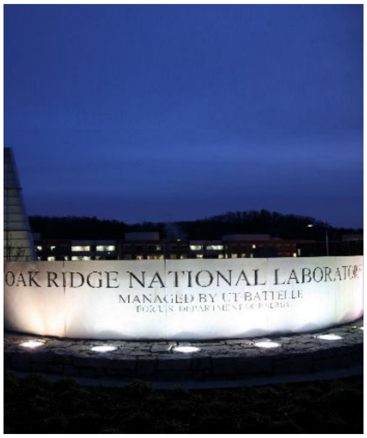


DOE's Oak Ridge National Laboratory is the nation's largest multiprogram science and technology laboratory. ORNL's mission has grown and expanded through the years, and now it is at the forefront of supercomputing, advanced manufacturing, materials research, neutron science, clean energy, and national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

5

Oak Ridge National Laboratory

ORNL is a thriving multiprogram research campus with world-leading facilities and a talented and diverse workforce of innovators and problem solvers. Researchers use these unique facilities along with sophisticated tools and signature strengths in neutron science, high-performance computing, advanced materials, nuclear science and engineering, and isotopes to benefit science and society, making it possible to meet the following goals:

- Advance understanding, design, and use of new materials and chemical processes
- Reveal unmatched insights through computing and data
- Ensure safe, clean 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, from genes to ecosystems

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

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

ORNL is managed by UT-Battelle LLC, a partnership between the University of Tennessee and Battelle Memorial Institute. Other DOE contractors conducting activities at ORNL in 2020 included North Wind Solutions, LLC; UCOR; and Isotek Systems, LLC (Isotek).

In 2020, the coronavirus disease (COVID-19) introduced unique challenges and opportunities at ORNL. To maximize social distancing, roughly two-thirds of ORNL's staff began working remotely, necessitating abrupt and dramatic changes in the conduct of work both on and off the ORNL site. On-site, procedures to prevent COVID-19 exposure and infection were quickly developed to protect staff members with jobs that cannot be performed remotely. The relocation of a majority of employees to remote workplaces in a short period of time created ergonomic concerns and presented challenges for the UT-Battelle Information Technology Services Division as the demand for connection clients for remote workers grew substantially and rapidly.

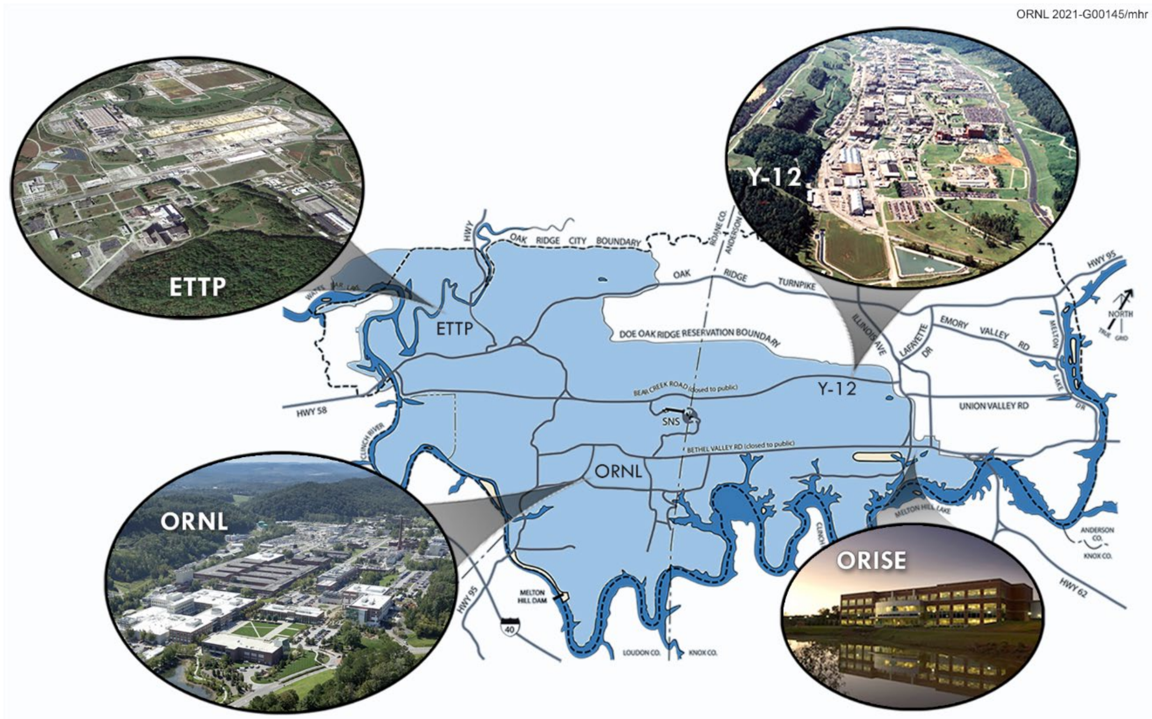
At the same time, ORNL researchers rapidly shifted their efforts and resources toward joining the fight to identify solutions to the pandemic. Remote rapid access to ORNL's cutting-edge facilities was made available to scientists from other government facilities, medical institutions, industry, and academia to allow collaborative exploration of effective COVID-19 preventative measures, tests, and treatments.

In the midst of these unexpected and unprecedented changes, UT-Battelle continued to meet commitments to provide a safe and healthy workplace, protect the public and the environment, and meet regulatory requirements and commitments. All required state and federal environmental monitoring, sampling, and reporting tasks were completed in 2020. No 2020 environmental compliance issues resulted from changes in ORNL operations and procedures as a result of COVID-19.

5.1. Description of Site, Missions, and Operations

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

In March 2007, Isotek assumed responsibility for the Building 3019 Complex at ORNL, where the national repository of ^{233}U has been kept since 1962. In 2010, an Analysis of Alternatives was conducted to evaluate methods available for ^{233}U disposition, and in 2011, the recommendations in the *Final Draft ^{233}U Alternatives Analysis Phase I Report* (DOE 2011b) were endorsed. The Phase I recommendations included (1) transfer of Zero-Power Reactor plate canisters to the National Nuclear Security Administration and disposal of Consolidated Edison Uranium Solidification Project material canisters and (2) completing 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 material canisters began in 2015 and was completed in 2017. UT-Battelle provides air and water quality monitoring support for the Building 3019 complex; results are included in the UT-Battelle air and water monitoring discussions in this chapter.



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

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

Responsibility for Building 2026 was transferred from UT-Battelle to Isotek in May 2017. Isotek began processing ^{233}U material inside glove boxes in Building 2026 in the fall of 2019. The processing of the ^{233}U material produces a solidified, low-level radioactive waste (LLW) form that is acceptable for disposal. Additionally, Isotek is extracting ^{229}Th from the material and is transferring it to a customer for use as source material for medical isotope production.

UCOR is the DOE ORR cleanup contractor. The scope of UCOR activities at ORNL includes long-term surveillance, maintenance, and management of inactive waste disposal sites, structures, and buildings. Characterization and deactivation of former reactors and isotope production facilities continued in 2020. One of the priority projects was to prepare the 3026 facility—the Radioisotope Development Lab—for demolition. Using a 175 ton crane, workers installed a protective tent to keep nearby research facilities protected while the final two hot cells are being demolished. Characterization and deactivation also continued in former reactors and isotope production facilities, including Buildings 3005, 3010, 3042, 3009, 3010, 3010-A, 3080, 3083, 3107 and 11 facilities in the area that supported and produced radioisotopes ("Isotope Row"). Actions included asbestos abatement, removal of combustible materials, and isolation of electrical and mechanical utilities at the facilities.
Other activities include groundwater monitoring, transuranic (TRU) waste storage, and operation of the wastewater treatment facility and the waste-processing facility for liquid LLW.

As of December 11, 2015, North Wind Solutions, LLC, (NWSol) has been the prime contractor for the Transuranic Waste Processing Center (TWPC), which is located on the western boundary of ORNL on about 26 acres of land adjacent to the Melton Valley Storage Tanks along State Route 95. TWPC's mission is to receive, process, treat, and repackage TRU wastes for shipment to designated facilities for final disposal. TWPC consists of the waste-processing facility, the personnel building, and numerous support buildings and storage areas. TWPC began processing supernatant liquid from the Melton Valley Storage Tanks in 2002, contact-handled 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 the TWPC, and results are included in water monitoring discussions in this chapter. Air monitoring data from TWPC are provided to UT-Battelle for inclusion in the ORR National Emission Standards for Hazardous Air Pollutants for Radionuclides (Rad-NESHAPs) annual report and is incorporated into air monitoring discussions in this chapter.

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

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 hosts the Institute for Advanced Composites Manufacturing Innovation lab space and an outreach program for local high school students.

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

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

Photo by Carlos Jones. Approved for public release.

Figure 5.2. Carbon Fiber Technology Facility

5.2. Environmental Management Systems

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

5.2.1. UT-Battelle Environmental Management System

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

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

5.2.1.1. Integration with the Integrated Safety Management System

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

5.2.1.2. UT-Battelle Environmental Policy for ORNL

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

5.2.1.3. Environmental Management System Planning

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 both the line organization level and the laboratory level. Activities that are relative to any of the aspects are carefully controlled to minimize or eliminate impacts to the environment. Nine significant environmental aspects (listed on the

ORNL website **here**) have been identified as potentially having significant environmental impacts.

UT-Battelle legal and other requirements

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

UT-Battelle objectives

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

UT-Battelle programs

UT-Battelle has established an organizational structure to ensure that environmental stewardship practices are integrated into all facets of its missions at ORNL. Programs led by experts in environmental protection and compliance, energy and resource conservation, pollution prevention, and waste management ensure that laboratory activities are conducted in accordance with the environmental policy (see Section 5.2.1.2). Information on UT-Battelle's 2020 compliance status, activities, and accomplishments is presented in Section 5.3.

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

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

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

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

- Waste service representatives provide technical support to waste generators to properly manage waste by assisting in identifying, characterizing, packaging, and certifying wastes for disposal;
- The waste-handling team performs waste-packing operations and conducts inspections of waste items, areas, and containers.
- The transportation management team ensures that both the on-site and off-site packaging and transportation activities are performed in an efficient and compliant manner.
- The hazardous material spill response team is the first line of response to hazardous materials spills at ORNL and controls and contains spills until the situation is stabilized.

5.2.1.4. Site Sustainability

As required by DOE Order 436.1, Department Sustainability (DOE 2011), The Oak Ridge National Laboratory FY 2021 Site Sustainability Plan (SSP), an internal document that includes FY 2020 performance data, was completed in December 2020 in compliance with annual DOE guidance.

To attain the federal sustainability goals outlined in the SSP, sites operated by DOE are expected to contribute toward all targets and to identify strengths that can be adapted as agencywide best practices. To meet the SSP goals at ORNL, UT-Battelle identifies opportunities for continuous improvements in operational and business processes and implements practices to maximize the return on investment in modernizing facilities and equipment.

ORNL Facilities Management Division (FMD) is tasked with the management of distinctive research facilities and extraordinary scientific equipment. The commissioning dates of the systems range from the 1940s to 2020. As such, many facilities require a customized methodology to enhance sustainability; a boilerplate approach would not be sufficient to operate efficiently and deliver the desired results. FMD's Energy Efficiency and Sustainability Program (EESP) is tasked with the daily management of the energy- and water-saving projects that are the key to results in operational savings and sustainable practices.

The Sustainable ORNL website is actively managed and is available for employee and public view **here**. Sustainable ORNL promotes systemwide best practices, management commitment, and employee engagement that will help lead ORNL into a future of efficient, sustainable operations.

Sustainable ORNL awards

Awards and recognition for sustainability efforts at ORNL received in FY 2020 are listed below. Information about ORNL awards can be found at the on the Sustainable ORNL website **here**, on the *R&D Magazine* website **here**, and on the Federal Laboratory Consortium website **here**.

- US DOE awards
  - Sustainability Champion: Amy Albaugh, of FMD's EESP, for initiatives to foster behavioral change at ORNL that advanced the progress in meeting sustainability goals such as those pertaining to energy and water in Executive Order 13834 (EO 2018)
  - Sustainability Program/Project: ORNL Water Use Reduction, Facility and Research Cooperation
  - Strategic Partnerships for Sustainability: ORNL Arboretum in Partnership with the University of Tennessee and the State of Tennessee
- *R&D Magazine* R&D 100 Awards
  - Biomacromolecule Engineering by Soft Chain Coupling
  - Cobalt-Free Li-ion Battery Cathode Material developed by ORNL and Sparkz
- Federal Laboratory Consortium 2021 Excellence in Technology Transfer National Technology Transfer Awards

- Impactful Technology Transfer of Revolutionary Large-Scale, Energy-Efficient 3D-Printer by ORNL and Magnum Venus Products
- Building Sustainability with Cobalt-Free Battery Technologies

▪ Recognition for sustainable transportation and commuting by community partners
  - 2020 Best Workplace for Commuters, National Standard of Excellence, February 2020
  - Knoxville Area Smart Trips 2019 Top Employer, February 2020

Sustainable ORNL Notable Achievements

To promote regional outreach and involvement, the Oak Ridge National Laboratory Annual Sustainability Report is published annually by the Sustainable ORNL program and distributed electronically to ORNL staff and associates as well as the surrounding communities (city/county governments and educational institutions). Reports for ORNL are archived on the ORNL website **here**. The purpose of the reports is to share the positive benefits that can be experienced by all entities that commit to sustainable practices, energy conservation, and the reduction of long-term risks due to carbon emissions. The 2020 ORNL report (ORNL 2020) can be viewed and downloaded from the ORNL website **here**.

DOE 50001 Ready. In FY 2020 FMD's EESP was successful in the attainment of DOE's 50001 Ready recertification. The 50001 Ready program recognizes facilities and organizations that attest to the implementation of an ISO 50001–based energy management system. DOE launched the 50001 Ready Program in 2017, and ORNL is the third federal location and the second national laboratory to receive the certification. The program, which is described on the DOE website **here,** is a self-guided, self-paced approach for organizations to realize improvements in energy management that does not require external audits or certifications. To obtain certification, organizations are responsible for completing all 25 tasks in the 50001 Ready Navigator online tool **here** and for measuring and improving energy performance over time.

The program recognizes organizations that demonstrate outstanding energy management standards and best practices in their facilities. The certification covers more than 3 million ft^2 in 65 buildings at ORNL that are equipped with advanced metering. ORNL's advanced metering system aids in the reporting of quality energy data and supports the monitoring of facility energy performance toward the goal of savings in utility use and operations cost. The EESP led the certification effort, but contributions and support from many other divisions were necessary for achievement of the project goals.

The Sustainable ORNL website "News" page **here** provides more information about the certification and a link to DOE's announcement. The effort is described in "Oak Ridge National Laboratory—50001 Ready Facility," a case study on the DOE Better Buildings website **here**.

Summary of performance data for energy, water, and waste

Executive Order 13834 (EO 2018) directs federal agencies to manage their buildings, vehicles, and overall operations to optimize energy and environmental performance, reduce waste, and cut costs. ORNL collects data and publishes the results in the Annual Sustainability Report to document its compliance with Executive Order 13834 and other applicable guidance. In FY 2020 the annual SSP guidance and ORNL's submittal were updated to include modifications made to executive orders and applicable federal statutes (ORNL 2020).

Energy use intensity. Based on FY 2020 data, energy use in the buildings category at ORNL was 1,024 billion Btu, not including ORNL's excluded facilities as defined by the Energy Policy Act of 1992 (EPACT 1992). "Energy use intensity," given in British thermal units per square foot, is the metric used at ORNL to monitor energy use. Based on 4,314,051 ft^2 of energy-consuming buildings, trailers, and other structures and facilities identified in the Facilities Information Management System (DOE 2020), the FY 2020 calculated energy use intensity was 237,298 Btu/ft², a cumulative reduction of 34.8 percent since FY 2003 and a reduction of 1.36 percent since FY 2019 (Figure 5.3).

Efforts to maintain steady progress toward energy use intensity reductions at ORNL focus on sustainable, energy-efficient design in construction projects, smart repurposing of existing facilities, and continuous improvements in facility and utility operations. Modernization continues at ORNL as old, energy-inefficient buildings are demolished to make way for the construction of high-performance buildings. Improvements in utilities services have reduced the costs of energy, fuel, water, and maintenance and have increased reliability in the delivery of steam, chilled water, and potable water.

ORNL 2021-G00152/mhr

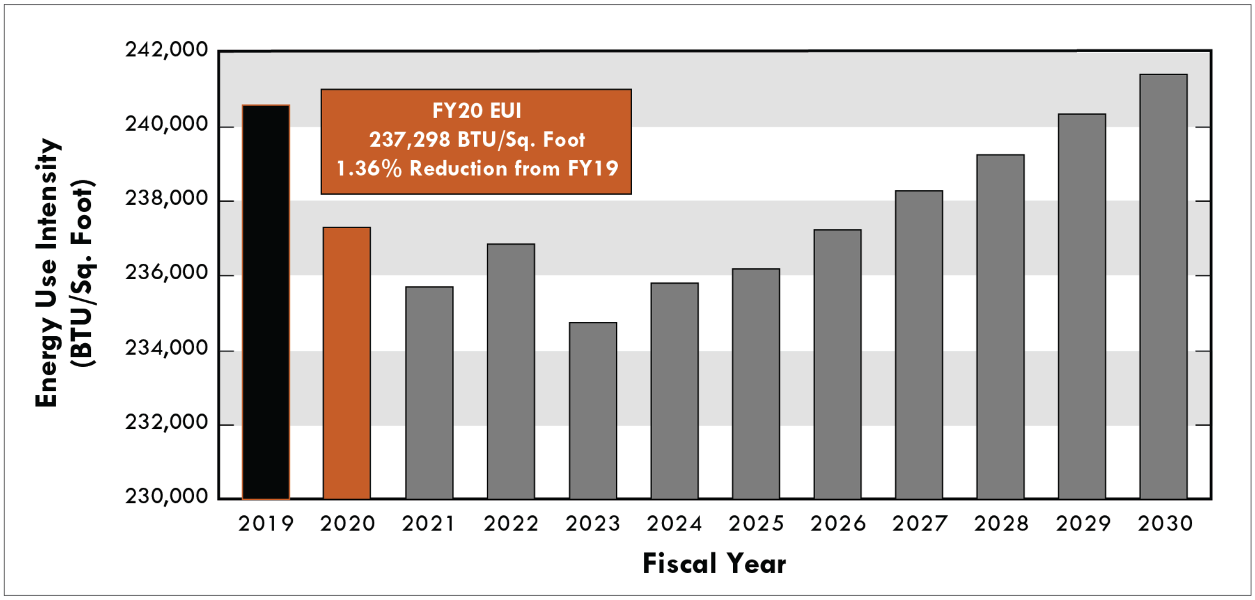


Figure 5.3. Recent, current (FY 2020), and projected energy use intensity at ORNL

Energy use intensity reduction in existing ORNL facilities is data-driven, and efforts are made to quantify and bring awareness to building energy performance so that operations staff can make informed decisions. FMD pursues approaches to energy consumption awareness using data visualization and reporting. Building data analytics, including fault detection and diagnostics, are also being added to ORNL's energy conservation tools. In FY 2020, FMD purchased a license for a new fault detection and diagnostics system after prior pilots of multiple systems. EESP elected the system after learning about it from other national laboratories during a peer discussion meeting. A graded approach is planned to introduce the new platform while staff are learning to utilize the tool to its full potential. The establishment of the standards-driven DOE 50001 Ready program will allow FMD and the EESP staff to concentrate limited resources on the most significant energy users to better influence return on investments.

Implementation of improvements in utility services to realize reduced costs for energy, fuel, water, and maintenance and improvements in the delivery of potable and chilled water and steam continued across ORNL in 2020. The Utilities Division is currently conducting a comprehensive utility study that encompasses all major utility systems throughout the campus. This study focuses on improved operations, resiliency, and efficiency.

Water use intensity. ORNL procures potable water from the City of Oak Ridge for domestic use (handwashing, flushing), cooling (cooling towers, chillers), heating (steam generation, hot water generation), laboratories, and special research processes. "Water use intensity," given in kilogallons per square foot, is the metric used at ORNL to monitor water consumption.

Even before the baseline target year of 2007, numerous strategies to reduce water consumption were in place. Strategies include repairing leaks, replacing old lines in the site water distribution system, and eliminating once-through-cooling where possible. FY 2020 water consumption increased 25.3 percent from FY 2019, primarily due to HFIR's return to normal operations from a year-long maintenance outage. In addition, the high-performance computing operations of ORNL's Summit supercomputer increased in FY 2020, resulting in more water utilization for the cooling tower. An increase in research activities at the Spallation Neutron Source (SNS) also added to the consumption of cooling tower water. Even though water use increased from FY 2019 to FY 2020, total annual water use at ORNL has been reduced by 27.2 percent since FY 2007 (see Figure 5.4). Water consumption at ORNL is expected to rise to support additional high-performance computing and SNS activities. A 41 percent increase is anticipated by FY 2030. Mitigation factors (such as the comprehensive study being carried out by the Utilities Division to reduce costs for energy, fuel, water, and maintenance) will continue to be deployed; however, the increase in laboratory mission growth will require the continued increase in water resources.

Waste diversion. The diversion rate for municipal solid waste at ORNL was 49 percent in FY 2020; the DOE sustainability goal remained at 50 percent. The diversion rate for construction and demolition materials and debris was 75 percent and exceeded the DOE target.

Pollution prevention. Source reduction efforts at ORNL include increases in the use of acceptable nontoxic or less-toxic alternative chemicals and processes while minimizing the acquisition of hazardous chemicals and materials through material substitution, operational assessments, and inventory management. In cases where the complete elimination of a particular hazardous material is not possible, a combination of actions is pursued, including controls to limit use, procurement alternatives, and recycling processes to mitigate the environmental impact. UT-Battelle implemented 24 new pollution prevention projects and ongoing reuse/recycle projects at ORNL during 2020, eliminating more than 3 million kg of waste. Researchers implement traditional recycling options and create processes for others through R&D when a need is identified. For instance, in 2020 ORNL researchers and a commercial partner recognized the need for and invented a process to extract and recover more than 97 percent of the rare earth elements from scrapped magnets in electronics at purities exceeding 99.5 percent. (Figure 5.5).

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

Electronic stewardship. Environmentally sound disposition (reuse or recycle) of all used electronics is accomplished at ORNL by implementation of the property management and environmental management policies and procedures documented in SBMS. Options include transfer to other DOE contractors, nonprofit organizations, and qualified educational institutions. Traditional electronic equipment is recycled through an off-site certified recycler. These efforts continue to close the recycling loop for electronics.

Sustainable vehicle fleet. ORNL recently transitioned to a General Services Administration leased fleet. This change in vehicle management enables ORNL to replace older, less fuel-efficient vehicles in its fleet with new alternative-fuel vehicles at a faster rate. Orders for 305 new vehicles were placed in FY 2020, and is better aligned to comply with DOE guidance concerning sustainable fleet management practices. To date, approximately 100 new vehicles have been received at ORNL. With these additions, approximately 90 percent of ORNL's 467 vehicle fleet is compliant with the alternative-fuel vehicle criteria. In 2020,100 percent of light-duty vehicles operated on alternative fuels, exceeding DOE fleet management goals.

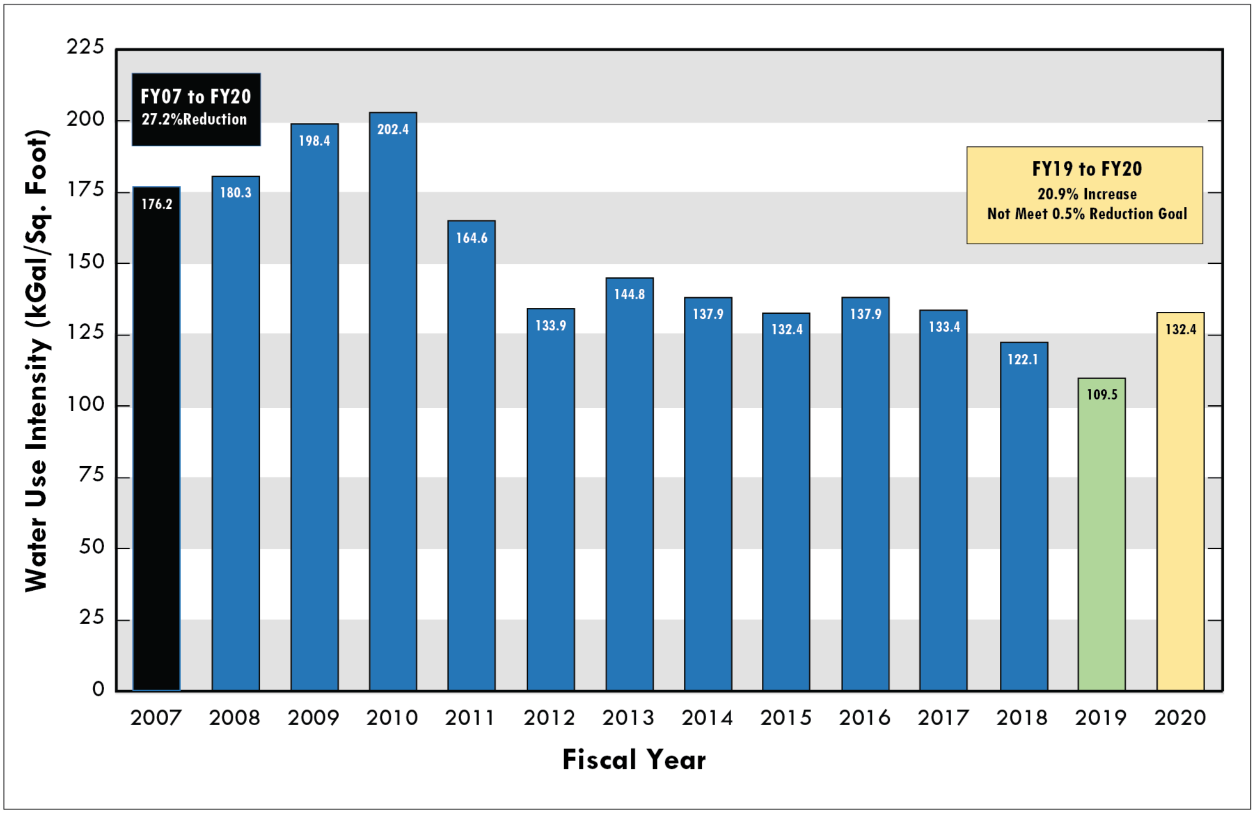


Figure 5.4. Historical and current (FY 2020) water use intensity at ORNL

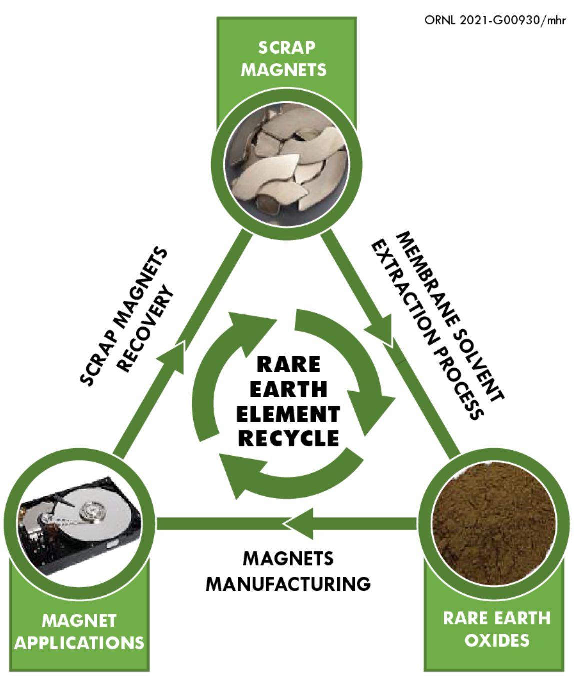


Figure 5.5. The rare earth recycling process at ORNL

High-performance sustainable buildings: Guiding principles. In FY 2020, on-site High Performance Sustainable Buildings (HPSBs) at ORNL included 22 buildings that are certified, either by being grandfathered through Leadership in Energy and Environmental Design (LEED) certification or by having attained 100 percent compliance with the HPSB guiding principles (EO 2007, DOE 2020a). This meets the current DOE SSP target.

One of the ways in which ORNL achieved success in meeting the guiding principles was through our long association with the LEED certification program. Although LEED certification has been a focus for ORNL in the past, ORNL is shifting focus to the HPSB guiding principles certification. This year, ORNL added two new buildings and 20,000 ft^2 of a third building to the list of HPSB-compliant buildings per the grandfathering provisions established in the 2016 Guiding Principles Guidance (CEQ 2016). LEED program information is available at the US Green Building Council website **here**.

