5. Oak Ridge National Laboratory

ORNL is the largest DOE science and energy laboratory. Basic and applied research at ORNL delivers transformative solutions to compelling problems in energy and security.

Diverse capabilities at ORNL span a broad range of scientific and engineering disciplines, enabling the exploration of fundamental science challenges and the research needed to accelerate the delivery of solutions to the marketplace. ORNL supports DOE's national missions of scientific discovery, clean energy, and security through four major areas:

- **Neutrons**—The Spallation Neutron Source and the High Flux Isotope Reactor, two of the world's leading neutron sources, are operated at ORNL, enabling scientists and engineers to gain new insights into materials and biological systems.
- **Computing**—ORNL programs accelerate scientific discovery through modeling and simulation on powerful supercomputers and advance data-intensive science and US leadership in high-performance computing.
- **Materials**—Basic research and applied research are integrated at ORNL to develop advanced materials for energy applications.
- **Nuclear**—ORNL programs advance the scientific basis for 21st century nuclear fission and fusion technologies and systems and produce isotopes for research, industry, and medicine.

In addition, nine world-class facilities that support ORNL's research and development activities are also available to users from universities, industry, and other institutions:

- Building Technologies Research and Integration Center
- Carbon Fiber Technology Facility
- Center for Nanophase Materials Sciences
- Center for Structural Molecular Biology
- High Flux Isotope Reactor
- Manufacturing Demonstration Facility
- National Transportation Research Center
- Oak Ridge Leadership Computing Facility
- Spallation Neutron Source

ORNL is managed by UT-Battelle, LLC, a partnership between the University of Tennessee and Battelle Memorial Institute. Other DOE contractors conducting activities at ORNL in 2019 included North Wind Solutions, LLC; UCOR, an Amentum-led partnership with Jacobs; and Isotek Systems, LLC. Activities of these contractors were conducted to comply with contractual and regulatory environmental requirements.

Due to different permit reporting requirements and instrument capabilities, this report uses various units of measurement. The lists of units of measure and conversion factors on pages xxvii and xxviii are included to help readers convert numeric values presented herein as needed for specific calculations and comparisons.

5.1 Description of Site, Missions, and Operations

ORNL, which is managed for DOE by UT-Battelle, LLC, a partnership of the University of Tennessee and Battelle Memorial Institute, lies in the southwest corner of ORR (Figure 5.1) and includes facilities in two valleys (Bethel and Melton) and on Chestnut Ridge. ORNL was established in 1943 as part of the secret Manhattan Project to pioneer a method for producing and separating plutonium. During the 1950s and 1960s, and with the creation of DOE in the 1970s, ORNL became an international center for the study of nuclear energy and related research in the physical and life sciences. By the turn of the century, the laboratory supported the nation with a peacetime science and technology mission that was just as important as, but very different from, the work carried out in the days of the Manhattan Project.

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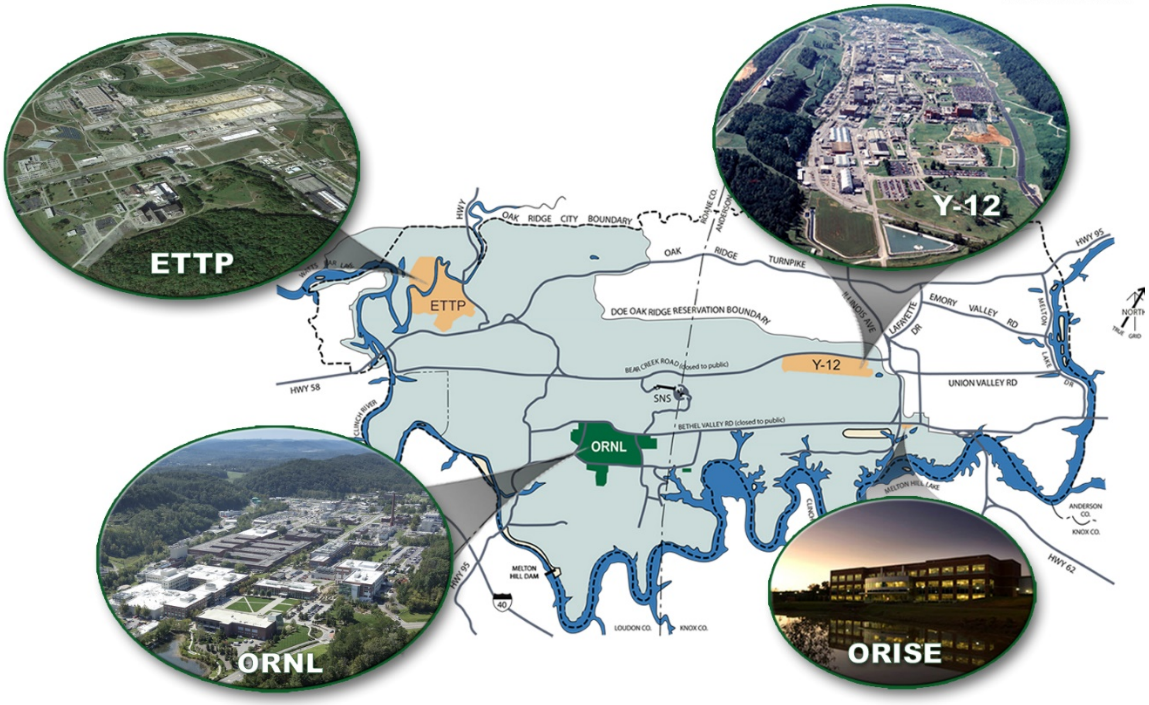


Acronyms:

ETTP = East Tennessee Technology Park
ORNL = Oak Ridge National Laboratory
ORISE = Oak Ridge Institute for Science and Education
Y-12 = Y-12 National Security Complex

Figure 5.1. Location of Oak Ridge National Laboratory within ORR and its relationship to other local DOE facilities

In March 2007, Isotek Systems, LLC (Isotek) assumed responsibility for the Building 3019 Complex at ORNL, where the national repository of ^{233}U has been kept since 1962. In 2010, an “alternatives analysis” was conducted to evaluate methods available for ^{233}U disposition, and in 2011, the recommendations in the *Final Draft* ^{233}*U Alternatives Analysis Phase I Report* (DOE 2011b) were endorsed. The Phase I recommendations included (1) transfer of Zero-Power Reactor (ZPR) plate canisters to the National Nuclear Security Administration and disposal of Consolidated Edison Uranium Solidification Project (CEUSP) material canisters and (2) completing a Phase II alternatives analysis for processing the remaining 50 percent of the inventory. The transfer of the ZPR plate canisters was completed in 2012. Disposal of the CEUSP material canisters began in 2015 and was completed in 2017. Building 2026 was transferred from UT-Battelle to Isotek in May of 2017. Isotek began processing ^{233}U material inside glove boxes in Building 2026 in the fall of 2019. The processing of the ^{233}U material produces a solidified, low-level waste form acceptable for disposal.

Additionally, Isotek is extracting ^{229}Th from the material and is transferring it to a customer for use as source material for medical isotope production.

UT-Battelle provides air and water quality monitoring support for the Building 3019 complex; results are included in the UT-Battelle air and water monitoring discussions in this chapter.

UCOR, an Amentum-led partnership with Jacobs, is the DOE ORR cleanup contractor. The scope of UCOR activities at ORNL includes long-term surveillance, maintenance, and management of inactive waste disposal sites, structures, and buildings. Characterization and deactivation of former reactors and isotope production facilities began in FY 2020. Other activities include groundwater monitoring, transuranic (TRU) waste storage, and operation of the wastewater treatment facility and the waste-processing facility for liquid low-level radioactive waste (LLW).

As of December 11, 2015, North Wind Solutions, LLC, (NWSol) has been the prime contractor for the Transuranic Waste Processing Center (TWPC), which is located on the western boundary of ORNL on about 26 acres of land adjacent to the Melton Valley Storage Tanks along State Route 95. TWPC's mission is to receive TRU wastes for processing, treatment, repackaging, and shipment to designated facilities for final disposal. TWPC consists of the waste-processing facility, the personnel building, and numerous support buildings and storage areas. TWPC began processing supernatant liquid from the Melton Valley Storage Tanks in 2002, contact-handled (CH) debris waste in December 2005, and remotely handled (RH) debris waste in May 2008. Based on the definition of TRU waste, some waste being managed as TRU is later determined to be LLW or mixed LLW. UT-Battelle provides water quality monitoring for operations at the TWPC, and results are included in water monitoring discussions in this chapter. Air monitoring data from TWPC are provided to UT-Battelle for inclusion in the ORR National Emission Standards for Hazardous Air Pollutants for Radionuclides (Rad-NESHAPs) annual report and is incorporated into air monitoring discussions in this chapter.

UT-Battelle manages several facilities located off the main ORNL campus for DOE. The Hardin Valley Campus (HVC) is home to the National Transportation Research Center (NTRC) **here** and the Manufacturing Demonstration Facility (MDF) **here**. HVC is located on a 6 acre site owned by Pellissippi Investors, LLC, and is leased to UT-Battelle and the University of Tennessee. Approximately 152 industry partners work at the HVC to shape America's mobility future. NTRC is DOE's only user facility dedicated to transportation and serves as the gateway to UT-Battelle's comprehensive capabilities for transportation research and development (R&D). Research focuses on fuels and lubricants, engines, emissions, electric drive technologies, lightweight and power-train materials, vehicle systems integration, energy storage and fuel cell technologies, vehicle cyber security, and intelligent transportation systems.

MDF focuses on advanced manufacturing research, including the development of carbon fiber composites and additive manufacturing involving polymers, metal wires, and metal powders. The facility hosts the Institute for Advanced Composites Manufacturing Innovation lab space and an outreach program for local high school students.

The Carbon Fiber Technology Facility (CFTF), a leased 42,000 ft^2 innovative technology facility located in the Horizon Center Business Park, offers a flexible, highly instrumented carbon fiber line for demonstrating the scalability of advanced carbon fiber technology and for producing market-development volumes of prototypical carbon fibers (Figure 5.2). The CFTF is the world's most capable open-access facility for the scale-up of emerging carbon fiber technology. The cost of carbon fiber material remains relatively high, prohibiting widespread adoption of carbon fiber–containing composite materials in the automotive manufacturing industry, which requires lower commodity pricing. The lower-cost carbon fiber produced at ORNL meets the performance criteria prescribed by some automotive manufacturers for carbon fiber materials for use in high-volume vehicle applications.

UT-Battelle also manages several buildings and trailers located at Y-12 and in the city of Oak Ridge.

Photo by Jason Richards.

Figure 5.2. Production of lower-cost carbon fiber at the Carbon Fiber Technology Facility

5.2 Environmental Management Systems

Demonstration of environmental excellence through high-level policies that clearly state expectations for continual improvement, pollution prevention, and compliance with regulations and other requirements is a priority at ORNL. In accordance with DOE Order 436.1, *Departmental Sustainability* (DOE 2011), UT-Battelle, NWSol, UCOR, and Isotek have implemented environmental management systems (EMSs), modeled after International Organization for Standardization (ISO) 1400: 2015, to measure, manage, and control environmental impacts. An EMS is a continuing cycle of planning, implementing, evaluating, and improving processes and actions undertaken to achieve environmental goals.

5.2.1 UT-Battelle Environmental Management System

UT-Battelle's EMS is designed to fully comply with all applicable requirements and to continually improve ORNL's environmental performance. Until August 2018, UT-Battelle was registered to the ISO 14001:2015 standard and had maintained ISO 14001 registration since 2004. In FY 2018 a management decision was made to transition from registration to a declaration of conformance to ISO 14001:2015. Because of that decision, the external registration audits have been discontinued.

UT-Battelle's EMS is a fully integrated set of environmental management services for UT-Battelle activities and facilities. Services include pollution prevention, waste management, effluent management, regulatory review, reporting, permitting, and other environmental management programs. Through the UT-Battelle Standards-Based Management System (SBMS), the EMS establishes environmental policy and translates environmental laws, applicable DOE orders, and other requirements into laboratory-wide documents (procedures, and guidelines). Through environmental protection officers, environmental compliance representatives, and waste services representatives, the UT-Battelle EMS assists the line organizations in complying with environmental requirements.

5.2.1.1 Integration with the Integrated Safety Management System

The objective of the UT-Battelle Integrated Safety Management System (ISMS) is to systematically integrate environment, safety, and health (ES&H) requirements and controls into all work activities and to ensure protection of the workers, the environment, and the public. The UT-Battelle EMS and the ISMS are integrated to provide a unified strategy for the management of resources, the control and attenuation of risks, and the establishment and achievement of the organization's ES&H goals. Guided by the ISMS and EMS, UT-Battelle strives for continual improvement through "plan-do-check-act" cycles. Under the ISMS, the term "safety" also encompasses ES&H, including pollution prevention, waste minimization, and resource conservation. Therefore, the guiding principles and core functions in the ISMS apply both to the protection of the environment and to safety. The UT-Battelle EMS is consistent with the ISMS and includes all the elements in the ISO 14001:2015 standard.

5.2.1.2 UT-Battelle Environmental Policy for Oak Ridge National Laboratory

UT-Battelle's Environmental Policy for ORNL, which can be found **here,** clearly states expectations and provides the framework for setting and reviewing environmental objectives.

5.2.1.3 Planning

UT-Battelle Environmental Aspects

Environmental aspects are elements of an organization's activities, products, or services that can interact with the environment. Environmental aspects associated with UT-Battelle activities, products, and services have been identified at both the division level and the laboratory level. Activities that are relative to any of the aspects are carefully controlled to minimize or eliminate impacts to the environment. Nine significant environmental aspects (listed **here**) have been identified as potentially having significant environmental impacts.

UT-Battelle Legal and Other Requirements

Legal and other requirements that apply to the environmental aspects identified by UT-Battelle include federal, state, and local laws and regulations; environmental permits; applicable DOE orders; UT-Battelle contract clauses; waste acceptance criteria; and voluntary requirements such as ISO 14001:2015. UT-Battelle has established procedures to ensure that all applicable requirements are reviewed and that changes and updates are communicated to staff and are incorporated into work-planning activities. UT-Battelle's environmental compliance status is discussed in Section 5.3.

UT-Battelle Objectives

To improve environmental performance, UT-Battelle establishes objectives and indicators for monitoring progress for appropriate functions and activities. Laboratory-level environmental objectives are documented in the annual *Site Sustainability Plan* (DOE 2019) **here**. Line organization objectives are developed annually, entered into a commitment tracking system, and tracked to completion. In all cases, the objectives and indicators for monitoring progress are consistent with the UT-Battelle Policy for ORNL (found online here), are supportive of the laboratory mission, and where practical, are measurable.

UT-Battelle Programs

UT-Battelle has established an organizational structure to ensure that environmental stewardship practices are integrated into all facets of UT-Battelle's missions at ORNL. Programs led by experts in environmental protection and compliance, energy and resource conservation, pollution prevention, and waste management ensure that laboratory activities are conducted in accordance with the environmental policy (see Section 5.2.1.2). Information on UT-Battelle’s 2019 compliance status, activities, and accomplishments is presented in Section 5.3.

Environmental protection and waste management staff provide critical support services in the following areas:

- Waste management
- Solid and hazardous waste compliance
- National Environmental Policy Act (NEPA 1969) compliance
- Air quality compliance
- Water quality compliance
- US Department of Agriculture (USDA) compliance
- Transportation safety
- Environmental sampling and data evaluation
- Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA 1980) interface

UT-Battelle also has subject matter experts on its staff who provide critical waste management, transportation, and disposition support services to research, operations, and support divisions:

- Pollution prevention staff manage recycling programs, work with staff to reduce waste generation and to promote sustainable acquisition.
- Radiological engineering staff provide radiological characterization support to generators and waste service representatives, develop tools to help ensure compliance with facility safety and transportation, and provide packaging support.
- Waste acceptance and disposition staff review and approve waste characterization methods, accept waste from generator areas into Transportation and Waste Management Division storage areas, review waste disposal paperwork to ensure compliance with the disposal facility’s waste acceptance criteria, certify waste packages, and coordinate off-site disposition of UT-Battelle’s newly generated waste.
- Waste service representatives provide technical support to waste generators to properly manage waste by assisting in identifying, characterizing, packaging, and certifying wastes for disposal;
- The waste-handling team performs waste-packing operations and conducts inspections of waste items, areas, and containers.
- The transportation management team ensures that both the on-site and off-site packaging and transportation activities are performed in an efficient and compliant manner.
- The hazardous material spill response team is the first line of response to hazardous materials spills at ORNL and controls and contains spills until the situation is stabilized.

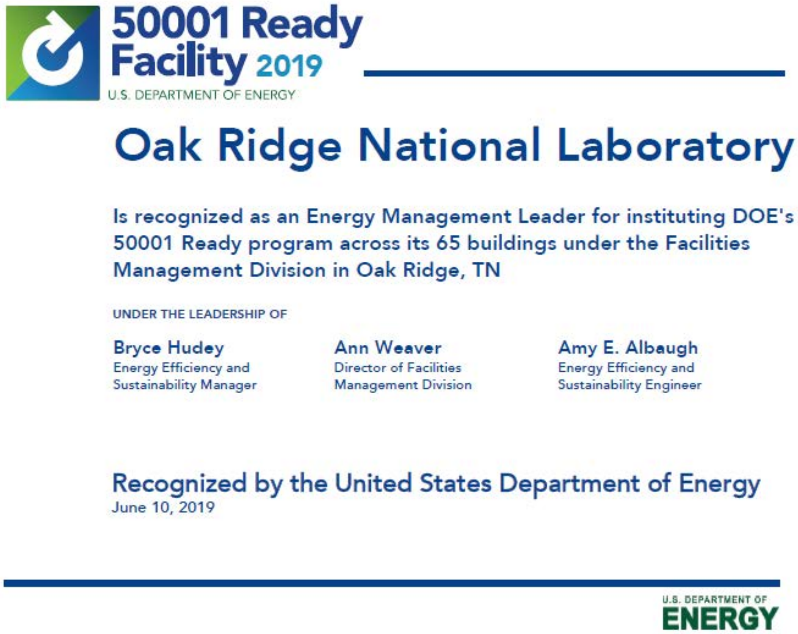
5.2.1.4 Site Sustainability

As required by DOE Order 436.1, *Department Sustainability* (DOE 2011)*, The Oak Ridge National Laboratory FY 2020 Site Sustainability Plan* (SSP) (DOE 2019) (found online here) was completed in December 2019 in compliance with annual DOE guidance.

To meet the goals articulated in the SSP, opportunities for continuous improvements in operational and business processes must be identified, and the changes must be implemented to maximize the return on investment from modernizing facilities and equipment. The Sustainable ORNL program (**here**) promotes system-wide best practices, management commitment, and employee engagement that will lead ORNL into a future of efficient, sustainable operations.

In 2019, The Energy Efficiency and Sustainability Program (EESP) in ORNL's Facilities Management Division (FMD) was successful in the attainment of DOE's 50001 Ready certification. The program recognizes organizations that demonstrate outstanding energy management standards and best practices in their facilities. The certification covers more than 3 million ft^2 in 65 FMD buildings that are equipped with advanced metering. ORNL's advanced metering system aids in the reporting of quality energy data and supports the monitoring of facility energy performance toward the goal of savings in utility use and operations cost. FMD's EESP led the certification effort, but contributions and support from many other divisions were necessary for achievement of the project goals.

DOE launched the 50001 Ready Program in 2017, and ORNL is the third federal location and the second national laboratory to receive the certification (Figure 5.3). The program is a self-guided approach for facilities to validate an energy management system and self-attest to the structure of ISO 50001 standards for energy-efficient operations. To achieve the 50001 Ready certification, organizations are responsible for completing all 25 tasks in the 50001 Ready Navigator online tool and for measuring and improving energy performance over time.



50001 Ready Facility 2019
U.S. DEPARTMENT OF ENERGY

Oak Ridge National Laboratory

Is recognized as an Energy Management Leader for instituting DOE's 50001 Ready program across its 65 buildings under the Facilities Management Division in Oak Ridge, TN

UNDER THE LEADERSHIP OF

Bryce Hudey
Energy Efficiency and Sustainability Manager

Ann Weaver
Director of Facilities Management Division

Amy E. Albaugh
Energy Efficiency and Sustainability Engineer

Recognized by the United States Department of Energy
June 10, 2019

U.S. DEPARTMENT OF ENERGY

Figure 5.3. Oak Ridge National Laboratory is the third federal location and the second national laboratory to receive the 50001 Ready Program certification

FY 2019 SSP Performance Summary Data for Energy, Water, and Waste

Executive Order (EO) 13834 (EO 2018), "Efficient Federal Operations," directs federal agencies to manage buildings, vehicles, and operations to optimize energy and environmental performance, reduce waste, and cut costs. In April 2019, instructions for implementing EO 13834 were finalized (CEQ 2019). The SSP guidance and ORNL's submittal were updated to reflect the goals of the final EO 13834 implementation.

Energy Use Intensity

Based on FY 2019 data, energy use in the buildings category at ORNL is 1,273 billion Btu. That total excludes certain buildings (e.g., some buildings at ORNL defined under the Energy Policy Act of 1992 [EPACT 1992]). Given an area of 5,291,856 GSF of energy-consuming buildings, trailers, and other structures and facilities identified in the ORNL Facilities Information Management System, the FY 2019 calculated energy use intensity (EUI) is 240,567 Btu/GSF, a reduction of 3.4% from FY 2018 (Figure 5.4).

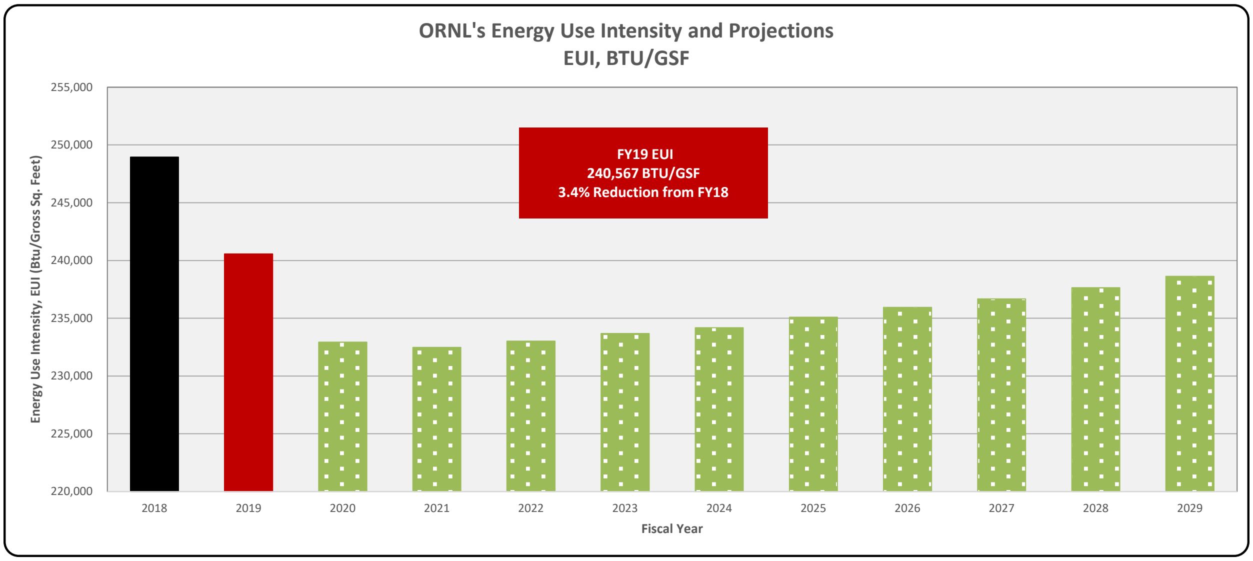


Figure 5.4. Historical, current (FY 2019), and projected energy use intensity at Oak Ridge National Laboratory

To maintain steady progress toward EUI reductions, ORNL focuses on energy-efficient and sustainable design in new construction projects, smart repurposing of existing facilities, and continuous improvement in facility and utility operations. ORNL continues to modernize by demolishing old, energy-inefficient buildings to make way for the construction of new, high-performance buildings that better serve the ORNL mission. Improvements in utilities services have reduced the costs of energy, fuel, water, and maintenance and have increased reliability in the delivery of steam, chilled water, and potable water.

EUI reduction in existing ORNL facilities is data-driven, and efforts are made to quantify and bring awareness to building energy performance so that operations staff can make informed decisions. The establishment of the standards-driven DOE 50001 Ready program will allow FMD and the EESP staff to concentrate limited resources on the most significant energy users to better influence the return on investments. Initiatives in FY 2019 included new approaches to energy consumption awareness using data visualization and reporting. Building data analytics, including fault detection and diagnostics, are also being evaluated as energy conservation tools. To bolster this effort, ORNL has elected to participate in the DOE Better Buildings Smart Energy Analytics Campaign. New and innovative methods are being employed with time-tested approaches to energy conservation, including lighting upgrades; existing building commissioning; and heating, ventilation, and air-conditioning control system improvements.

Water Use Intensity

ORNL procures potable water from the City of Oak Ridge for domestic use (handwashing, flushing), cooling (cooling towers, chillers), heating (steam generation, hot water generation), laboratories, and special research processes.

The benefits of water management practices have been demonstrated at ORNL by the achievement of a 66% reduction in water use compared with the highest level, which occurred in FY 1985. An established, aggressive plan continues to be deployed. The numerous strategies engaged to reduce water consumption include repairing leaks, replacing old lines in the site water distribution system, and eliminating once-through cooling (OTC) where possible. The extended shutdown of the High Flux Isotope Reactor (HFIR) during FY 2019 further reduced water consumption this year; resulting in a 37% reduction in water use intensity since FY 2007 (Figure 5.5). HFIR is expected to return to normal operations in FY 2020. An anticipated 53% increase in water consumption is also expected by 2029 to support additional high-performance computing and Spallation Neutron Source (SNS) activities.

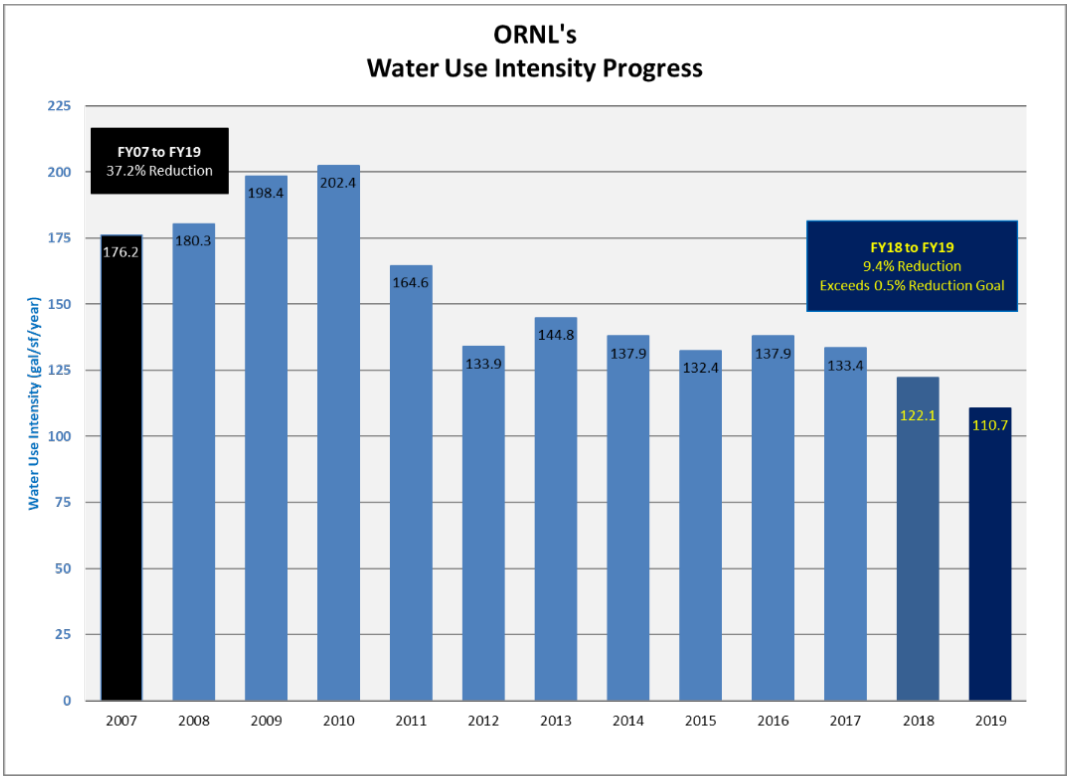


Figure 5.5. Historical and current (FY 2019) water use intensity at Oak Ridge National Laboratory

Waste Diversion

In FY 2019, ORNL's diversion rate for municipal solid waste reached 50 percent and reached 64 percent for construction and demolition (C&D) waste materials and debris.

Pollution Prevention

ORNL source reduction efforts include increases in the use of acceptable nontoxic or less-toxic alternative chemicals and processes while minimizing the acquisition of hazardous chemicals and materials through material substitution, operational assessments, and inventory management. In cases where the complete elimination of a particular hazardous material is not possible, ORNL pursues a combination of actions, including controls to limit use, procurement alternatives, and recycling processes to mitigate the environmental impact. UT-Battelle implemented 26 new pollution prevention projects and ongoing reuse/recycle projects at ORNL during 2019, eliminating more than 3 million kg of waste. An innovative project encompassed the effort to procure recycled-content carpet along with recycling old carpet back through the carpet manufacturer. That effort totally closes the recycling loop for carpeting material (Figure 5.6).

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UT Battelle, LLC: Project: Oak Ridge National Laboratory

for the reclamation of approximately 13,299
pounds of post-consumer carpet on 04/2019.

Your decision has helped to eliminate landfill waste. Your contribution of used carpet to our recycling program will help create new energy and/or new materials for future generations.

Thank you for supporting our commitment to Sustainability through Innovation™ the Shaw Green Edge®

Robert Chandler
Bob Chandler, Vice President, Shaw Industries, Inc.

May 13, 2019
date

Figure 5.6. Oak Ridge National Laboratory received an environmental stewardship carpet recycle certificate in 2019. Pallets of recycled carpet materials are shown in the photo

Sustainable Vehicle Fleet

ORNL recently transitioned to a General Services Administration leased fleet. This change in fleet management positions ORNL to replace older, less fuel-efficient vehicles with new alternative fuel vehicles (AFVs) at a faster rate. ORNL is now better aligned to comply with DOE guidance concerning sustainable fleet management requirements.

Fifty-two fleet vehicles were replaced over the past 3 years. Of those replacements, 46 were AFVs, and the remaining 6 had no alternative fuel options available. With these additions, approximately 75% of ORNL’s 466 vehicle fleet are AFVs, and 100% of light-duty vehicles operate on alternative fuels, exceeding DOE fleet management goals.

High-Performance Sustainable Buildings: Guiding Principles

In FY 2019, ORNL’s high-performance sustainable building (HPSB) inventory included a total of 20 buildings that are certified as having attained 100% of the current target for DOE Green Buildings as described in the HPSB *Guiding Principles for Sustainable Federal Building*s (CEQ 2016, FEMP 2020); i.e., the 20 buildings represent 15% of ORNL’s total site buildings that are applicable according to the guiding principles. In compliance with the most recently revised HPSB guiding principles, no contractor-owned leased facilities, as classified in the Facilities Information Management System (DOE 2020) were included in the total and percentage calculation for the target.

One of the ways that ORNL achieves HPSB success is through a long association with the US Green Building Council (USGBC) Leadership in Energy and Environmental Design (LEED) certification program. For example, ORNL's Research Support Center was awarded USGBC LEED Gold certification in FY 2019 because of performance improvements based on USGBC LEED criteria that were made in FY 2018. LEED Arc, a new USGBC LEED digital platform for performance data, was used to achieve certification. Arc allows buildings and spaces to connect to the built environment[1] in a new way and allows building managers to compare performance metrics and to apply green building strategies. It is a complement to LEED and other green building systems, standards, and protocols. The process uses real-time data to help measure, track, and improve building sustainability performance using a real-time performance metrics score. The platform creates a holistic view of sustainability efforts through five major categories: energy, water, waste, transportation, and human experience. Arc provides greater transparency to building occupants and operations managers through regularly updated data, so more informed decisions can be made for building operations.

Oak Ridge National Laboratory Commuting Options: EV Owners Club

ORNL is a leader in the region in promoting electric vehicle (EV) use and has been actively participating in regional workplace charging efforts. Currently ORNL manages 32 employee EV charging stations at SNS, NTRC, and ORNL's main campus. The program allows employees access to charging stations. In 2019 there were 71 members in the ORNL EV Owner's Club with access to charging station locations. Members pay an annual fee to join the club and can use the charging stations during work hours. Membership fees support the cost and maintenance of the EV chargers devoted to non-fleet charging. There are an additional five charging stations on the ORNL site devoted to fleet (government-owned) EVs.

Electronic Stewardship

Through ORNL property management and environmental management policies and procedures, 100 percent of used electronics are recycled or reused in accordance with environmentally sound disposition guidance. Options include transfer to other DOE contractors, nonprofit organizations, and educational institutions by means of programs such as the General Services Administration's Computers For Learning Program (found online here). Electronics that have reached end of life are recycled through a certified Responsible Recycling Practices recycler.

Sustainable ORNL Highlights and Achievements: FY 2019 Recognition and Award Submittals

ORNL received two awards for its sustainability efforts in FY 2019:

- **Tennessee Green Fleet Certification Award.** Tennessee Clean Fuels certified the ORNL fleet for its emission reductions via the "Tennessee Green Fleets" Certification Program.
- **2019 Tennessee Chamber of Commerce and Industry Environment and Energy Award.** ORNL received this award in the Energy Excellence category for "Innovatively Striving for the Highest Sustainable Level—Integrating LEED ARC into ORNL's HSPB Approach."

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[1] The term "built environment" refers to alterations in the surroundings that provide the setting for human activities (in this case work activity). The built environment can include buildings/facilities, transportation options, and landscaping and green spaces. The term often includes supporting infrastructure, such as water supply, or energy systems, and in this case waste disposal systems.

The DOE 50001 Ready Project was nominated for UT-Battelle Awards Night and will be included in the next DOE award nominations.

Three 2019 DOE Sustainability nominations were submitted to the Sustainability Performance Office:

- "ORNL Building 5200 LEED ARC and HPSB Approach" for the Innovative Approach to Sustainability Category
- "ORNL Water Use Efficiency; OTC Reduction for Research Systems (Building 4508)" for the Outstanding Sustainability Project Category
- "Driving Comprehensive National Sustainability through ORNL's Additive Manufacturing Strategic Partnerships" for the Strategic Partnerships for Sustainability Category

Employee Engagement

The integrated Sustainable ORNL program promotes employee engagement through announcements, promotions, and numerous activities, including the following activities during FY 2019:

- Submitting articles to *ORNL Today*, a web-based newsletter
- Submitting articles to the DOE *Sustainability SPOtlight* Newsletter
- Posting public relations information on Scala screens throughout the campus
- Launching and promoting a new web site (http://www.ornl.gov/sustainable-ornl)
- Holding quarterly workshops with Sustainable ORNL Roadmap owners
- Issuing quarterly updates to the ORNL leadership team
- Planning and delivering the Earth Day Campaign
- Managing and promoting the ORNL EV Owners Club (for use of EV charging stations)
- Managing and promoting bus service between the University of Tennessee, Knoxville; Pellissippi State Community College; and the ORNL main campus

5.2.1.5 Storm Water Management and the Energy Independence and Security Act of 2007

Section 438 of the Energy Independence and Security Act of 2007 (EISA 2007) stipulates the following:

> The sponsor of any development or redevelopment project involving a Federal facility with a footprint that exceeds 5,000 square feet shall use site planning, design, construction, and maintenance strategies for the property to maintain or restore, to the maximum extent technically feasible, the predevelopment hydrology of the property with regard to the temperature, rate, volume, and duration of flow. (EISA 2007)

For the purposes of this provision, "development or redevelopment" is defined as

> any action that results in the alteration of the landscape during construction of buildings or other infrastructure such as parking lots, roads, etc. (e.g., grading, removal of vegetation, soil compaction) such that the changes affect runoff volumes, rates, temperature, and duration of flow. Examples of projects that would fall under 'redevelopment' include structures or other infrastructure that are being reconstructed or replaced and the landscape is altered. Typical patching or resurfacing of parking lots or other travel areas would not fall under this requirement (EISA 2007).

Strategic plans for demolition and renovation of old facilities and construction of new facilities at ORNL incorporate green infrastructure and low-impact development (GI/LID) practices to infiltrate, evapotranspire, and/or harvest and use storm water on site to the maximum extent feasible. GI/LID approaches and technologies have been used to mimic the natural processes of the hydrologic cycle (infiltration, evapotranspiration, and use). The following GI/LID practices have been incorporated at ORNL:

- Trees and tree boxes
- Rain gardens
- Vegetated swales
- Pocket wetlands
- Infiltration planters
- Porous and permeable pavements
- Vegetated median strips
- Reforestation and revegetation
- Protection of riparian buffers and floodplains
- Retention ponds
- Water reuse (e.g., tanks in restrooms to collect water for reuse in irrigation)

A three-step approach is applied as needed to ensure that GI/LID practices at ORNL meet the requirements of EISA Section 438:

- If the necessary volume of runoff can be infiltrated or retained on site, practices are applied to manage the runoff within the project boundaries.
- If the necessary volume of runoff cannot be infiltrated or retained on site, practices are applied that include land immediately adjacent to the project boundaries.
- If the necessary volume of runoff cannot be infiltrated or retained on land immediately adjacent to the project boundaries, practices are applied that keep the runoff within the same valley or ridge area (e.g., within Bethel Valley if the project is within Bethel Valley; within Melton Valley if the project is within Melton Valley).

In addition to GI/LID practices, the projects may remove impervious areas and reestablish pervious areas to allow infiltration or evapotranspiration to occur.

5.2.1.6 Emergency Preparedness and Response

The UT-Battelle Emergency Management Program supplies the resources and capabilities to provide emergency preparedness services and, in the event of an accident, emergency response services. Emergency preparedness personnel perform hazard surveys and hazard assessments to identify potential emergency situations. Procedures and plans have been developed to prepare for and respond to a wide variety of potential emergency situations. Training is provided to ensure appropriate response and performance during emergency events. Frequent exercises and drills are scheduled to ensure the effective performance of the procedures and plans. An environmental subject matter expert is a member of the emergency response team and participates in drills and exercises to ensure that environmental requirements are met and that environmental impacts from an event and the response are mitigated.

5.2.1.7 Checking

Monitoring and Measurement

UT-Battelle has developed monitoring and measurement processes for each operation or activity that can have a significant adverse effect on the environment. Several SBMS subject areas include requirements for managers to establish performance objectives and indicators, conduct performance assessments to collect data and monitor progress, and evaluate the data to identify strengths and weaknesses in performance and areas for improvement.

UT-Battelle Environmental Management System Assessments

UT-Battelle uses several methods to evaluate compliance with legal and other environmental requirements. Most of the compliance evaluation activities are implemented through the EMS or participation in line-organization assessment activities. If a nonconformance were identified, the ORNL issues-management process requires that any regulatory or management system nonconformance be reviewed for cause and that corrective and/or preventive actions be developed. These actions would then be implemented and tracked to completion.

Environmental assessments that cover legal and other requirements are performed periodically. Additionally, management system owners are required to assess management system performance and to address issues identified from customer feedback, staff suggestions, and other assessment activities.

UT-Battelle also uses the results from numerous external compliance inspections conducted by regulators to verify compliance with requirements. In addition to regulatory compliance assessments, internal and external EMS assessments are performed annually to ensure that the UT-Battelle EMS continues to conform to ISO requirements. An independent internal audit conducted in 2019 verified that the EMS conforms to ISO 14001:2015. In addition to verifying conformance, these management system assessments also identify continual improvement opportunities.

