virginiana	chokecherry			
Purshia tridentata	Antelope-brush			
Rhaponticum repens	hardheads (Russian knapweed)			B
Rhus glabra	smooth sumac			
Ribes aureum	golden currant			
Robinia pseudoacacia	black locust			
Rosa woodsii	rose			
Rubus bifrons	Himalayan blackberry			C
Rumex crispus	curly dock			
Rumex patienta	patience dock			
Rumex salicifolius	willow dock			
Rumex venosus	veiny dock			
Salix exigua	coyote willow			
Salsola tragus	Russian thistle			
Sisymbrium altissimum	tall tumblemustard			
Solidago lepida	western Canada goldenrod			
Solanum dulcamara	climbing nightshade			
Sphaeralcea munroana	Munro's globemallow			
Sporobolus cryptandrus	sand dropseed			
Stephanomeria paniculata	stiff-branched wirelettuce			
Taraxacum officinale	common dandelion			
Tragopogon dubius	yellow salsify			
Ulmus americana	American elm			
Verbascum thapsus	common mullein			
Vicia cracca	bird vetch			
Xanthium strumarium	common cocklebur			

(a) 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.
(b) 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.

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
Actitis macularius	spotted sandpiper		
Agelaius phoeniceus	red-winged blackbird		
Anas platyrhynchos	mallard		
Ardea herodias	great blue heron		
Branta canadensis	Canada goose		
Bubo virginianus	great-horned owl		
Calidris bairdii	Baird's sandpiper		
Calidris mauri	western sandpiper		
Callipepla californica	California quail		
Ardea alba	great egret		
Columba livia	rock pigeon		
Corvus corax	common raven		
Icterus bullockii	Bullock's oriole		
Larus californicus	California gull		
Megaceryle alcyon	belted kingfisher		
Melospiza lincolnii	Lincoln's sparrow		
Melospiza melodia	song sparrow		
Mergus merganser	common merganser		
Nycticorax nycticorax	black-crowned night heron		
Pandion halaetus	osprey		
Pelecanus erythrorhynchos	American white pelican	Threatened	
Phalacrocorax auritus	double-crested cormorant		
Pica pica	black-billed magpie		
Riparia riparia	bank swallow		
Sturnus vulgaris	European starling		
Tyrannus tyrannus	eastern kingbird		
Tyrannus verticalis	western kingbird		
Turdus migratorius	American robin		
Zenaida macroura	mourning dove		

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
Canis latrans	coyote		
Castor canadensis	American beaver		
Erithizon dorsatum	porcupine		
Odocoileus hemionus	mule deer		
Sciurus niger	eastern fox squirrel		

This page intentionally left blank

Appendix B

Plant and Animal Species Observed On and In the Vicinity of the PNNL Sequim Campus

This page intentionally left blank

Appendix B

Plant and Animal Species Observed On and In the Vicinity of the PNNL Sequim Campus

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

Species Name[(a)]	Common Name[(a)]	State Status	Federal Status	Noxious Weed Class[(b)]
Abies grandis	grand fir			
Abronia latifolia	yellow sand verbena			
Acer circinatum	vine maple			
Acer glabrum	Rocky Mountain maple			
Acer macrophyllum	bigleaf maple			
Achillea millefolium	common yarrow			
Agropyron repens	quackgrass			
Alnus rubra	red alder			
Ambrosia chamissonis	silver bursage			
Amelanchier alnifolia	Saskatoon serviceberry			
Anaphalis margaritacea	pearly-everlasting			
Arbutus menziesii	madrone			
Arctostaphylos uva-ursi	kinnikinnick			
Artemisia suksdorfii	Suksdorf's sagebrush			
Atriplex patula	spear orache			
Avena sp.	oat			
Bellis perennis	daisy			
Berberis aquifolium	shining Oregon-grape			
Berberis nervosa	dull Oregon-grape			
Brassica rapa	field mustard			
Cakile edentula	American searocket			
Calystegia soldanella	beach morning-glory			
Capsella bursa-pastoris	shepherd's-purse			
Carex sp.	sedge			
Castilleja hispida	harsh Indian-paintbrush			
Cerastium arvense	field chickweed			
Chamaenerion angustifolium	fireweed			
Chenopodium album	white goosefoot			
Cirsium arvense	creeping thistle			C
Cirsium remotifolium	Pacific fringed thistle			
Cirsium vulgare	bull thistle			
Claytonia perfoliata	miner's lettuce			
Collinsia parviflora	small-flowered blue-eyed Mary			
Conium maculatum	poison-hemlock			B
Convolvulus arvensis	small bindweed			
Cornus stolonifera	red-osier dogwood			
Corylus cornuta var. *californica*	beaked hazelnut			
Crataegus douglasii	Douglas's hawthorne			