Candidate buildings will be identified by Sustainable ORNL based on existing building space use, existing metering infrastructure, and known energy conservation opportunities. Action plans for establishing building-specific guiding principles will be developed and executed. Laboratory-wide standards will be used when feasible to fulfill applicable policies and procedures found in the guiding principles across multiple facilities. As experience with the guiding principles grows, the focus of ORNL's efforts remains on certifying office buildings for which the guidance is clearly applicable while establishing a path for future certification in larger, more complex facilities such as laboratories and mixed-use buildings. Information about DOE's HPSB directives can be found **here**.

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

Section 438 of the Energy Independence and Security Act of 2007 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).

In 2020, ORNL's approach to addressing EISA-438 requirements for storm water management was revised. Due to the type of soils (low permeability) and karst geology, conditions exist at ORNL that would allow claiming "technical infeasibility," as described in technical guidance from EPA (EPA 2009b). 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 not being pursued. Instead, mitigation strategies (e.g., for streams and their associated buffer zones, installation of water quality systems and devices to improve water quality, and strategies that would allow for additional evapotranspiration) are being pursued. Implementing this revised approach to EISA-438 compliance, as opposed to claiming "technical infeasibility" demonstrates ORNL's commitment to environmental stewardship.

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

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

If projects are located 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 2020, one of several water quality improvements for the 7000 area of ORNL was completed. Two water quality structures that aid in removal of sediments and floatables from storm water runoff from approximately two-thirds of the 7000 area were installed. Remaining water quality improvements will be completed in 2021 and will be summarized in the 2021 ASER.

5.2.1.6. Emergency Preparedness and Response

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

5.2.1.7. Environmental Management System Performance Evaluation

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

Monitoring and measurement

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

UT-Battelle Environmental Management System assessments

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

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

UT-Battelle also uses the results from numerous external compliance inspections conducted by regulators to verify compliance with requirements. In addition to regulatory compliance assessments, an internal EMS assessment is performed annually to ensure that the UT-Battelle EMS continues to conform to ISO requirements. An independent internal audit conducted in 2020 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 the Transuranic Waste Processing Center

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

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

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

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

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

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

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

5.2.3. Environmental Management System for Isotek

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

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

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

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

5.3. Compliance Programs and Status

During 2020 UT-Battelle, UCOR, NWSol, and Isotek operations were conducted to comply with contractual and regulatory environmental requirements. Table 5.1 presents a summary of environmental audits conducted at ORNL in 2020. The following discussions summarize the major environmental programs and activities carried out at ORNL during 2020 and provide an overview of the compliance status for the year.

Table 5.1. Summary of regulatory environmental audits, evaluations, inspections, and assessments conducted at ORNL, 2020

Date	Reviewer	Subject	Issues
March 4	TDEC	Hazardous Waste Compliance Evaluation Inspection (ORNL Warehouse)	0
March 11–12	TDEC	Hazardous Waste Compliance Evaluation Inspection (including UT-Battelle, Transuranic Waste Processing Center, and UCOR)	1
January 3	City of Oak Ridge	Carbon Fiber Technology Facility Wastewater Inspection	0
July 21	KCDAQM[a]	National Transportation Research Center Clean Air Act Inspection	0
August 25	City of Oak Ridge	CFTF Wastewater Inspection	0
October 22	TDEC[b]	Annual CAA Inspection for ORNL and CFTF	0

[a] *Knox County Department of Air Quality Management* [b] *Tennessee Department of Environment and Conservation*

5.3.1. Environmental Permits

Table 5.2 contains a list of environmental permits that were in effect in 2020 at ORNL.

Table 5.2. Environmental permits in effect at ORNL in 2020

Regulatory driver	Permit title/description	Permit number	Owner	Operator	Responsible contractor
CAA	Title V Major Source Operating Permit, ORNL	571359	DOE	UT-B	UT-B
CAA	Operating Permit, NTRC	17-0941-R1	DOE	UT-B	UT-B
CAA	Operating Permit, NWSol	071009P	DOE	NWSol	NWSol
CAA	Construction Permit, 3525 Area Off Gas System	971543P	DOE	UT-B	UT-B
CAA	Operating Permit, NWSol emergency generators	071010P	DOE	NWSol	NWSol
CAA	Title V Major Source Operating Permit, ORNL	569768	DOE	UCOR	UCOR
CAA	CFTF CAA Operating Permit (Conditional Major)	474951	DOE	UT-B	UT-B
CAA	CAA Title V Operating Permit for Isotek operations at ORNL Administrative Amendment #1	576448	DOE	Isotek	Isotek
CWA	ORNL NPDES Permit (ORNL sitewide wastewater discharge permit)	TN0002941	DOE	DOE	UT-B, UCOR, NWSol
CWA	Industrial and Commercial User Waste Water Discharge Permit (CFTF)	1-12	UT-B	UT-B	UT-B
CWA	Tennessee Operating Permit, Holding Tank/Haul System for Domestic Wastewater	SOP-07014	UCOR	UCOR	UCOR
CWA	Tennessee Operating Permit (sewage)	SOP-02056	DOE	NWSol	NWSol
CWA	Construction Storm Water Permit—ROSC Building	TNR 135617	DOE	UT-B	UT-B
CWA	Construction Storm Water Permit—Leadership Imaging Facility Building	TNR 135602	DOE	UT-B	UT-B
CWA	Aquatic Resources Alteration Permit—Leadership Imaging Facility Building	ARAP-NR1803.153	DOE	UT-B	UT-B
CWA	ARAP—General Permit for Maintenance of the Swan Pond Water Feature 5007	NR1903.038	DOE	UT-B	UT-B
CWA	Notice of Coverage Under the General NPDES Permit for Storm Water for 2000–3000 Area Utility Modernization	TNR136015	DOE	UT-B	UT-B
CWA	Notice of Coverage Under the General NPDES Permit for Storm Water for OLCF-5 Power Line	TNR135839	DOE	UT-B	UT-B

Table 5.2. Environmental permits in effect at ORNL in 2020 (continued)

Regulatory driver	Permit title/description	Permit number	Owner	Operator	Responsible contractor
CWA	NWP-12 - Utility Line Activities for OLCF-5 Power Line	LNR-2019-00571	UT-B	UT-B	UT-B
CWA	TVA Section 26A Permit for OLCF-5 Power Line	TVA 4003683	UT-B	UT-B	UT-B
CWA	Notice of Coverage Under the General NPDES Permit for Storm Water for 7000 Area Infrastructure Modernization	TNR136181	DOE	UT-B	UT-B
CWA	Notice of Coverage Under the General NPDES Permit for Storm Water for 2000-3000 Area Utility Modernization (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 Container Storage and Treatment Units	TNHW-145	DOE	DOE/ UCOR/ NWSol	UCOR/NWSol
RCRA	Hazardous and Mixed Waste Storage Permit	TNHW-178	DOE	DOE/UT-B	UT-B

Acronyms:
ARAP = Aquatic Resources Alteration Permit
CAA = Clean Air Act
CFTF = Carbon Fiber Technology Facility
CWA = Clean Water Act
DOE = US Department of Energy
Isotek = Isotek Systems, LLC
NPDES = National Pollutant Discharge Elimination System
NTRC = National Transportation Research Center
NWSol = North Wind Solutions, LLC
OLCF = Oak Ridge Leadership Computing Facility
ROSC = Research Operations Support Center
RCRA = Resource Conservation and Recovery Act
TRC = Translational Research Capability
UT-B = UT-Battelle LLC

5.3.2. National Environmental Policy Act/National Historic Preservation Act

NEPA provides a means to evaluate the potential environmental impact of proposed federal activities and to examine alternatives to those actions. UT-Battelle, NWSol, and Isotek maintain compliance with NEPA using site-level procedures and program descriptions that establish effective and responsive communications with program managers and project engineers to establish NEPA as a key consideration in the formative stages of project planning. Table 5.3 summarizes NEPA activities conducted at ORNL during 2020.

Table 5.3. National Environmental Policy Act activities, 2020

Types of NEPA documentation	Number of instances
UT-Battelle LLC	
Approved under general actions or generic CX determinations[a]	127
Project-specific CX determinations[b]	0
North Wind Solutions, LLC	
Approved under general actions[a] or generic CX determinations	2

[a] Projects that were reviewed and documented through the site NEPA compliance coordinator
[b] Projects that were reviewed and approved through the DOE Site Office and the NEPA compliance officer
Acronyms:
CX = categorical exclusion
DOE = US Department of Energy
NEPA = National Environmental Policy Act

During 2020, UT-Battelle and NWSol continued to operate under site-level procedures that provide requirements for project reviews and NEPA compliance. The procedures call for a review of each proposed project, activity, or facility to determine the potential for impacts to the environment. To streamline the NEPA review and documentation process, the DOE has approved generic categorical exclusion 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 CFR 1508.4 that does not individually or cumulatively have a significant effect on the human environment and for which neither an environmental assessment nor an environmental impact statement is normally required.

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

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

5.3.3. Clean Air Act Compliance Status

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

NTRC and CFTF are two off-site CAA-regulated facilities maintained and operated by UT-Battelle. An operating permit, issued by Knox County for two emergency generators located at NTRC, was issued in January 2020. The CFTF operates under a conditional major operating permit issued to UT-Battelle by TDEC in February 2020.

In summary, there were no UT-Battelle CAA violations and no Isotek, UCOR, or NWSol CAA violations or exceedances in 2020. Section 5.4 provides detailed information on 2020 activities conducted by UT-Battelle in support of the CAA.

5.3.4. Clean Water Act Compliance Status

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

In 2020, compliance with the ORNL NPDES permit was determined by approximately 1,800 laboratory analyses and field measurements. ORNL wastewater treatment facilities achieved a numeric permit compliance rate of more than 99 percent in 2020. One numeric noncompliance was reported for a wastewater treatment facility during 2020. In June, the annual whole effluent toxicity test for the Sewage Treatment Plant (Outfall X01) did not pass the NPDES permit limit of more than 44.3 percent effluent for fathead minnow (*Pimephales promelas*) survival and reproduction. A follow-up test was initiated within 7 days per the testing requirements in the permit and passed at more than 44.3 percent. The NPDES permit limit compliance rate for all discharge points for 2020 was more than 99 percent (see Table 5.4).

In May 2020, a hose on a mobile generator failed, leaking diesel to a storm drain inlet to Outfall 227 on White Oak Creek (WOC). The event was reported to TDEC because it caused a sheen for a short period of time before absorbent booms could be placed at the spill site and in the creek.

ORNL received a renewed NPDES permit in May 2019. Several conditions in the permit were appealed and remained unresolved during 2020.

Table 5.4. National Pollutant Discharge Elimination System compliance at ORNL, January through December 2020

Effluent parameters[a,b]	Number of numeric noncompliances	Number of compliance measurements[c]	Percentage of compliance[d]
	X01 (Sewage Treatment Plant)		
IC_{25} Static renewal 7-day chronic *Ceriodaphnia dubia* (%)	0	2	100
IC_{25} Static renewal 7-day chronic *Pimephales promelas* (%)	1	2	50
Ammonia, as N (summer)	0	26	100
Ammonia, as N (winter)	0	26	100
Carbonaceous biological oxygen demand	0	53	100
Dissolved oxygen	0	53	100
Escherichia coliform (col/100 mL)	0	53	100
Peracetic acid	0	3	100
pH (standard units)	0	53	100
Total suspended solids	0	53	100
	X12 (Process Waste Treatment Complex)		
IC_{25} C. *dubia* survival (%)	0	1	100
IC_{25} C. *dubia* reproduction (%)	0	1	100
IC_{25} *P. promelas* survival (%)	0	1	100
IC_{25} *P. promelas* reproduction (%)	0	1	100
Oil and grease	0	4	100
pH (standard units)	0	53	100
Temperature (°C)	0	53	100
	X16 through X27 (twelve instream monitoring locations)		
Total residual oxidant	0	288	100
	X28 and X29 (two additional instream monitoring locations)		
Peracetic acid	0	6	100
Hydrogen peroxide	0	6	100

[a] *Only permit parameters with a numerical limit are listed.*

[b] *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.*

[c] *Total number of readings taken in the year by approved method for the given parameter.*

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

5.3.5. Safe Drinking Water Act Compliance Status

ORNL's water distribution system is designated as a "non-transient, non-community" 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 for compliance with state and federal regulations:

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

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

In 2020, sampling results for ORNL's water system residual chlorine levels, bacterial constituents, lead and copper, and disinfectant by-products were all within acceptable limits. Sampling for lead and copper is required in 2021.

5.3.6. Resource Conservation and Recovery Act Compliance Status

The Hazardous Waste Program under the Resource Conservation and Recovery Act (RCRA 1976) establishes a system for regulating hazardous wastes from the initial point of generation through final disposal. In Tennessee, TDEC has been delegated authority by EPA to implement the Hazardous Waste Program; EPA retains an oversight role. In 2020, 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 2020.

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 5.5. In 2020, 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 2020 was 338,357 kg; mixed wastewater accounted for 299,889 kg. ORNL generators treated 3,145 kg of hazardous waste by elementary neutralization. The quantity of hazardous/mixed waste treated in permitted treatment facilities at ORNL in 2020 was 431,687 kg. This included waste treated by macroencapsulation, size reduction, stabilization/solidification, and wastewater treatment at the Process Waste Treatment Complex (PWTC). The amount of hazardous/mixed waste shipped off site to commercial treatment, storage, and disposal facilities was 110,078 kg in 2020.

Table 5.5. ORNL Resource Conservation and Recovery Act operating permits, 2020

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

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

In March 2020, TDEC Division of Solid Waste Management conducted a Hazardous Waste Compliance Evaluation inspection of ORNL generator areas; used oil storage 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 RCRA records. TDEC also reviewed the Hazardous Waste Transporter Permit, hazardous waste manifests, and US Department of Transportation training records. One violation was identified: UT-Battelle failed to record the inspection time on a total of five weekly inspection logs at a 90 day storage area. The operator corrected the violation when identified, returning the facility to compliance, so no follow-up inspections were conducted.

In 2018 ORNL requested an EPA ID number for hazardous waste activities at 115A Union Valley Road in Oak Ridge. This is ORNL's property sales warehouse for excessing and surplus sales. A surplus piece of equipment was determined to have contamination and had to be disposed of as hazardous waste. The equipment weighed

1,391 kg, which qualified Property Sales as a large quantity generator for the onetime shipment. The EPA ID number was subsequently deactivated. On March 4, 2020, the TDEC Division of Solid Waste Management conducted a Hazardous Waste Compliance Evaluation inspection to confirm that the status of the property sales warehouse had returned to non-generator status. No violations were observed.

DOE and UT-Battelle operations at the Jones Island Road 0800 Area, the HVC, and the CFTF were regulated as "conditionally exempt small-quantity generators" in 2020, meaning that less than 100 kg of hazardous waste was generated per month.

In 2020, no hazardous/mixed wastes were generated, accumulated, or shipped by DOE or UT-Battelle from Property Sales or the DOE Office of Scientific and Technical Information.

5.3.7. ORNL RCRA-CERCLA Coordination

The Federal Facility Agreement for the Oak Ridge Reservation (DOE 2014) is intended to coordinate the corrective action processes of RCRA required under the Hazardous and Solid Waste Amendments permit with CERCLA response actions. Annual updates for 2019 for ORNL's solid waste management units and areas of concern were consolidated with updates for ETTP, the Y-12 Complex, and ORR and were reported to TDEC, DOE, and the EPA Region 4 in January 2020.

Periodic updates of 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 the effectiveness of previously completed CERCLA environmental remediation actions and that they do not adversely affect future CERCLA environmental remediation actions.

5.3.7.1. CERCLA Activities in Bethel Valley

In 2019, ORNL completed work on a CERCLA project initiated in 2018 to perform limited environmental remediation in the 3500 Area of the Central Campus to facilitate future brownfield redevelopment. Characterization of the area was completed in August 2018, and data were evaluated against remediation levels defined in the Bethel Valley Interim Record of Decision (DOE 2002) to identify required cleanup scope. An addendum to the approved Waste Handling Plan was developed and approved. Additionally, a technical memorandum was submitted and received regulatory approval in April 2019 as an appendix to the approved *Remedial Design Report/Remedial Action Work Plan for Bethel Valley Soils and Sediments* to document the proposed remedial actions (DOE 2021). In May 2019, a contractor was mobilized, and remedial actions and site restoration were completed in September 2019. Following completion of waste disposal, a phased construction completion report was developed and was submitted for regulatory approval in March 2020 to document completed actions, final waste volumes, and waste disposition. The phased construction completion report was approved June 3, 2020.

5.3.7.2. RCRA Underground Storage Tanks

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

ORNL has two USTs registered with TDEC under Facility ID 0-730089. These USTs are in service (petroleum) and meet the current UST standards. No compliance inspections by TDEC occurred in 2020.

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 and/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 the wastes in accordance with specific waste acceptance criteria under an agreement with state and federal regulators.

5.3.9. Toxic Substances Control Act Compliance Status

PCB uses and waste at ORNL are regulated under the Toxic Substance Control Act (TSCA). PCB waste generation, transportation, and storage at ORNL are reported under EPA ID TN1890090003. In 2020, UT-Battelle operated six PCB waste storage areas. When longer-term storage was necessary, PCB/radioactive wastes were stored in RCRA-permitted storage buildings at ORNL. One of the PCB waste storage areas was operated at a UT-Battelle facility in the Y-12 Complex. The continued use of authorized PCBs in electrical systems and/or equipment (e.g., transformers, capacitors, rectifiers) is regulated at ORNL. Most of the equipment at ORNL that required regulation under TSCA has been dispositioned. However, some of the ORNL facilities at the Y-12 Complex continue to use (or store for future reuse) PCB equipment.

Because of the age of many of the ORNL facilities and the continued presence of PCBs in gaskets, grease, building construction, and equipment, DOE self-disclosed unauthorized use of PCBs to EPA in the late 1980s. As a result, DOE and ORNL contractors negotiated a compliance agreement with EPA (see Chapter 2, Table 2.1, under "Toxic Substances Control Act") to address the compliance issues related to these unauthorized uses and to allow for continued use pending decontamination or disposal. As a result of that agreement, DOE continues to notify EPA when additional unauthorized uses of PCBs, such as PCBs in paint, adhesives, electrical wiring, or floor tile, are identified at ORNL. No new unauthorized uses of PCBs were identified during 2020.

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 5.6 describes the main elements of EPCRA. UT-Battelle complied with these requirements in 2020 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.

ORNL had no releases of extremely hazardous substances, as defined by EPCRA in 2020. 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 5.6. Main elements of the Emergency Planning and Community Right-to-Know Act

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

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

5.3.10.1. Safety Data Sheet/Chemical Inventory (Section 312)

Inventories, locations, and associated hazards of hazardous chemicals and/or extremely hazardous substances were submitted in an annual report to the E-Plan as required by the State of Tennessee. In 2020, there were 28 hazardous and/or extremely hazardous substances at ORNL that met EPCRA reporting criteria.

Private-sector lessees were not included in the 2020 submittals. Under the terms of their leases, lessees must evaluate their own inventories of hazardous and extremely hazardous chemicals and must submit information as required by the regulations.

5.3.10.2. Toxic Chemical Release Reporting (EPCRA Section 313)

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

For 2020, ORNL exceeded the reporting threshold and reported on the otherwise use of nitric acid and the manufacture of nitrate compounds. Most of the nitric acid was used in wastewater treatment operations at the PWTC. Nitrate compounds were coincidentally manufactured as by-products of neutralizing the nitric acid waste and as by-products of on-site sewage treatment.

5.3.11. US Department of Agriculture/Tennessee Department of Agriculture

USDA, through Animal and Plant Health Inspection Services, issues permits for the import, transit, and controlled release of regulated animals, animal products, veterinary biologics, plants, plant products, pests, organisms, soil, and genetically engineered organisms. The Tennessee Department of Agriculture issues agreements and jointly regulates domestic soil. In 2020, UT-Battelle personnel had 21 permits and agreements for the receipt, movement, or controlled release of regulated articles.

5.3.12. Wetlands

Approximately 25 wetlands, encompassing 10 acres, were surveyed at potential project sites in 2020. Although no official delineations were conducted in 2020, surveys reconfirmed presence of historically known wetlands and provided approximate boundaries of newly discovered wetland locations for sensitive resource survey reports. Assessing the potential for jurisdictional wetlands during the site selection process and early planning stages can help projects reduce wetland impacts, design changes, and mitigation costs. Wetland delineations are conducted to facilitate compliance with TDEC and US Army Corps of Engineers wetland protection requirements.

5.3.13. Radiological Clearance of Property at ORNL

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

5.3.13.1. Graded Approach to Evaluate Material and Equipment for Release

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

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

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

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

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

In accordance with DOE Order 458.1 Section k.(6)(f)2 b, "Pre-Approved Authorized Limits," UT Battelle continues to use the preapproved authorized limits for surface contamination originally established in Table IV-1 of DOE Order 5400.5 (cancelled in 2011) and the November 17, 1995, Pelletier memorandum (Pelletier 1995) for TRU alpha contamination. UT-Battelle also continues to follow the requirements of the scrap metal suspension. No scrap metal directly released from radiological areas is being recycled. In 2020, UT-Battelle cleared more than 10,889 items through the excess items and property sales processes. A summary of items requested for release through these processes is shown in Table 5.7.

Table 5.7. Excess items requested for release and/or recycling, 2020

Item	Process knowledge	Radiologically surveyed
Release request totals for 2020		
Totals	9,525	1,364
Recycling request totals for 2020		
Cardboard (tons)	310,460	
Scrap metal (nonradiological areas) (tons)	606.79	

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 2011c) and associated guidance. The sample clearance limits are based on an assessment of potential doses against a threshold of 1 mrem/year to an individual and evaluation of other potentially applicable requirements (e.g., Nuclear Regulatory Commission) licensing regulations). Implementation of the clearance limits involves use of unique instrument screening and methods for prediction of sample activity to provide an efficient and defensible process to release neutron scattering experiment samples to researchers without further DOE control.

In 2020 ORNL cleared a total of 63 samples from neutron scattering experiments using the sample authorized limits process. Of those, 48 samples were from SNS and 15 were 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 2020 air monitoring activities are summarized in the following sections.

5.4.1. Construction and Operating Permits

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

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

DOE/NWSol has two non-Title V Major Source Operating Permits for one emission source and two emergency generators at TWPC. During 2020 no permit limits were exceeded. Isotek has a Title V Major Source Operating Permit (576448) for the Radiochemical Development Facility (Building 3019 complex). During 2020 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. Although the permit expired on September 17, 2020, it remains in effect because a timely application for renewal was submitted in March 2020. During 2020 no permit limits were exceeded.

5.4.2. National Emission Standards for Hazardous Air Pollutants—Asbestos

Numerous facilities, structures, and facility components and various pieces of equipment at ORNL contain asbestos-containing material. UT-Battelle's Asbestos Management Program manages the compliance of work activities involving the removal and disposal of asbestos-containing material, which include notifications to TDEC for all demolition activities and required renovation activities, approval of asbestos work authorization requests, current use of engineering controls and work practices, inspections, air monitoring, and waste tracking of asbestos-contaminated waste material. During 2020 there were no deviations or releases of reportable quantities of asbestos-containing material.

5.4.3. Radiological Airborne Effluent Monitoring

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

The major radiological emission point sources for ORNL consist of the following eight stacks. Seven are located in Bethel and Melton Valleys, and one, the SNS Central Exhaust Facility stack, is located on Chestnut Ridge (Figure 5.6):

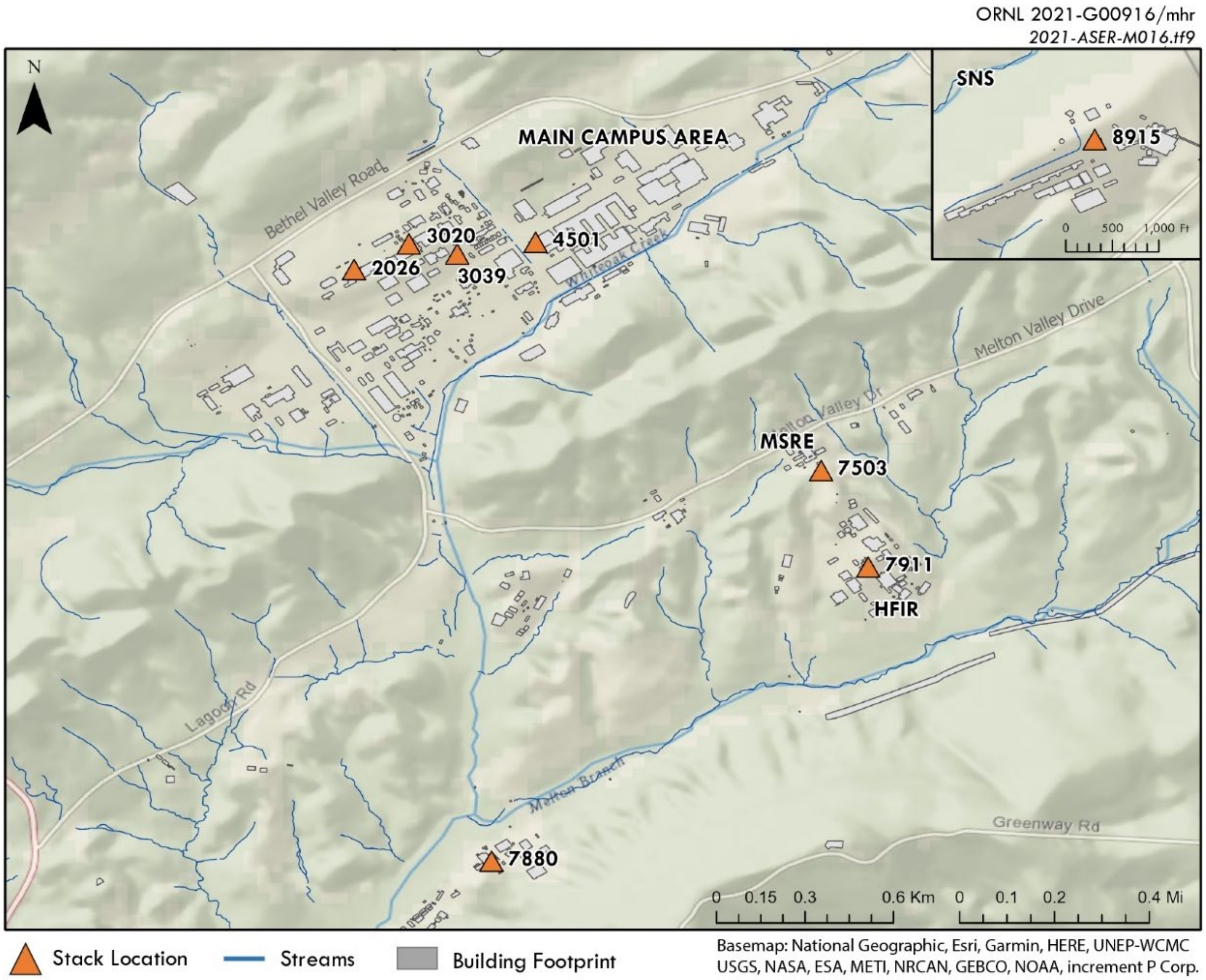
- 2026 Radioactive Materials Analytical Laboratory
- 3020 Radiochemical Development Facility
- 3039 central off-gas and scrubber system, which includes the 3500 cell ventilation system, isotope area cell ventilation system, 3025/3026 cell ventilation system, 3042 ventilation system, and 3092 central off-gas system
- 4501 Radiochemistry Laboratory Area Off-Gas System
- 7503 Molten Salt Reactor Experiment Facility
- 7880 TWPC
- 7911 Melton Valley complex, which includes HFIR and the Radiochemical Engineering Development Center
- 8915 SNS Central Exhaust Facility stack

In 2020 there were 14 minor point/group sources, and emission calculations/estimates were made for each of them.

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). The sampling systems generally consist of a multipoint in-stack sampling probe, a sample transport line, a particulate filter, activated charcoal cartridges (or canister), a silica gel cartridge (if required), flow-measurement and totalizing instruments, a sampling pump, and a return line to the stack. The 2026 (Radioactive Materials Analytical Laboratory), 4501(Radiochemistry Laboratory), 7911 (Melton Valley complex), and 7880 (TWPC) stacks are equipped with in-stack source-sampling systems that comply with criteria in the ANSI–Health Physics Society standard ANSI/HPS N13.1-1999 (ANSI 1999).

