DOE's Oak Ridge National Laboratory is the nation's largest multiprogram science and technology laboratory. ORNL's mission has grown and expanded through the years, and now it is at the forefront of supercomputing, advanced manufacturing, materials research, neutron science, clean energy, and national security.

Photo by Carlos Jones

5

Oak Ridge National Laboratory

As DOE's largest multidisciplinary laboratory, ORNL delivers scientific discoveries and technical breakthroughs to realize solutions for complex challenges, including the transition to clean energy, mitigation of climate change, improvements to human health, and innovation that strengthens economic competitiveness.

ORNL plays a pivotal role in building a clean, efficient, flexible, and secure energy future. Scientists work with many of America's best innovators and businesses to research, develop, and deploy cutting-edge technologies and to break down market barriers in sustainable transportation, smart power systems, and energy efficiency for homes, buildings, and manufacturing.

ORNL advances the science behind national security by securing critical assets to keep national infrastructure running and people safe. ORNL's work protects nuclear materials to enable their secure, peaceful use for energy production, medical applications, and scientific discovery around the world.

More than 6,000 scientists, engineers, technicians, and support staff representing more than 60 nations form a dynamic culture of innovation at ORNL. ORNL's focus on community, collaboration, and the environment shapes its culture and is integral to its success.

ORNL is managed by UT-Battelle LLC, a partnership between the University of Tennessee and Battelle Memorial Institute. Other DOE contractors that conducted activities at ORNL in 2023 included UCOR and Isotek Systems LLC (Isotek).

5.1. Description of Site, Missions, and Operations

ORNL 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 was supporting 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.

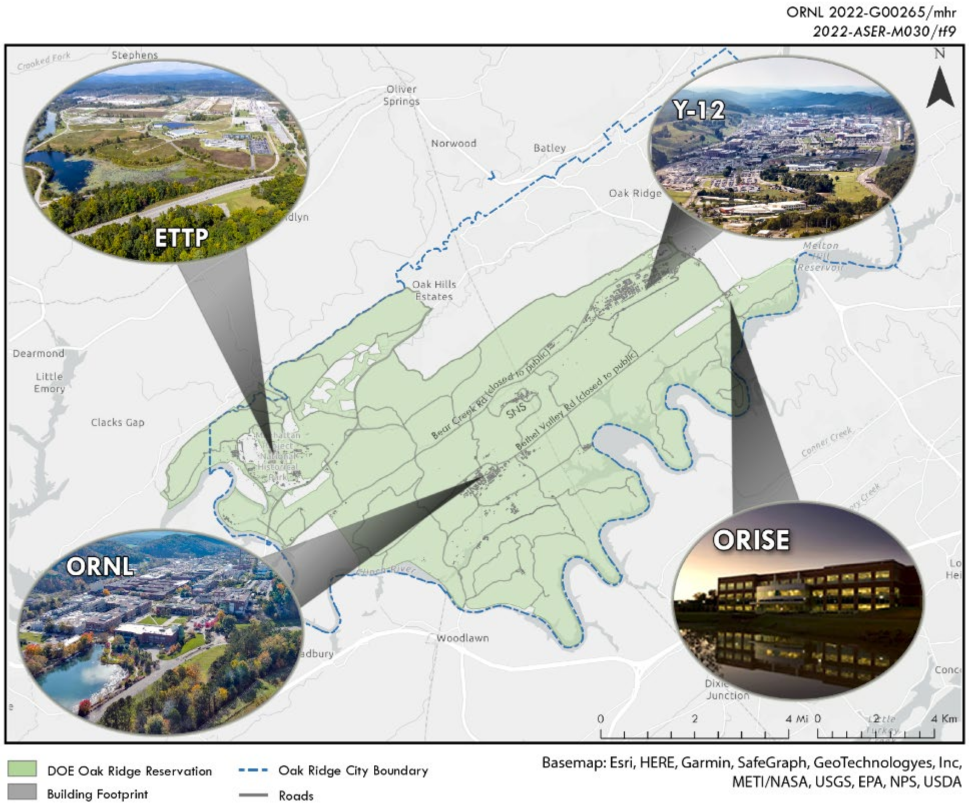
Leveraging the talents of its world-class researchers and exceptional support staff, ORNL is helping solve critical scientific and technical challenges and in so doing is creating economic opportunity for the nation. ORNL's unique facilities, laboratories, and equipment draw thousands of visiting researchers each year and enable the development of scientific and technological solutions in these areas:

- Biology and environment
- Materials
- Clean energy
- National security
- Fusion and fission
- Neutron science
- Isotopes
- Supercomputing

World-class facilities that support ORNL's research and development (R&D) activities are available to users from universities, industry, and other institutions:

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

In March 2007, 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 analysis of alternatives 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 2011a) were endorsed. The Phase I recommendations included (1) transfer of Zero-Power Reactor plate canisters to the National Nuclear Security Administration and disposal of Consolidated Edison Uranium Solidification Project material canisters and (2) completion of a Phase II alternatives analysis for processing the remaining 50 percent of the inventory. The transfer of the reactor plate canisters was completed in 2012. Disposal of the Consolidated Edison Uranium Solidification Project material canisters began in 2015 and was completed in 2017.



Acronyms:

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

Figure 5.1. Location of ORNL within ORR and its relationship to other local DOE facilities

Responsibility for Building 2026 was transferred from UT-Battelle to Isotek in May 2017. Isotek began processing ^{233}U material inside glove boxes in Building 2026 in the fall of 2019. This campaign was completed in August 2021. The remaining inventory requires processing in shielded hot cells because of the high radiation levels of the material. Isotek began processing ^{233}U material in Building 2026 hot cells in October 2022. Hot cell processing is expected to continue for the next few years. The processing of the ^{233}U material produces a solidified, low-level radioactive waste (LLW) form that is acceptable for disposal. Additionally, Isotek is extracting ^{229}Th from the material and transferring it to a customer for use as source material to produce vital medical isotopes ideal for targeted alpha therapy, a promising new cancer treatment.

UCOR is the DOE ORR cleanup contractor for the DOE Oak Ridge Office of Environmental Management (OREM). The scope of UCOR activities at ORNL includes operation of the Transuranic Waste Processing Center (TWPC) and the long-term surveillance, maintenance, and management of inactive waste disposal sites, structures, and buildings. The *FY 2023 Cleanup Progress: Annual Report on Oak Ridge Reservation Cleanup* (UCOR 2023) **here** provides detailed information on UCOR activities at ORNL. These activities included the demolition of the Low Intensity Test Reactor, preparation of the Oak Ridge Research Reactor (Figure 5.2) and three support facilities at the Graphite Reactor for demolition, removal of a highly irradiated component from a hot cell in Building 3026, and continued processing of the ^{233}U inventory stored at ORNL.

Photograph by UCOR. Approved for public release.

Figure 5.2. Removal of the 30-ft-long Low Intensity Test Reactor

In October 2022, UCOR assumed responsibility for operations at TWPC, which is located on about 26 acres of land adjacent to the Melton Valley Storage Tanks along State Route 95. UCOR's mission at TWPC is to receive, process, treat, and repackage transuranic (TRU) wastes for shipment to designated facilities for final disposal. TWPC consists of a waste-processing facility, a personnel building, and numerous support buildings and storage areas. TWPC began processing supernatant liquid from the Melton Valley Storage Tanks in 2002, contact-handled debris waste in December 2005, and remotely handled 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 TWPC, and results are included in water-monitoring discussions in Section 5.5. 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 are 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) (see website **here**), the Grid Research Integration and Deployment Center (see website **here**), and the Manufacturing Demonstration Facility (see website **here**). The HVC is located on a 23-acre site owned by Pellissippi Investors LLC and is leased to UT-Battelle and the University of Tennessee. Approximately 152 industry partners work on the HVC to shape the mobility, energy infrastructure, and manufacturing future of the United States.

NTRC is DOE's only user facility dedicated to transportation and serves as the gateway to UT-Battelle's comprehensive capabilities for transportation 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 cybersecurity, and intelligent transportation systems.

The Grid Research Integration and Deployment Center combines multiple electrification research activities (e.g., utilities, buildings, vehicles) into one facility. The combination of the following innovative R&D disciplines enables breakthroughs to support a resilient and secure power grid from the first instant of electricity generation to end use:

- Power and energy systems
- Vehicle and buildings science
- Power electronics
- Energy storage
- Sensors and controls
- Data science and modeling
- Cybersecurity

The Manufacturing Demonstration Facility focuses on advanced manufacturing research, including the development of carbon fiber composites and additive manufacturing involving polymers, metal wires, and metal powders. The facility provides lab space for the Institute for Advanced Composites Manufacturing Innovation and hosts 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. 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.

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 436.1A, Departmental Sustainability (DOE 2023a), UT-Battelle, UCOR, and Isotek have implemented environmental management systems (EMSs) modeled after the International Organization for Standardization (ISO) 14001 standard to measure, manage, and control environmental impacts (ISO 2015). 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 comply fully with all applicable requirements and to improve ORNL's environmental performance continually. Until August 2018, UT-Battelle was registered to the ISO 14001:2015 standard and had maintained ISO 14001 registration since 2004. In fiscal year (FY) 2018, a management decision was made to transition from registration to a declaration of conformance to ISO 14001:2015, and external registration audits were replaced with annual internal independent ISO 14001 audits.

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 policies and translates environmental laws, applicable DOE orders, and other requirements into laboratory-wide documents (procedures and guidelines). Through environmental protection officers, environmental compliance representatives, waste services representatives, and environment, safety, health, and quality (ESH&Q) coordinators, 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 ESH&Q requirements and controls into all work activities and to ensure protection of workers, the environment, and the public. The UT-Battelle EMS and 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 ESH&Q 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 ESH&Q, including pollution prevention, waste minimization, and resource conservation. Therefore, the guiding principles and core functions in the ISMS include protection of the environment. 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 ORNL

UT-Battelle's environmental policy for ORNL, which can be found on the ORNL website **here**, clearly states expectations and includes commitments to continual improvement, pollution prevention, environmental justice, and compliance with regulations and other requirements.

5.2.1.3. Environmental Management System Planning

The ISO 14001 planning clause requires organizations to identify the environmental aspects and impacts of their operations, products, and services; identify applicable regulations and requirements; establish objectives; implement plans to achieve the objectives; and identify and control risks and opportunities.

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 the line organization 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 on the ORNL website **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; 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 for monitoring the progress of appropriate functions and activities. Laboratory-level environmental objectives are documented in the site sustainability plan (SSP) (ORNL 2024 [**here**]). Line organization objectives are developed annually, entered into a commitment tracking system, and tracked to completion. In all cases, the objectives are consistent with the UT-Battelle environmental policy for ORNL (found on the ORNL website **here**), support 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 its 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 2023 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
- Environmental sampling and data evaluation
- Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA 1980) interface

Subject matter experts (SMEs) at UT-Battelle provide expertise in waste management, transportation, and disposition support services to research, operations, and support divisions:

- Pollution prevention staff manage recycling programs and 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 requirements.
- 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 on-site and off-site packaging and transportation activities are performed in a safe, efficient, and compliant manner.
- The hazardous material spill response team is the first line of response to hazardous material spills at ORNL and controls and contains spills until the situation is stabilized.

5.2.1.4. Site Sustainability

To attain the sustainability goals outlined in the DOE SSP instructions **here** (DOE 2023b), sites operated by DOE are expected to contribute toward all targets and to identify strengths that can be adapted as agencywide best practices.

Sustainable ORNL

To achieve sustainability goals at ORNL, the UT-Battelle Sustainable ORNL program identifies opportunities for continuous improvements in operational and business processes and implements practices to maximize the return on investment in modernizing facilities and equipment. This program—led by two coleads, one from R&D and one from mission support—promotes systemwide best practices, management commitment, and employee engagement that will help lead ORNL into a future of efficient, sustainable operations. The Sustainable ORNL website is actively managed and is available for employee and public view **here**.

The Sustainable ORNL roadmap structure endorses 15 vital roadmaps. Figure 5.3 summarizes the current sustainability focus areas (i.e., roadmaps). Designated SMEs report the sustainability progress for their respective focus areas annually. Continuous employee engagement and regular status reports confirm the goals of the program are being met.

The roadmap structure is not static; as the science mission advances and the needs of the organization evolve, structural elements in the Sustainable ORNL roadmaps are modified to align with developing priorities. In FY 2022, Sustainable ORNL made roadmap changes that were implemented in FY 2023 to better align ORNL to support updated goals and requirements as issued by federal and DOE directives.

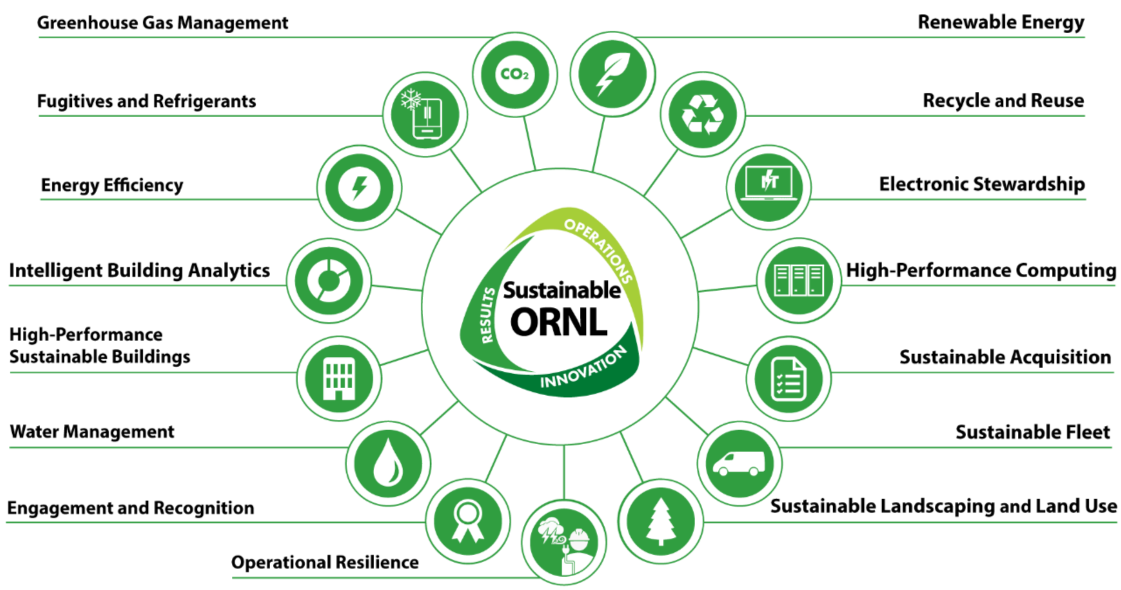


Figure 5.3. Sustainable ORNL focus areas (roadmaps) for fiscal year 2023

Sustainable ORNL awards

In 2023, R&D World and the Federal Laboratory Consortium recognized sustainability efforts at ORNL with the following awards:

- R&D World R&D 100 Awards (details **here**)
- Additively Manufactured Thermally Conductive Collimators for Neutron Instrumentation
- OpeN-AM: A Platform for Operando Neutron Diffraction Measurements of Additive Manufacturing
- Precise, Continuous, and High-Speed Manufacturing of Thermoplastic Composites Using Additive Manufacturing-Compression Molding, AM-CM
- Federal Laboratory Consortium 2023 Technology Transfer Awards (details **here**)
- Excellence in Technology Transfer: ORNL Spinoff's Food Waste Conversion Process
- State and Local Economic Development: Oak Ridge Reimagined: Nuclear Hub for a Carbon-Free Energy Future

Updates to federal sustainability guidance

Changes in federal government and DOE priorities resulted in a year of major transition and change in sustainability goals and priorities. DOE Order 436.1A, *Departmental Sustainability*, was issued in April 2023 and was added to the UT-Battelle prime contract later in FY 2023 (DOE 2023a). This order replaces DOE Order 436.1 (issued in May 2011) and includes a seven-page contractor requirements document (CRD) that is significantly more detailed that the one-page CRD associated with DOE Order 436.1. The CRD revisions demonstrate DOE's strengthening commitment to sustainable operations. Goals from Executive Order (EO) 14008, *Tackling the Climate Crisis at Home and Abroad* (EO 2021a); EO 14057, *Catalyzing Clean Energy Industries and Jobs Through Federal Sustainability* (EO 2021b); and EO 14072, *Strengthening the Nation's Forests, Communities, and Local Economies* (EO 2022), have been incorporated into DOE Order 436.1A. In 2023, ORNL completed an impact assessment on DOE Order 436.1A and developed an implementation plan for CRD compliance that includes action items for various organizations throughout the lab (e.g., Acquisition Management, Environmental Protection Services, Fleet Management). In FY 2022, the SSP instructions issued by the DOE Sustainability Performance Office were updated to capture requirements from EO 14008, the Energy Act of 2020 (EAct 2020), and EO 14057 as well as actions outlined in DOE's *Climate Adaptation and Resilience Plan and Sustainability Plan* (DOE 2021a). Updates in SSP guidance help to minimize and streamline reporting while addressing updated federal requirements.

ORNL Site Sustainability Plan

As required by DOE Order 436.1A, the ORNL FY 2024 SSP (ORNL 2024), which includes FY 2023 performance data, was completed and submitted to the DOE Sustainability Performance Office in December 2023. SSPs are used by DOE to outline various site contributions toward departmental sustainability goals as federal sites manage their buildings, vehicles, and overall operations to optimize energy and environmental performance, reduce waste, and cut costs. The ORNL FY 2024 SSP with FY 2023 performance data can be found **here**, and DOE's instruction document and template for submittal can be found **here**.

Summary of performance data for energy, water, and other federal sustainability performance goals

Table 5.1 summarizes ORNL's 2023 performance and progress toward meeting federal sustainability goals.

ORNL greenhouse gas and net-zero baseline

The sources of greenhouse gas (GHG) emissions at ORNL and the inventory for FY 2023 were reported and calculated via the SSP reporting process and are summarized in Figure 5.4. By far, the most significant components of GHG emissions at ORNL were the production and delivery factors associated with electrical power production, netting 76% of ORNL emissions in FY 2023. Over the past 15 years, GHG emission factors from electricity have improved slowly but steadily, but that is expected to change as the ORNL science mission continues to grow. Scope 1 emissions are direct GHG emissions from sources that are controlled or owned by an organization (e.g., emissions associated with fuel combustion in boilers, furnaces, or vehicles). Scope 2 emissions are indirect GHG emissions associated with the purchase of electricity, steam, heat, or cooling. Although scope 2 emissions physically occur at the facilities where they are generated, they are accounted for in an organization's GHG inventory because they are a result of the organization's energy use (EPA 2024a). The FY 2023 ORNL scope 1 and scope 2 GHG inventory was 237,169 $MTCO_2e$ (net after renewable energy credits [RECs]), an increase of 11% from FY 2022. Because the science mission at ORNL is growing and federal accounting guidance allows no GHG emissions exceptions or exclusions, regardless of mission, emissions are expected to increase in the near term.

Table 5.1. ORNL 2023 sustainability performance status and planned actions and contributions

DOE goal	Current performance status	Planned actions and contributions
Energy management		
Reduce EUI (Btu/GSF) in goal-subject buildings by 50% by the end of FY 2030.	ORNL's FY 2023 calculated EUI was 237,514 Btu/GSF. This is a cumulative reduction of 34.7% since FY 2003 and a reduction of 1.43% from the FY 2021 baseline but is an increase of 1.41% from FY 2022. ORNL continues to improve identification of energy-consuming facilities as the mission expands.	Continued EUI reduction for goal-subject facilities is considered attainable by concentrating on the best mix of ECM projects for energy savings and by incorporating net-zero strategies into all levels of lab planning efforts.
Achieve a net-zero emissions building portfolio by 2045 through building electrification and other efforts.	ORNL is currently investigating replacing dedicated fuel oil–powered boilers (not associated with the ORNL steam plant) with electric-powered boilers. A "mini-campus" would be made all electric if a project were pursued to replace the fuel oil–powered boiler with an electric-powered boiler.	ORNL is looking into the possibility of conducting an electrification study for the campus in the future.
Perform Energy Independence and Security Act Section 432 continuous (4-year cycle) energy and water evaluations.	FY 2023, the third year of the 4-year energy audit cycle, included 22 building audits to cover a quarter of the buildings that are qualified for audit inclusion.	ORNL will continue the current 4-year cycle of auditing and assessments to align with work priorities. In FY 2024, ORNL will conduct the final year of the 4-year energy audit cycle.
Meter individual buildings for electricity, natural gas, steam, and water to adhere to federal metering guidance.	In FY 2023, ORNL added 23 new advanced utility meters (including computational metering and electrical utility distribution metering), migrated 1 new data stream from other systems across the lab, and replaced 3 meters. ORNL meter installations included electrical, steam/hot water, natural gas, chilled water, and potable water.	ORNL will continue to use the metering-tracking process and plan for guidance in installation of additional advanced utility meters on all utilities per the new federal metering guidance.

Table 5.1. ORNL 2023 sustainability performance status and planned actions and contributions (continued)

DOE goal	Current performance status	Planned actions and contributions
Water management		
Reduce WUI for potable water (G/GSF).	Annual water consumption resulted in a WUI of 148.2 G/GSF in FY 2023, which is an increase of 8.7% from FY 2022, missing the 0.5% reduction goal compared with the previous year. Continued improvements in the identification of water-consuming facilities yielded a 1% decrease in GSF in support of the WUI calculation.	ORNL's WUI is subject to rise because of increased demands for cooling tower makeup water to support growth of high-performance computing systems. In conjunction with continued modernization activities that include the elimination of old facilities and the addition of new facilities, ORNL will consider more water-efficient systems and will maintain a focus on water management best practices to meet future WUI reduction goals.
Waste management		
Reduce nonhazardous solid waste sent to treatment and disposal facilities.	In FY 2023, ORNL's diversion rate for municipal solid waste reached 65.7%.	ORNL will continue to identify source reduction opportunities.
Reduce C&D materials and debris sent to treatment and disposal facilities.	In FY 2023, ORNL's C&D diversion rate for waste building materials and deactivation and decommissioning debris was 94.1%.	ORNL will continue to employ terms and conditions in construction contracts to manage construction waste and recycling. C&D recycle rates will vary as the proper characterization of debris dictates.
Fleet management		
Reduce petroleum consumption.	ORNL continues to optimize utilization, purchase vehicles with improved fuel economy and EVs when available, and purchase vehicles with anti-idling technology.	ORNL will launch a passenger-carrying vehicle-pooling project, encourage using the ORNL taxi service, and continue to replace fleet vehicles with improved–fuel economy vehicles.
Increase alternative fuel consumption.	Eighty percent of all ORNL vehicles are AFVs, and 88% of all replacements since FY 2020 have been AFVs or EVs. Also, 93% of light-duty vehicles operate on alternative fuels.	ORNL will continue to purchase AFVs and limit accessibility of non–alternative fuel at ORNL gas pumps.
Achieve 100% zero-emission vehicle acquisitions by 2035, including 100% zero-emission light-duty vehicle acquisitions by 2027.	ORNL is currently meeting the AFV requirement. If an AFV or EV has been available and has met mission requirements, it has been purchased or leased during the replacement process.	ORNL will continue the effort of replacing conventional vehicles with AFVs or EVs if available and if they meet the mission requirements.

Table 5.1. ORNL 2023 sustainability performance status and planned actions and contributions (continued)

DOE goal	Current performance status	Planned actions and contributions
Clean and renewable energy		
Achieve 100% carbon pollution–free electricity on a net annual basis by 2030, including 50% 24/7 CFE.	ORNL purchased 48,400 MWh RECs to supplement on-site renewable energy generation. The RECs represent 8.6% of the lab's electrical energy consumption, exceeding the 7.5% statutory requirement. TVA's specific percentage CFE with the 7.5% REC equivalent results in 58.5% CFE.	ORNL will remain compliant with the 7.5% renewable electric energy requirement of the Energy Policy Act (EPAct 2005) via REC purchases and will continue to explore innovative renewable energy projects. REC purchases will reflect significant mission growth in the near future and will transition to energy attribute certificates as ORNL works toward meeting CFE requirements. ORNL will continue to consider TVA's specific percentage CFE to better reflect grid-provided CFE.
Sustainable buildings		
Increase the number of ORNL-owned buildings that are compliant with the GPs for sustainable buildings.	ORNL's sustainable buildings inventory did not increase in FY 2023. ORNL has seven sustainable buildings that are GP certified.	In the next 2 years, ORNL plans to have at least two new buildings and to reassess the existing seven sustainable buildings to maintain the seven GP-certified buildings inventory.
Acquisition and procurement		
Promote sustainable acquisition and procurement to the maximum extent practicable, ensuring all sustainability clauses are included as appropriate.	ORNL maintained 100% compliance in FY 2023. All subcontracts contain multistatutory terms and conditions that invoke requirements for sustainable acquisitions as defined in the UT-Battelle prime contract as flow-down requirements.	ORNL will continue its mission commitment to include all applicable federal acquisition regulation clauses and provisions in each new contract. ORNL will maintain compliance with DOE Order 436.1A and will assist with a future supply chain risk assessment.
Investments: improvement measures, workforce, and community		
Implement life cycle cost-effective efficiency and conservation measures with appropriated funds and/or performance contracts.	The ORNL Energy Efficiency and Sustainability program provides, on average, over $500,000/year toward ECMs. DOE has a current contract with Johnson Controls Inc. for an ORNL energy-savings performance contract project. The contract was issued July 31, 2008, with a term of 24 years and 7 months. It includes ECMs consisting of steam system decentralization, building management system improvements, advanced meter installations, energy-efficient lighting upgrades, and domestic water conservation.	An evaluation of ORNL ECMs needs to be performed to identify and install or implement ECMs that are life cycle cost-effective at the maximum level of funding available. ORNL plans on expanding the auditing process and integrating this process with the facility condition assessments. ORNL will then continue to investigate the best potential funding pathway strategies as the life cycle cost-effective ECM list grows.

Table 5.1. ORNL 2023 sustainability performance status and planned actions and contributions (continued)

DOE goal	Current performance status	Planned actions and contributions
Electronic stewardship		
Increase acquisition of sustainable electronics and promote sustainable information technology and end-of-life practices.	ORNL maintained 100% compliance in the acquisition of environmentally certified products. ORNL actively maintained power management features on 100% of all eligible devices in operation. Disposition of 100% of end-of-life electronics was performed through government reuse programs and certified recyclers.	ORNL plans to maintain 100% compliance with all electronic stewardship goals and categories. There are no foreseen obstacles to the goal.
Adaptation and resilience		
Implement climate adaptation and resilience measures.	In response to EO 14008 and DOE directives, ORNL submitted its vulnerability assessment and resilience plan in September 2022 along with a portfolio of actionable resiliency solutions. In FY 2023, ORNL updated the resiliency project status. One project was funded and completed in FY 2023.	Updates of the implementation status of ORNL's solutions will be reported annually to the Sustainability Performance Office.
Multiple categories		
Reduce scope 1 and scope 2 GHG emissions.	The FY 2023 scope 1 and scope 2 GHG inventory was 237,169 MTCO2e (net after RECs), a year-over-year increase of 11%. Purchased electricity (scope 2) comprised 76% of ORNL GHG emissions. EPA Emissions & Generation Resource Integrated Database emissions factors and rebounding from COVID-19 levels contributed to ORNL's scope 2 GHG increase.	Mission growth will limit the ability to reduce emissions in the next 5 years. However, forward-looking DOE priorities combined with net-zero initiatives will reverse the trend of higher emissions.
Reduce scope 3 GHG emissions.	The FY 2023 scope 3 GHG inventory was 25,536 MTCO2e, an 8% increase from FY 2022. Scope 3 activities at ORNL included distribution losses from purchased electricity and increased employee commuting and business travel.	Employee commuting and business travel categories are returning to pre–COVID-19 levels, which has reversed the scope 3 reductions of FY 2020 and FY 2021.

Acronyms:

AFV = alternative-fuel vehicle
C&D = construction and demolition
CFE = carbon pollution–free electricity
DOE = US Department of Energy
ECM = energy conservation measure
EO = executive order
EPA = US Environmental Protection Agency
EUI = energy use intensity
EV = electric vehicle
FY = fiscal year
G = gallon
GHG = greenhouse gas
GP = Guiding Principle
GSF = gross square foot
ORNL = Oak Ridge National Laboratory
REC = renewable energy credit
TVA = Tennessee Valley Authority
WUI = water use intensity

Figure 5.4. ORNL greenhouse gas inventory FY 2023 summary

The rate of progress toward achieving carbon pollution–free electricity (CFE) goals is expected to accelerate as the producers of CFE deploy clean energy strategies nationwide. Tennessee Valley Authority (TVA) is ORNL's wholesale electricity provider, and ORNL determines its CFE percentage from specific TVA data, which are usually a year or more old when they become available. ORNL will be able to extract a more relevant CFE percentage from TVA data as DOE works toward developing a process that reflects emissions factors associated with electricity production.

The FY 2023 scope 3 GHG inventory was 25,536 MTCO2e, an 8 percent increase from FY 2022. Employee commuting and business travel categories are returning to pre–COVID-19 levels. Federal priorities, programs, and initiatives including EOs 14008 and 14057 are expected to reduce GHG emissions significantly by 2030.

Pollution prevention

Source reduction efforts at ORNL include increasing the use of acceptable nontoxic or less-toxic alternative chemicals and processes while minimizing the acquisition of hazardous chemicals and materials via material substitution, operational assessments, and inventory management. In cases where the complete elimination of a particular hazardous material is not possible, a combination of actions is pursued, including controls to limit use, procurement alternatives, and recycling processes to mitigate the environmental impact. Sustainability is integrated across ORNL by procuring and using sustainable products with biobased and recycled content, including by using biobased foam handwash that is dispensed in limited amounts, using biobased and recycled-content paper towels in dispensers that limit single-use amounts, and upgrading aging transformers with new models that use biobased and biodegradable oils instead of mineral oils.