Species Name(a)	Common Name(a)	State Status	Federal Status	Noxious Weed Class(b)
Crataegus monogyna	1-seed hawthorn			C
Crepis capillaris	smooth hawksbeard			
Cuscuta pacifica	Pacific salt marsh dodder			
Cytisus scoparius	Scot's broom			B
Dactylis glomerata	orchard-grass			
Danthonia intermedia	timber oatgrass			
Delphinium sp.	larkspur			
Deschampsia caespitosa	tufted hairgrass			
Dipsacus sylvestris	teasel			C
Distichlis spicata	saltgrass			
Draba verna	Whitlow-grass			
Elymus glaucus	blue wildrye			
Elymus mollis	American dunegrass			
Epilobium ciliatum	common willow-herb			
Epilobium minutum	small-flowered willow-herb			
Equisetum arvense	common horsetail			
Equisetum hyemale	common scouring-rush			
Erodium cicutarium	redstem stork's bill			
Eschscholzia californica	poppy			
Fragaria virginiana	mountain strawberry			
Fritillaria affinis	checker lily			
Galium aparine	stickywilly			
Galium triflorum	sweetscented bedstraw			
Gaultheria shallon	salal			
Geranium molle	dovefoot geranium			
Glehnia leiocarpa	glehnia			
Grindelia integrifolia	Puget Sound gumweed			
Hedera helix	English ivy			
Heracleum maximum	common cow-parsnip			
Hieraceum sp.	hawkweed			
Holodiscus discolor	oceanspray			
Hordeum brachyanterum	meadow barley			
Hypericum scouleri	western St. John's-wort			
Hypochaeris radicata	hairy cat's ear			C
Ilex aquifolium	holly			M
Juncus sp.	rush			
Lathyrus japonicus	sea peavine			
Lathyrus polyphyllus	leafy peavine			
Lepidium densiflorum	common pepperweed			
Leucanthemum vulgare	oxeye-daisy			C
Linnaea borealis	twinflower			
Lomatium nudicaule	bare-stemmed biscuitroot			
Lonicera ciliosa	orange honeysuckle			
Lonicera hispidula	California honeysuckle			
Lupinus sp.	lupine			
Lysichiton americanus	skunk cabbage			
Lysimachia latifolia	western starflower			

Species Name[a]	Common Name[a]	State Status	Federal Status	Noxious Weed Class[b]
Maianthemum dilatatum	false lily-of-the-valley			
Maianthemum racemosum ssp. *amplexicaule*	large false Solomon's seal			
Malus fusca	Oregon crabapple			
Matricaria discoidea	pineapple weed			
Medicago lupulina	black medick			
Mycelis muralis	mycelis			
Myosotis laxa	small-flowered forget-me-not			
Oemleria cerasiformis	Indian plum			
Osmorhiza berteroi	sweet-cicely			
Petasites frigidus	sweet coltsfoot			
Physocarpus capitatus	Pacific ninebark			
Plantago lanceolata	English plantain			
Plantago major	common plantain			
Plantago maritima	sea tongue			
Plectritis congesta	sea blush			
Polygonum paronychia	black knotweed			
Polystichum munitum	western swordfern			
Populus trichocarpa	black cottonwood			
Potentilla anserina	cinquefoil			
Prunella vulgaris	self-heal			
Prunus emarginata	bitter cherry			
Prunus laurocerasus	cherry laurel			
Pseudotsuga menziesii	Douglas fir			
Pteridium aquilinum	bracken fern			
Ranunculus repens	creeping buttercup			
Ranunculus uncinatus	little buttercup			
Ribes divaricatum	straggly gooseberry			
Ribes sanguineum	redflower currant			
Rosa gymnocarpa	little wild rose			
Rosa nutkana	Nootka rose			
Rubus bifrons	Himalayan blackberry			C
Rubus leucodermis	blackcap			
Rubus nutkanus	thimbleberry			
Rubus ursinus	Pacific blackberry			
Rumex acetosella	sheep sorrel			
Rumex crispus	curly dock			
Rumex occidentalis	western dock			
Salicornia depressa	low glasswort			
Salix sitchensis	Sitka willow			
Sambucus racemosa	red elderberry			
Senecio vulgaris	old-man-in-the-spring			
Senecio sylvaticus	wood groundsel			
Sonchus asper	prickly sow-thistle			
Spiraea douglasii	spirea			
Stellaria media	common chickweed			
Struthiopteris spicant	hard fern			

