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

At ORNL, DOE's largest multidisciplinary laboratory, researchers apply unique facilities, sophisticated tools, and signature strengths in key scientific and technological areas to benefit science and society, enabling ORNL to do the following:

- Advance understanding, design, and use of new materials and chemical processes
- Reveal unmatched insights through computing and data
- Ensure safe nuclear power and secure nuclear materials
- Produce rare isotopes for medicine, industry, security, research, and space exploration
- Increase and exploit understanding of biological and environmental systems

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 2024 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 doing so 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

Isotek is responsible for the Building 3019 Complex at ORNL, where the national repository of ^{233}U has been kept since 1962. Recommendations in the Final Draft ^{233}U Alternatives Analysis Phase I Report (DOE 2011a) have been completed. 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.

ORNL 2025-G03328/i72
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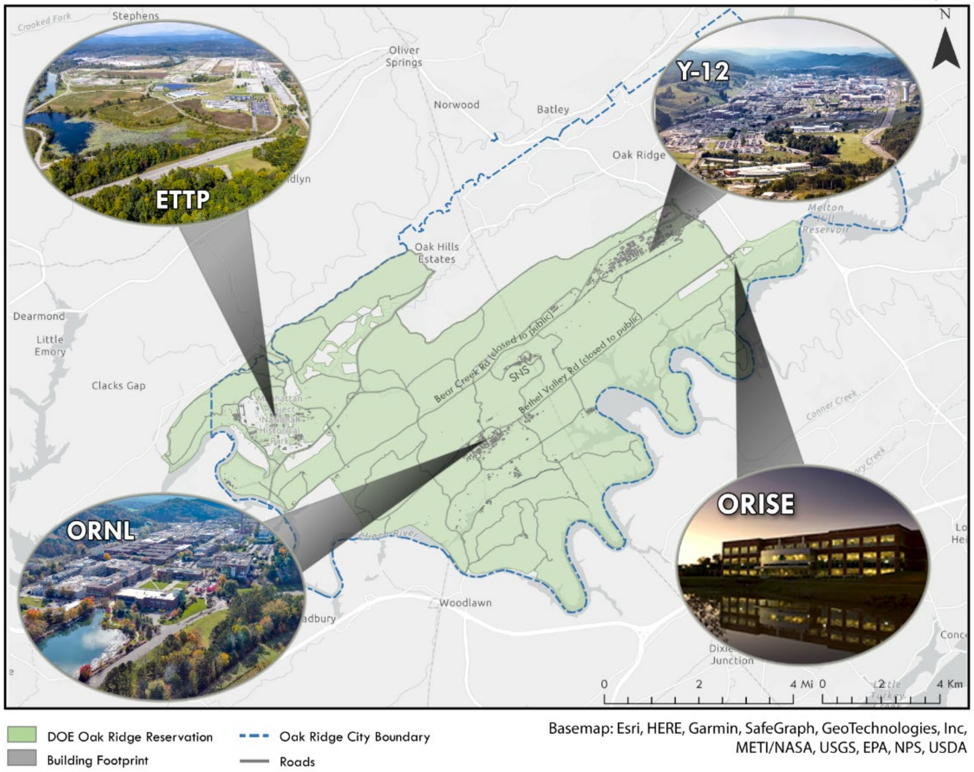


Acronyms:

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

Isotek has been responsible for Building 2026 since May 2017. Isotek finished processing ^{233}U material inside glove boxes in Building 2026 in 2021. Processing the remaining ^{233}U inventory began in 2022 and is expected to be completed in 2030. This work is performed in shielded hot cells because of the high radiation levels of the material and produces a solidified, low-level radioactive waste (LLW) form that is acceptable for disposal. Additionally, Isotek is extracting ^{229}Th from the ^{233}U 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). UCOR activities at ORNL include 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 2024 Cleanup Progress: Annual Report on Oak Ridge Reservation Cleanup* (UCOR 2024) **here** provides detailed information on UCOR activities at ORNL.

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 Innovation and Development 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. 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 Innovation and Development 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 the CFTF 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

ORNL prioritizes demonstration of environmental excellence through high-level policies that clearly state expectations for continual improvement and compliance with regulations and other requirements. 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. The UT-Battelle and Isotek EMSs are discussed in the following sections, and the UCOR EMS is discussed in Chapter 3.

5.2.1. UT-Battelle Environmental Management System

UT-Battelle's contract with DOE requires an EMS designed to comply with all applicable requirements and to improve ORNL's environmental performance continually. Annual internal independent audits are performed to confirm that the UT-Battelle EMS conforms to the ISO 14001:2015 framework.

UT-Battelle's EMS is a fully integrated set of environmental management services for UT-Battelle activities and facilities. Services include pollution prevention, waste minimization, 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 protect 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 **here**, includes expectations and commitments to continual improvement 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 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; and waste acceptance criteria. UT-Battelle has established procedures to ensure that all applicable requirements are reviewed and that changes and updates are communicated to staff and 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 laboratory-level and line organization–level objectives that support the laboratory mission and, where practical, are measurable.

UT-Battelle programs

UT-Battelle has established an organizational structure to ensure that environmental programs are led by experts in environmental protection and compliance, energy and resource conservation, waste minimization, pollution prevention, and waste management and to ensure that laboratory activities are conducted in accordance with the environmental policy (see Section 5.2.1.2). Information on UT-Battelle's 2024 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:

- Waste management staff manage recycling and waste minimization programs and work with other staff to reduce waste generation.
- Radiological engineering staff provide radiological characterization support to generators and waste services representatives, develop tools to help ensure compliance with facility safety and transportation requirements, and provide packaging support.
- Waste acceptance and disposition staff review and approve waste characterization methods, accept waste from generator areas into Transportation and Waste Management Division storage areas, review waste disposal paperwork to ensure compliance with the disposal facility's waste acceptance criteria, certify waste packages, and coordinate off-site disposition of UT-Battelle's newly generated waste.
- Waste services 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- 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. Operational Efficiency and Energy Management Overview

The Facilities and Operations Directorate at ORNL manages an extraordinary set of distinctive scientific facilities, systems, and equipment for DOE. ORNL's vast portfolio of research facilities must be maintained and upgraded to protect the country's investment in scientific analysis. Designed to ensure the reliability and maintainability of these complex scientific facilities and systems, the Facilities and Operations Directorate's operational processes enable more effective and efficient execution of ORNL's science and technology mission. Implementing efficient operational practices involves identifying opportunities to continually improve operational results and remaining diligent in energy and environmental stewardship.

ORNL is expected to contribute toward DOE initiatives, including those directed by 42 U.S.C. 17143, "Government Efficiency Status Reports," and to identify strengths that can potentially be adapted as agencywide best practices. Other federal laws covering the operational efficiency of government-owned facilities include the Energy Independence and Security Act of 2007 (EISA 2007), Section 432, "Management of Energy and Water Efficiency in Federal Buildings," whose reporting requirements are summarized **here**; the Energy Act of 2020 (EAct 2020), Section 1002, "Use of Energy and Water Efficiency Measures in Federal Buildings," whose requirements for energy and water efficiency measures are summarized **here**; and 42 U.S.C. 8253, "Energy and Water Management Requirements."

Considerable progress has been made toward reducing ORNL's energy use by targeting readily applied energy conservation measures (ECMs) in existing buildings. As these opportunities become less prevalent, ORNL projects with the potential to reduce energy consumption will need to be identified and evaluated on several operational efficiency priorities, including energy, water, and cost savings from ECMs and enhanced operational resilience.

ORNL continues to promote awareness of energy efficiency and to incorporate it in daily operations. It is important that all decision-making processes include energy efficiency considerations and life cycle cost analyses.

Operational efficiency and energy reporting

DOE compiles consolidated annual government efficiency reports (available **here**) covering the status of DOE's implementation of initiatives to improve energy efficiency, reduce energy costs, and provide savings for US taxpayers. Performance data from each DOE site are combined to show the progress of each program office and comprehensive progress for the agency. As part of this effort, ORNL provides annual performance data capturing energy usage and progress on initiatives for entry into DOE reporting systems. In addition to providing information on energy usage, these data provide an overview of ORNL's planned actions and of efforts and accomplishments during the reporting period. Table 5.1 summarizes operational efficiency progress and performance data for DOE goals related to energy and water management, waste avoidance, and utility savings.

To implement operational efficiency goals at ORNL, UT-Battelle identifies opportunities for continuous improvement in operational and business processes, implements practices to maximize the return on investment in modernizing facilities and equipment, and reports information about initiatives and energy use data to the DOE Office of Asset Management. The Office of Asset Management assists program offices in safeguarding their missions, freeing up resources by reducing waste, avoiding excess expenditures on utilities, maximizing productivity, and improving the efficiency of facilities and processes. By focusing on mission needs, programs and associated DOE sites can help the agency meet efficiency and savings goals outlined in federal statutory and regulatory requirements. Updates in annual reporting directions help minimize and streamline reporting and address updated federal requirements and DOE priorities.

Table 5.1. ORNL FY 2024 performance status and planned actions and contributions

DOE goal	Current performance status	Planned actions and contribution
	Energy management	
Reduce energy intensity (British thermal units per gsf) in goal-subject buildings by 50% by the end of FY 2030.	ORNL's FY 2024 calculated EUI was 250,387 Btu/gsf. This is a cumulative reduction of 31.2% since FY 2003 and a reduction of 39.1% from the FY 2021 baseline but is an increase of 5.42% from FY 2023. ORNL continues to improve identification of energy-consuming facilities as the mission expands.	Continued EUI reduction for goal-subject facilities is seen as attainable by concentrating on the best mix of ECM projects for energy savings and by identifying and prioritizing maintenance issues, including some that may have energy efficiency impacts on buildings.
Perform EISA Section 432 continuous (4-year cycle) energy and water evaluations.	In FY 2024, ORNL started the fourth year of the 4-year energy audit cycle by conducting 21 building audits throughout the year to cover a quarter of the buildings that are qualified for audit inclusion.	In FY 2025, ORNL will start the first year of a new 4-year energy audit cycle. ORNL will continue to use the building energy audit evaluation tool and conduct FCAs.
Meter individual buildings for electricity, natural gas, steam, and water to adhere to federal metering guidance.	In FY 2024, ORNL added 27 new advanced utility meters (including computational and electrical utility distribution meters), migrated one new data stream from other systems across the lab, and replaced seven meters. ORNL meter installations have included electrical, steam/hot water, natural gas, chilled water, and potable water.	ORNL will continue to use the metering–tracking process for guidance in the installation of additional advanced utility meters on all utilities per new federal metering guidance.
	Water management	
Reduce potable water use intensity (gallons per gsf).	Annual water consumption resulted in a WUI of 155.7 gal/gsf in FY 2024, which is an increase of 5.0% from FY 2023 and is 15.0% higher than the FY 2021 baseline. (The target is a 50% reduction by FY 2030.) Continued improvements in the identification of water-consuming facilities yielded a 2.8% 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 the growth of high-performance computing systems. 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 focus on water management best practices to meet future WUI reduction goals.
	Fleet management	
Increase alternative fuel consumption.	Presently, 80% of all ORNL vehicles are AFVs, and 86% of all replacements since FY 2020 have been AFVs or EVs. Also, 77% of light-duty vehicles operate on alternative fuels.	ORNL will continue to align its use of AFVs with statutory and regulatory requirements and guidance.
	Investments: improvement measures, workforce, and community	
Implement life cycle cost-effective efficiency and conservation measures with appropriated funds and/or performance contracts.	DOE has an ESPC with JCI for ORNL. The delivery order was awarded on July 31, 2008. It includes ECMs consisting of steam system decentralization, building management system improvements, advanced meter installations, energy-efficient lighting upgrades, and domestic water conservation.	ORNL's ECMs need to be evaluated to determine which are life cycle cost-effective. Those found to be so need to be funded and implemented to the maximum extent possible with approved funding. ORNL plans on expanding the auditing process and integrating this process with the FCAs. ORNL will then continue to investigate the best potential funding strategies as the life cycle cost-effective ECM list grows.

Table 5.1. ORNL FY 2024 performance status and planned actions and contributions (continued)

DOE goal	Current performance status	Planned actions and contribution
	Electronic stewardship	
Increase acquisition of certified electronics and promote operational efficiencies 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 eligible IT devices. 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. No obstacles to the goal are foreseen.

Acronyms:

AFV = alternative fuel vehicle

DOE = US Department of Energy

ECM = energy conservation measure

EISA = Energy Independence and Security Act of 2007

ESPC = Energy Savings and Performance Contract

EUI = energy use intensity

EV = electric vehicle

FCA = facility condition assessment

FY = fiscal year

gsf = gross square feet

JCI = Johnson Controls Inc.

ORNL = Oak Ridge National Laboratory

WUI = water use intensity

Monitoring and assessments of utility consumption and costs

The foundation of the ORNL energy management program is the comprehensive understanding of utility consumption obtained through ongoing monitoring and assessments of all energy and water usage. Site utilities include electrical power, natural gas, fuel oil, steam, chilled water, and potable/process water to support ORNL's mission and research programs. ORNL's utility consumption and costs reflect various research and support facilities on the ORNL main campus, including those owned by the DOE Office of Science and OREM; the Spallation Neutron Source (SNS) site; and leased spaces, primarily NTRC at the HVC. Table 5.2 outlines ORNL's utility consumption and costs for fiscal year (FY) 2024.

Table 5.2. ORNL FY 2024 utility consumption and costs

Utility	Consumption	Cost
Electricity	564,744 MWh	$35,815,000
Natural gas	635,285 MCF	$3,812,000
Fuel oil	56 kgal	$164,000
Potable water	693.074 Mgal	$1,386,000

Acronyms:

FY = fiscal year

ORNL = Oak Ridge National Laboratory

MCF = thousand cubic feet

Figure 5.2 breaks down ORNL's energy consumption for FY 2024. Electricity, including that used for basic power needs, chilled water service, and direct cooling applications, accounted for 74.5 percent of ORNL's total energy consumption. Electricity dominated ORNL's energy consumption primarily because of high-energy mission-specific facilities, which house critical, energy-intensive operations that create unique energy efficiency challenges. Electricity accounts for 87 percent of the utility provider commodity budget at ORNL.

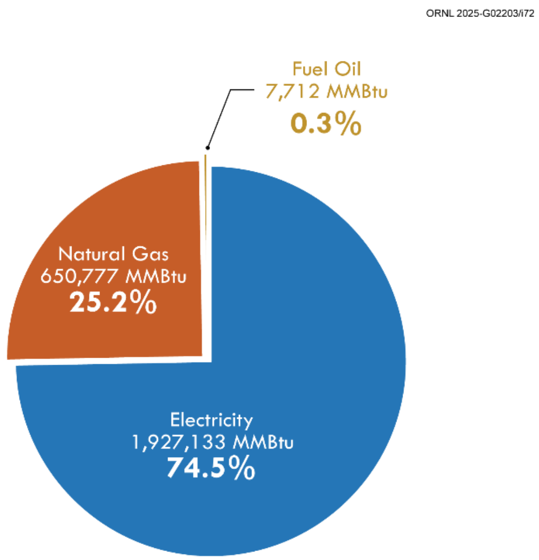


Figure 5.2. FY 2024 total energy consumption breakdown

Heating energy generated from natural gas and fuel oil accounted for 25.2 and 0.3 percent, respectively, of energy consumption at ORNL in FY 2024. Natural gas is the primary fuel used for steam generation at the ORNL main campus steam plant and the Melton Valley Steam Plant and for hot water generation at the Central Utilities Building supporting SNS. Natural gas is also used in direct heating and research applications. Fuel oil is used for steam generation during curtailment and maintenance periods and for heating at the Energy System Test Complex.

ORNL will continue to analyze building operations data from existing systems, including the building automation system and metering systems, to identify opportunities for enhancing operational efficiency. New sensors and meters will be added in strategic locations, and new capabilities will be built out in existing systems or layered with new systems, as necessary. ORNL will focus on developing tools for operations staff to maintain building systems in a way that supports reliability, meets the needs of building occupants, and achieves energy efficiency. The Utilities Division will continue to evaluate utility systems for opportunities to improve operations, improve reliability, and reduce maintenance costs. The knowledge gained by analyzing past and current energy consumption will better position ORNL to develop plans for improving energy efficiency and reducing greenhouse gases in facility operations.

Facility metering

Meters are used to track the use of energy, fuel, and water for various data-reporting requirements and to help identify problems and potential conservation opportunities throughout the ORNL campus. In FY 2024, ORNL added 27 new advanced utility meters (including computational meters and electrical utility distribution meters), migrated 1 new data stream from other systems across the lab, and replaced 7 meters. Meters have been installed at ORNL for electrical, steam/hot water, natural gas, chilled water, and potable water systems. The meters were connected to ORNL's Central Energy Data System (CEDS), a network of systems used for data archiving and analysis. CEDS securely collects, archives, and displays advanced utility meter data from the network of utility meters installed throughout the laboratory. CEDS logs multiple parameters from each meter on a standard 15 min interval. This system also enables trend analysis and consumption reporting and includes an energy awareness dashboard. Data can be exported from CEDS for use in other analyses.

One of the tools used in CEDS is Resource Advisor. Resource Advisor's advanced configuration capabilities have been used to easily calculate and quickly display total building energy consumption using data from the advanced utility meters. Resource Advisor includes a comprehensive dashboard and energy analysis capabilities that support ORNL's continued maturation in energy data utilization. Resource Advisor also directly feeds metered energy data into ENERGY STAR for benchmarking.

Energy savings performance contracts

An energy savings performance contract (ESPC) between ORNL and Johnson Controls Inc. (JCI) has been the primary mechanism for achieving the goals established to comply with Energy Policy Act of 2005 (EPAct 2005) directives. A delivery order with JCI was awarded in July 2008 and accepted in

July 2012 and has created opportunities for ORNL to deepen its experience in performance contracting and to better understand the most effective use of ESPCs. Total ESPC savings of $13,696,000 were realized in the 11th year of the contract and included $10,507,000 (762 million Btu) of electricity, natural gas, and fuel oil savings; $449,000 (197 million gal) of water savings; and $2,740,000 of operations and maintenance savings.

As part of the ESPC, a dual-fuel natural gas/fuel oil boiler replaced the biomass gasification system and became operational in FY 2016. The new boiler has reduced natural gas and fuel oil consumption. Steam distribution decentralization and steam production efficiency improvements have further improved ORNL's steam service and reliability.

Other ESPC improvements include lighting upgrades and water conservation measures. Equipment upgrades, a building management system, and modernized HVAC control systems provide the means to significantly reduce or eliminate energy-intensive simultaneous heating and cooling in several large air-handling units.

In accordance with the ORNL–JCI ESPC, measurement and verification (M&V) of the ECMs completed under the contract are ongoing. JCI employs an on-site performance assurance engineer who leads the M&V effort. M&V activities are reviewed by the ORNL DOE Site Office contracting officer's representative, who obtains input from UT-Battelle staff. JCI holds monthly ESPC performance reviews with ORNL DOE Site Office management and ORNL personnel. The same parties conduct an annual M&V report review and comment resolution process.

Pollution prevention and waste minimization

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 implementing controls to limit use, procuring alternative materials, and using recycling processes to mitigate the environmental impact. These efforts comply with state and federal regulatory requirements. Efficient waste minimization is integrated across ORNL by procuring and using sustainable products.