During 2023, UT-Battelle implemented 29 ongoing and new pollution prevention projects. These projects and ongoing reuse and recycle efforts eliminated more than 11.8 million kg of waste. Researchers at ORNL implement traditional recycling options when feasible and investigate new options when a need is identified. Moreover, ORNL recognizes the need to close the loop for recycled materials and supports these efforts by procuring materials with postconsumer recycled content and by performing research to support closing the loop for plastic recycling. Specifically, the DOE Manufacturing Demonstration Facility at ORNL works with industry to replace material disposability with renewability through research focused on closing the loop in the modern material supply chain. Through research, some conducted at ORNL, today's advanced manufacturing composite waste becomes tomorrow's valuable raw materials. (Details on composites recycling at ORNL are available **here**.) Researchers are investigating and deploying new processes that convert feedstocks used in advanced manufacturing into reusable materials. These efforts, including the development of processing and material technologies that provide automotive class A surface appearance and suitable mechanical properties for automotive body panels utilizing a thermoplastic matrix reinforced with discontinuous recycled carbon fibers (Figure 5.5), continue to close the recycling loop for plastics. (More details on these efforts can be found **here**.)

Efforts to further reduce and divert the amount of material going to the landfill also include the development of contract language requiring construction contractors to recycle as much construction debris as possible. Within ORNL, the extensive use of training, awareness, presentations, and outreach encourages source reduction and recycling by all associates.

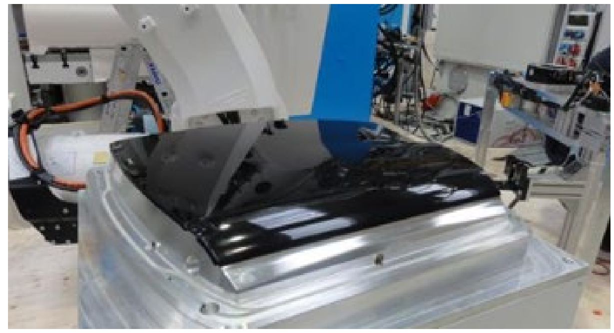


Figure 5.5. Recycled carbon fibers are being used in the development of nonwoven, discontinuous-fiber prepregs for thermoplastic compression molding of class A automotive body panels

Carbon pollution–free electricity

Electricity consumption is the largest contributor to ORNL GHG scope 2 emissions. CFE will be required to reach the goals of a net-zero energy economy, and the availability of CFE is largely dependent on electric utility suppliers. EO 14008 calls on electricity providers to reach annual CFE goals and to provide CFE by 2030, which will be a key step toward the attainment of net-zero operations that DOE is tracking via the SSP and reporting for federal sustainability goals.

DOE is still refining the methods for calculating and reporting meaningful CFE values at the site level. In FY 2022, ORNL's CFE percentage (41.3 percent) was calculated using defined methods based on regional data from EPA's Emissions & Generation Resource Integrated Database. In FY 2023, ORNL's CFE percentage (58.5 percent) was calculated using TVA's specific generation resource mix estimate (50.98 percent) for calendar year (CY) 2022 (the most recent data available) and the EPAct 2005 7.5 percent renewable electric energy requirement. TVA's estimated CFE percentage is higher than the regional percentage in the EPA database, and TVA directly supplies electricity to ORNL.

ORNL's ability to realize annual CFE target increases relies mainly on TVA's commitment to

CFE increases through FY 2030. TVA has projected that it will reach approximately 70 percent CFE by 2030. Because ORNL is a direct feed from TVA, the lab forecasts 70 percent CFE by FY 2029.

On December 7, 2023, DOE and TVA announced that they had signed a memorandum of understanding to provide ORNL, Y-12, and potentially other federal facilities in TVA's service territory with 100 percent locally supplied CFE by 2030. (The DOE press release is available **here**.) This would surpass the 2030 70 percent CFE commitment.

Sustainable ORNL Sustainability showcase projects for net-zero research

Net-zero initiatives do not operate in isolation. Rather, they work in conjunction with other priorities to reach a number of agency objectives. Throughout the ORNL campus, projects are evaluated on several sustainability priorities, including savings in energy, water, and cost from energy conservation measures, net-zero initiatives, and operational resilience. ORNL has an opportunity and a responsibility to lead by example and integrate climate and sustainability into all aspects of its operations. The goal is to develop a dynamic inventory of research and operational projects that represent opportunities to advance the ORNL campus toward net-zero strategies.

Each year, Sustainable ORNL makes funding available for projects that showcase creative measures that can improve ORNL's sustainability. In 2023, three showcase projects geared toward net-zero and energy-improvement research topics were chosen:

- 5600-5700-5800 complex sustainability and decarbonization using waste heat recovery from the Oak Ridge Leadership Computing Facility's high-performance computing data center
- Monitoring and replacement of a delinquent 250 gal natural gas water heater with a heat-pump water heater for a demonstration of carbon dioxide reduction and energy savings
- A pilot living laboratory demonstration of personalized heating and cooling management for efficient, grid-interactive buildings

Leadership-funded sustainability projects

ORNL leadership provided funding for three projects to aid in ORNL's GHG net-zero endeavors in FY 2023:

- Develop a design to allow migration of a legacy fuel oil boiler to an electric boiler at Building 7601. This replacement will reduce maintenance costs and ORNL's scope 1 GHG emissions. The replacement boiler will allow the facility and adjacent buildings to move toward net-zero GHG as ORNL's electricity supply moves closer to being completely carbon free.
- Purchase hardware and software needed to implement a vehicle-pooling program for ORNL's government fleet vehicles. Once implemented, fleet vehicles will be pooled in several locations across ORNL rather than being assigned to individuals or groups. This change will enable ORNL to right-size the fleet, thus decreasing scope 3 GHG emissions. Charging stations at the pooling locations will enable a smooth transition from internal combustion engine–powered vehicles to EVs.
- Accelerate the transition of lighting at ORNL to energy-efficient LED fixtures in support of the Energy Act of 2020. This additional funding enabled LED replacements beyond those that were originally scheduled for 2023.

Earth Day

Sustainable ORNL hosts an annual Earth Day celebration with engagement activities for staff and the community. ORNL celebrated Earth Day in 2023 for the first time since the start of the COVID-19 epidemic. "Sustainable ORNL 2023 Earth Day—Invest in our Planet" featured 28 vendors, an EV/hybrid car show, and an EV ride-and-drive event. ORNL also hosted three seminars during the week of Earth Day:

- "Growing Greener Communities through Tennessee Smart Yards," Dr. Andrea Ludwig, the University of Tennessee, April 17
- "Science and Society: Working Together for a Nature-Inclusive Energy Transition," Dr. David McCollum, ORNL senior R&D staff, April 20
- "The State of Sustainability in Tennessee," Chris Pianta, program manager, Tennessee Department of Environment and Conservation (TDEC) Office of Sustainable Practices

2023 Annual Sustainability Report

ORNL publishes the Annual Sustainability Report to share the benefits of committing to sustainable practices, such as energy conservation and the reduction of long-term risks due to carbon emissions (Figure 5.6). The report is available to the public to promote regional outreach and involvement. The current report and several past issues may be viewed **here**.

University of Tennessee/Pellissippi State Community College/ORNL transportation route

In August 2015, ORNL and the University of Tennessee partnered on a new bus route that connects the University of Tennessee's Knoxville campus, Pellissippi State Community College in west Knox County, and ORNL, providing transportation to staff, students, and faculty. The bus offers three round-trip routes each day to all three sites based on the University of Tennessee's semester schedules. The transportation route has grown with stops at ORNL's NTRC and Spallation Neutron Source (SNS) campuses and has expanded to year-round service with the exception of federal holidays and the week of Christmas. In 2023, ridership grew in the summer months with the influx of ORNL summer interns.

Figure 5.6. *Annual Sustainability Report* cover for 2023 and sample pages

Environmental justice

Environmental justice (EJ) is the fair treatment and meaningful involvement of all people regardless of race, color, national origin, or income with respect to the development, implementation, and enforcement of environmental laws, regulations, and policies (EPA 2023). EJ is achieved when everyone enjoys the same degree of protection from environmental and health hazards and equal access to the decision-making process to have a healthy environment in which to live, learn, and work.

EJ principles are integrated into all ORNL programs and activities to comply with the following executive orders:

- EO 12898, Federal Actions to Address Environmental Justice in Minority Populations and Low-Income Populations (EO 1994)
- EO 14008, Tackling the Climate Crisis at Home and Abroad (EO 2021a)
- EO 14057, Catalyzing Clean Energy Industries and Jobs Through Federal Sustainability (EO 2021b)

In keeping with a presidential memorandum accompanying EO 12898, NEPA evaluations for proposed actions at ORNL include an analysis of environmental effects, including human health–related, economic, and social effects on minority and low-income communities. No actions requiring NEPA evaluations were proposed for ORNL in 2023.

ORNL's Environmental Protection Services Division conducts environmental monitoring and sampling for the ORR-wide environmental surveillance program discussed in Chapter 6. The objectives of this program are to (1) characterize environmental conditions in areas outside facility boundaries on ORR and in areas adjacent to or near ORR and (2) ensure that doses to members of the public from radionuclides and chemicals released from ORR are not above established limits. Elements of the ORR-wide surveillance program include monitoring ambient air, external gamma exposure, water, fish, and food crops in several communities near ORR, including a historically minority community that borders ORR.

One of the most serious EJ concerns is climate change, which often has disproportionate adverse social, economic, and health effects on marginalized and underserved communities. ORNL uses its world-leading capabilities in supercomputing and large-scale experiments to advance understanding of climate change. ORNL's Climate Change Science Institute was formed in 2009 to integrate climate science activities across ORNL and to evaluate the interactions of climate change with human and natural systems. This research helps to develop adaptation and mitigation solutions at the intersection of climate, clean energy, national security, and EJ.

Native Americans are particularly vulnerable to environmental threats because of the crucial role that nature plays in their culture and their reliance on natural resources. To help ensure that plant species with cultural significance to the Eastern Band of Cherokee Indians and across the region are protected and preserved, ORNL participates in the Southeastern Appalachian Man and the Biosphere (SAMAB) Cooperative, a collaboration of land management agencies promoting sustainability. Core to SAMAB are five areas recognized internationally for their significance to the natural world: Great Smoky Mountains National Park, Mount Mitchell State Park, Grandfather Mountain, Coweeta Hydrologic Lab, and the ORNL National Environmental Research Park. The National Environmental Research Park, a major resource for conducting ecological studies, is a 20,000-acre research facility with over 1,100 plants, some of which hold rich cultural importance. This prompted ORNL's participation in the Culturally Significant Plant Species Initiative, a collaboration between the Eastern Band of Cherokee Indians and SAMAB focused on the sustainability, conservation, and management of plants with cultural significance to the Cherokee through education and increased access.

Other ORNL programs that invest in and engage with historically underserved communities while also contributing to a greener and more inclusive economy include the following:

- Collaborations and partnerships with tribal communities and universities, minority-serving institutions, and historically black colleges and universities to enhance the accessibility of ORNL resources to underrepresented entities
- Recruiting programs to attract staff from minority-serving institutions
- A comprehensive diversity, equity, inclusion, and accessibility plan that includes recruiting, onboarding, and career development strategies to close gaps in representation
- Community engagement and corporate giving programs to support local communities, including minority and underserved populations
- ORNL Small Business Programs Office initiatives to significantly increase opportunities for small, disadvantaged businesses to provide the goods and services that are used at ORNL

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) 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 follows:

> 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).

Because of the soil types (low permeability) and karst geology, conditions exist at ORNL that would allow for claiming technical infeasibility, as described in technical guidance from EPA (EPA 2009a). Clay soils have low infiltrative capacities, and the introduction of more water to the subsurface in a karst geology can accelerate the formation of sinkholes. As a result of these two geological conditions at ORNL, the use of subsurface infiltration to address EISA-438 is being pursued on a limited basis. Instead, mitigation strategies are being pursued (e.g., installation of water quality systems and devices to improve water quality and strategies that would allow for additional evapotranspiration for streams and their associated buffer zones).

Implementing this revised approach to EISA-438 compliance, as opposed to claiming technical infeasibility, demonstrates ORNL's commitment to environmental stewardship. If projects take place in existing contaminated areas or where an area approach is not feasible, technical infeasibility is claimed to prevent potential movement of contamination within soil or groundwater.

When possible, this environmental stewardship approach is implemented on an area basis at ORNL. Addressing EISA-438 on an area basis, instead of a project-by-project basis, allows for the following:

- Storm water runoff from adjacent areas can be diverted around developed areas to keep water quality high.
- Water quality structures and devices can be installed to handle runoff from developed areas, therefore reducing the number of water quality structures and devices to be installed and maintained.
- Individual projects are not burdened with the costs associated with addressing EISA-438 requirements.

In 2023, no water quality improvements for projects subject to EISA-438 were completed.

5.2.1.6. Emergency Preparedness and Response

The UT-Battelle Emergency Management Program supplies the resources and capabilities to provide emergency preparedness and emergency response services. The on-site emergency management organization provides emergency call answering and dispatch, emergency medical care and transport, firefighting capability, technical rescue services, and hazardous materials release mitigation. Emergency management 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 execution of the procedures and plans. Emergency responders to expanding and complex incidents are supported by an emergency operations center consisting of laboratory leaders and SMEs. An environmental SME is a member of the emergency response organization. The environmental SME participates in real events, drills, and exercises to ensure that environmental requirements are met and that environmental impacts are mitigated.

5.2.1.7. Environmental Management System Performance Evaluation

ISO 14001 includes requirements to monitor, measure, analyze, and regularly evaluate the performance of the EMS. EMS performance evaluations ensure that goals and objectives are being met and that opportunities to continually improve are identified.

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. SBMS includes requirements for management system owners 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 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, an internal EMS assessment is performed annually to ensure that the UT-Battelle EMS continues to conform to ISO 14001:2015 requirements. An independent internal audit conducted in 2023 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. Environmental Management System for Isotek

Isotek has developed and implemented an EMS for the Uranium-233 Disposition Project that reflects the elements and framework found in the ISO 14001:2004 standard (ISO 2004) and 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 Uranium-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 Uranium-233 Disposition Project has a well-established recycling program that is implemented at all Isotek-managed facilities and includes Building 3017, the Building 3019 Complex, Building 2026, and Building 3137. Materials Isotek currently recycles 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 to continually improve the EMS.

5.3. Compliance Programs and Status

During 2023, UT-Battelle, UCOR, and Isotek operations were conducted to comply with contractual and regulatory environmental requirements. Table 5.2 summarizes environmental audits conducted at ORNL in 2023. The following discussions summarize the major environmental programs and activities carried out at ORNL during 2023 and provide an overview of the compliance status for the year. Summary information on 2023 noncompliances at ORNL is also available under Federal Services Registry ID number 110002040201 on EPA's Enforcement and Compliance History Online website **here**.

5.3.1. Environmental Permits

Table 5.3 lists the environmental permits that were in effect in 2023 at ORNL.

Table 5.2. Summary of regulatory environmental audits, evaluations, inspections, and assessments conducted at ORNL, 2023

Date	Reviewer	Subject	Issues
March 8–9	TDEC	Hazardous Waste Compliance Evaluation Inspection (including UT-Battelle, Transuranic Waste Processing Center, and UCOR)	0
March 9	City of Oak Ridge	CFTF Wastewater Pretreatment Permit Inspection	0
June 7	KCDAQM	Hardin Valley Campus Clean Air Act Inspection	0
June 21–23	TDEC	Biennial NPDES Permit Inspection	0
July 27	City of Oak Ridge	CFTF Wastewater Pretreatment Permit Inspection	0
August 9	TDEC	TWPC Clean Air Act Inspection	0
August 10	TDEC	CFTF Clean Air Act Inspection	0

Acronyms:

CFTF = Carbon Fiber Technology Facility

KCDAQM = Knox County Department of Air Quality Management

TDEC = Tennessee Department of Environment and Conservation

TWPC = Transuranic Waste Processing Center

UCOR = United Cleanup Oak Ridge LLC

Table 5.3. Environmental permits in effect at ORNL in 2023

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	22-0941	DOE	UT-B	UT-B
CAA	Operating Permit, TRU	071009P	DOE	UCOR	UCOR
CAA	Construction Permit, 3525 Area Off Gas System	971543P	DOE	UT-B	UT-B
CAA	Permit-by-Rule, TRU emergency generators	R80800	DOE	UCOR	UCOR
CAA	Title V Major Source Operating Permit, ORNL	578132	DOE	UCOR	UCOR
CAA	CFTF CAA Operating Permit (Conditional Major)	474951	DOE	UT-B	UT-B

Table 5.3. Environmental permits in effect at ORNL in 2023 (continued)

Regulatory driver	Permit title/description	Permit number	Owner	Operator	Responsible contractor
CAA	Construction Permit, NTRC	C-21-0941-02-01	DOE	UT-B	UT-B
CAA	CAA Title V Operating Permit for Isotek operations at ORNL	576448	DOE	Isotek	Isotek
CAA	Construction Permit, CFTF	980167	DOE	UT-B	UT-B
CAA	Construction Permit, SNS 8915 Upgrade	980182	DOE	UT-B	UT-B
CWA	ORNL NPDES Permit (ORNL sitewide wastewater discharge permit)	TN0002941	DOE	DOE	UT-B, UCOR, Isotek
CWA	Industrial and Commercial User Wastewater Discharge Permit (CFTF)	1-12	UT-B	UT-B	UT-B
CWA	General NPDES Permit for Storm Water Discharges Associated with Craft Resources Support Facility Construction Activities	TNR136355	DOE	UT-B	UT-B
CWA	General NPDES Permit for Storm Water for ORNL Experimental Gas Cooled Reactor Parking Lot	TNR136470	DOE	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	DOE	UCOR
CWA	Notice of Coverage Under the General NPDES Permit for Storm Water for TRC Project	TNR136285	DOE	UT-B	UT-B
RCRA	Hazardous Waste Transporter Permit	TN1890090003	DOE	UT-B	UT-B, UCOR
RCRA	Hazardous Waste Corrective Action Permit	TNHW-164	DOE	DOE/all	DOE/all
RCRA	Hazardous Waste Storage and Treatment Permit	TNHW-145	DOE	DOE/ UCOR	UCOR
RCRA	Hazardous and Mixed Waste Storage Permit	TNHW-178	DOE	DOE/UT-B	UT-B
PCB	PCB Risk Based Agreement between UT-B and EPA	TN1890090003	DOE	UT-B	UT-B
PCB	PCB Risk Based Agreement between UCOR and EPA	TN1890090003	DOE	UCOR	UCOR
CWA	ARAP—Construction of a New Outfall Consisting of a Headwall and Riprap Apron	NR2203.208	DOE	UT-B	UT-B
CWA	ARAP—Installation of a New Effluent Flow Monitoring Station with a Parshall Flume and New Outfall Line[a]	NR2203.188	DOE	UT-B	UT-B

Table 5.3. Environmental permits in effect at ORNL in 2023 (continued)

Regulatory driver	Permit title/description	Permit number	Owner	Operator	Responsible contractor
CWA	Tennessee Operating Permit, No-Discharge Wastewater Collection System for New GEARS Facility	SOP-22033	DOE	UT-B	UT-B
MBTA	US Fish and Wildlife Service Permit for Canada Geese	MB836291	UT-B	UT-B	UT-B
TCA 70	TWRA Scientific Collection Permit for Sunfish and Catfish	TWRA 1630	UT-B	UT-B	UT-B
TCA 70	TWRA Scientific Collection Permit for Canada Geese	TWRA 1631	UT-B	UT-B	UT-B
CWA	General NPDES Permit for Storm Water Discharges Associated with Stable Isotope and Production Research Center Site Prep	TNR136958	DOE	UT-B	UT-B
CWA	General Permit for Storm Water Discharges Associated with the ORNL 6000E Parking Lots	TNR137306	DOE	UT-B	UT-B
CWA	ARAP—Fifth Creek Culvert Maintenance Activities	NR2103.308	DOE	UT-B	UT-B
CWA	ARAP—Bank Armoring and Vegetative Stabilization for Jones Island Road Project [a]	NR2303.026	DOE	UT-B	UT-B
CWA	ARAP—Construction of Intake and Outfall Structures at NPDES Outfall 302	NR2303.163	DOE	UT-B	UT-B

[a] *Permit terminated during 2023.*

Acronyms:

ARAP = Aquatic Resources Alteration Permit
CAA = Clean Air Act
CFTF = Carbon Fiber Technology Facility
CWA = Clean Water Act
DOE = US Department of Energy
EPA = US Environmental Protection Agency
GEARS = Global Evaluation, Analysis, Research, and Security
Isotek = Isotek Systems LLC
MBTA = Migratory Bird Treaty Act of 1918
NPDES = National Pollutant Discharge Elimination System
NTRC = National Transportation Research Center
ORNL = Oak Ridge National Laboratory
PCB = polychlorinated biphenyl
RCRA = Resource Conservation and Recovery Act
SNS = Spallation Neutron Source
TCA 70 = T.C.A. 70-2-213
TRC = Translational Research Capability
TRU = transuranic
TWRA = Tennessee Wildlife Resources Agency
UCOR = United Cleanup Oak Ridge LLC
UT-B = UT-Battelle LLC

5.3.2. National Environmental Policy Act/National Historic Preservation Act

The NEPA process is used to evaluate the potential environmental impact of proposed federal activities and to examine alternatives to those actions. UT-Battelle, UCOR, 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 5.4 summarizes NEPA activities conducted at ORNL during 2023.

During 2023, UT-Battelle and UCOR 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, DOE has approved generic categorical exclusion determinations that cover proposed bench-scale and pilot-scale research activities and generic categorical exclusions that cover proposed nonresearch activities (e.g., maintenance activities, facilities upgrades, personnel safety enhancements). A categorical exclusion is one of a category of actions defined in 40 *Code of Federal Regulations* (CFR) Part 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 (NHPA 1966) is achieved and maintained at ORNL in conjunction with NEPA compliance. The scope of proposed actions is reviewed in accordance with the *Cultural Resource Management Plan* (Souza et al. 2001).

Table 5.4. National Environmental Policy Act activities, 2022–2023

Types of NEPA documentation	Number of instances
UT-Battelle LLC	
Environmental Assessments	0
Approved under general actions or generic CX determinations[a]	65
Project-specific CX determinations[b]	0
UCOR	
Approved under general actions[a] or generic CX determinations	0

[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

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 EPA and the TDEC Division of Air Pollution Control. The most recent sitewide UT-Battelle Title V Major Source Operating Permit was issued in December 2023. The Title V Major Source Operating Permit for the 3039 stack, operated by UCOR, was issued in January 2022. 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, a family of poisonous, highly reactive gases defined collectively as a criteria pollutant by EPA (EPA 2024b), 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. In December 2022, an operating permit was issued by Knox County for two emergency generators located at NTRC. The CFTF operates under a conditional major operating permit issued to UT-Battelle by TDEC in 2022.

In summary, no UT-Battelle, Isotek, or UCOR CAA violations or exceedances occurred in 2023. Section 5.4. provides detailed information on 2023 activities conducted by UT-Battelle in support of the CAA.

5.3.4. Clean Water Act Compliance Status

The Clean Water Act (CWA 1972) is the primary federal statute governing the restoration, maintenance, and protection of the integrity of the nation's waters. The CWA establishes several major integrated regulatory programs, standards, and plans, including the National Pollutant Discharge Elimination System (NPDES) program, national and local pretreatment standards, Dredge or Fill Discharge Permit Program, Sewage Sludge Use and Disposal Program, and water quality management.

The CWA is the basis for comprehensive federal and state programs to protect the nation's waters from pollutants. (See Appendix C for water quality reference standards.) As a part of the CWA, EPA developed the NPDES permit program to address water pollution by regulating point sources that discharge pollutants to US waters. 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 permit program to the State of Tennessee.

The pretreatment program is a component of the NPDES program. This program is designed to reduce the level of toxic pollutants discharged by industry and other nondomestic wastewater sources into municipal sewer systems and treatment facilities. Local municipalities with approved pretreatment programs control sources of nondomestic discharges through permitting and are responsible for conducting inspections, sampling, and enforcement in Tennessee.

Wastewater discharges from ORNL facilities are subject to regulation by EPA and the TDEC Division of Water Resources. DOE received a renewed ORNL NPDES permit in May 2019 from TDEC. Several conditions in the permit were appealed, and others were addressed in permit modifications issued in December 2022 and February 2023. Another minor modification was scheduled to become effective on March 1, 2023, but some conditions were appealed and remained unresolved in 2023. An NPDES permit renewal application was submitted to TDEC in June 2023, and until a new permit is issued, the February 2023 permit, which expired December 31, 2023, has been administratively extended.

In 2023, compliance with the ORNL NPDES permit was calculated based on a total of 1,736 laboratory analyses and field measurements. One *Escherichia* coliform exceedance occurred in June 2023 at X01 (Sewage Treatment Plant) due to an operational issue with the disinfection system ozone diffuser. The diffuser has since been fixed. The wastewater treatment facilities achieved a numeric permit compliance rate of 99.9 percent in 2023 (see Table 5.5). The CFTF achieved 100 percent compliance with the UT-Battelle City of Oak Ridge Industrial and Commercial User Discharge Permit in 2023.

Table 5.5. National Pollutant Discharge Elimination System (TN0002941) compliance at ORNL, January through December 2023

Effluent parameters[a]	Number of numeric noncompliances	Number of compliance measurements[b]	Percentage of compliance[c]
X01 (Sewage Treatment Plant)			
IC_{25} static renewal 7-day chronic *Ceriodaphnia dubia* (%)[d]	0	1	100
IC_{25} static renewal 7-day chronic *Pimephales promelas* (%)[d]	0	1	100
Ammonia, as N (summer)	0	27	100
Ammonia, as N (winter)	0	25	100
Carbonaceous biological oxygen demand	0	52	100
Dissolved oxygen	0	52	100
Escherichia coliform (col/100 mL)	1	53	98.1
Peracetic acid	0	0	100
pH (standard units)	0	52	100
Total suspended solids	0	52	100
Carbonaceous biological oxygen demand	0	52	100
IC_{25} static renewal 7-day chronic *Ceriodaphnia dubia* (%)[d]	0	1	100
IC_{25} static renewal 7-day chronic *Pimephales promelas* (%)[d]	0	1	100
Oil and grease	0	4	100
pH (standard units)	0	52	100
Temperature (°C)	0	52	100
X16 through X27 (12 instream monitoring locations)			
Total residual oxidant	0	288	100
X28 and X29 (two additional instream monitoring locations)			
Peracetic acid	0	0	100
Hydrogen peroxide	0	0	100

[a] *Only permit parameters with a numerical limit are listed.*
[b] *Total number of readings taken in the year by approved method for the given parameter.*
[c] *Percentage compliance = 100 − [(number of noncompliances/number of samples) × 100].*
[d] *The inhibition concentration (IC_{25}) is the concentration (as a percentage of full-strength wastewater) that reduces survival or reproduction of the test species by 25 percent when compared to a control treatment.*

5.3.5. Safe Drinking Water Act Compliance Status

ORNL's water distribution system is designated as a "nontransient, noncommunity" public water system by the TDEC Division of Water Supply. TDEC's water supply rules—Chapter 0400-45-01, "Public Water Systems" (TDEC 2020)—set limits for biological contaminants and for chemical activities and chemical contaminants. TDEC requires sampling for the following constituents to demonstrate compliance with state and federal regulations:

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

The fifth Unregulated Contaminant Monitoring Rule (UCMR 5), published on December 27, 2021, requires sample collection and analyses for 30 chemical contaminants in 2023, 2024, and 2025 using methods developed by EPA and consensus organizations. Sample collection at ORNL for UCMR 5 began in 2023 and will continue through 2026. Samples were taken five times in 2023 (January, April, July, October, and December) at the entry point of the distribution system.

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 2023, sampling results for ORNL's water system residual chlorine levels, bacterial constituents, and disinfectant by-products were all within acceptable limits. Sampling for lead and copper is not required until 2024.

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 2023, 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 2023.

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 5.6. In 2023, UT-Battelle and UCOR were permitted to transport hazardous wastes under the EPA ID number issued for ORNL activities. TNHW-164 is a set of conditions pertaining to the current status of all solid waste management units and areas of concern at ETTP, ORNL, and the Y-12 Complex. The corrective action conditions require that the solid waste management units and areas of concern be investigated and, as necessary, remediated.

Reporting is required for hazardous waste activities on 12 active waste streams at ORNL, some of which involve mixed wastes. The quantity of hazardous/mixed waste generated at ORNL in 2023 was 795,473 kg, of which 590,990 kg was mixed wastewater.

Table 5.6. ORNL Resource Conservation and Recovery Act operating permits, 2023

Permit number	Storage and treatment/description
	Oak Ridge National Laboratory
TNHW-178	Building 7651 Mixed Waste Container Storage Unit Building 7652 Hazardous Waste Container Storage and Treatment Unit Building 7653 Chemical Waste Container Storage Unit Building 7654 Mixed Waste Container Storage and Treatment Unit
TNHW-145	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 Macroencapsulation Treatment[a] T-2 Solidification/Stabilization Treatment[a] T-3 Amalgamation Treatment[a] T-4 Groundwater Absorption Treatment[a] T-5 Size Reduction[a] T-6 Groundwater Filtration Treatment[a] T-7 Neutralization[a] T-8 Oxidation/Deactivation[a] T-9 Puncturing Potentially Pressurized Containers[a]
	Oak Ridge Reservation
TNHW-164	Hazardous Waste Corrective Action Document

[a] *Treatment methodologies within Transuranic Waste Processing Center facilities.*

ORNL generators treated 4,108 kg of hazardous waste by elementary neutralization. The quantity of hazardous/mixed waste treated in permitted treatment facilities at ORNL in 2023 was 591,524 kg. This includes waste treated by macroencapsulation, size reduction, and stabilization/solidification as well as wastewater treatment at the Process Waste Treatment Complex (PWTC). In 2023, 203,112 kg of hazardous/mixed waste was shipped off-site to commercial treatment, storage, and disposal facilities. In March 2023, the TDEC Division of Solid Waste Management conducted a hazardous waste compliance evaluation inspection of the following:

- ORNL generator areas
- Used-oil collection areas
- Universal waste collection areas
- RCRA-permitted treatment, storage, and disposal facilities
- Hazardous waste training records
- Site-specific contingency plans
- Hazardous waste reduction plan
- Active mutual aid and memorandums of agreement with local authorities
- Waste determinations
- RCRA records

TDEC also reviewed the Hazardous Waste Transporter Permit and hazardous waste manifests. No violations were observed.