The 2026, 4501 and 7911 sampling systems have the same components as the ANSI 1969 sampling systems used for the four major point sources but use a stainless-steel-shrouded probe instead of a multipoint in-stack sampling probe. The 7911 sampling system also consists of a high-purity germanium detector with an analog-to-digital converter and ORTEC GammaVision software, which allows for continuous isotopic identification and quantification of radioactive noble gases (e.g., ^{41}Ar) in the effluent stream. The 7880 sampling system consists of a stainless-steel-shrouded probe, an in-line filter-cartridge holder placed at the probe to minimize line losses, a particulate filter, a sample transport line, a rotary vane vacuum pump, and a return line to the stack. The sample probes from both the ANSI 1969 and ANSI 1999 stack-sampling systems are removed, inspected, and cleaned annually. The SNS Central Exhaust Facility (8915) stack is equipped with an in-stack radiation detector that complies with criteria in ANSI/HPS N13.1-1999 (ANSI 1999). The detector monitors radioactive gases flowing through the exhaust stack and provides a continual readout of activity detected by a scintillator probe. The detector is calibrated to correlate with isotopic emissions.



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

Figure 5.6. Locations of major radiological emission points at ORNL, 2020

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 Part 60, Appendix A-1, Method 2) are followed. The profiles provide accurate stack flow data for subsequent emission-rate calculations. An annual leak-check program is carried out to verify the integrity of the sample transport system. An annual comparison is performed for the 7880 stack between the effluent flow rate totalizer and EPA Method 2. The response of the stack effluent-flow-rate monitoring system is checked quarterly with the manufacturer's instrument test procedures. The stack sampler rotameter is calibrated at least quarterly in comparison with a secondary (transfer) standard. Only a certified secondary standard is used for all rotameter tests.

Starting in 2017, the 3039 emissions were calculated using a fixed stack flow rate. A fixed stack flow rate was used because the stack velocity at the sampling level is at or below the sensitivity of standard methods for measuring the velocity and therefore stack flow rates can no longer be determined. Low effluent velocity measurements are due to stack flow reductions resulting from the removal of facilities exhausting through the stack. The EPA Region 4 office approved a request to use an alternative fixed stack flow for emission calculations for the 3039 stack in a letter dated April 27, 2017 (V. Anne Heard, Acting Regional Administrator, United States Environmental Protection Agency Region 4 to Raymond J. Skwarek, Environmental Safety, Health and Quality Assurance Manager, UCOR, April 27, 2017). 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, but the stack velocity result obtained in 2020 was used for emission calculation purposes.

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

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

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

5.4.3.2. Results

Annual radioactive airborne emissions for ORNL in 2020 are presented in Appendix G.

Historical trends for tritium (^{3}H) and ^{131}I are presented in Figures 5.7 and 5.8. For 2020, tritium emissions totaled about 1,023 Ci (Figure 5.8), comparable to what was seen in 2019; ^{131}I emissions totaled 0.07 Ci (Figure 5.8), comparable to what was seen in 2019. For 2020, of the 357 radionuclides (excluding radionuclides with multiple solubility type) 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 48 percent, and ^{138}Cs, which contributed about 13 percent to the total ORNL dose.

Emissions of ^{212}Pb result from research activities and from the radiation decay of legacy material stored on-site and areas containing isotopes of ^{228}Th, ^{232}Th, and ^{232}U. Emissions of ^{212}Pb were from the following stacks: 2026, 3020, 3039, 4501, 7503, 7856, 7911, and the 3000, 4000 area, and 7000 laboratory hoods. Cesium-138 emissions result from Radiochemical Engineering Development Center research activities and HFIR operations. For 2020, ^{212}Pb emissions totaled 13.91 Ci, ^{138}Cs emissions totaled 1,070 Ci, and ^{41}Ar emissions totaled 1,119 Ci (see Figure 5.9).

The calculated radiation dose to the maximally exposed individual (MEI) from all radiological airborne release points at ORR during 2020 was 0.4 mrem. The dose contribution to the MEI from all ORNL radiological airborne release points was 1 percent of the ORR dose. This dose is well below the Rad-NESHAPs standard of 10 mrem and is equal to approximately 0.10 percent of the roughly 300 mrem that the average individual receives from natural sources of radiation. (See Section 7.1.2 for an explanation of how the airborne radionuclide dose was determined.)

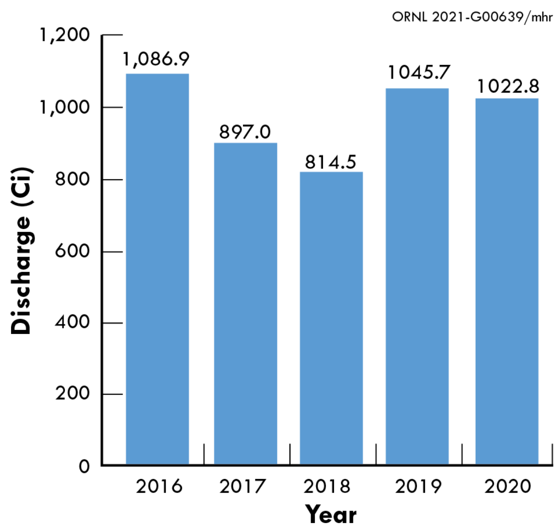


Figure 5.7. Total curies of tritium discharged from ORNL to the atmosphere, 2016–2020

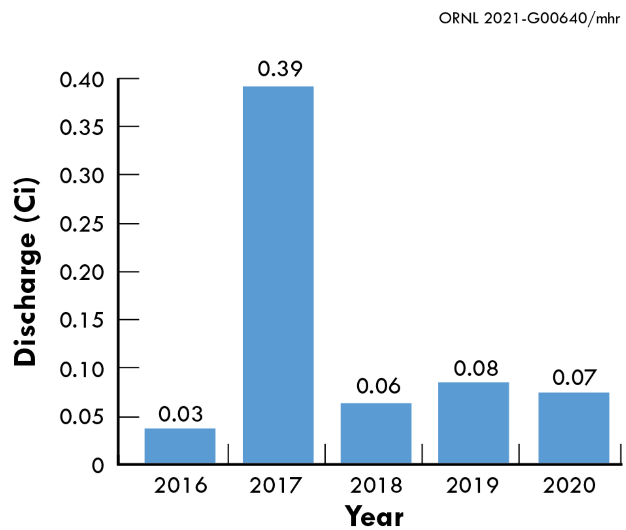


Figure 5.8. Total curies of ^{131}I discharged from ORNL to the atmosphere, 2016–2020

5.4.4. Stratospheric Ozone Protection

As required by the CAA Title VI Amendments of 1990 and in accordance with 40 CFR Part 82, actions have been implemented to comply with the prohibition against intentionally releasing ozone-depleting substances during maintenance activities performed on refrigeration equipment. In 2017, EPA enacted major revisions to the Stratospheric Ozone rules to include the regulation of substitutes for ozone-depleting substances as part of 40 CFR 82 Subpart F.

The revisions were effective January 1, 2018, for disposal of small appliances and January 1, 2019, for the leak rate provisions for large appliances. Necessary changes to the Stratospheric Ozone Protection compliance program were implemented to comply with the requirements of the new rule. Service requirements for refrigeration systems (including motor vehicle air conditioners), technician certification requirements, record-keeping requirements, and labeling requirements were implemented in accordance with 40 CFR 82 Subpart F.

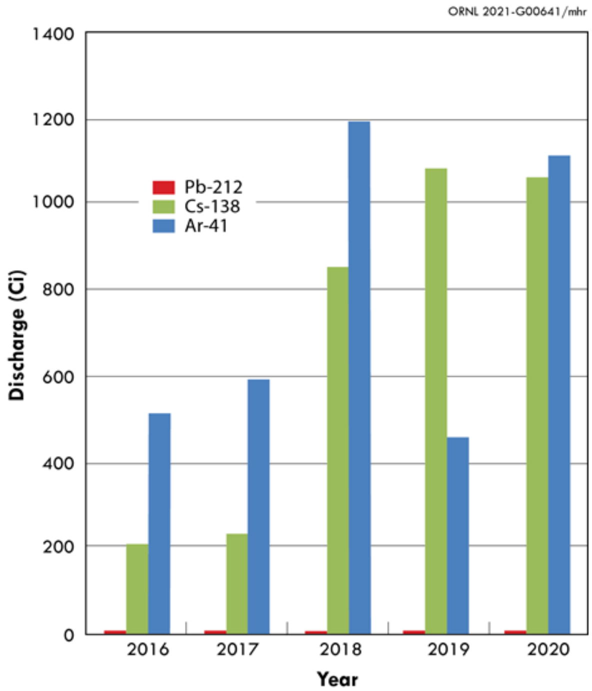


Figure 5.9. Total curies of ^{41}Ar, ^{138}Cs, and ^{212}Pb discharged from ORNL to the atmosphere, 2016–2020

5.4.5. Ambient Air

Station 7 in the ORNL 7000 maintenance area is the site-specific ambient air monitoring location. During 2020, the sampling system at Station 7 was used to quantify levels of tritium; uranium; and gross alpha-, beta-, and gamma-emitting radionuclides. A low-volume air sampler was used for particulate collection. The 47 mm glass-fiber filters were collected biweekly and were composited annually for laboratory analysis. A silica-gel column was used for collection of tritium as tritiated water. The silica gel was collected biweekly or weekly, depending on ambient humidity, and was composited quarterly for tritium analysis. Station 7 sampling data (Table 5.8) are compared with derived concentration standards (DCSs) for air established by DOE as guidelines for controlling exposure to members of the public (DOE 2011a). During 2020 average radionuclide concentrations at Station 7 were less than 1 percent of the applicable DCSs in all cases.

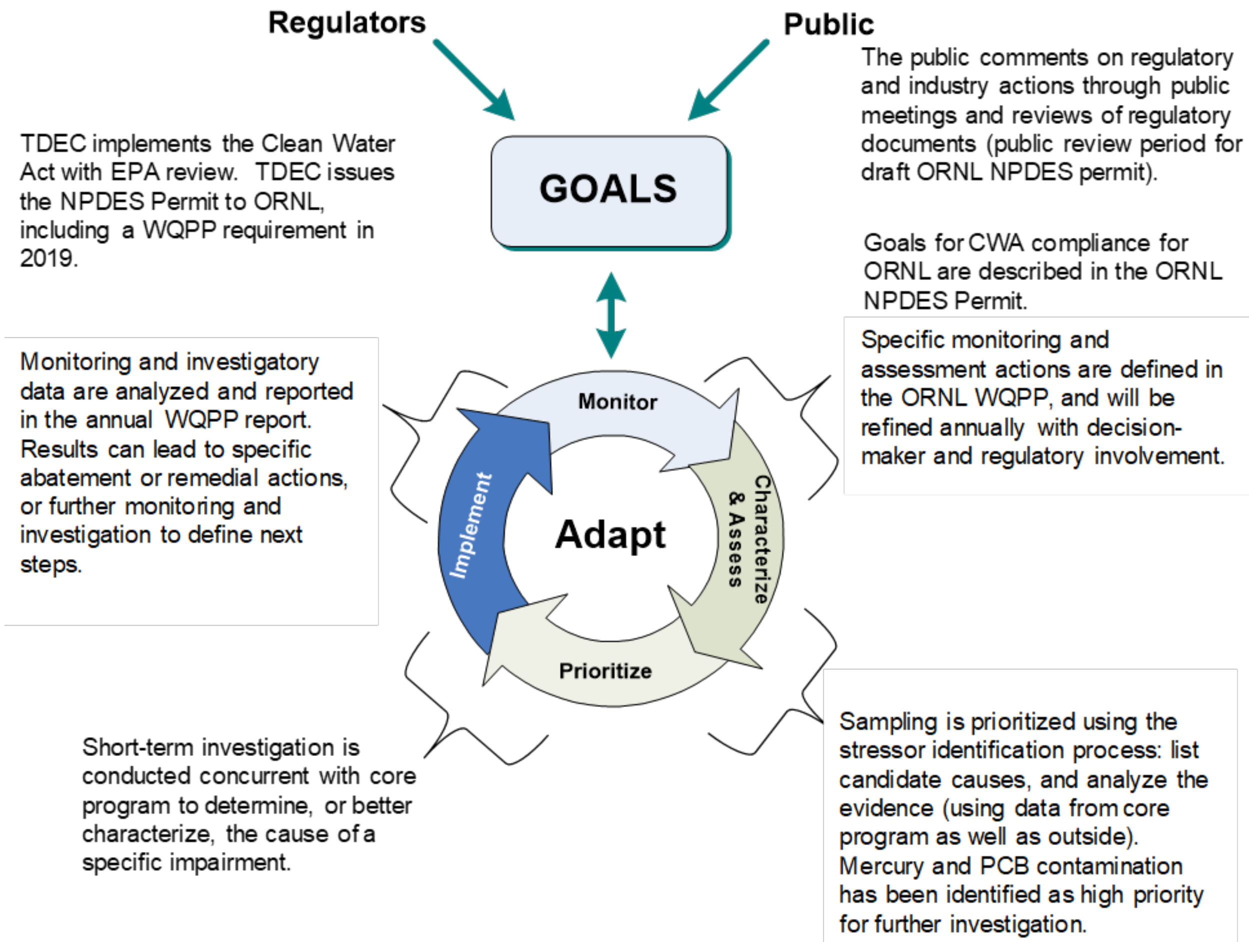
Table 5.8. Radionuclide concentrations measured at ORNL air monitoring Station 7, 2020

Parameter	Concentration (pCi/mL)[a]
Alpha	6.50E-09
^{7}Be	2.30E-08
Beta	1.49E-08
^{40}K	1.53E-09
Tritium	6.63E-06
^{234}U	1.90E-11
^{235}U	1.95E-12
^{238}U	1.60E-11
Total U	3.70E-11

[a] 1 pCi = 3.7 × 10^{-2} Bq.

5.5. ORNL Water Quality Program

NPDES permit TN 0002941, issued to DOE for the ORNL site and renewed by the State of Tennessee in 2019, includes requirements for discharging wastewaters from the two ORNL on-site wastewater treatment facilities and from more than 150 category outfalls (outfalls with nonprocess wastewaters such as cooling water, condensate, groundwater, and storm water), and for the development and implementation of a water quality protection plan (WQPP). The permit calls for a WQPP to "efficiently utilize the facility's financial resources to measure its environmental impacts." Rather than prescribing rigid monitoring schedules, the ORNL WQPP is flexible and focuses on significant findings. It is implemented utilizing an adaptive management approach (Figure 5.10), whereby results of investigations are routinely evaluated and strategies for achieving goals are modified based on those evaluations. The goals established for the WQPP are to meet the requirements of the NPDES permit, improve the quality of aquatic resources on the ORNL site, prevent further impacts to aquatic resources from current activities, identify the stressors that contribute to impairment of aquatic resources, use available resources efficiently, and communicate outcomes with decision makers and stakeholders.



Adapted from the US Environmental Protection Agency (EPA) stressor guidance document (*Stressor Identification Guidance Document*. EPA-822-B-00-025. US Environmental Protection Agency, Office of Water, Washington, DC.).

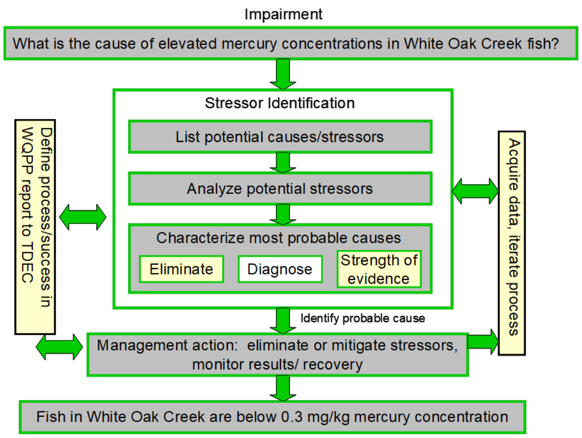
Acronyms:
CWA = Clean Water Act
NPDES = National Pollutant Discharge Elimination System
PCB = polychlorinated biphenyl
TDEC = Tennessee Department of Environment and Conservation
WQPP = Water Quality Protection Plan

Figure 5.10. Diagram of the adaptive management framework with step-wise planning specific to the ORNL Water Quality Protection Plan

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

To prioritize the stressors and/or contaminant sources that may be of greatest concern to water quality and to define conceptual models that would guide any special investigations, the WQPP strategy was defined using EPA's *Stressor Identification Guidance Document* (EPA 2000a). Figure 5.11 summarizes that process. The process involves three major steps for identifying the cause of any impairment:

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



Modified from Figure 1-1 in the US Environmental Protection Agency stressor guidance document (*Stressor Identification Guidance Document*. EPA-822-B-00-025. US Environmental Protection Agency, Office of Water, Washington, DC.).

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

Figure 5.11. Application of stressor identification guidance to address mercury impairment in the White Oak Creek watershed

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

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

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

5.5.1. Treatment Facility Discharges

The ORNL STP and the ORNL PWTC provide appropriate treatment of the various R&D, operational, and domestic wastewaters generated by site staff and 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, water-quality-based, and radiological constituents and for effluent toxicity, with numeric parameter-specific compliance limits established by TDEC as determined to be necessary. TDEC last renewed the ORNL NPDES permit in May 2019. The results of field measurements and laboratory analyses to assess compliance for the parameters required by the NPDES permit and rates of compliance with numeric limits established in the permit are provided in Section 5.3.4 (Table 5.4). Compliance with permit limits for ORNL wastewater treatment facilities was greater than 99 percent in 2020.

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

Toxicity test requirements under the current NPDES permit include annual testing for chronic toxicity from the ORNL STP and PWTC. Both test species are tested on a series of four aliquots of effluent, collected at 6 h intervals over a 24 h period. An "inhibition concentration" of 25 percent was used in the testing.

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. The City adds 2 to 3 mg/L of free chlorine prior to distribution. On the ORNL site, the 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 if discharged to surface water, can be toxic to fish and other aquatic life. Residual chlorine in wastewater routed to the STP is generally consumed in reactions with other substances within the collection and treatment system (i.e., it is used up in reaction with organics), and any residual chlorine in wastewater routed to the PWTC is removed by final activated carbon filtration. Air-conditioning systems that used once-through cooling water and discharged to storm outfalls have been replaced (except for one) with air-cooled systems that discharge only condensate to the ground or a storm drain. Newer buildings and complexes have been constructed to utilize cooling towers for air-conditioning and dehumidifying and to remove heat from instrumentation and computer systems. Two main campus Outfalls (211 and 210) still receive research-generated, once-through cooling water, but flows have been reduced by water-recycling efforts.

Leaks or discharge from any of these systems to storm drains are dechlorinated and monitored via the WQQP Chlorine Control Strategy. DOE's NPDES Permit for ORNL establishes an action level of 1.2 g/day for total residual oxidant (TRO) loading at all outfalls. If that level is exceeded, ORNL is required to investigate and remove TRO sources to reduce chlorine/bromine loading to less than 1.2 g/day. TRO is monitored twice a month at outfalls that receive cooling tower discharges and once-through cooling water. Less frequent monitoring is conducted at other outfalls (semimonthly, monthly, quarterly, or semiannually if flow is present). Chlorine Control Strategy data were collected at 20 locations in 2020, and 376 sets of data were obtained. Activities in response to TRO monitoring in 2020 included several emergency repairs in addition to the routine mitigation measures at TRO sources. Although numerous TRO findings were made in 2020, no TRO was found at any of the 12 instream monitoring points during 2020.

5.5.2.1. Leaks and Emergency Repairs

The following emergency repairs were carried out in 2020 in response to the results of TRO monitoring (see Table 5.9):

- A bisulfate supply in the Building 4508 dechlorination system failed (Outfall 210).
- A valve replacement was required in the HFIR dechlorination system (Outfall 228).
- A fire hydrant weep-drain port required closure (Outfall 231).
- A leaking fire hydrant was removed from service (Outfall 304).
- A dechlorinator box was repaired (Outfall 281).

Table 5.9. Total residual oxidant mitigation summary: Emergency repairs, 2020

Location	Date	TRO (mg/L)	Flow (gpm)	Load (g/day)	Receiving stream	Downstream integration point	Location[a]	TRO source
082	9/21	0.4	2	4.36	MB	MEK 0.6	X27	MSRE air conditioner
082	10/22	0.3	1	1.64	MB	MEK 0.6	X27	MSRE air conditioner
207	4/16	0.1	2	1.09	WOC	WCK 4.1	X21	Unknown leak
210	3/9	0.8	50	218.04	WOC	WCK 4.1	X18	Sodium bisulfite hose replaced
231	5/11	0.2	12	13.08	WOC	WCK 4.4	X25	Hydrant weep-drain
231	5/26	0.2	20	21.80	WOC	WCK 4.4	X25	Hydrant weep-drain
231	6/9	0.3	20	32.71	WOC	WCK 4.4	X25	Hydrant weep-drain
231	6/29	0.2	10	10.90	WOC	WCK 4.4	X25	Hydrant weep-drain
231	7/16	0.4	80	174.43	WOC	WCK 4.4	X25	Hydrant or construction
231	8/28	0.2	10	10.90	WOC	WCK 4.4	X25	Hydrant weep-drain
231	9/16	0.3	15	24.53	WOC	WCK 4.4	X25	Hydrant weep-drain
231	9/23	0.2	12	13.08	WOC	WCK 4.4	X25	Hydrant weep-drain
235	2/25	0.1	10	5.45	WOC	WCK 3.4	X28	Steam Plant
235	7/16	0.1	10	5.45	WOC	WCK 3.4	X28	Steam Plant
281	11/23	0.1	50	27.25	MB	MEK.06	X27	Sodium bisulfite pump valve
282	1/30	0.3	5	8.18	MB	MEK 0.6	X13	Storm damage to dechlor box
304	3/9	0.1	0.1	0.05	WOC	WCK 3.9	X21	Hydrant removed from service
585	2/17	0.2	0.1	0.11	MB	MEK 0.6	X27	Melton Valley Steam Plant

[a] *Nearest downstream TRO monitoring location*

Acronyms:
MB = Melton Branch
MEK = Melton Branch kilometer
MSRE = Molten Salt Reactor Experiment
TRO = total residual oxidant
WCK White Oak Creek kilometer
WOC = White Oak Creek

Unresolved issues include identification of the source of chlorinated water leaking to Outfalls 281 and 207. Steam Plant discharges of chlorinated water may be related to overflow from the supply to a reverse-osmosis water treatment system.

Outfall 211 and 210 are the only two remaining outfalls that receive once-through cooling water discharges. Outfall 211 receives cooling water from multiple small sources. Two dechlorinator boxes are mounted in a weir located at the point where the outfall discharges to WOC. Each box is designed to treat chlorinated discharges at flow rates up to 50 gpm. Flows ranged from 25 to 65 gpm above the dechlorinator; TRO levels above the dechlorinator ranged from 0.5 to 1.2 mg/L TRO. There were no TRO exceedances at Outfall 211 (downstream of the dechlorinator) in 2020. A liquid sodium bisulfite dechlorinator, located inside Building 4508, is used to treat discharges from Outfall 210. The dechlorinator treats cooling water from instrumentation that cannot use the recycled cooling water system. On April 9, 2020, TRO was found at Outfall 210. It was dechlorinated with tablets until April 15, 2020, when the liquid sodium bisulfite dosing hose was replaced.

A sodium bisulfite dechlorination system is used at the HFIR to treat cooling tower discharges. In November 2020, TRO was detected at Outfall 281, and an investigation showed that a valve responsible for pumping sodium bisulfite had failed. Dechlorination tablets were used to treat the discharge until the valve was replaced 2 days later.

In past years, Outfall 231 received blowdown from multiple Building 5800 cooling towers; however, the cooling towers were taken off-line in 2020. Additional Oak Ridge Leadership Computing Facility (OLCF5) towers were installed on the west end of Building 5800 during 2020 and became operational in 2021. There were no discharges to Outfall 231 from the 5800 towers or the new OLCF5 towers in 2020. There had been three previous TRO exceedances at Outfall 231, and no cause was found. When an exceedance occurred in May 2020, sodium sulfite tablets were placed at the outfall, and a survey of laboratory drains and discharges from Building 5800 was conducted. No cooling water or supply discharges were found. Construction zones on top of the supply and storm piping complicated access, but a camera survey of the storm pipe was done in October 2020. No supply leaks were found, but flow was observed bubbling up between storm pipe sections. A Fire Department inspection found that Hydrant 4-44 on the construction site was not fully closed, allowing the valve weep/drain port to release supply water. The fire hydrant may have been leaking intermittently since 2019, and leaking water may have periodically been absorbed by soil during dry weather and/or neutralized by excess dechlorination chemicals when 5800 towers were discharging. No TRO exceedances have occurred at Outfall 231since the valve was fully closed.

Outfall 082, located on a tributary to Melton Branch, receives seasonal cooling water from the only remaining water-cooled air-conditioning system at ORNL's Molten Salt Reactor Experiment facility. During the fall, TRO loads exceeded 1.2 g/d on two occasions; dechlorination tablets were in use but were ineffective. Discharges from another Molten Salt Reactor Experiment Outfall (282) are also treated with a tablet-feeder dechlorinator. TRO was detected at Outfall 282 in 2020, after high storm water levels damaged the dechlorinator. Investigations into the source of the leak were initiated, and dechlorination resumed. Chlorinated discharges from within the building and hydrant leaks have been eliminated as potential sources of the chlorine at the outfall.

Outfall 207 has no known sources of chlorine, but TRO was found there on two occasions in 2019 and on one occasion in 2020. For the measured TRO concentration, the flow rate was low enough to result in a loading (1.09 g/day) that was below the 1.2 g/day action level. Dry and wet catch basin sampling completed in 2020 did not lead to the identification of the chlorine source. The limited-duration presence of detectable chlorine at the outfall may be dependent on an intermittent water-using process in a nearby facility.

5.5.2.2. Outfalls and Cooling Tower Discharge

Chlorine- and bromine-based chemicals are added to supply water to control bacterial growth.

(Anticorrosion chemicals are also added.) Residuals of chlorine and bromine remain in the water in cooling towers if they do not evaporate or are not consumed by bacterial growth. Additionally, as the cooling towers lose water by evaporation, higher conductivity (caused by an increase in the concentration of minerals such as calcium, which occur naturally in the water and do not evaporate), triggers a blowdown, resulting in a discharge that may contain chlorine and bromine residuals. The discharge must be treated to reduce the residual oxidants to less than 0.05 mg/L TRO. In the past, sodium sulfite tablets in four-tube tablet feeders at or near tower sources or additions of liquid sodium bisulfite solution (38 to 40 percent, in proportion to the flow rate), have been used at ORNL to neutralize the residual chlorine and bromine in the discharges.

In 2020, potassium sulfite was used as a pretreatment in one location and is proposed for use at the new OLCF 5 cooling towers. In some cases, pretreatment enhances the effectiveness of the primary dechlorination tablet feeders. Inspections of tablet feeders are conducted multiple times a week to ensure that sodium sulfite tablets are refilled, that those remaining are in good condition, and that any swollen or fouled tablets are removed for disposal. Table 5.10 summarizes 2020 cooling tower discharges that exceeded TRO permit action levels.

Outfall 014 discharges only cooling tower blowdown from towers 4510 and 4521. During 2020, weekly observations were made in an effort to monitor discharges at least twice a month. On a scheduled monitoring day, up to three observations were made. During the first several months of 2020, piping repairs were being made, and no flows were found until May 11, 2020. By the end of May, discharge flows at Outfall 014 were estimated to be greater than 90 gpm, and TRO loads exceeded 1.2 g/day. An additional dechlorination box was installed for 4521 tower discharges. Tower 4510 discharges were greater than 50 gpm with elevated TRO, so additional sodium sulfite tubes were added as a temporary remedy. In 2020 potassium sulfite injection was initiated to pretreat 4510 tower discharges prior to release through the sodium bisulfite box. A similar pretreatment system is being considered for 4521 blowdown. There were no further TRO exceedances after October 2020.

Outfall 227 receives large blowdown flows from multiple cooling towers in Building 5600 and 5511. There were no TRO exceedances in 2020. Primary dechlorination occurs in Building 5600, and a secondary dechlorination box located at WOC is continually utilized as backup. Combined use of two dechlorination boxes enables approximately 4 mg/L TRO to be removed before cooling tower discharges enter the creek. To better understand dechlorination needs, TRO is monitored above and below secondary dechlorination. In 2020, results of the monitoring indicated that TRO discharges would have exceeded 1.2 g/day at the outfall in four instances if it were not for the secondary treatment.