Species Name[(a)]	Common Name[(a)]	State Status	Federal Status	Noxious Weed Class[(b)]
Symphoricarpos albus	common snowberry			
Taraxacum officinale	common dandelion			
Tellima grandiflora	fringecup			
Thuja plicata	western red cedar			
Tolmiea menziesii	youth-on-age			
Tragopogon dubius	yellow salsify			
Trifolium dubium	suckling clover			
Trifolium pratense	red clover			
Trifolium repens	white clover			
Triglochin maritima	seaside arrow-grass			
Triphysaria pusilla	dwarf owl-clover			
Tsuga heterophylla	western hemlock			
Urtica dioica	stinging nettle			
Vicia americana	American vetch			
Vicia cracca	bird vetch			
Vicia nigricans	giant vetch			
Vicia sativa	common vetch			

(a) 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.

(b) 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, 2010–2019

Species Name	Common Name	State Status	Federal Status
Accipiter cooperii	Cooper's hawk		
Agelaius phoeniceus	red-winged blackbird		
Accipiter striatus	sharp-shinned hawk		
Aechmophorus occidentalis	western grebe	Candidate	
Agelaius phoeniceus	red-winged blackbird		
Anas platyrhynchos	mallard		
Anthus rubescens	American pipit		
Ardea herodias	great blue heron		
Aythya marila	greater scaup		
Branta bernicla	brandt		
Branta canadensis	Canada goose		
Bubo virginianus	great-horned owl		
Bucephala albeola	bufflehead		
Bucephala clangula	common goldeneye		
Buteo jamaicensis	red-tailed hawk		
Calidris alpina	dunlin		
Callipepla californica	California quail		
Calypte anna	Anna's hummingbird		
Cardellina pusilla	Wilson's warbler		
Cathartes aura	turkey vulture		

Species Name	Common Name	State Status	Federal Status
Catharus ustulatus	Swainson's thrush		
Catharus guttatus	hermit thrush		
Cepphus columba	pigeon guillemot		
Cerorhinca monocerata	rhinoceros auklet		
Certhia americana	brown creeper		
Charadrius vociferus	killdeer		
Circus hudsoneus	northern harrier		
Cistothorus palustris	marsh wren		
Coccothraustes vespertinus	evening grosbeak		
Clangula hyemalis	long-tailed duck		
Colaptes auratus	northern flicker		
Columba livia	rock dove (pigeon)		
Contopus cooperi	olive-sided flycatcher		
Corvus brachyrhynchos	American crow		
Corvus corax	common raven		
Cyanocitta stelleri	Steller's jay		
Dryobates pubescens	downy woodpecker		
Dryobates villosus	hairy woodpecker		
Empidonax difficilis	Pacific-slope flycatcher		
Empidonax hammondii	Hammond's flycatcher		
Euphagus cyanocephalus	Brewer's blackbird		
Falco peregrinus	peregrine falcon		
Haematopus bachmani	black oystercatcher		
Haemorhous mexicanus	house finch		
Haliaeetus leucocephalus	bald eagle		
Hirundo rustica	barn swallow		
Histrionicus	harlequin duck		
Hydroprogne caspia	Caspian tern		
Ixoreus naevius	varied thrush		
Junco hyemalis	dark-eyed junco		
Larus glaucescens	glaucus-winged gull		
Larus glaucescens x L. occidentalis	Olympic gull		
Larus occidentalis	western gull		
Leiothlypis celata	orange-crowned warbler		
Lophodytes cucullatus	hooded merganser		
Megaceryle alcyon	belted kingfisher		
Melanitta deglandi	white-winged scoter		
Melospiza lincolnii	Lincoln's sparrow		
Melospiza melodia	song sparrow		
Mergus merganser	common merganser		
Mergus serrator	red-breasted merganser		
Molothrus ater	brown-headed cowbird		
Passerculus sandwichensis	savannah sparrow		
Passerella iliaca	fox sparrow		
Patagioenas fasciata	band-tailed pigeon		
Petrochelidon pyrrhonota	cliff swallow		
Phalacrocorax auritus	double-crested cormorant		