In June 2023 DOE and UT-Battelle operations at the HVC changed generator category from a very small quantity generator to a small quantity generator. HVC does not generate mixed waste. Hazardous wastes are accumulated in satellite accumulation areas or in less-than-180-day accumulation areas. Reporting is required for hazardous waste activities in nine active waste streams at HVC. During 2023 HVC generated 1,630 kg of hazardous waste and shipped 1,367 kg of hazardous waste for treatment and disposal.

CFTF was categorized as a very small quantity generator in 2023, meaning that less than 100 kg of hazardous waste was generated per month.

In 2023, no hazardous/mixed wastes were generated, accumulated, or shipped by DOE or UT-Battelle from the Jones Island Road 0800 Area, Property Sales, or the DOE Office of Scientific and Technical Information.

5.3.7. ORNL RCRA-CERCLA Coordination

The *Federal Facility Agreement for Oak Ridge Reservation* (DOE 1992) 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 2022 for ORNL's solid waste management units and areas of concern were consolidated with updates for ETTP, the Y-12 Complex, and ORR and were reported to TDEC, DOE, and EPA Region 4 in January 2023.

Periodic updates on proposed construction and demolition 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 construction and demolition projects and facilities that warrant CERCLA oversight. The goal is to ensure that modernization efforts do not adversely affect future CERCLA environmental remediation actions or the effectiveness of previously completed CERCLA environmental remediation actions.

5.3.7.1. RCRA Underground Storage Tanks

Underground storage tanks (USTs) containing petroleum and hazardous substances are regulated under RCRA Subtitle I (40 CFR 280). EPA has granted TDEC the authority to regulate USTs containing petroleum under TDEC Rule 400-18-01 (TDEC 2021a); however, EPA still regulates hazardous-substance USTs.

ORNL has two USTs registered with TDEC under Facility ID 0-730089. These USTs are in service (for petroleum storage) and meet the current UST standards. TDEC did not conduct any compliance inspections in 2023.

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 is a comprehensive list of sites and facilities that have been found to pose a sufficient threat to human health or the environment to warrant cleanup under CERCLA.

In 1989, ORR was placed on the National Priorities List. In 1992, the ORR Federal Facility Agreement became effective among EPA, TDEC, and DOE and established the framework and schedule for developing, implementing, and monitoring remedial actions (RAs) on ORR. UCOR operates the on-site CERCLA Environmental Management Waste Management Facility (EMWMF) 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 these 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 Substances Control Act (TSCA 1976). PCB waste generation, transportation, and storage at ORNL are reported under EPA ID TN1890090003. In 2023, ORNL contractors operated five 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 equipment (e.g., transformers, capacitors, rectifiers) is regulated at ORNL. Most of the equipment at ORNL that required regulation under the Toxic Substances Control Act 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 materials, 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 in paint, adhesives, electrical wiring, or floor tile, are identified at ORNL. No new unauthorized uses of PCBs were identified during 2023.

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 Emergency Response Information System (E-Plan), which is an electronic database managed by the University of Texas at 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 5.7 describes the main elements of EPCRA. UT-Battelle complied with these requirements in 2023 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.

In 2023, ORNL had no releases of extremely hazardous substances as defined by EPCRA. Releases of toxic chemicals that were greater than the reportable threshold quantities designated in Section 313 are discussed in Section 5.3.10.2.

Table 5.7. 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, 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

5.3.10.1. Safety Data Sheet/Chemical Inventory (EPCRA 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 2023, there were 44 hazardous and 39 extremely hazardous substances at ORNL that met EPCRA reporting criteria.

Private-sector lessees were not included in the 2023 submittals. Under the terms of their leases, lessees must evaluate their own inventories of hazardous and extremely hazardous chemicals and 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.

In 2023, ORNL exceeded the reporting threshold for nitrate compounds and reported on their manufacture. Nitrate compounds were coincidentally manufactured 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 with USDA. In 2023, UT-Battelle personnel had 22 permits and agreements for the receipt, movement, or controlled release of regulated articles.

5.3.12. Wetlands

Wetland delineations are conducted to facilitate compliance with TDEC and US Army Corps of Engineers wetland protection requirements. In

2023, four wetlands were delineated on the ORNL campus. Two of these delineations helped projects avoid wetland impacts, and two were conducted to include in Aquatic Resources Alteration Permits.

5.3.13. Radiological Clearance of Property at ORNL

DOE Order 458.1, *Radiation Protection of the Public and the Environment* (DOE 2020), 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; samples from those items undergo 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 required by DOE Order 458.1 (DOE 2020) 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 2023, UT-Battelle cleared more than 19,930 items through the excess items and property sales processes. A summary of items requested for release through these processes is shown in Table 5.8.

Table 5.8. Excess items requested for release or recycling, 2023

Item	Process knowledge	Radiologically surveyed
Release request totals for 2023		
Totals	18,201	1,729
Recycling request totals for 2023		
Cardboard (lb)	314,012	
Scrap metal (nonradiological areas) (tons)	421.06	

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

The SNS and High Flux Isotope Reactor (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 2020) 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 licensing regulations). Implementation of the clearance limits involves using unique instrument screening and methods to predict sample activity to provide an efficient and defensible process to release neutron scattering experiment samples to researchers without further DOE control.

In 2023, ORNL cleared a total of 11 samples from neutron scattering experiments using the sample authorized limits process. All 11 samples were from HFIR. No samples were cleared from SNS in 2023 using the sample authorized limit process.

5.4. Air Quality Program

Permits issued by the State of Tennessee convey the clean air requirements that are applicable to ORNL. These permits and the results of 2023 air monitoring activities are summarized in the following sections.

5.4.1. Construction and Operating Permits

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 for the NTRC facilities, which are 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. The most recent Conditional Major Source Operating Permit for the facility was issued in September 2023 (Permit No. 474951).

DOE/UCOR has one non-Title V Major Source Operating Permit for one emission source at TWPC (Permit No. 071009P and Permit-by-Rule R80800). During 2023, no permit limits were exceeded. Isotek has a Title V Major Source Operating Permit (576448) for the Radiochemical Development Facility (Building 3019 Complex). During 2023, 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. The current operating permit (578132) was issued in July 2022. During 2023, no permit limits were exceeded.

5.4.2. National Emission Standards for Hazardous Air Pollutants—Asbestos

Numerous facilities, structures, facility components, and pieces of equipment at ORNL contain asbestos-containing material. UT-Battelle's Asbestos Management Program manages the compliance of work activities involving the removal and disposal of asbestos-containing material. This program includes notifications to TDEC for all demolition activities and required renovation activities, approval of asbestos work authorization requests, implementation of engineering controls and work practices, inspections, air monitoring, and waste tracking of asbestos-contaminated waste material. During 2023, no deviations or releases of reportable quantities of asbestos-containing material occurred.

In 2023, activities related to the Asbestos Management Program included the following:

- No Notification of Demolition or Asbestos Renovation Application submittals were required for the projects contracted or for the removal work activities performed during the calendar year.
- The revised friable asbestos removal annual estimates CY 2023 letter was submitted in November 2023 to modify CY 2023 annual estimates, as required, with quantities of 1,005 ft, 35 ft^2, and 7 ft^3.
- The estimates of friable asbestos removal for CY 2024 (1,185 ft, 285 ft^2, and 50 ft^3) were submitted in December 2023.
- During 2023, a total of 98 asbestos work authorizations were completed for asbestos removal work activities primarily involving pipe insulation and floor tile materials.

5.4.3. Radiological Airborne Effluent Monitoring

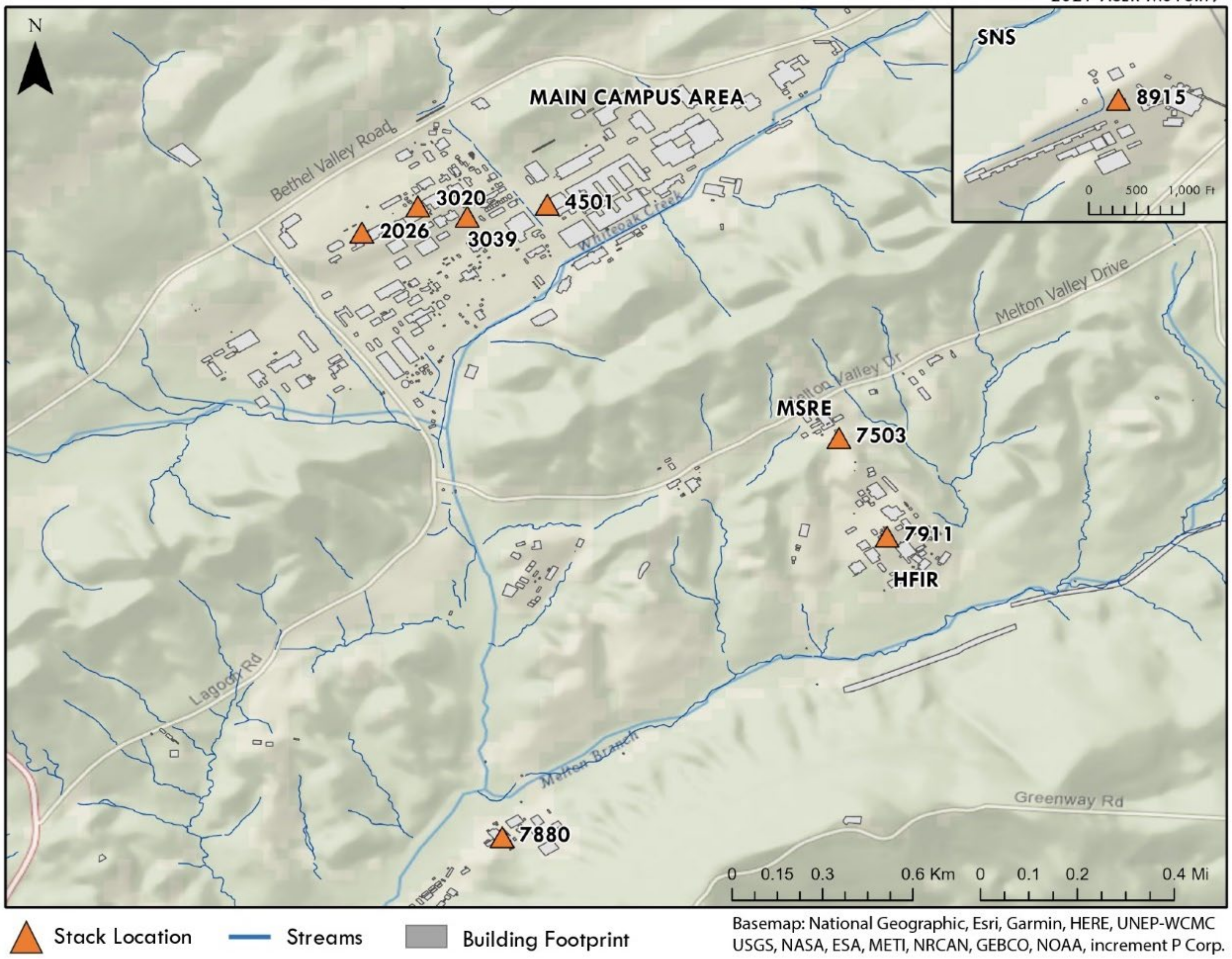
Radioactive airborne discharges at ORNL are subject to Rad-NESHAPs and consist primarily of ventilation air from radioactively contaminated or potentially contaminated areas, vents from tanks and processes, and ventilation for hot cell operations and reactor facilities. The airborne emissions are treated 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 (^{3}H), 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
- 7880 TWPC
- 7911 Melton Valley complex, which includes HFIR and the Radiochemical Engineering Development Center
- 8915 SNS Central Exhaust Facility stack

In 2023, there were 14 minor point/group sources, and emission calculations/estimates were made for each of them.

ORNL 2021-G00916/mhr
2021-ASER-M016.tf9



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 ORNL, 2023

5.4.3.1. Sample Collection and Analytical Procedure

Three of the major point sources (stacks 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).

Each sampling system generally comprises 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 2026 (Radioactive Materials Analytical Laboratory), 4501 (Radiochemistry Laboratory), 7911 (Melton Valley complex), and 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 2026, 4501, and 7911 sampling systems have the same components as the ANSI 1969 sampling systems used for the four major point sources but use stainless-steel-shrouded probes instead of multipoint in-stack sampling probes. The 7911 sampling system also includes 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., 41Ar) 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 (40 CFR 60, Appendix A-1, Method 2) 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. Results obtained from the effluent flow rate totalizer and from EPA Method 2 are compared annually for the 7880 stack. 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 were calculated using a fixed stack flow rate. A fixed stack flow rate was used because the stack velocity at the sampling level was at or below the sensitivity of standard methods for measuring the velocity, and therefore stack flow rates could not be determined. The reduction in velocity was 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 to 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). The 3039 stack velocity was successfully measured with new equipment in November 2019 and in July 2020. Both results were below the fixed stack flow rate; the stack velocity result obtained in 2020 was used for emission calculation purposes in 2023.

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 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 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 and 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 composited quarterly or semiannually and are analyzed for alpha-, beta-, and gamma-emitting isotopes. At stack 7880, the filters are collected monthly and analyzed for alpha-, beta-, and gamma-emitting isotopes. The sampling system on stack 7880 requires no other type of radionuclide collection media. Monthly sampling provides a better opportunity for quantification of the low-concentration isotopes. Silica gel traps are used to capture water vapor that may contain ^{3}H. Analysis is performed weekly to biweekly. At the end of the year, the sample probes for all 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. Contaminant deposits are not expected to 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 not more often than every 3 years unless particulate emissions increase, detectable radionuclides in the sample media increase, or process modifications occur.

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 2023 are presented in Appendix G.

Historical trends for ^{3}H and ^{131}I are presented in Figures 5.8 and 5.9. For 2023, 3H emissions totaled about 1,319 Ci (Figure 5.8), comparable to what was seen in 2022; ^{131}I emissions totaled 0.17 Ci (Figure 5.9), an increase from what was seen in 2022. For 2023, of the 404 radionuclides (excluding radionuclides with multiple solubility types) released from ORNL operations and evaluated, the isotopes that contributed 10 percent or more to the off-site dose from ORNL included ^{212}Pb, which contributed about 27 percent, and ^{138}Cs, which contributed about 39 percent to the total ORNL dose.

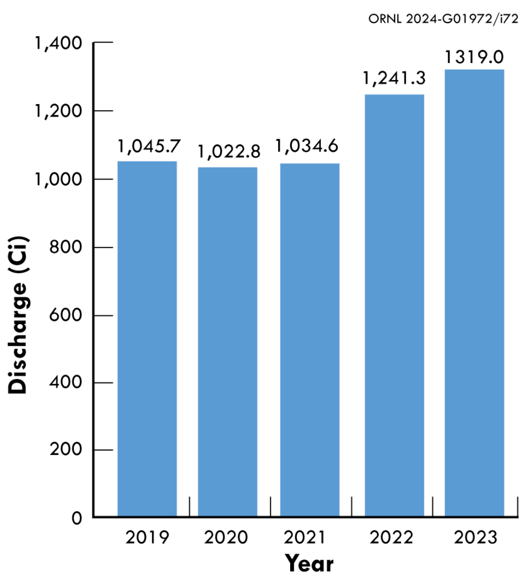


Figure 5.8. Total curies of ^{3}H discharged from ORNL to the atmosphere, 2019–2023

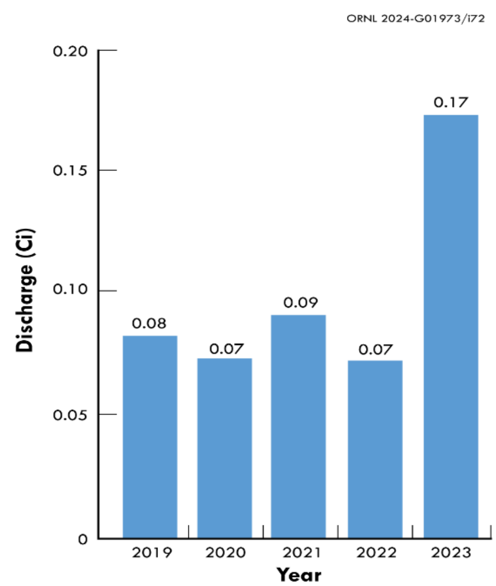


Figure 5.9. Total curies of ^{131}I discharged from ORNL to the atmosphere, 2019–2023

Emissions of ^{212}Pb result from research activities and from the radiation decay of legacy material stored on-site and from areas containing ^{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. Emissions of ^{138}Cs result from Radiochemical Engineering Development Center research activities and HFIR operations. For 2023, ^{212}Pb emissions totaled 5.31 Ci, ^{138}Cs emissions totaled 2,190 Ci, and ^{41}Ar emissions totaled 1,040.5 Ci (Figure 5.10).

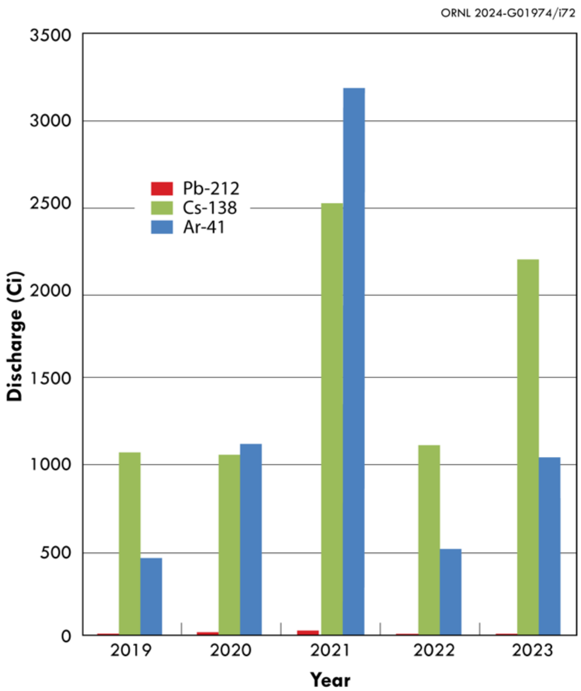


Figure 5.10. Total curies of ^{41}Ar, ^{138}Cs, and ^{212}Pb discharged from ORNL to the atmosphere, 2019–2023

The calculated radiation dose to the maximally exposed individual (MEI) from all radiological airborne release points at ORR during 2023 was 0.6 mrem. The dose contribution to the MEI from all ORNL radiological airborne release points was 15 percent of the ORR dose. This dose is well below the Rad-NESHAPs standard of 10 mrem and is equal to approximately 0.2 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.)

5.4.4. Stratospheric Ozone Protection and Hydrofluorocarbon Phasedown

As required by the CAA Title VI Amendments of 1990 and in accordance with 40 CFR 82, actions have been implemented to comply with the prohibition against intentionally releasing ozone-depleting substances during maintenance activities performed on refrigeration equipment. In 2017, EPA enacted major revisions to the stratospheric ozone rules to include the regulation of substitutes for ozone-depleting substances as part of 40 CFR 82 Subpart F. The revisions became effective January 1, 2018, for the 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. On October 1, 2021, EPA began implementing the hydrofluorocarbons phasedown requirements of the American Innovation and Manufacturing Act (AIM 2020), which seeks to reduce hydrofluorocarbon consumption and production to 15 percent of a 2011–2013 baseline by 2036. (*Phasedown of Hydrofluorocarbons: Establishing the Allowance Allocation and Trading Program under the AIM Act* [EPA 2022a] is available **here**.) Sitewide use of hydrofluorocarbons is being evaluated to understand future effects of AIM Act phasedowns.

5.4.5. Ambient Air

Station 7 in the ORNL 7000 maintenance area is the site-specific ambient air monitoring location. During 2023, the sampling system at Station 7 was used to quantify levels of ^{3}H; 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 ^{3}H as tritiated water. The silica gel was collected biweekly or weekly, depending on ambient humidity, and was composited quarterly for ^{3}H analysis. Station 7 sampling data (Table 5.9) were compared with the derived concentration standards (DCSs) for air established by DOE as guidelines for controlling exposure to members of the public (DOE 2021b). During 2023, average radionuclide concentrations at Station 7 were less than 1 percent of the applicable DCSs in all cases.

Table 5.9. Radionuclide concentrations measured at ORNL air monitoring Station 7, 2023[a]

Parameter	Concentration (pCi/mL)[b]
Alpha	3.4×10^{-9}
^{7}Be	2.7×10^{-8}
Beta	1.8×10^{-8}
^{40}K	1.9×10^{-9}
^{3}H[c]	6.6×10^{-6}
$^{233/234}U$	2.9×10^{-11}
$^{235/236}U$	0
^{238}U	2.8×10^{-11}

[a] *Except for ^{3}H, each concentration value is based on a single result from annual composites of low-volume filters.*

[b] *1 pCi = 3.7×10^{-2} Bq.*

[c] *Silica gels are composited quarterly for ^{3}H analysis. The ^{3}H concentration is the calculated annual average.*

5.5. ORNL Water Quality Program

NPDES Permit TN0002941—issued to DOE for the ORNL site, reissued by the State of Tennessee in 2019, and modified in 2022 and again in 2023—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, and storm water) and requirements for developing and implementing 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 using an adaptive management approach whereby results of investigations are routinely evaluated and strategies for achieving goals are modified based on those evaluations. The goals of 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 DOE and was approved by TDEC in 2008, and WQPP monitoring was initiated in 2009. The WQPP originally incorporated several control plans that were required under the previous NPDES permit, including a biological monitoring and abatement plan, a chlorine control strategy, a storm water pollution prevention plan, a non–storm water best management practices plan, and a radiological monitoring plan. Radiological monitoring requirements were removed in the February 2023 permit modification, but some radiological monitoring is still performed to comply with DOE Order 458.1.

To prioritize the stressors and contaminant sources that may be of greatest concern to water quality and to define conceptual models to guide any special investigations, the WQPP strategy was defined using EPA's *Stressor Identification Guidance Document* (EPA 2000). 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.

Special investigations were designed to identify specific source areas and to revise the conceptual model of the major causes of contamination in the White Oak Creek (WOC) watershed.

Monitoring and investigation data collected under the ORNL WQPP are analyzed, interpreted, reported, and compared with past results at least annually. A summary of significant findings is reported in the *Annual Site Environmental Report*, and a more comprehensive report of findings is submitted to TDEC on an annual basis. This information is used to assess 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.

5.5.1. Treatment Facility Discharges

The ORNL Sewage Treatment Plant (STP) and the ORNL PWTC appropriately treat the various R&D, operational, and domestic wastewaters generated by site staff and research activities. Both are permitted to discharge treated wastewater and are monitored under NPDES Permit TN0002941, issued by TDEC to DOE for the ORNL site. The ORNL NPDES permit requirements include monitoring the two ORNL wastewater treatment facility effluents for conventional and water quality–based constituents and for effluent toxicity with numeric parameter-specific compliance limits established by TDEC as determined to be necessary. 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 Section 5.3.4 (Table 5.5). Compliance with permit limits for ORNL wastewater treatment facilities was 99.9 percent in 2023.

Toxicity testing provides an assessment of any potential harmful effects from the total combined constituents in discharges from ORNL wastewater treatment facilities. The NPDES permit has required testing of effluents from the STP for toxicity to aquatic species since 1986, and effluents from the 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. In past years, the STP and PWTC have 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. In 2023 no toxicity was observed in any of the tests at either of the wastewater treatment facilities. In addition, the TDEC Division of Water Resources performed an NPDES permit compliance evaluation inspection at ORNL in 2023, which included a supplementary toxicity test at both the STP and PWTC, and no toxicity was observed in the results from either test.

5.5.2. Residual Bromine and Chlorine Monitoring

ORNL receives potable water from the City of Oak Ridge Department of Public Works, which uses chlorine as a final disinfectant. On the ORNL site, potable water is used for drinking, sanitary, and housekeeping purposes as well as for research processes and in cooling systems. After the water is used, residual chlorine remains and can be toxic to fish and other aquatic life if discharged to surface water. Residual chlorine in wastewater routed to the STP is generally consumed in reactions with other substances within the collection and treatment system, and any residual chlorine in wastewater routed to the PWTC is removed by final activated carbon filtration.

The NPDES permit requires monitoring total residual oxidant (TRO) levels at 12 different instream locations twice a month. In addition, oxidant levels at outfalls with potential chlorine/bromine sources are routinely monitored via the WQPP TRO control strategy (also referred to as the chlorine control strategy). The NPDES permit establishes an action level of 1.2 g/day for TRO loading at all outfalls. A root cause analysis is performed for action level exceedances, and corrective actions are taken to reduce chlorine/bromine loading to less than 1.2 g/day.

In 2023, TRO was monitored twice a month at outfalls that receive cooling tower discharges and once-through cooling water. Less frequent monitoring was conducted at other outfalls (semimonthly, monthly, quarterly, or semiannually if flow was present). A total of 388 TRO measurements were taken at 25 locations, in addition to 288 semimonthly instream measurements. TRO was detected at or above the end-of-pipe action level on 19 occasions during 2023 but was never detected at any of the 12 instream monitoring points (Table 5.10).

Table 5.10. Overview of 2023 chlorine control strategy

Total residual oxidant sampling events	676
Below detection (<0.05 mg/L)	604
Instream total residual oxidant exceedances	0
Outfall detections	19
Outfall action level detections (>1.2 g/day)	19
Number of outfalls with action level detections	6

5.5.2.1. Monitoring Results and Corrective Actions

Actions in response to point-source TRO monitoring include source investigations, source elimination, addition of pretreatment dechlorination systems, emergency repairs, and dechlorination system adjustments. Inspections of the sodium sulfite tablet feeders are also conducted to ensure that they are refilled and in good condition and that any fouled tablets are removed for disposal. In addition, as a storm water best management practice, potential residual chlorine/bromine sources or leaks are dechlorinated prior to discharge in the WOC watershed to reduce risk of harm to aquatic life and the environment.

Table 5.11 summarizes 2023 TRO detections greater than 1.2 g/day and any additional investigation actions or repairs.

Table 5.11. Total residual oxidant mitigation summary: emergency repairs, 2023

Outfall	Date	TRO (mg/L)	Flow (gpm)	Load (g/day)	Receiving stream	Downstream water kilometer	Instream monitoring point	Notes
210	3/16/2023	2.2	40	477.51	WOC	WCK 4.1	X18	Once-through cooling liquid dechlorination system was inoperable in 2023 due to pump failure. Dechlorination was facilitated with sodium sulfite tablets.
210	4/21/2023	2.0	25	269.82	WOC	WCK 4.1	X18	
210	6/29/2023	0.3	25	36.52	WOC	WCK 4.1	X18	
210	7/24/2032	1.8	15	147.18	WOC	WCK 4.1	X18	
210	9/18/2023	0.3	20	30.53	WOC	WCK 4.1	X18	
210	11/27/2023	1.7	45	417.00	WOC	WCK 4.1	X18	
210	12/7/2023	1.2	35	228.94	WOC	WCK 4.1	X18	
211	7/24/2023	0.4	45	98.12	WOC	WCK 4.4	X22	Once-through cooling is present in this drainage network. Flows are dechlorinated at the end of the pipe with tablets.
231	11/27/2023	1.3	120	850.35	WOC	WCK 4.4	X25	Sodium sulfite tablets placed in a bucket at outfall.
231	12/22/2023	0.1	20	7.63	WOC	WCK 4.4	X25	
267	1/6/2023	0.1	25	13.63	FFK	FFK 0.1	X20	Source unknown but suspected as coming from drainage in Building 3144.
267	5/17/2023	1.2	3	18.81	FFK	FFK 0.1	X20	
267	8/21/2023	0.1	5	2.73	FFK	FFK 0.1	X20	
267	10/16/2023	0.8	15	67.05	FFK	FFK 0.1	X20	
314	1/6/2023	0.1	45	24.53	WOC	WCK 4.4	X26	Foundation sump pumping of chlorinated water, which was redirected and dechlorinated with tablets.
314	1/27/2023	0.7	20	76.31	WOC	WCK 4.4	X26	
314	5/26/2023	0.3	1	1.64	WOC	WCK 4.4	X26	Cooling tower tablet dechlorination failure. Tablets replaced.
363	7/10/2023	1.5	20	163.53	FFK	FFK 0.1	X20	Cooling tower blowdown dechlorination system failure. Sodium sulfite tablets are placed at the end of pipe.
363	8/21/2023	1.6	20	173.34	FFK	FFK 0.1	X20	

Acronyms:

FFK = Fifth Creek kilometer

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 per DOE Order 458.1. Table 5.12 details the analyses performed on samples collected in 2023 at 2 treatment facility outfalls, 4 instream monitoring locations, and 16 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 2023, dry-weather grab samples were collected at 11 of the 16 category outfalls targeted for sampling. Five category outfalls were not sampled because no discharge was present during sampling attempts.

The two ORNL treatment facility outfalls that were monitored for radioactivity in 2023 were the STP outfall (Outfall X01) and the PWTC outfall (Outfall X12). The four instream locations that were monitored were the WOC headwaters, X13 on Melton Branch, X14 on WOC, and X15 at White Oak Dam (WOD) (Figure 5.11). At each treatment facility outfall and instream monitoring location, monthly flow-proportional composite samples were collected using dedicated automatic water samplers.

A DCS for each radioisotope is used to evaluate discharges of radioactivity from DOE facilities (DOE 2021b). 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 met or exceeded 4 percent of the relevant DCS concentration in dry-weather discharges from Outfalls X01, X12, 085, 207, 302, and 304 (Figure 5.12). In 2023, no dry-weather discharges from sampled outfalls had an annual mean radioactivity concentration greater than 100 percent of a DCS.

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 5.13 through 5.17. Because discharges of radioactivity are somewhat correlated to stream flow, annual flow volumes measured at the WOD monitoring station are given in Figure 5.18. Discharges of radioactivity at WOD in 2023 were similar to discharges during other recent years, particularly when differences in annual flow volume are considered, and continue to be generally lower than in the years preceding completion of the waste area caps in Melton Valley (substantially complete by 2006).

No wet-weather sampling was conducted in 2023 due to changes in the NPDES permit.