Outfall 363 also receives discharges from multiple cooling towers. Data show that residual oxidants remain in discharges after primary dechlorination at the tower/building sources. Since 2017, sodium sulfite tablet bags have been placed below the Outfall 363 pipe as secondary dechlorination. More than 1.2 g/day of TRO was discharged in August and November 2020 despite the secondary dechlorination. Without secondary treatment with sodium bisulfite below the outfall, data show that the TRO load would have exceeded 1.2 g/day in eight additional instances.

SNS Cooling Tower discharges are monitored to verify that dechlorination is adequate at the 435 Internal Monitoring Point 1 (435INT1) prior to merging with a larger wet weather channel above the west SNS storm water retention basin and Outfall 435. Outfall 435, which discharges to WOC several hundred feet downstream, is not monitored for TRO as it would not be expected there after it is dechlorinated at the cooling tower. The number of TRO findings at 435INT1 increased during 2020. Discharge flows for both towers were recorded as 70 gpm during 2019, but one is recorded as 70 to 180 gpm in 2020. There were instances in February, May, July, October, and December when more than 1.2 g/day of TRO were discharged to the west retention pond.

Table 5.10. Total residual oxidant mitigation summary: Cooling tower outfalls exceeding the total residual oxidant NPDES action level, 2020

Location	Date	TRO (mg/L)	Flow (gpm)	Load (g/day)	Receiving stream	Downstream integration point	Location[a]	TRO source
014	05/26/20	0.5	115	313.43	WOC	WCK 4.4	X23	4510/4521 Cooling towers
014	06/26/20	0.4	90	196.24	WOC	WCK 4.4	X23	4510/4521 Cooling towers
014	06/29/20	0.3	90	147.18	WOC	WCK 4.4	X23	4510/4521 Cooling towers
014	07/16/20	0.8	115	501.49	WOC	WCK 4.4	X23	4510/4521 Cooling towers
363	10/22/20	0.3	5	8.18	Fifth Creek	FFK 0.2	X18	5300/5309 Cooling towers
363	08/28/20	0.5	20	54.51	Fifth Creek	FFK 0.2	X18	5300/5309 Cooling towers
435IMP1	02/17/20	0.1	100	54.51	WOC	WCK 5.2	435	SNS Cooling towers
435IMP1	05/11/20	0.1	25	13.63	WOC	WCK 5.2	435	SNS Cooling towers
435IMP1	07/16/20	0.1	3	1.64	WOC	WCK 5.2	435	SNS Cooling towers
435IMP1	10/27/20	0.1	25	13.63	WOC	WCK 5.2	435	SNS Cooling towers
435IMP1	12/10/20	0.2	30	32.71	WOC	WCK 5.2	435	SNS Cooling towers

[a] *Nearest downstream TRO monitoring location*

Acronyms:

FFK = Fifth Creek kilometer
NPDES = National Pollutant Discharge Elimination System
SNS = Spallation Neutron Source
TRO = total residual oxidant
WCK =.White Oak Creek kilometer
WOC = White Oak Creek

5.5.3. Radiological Monitoring

At ORNL, monitoring of liquid effluents and selected instream locations for radioactivity is conducted under the WQPP. Table 5.11 details the analyses performed on samples collected in 2020 at two treatment facility outfalls, three instream monitoring locations, and 20 category outfalls (outfalls that are categorized into groups with similar effluent characteristics for the purposes of setting monitoring and reporting requirements in the site NPDES permit). Dry-weather discharges from category outfalls are primarily cooling water, groundwater, and condensate. Low levels of radioactivity can be discharged from category outfalls in areas where groundwater contamination exists and where contaminated groundwater enters category outfall collection systems by direct infiltration and from building sumps, facility sumps, and building footer drains. In 2020, dry-weather grab samples were collected at 13 of the 20 category outfalls targeted for sampling. Seven category outfalls (see Table 5.11) were not sampled because there was no discharge present during sampling attempts.

The two ORNL treatment facility outfalls that were monitored for radioactivity in 2020 were the STP outfall (Outfall X01) and the PWTC outfall (Outfall X12). The three instream locations that were monitored were X13 on Melton Branch, X14 on WOC, and X15 at White Oak Dam (WOD) (Figure 5.12). At each treatment facility and instream monitoring location, monthly flow-proportional composite samples were collected using dedicated automatic water samplers.

For each radioisotope, a DCS is published in DOE directives and is used to evaluate discharges of radioactivity from DOE facilities (DOE 2011a). DCSs were developed for evaluating effluent discharges and are not intended to be applied to instream values, but the comparisons can provide a useful frame of reference. Four percent of the DCS is used as a comparison point. Although comparisons are made, neither ORNL effluents nor ambient surface waters are direct sources of drinking water. The annual average concentration of at least one radionuclide exceeded 4 percent of the relevant DCS concentration in dry-weather discharges from Outfalls 085, 207, 302, 304, X01, and X12 and at instream sampling locations WOC (X14) and WOD (X15). (Figure 5.13).

In 2020, dry-weather discharges from two outfalls (207 and 304) had an annual mean radioactivity concentration greater than 100 percent of a DCS. Samples from both outfalls had an average total radioactive strontium ($^{89/90}$Sr) concentration that exceeded the DCS for ^{90}Sr (it is reasonable, for an ORNL environmental sample, to assume that $^{89/90}$Sr activity is comparable to ^{90}Sr activity due to the relatively short half-life of ^{89}Sr [50.55 days]). The concentrations of $^{89/90}$Sr at Outfalls 207 and 304 were 5,000 and 200 percent of the DCS, respectively. Consequently, concentrations of radioactivity in the discharge from Outfalls 207 and 304 was also greater than the DCS level on a sum-of-fractions basis (i.e., the summation of DCS percentages of multiple radiological parameters); and the sums of the fractions for Outfalls 207 and 304 were 5,030 and 212 percent, respectively.

Under normal baseflow conditions, ORNL storm drain Outfall 207 has no flow at the end of the pipe where its discharge enters WOC. As a result of rainfall events, surface water runoff is conducted to WOC via this outfall. It is believed that the elevated activity at the outfall was caused by the failure of the drywell pump that is located near the DOE Office of Environmental Management (OREM) WC-9 liquid LLW tank. Contaminated groundwater present in the area migrated to a nearby storm drain via the pipe backfill and infiltrated the pipe that leads to the outfall. The pump was replaced on October 23, 2020, immediately following discovery of elevated radiological concentrations at the outfall. and flow from Outfall 207 ceased within several days of the pump replacement.

Levels of radioactivity in discharges from Outfall 304 have been elevated since 2014 because of two unrelated infrastructure issues. In 2014, a sump pump failed in a groundwater suppression system near the WC-9 liquid LLW tank, which is within a CERCLA soil and groundwater contamination area. Without groundwater suppression in the tank farm area, contaminated groundwater enters the

Outfall 304 storm drain system. The pump failed again in 2020, and it was out of service for a relatively short period of time. This outage had a significant effect on $^{89/90}$Sr concentrations at Outfall 207, but very little effect on $^{89/90}$Sr concentrations at Outfall 304.

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 that a hydraulic connection exists between the pipe and the storm water collection system that discharges through Outfall 304, and the pipe was subsequently bypassed and taken out of service. Before he pipe was bypassed, the $^{89/90}$Sr concentration at Outfall 304 peaked at 29,000 pCi/L (August and September 2015). Since the bypass was implemented, $^{89/90}$Sr levels in the outfall effluent have trended downward, but they remained above DCS levels in 2020.

No additional infrastructure issues affecting Outfall 304 have been discovered, and it is believed that concentrations of radioactivity at the outfall will continue to decline as concentrations of radioactivity in the groundwater surrounding the outfall pipe decline by means of normal hydrologic processes.

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 5.14 through 5.18. Because discharges of radioactivity are somewhat correlated to stream flow, annual flow volumes measured at the WOD monitoring station are given in Figure 5.19. Discharges of radioactivity at WOD in 2020 were similar to discharges during other recent years, particularly when differences in annual flow volume are taken into account and continue to be generally lower than in the years preceding completion of the waste area caps in Melton Valley (substantially complete by 2006).

Radiological monitoring at category outfalls in 2020 also included monitoring during storm runoff conditions. Eight storm water outfalls were monitored. Storm water samples were analyzed for gross alpha, gross beta, ^{137}Cs, $^{89/90}$Sr, and tritium activities. A gamma scan analysis was also performed. The monitoring plan calls for additional analyses to be added when sufficient gross alpha and/or beta activity is present in a sample to indicate that levels of radioactivity may exceed DCS levels and if the radionuclides contributing to the gross activities are not identified by routine analyses. In 2020, Outfall 301 required additional analyses.

Concentrations of radioactivity in storm water discharges were compared with DCSs if a DCS existed for that parameter (no DCSs exist for gross alpha or gross beta activities) and if a concentration was greater than or equal to the minimum detectable activity for the measurement. In 2020, the radionuclide $^{89/90}$Sr exceeded 4 percent of the relevant DCS concentration in wet-weather discharges from Outfalls 004, 204, 301, and 341 (see Figure 5.13).

In 2020, one storm water outfall (004) had a radioactivity concentration greater than 100 percent of a DCS. There was only one storm water sampling event at Outfall 004 for the year. Therefore, that single set of sample results is all that is available to estimate annual average concentrations. The $^{89/90}$Sr concentration in that one storm water sample exceeded the DCS for ^{90}Sr (it is reasonable, for an ORNL environmental sample, to assume that $^{89/90}$Sr activity is comparable to ^{90}Sr activity due to the relatively short half-life of ^{89}Sr [50.55 days]). The $^{89/90}$Sr concentration in the storm water sample collected at Outfall 004 was 140 percent of the DCS.

Outfall 004 is a valve pit that has been abandoned for many years; it has no known active connections. Not being tied to any active infrastructure, all the radiological constituents are assumed to be coming from historically contaminated areas. The Outfall 004 pipe is very close in proximity to the Outfall 304 pipe; thus the $^{89/90}$Sr source to Outfall 004 is suspected to be contaminated groundwater, the same as for Outfall 304.

Table 5.11. Radiological monitoring conducted under the ORNL Water Quality Protection Plan, 2020

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

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

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

Acronyms:

STP = Sewage Treatment Plan

WTC = Process Waste Treatment Complex

WOC = White Oak Creek

WOD = White Oak Dam

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

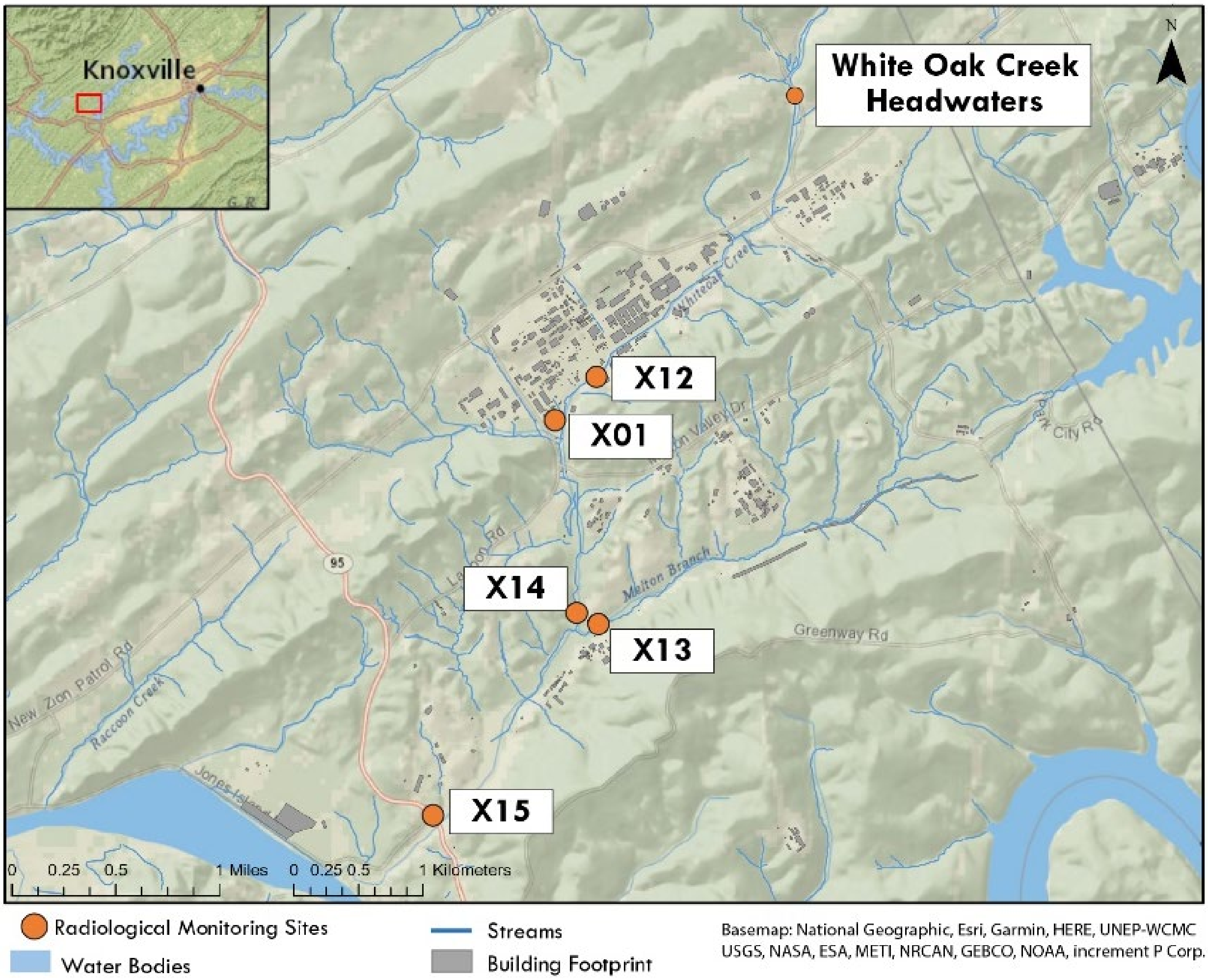
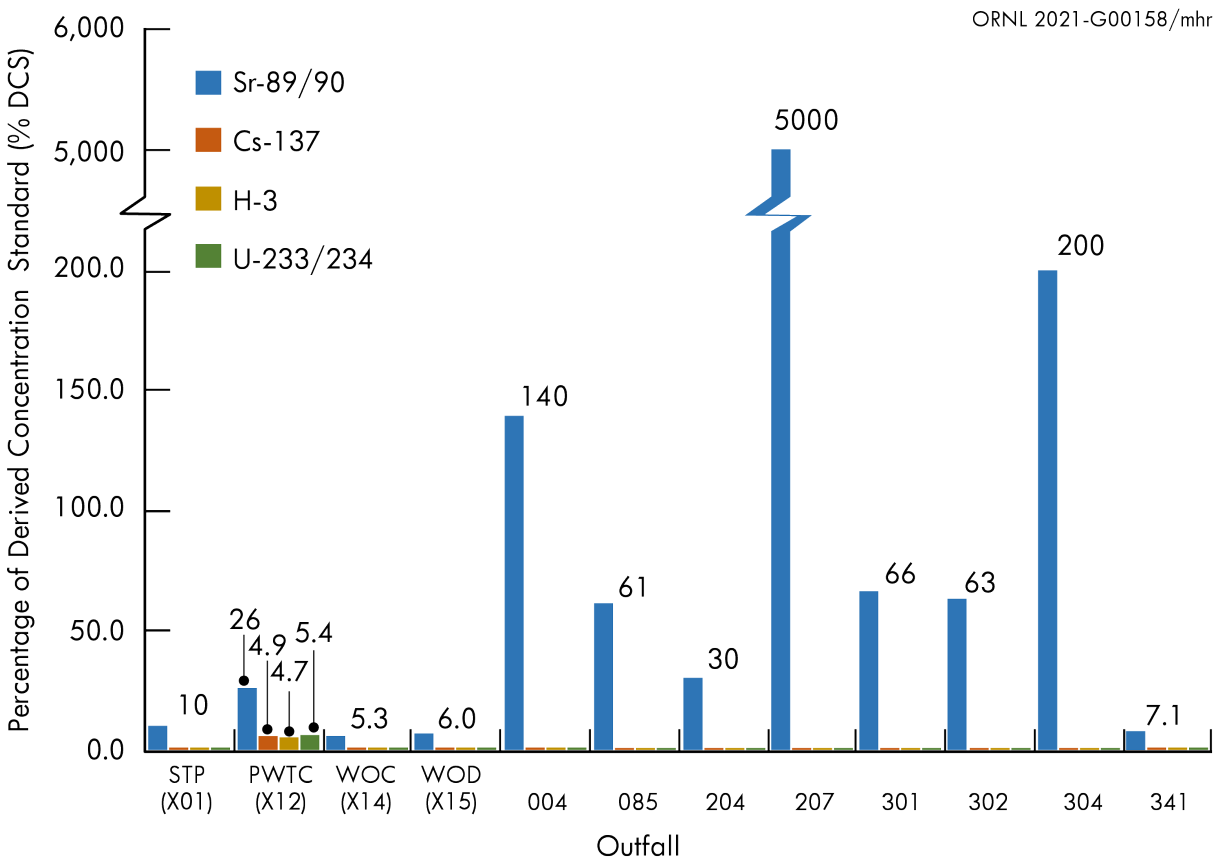


Figure 5.12. Selected surface water, National Pollutant Discharge Elimination System, and reference sampling locations at ORNL, 2020



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

Figure 5.13. Outfalls and instream locations at ORNL with average radionuclide concentrations greater than 4 percent of the relevant derived concentration standards in 2020

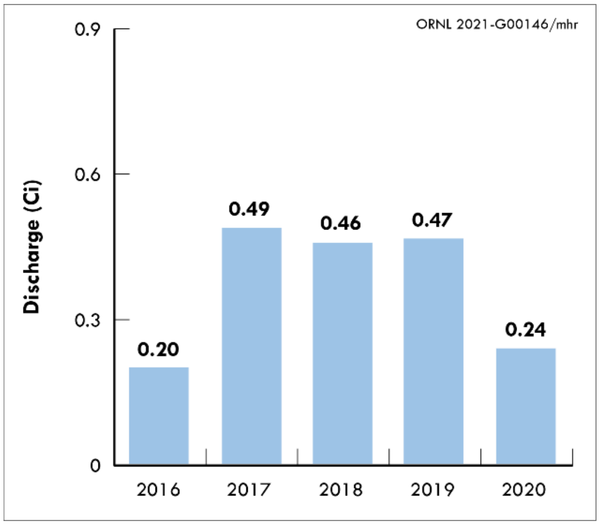


Figure 5.14. Cesium-137 discharges at White Oak Dam, 2016–2020

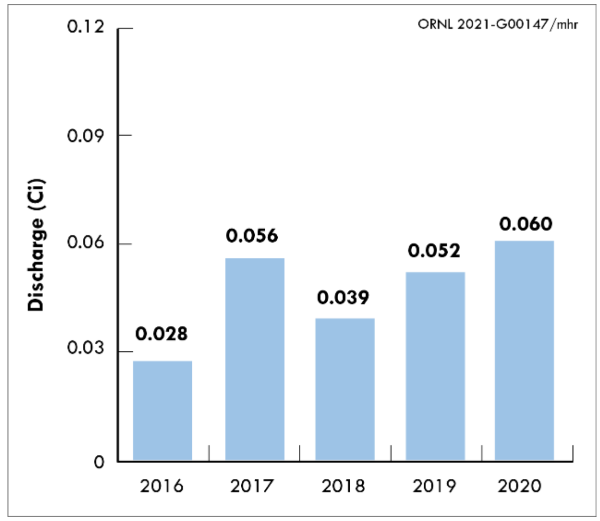


Figure 5.15. Gross alpha discharges at White Oak Dam, 2016–2020

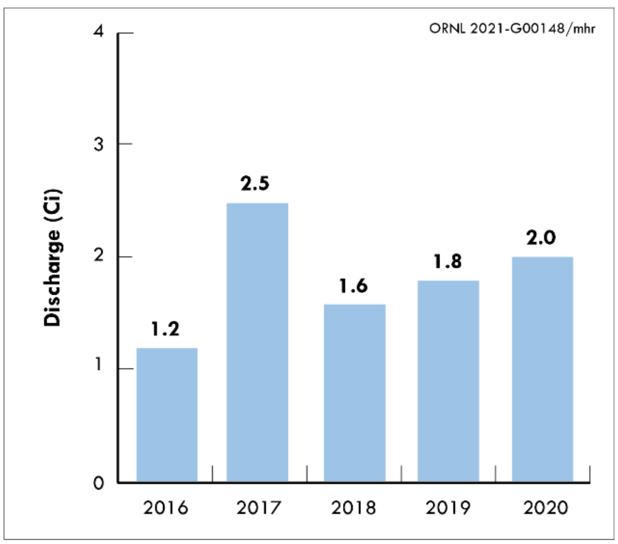


Figure 5.16. Gross beta discharges at White Oak Dam, 2016–2020

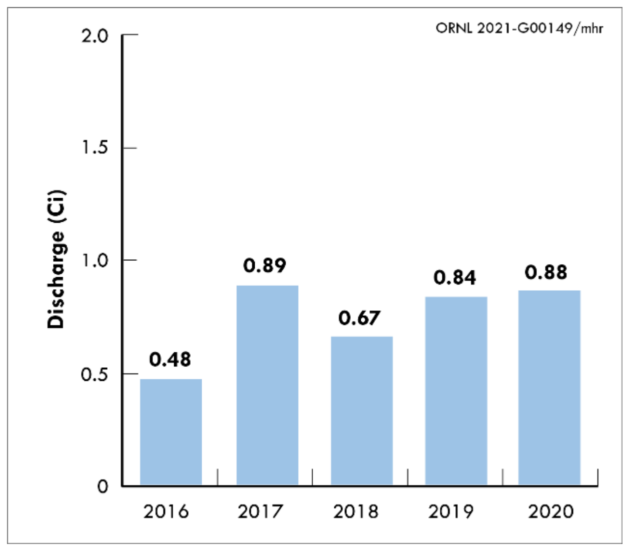


Figure 5.17. Total radioactive strontium discharges at White Oak Dam, 2016–2020

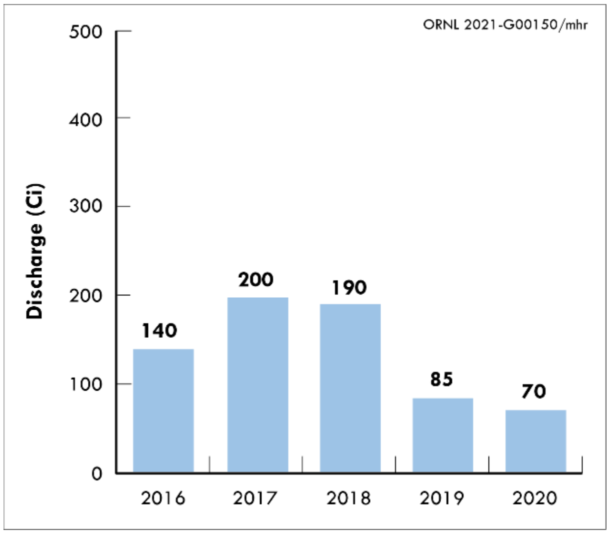


Figure 5.18. Tritium discharges at White Oak Dam, 2016–2020

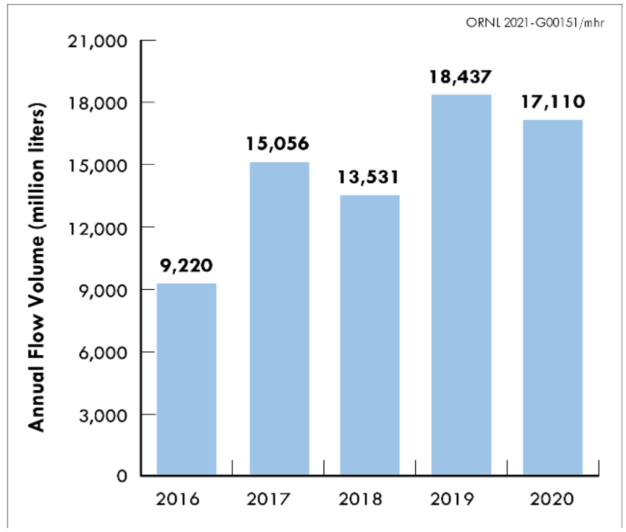


Figure 5.19. Annual flow volume at White Oak Dam, 2016–2020

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 4501, 4505, and 3592 and in spent-fuel reprocessing in Building 3503. By 1963 this work was transferred to Y-12.

Buildings 4501 and 4505 are active research facilities located east of Fifth Creek and north of WOC. In 1996, the Building 4501 foundation sump was found to contain legacy Hg due to its use and spills in the 1950s and to its volatility. The foundation sump discharged to storm Outfall 211 (Figure 5.20) on WOC; a smaller foundation sump in the building discharged to Outfall 263 on Fifth Creek. By 2011, an Hg pretreatment system had been installed on the larger sump. It had also been rerouted along with the smaller sump and a 4500N foundation sump to the PWTC. Outfall 211 and Outfall 363 storm piping still receive other sources of storm water, cooling water, and steam condensate discharges. Due to the persistence of elemental Hg, its volatility, and the complexity of its interactions in piping and soil, Hg continues to be monitored and assessed at these storm outfalls.

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. Mercury associated with process infrastructure has been found in other areas, such as north of the Fifth Street and Central Avenue intersection and in the Outfall 304 drainage area. Storm water exchange with process leaks or overflows has occurred under certain situations.

5.5.4.1. Buildings 3592 and 3503

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. Mercury associated with process infrastructure has been found in other areas, such as north of the Fifth Street and Central Avenue intersection and in the Outfall 304 drainage area. Storm water exchange with process leaks or overflows has occurred under certain situations.

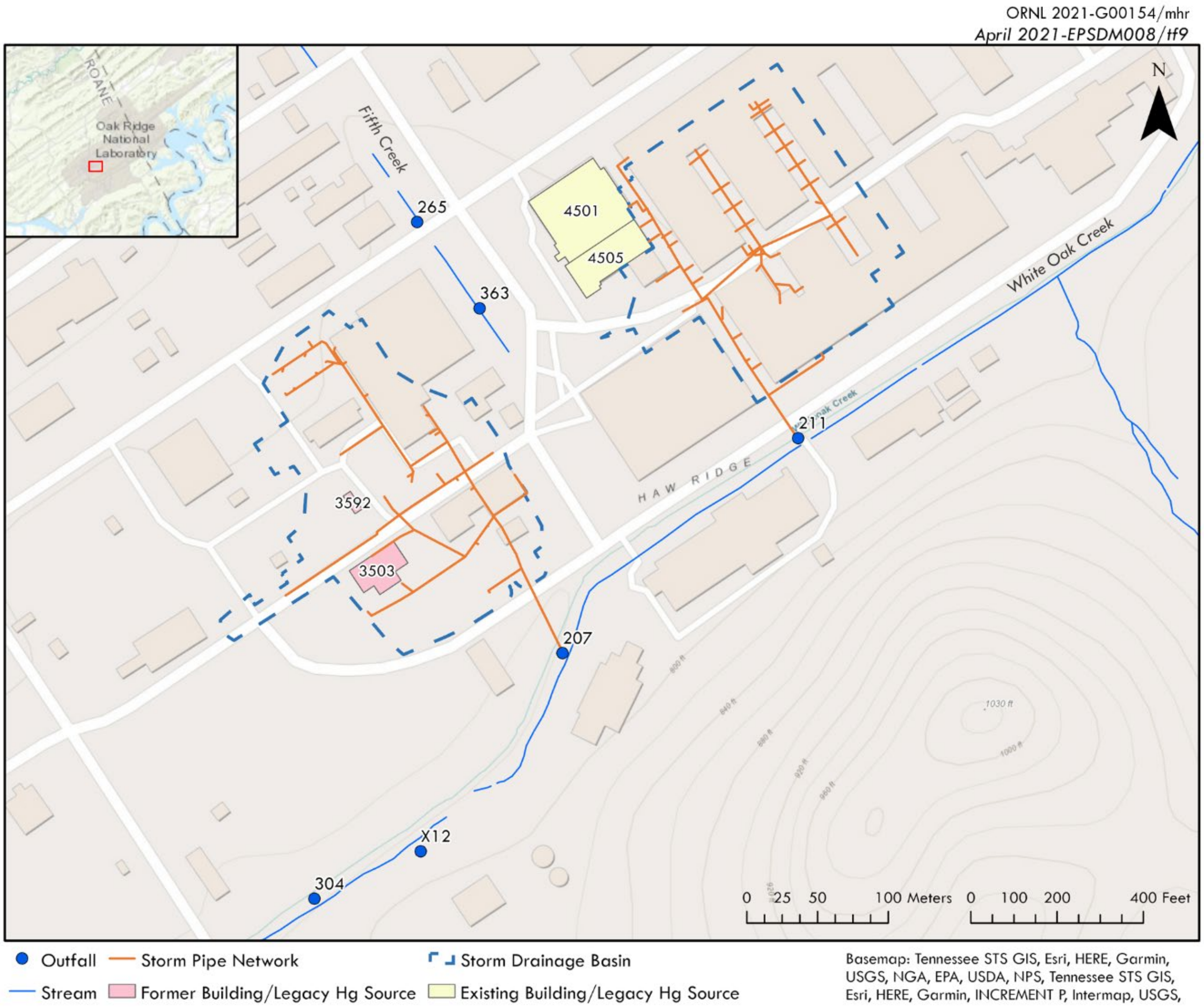


Figure 5.20. Outfalls 211 and 207 and associated storm drain connections that are potential mercury sources

5.5.4.2. Ambient Mercury in Water

Aqueous Hg monitoring in WOC was initiated in 1997 and continued in 2020 with quarterly sampling at four sites: White Oak Creek kilometer (WCK) 1.5, WCK 3.4, WCK 4.1, and WCK 6.8 (Figure 5.21). 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.