5.2.2 Other Environmental Management System Assessments

5.2.2.1 Environmental Management System for the Transuranic Waste Processing Center

The National Sanitation Foundation, International Strategic Registrations, Ltd. (NSF-ISR) registered the TWPC EMS for activities to the ISO 14001:2015 standard (ISO 2015) in May 2017. The EMS is integrated with ISMS to provide a unified strategy for the management of resources, the control and reduction of risks, and the establishment and achievement of the organization’s ES&H goals. The EMS and ISMS are incorporated into the *Integrated Safety Management System Description* (BJC 2009), and a “plan-do-check-act” cycle is used for continual improvement in both. NSF-ISR conducted a recertification audit in April. No nonconformances or issues were identified, and several significant practices were noted.

The TWPC EMS incorporates applicable environmental laws, DOE orders, and other requirements (i.e., DOE directives and federal, state, and local laws) according to internal NWSol documentation that describes how the various requirements are incorporated into subject area documents (procedures and guidelines). The EMS assists NWSol line organizations in identifying and addressing environmental issues.

Environmental aspects are elements of an organization’s activities, products, or services that can interact with the environment. NWSol has identified environmental aspects associated with TWPC activities, products, and services at both the project and activity level and has identified waste management activities, air emissions, storm water contamination, pollution prevention, habitat alteration, and energy consumption as potentially having significant environmental impacts. Activities that are relative to any of those environmental aspects are carefully controlled to minimize or eliminate impacts to the environment. NWSol has established and implemented objectives and measurable performance indicators for the targets associated with the identified significant impacts.

The pollution prevention programs at TWPC involve waste reduction efforts and implementation of sustainable practices that reduce the environmental impacts of the activities conducted at TWPC. The TWPC EMS establishes annual goals and targets to reduce the impact of TWPC's environmental aspects.

NWSol has a well-established recycling program at TWPC and continues to identify new material-recycling streams and to expand the types of materials included in the program. Currently, recycle streams at TWPC range from office materials such as paper, aluminum cans, plastic drinking bottles, foam beverage cups, alkaline batteries, and toner cartridges to operations-oriented materials such as cardboard and batteries. The "single stream" recycling program established by NWSol allows the mixing of multiple types of recyclables and thus increases the amount of recyclable items and improves compliance.

"Environmentally preferable purchasing" is a term used to describe an organization's policy to reduce packaging and to purchase products made with recycled material or biobased materials and other environmentally friendly products. NWSol ensures that environmentally preferable products are purchased by incorporating the "green" procurement requirements in NWSol procurement procedures.

NWSol uses several methods to evaluate compliance with legal and other requirements. Most of these compliance evaluation activities are implemented by internal and external environmental and management assessment activities and by routine reporting and reviews. NWSol also uses the results from numerous external compliance inspections conducted by regulators and contractors to verify compliance with requirements.

5.2.2.2 Environmental Management System for Isotek

Isotek has developed and implemented an EMS for the U-233 Disposition Project that reflects the elements and framework found in the ISO14001:2004 standard (ISO 2004) and that satisfies the applicable requirements of DOE Order 450.1A, *Environmental Protection Program* (DOE 2008). The scope of the Isotek EMS is to achieve and demonstrate environmental excellence by identifying, assessing, and controlling the impact of Isotek activities and facilities on the environment. The EMS is designed to ensure compliance with environmental laws, regulations, and other applicable requirements and to improve effectiveness and efficiency, reduce costs, and earn and retain regulator and community trust. The Isotek EMS and ISMS are fully integrated.

Project procedures provide a systematic approach to integrating environmental considerations into all aspects of Isotek's activities at ORNL. The Isotek EMS includes a procedure for identifying environmental aspects associated with the U-233 Disposition Project and for determining whether those aspects can have significant environmental impacts. Isotek has identified radiological air emissions as the only environmental aspect of its operations that has potentially significant environmental impacts and has developed an environmental management plan with measurable objectives and targets to address that aspect. Isotek reviews environmental aspects, potential impacts, objectives, targets, and its environmental management plan at least annually and updates them as necessary.

The U-233 Disposition Project has a well-established recycling program that is implemented at all Isotek-managed facilities and includes Buildings 3017, 3019 Complex, 2026, and 3137 at ORNL and two off-site administrative offices in Oak Ridge. The materials currently recycled by Isotek include paper, cardboard, aluminum cans, plastic bottles, inkjet and toner cartridges, lamps, batteries, scrap metal, circuit boards, aerosol cans, and used oil.

To evaluate compliance with legal and other requirements, Isotek conducts an EMS audit every 3 years, annual management assessments, and periodic surveillances. Compliance with requirements is also evaluated through inspections performed by regulatory agencies. The results of the compliance evaluations are used for continual improvement of the EMS.

5.3 Compliance Programs and Status

During 2019 UT-Battelle, UCOR, NWSol, and Isotek operations were conducted to comply with contractual and regulatory environmental requirements. Table 5.1 presents a summary of environmental audits conducted at ORNL in 2019. The following discussions summarize the major environmental programs and activities carried out at ORNL during 2019 and provide an overview of the compliance status for the year.

Table 5.1. Summary of regulatory environmental audits, evaluations, inspections, and assessments conducted at Oak Ridge National Laboratory, 2019

Date	Reviewer	Subject	Issues
January 8	TDEC	Notice of Termination for Construction Storm Water Permit Coverage	0
February 11-13	EPA/TDEC	Unannounced EPA/TDEC RCRA Inspection (including UT-Battelle, TWPC, and UCOR)	2
February 26	City of Oak Ridge	CFTF Wastewater Inspection	0
March 25	KCDAQM	NTRC CAA Inspection	0
May 14	TDEC	NPDES Permit Inspection	0
August 22	TDEC	UST Compliance Inspection	1
September 27	City of Oak Ridge	CFTF Wastewater Inspection	0
October 24	TDEC	Annual CAA Inspection for ORNL and CFTF	0

Acronyms:
CAA = Clean Air Act
CFTF = Carbon Fiber Technology Facility
EPA = US Environmental Protection Agency
KCDAQM = Knox County Department of Air Quality Management
NPDES = National Pollutant Discharge Elimination System
NTRC = National Transportation Research Center
RCRA = Resource Conservation and Recovery Act
TDEC = Tennessee Department of Environment and Conservation
TWPC = Transuranic Waste Processing Center
UST = underground storage tank

5.3.1 Environmental Permits

Table 5.2 contains a list of environmental permits that were in effect in 2019 at ORNL.

Table 5.2. Environmental permits in effect at Oak Ridge National Laboratory in 2019

Regulatory driver	Permit title/description	Permit number	Owner	Operator	Responsible contractor
CAA	Title V Major Source Operating Permit, ORNL	571359	DOE	UT-B	UT-B
CAA	Operating Permit, NTRC	17-0941-R1	DOE	UT-B	UT-B
CAA	Operating Permit, NWSol	071009P	DOE	NWSol	NWSol
CAA	Construction Permit, 3525 Area Off Gas System	971543P	DOE	UT-B	UT-B
CAA	Operating Permit, NWSol emergency generators	071010P	DOE	NWSol	NWSol
CAA	Title V Major Source Operating Permit, ORNL	569768	DOE	UCOR	UCOR
CAA	Title V Major Source Operating Permit, Isotek	568276	DOE	Isotek	Isotek
CAA	Construction Permit, UCOR	974744	DOE	UCOR	UCOR
CWA	ORNL NPDES Permit (ORNL sitewide wastewater discharge permit)	TN0002941	DOE	DOE	UT-B, UCOR, NWSol
CWA	Industrial and Commercial User Waste Water Discharge Permit (CFTF)	1-12	UT-B	UT-B	UT-B
CWA	Tennessee Operating Permit, Holding Tank/Haul System for Domestic Wastewater	SOP-07014	UCOR	UCOR	UCOR
CWA	Tennessee Operating Permit (sewage)	SOP-02056	DOE	NWSol	NWSol
CWA	Construction Storm Water Permit—ROSC Building	TNR 135617	DOE	UT-B	UT-B
CWA	Construction Storm Water Permit— Leadership Imaging Facility Building	TNR 135602	DOE	UT-B	UT-B
CWA	Aquatic Resources Alteration Permit—Leadership Imaging Facility Building	ARAP - NR1803.153	DOE	UT-B	UT-B
CWA	Construction Storm Water Permit—ROSC Building	TNR135617	DOE	UT-B	UT-B
CWA	ARAP – General Permit for Maintenance of the Swan Pond Water Feature 5007	NR1903.038	DOE	UT-B	UT-B
RCRA	Hazardous Waste Transporter Permit	TN1890090003	DOE	DOE	UT-B, UCOR
RCRA	Hazardous Waste Corrective Action Permit	TNHW-164	DOE	DOE/all	DOE/all

Table 5.2. Environmental permits in effect at ORNL in 2019 (continued)

Regulatory driver	Permit title/description	Permit number	Owner	Operator	Responsible contractor
RCRA	Hazardous Waste Container Storage and Treatment Units	TNHW-145	DOE	DOE/ UCOR/ NWSol	UCOR/NWSol
RCRA	Hazardous and Mixed Waste Storage Permit	TNHW-178[a]	DOE	DOE/UT-B	UT-B

[a] Permit TNHW-134 was reissued as TNHW-178 on August 15, 2019.

Acronyms:
ARAP = Aquatic Resources Alteration Permit
CAA = Clean Air Act
CFTF = Carbon Fiber Technology Facility
CWA = Clean Water Act
DOE = US Department of Energy
ETTP = East Tennessee Technology Park
Isotek = Isotek Systems, LLC
NTRC = National Transportation Research Center
NWSol = North Wind Solutions, LLC
ROSC = Research Operations Support Center
RCRA = Resource Conservation and Recovery Act
UT-B = UT-Battelle, LLC

5.3.2 National Environmental Policy Act/National Historic Preservation Act

NEPA provides a means to evaluate the potential environmental impact of proposed federal activities and to examine alternatives to those actions. UT-Battelle, NWSol, and Isotek maintain compliance with NEPA using site-level procedures and program descriptions that establish effective and responsive communications with program managers and project engineers to establish NEPA as a key consideration in the formative stages of project planning. Table 5.3 summarizes NEPA activities conducted at ORNL during 2019.

Table 5.3. National Environmental Policy Act activities, 2019

Types of NEPA documentation	Number of instances
UT-Battelle, LLC	
Approved under general actions or generic CX determinations[a]	85
Project-specific CX determinations[b]	1
North Wind Solutions, LLC	
Approved under general actions[a] or generic CX determinations	1

[a] Projects that were reviewed and documented through the site NEPA compliance coordinator.

[b] Projects that were reviewed and approved through the DOE Site Office and the NEPA compliance officer.

Acronyms:
CX = categorical exclusion
DOE = US Department of Energy
NEPA = National Environmental Policy Act

During 2019, UT-Battelle and NWSol continued to operate under site-level procedures that provide requirements for project reviews and NEPA compliance. The procedures call for a review of each proposed project, activity, or facility to determine the potential for impacts to the environment. To streamline the NEPA review and documentation process, the DOE has approved generic categorical exclusion (CX) determinations that cover proposed bench-scale and pilot-scale research activities and generic CXs that cover proposed nonresearch activities (e.g., maintenance activities, facilities upgrades, personnel safety enhancements). A CX is one of a category of actions defined in 40 CFR 1508.4 that does not individually or cumulatively have a significant effect on the human environment and for which neither an environmental assessment nor an environmental impact statement is normally required.

UT-Battelle uses SBMS as the delivery system for guidance and requirements to manage and control work at ORNL. NEPA is an integral part of SBMS, and a UT-Battelle NEPA coordinator works with principal investigators, environmental compliance representatives, and environmental protection officers within each UT-Battelle division to determine appropriate NEPA decisions.

Compliance with the National Historic Preservation Act (1966) is achieved and maintained at ORNL in conjunction with NEPA compliance. The scope of proposed actions is reviewed in accordance with the ORR cultural resource management plan (Souza et al. 2001).

5.3.3 Clean Air Act Compliance Status

The Clean Air Act (CAA 1970), passed in 1970 and amended in 1977 and 1990, forms the basis for the national air pollution control effort. This legislation established comprehensive federal and state regulations to limit air emissions. It includes four major regulatory programs: the national ambient air quality standards, state implementation plans, new source performance standards, and Rad-NESHAPs. Airborne discharges from DOE Oak Ridge facilities, both radioactive and nonradioactive, are subject to regulation by the US Environmental Protection Agency (EPA) and the Tennessee Department of Environment and Conservation (TDEC) Division of Air Pollution Control. The most recent sitewide UT-Battelle Title V Major Source Operating Permit was issued in October 2018. The Title V Major Source Operating Permit for the 3039 stack, operated by UCOR, is scheduled for renewal in 2020. To demonstrate compliance with the Title V major source operating permits, more than 1,500 data points are collected and reported every year. In addition, nitrogen oxides (NO_x), a family of poisonous, highly reactive gases and defined collectively as a criteria pollutant by the EPA (EPA 2016), are monitored continuously at one location. Samples are collected continuously from 8 major radionuclide sources and periodically from 14 minor radionuclide sources. There are numerous other demonstrations of compliance with generally applicable air quality protection requirements (e.g., asbestos, stratospheric ozone).

NTRC and CFTF are two off-site CAA-regulated facilities maintained and operated by UT-Battelle. An operating permit, issued by Knox County for two emergency generators located at NTRC was pending issuance at the end of 2019. The new NTRC operating permit will be issued in 2020. The CFTF operates under two construction permits issued by TDEC. A permit application to convert them to a Conditional Major operating air permit was submitted in 2018 and was issued for draft review by UT-Battelle at the end of 2019. The final CFTF Condition Major operating permit will be issued in 2020.

In summary, there were no UT-Battelle CAA violations and no Isotek, UCOR, or NWSol CAA violations or exceedances in 2019. Section 5.4 provides detailed information on 2019 activities conducted by UT-Battelle in support of the CAA.

5.3.4 Clean Water Act Compliance Status

The objective of the Clean Water Act (CWA 1972) is to restore, maintain, and protect the integrity of the nation’s waters. The CWA serves as the basis for comprehensive federal and state programs to protect the nation’s waters from pollutants. (See Appendix C for water quality reference standards.) One of the strategies developed to achieve the goals of CWA was the EPA’s establishment of limits on specific pollutants allowed to be discharged to US waters by municipal sewage treatment plants (STPs) and industrial facilities. EPA established the National Pollutant Discharge Elimination System (NPDES) permitting program to regulate compliance with pollutant limitations. The program was designed to protect surface waters by limiting effluent discharges into streams, reservoirs, wetlands, and other surface waters. EPA has delegated authority for implementation and enforcement of the NPDES program to the State of Tennessee.

In 2019, compliance with the ORNL NPDES permit was determined by about 1,800 laboratory analyses and field measurements. ORNL wastewater treatment facilities achieved a >99 percent numeric permit compliance rate in 2019. A large storm in March 2019 caused heavy inflow into the ORNL STP, causing concentration and loading effluent limit numeric noncompliances for total suspended solids. There were two nonnumeric permit noncompliances in 2019; a total suspended solids sample and an oil and grease sample for Outfall X12 were not collected during the required quarterly reporting period. The samples were collected and reported during the next quarterly reporting period. A fish kill at Melton Branch also occurred in May 2019, and is discussed in more detail in Section 5.5.2.

The NPDES permit limit compliance rate for all discharge points for 2019 was > 99 percent.

ORNL received a renewed permit in May 2019. Several conditions in the permit were appealed and remained unresolved.

5.3.5 Safe Drinking Water Act Compliance Status

ORNL's water distribution system is designated as a "nontransient, noncommunity" water system by the TDEC Division of Water Supply. TDEC's water supply rules, Chapter 0400-45-01, "Public Water Systems" (TDEC 2019), set limits for biological contaminants and for chemical activities and chemical contaminants. TDEC requires sampling for the following constituents for compliance with state and federal regulations:

- Residual chlorine
- Bacteria (total coliform)
- Disinfectant by-product (trihalomethanes and haloacetic acids)
- Lead and copper (required once every 3 years)

The City of Oak Ridge supplies potable water to the ORNL water distribution system and meets all regulatory requirements for drinking water. The water treatment plant, located on ORR, north of the Y-12 Complex, is owned and operated by the City of Oak Ridge.

In 2019, sampling results for ORNL's water system residual chlorine levels, bacterial constituents, lead/copper, and disinfectant by-products were all within acceptable limits. Sampling for lead and copper will not be required again until 2021.

5.3.6 Resource Conservation and Recovery Act Compliance Status

The Hazardous Waste Program under the Resource Conservation and Recovery Act (RCRA 1976) establishes a system for regulating hazardous wastes from the initial point of generation through final disposal. In Tennessee, TDEC has been delegated authority by EPA to implement the Hazardous Waste Program; EPA retains an oversight role. In 2019, DOE and its contractors at ORNL were jointly regulated as a "large-quantity generator of hazardous waste" under EPA ID TN1890090003 because, collectively, they generated more than 1,000 kg of hazardous/mixed wastes in at least one calendar month during 2019.

Mixed wastes are both hazardous (under RCRA regulations) and radioactive. Hazardous/mixed wastes are accumulated in satellite accumulation areas or in less-than-90-day accumulation areas and are stored and/or treated in RCRA-permitted units. In addition, hazardous/mixed wastes are shipped off site for treatment and disposal. The RCRA units operate under three permits at ORNL, as shown in Table 5.4. In 2019, UT-Battelle and UCOR were permitted to transport hazardous wastes under the EPA ID number issued for ORNL activities. On September 15, 2015, the ORR Hazardous Waste Corrective Action Permit TNHW-121 was reissued as TNHW-164. TNHW-164 is a set of conditions pertaining to the current status of all solid waste management units (SWMUs) and areas of concern (AOCs) at East Tennessee Technology Park (ETTP), ORNL, and the Y-12 National Security Complex. The corrective action conditions require that the SWMUs and AOCs be investigated and, as necessary, remediated.

Reporting is required for hazardous waste activities on 12 active waste streams at ORNL, some of which are mixed wastes. The quantity of hazardous/mixed waste generated at ORNL in 2019 was 555,699 kg, with mixed wastewater accounting for 515,050 kg. ORNL generators treated 6,594 kg of hazardous/mixed waste by elementary neutralization, silver recovery, and deactivation. The quantity of hazardous/mixed waste treated in RCRA-permitted treatment facilities at ORNL in 2019 was 2,264 kg. This included waste treated by macroencapsulation, size reduction, stabilization/solidification, and wastewater treatment at the Process Waste Treatment Complex (PWTC). The amount of hazardous/mixed waste shipped off site to commercial treatment, storage, and disposal facilities was 220,539 kg in 2019.

Table 5.4. Oak Ridge National Laboratory Resource Conservation and Recovery Act operating permits, 2019

Permit number	Storage and treatment/description
	Oak Ridge National Laboratory
TNHW-178[a]	Building 7651 Container Storage Unit Building 7652 Container Storage Unit Building 7653 Container Storage Unit Building 7654 Container Storage Unit Portable Unit 2 Storage and Treatment Unit
TNHW-145	Portable Unit 1 Building 7572 Contact-Handled Transuranic Waste Storage Facility Building 7574 Transuranic Storage Facility Building 7855 Remote-Handled Transuranic Retrievable Storage Facility Building 7860A Remote-Handled Transuranic Retrievable Storage Facility Building 7879 Transuranic /Low Level Waste Storage Facility Building 7883 Remote-Handled Transuranic Storage Bunker Building 7831F Flammable Storage Unit[a] Transuranic Waste Processing Center (TWPC)-1 Contact-Handled Storage Area TWPC-2 Waste Processing Building Second Floor TWPC-3 Drum Aging Criteria Area TWPC-4 Waste Processing Building First Floor TWPC-5 Container Storage Area TWPC-6 Contact-Handled Marshaling Building TWPC-7 Drum-Venting Building TWPC-8 Multipurpose Building T-1[b] Macroencapsulation Treatment T-2[b] Solidification/Stabilization Treatment T-3[b] Amalgamation Treatment T-4[b] Groundwater Absorption Treatment T-5[b] Size Reduction T-6[b] Groundwater Filtration Treatment T-7[b] Neutralization T-8[b] Oxidation/Deactivation
	Oak Ridge Reservation
TNHW-164[c]	Hazardous Waste Corrective Action Document

[a] Permit TNHW-134 was reissued as TNHW-178 on August 15, 2019.
[b] Treatment methodologies within TWPC facilities.
[c] ORR Hazardous Waste Corrective Action Permit TNHW-121 was reissued as TNHW-164 on September 15, 2015.

In February 2019, TDEC Division of Solid Waste Management and the EPA conducted a Hazardous Waste Compliance Evaluation inspection of ORNL generator areas; universal waste collection areas; RCRA-permitted treatment, storage, and disposal facilities; hazardous waste training records; site-specific contingency plans; and RCRA records. TDEC also reviewed the Hazardous Waste Transporter Permit, hazardous waste manifests, and US Department of Transportation training records. Two violations were identified: (1) Two containers of broken waste lamps destined for disposal were being managed as universal waste and were not labeled "hazardous waste;" (2) during records review, three new-hire personnel failed to acquire hazardous waste training within 6 months of their date of employment. Both violations were corrected when identified, returning the facility to compliance, so no follow-up inspections were conducted.

In 2018 ORNL requested an EPA ID number for hazardous waste activities at 115A Union Valley Road in Oak Ridge. This is ORNL's property sales warehouse for excessing and surplus sales. A surplus piece of equipment was determined to have contamination and had to be disposed of as hazardous waste. The equipment weighed 1,391 kg, which qualified Property Sales as a large quantity generator for the onetime shipment. The EPA ID number was subsequently deactivated. On March 4, 2020, the TDEC Division of Solid Waste Management conducted a Hazardous Waste Compliance Evaluation inspection to confirm that the status of the property sales warehouse had returned to non-generator status. No violations were observed.

DOE and UT-Battelle operations at NTRC and CFTF were regulated as "conditionally exempt small-quantity generators" in 2019, meaning that less than 100 kg of hazardous waste was generated per month.

In 2019, no hazardous/mixed wastes were generated, accumulated, or shipped by DOE or UT-Battelle at the DOE Office of Scientific and Technical Information, or the 0800 Area.

In 2019 DOE and UT-Battelle submitted closure documentation for DOE Building 1916-T2.

ORNL submitted a RCRA permit application in 2018 to renew Permit TNHW-134. A new Permit TNHW-178 was issued by TDEC Division of Solid Waste Management on August 15, 2019.

5.3.7 Oak Ridge National Laboratory RCRA-CERCLA Coordination

The Federal Facility Agreement for the Oak Ridge Reservation (FFA) (DOE 2014) is intended to coordinate the corrective action processes of RCRA required under the Hazardous and Solid Waste Amendments permit with CERCLA response actions. Annual updates for 2018 for ORNL's SWMUs and AOCs were consolidated with updates for ETTP, the Y-12 Complex, and ORR and were reported to TDEC, DOE, and the EPA Region 4 in January 2019.

Periodic updates of proposed C&D activities of facilities at ORNL have been provided to managers and project personnel from the TDEC Remediation Division and EPA Region 4. A CERCLA screening process is used to identify proposed C&D projects and facilities that warrant CERCLA oversight. The goal is to ensure that modernization efforts do not adversely affect the effectiveness of previously completed CERCLA environmental remediation actions and that they do not adversely affect future CERCLA environmental remediation actions.

5.3.7.1 CERCLA Activities in Bethel Valley

In 2019, ORNL completed work on a CERCLA project initiated in 2018 to perform limited environmental remediation in the 3500 Area of the Central Campus to facilitate future brownfield redevelopment. Characterization of the area was completed in August 2018, and data were evaluated against remediation levels defined in the Bethel Valley Interim Record of Decision to identify required cleanup scope. An addendum to the approved Waste Handling Plan was developed and approved. Additionally, a technical memorandum (TM) was submitted and received regulatory approval in April 2019 as an appendix to the approved Remedial Design Report/Remedial Action Work Plan for Bethel

Valley Soils and Sediments to document the proposed remedial actions. In May 2019, a contractor was mobilized, and remedial actions and site restoration were completed in September 2019. Following completion of waste disposal, a phased construction completion report was developed and was submitted for regulatory approval in March 2020 to document completed actions, final waste volumes, and waste disposition.

5.3.7.2 Utilities Project Upgrade

In 2019, ORNL also initiated a utilities upgrade project to address the aging utilities services that provide electrical service and handle potable water, steam, storm water, and wastewater. Although utilities work is not typically performed under CERCLA and instead is considered routine maintenance and operations, the utilities upgrade projects are large-scale upgrades that may generate significant volumes of soils for disposition that may be contaminated from legacy R&D and may be remediated as a consequence of the utilities modernization efforts. Therefore, a TM was developed that addresses utilities modernization projects within ORNL Bethel Valley. The TM documents the process for characterization activities to be performed, data evaluation to be conducted to identify areas where contaminated soil will be removed to meet CERCLA requirements under the Bethel Valley Interim Record of Decision and the ORNL Soils and Sediments Remedial Design Report/Remedial Action Work Plan, and the estimated soil volumes to be removed and disposed under CERCLA at the Environmental Management Waste Management Facility (EMWMF). A phased construction completion report will be prepared following completion of ORNL Bethel Valley utilities upgrade projects to document the actual scope of soil removal, waste volumes, and disposal paths.

5.3.7.3 RCRA Underground Storage Tanks

Underground storage tanks (USTs) containing petroleum and hazardous substances are regulated under RCRA Subtitle I (40 CFR 280). TDEC has been granted authority by EPA to regulate USTs containing petroleum under TDEC Rule 400-18-01; however, hazardous-substance USTs are still regulated by EPA.

ORNL has two USTs registered with TDEC under Facility ID 0-730089. These USTs are in service (petroleum) and meet the current UST standards. A compliance inspection by TDEC occurred in August 2019. TDEC noted one violation for the gasoline tank, cathodic protection testing had been performed in an interval greater than 3 years [every 3 years required by TN Rule 0400-18-01-.02(4)(c)2(i)]. No corrective actions were needed, and no fines were assessed.

5.3.8 CERCLA Compliance Status

CERCLA, also known as Superfund, was passed in 1980 and was amended in 1986 by the Superfund Amendments and Reauthorization Act (SARA 1986). Under CERCLA, a site is investigated and remediated if it poses significant risk to health or the environment. The EPA National Priorities List (NPL) is a comprehensive list of sites and facilities that have been found to pose a sufficient threat to human health and/or the environment to warrant cleanup under CERCLA.

In 1989, ORR was placed on the EPA NPL. In 1992, the ORR FFA became effective among EPA, TDEC, and DOE and established the framework and schedule for developing, implementing, and monitoring remedial actions (RAs) on ORR. The on-site CERCLA Environmental Management Waste Management Facility (EMWMF) is operated by UCOR for DOE. Located in Bear Creek Valley, the EMWMF is used for disposal of waste resulting from CERCLA cleanup actions on ORR, including ORNL. The EMWMF is an engineered landfill that accepts low-level radioactive, hazardous, asbestos, and polychlorinated biphenyl (PCB) wastes and combinations of the wastes in accordance with specific waste acceptance criteria under an agreement with state and federal regulators.

5.3.9 Toxic Substances Control Act Compliance Status

PCB uses and waste at ORNL are regulated under the Toxic Substance Control Act (TSCA). PCB waste generation, transportation, and storage at ORNL are reported under EPA ID TN1890090003. In 2019, UT-Battelle operated nine PCB waste storage areas. When longer-term storage was necessary, PCB/radioactive wastes were stored in RCRA-permitted storage buildings at ORNL. One of the PCB waste storage areas was operated at a UT-Battelle facility in the Y-12 Complex. The continued use of authorized PCBs in electrical systems and/or equipment (e.g., transformers, capacitors, rectifiers) is regulated at ORNL. Most of the equipment at ORNL that required regulation under TSCA has been dispositioned. However, some of the ORNL facilities at the Y-12 Complex continue to use (or store for future reuse) PCB equipment.

Because of the age of many of the ORNL facilities and the continued presence of PCBs in gaskets, grease, building construction, and equipment, DOE self-disclosed unauthorized use of PCBs to EPA in the late 1980s. As a result, DOE and ORNL contractors negotiated a compliance agreement with EPA (see Chapter 2, Table 2.1, under "Toxic Substances Control Act") to address the compliance issues related to these unauthorized uses and to allow for continued use pending decontamination or disposal. As a result of that agreement, DOE continues to notify EPA when additional unauthorized uses of PCBs, such as PCBs in paint, adhesives, electrical wiring, or floor tile, are identified at ORNL. No new unauthorized uses of PCBs were identified during 2019.

5.3.10 Emergency Planning and Community Right-to-Know Act Compliance Status

The Emergency Planning and Community Right-to-Know Act (EPCRA 1986) and Title III of SARA require that facilities report inventories and releases of certain chemicals that exceed specific release thresholds. The inventory report is submitted to the University of Texas at Dallas (UT-Dallas) Emergency Response Information System (E-Plan), which is an electronic database managed by UT-Dallas and funded by the US Department of Homeland Security. The State of Tennessee Emergency Response Commission has access to ORNL EPCRA data via the E-Plan system.

Table 5.5 describes the main elements of EPCRA. UT-Battelle complied with these requirements in 2019 through the submittal of reports under EPCRA Sections 302, 303, 311, 312, and 313. The reports contain information on all DOE prime contractors and their subcontractors who reported activities at the ORNL site.

Table 5.5. Main elements of the Emergency Planning and Community Right-to-Know Act

Title	Description
Sections 302 and 303, Planning Notification	Requires that local planning committee and state emergency response commission be notified of EPCRA-related planning
Section 304, Extremely Hazardous Substance Release Notification	Addresses reporting to state and local authorities of off-site releases
Sections 311–312, Material Safety Data Sheet/Chemical Inventory	Requires that either safety data sheets or lists of hazardous chemicals for which they are required be provided to state and local authorities for emergency planning. Requires that an inventory of hazardous chemicals maintained in quantities over thresholds be reported annually to EPA
Section 313, Toxic Chemical Release Reporting	Requires that releases of toxic chemicals be reported annually to EPA

Acronyms:
EPA = US Environmental Protection Agency
EPCRA = Emergency Planning and Community Right-to-Know Act

ORNL had no releases of extremely hazardous substances, as defined by EPCRA, in 2019. Releases of toxic chemicals that were greater than the Section 313 designated reportable threshold quantities are discussed in Section 5.3.10.2.

5.3.10.1 Safety Data Sheet/Chemical Inventory (Section 312)

Inventories, locations, and associated hazards of hazardous chemicals and/or extremely hazardous substances were submitted in an annual report to the E-Plan as required by the State of Tennessee. In 2019, there were 27 hazardous and/or extremely hazardous substances at ORNL that met EPCRA reporting criteria.

Private-sector lessees were not included in the 2019 submittals. Under the terms of their leases, lessees must evaluate their own inventories of hazardous and extremely hazardous chemicals and must submit information as required by the regulations.

5.3.10.2 Toxic Chemical Release Reporting (EPCRA Section 313)

DOE submits annual toxic release inventory reports to EPA and the Tennessee Emergency Management Agency on or before July 1 of each year. The reports cover the previous calendar year and track the management of certain chemicals that are released to the environment and/or managed through recycling, energy recovery, and treatment. (A “release” of a chemical means that it is emitted to the air or water or that it is placed in some type of land disposal.) Operations involving certain chemicals were compared with regulatory reporting thresholds to determine which chemicals exceeded individual thresholds on amounts manufactured, amounts processed, or amounts otherwise used. Releases and other waste management activities were determined for each chemical that exceeded one or more threshold.

For 2019, ORNL exceeded the reporting threshold and reported on the otherwise use of nitric acid and the manufacture of nitrate compounds. Most of the nitric acid was used in wastewater treatment operations at the PWTC. Nitrate compounds were coincidentally manufactured as by-products of neutralizing the nitric acid waste and as by-products of on-site sewage treatment.

5.3.11 US Department of Agriculture/Tennessee Department of Agriculture

USDA, through Animal and Plant Health Inspection Services, issues permits for the import, transit, and controlled release of regulated animals, animal products, veterinary biologics, plants, plant products, pests, organisms, soil, and genetically engineered organisms. The Tennessee Department of Agriculture issues agreements and jointly regulates domestic soil. In 2019, UT-Battelle personnel had 19 permits and agreements for the receipt, movement, or controlled release of regulated articles.

5.3.12 Wetlands

Wetland delineations of potential project sites are conducted to facilitate compliance with TDEC and US Army Corps of Engineers wetlands protection requirements. Although no official delineations were conducted in 2019, sensitive resource surveys and knowledge of previous delineations provided general locations of wetlands to project managers. Assessing the potential for jurisdictional wetlands during the site selection process and early planning stages can help projects reduce wetland impacts, design changes, and mitigation costs.

5.3.13 Radiological Clearance of Property at Oak Ridge National Laboratory

DOE Order 458.1, *Radiation Protection of the Public and the Environment* (DOE 2011c), established standards and requirements for operations of DOE and its contractors with respect to protection of members of the public and the environment against undue risk from radiation. In addition to discharges to the environment, the release of property containing residual radioactive material is a potential contributor to the dose received by the public, and DOE Order 458.1 established requirements for clearance of property from DOE control and for public notification of clearance of property.

5.3.13.1 Graded Approach to Evaluate Material and Equipment for Release

At ORNL, UT-Battelle uses a graded approach for release of material and equipment for unrestricted public use. Material that may be released to the public has been categorized so that in some cases an administrative release can be accomplished without a radiological survey. Such material originates from nonradiological areas and includes items such as the following:

- Documents, mail, diskettes, compact disks, and other office media
- Nonradioactive items or materials received that are immediately (within the same shift) determined to have been delivered in error or damaged
- Personal items or materials
- Paper, plastic products, aluminum beverage cans, toner cartridges, and other items released for recycling
- Office trash
- Housekeeping materials and associated waste
- Breakroom, cafeteria, and medical wastes
- Compressed gas cylinders and fire extinguishers
- Medical and bioassay samples
- Other items with an approved release plan

Items that are not in the listed categories and that originate from nonradiological areas within ORNL’s controlled areas are surveyed before release to the public, or a process knowledge evaluation is conducted to ensure that the material has not been exposed to radioactive material or beams of radiation capable of creating radioactive material. In some cases, both a radiological survey and a process knowledge evaluation are performed (e.g., a radiological survey is conducted on the outside of the item, and a process knowledge form is signed by the custodian for inaccessible surfaces). A similar approach is used for material released to state-permitted landfills on ORR. The only exception is for items that could be internally contaminated; those items are also sampled by laboratory analysis to ensure that landfill permit criteria are met.

When the process knowledge approach is used, the item’s custodian is required to sign a statement that specifies that the history of the item or material is known and that the material is known to be free of contamination. This process knowledge certification is more stringent than what is allowed by DOE Order 458.1 (DOE 2011c) in that ORNL requires an individual to take personal responsibility and accountability for knowing the complete history of an item before it can be cleared using process knowledge alone. DOE Order 458.1 allows use of procedures for evaluating operational records and operating history to make process knowledge release decisions, but UT-Battelle has chosen to continue to require personal certification of the status of an item. This requirement ensures that each individual certifying the item is aware of the significance of this decision and encourages the individual to obtain a survey of the item if he or she is not confident that the item can be certified as being free of contamination.

A survey and release plan may be developed to direct the radiological survey process for large recycling programs or for clearance of bulk items with low contamination potential. For such projects, survey and release plans are developed based on guidance from the *Multi-Agency Radiation Survey and Site Investigation Manual* (MARSSIM) (NRC 2000) or the *Multi-Agency Radiation Survey and Assessment of Materials and Equipment Manual* (MARSAME) (NRC 2009). MARSSIM and MARSAME allow for statistically based survey protocols that typically require survey measurements for a representative portion of the items being released. The survey protocols are documented in separate survey and release plans, and the measurements from such surveys are documented in radiological release survey reports.

In accordance with DOE Order 458.1 Section k.(6)(f)2 b, "Pre-Approved Authorized Limits," UT Battelle continues to use the preapproved authorized limits for surface contamination originally established in Table IV-1 of DOE Order 5400.5 (cancelled in 2011) and the November 17, 1995, Pelletier memorandum (Pelletier 1995) for TRU alpha contamination. UT-Battelle also continues to follow the requirements of the scrap metal suspension. No scrap metal directly released from radiological areas is being recycled. In 2018, UT-Battelle cleared more than 20,000 items through the excess items and property sales processes. A summary of items requested for release through these processes is shown in Table 5.6.

Table 5.6. Excess items requested for release and/or recycling, 2019

Item	Process knowledge	Radiologically surveyed
	Release request totals for 2019	
Totals	16,885	1,811
	Recycling request totals for 2019	
Cardboard (tons)	194.31	
Scrap metal (nonradiological areas) (tons)	602.42	

5.3.13.2 Authorized Limits Clearance Process for Spallation Neutron Source and High Flux Isotope Reactor Neutron Scattering Experiment Samples

The SNS and HFIR facilities provide unique neutron scattering experiment capabilities that allow researchers to explore the properties of various materials by exposing samples to well-characterized neutron beams. Because materials exposed to neutrons can become radioactive, a process has been developed to evaluate and clear samples for release to off-site facilities. DOE regulations and orders governing radiological release of material do not specifically cover items that may have radioactivity distributed throughout the volume of the material. To address sample clearance, activity-based limits were established using the authorized limits process defined in DOE Order 458.1 (DOE 2011c) and associated guidance. The sample clearance limits are based on an assessment of potential doses against a threshold of 1 mrem/year to an individual and evaluation of other potentially applicable requirements (e.g., Nuclear Regulatory Commission [NRC]) licensing regulations). Implementation of the clearance limits involves use of unique instrument screening and methods for prediction of sample activity to provide an efficient and defensible process to release neutron scattering experiment samples to researchers without further DOE control.

In 2019 ORNL cleared a total of 83 samples from neutron scattering experiments using the sample authorized limits process. Of these, 73 samples were from SNS and 10 were from HFIR.

5.4 Air Quality Program

5.4.1 Construction and Operating Permits

Permits issued by the State of Tennessee convey the clean air requirements that are applicable to ORNL. New projects are governed by construction permits until the projects are converted to operating status.

The sitewide Title V Major Source Operating Permits include requirements that are generally applicable to large operations such as national laboratories (e.g., asbestos and stratospheric ozone) as well as specific requirements directly applicable to individual air emission sources. Source-specific requirements include Rad-NESHAPs (see Section 5.4.3), requirements applicable to sources of radiological air pollutants, and requirements applicable to sources of other hazardous (nonradiological) air pollutants. In August 2017, the State of Tennessee issued Title V Major Source Operating Permit 571359 to DOE and UT-Battelle for operations at ORNL. DOE and UT-Battelle also maintained a valid minor source operating permit with the Knox County Department of Air Quality Management Division for NTRC facilities located in Knox County.

The CFTF was constructed at an off-site location in the Horizon Center Business Park in Oak Ridge, Tennessee. UT-Battelle applied for and received two construction permits for construction of the CFTF (Permit No. 965013P in 2012 and Permit No. 967180P in 2014). The initial start-up of the CFTF occurred in March 2013. A Conditional Major Source Operating Permit for the facility will be issued in 2020.

DOE/NWSol has two non-Title V Major Source Operating Permits for one emission source and two emergency generators at TWPC. During 2019 no permit limits were exceeded. Isotek has a Title V Major Source Operating Permit (568276) for the Radiochemical Development Facility (Building 3019 complex). During 2019 no permit limits were exceeded. UCOR was issued a Title V Major Source Operating Permit (569768) on September 18, 2015, for the Building 3039 Process Off-Gas and Hot Cell Ventilation System. Construction Permit 974744 was issued on November 19, 2018, to implement several proposed modifications to the Title V Operating Permit, and Significant Modification #1 to the Title V Operating Permit was issued on April 5, 2019, incorporating those modifications. During 2019 no permit limits were exceeded.