Table 5.12. Radiological outfall and instream monitoring conducted at ORNL, 2023

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	Annually	X								
Outfall 080[a]	Annually									
Outfall 081	Annually	X		X						
Outfall 085	Monthly	X	X			X				
Outfall 203[a]	Annually									
Outfall 207	Monthly	X	X							
Outfall 211	Annually	X	X			X				
Outfall 234[a]	Annually									
Outfall 281	Quarterly	X		X						
Outfall 282	Annually	X								
Outfall 302	Monthly	X	X	X		X	X	X	X	X
Outfall 304	Monthly	X	X	X		X	X	X	X	X
Outfall 365	Annually	X								
Outfall 368[a]	Annually									
Outfall 383	Annually	X		X						
Outfall 484[a]	Annually									
WOCHW	Monthly	X	X	X	X	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 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

WOCHW = White Oak Creek headwaters

WOD = White Oak Dam

ORNL 2021-G00642/mhr
March 2021-EPSDM005.tf9

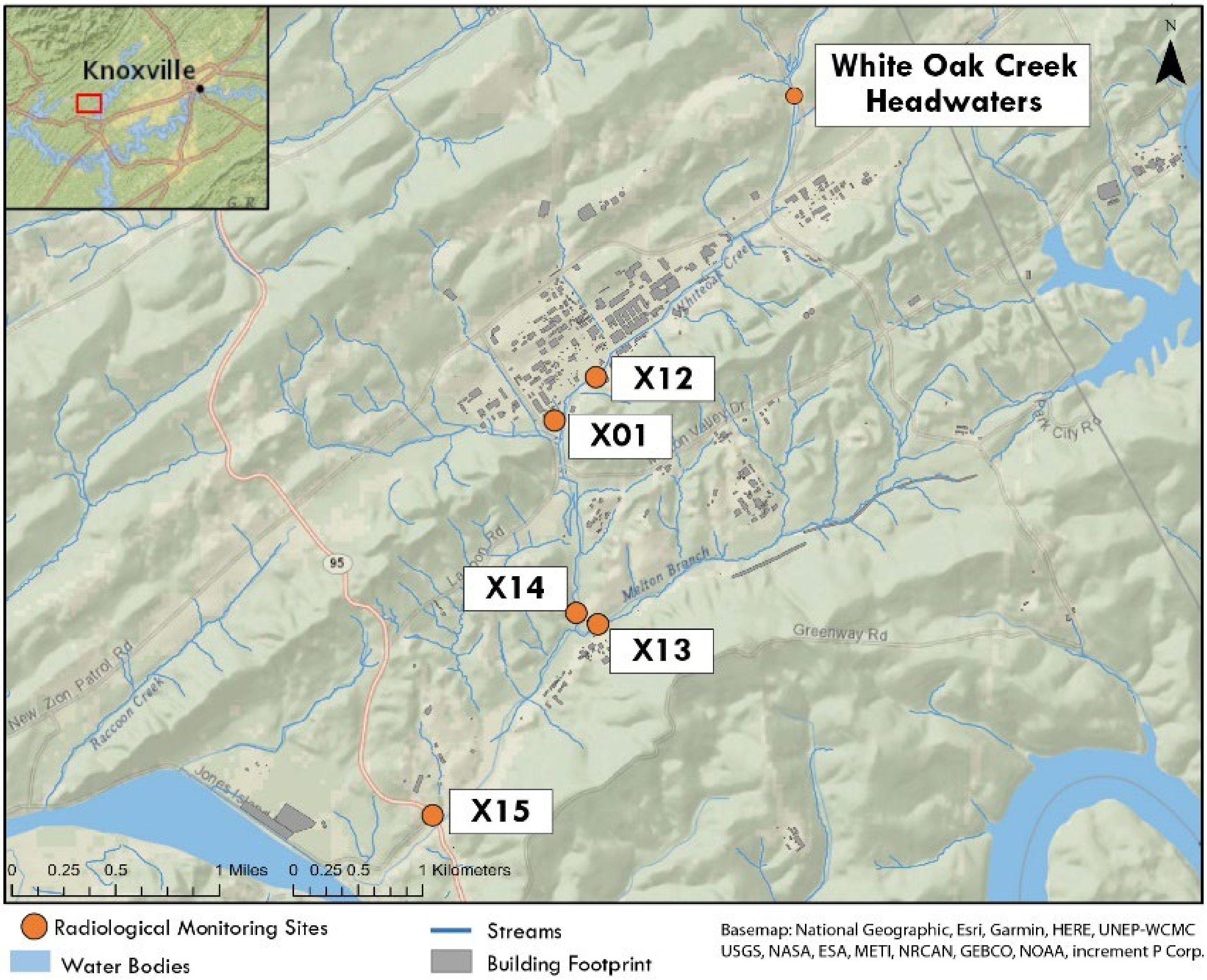


Figure 5.11. Selected surface water, National Pollutant Discharge Elimination System, and reference sampling locations at ORNL

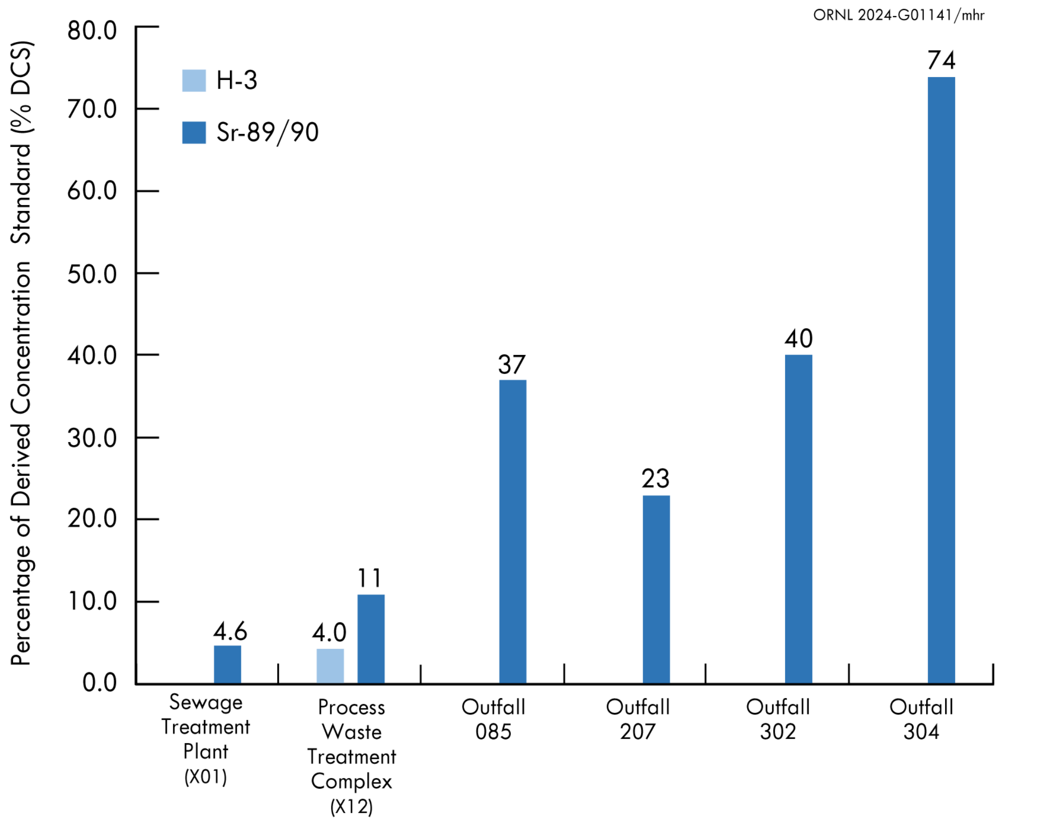


Figure 5.12. Outfalls and instream locations at ORNL with average radionuclide concentrations greater than 4 percent of the relevant derived concentration standards, 2023

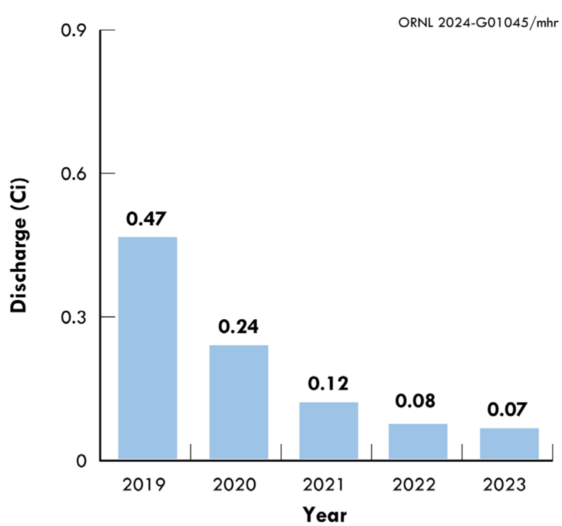


Figure 5.13. Cesium-137 discharges at White Oak Dam, 2019–2023

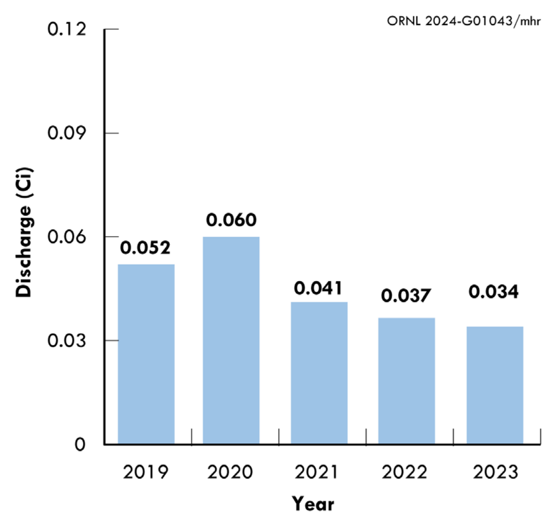


Figure 5.14. Gross alpha discharges at White Oak Dam, 2019–2023

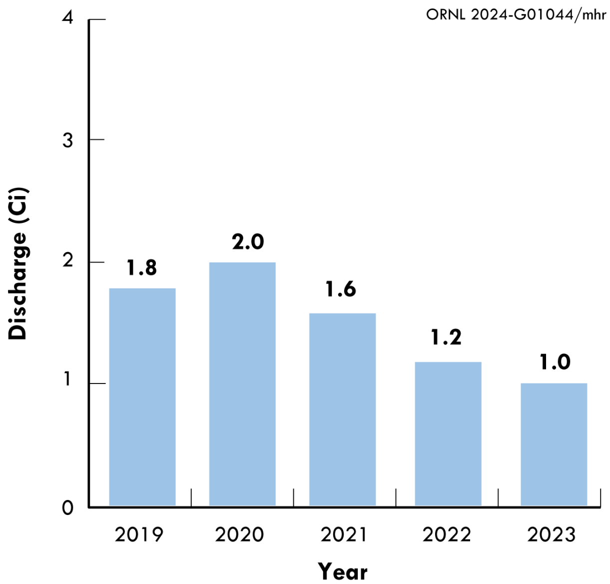


Figure 5.15. Gross beta discharges at White Oak Dam, 2019–2023

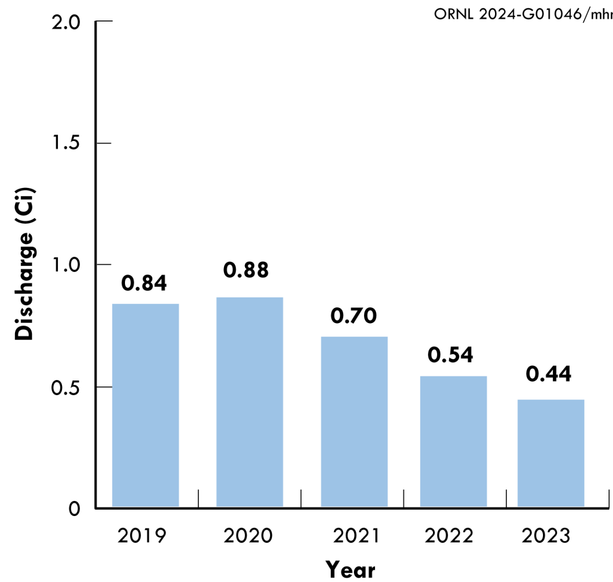


Figure 5.16. Total radioactive strontium discharges at White Oak Dam, 2019–2023

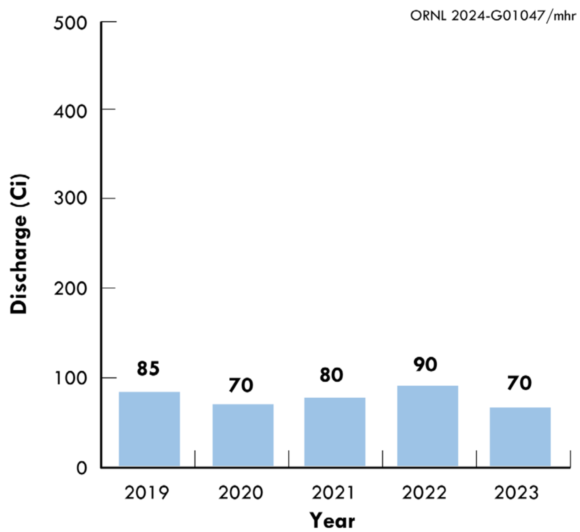


Figure 5.17. Tritium discharges at White Oak Dam, 2019–2023

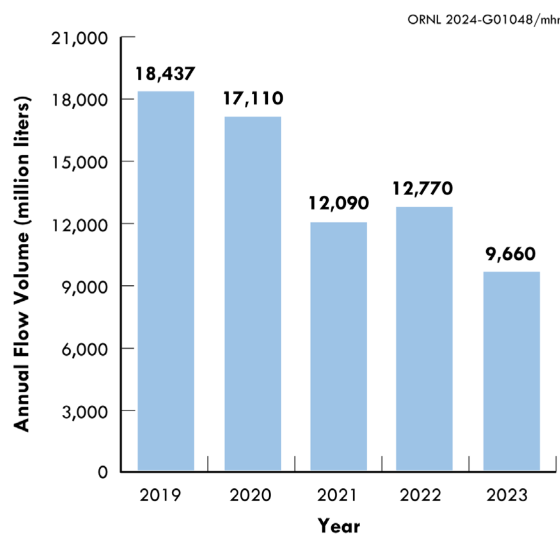


Figure 5.18. Annual flow volume at White Oak Dam 2019–2023

5.5.4. Mercury in the White Oak Creek Watershed

During the mid-1950s, mercury (Hg) was used for pilot-scale isotope separation work in Buildings 3592, 4501, and 4505 and in spent-fuel reprocessing in Building 3503. By 1963, this work had transferred to Y-12. Buildings 4501 and 4505, located east of Fifth Creek and north of WOC, are still active research facilities. In the 1990s two settling ponds for process wastewaters from these buildings were removed, and discharges were rerouted to the PWTC for treatment. Figure 5.19 depicts Outfalls 211 and 207 and associated storm drain connections that are potential legacy Hg sources.

In 1996, the Building 4501 foundation sump was found to contain legacy Hg because of its volatility and from its use and spills in the 1950s. The foundation sump discharged to storm Outfall 211 (Figure 5.19) on WOC; a smaller foundation sump in the building discharged to Outfall 263 on Fifth Creek. By 2008 the foundation sump had been rerouted to the PWTC, and by 2011, an Hg pretreatment system had been installed on the larger sump. Discharge from the foundation sumps in Buildings 4501 and 4500N and from the smaller sump in Building 4501 had also been rerouted along with the smaller sump and a 4500N foundation sump to the PWTC. Outfall 211 and Outfall 363 storm piping still receives other sources of storm water, cooling water, and steam condensate discharges. Buildings 3592 and 3503 were demolished 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. Because of the persistence of elemental Hg, its volatility, and the complexity of its interactions in piping and soil, legacy Hg continues to be monitored and assessed at these storm outfalls.

Legacy Hg associated with process infrastructure has also been found 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 has occurred in the past.

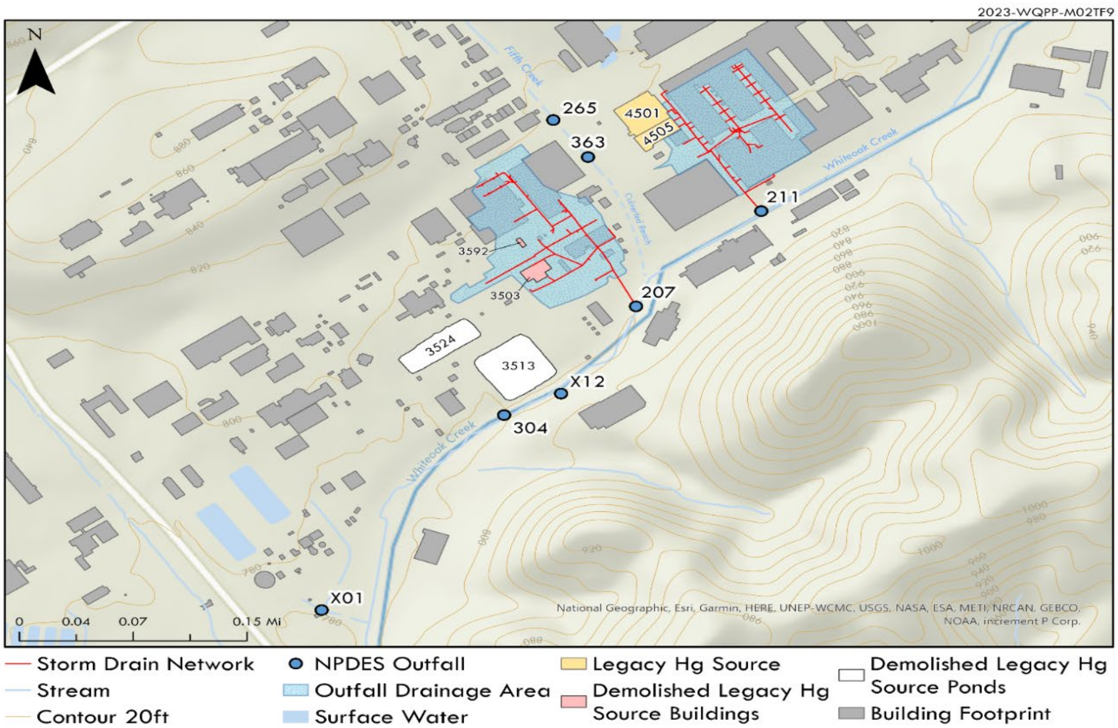


Figure 5.19. Outfalls and associated storm drain connections that are potential mercury sources, 2023

5.5.4.1. Mercury in Ambient Water

Aqueous Hg monitoring in WOC continued in 2023 with quarterly grab sampling at five instream sites: White Oak Creek kilometer (WCK) 1.5, WCK 2.3, WCK 3.4, WCK 4.1, and WCK 6.8 (Figure 5.20). Samples were collected to be representative of seasonal base flow conditions (dry weather, clear flow). Historical sampling results show that Hg concentrations are typically higher under those conditions.

In 2023, the average concentration of Hg in WOC upstream from ORNL (WCK 6.8) was less than 3 ng/L, and the highest value was 3.5 ng/L. Waterborne Hg concentrations in WOC downstream of ORNL (Figure 5.21) were above Tennessee recreational-use water quality criteria (WQCs) from 1997 to 2007 but declined abruptly in 2008 as a result of actions to reduce Hg discharges to WOC at Outfall 211 (sump reroutes to the PWTC) and to reduce Hg discharges from the PWTC. Since 2008, the results from WQPP Hg monitoring have met Tennessee Hg WQCs for recreational use (51 ng/L), with only a few exceptions. Applying recreational-use WQCs to the WOC watershed is very conservative because the watershed is on ORR and is not accessible to the public. In general, ambient concentrations have remained low since 2008, with a few exceptions. In 2023, Hg concentrations were well below WQCs at all the instream sites that were monitored (Figure 5.21). The average aqueous Hg concentration at WOD (WCK 1.5) was 27.45 ng/L compared with 16.33 ng/L in 2022.

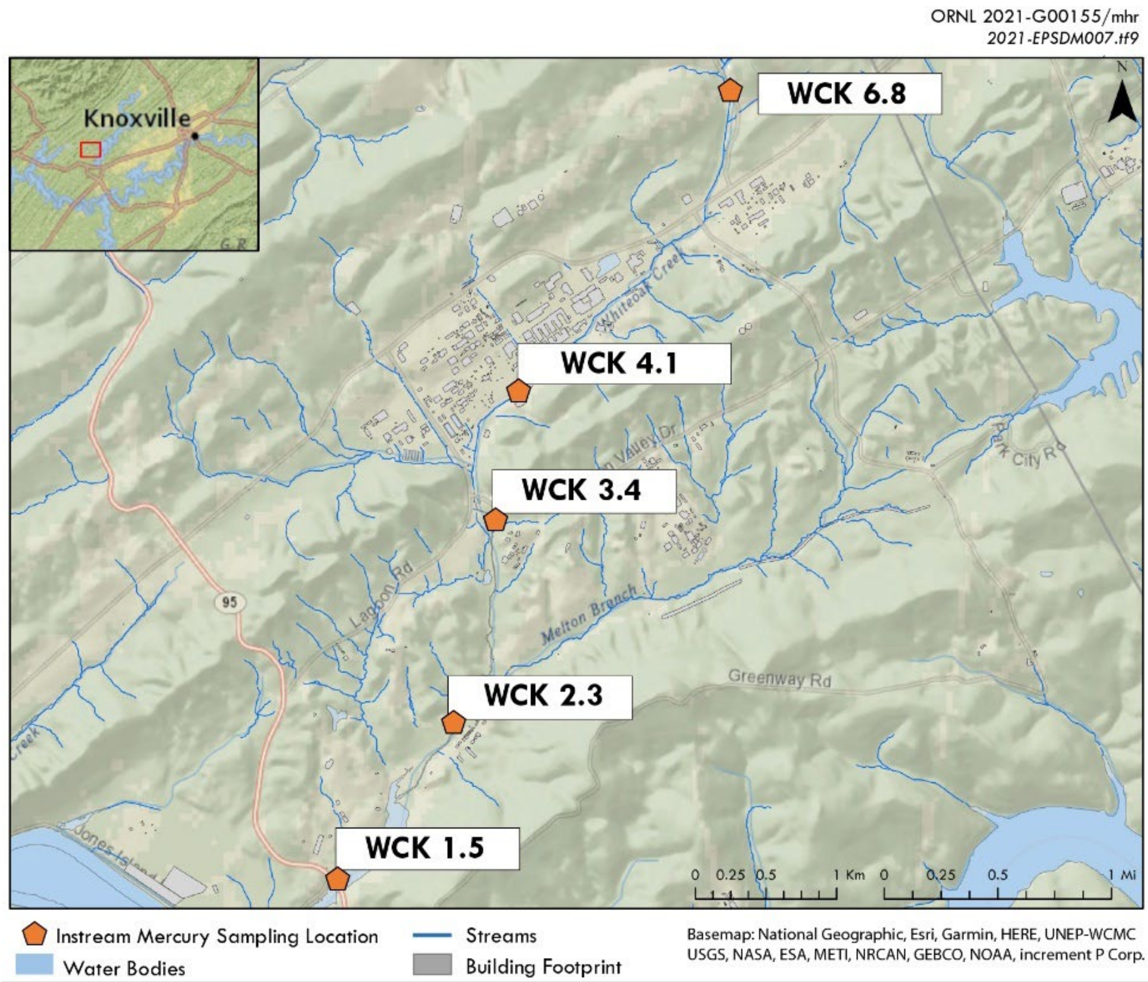
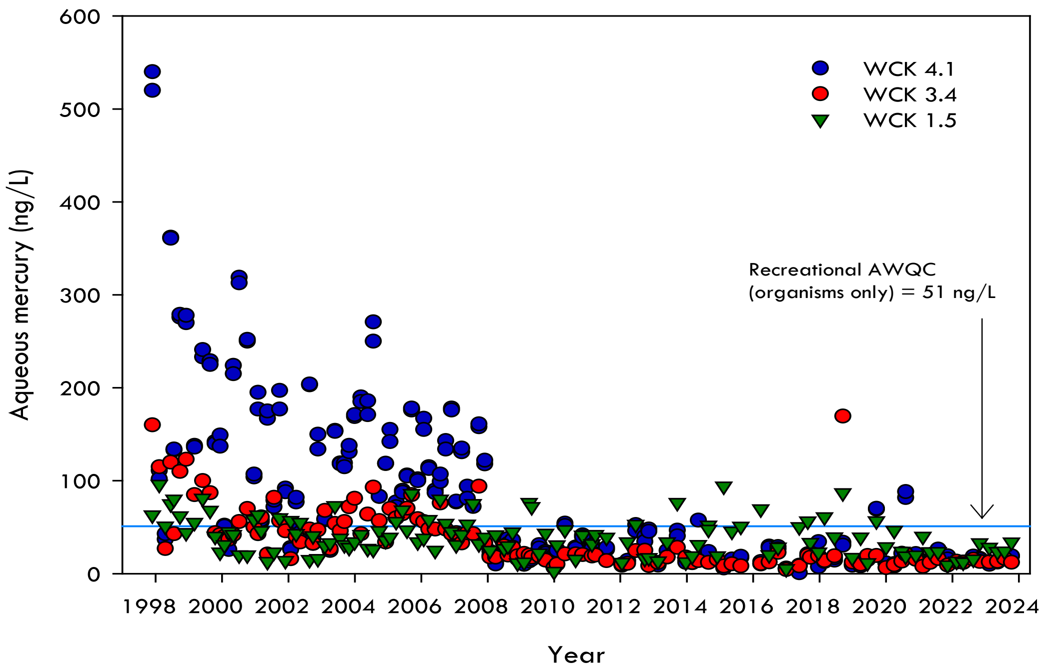


Figure 5.20. Instream mercury monitoring and data locations, 2023



Note: *The blue line at 51 ng/L shows the recreational water quality criteria for water and organisms.*
Acronym: *WCK = White Oak Creek kilometer AWQC = ambient water quality criterion*

Figure 5.21. Aqueous mercury concentrations of grab samples at sites in White Oak Creek downstream from ORNL, 1998–2023

5.5.4.2. Water Quality Protection Plan Mercury Investigation—Treatment Plants

The STP and the PWTC (Outfalls X01 and X12, respectively) are monitored quarterly for Hg, and results are reported to TDEC in monthly discharge monitoring reports required by the NPDES permit. Twenty-four-hour composite samples are taken at both locations, and flow rates are measured and recorded.

Concentrations of Hg in discharges from the STP (X01) averaged 2.0 ng/L in 2023, and Hg concentrations in discharges from the PWTC (X12) averaged 48.75 ng/L. Trends in total Hg concentrations are shown in Figure 5.22 for the STP (Outfall X01) from 2012 to 2023 and in Figure 5.23 for the PWTC (Outfall X12) from 2009 to 2023.

The 2023 quarterly dry-weather sampling at X01 and X12 was coordinated with Hg sampling at instream locations WCK 4.4 (upstream of the two treatment plant outfalls), WCK 3.4 (7500 Bridge monitoring station downstream of the ORNL central campus and both wastewater treatment plant outfalls), and WCK 1.5 (X15) at WOD. These data are presented in Figure 5.24.

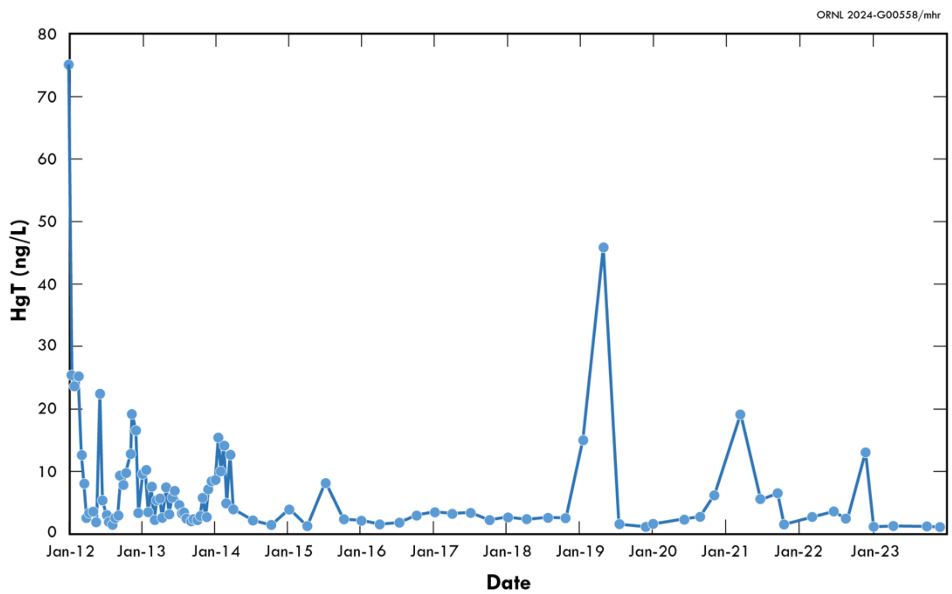


Figure 5.22. Total mercury concentrations in discharges to Outfall X01 from the Sewage Treatment Plant, 2012–2023

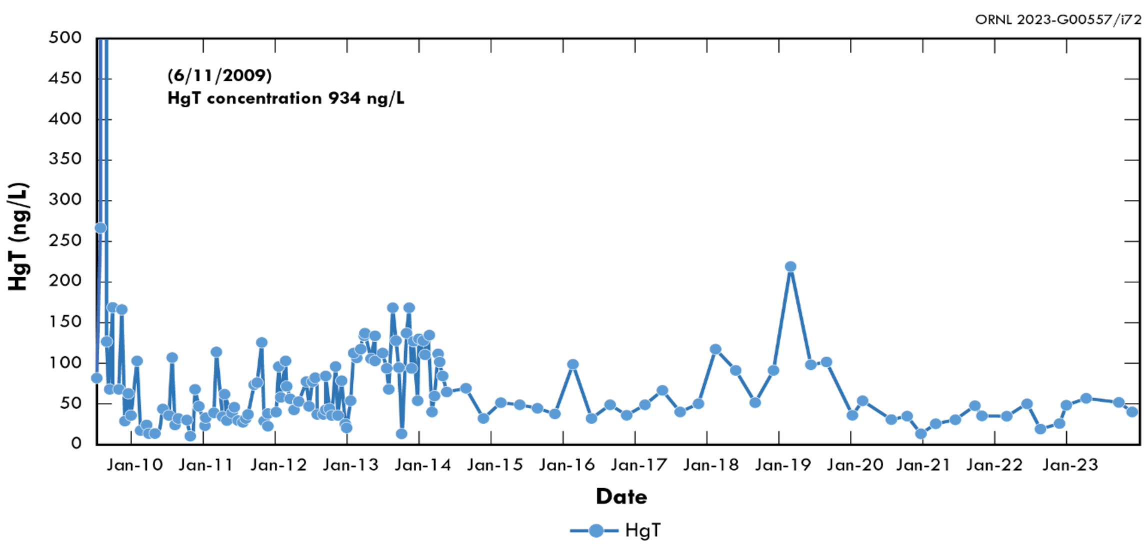


Figure 5.23. Total mercury concentrations in discharges to Outfall X12 from the Process Waste Treatment Complex, 2009–2023

ORNL 2023-G000559_VerA/mhr

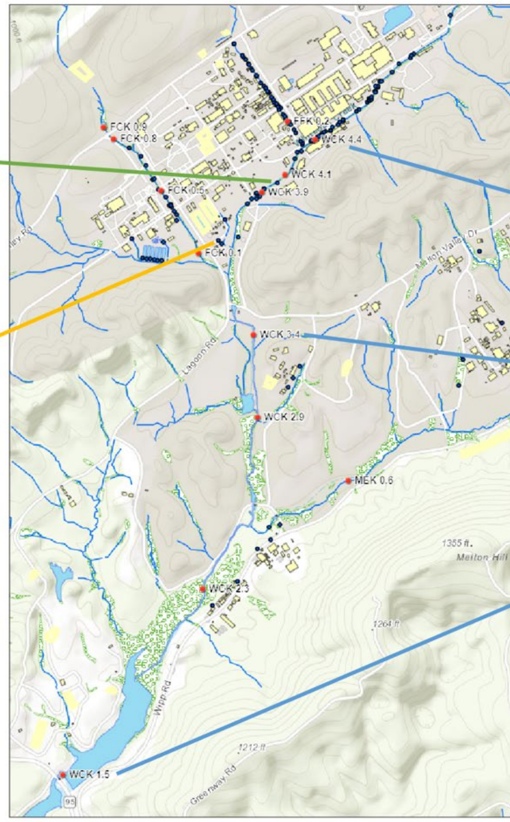
Treatment Plant
24 h composites HgT

Outfall X12 (PWTC)

Date	HgT (ng/L)
01/10/23	48
04/12/23	56
09/06/23	51
11/28/23	40

Outfall X01 (STP)

Date	HgT (ng/L)
01/10/23	1.9
04/12/23	3.0
09/06/23	1.79
11/28/23	1.31



Instream
24 h composites
HgT (51 ng/L WQC)

WCK 4.4

Date	HgT (ng/L)
01/10/23	2.1
04/12/23	15.0
09/06/23	13.6
11/28/23	21.5

WCK 3.4 (7500 Bridge)

Date	HgT (ng/L)
01/10/23	6.3
04/12/23	9.1
09/06/23	14.4
11/28/23	11.6

WCK 1.5 (White Oak Dam)

Date	HgT (ng/L)
01/10/23	15
04/12/23	17
09/06/23	27
11/28/23	18.2

Acronyms:
PWTC = Process Waste Treatment Complex
STP = Sewage Treatment Plant
WCK = White Oak Creek kilometer
WQC = water quality criteria

Figure 5.24. Coordination of treatment plant sampling with instream sampling sites at ORNL, 2023

5.5.4.3. Legacy Outfall Point Source and Non–Point Source Investigation

Legacy Hg outfalls are investigated as part of the WQPP to better delineate Hg sources and to prioritize future abatement actions. WQPP Hg monitoring includes both point source outfalls and non–point source storm water runoff but focuses mainly on several outfalls in the central part of the main ORNL campus known to be contaminated with legacy Hg.