Species Name	Common Name	State Status	Federal Status
Phalacrocorax pelagicus	pelagic cormorant		
Phalacrocorax penicillatus	Brant's cormorant		
Pheucticus melanocephalus	black-headed grosbeak		
Pipilo maculatus	spotted towhee		
Piranga ludoviciana	western tanager		
Podiceps nigricollis	eared grebe		
Podilymbus podiceps	pied-billed grebe		
Poecile atricapillus	black-capped chickadee		
Poecile rufescens	chestnut-backed chickadee		
Progne subis	purple martin		
Psaltriparus minimus	bushtit		
Regulus calendula	ruby-crowned kinglet		
Regulus satrapa	golden-crowned kinglet		
Selasphorus rufus	rufous hummingbird		
Setophaga coronata	yellow-rumped warbler		
Setophaga townsendi	Townsend's warbler		
Sitta canadensis	red-breasted nuthatch		
Sphyrapicus ruber	red-breasted sapsucker		
Spinus tristis	American goldfinch		
Stelgidopteryx serripennis	northern rough-winged swallow		
Sterna caspia	Caspian tern		
Strix varia	barred owl		
Sturnus vulgaris	European starling		
Tachycineta bicolor	tree swallow		
Tachycineta thalassina	violet-green swallow		
Thryomanes bewickii	Bewick's wren		
Troglodytes pacificus	Pacific wren		
Turdus migratorius	American robin		
Zenaida macroura	mourning dove		
Zonotrichia leucophrys	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
Anaxyrus boreas	western toad		
Canis latrans	coyote		
Odocoileus hemionus	black-tailed deer		
Rana aurora	northern red-legged frog		
Sorex sp.	shrew		
Tamiasciurus douglasii	Douglas squirrel		
Taricha granulosa	rough-skinned newt		

Appendix C

Ambient External Dose Surveillance Results CY 2020

This page intentionally left blank

Appendix C

Ambient External Dose Surveillance Results CY 2020

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

Column Heading	Data Type/Format	Content
Sample Site Name	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 Transit Control – to measure exposure during shipment to and from vendor (value is NOT subtracted from the monitoring station data shown in Table C.2)
Vendor Location ID	Number (#####)	Five-digit number assigned by dosimeter vendor.
Sample Method	Text	Optically stimulated luminescence dosimeter (OSLD).
Sample Date Time On	date (DD-MMM-YY HH:MM [24 hr])	Date and time when dosimeter sampling started (time field is truncated in Table C.2).
Sample Date Time	date (DD-MMM-YY HH:MM [24 hr])	Date and time when dosimeter sampling ended (time field is truncated in Table C.2).
Quarter	Text (Q#)	Calendar quarter when the dosimeter was deployed. This may differ from the quarter indicated by the vendor because the vendor may indicate the quarter when the dosimeter was purchased.
Value Reported	Integer number	Net dose (no control value subtracted) result millirem for the dosimeter deployment period.