5.4.2 National Emission Standards for Hazardous Air Pollutants—Asbestos

Numerous facilities, structures, and facility components and various pieces of equipment at ORNL contain asbestos-containing material (ACM). UT-Battelle's Asbestos Management Program manages the compliance of work activities involving the removal and disposal of ACM, which include notifications to TDEC for all demolition activities and required renovation activities, approval of asbestos work authorization requests, current use of engineering controls and work practices, inspections, air monitoring, and waste tracking of asbestos-contaminated waste material. During 2019 there were no deviations or releases of reportable quantities of ACM.

5.4.3 Radiological Airborne Effluent Monitoring

Radioactive airborne discharges at ORNL are subject to Rad-NESHAPs and consist primarily of ventilation air from radioactively contaminated or potentially contaminated areas, vents from tanks and processes, and ventilation for hot cell operations and reactor facilities. The airborne emissions are treated and then filtered with high-efficiency particulate air filters and/or charcoal filters before discharge. Radiological airborne emissions from ORNL consist of solid particulates, tritium, adsorbable gases (e.g., iodine), and nonadsorbable gases (e.g., noble gases).

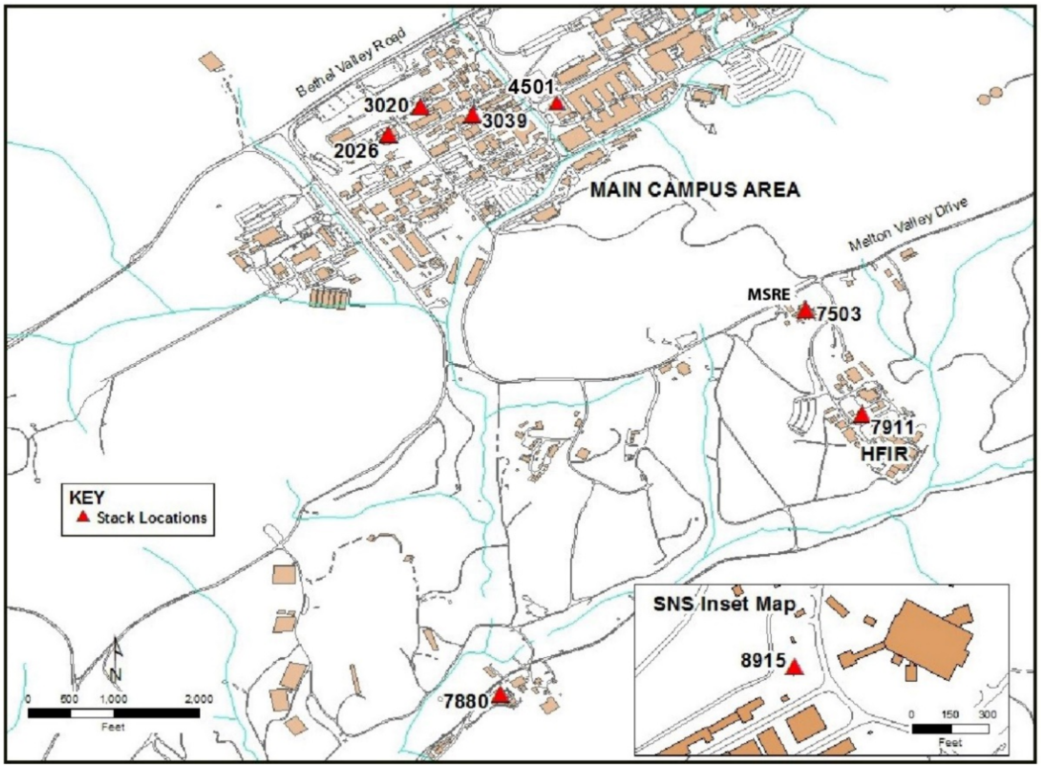
The major radiological emission point sources for ORNL consist of the following eight stacks. Seven are located in Bethel and Melton Valleys, and one, the SNS Central Exhaust Facility stack, is located on Chestnut Ridge (Figure 5.7):

- 2026 Radioactive Materials Analytical Laboratory
- 3020 Radiochemical Development Facility

- 3039 central off-gas and scrubber system, which includes the 3500 cell ventilation system, isotope area cell ventilation system, 3025/3026 cell ventilation system, 3042 ventilation system, and 3092 central off-gas system
- 4501 Radiochemistry Laboratory Area Off-Gas System
- 7503 Molten Salt Reactor Experiment Facility (MSRE)
- 7880 TWPC
- 7911 Melton Valley complex, which includes HFIR and the Radiochemical Engineering Development Center
- 8915 SNS Central Exhaust Facility stack

In 2019 there were 14 minor point/group sources, and emission calculations/estimates were made for each of them.

ORNL 2020-G00518/mhr



Acronyms:
HFIR = High Flux Isotope Reactor
MSRE = Molten Salt Reactor Experiment
SNS = Spallation Neutron Source

Figure 5.7. Locations of major radiological emission points at Oak Ridge National Laboratory, 2019

5.4.3.1 Sample Collection and Analytical Procedure

Four of the major point sources (stacks 2026, 3020, 3039, and 7503) are equipped with in-stack source-sampling systems that comply with criteria in the American National Standards Institute (ANSI) standard ANSI N 13.1-1969R (ANSI 1969). The sampling systems generally consist of a multipoint in-stack sampling probe, a sample transport line, a particulate filter, activated charcoal cartridges (or canister), a silica gel cartridge (if required), flow-measurement and totalizing instruments, a sampling pump, and a return line to the stack. The 4501 (Radiochemistry Laboratory), 7911 (Melton Valley complex), and the 7880 (TWPC) stacks are equipped with in-stack source-sampling systems that comply with criteria in the ANSI–Health Physics Society standard ANSI/HPS N13.1-1999 (ANSI 1999).

The 4501 and 7911 sampling systems have the same components as the ANSI 1969 sampling systems used for the four major point sources but use a stainless-steel-shrouded probe instead of a multipoint in-stack sampling probe. The 7911 sampling system also consists of a high-purity germanium detector with an analog-to-digital converter and ORTEC GammaVision software, which allows for continuous isotopic identification and quantification of radioactive noble gases (e.g., ^{41}Ar) in the effluent stream. The 7880 sampling system consists of a stainless-steel-shrouded probe, an in-line filter-cartridge holder placed at the probe to minimize line losses, a particulate filter, a sample transport line, a rotary vane vacuum pump, and a return line to the stack. The sample probes from both the ANSI 1969 and ANSI 1999 stack-sampling systems are removed, inspected, and cleaned annually. The SNS Central Exhaust Facility (8915) stack is equipped with an in-stack radiation detector that complies with criteria in ANSI/HPS N13.1-1999 (ANSI 1999). The detector monitors radioactive gases flowing through the exhaust stack and provides a continual readout of activity detected by a scintillator probe. The detector is calibrated to correlate with isotopic emissions.

Velocity profiles are performed quarterly at major sources (except for the 3039 stack) and at some minor sources; the criteria in EPA Method 2 (EPA 2010) are followed. The profiles provide accurate stack flow data for subsequent emission-rate calculations. An annual leak-check program is carried out to verify the integrity of the sample transport system. An annual comparison is performed for the 7880 stack between the effluent flow rate totalizer and EPA Method 2. The response of the stack effluent-flow-rate monitoring system is checked quarterly with the manufacturer’s instrument test procedures. The stack sampler rotameter is calibrated at least quarterly in comparison with a secondary (transfer) standard. Only a certified secondary standard is used for all rotameter tests.

Starting in 2017, the 3039 emissions are calculated using a fixed stack flow rate. A fixed stack flow rate is used because the stack velocity at the sampling level is at or below the sensitivity of standard methods for measuring the velocity and therefore stack flow rates can no longer be determined. Low effluent velocity measurements are due to stack flow reductions resulting from the removal of facilities exhausting through the stack. The EPA Region 4 office approved a request to use an alternative fixed stack flow for emission calculations for the 3039 stack in a letter dated April 27, 2017 (V. Anne Heard, Acting Regional Administrator, United States Environmental Protection Agency Region 4 to Raymond J. Skwarek, Environmental Safety, Health and Quality Assurance Manager, UCOR, April 27, 2017).

In addition to the major sources, ORNL has several minor sources that have the potential to emit radionuclides to the atmosphere. A minor source is defined as any ventilation system or component such as a vent, laboratory hood, room exhaust, or stack that does not meet the approved regulatory criteria for a major source but that is located in or vents from a radiological control area as defined by Radiological Support Services of the UT-Battelle Nuclear and Radiological Protection Division. Various methods are used to determine the emissions from the various minor sources. Methods used for calculations of minor source emissions comply with EPA criteria. The minor sources are evaluated on a 1- to 5-year basis. Major and minor emissions are compiled annually to determine the overall ORNL source term and associated dose.

The charcoal cartridges/canisters, particulate filters, and silica-gel traps are collected weekly to biweekly. The use of charcoal cartridges (or canisters) is a standard method for capturing and quantifying radioactive iodine in airborne emissions. Gamma spectrometric analysis of the charcoal samples quantifies the adsorbable gases. Analyses are performed weekly to biweekly. Particulate filters are held for 8 days before a weekly gross alpha and gross beta analysis to minimize the contribution from short-lived isotopes such as ^{220}Rn and its daughter products. At stack 7911, a weekly gamma scan is conducted to better detect short-lived gamma isotopes. The filters are then composited quarterly or semiannually and are analyzed for alpha-, beta-, and gamma-emitting isotopes. At stack 7880, the filters are composited monthly and analyzed for alpha-, beta-, and gamma-emitting isotopes. The sampling system on stack 7880 requires no other type of radionuclide collection media. Compositing provides a better opportunity for quantification of the low-concentration isotopes. Silica-gel traps are used to capture water vapor that may contain tritium. Analysis is performed weekly to biweekly. At the end of the year, the sample probes for all of the stacks are rinsed, except for the 8915 and 7880 probes, and the rinsate is collected and submitted for isotopic analysis identical to that performed on the particulate filters. A probe-cleaning program has been determined unnecessary for 8915 because the sample probe is a scintillator probe used to detect radiation and not to extract a sample of stack exhaust emissions. It is not anticipated that contaminant deposits would collect on the scintillator probe. A probe-cleaning program for 7880 has established that rinse analysis historically showed no detectable contamination. Therefore, the frequency of probe rinse collection and analysis is no more often than every 3 years unless there is an increase in particulate emissions, an increase in detectable radionuclides in the sample media, or process modifications.

The data from the charcoal cartridges (or canisters), silica gel, probe wash, and filter composites are compiled to give the annual emissions for each major source and some minor sources.

5.4.3.2 Results

Annual radioactive airborne emissions for ORNL in 2019 are presented in Table 5.7. All data presented were determined to be statistically different from zero at the 95 percent confidence level. Any number not statistically different from zero was not included in the emission calculation. Because measuring a radionuclide requires counting random radioactive emissions from a sample, the same result may not be obtained if the sample is analyzed repeatedly. This deviation is referred to as the “counting uncertainty.” Statistical significance at the 95 percent confidence level means that there is a 5 percent chance that the results could be erroneous.

Historical trends for tritium (^{3}H) and ^{131}I are presented in Figures 5.8 and 5.9. For 2019, tritium emissions totaled about 1,046 Ci (Figure 5.8), comparable to what was seen in 2016; ^{131}I emissions totaled 0.08 Ci (Figure 5.9), a significant decrease from 2017 but comparable to what was seen in 2018. For 2019, of the 317 radionuclides (excluding radionuclides with multiple solubility type) released from ORNL operations and evaluated, the isotopes that contributed 10% or more to the off-site dose from ORNL included ^{212}Pb, which contributed about 40%, ^{232}Th, which contributed about 22%, and ^{138}Cs, which contributed about 15% to the total ORNL dose. Emissions of ^{212}Pb and ^{232}Th result from research activities and from the radiation decay of legacy material stored on site and areas containing isotopes of ^{228}Th, ^{232}Th, and ^{232}U. Emissions of ^{212}Pb were from the following stacks: 2026, 3020, 3039, 4501, 7503, 7856, 7911, and the 3000 and 4000 area laboratory hoods. Cesium-138 and ^{41}Ar emissions result from Radiochemical Engineering Development Center research activities and HFIR operations. For 2019, ^{212}Pb emissions totaled 6.47 Ci, ^{138}Cs emissions totaled 1,090 Ci, and ^{41}Ar emissions totaled 462 Ci (see Figure 5.10).

The calculated radiation dose to the maximally exposed individual (MEI) from all radiological airborne release points at ORR during 2019 was 0.4 mrem. The dose contribution to the MEI from all ORNL radiological airborne release points was 1 percent of the ORR dose. This dose is well below the Rad-NESHAPs standard of 10 mrem and is equal to approximately 0.10 percent of the roughly 300 mrem that the average individual receives from natural sources of radiation. (See Section 7.1.2 for an explanation of how the airborne radionuclide dose was determined.)

Table 5.7. Radiological airborne emissions from all sources at Oak Ridge National Laboratory, 2019 (Ci)[a]

Isotope	Inhalation form[b]	Chemical form	Stack									
			X-2026	X-3020	X-3039	X-4501	X-7503	X-7880	X-7911	X-8915	Total minor sources	ORNL total
^{225}Ac	M	particulate									2.18E-06	2.18E-06
^{226}Ac	M	particulate									1.07E-07	1.07E-07
^{227}Ac	M	particulate									1.86E-08	1.86E-08
^{228}Ac	M	particulate									1.6E-27	1.6E-27
^{106}Ag	M	particulate									7.E-34	7.E-34
^{108}Ag	B	unspecified									1.94E-20	1.94E-20
^{108m}Ag	M	particulate									3.67E-14	3.67E-14
^{109m}Ag	B	unspecified									9.79E-21	9.79E-21
^{110}Ag	B	unspecified									3.1E-15	3.1E-15
^{110m}Ag	M	particulate									1.67E-09	1.67E-09
^{111}Ag	M	particulate									4.23E-06	4.23E-06
^{112}Ag	M	particulate									5.62E-08	5.62E-08
^{241}Am	F	particulate			1.03E-07		9.31E-09	3.59E-07			3.24E-09	4.75E-07
^{241}Am	M	particulate	3.81E-08	4.93E-07		5.53E-10			1.4E-08		6.4E-07	1.19E-06
^{242}Am	M	particulate									3.59E-10	3.59E-10
^{242m}Am	M	particulate									3.62E-10	3.62E-10
^{243}Am	M	particulate									2.11E-08	2.11E-08
^{245}Am	M	particulate									3.29E-27	3.29E-27
^{246}Am	M	particulate									3.98E-32	3.98E-32
^{39}Ar	B	unspecified									1.25E-10	1.25E-10
^{41}Ar	B	unspecified							4.43E+02	1.9E+01		4.62E+02
^{217}At	B	unspecified									9.05E-24	9.05E-24
^{131}Ba	M	particulate									2.15E-06	2.15E-06
^{133}Ba	M	particulate									2.65E-05	2.65E-05
^{136m}Ba	M	particulate									8.34E-22	8.34E-22
^{137m}Ba	B	unspecified									2.82E-06	2.82E-06

Table 5.7. Radiological airborne emissions from all sources at ORNL, 2019 (Ci)[a] (continued)

Isotope	Inhalation form[b]	Chemical form	Stack									
			X-2026	X-3020	X-3039	X-4501	X-7503	X-7880	X-7911	X-8915	Total minor sources	ORNL total
^{139}Ba	M	particulate							3.02E-01			3.02E-01
^{140}Ba	M	particulate							5.57E-04		7.28E-07	5.58E-04
^{7}Be	M	particulate	2.57E-07	4.28E-07		9.69E-07					6.64E-06	8.29E-06
^{7}Be	S	particulate			7.34E-06		7.71E-08				2.79E-06	1.02E-05
^{10}Be	M	particulate									9.67E-20	9.67E-20
^{206}Bi	M	particulate									3.21E-07	3.21E-07
^{208}Bi	B	unspecified									5.14E-35	5.14E-35
^{209}Bi	B	unspecified									1.25E-42	1.25E-42
^{210}Bi	M	particulate									7.8E-25	7.8E-25
^{210m}Bi	M	particulate									3.34E-35	3.34E-35
^{211}Bi	B	unspecified									5.82E-11	5.82E-11
^{212}Bi	M	particulate									4.14E-07	4.14E-07
^{213}Bi	M	particulate									9.06E-24	9.06E-24
^{214}Bi	M	particulate									1.3E-23	1.3E-23
^{249}Bk	M	particulate									7.E-11	7.E-11
^{250}Bk	M	particulate									8.75E-29	8.75E-29
^{82}Br	M	particulate									6.58E-08	6.58E-08
^{11}C	G	dioxide								1.35E+04		1.35E+04
^{14}C	M	particulate									2.74E-11	2.74E-11
^{45}Ca	M	particulate									1.16E-09	1.16E-09
^{47}Ca	M	particulate									1.08E-10	1.08E-10
^{109}Cd	M	particulate									1.59E-11	1.59E-11
^{113}Cd	M	particulate									3.18E-30	3.18E-30
^{113m}Cd	M	particulate									1.27E-10	1.27E-10
^{115}Cd	M	particulate									1.16E-06	1.16E-06
^{115m}Cd	M	particulate									8.84E-17	8.84E-17
^{139}Ce	M	particulate									2.26E-08	2.26E-08

Table 5.7. Radiological airborne emissions from all sources at ORNL, 2019 (Ci)[a] (continued)

Isotope	Inhalation form[b]	Chemical form	Stack									
			X-2026	X-3020	X-3039	X-4501	X-7503	X-7880	X-7911	X-8915	Total minor sources	ORNL total
^{141}Ce	M	particulate							2.43E-07		5.44E-07	7.87E-07
^{142}Ce	M	particulate									8.26E-27	8.26E-27
^{143}Ce	M	particulate									8.38E-08	8.38E-08
^{144}Ce	M	particulate									5.47E-07	5.47E-07
^{249}Cf	M	particulate									1.11E-11	1.11E-11
^{250}Cf	M	particulate									2.44E-11	2.44E-11
^{251}Cf	M	particulate									1.86E-13	1.86E-13
^{252}Cf	M	particulate							1.13E-08		4.53E-08	5.66E-08
^{253}Cf	M	particulate									2.42E-32	2.42E-32
^{254}Cf	M	particulate									4.26E-30	4.26E-30
^{36}Cl	M	particulate									5.64E-14	5.64E-14
^{241}Cm	M	particulate									1.57E-22	1.57E-22
^{242}Cm	M	particulate									1.47E-11	1.47E-11
^{243}Cm	F	particulate						8.70E-08			3.58E-10	8.74E-08
^{243}Cm	M	particulate	6.55E-08								2.92E-07	3.58E-07
^{244}Cm	F	particulate						8.70E-08			3.58E-10	8.74E-08
^{244}Cm	M	particulate	6.55E-08								4.34E-06	4.41E-06
^{245}Cm	M	particulate									5.46E-09	5.46E-09
^{246}Cm	M	particulate									4.76E-09	4.76E-09
^{247}Cm	M	particulate									1.41E-11	1.41E-11
^{248}Cm	M	particulate									2.51E-09	2.51E-09
^{249}Cm	M	particulate									7.53E-35	7.53E-35
^{250}Cm	M	particulate									2.95E-32	2.95E-32
^{57}Co	M	particulate									2.59E-09	2.59E-09
^{58}Co	M	particulate									2.08E-11	2.08E-11
^{60}Co	S	particulate			6.72E-06							6.72E-06
^{60}Co	M	particulate									7.09E-07	7.09E-07

Table 5.7. Radiological airborne emissions from all sources at ORNL, 2019 (Ci)[a] (continued)

Isotope	Inhalation form[b]	Chemical form	Stack									
			X-2026	X-3020	X-3039	X-4501	X-7503	X-7880	X-7911	X-8915	Total minor sources	ORNL total
^{51}Cr	M	particulate				2.38E-06					2.53E-04	2.55E-04
^{131}Cs	F	particulate									2.2E-06	2.2E-06
^{132}Cs	F	particulate									1.04E-07	1.04E-07
^{134}Cs	F	particulate									9.66E-07	9.66E-07
^{135}Cs	F	particulate									1.87E-11	1.87E-11
^{136}Cs	F	particulate									8.93E-07	8.93E-07
^{137}Cs	S	particulate			2.27E-05						1.51E-04	1.73E-04
^{137}Cs	F	particulate	9.31E-07	4.87E-06					5.45E-06		2.71E-04	2.82E-04
^{138}Cs	F	particulate							1.09E+03			1.09E+03
^{64}Cu	M	particulate									3.E-05	3.E-05
^{67}Cu	M	particulate									1.06E-08	1.06E-08
^{169}Er	M	particulate									3.31E-30	3.31E-30
^{253}Es	M	particulate									9.4E-31	9.4E-31
^{254}Es	M	particulate									8.72E-29	8.72E-29
^{150}Eu	M	particulate									1.15E-19	1.15E-19
^{152}Eu	M	particulate									3.99E-07	3.99E-07
^{154}Eu	M	particulate									4.3E-07	4.3E-07
^{155}Eu	M	particulate									4.58E-08	4.58E-08
^{156}Eu	M	particulate									4.63E-19	4.63E-19
^{55}Fe	M	particulate									7.24E-06	7.24E-06
^{59}Fe	M	particulate									2.96E-06	2.96E-06
^{221}Fr	B	unspecified									8.86E-24	8.86E-24
^{223}Fr	M	particulate									2.96E-24	2.96E-24
^{68}Ga	M	particulate									7.37E-12	7.37E-12
^{72}Ga	M	particulate									1.13E-11	1.13E-11
^{152}Gd	M	particulate									1.92E-29	1.92E-29
^{153}Gd	M	particulate									2.19E-10	2.19E-10

Table 5.7. Radiological airborne emissions from all sources at ORNL, 2019 (Ci)[a] (continued)

Isotope	Inhalation form[b]	Chemical form	Stack									
			X-2026	X-3020	X-3039	X-4501	X-7503	X-7880	X-7911	X-8915	Total minor sources	ORNL total
^{68}Ge	M	particulate									7.37E-12	7.37E-12
^{71}Ge	M	particulate									8.44E-10	8.44E-10
^{3}H	V	vapor	2.93E-03		2.36E+00	1.16E-03	4.97E-01		7.63E+01	9.57E+02	9.56E+00	1.05E+03
^{175}Hf	M	particulate									4.11E-08	4.11E-08
^{181}Hf	M	particulate									9.08E-07	9.08E-07
^{166m}Ho	M	particulate									1.9E-12	1.9E-12
^{126}I	F	particulate				9.82E-05					1.57E-07	9.84E-05
^{129}I	F	particulate						1.15E-06			1.37E-05	1.49E-05
^{131}I	F	particulate				1.55E-02			6.65E-02		2.68E-06	8.2E-02
^{132}I	F	particulate				3.55E-02			4.86E-01			5.22E-01
^{133}I	F	particulate							2.84E-01			2.84E-01
^{134}I	F	particulate							5.41E-02			5.41E-02
^{135}I	F	particulate							8.81E-01			8.81E-01
^{113m}In	M	particulate									2.62E-09	2.62E-09
^{114}In	B	unspecified									2.11E-11	2.11E-11
^{114m}In	M	particulate									2.18E-11	2.18E-11
^{115}In	M	particulate									1.53E-27	1.53E-27
^{115m}In	M	particulate									5.95E-21	5.95E-21
^{40}K	M	particulate									3.68E-07	3.68E-07
^{42}K	M	particulate									1.03E-11	1.03E-11
^{81}Kr	B	unspecified									1.08E-11	1.08E-11
^{85}Kr	B	unspecified							2.61E+02		1.57E+02	4.18E+02
^{85m}Kr	B	unspecified							8.73E+00			8.73E+00
^{87}Kr	B	unspecified							5.07E+01	2.8E+01		7.87E+01
^{88}Kr	B	unspecified							5.44E+01	1.5E+01		6.94E+01
^{89}Kr	B	unspecified							3.39E+01			3.39E+01
^{138}La	M	particulate									2.95E-26	2.95E-26

Table 5.7. Radiological airborne emissions from all sources at ORNL, 2019 (Ci)[a] (continued)

Isotope	Inhalation form[b]	Chemical form	Stack									
			X-2026	X-3020	X-3039	X-4501	X-7503	X-7880	X-7911	X-8915	Total minor sources	ORNL total
^{140}La	M	particulate									7.36E-07	7.36E-07
^{176m}Lu	M	particulate									3.39E-13	3.39E-13
^{177}Lu	M	particulate									6.67E-05	6.67E-05
^{177m}Lu	M	particulate									8.12E-09	8.12E-09
^{54}Mn	M	particulate									3.27E-07	3.27E-07
^{56}Mn	M	particulate									5.33E-12	5.33E-12
^{100}Mo	M	particulate									6.26E-29	6.26E-29
^{93}Mo	M	particulate									4.22E-12	4.22E-12
^{99}Mo	M	particulate									1.75E-06	1.75E-06
^{13}N	B	unspecified								2.92E+02		2.92E+02
^{22}Na	M	particulate									9.36E-10	9.36E-10
^{24}Na	M	particulate									3.95E-06	3.95E-06
^{91}Nb	B	unspecified									1.74E-11	1.74E-11
^{92}Nb	B	unspecified									6.95E-43	6.95E-43
^{93m}Nb	M	particulate									1.17E-09	1.17E-09
^{94}Nb	M	particulate									7.21E-11	7.21E-11
^{95}Nb	M	particulate									3.19E-07	3.19E-07
^{95m}Nb	M	particulate									7.12E-15	7.12E-15
^{96}Nb	M	particulate									9.67E-09	9.67E-09
^{97}Nb	M	particulate									5.95E-09	5.95E-09
^{144}Nd	B	unspecified									2.14E-25	2.14E-25
^{147}Nd	M	particulate									2.12E-07	2.12E-07
^{150}Nd	M	particulate									6.51E-30	6.51E-30
^{59}Ni	M	particulate									7.82E-12	7.82E-12
^{63}Ni	M	particulate									3.39E-03	3.39E-03
^{235}Np	M	particulate									1.24E-16	1.24E-16
^{236}Np	M	particulate									3.35E-19	3.35E-19

Table 5.7. Radiological airborne emissions from all sources at ORNL, 2019 (Ci)[a] (continued)

Isotope	Inhalation form[b]	Chemical form	Stack									
			X-2026	X-3020	X-3039	X-4501	X-7503	X-7880	X-7911	X-8915	Total minor sources	ORNL total
^{237}Np	M	particulate									9.49E-08	9.49E-08
^{238}Np	M	particulate									7.25E-16	7.25E-16
^{239}Np	M	particulate									3.16E-09	3.16E-09
^{240m}Np	B	unspecified									1.08E-20	1.08E-20
^{32}P	M	particulate									1.65E-09	1.65E-09
^{228}Pa	M	particulate									5.5E-09	5.5E-09
^{230}Pa	M	particulate									3.72E-07	3.72E-07
^{231}Pa	M	particulate									6.63E-16	6.63E-16
^{232}Pa	M	particulate									1.4E-08	1.4E-08
^{233}Pa	M	particulate									3.8E-06	3.8E-06
^{234}Pa	M	particulate									1.41E-20	1.41E-20
^{234m}Pa	B	unspecified									1.1E-17	1.1E-17
^{209}Pb	M	particulate									9.18E-24	9.18E-24
^{210}Pb	M	particulate									7.83E-25	7.83E-25
^{211}Pb	M	particulate									2.16E-22	2.16E-22
^{212}Pb	S	particulate			5.51E+00		6.25E-02				4.93E-02	5.62E+00
^{212}Pb	M	particulate	4.15E-01	4.05E-01		7.87E-03			2.11E-02		4.14E-07	8.49E-01
^{214}Pb	S	particulate			3.18E-01							3.18E-01
^{214}Pb	M	particulate				1.08E-03					1.3E-23	1.08E-03
^{107}Pd	M	particulate									3.74E-12	3.74E-12
^{146}Pm	M	particulate									3.43E-12	3.43E-12
^{147}Pm	M	particulate									8.46E-08	8.46E-08
^{148}Pm	M	particulate									3.E-10	3.E-10
^{148m}Pm	M	particulate									2.75E-08	2.75E-08
^{210}Po	B	inorganic									5.87E-12	5.87E-12
^{211}Po	B	unspecified									6.58E-25	6.58E-25
^{212}Po	B	unspecified									3.51E-25	3.51E-25

Table 5.7. Radiological airborne emissions from all sources at ORNL, 2019 (Ci)[a] (continued)

Isotope	Inhalation form[b]	Chemical form	Stack								Total minor sources	ORNL total
			X-2026	X-3020	X-3039	X-4501	X-7503	X-7880	X-7911	X-8915		
^{213}Po	B	unspecified									8.85E-24	8.85E-24
^{214}Po	B	unspecified									1.3E-23	1.3E-23
^{215}Po	B	unspecified									2.16E-22	2.16E-22
^{216}Po	B	unspecified									5.65E-19	5.65E-19
^{218}Po	B	unspecified									1.28E-23	1.28E-23
^{143}Pr	M	particulate									5.46E-19	5.46E-19
^{144}Pr	M	particulate									1.73E-09	1.73E-09
^{144m}Pr	B	unspecified									3.52E-13	3.52E-13
^{236}Pu	M	particulate									1.12E-09	1.12E-09
^{237}Pu	M	particulate									2.39E-17	2.39E-17
^{238}Pu	F	particulate			2.93E-08		2.05E-08	4.12E-07			1.91E-09	4.64E-07
^{238}Pu	M	particulate	2.73E-08	1.07E-07					6.4E-08		1.71E-04	1.71E-04
^{239}Pu	F	particulate			2.67E-07		1.08E-08	1.51E-07			2.35E-08	4.52E-07
^{239}Pu	M	particulate	1.52E-08	6.15E-07					2.44E-08		6.32E-05	6.39E-05
^{240}Pu	F	particulate			2.67E-07		1.08E-08	1.51E-07			2.47E-09	4.31E-07
^{240}Pu	M	particulate	1.52E-08	6.15E-07					2.44E-08		1.42E-05	1.49E-05
^{241}Pu	M	particulate									2.61E-03	2.61E-03
^{242}Pu	M	particulate									6.34E-09	6.34E-09
^{243}Pu	M	particulate									4.97E-17	4.97E-17
^{244}Pu	M	particulate									2.85E-12	2.85E-12
^{246}Pu	M	particulate									6.2E-29	6.2E-29
^{222}Ra	B	unspecified									6.71E-30	6.71E-30
^{223}Ra	M	particulate									2.34E-06	2.34E-06
^{224}Ra	M	particulate									9.13E-07	9.13E-07
^{225}Ra	M	particulate									1.09E-07	1.09E-07
^{226}Ra	M	particulate									1.E-07	1.E-07
^{228}Ra	M	particulate									6.41E-10	6.41E-10

Table 5.7. Radiological airborne emissions from all sources at ORNL, 2019 (Ci)[a] (continued)

Isotope	Inhalation form[b]	Chemical form	Stack									
			X-2026	X-3020	X-3039	X-4501	X-7503	X-7880	X-7911	X-8915	Total minor sources	ORNL total
^{86}Rb	M	particulate									6.82E-17	6.82E-17
^{87}Rb	M	particulate									5.97E-16	5.97E-16
^{186}Re	M	particulate									5.49E-10	5.49E-10
^{188}Re	M	particulate									2.63E-08	2.63E-08
^{102}Rh	M	particulate									6.03E-13	6.03E-13
^{103m}Rh	M	particulate									6.25E-11	6.25E-11
^{105}Rh	M	particulate									5.44E-07	5.44E-07
^{106}Rh	B	unspecified									1.26E-08	1.26E-08
^{218}Rn	B	unspecified									6.39E-27	6.39E-27
^{219}Rn	B	unspecified									3.8E-11	3.8E-11
^{220}Rn	B	unspecified									4.14E-07	4.14E-07
^{222}Rn	B	unspecified									8.58E-11	8.58E-11
^{103}Ru	M	particulate									1.45E-06	1.45E-06
^{106}Ru	M	particulate									9.95E-07	9.95E-07
^{120m}Sb	M	particulate									1.46E-07	1.46E-07
^{122}Sb	M	particulate				7.42E-03					3.01E-07	7.42E-03
^{124}Sb	M	particulate				8.22E-03					1.99E-07	8.22E-03
^{125}Sb	M	particulate				1.07E-03					2.01E-08	1.07E-03
^{126}Sb	M	particulate				1.75E-02					5.26E-07	1.75E-02
^{126m}Sb	M	particulate									2.23E-11	2.23E-11
^{127}Sb	M	particulate									4.53E-07	4.53E-07
^{46}Sc	M	particulate									1.2E-08	1.2E-08
^{47}Sc	M	particulate									7.37E-08	7.37E-08
^{48}Sc	M	particulate									2.36E-07	2.36E-07
^{75}Se	F	particulate									2.08E-05	2.08E-05
^{75}Se	S	particulate			1.1E-05							1.1E-05
^{79}Se	F	particulate									1.65E-13	1.65E-13

Table 5.7. Radiological airborne emissions from all sources at ORNL, 2019 (Ci)[a] (continued)

Isotope	Inhalation form[b]	Chemical form	Stack									
			X-2026	X-3020	X-3039	X-4501	X-7503	X-7880	X-7911	X-8915	Total minor sources	ORNL total
^{145}Sm	M	particulate									2.91E-10	2.91E-10
^{146}Sm	M	particulate									2.74E-19	2.74E-19
^{147}Sm	M	particulate									1.44E-16	1.44E-16
^{148}Sm	B	unspecified									7.58E-24	7.58E-24
^{151}Sm	M	particulate									1.11E-08	1.11E-08
^{113}Sn	M	particulate									2.61E-09	2.61E-09
^{117m}Sn	M	particulate									9.76E-08	9.76E-08
^{119m}Sn	M	particulate									6.23E-10	6.23E-10
^{121}Sn	M	particulate									1.64E-10	1.64E-10
^{121m}Sn	M	particulate									1.37E-11	1.37E-11
^{123}Sn	M	particulate									1.06E-11	1.06E-11
^{125}Sn	M	particulate									3.63E-07	3.63E-07
^{126}Sn	M	particulate									2.48E-11	2.48E-11
^{85}Sr	M	particulate									1.51E-07	1.51E-07
^{89}Sr	S	particulate			7.7E-06		2.06E-08				2.19E-06	9.91E-06
^{89}Sr	M	particulate	7.9E-08	2.18E-06		5.45E-09			6.45E-06		9.44E-05	1.03E-04
^{90}Sr	S	particulate			7.7E-06		2.06E-08	2.17E-06			2.46E-06	1.24E-05
^{90}Sr	M	particulate	7.9E-08	2.18E-06		5.45E-09			6.45E-06		1.17E-04	1.25E-04
^{91}Sr	M	particulate									1.19E-11	1.19E-11
^{182}Ta	M	particulate									7.3E-08	7.3E-08
^{183}Ta	M	particulate									5.4E-06	5.4E-06
^{160}Tb	M	particulate									3.41E-13	3.41E-13
^{161}Tb	M	particulate							1.22E+01		4.63E-27	1.22E+01
^{96}Tc	M	particulate									1.97E-08	1.97E-08
^{98}Tc	M	particulate									5.13E-19	5.13E-19
^{99}Tc	M	particulate									2.E-05	2.E-05
^{99m}Tc	M	particulate									6.56E-09	6.56E-09

Table 5.7. Radiological airborne emissions from all sources at ORNL, 2019 (Ci)[a] (continued)

Isotope	Inhalation form[b]	Chemical form	Stack									
			X-2026	X-3020	X-3039	X-4501	X-7503	X-7880	X-7911	X-8915	Total minor sources	ORNL total
^{121}Te	M	particulate									4.05E-08	4.05E-08
^{121m}Te	M	particulate									5.41E-09	5.41E-09
^{123}Te	M	particulate									5.66E-30	5.66E-30
^{123m}Te	M	particulate									1.04E-14	1.04E-14
^{125m}Te	M	particulate									1.58E-09	1.58E-09
^{127}Te	M	particulate									1.56E-11	1.56E-11
^{127m}Te	M	particulate									1.59E-11	1.59E-11
^{128}Te	M	particulate									4.19E-27	4.19E-27
^{129}Te	M	particulate									4.78E-13	4.78E-13
^{129m}Te	M	particulate									7.34E-13	7.34E-13
^{130}Te	M	particulate									2.4E-31	2.4E-31
^{131m}Te	M	particulate									9.13E-08	9.13E-08
^{132}Te	M	particulate									3.03E-07	3.03E-07
^{226}Th	S	particulate									6.48E-27	6.48E-27
^{227}Th	S	particulate									1.61E-06	1.61E-06
^{228}Th	S	particulate	7.7E-09	1.01E-08	1.9E-08	7.04E-10	5.88E-09		1.2E-08		6.02E-07	6.57E-07
^{229}Th	S	particulate									4.09E-08	4.09E-08
^{230}Th	S	particulate	3.67E-09	1.03E-08		5.93E-10			4.27E-09		3.04E-08	4.92E-08
^{230}Th	F	particulate			2.87E-08		1.31E-09				1.71E-09	3.17E-08
^{231}Th	S	particulate									3.57E-10	3.57E-10
^{232}Th	F	particulate			2.04E-08		1.12E-09				1.75E-09	2.33E-08
^{232}Th	S	particulate	3.62E-09	1.34E-09		6.84E-10			4.93E-09		3.7E-03	3.7E-03
^{234}Th	S	particulate									6.37E-09	6.37E-09
^{44}Ti	M	particulate									9.45E-11	9.45E-11
^{206}Tl	B	unspecified									3.36E-35	3.36E-35
^{207}Tl	B	unspecified									2.16E-22	2.16E-22
^{208}Tl	B	unspecified									4.14E-07	4.14E-07

Table 5.7. Radiological airborne emissions from all sources at ORNL, 2019 (Ci)[a] (continued)

Isotope	Inhalation form[b]	Chemical form	Stack									
			X-2026	X-3020	X-3039	X-4501	X-7503	X-7880	X-7911	X-8915	Total minor sources	ORNL total
^{209}Tl	B	Unspecified									1.95E-25	1.95E-25
^{170}Tm	M	Particulate									1.96E-20	1.96E-20
^{171}Tm	M	Particulate									1.75E-19	1.75E-19
^{230}U	M	Particulate									6.38E-30	6.38E-30
^{232}U	M	Particulate									1.74E-07	1.74E-07
^{233}U	S	Particulate			4.93E-08		7.7E-09				2.58E-08	8.28E-08
^{233}U	M	Particulate	3.52E-08	2.83E-07		2.50E-09			1.91E-08		3.63E-08	3.76E-07
^{234}U	S	Particulate			4.93E-08		7.7E-09				2.58E-08	8.28E-08
^{234}U	M	Particulate	3.52E-08	2.83E-07		2.50E-09			1.91E-08		5.14E-07	8.53E-07
^{235}U	S	Particulate			4.96E-09		4.98E-10				1.79E-09	7.25E-09
^{235}U	M	Particulate	3.31E-10	9.26E-09							7.08E-06	7.09E-06
^{236}U	M	Particulate									1.83E-11	1.83E-11
^{237}U	M	Particulate									1.78E-16	1.78E-16
^{238}U	S	Particulate			4.64E-08		3.52E-09				8.18E-09	5.81E-08
^{238}U	M	Particulate	7.58E-09	4.05E-08		2.30E-09			3.17E-08		2.01E-05	2.02E-05
^{240}U	M	Particulate									3.44E-17	3.44E-17
^{49}V	M	Particulate									7.35E-09	7.35E-09
^{181}W	M	Particulate									4.94E-11	4.94E-11
^{185}W	M	Particulate									2.39E-08	2.39E-08
^{187}W	M	Particulate									2.74E-09	2.74E-09
^{188}W	M	Particulate									4.31E-08	4.31E-08
^{127}Xe	B	Unspecified								6.4E+01	5.43E-22	6.4E+01
^{129m}Xe	B	Unspecified									1.25E-30	1.25E-30
^{131m}Xe	B	Unspecified							1.51E+02		7.68E-22	1.51E+02
^{133}Xe	B	Unspecified				9.64E-04			1.03E+01		1.1E-31	1.03E+01
^{133m}Xe	B	Unspecified							2.83E+01			2.83E+01
^{135} Xe	B	Unspecified							5.26E+01			5.26E+01

Table 5.7. Radiological airborne emissions from all sources at ORNL, 2019 (Ci)[a] (continued)

Isotope	Inhalation form[b]	Chemical form	Stack									
			X-2026	X-3020	X-3039	X-4501	X-7503	X-7880	X-7911	X-8915	Total minor sources	ORNL total
^{135m}Xe	B	Unspecified							3.88E+01			3.88E+01
^{136}Xe	B	Unspecified									3.67E-31	3.67E-31
^{137}Xe	B	Unspecified							1.08E+02			1.08E+02
^{138}Xe	B	Unspecified							2.22E+02			2.22E+02
^{90}Y	M	Particulate									2.3E-06	2.3E-06
^{91}Y	M	Particulate									2.1E-11	2.1E-11
^{169}Yb	M	Particulate									2.33E-08	2.33E-08
^{175}Yb	M	Particulate									4.92E-06	4.92E-06
^{65}Zn	M	Particulate									2.4E-05	2.4E-05
^{69}Zn	M	Particulate									9.87E-07	9.87E-07
^{69m}Zn	M	Particulate									9.2E-07	9.2E-07
^{93}Zr	M	Particulate									7.6E-08	7.6E-08
^{95}Zr	M	Particulate									7.73E-07	7.73E-07
^{97}Zr	M	Particulate									3.72E-09	3.72E-09
Totals			**4.18E-01**	**4.05E-01**	**8.19E+00**	**9.64E-02**	**5.6E-01**	**4.57E-06**	**2.64E+03**	**1.49E+04**	**1.67E+02**	**1.77E+04**

[a] Emissions given in curies (Ci). 1 Ci = 3.7E+10 Bq

[b] The designation of F, M, and S refers to the lung clearance type—fast (F), moderate (M), and slow (S) for the given radionuclide. G stands for gaseous, V stands for vapor, and B stands for blank, unspecified form.