In 2023 most of the WQPP dry-weather Hg monitoring was conducted along WOC and portions of Fifth Creek at Outfalls 207, 211, 265, 304, and 363 (Figure 5.19). As in past years, 2023 WQPP legacy Hg monitoring focused on Outfalls 207 and 211, which generally show the highest Hg concentrations. In 2023, discharged water volumes, and therefore Hg fluxes, from Outfall 211 were higher than those from Outfall 207. This is consistent with previous volume and flux measurements from these locations. Figures 5.25 and 5.26 show trends in dry-weather Hg sampling from Outfalls 207 and 211, respectively. In 2023, point source Hg investigations and monitoring (if flow was present) were also performed at Outfalls 265, 304, and 363, where Hg has been detected at levels of interest in the past likely due to the prevalence of Hg used historically in nearby buildings and from other legacy sources in these areas. In 2023, no dry-weather flow was recorded at Outfall 265, and the average dry-weather Hg concentrations at Outfalls 304 and 363 were low (4.94 and 45.3 ng/L, respectively).

WQPP non–point source Hg monitoring was also undertaken in 2023. Semiannual wet-weather sampling at Outfalls 207, 211, 265, 304, and 363 was completed. Trends in wet-weather unfiltered Hg sampling results at Outfalls 207 and 211 are presented in Figures 5.27 and 5.28, respectively. In 2023, the average wet-weather sampling results were approximately 8.25 ng/L at Outfall 265, 8.65 ng/L at Outfall 304, and 21.85 ng/L at Outfall 363. Dry- and wet-weather Hg fluxes at Outfalls 207 and 211 either declined in 2023 or were comparable to fluxes in previous years (Figures 5.25–5.28).

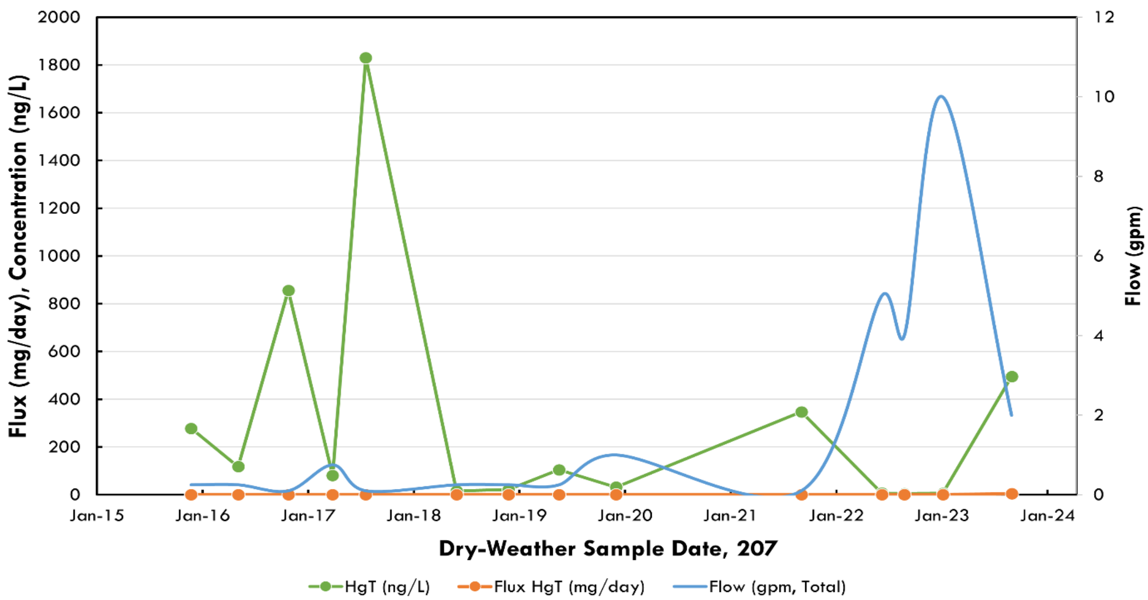


Figure 5.25. Outfall 207 dry-weather flow rate, total mercury concentration (unfiltered), and flux, 2016–2023

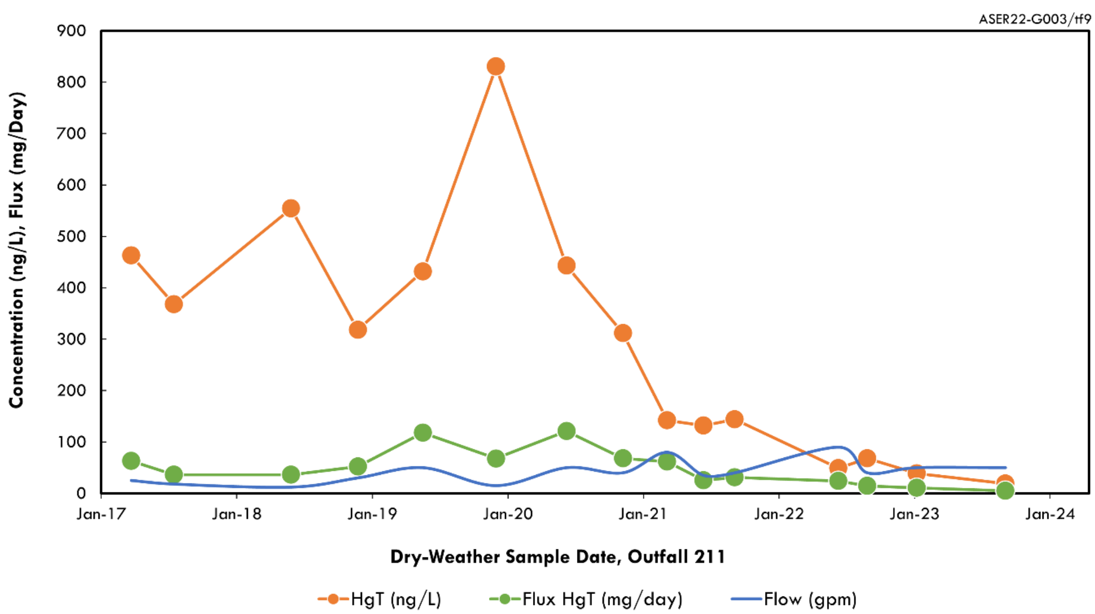


Figure 5.26. Outfall 211 dry-weather flow rate, total mercury concentration (unfiltered), and flux, 2017–2023

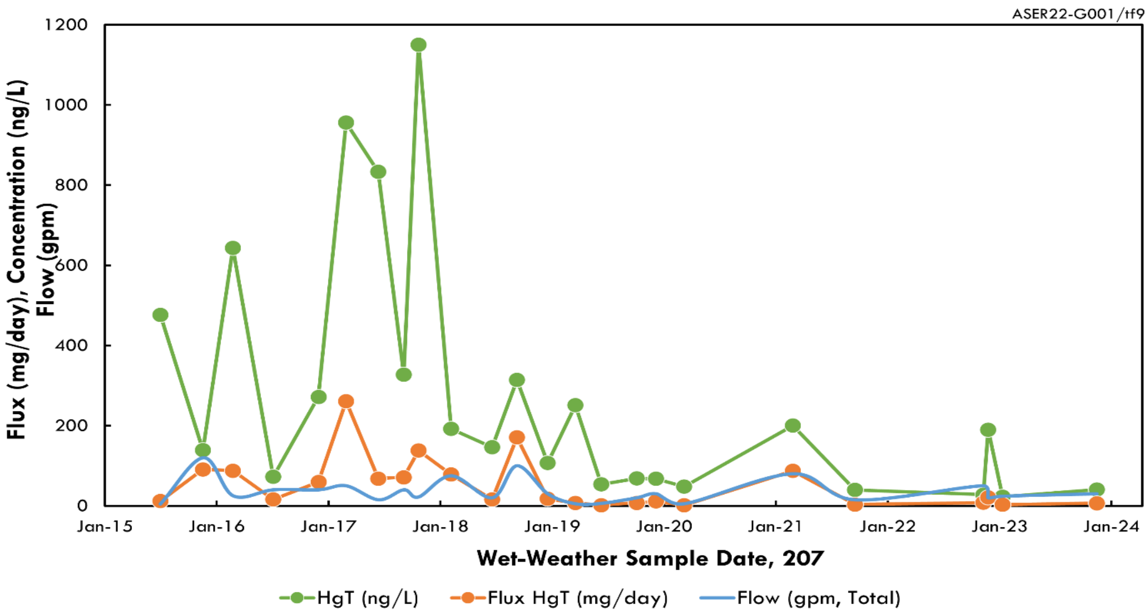


Figure 5.27. Outfall 207 wet-weather flow rate, total mercury concentration (unfiltered), and flux, 2015–2023

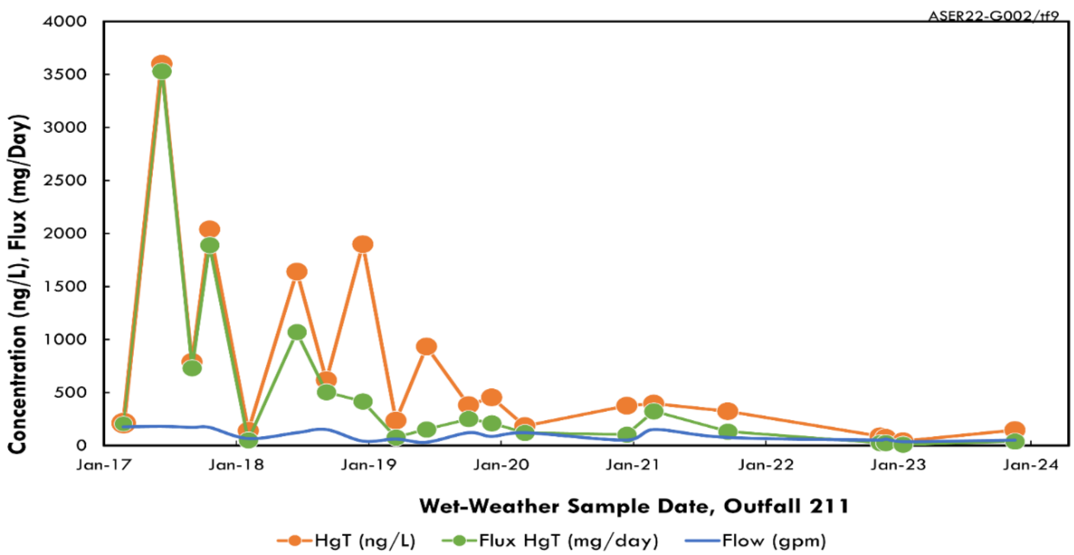


Figure 5.28. Outfall 211 wet-weather flow rate, total mercury concentration (unfiltered), and flux, 2017–2023

5.5.5. Storm Water Surveillances and Construction Activities

Storm water drainage areas at ORNL are inspected semiannually in accordance with WQPP requirements. These areas encompass typical office, industrial, and research settings with surface features such as laboratories, support facilities, paved areas, and grassy lawns. ORNL maintains a robust safety materials management system, ensuring proper tracking, handling, and storage of materials to mitigate potential impacts to storm water. Additionally, ORNL adheres to various regulations governing materials handling, storage, and disposal and waste management, minimizing the risk of environmental release. ORNL also has a storm water best management practice plan that outlines approved actions and guidance to minimize storm water runoff impacts.

Although outdoor materials are temporarily located throughout the ORNL campus, most movement and storage activities occur in the 7000 Area, which is situated on the east end of the site and houses craft and maintenance shops. Smaller outdoor storage areas are dispersed across the site, including loading docks and material delivery areas at laboratory and office buildings. Outdoor materials typically are finished metal items; equipment awaiting use, disposal, or repair; aging infrastructure; and construction equipment and materials, as observed during field inspections. Results of drainage area inspections are documented in electronic map files by the Water Quality Protection group.

Any construction project exceeding 1 acre is required to be permitted under the Tennessee General NPDES Permit for Storm Water Discharges Associated with Construction Activity, necessitating routine inspections by Tennessee-certified erosion and sedimentation control inspectors throughout the project duration. As a best management practice, ORNL mandates routine inspections by Tennessee-certified erosion and sedimentation control inspectors for subcontracted construction projects that are smaller than 1 acre and not covered under the Tennessee General NPDES Permit for Storm Water Discharges Associated with Construction Activity.

Storm water discharges from current ORNL research laboratory operations contain minimal pollutants primarily originating from ongoing site construction, grounds maintenance, and utility operations. Despite being an active cleanup site with legacy contamination regulated under CERCLA and the Atomic Energy Act for radiological constituents, historical storm water pollutants at ORNL have been limited.

5.5.6. Biological Monitoring

Biological monitoring programs conducted at ORNL in 2023 included bioaccumulation studies in the WOC watershed; benthic macroinvertebrate monitoring in WOC, First Creek, and Fifth Creek; and fish community monitoring in WOC and its major tributaries. The following sections summarize the biological monitoring programs at ORNL and the results for 2023.

5.5.6.1. Bioaccumulation Studies

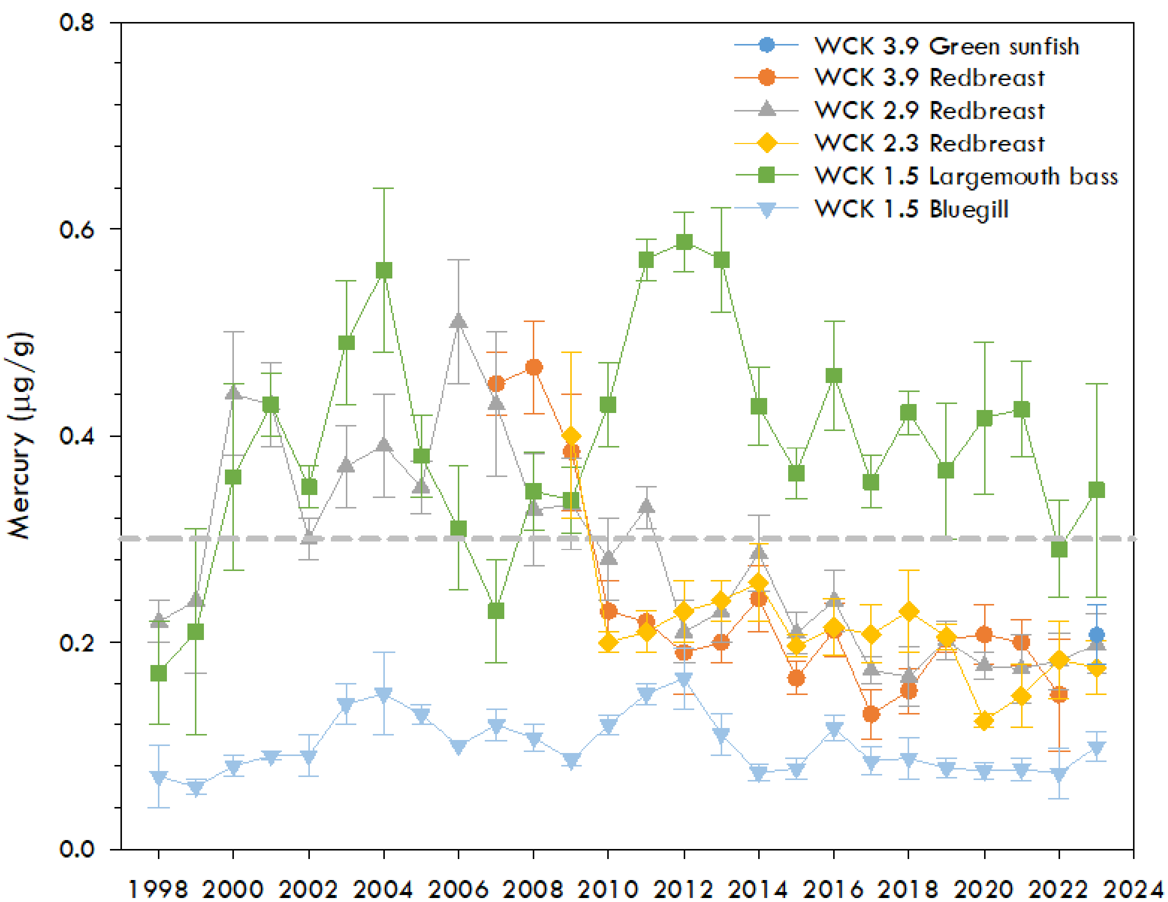
Bioaccumulation tasks for the biological monitoring and abatement plan address two NPDES permit requirements at ORNL: (1) evaluate whether Hg at the site is contributing to streams at a level that will adversely affect fish and other aquatic life or that will violate the recreational criteria and (2) monitor the status of PCB contamination in fish tissue in the WOC watershed. Concentrations of Hg in fish in the WOC watershed are monitored annually and are evaluated relative to the EPA ambient water quality criterion (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 TDEC fish advisory limits.

Bioaccumulation in fish

Mercury concentrations in fish have been below human health risk thresholds (e.g., EPA-recommended fish-based AWQCs [0.3 µg/g for Hg]) in the stream portions of WOC for a decade due to actions taken in 2007 to treat the water in a Hg-contaminated sump (Figure 5.29). In 2023, Hg concentrations in fish collected throughout WOC remained similar those seen in 2022. In 2023, Hg concentrations in bluegill and redbreast sunfish samples collected throughout the WOC watershed remained below the AWQC for Hg in fish; Hg concentrations in largemouth bass samples from WCK 1.5 were slightly above this AWQC. Largemouth bass are larger, longer-lived fish at the top of the food web and are therefore expected to have higher Hg concentrations than other sunfish species, but longer-term trends suggest a significant decrease in Hg concentrations over the past decade in this species.

In 2023, PCB concentrations (defined as the sum of Aroclors 1248, 1254, and 1260) in fish collected throughout the WOC watershed remained within historical ranges at all stream sites, averaging below 0.4 µg/g (Figure 5.30).

While these concentrations are above concentrations seen in fish collected from reference sites off ORR, there are no federal guidelines for fish advisories for PCBs. PCB advisories may consider either acute, chronic noncancer, or chronic cancer health risks, which leads to a wide range of difference across states (Cleary et al. 2021). Most recently the AWQC has been used to calculate the fish tissue concentration triggering impairment and a total maximum daily load; this concentration is 0.02 µg/g in fish fillets (TDEC 2010 a,b,c). The average PCB concentrations in fish in WOC (and across ORR) exceed this conservative guideline (Figure 5.30), but recent work has shown that PCB concentrations have generally been declining in WOC sites at rates of up to approximately 1 percent per year through natural attenuation (Matson et al. 2022). Work to mitigate sources of PCBs within ORNL facilities (Section 5.5.7) may increase these attenuation rates.

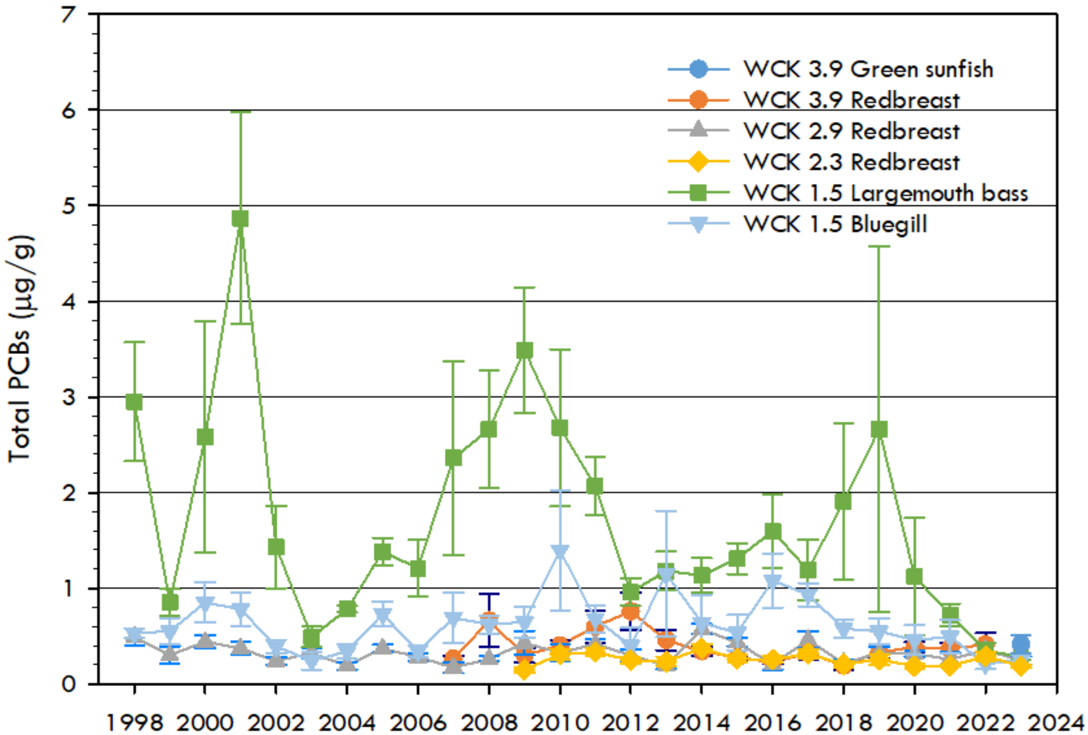


Notes:

1. *Mean concentrations of mercury (± standard error, n = 6) in tissue taken from sampled fish.*
2. *The dashed grey line at 0.3 µg/g indicates the US Environmental Protection Agency ambient water quality criterion for mercury in fish tissue.*

Acronym: *WCK = White Oak Creek kilometer*

Figure 5.29. Mean mercury concentrations in muscle tissue of sunfish and bass sampled from the White Oak Creek watershed, 1998–2023



Note: *Mean total PCB concentrations (± standard error, n = 6) found in fish fillets.*
Acronyms: *PCB = polychlorinated biphenyl WCK = White Oak Creek kilometer*

Figure 5.30. Mean total PCB concentrations in fish sampled from the White Oak Creek watershed, 1998–2023

5.5.6.2. Benthic Macroinvertebrate Communities

Monitoring of benthic macroinvertebrate communities in WOC, First Creek, and Fifth Creek continued in 2023. Additionally, monitoring of the macroinvertebrate community in lower Melton Branch (Melton Branch kilometer [MEK] 0.6) continued under the OREM Water Resources Restoration Program (WRRP). Benthic macroinvertebrate samples have been collected annually following TDEC protocols since 2009 and following protocols developed by ORNL staff since 1987. The protocols developed by ORNL staff provide a long-term record (37 years) of spatial and temporal trends in invertebrate communities from which the effectiveness of pollution abatement and remedial actions taken at ORNL can be evaluated. 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.

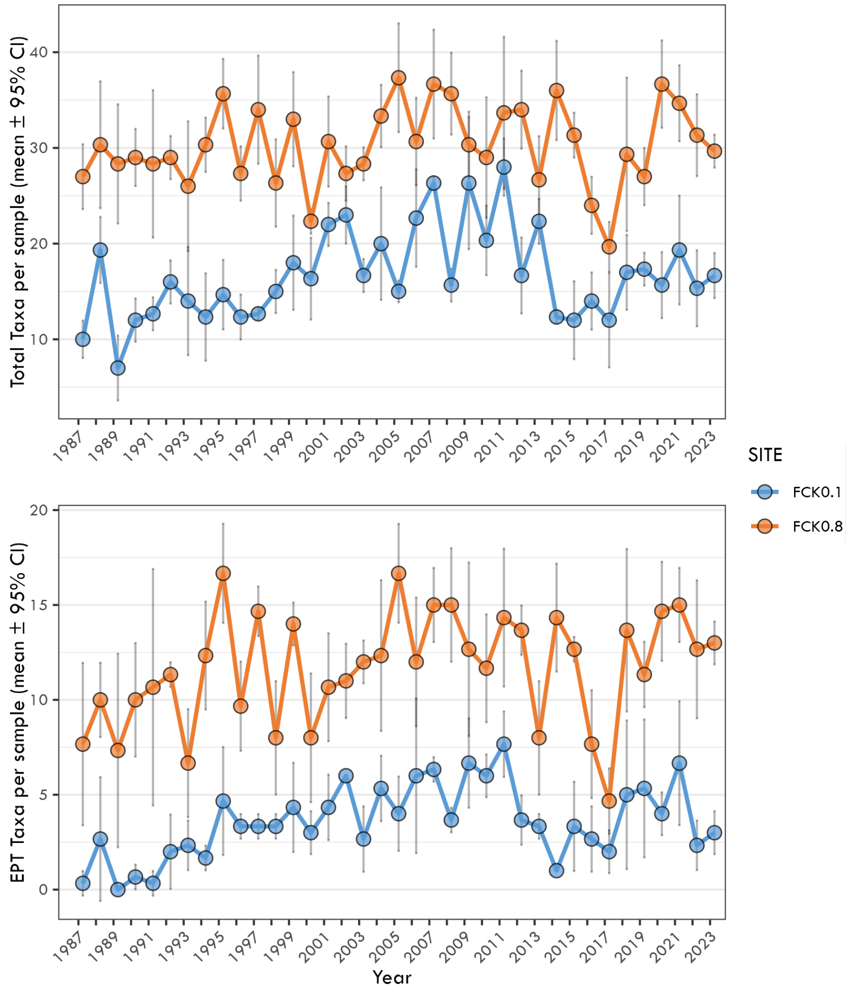
General trends in the results obtained using ORNL protocols indicated significant recovery in benthic macroinvertebrate communities since 1987, but community characteristics suggest that ecological impairment remains (Figures 5.31, 5.32, and 5.33). Total taxonomic richness (i.e., the number of different species per sample) and richness of the pollution-intolerant taxa (i.e., the number of different mayfly, stonefly, and caddisfly species per sample or Ephemeroptera, Plecoptera, and Trichoptera [EPT] taxa richness) continued to be lower at downstream sites relative to respective upstream reference 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 5.31). Total taxa richness then increased at FCK 0.1 from 2018 to 2023, reaching values not observed prior to 2014. 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 (Figure 5.31). After 2021, when values were the highest they had been in the past 10 years, EPT taxa richness values in 2022 and 2023 fell to pre-2018 levels. In upper First Creek (FCK 0.8), which serves as a reference for FCK 0.1, total taxa richness and EPT taxa richness declined for 3 consecutive years, from 2015 to 2017, before rebounding in 2018. Since 2018, total taxa richness and EPT taxa richness at FCK 0.8 both increased and have returned to pre-2015 levels (Figure 5.31). Low EPT taxa richness values observed over a 6-year period (2012 to 2017) at FCK 0.1 were mirrored only in some years at FCK 0.8 (i.e., EPT taxa richness was low at both sites in 2013, 2016, and 2017). 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. The increases in EPT taxa richness at both sites in 2023, while slight, suggest conditions may be improving, though further monitoring is necessary to determine whether the previously mentioned decline was due to an acute or a longer-term impact to the system.