During 2024, UT-Battelle implemented 28 ongoing and new waste minimization and pollution prevention projects. These cost-effective projects and ongoing reuse and recycle efforts eliminated more than 2.6 million kg of waste. Researchers at ORNL implement traditional recycling options when feasible and investigate new options when a need is identified.

Efforts to 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. Furthermore, training and outreach encourage source reduction and recycling by all associates. ORNL shares the lessons learned from its waste minimization successes with other DOE sites and the public through several avenues, including its public website, ORR virtual and in-person meetings, DOE-organized webinars and meetings, and appropriate external conferences.

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

EISA Section 438 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 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. When possible, this 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 that manage runoff, filter pollutants, and slow down water flow from developed areas can be installed, potentially reducing the overall need for downstream water quality structures and devices.
- Individual projects are not burdened with the costs associated with addressing EISA-438 requirements.

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.

In 2024, 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 EMS performance. 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 is identified, the ORNL issues management process requires identifying the cause and developing corrective and/or preventive actions. These actions are then 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 2024 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 2024, UT-Battelle, UCOR, and Isotek operations were conducted to comply with contractual and regulatory environmental requirements. Table 5.3 summarizes environmental audits conducted at ORNL in 2024. The following discussions summarize the major environmental programs and activities carried out at ORNL during 2024 and provide an overview of the compliance status for the year. Summary information on 2024 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 5.4 lists the environmental permits that were in effect in 2024 at ORNL.

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 5.5 summarizes NEPA activities conducted at ORNL during 2024.

During 2024, 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 5.3. Summary of regulatory environmental audits, evaluations, inspections, and assessments conducted at ORNL, 2024

Date	Reviewer	Subject	Issues
March 4–5	TDEC	Hazardous Waste Compliance Evaluation Inspection (including UT-Battelle, TWPC, and UCOR)	0
March 26	City of Oak Ridge	CFTF Wastewater Pretreatment Permit Inspection	0
April 3	KCDAQM	Hardin Valley Campus Clean Air Act Inspection	0
September 23	City of Oak Ridge	CFTF Wastewater Pretreatment Permit Inspection	0
August 9	TDEC	TWPC Clean Air Act Inspection	0
December 4	TDEC	Clean Air Inspection for ORNL	0

Acronyms:
CFTF = Carbon Fiber Technology Facility
KCDAQM = Knox County Department of Air Quality Management
ORNL = Oak Ridge National Laboratory
TDEC = Tennessee Department of Environment and Conservation
TWPC = Transuranic Waste Processing Center
UCOR = United Cleanup Oak Ridge LLC

Table 5.4. Environmental permits in effect at ORNL, 2024

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	22-0941R2	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
CAA	Construction Permit, NTRC[a]	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

Table 5.4. Environmental permits in effect at ORNL, 2024 (continued)

Regulatory driver	Permit title/description	Permit number	Owner	Operator	Responsible contractor
CAA	Construction Permit, ^{233}U Processing at Building 2026	982390	DOE	Isotek	Isotek
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[a]	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	General NPDES Permit for Storm Water Discharges Associated with 1000 Area Parking Lot Improvements	TNR137699	DOE	UT-B	UT-B
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

Table 5.4. Environmental permits in effect at ORNL, 2024 (continued)

Regulatory driver	Permit title/description	Permit number	Owner	Operator	Responsible contractor
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	General NPDES Permit for Storm Water Discharges Associated with Graphite Reactor and 2040 Parking Lot Improvements	TNR137673	DOE	UT-B	UT-B
CWA	General NPDES Permit for Storm Water Discharges Associated with Spallation Neutron Source Second Target Station	TNR137697	DOE	UT-B	UT-B
CWA	General Permit for Minor Alterations to Wetlands (installation of new fiber optic lines onto existing power poles—one of the power poles, Q011, is located within a wetland)	ARAP-NR2403.026	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 2024.*

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

Table 5.5. National Environmental Policy Act activities, 2023–2024

Types of NEPA documentation	Number of instances
UT-Battelle, LLC	
Environmental assessments	0
Approved under general actions or generic CX determinations[a]	152
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

UCOR = United Cleanup Oak Ridge LLC

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 establishes 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 Tennessee Department of Environment and Conservation (TDEC) Division of Air Pollution Control. The most recent sitewide UT-Battelle Title V Major Source Operating Permit was issued in 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 2024), 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 the CFTF are two off-site CAA-regulated facilities maintained and operated by UT-Battelle. In December 2022, Knox County issued an operating permit 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 2024. Section 5.4. provides detailed information on 2024 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 programs, storm water management program, Section 404 dredge or fill discharge program, biosolids program, and oil spills and spill prevention program.

As part of the CWA, EPA developed the NPDES permit program to address water pollution by regulating point sources that discharge pollutants to US waters. (See Appendix C for water quality reference standards.) 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 2024, compliance with the ORNL NPDES permit was calculated based on a total of 1,736 laboratory analyses and field measurements. The wastewater treatment facilities achieved a numeric permit compliance rate of 100 percent in 2024 (see Table 5.6). The CFTF also achieved 100 percent compliance with the UT-Battelle City of Oak Ridge Industrial and Commercial User Discharge Pre-Treatment Permit in 2024.

Table 5.6. National Pollutant Discharge Elimination System (TN0002941) compliance at ORNL, January through December 2024

Effluent parameters[a]	Number of numeric noncompliances	Number of compliance measurements[b]	Compliance rate (%)[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	26	100
Ammonia, as N (winter)	0	27	100
Carbonaceous biological oxygen demand	0	52	100
Dissolved oxygen	0	52	100
Escherichia coliform (col/100 mL)	0	53	100
Peracetic acid	0	0	100
pH (standard units)	0	52	100
Total suspended solids	0	53	100

Table 5.6. National Pollutant Discharge Elimination System (TN0002941) compliance at ORNL, January through December 2024 (continued)

Effluent parameters[a]	Number of numeric noncompliances	Number of compliance measurements[b]	Compliance rate (%)[c]
	X12 (Process Waste Treatment Complex)		
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 an approved method for the given parameter.*
[c] *Compliance rate = 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, published on December 27, 2021, requires sample collection and analyses for 30 chemical contaminants between 2023 and 2025 using methods developed by EPA and consensus organizations. Sample collection at ORNL for the fifth Unregulated Contaminant Monitoring Rule 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. No sampling was required in 2024.

EPA issued a new lead and copper rule for water systems that became final on December 17, 2021. In accordance with 40 CFR 141.86, the rule required that lead service line inventories be developed for all drinking water systems and submitted to TDEC no later than October 16, 2024. Potential lead exposure risk notices for facility service lines that were not identified and were assigned an *unknown* status in the lead service line inventory were sent to facility managers by November 15, 2024. TDEC is expected to provide further information and incorporate additional new rules regulating lead and copper.

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. The City of Oak Ridge is currently managing the construction of a new water treatment plant to replace the antiquated water treatment plant currently in service.

In 2024, sampling results for ORNL's water system residual chlorine levels, bacterial constituents, disinfectant by-products, and lead and copper were all within acceptable limits.

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 2024, 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 2024.

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 5.7. In 2024, 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 2024 was 544,316 kg, of which 169,234 kg was mixed wastewater.

ORNL generators treated 3,374 kg of hazardous waste by elementary neutralization. The quantity of hazardous/mixed waste treated in permitted treatment facilities at ORNL in 2024 was 169,740 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 2024, 360,806 kg of hazardous/mixed waste was shipped off-site to commercial treatment, storage, and disposal facilities.

In March 2024, 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 and annual progress report, updated March 2023
- *2023 Hazardous Waste Annual Report*
- Active mutual aid agreements and memorandums of agreement with local authorities
- Waste determination records
- RCRA records

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

Table 5.7. ORNL Resource Conservation and Recovery Act operating permits, 2024

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.*

In June 2023, DOE and UT-Battelle operations at the HVC changed generator category from a very small quantity generator to small quantity generator. The 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 the HVC. During 2024, the HVC generated 3,157 kg of hazardous waste and shipped 3,175 kg of hazardous waste for treatment and disposal.

The CFTF was categorized as a very small quantity generator in 2024, meaning that less than 100 kg of hazardous waste was generated per month.

In 2024, 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 2024 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 and DOE in January 2025.

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 conducted a compliance inspection on December 12, 2024, and a minor violation was issued. The violation was immediately resolved and was closed by TDEC on January 14, 2025.

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 2024, ORNL contractors operated four 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 2024.

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 5.8 describes the main elements of EPCRA. UT-Battelle complied with these requirements in 2024 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 2024, 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 5.8. Main elements of the Emergency Planning and Community Right-to-Know Act

Title	Description
Sections 302 and 303, Planning Notification	Requires that the 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 and 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 Sections 311 and 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 2024, 46 hazardous and 11 extremely hazardous substances at ORNL met EPCRA reporting criteria.

Private-sector lessees were not included in the 2024 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.

The ORNL chemical safety SME participated in a Battelle environmental subgroup meeting in March 2024 to discuss and benchmark the participating sites' chemical management systems. ORNL qualified health and safety professionals also participated in the 2024 spring and fall Energy Facility Contractors Group Industrial Hygiene, Safety, and Chemical Management conferences, which provided opportunities to share information and lessons learned.

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 into the environment and/or managed through recycling, energy recovery, and treatment. (A release of a chemical means that it is emitted into 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, processed, or otherwise used. Releases and other waste management activities were determined for each chemical that exceeded one or more threshold.

In 2024, 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 2024, UT-Battelle personnel had 31 permits and agreements for the receipt, movement, or controlled release of regulated articles.

5.3.12. Wetlands

Wetland delineations facilitate compliance with TDEC and US Army Corps of Engineers wetland protection requirements. In 2024, two wetlands were delineated on the ORNL campus to ensure project activities did not have negative impacts on wetlands. One was included in an Aquatic Resource Alteration Permit.

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 into 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 is known and that the item 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 (canceled 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 2024, UT-Battelle cleared more than 20,891 items through the excess items and property sales processes. A summary of items requested for release through these processes is shown in Table 5.9.

Table 5.9. Excess items requested for release or recycling, 2024

Item	Process knowledge	Radiologically surveyed
Release request totals for 2024		
Totals	19,537	1,354
Recycling request totals for 2024		
Cardboard (lb)	377,096	
Scrap metal (nonradiological areas) (tons)	567.2094	

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 for releasing neutron scattering experiment samples to researchers without further DOE control.

In 2024, ORNL cleared a total of 11 samples from neutron scattering experiments using the sample authorized limits release process. Five samples were released from SNS, and six samples were released from HFIR.

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 2024 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, 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 2024, no permit limits were exceeded. Isotek has a Title V Major Source Operating Permit (576448) for the Radiochemical Development Center (Building 3019 Complex). During 2024, 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 2024, 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 have 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 2024, no deviations or releases of reportable quantities of asbestos-containing material occurred.

In 2024, activities related to the Asbestos Management Program included the following:

- One Notification of Demolition and/or Asbestos Renovation was submitted to TDEC in December 2024 for the "FY25 HFIR Shed Demo and Laydown Yard Cleanup Task" project, which included demolition work activities for Buildings 7986, 7980A, 7980B, and 0808T and three unnumbered sheds. This task did not involve regulated asbestos-containing materials, and an asbestos work authorization was not required.
- The Building 2523 laundry facility was demolished in accordance with CERCLA requirements. This demolition included the removal of 5 ft of regulated asbestos-containing materials and 330 ft^2 of Category I and II nonfriable materials such as window glazing, electrical wiring, caulking/filler materials, transite wall panels, and roofing materials.
- Revised friable asbestos removal annual estimates for calendar year 2024 were submitted on November 21, 2024. The revised estimates were 900 ft, 6 ft^2, and 18 ft^3.
- Estimates for calendar year 2025 friable asbestos removal (1,035 ft, 260 ft^2, and 50 ft^3) were submitted on December 12, 2024.
- During 2024, a total of 89 work authorizations for asbestos removal work activities were completed, primarily for asbestos 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, ^{3}H, adsorbable gases (e.g., iodine), and nonadsorbable gases (e.g., noble gases).

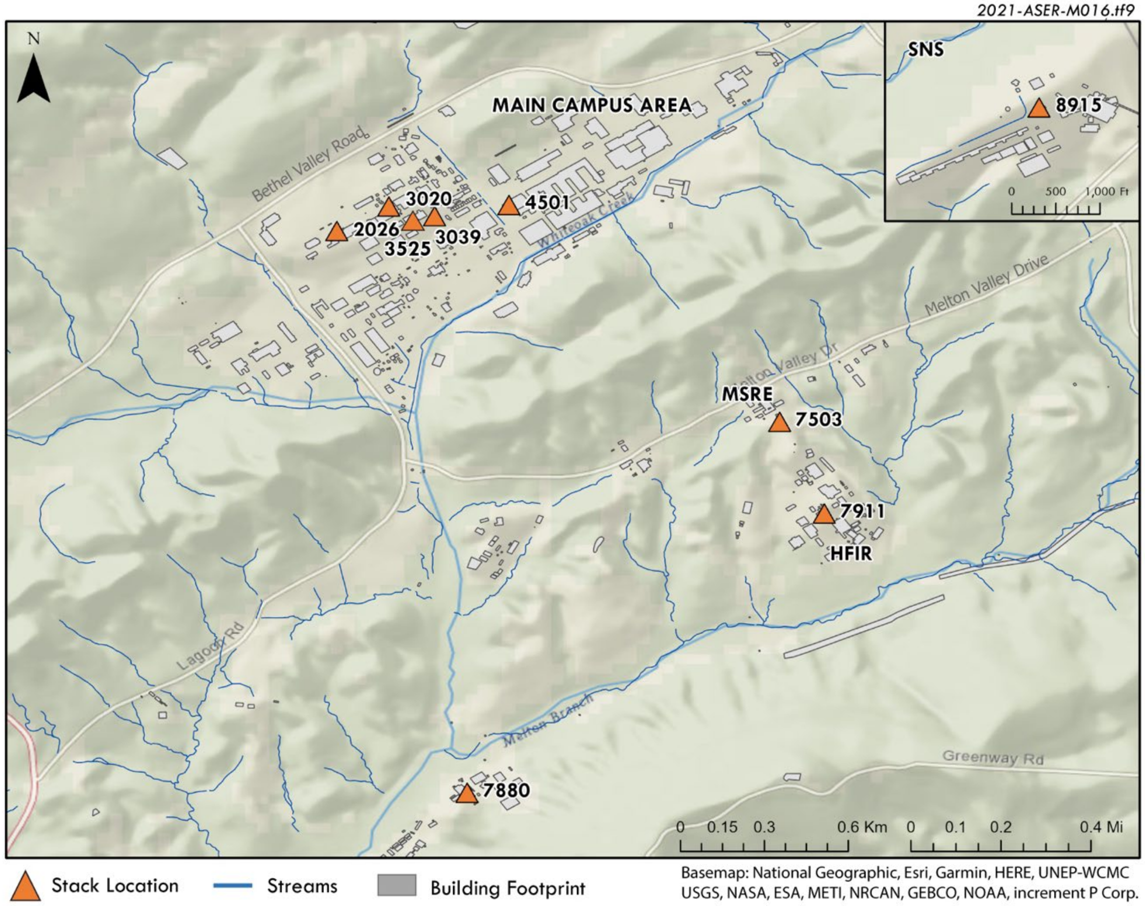
The major radiological emission point sources for ORNL consist of the following nine stacks. Seven are located in Bethel and Melton Valleys, and one, the SNS Central Exhaust Facility stack, is located on Chestnut Ridge (Figure 5.3):

- 2026 Radioactive Materials Analytical Laboratory
- 3020 Radiochemical Development Facility
- 3039 central off-gas and scrubber system, which includes the 3025/3026 cell ventilation system, 3042 ventilation system, and 3092 central off-gas system
- 3525 Irradiated Fuels Examination Laboratory area 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 2024, emission calculations/estimates were made for each of the 15 minor point/group sources.

ORNL 2025-G02288/i72
2021-ASER-M016.tf9



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

Figure 5.3. Locations of major radiological emission points at ORNL, 2024

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), 3525 (Irradiated Fuels Examination 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, 3525, 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., ^{41}Ar) in the effluent stream. The 7880 sampling system consists of a stainless-steel-shrouded probe, an in-line filter cartridge holder placed at the probe to minimize line losses, a particulate filter, a sample transport line, a rotary vane vacuum pump, and a return line to the stack. The sample probes from both the ANSI 1969 and ANSI 1999 stack-sampling systems are removed, inspected, and cleaned annually.

The 8915 (SNS Central Exhaust Facility) 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 implemented 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 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 has been used for subsequent emission calculations. In addition to the major sources, ORNL has several minor sources that have the potential to emit radionuclides into 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 analyses of the charcoal samples are performed weekly to biweekly to quantify the adsorbable gases.

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, and contaminant deposits are not expected to collect on the scintillator probe. A probe-cleaning program for 7880 has established that rinse analysis has historically shown 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.

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 2024 are presented in Appendix G.

Historical trends for ^{3}H and ^{131}I are presented in Figures 5.4 and 5.5. For 2024, ^{3}H emissions totaled about 1,001 Ci (Figure 5.4), comparable to what was seen in 2023; ^{131}I emissions totaled 0.07 Ci (Figure 5.5), a decrease from what was seen in 2023. For 2024, of the 320 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 69 percent, and ^{237}Np, which contributed about 11 percent to the total ORNL dose.