Acronym:
ORNL = Oak Ridge National Laboratory

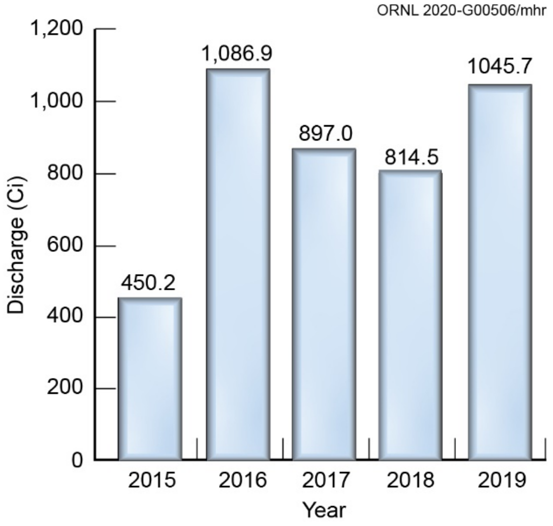


Figure 5.8. Total curies of tritium discharged from Oak Ridge National Laboratory to the atmosphere, 2015–2019

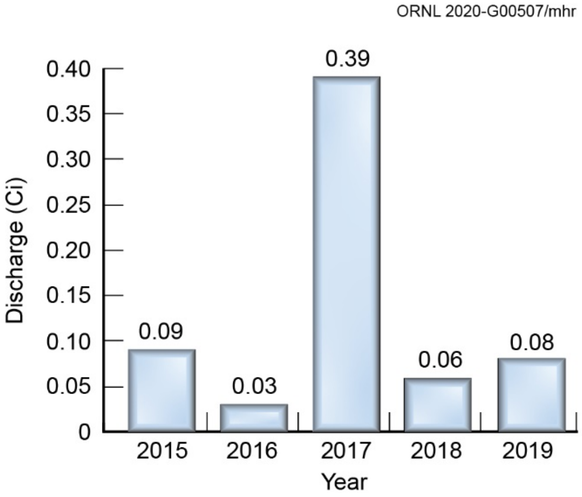


Figure 5.9. Total curies of ^{131}I discharged from Oak Ridge National Laboratory to the atmosphere, 2015–2019

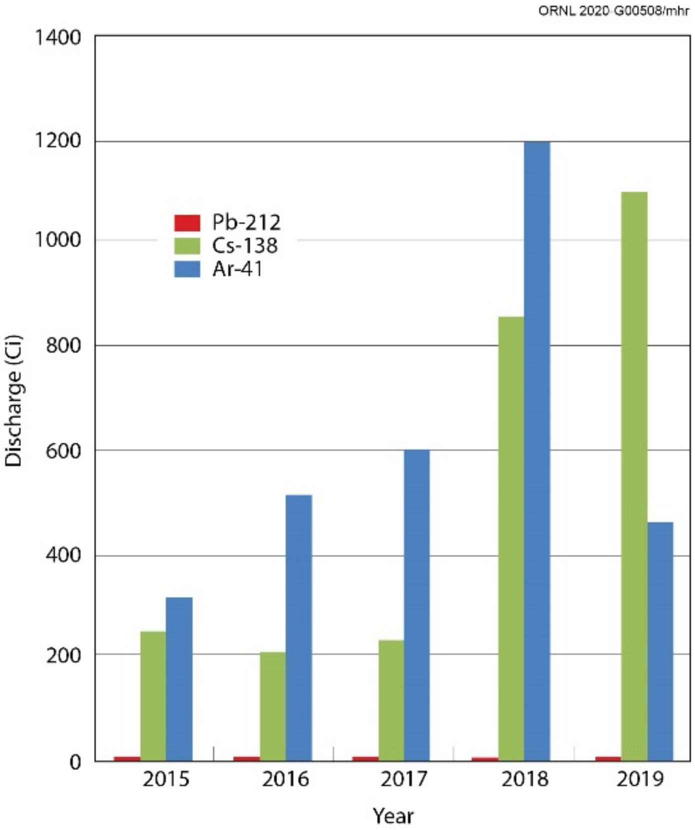


Figure 5.10. Total curies of ^{41}Ar, ^{138}Cs, and ^{212}Pb discharged from Oak Ridge National Laboratory to the atmosphere, 2015–2019

5.4.4 Stratospheric Ozone Protection

As required by the CAA Title VI Amendments of 1990 and in accordance with 40 CFR Part 82, actions have been implemented to comply with the prohibition against intentionally releasing ozone-depleting substances (ODSs) during maintenance activities performed on refrigeration equipment. In 2017, EPA enacted major revisions to the Stratospheric Ozone rules to include the regulation of non-ODS substitutes as part of 40 CFR 82 Subpart F. These revisions were effective January 1, 2018, for disposal of small appliances and January 1, 2019, for the leak rate provisions for large appliances. Necessary changes to the Stratospheric Ozone Protection compliance program were implemented to comply with the requirements of the new rule. Service requirements for refrigeration systems (including motor vehicle air conditioners), technician certification requirements, record-keeping requirements, and labeling requirements were implemented in accordance with 40 CFR 82 Subpart F.

5.4.5 Ambient Air

Station 7 in the ORNL 7000 maintenance area is the site-specific ambient air monitoring location. During 2019, the sampling system at Station 7 was used to quantify levels of tritium; uranium; and gross alpha-, beta-, and gamma-emitting radionuclides. A low-volume air sampler was used for particulate collection. The 47 mm glass-fiber filters were collected biweekly and were composited annually for laboratory analysis. A silica-gel column was used for collection of tritium as tritiated water. The silica gel was collected biweekly or weekly, depending on ambient humidity, and was composited quarterly for tritium analysis. Station 7 sampling data (Table 5.8) are compared with derived concentration standards (DCSs) for air established by DOE as guidelines for controlling exposure to members of the public (DOE 2011a). During 2019 average radionuclide concentrations at Station 7 were less than 1 percent of the applicable DCSs in all cases.

Table 5.8. Radionuclide concentrations measured at Oak Ridge National Laboratory air monitoring Station 7, 2019

Parameter	Concentration (pCi/mL)[a]
Alpha	5.79E-09
^{7}Be	3.46E-08
Beta	1.86E-08
^{40}K	-2.74E-10[b]
Tritium	4.42E-06
^{234}U	1.87E-11
^{235}U	3.48E-13
^{238}U	1.69E-11
Total U	3.59E-11

[a] 1 pCi = 3.7 × 10^{-2} Bq.

[b] At very low sample activity levels, close to the instrument background, it is possible to obtain a sample result that is less than the background. When the background activity is subtracted from the sample activity to obtain a net value, a negative value results.

5.5 Oak Ridge National Laboratory Water Quality Program

NPDES permit TN 0002941, issued to DOE for the ORNL site and renewed by the State of Tennessee in 2019, includes requirements for discharging wastewaters from the two ORNL on-site wastewater treatment facilities and from more than 150 category outfalls (outfalls with nonprocess wastewaters such as cooling water, condensate, groundwater, and storm water), and for the development and implementation of a water quality protection plan (WQPP). The permit calls for a WQPP to "efficiently utilize the facility's financial resources to measure its environmental impacts." Rather than prescribing rigid monitoring schedules, the ORNL WQPP is flexible and focuses on significant findings. It is implemented utilizing an adaptive management approach (Figure 5.11) whereby results of investigations are routinely evaluated and strategies for achieving goals are modified based on those evaluations. The goals established for the WQPP are to meet the requirements of the NPDES permit, improve the quality of aquatic resources on the ORNL site, prevent further impacts to aquatic resources from current activities, identify the stressors that contribute to impairment of aquatic resources, use available resources efficiently, and communicate outcomes with decision makers and stakeholders.

The ORNL WQPP was developed by UT-Battelle and was approved by TDEC in 2008, and the WQPP monitoring was initiated in 2009. Revisions to the WQPP are submitted to TDEC for review and comment. The WQPP incorporated several control plans that were required under the previous NPDES permit, including a biological monitoring and abatement plan (BMAP), a chlorine control strategy, a storm water pollution prevention plan, a non-storm water best management practices plan, and an NPDES radiological monitoring plan.

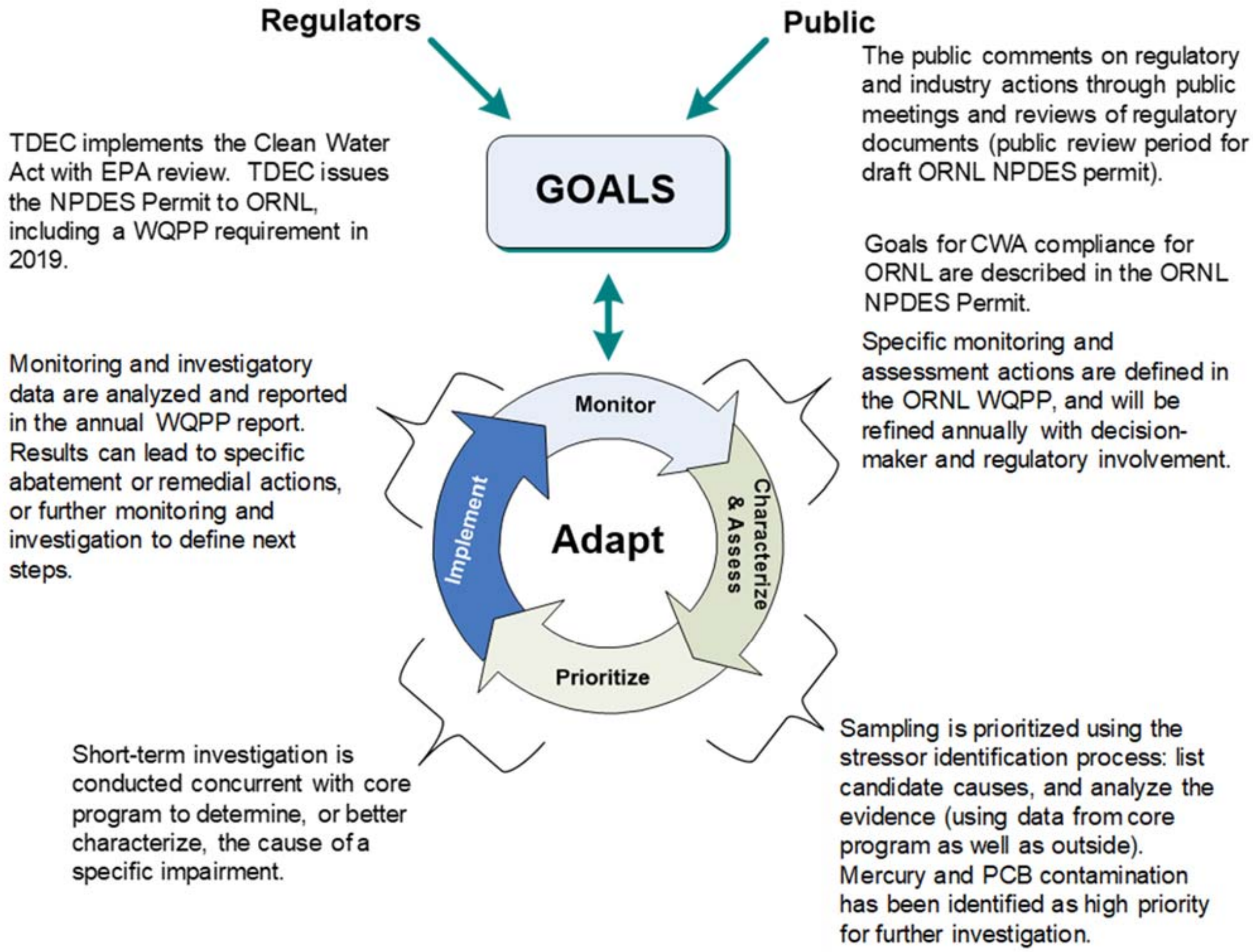
To prioritize the stressors and/or contaminant sources that may be of greatest concern to water quality and to define conceptual models that would guide any special investigations, the WQPP strategy was defined using EPA's Stressor Identification Guidance Document (EPA 2000a). Figure 5.12 summarizes that process. The process involves three major steps for identifying the cause of any impairment:

1. List candidate causes of impairment (based on historical data and a working conceptual model).
2. Analyze the evidence (using both case study and outside data).
3. Characterize the causes.

The first two steps of the stressor identification process were initiated in 2009, focusing first on mercury impairment (Figure 5.12) and then on PCB impairment because mercury and PCB concentrations in fish from White Oak Creek (WOC) are at or near human health risk thresholds (e.g., EPA ambient water quality criteria [AWQCs] and TDEC fish advisory limits). Some of the major sources of mercury to biota in the WOC watershed are known, providing a good basis from which to define an appropriate conceptual model for mercury contamination in WOC. A list of potential causes of PCB contamination was also developed.

After potential causes were listed and the available evidence of mercury and PCB contamination in the WOC watershed was analyzed, it was clear that additional investigation was needed to characterize the causes. Special investigations were designed to identify specific source areas and to revise the conceptual model of the major causes of contamination in the WOC watershed.

Monitoring and investigation data collected under the ORNL WQPP are analyzed, interpreted, reported, and compared with past results at least annually. The significant findings are reported in the *Annual Site Environmental Report*, and a more comprehensive report of findings is submitted to TDEC on a biannual basis. This information provides an assessment of the status of ORNL's receiving-stream watersheds and the impact of ongoing efforts to protect and restore those watersheds and will guide efforts to improve the water quality in the watershed.



TDEC implements the Clean Water Act with EPA review. TDEC issues the NPDES Permit to ORNL, including a WQPP requirement in 2019.

The public comments on regulatory and industry actions through public meetings and reviews of regulatory documents (public review period for draft ORNL NPDES permit).

Goals for CWA compliance for ORNL are described in the ORNL NPDES Permit.

Specific monitoring and assessment actions are defined in the ORNL WQPP, and will be refined annually with decision-maker and regulatory involvement.

Monitoring and investigatory data are analyzed and reported in the annual WQPP report. Results can lead to specific abatement or remedial actions, or further monitoring and investigation to define next steps.

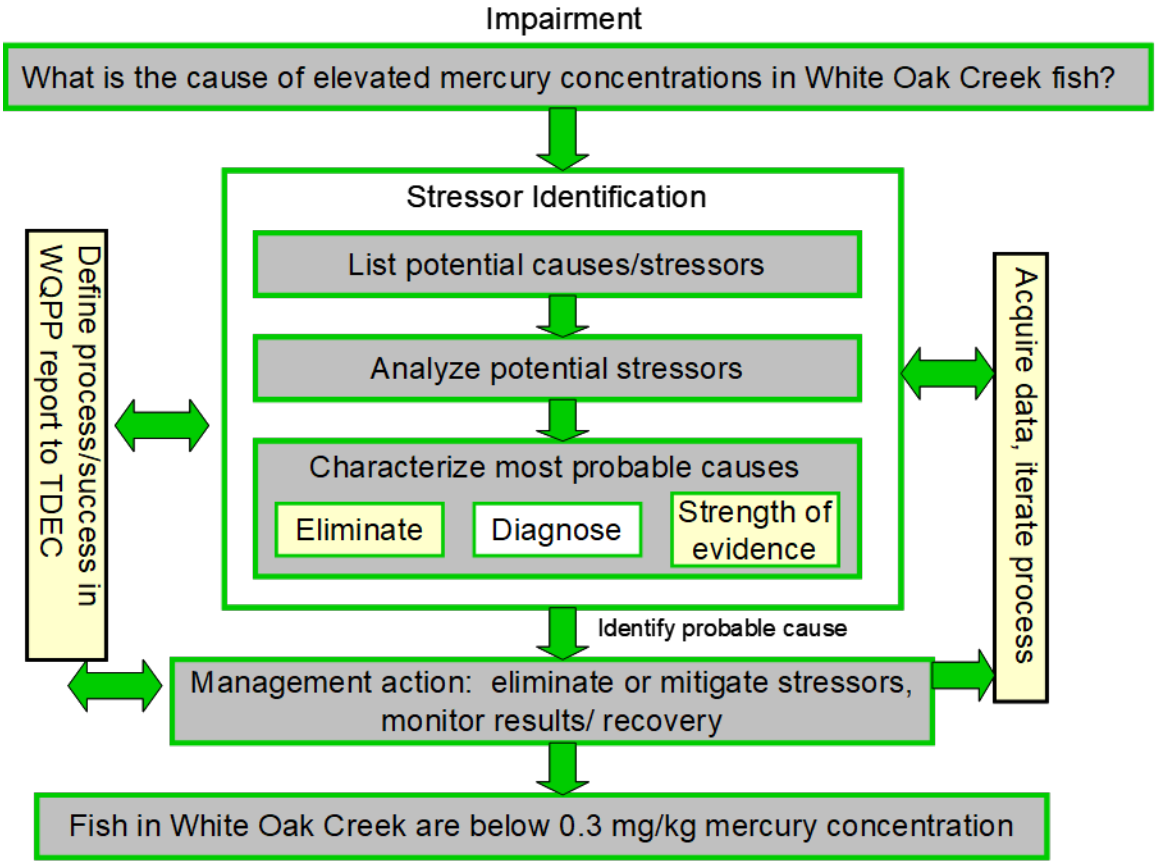
Short-term investigation is conducted concurrent with core program to determine, or better characterize, the cause of a specific impairment.

Sampling is prioritized using the stressor identification process: list candidate causes, and analyze the evidence (using data from core program as well as outside). Mercury and PCB contamination has been identified as high priority for further investigation.

Adapted from the US Environmental Protection Agency (EPA) stressor guidance document (EPA 2000a).

Acronyms:
CWA = Clean Water Act
NPDES = National Pollutant Discharge Elimination System
PCB = polychlorinated biphenyl
TDEC = Tennessee Department of Environment and Conservation
WQPP = Water Quality Protection Plan

Figure 5.11. Diagram of the adaptive management framework with step-wise planning specific to the Oak Ridge National Laboratory Water Quality Protection Plan



Modified from Figure 1-1 in the US Environmental Protection Agency stressor guidance document (EPA 2000a).

Acronyms:
TDEC = Tennessee Department of Environment and Conservation
WQPP = water quality protection plan

Figure 5.12. Application of stressor identification guidance to address mercury impairment in the White Oak Creek watershed

5.5.1 Treatment Facility Discharges

Two on-site wastewater treatment systems were operated at ORNL in 2019 to provide appropriate treatment of the various R&D, operational, and domestic wastewaters generated by site staff and activities. Both were permitted to discharge treated wastewater and were monitored under NPDES Permit TN0002941, issued by TDEC to DOE for the ORNL site. These are the ORNL STP (Outfall X01) and the ORNL PWTC (Outfall X12). The ORNL NPDES permit requirements include monitoring the two ORNL wastewater treatment facility effluents for conventional, water-quality-based, and radiological constituents and for effluent toxicity, with numeric parameter-specific compliance limits established by TDEC as determined to be necessary. The ORNL NPDES permit was last renewed by TDEC in May 2019. The results of field measurements and laboratory analyses to assess compliance for the parameters required by the NPDES permit and rates of compliance with numeric limits established in the permit are provided in Table 5.9. ORNL wastewater treatment facilities achieved 100 percent compliance with permit limits in 2019. One permit condition was not in compliance in 2019; a total suspended solids sample for Outfall X12 was not collected during the required quarterly reporting period. The sample was collected and reported during the next quarterly reporting period.

Table 5.9. National Pollutant Discharge Elimination System compliance at Oak Ridge National Laboratory, January through December 2019

Effluent parameters[a]	Permit limits					Permit compliance		
	Monthly average (lb/day)	Daily max. (lb/day)	Monthly average (mg/L)	Daily max. (mg/L)	Daily min. (mg/L)	Number of numeric noncompliances	Number of samples	Percentage of compliance[b]
X01 (Sewage Treatment Plant)								
Ammonia, as N (summer)	6.26	9.39	2.5	3.75		0	26	100
Ammonia, as N (winter)	13.14	19.78	5.25	7.9		0	26	100
Carbonaceous biological oxygen demand	19.2	28.8	10	15		0	52	100
Dissolved oxygen					6	0	52	100
Escherichia coliform (col/100 mL)			941	126		0	52	100
Oil and grease				15		0	1	100
Peracetic acid			1			0	11	100
pH (standard units)				9	6	0	52	100
Total suspended solids	57.5	86.3	30	45		2[c]	52	>98
X12 (Process Waste Treatment Complex)[d]								
Arsenic, total				0.014		0	1	100
Chromium, total				0.44		0	1	100
Copper, total				0.11		0	1	100
Cyanide, total				0.046		0	1	100
Lead, total				0.69		0	1	100
Oil and grease				15		0	7	100
pH (standard units)				9.0	6.0	0	52	100
Temperature (°C)				30.5		0	52	100

[a] The Oak Ridge National Laboratory (ORNL) National Pollutant Discharge Elimination System (NPDES) Permit was reissued with modified effluent parameters limits, and monitoring frequencies which went into effect in June 2019.

[b] Percentage compliance = 100 – [(number of noncompliances/number of samples) × 100].

[c] A large storm in March 2019 caused heavy inflow into the ORNL sewage treatment plant, causing concentration and loading effluent limit noncompliances for total suspended solids.

[d] There were two nonnumeric permit noncompliances in 2019. A total suspended solids sample and an oil and grease sample for Outfall X12 were not collected during the required quarterly reporting period. The samples were collected and reported during the next quarterly reporting period.

Toxicity testing provides an assessment of any harmful effects that could occur from the total combined constituents in discharges from ORNL wastewater treatment facilities. Effluents from the STP have been required to be tested for toxicity to aquatic species under the NPDES permit every year since 1986, and effluents from PWTC have been tested since it went into operation in 1990. Test species have been *Ceriodaphnia dubia*, an aquatic invertebrate, and fathead minnow (*Pimephales promelas*) larvae. Tests have been conducted using EPA chronic or acute test protocols at frequencies ranging from one to four times per year. PWTC effluent has always been shown to be nontoxic. The STP has shown isolated indications of effluent toxicity, but confirmatory tests conducted as required by the permit have shown that either the result of the routine test was an anomaly or that the condition of toxicity that existed at the time of the routine test was temporary and of short duration.

Toxicity test requirements under the current NPDES permit include annual testing for chronic toxicity from the ORNL STP and PWTC. Both test species are tested on a series of four aliquots of effluent, collected at 6 h intervals over a 24 h period. An "inhibition concentration" of 25% was used in the testing.[2] In June 2019, chronic toxicity test results for the STP demonstrated (IC_{25}) values of > 100% for survival in *C. dubia*, and survival and growth in *P. promelas*. However, this test also indicated reduced fecundity in *C. dubia* (IC_{25} = 48.36%). While this value was not in violation of permit requirements (44.3%), confirmatory tests were initiated. Monthly follow-up chronic tests were conducted on STP effluent with *C. dubia,* with all results indicating IC_{25} values > 100%. Results from chronic tests using PWTC effluent in 2019 did not indicate toxicity in either species with all IC_{25} values > 100% (Table 5.10).

Table 5.10. Whole effluent toxicity testing, National Pollutant Discharge Elimination System compliance at Oak Ridge National Laboratory, 2019

Testing parameters[a]	Permit limits[a]		Permit compliance		
	IC_{25} permit limit (%)	IC_{25} test result (%)	Number of noncompliances	Number of samples	Percentage of compliance[b]
		X01 (Sewage Treatment Plant)			
C. dubia survival	44.3	100	0	1	100
C. dubia reproduction	44.3	48.36	0	1	100
P. promelas survival	44.3	100	0	1	100
P. promelas growth	44.3	100	0	1	100
		X12 (Process Waste Treatment Complex)			
C. dubia survival	44.3	100	0	1	100
C. dubia reproduction	44.3	100	0	1	100
P. promelas survival	44.3	100	0	1	100
P. promelas growth	44.3	100	0	1	100

[a] IC_{25} = inhibition concentration; the concentration (as a percentage of full-strength wastewater) that reduces survival or reproduction of the test species by 25% when compared to a control treatment.
[b] Percentage compliance = 100 – [(number of noncompliances/number of samples) × 100]

5.5.2 Residual Bromine and Chlorine Monitoring

ORNL receives its water supply from the City of Oak Ridge Water Treatment Plant, which uses chlorine as a final disinfectant. Before the water is distributed, 2.0 to 3.0 mg/L of free chlorine is typically added. On the ORNL site, this water is used for drinking, sanitary, and housekeeping purposes as well as for

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[2] An inhibition concentration is a point estimate of the effluent concentration or dilution that would cause a given percentage (25 percent in this case) reduction with respect to a control in a toxicological endpoint such as survival, growth, or reproduction.

research and in cooling systems. After water is used, residual chlorine remains. If discharged to surface water, the residual chlorine can be toxic to fish and other aquatic life. Residual chlorine in sewage routed to the STP would damage the bacterial treatment system used in the biological digestion process if it were not used up en route. Any residual chlorine routed to process wastewater treatment is removed by final filtration. In the past, older water-cooled air-conditioning systems commonly discharged once-through cooling water to storm outfalls; all but one of these units have been replaced with air-cooled systems that discharge condensate to the ground or storm drains.

Although once-through cooling discharges have declined, the year-round demand has grown for cooling towers to condition/dehumidify space and to remove heat from instrumentation and computer systems. Additional chlorine- and bromine-based chemicals are added to already chlorinated supply water to control bacterial growth in cooling towers; anticorrosion chemicals are also added. When chlorine and bromine do not evaporate or are not consumed by bacterial growth in the tower, they are residual in the discharge. As the cooling towers lose water via evaporation, higher conductivity (caused by minerals such as calcium, which occur naturally in the water and do not evaporate), triggers blowdown that may contain these residual oxidants. ORNL uses 92 percent sodium sulfite tablets or a 38 to 40 percent liquid sodium bisulfite drip proportionate to flow to neutralize/dechlorinate these discharges. Twice a month, once-through cooling water and outfalls that receive cooling tower discharges are monitored for total residual oxidant (TRO). The remaining water-cooled air-conditioning system is monitored seasonally; less frequent monitoring is done at outfalls where infrastructure leaks have been found and fixed. In 2019, 23 locations (20 outfalls and 3 pipes above the instream dechlorinators) were monitored for TRO semimonthly, monthly, quarterly, or semiannually if flow was present. The TDEC NPDES permit load action level is 1.20 g/day TRO at the outfall. If TRO concentration is found at or above the field analytical detection limit (> 0.05 mg/L), steps are taken to improve dechlorination.

By the end of 2016, dechlorination systems had been installed at each cooling tower or cooling tower system source to reduce dependence on dechlorination performed at the creek level. In 2017, TRO exceedances continued, and all tablet feeder boxes at the sources were inspected. Eight of the boxes were repaired or replaced to keep tablets dry between flows and to improve contact between the discharged water and the sodium sulfite tablets. Since then, procedures have been implemented to stock fewer sodium sulfite tablets and to remove swollen tablets, which, although still chemically active, prevent appropriate water circulation around the tablets in the feed tubes.

Table 5.11 shows 2019 cooling tower discharges exceeding the TRO permit action level, despite multiple dechlorination checks each week and increased removal and replacement of swollen sodium sulfite tablets. In November 2018, the target range for oxidant used in cooling towers was modified from 1.50 to 1.00 mg/L of free halogen; it is not clear that the new target has been reached. It is hoped that lower levels of oxidant use in the main plant area will make dechlorination more effective and that it will eliminate TRO discharges from cooling towers.

Observation of discharge from Outfall 014 is scheduled twice a month; however, since the discharge consists only of cooling tower blowdown, up to three attempts to sample are made each month. During 2019, all but one of the monitored discharges exceeded the TRO load of 1.20 g/day. A sodium bisulfite dechlorination box is estimated to remove 2.0 mg/L Cl, so discharges prior to dechlorination may have contained up to 3.50 mg/L TRO. Weekly observations at Outfall 014 are scheduled in 2020 in an attempt to collect two samples per month.

Outfall 227 receives large blowdowns from the Building 5600 and 5511 cooling towers. There were no TRO exceedances at this Outfall in 2019. An old secondary dechlorination box located at the creek, is still utilized as a backup. Its use enables a total of about 4.0 mg/L TRO to be removed before the flow enters WOC. During 2019 each time TRO was monitored at the outfall, measurements were also taken above the secondary dechlorination box. There were five instances (February, June, July, and twice in September) when TRO discharge action limits would have been exceeded at the outfall without secondary treatment (+ 0.2–0.7 mg/L).

Outfall 363 is similar to Outfall 227 in that it receives multiple cooling tower flows, but from newer buildings, so a secondary dechlorinator is not installed at the creek. Instead, if source dechlorination is found to be inadequate, bags of sodium sulfite tablets are placed below the outfall pipe. Since 2017, the bags have been kept in place as backup and have been replenished multiple times a week. There were four TRO exceedances in 2019 at Outfall 363 despite the use of the bags, and simultaneous monitoring above the bags shows TRO present in June and August that was neutralized by the bags. Table 5.11 shows that an additional 0.2–0.6 mg/L TRO remains after dechlorination at the source.

There were two 2019 TRO exceedances at Outfall 281, located at HFIR. The first incident, in May, occurred while the towers were off-line for maintenance, and a temporary dechlorination system that had been working well for a month ran low on sodium bisulfide. Environmental Sciences Division staff who were doing a fish survey in Melton Branch found fish conspicuously absent below the outfall. HFIR personnel were notified and immediately fixed the problem. The creek was surveyed, and 13 dead fish were reported to TDEC. No further difficulties were encountered with the temporary dechlorination system, which was utilized through July 2. The second exceedance occurred in October as HFIR was restarting after being shut down. Between shift changes the sodium bisulfite level in the dechlorination system dropped below levels required for effective treatment. The problem was noticed within 12 hours, and the sodium bisulfite was replenished. The monitored flow was 100 gpm, less than one-fourth of the flow in May. Probably less than half the calculated load per day of sodium bisulfite was delivered by the time more was added; any adverse effects are unknown.

Research-generated once-through cooling water is still discharged through Outfalls 210 and 211, but due to water-recycling efforts, the flows are much lower than they were several years ago. There were no TRO exceedances at Outfall 210 in 2019. However, there were three exceedances at Outfall 211. That outfall receives multiple small cooling water sources, and two dechlorinator boxes are mounted in a weir where discharge enters the creek. When creek water rises, the dechlorinator boxes flood, and function is minimized until the water subsides and tablets are restocked. The February and March flow values at Outfall 211 of 100 gpm and 70 gpm indicate that there was abundant storm water mixing with the cooling water. Cooling water flows there in 2019 averaged 57 gpm but are generally < 25 gpm. The November flow of 5.0 gpm was low enough that it may not have received adequate contact with sodium sulfite tablets in either box (each set up for 50 gpm). Outfall 207 on WOC, downstream of the Fifth Creek confluence, receives no known chlorinated discharges, but TRO was found there on two occasions. Dry and wet catch-basin sampling is planned during 2020 to determine the source.

Outfall 231 currently receives blowdown from multiple Building 5800 cooling towers, and more towers are being installed during 2020. In 2019 there were three TRO exceedances at Outfall 231. Plans are being made to implement a liquid sodium bisulfite dechlorination system at the Building 5800 location.

In 2019, steps were taken to correct issues with the dechlorination systems at Outfalls 082 and 282, which are outfalls associated with MSRE. (The outfalls are monitored, but they are not listed on Table 5.11.) Outfall 082, which is located east of MSRE, receives once-through cooling water from a water-cooled air-conditioning system. Fresh tablets were added to the dechlorination system at Outfall 82 in May, after it was discovered that they needed to be replenished. In 2019, two issues were addressed at Outfall 282, which is located west of MSRE. A dechlorinator is installed at Outfall 282 to treat water from a small unidentified source. Fresh tablets were added to the dechlorination system in May, when it was found that they needed to be replenished, and the system was repaired in December, after high storm water flow had caused it to malfunction. UCOR, DOE's primary cleanup contractor for ORR, has offices at MSRE and has asked UT-Battelle Utilities for help in finding the unidentified source.

Table 5.11. Outfalls exceeding total residual oxidant National Pollutant Discharge Elimination System permit action level in 2019[a]

Outfall	Sample Date	TRO (mg/L)	Flow (gpm)	Load (g/day)	Receiving stream	Downstream integration point	Instream TRO point	TRO Source
014	5/9/19	0.40	80	84.07	WOC	WCK 4.4	X23	4510/4521 CTs
014	6/14/19	1.50	40	157.63	WOC	WCK 4.4	X23	4510/4521 CTs
014	8/19/19	1.40	35	128.73	WOC	WCK 4.4	X23	4510/4521 CTs
014	9/19/19	0.70	20	36.78	WOC	WCK 4.4	X23	4510/4521 CTs
207	7/30/19	0.10	0.1	0.03	WOC	WCK 4.1	X21	Unknown
207	12/16/19	0.10	8	2.10	WOC	WCK 4.1	X21	Unknown
211	02/27/19	0.70	100	183.90	WOC	WCK 4.4	X22	CW
211	03/06/19	0.10	70	18.39	WOC	WCK 4.4	X22	CW
211	11/11/19	1.04	5	13.66	WOC	WCK 4.4	X22	CW
231	5/9/19	0.10	10	2.63	WOC	WCK 4.4	X25	5800 CTs
231	5/23/19	0.10	15	3.94	WOC	WCK 4.4	X25	5800 CTs
231	7/5/19	1.20	10	31.53	WOC	WCK 4.4	X25	5800 CTs
281	5/23/19	0.20	450	236.44	MB	MEK.06	X27	7902 CTs
281	10/21/19	1.00	100	262.71	MB	MEK.06	X27	7902 CTs
363	5/9/19	0.60	15	23.64	Fifth Creek	FFK 0.2	X18	5300/5309 CTs
363	5/23/19	0.30	30	23.64	Fifth Creek	FFK 0.2	X18	5300/5309 CTs
363	7/5/19	0.30	30	23.64	Fifth Creek	FFK 0.2	X18	5300/5309 CTs
363	9/19/19	0.20	12	6.31	Fifth Creek	FFK 0.2	X18	5300/5309 CTs

[a] The NPDES action level is 1.2 g/day

Acronyms:
CT = cooling tower
CW = once-through cooling water
FFK = Fifth Creek kilometer MB = Melton Branch
MEK = Melton Branch kilometer
NPDES = National Pollutant Discharge Elimination System
TRO = total residual oxidant
WCK = White Oak Creek kilometer
WOC = White Oak Creek

5.5.3 Radiological Monitoring

At ORNL, monitoring of liquid effluents and selected instream locations for radioactivity is conducted under the WQPP. Table 5.12 details the analyses performed on samples collected in 2019 at two treatment facility outfalls, three instream monitoring locations, and 20 category outfalls (outfalls that are categorized into groups with similar effluent characteristics for the purposes of setting monitoring and reporting requirements in the site NPDES permit). Dry-weather discharges from category outfalls are primarily cooling water, groundwater, and condensate. Low levels of radioactivity can be discharged from category outfalls in areas where groundwater contamination exists and where contaminated groundwater enters category outfall collection systems by direct infiltration and from building sumps, facility sumps, and building footer drains. In 2019, dry-weather grab samples were collected at 15 of the 20 category outfalls targeted for sampling. Five category outfalls (refer to Table 5.12) were not sampled because there was no discharge present during sampling attempts.

The two ORNL treatment facility outfalls that were monitored for radioactivity in 2019 were the STP outfall (Outfall X01) and the PWTC outfall (Outfall X12). The three instream locations that were monitored were X13 on Melton Branch, X14 on WOC, and X15 at White Oak Dam (WOD) (Figure 5.13). At each treatment facility and instream monitoring location, monthly flow-proportional composite samples were collected using dedicated automatic water samplers.

For each radioisotope, a DCS is published in DOE directives and is used to evaluate discharges of radioactivity from DOE facilities (DOE 2011a). DCSs were developed for evaluating effluent discharges and are not intended to be applied to instream values, but the comparisons can provide a useful frame of reference. Four percent of the DCS is used as a comparison point. Although comparisons are made, neither ORNL effluents nor ambient surface waters are direct sources of drinking water. The annual average concentration of at least one radionuclide exceeded 4 percent of the relevant DCS concentration in dry-weather discharges from NPDES Outfalls 085, 204, 302, 304, X01,and X12 and at instream sampling location WOD (X15) (Figure 5.14).

In 2019, two outfalls (085 and 304) had an annual mean radioactivity concentration greater than 100 percent of a DCS. Samples from both outfalls had an average total radioactive strontium ($^{89/90}$Sr) concentration that exceeded the DCS for ^{90}Sr (it is reasonable, for an ORNL environmental sample, to assume that $^{89/90}$Sr activity is comparable to ^{90}Sr activity due to the relatively short half-life of ^{89}Sr—50.55 days). The concentration of $^{89/90}$Sr was 200 and 130 percent of the DCS at Outfalls 085 and 304, respectively. Consequently, concentrations of radioactivity in the discharge from Outfalls 085 and 304 was also greater than the DCS level on a sum-of-fractions basis (i.e., the summation of DCS percentages of multiple radiological parameters); and the sum of the fractions was 213 and 137 percent for Outfalls 085 and 304, respectively.