Total taxa richness at Fifth Creek kilometer (FFK) 0.2 increased in the late 1980s and early 1990s and then was fairly consistent until decreasing significantly between 2007 and 2008 (Figure 5.32), suggesting that conditions changed at the site during that time. Total taxa richness returned to predecline levels over a period of about 5 years and then decreased again over a 4-year period (2018 to 2021) until increasing slightly in 2022 and 2023 (Figure 5.32). EPT taxa richness at FFK 0.2 increased slowly from the late 1980s to early 2000s before decreasing for several years (~2003–2011). From 2011 to 2018, EPT taxa richness remained steady at about five EPT taxa per sample but decreased in 2019 and remained low in 2020 and 2021 before increasing in 2022 back to five EPT taxa per sample. In 2023, EPT taxa richness increased again to the highest value seen since 2002 (seven EPT taxa per sample). It is not known whether this increase will persist in future years or instead reflects interannual variation in invertebrate community composition. Total and EPT richness values at FFK 1.0 (which serves as a reference for FFK 0.2) increased between 2022 and 2023 and have remained higher than at FFK 0.2 since sampling began in 1987.

Invertebrate metric values for WCK 2.3 and WCK 3.9 remained within the ranges of values found since the late 1990s and early 2000s, although total taxa richness and EPT taxa richness were lower at WCK 2.3 and WCK 3.9 over the past 8 to 9 years. The total taxa richness and EPT taxa richness at WCK 2.3 and WCK 3.9 continued to be notably lower than at the reference sites. Neither total nor EPT taxa richness at WCK 3.9 has rebounded following the large decline that began in 2015, and while increased richness values were observed in 2021, these values stabilized at a lower level in 2022 and 2023. The cause of the initial decline in 2015 and what has prevented recovery are unknown, though changes in the chemical and physical conditions at WCK 3.9 may be contributing to these observed patterns. Since 2001 (except for one sampling event in 1987), Walker Branch kilometer (WBK) 1.0 has served as an additional reference site for WOC main-stem sites downstream of Bethel Valley Road (Figure 5.33). Comparisons of WCK 6.8 with WBK 1.0 show that communities in WCK 6.8 represent ideal reference conditions. Additionally, the comparison of WBK 1.0 with downstream sites in WOC shows that those WOC communities remain impaired.



***Note:** Taxonomic richness (number of taxa per sample), 1987–2023. FCK 0.8 serves as a reference site.*

Top: Total taxonomic richness.

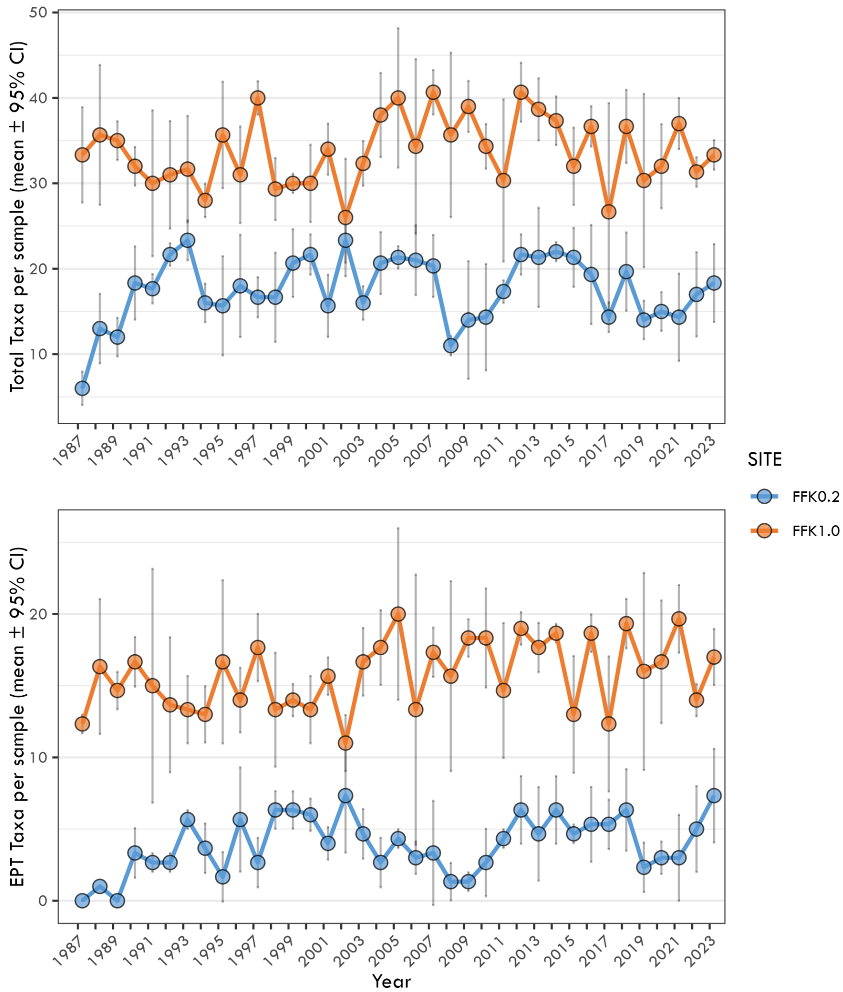
Bottom: Taxonomic richness of the pollution-intolerant taxa Ephemeroptera, Plecoptera, and Trichoptera (EPT).

Acronyms:

CI = confidence interval

FCK = First Creek kilometer

Figure 5.31. Benthic macroinvertebrate communities in First Creek, 1987–2023



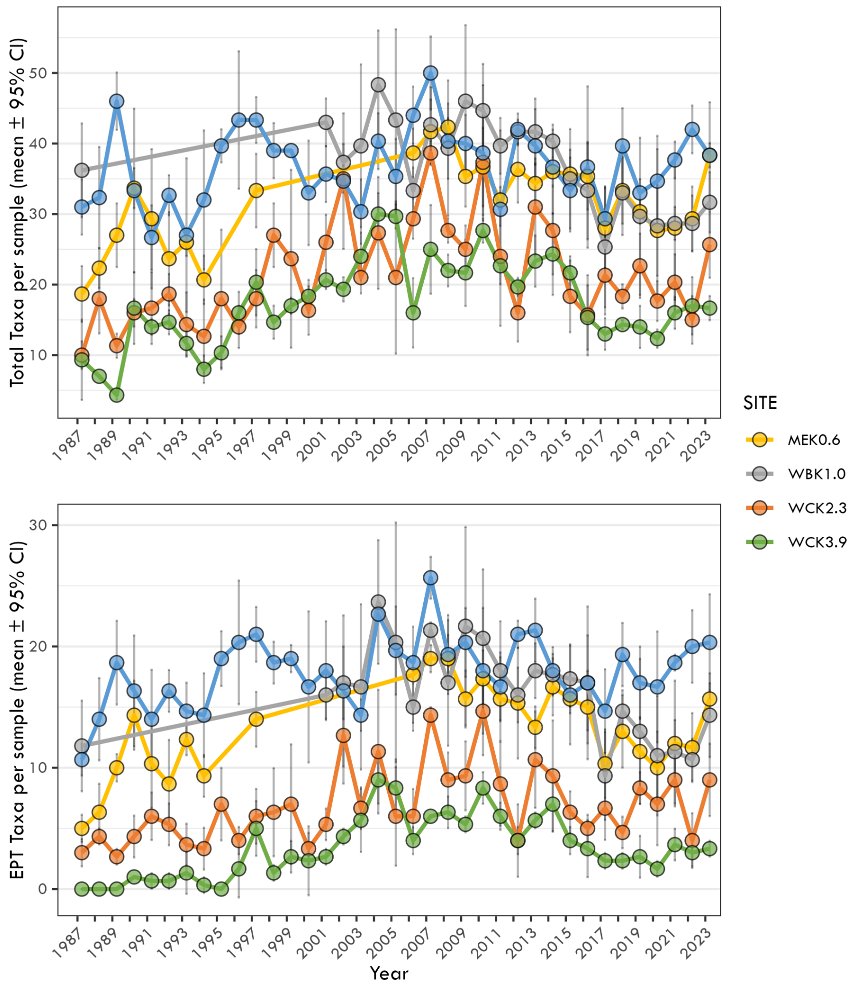
Note: *Taxonomic richness (number of taxa per sample), 1987–2023. FFK 1.0 serves as a reference site.*
Top: Total taxonomic richness.
Bottom: Taxonomic richness of the pollution-intolerant taxa Ephemeroptera, Plecoptera, and Trichoptera (EPT).

Acronyms:

CI = confidence interval

FFK = Fifth Creek kilometer

Figure 5.32. Benthic macroinvertebrate communities in Fifth Creek, 1987–2023



Note: *Taxonomic richness (number of taxa per sample), 1987–2023. WCK 6.8 and WBK 1.0 serve as reference sites.*
Top: Total taxonomic richness.
Bottom: Taxonomic richness of the pollution-intolerant taxa Ephemeroptera, Plecoptera, and Trichoptera (EPT).

Acronyms:

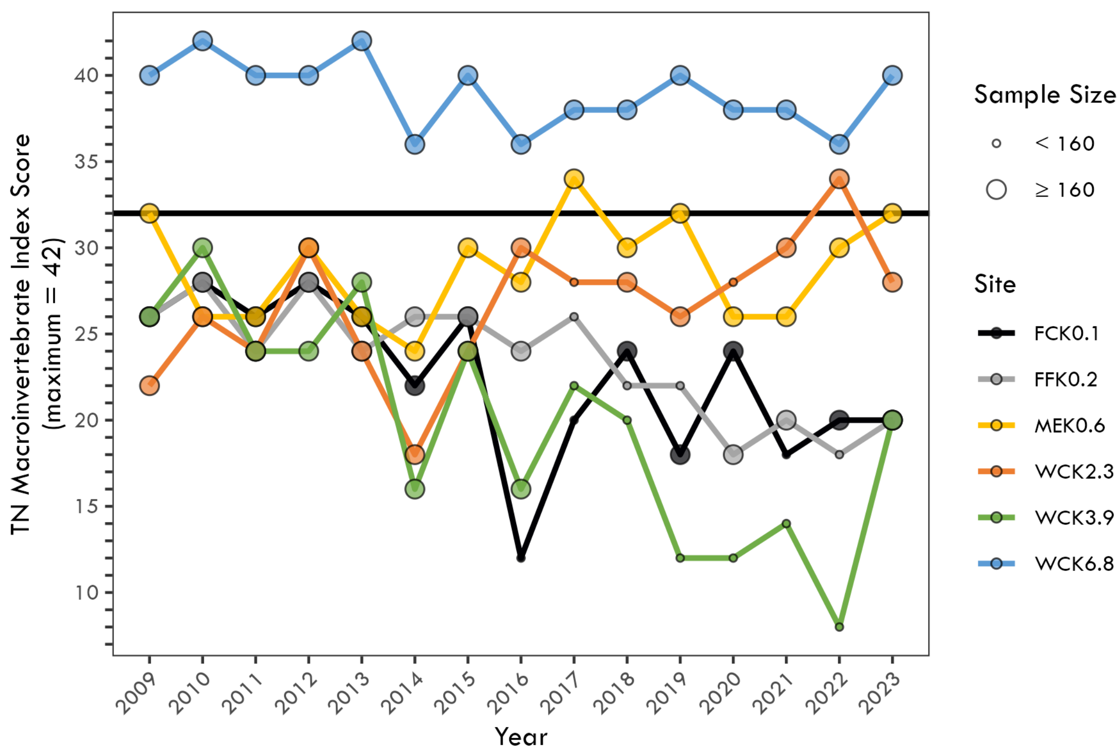
CI = confidence interval
MEK = Melton Branch kilometer
WBK = Walker Branch kilometer
WCK = White Oak Creek kilometer

Figure 5.33. Benthic macroinvertebrate communities in Walker Branch, Melton Branch, and White Oak Creek, 1987–2023

Macroinvertebrate metrics for Melton Branch (MEK 0.6) suggested that total taxa and EPT taxa richness continued to be similar to those in reference sites in 2023, particularly WBK 1.0 (Figure 5.33). However, other invertebrate community metrics at MEK 0.6, 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 8 years (2016–2023), EPT density has generally been lower in MEK 0.6 than in WCK 6.8 and WBK 1.0, whereas the density of pollution-tolerant species (oligochaetes and chironomids [worms and nonbiting midges]) was higher in MEK 0.6 than in those two reference sites.

Based on TDEC protocols (TDEC 2021b), scores for the TDEC Tennessee Macroinvertebrate Index (TMI) in 2023 rated the invertebrate communities at the reference site, WCK 6.8, and MEK 0.6 as passing biocriteria guidelines, while scores from FCK 0.1, FFK 0.2, and WCK 3.9 were below these guidelines (Figure 5.34, Table 5.13). Scores improved at two of the four sites (WCK 3.9 and FFK 0.2), remained the same at one site (FCK 0.1), and declined at one site (WCK 2.3).

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 these sites had low percentages of oligochaetes and chironomids and thus received high scores for this category. WCK 6.8 received the highest attainable scores for all categories except for total taxa richness (Table 5.13).



Note: *The black horizontal line shows the threshold for Tennessee Macroinvertebrate Index scores. The values above the threshold are passing scores; those below are not.*

Acronyms:

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

Figure 5.34. Temporal trends in Tennessee Department of Environment and Conservation Tennessee Macroinvertebrate Index scores for White Oak Creek watershed streams, August sampling, 2009–2023

Table 5.13. Tennessee Macroinvertebrate Index metric values, metric scores, and index scores for White Oak Creek, First Creek, Fifth Creek, and Melton Branch streams, August 22, 2023[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	26	5	29	22.4	5.3	44.8	53.6	4	2	4	6	4	4	4	28
WCK 3.9	14	3	37.4	12.9	5.1	12.3	38	2	0	4	6	4	0	4	20
WCK 6.8	29	14	55.6	3.7	2.9	76.6	13.1	4	6	6	6	6	6	6	40 [pass]
FCK 0.1	12	1	0	3.5	5.8	25.7	19.3	2	0	0	6	4	2	6	20
FFK 0.2	14	6	22.7	3.2	5.2	28.6	53.2	2	2	2	6	4	2	2	20
MEK 0.6	28	10	31.4	3.3	4.5	44.8	36.2	4	4	4	6	6	4	4	32 [pass]

[a] *TMI metric calculations and scoring and index calculations are based on TDEC protocols for Ecoregion 67f (TDEC 2021b)*

[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. Higher index scores indicate higher quality conditions. A score of ≥32 is considered to pass biocriteria guidelines.*

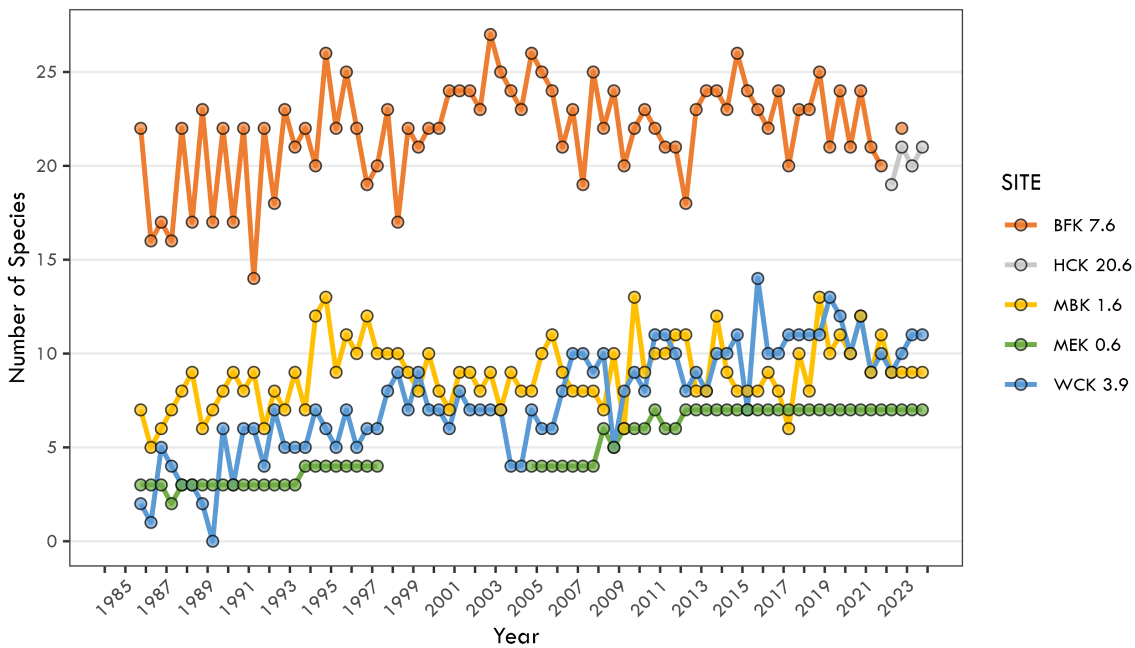
Acronyms:

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

5.5.6.3. Fish Communities

Monitoring of the fish communities in WOC and its major tributaries continued in 2023. 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 Hinds Creek) were also sampled as reference sites for comparison.

In the WOC watershed, the fish community continued to be slightly degraded in 2023 compared with communities in reference streams. Sites closest to outfalls within the ORNL campus had lower species richness (number of species) (Figure 5.35) 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 continued to be negatively affected by ORNL effluent in 2023 relative to reference streams and upstream sites.



Note: *BFK 7.6 was not surveyed in the spring of 2022 or in 2023 because of lack of access to the site.*

Acronyms:

BFK = Brushy Fork kilometer

HCK = Hinds Creek kilometer

MBK = Mill Branch kilometer

MEK = Melton Branch kilometer

WCK = White Oak Creek kilometer

Figure 5.35. 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, 1985–2023

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. In response, introductions to supplement the small populations of those fish species were continued at sites within the watershed until 2019.

One exception to the apparent difficulty of expansion 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 those locations. The introductions have enhanced species richness at almost all sample locations within the watershed. This may indicate 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 below White Oak Lake.

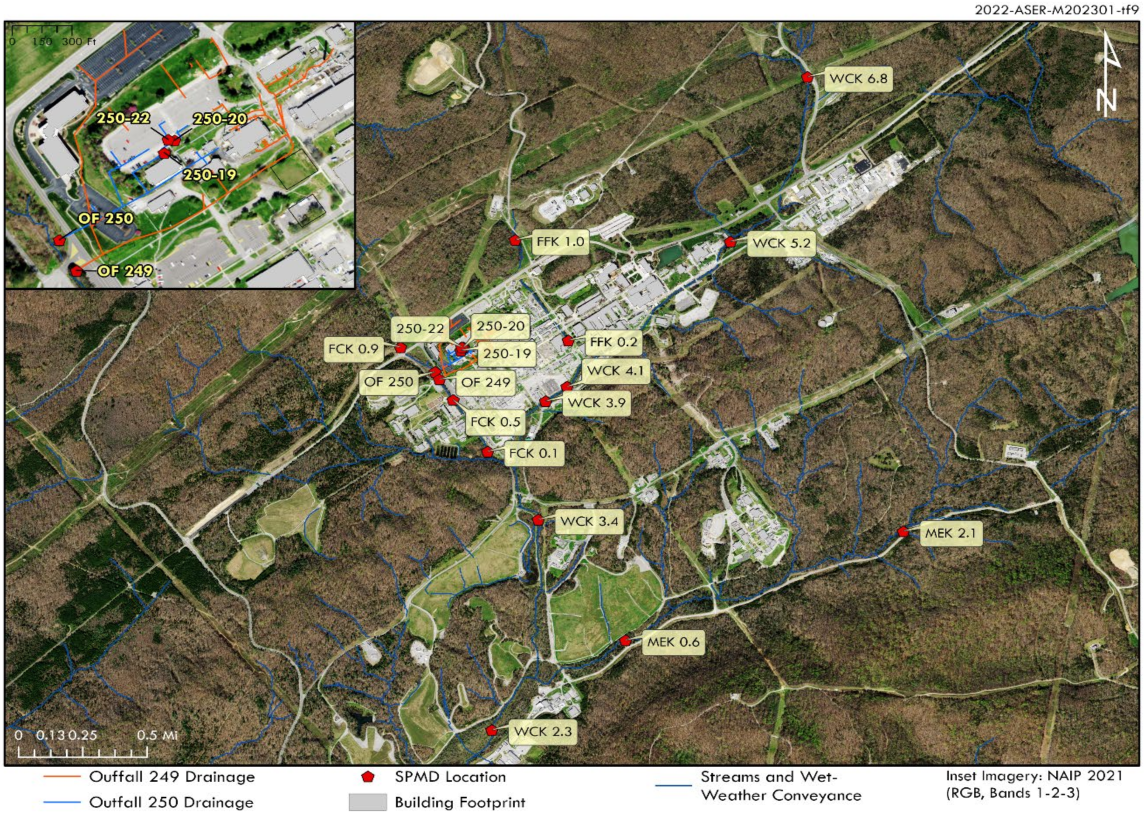
5.5.7. Polychlorinated Biphenyls in the White Oak Creek Watershed

The original objective of the PCB investigation in the WOC watershed was to identify the stream reaches, outfalls, or sediment areas that were contributing to elevated PCB levels. Past ORNL PCB monitoring efforts have identified upper parts of First Creek, particularly the storm drain network leading to Outfall 250, as sources of PCBs to the WOC watershed. Because PCBs are hydrophobic and do not readily dissolve in water, concentrations in samples from the WOC watershed analyzed by conventional methods have historically been below detection limits. However, PCB concentrations in largemouth bass in White Oak Lake have been above levels recommended by TDEC and EPA for frequent consumption, confirming elevated levels at this site. Because fish are mobile, source identification is not possible from the data.

Semipermeable membrane devices (SPMDs), thin plastic sleeves filled with oil in which PCBs are soluble, have proven to be useful tools to identify sources of PCBs. Because SPMDs are deployed at a given site for 4 weeks and have a high affinity for PCBs, they overcome the limitations associated with conventional analytical methods and allow for a time-integrated semiquantitative index of the relative PCB concentrations in the water column (compared to a snapshot value that would be obtained from a conventional surface water grab sample).

The most recent PCB monitoring was done in 2022, when SPMDs were deployed in the same locations monitored in 2009 and 2010 (Figure 5.36) to determine whether changes in PCB sources had occurred. Forage fish were also collected at three sites in First Creek to examine PCB exposure to biota in the stream. Spatial patterns from the 2022 SPMD deployment were very similar to those from the 2009 and 2010 deployments, with First Creek being the greatest contributor to aqueous PCBs in the WOC watershed (Figure 5.37). The Outfall 250 storm drain network, particularly the location at 250-19, remained the greatest contributor of PCBs to the First Creek watershed. PCB concentrations in forage fish in First Creek decreased with downstream distance from this outfall. While SPMDs are semiquantitative, allowing for a relative assessment of PCB sources to the stream, the overall concentrations in the SPMDs were comparable to those in previous years, suggesting no major changes have occurred in aqueous PCB concentrations in the WOC watershed over the past decade.

The upper reaches of the Outfall 250 storm drain network lie beneath an area where two buildings with known PCB materials were once located. A closed-circuit television investigation of the Outfall 250 storm drain system has been initiated.



Acronyms:

FCK = First Creek kilometer
FFK = Fifth Creek kilometer
MEK = Melton Branch kilometer
OF = outfall
SPMD = semipermeable membrane device
WCK = White Oak Creek kilometer

Figure 5.36. Locations of monitoring points for First Creek source investigations, 2009 and 2022

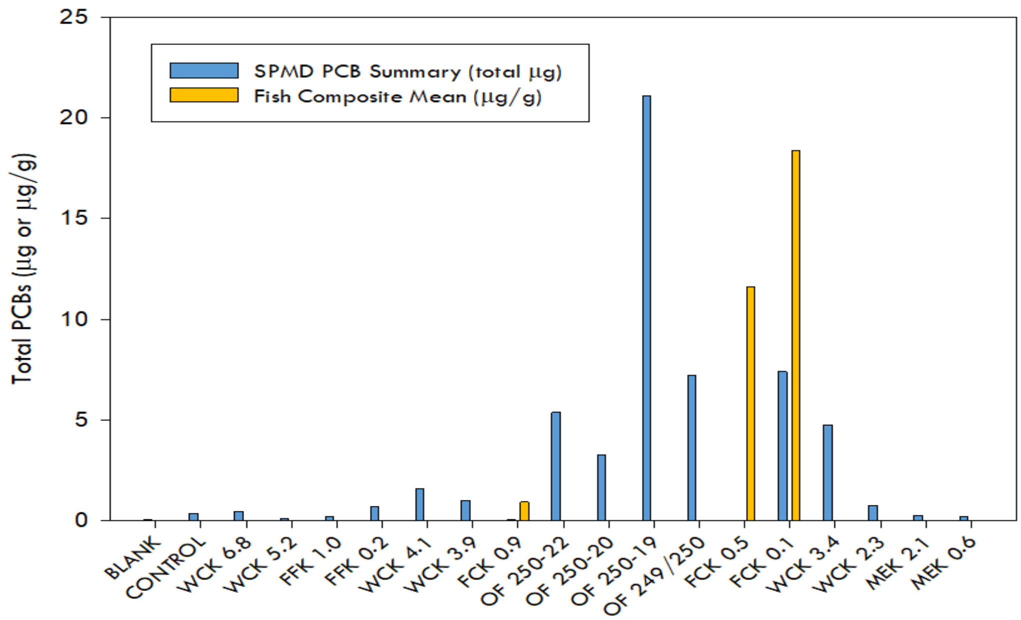


Figure 5.37. Total polychlorinated biphenyl content (µg) in semipermeable membrane devices in the White Oak Creek watershed and in First Creek forage fish composite samples (*n* = 3), 2022

5.5.8. Oil Pollution Prevention

Requirements for the prevention of oil discharges at specific nontransportation-related facilities are set forth in 40 CFR 112, "Oil Pollution Prevention." These requirements were originally published in Section 311 of the Federal Water Pollution Control Act, now the CWA, in 1973. Discharge includes any spilling, leaking, pumping, pouring, emitting, emptying, or dumping but excludes permitted discharges (e.g., via an NPDES permit). To contain oil discharges and to prevent them from reaching navigable waters or adjoining shorelines, these facilities are required to develop and implement spill prevention, control, and countermeasure (SPCC) plans and to provide annual training for oil-handling personnel.

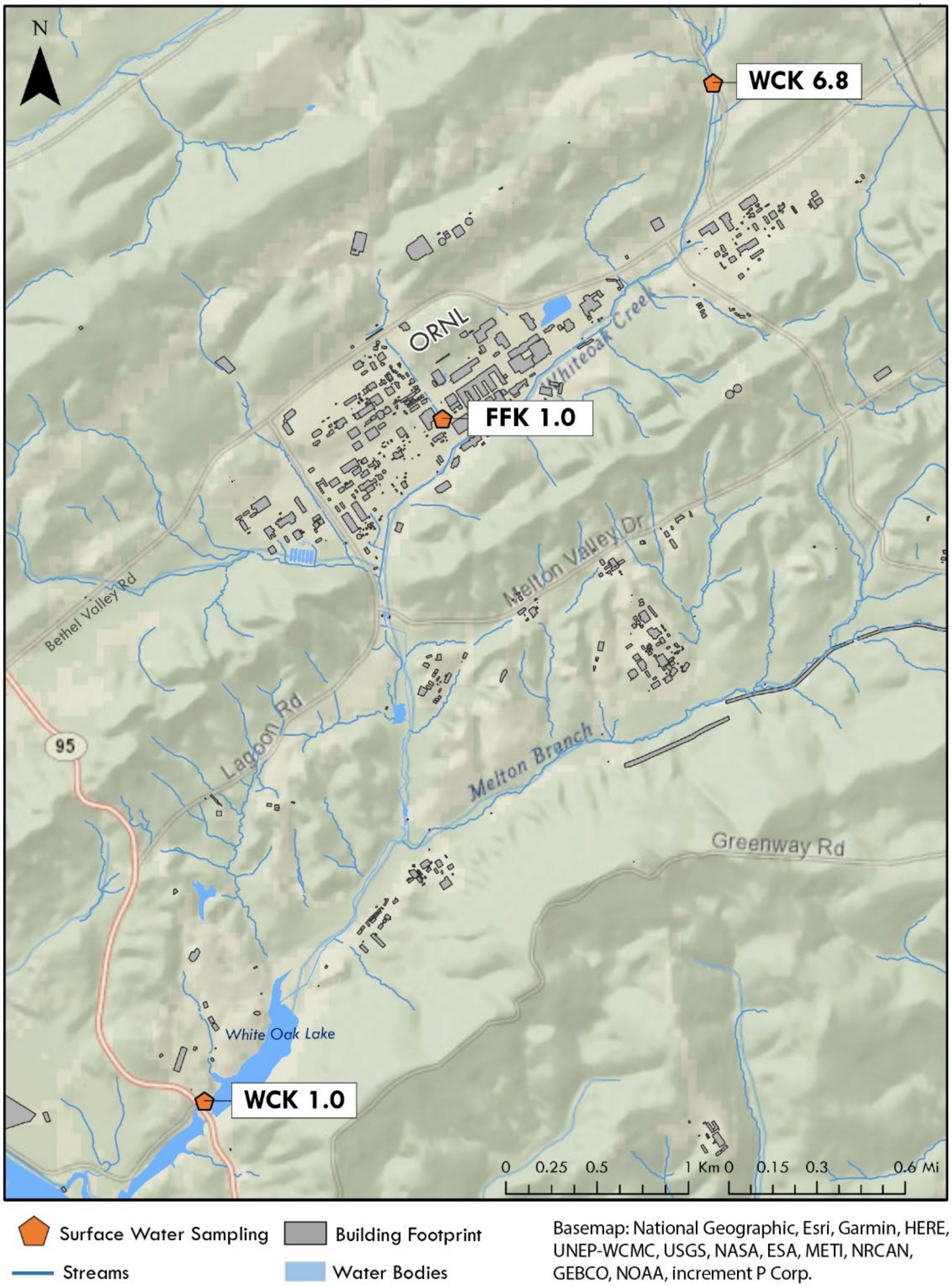
Currently, separate SPCC plans are implemented for the ORNL site and for the HVC, which is located off ORR. An SPCC plan is not required for the CFTF, which is off the ORNL campus in the Heritage Center Business Park. The ORNL SPCC and HVC SPCC plans were revised in 2023. Inventories for both SPCC plans are maintained electronically in the ORNL geographic information system and are updated throughout each year as SPCC inventories change. No regulatory actions related to oil pollution prevention were taken at ORNL or HVC in 2023.