The concentration of Hg in WOC upstream from ORNL (WCK 6.8) was less than 10 ng/L in 2020. Waterborne Hg concentrations downstream of ORNL (Figure 5.22) were above Tennessee water quality criteria (WQCs) from 1997 to 2007, but declined abruptly in 2008 and remained low through 2020 as a result of actions: (1) to lessen Hg discharges to WOC at Outfall 211 (sump reroutes to PWTC) and (2) to reduce discharges from PWTC. In general, ambient concentrations have remained low since 2008, with a few exceptions. A significant spike in Hg concentrations was seen at WCK 3.4, downstream of the PWTC and Sewage Treatment Plant outfalls (Outfalls X12 and X01, respectively) in September 2018, and was likely due to issues with filters at the PWTC. Filters were changed in 2019, and Hg concentrations measured at WCK 3.4 dropped below the WQCs, averaging 13.84 ± 6.64 ng/L in 2019, compared with 55.49 ± 76.05 ng/L in 2018.

In contrast, the mean total Hg concentration at WCK 4.1 (downstream of Fifth Creek but upstream of Outfall X12) increased from 26.46 ng/L in 2019 to 33.34 ng/L in 2020. This increase was due to elevated concentrations in samples collected from WCK 4.1 in August 2020 that exceeded the WQCs. The average concentration of August 2020 samples was 85 ng/L. The average aqueous Hg concentration at WOD (WCK 1.5) was 29.48 ng/L compared to 34.01ng/L in 2019. Mercury concentrations at WCK 1.5 are more variable than at other sites in WOC, likely because of the variability in total suspended solids at this site.

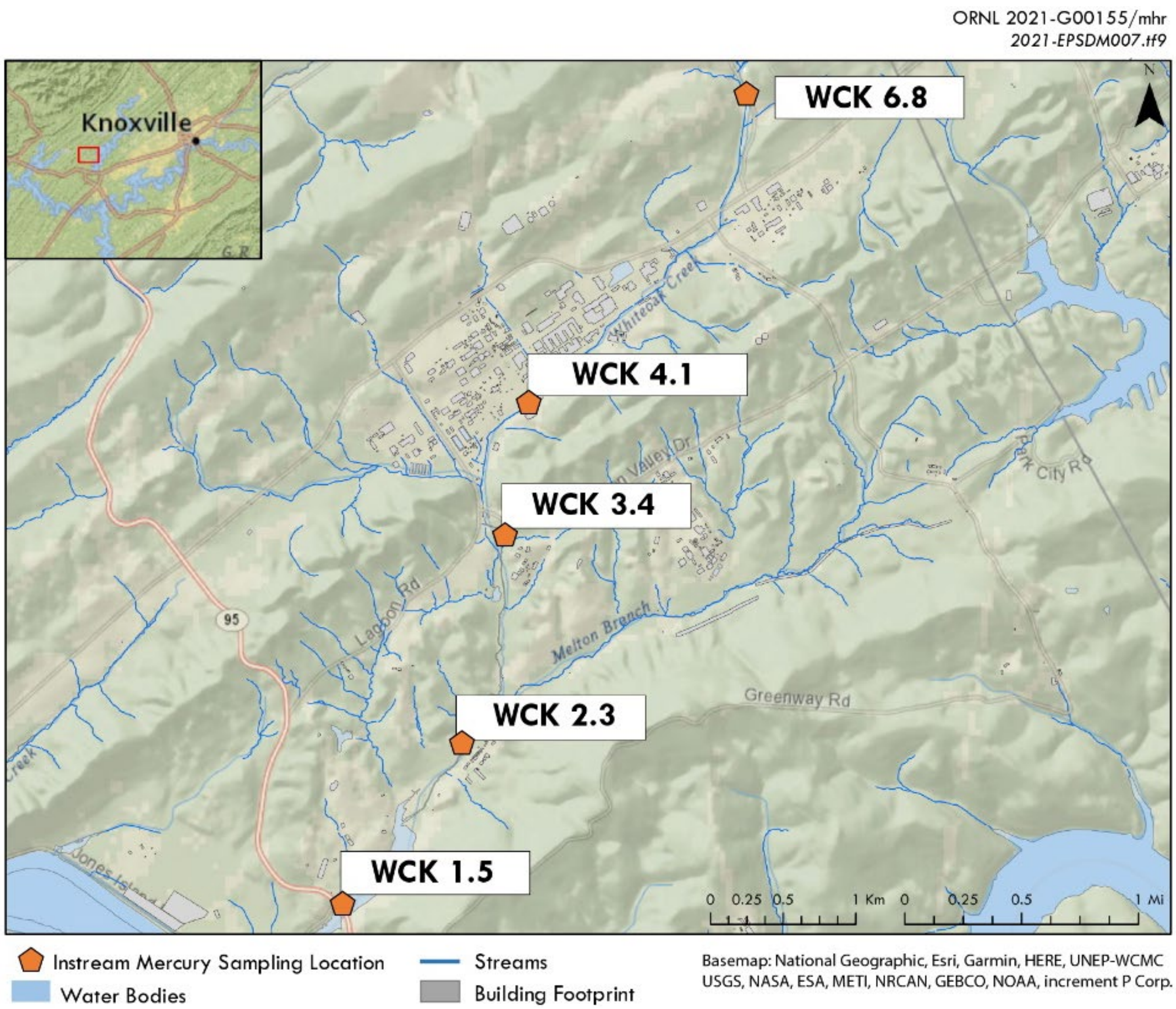
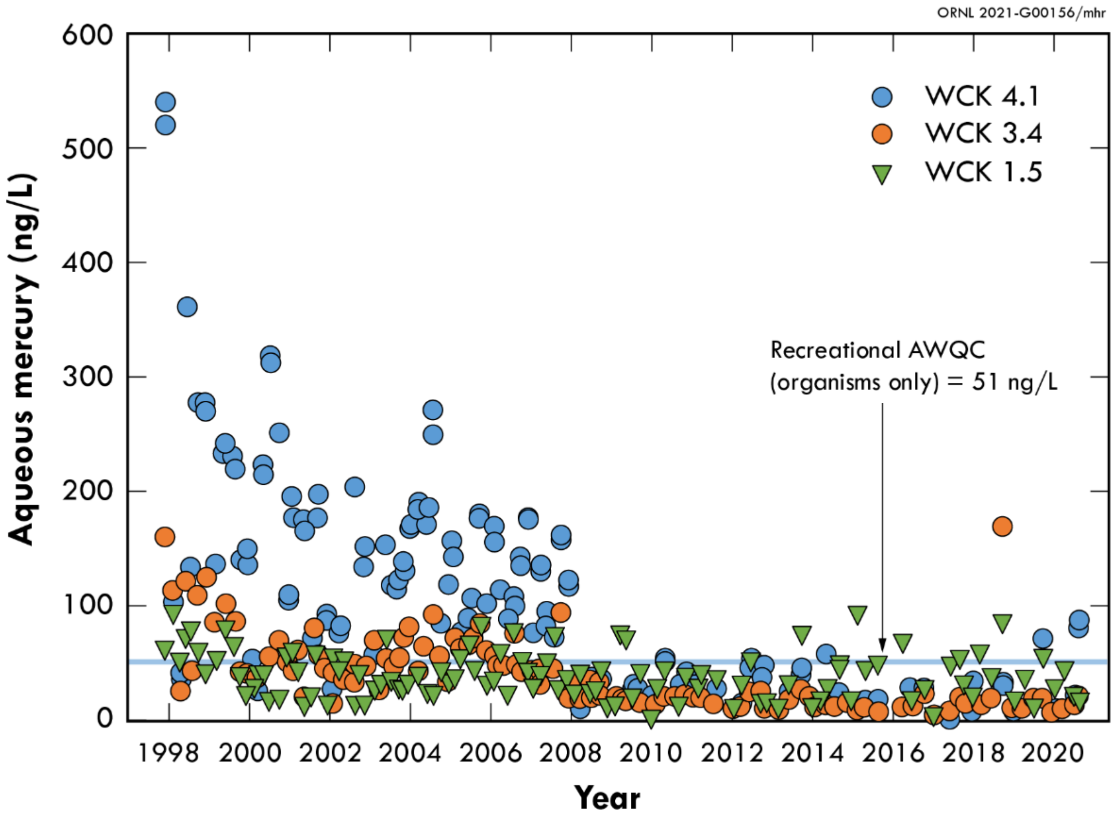


Figure 5.21. Instream mercury monitoring and data locations, 2020



Note: The blue line at 51 ng/L shows the Recreational Water Quality Criteria for Water and Organisms.
Acronym: *WCK = White Oak Creek kilometer*

Figure 5.22. Aqueous mercury concentrations at sites in White Oak Creek downstream from ORNL, 1998–2020

5.5.4.3. Water Quality Protection Plan Mercury Investigation

Outfalls X01 and X12 are monitored for Hg quarterly. Twenty-four–hour composite samples are taken, and discharge flows are measured and recorded. Figure 5.23 shows the total Hg concentration STP discharges to Outfall X01 from 2010 to 2020. Concentrations of Hg discharged from the STP at Outfall X01 have been less than 10 ng/L since 2014 until there was an increase to 46 ng/L in May 2019. After a sand filter media change-out on July 14, 2019, discharge concentrations dropped to 2 ng/L. In 2020, a preliminary investigation was undertaken to find out if and where mercury might be entering the sewage piping system. Samples taken from nine sewage manhole access points were evaluated for the presence of total Hg. Mercury was detected at Manhole M401 in the 4500 area south of Building 4501 and in wastewater coming from the west lagoon. A sample taken before sand filtering had a slightly higher concentration than the 24-hour composite value from X01 (2.33 ng/L) for the same day; the sand filter is backwashed weekly.

Figure 5.24 shows trends in X12 total Hg concentrations for 2009 through 2020 (worst-case loads are calculated in milligrams per day based on concentration and flow using 24-hour discharge rates). Concentrations of mercury in discharges from Outfall X12 (PWTC) reached 219 ng/L in January 2019. This concentration is higher than any measured since June 2009. It is thought that in the process of upgrading PWTC filters (September 2018–July 2019) there was fluctuation in total Hg flux discharge concentrations. After final replacement of dual-media and Mersorb filters on July 25, 2019, mercury concentrations and fluxes declined.

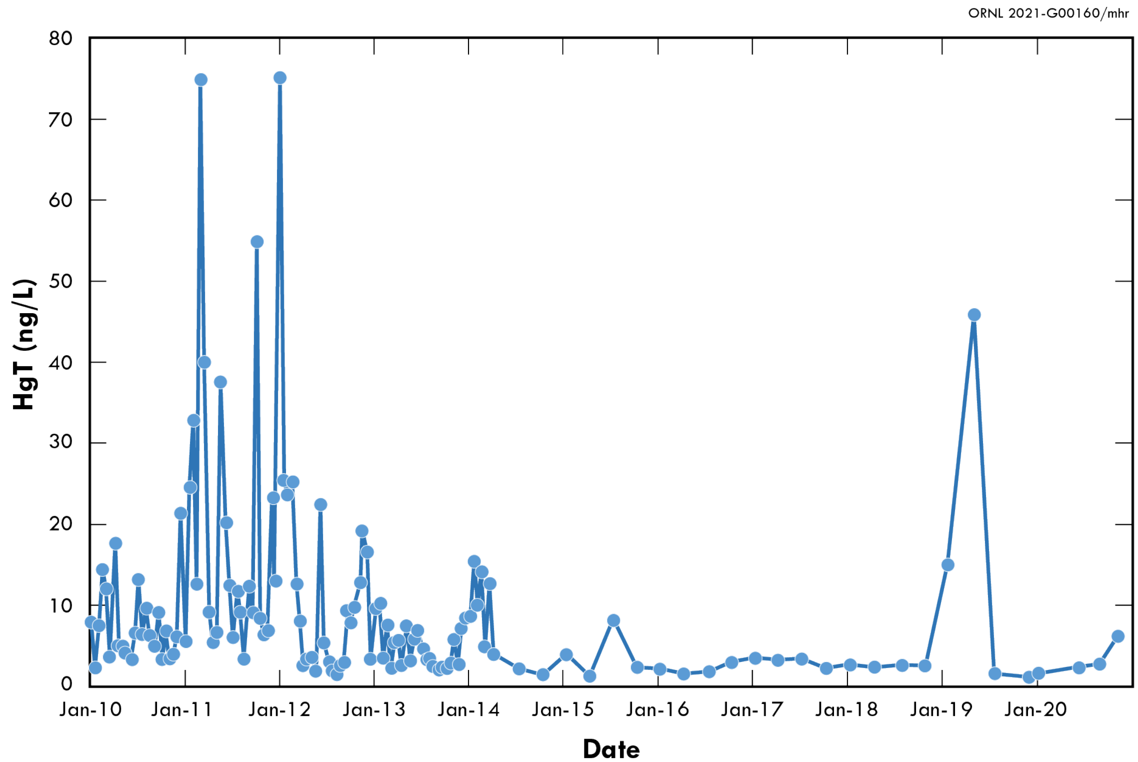
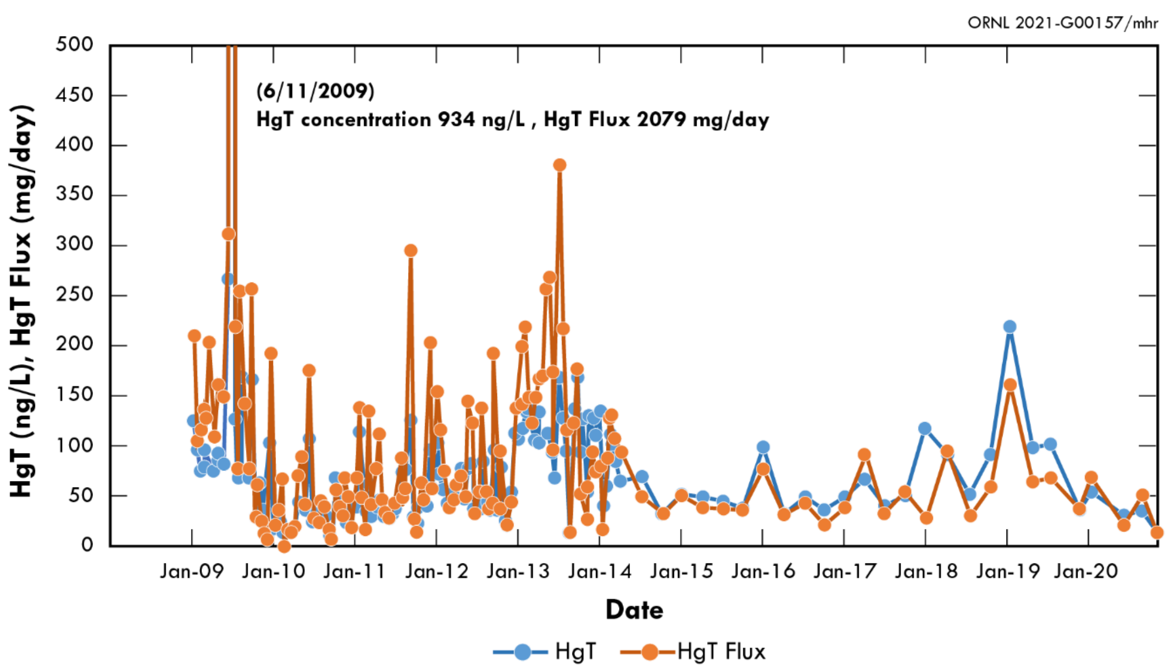


Figure 5.23. Total mercury concentration in discharges to Outfall X01 from the Sewage Treatment Plant, 2010–2020



Acronym: *PWTC: Process Waste Treatment Complex*

Figure 5.24. Total mercury concentrations and fluxes in Process Waste Treatment Complex discharges to Outfall X12, 2008–2020

Starting in the second quarter of 2020, dry weather sampling at Outfalls X01 and X12 was coordinated with 24-hour Hg sampling at three instream locations (Figure 5.25). Instream locations were WCK 4.4, which is upstream of the two treatment plant outfalls; WCK 3.4 at 7500 Bridge, downstream of both treatment plant outfalls; and X15 at WOD. Flow measurements were not available to calculate fluxes at the upstream point WCK 4.4 but were available for treatment plant discharges and for the two locations downstream of the treatment plants (see Figure 5.26). Total Hg concentration and flux measured in the third quarter of 2020 at WCK 3.4 (sample collected on September 1), were higher than concentrations and flux from WOD (Outfall X15). A sample of wastewater leaking from a PWTC transfer line to Outfall 403 (located on WOC just downstream of Outfalls X12 and 304) was collected on September 9, 2020. Total Hg concentrations in the sample were 44.9 to 55.7 ng/L, which indicates that the elevated third-quarter instream composite results may be due to the leaking PWTC transfer line. That transfer line was rerouted to the radiological treatment side of the PWTC on October 1, 2020, and will remain rerouted until piping repairs are made. Instream grab samples taken at WCK 3.4 on August 8, 2020, did not show elevated total Hg; concentrations were 21 to 22 ng/L.

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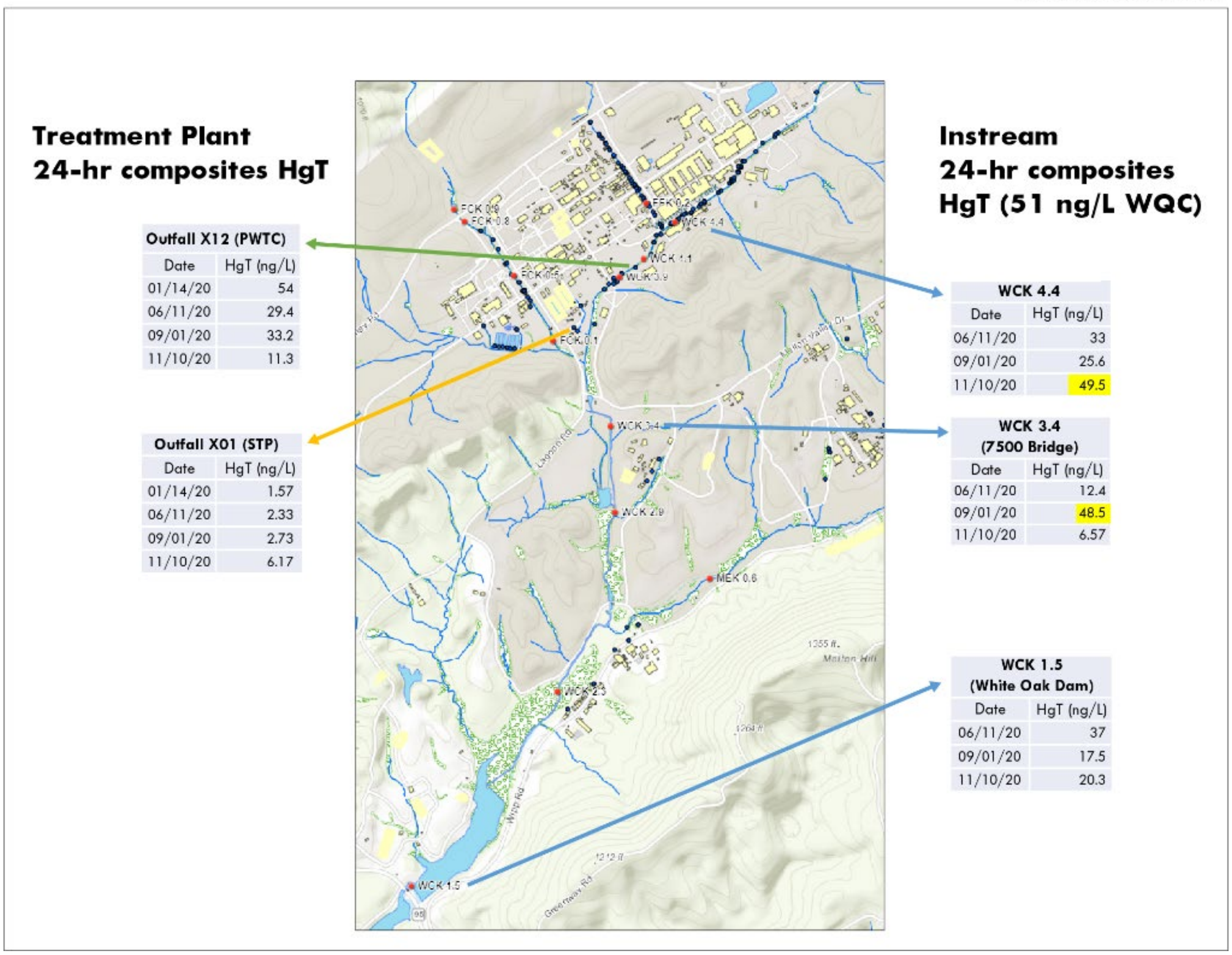
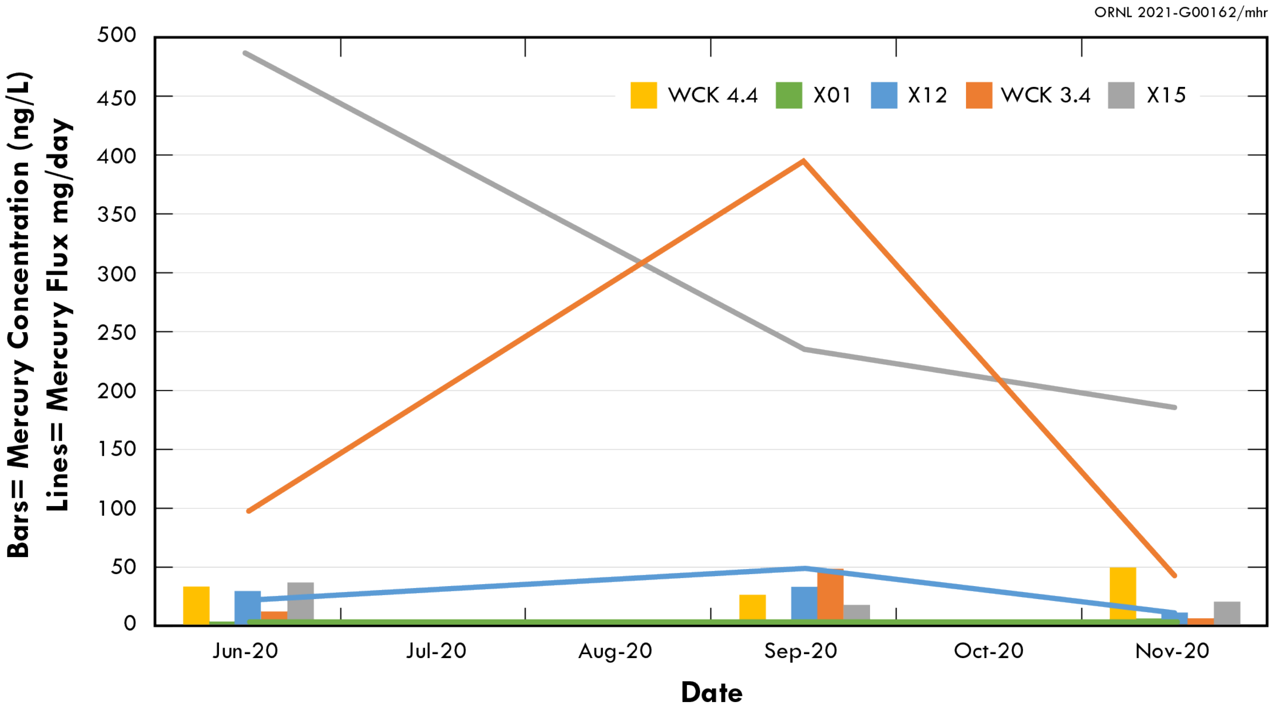


Figure 5.25. Locations and data for instream sampling sites coordinated with treatment plant sampling



Acronym: *WCK = White Oak Creek kilometer*

Figure 5.26. Mercury concentrations and fluxes of treatment plant discharges compared with instream values at WCK 4.4 (no flux available), WCK 3.4, and X15 (White Oak Dam)

5.5.4.4. Legacy Outfall Source Investigation

Legacy outfalls are investigated as part of the WQPP to better delineate Hg sources and to prioritize future abatement actions. In recent years, WQPP monitoring has focused on Outfalls 207 and 211, which generally contribute the highest Hg concentrations. Discharged water volumes (and therefore fluxes) from Outfall 211 are higher than discharges from Outfall 207. In 2020, Hg monitoring was performed at Outfalls 265 and 363, which both discharge to Fifth Creek. There was a period prior to 2014 when a supply water leak under Central Avenue mobilized Hg contamination located south of demolished Building 3026 to Outfall 265. The problem abated when the leak was repaired. The last leg of the Outfall 363 storm drain, which enters Fifth Creek just south of Central Avenue, contains significant debris. In a camera survey of the pipe in 2010, the camera was not able to pass through it. Because of its age and location near the Waste Area Grouping 1.0 Mercury Contaminated Soil Unit, it is suspected that the debris contains residual Hg. Large volumes of cooling tower blowdown, which still retain some chlorine after primary treatment, pass through this storm drain to Fifth Creek, potentially mobilizing Hg trapped behind debris.

Figure 5.27 shows sampling results for dissolved and total Hg at legacy outfalls and total Hg results for instream locations sampled during 2020. During the November 10 sampling event, the concentrations of total Hg in effluent from Outfall 211 was 312 ng/L, and the total Hg concentration measured at the closest instream location downstream of the outfall (WCK 4.4) was of 49.5 ng/L The available dilution provided by background flow in the stream at the time was not quantified, but based on historical water quality data for the relative difference between the outfall flow rate and the stream flow rate (during baseflow conditions), it is likely that Hg discharged from Outfall 211 accounts for the majority of the total Hg that is present at WCK 4.4 (see Figures 5.28 and 5.29 for historic Outfall 211 dry and wet weather trends). On the same day, the total Hg concentration in the stream further downstream at WCK 3.4 was 6.57 ng/L. Dilution provided by flow from tributaries and wastewater discharges entering WOC between WCK 4.4 and WCK 3.4 accounts for at least some of the reduction in concentration between the two instream sites. Separate grab samples are collected for the determination of dissolved and total Hg, and it is likely that the elapsed time between collection of the separate grab samples explains why dissolved Hg concentrations are higher than total Hg concentrations. Pollutant concentrations can change quickly at an outfall during a storm runoff event when flow rates and sediment loads are changing rapidly.