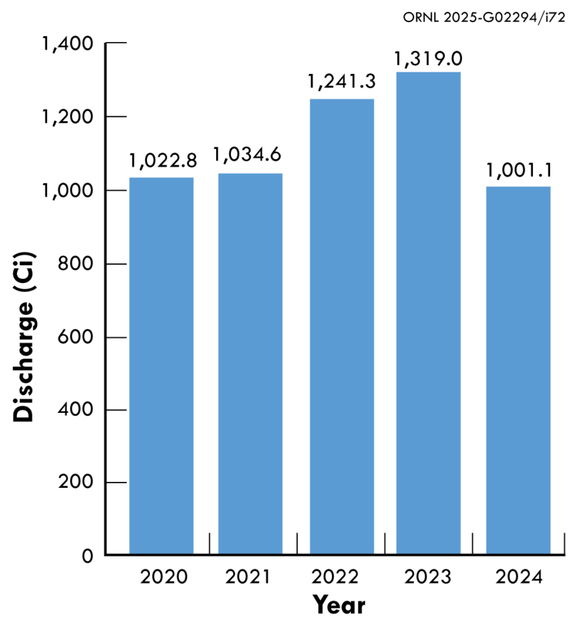


Figure 5.4. Total curies of ^{3}H discharged from ORNL to the atmosphere, 2020–2024

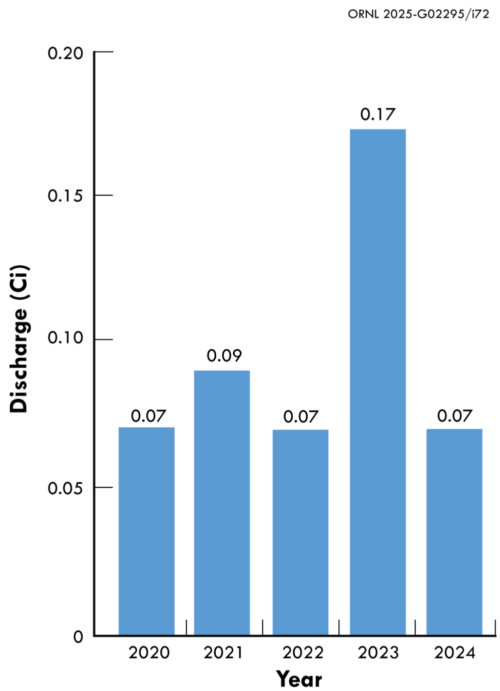


Figure 5.5. Total curies of ^{131}I discharged from ORNL to the atmosphere, 2020–2024

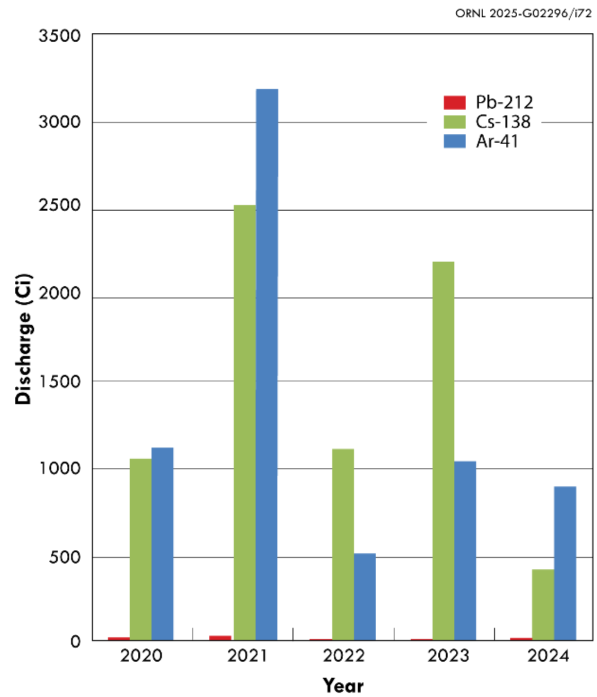


Figure 5.6. Total curies of ^{41}Ar, ^{138}Cs, and ^{212}Pb discharged from ORNL to the atmosphere, 2020–2024

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 $^{232/233}U$. Emissions of ^{212}Pb were from the following stacks: 2026, 3020, 3039, 3525, 4501, 7503, 7856, 7911, and 4000 area laboratory hoods. Emissions of ^{237}Np result from 3000, 4000, and 7000 area laboratory hood research activities. For 2024, ^{212}Pb emissions totaled 12.46 Ci, ^{138}Cs emissions totaled 412.0 Ci, and ^{41}Ar emissions totaled 891.3 Ci (Figure 5.6).

The calculated radiation dose to the maximally exposed individual from all radiological airborne release points at ORR during 2024 was 0.6 mrem. The dose contribution to the maximally exposed individual from all ORNL radiological airborne release points was 13 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. Regulations of substitutes for ozone-depleting substances are included in 40 CFR 82 Subpart F. In 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 and purchase of hydrofluorocarbon-containing appliances are being tracked to remain in compliance with the AIM Act phasedowns in accordance with 40 CFR 84 Subparts B and C.

5.4.5. Ambient Air

Station 7 in the ORNL 7000 maintenance area is the site-specific ambient air monitoring location. During 2024, 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 an annual composite was submitted 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 5.10) were compared with the derived concentration standards (DCSs) for air established by DOE as guidelines for controlling exposure to members of the public (DOE 2021). During 2024, average radionuclide concentrations at Station 7 were less than 1 percent of the applicable DCSs in all cases.

Table 5.10. Radionuclide concentrations measured at ORNL air monitoring Station 7, 2024[a]

Parameter	Concentration (pCi/mL)[b]
Alpha	7.4×10^{-9}
^{7}Be	2.3×10^{-8}
Beta	3.1×10^{-8}
^{40}K	-2.3×10^{-9}
^{3}H[c]	9.1×10^{-6}
$^{233/234}U$	3.4×10^{-11}
$^{235/236}U$	1.7×10^{-12}
^{238}U	3.0×10^{-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 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 watersheds.

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 in the permit. 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 5.6). Compliance with permit limits for ORNL wastewater treatment facilities was 100 percent in 2024.

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.

Toxicity test requirements under the current NPDES permit include annual testing for chronic toxicity from the ORNL STP and PWTC. In 2024 no toxicity was observed in any of the tests at either of the wastewater treatment facilities.

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 2024, TRO levels were 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 396 TRO measurements were taken at 26 locations, in addition to 288 semimonthly instream measurements. TRO levels at or above the end-of-pipe action level were detected on 33 occasions during 2024 but were never detected at any of the 12 instream monitoring points (Table 5.11).

Table 5.11. Overview of 2024 chlorine control strategy

Total residual oxidant sampling events	684
Below detection (<0.05 mg/L)	606
Instream total residual oxidant exceedances	0
Outfall detections	33
Outfall action level detections (>1.2 g/day)	33
Number of outfalls with action level detections	9

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 5.12 summarizes 2024 TRO detections greater than 1.2 g/day and any additional investigation actions or repairs.

Table 5.12. Total residual oxidant mitigation summary: emergency repairs, 2024

Outfall	Date	TRO (mg/L)	Flow (gpm)	Load (g/day)	Receiving stream	Downstream water kilometer	Downstream instream monitoring point	Source/notes/actions
210	1/4/2024	0.84	40	183.15	WOC	WCK 4.1	X18	Once-through cooling liquid dechlorination system was inoperable in the first half of 2024 due to pump failure. Dechlorination was facilitated with sodium sulfite tablets until the pump was returned to service.
210	1/29/2024	1.13	25	153.99	WOC	WCK 4.1	X18	
210	2/15/2024	1.96	30	320.52	WOC	WCK 4.1	X18	
210	3/4/2024	1.55	30	253.47	WOC	WCK 4.1	X18	
210	4/18/2024	1.37	12	89.61	WOC	WCK 4.1	X18	
210	6/20/2024	1.28	25	174.43	WOC	WCK 4.1	X18	
211	7/24/2024	0.4	45	98.12	WOC	WCK 4.4	X22	Once-through cooling water is present in this drainage network. Flows are dechlorinated at the end of the pipe with tablets. Source investigations are underway in this drainage network due to the unusual trend in detections.
211	2/22/2024	1.1	50	299.80	WOC	WCK 4.4	X22	
211	4/18/2024	0.37	40	80.67	WOC	WCK 4.4	X22	
211	5/10/2024	1.22	50	332.51	WOC	WCK 4.4	X22	
211	5/23/2024	0.58	50	158.08	WOC	WCK 4.4	X22	
211	6/14/2024	1.5	40	327.06	WOC	WCK 4.4	X22	
211	6/20/2024	0.34	60	111.20	WOC	WCK 4.4	X22	
211	7/15/2024	0.9	40	196.24	WOC	WCK 4.4	X22	
211	7/22/2024	1.19	50	324.33	WOC	WCK 4.4	X22	
211	8/1/2024	1.43	45	350.77	WOC	WCK 4.4	X22	
211	8/26/2024	1.4	45	343.41	WOC	WCK 4.4	X22	
211	9/12/2024	0.98	40	213.68	WOC	WCK 4.4	X22	
211	10/17/2024	1.06	40	231.12	WOC	WCK 4.4	X22	
211	12/5/2024	0.2	30	32.71	WOC	WCK 4.4	X22	
211	12/19/2024	0.89	50	242.57	WOC	WCK 4.4	X22	
227	7/22/2024	1.18	50	321.61	WOC	WCK 4.4	X25	Cooling tower blowdown is discharged at this outfall. Dechlorination boxes were checked and adjusted.
227	10/28/2024	1.51	40	329.34	WOC	WCK 4.4	X25	

Table 5.12. Total residual oxidant mitigation summary: emergency repairs, 2024 (continued)

Outfall	Date	TRO (mg/L)	Flow (gpm)	Load (g/day)	Receiving stream	Downstream water kilometer	Downstream instream monitoring point	Source/notes/actions
231	11/25/2024	1.9	75	776.77	WOC	WCK 4.4	X25	Potassium bisulfite quill was replaced in the 5800X cooling tower dechlorination system.
267	6/14/2024	0.21	20	22.89	FFK	FFK 0.1	X20	Source is under investigation following potable water outages near Building 3144.
267	8/1/2024	0.19	30	31.07	FFK	FFK 0.1	X20	
267	12/5/2024	0.3	8	13.08	FFK	FFK 0.1	X20	
314	7/22/2024	30	0.31	50.69	WOC	WCK 4.4	X26	Dechlorination box was checked and adjusted.
314	12/5/2024	75	0.6	245.29	WOC	WCK 4.4	X26	
363	7/22/2024	45	0.74	181.52	FFK	FFK 0.1	X20	Cooling tower blowdown is discharged at this outfall. In both instances, high storm flows had washed out the backup dechlorination tablets, which were replaced.
363	12/19/2024	10	0.61	33.25	FFK	FFK 0.1	X20	
4510 Box (014)	6/14/2024	1.5	60	490.59	WOC	WCK 4.4	X23	Tablet box was adjusted.
4510 Box (014)	7/22/2024	2.24	50	610.51	WOC	WCK 4.4	X23	A defective foot valve was identified on the dechlorination chemical pump, which was repaired.

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 5.13 details the analyses performed on samples collected in 2024 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 2024, 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 2024 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 5.7). 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 2021). 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. 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 5.8).

In 2024, dry-weather discharges from Outfalls 304 and 085 had annual mean radioactivity concentrations greater than 100 percent of the DCS for $^{89/90}$Sr. Concentrations at Outfall 304 have historically been affected by pump failures in a groundwater suppression sump near the OREM low-level liquid waste tank WC-9, which is within a CERCLA soil and groundwater contamination area. When pump failures occur, contaminated groundwater in the WC-9 tank area can enter the Outfall 304 storm drain system. A second infrastructure issue, which had an even greater influence on Outfall 304 radiological concentrations, occurred in 2015. A leak developed in a pipe leading from Pump Station #2 in the process waste collection system to a downstream diversion box. A dye tracer test confirmed a hydraulic connection between the pipe and the storm water collection system that discharges through Outfall 304. The pipe was subsequently bypassed and taken out of service. Before the leaking pipe was bypassed, the $^{89/90}$Sr concentration at Outfall 304 peaked at 29,000 pCi/L in 2015, exceeding the DCS of 1,700 pCi/L. Since the bypass was implemented, $^{89/90}$Sr levels in the outfall effluent have trended downward. Concentrations of $^{89/90}$Sr rose above the DCS in early 2024 and remained there throughout the year. The reason for the increase is uncertain but is under investigation by UCOR.

Levels of radioactivity at Outfall 085 have been elevated since early 2015, when a water leak occurred in Building 7830A. The foundation drain for that building is connected to Outfall 085. The water leaked from a pipe in the building's fire suppression system that ruptured when it froze in the early morning hours of February 23, 2015. Leaked water is believed to have mobilized underground contamination to a location where it could enter the building foundation drain. Concentrations began declining in April 2015, and the rate of decline slowed in the latter part of 2016. Concentrations of $^{89/90}$Sr began to increase again in early 2024 and appear to have peaked in October 2024 at 4,400 pCi/L before declining to

3,300 pCi/L in December 2024. The cause of the increasing $^{89/90}Sr$ is not known but is under investigation by UCOR.

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 5.9 through 5.13. Because discharges of radioactivity are somewhat correlated to stream flow, annual flow volumes measured at the WOD monitoring station are given in Figure 5.14. Discharges of radioactivity at WOD in 2024 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).

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 5.15 depicts outfalls and associated storm drain connections that are 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 5.15) 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. Discharges from the foundation sumps in Buildings 4501 and 4500N and from the smaller sump in Building 4501 had also been rerouted to the PWTC along with the smaller sump and a 4500N foundation sump. 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 legacy 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.

Table 5.13. Radiological outfall and instream monitoring conducted at ORNL, 2024

Location	Frequency	Gross alpha/beta	Gamma scan	^{3}H	^{14}C	$^{89/90}Sr$	Isotopic uranium	Isotopic plutonium	^{241}Am	$^{243/244}Cm$	^{99}Tc
Outfall 001	Annually	X									
Outfall 080[a]	Annually										
Outfall 081	Annually	X		X							
Outfall 085	Monthly	X	X			X	X	X			
Outfall 203[a]	Annually										
Outfall 207	Monthly	X	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				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

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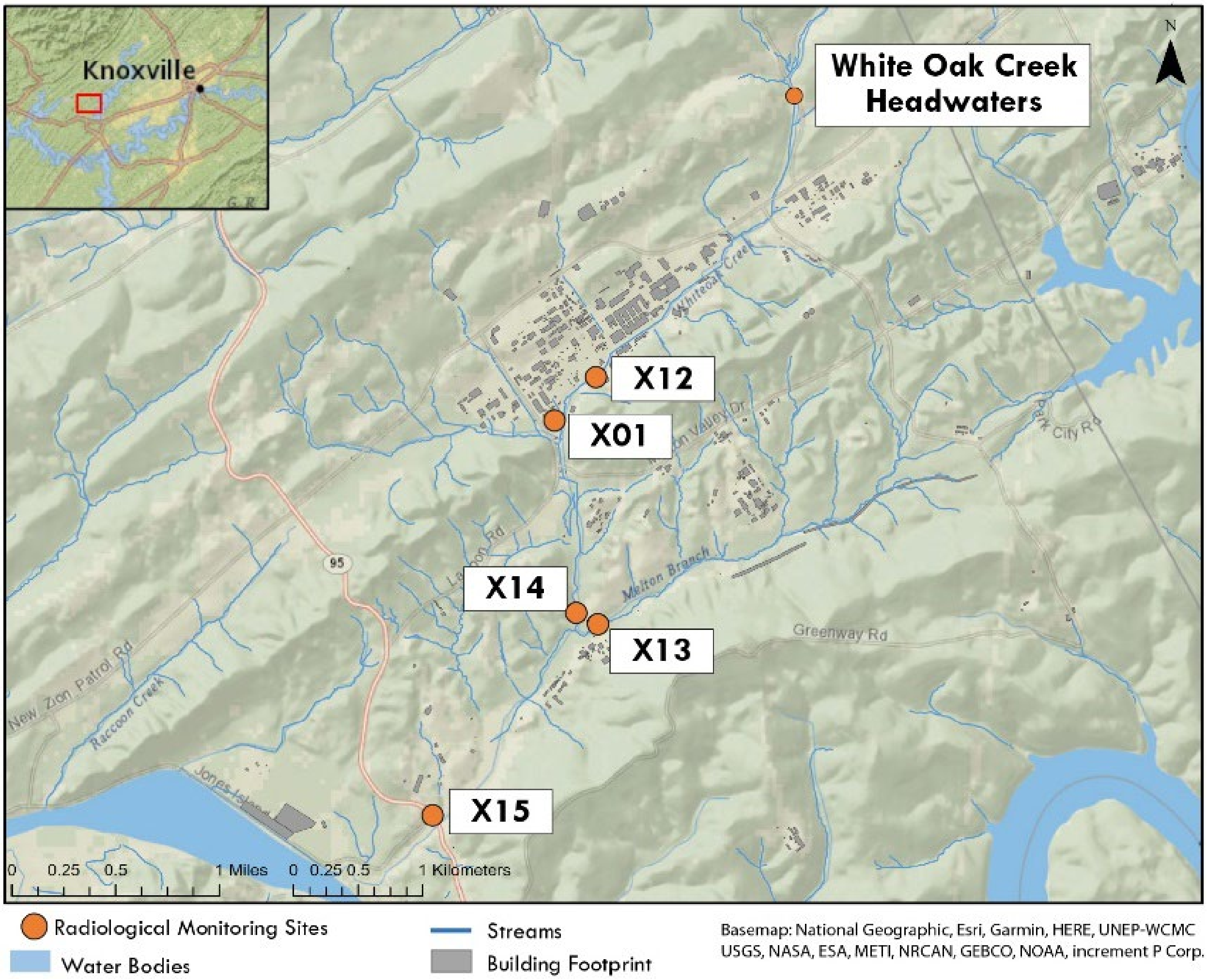

Figure 5.7. Selected surface water, National Pollutant Discharge Elimination System, and reference sampling locations at ORNL

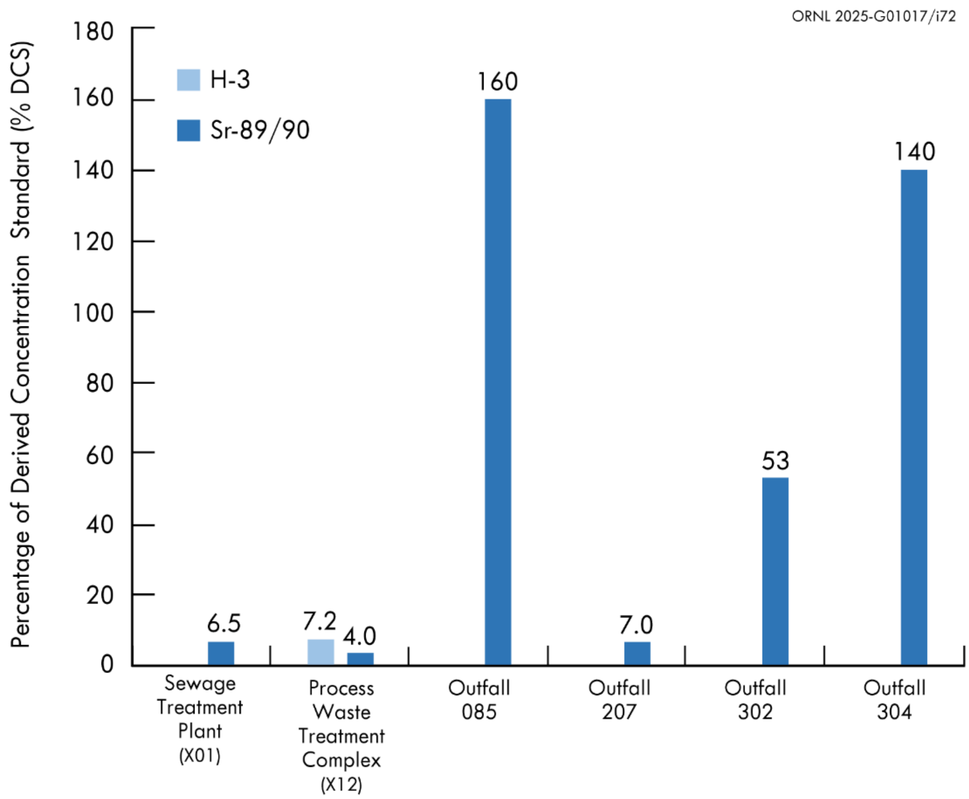

Figure 5.8. Outfalls and instream locations at ORNL with average radionuclide concentrations greater than 4 percent of the relevant derived concentration standards, 2024