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 5.38) 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. Monitoring at WCK 1.0 is conducted monthly for radiological parameters and quarterly for Hg under the ORNL WQPP (Section 5.5.4); therefore, those parameters are not duplicated by this program. Radiological monitoring at WCK 6.8 is also conducted monthly under the ORNL WQPP and therefore is not included in the ORNL surface water monitoring program.

ORNL 2021-G00715/mhr
2021-EPSDM013.tf9



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

Figure 5.38. ORNL surface water sampling locations, 2023

Table 5.14. ORNL surface water sampling locations, frequencies, and parameters, 2023

Location[a]	Description	Frequency and type	Parameters
WCK 1.0[b]	White Oak Lake at WOD	Quarterly, grab	Volatiles, PCBs, field measurements[c]
WCK 6.8[d]	WOC upstream from ORNL	Quarterly, grab	PCBs, field measurements[c]
FFK 0.1	Fifth Creek just upstream of WOC (ORNL)	Semiannually, grab	Gross alpha, gross beta, total radioactive strontium, gamma scan, ^{3}H, 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 WOC and the Clinch River).*

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

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

[d] *Radiological monitoring is performed at this location as part of the WQPP.*

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

Samples are collected and analyzed for general water quality parameters and are screened for radioactivity at all locations (as part of this program or the WQPP). Samples are further analyzed for specific radionuclides when general screening levels are exceeded. Samples from WCK 1.0 are analyzed for volatile organic compounds (VOCs) and PCBs. Samples from WCK 6.8 are also analyzed for PCBs. The State of Tennessee has designated use classifications for all surface water bodies in the state. Each classification has different WQCs to protect water bodies according to their designated uses. WCK 6.8 and WCK 1.0 are classified for freshwater fish and aquatic life. Tennessee WQCs associated with these classifications are used as references where applicable (TDEC 2019). The Tennessee WQCs do not include criteria for radionuclides. Four percent of the DOE DCS (DOE 2021b) is used for radionuclide comparison.

No radionuclides were reported above 4 percent of the DCS at the Fifth Creek location (FFK 0.1) in 2023. Beta activity and $^{89/90}Sr$ 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 the DCS were reported for samples collected at the upstream WOC sampling location (WCK 6.8). The other radionuclide results from WCK 6.8 and from samples collected at WOD (before WOC empties into the Clinch River) are discussed in Section 5.5.3.

Low estimated concentrations of Aroclors 1254 and 1260 were detected in the August 2023 sample collected at WCK 1.0. PCBs were not detected in any other 2023 samples from this location. Since 2017, PCBs have been detected on only two other occasions at WCK 1.0: Aroclor 1254 was detected at a low estimated concentration in September 2022, and in 2021 Aroclors 1254 and 1260 were detected in one sample, also at low estimated concentrations.

Two VOCs were detected in samples from WCK 1.0 during 2023: methylene chloride was detected in the sample collected in May, and acetone was detected in the samples collected in all four quarters. All VOC detections were at low estimated values. Methylene chloride was detected at a low estimated value in the associated May trip blank. Acetone was detected in the associated trip blanks at levels similar to those in the WCK 1.0 samples in three out of four quarters and was detected in one associated method blank. All VOCs detected in 2023 have previously been detected at WCK 1.0. In addition, acetone and methylene chloride have occasionally been detected in at least one on-site groundwater well in past monitoring. Acetone and methylene chloride are common laboratory contaminants.

5.5.10. Carbon Fiber Technology Facility Wastewater Monitoring

Wastewaters 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 2023 compliance status for this permit are summarized in Table 5.15.

Table 5.15. Industrial and commercial user wastewater discharge permit compliance at the ORNL Carbon Fiber Technology Facility, 2023

Effluent parameters	Permit limits		Permit compliance		
	Daily max. (mg/L)	Monthly ave. (mg/L)	Number of noncompliances	Number of samples	Percentage of compliance[a]
Outfall 01 (Underground Quench Water Tank)					
Cyanide	3.9	0.1	0	0	100
pH (standard units)	6–9	-	0	0	100
Outfall 02 (Electrolytic Bath Tank)					
pH (standard units)	6–9	-	0	1	100
Outfall 03 (Sizing Bath Tank)					
Copper	0.87	0.10	0	0	100
Zinc	1.24	0.60	0	0	100
Total phenol	4.20	-	0	0	100
pH (standard units)	6–9	-	0	0	100
Outfall 04 (Steam Stretcher Condensate)					
Copper	0.87	0.10	0	0	100
Zinc	1.24	0.60	0	0	100
Total phenol	4.20	-	0	0	100
pH (standard units)	6–9	-	0	0	100

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

5.6. ORNL Groundwater Monitoring Program

Groundwater monitoring at ORNL was conducted under two sampling programs in 2023: OREM monitoring and DOE Office of Science (SC) surveillance monitoring. The OREM groundwater monitoring program was conducted by UCOR in 2023. 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 on the ORNL site. Groundwater monitoring for baseline and trend evaluation in addition to measuring effectiveness of completed CERCLA RAs is conducted as part of the WRRP. The WRRP is managed by UCOR for the OREM program. The results of CERCLA monitoring for ORR for FY 2023, including monitoring at ORNL, are evaluated and reported in the *2024 Remediation Effectiveness Report* (DOE 2024) as required by the ORR Federal Facility Agreement.

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 a groundwater treatability study at the Bethel Valley 7000 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. Post-treatment monitoring of the 7000 Area plume continues.

During FY 2023, post-remediation monitoring continued at Solid Waste Storage Area (SWSA) 3 to evaluate the effectiveness of the 2011 hydrologic isolation of the area that included construction of a multilayer cap and an upgradient storm flow and 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 post-remediation groundwater-level suppression. Sampling and analysis to evaluate groundwater quality and contaminant concentrations were also conducted. Post-remediation 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 synoptic groundwater-level monitoring in 42 wells in addition to 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 2023 monitoring results showed that the cap was effectively enabling attainment of the groundwater-level goals established in the post-remediation completion report. Uncertainty regarding the elevation of bedrock at three monitoring wells was resolved by geophysical measurements that confirmed the groundwater elevation was at or below the bedrock surface. Drinking water standards are used as screening water quality concentrations to evaluate the site response to remediation. Concentrations of 90Sr, a signature contaminant at SWSA 3, decreased significantly in groundwater and at the adjacent surface water monitoring sites at Raccoon Creek and the Northwest Tributary. Groundwater data trend evaluation shows that 90Sr trends are decreasing to stable at the four monitoring wells where FY 2023 90Sr concentrations exceeded the 8 pCi/L maximum contaminant-level derived concentration. Concentrations of benzene, potentially from natural sources, exhibited a stable trend in one well and an increasing trend in a second well; FY 2023 maxima were 0.006 mg/L for the first well and 0.007 mg/L for the second well, which are slightly greater than the 0.005 mg/L maximum contaminant level. During FY 2023, as part of the 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 and 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 *2024 Remediation Effectiveness Report for the US Department of Energy Oak Ridge Site, Oak Ridge, Tennessee, Data and Evaluations* (DOE 2024). To enhance exit pathway groundwater monitoring near the ORR property boundary at the Clinch River in western Bethel Valley, three deep boreholes were drilled and characterized. During FY 2021, Westbay multizone sampling systems were installed to enable discrete zone sampling in the carbonate bedrock units. The three new exit pathway multizone wells were sampled quarterly throughout FY 2023 to assess groundwater quality conditions near the DOE property boundary at the western end of Bethel Valley. Project documentation and monitoring results are presented in the remedial investigation completion report that was issued in August 2023 (DOE 2023c).

Groundwater monitoring continued at the ORNL 7000 Area during FY 2023 to evaluate treatability of the VOC plume at that site. Site characterization testing of the endemic microbial community showed that microbes present at that site 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 shows 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.

Strontium-90 is a principal CERCLA contaminant of concern in surface water in WOC. The ROD established a 37 pCi/L goal for the annual average concentration of ^{90}Sr at the 7500 Bridge Weir. During FY 2023, this goal was not attained. Over the past several years, various problems have occurred in Bethel Valley that have caused the failure to meet the ^{90}Sr concentration goal. Belowground infrastructure deterioration related to process liquid wastewater handling in the aging ORNL Central Campus area allowed contaminant releases. Furthermore, treatment facility upset conditions during start-up of new treatment processes reduced the effectiveness of ^{90}Sr removal during part of FY 2021. OREM is investigating sources of groundwater ^{90}Sr contamination that seep directly into WOC as nonpoint discharges to the stream.

5.6.1.2. Melton Valley

The Melton Valley ROD (DOE 2000) established goals for reducing contaminant levels in surface water, reducing groundwater-level fluctuation within hydrologically isolated areas, and mitigating impacts to groundwater. 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 at ORNL during FY 2023 was about 51 in., which is about 3 in. less 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. At SWSA 6, groundwater quality monitoring that is substantively equivalent to the former RCRA monitoring continues. Several VOCs continue to be detected in wells along the eastern edge of the site at essentially stable concentrations.

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, ^{3}H, uranium, and VOCs have been detected intermittently in several of the multizone sampling locations. Groundwater in the exit pathway wells has high alkalinity and sodium and exhibits elevated pH. During FY 2020, 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 2024 *Remediation Effectiveness Report* (DOE 2024).

5.6.2. DOE Office of Science Groundwater Surveillance Monitoring

DOE Order 458.1 (DOE 2020) is the primary requirement for a sitewide 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 SC groundwater surveillance monitoring are reported in the following sections.

Exit pathway and active-sites groundwater surveillance monitoring points sampled during 2023 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 among locations, results were compared with 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 2021b). 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 2023, exit pathway groundwater surveillance monitoring was performed in accordance with the exit pathway sampling and analysis plan (Bonine 2013). Groundwater exit pathways at ORNL include areas from watersheds or subwatersheds 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 5.39 shows the locations of the exit pathway monitoring points targeted for sampling in 2023:

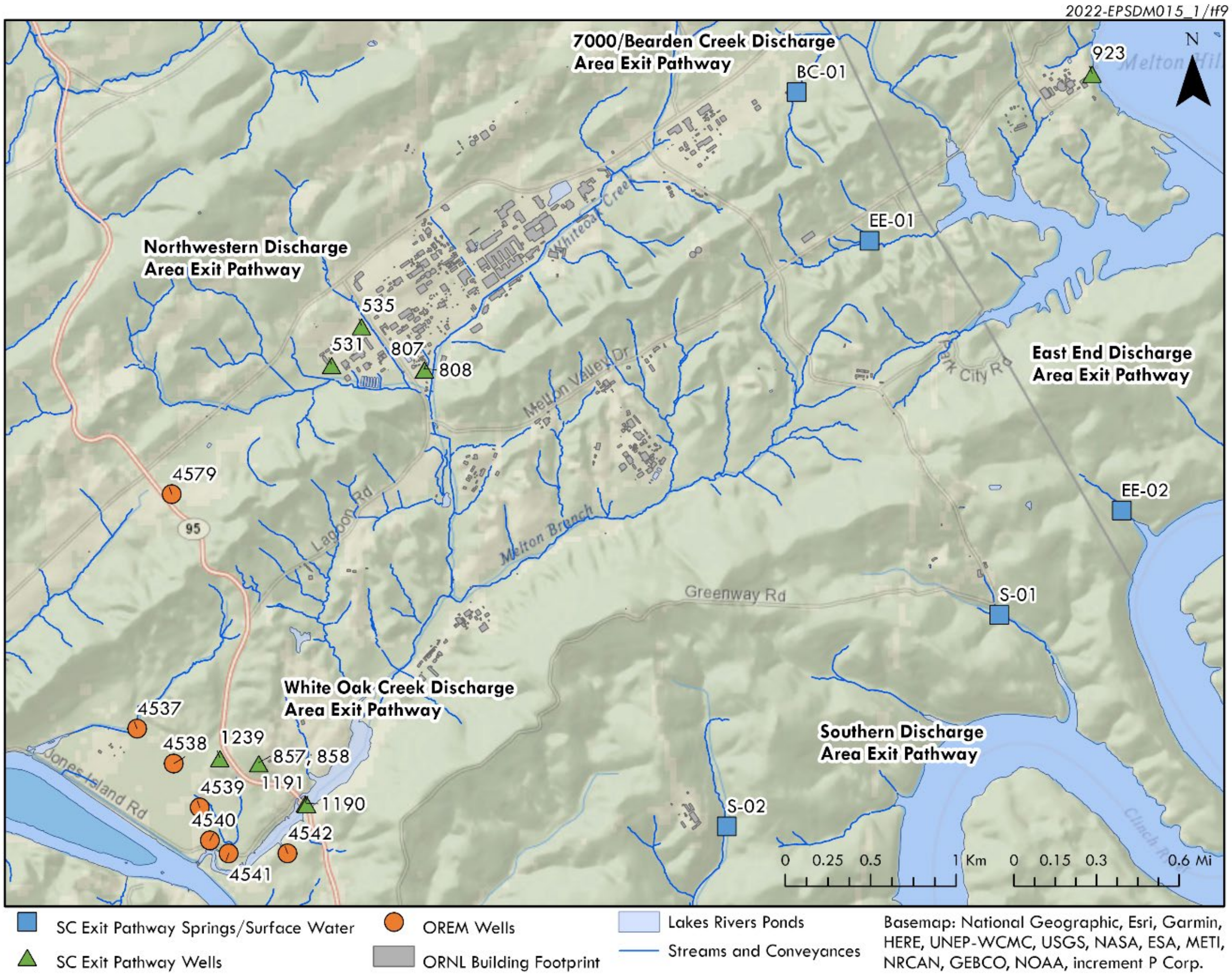
- The 7000/Bearden Creek Discharge Area Exit Pathway
- The East End Discharge Area Exit Pathway
- The Northwestern Discharge Area Exit Pathway
- The Southern Discharge Area Exit Pathway
- The WOC Discharge Area Exit Pathway

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 staggered groundwater monitoring schedule and analytical suite selection. This approach was initiated in 2012. The groundwater monitoring that was conducted in 2023 is summarized in Table 5.16.

Unfiltered samples were collected. The organic suite comprised VOCs and semivolatile organic compounds; the metallic suite included heavy and nonheavy metals; and the radionuclide suite comprised gross alpha/gross beta activity, gamma emitters, $^{89/90}$Sr, and ^{3}H. In 2023, dry-season samples were collected in July through October, and wet-season samples were collected in March.

Exit pathway monitoring results

Table 5.17 summarizes radiological parameters detected in samples collected from exit pathway monitoring points during 2023. Metals are ubiquitous in groundwater exit pathways and so are not summarized in the table.



Acronyms:
OREM = DOE Oak Ridge Office of Environmental Management
ORNL = Oak Ridge National Laboratory
SC = DOE Office of Science

Figure 5.39. UT-Battelle exit pathway groundwater monitoring locations at ORNL, 2023

Table 5.16. Exit pathway groundwater monitoring conducted in 2023

Monitoring point	Season	
	Wet	Dry
7000 Bearden Creek Discharge Area		
BC-01	Radiological	Radiological
East End Discharge Area		
923	Radiological	Radiological
EE-01	Radiological	Radiological
EE-02	Radiological, organics, and metals	Not sampled[a]
Northwestern Discharge Area		
531	Radiological	Radiological
535	Radiological	Radiological, organics, and metals
807	Radiological	Radiological
808	Radiological	Radiological
Southern Discharge Area		
S-01	Radiological	Not sampled[a]
S-02	Radiological	Radiological, organics, and metals
White Oak Creek Discharge Area		
857	Radiological	Radiological, organics, and metals
858	Radiological	Radiological
1190	Radiological, organics, and metals	Radiological, organics, and metals
1191	Radiological, organics, and metals	Radiological, organics, and metals
1239	Radiological	Radiological

[a] *Locations EE-02 and S-01 (stream locations) were not sampled in the 2023 dry season because of lack of water flow.*

Table 5.17. Radiological parameters detected in 2023 exit pathway groundwater monitoring

Monitoring Location	Parameter	Concentration (pCi/L)		
		Wet season[a]	Dry season[a]	Reference value[b]
7000 Bearden Creek Discharge Area				
Spring BC-01	^{214}Bi	23.3	ND	40,000
Spring BC-01	^{137}Cs	2.31	ND	164
Spring BC-01	^{212}Pb	6.34	ND	292
Spring BC-01	^{214}Pb	21.1	ND	23,600
East End Discharge Area				
Well 923	Alpha	3.57	U1.24	15
Well 923	Beta	3.12	3.69	50
Well 923	^{214}Bi	7.62	ND	40,000
Well 923	^{40}K	U27.1	38	640
Stream EE-01	Alpha	U1.04	2.38	15
Stream EE-01	Beta	4.19	U0.917	50
Stream EE-01	^{214}Bi	11.6	ND	40,000
Stream EE-01	^{214}Pb	14.5	ND	23,600
Stream EE-02	Beta	3.68	NF	50
Stream EE-02	^{214}Bi	73.5	NF	40,000
Stream EE-02	^{212}Pb	6.6	NF	292
Stream EE-02	^{214}Pb	60.2	NF	23,600
Northwestern Discharge Area				
Well 531	Beta	U2.46	2.07	50
Well 531	^{214}Bi	8.85	ND	40,000
Well 807	Beta	2.72	2.54	50
Well 807	^{214}Bi	9.21	ND	40,000
Well 807	^{212}Pb	8.91	ND	292
Well 807	$^{89/90}$Sr	U0.951	1.54	68
Well 808	Beta	6.63	3.56	50
Well 808	^{214}Bi	5.91	ND	40,000
Well 808	^{212}Pb	8.01	ND	292
Well 808	$^{89/90}$Sr	1.92	U1.06	68
Southern Discharge Area				
Stream S-01	Beta	3.06	NF	50
Stream S-01	^{214}Bi	38	NF	40,000
Stream S-01	^{214}Pb	36.3	NF	23,600
Stream S-02	Beta	3.06	U1.18	50
Stream S-02	^{214}Bi	23.3	ND	40,000
Stream S-02	^{137}Cs	ND	5.43	164
Stream S-02	^{212}Pb	7.07	ND	292
Stream S-02	^{214}Pb	12	ND	23,600

Table 5.17. Radiological parameters detected in 2023 exit pathway groundwater monitoring (continued)

Monitoring Location	Parameter	Concentration (pCi/L)		
		Wet season[a]	Dry season[a]	Reference value[b]
White Oak Creek Discharge Area				
Well 857	Beta	U1.98	2.95	50
Well 858	Beta	3.64	4.1	50
Well 858	$^{89/90}Sr$	2.72	U0.544	68
Well 1190	Beta	U2.61	3.97	50
Well 1190	^{214}Bi	ND	6.06	40,000
Well 1190	^{3}H	10,400	13,400	20,000
Well 1191	Beta	253	240	50
Well 1191	^{214}Bi	6.51	9.08	40,000
Well 1191	$^{89/90}Sr$	76.3	123	68
Well 1191	^{3}H	8,170	8,030	20,000
Well 1239	Alpha	11.7	U0.224	15
Well 1239	Beta	4.01	U1.01	50
Well 1239	$^{89/90}Sr$	2.11	U0.155	68

[a] NF = there was no flow at the spring or stream sampling location during sampling attempts

ND = the analyte was not detected in the gamma scan that was performed

U = the analyte was measured but not detected above the practical quantitation limit/contractor-required detection limit

[b] Current federal and state standards are used as reference values. If no federal or state standard exists for the analyte, 4 percent of the DOE 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 2023 at ORNL were generally consistent with observations reported in past annual site environmental reports for ORR. Based on the results of the 2023 monitoring effort, there is no indication that current SC operations are significantly introducing contaminants to the groundwater at ORNL.

Nine radiological contaminants were detected in exit pathway groundwater samples collected in 2023. Gross beta and $^{89/90}$Sr were the only radiological parameters that exceeded reference values at any of the discharge areas. Consistent with previous monitoring, these parameters were observed at concentrations above their respective reference values in the WOC discharge area.

Cesium-137 was detected for the first time at two locations in 2023: in wet-season sampling at spring BC-01 (2.31 pCi/L) in the Bearden Creek Discharge Area and in dry-season sampling at S-02 (5.43 pCi/L) in the Southern Discharge Area. Although historic data at these locations do not include detections for comparison, both measured concentrations of ^{137}Cs were below the reference value. Lead-212 was detected for the first time at well 807 (8.91 pCi/L) in the Northwest Discharge Area in the wet-season sampling event.

Twenty-eight metallic parameters were detected in exit pathway groundwater samples collected in 2023. Only three metals, aluminum, iron, and manganese, were detected at concentrations exceeding reference values. These metals are commonly found in groundwater at ORNL.

No organic compounds were detected at concentrations above the analytical method practical quantitation limit in exit pathway groundwater monitoring during 2023. Three organic compounds were detected at estimated concentrations (i.e., concentrations between the method analytical detection level and the practical quantitation limit). Acetone was detected during wet-season monitoring in samples from well 1191 and spring/surface water monitoring point EE-02. Bis(2-ethylhexyl) phthalate was detected in the sample from well 535 in dry-season monitoring. Toluene was detected in samples from well 857 and EE-02 during wet-season monitoring and from well 1190 and S-02 during dry-season monitoring. Methylene chloride was detected at an estimated concentration below the detection limit during wet-season monitoring at EE-02. Acetone, methylene chloride, toluene, and some phthalate compounds are common laboratory contaminants (EPA 2014).

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 5.5.3 for a discussion of results.)

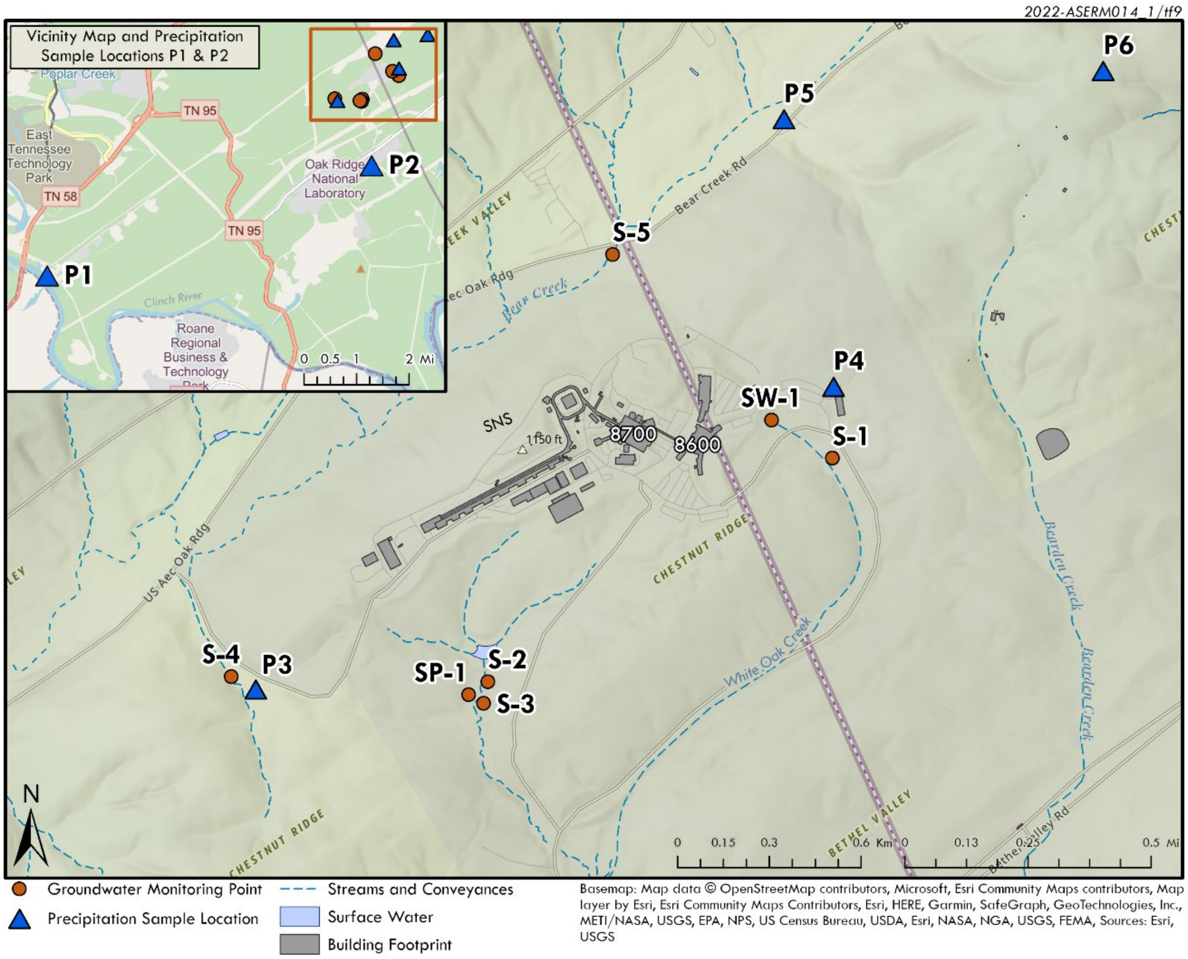
5.6.2.3. Active-Sites Monitoring—Spallation Neutron Source

Active-sites groundwater surveillance monitoring was performed in 2023 at the SNS site under the SNS operational monitoring plan (Bonine, Ketelle, and Trotter 2007) because of the potential for adverse impact on groundwater resources at ORNL should a release occur.

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 consistent with 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, 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 operational monitoring plan include maintaining compliance with applicable DOE contract requirements and environmental quality standards and providing 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. Since 2016, precipitation samples have also been collected for ^{3}H analysis at six of the springs, seeps, and surface water locations. Figure 5.40 shows the locations of the specific monitoring points sampled during 2023.



Acronyms:
P = precipitation monitoring point *S = spring* *SP = seep* *SW = surface water sampling area*

Figure 5.40. Groundwater and precipitation monitoring locations at the Spallation Neutron Source, 2023

In November 2011, the SNS historical ^{3}H data were evaluated to determine whether sampling could be optimized. The influence of flow condition on the proportion of ^{3}H 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. The results of the analysis indicate 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 ^{3}H detects to nondetects. The results of the statistical analysis of the April 2004–September 2011 data were the basis for the modified operational plan monitoring scheme implemented in 2012.

Quarterly sampling at each monitoring point continued in 2023. All sampling performed in 2023 was performed in conjunction with rainfall events, with samples being collected during rising or falling (recession) limb flow conditions. Table 5.18 shows the sampling and parameter analysis schedule followed in 2023.

Table 5.18. Spallation Neutron Source monitoring program schedule, 2023

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

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

Acronyms:

S = spring

SP = seep

SW = surface water sampling area

Spallation Neutron Source site results

Sampling at the SNS site occurred quarterly in 2023. Low concentrations of alpha and beta activities were detected at spring S-5. The alpha and beta activities detected at the S-5 monitoring location are attributed to CERCLA contaminants in Bear Creek Valley associated with legacy waste management practices at the Y-12 facility. Very low beta activity was detected at seep SP-1. Table 5.19 summarizes SNS sampling locations and radionuclide detections for 2023. Analytical results were compared with current federal or state standards or 4 percent of the DCS. Only alpha activity measured at the S-5 location exceeded its reference value in 2023.

In addition to SNS surface water sampling, precipitation monitoring for ^{3}H has been conducted at six locations since 2016. The precipitation sampling is conducted contemporaneously with the surface water sampling. Tritium can be an airborne constituent that is released from several DOE facilities at ORNL, from TVA reactor sites, and from commercial radiological waste processing facilities in the area. The precipitation sampling locations are shown in Figure 5.40, and the results are summarized in Table 5.20. Thirty-two sampling events have been conducted at each of the precipitation monitoring locations. The highest ^{3}H concentrations and frequencies of detection were at sample location P1, approximately 6 miles southwest of the SNS site. The second-highest concentrations and detection frequency occurred at location P4, which is located within 2,000 ft northeast of the SNS target facility. Tritium rainout from atmospheric ^{3}H releases from sources including DOE facilities, TVA facilities, and commercial radiological waste-handling and waste-processing facilities creates a regional background of ^{3}H in some surface water and groundwater samples.

Table 5.19. Radiological concentrations detected in samples collected at the Spallation Neutron Source, 2023[a]

Parameter	Concentrations (pCi/L)				Reference value[b]
	February	June	October	December	
			SW-1[c]		
^{3}H	1,620		2,640	2,050	20,000
			***S-1*[d]**		
^{214}Bi			22.8		40,000
^{3}H	974		835	1,390	20,000
			***S-2*[e]**		
^{3}H	614	914	896	1,320	20,000
			***S-3*[f]**		
^{214}Bi	17.9			53.8	23,600
^{214}Pb	13.1			32.2	40,000
^{3}H	432	188	269	548	20,000
			***S-4*[g]**		
^{3}H	411		262	314	20,000
			***S-5*[g]**		
Alpha		18.4			15
Beta		15.7			50
^{3}H				323	20,000
			***SP-1*[d]**		
Beta			4.49		50
^{3}H	490	260	263	402	20,000

[a] In addition to ^{3}H analyses, an extended suite of parameters was analyzed at each location during one 2023 sampling event. The extended suite includes gross alpha, gross beta, gamma scan, and ^{14}C. Results for ^{3}H and detected concentrations from the extended suite are listed in the table.

[b] Current federal and state standards are 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] Analysis of extended suite completed in June.

[d] Analysis of extended suite completed in October.

[e] Analysis of extended suite completed in February and December.

[f] Analysis of extended suite completed in February.

[g] Analysis of extended suite completed in June.

***Acronyms:** S = spring SP = seep SW = surface water sampling area*

Table 5.20. Summary of precipitation ^3H monitoring results, 2016–2023

Sample location	Total samples	Total detects	Maximum detect (pCi/L)	Date of maximum detect	Date of most recent detect
P1	32	8	4,930	05/21/2016	12/23/2023
P2	32	2	1,070	05/21/2016	02/07/2018
P3	32	4	1,230	05/21/2016	06/27/2022
P4	32	8	3,560	10/07/2023	10/07/2023
P5	32	5	908	05/21/2016	10/07/2023
P6	32	3	1,240	02/07/2018	10/07/2023

5.6.2.4. Emerging Contaminant Assessment—Potential for Per- and Polyfluoroalkyl Substances in ORNL Area Groundwater

A group of fluorinated organic chemical compounds collectively referred to as per- and polyfluoroalkyl substances (PFAS) are contaminants of emerging concern. PFAS compounds are persistent in the environment, and some are known to bioaccumulate in humans 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 been studied most. Through 2001, PFOS and other PFAS compounds were used in the manufacture of aqueous film-forming foams (AFFFs), and use of such foams, including in firefighting training activities, may have contributed to environmental releases. The information contained in this and the previous paragraph is summarized from EPA's *Technical Fact Sheet—Perfluorooctane Sulfonate (PFOS) and Perfluorooctanoic Acid (PFOA)* (EPA 2017).