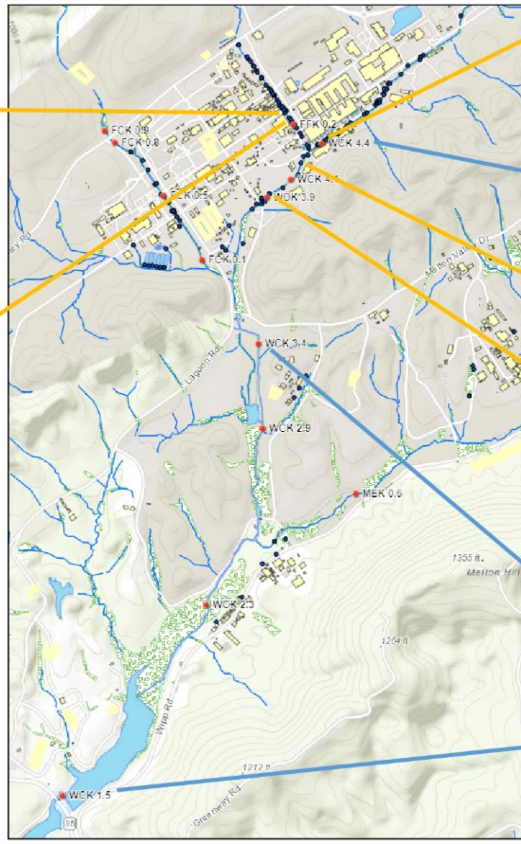
In 2010 a camera system was used to conduct an inspection inside the main Outfall 211 storm pipe. The upper, older pipe sections had debris upstream of each pipe joint. In places, pipe sections had settled, and gaps had formed. Mercury can reside behind and within these irregularities. It is thought that sheltered Hg beads oxidize during dry periods (Miller et al. 2015). The coatings are disturbed and dissolved by storm water and particularly by chlorinated once-through cooling water moving through the pipes. The volumes of dry-weather discharges dropped after 2012, when water conservation efforts were made to recirculate once-through cooling water. Figure 5.28 shows that Hg concentrations and fluxes in dry-weather discharges to Outfall 211 have been gradually increasing since then. The highest concentration (830 ng/L) was measured in December of 2019 (830 ng/L); and while flows have remained at about 50 mg/day, fluxes have trended slightly upward. During storms, there has been a downward trend in flux that may be the result of periodic sediment removal from the Outfall 211 weir box. Plans are being made to remove accumulated sediments from the Outfall 211 weir box on a regular basis.

Since 2015, Outfall 207 has had dry weather flows of 1 gpm or less, with fluxes of less than 1 mg/day total Hg. Flow rates for storm water discharged through Outfall 207 (Figure 5.30) have varied from 5 gpm to more than 100 gpm; higher fluxes occurred during storms. Maximum storm water fluxes of total Hg at Outfall 207 are less than half those contributed by Outfall 211.

Outfall 363 receives regular cooling tower blowdown, and monitoring is performed twice monthly. Dry weather flows ranged from about 3 to 35 gpm. Maximum flows measured in conjunction with dry weather sampling events have are about 8 gpm (total Hg concentrations are about 20 ng/L). Limited information regarding storm discharges from Outfall 363 shows less dissolved Hg than is seen at Outfall 211 (about 80 percent to 100 percent less in 2020). The difference may be due to the configuration and accessibility of contaminants remaining in storm piping.

The 2020 data for Outfall 265 show that storm concentrations of Hg remain low compared with the 176 ng/L measured during storm conditions on October 29, 2014. A leaking supply pipe that had been mobilizing Hg in the leak pathway was repaired on September 17, 2014.

ORNL 2021-G00163/mhr



Outfall 265			
Date	Flow (gpm)	HgD (ng/L)	HgT (ng/L)
3/10/2020 Wet	7	6.4	9.52
12/16/2020 Wet	1	10.2	16.50

Outfall 363			
Date	Flow (gpm)	HgD (ng/L)	HgT (ng/L)
6/11/2020 Dry	8		20.6
11/10/2020 Dry	8		20.3
3/10/2020 Wet	15	8.68	12.7
12/16/2020 Wet	12	9.94	43.4

Outfall 211 Weir Box			
Date	Flow (gpm)	HgD (ng/L)	HgT (ng/L)
6/11/2020 Dry	50		443
11/10/2020 Dry	40		312
3/10/2020 Wet	120	148	184
12/16/2020 Wet	50	420	375

WCK 4.4	
Date	HgT (ng/L)
06/11/2020	33.0
09/01/2020	25.6
11/10/2020	49.5

Outfall 207			
Date	Flow (gpm)	HgD (ng/L)	HgT (ng/L)
3/10/2020 Wet	5	10.5	47.7

Outfall 304			
Date	Flow (gpm)	HgD (ng/L)	HgT (ng/L)
6/4/2020 Dry			10.30
6/11/2020 Dry	0.5		11.20
11/10/2020 Dry	0.1		6.57
3/10/2020 Wet	12.0	5.87	14.50
5/28/2020 Wet			10.80
12/16/2020 Wet	2.0	1.26	9.97

WCK 3.4	
Date	HgT (ng/L)
06/11/2020	12.4
09/01/2020	48.5
11/10/2020	6.57

WCK 1.5 (X15)	
Date	HgT (ng/L)
06/11/2020	37.0
09/01/2020	17.5
11/10/2020	20.3

Acronym:
WCK = White Oak Creek kilometer

Figure 5.27. Dissolved and total mercury concentrations of legacy outfalls compared to instream (total mercury) values at WCK 4.4, WCK 3.4, and X15 (White Oak Dam)

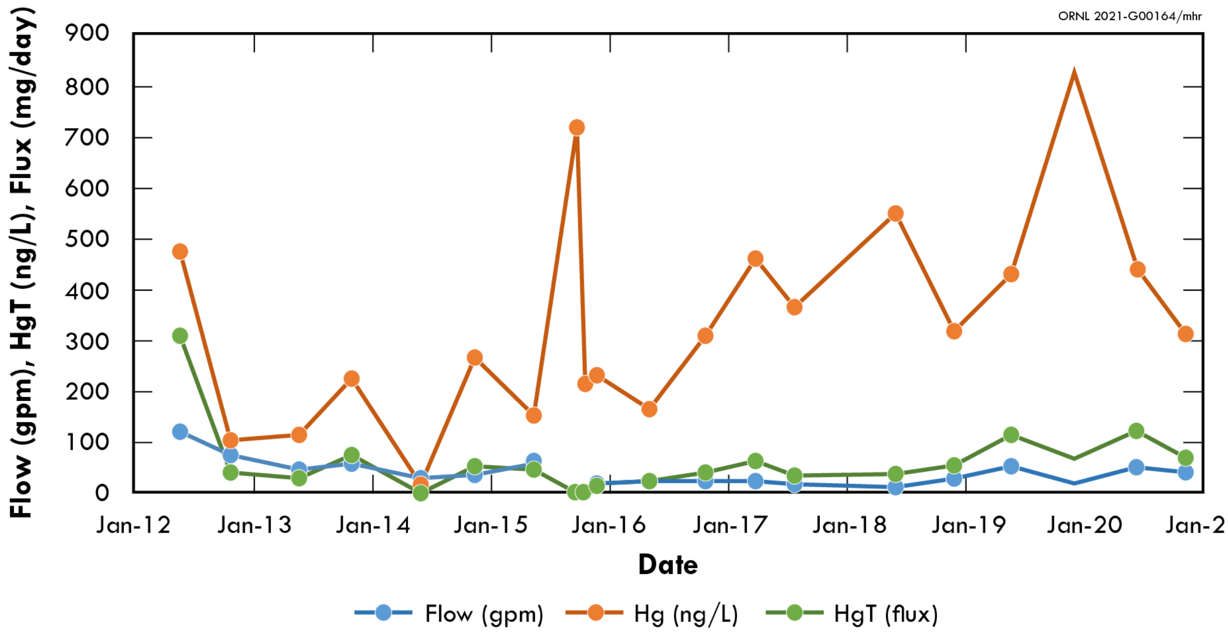


Figure 5.28. Outfall 211 dry-weather flow, concentration, and flux 2012–2020

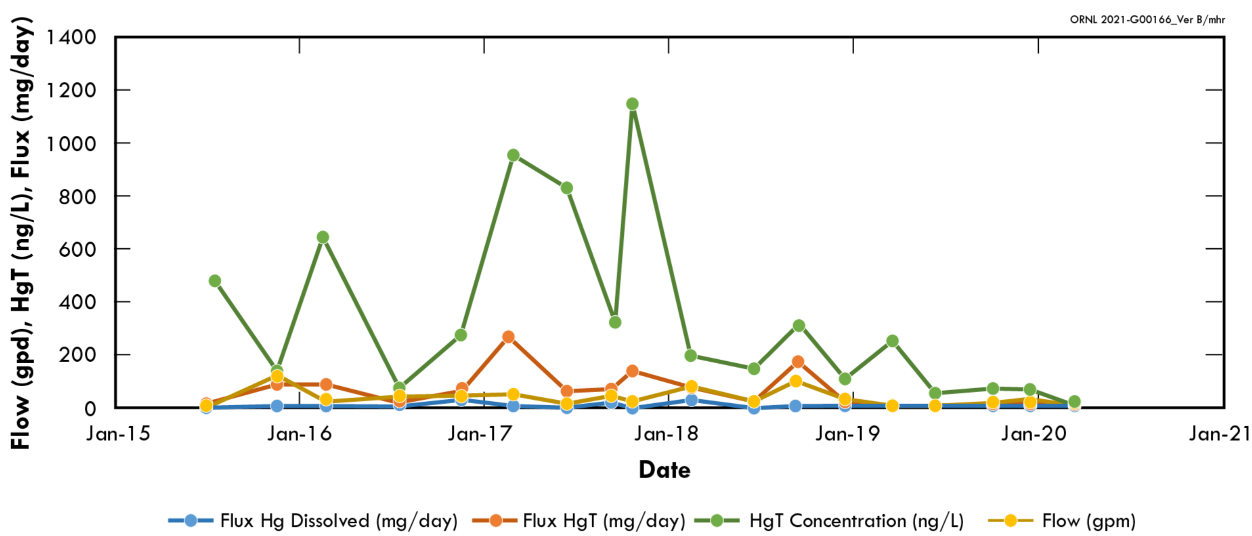


Figure 5.29. Outfall 211 storm flow, dissolved and total mercury flux 2015–2020

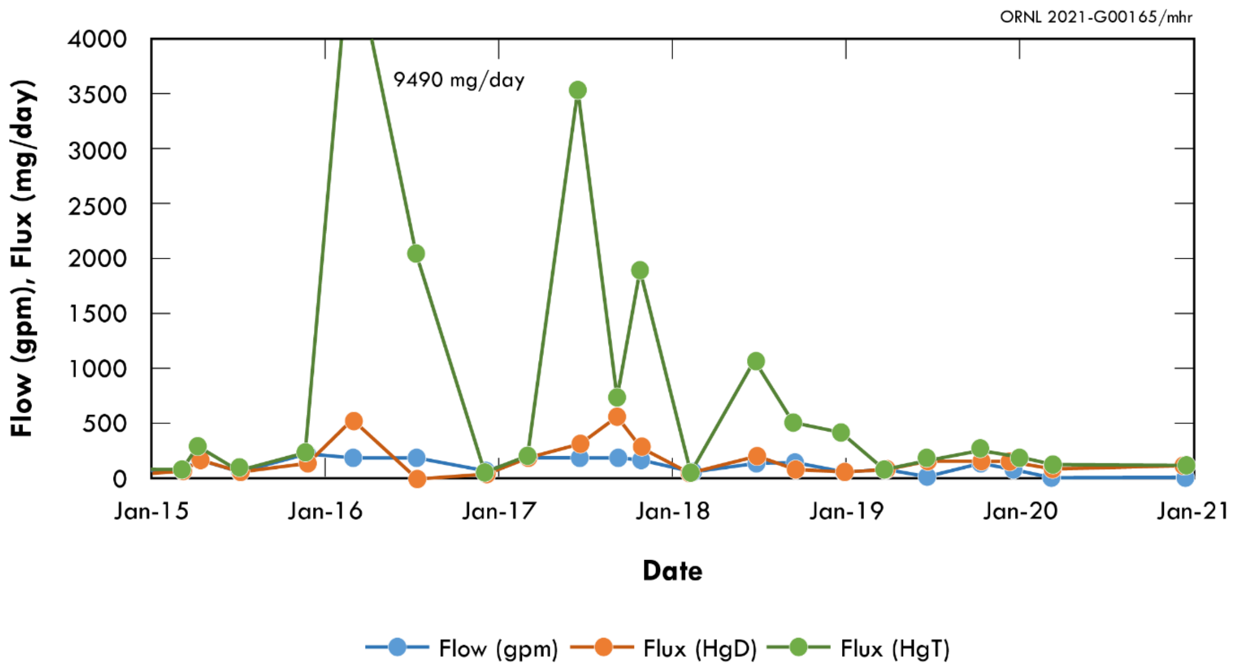
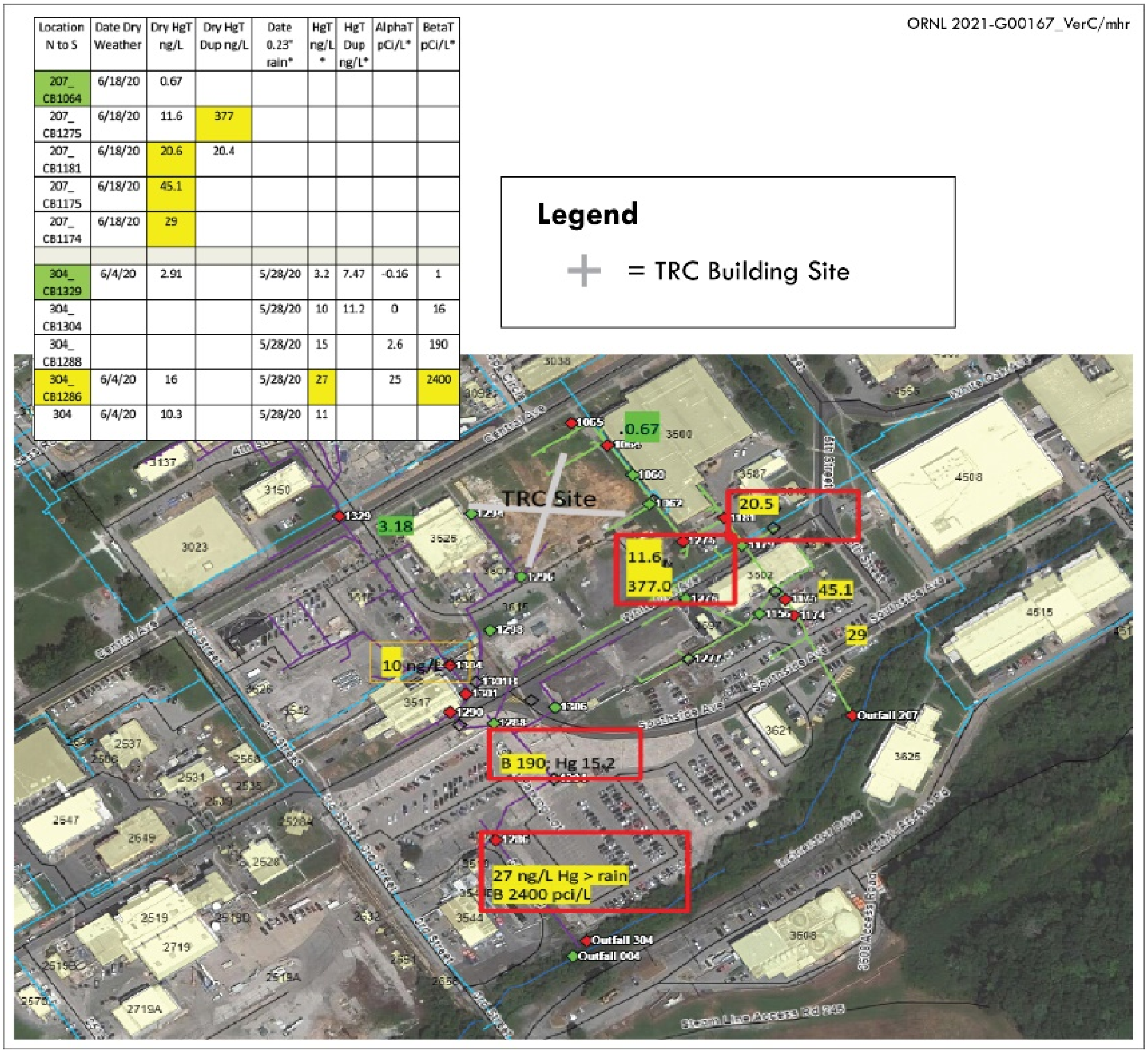


Figure 5.30. Outfall 207 storm flow, dissolved Hg flux, and total Hg flux

5.5.4.5. Baseline Preconstruction Investigation of 207 and 304 Storm Catch Basins

Redevelopment is planned for a central portion of the ORNL main plant area, west of Building 3500. The soil just south of the construction site contains legacy Hg contamination. It was thought that construction of the new building and/or subsequent discharges from its cooling towers or roof through old storm piping might increase Hg discharges through Outfalls 207 and 304. Sampling and preconstruction investigation of storm water catch basins in the Outfall 207 and 304 drainage areas were initiated in 2020 (Figure 5.31). However, construction plans were revised, and the cooling tower discharge and most of the roof drainage are being routed to Outfall 264 on Fifth Creek. The remaining roof and storm water discharges will be routed to Outfall 207. As construction plans changed, attempts were made to sample baseline discharges from Outfall 264; however, no water was flowing through Outfall 264 during any of the attempted sampling events. Efforts to collect samples will continue.

The storm drain systems at Outfalls 304 and 207 are original and currently have no cooling water discharge inputs. However, standing water (accumulated discharges from a groundwater sump, steam condensate discharges, and unknown leakage) was found and sampled in the storm water system during dry weather. Mercury was detected (~20.5 ng/L) in Building 3500 groundwater sump discharge to the Outfall 207 storm drain network. Mercury was also found in standing water in Catch Basin 1275, southeast of Building 3500 (11.6 ng/L and duplicate result 377 ng/L). The large discrepancy between duplicate sample results is likely due to the entrainment of particulates containing Hg. Sediment removal in Catch Basin 1275 is under consideration. North of Building 3502, Hg was also present in Catch Basin 1175 (45.1 ng/L) where a small flow (of unknown origin) entered and continued through Catch Basin 1174 (29 ng/L) south of Building 3523. Dry weather mercury concentrations at Outfall 207 (0.67 ng/L) were lower than in the contributing catch basins.



Location N to S	Date Dry Weather	Dry HgT ng/L	Dry HgT Dup ng/L	Date 0.23" rain*	HgT ng/L *	HgT Dup ng/L*	AlphaT pCi/L*	BetaT pCi/L*
207_ CB1064	6/18/20	0.67						
207_ CB1275	6/18/20	11.6	377					
207_ CB1181	6/18/20	20.6	20.4					
207_ CB1175	6/18/20	45.1						
207_ CB1174	6/18/20	29						
304_ CB1329	6/4/20	2.91		5/28/20	3.2	7.47	-0.16	1
304_ CB1304				5/28/20	10	11.2	0	16
304_ CB1288				5/28/20	15		2.6	190
304_ CB1286	6/4/20	16		5/28/20	27		25	2400
304	6/4/20	10.3		5/28/20	11			

Figure 5.31. Preconstruction surveillance of Outfalls 207 and 304 storm drainage catch basins

In 2020, the Outfall 304 drainage system was also sampled for Hg during dry weather (flow due to mainly steam condensate discharge), and follow-up sampling was performed during rainfall. Mercury concentrations (both dry and wet weather) were less than those found in the Outfall 207 storm drainage system. Samples were also evaluated for radioactivity because process wastewater overflowed into the Outfall 304 drainage system near Catch Basin 1306 during a large local rainfall on August 29, 2019, and other process piping problems are known to exist. During the 2020 sampling effort, the highest total Hg concentration (27 ng/L) was found during rainfall at Catch Basin 1286, just northeast of the old 3544 Radioactive Treatment Plant. Even during rainfall, samples were hard to obtain in the 304 drainage because of storm pipe leakage and low flow rates. As was the case at Outfall 207, the Hg concentration at Outfall 304 (3.2 ng/L), was lower than the concentrations of Hg in the catch basins contributing to it.

5.5.5. Storm Water Surveillances and Construction Activities

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

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

5.5.6. Biological Monitoring

Biological monitoring programs conducted at ORNL in 2020 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 2020.

5.5.6.1. Bioaccumulation Studies

The bioaccumulation task for the biological monitoring and abatement plan addresses two NPDES permit requirements at ORNL: (1) evaluate whether mercury 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 mercury in fish in the WOC watershed are monitored annually and are evaluated relative to the EPA AWQC of 0.3 μg/g in fish fillets, a concentration considered protective of human health and the environment. Concentrations of PCBs in fish fillets are also monitored annually and are evaluated relative to the TDEC fish advisory limit of 1 μg/g.

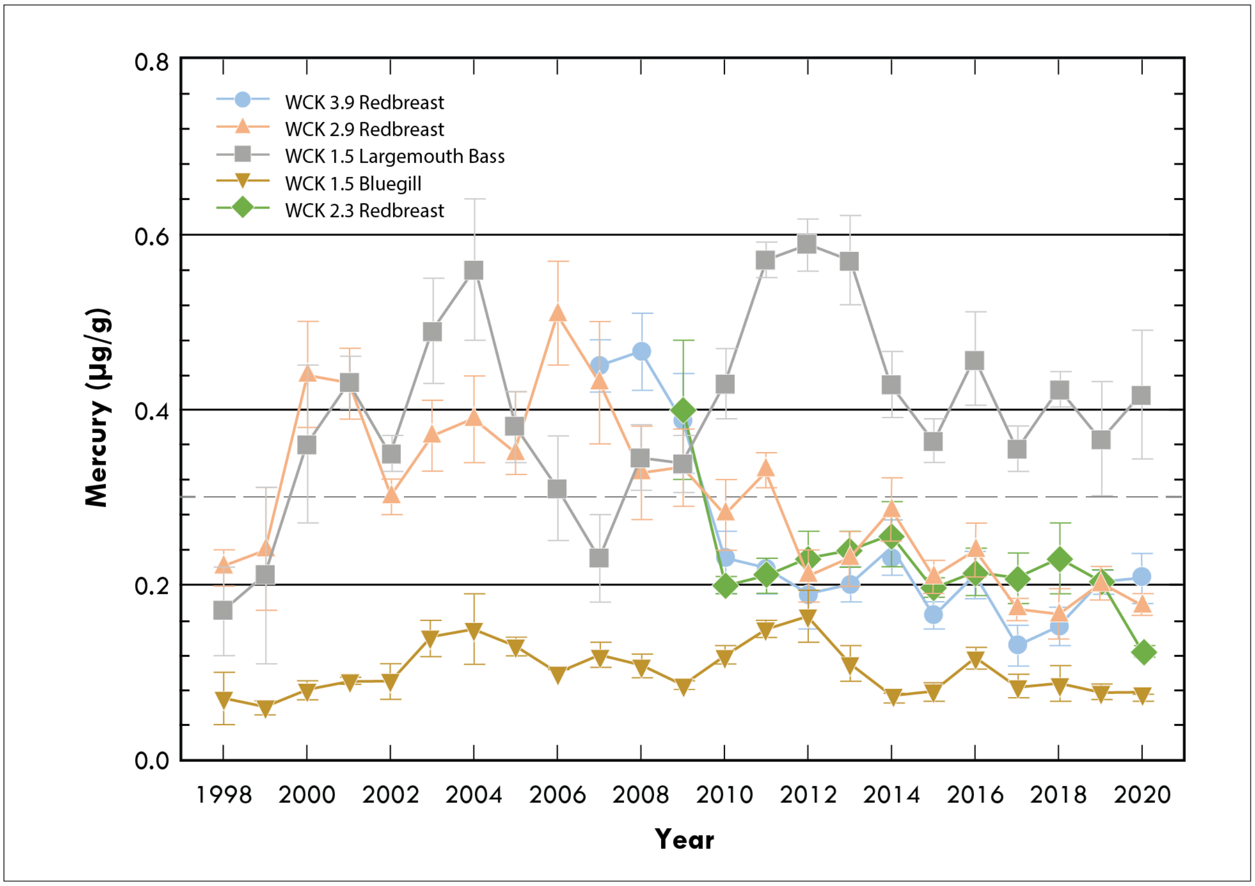
Bioaccumulation in Fish

In WOC, mercury and PCB concentrations in fish have been at or near human health risk thresholds (e.g., EPA recommended fish-based AWQC [0.3 μg/g for mercury], TDEC fish advisory limits for PCBs) (see Figure 5.32). Actions taken in 2007 to treat a mercury-contaminated sump resulted in significant decreases in mercury concentrations in fish throughout WOC. The decreases were most apparent at upstream locations closest to the sump water reroute. While the overall trends in the uppermost locations sampled in the creek suggest that fish tissue concentrations are decreasing overall, there is some interannual variability. Fillet concentrations remained consistent from 2019 to 2020 at the two uppermost WOC stream sites and stayed well below the AWQC for mercury in fish. Mean fillet concentrations increased from 0.20 μg/g in 2019 to 0.21 μg/g in 2020 at WCK 3.9 and decreased from 0.20 μg/g in 2019 to 0.18 μg/g in 2020 at WCK 2.9. Mercury concentrations in largemouth bass collected from WCK 1.5 (White Oak Lake) have been fluctuating in recent years and increased from 0.37 μg/g in 2019 to 0.42 μg/g in

2020 and remained above the guideline. No change in mercury concentrations in bluegill collected from WCK 1.5 was observed from 2019 to 2020 (0.08 µg/g), and mercury concentrations remained below the recommended guideline.

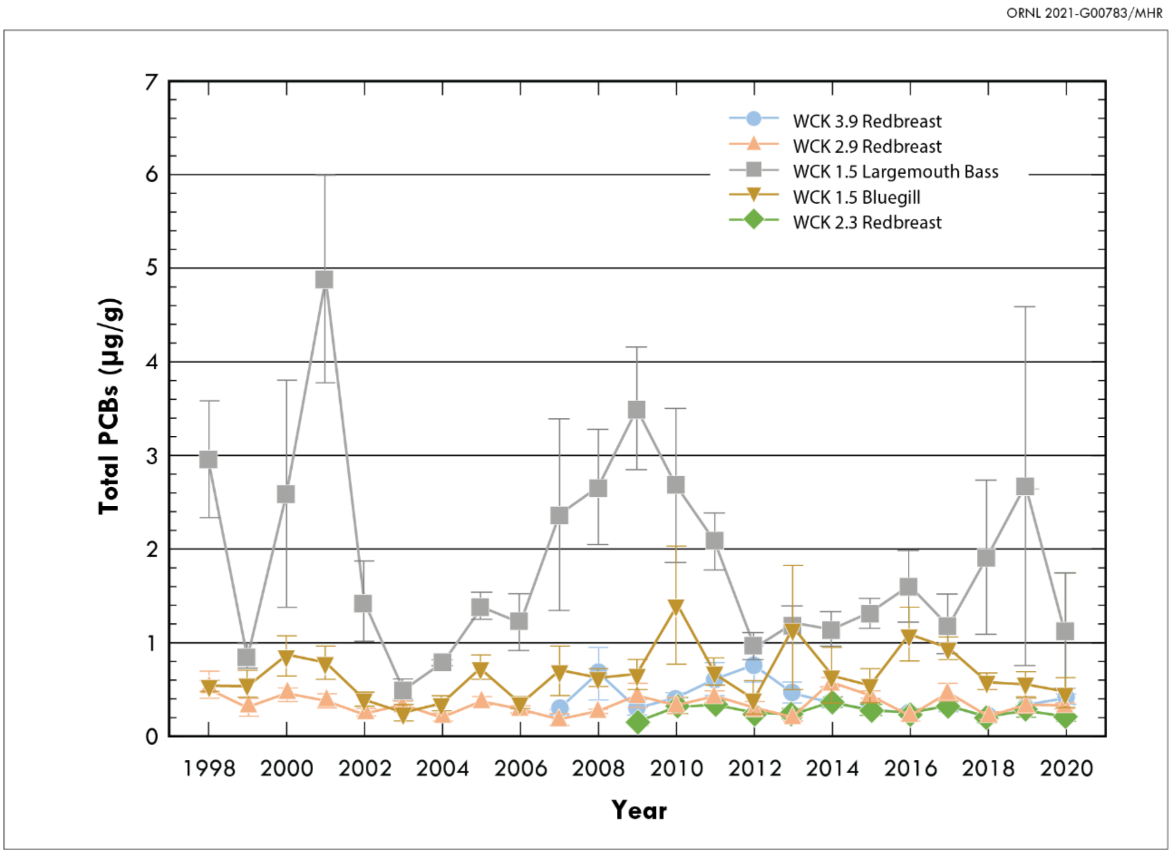
PCB concentrations (defined as the sum of Aroclors 1248, 1254, and 1260) in redbreast sunfish from the WOC watershed remained within historical ranges (see Figure 5.33). Mean concentrations in 2020 were 0.38 µg/g at WCK 3.9, 0.31 µg/g at WCK 2.9, and 0.18 µg/g at WCK 2.3 (compared to 0.33 µg/g at WCK 3.9, 0.32 µg/g at WCK 2.9, and 0.26 µg/g at WCK 2.3 in 2019). PCB concentrations in bluegill collected from WCK 1.5 decreased from 0.55 µg/g in 2019 to 0.46 µg/g in 2020 and were below the TDEC fish advisory limit of 1 µg/g; concentrations in largemouth bass collected from WCK 1.5 decreased from 2.66 µg/g in 2019 to 1.12 µg/g in 2020 and were slightly above the TDEC fish advisory.