Levels of radioactivity at Outfall 085 have been elevated since early 2015, when a water leak occurred in Building 7830A. The foundation drain for that building is connected to Outfall 085. The water leaked from a pipe in the building's fire suppression system that ruptured when it froze in the early morning hours of February 23, 2015. It is believed that leaked water mobilized underground contamination to a location where it could enter the building foundation drain. Concentrations have been declining since April 2015, although the rate of decline slowed in the latter part of 2016 and concentrations have not yet returned to levels that existed prior to 2015.

Levels of radioactivity in discharges from Outfall 304 have been elevated since 2014 because of two unrelated infrastructure issues. In 2014, a pump failed in a groundwater suppression sump near the DOE Office of Environmental Management (OREM) low-level liquid waste tank WC-9, which is within a CERCLA soil and groundwater contamination area. Without groundwater suppression in the tank farm area, contaminated groundwater enters the Outfall 304 storm drain system. A second infrastructure issue, which had an even greater influence on Outfall 304 radiological concentrations, occurred in 2015. A leak developed in a pipe leading from Pump Station #2 in the Process Waste Collection System to a downstream diversion box. A dye tracer test confirmed a hydraulic connection between the pipe and the storm water collection system that discharges through Outfall 304, and the pipe was subsequently bypassed and taken out of service. Before the leaky pipe was bypassed, the 89/90Sr concentration at Outfall 304 peaked at 29,000 pCi/L (August and September 2015). Since the bypass was implemented, 89/90Sr levels in the outfall effluent have trended downward, but they remained above DCS levels in 2019. No additional infrastructure issues affecting Outfall 304 have been discovered, and it is believed that concentrations of radioactivity at the outfall will slowly decline as concentrations of radioactivity in the groundwater surrounding the outfall pipe decline by means of normal hydrologic processes.

Table 5.12. Radiological monitoring conducted under the Oak Ridge National Laboratory Water Quality Protection Plan, 2019

Location	Frequency	Gross alpha/beta	Gamma scan	^{3}H	^{14}C	$^{89/90}$Sr	Isotopic uranium	Isotopic plutonium	^{241}Am	$^{243/244}$Cm
Outfall 001	Annual	X								
Outfall 080	Monthly	X	X	X		X			X[a]	X
Outfall 081	Annual	X								
Outfall 085	Quarterly	X	X	X		X				
Outfall 203	Annual	X	X			X				
Outfall 204	Semiannual	X	X			X				
Outfall 205[b]	Annual									
Outfall 207	Quarterly	X								
Outfall 211	Annual	X								
Outfall 234[b]	Annual									
Outfall 241[b]	Quarterly									
Outfall 265[b]	Annual									
Outfall 281	Quarterly	X		X						
Outfall 282	Quarterly	X								
Outfall 302	Monthly	X	X	X		X	X[a]	X[a]	X[a]	X[a]
Outfall 304	Monthly	X	X	X		X	X[a]	X[a]	X[a]	X[a]
Outfall 365	Semiannual	X								
Outfall 368[b]	Annual									
Outfall 383	Annual	X		X						
Outfall 484	Annual	X								
STP (X01)	Monthly	X	X	X	X	X				
PWTC (X12)	Monthly	X	X	X		X	X			
Melton Branch (X13)	Monthly	X	X	X		X				
WOC (X14)	Monthly	X	X	X		X				
WOD (X15)	Monthly	X	X	X		X				

[a] The Water Quality Protection Plan does not require this parameter for this location, and therefore it may have been monitored on a frequency less than indicated in the table. Additional analyses are sometimes performed on samples, the most common reason being that gross alpha and gross beta activities exceeded a screening criterion (as described in the May 2012 update to the Water Quality Protection Plan).

[b] The outfall was included in the monitoring plan, but samples were not collected because no discharge was present during sampling attempts.

Acronyms:

PWTC = Process Waste Treatment Complex
STP = Sewage Treatment Plant
WOC = White Oak Creek
WOD = White Oak Dam

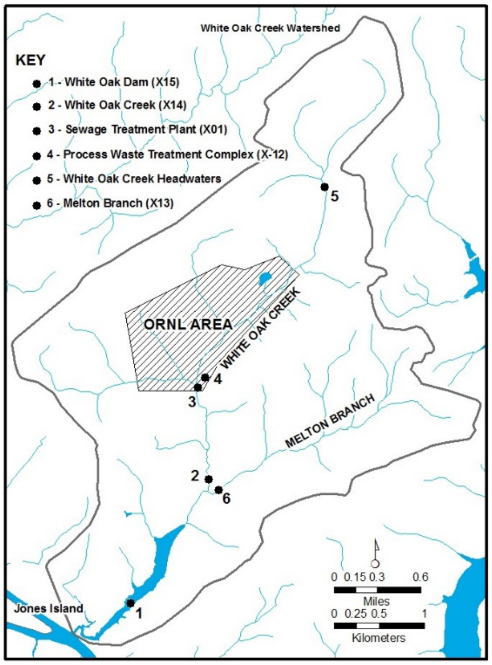


Figure 5.13. Selected surface water, National Pollutant Discharge Elimination System, and reference sampling locations at Oak Ridge National Laboratory, 2019

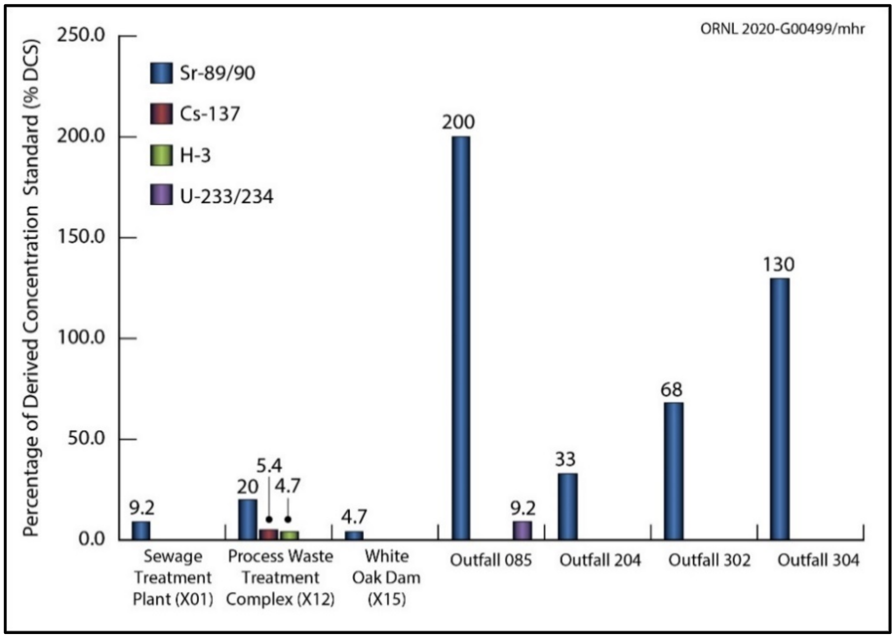


Figure 5.14. Outfalls and instream locations at Oak Ridge National Laboratory with average radionuclide concentrations greater than 4 percent of the relevant derived concentration standards in 2019

The total annual discharges (or amounts) of radioactivity measured in stream water at WOD, the final monitoring point on WOC before the stream flow leaves ORNL, were calculated from concentration and flow. Results of those calculations for each of the past 5 years are shown in Figures 5.15 through 5.19. Because discharges of radioactivity are somewhat correlated to stream flow, annual flow volumes measured at the WOD monitoring station are given in Figure 5.20. Discharges of radioactivity at WOD in

2019 were similar to discharges during other recent years, particularly when differences in annual flow volume are taken into account and continue to be generally lower than in the years preceding completion of the waste area caps in Melton Valley (substantially complete by 2006).

Radiological monitoring at category outfalls in 2019 also included monitoring during storm runoff conditions. Ten storm water outfalls were monitored. Storm water samples were analyzed for gross alpha, gross beta, $^{89/90}$Sr, and tritium activities. A gamma scan analysis was also performed. The monitoring plan calls for additional analyses to be added when sufficient gross alpha and/or beta activity is present in a sample to indicate that levels of radioactivity may exceed DCS levels, but in 2019 no additional analyses were required for storm water samples.

Concentrations of radioactivity in storm water discharges were compared with DCSs if a DCS existed for that parameter (no DCSs exist for gross alpha or gross beta activities) and if a concentration was greater than or equal to the minimum detectable activity for the measurement. In 2019, the radionuclide $^{89/90}$Sr exceeded 4 percent of the relevant DCS concentration in wet-weather discharges from Outfall 304.

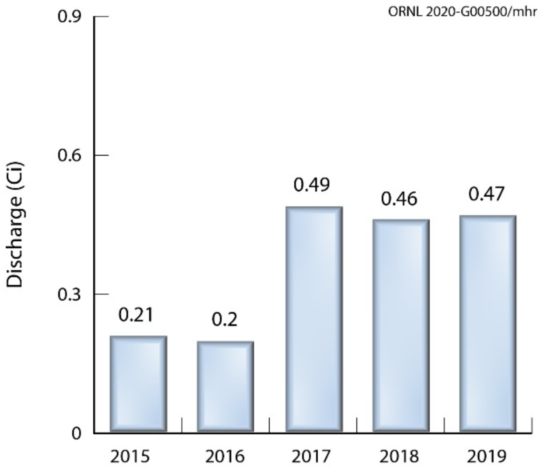


Figure 5.15. Cesium-137 discharges at White Oak Dam, 2015−2019

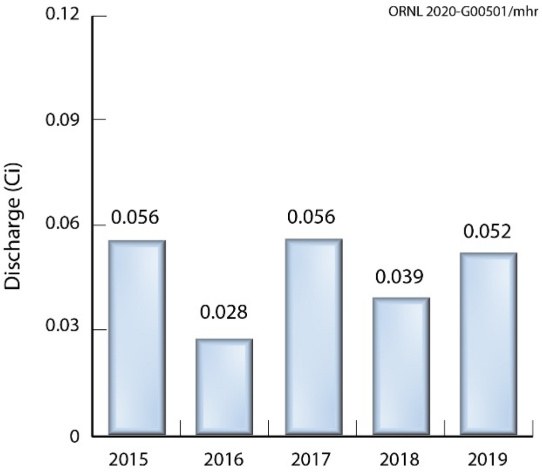


Figure 5.16. Gross alpha discharges at White Oak Dam, 2015−2019

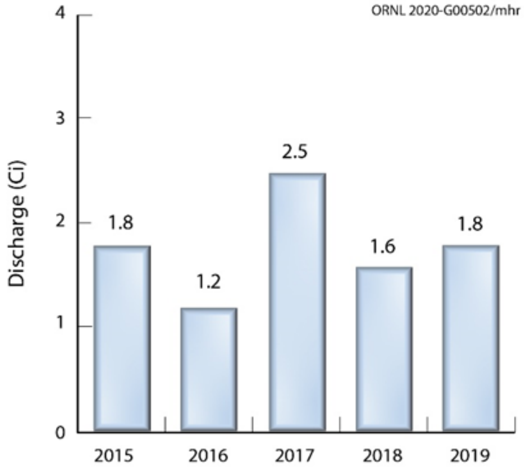


Figure 5.17. Gross beta discharges at White Oak Dam, 2015−2019

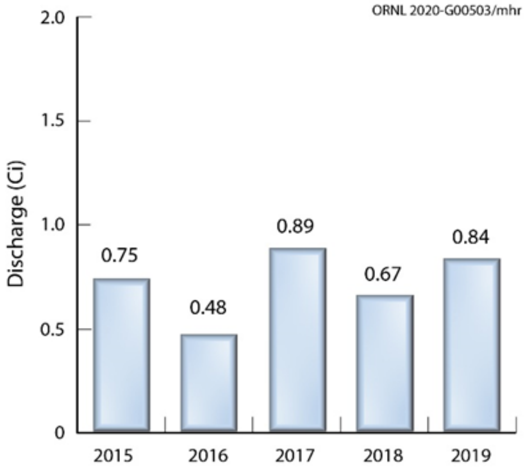
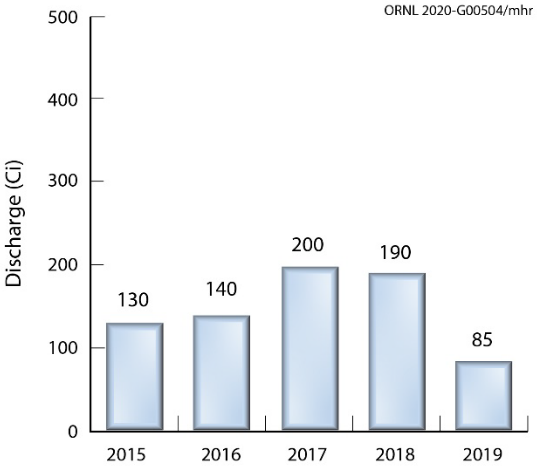


Figure 5.18. Total radioactive strontium discharges at White Oak Dam, 2015−2019



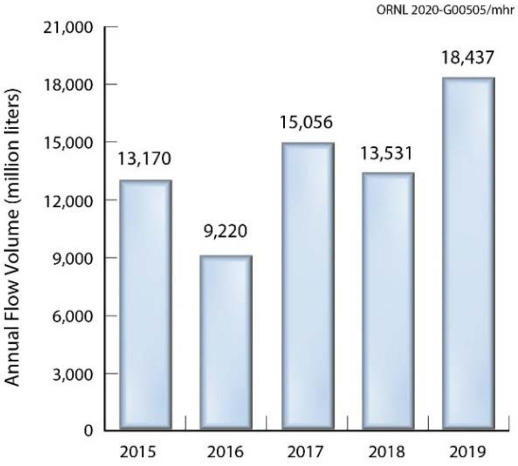


Figure 5.19. Tritium discharges at White Oak Dam, 2015−2019

Figure 5.20. Annual flow volume at White Oak Dam, 2015−2019

5.5.4 Mercury in the White Oak Creek Watershed

During the mid-1950s, mercury was used for pilot-scale isotope separation work in Buildings 4501, 4505, and 3592 and in spent-fuel reprocessing in Building 3503.

5.5.4.1 Buildings 4501 and 4505

Buildings 4501 and 4505 are still active research facilities located east of Fifth Creek and north of WOC As active facilities, process wastewater discharges are routed to the PWTC. Building foundation sumps that had been routed south to storm Outfall 211 on WOC (Figure 5.21) and west to storm Outfall 363 on Fifth Creek were found to contain mercury and were re-routed to the PWTC between December 2007 and November 2010. Outfall 211 piping still receives storm, cooling water, and steam condensate discharges. Due to the persistence of elemental mercury, its volatility, and the complexity of its interactions in piping and soil, mercury continues to be a contaminant associated with Outfall 211.

5.5.4.2 Buildings 3592 and 3503

Buildings 3592 and 3503 were removed under the CERCLA remedial process in 2011 and 2012, respectively; their footprints and associated storm water drains remain in the Outfall 207 storm water drainage system. Mercury has been found associated with process infrastructure in other areas such as north of the Fifth Street and Central Avenue intersection and in the Outfall 304 drainage area; storm water exchange with process leaks or overflows has occurred under certain situations.

ORNL 2018-G00384/mhr

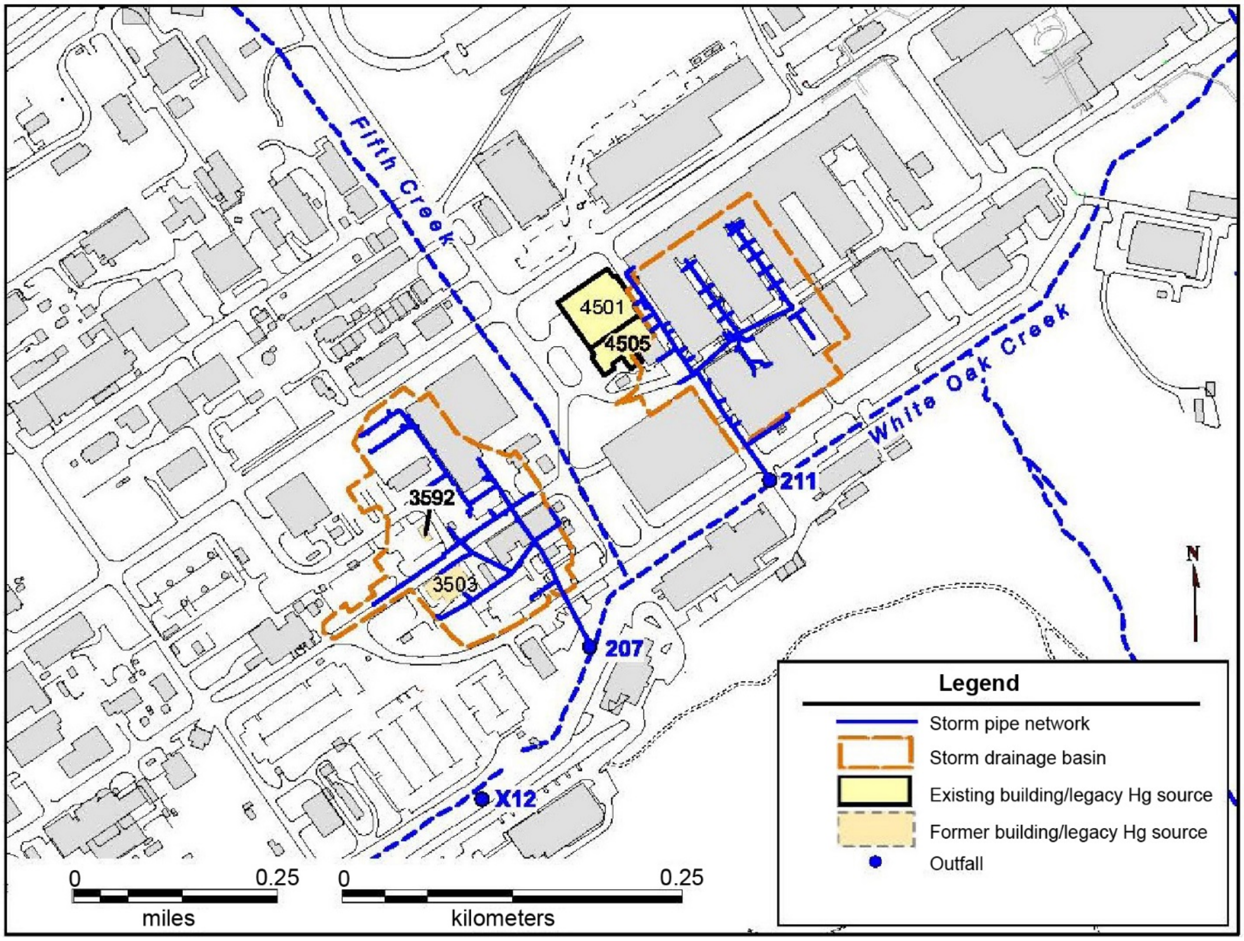


Figure 5.21. Outfalls with known historic mercury sources to White Oak Creek

5.5.4.3 Ambient Mercury in Water

Aqueous mercury monitoring in WOC, started in 1997, continues with quarterly water samples collected at four sites: White Oak Creek kilometer (WCK) 1.5, WCK 3.4, WCK 4.1, and WCK 6.8 (Figure 5.22). Stream conditions were selected to be representative of seasonal base-flow conditions (dry weather, clear flow) based on historical results that indicate higher mercury concentrations under those conditions.

Long-term trends in waterborne mercury in the WOC system downstream of ORNL are shown in Figure 5.23. The concentration of mercury in WOC upstream from ORNL (WCK 6.8) was less than 10 ng/L in 2019. Waterborne mercury concentrations downstream of ORNL were elevated but declined abruptly in 2008 and remained low through 2019 as a result of actions: (1) to lessen mercury discharges to WOC at Outfall 211 (sump reroutes to PWTC) and (2) to reduce discharges from PWTC (X12). In general, ambient concentrations have remained low since that time, with a few exceptions. A significant spike in mercury concentrations was seen at WCK 3.4 (downstream of Outfalls X12 and X01) in September 2018, and was likely due to issues with filters at the PWTC. Filters were changed in 2019 and mercury concentrations measured at WCK 3.4 dropped below the AWQC, averaging 13.84 ± 6.64 ng/L in 2019, compared with 55.49 ± 76.05 ng/L in 2018. In contrast, the mean total mercury concentration at WCK 4.1 increased to 26.46 ± 26.82 ng/L in 2019, from 17.17 ± 9.88 ng/L in 2018. Increases in concentration (~70 ng/L) exceeding the AWQC occurred in September 2019. In general, though, concentrations have been low with occasional spikes. The average aqueous mercury concentration at

WOD (WCK 1.5) was 34.01 ± 18.93 ng/L compared to 52.55 ± 27.59 ng/L in 2018. Mercury concentrations at WCK 1.5 are more variable than at other sites in WOC, likely because of the variability in total suspended solids at this site.

ORNL 2019-G00162/mhr

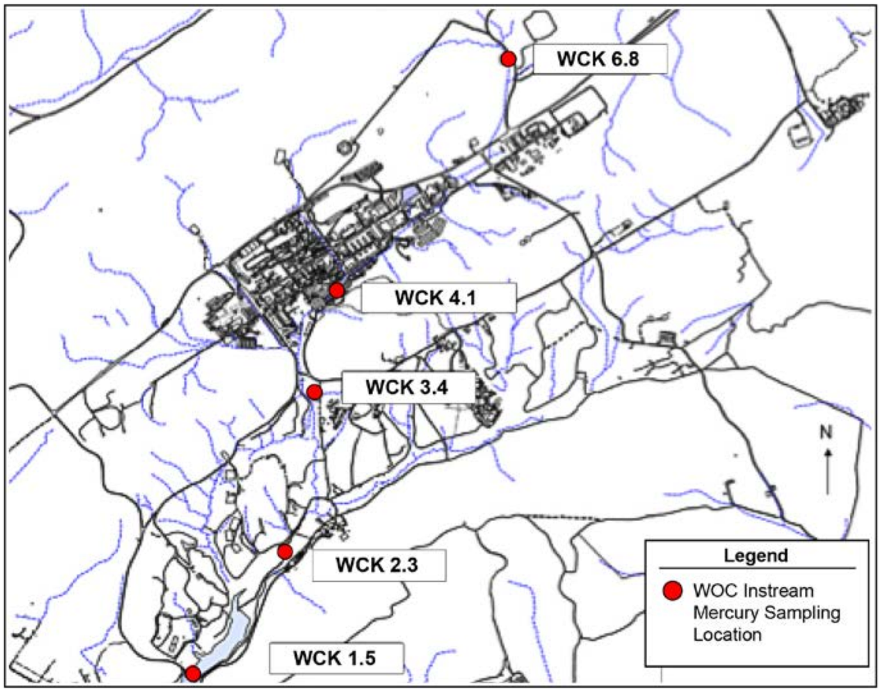
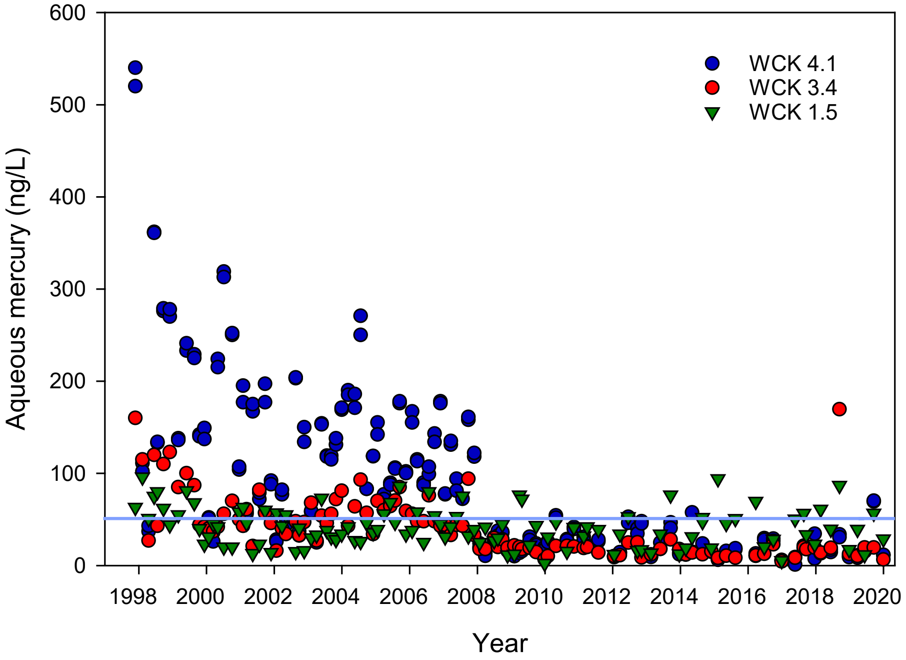


Figure 5.22. Instream mercury monitoring and data locations, 2019



The blue line at 51 ng/L shows the Recreational Water Quality Criteria for Water and Organisms.

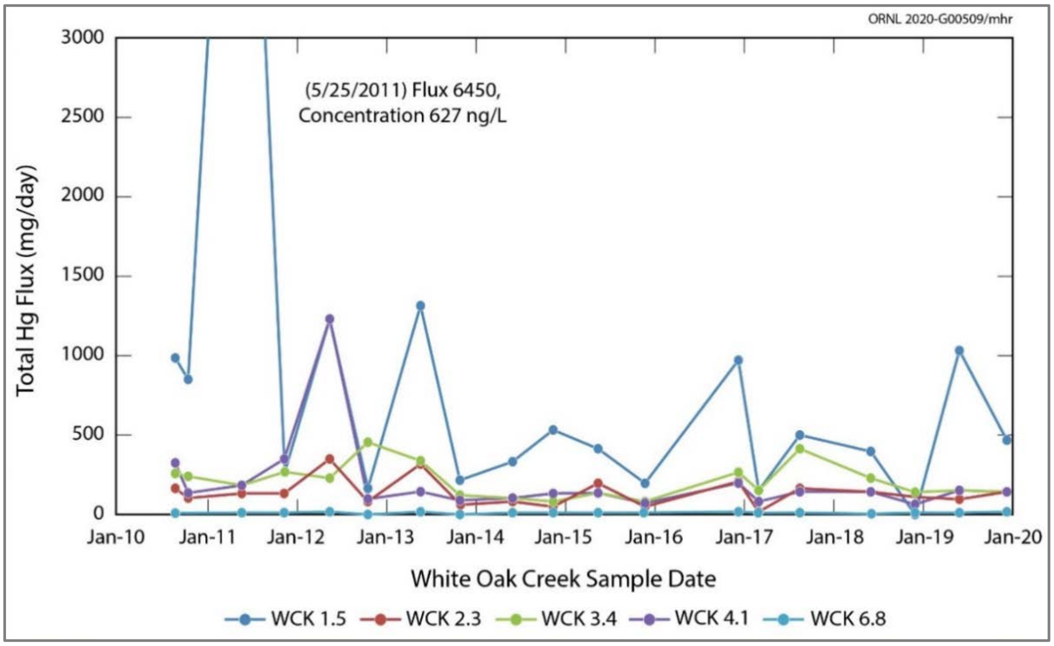
Acronym: WCK = White Oak Creek kilometer

Figure 5.23. Total aqueous mercury concentrations at sites in White Oak Creek downstream from Oak Ridge National Laboratory, 1998–2019

Water Quality Protection Plan Mercury Investigation

Twice a year, additional dry weather samples have been taken at instream locations shown in Figure 5.24, for calculation of total and dissolved mercury fluxes (i.e., the amount of a substance per unit time in flowing water) based on instream mercury concentrations and stream flow. It is now thought that the very low November 2018 mercury flux calculation for mercury at WOD is a data anomaly because it is lower than any other historical result at that site. In contrast, 2019 data show a higher mercury flux at WOD than has been seen since 2016: 1,020 mg/day (based on a concentration of 40 ng/L). Operational events during 2019 were examined to possibly explain the spring 2019 increase.

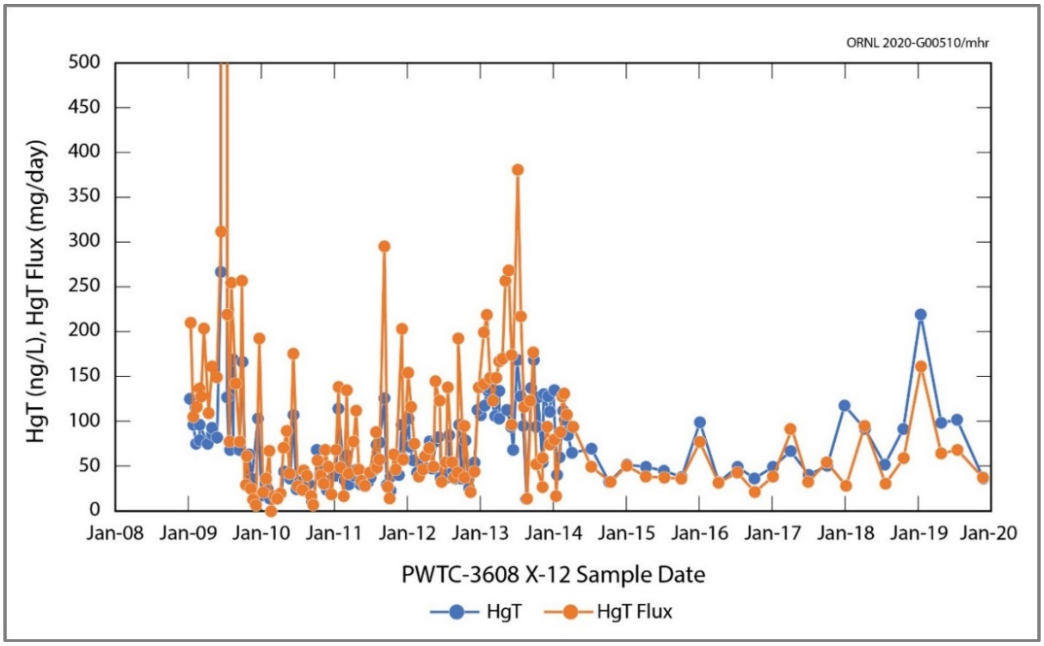
Monitoring of Hg concentrations in discharges from the two ORNL wastewater treatment plants is performed quarterly under the NPDES permit. Mercury discharge concentrations reached 219 ng/L at Outfall X12 (PWTC-3608) in January 2019, higher than any concentration measured since June 2009 (Figure 5.25). It is thought that in the process of changing out PWTC-3608 filters (September 2018–July 2019) the fluctuation in HgT discharge concentration increased. After final replacement of dual-media and MERSORB filters on July 25, 2019, mercury concentrations and fluxes through X12 dropped to 36 ng/L New sand filter media was also installed at the STP on July 14, 2019, lowering HgT concentrations in discharge through X01 from 46 ng/L in May to 2 ng/L in July. These filtration improvements appear to have also lowered concentrations at instream sampling points WCK 3.4 and at WCK 1.5 downstream of the treatment facilities. The HgT flux at WOD in December 2019 was about half of what it was in May.



Acronym: WCK = White Oak Creek kilometer

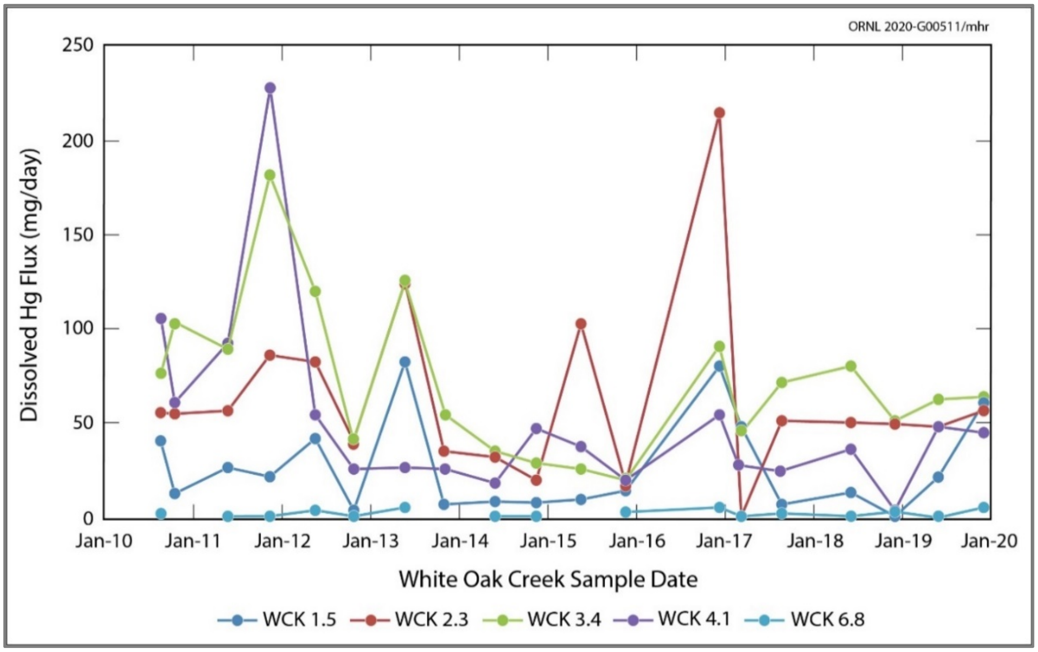
Figure 5.24. Total mercury fluxes (HgT, mg/day) at White Oak Creek instream monitoring locations WCK 1.5, WCK 2.3, WCK 3.4, WCK 4.1, and WCK 6.8; 2010–2019

Most of the total mercury flux at X15 (WOD) is associated with particulates and was three times higher in December 2019 (61 mg/day) than in May (22 mg/day). The corresponding dissolved mercury flux (Figure 5.26) is an order of magnitude lower. Dissolved mercury flux at WCK 2.3, upstream of the dam, was also slightly higher in December but remained relatively consistent at the four instream points (WCK1.5, WCK 2.3, WCK 3.4, and WCK 4.1). Between May and December 2019 three incidents occurred at storm outfalls that may have contributed mercury to WOC: a local rainfall on August 28, 2019 caused a PWTC pump station overflow to a storm drain (Outfall 304, at Third Street above WCK 3.4); a chilled water leak (September 13–October 2, 2019) to Outfall 211 increased flows by up to 15 gpm upstream of WCK 4.1; and a process transfer line began leaking to storm Outfall 403 (September 25, 2019), also located near Third Street above WCK 3.4. Those issues may have temporarily contributed mercury through storm piping.



Acronym: PWTC = Process Waste Treatment Complex

Figure 5.25 Total mercury concentration and total mercury flux (HgT) of PWTC-3608 discharges to White Oak Creek (Outfall X12), 2009–2019



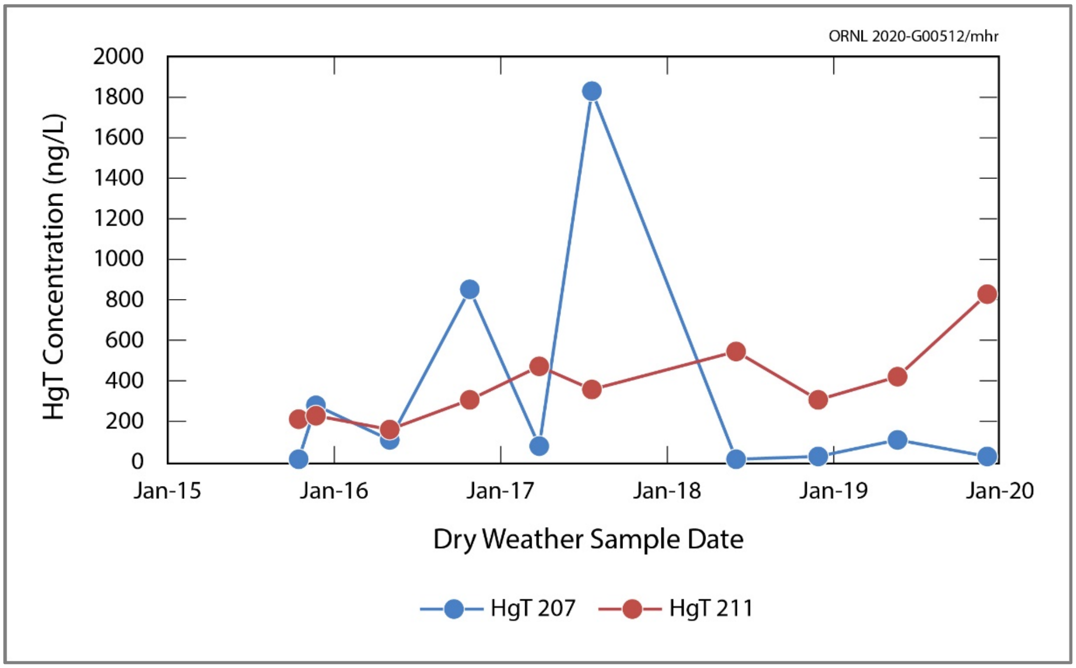
Acronym: WCK = White Oak Creek kilometer

Figure 5.26. Dissolved mercury fluxes (mg/day) at White Oak Creek instream monitoring locations WCK 1.5, WCK 2.3, WCK 3.4, WCK 4.1, and WCK 6.8; 2010–2019

Outfall Source Investigation

Individual outfalls that contribute mercury are investigated as part of the WQPP to better delineate mercury sources and to prioritize future abatement actions. Storm and treatment plant infrastructure improvements have historically reduced legacy mercury release to WOC. Discharges of mercury at Outfall 211 were reduced between 2007 and 2011 when foundation sumps (in Buildings 4501 and 4500N) were removed from storm drains and were redirected to the PWTC. In November 2009, pretreatment was installed on the main 4501 foundation sump, reducing the Hg concentrations in the outgoing sump wastewater (going to PWTC). Infrastructure upgrades in filtration technology at the PWTC have also reduced mercury release. In 2014 a MERSORB (sulfur-impregnated carbon filter optimized for mercury removal) filter replaced one granular activated carbon filter. On July 25, 2019, a new dual media filter and new MERSORB filters were installed at the PWTC. Figure 5.25 shows the effect that filtration improvements at the PWTC made in 2014 and again in May 2019; mercury concentrations discharged through Outfall X-12 dropped dramatically.

Historically, dry- and wet-weather samples taken at storm water Outfalls 211 and 207 have contained the highest concentrations of legacy mercury. Total mercury concentrations in the dry weather discharges are usually lower at Outfall 207 but have been similar to or higher than at Outfall 211 on several occasions (Figure 5.27).



(HgT = total mercury flux)

Figure 5.27. Dry weather total mercury concentration at Outfall 207 vs. Outfall 211

Outfall 207 does not receive any once-through cooling water, and very little steam condensate or foundation water reaches the outfall discharge. Thus flows during dry weather can be less than 1.0 gpm. Dry-weather flows and total mercury fluxes for Outfall 207 and 211 are compared in Figure 5.28, and Figure 5.29 shows only the small Outfall 207 dry weather flows and fluxes not discernable in Figure 5.28.

After water-recycling efforts were implemented in 2012, Outfall 211 cooling water discharge rates were reduced from flows often reaching 150 gpm to flows of generally less than 25 gpm. However, Outfall 211 discharges (above outfall dechlorination) contain once-through cooling water with residual chlorine, and the flows are still an order of magnitude larger than at Outfall 207. Much lower flows at Outfall 207 result in much lower mercury fluxes; even the highest mercury concentration (1,830 ng/L, measured on July 20, 2017), with a flow of 0.25 gpm, had a calculated flux of only about 1.0 mg Hg/day, resulting in the flux for Outfall 207 shown in Figure 5.28 being consistently less than 1.0 mg/day. The relationship between small dry-weather flows and flux (< 1.0 mg/day) at Outfall 207 is shown in Figure 5.29.