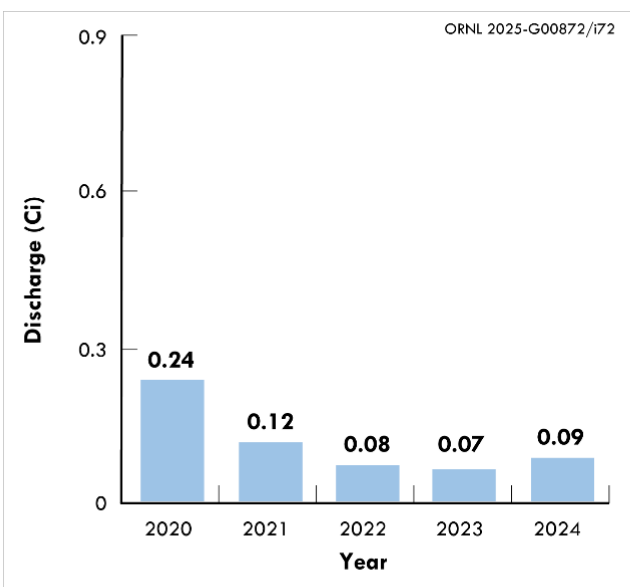

Figure 5.9. Cesium-137 discharges at White Oak Dam, 2020–2024

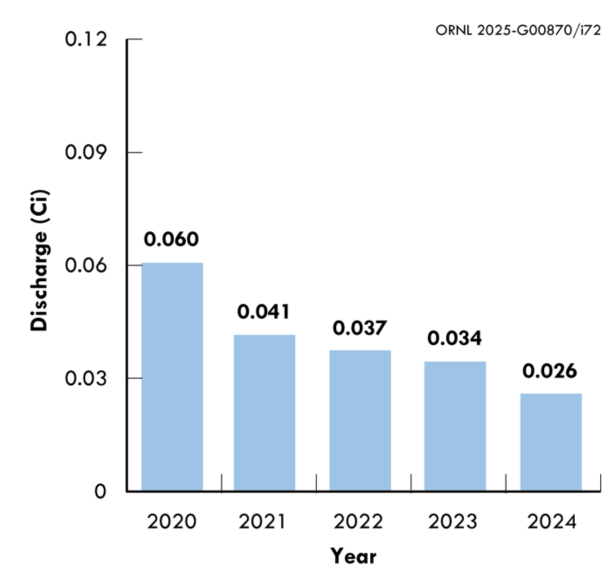

Figure 5.10. Gross alpha discharges at White Oak Dam, 2020–2024

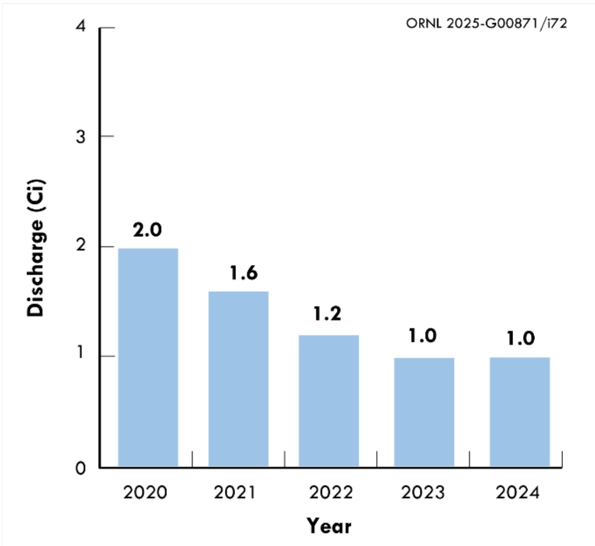

Figure 5.11. Gross beta discharges at White Oak Dam, 2020–2024

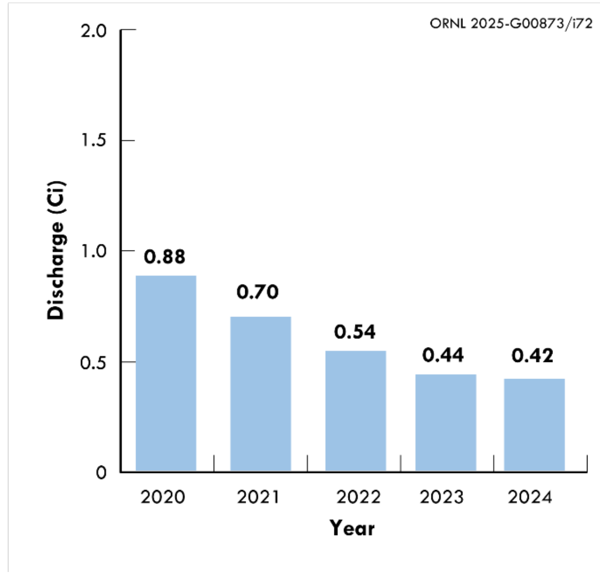

Figure 5.12. Total radioactive strontium discharges at White Oak Dam, 2020–2024

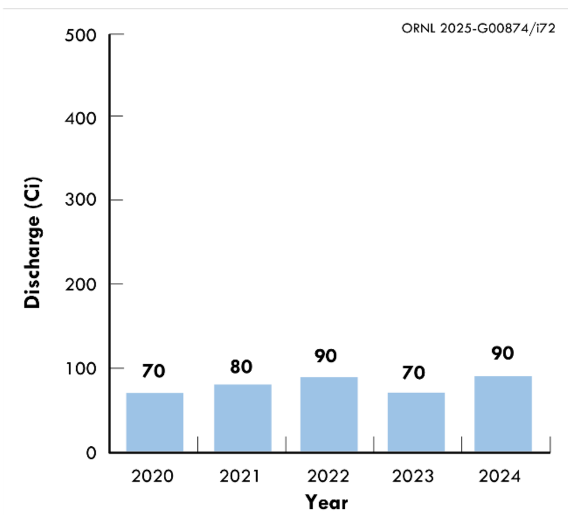

Figure 5.13. Tritium discharges at White Oak Dam, 2020–2024

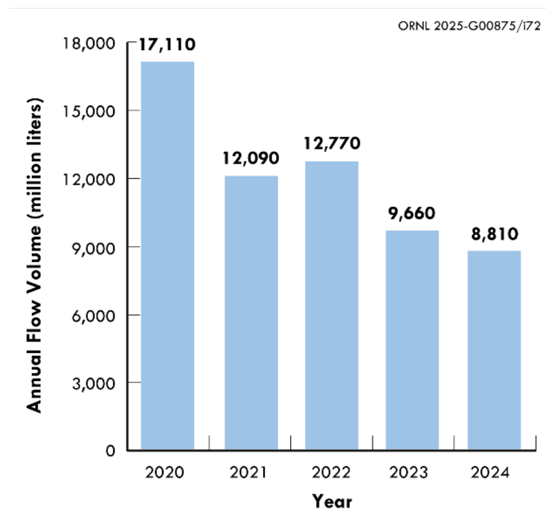

Figure 5.14. Annual flow volume at White Oak Dam 2020–2024

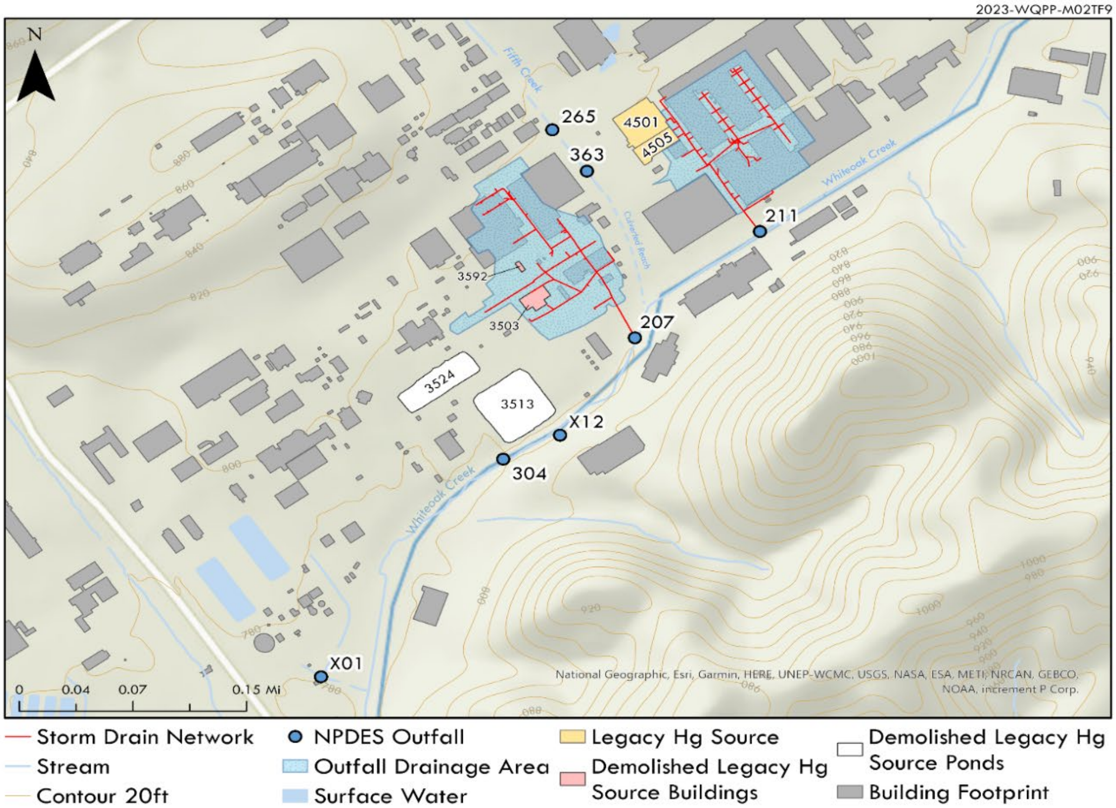

Figure 5.15. Outfalls and associated storm drain connections that are potential mercury sources, 2024

5.5.4.1. Mercury in Ambient Water

Aqueous Hg monitoring in WOC continued in 2024 as part of bioaccumulation studies in the WOC watershed. Quarterly grab sampling was performed 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 5.16). 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 2024, the average concentration of Hg in WOC upstream from ORNL (WCK 6.8) was less than 3 ng/L, and the highest value was 3.4 ng/L. Waterborne Hg concentrations in WOC downstream of ORNL (Figure 5.17) 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. Ambient concentrations have remained low since 2008, with a few exceptions. In 2024, Hg concentrations were well below WQCs at all the instream sites that were monitored (Figure 5.17). The average aqueous Hg concentration at WOD (WCK 1.5) was 21.48 ng/L in 2024 compared with 27.45 ng/L in 2023.

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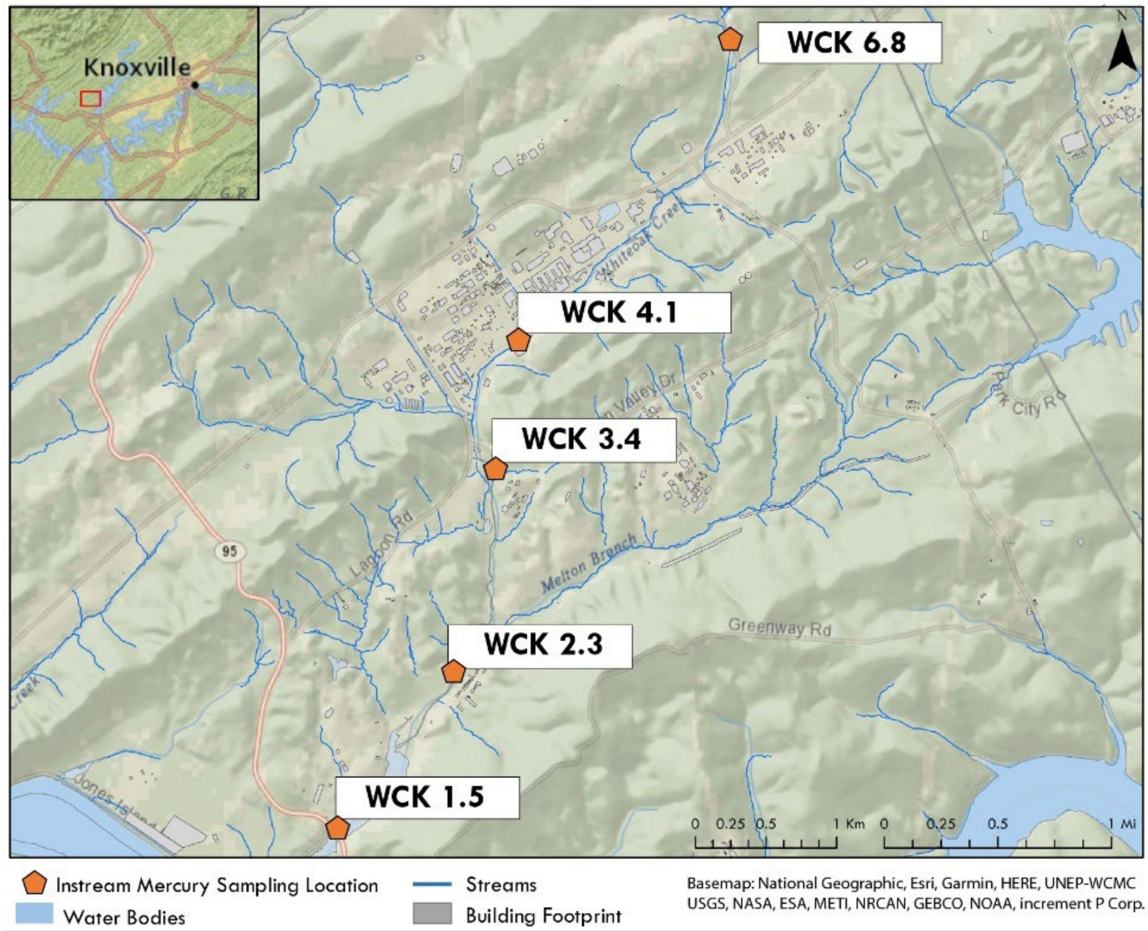
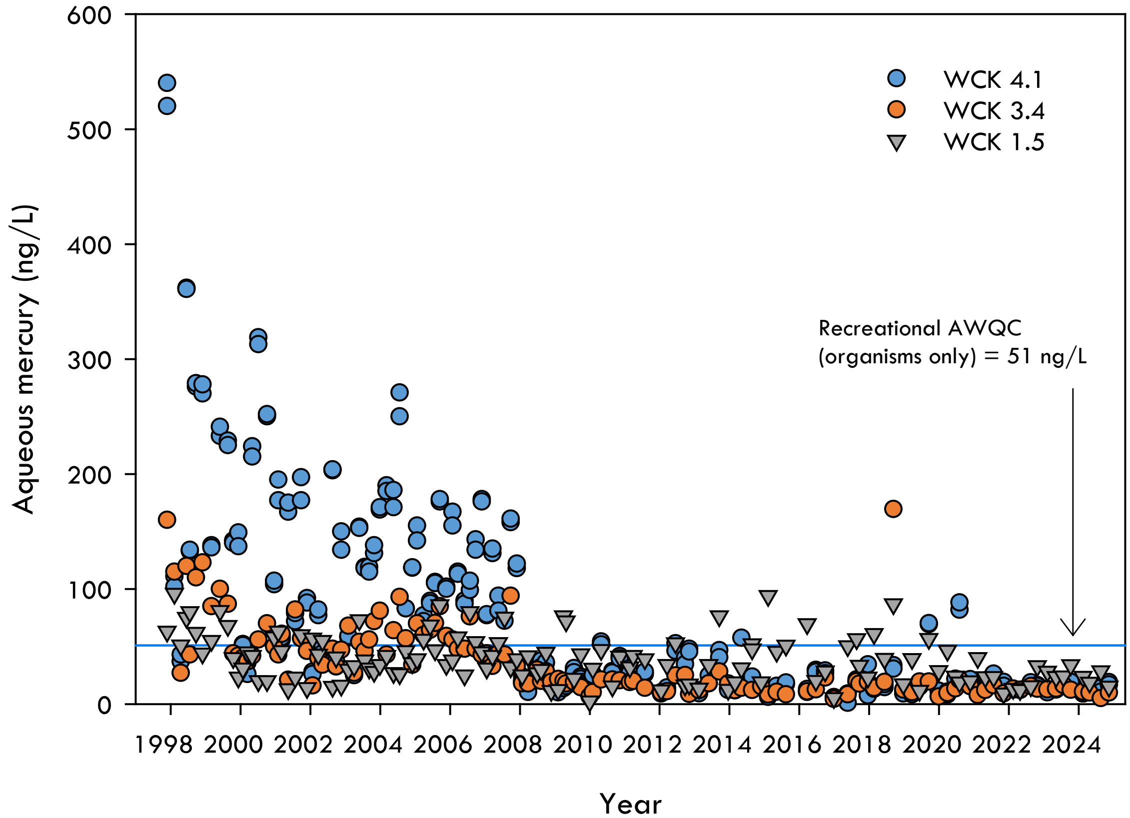


Figure 5.16. Instream mercury monitoring and data locations, 2024



Note: *The blue line at 51 ng/L shows the recreational water quality criterion for organisms.*

Acronyms:

AWQC = ambient water quality criterion *WCK = White Oak Creek kilometer*

Figure 5.17. Aqueous mercury concentrations of grab samples at sites in White Oak Creek downstream from ORNL, 1998–2024

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 also measured and recorded.

Concentrations of Hg in discharges from the STP (X01) averaged 1.9 ng/L in 2024, and Hg concentrations in discharges from the PWTC (X12) averaged 51.25 ng/L. Trends in total Hg concentrations are shown in Figure 5.18 for the STP (Outfall X01) from 2012 to 2024 and in Figure 5.19 for the PWTC (Outfall X12) from 2009 to 2024.

The 2024 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 5.20.