ORNL 2021-G00782/MHR



Notes:
1. Mean concentrations of Hg (± standard error, N = 6) in tissue taken from sampled fish.
2. Thee 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 5.32. Mean mercury concentrations in muscle tissue of sunfish and bass sampled from the White Oak Creek watershed, 1998–2020



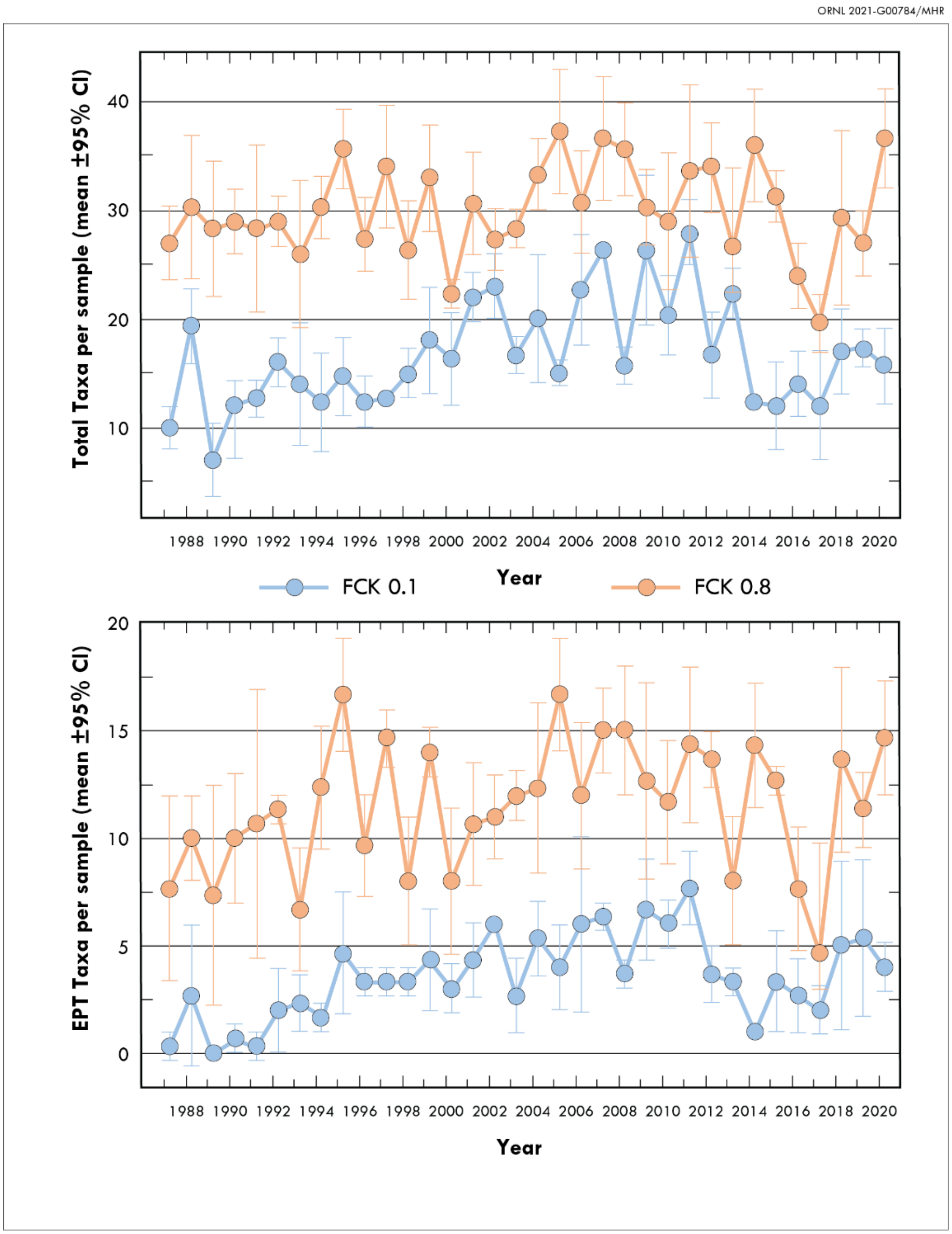
Note: *Mean total PCB concentrations (± standard error, N = 6) found in fish fillets.*
Acronyms:
PCB = polychlorinated biphenyl
WCK = White Oak Creek kilometer

Figure 5.33. Mean total PCB concentrations in fish sampled from the White Oak Creek watershed, 1998–2020

5.5.6.2. Benthic Macroinvertebrate Communities

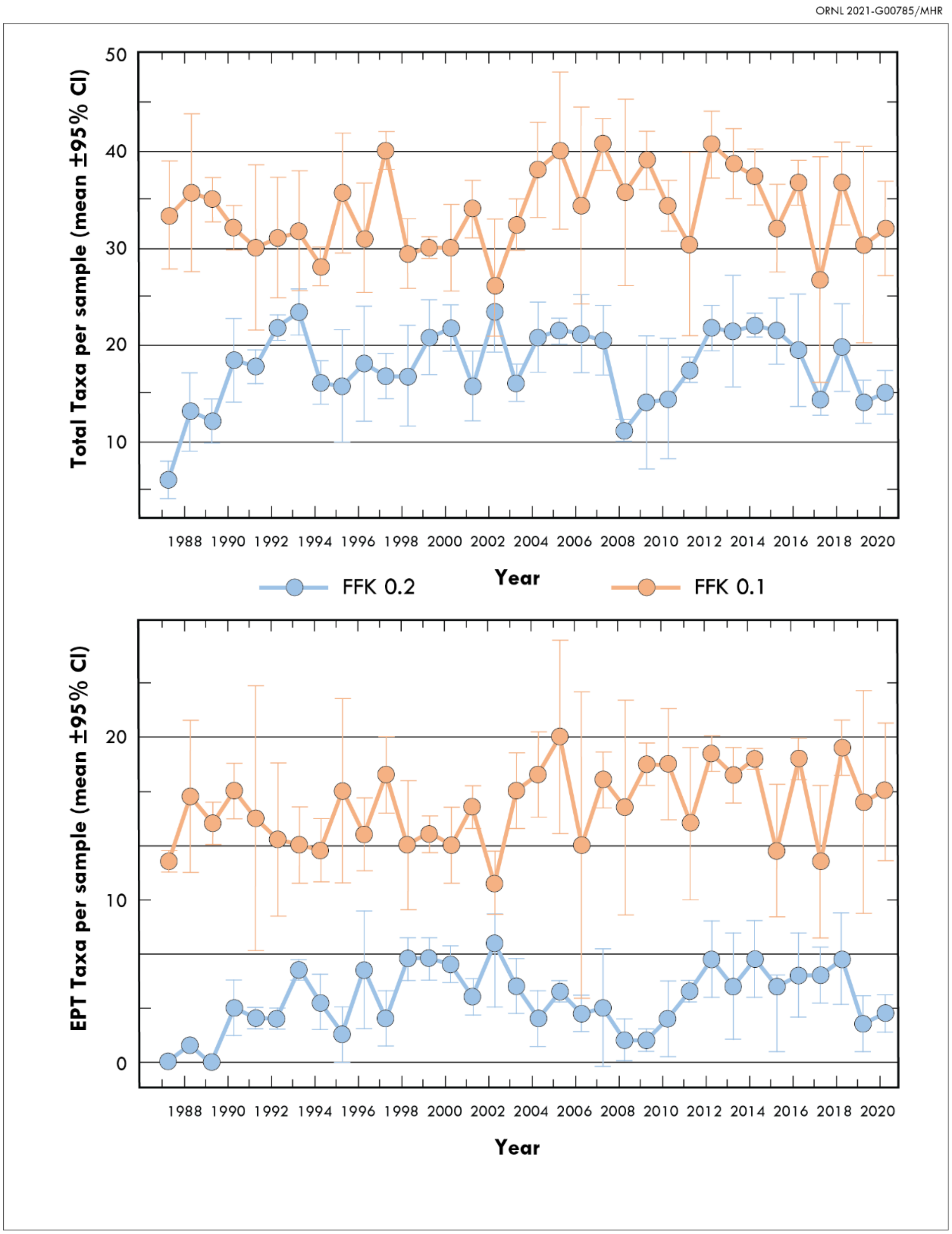
Monitoring of benthic macroinvertebrate communities in WOC, First Creek, and Fifth Creek continued in 2020. Additionally, monitoring of the macroinvertebrate community in lower Melton Branch (MEK 0.6) continued under the OREM Water Resources Restoration Program (WRRP). Benthic macroinvertebrate samples are collected annually following TDEC protocols (since 2009) and protocols developed by ORNL staff (since 1987). The protocols developed by ORNL staff provide a long-term record (34 years) of spatial and temporal trends in the invertebrate community from which the effectiveness of pollution abatement and remedial actions taken at ORNL can be evaluated and verified. The ORNL protocols also provide quantitative results that can be used to statistically evaluate changes in trends relative to historical conditions. The TDEC protocols provide a qualitative estimate of the condition of a macroinvertebrate community relative to a state-defined reference condition.

General trends in the results of ORNL protocols indicated significant recovery in these communities since 1987, but community characteristics suggest that ecological impairment remains (Figures 5.34–5.36). Relative to respective upstream reference sites, total taxonomic richness (i.e., the mean number of different species per sample) and richness of the pollution-intolerant taxa (i.e., the mean number of different mayfly, stonefly, and caddisfly species per sample or Ephemeroptera, Plecoptera, and Trichoptera [EPT] taxa richness) continued to be lower at these downstream sites.



Note: *Taxonomic richness (mean number of taxa per sample), 1987–2020. 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 5.34. Benthic macroinvertebrate communities in First Creek



Note: *Taxonomic richness (mean number of taxa per sample), 1987–2020. 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 5.35. Benthic macroinvertebrate communities in Fifth Creek

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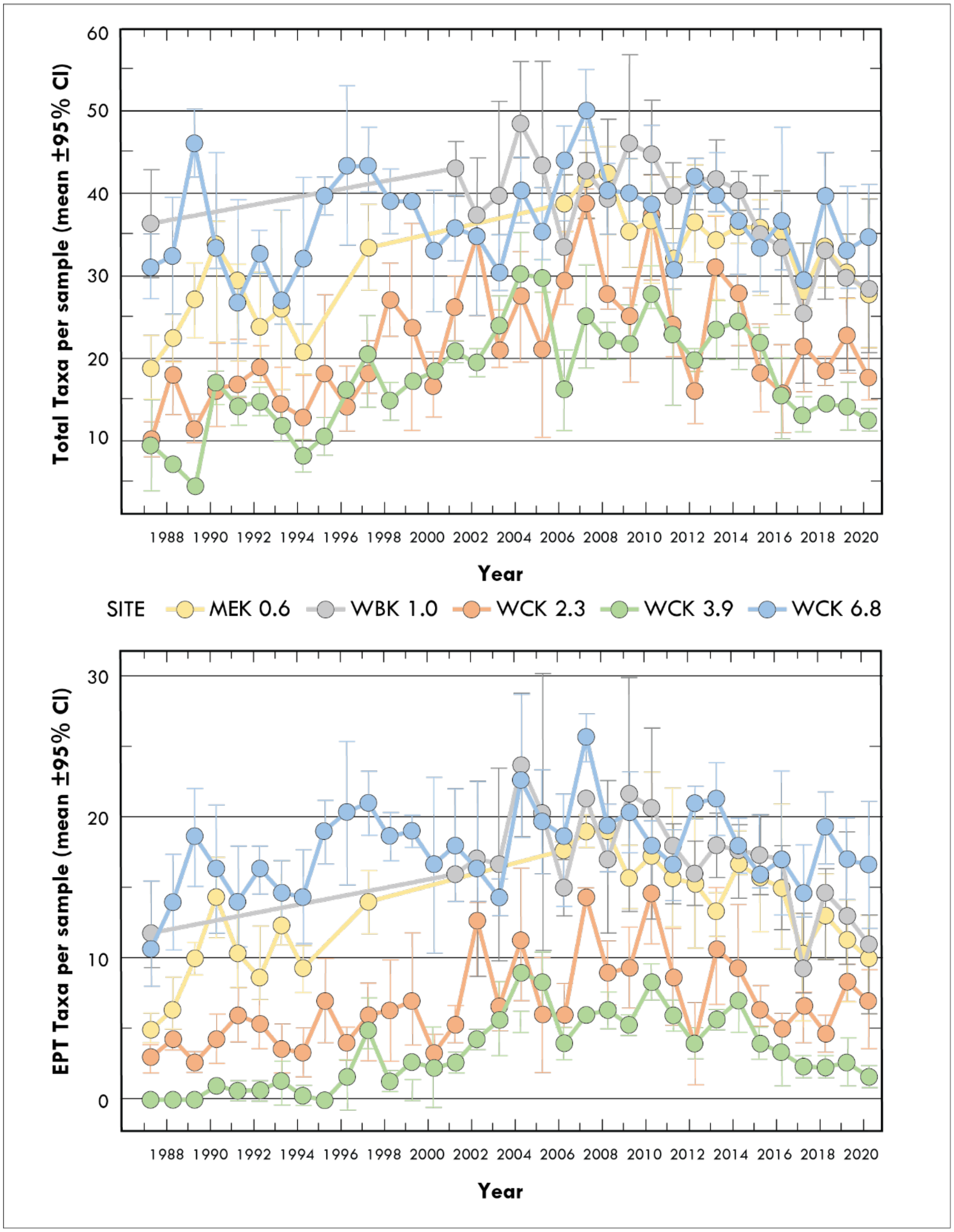


Note: *Taxonomic richness (mean number of taxa per sample), 1987–2020. WCK 6.8 and WBK 1.0 serve as a reference site.*
Top: Total taxonomic richness.
Bottom: Taxonomic richness of the pollution-intolerant taxa Ephemeroptera, Plecoptera, and Trichoptera (EPT).
Acronyms:
CI = confidence interval
MEK = Melton Branch kilometer
WBK = Walker Branch kilometer
WCK = White Oak Creek kilometer

Figure 5.36. Benthic macroinvertebrate communities in Walker Branch, Melton Branch, and White Oak Creek

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 5.34). Total taxa richness has increased at FCK 0.1 in the past three years (2018 to 2020), reaching values that were previously observed in the late 1990s. Similarly, the number of pollution-intolerant EPT taxa decreased in 2012, and in 2014, EPT taxa richness was the lowest it had been since the early 1990s. After 6 consecutive years of low EPT taxa richness, values increased in 2018 and 2019 to levels previously recorded in the late 2000s, while decreasing slightly in 2020. Additionally, in upper First Creek (FCK 0.8), which serves as a reference for FCK 0.1, metrics for total taxa richness and EPT taxa richness declined for three consecutive years (from 2014 to 2017) , but those metrics have since returned to levels near the highest values from previous years. The 6 year period of extremely low values in FCK 0.1 did not mirror those in FCK 0.8. This suggests that while climate or hydrological change may have influenced conditions within the entire stream (both FCK 0.1 and FCK 0.8), a more localized change may have also occurred in lower First Creek. If a change has occurred, it is not known whether it is related to a change in chemical conditions (e.g., change in water quality or the possible presence of a toxicant), physical conditions (e.g., unstable substrate, increased frequency of high-discharge events), or natural variation. Additionally, it is unclear at this time whether conditions at FCK 0.1 have improved temporarily or for the long term.

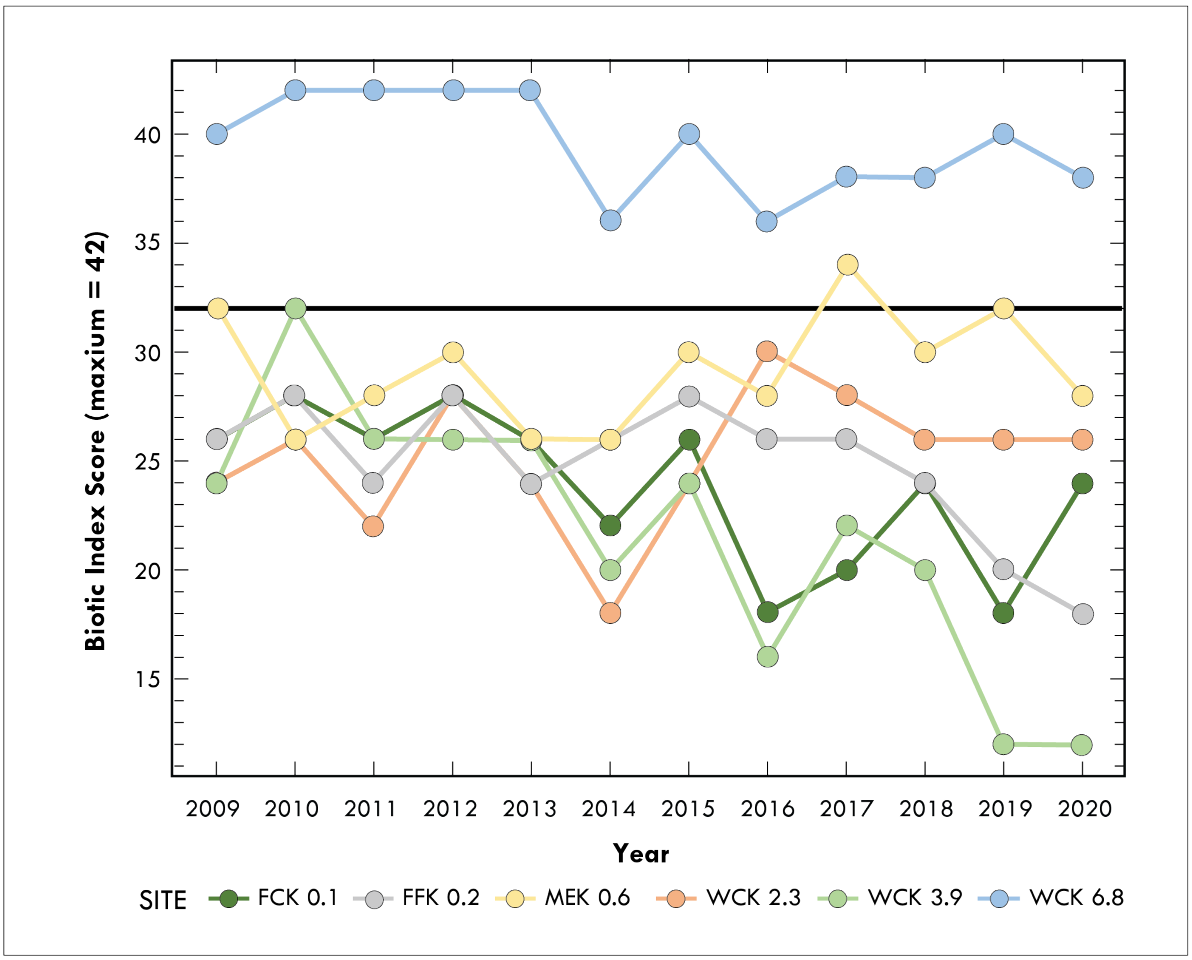
Total taxa richness at Fifth Creek kilometer (FFK) 0.2 increased in the late 1980s, and then reached a fairly consistent level until exhibiting a large decrease between 2007 and 2008 (Figure 5.35), suggesting a change in conditions occurred at the site during that time. Total taxa richness returned to predecline levels over a period of about 5 years. EPT taxa richness at FFK 0.2 increased slowly from the late 1980s to early 2000s before decreasing for several years (~2003–2011). More recently, EPT taxa richness has remained steady at about five to six EPT taxa per sample (2011–2018). However, EPT taxa richness in 2019 decreased by four (from six EPT taxa/sample in 2018 to two EPT taxa/sample in 2019) and remained low in 2020. It is not known whether this decrease will persist in future years or whether it instead reflects interannual variation in invertebrate community composition. This recent decline was also seen at upper Fifth Creek (FFK 1.0), which serves as a reference for FFK 0.2, though total and EPT richness values remained higher at the upstream site.

Invertebrate metric values for WCK 2.3 and WCK 3.9 continued to remain within the ranges of values found since the late 1990s and early 2000s, although total taxa richness and EPT taxa richness were lower at WCK 2.3 and WCK 3.9 over the past 5 to 6 years. As with FCK 0.1 and FFK 0.2, the total taxa richness and EPT taxa richness at WCK 2.3 and WCK 3.9 continued to be notably lower than those for the reference sites. Since 2001 (except for one sampling event in 1987), Walker Branch has served as an additional reference site for WOC mainstem sites downstream of Bethel Valley Road (Figure 5.36). Comparisons of WCK 6.8 to Walker Branch kilometer (WBK) 1.0 show that communities in WCK 6.8 represent ideal reference conditions. Additionally, the comparison of Walker Branch to downstream sites in WOC show that those WOC communities remain impaired. Interestingly, a pattern similar to FCK 0.8 and FFK 1.0 occurred in both WCK 6.8 and WBK 1.0, where consecutive declines in total taxa richness and EPT taxa richness were observed in 2018 and 2019, though responses in 2020 varied with sites increasing (FCK 0.8), decreasing (WBK 1.0), or showing little change (FFK 1.0, WCK 6.8). This suggests that similar climatological or environmental changes may be contributing to some of these patterns across the entire watershed, if not the entire ORR, but local drivers may also be present. Macroinvertebrate metrics for lower Melton Branch (Melton Branch kilometer [MEK] 0.6) suggested that total taxa and EPT taxa richness continued to be similar to those in reference sites in 2020 (Figure 5.36). However, other invertebrate community metrics at MEK 0.6 potentially sensitive to more specific types of pollutants, such as the density of pollution-intolerant and pollution-tolerant species (not shown), continued to fluctuate annually between comparable values and values below those of the reference sites. For the past five years (2016–2020), EPT density was generally lower in MEK 0.6 than WCK 6.8 and WBK 1.0 while the density of pollution-tolerant species (oligochaetes and chironomids) was higher in MEK 0.6 than in those two reference sites.

Based on 2017 TDEC protocols (TDEC 2017), scores for the TDEC Tennessee Macroinvertebrate Index (TMI) in 2020 rated the invertebrate communities at WCK 6.8 as passing biocriteria guidelines; scores from FCK 0.1, FFK 0.2, MEK 0.6, WCK 2.3, and WCK 3.9 were below these guidelines (Figure 5.37, Table 5.12). Of the five sites below the biocriteria threshold, scores improved at one site from 2019 to 2020 (FCK 0.1), declined at two sites (MEK 0.6 and FFK 0.2), and remained stable at two sites (WCK 2.3, WCK 3.9).

Low TMI scores in FCK 0.1, FFK 0.2, MEK 0.6, WCK 2.3, and WCK 3.9 were primarily due to low values for EPT percentage and EPT taxa richness (Table 5.12). However, all of the sites had low percentages of oligochaetes and chironomids (worms and non-biting midges) and thus received high scores for this category. WCK 6.8 received the highest attainable scores for all categories except for total taxa richness and EPT taxa richness.

ORNL 2021-G00787/mhr



__Note:__ The black horizontal line shows the threshold for Tennessee Macroinvertebrate Index scores. The values above the threshold represent passing scores; those below do not.

Acronyms:

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

Figure 5.37. Temporal trends in Tennessee Department of Environment and Conservation Tennessee Macroinvertebrate Index scores for White Oak Creek watershed streams, August sampling

Table 5.12. Tennessee Macroinvertebrate Index metric values, metric scores, and index scores for White Oak Creek, First Creek, Fifth Creek, and Melton Branch, August 15 and 16, 2020[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	19	6	39.7	6.4	5.4	34.8	41.8	4	2	4	6	4	2	4	26
WCK 3.9	10	2	5.3	21.2	6.2	13.3	77.9	2	0	0	6	4	0	0	12
WCK 6.8	27	11	57.9	6	2.7	83.3	12.5	4	4	6	6	6	6	6	38 [pass]
FCK 0.1	16	4	6.3	3.4	4.3	45.4	44.4	2	2	0	6	6	4	4	24
FFK 0.2	13	5	7	8	5.5	30.7	62.8	2	2	0	6	4	2	2	18
MEK 0.6	19	7	14.8	2.4	4	65.1	32	2	2	2	6	6	6	4	28

[a] TMI metric calculations and scoring and index calculations are based on TDEC protocols for Ecoregion 67f (TDEC. 2017. Quality System Standard Operating Procedures for Macroinvertebrate Stream Surveys, TDEC Division of Water Pollution Control, Nashville, Tennessee. Available ***here****.*

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

[c] TMI is the total index score. Higher index scores indicate higher quality conditions. A score of ≥ 32 is considered to pass biocriteria guidelines.

Acronyms:

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

5.5.6.3. Fish Communities

Monitoring of the fish communities in WOC and its major tributaries continued in 2020. Fish community surveys were conducted at 11 sites in the WOC watershed, including 5 sites in the main channel, 2 sites in First Creek, 2 sites in Fifth Creek, and 2 sites in Melton Branch. Streams located near or within the city of Oak Ridge (Mill Branch and Brushy Fork) were also sampled as reference sites for comparison.

In the WOC watershed, the fish community continued to be slightly degraded in 2020 compared with communities in reference streams. Sites closest to outfalls within the ORNL campus had lower species richness (number of species) (Figure 5.38), and fewer pollution-sensitive species than a slightly larger reference site and more closely resembled values found in a smaller reference reach. WOC sites also had more pollution-tolerant species and elevated densities (number of fish per square meter) of pollution-tolerant species compared with reference streams. Seasonal fluctuations in diversity and density are expected and may explain some of the variability seen at these sites. However, the combination of these factors indicates degraded water quality and/or habitat conditions. Overall, the fish communities in tributary sites adjacent to and downstream of ORNL outfalls continued to be negatively affected by ORNL effluent in 2020 relative to reference streams and upstream sites.