Table C.2. Ambient External Dose Surveillance 2020 PNNL Richland Campus

Sample Site Name	Vendor Location ID	Sample Method	Sample Date Time On	Sample Date Time	Quarter[a]	Value Reported (mrem)
PNL-1	00091	OSLD	31-Dec-19	25-Mar-20	Q1	29
PNL-2	00092	OSLD	31-Dec-19	25-Mar-20	Q1	31
PNL-3	00093	OSLD	31-Dec-19	25-Mar-20	Q1	29
PNL-4	00094	OSLD	31-Dec-19	25-Mar-20	Q1	31
PNL-5	00095	OSLD	31-Dec-19	25-Mar-20	Q1	29
PNL-T	00096	OSLD	31-Dec-19	25-Mar-20	Q1	24
Transit Control	00097	OSLD	31-Dec-19	25-Mar-20	Q1	22
PNL-1	00098	OSLD	25-Mar-20	17-Jun-20	Q2	28
PNL-2	00099	OSLD	25-Mar-20	17-Jun-20	Q2	28
PNL-3	00100	OSLD	25-Mar-20	17-Jun-20	Q2	27
PNL-4	00101	OSLD	25-Mar-20	17-Jun-20	Q2	26
PNL-5	00102	OSLD	25-Mar-20	17-Jun-20	Q2	27
PNL-T	00103	OSLD	25-Mar-20	17-Jun-20	Q2	17
Transit Control	00104	OSLD	25-Mar-20	17-Jun-20	Q2	21
PNL-1	00105	OSLD	17-Jun-20	23-Sep-20	Q3	35
PNL-2	00106	OSLD	17-Jun-20	23-Sep-20	Q3	32
PNL-3	00107	OSLD	17-Jun-20	23-Sep-20	Q3	39
PNL-4	00108	OSLD	17-Jun-20	23-Sep-20	Q3	31
PNL-5	00109	OSLD	17-Jun-20	23-Sep-20	Q3	32
PNL-T	00110	OSLD	17-Jun-20	23-Sep-20	Q3	25
Transit Control	00111	OSLD	17-Jun-20	23-Sep-20	Q3	24
PNL-1	00112	OSLD	23-Sep-20	30-Dec-20	Q4	34
PNL-2	00113	OSLD	23-Sep-20	30-Dec-20	Q4	32
PNL-3	00114	OSLD	23-Sep-20	30-Dec-20	Q4	35
PNL-4	00115	OSLD	23-Sep-20	30-Dec-20	Q4	34
PNL-5	00116	OSLD	23-Sep-20	30-Dec-20	Q4	35
PNL-T	00117	OSLD	23-Sep-20	30-Dec-20	Q4	21
Transit Control	00118	OSLD	23-Sep-20	30-Dec-20	Q4	24

OSLD = optically stimulated luminescence dosimeter.
(a) Third quarter (Q3) air quality index at unhealthy to hazardous levels at end of quarter due to fires in surrounding areas.

Table C.3. 2020 PNNL Richland Campus Ambient External Dose Calculated for ANSI/HPS N13.37-2014 (HPS 2019) 91-d Normalized Quarters

2020 91-d Normalized Quarter Dose	PNL-1	PNL-2	PNL-3	PNL-4	PNL-5[(a)]
Normalized Q1 (mrem/Q)	7.49	9.63	7.49	9.63	7.49
Normalized Q2 (mrem/Q)	7.58	7.58	6.50	5.42	6.50
Normalized Q3 (mrem/Q)	10.21	7.43	13.93	6.50	7.43
Normalized Q4 (mrem/Q)	9.28	7.43	10.21	9.28	10.21
Total (mrem/yr)	34.6	32.1	38.1	30.8	31.6

(a) PNL-5 is the background station. No background values were subtracted from listed Campus perimeter stations (PNL-1 through PNL-4) results.

This page intentionally left blank

Appendix D

Helpful Information

This page intentionally left blank

Appendix D

Helpful Information

The following information 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 can be found 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 1×10^9 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 2.0×10^3 (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 2.0×10^{-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.