On June 21, 2022, EPA published updated health advisories for PFOA and PFOS of 0.004 ng/L and 0.02 ng/L, respectively (EPA 2022b). These replaced the final health advisory of 70 ng/L for combined PFOA and PFOS that was issued in 2016. At the same time, the EPA also issued final health advisories for hexafluoropropylene oxide dimer acid and its ammonium salt (collectively referred to as GenX chemicals) and perfluorobutane sulfonic acid and the related compound potassium perfluorobutane sulfonate (together referred to as PFBS) of 10 ng/L and 2,000 ng/L, respectively.

In April 2022, EPA proposed the first CWA aquatic life criteria for PFAS (Table 5.21), which focus on PFOA and PFOS chemical groups. These draft recommendations reflect the latest peer-reviewed scientific knowledge regarding the toxicological effects of PFOA and PFOS on freshwater aquatic organisms.

Historically, firefighter training at ORNL included training in the use of AFFFs, and the foams that were used in past training activities may have contained PFAS compounds. The discharges of these foams are suspected to be the most significant potential source of PFAS in environmental media 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. A sampling and analysis plan has been developed and was implemented in 2023 to assess these areas for the presence of PFAS compounds in groundwater and in surface water bodies in these areas.

Table 5.21. Draft recommended freshwater aquatic life water quality criteria for PFOA and PFOS (EPA 2022c)

Criteria Component	Acute Water Column (CMC)	Chronic Water Column (CCC)	Invertebrate Whole-Body	Fish Whole-Body	Fish Muscle
PFOA magnitude	49 mg/L	0.094 mg/L	1.11 mg/kg ww	6.10 mg/kg ww	0.125 mg/kg ww
PFOS magnitude	3.0 mg/L	0.0084 mg/L	0.937 mg/kg ww	6.75 mg/kg ww	2.91 mg/kg ww
Duration	1 h average	4-day average	Instantaneous[a]		
Frequency	Not to be exceeded more than once in 3 years, on average	Not to be exceeded more than once in 3 years, on average	Not to be exceeded more than once in 10 years, on average		

[a] *Tissue data provide instantaneous point measurements that reflect integrative accumulation of PFOA or PFOS over time and space in aquatic life population(s) at a given site.*

Acronyms:
CCC = *criterion continuous concentration*
CMC = *criterion maximum concentration*
PFOA = perfluorooctanoic acid
PFOS = perfluorooctane sulfonate
ww = wet weight

The sampling and analysis plan also includes monitoring surface water locations in other parts of the ORNL campus, including former waste storage areas, to determine whether PFAS compounds from sources other than the use of AFFFs are present and are reaching surface water bodies. Surface water monitoring includes the use of passive sampling devices, which are deployed in stream environments for long periods (typically 4 weeks) and therefore can accumulate PFAS compounds and detect trace concentrations that might not be detectable with traditional water sampling techniques.

Neither groundwater nor surface water at ORNL is a direct source of drinking water. ORNL's water supply is municipal water purchased from the City of Oak Ridge. DOE owns the water distribution system on the ORNL site; limited sampling of the ORNL water distribution system for the presence of PFAS compounds was completed for 2023.

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, Quality Assurance (DOE 2011b). The methods used for successful implementation of the QMS rely on the integration and implementation of quality elements and 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 on 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 perform work safely and effectively. 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 Enterprise Document and Records Management System.

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 staff 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.

EPSD team leaders are responsible for identifying the training needs, qualifications, and requirements for staff who conduct sampling, data management, and reporting tasks associated with ORNL and ORR-wide environmental surveillance programs. Training status is routinely monitored by the division training officer, and notices of training needs or deficiencies are automatically sent to individual employees. The training program is supplemented by a division-wide required reading program. This program ensures that staff members have reviewed new or revised documents (e.g., procedures, lessons learned) that are applicable to their jobs.

5.7.3. Equipment and Instrumentation

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 EPSD environmental monitoring programs through a maintenance recall program to ensure that equipment is functioning properly and within defined tolerance ranges.

5.7.3.1. Calibration

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 is performed annually to certify the Predictive Emissions Monitoring System for nitrogen oxides and oxygen. The purpose of a relative accuracy test audit is to provide a rigorous QA assessment in accordance with "Performance Specification 16" (EPA 2009b). The results of the QA tests are provided to TDEC quarterly, semiannually, or annually, as applicable.

5.7.3.2. Standardization

EPSD sampling procedures are maintained in the Enterprise Document and Records Management System 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 perform 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 5.2 lists environmental audits and assessments performed at ORNL in 2023 and the number of findings identified. EPSD also conducts internal assessments of UT-Battelle environmental monitoring activities. Surveillance results, recommendations, and completion of corrective actions, if required, are also documented and tracked in the UT-Battelle Assessment and Commitment Tracking System.

Independent audits, surveillances, and internal management assessments are performed at TWPC and Building 3019 to verify that requirements have been accurately specified and that activities that have been performed conform to expectations and requirements. Corrective actions at TWPC, if required, are documented and tracked using the UCOR Quality Assurance and Corrective Action Management Systems, and Isotek corrective actions for Building 3019 are tracked in its Assessment and Commitment Tracking System.

5.7.5. Analytical Quality Assurance

Laboratories that analyze environmental samples collected for EPSD environmental sampling programs are required to have documented QA/QC programs, trained and qualified staff, appropriately maintained equipment and facilities, and applicable certifications. The laboratories also participate in accreditation, certification, and performance evaluation programs such as the National Environmental Laboratory Accreditation Program (NELAP), Mixed Analyte Performance Evaluation Program (MAPEP), Discharge Monitoring Report Quality Assurance Study (DMRQA), and DOE Environmental Management Consolidated Audit Program (DOECAP), which evaluate laboratories according to stringent and widely accepted criteria for quality, accuracy, reliability, and efficiency. Any issues identified through accreditation or certification programs or through performance evaluation testing are addressed with analytical laboratories and are considered when determinations are made on data integrity. Blank and duplicate samples are submitted along with environmental samples to provide an additional check on analytical laboratory performance.

Environmental samples collected in support of EPSD environmental monitoring programs in 2023 were analyzed by one of two contracted commercial laboratories (GEL Laboratories or Eurofins) or by the UT-Battelle Radiochemical Materials Analytical Laboratory (RMAL) or the UT-Battelle Environmental Toxicology Laboratory. Contracts with analytical laboratories include statements of work that specify the scope of work, data deliverables, turnaround times, required methods, and detection limits.

GEL Laboratories, a contracted commercial radiochemistry and environmental laboratory in Charleston, South Carolina, holds more than 40 federal and state certifications, accreditations, and approvals, including for ISO 17025 (which contains general requirements for the competence of testing and calibration laboratories) and from the Department of Defense Environmental Laboratory Accreditation Program (DOD-ELAP), DOECAP, and NELAP. Four external audits were performed on-site in 2023. Ten internal audits focusing on analytical and support service activities were conducted to verify compliance with the requirements of the GEL QA/QC program and with client-specified terms. No issues were identified that would affect analytical data reported to clients. In 2023, GEL reported results from 5,331 performance test analyses (including DMRQA, MAPEP, DOECAP, and NELAP). Of these, 5,192 (97.4 percent) fell within acceptance ranges. Those that did not meet acceptance criteria were found to have no effect on data reported to clients.

Eurofins, a contracted environmental laboratory in Tacoma, Washington, is accredited, licensed, or approved by 11 third-party programs, including ISO 17025, DOD-ELAP, DOECAP, NELAP, and several state licensing or accrediting programs. In 2023, Eurofins participated in MAPEP and DMRQA, and all applicable test results were within acceptable ranges.

RMAL received ISO 17025:2017 (ISO 2017) accreditation in April 2023. Additionally, RMAL operates in compliance with the US Department of Defense/DOE *Consolidated Quality Systems Manual* (DOD/DOE 2018) and with the requirements of DOE 414.1D (DOE 2011b) and 10 CFR 830 Subpart A, "Quality Assurance Requirements." The UT-Battelle Chemical Sciences Division's QA plan also meets applicable requirements of the American Society of Mechanical Engineers' Nuclear Quality Assurance Program. In 2023, RMAL participated in several external audits, including the annual TDEC Waste Compliance Audit, the initial ISO 17025 accreditation audit performed by A2LA, and 10 internal assessments, that focused on adherence to approved analytical methods, waste management, and record keeping. No issues that required reanalysis or data corrections related to environmental sampling results were identified. In 2023, RMAL participated in MAPEP and DMRQA, and all results for analyses that RMAL performed in support of EPSD environmental monitoring programs were within acceptable ranges.

The Environmental Toxicology Laboratory does not hold any outside accreditations, but it operates in compliance with all methods required by EPA, TDEC, NPDES, and the UT-Battelle Environmental Sciences Division's Quality Assurance Management Program. In 2023, six internal assessments focused on adherence to approved analytical methods and data analysis were performed. No issues requiring reanalysis or data corrections related to standard toxicity testing results were identified. Updates of all standard operating procedures, reference toxicity control charts, and training requirements were completed in 2021. All standard operating procedures and lab methods comply with EPA's acute (EPA 2002a) and chronic (EPA 2002b) testing requirements for freshwater species. In 2023, the Environmental Toxicology Laboratory participated in the DMRQA program for whole effluent toxicity testing of *Pimephales promelas* (the fathead minnow, a freshwater fish) and *Ceriodaphnia dubia* (the water flea, a freshwater invertebrate). All *C. dubia* and *P. promelas* results were in acceptable ranges.

5.7.6. Data Management and Reporting

Data collected by UT-Battelle in conjunction with ORR and ORNL environmental surveillance programs and CWA activities at ORNL are managed 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 the 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 Requirements, Documents, and Records Management System provides the requirements for managing all UT-Battelle records. Requirements include creating, maintaining, and using records; scheduling, protecting, and storing records; and destroying records.

Records management programs for TWPC and Building 3019 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 ORNL

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 of past operations. The contaminated portions of ORR are on the EPA National Priorities List, 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 EPA and TDEC. The *FY 2023 Cleanup Progress: Annual Report on Oak Ridge Reservation Cleanup* (UCOR 2023) provides detailed information on OREM's 2023 cleanup activities (**here**).

5.8.1. Wastewater Treatment

At ORNL, OREM operates PWTC and the Liquid Low-Level Waste Treatment Facility. In 2023, 442.9 million L of wastewater was treated and released at PWTC. In addition, the liquid LLW system at ORNL received 427,199 L of waste. The waste treatment activities of these facilities support both OREM and 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 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 by-products 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 managing most of the wastes generated from R&D activities and wastes generated from operation of the R&D facilities. If possible, waste streams are treated by on-site liquid or gaseous waste treatment facilities operated by OREM. 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 2023, ORNL performed 101 waste and recycle shipments to off-site hazardous, radiological, or mixed-waste treatment or disposal vendors.

5.8.3. Transuranic Waste Processing Center

TRU waste processing activities performed for DOE in 2023 by UCOR addressed both contact-handled and remotely handled solids and debris. These activities involved processing, treating, and repackaging waste. LLW and mixed LLW are transported to the Nevada National Security Site or to another approved off-site facility for disposal.

In 2023, 135.0 m^3 of contact-handled TRU waste was shipped from TWPC in 18 shipments (643 containers). During 2023, 5.84 m^3 of contact-handled waste was processed; no remotely handled waste was processed, and no mixed LLW (TRU waste that was recharacterized as LLW) was shipped off-site.

5.9. References

10 CFR 830. "Nuclear Safety Management." *US Code of Federal Regulations*, Washington, DC. Retrieved May 5, 2021, from https://www.govinfo.gov/content/pkg/CFR-2011-title10-vol4/pdf/CFR-2011-title10-vol4-part830.pdf.

40 CFR 60, Appendix A-1. "Method 2—Determination of Stack Gas Velocity and Volumetric Flow Rate (Type S Pitot Tube)." *US Code of Federal Regulations*, Washington, DC.

40 CFR 82. "Protection of Stratospheric Ozone." *US Code of Federal Regulations*, Washington, DC. Retrieved June 3, 2020, from https://www.ecfr.gov/cgi-bin/text-idx?rgn=div6;node=40%3A18.0.1.1.2.6.

40 CFR 112. "Oil Pollution Protection." *US Code of Federal Regulations,* Washington, DC. Retrieved June 4, 2020, from https://www.epa.gov/sites/production/files/2014-04/documents/b_40cfr112.pdf.

40 CFR 280. "Technical Standards and Corrective Action Requirements for Owners and Operators of Underground Storage Tanks (UST)." *US Code of Federal Regulations,* Washington, DC. Retrieved June 9, 2020, from https://www.ecfr.gov/cgi-bin/text-idx?SID=165cbbe4db4970349d085d9840b78873&mc=true&node=pt40.29.280&rgn=div5.

40 CFR 1508.4. "Categorical Exclusion." *US Code of Federal Regulations*, Washington, DC. Retrieved May 2, 2020, from https://www.ecfr.gov/cgi-bin/text-idx?SID=079d239aa6c408b31009767e801d0d90&mc=true&node=pt40.37.1508&rgn=div5#se40.37.1508_14.

AIM 2020. *American Innovation and Manufacturing Act*. Title 42 US Code §7675.

ANSI 1969. Guide *to Sampling Airborne Radioactive Materials in Nuclear Facilities*. ANSI N13.1-1969R. American National Standards Institute, Washington, DC.

ANSI 1999. *Sampling and Monitoring Releases of Airborne Radioactive Substances from the Stacks and Ducts of Nuclear Facilities.* ANSI/HPS N13.1-1999. American National Standards Institute, Health Physics Society, New York, New York.

Bonine 2013. Bonine, T. M. *UT-Battelle Sampling and Analysis Plan for Surveillance Monitoring of Exit Pathway Groundwater at Oak Ridge National Laboratory*. Oak Ridge National Laboratory, Oak Ridge, Tennessee.

Bonine, Ketelle, and Trotter 2007. Bonine, T. M., R. H. Ketelle, and S. M. Trotter. *Operational Groundwater Monitoring Plan for the Spallation Neutron Source Site*. SNS 102040000-ES0001-R01, ORNL/TM-2004/118, Oak Ridge National Laboratory, Oak Ridge, Tennessee.

CAA 1970. *Clean Air Act.* Title 42 US Code §7401 et seq.

CERCLA 1980. *Comprehensive Environmental Response, Compensation, and Liability*. Title 42 US Code Chapter 103.

Cleary et al. 2021. Cleary, B.M., M. E. Romano, C. Y. Chen, W. Heiger-Bernays, and K. A. Crawford, "Comparison of Recreational Fish Consumption Advisories across the USA." Current Environmental Health Reports 8(2), 71–88.

CWA 1972. *Clean Water Act.* Title 33 US Code §1251 et seq.

DOD/DOE 2018. *Department of Defense (DoD)/Department of Energy (DOE) Consolidated Quality Systems Manual (QSM) for Environmental Laboratories*. DoD/DOE QSM 5.5.1, US Department of Defense, and US Department of Energy, Washington, DC. Retrieved April 30, 2021, from https://denix.osd.mil/edqw/documents/documents/qsm-version-5-1-1-final/.

DOE 1992. *Federal Facility Agreement for the Oak Ridge Reservation*. FFA-PM/18-011, DOE/OR-014, January 1, 1992, or latest revision, US Environmental Protection Agency Region IV, US Department of Energy, and Tennessee Department of Environment and Conservation, Oak Ridge, Tennessee. Retrieved August 18, 2022, from https://www.energy.gov/sites/prod/files/em/2001_Agreements/ORR_FFA_1-1-92.pdf .

DOE 2000. *Record of Decision for Interim Actions for the Melton Valley Watershed at the Oak Ridge National Laboratory, Oak Ridge, Tennessee*. DOE/OR/01-1826&D3, US Department of Energy, Washington, DC.

DOE 2002. *Record of Decision for Interim Actions in Bethel Valley Watershed, Oak Ridge, Tennessee*. DOE/OR/01-1862&D4, US Department of Energy, Washington, DC.

DOE 2008. *Environmental Protection Program.* DOE Order 450.1A. Approved June 4, 2008. US Department of Energy, Washington, DC.

DOE 2011a. *Final Draft ^{233}U Alternatives Analysis, Phase I Report: Screening of Alternative Disposition Approaches.* US Department of Energy, Washington, DC.

DOE 2011b. *Quality Assurance.* DOE Order 414.1D. Approved April 25, 2011. US Department of Energy, Washington, DC.

DOE 2012. *Phased Construction Completion Report for the Bethel Valley Burial Grounds at the Oak Ridge National Laboratory, Oak Ridge, Tennessee*. DOE/OR/01-2533&D2. UCOR, Oak Ridge, Tennessee.

DOE 2020. *Radiation Protection of the Public and the Environment.* DOE Order 458.1, Change 4. Approved September 15, 2020. US Department of Energy, Washington, DC.

DOE 2021a. *2021 Climate Adaptation and Resilience Plan: Report to the White House National Climate Task Force and Federal Chief Sustainability Officer*. US Department of Energy, Washington, DC. August 2021. https://www.energy.gov/sites/default/files/2021-09/DOEClimateAdaptationandResiliencePlanSept21.pdf.

DOE 2021b. *Derived Concentration Technical Standard*. DOE-STD-1196-2021. US Department of Energy, Washington, DC. July 2021. https://www.standards.doe.gov/standards-documents/1100/1196-astd-2021.

DOE 2023a. *Departmental Sustainability.* DOE Order 436.1A. Approved April 25, 2023. US Department of Energy, Washington, DC.

DOE 2023b. *Fiscal Year 2024 Site Sustainability Plan Instructions*. US Department of Energy, Washington, DC. https://sustainabilitydashboard.doe.gov/PDF/Resources/FY%202024%20SSP%20Instructions%20Final-1-2.pdf

DOE 2023c. *Melton Valley/Bethel Valley Exit Pathway Phase 1 Remedial Investigation Completion Report for the U.S. Department of Energy Oak Ridge Site Oak Ridge, Tennessee.* DOE/OR/01-2953&D1, US Department of Energy, Washington, DC.

EAct 2020. *The Energy Act of 2020*. Public Law 116-260, Division Z.

EISA 2007. *Energy Independence and Security Act of 2007*. Public Law 110-140.

EO 1994. Executive Order 12898, *Federal Actions to Address Environmental Justice in Minority Populations and Low-Income Populations*. Issued February 11, 1994. Retrieved May 5, 2023, from https://www.federalregister.gov/documents/1994/02/16/94-3685/federal-actions-to-address-environmental-justice-in-minority-populations-and-low-income-populations.

EO 2021a. Executive Order 14008, *Tackling the Climate Crisis at Home and Abroad*. Issued January 27, 2021. Retrieved April 5, 2022, from https://www.federalregister.gov/documents/2021/02/01/2021-02177/tackling-the-climate-crisis-at-home-and-abroad.

EO 2021b. Executive Order 14057, *Catalyzing Clean Energy Industries and Jobs Through Federal Sustainability*. Issued December 8, 2021. Retrieved May 5, 2023, from https://www.whitehouse.gov/briefing-room/presidential-actions/2021/12/08/executive-order-on-catalyzing-clean-energy-industries-and-jobs-through-federal-sustainability/.

EO 2022. Executive Order 14072, *Strengthening the Nation's Forests, Communities, and Local Economies.* Issued April 22, 2022. https://www.whitehouse.gov/briefing-room/presidential-actions/2022/04/22/executive-order-on-strengthening-the-nations-forests-communities-and-local-economies/.

EPA 2000. *Stressor Identification Guidance Document.* EPA-822-B-00-025, US Environmental Protection Agency, Office of Water, Washington, DC.

EPA 2002a. *Methods for Measuring the Acute Toxicity of Effluents and Receiving Waters to Freshwater and Marine Organisms*. EPA-821-R-02-012, US Environmental Protection Agency, Washington, DC. Retrieved April 17, 2021, from https://www.wbdg.org/FFC/EPA/EPACRIT/epa821_r_02_012.pdf.

EPA 2002b. *Short-Term Methods for Estimating the Chronic Toxicity of Effluents and Receiving Waters to Freshwater Organisms*. EPA-821-R-02-013, US Environmental Protection Agency, Washington, DC. Retrieved April 17, 2021, from https://www.epa.gov/sites/production/files/2015-08/documents/short-term-chronic-freshwater-wet-manual_2002.pdf.

EPA 2009a. *Technical Guidance on Implementing the Stormwater Runoff Requirements for Federal Projects under Section 438 of the Energy Independence and Security Act*. EPA 841-B-09-001, US Environmental Protection Agency, Washington, DC. https://www.epa.gov/sites/default/files/2015-09/documents/eisa-438.pdf.

EPA 2009b. *Performance Specification 16 for Predictive Emissions Monitoring Systems and Amendments to Testing and Monitoring Provisions*. US Environmental Protection Agency, Washington, DC. https://www.federalregister.gov/documents/2009/03/25/E9-6275/performance-specification-16-for-predictive-emissions-monitoring-systems-and-amendments-to-testing.

EPA 2014. *Laboratory Data Review for the Non-Chemist*. US Environmental Protection Agency, Region 9, San Francisco, California. https://clu-in.org/conf/tio/rcraexpert_100516/slides/Data-Review-Manual-110114.pdf.

EPA 2017. *Technical Fact Sheet—Perfluorooctane Sulfonate (PFOS) and Perfluorooctanoic Acid (PFOA)*. EPA 505-F-17-001, US Environmental Protection Agency. https://www.epa.gov/sites/production/files/2017-12/documents/ ffrrofactsheet_contaminants_pfos_pfoa_11-20-17_508_0.pdf.

EPA 2022a. *Phasedown of Hydrofluorocarbons: Establishing the Allowance Allocation and Trading Program under the AIM Act.* US Environmental Protection Agency, Washington, DC. Retrieved April 6, 2022, from https://www.federalregister.gov/documents/2021/10/05/2021-21030/phasedown-of-hydrofluorocarbons-establishing-the-allowance-allocation-and-trading-program-under-the.

EPA 2022b. "Lifetime Drinking Water Health Advisories for Four Perfluoroalkyl Substances." US Environmental Protection Agency, Federal Register, Vol. 87, No. 118. Approved June 21, 2022. https://www.govinfo.gov/app/details/FR-2022-06-21/summary (accessed March 19, 2023).

EPA 2022c. "Fact Sheet: Draft 2022 Aquatic Life Ambient Water Quality Criteria for Perfluorooctanoic acid (PFOA) and Perfluorooctane Sulfonic Acid (PFOS)." EPA 842-D-22-005, US Environmental Protection Agency, Office of Water. Retrieved March 25, 2024, from https://www.epa.gov/system/files/documents/2022-04/pfoa-pfos-draft-factsheet-2022.pdf.

EPA 2023. "Environmental Justice." US Environmental Protection Agency, Washington, DC. Retrieved March 19, 2023, from https://www.epa.gov/environmentaljustice#:~:text=Environmental%20justice%20is%20the%20fair,laws%2C%20regulations%2C%20and%20policies.

EPA 2024a. "Scope 1 and Scope 2 Inventory Guidance." US Environmental Protection Agency, Center for Corporate Climate Leadership, Washington, DC. Retrieved June 4, 2024, from https://www.epa.gov/climateleadership/scope-1-and-scope-2-inventory-guidance.

EPA 2024b. *Criteria Air Pollutants*. US Environmental Protection Agency. February 2024. https://www.epa.gov/criteria-air-pollutants.

EPAct 2005. *Energy Policy Act of 2005*. Public Law 109-58.

EPCRA 1986. *Emergency Planning and Community Right-to-Know Act*. Title 42 US Code Chapter 116.

ISO 2004. *Environmental Management Systems—Requirements with Guidance for Use*. ISO 14001:2004, International Organization for Standardization. http://www.iso.org.

ISO 2015. *Environmental Management Systems—Requirements with Guidance for Use*. ISO 14001:2015, International Organization for Standardization. http://www.iso.org.

ISO 2017. *General Requirements for the Competence of Testing and Calibration Laboratories*. ISO/IEC 17025, International Organization for Standardization. Retrieved April 17, 2021, from https://www.iso.org/publication/PUB100424.html.

Matson et al. 2022. Matson, P. G., L. M. Stevenson, R. A. Efroymson, R. T. Jett, M. W. Jones, M. J. Peterson, and T. J. Mathews, "Variation in Natural Attenuation Rates of Polychlorinated Biphenyls (PCBs) in Fish from Streams and Reservoirs in East Tennessee Observed over a 35-Year Period." *Journal of Hazardous Materials* 438, 129427.

Miller et al. 2015. Miller, C. L., D. B. Watson, B. P. Lester, J. Y. Howe, D. H. Phillips, F. He, L. Liang, and E. M. Pierce. "Formation of Soluble Mercury Oxide Coatings: Transformation of Elemental Mercury in Soils." *Environmental Science and Technology* 49, 12105–12111.

NEPA 1969. *National Environmental Policy*. Title 42 US Code Chapter 55.

NHPA 1966. *National Historic Preservation Act*. Public Law 89-665; Title 54 US Code §300101 et seq.

NRC 2000. *Multi-Agency Radiation Survey and Site Investigation Manual (MARSSIM)*. NUREG-1575, Rev. 1/EPA 402-R-97-016, Rev. 1/DOE/EH-0624, Rev. 1, US Nuclear Regulatory Commission, Environmental Protection Agency, Department of Defense, and Department of Energy, Washington, DC.

NRC 2009. *Multi-Agency Radiation Survey and Assessment of Materials and Equipment Manual (MARSAME)*. NUREG-1575, Supplement 1/EPA 402-R-09-001/DOE/HS-0004. US Nuclear Regulatory Commission, Environmental Protection Agency, Department of Defense, and Department of Energy, Washington, DC.

ORNL 2024. Goins. M., A. A. Miller, M. Madgett, S. Sluder, L. Touton, and S. Stephenson. *Oak Ridge National Laboratory FY 2024 Site Sustainability Plan with FY 2023 Performance Data*. ORNL/SPR-2023/3213, Oak Ridge National Laboratory, Oak Ridge, Tennessee. https://info.ornl.gov/sites/publications/Files/Pub206094.pdf.

Pelletier 1995. Pelletier, R. F., "Application of DOE 5400.5 Requirements for Release and Control of Property Containing Residual Radioactive Material," correspondence to distribution. US Department of Energy, Office of Environmental Policy and Assistance, Washington, DC.

RCRA 1976. "Resource Conservation and Recovery Act." *Code of Federal Regulations* Title 40 parts 239–282.

SARA 1986. *The Superfund Amendments and Reauthorization Act.* Public Law 99-499. https://www.congress.gov/bill/99th-congress/house-bill/2005.

Souza et al. 2001. Souza, P. A., G. D. DuVall, and M. J. Hart. *Cultural Resource Management Plan, DOE Oak Ridge Reservation, Anderson and Roane Counties, Tennessee.* DOE/ORO/2085, US Department of Energy, Washington, DC.

TDEC 2010a. *Proposed Total Maximum Daily Loads (TMDLs) for Polychlorinated Biphenyls (PCBs) and Chlordane in Melton Hill Reservoir: Lower Clinch River Watershed (HUC 06010207), Anderson, Knox, Loudon, and Roane Counties, Tennessee*. Tennessee Water Pollution Control Board, Division of Water Pollution Control, Nashville, TN.

TDEC 2010b. *Proposed Total Maximum Daily Loads (TMDLs) for Polychlorinated Biphenyls (PCBs) and Chlordane in Watts Bar Reservoir: Watts Bar Lake Watershed (HUC 06010201), Lower Clinch River Watershed (HUC 06010207), and Emory River Watershed (HUC 06010208), Loudon, Meigs, Morgan, Rhea, and Roane Counties, Tennessee*. Tennessee Water Pollution Control Board, Division of Water Pollution Control, Nashville, TN.

TDEC 2010c. *Proposed Total Maximum Daily Loads (TMDLs) for Polychlorinated Biphenyls (PCBs) in Fort Loudoun Reservoir: Fort Loudoun Lake Watershed (HUC 06010201), Blount, Knox, and Loudon Counties, Tennessee*. Tennessee Water Pollution Control Board, Division of Water Pollution Control, Nashville, TN.

TDEC 2019. “General Water Quality Criteria.” *Rules of the Tennessee Department of Environment and Conservation.* Chapter 04000-40-03. Tennessee Department of Environment and Conservation, Bureau of Environment, Division of Water Supply. https://www.epa.gov/sites/default/files/2014-12/documents/tn-chapter1200-4-3.pdf.

TDEC 2020. “Public Water Systems.” *Rules of Tennessee Department of Environment and Conservation Division of Water Resources*. Chapter 0400-45-01. Tennessee Department of Environment and Conservation, Bureau of Environment, Division of Water Supply. https://publications.tnsosfiles.com/rules/0400/0400-45/0400-45-01.20190217.pdf.

TDEC 2021a. “Underground Storage Tank Program.” *Rules of Tennessee Department of Environment and Conservation*. Chapter 0400-18-01. Tennessee Department of Environment and Conservation, Division of Underground Storage Tanks.

TDEC 2021b. *Quality System Standard Operating Procedure for Macroinvertebrate Stream Surveys*. DWR-WP-P-01-QSSOP-Macroinvert-122821, Tennessee Department of Environment and Conservation Division of Water Resources, Nashville, Tennessee. https://www.tn.gov/content/dam/tn/environment/water/policy-and-guidance/DWR-PAS-P-01-Quality_System_SOP_for_Macroinvertebrate_Stream_Surveys-122821.pdf.

TSCA 1976. *Toxic Substances Control Act.* Title 15 US Code §2601 et seq. https://www.epa.gov/laws-regulations/summary-toxic-substances-control-act).

UCOR 2023. *FY 2023 Cleanup Progress: Annual Report on Oak Ridge Reservation Cleanup.* OREM-23-7632, US Department of Energy Oak Ridge Office of Environmental Management, Oak Ridge, Tennessee. Retrieved March 13, 2024, from https://www.energy.gov/sites/default/files/2023-11/Cleanup%20Progress%202023.pdf.