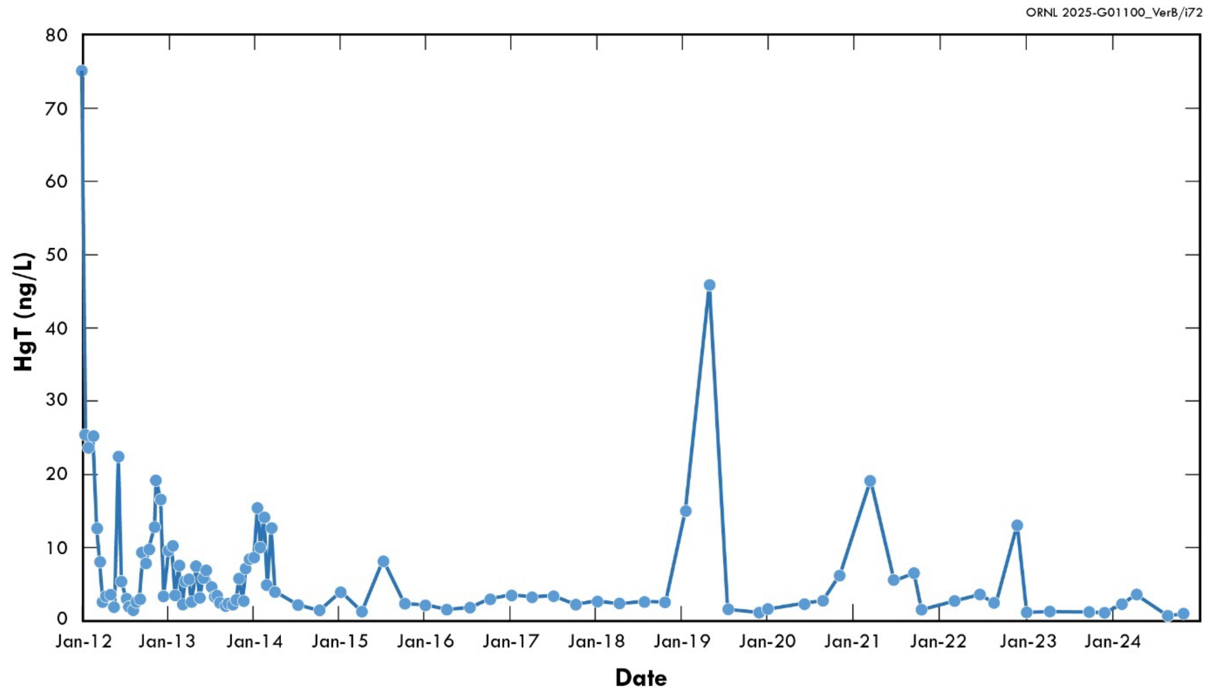


Figure 5.18. Total mercury concentrations in discharges to Outfall X01 from the Sewage Treatment Plant, 2012–2024

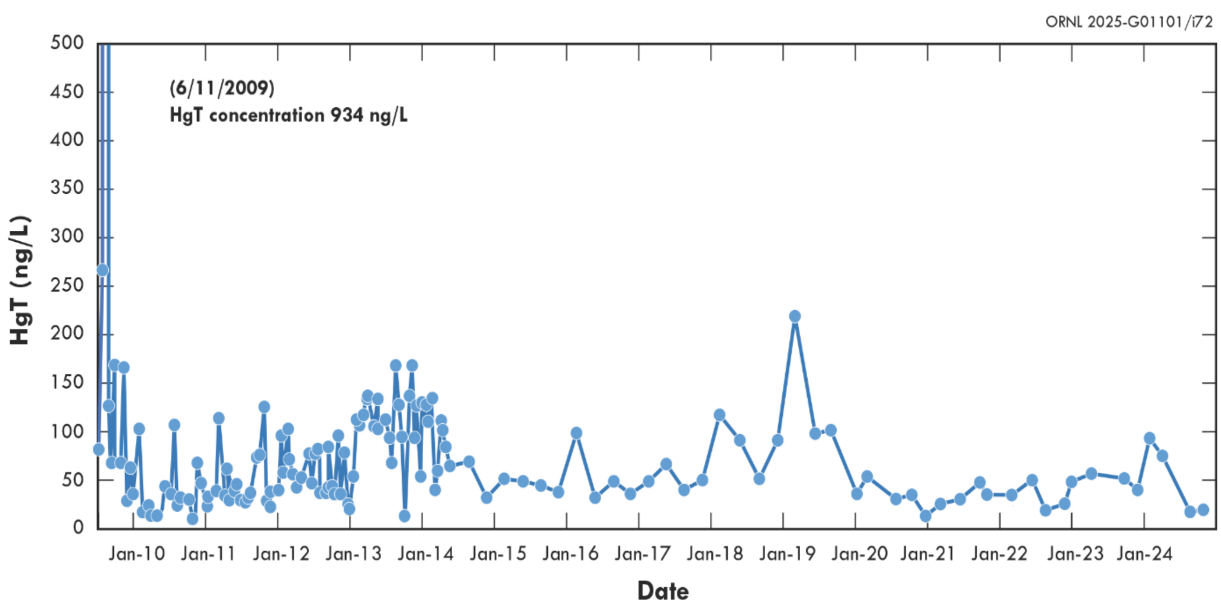


Figure 5.19. Total mercury concentrations in discharges to Outfall X12 from the Process Waste Treatment Complex, 2009–2024

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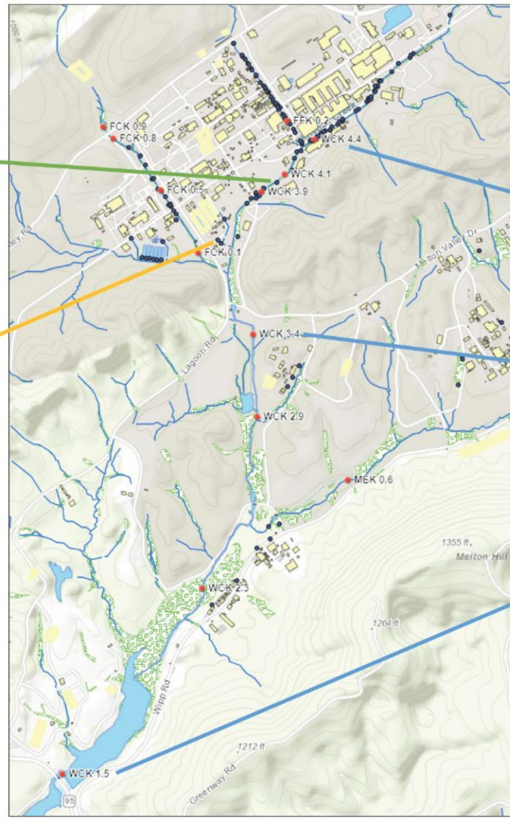
Treatment Plant 24 h composites HgT

Outfall X12 (PWTC)	
Date	HgT (ng/L)
02/20/24	96
04/16/24	75
08/12/24	16
10/09/24	18

Outfall X01 (STP)	
Date	HgT (ng/L)
02/20/24	2.20
04/16/24	3.60
08/12/24	0.79
10/09/24	1.00



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

WCK 4.4	
Date	HgT (ng/L)
02/20/24	3.7
04/16/24	5.4
08/12/24	1.3
11/28/24	7.8

WCK 3.4 (7500 Bridge)	
Date	HgT (ng/L)
02/20/24	15.0
04/16/24	10.0
08/12/24	9.7
10/09/24	44.0

WCK 1.5 (White Oak Dam)	
Date	HgT (ng/L)
02/20/24	10
04/16/24	30
08/12/24	210
10/09/24	18

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

Figure 5.20. Coordination of treatment plant sampling with instream sampling sites at ORNL, 2024

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 help 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 2024, 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 5.15). As in past years, 2024 WQPP legacy Hg point source monitoring focused on Outfalls 207 and 211, which historically have had the highest Hg concentrations. In 2024, 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 5.21 and 5.22 show trends in dry-weather Hg sampling from Outfalls 207 and 211, respectively. In 2024, 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 2024, no dry-weather flow was recorded at Outfall 265, and the average dry-weather Hg concentrations at Outfalls 304 and 363 were low (15.5 and 31.0 ng/L, respectively).

WQPP non–point source Hg monitoring was also undertaken in 2024. 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 5.23 and 5.24, respectively. In 2024, the average wet-weather sampling results were approximately 7.65 ng/L at Outfall 265, 14.0 ng/L at Outfall 304, and 12.0 ng/L at Outfall 363. Dry- and wet-weather Hg fluxes at Outfalls 207 and 211 either declined in 2024 or were comparable to fluxes in previous years (Figures 5.21–5.24).

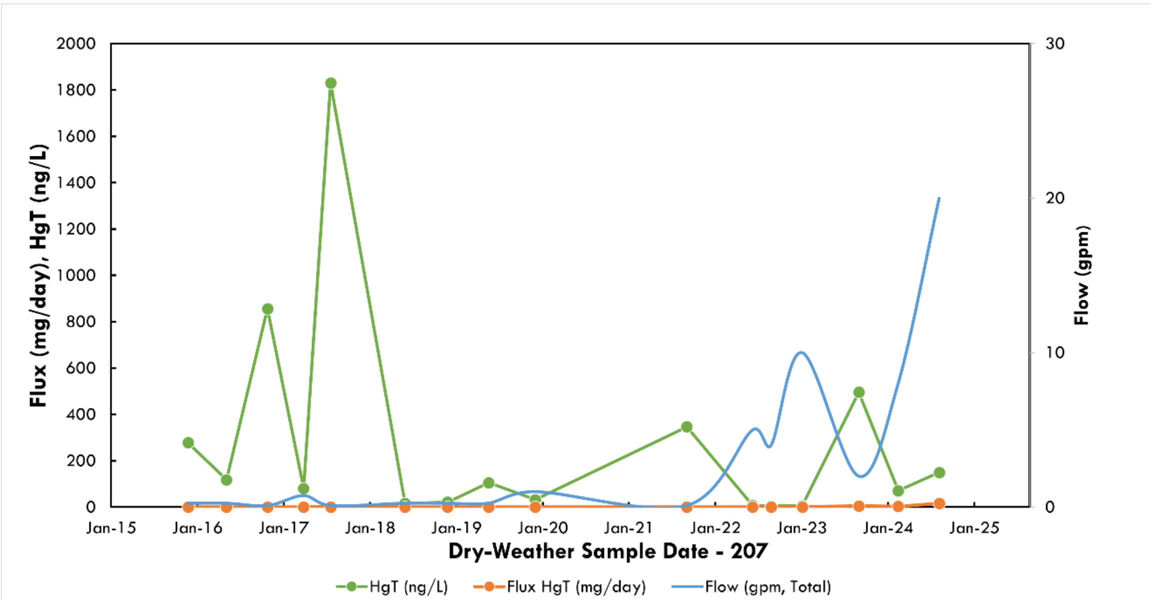


Figure 5.21. Outfall 207 dry-weather flow rate, total mercury concentration (unfiltered), and flux, 2016–2024

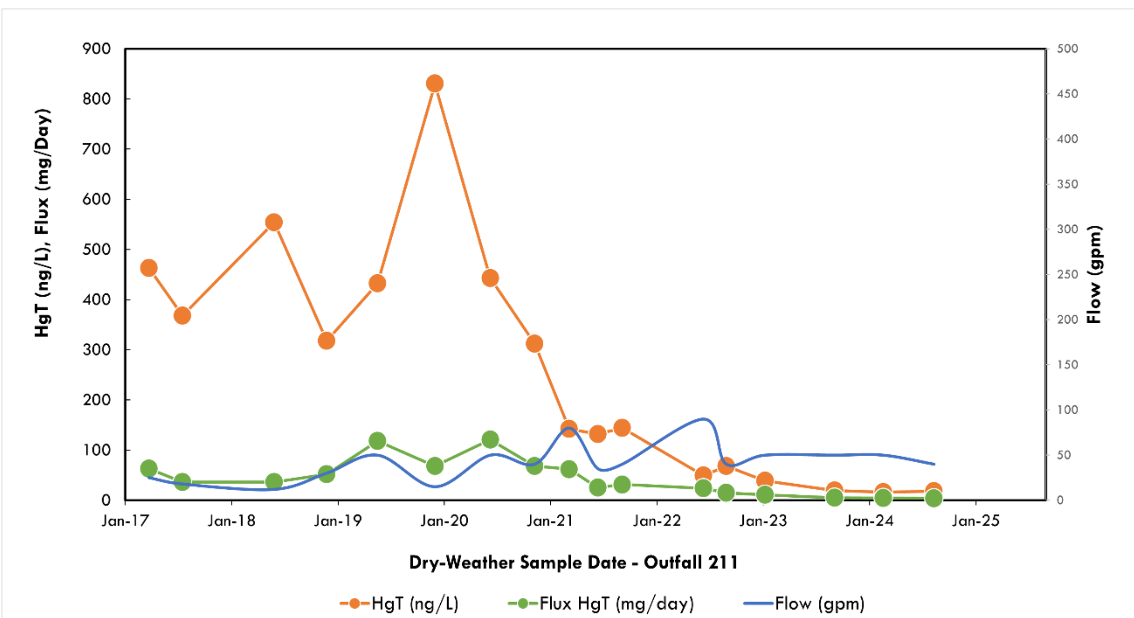


Figure 5.22. Outfall 211 dry-weather flow rate, total mercury concentration (unfiltered), and flux, 2017–2024

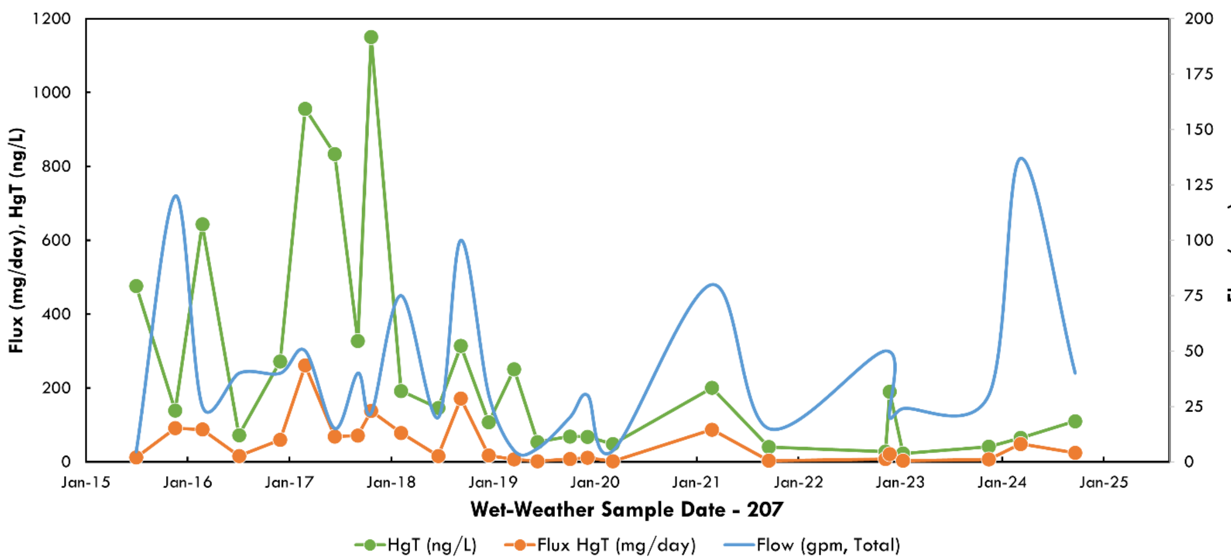


Figure 5.23. Outfall 207 wet-weather flow rate, total mercury concentration (unfiltered), and flux, 2015–2024

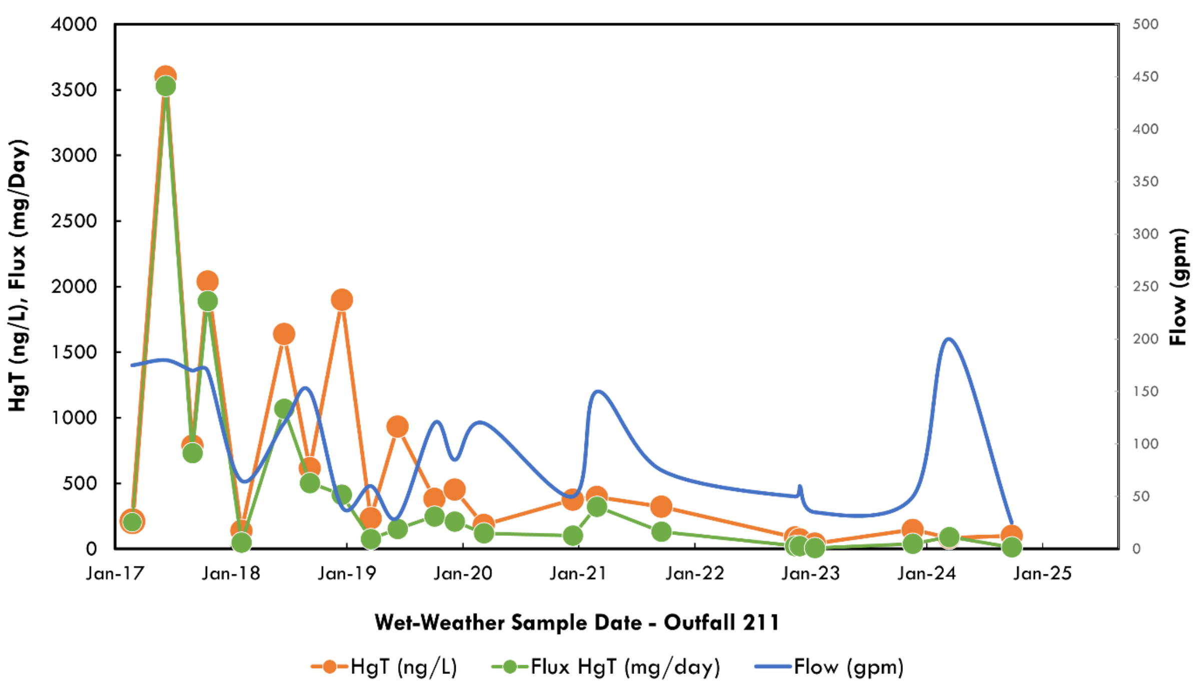


Figure 5.24. Outfall 211 wet-weather flow rate, total mercury concentration (unfiltered), and flux, 2017–2024

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 ORNL 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 2024 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 2024.

5.5.6.1. Bioaccumulation Studies

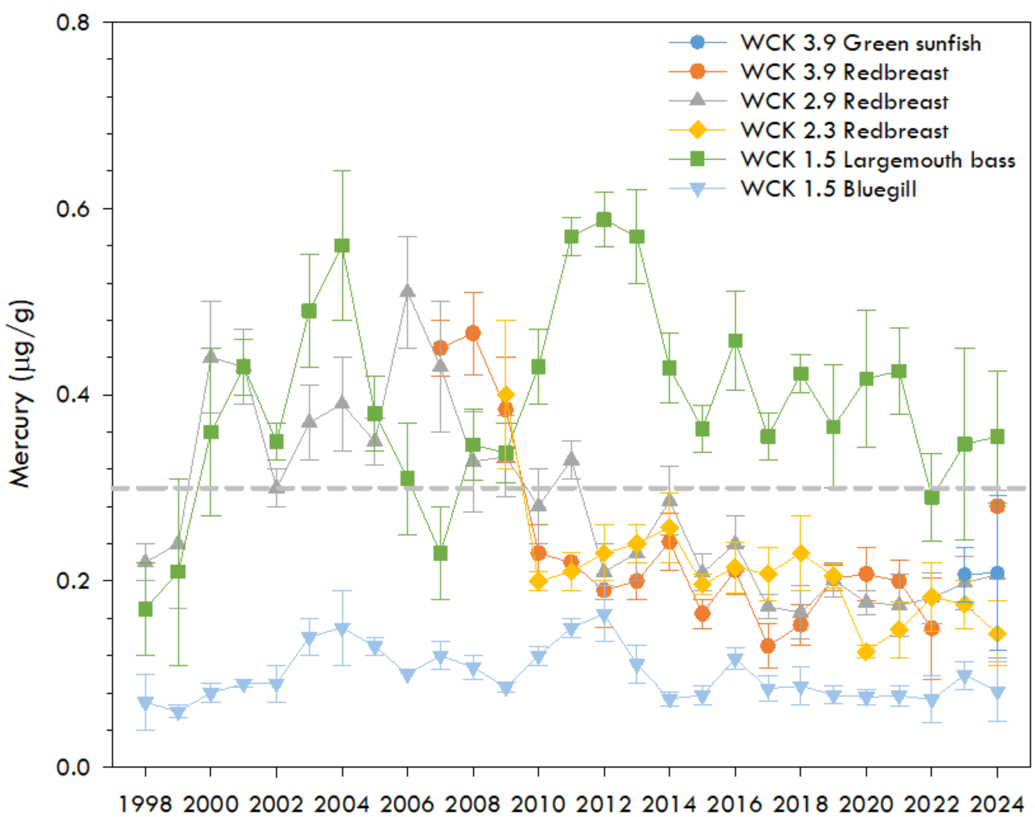
Bioaccumulation tasks for the biological monitoring and abatement plan address two NPDES permit requirements at ORNL: (1) evaluate whether Hg at the site is contributing to streams at a level that will adversely affect fish and other aquatic life or that will violate the recreational criteria and (2) 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 5.25). In 2024, Hg concentrations in fish collected throughout WOC remained similar to those seen in 2023. In 2024, 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 2024, 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 0.45 µg/g (Figure 5.26).