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.1. Names and Symbols for Units of Measure

Symbol	Name	Symbol	Name
Concentration		Area	
ppb	parts per billion	ha	hectare(s) (1 × 10^4 m^2)
ppm	parts per million	km^2	square kilometer(s)
ppmv	parts per million by volume	mi^2	square mile(s)
Length		ft^2	square foot (feet)
cm	centimeter(s) (1 × 10^{-2} m)	Mass	
ft	foot (feet)	g	gram(s)
in.	inch(es)	kg	kilogram(s) (1 × 10^3 g)
km	kilometer(s) (1 × 10^3 m)	mg	milligram(s) (1 × 10^{-3} g)
m	meter(s)	µg	microgram(s) (1 × 10^{-6} g)
mi	mile(s)	lb	pound(s)
mm	millimeter(s) (1 × 10^{-3} m)	Time	
µm	micrometer(s) (1 × 10^{-6} m)	d	day(s)
Rate		hr	hour(s)
cfs (or ft^3/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	Volume	
mR/hr	milliroentgen(s) per hour	cm^3	cubic centimeter(s)
mrem/d	millirem per day	ft^3	cubic foot (feet)
mrem/yr	millirem per year	gal	gallon(s)
µrem/hr	microrem per hour	L	liter(s)
Temperature		m^3	cubic meter(s)
°C	degrees Celsius	mL	milliliter(s) (1 × 10^{-3} L)
°F	degrees Fahrenheit	yd^3	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^2	10.76	ft^2	ft^2	0.093	m^2
ha	2.47	acres	acre	0.405	ha
km^2	0.386	mi^2	mi^2	2.59	km^2
m^3	35.31	ft^3	ft^3	0.0283	m^3
m^3	1.308	yd^3	yd^3	0.7646	m^3
pCi	1,000	nCi	nCi	0.001	pCi
µCi/mL	10^9	pCi/L	pCi/L	10^{-9}	µCi/mL
Ci/m^3	10^{12}	pCi/m^3	pCi/m^3	10^{-12}	Ci/m^3
mCi/cm^3	10^{15}	pCi/m^3	pCi/m^3	10^{-15}	mCi/cm^3
nCi/m^2	1.0	mCi/km^2	mCi/km^2	1.0	nCi/m^2
Ci	3.7×10^{10}	Bq	Bq	2.7×10^{-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

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

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

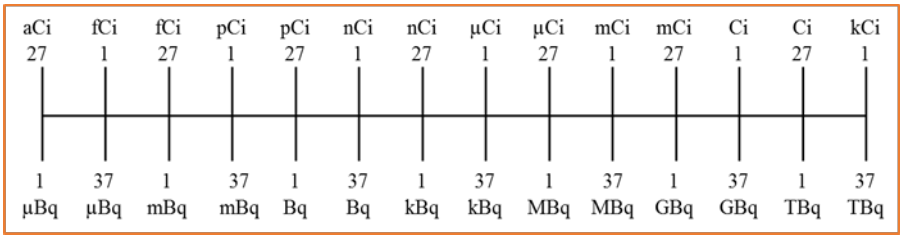


Figure D.1. Radioactivity Units, Curies to Becquerels

D.4 Radiological Dose Units

Radiological dose in this report is usually written in terms of effective dose equivalent (EDE) and reported numerically in units of millirem (mrem), with the metric units millisievert (mSv) or microsievert (µSv) following in parentheses or footnoted. The EDE and effective dose (ED) 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 µSv] 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.

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

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

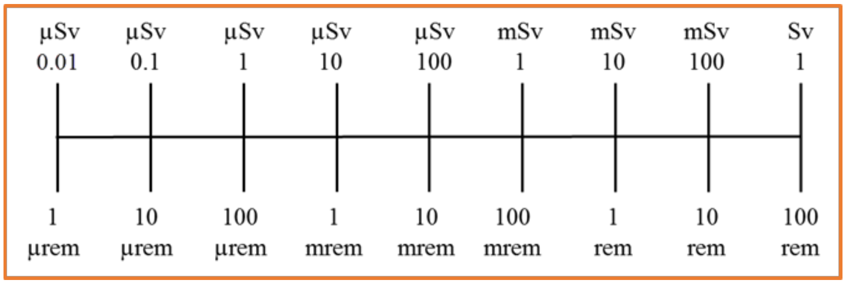


Figure D.2. Radiological Dose Units, Sieverts to Rem

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

Symbol	Name
mrad	millirad (1 × 10^{-3} rad)
mrem	millirem (1 × 10^{-3} rem)
µrem	microrem (1 × 10^{-6} rem)
Sv	sievert (100 rem)
mSv	millisievert (1 × 10^{-3} Sv)
µSv	microsievert (1 × 10^{-6} Sv)
Gy	gray (100 rad)
mGy	milligray (1 x 10^{-3} Gy)