During larger storm flows, both Outfall 207 and Outfall 211 have contributed higher mercury fluxes to WOC, so attempts have been made to sample during larger storms. The highest HgT storm flux shown for Outfall 207 (see Figure 5.30) occurred in February 2017 (261 mg/day) due to a storm flow of 50 gpm with total mercury concentration of 956 ng/L. Associated dissolved mercury concentration was only 3 ng/L. Most mercury in Outfall 207 storm flow appears to be associated with particulates; dissolved mercury flux has not exceeded 30 mg/day, and higher dissolved amounts are not necessarily aligned with the largest storm flows. A sampling plan for storm catch basins within the Outfall 207 and adjacent storm drainage pipe networks is being developed to determine piping branches or sections that may contain sources of mercury. Utilities improvements and building construction are planned at the intersection of Outfalls 207 and 304 drainages west of Building 3500. There may be old piping as has been found in the Outfall 211 drainage that can be targeted for abatement/replacement.

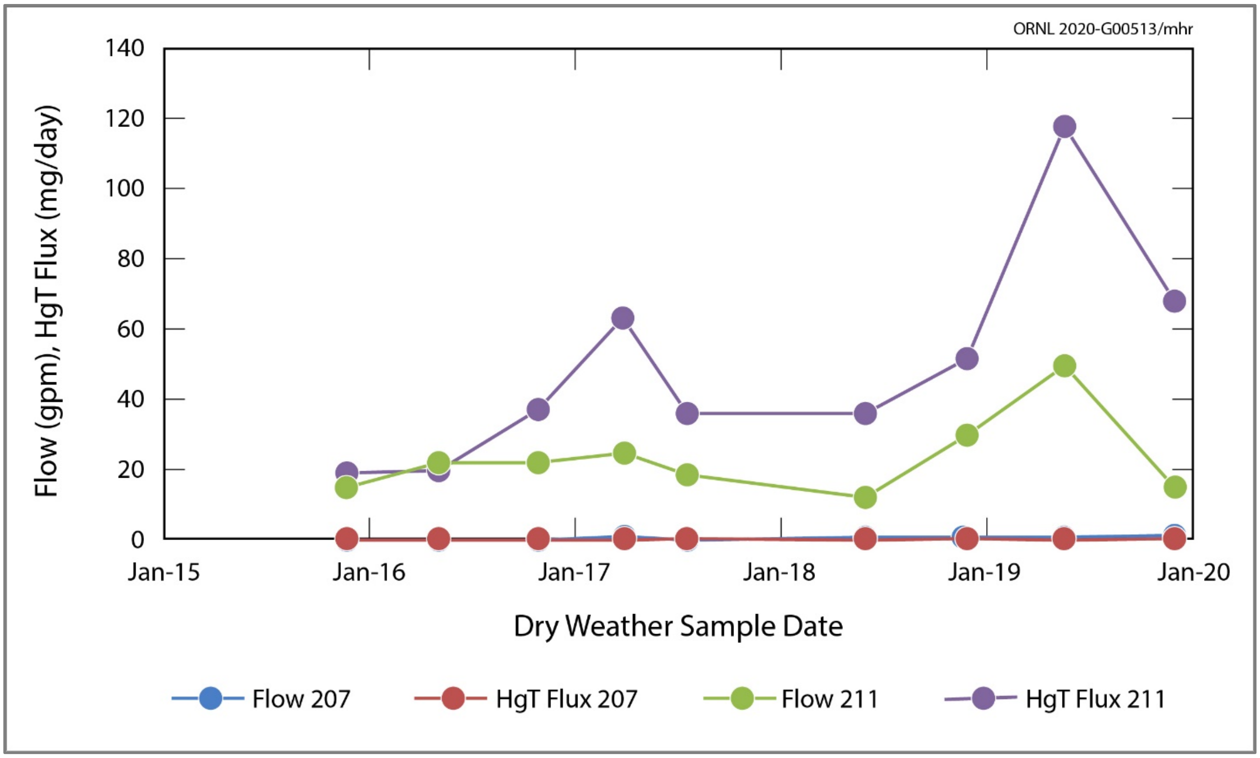


Figure 5.28. Dry-weather flows and fluxes at Outfall 207 vs. Outfall 211, 2015–2019

In 2010 a camera system was used to conduct an inspection inside the main Outfall 211 storm pipe. The upper older pipe sections had debris upstream of each pipe joint. In places, pipe sections had settled, and gaps had formed. Mercury can reside behind and within these irregularities. It is thought that sheltered mercury beads oxidize during dry periods; then the coatings are disturbed and dissolved by storm water and particularly by chlorinated once-through cooling water moving through the pipes. The volumes of dry-weather discharges have dropped at Outfall 211 since 2012, when water conservation efforts were made to recirculate once-through cooling water. Figure 5.31 shows that mercury concentrations of dry-weather discharges to Outfall 211 have been gradually increasing since then, with the highest in December of 2019 (830 ng/L) as flux has remained at about 50 mg/day.

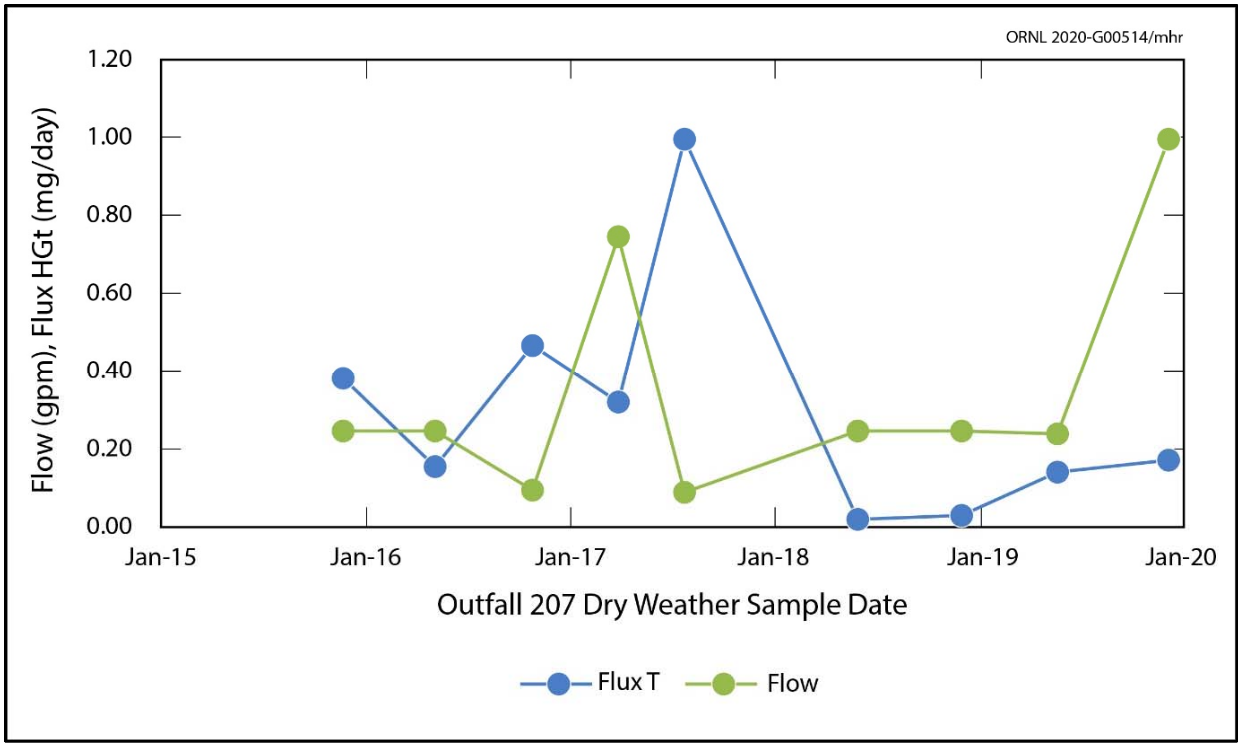


Figure 5.29. Outfall 207 dry weather flow and flux of total mercury, 2015–2019

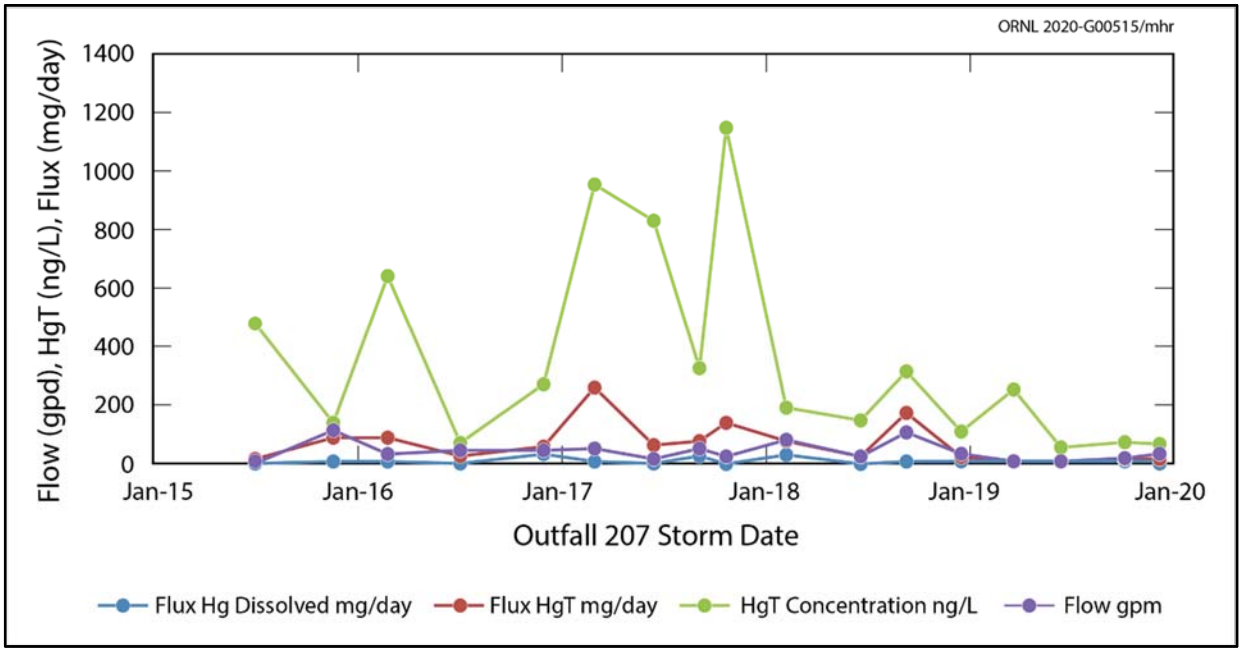


Figure 5.30. Storm flow at Outfall 207, mercury concentration, total and dissolved mercury flux, 2015−2019

At the terminus of the Outfall 211 pipe, a weir plate directs flow through two sodium sulfite tablet dechlorination boxes. During large storms, discharges from the dechlorination boxes enter below creek water level, and the weir fills with creek water. Sediment, deposited by the creek and by the storm pipe network during storms, accumulates behind the weir. An environmental action was implemented in 2018–2019 to remove the sediment on a quarterly basis (March 20, 2018, August 1, 2018, November 8, 2018, and April 1, 2019). It was thought that sediment removal might decrease mercury discharges when water backs up into this area. After the removal actions, HgT dry-weather mercury flux increased slightly with increased flow and concentration. In September 2019, water was found to be discharging to Outfall 211 from a leaking chilled water line southeast of Building 4508. The water line was repaired October 2. Dry weather concentrations continued to increase as flow and HgT flux decreased to about 70 mg/day in December 2019.

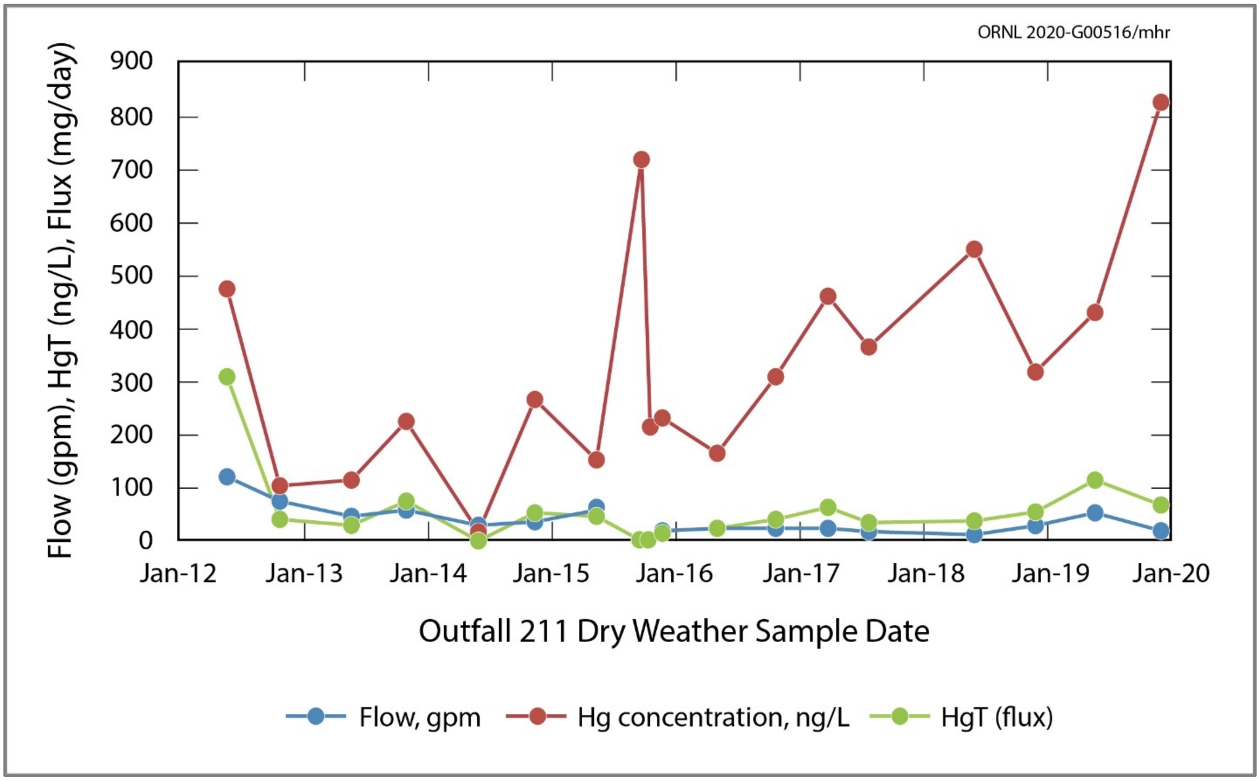


Figure 5.31. Outfall 211 dry weather flow, Hg concentration, and HgT flux, 2012−2019

During storms, Outfall 211 discharges much higher fluxes of total mercury than Outfall 207. The storm flow rates for the Outfall 211 piping system are estimated to be 50 to 225 gpm. The highest dissolved mercury fluxes do not always correlate with highest total mercury fluxes (Figure 5.32). The particulate-bound portion of the total creates the large spikes. Total fluxes have been lower since the high of 9,490 mg/day on February 24, 2016. It is possible that the high total count was caused by mercury-rich particulate matter that was suspended in the discharge from the upper Outfall 211 storm pipe or that was already present in the Outfall 211 weir box and was resuspended. In 2018 the maximum HgT flux was 1,070 mg/day (June 21). During 2019 the maximum total flux was a much lower 250 mg/day (October 7), and of that, a larger portion (141 mg/day) was dissolved. Since October 2017, the total flux has been moving closer to the dissolved flux; fewer particulates have been found in the storm discharges. This could be due to less mobilization of particulates within the pipe, or it may be due to 2018 efforts to remove accumulated sediment from the Outfall 211 weir box.

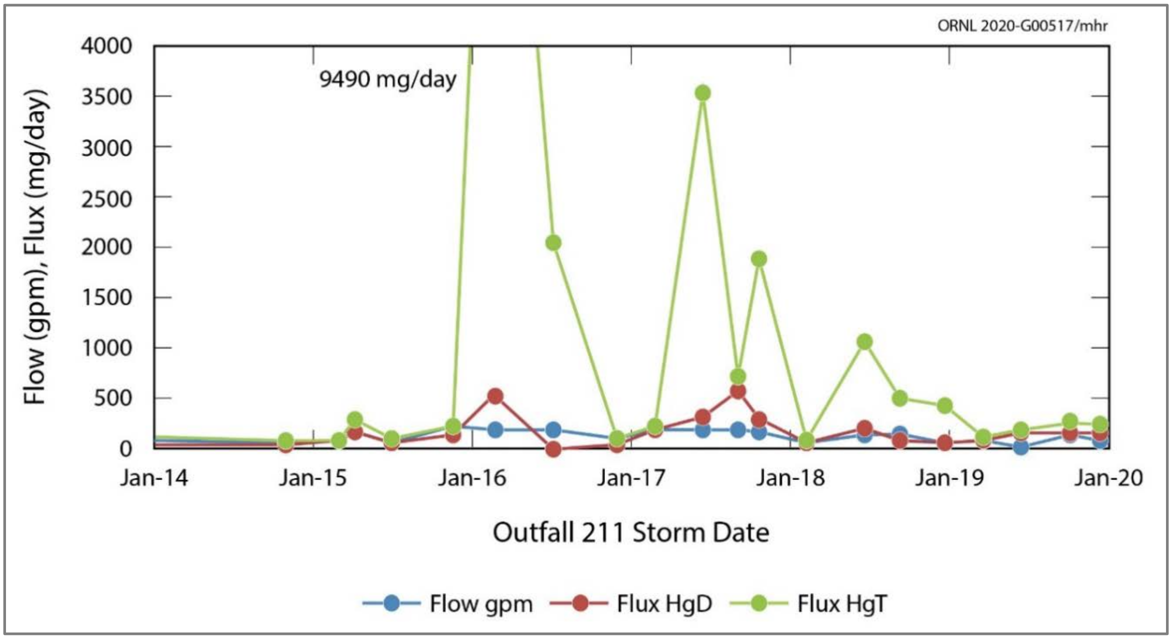


Figure 5.32. Outfall 211 storm flow, dissolved and total mercury flux 2014–2019

5.5.5 Storm Water Surveillances and Construction Activities

Storm water drainage areas at ORNL are inspected twice per year as directed in the WQPP. Land use within drainage areas is typical of office/industrial/research settings with surface features that include laboratories, support facilities, paved areas, and grassy lawns. Outdoor material is located temporarily in many places at ORNL, but most activity involving the movement and storage of outdoor material takes place in the 7000 area, which is located on the east end of the ORNL site and where most of the craft and maintenance shops are located. Smaller outdoor storage areas are located throughout the facility in and around loading docks and material delivery areas at laboratory and office buildings. The types of materials stored outside, as noted in field inspections, include finished metal items (pipes and parts); equipment awaiting use, disposal, or repair; aging (rusting) infrastructure; and construction equipment and material. While sites that are covered by a Tennessee construction general permit are considered to have more significant potential for runoff impacts, inspections and controls required by an approved storm water pollution prevention plan have proven effective at minimizing short-term and long-term impacts to nearby streams and waterways from construction sites.

Some construction activities are performed on third-party-funded construction projects on ORR under agreements with federal agencies other than DOE and with local and state agencies. There are mechanisms in place for ensuring effective storm water controls at the third-party sites, one of which includes staff from UT-Battelle acting as points of contact for communication interface on environmental conditions, erosion and sedimentation controls, spill/emergency responses, and other key issues.

5.5.6 Biological Monitoring

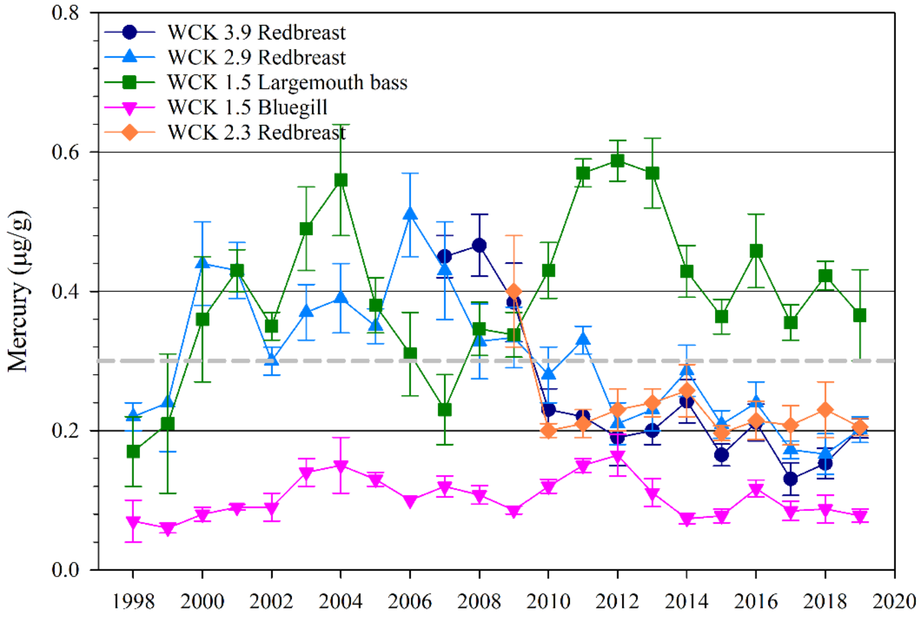
5.5.6.1 Bioaccumulation Studies

The bioaccumulation task for BMAP addresses two NPDES permit requirements at ORNL: (1) evaluate whether mercury at the site is contributing to a stream at a level that will adversely affect fish and other aquatic life or that will violate the recreational criteria and (2) monitor the status of PCB contamination in fish tissue in the WOC watershed. Concentrations of mercury in fish in the WOC watershed are monitored annually and are evaluated relative to the EPA AWQC of 0.3 µg/g in fish fillets, a concentration considered protective of human health and the environment. Concentrations of PCBs in fish fillets are also monitored annually and are evaluated relative to the TDEC fish advisory limit of 1 µg/g.

Bioaccumulation in Fish

In WOC, mercury and PCB concentrations in fish have been at or near human health risk thresholds (e.g., EPA recommended fish-based AWQC [0.3 µg/g for mercury], TDEC fish advisory limits for PCBs). Actions taken in 2007 to treat a mercury-contaminated sump resulted in significant decreases in mercury concentrations in fish throughout WOC. The decreases were most apparent at upstream locations closest to the sump water reroute (Figure 5.33). While the overall trends in the uppermost locations sampled in the creek suggest that fish tissue concentrations are decreasing overall, there is some interannual variability. Fillet concentrations increased slightly at the two uppermost stream sites in 2019 but remained below the AWQC for mercury in fish. Mean fillet concentrations increased from 0.15 µg/g in 2018 to 0.20 µg/g in 2019 at WCK 3.9 and increased from 0.17 µg/g in 2018 to 0.20 µg/g in 2019 at WCK 2.9 (Figure 5.33). Mercury concentrations in largemouth bass collected from WCK 1.5 (White Oak Lake) have been fluctuating in recent years and decreased from 0.42 µg/g in 2018 to 0.37 µg/g in 2019, but remained above the guideline. Mercury concentrations in bluegill collected from WCK 1.5 also decreased very slightly, from 0.088 µg/g in 2018 to 0.078 µg/g, and remained below the recommended guideline.

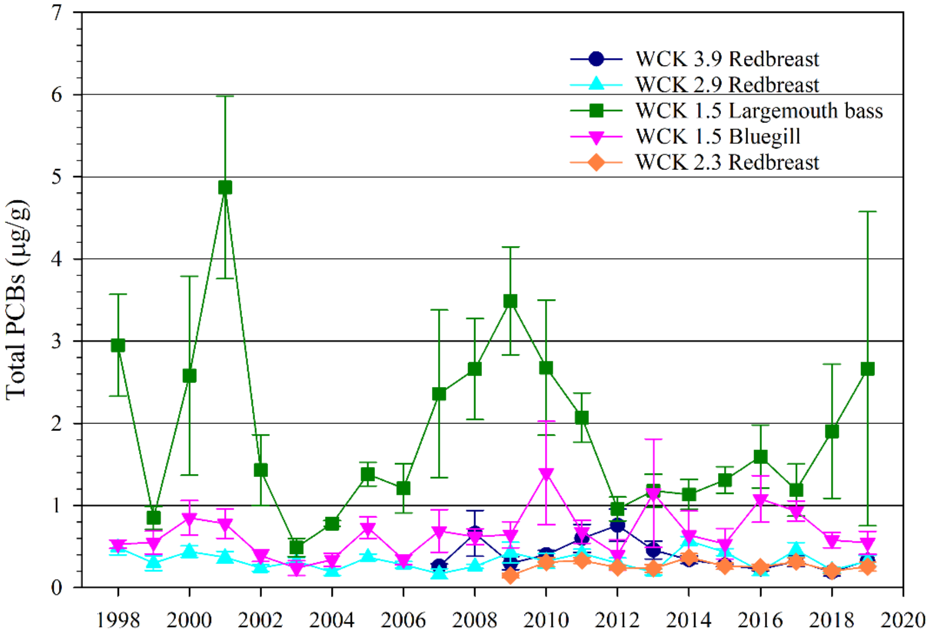
PCB concentrations (defined as the sum of Aroclors 1248, 1254, and 1260) in redbreast sunfish from the WOC watershed remained within historical ranges, with mean concentrations of 0.33 µg/g at WCK 3.9, 0.32 µg/g at WCK 2.9, and 0.26 µg/g at WCK 2.3 (compared to 0.19 µg/g at WCK 3.9, 0.21 µg/g at WCK 2.9, and 0.20 µg/g at WCK 2.3 in 2018 [Figure 5.33]). PCB concentrations in bluegill collected from WCK 1.5 decreased from 0.58 µg/g in 2018 to 0.55 µg/g in 2019; concentrations in largemouth bass collected from WCK 1.5 increased from 1.90 µg/g in 2018 to 2.66 µg/g in 2019 (Figure 5.34).



Dashed grey line indicates the US Environmental Protection Agency ambient water quality criterion for mercury (0.3 µg/g in fish tissue).

Acronym: WCK = White Oak Creek kilometer

Figure 5.33. Mean concentrations of mercury (± standard error, N = 6) in muscle tissue of sunfish and bass from WCKs 3.9, 2.9, and 2.3 and White Oak Lake (WCK 1.5), 1998–2019



Acronyms:
PCB = polychlorinated biphenyl
WCK = White Oak Creek kilometer

Figure 5.34. Mean total PCB concentrations (± standard error, N = 6) in fish fillets collected from the White Oak Creek watershed, 1998–2019

5.5.6.2 Benthic Macroinvertebrate Communities

Monitoring of benthic macroinvertebrate communities in WOC, First Creek, and Fifth Creek continued in 2019. Additionally, monitoring of the macroinvertebrate community in lower Melton Branch (MEK 0.6) continued under the OREM Water Resources Restoration Program (WRRP). Benthic macroinvertebrate samples are collected annually following TDEC protocols (since 2009) and protocols developed by ORNL staff (since 1986). The protocols developed by ORNL staff provide a long-term record (34 years) of spatial and temporal trends in the invertebrate community from which the effectiveness of pollution abatement and remedial actions taken at ORNL can be evaluated and verified. The ORNL protocols also provide quantitative results that can be used to statistically evaluate changes in trends relative to historical conditions. The TDEC protocols provide a qualitative estimate of the condition of a macroinvertebrate community relative to a state-defined reference condition.

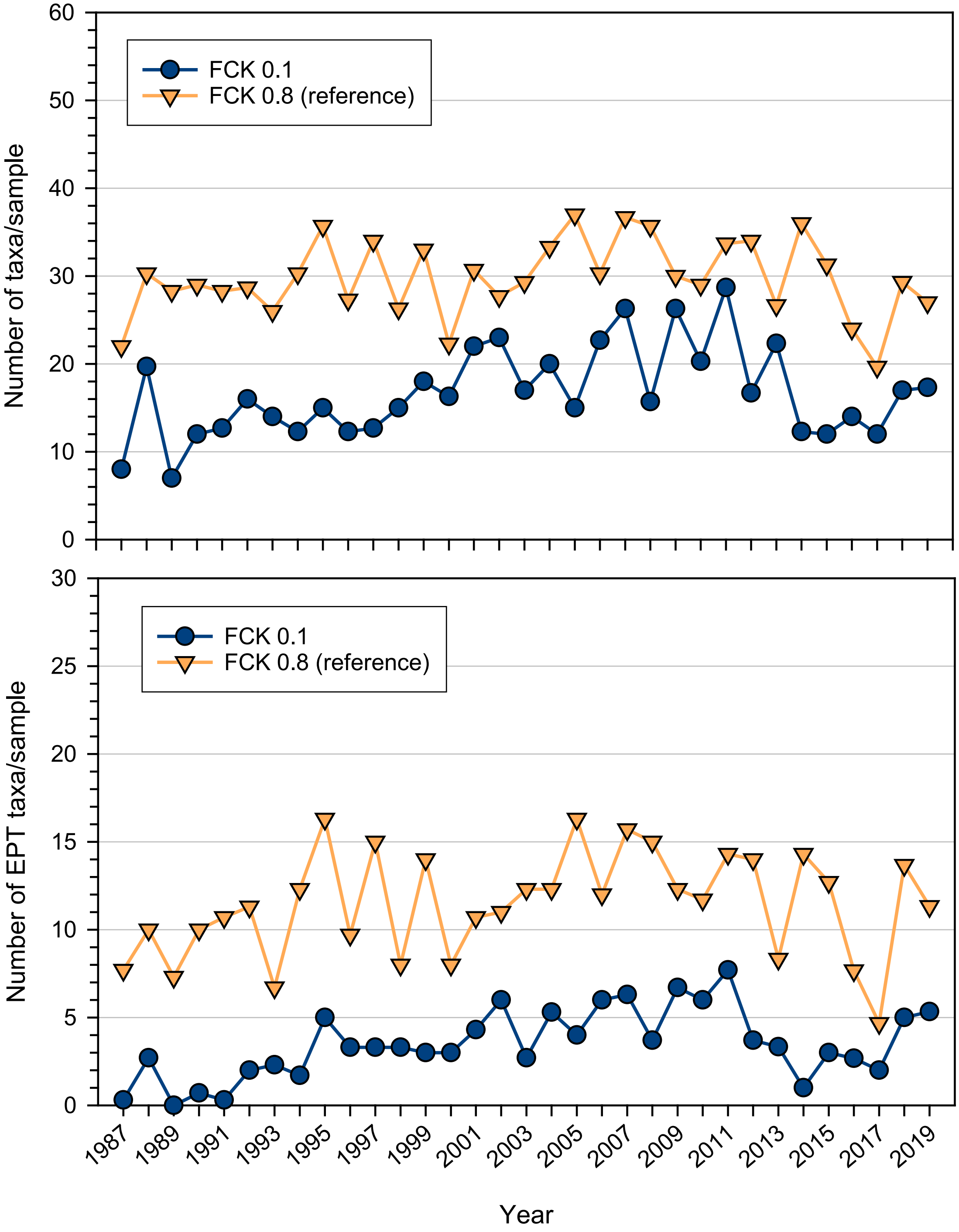
General trends in the results of ORNL protocols indicated significant recovery in these communities since 1987, but community characteristics suggest that ecological impairment remains (Figures 5.35–5.37). Relative to respective upstream reference sites, total taxonomic richness (i.e., the mean number of different species per sample) and richness of the pollution-intolerant taxa (i.e., the mean number of different mayfly, stonefly, and caddisfly species per sample or Ephemeroptera, Plecoptera, and Trichoptera [EPT] taxa richness) continued to be lower at these downstream sites.

In lower First Creek (First Creek kilometer [FCK] 0.1), total taxa richness increased gradually in the 1990s and 2000s but was then lower for 4 years beginning in 2014 (Figure 5.35). Total taxa richness has increased at FCK 0.1 in the past 2 years (2018, 2019), reaching values that were previously observed in the late 1990s. Similarly, the number of pollution-intolerant EPT taxa decreased in 2012, and in 2014, EPT taxa richness was the lowest it had been since the early 1990s. After 6 consecutive years of low EPT taxa richness, values increased in 2018 and 2019 to levels previously recorded in the late 2000s. Additionally, upper First Creek (FCK 0.8), which serves as a reference for FCK 0.1, displayed 3 years of consecutive declines in total taxa richness and EPT taxa richness from 2014 to 2017, but in 2018 and 2019, levels returned to values in previous years. The 6-year period of extremely low values in FCK 0.1 did not mirror those in FCK 0.8. This suggests that while climate or hydrological change may have influenced conditions within the entire stream (both FCK 0.1 and FCK 0.8), a more localized change may have also occurred in lower First Creek. If a change has occurred, it is not known whether it is related to a change in chemical conditions (e.g., change in water quality or the possible presence of a toxicant), physical conditions (e.g., unstable substrate, increased frequency of high-discharge events), or natural variation. Additionally, it is unclear at this time whether conditions at FCK 0.1 have improved temporarily or for the long term.

Total taxa richness at Fifth Creek kilometer (FFK) 0.2 increased in the late 1980s, and then reached a fairly consistent level until exhibiting a large decrease between 2007 and 2008 (Figure 5.36), suggesting a change in conditions occurred at the site during that time. It took ~5 years for total taxa richness to return to predecline levels (Figure 5.36). EPT taxa richness at FFK 0.2 increased slowly from the late 1980s to early 2000s before decreasing for several years (~2003–2011). More recently, EPT taxa richness has remained fairly steady at ~5–6 EPT taxa per sample (2011–2018). However, EPT taxa richness in 2019 decreased by 4 (from 6 EPT taxa/sample in 2018 to 2 EPT taxa/sample in 2019). It is not known whether this decrease will persist in future years or whether it instead reflects interannual variation in invertebrate community composition.

Invertebrate metric values for WCK 2.3 and WCK 3.9 continued to remain within the ranges of values found since the early 2000s, although total taxa richness and EPT taxa richness were lower at WCK 2.3 and WCK 3.9 over the past 4 to 5 years. As with FCK 0.1 and FFK 0.2, the total taxa richness and EPT taxa richness at WCK 2.3 and WCK 3.9 continued to be notably lower than those for the reference sites. Since 2001, Walker Branch has served as an additional reference site for WOC mainstem sites downstream of Bethel Valley Road (Figure 5.35). Comparisons of WCK 6.8 to WBK 1.0 show that communities in WCK 6.8 represent ideal reference conditions. Additionally, the comparison of Walker Branch to downstream sites in WOC show that those WOC communities remain impaired. Interestingly, a pattern similar to FCK 0.8 occurred in both WCK 6.8 and WBK 1.0, where consecutive declines in total taxa richness and EPT taxa richness have been observed in the past few years, followed by a return to higher levels in 2018 and 2019. This suggests that similar climatological or environmental changes may be driving some of these patterns across the entire watershed, if not the entire ORR.

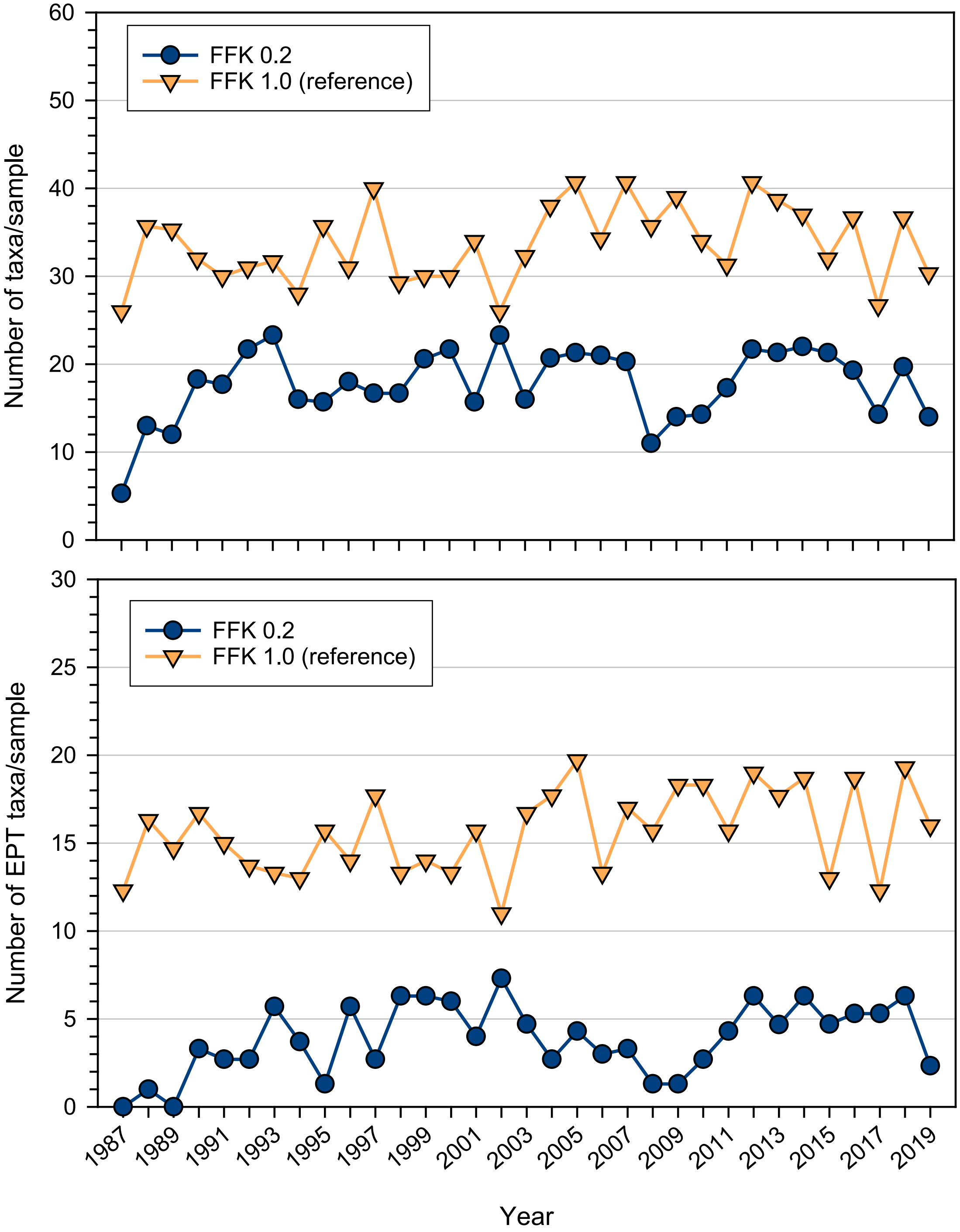
Macroinvertebrate metrics for lower Melton Branch (MEK 0.6) suggested that total taxa and EPT taxa richness continued to be similar to those in reference sites in 2019 (Figure 5.35). However, other invertebrate community metrics at MEK 0.6 potentially sensitive to more specific types of pollutants, such as the density of pollution-intolerant and pollution-tolerant species (not shown), continued to fluctuate annually between comparable values and values below those of the reference sites. For the past 3 years (2017–2019), EPT density was lower in MEK 0.6 than WCK 6.8 and WBK 1.0 while the density of pollution-tolerant species (oligochaetes and chironomids) was higher in MEK 0.6 than in those two reference sites.