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 2010a,b,c). The average PCB concentrations in fish in WOC (and across ORR) exceed this conservative guideline (Figure 5.26), 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.



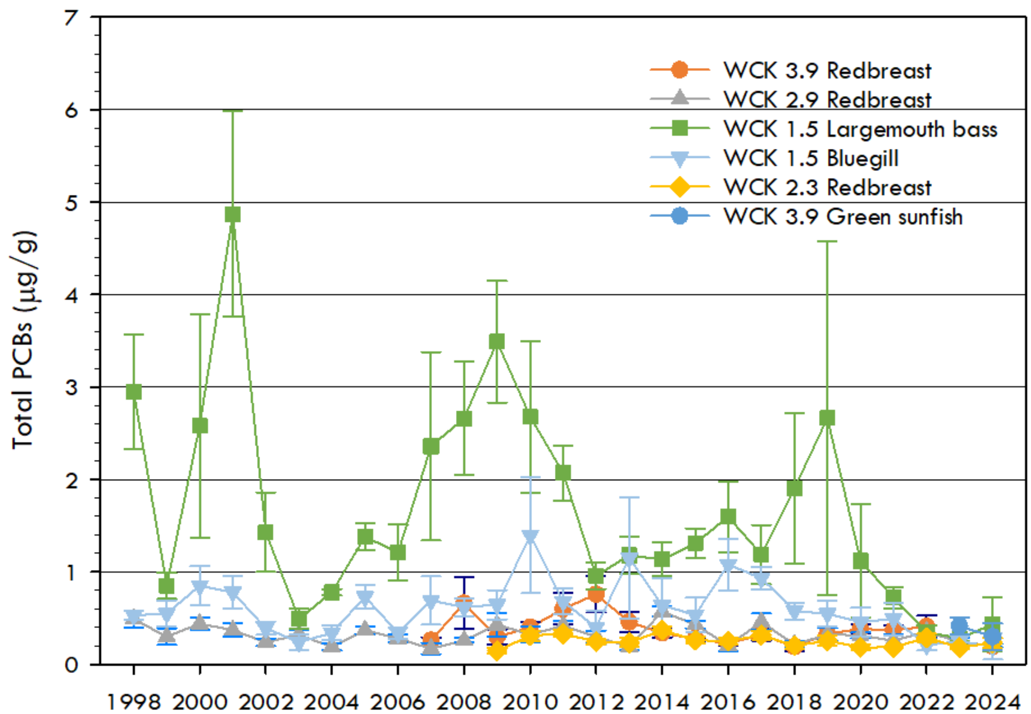
Notes:

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 5.25. Mean mercury concentrations in muscle tissue of sunfish and bass sampled from the White Oak Creek watershed, 1998–2024



Note: *Mean total PCB concentrations (± standard error, n = 6) found in fish fillets.*

Acronyms:

PCB = polychlorinated biphenyl *WCK = White Oak Creek kilometer*

Figure 5.26. Mean total PCB concentrations in fish sampled from the White Oak Creek watershed, 1998–2024

5.5.6.2. Benthic Macroinvertebrate Communities

Monitoring of benthic macroinvertebrate communities in WOC, First Creek, and Fifth Creek continued in 2024. 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 (38 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.

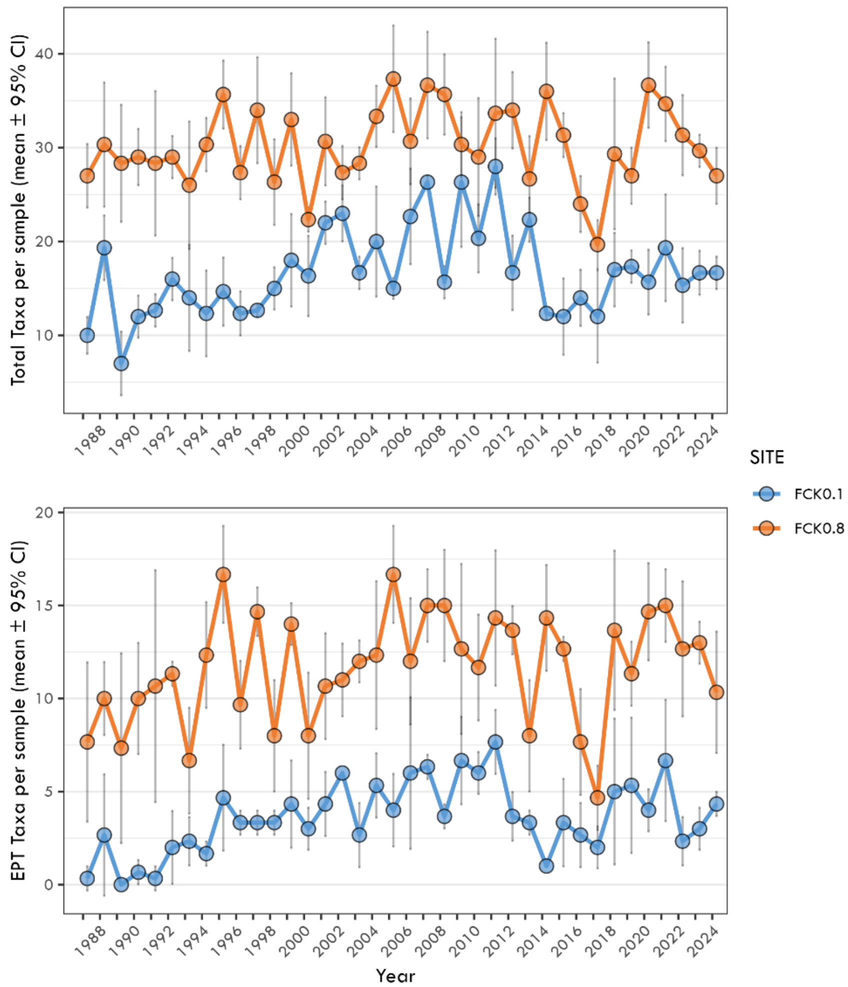
General trends in the results obtained using ORNL protocols indicate significant recovery in benthic macroinvertebrate communities since 1987, but community characteristics suggest that ecological impairment remains (Figures 5.27, 5.28, and 5.29). In 2024, total taxonomic richness (i.e., the number of 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 5.27). Total taxa richness then increased at FCK 0.1 from 2018 to 2024, 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 5.27). After 2021, when values were the highest they had been in the past 10 years, EPT taxa richness values fell sharply in 2022 but improved in 2023 and 2024. 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, and then increased until they peaked in 2020. Since 2020, total taxa richness and EPT taxa richness at FCK 0.8 have both sharply declined but remain similar to the long-term average (Figure 5.27). 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 increase in EPT taxa richness and the stability in total taxa richness at FCK 0.1 in 2024 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 5.28), suggesting that conditions changed at the site during that time. Total taxa richness returned to predecline levels over a period of about 5 years, decreased again from 2019 to 2021, and then improved from 2022 to 2024 (Figure 5.28). 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 and 2023. In 2024, EPT taxa richness remained relatively high at this site, similar to levels seen from 2012 to 2018. It is not known whether this represents an upper bound for EPT richness 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) have remained higher than at FFK 0.2 since sampling began in 1987 despite exhibiting varying levels of interannual variability from 1987 to 2024.

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 decreased during the mid-2010s and early 2020s. The EPT taxa richness at WCK 2.3 and WCK 3.9 continued to be notably lower than at the reference site, WCK 6.8. In 2024, total and EPT taxa richness at WCK 3.9 increased for the first time since the large decline that began in 2015. 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 5.29). Comparisons of WCK 6.8 with WBK 1.0 show that communities in WCK 6.8 represent ideal reference conditions, though significant declines in both total and EPT taxa richness were observed at WBK 1.0 in 2024, similar to the lowest values previously recorded in 2017, and richness values for WCK 6.8 declined but still remained near their long-term averages.



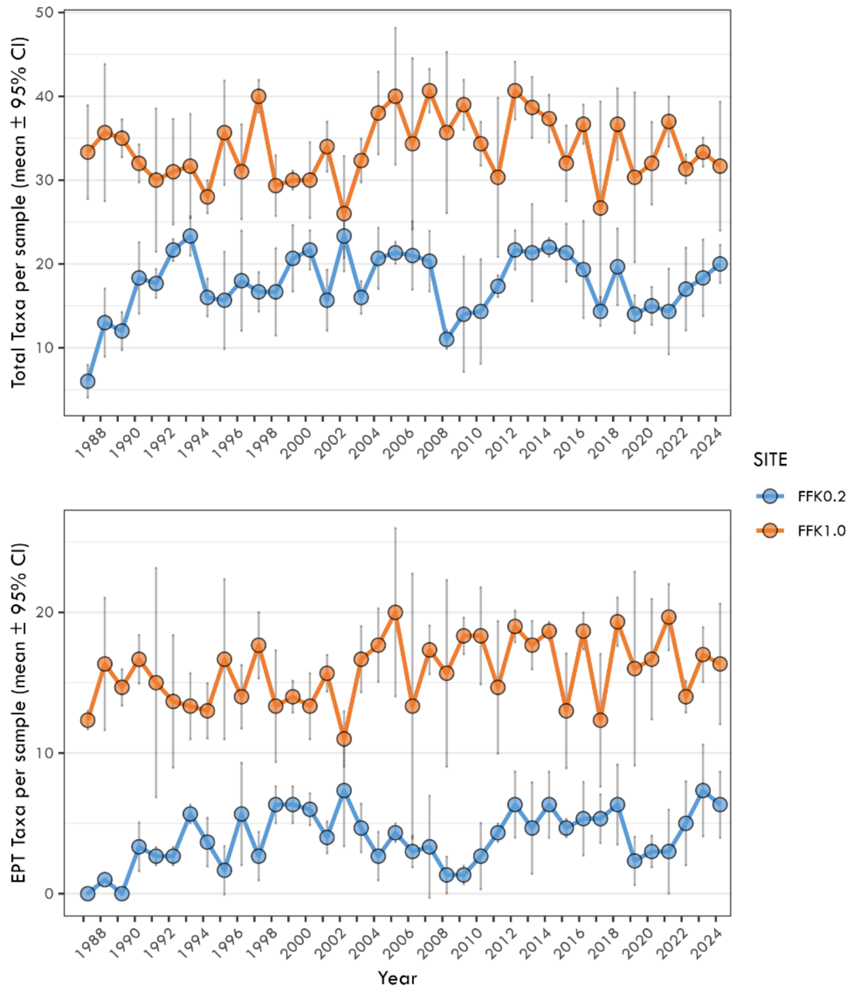
Note: *Taxonomic richness (number of taxa per sample), 1987–2024. FCK 0.8 serves as a reference site.*
Top: Total taxonomic richness.
Bottom: Taxonomic richness of the pollution-intolerant taxa Ephemeroptera, Plecoptera, and Trichoptera (EPT).

Acronyms:

CI = confidence interval

FCK = First Creek kilometer

Figure 5.27. Benthic macroinvertebrate communities in First Creek, 1987–2024



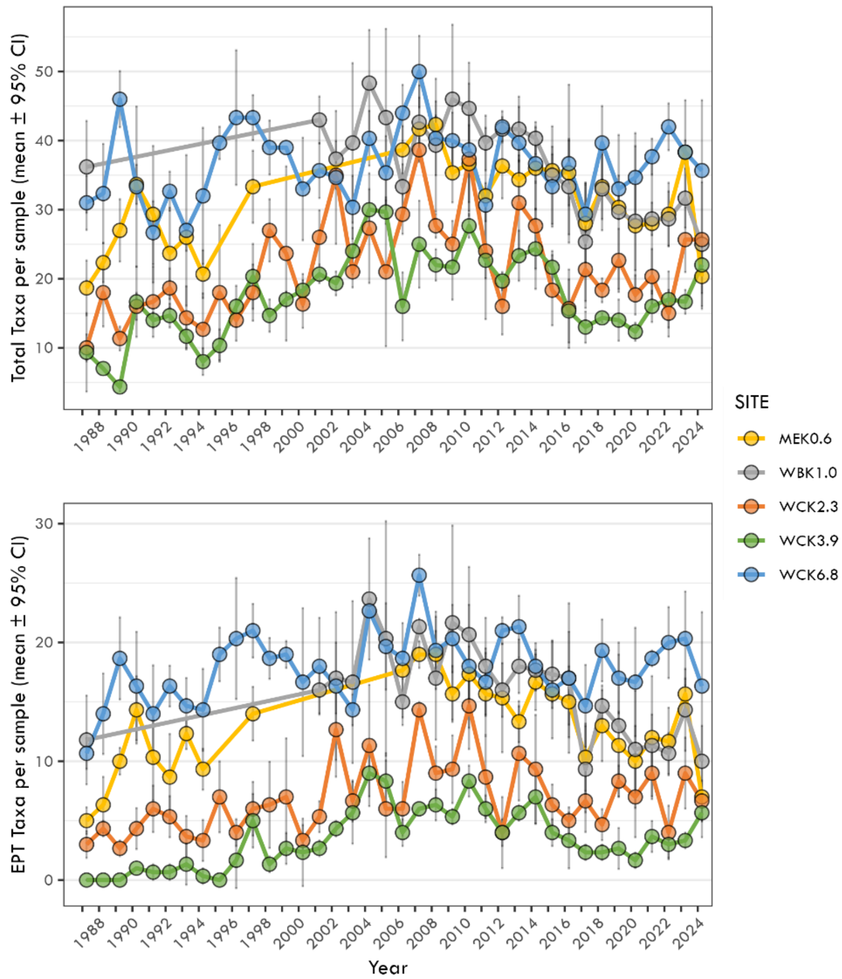
Note: *Taxonomic richness (number of taxa per sample), 1987–2024. FFK 1.0 serves as a reference site.*
Top: Total taxonomic richness.
Bottom: Taxonomic richness of the pollution-intolerant taxa Ephemeroptera, Plecoptera, and Trichoptera (EPT).

Acronyms:

CI = confidence interval

FFK = Fifth Creek kilometer

Figure 5.28. Benthic macroinvertebrate communities in Fifth Creek, 1987–2024



Note: *Taxonomic richness (number of taxa per sample), 1987–2024. 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:

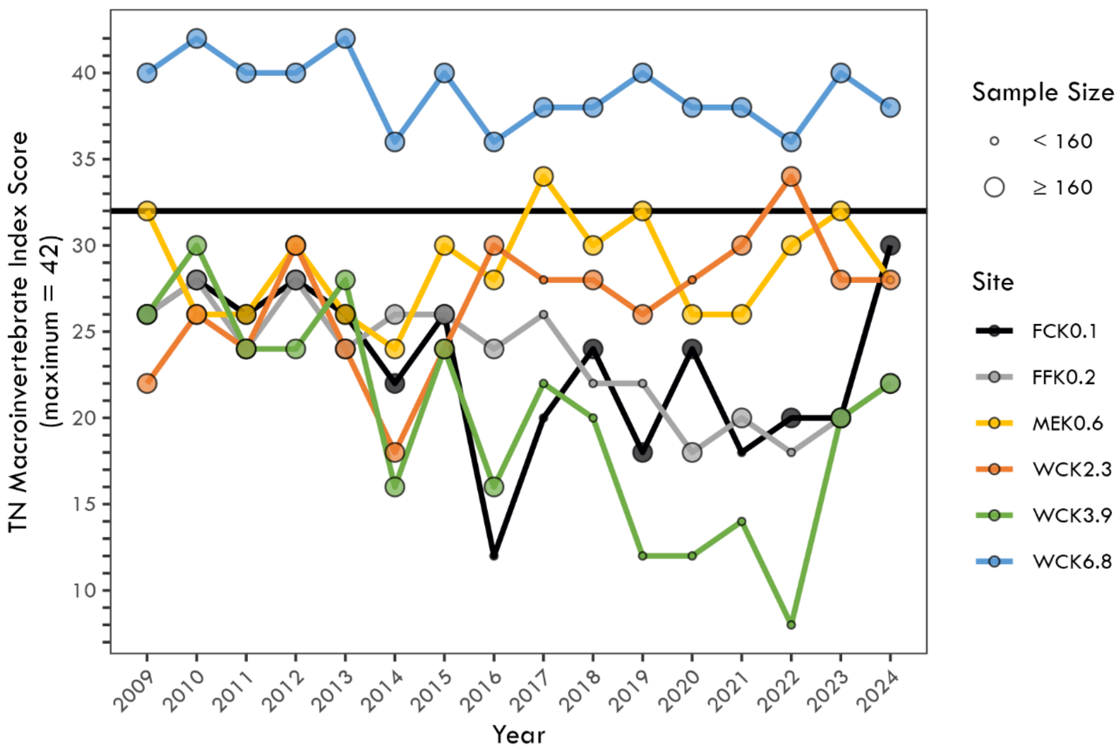
CI = confidence interval
MEK = Melton Branch kilometer
WBK = Walker Branch kilometer
WCK = White Oak Creek kilometer

Figure 5.29. Benthic macroinvertebrate communities in Walker Branch, Melton Branch, and White Oak Creek, 1987–2024

Macroinvertebrate metrics for Melton Branch (MEK 0.6) suggested that total taxa richness and EPT taxa richness were similar to those in reference sites from 2006 through 2023, but significant declines in both metrics similar to declines at WBK 1.0 were observed in 2024 (Figure 5.29). 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 9 years (2016–2024), 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]) has been 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 2024 rated the invertebrate community at the reference site, WCK 6.8, as passing biocriteria guidelines, while scores from FCK 0.1, FFK 0.2, WCK 3.9, and MEK 0.6 were below these guidelines. However, the score for MEK 0.6 should be interpreted with caution given the small (<160 individuals) sample size (Figure 5.30, Table 5.14). Scores improved at three sites (WCK 3.9, FFK 0.2, and FCK 0.1), remained the same at one site (WCK 2.3), and declined at one site (MEK 0.6).

Low TMI scores in FFK 0.2, WCK 2.3, and WCK 3.9 were primarily due to low values for EPT percentage and EPT taxa richness (Table 5.14). However, all these sites had low percentages of oligochaetes and chironomids and thus received high scores for this category. The improvement at FCK 0.1 was primarily due to an increased percent abundance of taxa that build fixed retreats or otherwise attach to substrate surfaces in flowing water and increased total and EPT richness (Table 5.14). WCK 6.8 received the highest attainable scores for all categories except for total and EPT taxa richness (Table 5.14).



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 5.30. Temporal trends in Tennessee Department of Environment and Conservation Tennessee Macroinvertebrate Index scores for White Oak Creek watershed streams, August sampling, 2009–2024

Table 5.14. Tennessee Macroinvertebrate Index metric values, metric scores, and index scores for White Oak Creek, First Creek, Fifth Creek, and Melton Branch streams, August 27, 2024[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	29	6	17.9	39.8	4.7	41.3	50.5	6	2	2	4	6	4	4	28
WCK 3.9	17	3	56.9	5.3	5	10.5	29.2	2	0	6	6	4	0	4	22
WCK 6.8	28	10	60.3	2.9	2.5	82.4	9.3	4	4	6	6	6	6	6	38 [pass]
FCK 0.1	21	6	5.3	5.8	3.9	68.1	17.4	4	2	0	6	6	6	6	30
FFK 0.2	12	6	24.8	5.4	5	33.8	44.1	2	2	2	6	4	2	4	22
MEK 0.6	25	9	23.1	5.1	4.8	50.4	29.9	4	4	2	6	4	4	4	28

[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.