Table D.5. Radionuclides and Their Half-Lives[a]

Symbol	Radionuclide	Half-Life	Symbol	Radionuclide	Half-Life
^{3}H	tritium	12.32 yr	^{140}Ba	barium-140	12.7527 d
^{7}Be	beryllium-7	53.22 d	^{152}Eu	europium-152	13.517 yr
^{14}C	carbon-14	5,700 yr	^{154}Eu	europium-154	8.601 yr
^{24}Na	sodium-24	14.997 h	^{155}Eu	europium-155	4.753 yr
^{40}K	potassium-40	1.248×10^{9} yr	^{177}Lu	lutetium-177	6.647 d
^{37}Ar	argon-37	35.04 d	^{208}Po	polonium-208	2.898 yr
^{39}Ar	argon-39	269 yr	^{210}Pb	lead-210	22.20 yr
^{51}Cr	chromium-51	27.7025 d	^{212}Pb	lead-212	10.64 h
^{54}Mn	manganese-54	312.20 d	^{220}Rn	radon-220	55.6 sec
^{55}Fe	iron-55	2.744 yr	^{222}Rn	radon-222	3.8235 d
^{59}Fe	iron-59	44.495 d	^{226}Ra	radium-226	1600 yr
^{59}Ni	nickel-59	7.6×10^{4} yr	^{228}Ra	radium-228	5.75 yr
^{57}Co	cobalt-57	271.74 d	^{228}Th	thorium-228	1.9125 yr
^{60}Co	cobalt-60	5.275 yr	^{229}Th	thorium-229	7932 yr
^{63}Ni	nickel-63	101.2 yr	^{230}Th	thorium-230	7.54×10^{4} yr
^{65}Zn	zinc-65	243.93 d	^{232}Th	thorium-232	1.40×10^{10} yr
^{82}Br	bromine-82	35.282 h	U or uranium	natural uranium	$\sim 4.5 \times 10^{9}$[b]
^{85}Kr	krypton-85	10.739 yr	^{233}U	uranium-233	1.592×10^{5} yr
^{89}Sr	strontium-89	50.563 d	^{234}U	uranium-234	2.455×10^{5} yr
^{90}Sr	strontium-90	28.9 yr	^{235}U	uranium-235	7.04×10^{8} yr
^{88}Y	yttrium-88	106.626 d	^{238}U	uranium-238	4.468×10^{9} yr
^{90}Y	yttrium-90	64.053 h	^{236}Np	neptunium-236	1.53×10^{5} yr
^{95}Zr	zirconium-95	64.032 d	^{237}Np	neptunium-237	2.144×10^{6} yr
^{99}Tc	technetium-99	2.111×10^{5} yr	^{238}Pu	plutonium-238	87.7 yr
^{103}Ru	ruthenium-103	39.247 d	^{239}Pu	plutonium-239	2.411×10^{4} yr
^{106}Ru	ruthenium-106	371.8 d	^{240}Pu	plutonium-240	6.561×10^{3} yr
^{109}Cd	cadmium-109	461.4 d	^{241}Pu	plutonium-241	14.329 yr
^{113}Sn	tin-113	115.09 d	^{242}Pu	plutonium-242	3.75×10^{5} yr
^{125}Sb	antimony-125	2.75856 yr	^{244}Pu	plutonium-244	8.0×10^{7} yr
^{129}I	iodine-129	1.57×10^{7} yr	^{241}Am	americium-241	432.6 yr
^{131}I	iodine-131	8.0252 d	^{243}Am	americium-243	7,364 yr
^{132}I	iodine-132	2.295 h	^{243}Cm	curium-243	29.1 yr
^{133}Xe	xenon-133	5.2475 d	^{244}Cm	curium-244	18.1 yr
^{134}Cs	cesium-134	2.0652 yr	^{245}Cm	curium-245	8,423 yr
^{137}Cs	cesium-137	30.08 yr	^{250}Cf	californium-250	13.08 yr
^{137m}Ba	barium-137m	2.552 min	^{252}Cf	californium-252	2.645 yr

(a) From NuDat 2.8 at https://www.nndc.bnl.gov/nudat2/chartNuc.jsp.
(b) Natural uranium is a mixture dominated by uranium-238.