(Top) total taxonomic richness (mean number of all taxa/sample) and (bottom) taxonomic richness of the pollution-intolerant taxa, Ephemeroptera, Plecoptera, and Trichoptera (EPT); mean number of EPT taxa/sample, April sampling periods, 1987−2019Figure 5.35. Benthic macroinvertebrate communities in First Creek

Acronym: FCK = First Creek kilometer

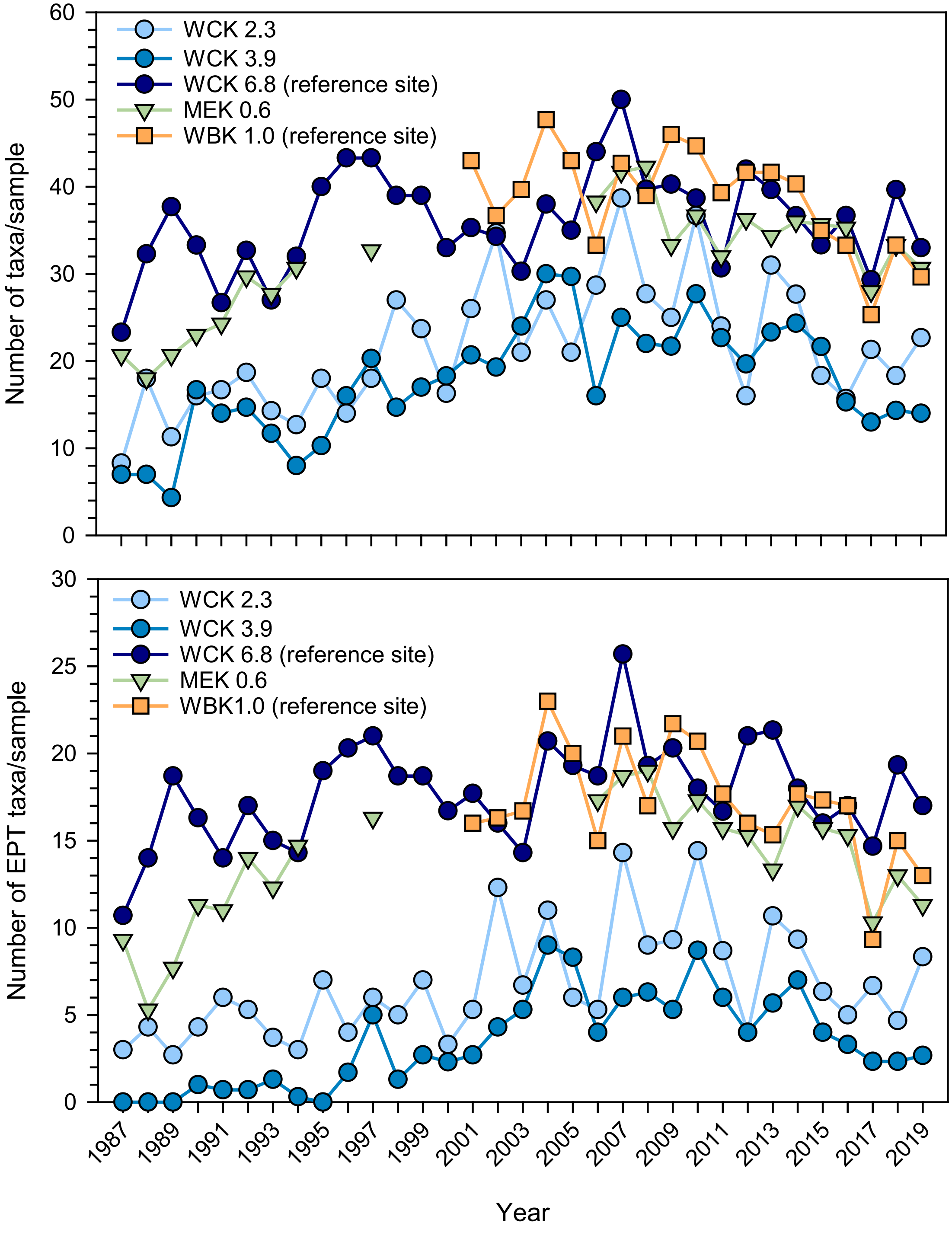
Figure 5.35. Benthic macroinvertebrate communities in First Creek



(Top) total taxonomic richness (mean number of all taxa/sample) and (bottom) taxonomic richness of the pollution-intolerant taxa, Ephemeroptera, Plecoptera, and Trichoptera (EPT) (mean number of EPT taxa/sample), April sampling periods, 1987−2019

Acronym: FFK = Fifth Creek kilometer

Figure 5.36. Benthic macroinvertebrate communities in Fifth Creek



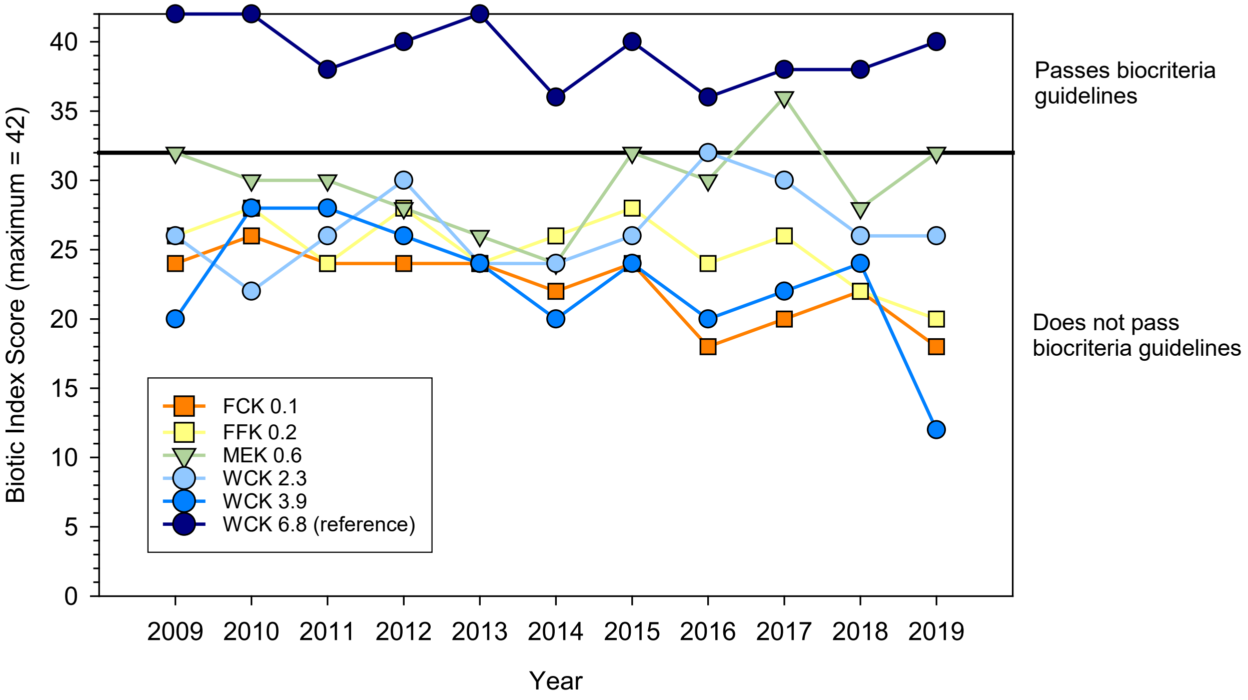
(Top) total taxonomic richness (mean number of all taxa/sample) and (bottom) taxonomic richness of the pollution-intolerant taxa, Ephemeroptera, Plecoptera, and Trichoptera (EPT); mean number of EPT taxa/sample), April sampling periods, 1987−2019

Acronyms:
MEK = Melton Branch kilometer
WBK = Walker Branch kilometer
WCK = White Oak Creek kilometer

Figure 5.37. Benthic macroinvertebrate communities in Walker Branch, Melton Branch, and White Oak Creek

Based on 2017 TDEC protocols, scores for the Tennessee Macroinvertebrate Index (TMI) in 2019 rated the invertebrate communities of WCK 6.8 and MEK 0.6 as passing biocriteria guidelines, while scores from FCK 0.1, FFK 0.2, WCK 2.3, and WCK 3.9 were below these guidelines (Figure 5.38, Table 5.13). In 2019, TMI scores at these four latter sites either stayed the same or decreased from 2018 scores. In contrast, 2019 TMI scores at WCK 6.8 and MEK 0.6 were higher than 2018 scores.

Low TMI scores in FCK 0.1, FFK 0.2, WCK 2.3, and WCK 3.9 were primarily due to low values for EPT percentage and EPT taxa richness (Table 5.13). However, all of these sites, except WCK 3.9, had low percentages of oligochaetes and chironomids (worms and non-biting midges) and thus received high scores for this category (Table 5.13). MEK 0.6 scored highly for most TMI categories, except for a lower score for EPT percentage. WCK 6.8 received the highest attainable scores for all categories except for total taxa richness (Table 5.13). However, per the 2017 TDEC protocol, TMI scores should only be calculated for samples with 160 to 240 invertebrates identified to genus (TDEC 2017). In August 2019, only 50 individuals were collected from WCK 3.9 and 66 individuals from FFK 0.2, so TMI scores for those sites should be interpreted with caution.



The black horizontal line shows the threshold for Tennessee Macroinvertebrate Index scores; respective narrative ratings above and below the threshold are shown to the right of the graph.

Acronyms:
FCK = First Creek kilometer
FFK = Fifth Creek kilometer
MEK = Melton Branch kilometer
WCK = White Oak Creek kilometer

Figure 5.38. Temporal trends in Tennessee Department of Environment and Conservation macroinvertebrate scores for White Oak Creek watershed streams, August sampling periods 2009–2019

Table 5.13. Tennessee Macroinvertebrate Index metric values, metric scores, and index scores for White Oak Creek, First Creek, Fifth Creek, and Melton Branch, August 15 and 16, 2019[a,b]

Site	Metric values							Metric scores							TMI[c]
	Taxa rich	EPT rich	%EPT	%OC	NCBI	%Cling	%TN Nuttol	Taxa rich	EPT rich	%EPT	%OC	NCBI	%Cling	%TN Nuttol	
WCK 2.3	27	6	26.4	14	5.47	28.7	54.6	6	2	2	6	4	2	4	**26**
WCK 3.9	12	2	2	54	5.64	26	68	2	0	0	2	4	2	2	**12[d]**
WCK 6.8	28	14	48.1	8.3	2.96	76.7	12.6	4	6	6	6	6	6	6	**40 [pass]**
FCK 0.1	13	4	10.3	2	5.16	19.6	72.1	2	2	0	6	4	2	2	**18**
FFK 0.2	15	5	7.6	24	5.08	42.4	57.6	2	2	0	6	4	4	2	**20[d]**
MEK 0.6	26	9	20.5	6.8	3.95	57.1	29.2	4	4	2	6	6	6	4	**32 [pass]**

[a] TMI metric calculations and scoring and index calculations are based on TDEC protocols for Ecoregion 67f (TDEC. 2017. *Quality System Standard Operating Procedures for Macroinvertebrate Stream Surveys*, TDEC Division of Water Pollution Control, Nashville, Tennessee. Available at https://www.tn.gov/content/dam/tn/environment/water/documents/DWR-PAS-P-01-Quality_System_SOP_for_Macroinvertebrate_Stream_Surveys-081117.pdf).

[b] Taxa rich = Taxa richness; EPT rich = taxa richness of (mayflies, stoneflies, and caddisflies); %EPT = EPT abundance excluding *Cheumatopsyche* spp.; %OC = percent abundance of oligochaetes (worms) and chironomids (nonbiting midges); NCBI = North Carolina Biotic Index; %Cling = percent abundance of taxa that build fixed retreats or otherwise attach to substrate surfaces in flowing water; %TN Nuttol. = percent abundance of nutrient-tolerant organisms.

[c] TMI is the total index score and higher index scores indicate higher quality conditions. A score of ≥ 32 is considered to pass biocriteria guidelines (green shading). TMI scores < 32 are indicated by yellow shading

[d] TDEC protocol states that TMI scores should only be calculated for samples with 160 to 240 invertebrates identified to genus. In August 2019, only 50 individuals were collected from WCK 3.9, and 66 individuals from FFK 0.2, so results from these sites should be interpreted with caution.

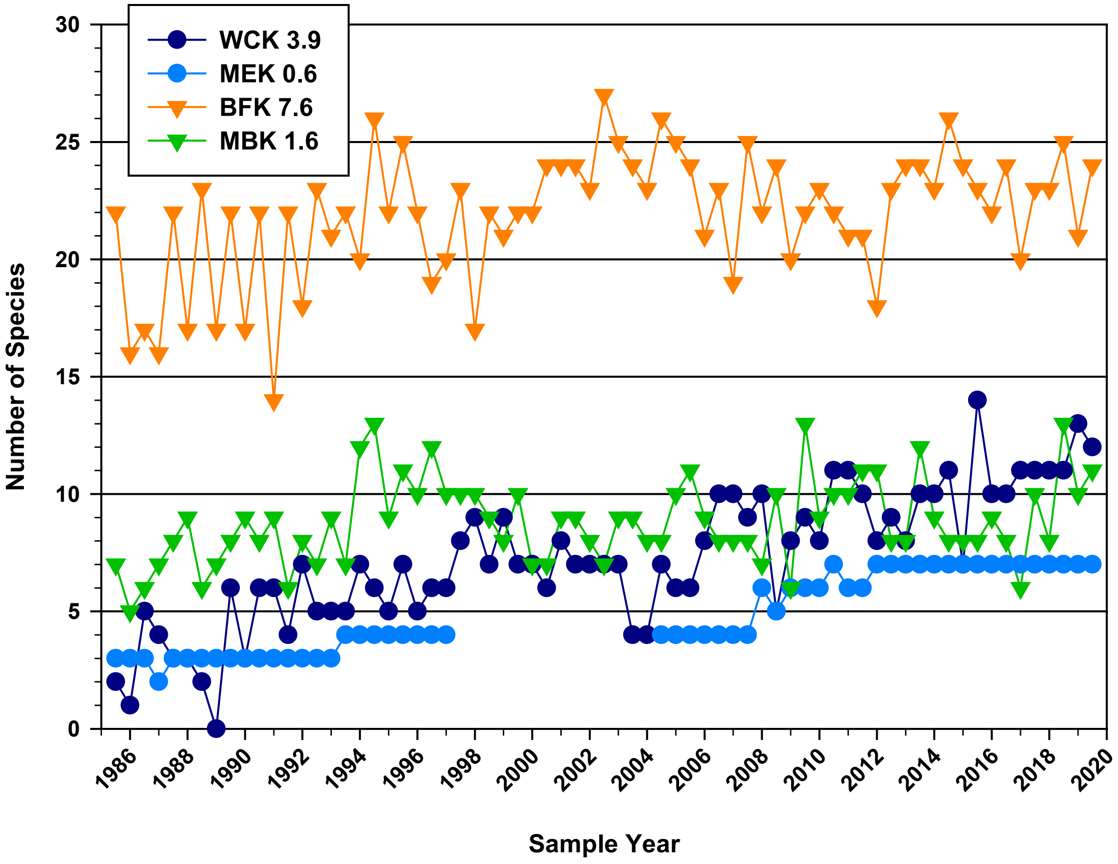
Acronyms:

EPT = Ephemeroptera, Plecoptera, and Trichoptera
FCK = First Creek kilometer
FFK = Fifth Creek kilometer
MEK = Melton Branch kilometer
NCBI = North Carolina Biotic Index
Nuttol = nutrition-tolerant organism
OC = percent abundance of oligochaetes (worms) and chironomids (nonbiting midges)
TDEC = Tennessee Department of Environment and Conservation
TMI = Tennessee Macroinvertebrate Index Score
WCK = White Oak Creek kilometer

5.5.6.3 Fish Communities

Monitoring of the fish communities in WOC and its major tributaries continued in 2019. Fish community surveys were conducted at 11 sites in the WOC watershed, including 5 sites in the main channel, 2 sites in First Creek, 2 sites in Fifth Creek, and 2 sites in Melton Branch. Streams located near or within the city of Oak Ridge (Mill Branch and Brushy Fork) were also sampled as reference sites for comparison.

In the WOC watershed, the fish community continued to be slightly degraded in 2019 compared with communities in reference streams. Sites closest to outfalls within the ORNL campus had lower species richness (number of species) (Figure 5.39), and fewer pollution-sensitive species than a slightly larger reference site and more closely resembled values found in a smaller reference reach. WOC sites also had more pollution-tolerant species and elevated densities (number of fish per square meter) of pollution-tolerant species compared with reference streams. Seasonal fluctuations in diversity and density are expected and may explain some of the variability seen at these sites. However, the combination of these factors indicates degraded water quality and/or habitat conditions. Overall, the fish communities in tributary sites adjacent to and downstream of ORNL outfalls also continued to be negatively affected by ORNL effluent in 2019 relative to reference streams and upstream sites.



Acronyms:
BFK = Brushy Fork kilomete
MBK = Mill Branch kilometer
MEK = Melton Branch kilometer
WCK = White Oak Creek kilometer

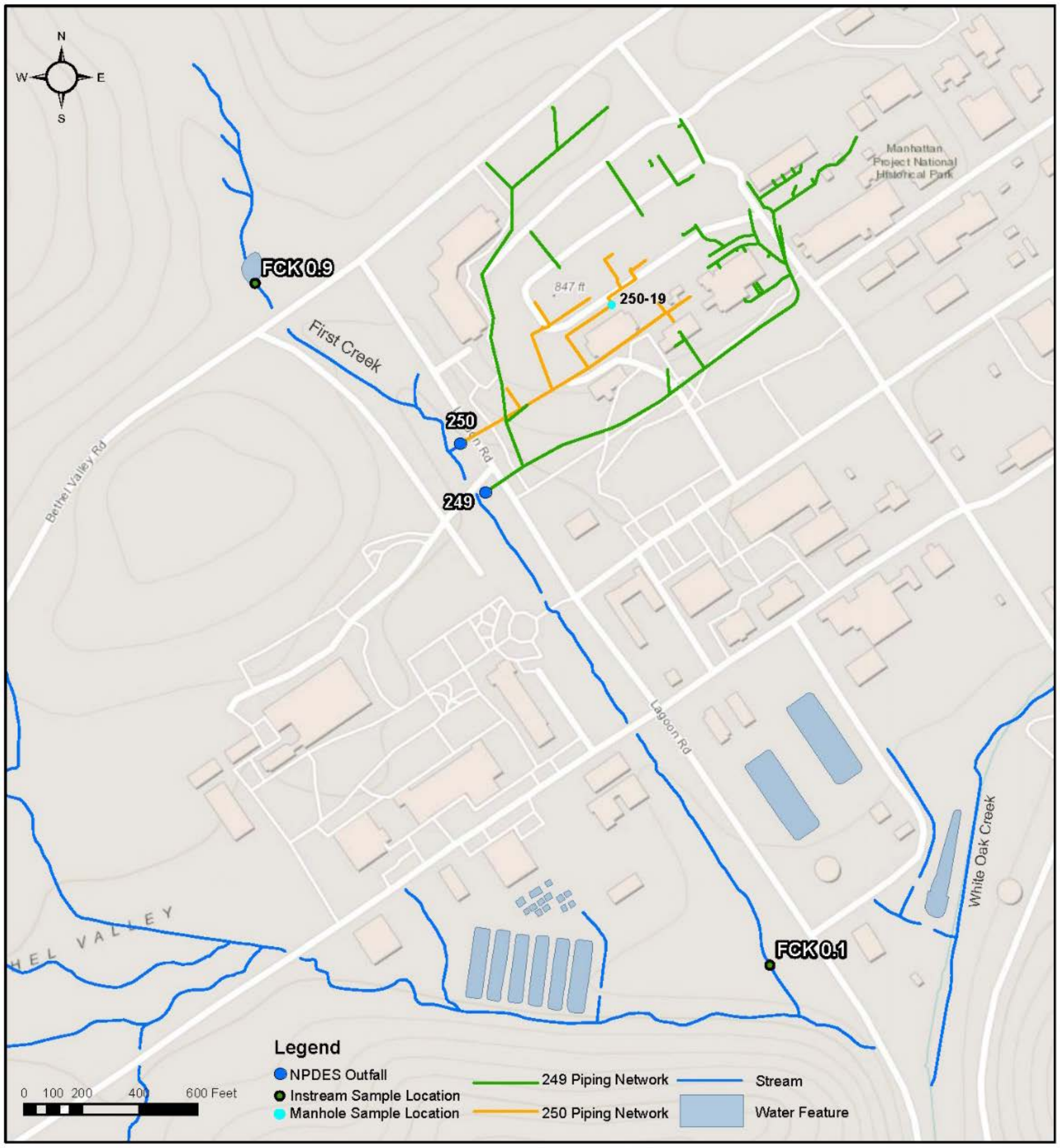
Figure 5.39. Fish species richness (number of species) in upper White Oak Creek and lower Melton Branch compared with two reference streams, Brushy Fork and Mill Branch, 1985–2019

A project to introduce fish species that were not found in the WOC watershed but that exist in similar systems on ORR and that may have historically existed in WOC was initiated in 2008 with the stocking of seven such native species. Continuing reproduction has been noted for six of the species, and several species have expanded their ranges downstream and upstream from initial introduction sites to establish new reproducing populations. In general, introduced species have had more difficulty establishing populations at upstream sites in both WOC and Melton Branch. This is likely due to numerous structures located within the watershed that act as barriers to upstream fish migration. As a result, introductions to supplement the small populations of those fish species have continued at sites within the watershed. One exception to this is the striped shiner (*Luxilus chrysocephalus*), which has expanded into upper Melton Branch, upper WOC, and lower First Creek, although established populations have not been observed in all of those locations. The introductions have enhanced species richness at almost all sample locations within the watershed and illustrate the capacity of this watershed to support increased fish diversity, which seems to be limited by impassible barriers such as dams, weirs, and culverts, and by limited access to source populations downstream in the Clinch River.

5.5.7 Polychlorinated Biphenyls in the White Oak Creek Watershed

The initial objective of the source identification task in the WOC watershed was to identify the stream reaches, outfalls, or sediment areas that are contributing to elevated PCB levels in the watershed (Figure 5.40). Sample results for largemouth bass collected from White Oak Lake showed tissue PCB concentrations higher than those recommended by TDEC and EPA for frequent consumption, but the mobility of the fish precluded the possibility of source identification. PCBs are hydrophobic and tend not to be dissolved in water, resulting in undetected PCB concentrations in water samples, using conventional analytical methods, even if collected from a contaminated site. Therefore, semipermeable membrane devices (SPMDs) are used to assess the chronic low-level sources of PCBs at critical sites on the reservation. SPMDs are thin plastic sleeves filled with oil in which PCBs are soluble. Because SPMDs are deployed at a given site for 4 weeks and have a high affinity for PCBs, they allow for a time-integrated semiquantitative index of the relative PCB concentrations in the water column rather than a "snapshot" value that would be obtained from a grab sample.

Over the past 10 years, ORNL's PCB monitoring efforts have identified upper parts of First Creek as a source of PCBs. In 2018, SPMDs were deployed in First Creek at Outfall 250 and in the piping network of Outfall 250, which contributes to First Creek (Figure 5.40). Results from this assessment indicate that PCBs remained available in the area despite previous actions to remove PCB-contaminated materials from the upper part of outfall 250 watershed. In September 2019, catch basin sediment in this drainage network was cleaned out and disposed of as solid waste. The focus of future monitoring will be to determine the effectiveness of the 2019 sediment removal. SPMDs will be deployed in locations that were previously monitored in First Creek and in the Outfall 250 drainage network.



Acronym: FCK = First Creek kilometer

Figure 5.40. Locations of monitoring points for First Creek source investigation

5.5.8 Oil Pollution Prevention

CWA Section 311 regulates the discharge of oils or petroleum products to waters of the United States and requires the development and implementation of spill prevention, control, and countermeasures (SPCC) plans to minimize the potential for oil discharges. These requirements are provided in 40 CFR 112, “Oil Pollution Prevention” (EPA 2000). Each ORR facility implements a site-specific SPCC plan. The HVC (home of NTRC and MDF), which is located off ORR, also has an SPCC plan covering the oil inventory at that location. CFTF is also located off ORR; however, that facility was evaluated, and a determination was made that an SPCC plan was not required. The ORNL and HVC SPCC plans were not changed in 2019. There were no regulatory actions related to oil pollution prevention at ORNL or HVC in 2019. An oil-handler training program exists to comply with training requirements in 40 CFR 112.

5.5.9 Surface Water Surveillance Monitoring

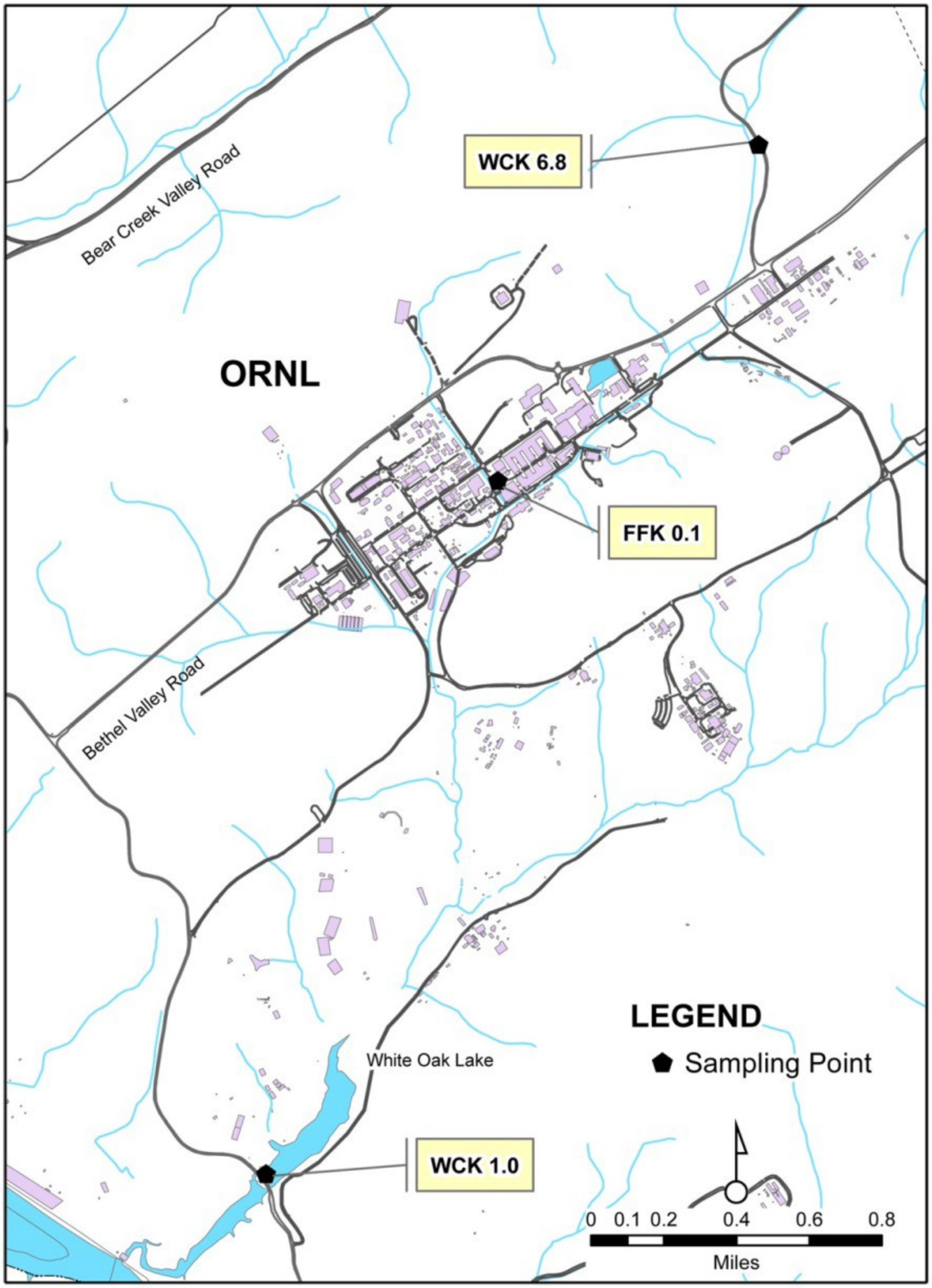
The ORNL surface water monitoring program is conducted in conjunction with the ORR surface water monitoring activities discussed in Section 6.4 to enable assessing the impacts of ongoing DOE operations on the quality of local surface water. The sampling locations (Figure 5.41) are used to monitor conditions upstream of ORNL main plant waste sources (WCK 6.8), within the ORNL campus (FFK 0.1), and downstream of ORNL discharge points (WCK 1.0).

Sampling frequencies and parameters vary by site and are shown in Table 5.14. Radiological monitoring at the discharge point downstream of ORNL (White Oak Lake at WOD) is conducted monthly under the ORNL WQPP (Section 5.5.3) and, therefore, is not duplicated by this program. Radiological monitoring at a point upstream of ORNL is conducted monthly under the ORNL WQPP and therefore is not duplicated by the surface water monitoring program. Total radioactive strontium is monitored quarterly by this surveillance program.

Samples are collected and analyzed for general water quality parameters and are screened for radioactivity at all locations (either under this program or under WQPP). Samples are further analyzed for specific radionuclides when general screening levels are exceeded. Samples from White Oak Lake at WOD are also checked for volatile organic compounds (VOCs), PCBs, and mercury. WCK 6.8 is also checked for PCBs. WCK 6.8 and WCK 1.0 are classified by the State of Tennessee for freshwater fish and aquatic life. Tennessee Water Quality Criteria (WQCs) associated with these classifications are used as references where applicable (TDEC 2015). The Tennessee WQCs do not include criteria for radionuclides. Four percent of the DOE DCS (DOE 2011a) is used for radionuclide comparison.

There were no radionuclides reported above 4 percent of DCS at the Fifth Creek location (FFK 0.1) in 2019. The beta activity and $^{89/90}$Sr concentrations were detected in samples from both sampling events at the Fifth Creek location and are related to known sources in the middle of the ORNL main campus. No $^{89/90}$Sr results above 4 percent of DCS were reported for samples collected at the upstream WOC sampling location (WCK 6.8). The other radionuclide results from WCK 6.8 and the radionuclide results from samples collected at WOD (before WOC empties into the Clinch River) are discussed in Section 5.5.3.

No PCBs were detected downstream of ORNL at WOD in 2019. Four VOCs were detected in samples from WOC at WOD during 2019: acetone was detected in the samples collected in June, September, and December; methylene chloride and tetrachloroethene were detected in the March sample; and chloroform was detected in the June sample. All VOC detections were at low, estimated values. Each of the VOCs has been detected in surface water samples from WOC at WOD before, and methylene chloride and acetone have occasionally been detected in at least one on-site groundwater well in past monitoring, including wells located in nearby Solid Waste Storage Area (SWSA) 6. Mercury was not detected at WOD in 2019.



Acronyms:
FFK = Fifth Creek kilometer
WCK = White Oak Creek kilometer

Figure 5.41. Oak Ridge National Laboratory surface water sampling locations, 2019

Table 5.14. Oak Ridge National Laboratory surface water sampling locations, frequencies, and parameters, 2019

Location[a]	Description	Frequency and type	Parameters
WCK 1.0[b]	White Oak Lake at WOD	Quarterly, grab	Volatiles, mercury, PCBs, field measurements[c]
WCK 6.8[d]	WOC upstream from ORNL	Quarterly, grab	PCBs, Total radioactive strontium, field measurements[c]
FFK 0.1	Fifth Creek just upstream of WOC (ORNL)	Semiannually, grab	Gross alpha, gross beta, total radioactive strontium, gamma scan, tritium, field measurements[c]

[a] Locations identify bodies of water and locations on them (e.g., WCK 1.0 is 1 km upstream from the confluence of White Oak Creek and the Clinch River).

[b] For this location, radiological parameters are monitored under another program (the WQPP) and therefore are not included in this plan.

[c] Field measurements consist of dissolved oxygen, pH, and temperature.

[d] For this location, gross alpha, gross beta, gamma scan, and tritium are monitored under another program (the WQPP) so those radiological parameters are not included in this plan.

Acronyms:
FFK = Fifth Creek kilometer
ORNL= Oak Ridge National Laboratory
PCB = polychlorinated biphenyl
WCK = WOC kilometer
WOC = White Oak Creek
WOD = White Oak Dam
WQPP = Water Quality Protection Plan

5.5.10 Carbon Fiber Technology Facility Wastewater Monitoring

Facility and process wastewater from activities at CFTF are discharged to the City of Oak Ridge sanitary sewer system under conditions established in City of Oak Ridge Industrial Wastewater Discharge Permit 1-12. Permit limits, parameters, and 2019 compliance status for this permit are summarized in Table 5.15.

Table 5.15. Industrial and commercial user wastewater discharge permit compliance at the Oak Ridge National Laboratory Carbon Fiber Technology Facility, 2019

Effluent parameters	Permit limits		Permit compliance		
	Daily max. (mg/L)	Daily min. (mg/L)	Number of noncompliances	Number of samples	Percentage of compliance[a]
			Outfall 01 (Underground Quench Water Tank)		
Cyanide	3.9		0	0	100
pH (standard units)	9.0	6.0	0	0	100
			Outfall 02 (Electrolytic Bath Tank)		
pH (standard units)	9.0	6.0	0	7	100
			Outfall 03 (Sizing Bath Tank)		
Copper	0.87		0	0	100
Zinc	1.24		0	0	100
Total phenol	4.20		0	0	100
pH (standard units)	9.0	6.0	0	0	100

[a] Percentage compliance = 100 – [(number of noncompliances/number of samples) × 100]

5.6 Oak Ridge National Laboratory Groundwater Monitoring Program

Groundwater monitoring at ORNL was conducted under two sampling programs in 2019: DOE OREM monitoring and DOE Office of Science (SC) surveillance monitoring. The DOE OREM groundwater monitoring program was conducted by UCOR in 2019. The SC groundwater monitoring surveillance program was conducted by UT-Battelle.

5.6.1 Summary of US Department of Energy Office of Environmental Management Groundwater Monitoring

Monitoring was performed as part of an ongoing comprehensive CERCLA cleanup effort in Bethel and Melton Valleys, the two administrative watersheds at the ORNL site. Groundwater monitoring for baseline and trend evaluation in addition to measuring effectiveness of completed CERCLA remedial actions (RAs) is conducted as part of the WRRP. The WRRP is managed by UCOR for the DOE OREM program. The results of CERCLA monitoring for ORR for FY 2019, including monitoring at ORNL, are evaluated and reported in the 2020 remediation effectiveness report (DOE 2020a) as required by the ORR FFA. The monitoring results and remedial effectiveness evaluations for Bethel and Melton Valleys are reported in Sections 2 and 3, respectively, in that report.

Groundwater monitoring conducted as part of the OREM program at ORNL includes routine sampling and analysis of groundwater in Bethel Valley to measure performance of several RAs and to continue contaminant and groundwater quality trend monitoring. In Melton Valley, where CERCLA RAs were completed in 2006 for the extensive waste management areas, the groundwater monitoring program includes monitoring groundwater levels to evaluate the effectiveness of hydrologic isolation of buried waste units. Additionally, groundwater is sampled and analyzed for a wide range of general chemical and contaminant parameters in 46 wells within the interior portion of the closed waste management area.

In FY 2010 DOE initiated activities on a groundwater treatability study at the Bethel Valley 7000 Services Area VOC plume. This plume contains trichloroethylene and its transformation products cis-1,2-dichloroethene and vinyl chloride, all at concentrations greater than EPA primary drinking water standards. The treatability study is a laboratory and field demonstration to determine whether microbes inherent to the existing subsurface microbial population can fully degrade the VOCs to nontoxic end products.

During FY 2019 postremediation monitoring continued at SWSA 3 to evaluate the effectiveness of the 2011 hydrologic isolation of the area that included construction of a multilayer cap and an upgradient stormflow/shallow groundwater diversion drain. RAs and monitoring were specified in a CERCLA RA work plan that was developed by DOE and approved by EPA and TDEC before the project was started.

5.6.1.1 Bethel Valley

During FY 2011 construction was completed for RAs at SWSA 1 and SWSA 3, two former waste storage sites that were used for disposal of radioactively contaminated solid wastes between 1944 and 1950. Wastes disposed of at SWSA 1 originated from the earliest operations of ORNL; those at SWSA 3 originated from ORNL, Y-12, the K-25 Site (ETTP), and off-site sources. Although most of the wastes disposed of at SWSA 3 were solids, some were containerized liquid wastes. Some wastes were encapsulated in concrete after placement in burial trenches, but most of the waste was covered with soil. The Bethel Valley Record of Decision (ROD) (DOE 2002) selected hydrologic isolation using multilayer caps and groundwater diversion trenches as the RA for the waste burial grounds and construction of soil covers over the former contractor's landfill and contaminated soil areas near SWSA 3. The baseline monitoring conducted during FY 2010 included measurement of groundwater levels to obtain baseline data to allow evaluation of postremediation groundwater-level suppression. Sampling and analysis of groundwater quality and contaminants were also conducted. Postremediation monitoring was specified for SWSA 3 in the *Phased Construction Completion Report for the Bethel Valley Burial Grounds at the Oak Ridge National Laboratory, Oak Ridge, Tennessee* (DOE 2012). Required monitoring includes quarterly groundwater-level monitoring in 42 wells with continuous water-level monitoring in 8 wells to confirm cap performance. Groundwater samples are collected semiannually at 13 wells for laboratory analyses to evaluate groundwater contaminant concentration trends.

FY 2019 monitoring results showed that the cap was effective, although target groundwater elevations have not yet been attained at three of eight wells. Drinking water standards are used as screening water quality concentrations to evaluate the site response to remediation. Strontium-90, a signature contaminant at SWSA 3, shows decreasing annual maximum concentrations with 6 of 10 monitored wells exhibiting ^{90}Sr concentrations less than the 8 pCi/L maximum contaminant level (MCL) derived concentration. Benzene, potentially from natural sources, shows decreasing annual maximum concentrations with FY 2019 maxima of 0.006 mg/L in two wells, which is just slightly greater than the 0.005 mg/L MCL. During FY 2019, as part of the DOE OREM program, three groundwater monitoring wells in Bethel Valley to the west of Tennessee Highway 95 were monitored to detect and track contamination from the SWSA 3 area. Data from those three wells supplement data being collected from a multiport well (4579) near SWSA 3 for exit pathway groundwater monitoring in western Bethel Valley. Groundwater monitoring near SWSA 3, along with the exit pathway, and groundwater and surface water monitoring at the northwest tributary of WOC and in the headwaters of Raccoon Creek allow integration of data concerning SWSA 3 contaminant releases. The data are presented in the 2020 remediation effectiveness report (DOE 2020a).

Groundwater monitoring continued at the ORNL 7000 Area during FY 2019 to evaluate treatability of the VOC plume at that site. Site characterization testing of the endemic microbial community showed that microbes were present that are capable of fully degrading trichloroethylene and its degradation products if sufficient electron donor compounds are present in the subsurface environment. During FY 2011 a mixture of emulsified vegetable oil and a hydrogen-releasing compound was injected into four existing monitoring wells in the 7000 area. Ongoing monitoring of VOC concentrations show that the effects of the biostimulation test continue to be apparent, although at decreasing levels.

The other principal element of the Bethel Valley ROD (DOE 2002) remedy that requires groundwater monitoring is the containment pumping to control and treat discharges from the ORNL Central Campus Core Hole 8 plume. The original action for the plume was a CERCLA removal action that was implemented in 1995 with the performance goal of reducing ^{90}Sr in WOC. The remedy had performed well until the latter portion of FY 2008, when conditions changed and ^{90}Sr and $^{233/234}$U concentrations in monitoring wells and the groundwater collection system began increasing. During FY 2009 the remedy did not meet its performance goal. In March 2012 DOE completed refurbishment and enhancement of the groundwater collection system to increase the effectiveness of the plume containment.

Between FY 2012 and FY 2015 the Bethel Valley ROD goal for ^{90}Sr concentrations at the 7500 Bridge Weir monitoring location was met. During FY 2016 and FY 2017 that goal was exceeded because of contaminant releases from a deteriorated radiological wastewater drain that caused ^{90}Sr discharges from storm drain Outfall 304 into WOC. During FY 2019 the Bethel Valley ROD goal for ^{90}Sr at the 7500 Bridge Weir site was met. Continuing ^{90}Sr influxes to WOC from groundwater and storm drain discharges fed by releases from deteriorated infrastructure comprise the majority of ^{90}Sr measured at the 7500 Bridge Weir site.