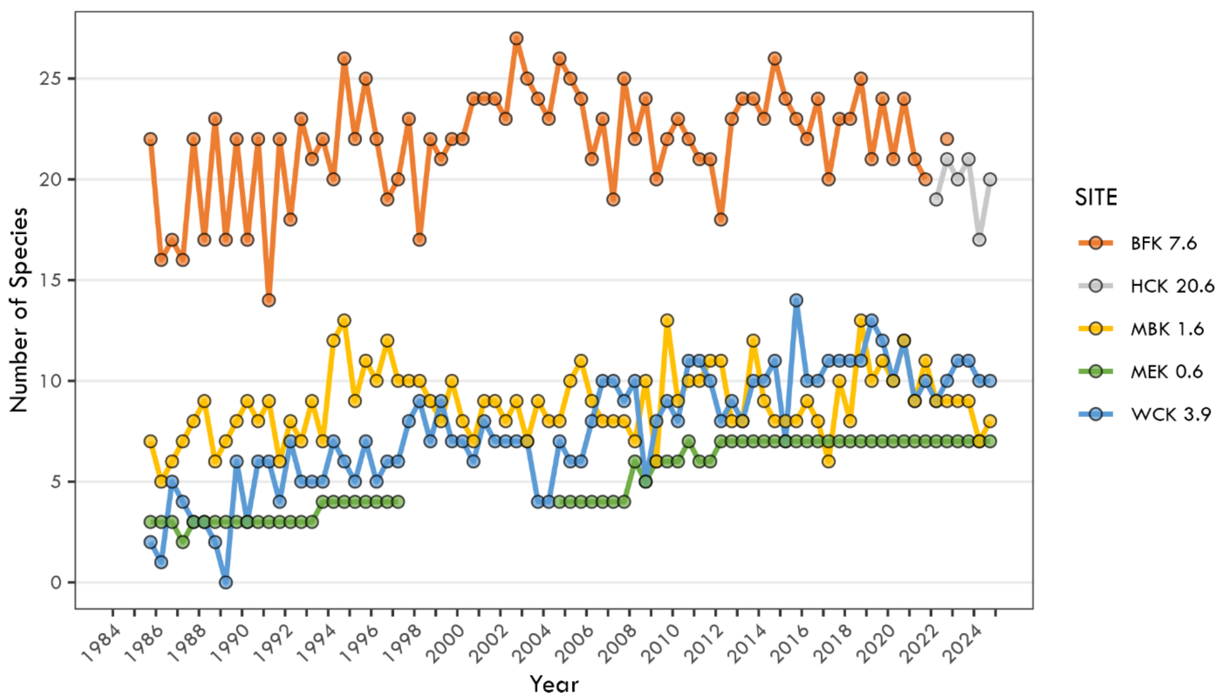
Acronyms:

EPT = Ephemeroptera, Plecoptera, and Trichoptera
FCK = First Creek kilometer
FFK = Fifth Creek kilometer
MEK = Melton Branch kilometer
TDEC = Tennessee Department of Environment and Conservation
TMI = Tennessee Macroinvertebrate Index
WCK = White Oak Creek kilometer

5.5.6.3. Fish Communities

Monitoring of the fish communities in WOC and its major tributaries continued in 2024. 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 2024 compared with communities in reference streams. Sites closest to outfalls within the ORNL campus had lower species richness (number of species) (Figure 5.31) 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 in 2024 relative to reference streams and upstream sites. These impacts may be related to effluent from outfalls, poor or altered habitat conditions, or barriers to fish passage within the watershed.



Note: *BFK 7.6 was not surveyed after 2023 because of lack of access to the site and was replaced with HCK 20.6.*
Acronyms:
BFK = Brushy Fork kilometer
HCK = Hinds Creek kilometer
MBK = Mill Branch kilometer
MEK = Melton Branch kilometer
WCK = White Oak Creek kilometer

Figure 5.31. Fish species richness (number of species) in upper White Oak Creek and lower Melton Branch compared with reference streams (Brushy Fork, Hinds Creek, and Mill Branch), 1985–2024

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.

Several exceptions to the apparent difficulty of expansion have been observed, including 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.

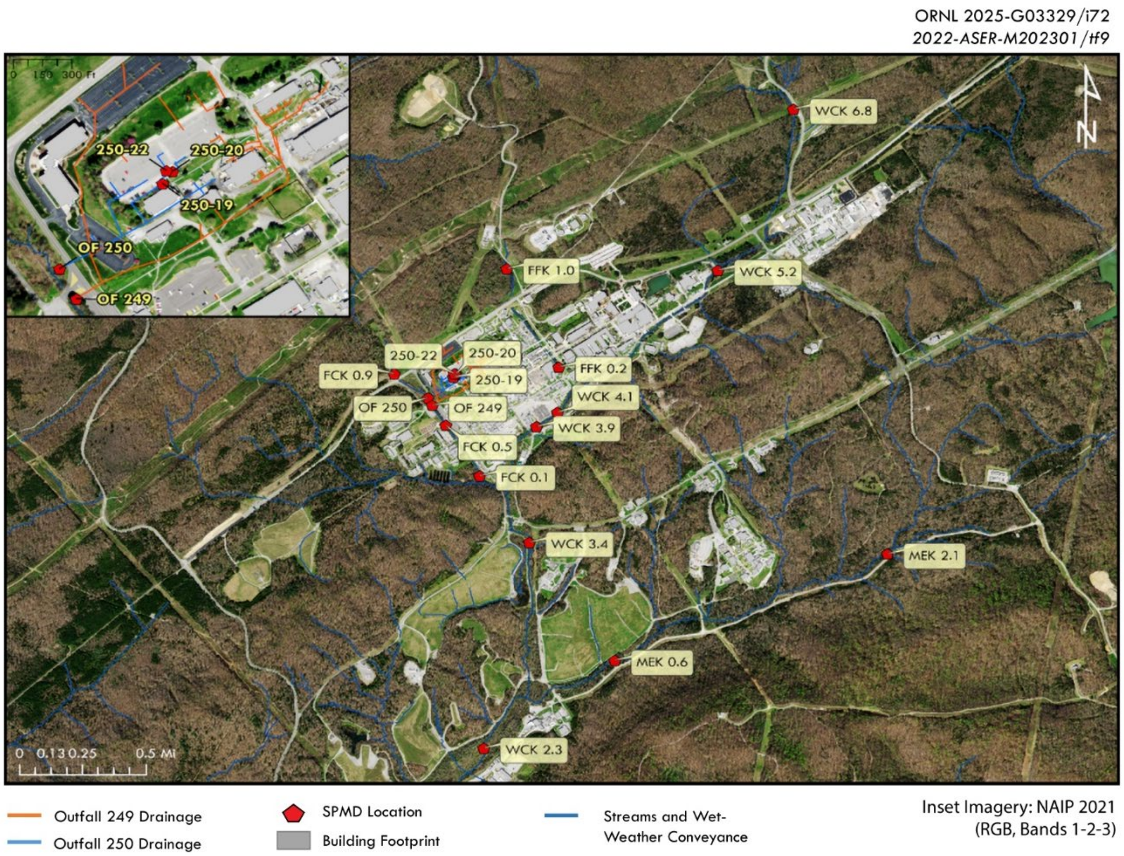
5.5.7. Polychlorinated Biphenyls in the White Oak Creek Watershed

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 5.32) 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 5.33). 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.

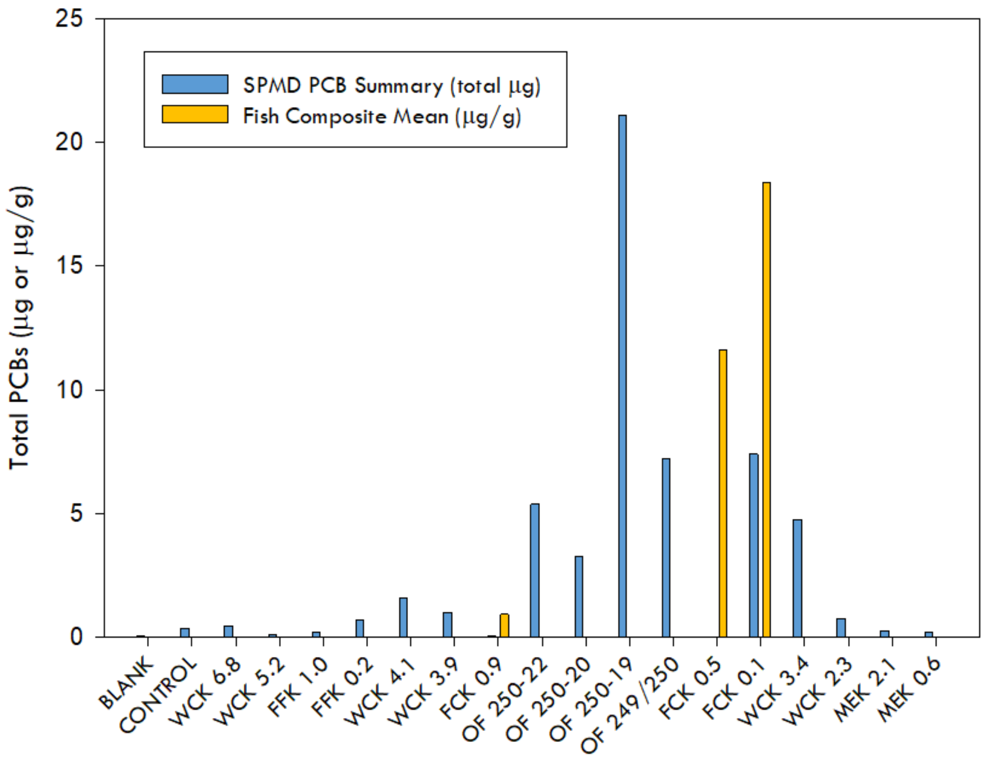
The upper reaches of the Outfall 250 storm drain network lie beneath a parking lot where two buildings with known PCB materials were once located. A closed-circuit television investigation of the Outfall 250 storm drain system was completed in 2024 and revealed that underground storm lines beneath the parking lot with no surface connections contain significant amounts of soil and rocky debris. These underground lines are likely legacy storm drains from the demolished buildings that remain connected to the larger Outfall 250 storm drain network. Based on the camera investigation, a sampling strategy was implemented in late 2024 to determine whether the legacy lines are a source of PCBs to the Outfall 250 network. Results will be available in 2025.



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



Acronyms:

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

Figure 5.33. 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." Discharges include any spilling, leaking, pumping, pouring, emitting, emptying, or dumping but exclude 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 follow procedures and methods established in 40 CFR 112 to prevent oil spills and clean up spills that do occur; to develop and implement spill prevention, control, and countermeasure (SPCC) plans; and to provide annual training for oil-handling personnel.

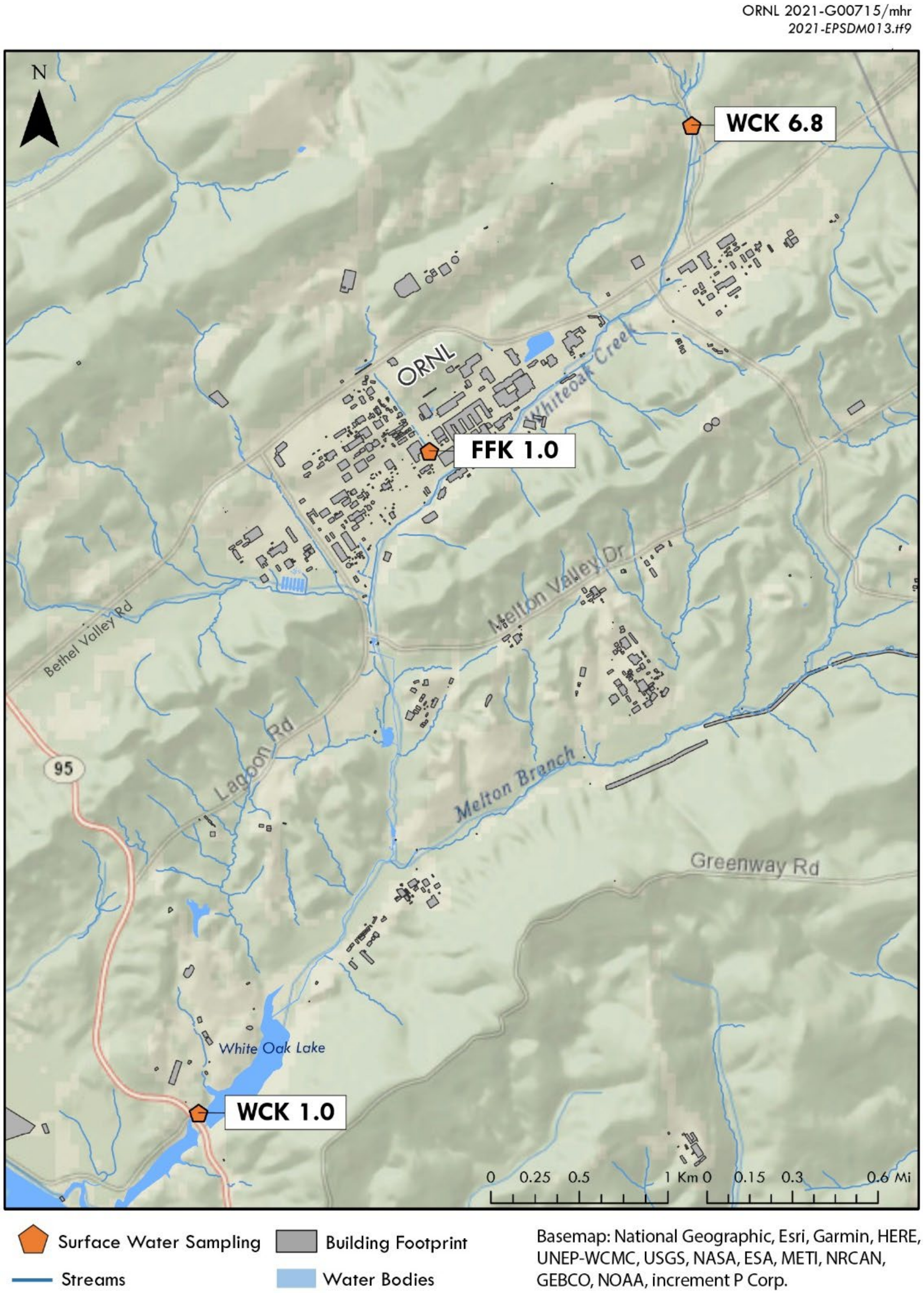
Currently, separate SPCC plans are implemented for the ORNL main campus and for the HVC, which is located off ORR. An SPCC plan is not required for the CFTF, which is also located away from ORNL in the Horizon Center Business Park. The ORNL and HVC SPCC plans were revised in 2023. Oil inventories for 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 the HVC in 2024.

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 assess the impacts of ongoing DOE operations on the quality of local surface water. The sampling locations (Figure 5.34) 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 5.15. 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.

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 1.0 and WCK 6.8 are classified for freshwater fish and aquatic life (TDEC 2024a). Tennessee WQCs associated with these classifications are used as references where applicable (TDEC 2024b). The Tennessee WQCs do not include criteria for radionuclides. Four percent of the DOE DCS (DOE 2021) is used for radionuclide comparison.



Acronyms:

FFK = Fifth Creek kilometer

ORNL = Oak Ridge National Laboratory

WCK = White Oak Creek kilometer

Figure 5.34. ORNL surface water sampling locations, 2024

Table 5.15. ORNL surface water sampling locations, frequencies, and parameters, 2024

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 = White Oak Creek kilometer
WOC = White Oak Creek
WOD = White Oak Dam
WQPP = water quality protection plan

No radionuclides were reported above 4 percent of the DCS at the Fifth Creek location (FFK 0.1) in 2024. 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.

No PCBs were detected at WCK 1.0 in 2024. Two VOCs were detected in samples from WCK 1.0 during 2024: chloroform was detected in the sample collected in February, and acetone was detected in the samples collected in February and May. All VOC detections were at low estimated values. Acetone was also detected at a low estimated value in the associated trip blank in February and was detected quantitatively in the May trip blank. Chloroform was not detected in any associated trip blank. All VOCs detected in 2024 have previously been detected at WCK 1.0. In addition, acetone and chloroform have occasionally been detected in at least one on-site groundwater well in past monitoring. Acetone and chloroform are common laboratory contaminants.

5.5.10. Carbon Fiber Technology Facility Wastewater Monitoring

Wastewaters from activities at the 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 the 2024 compliance status for this permit are summarized in Table 5.16.

Table 5.16. Industrial and commercial user wastewater discharge permit compliance at the ORNL Carbon Fiber Technology Facility, 2024

Effluent parameters	Permit limits		Permit compliance		
	Daily max (mg/L)	Monthly avg (mg/L)	Number of noncompliances	Number of samples	Compliance rate (%)[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	2	100
Outfall 03 (Sizing Bath Tank)					
Copper	0.87	0.10	0	6	100
Zinc	1.24	0.60	0	6	100
Total phenol	4.20	—	0	6	100
pH (standard units)	6–9	—	0	6	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] *Compliance rate = 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 2024: OREM monitoring and DOE Office of Science (SC) surveillance monitoring. The OREM groundwater monitoring program was conducted by UCOR in 2024. 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 is conducted as part of the WRRP to enable baseline and trend evaluation and to measure the effectiveness of completed CERCLA RAs. The WRRP is managed by UCOR for the OREM program. The results of CERCLA monitoring on ORR for FY 2024, including monitoring at ORNL, are evaluated and reported in the *2025 Remediation Effectiveness Report* (DOE 2025) 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. Posttreatment monitoring of the 7000 area plume continues.

During FY 2024, 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.

Monitoring results for 2024 showed that the cap has enabled the attainment of the groundwater-level goals established in the post-remediation completion report. Drinking water standards are used to screen water quality concentrations to evaluate the site response to remediation. Following completion of the remedial actions, concentrations of ^{90}Sr, 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. Trend evaluations using the Mann–Kendall test were conducted on ^{90}Sr results from the four wells where ^{90}Sr concentrations exceeded the 8 pCi/L maximum contaminant level derived concentration in 2024. The trend evaluations showed that ^{90}Sr concentrations for the most recent 10-year evaluation period decreased and were stable at three wells for the most recent 5-year evaluation period. No significant trend was identified for the fourth well.

Concentrations of benzene, potentially from natural sources, exhibited a stable trend for the most recent 5-year evaluation period for two wells where benzene results were equal to the 0.005 mg/L maximum contaminant level screening concentration during 2024. The data are presented in the *2025 Remediation Effectiveness Report* (DOE 2025).

Groundwater monitoring continued at the ORNL 7000 area during 2024 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 as part of a biostimulation test. Ongoing monitoring of VOC concentrations shows that the effects of the 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 to be attained after completion of all ROD-specified RAs. In 2024, 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 is suspected to contribute to nonpoint very shallow groundwater contaminant migration into WOC.

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 in 2024 was about 49 in., which is about 7 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, high sodium, and 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 *2025 Remediation Effectiveness Report* (DOE 2025).