This page intentionally left blank

Appendix E

Glossary

This page intentionally left blank

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 = 3.7×10^{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 *effective dose equivalent* 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 (3.7×10^{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. Quality control 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 *effective dose equivalent*. 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 *effective dose equivalent* and its variants in the International System of Units. The common unit for *effective dose equivalent* 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

Federal Offices

DOE Headquarters	DOE Office of Science Pacific Northwest Site Office
JM Blaikie	JK Erickson
A Wallo III	TM McDermott
A Williamson	TP Pietrok
	RE Snyder
DOE-Richland Operations Office	**DOE Office of River Protection**
TW Ferns	PK Call
DL Kreske	BR Trimberger
KE Lutz	**Mission Support Alliance**
MK Marvin	JW Cammann
Washington River Protection Solutions	KM Mendez
TG Beam	DD Teel
SG McKinney	**CH2M Hill Plateau Remediation Company**
KA Peterson	JA Lerch

Tribes

Confederated Tribes of the Umatilla Indian Reservation	Hoh Tribe
W Sigo IV, Chairman	D Gomez, Tribal Chairman
Jamestown S'Klallam Tribe	**Lower Elwha Klallam Tribe**
WR Allen, Chairman	FG Charles, Chairwoman
Lummi Nation	**Makah Tribe**
L Solomon, General Manager	TJ Greene, Chairman
Nez Perce Tribe	**Port Gamble S'Klallam Tribe**
S Wheeler, Chairman	JC Sullivan, Chairman
Quileute Nation	**Wanapum Tribe**
D Woodruff, Chairman	R Buck, Jr, Leader
Yakama Nation	
D Saluskin, Chairman	

State Senators and Representatives

M Boehnke	M Klicker
S Brown	B Klippert
B Chandler	S Rude
P Dozier	S Tharinger
J Dufault	K Van De Wege
J Honeyford	

Washington State Offices

Washington State Department of Health	Washington State Department of Ecology
SD Bervin	L Bauder
T Hay	K Wood
PJ Martell	
TA Rogers	
J Schmidt	
RJ Utley	

Regional Offices

Benton Clean Air Agency	Olympic Region Clean Air Agency
RB Priddy	F McNair

County Offices

Benton County Commissioners	Franklin County Commissioners
J Delvin	C Didier
W McKay	R Mullen
S Small	B Peck

Clallam County Health & Human Services	Clallam County Commissioners
A Brastad	R Johnson
	B Peach
	M Ozias

Clallam County Department of Community Development
ME Winborn

City Offices

City of Richland	City of Sequim
J Amundson	C Deschenes

Libraries

Richland Public Library	DOE Public Reading Room (printed copy)
Mid-Columbia Libraries	
North Olympic Library – Sequim Branch	

Pacific Northwest National Laboratory

EJ Antonio	BG Fritz
MA Aranda	TL Gervais
JM Barnett	KD Hand
JM Becker	GL Koller
LE Bisping	KB Larson
SD Cooke	KL Lowry
EG Damberg	KM McDonald
RA Del Mar	JL Mendez
CA Dissing	AL Miracle
CJ Duchsherer	TW Moon
JP Duncan	MJ Moran
MD Ellefson	CJ Nichols

Pacific Northwest National Laboratory (continued)	
GW Patton	JA Stegen
MR Peterson	JA Stephens
RM Pierson	MJ Stephenson
EA Raney	DM Storms
LY Renaud	J Su-Coker
SF Snyder	

Pacific Northwest
National Laboratory

902 Battelle Boulevard
P.O. Box 999
Richland, WA 99354
1-888-375-PNNL (7665)

www.pnnl.gov