5.6.1.2 Melton Valley

The Melton Valley ROD (DOE 2000) established goals for a reduction of contaminant levels in surface water, groundwater-level fluctuation reduction goals within hydrologically isolated areas, and minimization of the spread of groundwater contamination. Groundwater monitoring to determine the effectiveness of the remedy in Melton Valley includes groundwater-level monitoring in wells within and adjacent to hydrologically isolated shallow waste burial areas and groundwater quality monitoring in selected wells adjacent to buried waste areas.

Groundwater-level monitoring shows that the hydrologic isolation component of the Melton Valley remedy is effectively minimizing the amount of percolation water contacting buried waste and is reducing contaminated leachate formation. The total amount of rainfall on ORR during FY 2019 was about 70 in., which is about 16 in. greater than the long-term annual average for ORR. In a few areas, groundwater levels within capped areas continue to respond to groundwater fluctuations imposed from areas outside the caps, but contact of groundwater with buried waste is minimal. Overall, the hydrologic isolation systems are performing as designed.

Groundwater quality monitoring in the interior of Melton Valley shows that in general groundwater contaminant concentrations are declining or are stable following RAs. Groundwater quality monitoring that is substantively equivalent to the former RCRA monitoring continues at SWSA 6. Several VOCs continue to be detected in wells along the eastern edge of the site.

During the past 10 years of groundwater monitoring in the Melton Valley exit pathway, several site-related contaminants have been detected in groundwater near the Clinch River. Low concentrations of strontium, tritium, uranium, and VOCs have been detected intermittently in a number of the multizone sampling locations. Groundwater in the exit pathway wells has high alkalinity and sodium and exhibits elevated pH. During FY 2019 an off-site groundwater monitoring well array west of the Clinch River and adjacent to Melton Valley was monitored as part of the OREM program. Monitoring included groundwater-level monitoring to evaluate potential flowpaths near the river and sampling and analysis for a wide array of metals, anions, radionuclides, and VOCs. Groundwater-level monitoring showed that natural head gradient conditions cause groundwater seepage to converge toward the Clinch River from both the DOE (eastern) and off-site (western) sides of the river. Monitoring results are summarized in the 2020 remediation effectiveness report (DOE 2020a).

5.6.2 DOE Office of Science Groundwater Surveillance Monitoring

DOE Order 458.1 (DOE 2011c) is the primary requirement for a site-wide groundwater protection program at ORNL. As part of the groundwater protection program, and to be consistent with UT-Battelle management objectives, groundwater surveillance monitoring was performed to monitor ORNL groundwater exit pathways and UT-Battelle facilities (“active sites”) potentially posing a risk to groundwater resources at ORNL. Results of the DOE SC groundwater surveillance monitoring are reported in the following sections.

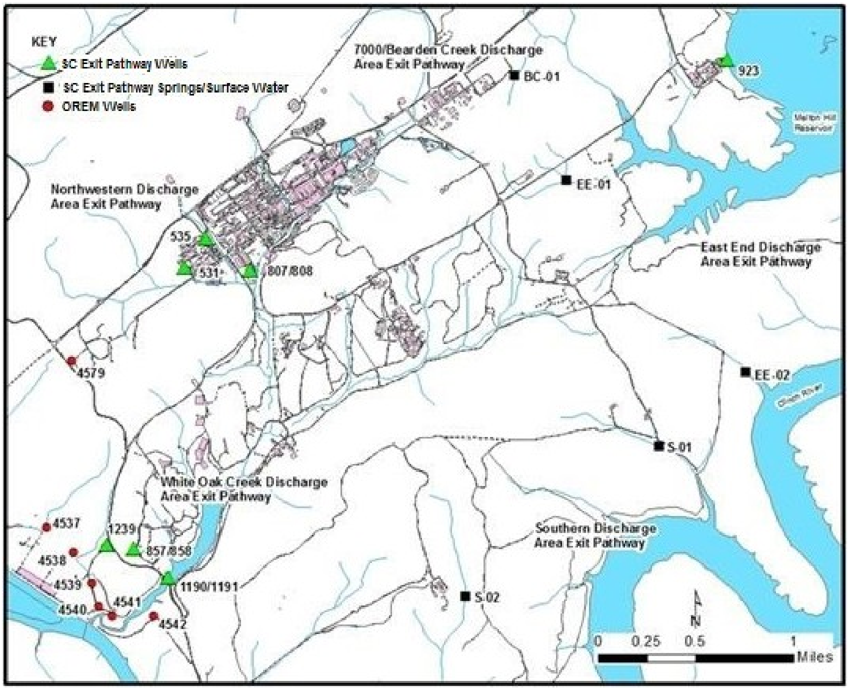
Exit pathway and active-sites groundwater surveillance monitoring points sampled during 2019 included seep/spring and surface-water monitoring locations in addition to groundwater surveillance monitoring wells. Seep/spring and surface-water monitoring points located in appropriate groundwater discharge areas were used in the absence of monitoring wells.

Groundwater pollutants monitored under the exit pathway groundwater surveillance and active-sites monitoring programs are not regulated by federal or state rules. Consequently, no permit-required or other applicable standards exist for evaluating results. To assess groundwater quality at these monitoring locations, and to facilitate comparison of results between locations, results were compared to selected federal and state standards even though those standards are not directly applicable. For radionuclide parameters for which alternative standards were not identified, results were compared to 4 percent of the DCSs (DOE 2011a). Regardless of the standards selected for comparison, it is important to note that no members of the public consume groundwater from ORNL wells, nor do any groundwater wells furnish drinking water to personnel at ORNL.

5.6.2.1 Exit Pathway Monitoring

During 2019, exit pathway groundwater surveillance monitoring was performed in accordance with the exit pathway sampling and analysis plan (Bonine 2012). Groundwater exit pathways at ORNL include areas from watersheds or sub-watersheds where groundwater discharges to the Clinch River–Melton Hill Reservoir to the west, south, and east of the ORNL main campus. The exit pathway monitoring points were chosen based on hydrologic features, screened interval depths (for wells), and locations relative to discharge areas proximate to DOE facilities operated by, or under the control of, UT-Battelle. The groundwater exit pathways at ORNL include four discharge zones identified by a data quality objectives process. One of the original exit pathway zones was split into two zones for geographic expediency. The Southern Discharge Area Exit Pathway was carved from the East End Discharge Area Exit Pathway. The five zones are listed below. Figure 5.42 shows the locations of the exit pathway monitoring points sampled in 2019. :

- The 7000–Bearden Creek Discharge Area Exit Pathway
- The East End Discharge Area Exit Pathway
- The Northwestern Discharge Area Exit Pathway
- The Southern Discharge Area Exit Pathway
- The WOC Discharge Area Exit Pathway



Acronyms: OREM = DOE Office of Environmental ManagementSC = DOE Office of Science

Figure 5.42. UT-Battelle exit pathway groundwater monitoring locations at Oak Ridge National Laboratory, 2019

The efficacy of the exit pathway monitoring program was reviewed in late 2011. As a result, the groundwater monitoring program was modified through an optimization approach that included frequency analysis of parameters and their concentrations based on an exhaustive review of historical groundwater sampling data. The modification resulted in a 10-year staggered groundwater monitoring schedule and analytical suite selection. This approach was initiated in 2012. The groundwater monitoring program implemented in 2019 is outlined in Table 5.16.

Unfiltered samples were collected from the exit pathway groundwater surveillance monitoring points in 2019. The organic suite was composed of VOCs and semivolatile organic compounds; the metallic suite included heavy and non-heavy metals; and the radionuclide suite was composed of gross alpha/gross beta activity, gamma emitters, $^{89/90}$Sr, and tritium. Under the monitoring strategy outlined in the exit pathway sampling and analysis plan (Bonine 2012), samples were collected semiannually during the wet (May–June) and dry (August–November) seasons.

Table 5.16. 2019 exit pathway groundwater monitoring schedule

Monitoring point	Season	
	Wet	Dry
	7000 Bearden Creek Discharge Area	
BC-01	Radiological	Radiological
	East End Discharge Area	
923	Radiological, organics, and metals	Radiological
EE-01	Radiological	Radiological
EE-02	Radiological[a]	Radiological[a]
	Northwestern Discharge Area	
531	Radiological, organics, and metals	Radiological
535	Radiological	Radiological
807	Radiological	Radiological
808	Radiological, organics, and metals	Radiological
	Southern Discharge Area	
S-01	Radiological[a]	Radiological[a]
S-02	Radiological, organics, and metals	Radiological
	White Oak Creek Discharge Area	
857	Radiological	Radiological
858	Radiological	Radiological
1190	Radiological, organics, and metals	Radiological
1191	Radiological, organics, and metals	Radiological
1239	Radiological, organics, and metals	Radiological

[a] Locations EE-02 and S01(stream locations) were not sampled in the 2019 dry season due to lack of water flow at those locations.

Exit Pathway Monitoring Results

Table 5.17 provides a summary of radiological parameters detected in samples collected from exit pathway monitoring points during 2019. Metals are ubiquitous in groundwater exit pathways and so are not summarized in the table.

Table 5.17. Radiological parameters detected in 2019 exit pathway groundwater monitoring

Monitoring location	Parameter	Wet season concentration[a]	Dry season concentration[a]	Reference value[b]
		(pCi/L)	(pCi/L)	(pCi/L)
7000 Bearden Creek Discharge Area				
Spring BC-01	Beta activity	3.4	U0.745	50
Spring BC-01	^{214}Bi	6.83	37.7	10,400
Spring BC-01	^{214}Pb	14.6	38.9	8,000
Spring BC-01	Tritium	198	U37.1	20,000
East End Discharge Area				
Well 923	Beta activity	2.13	2.6	50
Well 923	^{214}Bi	8.26	ND	10,400
Stream EE-01	Alpha activity	2.94	U0.329	15
Stream EE-01	Beta activity	3.5	U0.96	50
Stream EE-01	^{214}Bi	ND	95.3	10,400
Stream EE-01	^{40}K	25.2	U-22.8[c]	192
Stream EE-01	^{214}Pb	ND	107	8,000
Stream EE-01	^{208}Tl	3.25	ND	NA
Stream EE-02	^{214}Bi	64.6	NF	10,400
Stream EE-02	^{214}Pb	68.3	NF	8,000
Northwestern Discharge Area				
Well 531	Beta activity	1.54	3.07	50
Well 531	Tritium	U35	312	20,000
Well 535	Alpha activity	31.4	U0.39	15
Well 535	Beta activity	27.1	2.94	50
Well 535	^{214}Bi	ND	11.6	10,400
Well 535	^{214}Pb	ND	12.6	8,000
Well 535	Tot. Ra alpha	3.1	NM	5
Well 535	^{232}Th	1.15	NM	5.6
Well 807	Beta activity	4.28	5.1	50
Well 808	Beta activity	2.89	5.57	50
Well 808		ND	43.2	4,400
Southern Discharge Area				
Stream S-01	^{212}Bi	26.5	NF	4,400
Stream S-01	^{214}Bi	26.6	NF	10,400
Stream S-01	^{214}Pb	31.8	NF	8,000
Stream S-02	^{214}Bi	12.3	57.4	10,400
Stream S-02	^{214}Pb	7.9	64.2	8,000
White Oak Creek Discharge Area				
Well 857	Beta activity	5.11	U2.85	50
Well 857	^{214}Bi	27.2	ND	10,400
Well 857	^{214}Pb	28.8	5.5	8,000
Well 1190	Beta activity	5.45	2.45	50

Table 5.17. Radiological concentrations detected in 2019 exit pathway groundwater monitoring (continued)

Monitoring location	Parameter	Wet season concentration[a]	Dry season concentration[a]	Reference value[b]
		(pCi/L)	(pCi/L)	(pCi/L)
Well 1190	^{214}Bi	153	36.4	10,400
Well 1190	^{212}Pb	4.38	ND	152
Well 1190	^{214}Pb	172	43.4	8,000
Well 1190	Tritium	14,500	14,800	20,000
Well 1191	Alpha activity	5.49	U2.59	15
Well 1191	Beta activity	229	234	50
Well 1191	^{214}Bi	102	27.5	10,400
Well 1191	^{212}Pb	6.02	ND	152
Well 1191	^{214}Pb	105	31.6	8,000
Well 1191	$^{89/90}$Sr	110	109	44
Well 1191	Tritium	14,900	15,300	20,000
Well 1239	Alpha activity	U2.59	3.93	15
Well 1239	Beta activity	5.21	9.86	50
Well 1239	^{214}Bi	8.91	ND	10,400
Well 1239	^{214}Pb	8.72	ND	8,000
Well 1239	Tritium	417	U142	20,000

[a] U = the analyte was measured but not detected above the practical quantitation limit/contractor-required detection limit; ND = the analyte was not detected in the gamma scan that was performed.

[b] Current federal and state standards were used as reference values. If no federal or state standard exists for the analyte, 4% of the derived concentration standard is used as the reference value.

Exit Pathway Groundwater Surveillance Summary

Concentrations of metals and man-made radionuclides observed in groundwater exit pathway discharge areas in 2019 at ORNL were generally consistent with observations reported in past annual site environmental reports for ORR. Based on the results of the 2019 monitoring effort, there is no indication that current SC operations are significantly introducing contaminants to the groundwater at ORNL.

Twelve radiological contaminants were detected in exit pathway groundwater samples collected in 2019. Gross alpha, gross beta, and $^{89/90}$Sr were the only radiological parameters exceeding reference values at any of the discharge areas. Consistent with previous monitoring, gross beta and $^{89/90}$Sr were observed at concentrations above their respective reference values in the WOC discharge area in 2019. The reported result for gross alpha activity in the wet season sample from well 535, in the northwest discharge area, was above the reference value, but it is believed that that result is likely a data anomaly resulting from analytical testing. The laboratory performed multiple additional analyses to identify the alpha-emitting radionuclides responsible for the gross alpha activity in the sample and was only able to identify a small fraction of it. Analyses were added to measure ^{241}Am, $^{243/244}$Cm, ^{237}Np, ^{238}Pu, $^{239/240}$Pu, ^{228}Th, ^{230}Th, ^{232}Th, $^{233/234}$U, $^{235/236}$U, ^{238}U, and radium alpha activity; most of those parameters were below the minimum detectable activity concentrations of the tests. The gross alpha activity was reported to be 30.4 pCi/L; the only alpha emitters that were detected were ^{232}Th (1.15 pCi/L) and alpha-emitting radium isotopes, measured collectively as total radium alpha activity (3.1 pCi/L). Gross alpha activity in the following dry-season sample from well 535 was below the analytical minimum detectable activity, which is typical for that well. No other radiological contaminants exceeded reference values at other discharge areas.

New maximum concentrations were measured for two parameters at one monitoring location in the east end discharge area—surface water location EE-01—in the dry-season sampling event. The concentration of ^{214}Pb activity was measured at 107 pCi/L (compared to a previous maximum of 23.9 pCi/L); the concentration of ^{214}Bi activity was measured at 95.3 pCi/L (compared to a previous maximum of 22.6 pCi/L). Both radionuclides are short-lived radioisotopes in the decay chain of ^{226}Ra (NIST 2020). Radon is a naturally occurring radioactive metal and the ^{226}Ra isotope is part of the uranium decay series (EPA 2019). Although these newest concentrations are the highest measured to date at the EE-01 location, both ^{214}Pb and ^{214}Bi are often detected, sometimes at higher concentrations, in other surface water locations in the east end discharge area (location EE-02) and southern discharge area (locations S-01 and S-02).

Twenty-seven metallic contaminants were detected in exit pathway groundwater samples collected in 2019; however, only four metals (iron, manganese, mercury, and thallium) were detected at concentrations exceeding reference values. Iron and manganese are commonly found in groundwater at ORNL. Mercury and thallium were detected in samples from one well each at concentrations slightly above the report limits, and in both cases the metal was also found in the associated method blank.

No organic compounds were detected at a quantifiable concentration in exit pathway groundwater monitoring in 2019.

5.6.2.2 Active Sites Monitoring—High Flux Isotope Reactor

Two storm water outfall collection systems (Outfalls 281 and 383) intercept groundwater in the HFIR area and are routinely monitored under a monitoring plan associated with the ORNL NPDES permit. (See Section 5.5 for a discussion of results.)

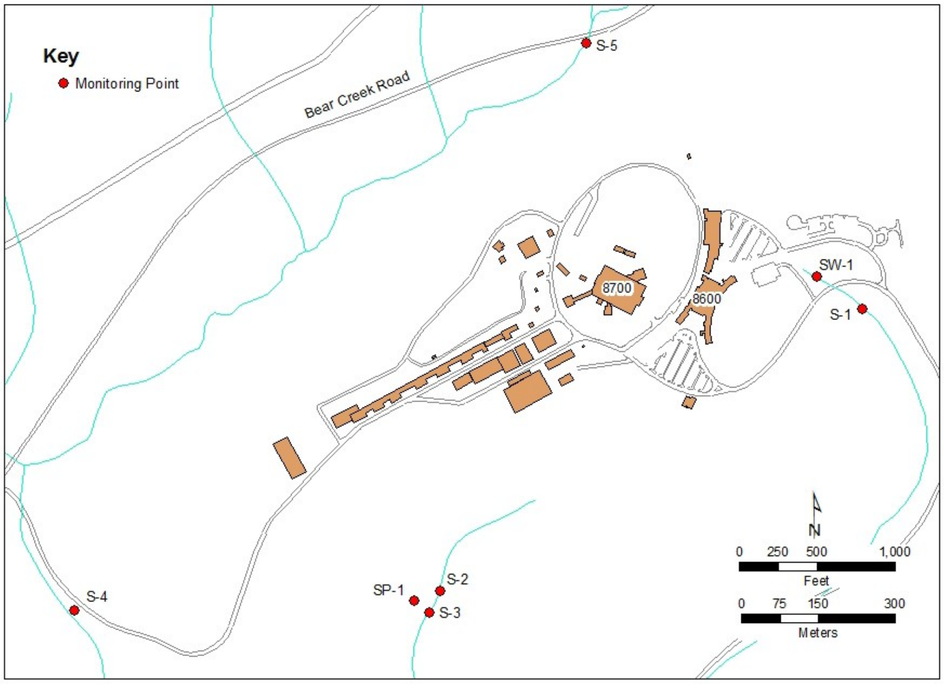
5.6.2.3 Active Sites Monitoring—Spallation Neutron Source

Active sites groundwater surveillance monitoring was performed in 2019 at the SNS site under the SNS operational monitoring plan (OMP) (Bonine, Ketelle, and Trotter 2007) due to the potential for adverse impact on groundwater resources at ORNL should a release occur. Operational monitoring was initiated following a 2-year (2004–2006) baseline monitoring program and will continue throughout the duration of SNS operations.

The SNS site is located atop Chestnut Ridge, northeast of the main ORNL facilities. The site slopes to the north and south, and small stream valleys, populated by springs and seeps, lie on the ridge flanks. Surface water drainage from the site flows into Bear Creek to the north and WOC to the south.

The SNS site is a hydrologic recharge area underlain by geologic formations that form karst geologic features. Groundwater flow directions at the site are based on the generally observed tendency for groundwater to flow parallel to geologic strike (parallel to the orientation of the rock beds) and via karst conduits that break out at the surface in springs and seeps located downgradient of the SNS site. A sizable fraction of infiltrating precipitation (groundwater recharge) flows to springs and seeps via the karst conduits. SNS operations have the potential for introducing radioactivity (via neutron activation) in the shielding berm surrounding the SNS linac, accumulator ring, and/or beam transport lines. A principal concern is the potential for water infiltrating the berm soils to transport radionuclide contamination generated by neutron activation to saturated groundwater zones. The ability to accurately model the fate and transport of neutron activation products generated by beam interactions with the engineered soil berm is complicated by multiple uncertainties resulting from a variety of factors, including hydraulic conductivity differences in earth materials found at depth, the distribution of water-bearing zones, the fate and transport characteristics of neutron activation products produced, diffusion and advection, and the presence of karst geomorphic features found on the SNS site. These uncertainties led to the initiation of the groundwater surveillance monitoring program at the SNS site. Objectives of the groundwater monitoring program outlined in the OMP include the following: (1) maintain compliance with applicable DOE contract requirements and environmental quality standards and (2) provide uninterrupted monitoring of the SNS site.

A total of seven springs, seeps, and surface water sampling points were routinely monitored as analogues to, and in lieu of, groundwater monitoring wells. Locations were chosen based on hydrogeological factors and proximity to the beam line. Figure 5.43 shows the locations of the specific monitoring points sampled during 2019.



Acronyms: S = springs, SP = seeps, SW = surface water sampling areas

Figure 5.43. Groundwater monitoring locations at the Spallation Neutron Source, 2019

In November 2011 the SNS historical tritium data were evaluated to determine whether sampling could be optimized. The influence of flow condition on the proportion of tritium detects and nondetects in water samples collected at SNS from April 2004 through September 2011 was examined. In addition, the effect of seasonality on the proportion of detects and nondetects was examined for the same data set. The results of the analysis indicated that the proportion of detects to nondetects is not related to flow conditions or seasonality. This implies that samples could be collected during any flow condition and season with the expectation that there would be no statistical difference in the proportion of tritium detects to nondetects.

The results of the statistical analysis of the April 2004–September 2011 data set were the basis for the modified OMP monitoring scheme implemented in 2012.

Quarterly sampling at each monitoring point continued in 2019, allowing the opportunity for monitoring in wet and dry seasons. All sampling performed in 2019 was performed in conjunction with rainfall events, with samples being collected during rising or falling (recession) limb flow conditions. In Figure 5.44, the curves represent spring or seep flow (base flow, through flow, overland flow, peak flow);

the bars represent rainfall amounts. Table 5.18 shows the sampling and parameter analysis schedule followed in 2019.

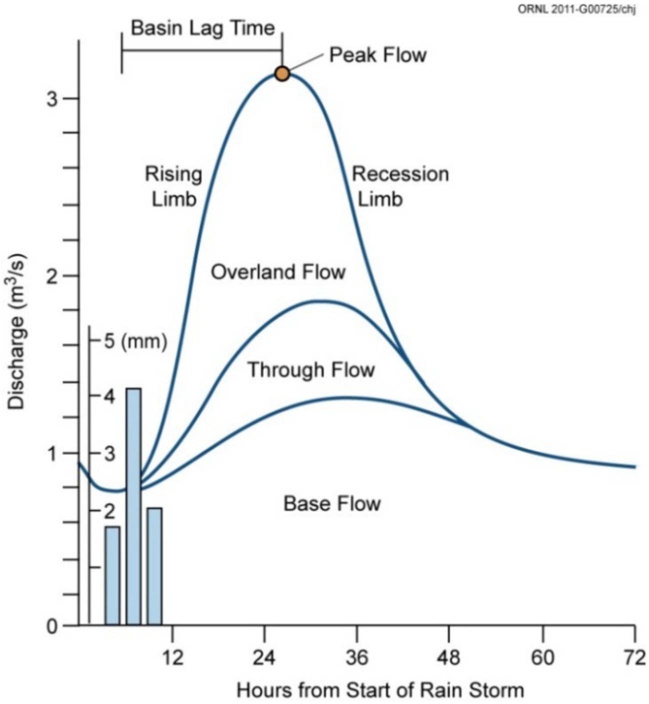


Figure 5.44. Simple hydrograph of spring discharge vs. time after initiation of rainfall

Table 5.18. 2019 Spallation Neutron Source monitoring program schedule

Monitoring location	Quarter 1 January–March	Quarter 2 April–June	Quarter 3 July–September	Quarter 4 October–December
SW-1	Tritium	Tritium	Tritium and expanded suite[a]	Tritium
S-1	Tritium	Tritium	Tritium and expanded suite[a] tritium	Tritium
S-2	Tritium	Tritium	Tritium	Tritium and expanded suite[a]
S-3	Tritium	Tritium	Tritium	Tritium and expanded suite[a]
S-4	Tritium and expanded suite[a]	Tritium	Tritium	Tritium
S-5	Tritium and expanded suite[a]	Tritium	Tritium	Tritium
SP-1	Tritium and expanded suite[a]	Tritium	Tritium	Tritium

[a] The expanded suite includes gross alpha and gross beta activity, ^{14}C, and gamma emitters.

Spallation Neutron Source Site Results. In 2019 sampling at the SNS site occurred during each quarter. Low concentrations of several radionuclides were detected numerous times during 2019. The ^{214}Bi and ^{214}Pb are daughter radionuclides in the uranium decay series and are considered to be of natural origins in the SNS water samples since no man-made uranium sources are present at the site. The low value of beta activity detected at the S-5 monitoring location is attributed to CERCLA contaminants in Bear Creek Valley associated with legacy waste management practices at the Y-12 facility. Table 5.19 provides a summary of the locations for radionuclide detections observed during 2019.

Sampling results were compared with reference values. Reference values used for comparison are current federal or state standards or 4 percent of the DCS. No detected radionuclide exceeded its reference value at SNS monitoring locations in 2019.

Table 5.19. Radiological concentrations detected in samples collected at the Spallation Neutron Source during 2019

Parameter	Concentrations^a (pCi/L)				Reference Value^b
	January	June	August	October	
SW-1					
			ND^c		
^{214}Bi			85		10,400
Tritium	2,410	1,760	1,990	3,930	20,000
S-1					
			ND^c		
^{214}Bi			40.1		10,400
^{214}Pb			35.5		8,000
Tritium	2,420	2,250	449	3,350	20,000
S-2					
			ND^c		
^{214}Pb			32.2		8,000
Tritium	622	741	646	1,150	20,000
S-3					
			ND^c		
^{214}Pb			33.9		8,000
Tritium	844	374	ND	269	20,000
S-4					
	ND^d				
^{214}Bi	42.9				10,400
^{214}Pb	40.3				8,000
Tritium	1,630	488	225	682	20,000
S-5					
	ND^c				
Beta	7.27				50
^{214}Bi	108				10,400
^{214}Pb	125				8,000
Tritium	534	295	ND	279	20,000
SP-1					
		ND^d			
Tritium	454	336	451	462	20,000

[a] ND: not detected. "U" means that the analyte was analyzed for but not detected above the practical quantitation limit/contractor required detection limit.

[b] Current federal and state standards were used as reference values. If no federal or state standard exists for a particular radionuclide, 4 percent of the derived concentration standard for a radionuclide is used.

[c] Only some of the parameters of the expanded suite (gross alpha and gross beta activity, ^{14}C, and gamma emitters) for this location/quarter were detected, and they are listed with their results.

[d] None of the parameters of the expanded suite (gross alpha and gross beta activity, ^{14}C, and gamma emitters) for this location/quarter was detected.

5.6.2.4 Emerging Contaminant Assessment—Potential for Per- and Polyfluoroalkyl Substances in Oak Ridge National Laboratory Area Groundwater

A group of fluorinated organic chemical compounds collectively referred to as per- and polyfluoroalkyl substances (PFASs) are contaminants of emerging concern. PFAS compounds are persistent in the environment, and some are known to bioaccumulate in humans and/or wildlife. They have been widely used in both consumer and industrial products, and traces have been detected in environmental media in many parts of the world.

Perfluorooctanoic acid (PFOA) and perfluorooctane sulfonate (PFOS) are the two PFAS compounds that have been produced in the largest amounts in the United States and that have received the most study. In May 2017, EPA established a drinking water health advisory of 70 µg/L of combined PFOA and PFOS, but EPA has not established an MCL for drinking water. Through 2001, PFOS and other PFAS compounds were used in the manufacture of aqueous film-forming foams (AFFFs), and use of such foams, including firefighting training activities, may have contributed to environmental releases. The information contained in this paragraph was summarized from EPA's *Technical Fact Sheet—Perfluorooctane Sulfonate (PFOS) and Perfluorooctanoic Acid (PFOA)* (EPA 2017).

Historically, training of firefighters at ORNL included training in the use of AFFFs, and it is believed that the foams that were used in past training activities contained PFAS compounds. It is suspected that discharges of these foams to the environment during the training activities are the most significant potential source of PFAS releases to the environment at ORNL. Most of the training was conducted at four locations: adjacent to the ORNL Fire Station (Building 2500), at the Fire Training and Test Facility (Building 2648), on the southeast corner of First Street and Bethel Valley Road (near where Building 2040 was later constructed), and at a location on the north side of Old Bethel Valley Road in the Bearden Creek watershed. In 2019, a sampling and analysis plan (SAP) was developed to assess these areas for the presence of PFAS compounds in groundwater and in surface water bodies draining these areas. The SAP also includes monitoring of surface water locations draining other parts of the ORNL campus, including former waste storage areas, to determine if PFAS compounds from sources other than the use of AFFFs are present and are reaching surface water bodies. Surface water monitoring will include the use of passive sampling devices, which are deployed in stream environments for long periods of time (typically 4-week deployment periods) and which can accumulate PFAS compounds and allow the detection of trace concentrations that might not be detectable with traditional water sampling techniques. The SAP will be implemented in 2020.

Neither groundwater nor surface water at ORNL is a direct source of drinking water; ORNL's water supply is municipal water from the City of Oak Ridge.

5.7 Quality Assurance Program

The UT-Battelle Quality Management System (QMS) has been developed to implement the requirements defined in DOE Order 414.1D (DOE 2011d). The methods used for successful implementation of the QMS rely on the integration and implementation of quality elements/criteria flowed down through multiple management systems and daily operating processes. These management systems and processes are described in SBMS, where basic requirements are communicated to UT-Battelle staff. Additional or specific customer requirements are addressed at the project or work activity level. The QMS provides a graded approach to implementation based upon risk. The application of quality assurance (QA) and quality control (QC) programs specifically focused on environmental monitoring activities on ORR is essential for generating data of known and defensible quality. Each aspect of an environmental monitoring program from sample collection to data management and record keeping must address and meet applicable quality standards. The activities associated with administration, sampling, data management, and reporting for ORNL environmental programs are performed by the UT-Battelle Environmental Protection Services Division (EPSD).

UT-Battelle uses SBMS to provide a systematic approach for integrating QA, environmental, and safety considerations into every aspect of environmental monitoring at ORNL. SBMS is a web-based system that provides a single point of access to all the requirements for staff to safely and effectively perform work. SBMS translates laws, orders, directives, policies, and best-management practices into laboratory-wide subject areas and procedures.

5.7.1 Work/Project Planning and Control

UT-Battelle's work/project planning and control directives establish the processes and requirements for executing work activities at ORNL. All environmental sampling tasks are performed following the four steps required in the work control subject areas:

- Define scope of work.
- Perform work planning—analyze hazards and define controls.
- Execute work.
- Provide feedback.

In addition, EPSD has approved project-specific standard operating procedures for all activities controlled and maintained through the Integrated Document Management System (IDMS).

Environmental sampling standard operating procedures developed for UT-Battelle environmental sampling programs provide detailed instructions on maintaining chain of custody; identifying, collecting, handling, and preserving samples; decontaminating equipment; and collecting QC samples such as field and trip blanks, duplicates, and equipment rinses.

5.7.2 Personnel Training and Qualifications

The UT-Battelle Training and Qualification Management System provides employees and nonemployee staff of UT-Battelle with the knowledge and skills necessary to perform their jobs safely, effectively, and efficiently with minimal supervision. This capability is accomplished by establishing site-level procedures and guidance for training program implementation with an infrastructure of supporting systems, services, and processes.

Likewise, the NWSol Training and Qualification program provides employees with the knowledge and skills necessary to perform their jobs safely, effectively, and efficiently with minimal supervision. This capability is accomplished by establishing site-level procedures and guidance for training program implementation with an infrastructure of supporting systems, services, and processes.

5.7.3 Equipment and Instrumentation

5.7.3.1 Calibration

The UT-Battelle QMS includes subject area directives that require all UT-Battelle staff to use equipment of known accuracy based on appropriate calibration requirements and traceable standards to ensure measurement quality and traceability. The UT-Battelle Facilities and Operations Instrumentation and Control Services team tracks all equipment used in the environmental monitoring programs conducted by

UT-Battelle for the ORNL site and ORR through a maintenance recall program to ensure that equipment is functioning properly and within defined tolerance ranges. The determination of calibration schedules and frequencies is based on a graded approach at the activity planning level. EPSD environmental monitoring programs follow rigorous calibration schedules to eliminate gross drift and the need for data adjustments. Instrument tolerances, functions, ranges, and calibration frequencies are established based on manufacturer specifications, program requirements, actual operating environment and conditions, and budget considerations.

In addition, a continuous monitor used for CAA compliance monitoring at ORNL Boiler 6 is subject to rigorous QA protocols as specified by EPA methods. A relative accuracy test audit (RATA) is performed annually to certify the Predictive Emissions Monitoring System (PEMS) for nitrogen oxides and oxygen. The purpose of a RATA is to provide a rigorous QA assessment in accordance with *Performance Specification 16* (EPA 2009). The accuracy of PEMS is also evaluated by performing relative accuracy audits in accordance with *Performance Specification 16*. The results of the QA tests are provided to TDEC quarterly, semiannually, or annually as applicable.

5.7.3.2 Standardization

The UT-Battelle IDMS provides the necessary functionality and controls to ensure that controlled documents are managed, distributed, revised, and maintained in accordance with ORNL document control requirements. EPSD sampling procedures are maintained in IDMS and include requirements and instructions for the proper standardization and use of monitoring equipment. Requirements include the use of traceable standards and measurements; performance of routine, before-use equipment standardizations; and actions to follow when standardization steps do not produce required values. Standard operating procedures for sampling also include instructions for designating nonconforming instruments as “out-of-service” and initiating requests for maintenance.

5.7.3.3 Visual Inspection, Housekeeping, and Grounds Maintenance

EPSD environmental sampling personnel conduct routine visual inspections of all sampling instrumentation and sampling locations. These inspections identify and address any safety, grounds keeping, general maintenance, and housekeeping issues or needs.

5.7.4 Assessment

Independent audits, surveillance, and internal management assessments are performed to verify that requirements have been accurately specified and that activities that have been performed conform to expectations and requirements. External assessments are scheduled based on requests from auditing agencies. Table 5.1 presents a list of environmental audits and assessments performed at ORNL in 2019 and information on the number of findings identified, if any. EPSD also conducts internal management assessments of UT-Battelle environmental monitoring procedural compliance, safety performance, and work planning and control. Surveillance results, recommendations, and completion of corrective actions, if required, are also documented and tracked in the UT-Battelle Assessment and Commitment Tracking System.

NWSol and Isotek perform independent audits, surveillances, and internal management assessments to verify that requirements have been accurately specified and that activities that have been performed conform to expectations and requirements. NWSol corrective actions, if required, are documented and tracked in an issues management database or a deficiency reporting database, and Isotek corrective actions are tracked in its Assessment and Commitment Tracking System.

5.7.5 Analytical Quality Assurance

The contract laboratories that perform analyses of environmental samples from the UT-Battelle environmental monitoring programs at ORNL and on ORR are required to have documented QA/QC programs, trained and qualified staff, appropriately maintained equipment and facilities, and applicable certifications. Several laboratories are contracted under basic ordering agreements to perform analytical work to characterize UT-Battelle environmental samples. As applicable, the laboratories participate in accreditation, certification, and performance evaluation programs, including the National Environmental Laboratory Accreditation Program, Mixed Analyte Performance Evaluation Program, Discharge Monitoring Report Quality Assurance Study, and DOE Environmental Management Consolidated Audit Program. Any issues of concern identified through accreditation/certification programs or performance evaluation testing are addressed with analytical laboratories and are considered when determinations are made on data integrity.

A statement of work for each project specifies any additional QA/QC requirements and includes detailed information on data deliverables, turnaround times, and required methods and detection limits. Blank and duplicate samples are routinely submitted along with ORR environmental samples to provide an additional check on analytical laboratory performance.

5.7.6 Data Management and Reporting

Management of data collected by UT-Battelle in conjunction with ORR and ORNL environmental surveillance programs and with CWA activities at ORNL is accomplished using the Environmental Surveillance System (ESS), a web interface data management tool. A software QA plan for ESS has been developed to document ESS user access rules; verification and validation methods; configuration and change management rules; release history; software registration information; and the employed methods, standards, practices, and tools.

Field measurements and sample information are entered into ESS, and an independent verification is performed on all records to ensure accurate data entry. Sample results and associated information are loaded into ESS from electronic files provided by analytical laboratories. An automated screening is performed to ensure that all required analyses were performed, appropriate analytical methods were used, holding times were met, and specified detection levels were achieved.

Following the screening, a series of checks is performed to determine whether results are consistent with expected outcomes and historical data. QC sample results (i.e., blanks and duplicates) are reviewed to check for potential sample contamination and to confirm repeatability of analytical methods within required limits. More in-depth investigations are conducted to explain results that are questionable or problematic.

ORNL radiological airborne effluent monitoring data are managed using the Rad-NESHAPs Inventory Web Application and the Rad-NESHAPs Source Data Application. Field measurements, analytical data inputs, and emission calculations results are independently verified.

5.7.7 Records Management

The UT-Battelle Records Management System provides the requirements for managing all UT-Battelle records. Requirements include creating and identifying record material; scheduling, protecting, and storing records in office areas and in the UT-Battelle Inactive Records Center; and destroying records.

NWSol and Isotek maintain all records specific to their projects at ORNL, and associated records management programs include the requirements for creating and identifying record material, protecting and storing records in applicable areas, and destroying records.

5.8 Environmental Management and Waste Management Activities at Oak Ridge National Laboratory

The three campuses on ORR have a rich history of research, innovation, and scientific discovery that shaped the course of the world. Unfortunately, today, despite their vitally important missions, they are hindered by environmental legacies remaining from past operations. The contaminated portions of ORR are on the EPA NPL, which includes hazardous waste sites across the nation that are to be cleaned up under CERCLA. Areas that require cleanup or further action on ORR have been clearly defined, and OREM is working to clean those areas under the Federal Facility Agreement with the EPA and TDEC. The *2019 Cleanup Progress Annual Report to the Oak Ridge Regional Community* (UCOR 2019) provides detailed information on DOE OREM's 2019 cleanup activities.

5.8.1 Wastewater Treatment

At ORNL, DOE OREM operates PWTC and the Liquid Low-Level Waste Treatment Facility. In 2019 321.6 million L of wastewater was treated and released at PWTC. In addition, the liquid LLW system at ORNL received 294,465 L of waste. The waste treatment activities of these facilities support both DOE OREM and DOE SC mission activities, ensuring that wastewaters from activities associated with projects of both offices are managed in a safe and compliant manner.

5.8.2 Newly Generated Waste Management

ORNL is the largest, most diverse DOE SC laboratory in the DOE complex. Although much effort is expended to prevent pollution and to eliminate waste generation, some waste streams are generated as a by-product of performing research and operational activities and must be managed to ensure that the environment is protected from associated hazards. As the prime contractor for the management of ORNL, UT-Battelle is responsible for management of most of the wastes generated from R&D activities and wastes generated from operation of the R&D facilities. Waste streams that can be treated by on-site liquid and/or gaseous waste treatment facilities operated by OREM are treated via these systems. Other R&D waste streams are generally packaged by UT-Battelle in appropriate shipping containers for off-site transport to commercial waste-processing facilities. In 2019, ORNL performed 100 waste and recycle shipments to off-site hazardous/radiological/mixed waste treatment and/or disposal vendors with no shipment rejections.

5.8.3 Transuranic Waste Processing Center

TRU waste-processing activities carried out for DOE in 2019 by NWSol addressed CH solids/debris and RH solids/debris, which involved processing, treating, and repackaging of waste. In 2019, LLW/mixed LLW was transported to the Nevada National Security Site or to another approved offsite facility for disposal. TRU waste disposal at the Waste Isolation Pilot Plant resumed in 2017. In 2019, NWSol shipped 226.0 m^3 of CH TRU waste from TWPC in 29 shipments (1,076 containers).

During 2019, 32.1 m^3 of CH waste and 6.4 m^3 of RH waste were processed, and 114.1 m^3 of mixed LLW (TRU waste that was recharacterized as LLW) was shipped off the site.

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