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 2024 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 2021). 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 2024, 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 originally included 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 5.35 shows the locations of the exit pathway monitoring points targeted for sampling in 2024:

- 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

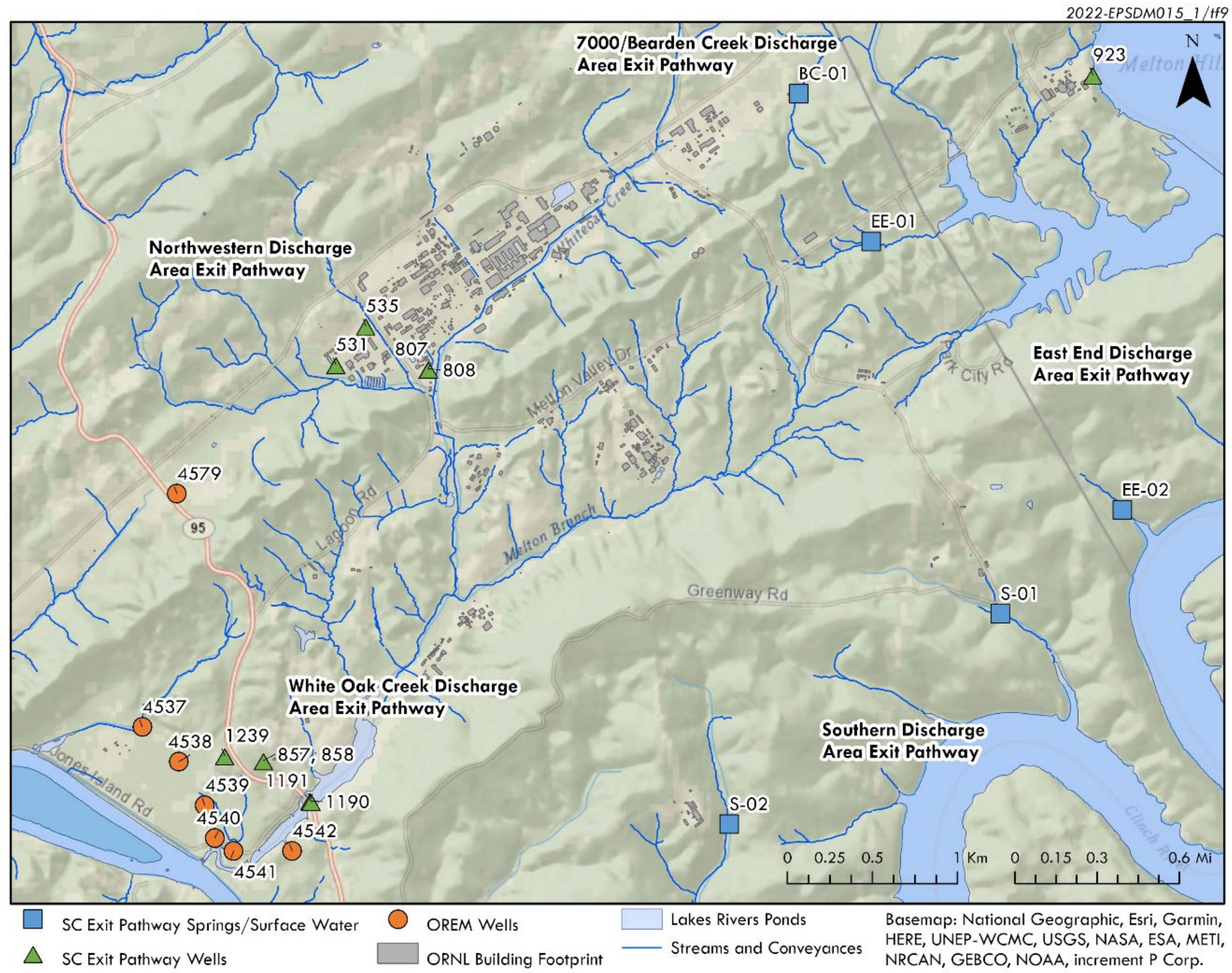
The efficacy of the exit pathway monitoring program was reviewed in late 2011. As a result, the groundwater monitoring program was modified through an optimization approach that included frequency analysis of parameters and their concentrations based on an exhaustive review of historical groundwater 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 2024 is summarized in Table 5.17.

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 2024, dry-season samples were collected in October and November, and wet-season samples were collected in March and April.

Exit pathway monitoring results

Table 5.18 summarizes radiological parameters detected in samples collected from exit pathway monitoring points during 2024. No radiological parameters were detected in 2024 samples from the 7000/Bearden Creek Discharge Area.

Metals are ubiquitous in groundwater exit pathways and 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 5.35. UT-Battelle exit pathway groundwater monitoring locations at ORNL, 2024

Table 5.17. Exit pathway groundwater monitoring conducted in 2024

Monitoring point	Wet	Dry
7000/Bearden Creek Discharge Area		
BC-01	Radiological, organics, and metals	Radiological
East End Discharge Area		
923	Radiological	Radiological
EE-01	Radiological, organics, and metals	Radiological
EE-02	Radiological	Not sampled[a]
Northwestern Discharge Area		
531	Radiological	Radiological
535	Radiological	Radiological
807	Radiological	Radiological, organics, and metals
808	Radiological	Radiological
Southern Discharge Area		
S-01	Radiological, organics, and metals	Not sampled[a]
S-02	Radiological	Radiological
White Oak Creek Discharge Area		
857	Radiological	Radiological
858	Radiological	Radiological, organics, and metals
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 2024 dry season because of lack of water flow.*

Table 5.18. Radiological parameters detected in 2024 exit pathway groundwater monitoring[a]

Monitoring location	Parameter	Concentration (pCi/L)		
		Wet season[b]	Dry season[b]	Reference value[c]
East End Discharge Area				
Well 923	Beta	3.2	3.08	50
Stream EE-01	Beta	U2.16	3.2	50
Northwestern Discharge Area				
Well 531	Beta	4.98	4.1	50
Well 807	Beta	4.69	4.57	50
Well 808	Beta	5.08	10.7	50
Southern Discharge Area				
Stream S-01	^{212}Bi	37.8	NF	
Stream S-01	^{214}Bi	5.24	NF	40,000
Stream S-02	Beta	3.04	2.78	50
White Oak Creek Discharge Area				
Well 857	Alpha	11.9	ND	15
Well 857	Beta	11.5	3.27	50
Well 1190	Alpha	U0.226	3.44	15
Well 1190	Beta	U1.91	6.44	50
Well 1190	^{208}Tl	ND	2.05	
Well 1190	^{3}H	11,200	11,500	20,000
Well 1191	Alpha	2.22	3.3	15
Well 1191	Beta	178	223	50
Well 1191	^{214}Bi	11.3	ND	40,000
Well 1191	$^{89/90}Sr$	91.4	107	68
Well 1191	^{3}H	4,480	6,050	20,000
Well 1239	Alpha	U0.291	3.34	15
Well 1239	Beta	U0.286	4.16	50

[a] No radiological parameters were detected in the 7000/Bearden Creek Discharge Area in 2024.
[b] 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.
[c] 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 2024 at ORNL were generally consistent with observations reported in past annual site environmental reports for ORR.

Based on the results of the 2024 monitoring effort, there is no indication that current SC operations are significantly introducing contaminants to the groundwater at ORNL.

Eight radiological contaminants were detected in exit pathway groundwater samples collected in

2024. 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. During the wet season, alpha activity was detected just above the normal range at well 857. Although below the reference value, this detection is the highest concentration recorded at this location to date.

Twenty-four metallic parameters were detected in exit pathway groundwater samples collected in 2024. 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 2024. 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 wells 1190 and 1191. Bis(2-ethylhexyl) phthalate and toluene were also detected in the sample from well 1191 in wet-season monitoring. Methylene chloride was detected at an estimated concentration below the detection limit during dry-season monitoring at wells 807 and 1191. 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

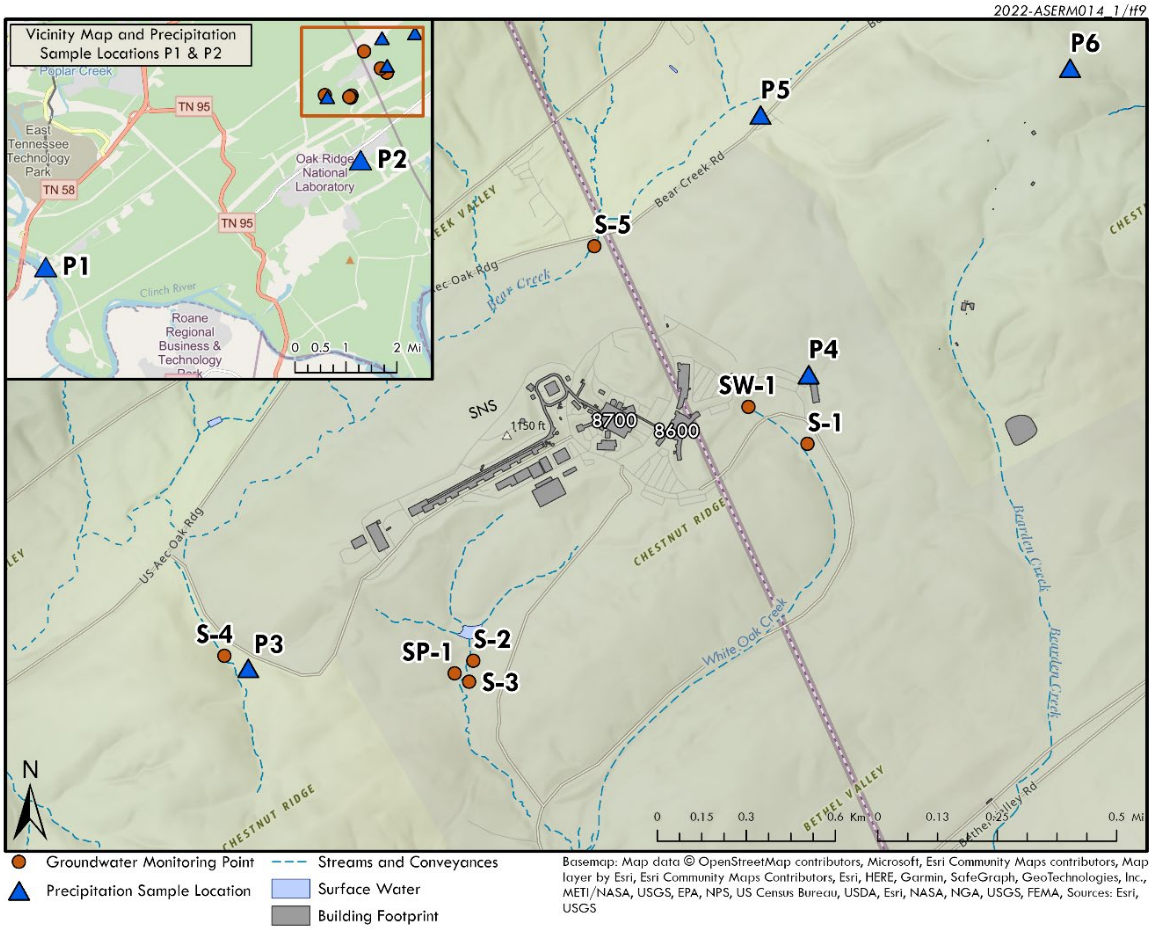
Active-sites groundwater surveillance monitoring was performed in 2024 at the SNS site under the SNS operational monitoring plan (Bonine, Ketelle, and Trotter 2007) because of the potential for adverse impact on groundwater resources at ORNL should a release occur.

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 transport characteristics of neutron activation products produced, diffusion and advection, and the presence of karst geomorphic features 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 5.36 shows the locations of the specific monitoring points sampled during 2024.



Acronyms:

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

Figure 5.36. Groundwater and precipitation monitoring locations at the Spallation Neutron Source, 2024

A modified SNS operational monitoring plan was implemented in 2012 and was based on statistical evaluations of data collected between 2004 and 2011.

Quarterly sampling at each monitoring point continued in 2024. In 2024, all sampling was performed in conjunction with rainfall events, with samples being collected during rising or falling (recession) limb flow conditions. Table 5.19 shows the sampling and parameter analysis schedule followed in 2024.

Table 5.19. Spallation Neutron Source monitoring program schedule, 2024

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

[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 2024. Low concentrations of alpha and beta activities were detected at spring S-5 and 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 spring S-2. Table 5.20 summarizes SNS sampling locations and radionuclide detections for 2024. Analytical results were compared with current federal or state standards or 4 percent of the DCS. None of the radiological constituents detected in the SNS groundwater and surface water sample locations exceeded reference values in 2024.

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 Tennessee Valley Authority reactor sites, and from commercial radiological waste processing facilities in the area. The precipitation sampling locations are shown in Figure 5.36, and the results are summarized in Table 5.21. Thirty-six 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, Tennessee Valley Authority 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 5.20. Radiological concentrations detected in samples collected at the Spallation Neutron Source, 2024[a]

Parameter	Concentrations (pCi/L)				Reference value[b]
	March	July	September	December	
			SW-1[c]		
^{3}H	1,630	3,120	2,700	1,190	20,000
			S-1[c]		
^{3}H	1,030	588	209	403	20,000
			S-2[c]		
Beta			4.25		50
^{3}H	980	913	600	661	20,000
			S-3[d]		
^{3}H	608	412		417	20,000
			S-4[e]		
Beta				2.28	50
^{3}H	337	816	866	417	20,000
			S-5[f]		
Alpha	11.9				15
Beta	10.7				50
^{3}H	277	241		207	20,000
			SP-1[a]		
^{3}H	441	337	440	454	20,000

[a] In addition to ^{3}H analyses, an extended suite of parameters was analyzed at each location during one 2024 sampling event. The extended suite included 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 September.

[d] Analysis of extended suite completed in December.

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

[f] Analysis of extended suite completed in March.

Acronyms:

S = spring

SP = seep

SW = surface water sampling area

Table 5.21. Summary of precipitation ^3H monitoring results, 2016–2024

Sample location	Total samples	Total detects	Maximum detect (pCi/L)	Date of maximum detect	Date of most recent detect
P1	36	10	4,930	05/21/2016	9/26/2024
P2	36	2	1,070	05/21/2016	12/10/2024
P3	36	7	1,230	05/21/2016	12/10/2024
P4	36	9	3,560	10/07/2023	12/10/2024
P5	36	6	908	05/21/2016	12/10/2024
P6	36	5	1,240	02/07/2018	12/10/2024

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

Fluorinated organic chemical compounds collectively referred to as per- and polyfluoroalkyl substances (PFAS) are contaminants of emerging concern. PFAS 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) have been produced in large amounts in the United States and have been studied more than other PFAS compounds. Through 2001, PFOS and other PFAS were used in the manufacture of aqueous film-forming foams, 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 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 and 2,000 ng/L, respectively.

In April 2022, EPA proposed the first CWA aquatic life criteria for PFAS (Table 5.22), 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 aqueous film-forming foams, and the foams that were used in past training activities may have contained PFAS. 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 was developed and was implemented in 2023 and 2024 to assess these areas for the presence of PFAS in groundwater and surface water bodies in these areas.

Table 5.22. 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 assess whether PFAS from non–aqueous film-forming foam sources are present and reaching surface waters. Surface water monitoring includes the use of passive sampling devices, which are deployed in stream environments for extended periods (typically 4 weeks) and accumulate PFAS that might not be measurable with traditional water sampling techniques. In 2024, surface water grab samples were taken in First Creek downstream of Building 2500 and in WOC upstream of the Fire Training and Test Facility. Samples were analyzed with EPA Method 537.1. Some PFAS analytes were detected in these areas, consistent with past aqueous film-forming foams use.

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, and limited sampling of this system for PFAS was conducted in 2024 as part of fifth Unregulated Contaminant Monitoring Rule efforts. No PFAS were detected in samples from the ORNL water distribution system.

To enable tracking of any current use and operational needs for PFAS-containing materials, the ORNL Hazardous Materials Management Information System generates reports to notify environmental protection staff when new PFAS-containing materials enter the system. This system also supports tracking of Toxics Release Inventory–reportable PFAS inventory. In 2024, the total inventory of these PFAS remained below the reportable threshold.

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. UT-Battelle Facilities and Operations staff track 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

Calibration schedules and frequencies are determined 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 5.3 lists environmental audits and assessments performed at ORNL in 2024 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 2024 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/IEC 17025 (which contains general requirements for the competence of testing and calibration laboratories) and from the US Department of Defense Environmental Laboratory Accreditation Program (DOD-ELAP), DOECAP, and NELAP. Seven external audits were performed on-site in 2024. No issues were identified that would affect analytical data reported to clients. In 2024, GEL Laboratories reported results from 5,752 performance test analyses (including DMRQA, MAPEP, DOECAP, and NELAP). Of these, 5,670 (98.6 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 2024, Eurofins participated in MAPEP and DMRQA, and all applicable test results were within acceptable ranges.

RMAL received ISO/IEC 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 2024, RMAL participated in several external audits, including the annual TDEC Waste Compliance Audit and an annual ISO/IEC 17025:2017 surveillance audit performed by A2LA, and 13 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 2024, 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 except for hexane extractable materials and mercury in soil. Remedial proficiency samples were analyzed for hexane extractable materials, and results of these analyses were acceptable. Analyses of remedial samples for mercury in soil are ongoing.

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 2024, nine 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 2024, 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). Results for *C. dubia* were in acceptable ranges, but *P. promelas* results initially were not. Corrective actions were implemented, and a retest was passed in November 2024.

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.

EPSD is committed to continual improvement in processes and activities and is pursuing opportunities to modernize and improve environmental data management strategies. Implementation of a multiyear database modernization plan is underway to improve data integrity, modernize data delivery, support compliance with cybersecurity and other DOE requirements, and increase program resilience. In 2024, ORNL staff interfaced with other DOE sites to benchmark environmental data management strategies, identify preferred software, and consider lessons learned from similar data modernization efforts undertaken at other DOE sites. These inputs were incorporated into the ORNL database modernization initiative, and the sharing of information across sites continues to optimize efforts.

The ORNL data management team takes part in a community of practice that connects DOE data management teams to discuss data management topics on a quarterly basis. ORNL staff have also joined the Office of Sustainable Environmental Stewardship environmental monitoring working group, which facilitates collaboration among DOE sites and establishes benchmarks for their monitoring programs; this group discusses data management topics and is another avenue for sharing data management best practices across DOE sites.

5.7.7. Records Management

The UT-Battelle Requirements, Documents, and Records Management System provides the requirements for managing all UT-Battelle records, including requirements for 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 2024 Cleanup Progress: Annual Report on Oak Ridge Reservation Cleanup* (UCOR 2024) provides detailed information on OREM's 2024 cleanup activities (**here**).

5.8.1. Wastewater Treatment

At ORNL, OREM operates PWTC and the Liquid Low-Level Waste Treatment Facility. In 2024, 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 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 2024, ORNL performed 120 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 2024 by UCOR addressed both contact-handled and remotely handled solids and debris. These activities involved processing, treating, and repackaging waste. All TRU waste is transported to the Waste Isolation Pilot Plant for disposal. LLW and mixed LLW are transported to the Nevada National Security Site or to another approved off-site facility for disposal.

In 2024, 68.3 m^3 of contact-handled TRU waste was shipped from TWPC in 12 shipments (643 containers). During 2024, 11.78 m^3 of contact-handled waste was processed; 0.21 m^3 of remotely handled waste was processed, and 126.6 m^3 of mixed LLW (TRU waste that was recharacterized as LLW) was shipped off-site.

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