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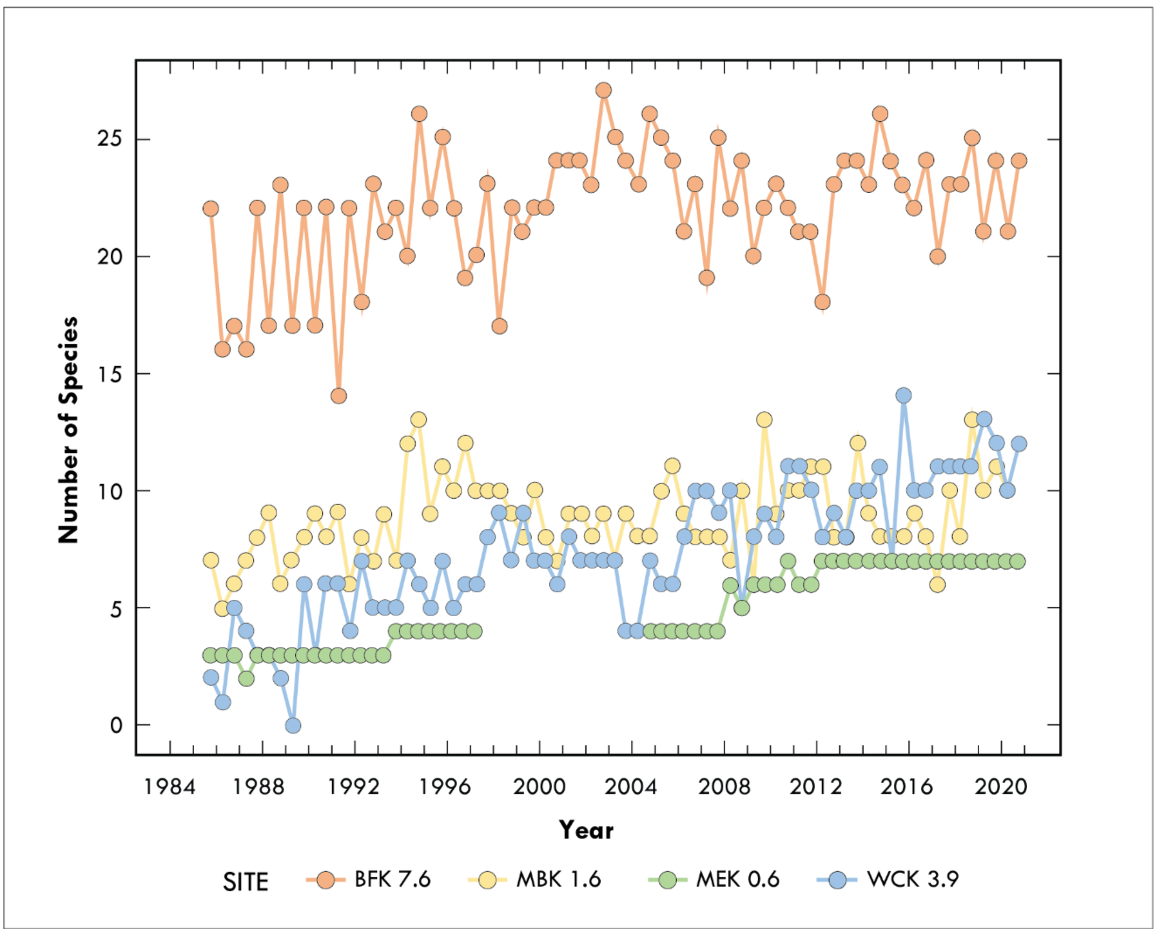


Acronyms:
BFK = Brushy Fork kilometer
MBK = Mill Branch kilometer
MEK = Melton Branch kilometer
WCK = White Oak Creek kilometer

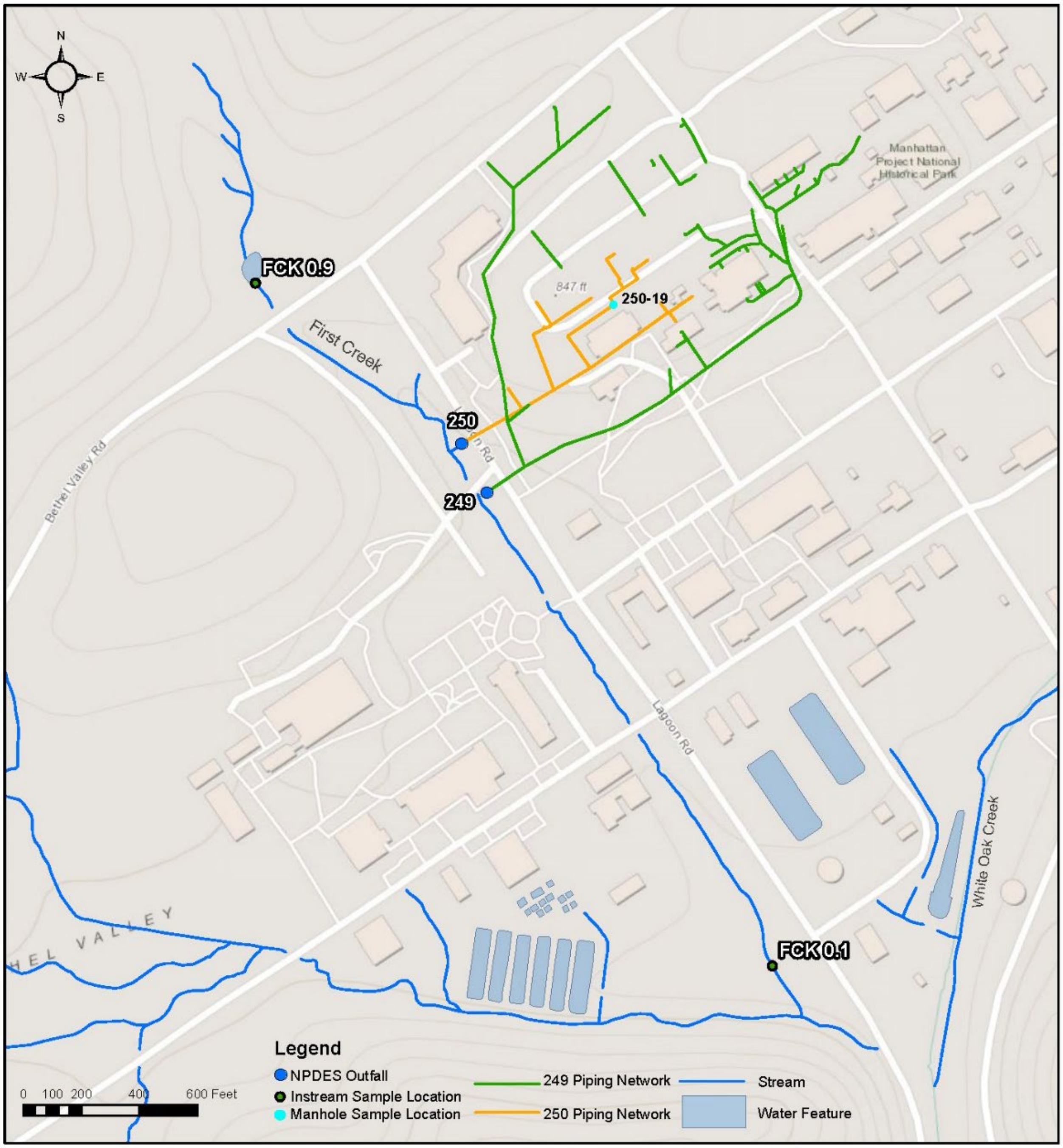
Figure 5.38. Fish species richness (number of species) in upper White Oak Creek and lower Melton Branch compared with two reference streams, Brushy Fork and Mill Branch, 1985–2020

A project to introduce fish species that were not found in the WOC watershed but that exist in similar systems on ORR and that may have historically existed in WOC was initiated in 2008 with the stocking of seven such native species. Continuing reproduction has been noted for six of the species, and several species have expanded their ranges downstream and upstream from initial introduction sites to establish new reproducing populations. In general, introduced species have had more difficulty establishing populations at upstream sites in both WOC and Melton Branch. This is likely due to numerous structures located within the watershed that act as barriers to upstream fish migration. As a result, introductions to supplement the small populations of those fish species were continued at sites within the watershed. One exception to this is the striped shiner (*Luxilus chrysocephalus*), which has expanded into upper Melton Branch, upper WOC, and lower First Creek, although established populations have not been observed in all of those locations. The introductions have enhanced species richness at almost all sample locations within the watershed and 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 initial objective of the source identification task in the WOC watershed was to identify the stream reaches, outfalls, or sediment areas that are contributing to elevated PCB levels in the watershed (Figure 5.39). Sample results for largemouth bass collected from White Oak Lake showed tissue PCB concentrations higher than those recommended by TDEC and EPA for frequent consumption, but the mobility of the fish precluded the possibility of source identification. PCBs are hydrophobic and tend not to be dissolved in water, resulting in undetected PCB concentrations in water samples, using conventional analytical methods, even if collected from a contaminated site. Therefore, semipermeable membrane devices are used to assess the chronic low-level sources of PCBs at critical sites on the reservation. Semipermeable membrane devices are thin plastic sleeves filled with oil in which PCBs are soluble. Because semipermeable membrane devices are deployed at a given site for 4 weeks and have a high affinity for PCBs, they allow for a time-integrated semiquantitative index of the relative PCB concentrations in the water column rather than a "snapshot" value that would be obtained from a grab sample.

Over the past 10 years, ORNL's PCB monitoring efforts have identified upper parts of First Creek as a source of PCBs. In September 2019, catch basin sediment in the drainage network leading to Outfall 250 was cleaned out and disposed of as solid waste. In 2020, semipermeable membrane devices were deployed in this piping network as well as in First Creek above and below Outfall 250 (Figure 5.39). Results from this assessment indicate that PCBs remained available in the area despite actions to remove PCB-contaminated materials from the upper part of Outfall 250 watershed, suggesting either that flows in 2020 remobilized PCBs or that another source is introducing PCBs to that section of piping. Future monitoring is needed to identify the sources of the PCBs found in to the Outfall 250 piping network.



Acronym:
FCK = First Creek kilometer

Figure 5.39. Locations of monitoring points for First Creek source investigation

5.5.8. Oil Pollution Prevention

CWA Section 311 regulates the discharge of oils or petroleum products to waters of the United States and requires the development and implementation of spill prevention, control, and countermeasures (SPCC) plans to minimize the potential for oil discharges. These requirements are provided in 40 CFR 112, "Oil Pollution Prevention." Each ORR facility implements a site-specific SPCC plan. The HVC (home of NTRC and the Manufacturing Demonstration Facility), which is located off ORR, also has an SPCC plan covering the oil inventory at that location. CFTF is also located off ORR; however, that facility was evaluated, and a determination was made that an SPCC plan was not required. The ORNL and HVC SPCC plans were not changed in 2020. There were no regulatory actions related to oil pollution prevention at ORNL or HVC in 2020. An oil-handler training program exists to comply with training requirements in 40 CFR 112.

5.5.9. Surface Water Surveillance Monitoring

The ORNL surface water monitoring program is conducted in conjunction with the ORR surface water monitoring activities discussed in Section 6.4 to enable assessing the impacts of ongoing DOE operations on the quality of local surface water. The sampling locations (Figure 5.40) 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 5.13. Monitoring at WCK 1.0 is conducted monthly for radiological parameters and quarterly for mercury under the ORNL WQPP (Section 5.5.3) and, 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 duplicated by the surface water monitoring program.

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

There were no radionuclides reported above 4 percent of DCS at the Fifth Creek location (FFK 0.1) in 2020. 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 DCS were reported for samples collected at the upstream WOC sampling location (WCK 6.8). The other radionuclide results from WCK 6.8 and the radionuclide results from samples collected at WOD (before WOC empties into the Clinch River) are discussed in Section 5.5.3.

No PCBs were detected at WCK 1.0 in 2020. One VOC, acetone, was detected in samples from WCK 1.0 during 2020, once in June and once in August. Both detections were at low, estimated values. Acetone has been detected in surface water samples from WCK 1.0 before, and acetone has occasionally been detected in at least one on-site groundwater well in past monitoring, including wells located in nearby Solid Waste Storage Area (SWSA) 6.

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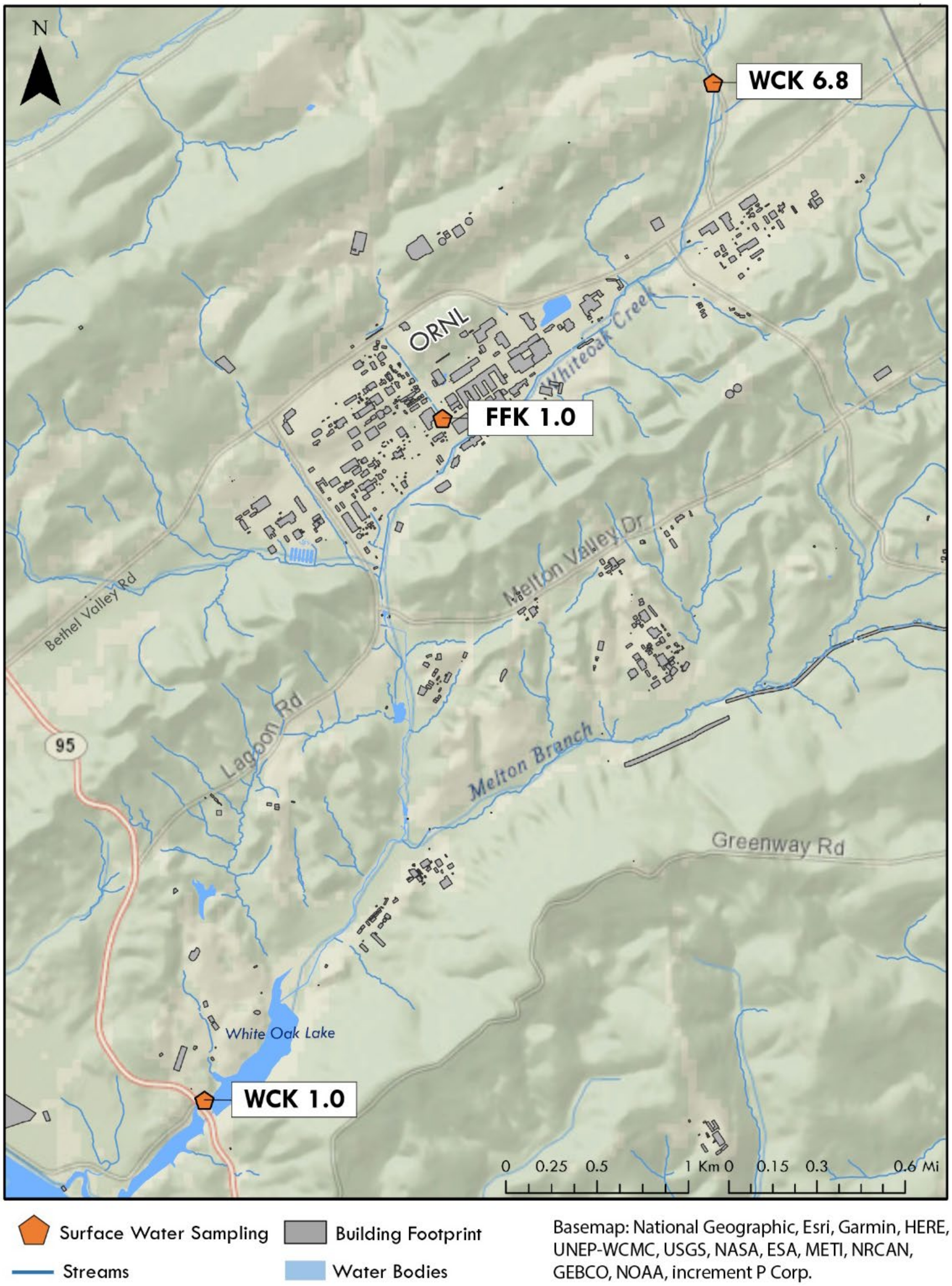

Acronyms: *FFK = Fifth Creek kilometer WCK = White Oak Creek kilometer*

Figure 5.40. ORNL surface water sampling locations, 2020

Table 5.13. ORNL surface water sampling locations, frequencies, and parameters, 2020

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, tritium, field measurements[c]

[a] Locations identify bodies of water and locations on them (e.g., WCK 1.0 is 1 km upstream from the confluence of White Oak Creek and the Clinch River).
[b] For this location, radiological parameters and mercury are monitored under another program (the WQPP) and therefore are not included in this plan.
[c] Field measurements consist of dissolved oxygen, pH, and temperature.
[d] Radiological monitoring is performed at this location in by the WQPP.

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

5.5.10. Carbon Fiber Technology Facility Wastewater Monitoring

Facility and process wastewater from activities at CFTF are discharged to the City of Oak Ridge sanitary sewer system under conditions established in City of Oak Ridge Industrial Wastewater Discharge Permit 1-12. Permit limits, parameters, and 2020 compliance status for this permit are summarized in Table 5.14.

Table 5.14. Industrial and commercial user wastewater discharge permit compliance at the ORNL Carbon Fiber Technology Facility, 2020

Effluent parameters	Permit limits		Permit compliance		
	Daily max. (mg/L)	Monthly ave. (mg/L)	Number of noncompliances	Number of samples	Percentage of compliance[a]
Outfall 01 (Underground Quench Water Tank)					
Cyanide	3.9	0.1	0	0	100
pH (standard units)	6–9		0	0	100
Outfall 02 (Electrolytic Bath Tank)					
pH (standard units)	6–9		0	4	100
Outfall 03 (Sizing Bath Tank)					
Copper	0.87	0.10	0	1	100
Zinc	1.24	0.60	0	1	100
Total phenol	4.20	-	0	1	100
pH (standard units)	6–9		0	1	100

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

5.6. ORNL Groundwater Monitoring Program

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

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

Monitoring was performed as part of an ongoing comprehensive CERCLA cleanup effort in Bethel and Melton Valleys, the two administrative watersheds at the ORNL site. Groundwater monitoring for baseline and trend evaluation in addition to measuring effectiveness of completed CERCLA RAs is conducted as part of the WRRP. The WRRP is managed by UCOR for the DOE OREM program. The results of CERCLA monitoring for ORR for FY 2020, including monitoring at ORNL, are evaluated and reported in the *Phased Groundwater Remedial Investigation Work Plan for the Bethel Valley Final Groundwater Record of Decision* (DOE 2021a) 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 activities on a groundwater treatability study at the Bethel Valley 7000 Area VOC plume. This plume contains trichloroethylene and its transformation products cis-1,2-dichloroethene and vinyl chloride, all at concentrations greater than EPA primary drinking water standards. The treatability study is a laboratory and field demonstration to determine whether microbes inherent to the existing subsurface microbial population can fully degrade the VOCs to nontoxic end products. Post-treatment monitoring of the 7000 Area plume continues.

During FY 2020 postremediation monitoring continued at SWSA 3 to evaluate the effectiveness of the 2011 hydrologic isolation of the area that included construction of a multilayer cap and an upgradient storm flow/shallow groundwater diversion drain. RAs and monitoring were specified in a CERCLA RA work plan that was developed by DOE and approved by EPA and TDEC before the project was started.

5.6.1.1. Bethel Valley

During FY 2011 construction was completed for RAs at SWSA 1 and SWSA 3, two former waste storage sites that were used for disposal of radioactively contaminated solid wastes between 1944 and 1950. Wastes disposed of at SWSA 1 originated from the earliest operations of ORNL; those at SWSA 3 originated from ORNL, Y-12, the K-25 Site (ETTP), and off-site sources. Although most of the wastes disposed of at SWSA 3 were solids, some were containerized liquid wastes. Some wastes were encapsulated in concrete after placement in burial trenches, but most of the waste was covered with soil. The Bethel Valley Record of Decision (ROD) (DOE 2002) selected hydrologic isolation using multilayer caps and groundwater diversion trenches as the RA for the waste burial grounds and construction of soil covers over the former contractor's landfill and contaminated soil areas near SWSA 3. The baseline monitoring conducted during FY 2010 included measurement of groundwater levels to obtain baseline data to allow evaluation of postremediation groundwater-level suppression.

Sampling and analysis of groundwater quality and contaminants were also conducted. Postremediation monitoring was specified for SWSA 3 in the *Phased Construction Completion Report for the Bethel Valley Burial Grounds at the Oak Ridge National Laboratory, Oak Ridge, Tennessee* (DOE 2012). Required monitoring includes quarterly groundwater-level monitoring in 42 wells with continuous water-level monitoring in 8 wells to confirm cap performance. Groundwater samples are collected semiannually at 13 wells for laboratory analyses to evaluate groundwater contaminant concentration trends.

FY 2020 monitoring results showed that the cap was effective, although target groundwater elevations have not yet been attained at three of eight wells. Drinking water standards are used as screening water quality concentrations to evaluate the site response to remediation. Strontium-90, a signature contaminant at SWSA 3, shows decreasing annual maximum concentrations with 6 of 10 monitored wells exhibiting ^{90}Sr concentrations less than the 8 pCi/L maximum contaminant level (MCL) derived concentration. Benzene, potentially from natural sources, shows decreasing annual maximum concentrations with FY 2020 maxima of 0.006 and 0.007 mg/L in two wells, which is just slightly greater than the 0.005 mg/L MCL. During FY 2020, as part of the DOE OREM program, three groundwater monitoring wells in Bethel Valley to the west of Tennessee Highway 95 were monitored to detect and track contamination from the SWSA 3 area. Data from those three wells supplement data being collected from a multiport well (4579) near SWSA 3 for exit pathway groundwater monitoring in western Bethel Valley. Groundwater monitoring near SWSA 3, along with the exit pathway, and groundwater and surface water monitoring at the northwest tributary of WOC and in the headwaters of Raccoon Creek allow integration of data concerning SWSA 3 contaminant releases. The data are presented in the *Phased Groundwater Remedial Investigation Work Plan for the Bethel Valley Final Groundwater Record of Decision* (DOE 2021a). To enhance exit pathway groundwater monitoring near the ORR property boundary at the Clinch River in western Bethel Valley 3 deep boreholes were drilled and characterized. During FY 2021 Westbay® multizone sampling systems will be installed to enable discrete zone sampling in the carbonate bedrock units.

Groundwater monitoring continued at the ORNL 7000 Area during FY 2020 to evaluate treatability of the VOC plume at that site. Site characterization testing of the endemic microbial community showed that microbes were present that are capable of fully degrading trichloroethylene and its degradation products if sufficient electron donor compounds are present in the subsurface environment. During FY 2011 a mixture of emulsified vegetable oil and a hydrogen-releasing compound was injected into four existing monitoring wells in the 7000 area. Ongoing monitoring of VOC concentrations show that the effects of the biostimulation test continue to be apparent, although at decreasing levels.

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

Between FY 2012 and FY 2015 the Bethel Valley ROD goal for ^{90}Sr concentrations at the 7500 Bridge Weir monitoring location was met. During FY 2020 that goal was exceeded because of contaminant releases from an ungauged Sr-90 see page into WOC. Continuing ^{90}Sr influxes to WOC from groundwater and storm drain discharges fed by releases from deteriorated infrastructure comprise the majority of ^{90}Sr measured at the 7500 Bridge Weir site.

5.6.1.2. Melton Valley

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

Groundwater-level monitoring shows that the hydrologic isolation component of the Melton Valley remedy is effectively minimizing the amount of percolation water contacting buried waste and is reducing contaminated leachate formation. The total amount of rainfall on ORR during FY 2020 was about 75 in., which is about 20 in. greater than the long-term annual average for ORR. In a few areas, groundwater levels within capped areas continue to respond to groundwater fluctuations imposed from areas outside the caps, but contact of groundwater with buried waste is minimal. Overall, the hydrologic isolation systems are performing as designed.

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

During the past 10 years of groundwater monitoring in the Melton Valley exit pathway, several site-related contaminants have been detected in groundwater near the Clinch River. Low concentrations of strontium, tritium, uranium, and VOCs have been detected intermittently in a number of the multizone sampling locations. Groundwater in the exit pathway wells has high alkalinity and sodium and exhibits elevated pH. During FY 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 *Phased Groundwater Remedial Investigation Work Plan for the Bethel Valley Final Groundwater Record of Decision* (DOE 2021a).

5.6.2. DOE Office of Science Groundwater Surveillance Monitoring

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

Exit pathway and active-sites groundwater surveillance monitoring points sampled during 2020 included seep/spring and surface-water monitoring locations in addition to groundwater surveillance monitoring wells. Seep/spring and surface-water monitoring points located in appropriate groundwater discharge areas were used in the absence of monitoring wells.

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

5.6.2.1. Exit Pathway Monitoring

During 2020, exit pathway groundwater surveillance monitoring was performed in accordance with the exit pathway sampling and analysis plan (Bonine 2012). Groundwater exit pathways at ORNL include areas from watersheds or sub-watersheds where groundwater discharges to the Clinch River–Melton Hill Reservoir to the west, south, and east of the ORNL main campus. The exit pathway monitoring points were chosen based on hydrologic features, screened interval depths (for wells), and locations relative to discharge areas proximate to DOE facilities operated by, or under the control of, UT-Battelle. The groundwater exit pathways at ORNL include four discharge zones identified by a data quality objectives process. One of the original exit pathway zones was split into two zones for geographic expediency. The Southern Discharge Area Exit Pathway was carved from the East End Discharge Area Exit Pathway. The five zones are listed below. Figure 5.41 shows the locations of the exit pathway monitoring points sampled in 2020:

- 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 10-year staggered groundwater monitoring schedule and analytical suite selection. This approach was initiated in 2012. A summary of the groundwater monitoring that was conducted in 2020 is outlined in Table 5.15.

Unfiltered samples were collected. The organic suite was composed of VOCs and semivolatile organic compounds; the metallic suite included heavy and non-heavy metals; and the radionuclide suite was composed of gross alpha/gross beta activity, gamma emitters, $^{89/90}$Sr, and tritium. In 2020, wet season samples were collected in March and April and dry season samples were collected in September and October.

Exit Pathway Monitoring Results

Table 5.16 provides a summary of radiological parameters detected in samples collected from exit pathway monitoring points during 2020. Metals are ubiquitous in groundwater exit pathways and so are not summarized in the table.

Exit Pathway Groundwater Surveillance Summary

Concentrations of metals and man-made radionuclides observed in groundwater exit pathway discharge areas in 2020 at ORNL were generally consistent with observations reported in past annual site environmental reports for ORR. Based on the results of the 2020 monitoring effort, there is no indication that current SC operations are significantly introducing contaminants to the groundwater at ORNL.

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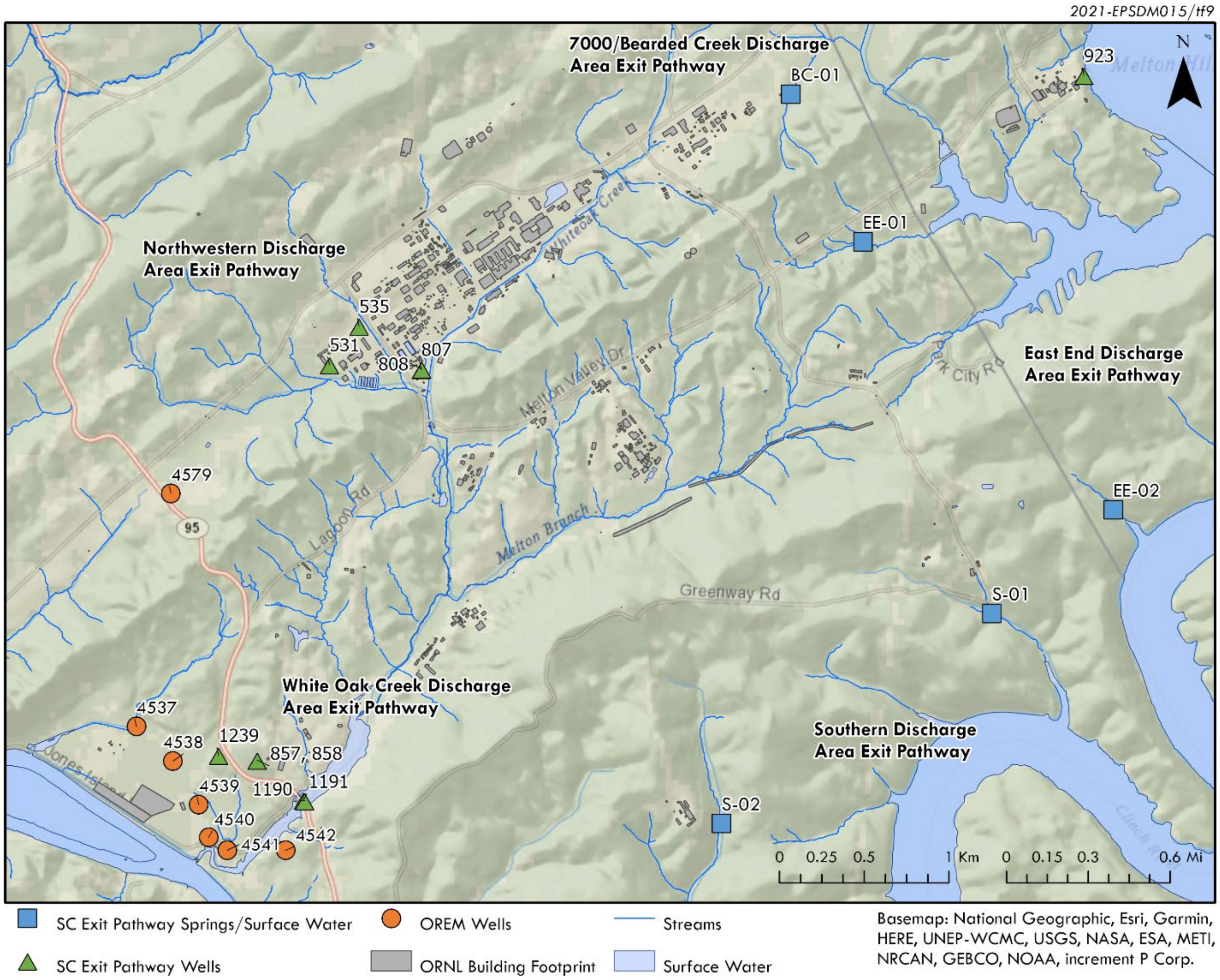

Acronyms:
OREM = DOE Office of Environmental Management
SC = DOE Office of Science

Figure 5.41. UT-Battelle exit pathway groundwater monitoring locations at ORNL, 2020

Table 5.15. Exit pathway groundwater monitoring conducted in 2020

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

[a] Locations BC-01, EE-02, and S-01 (stream locations) were not sampled in the 2020 dry season due to lack of water flow at those locations.

Table 5.16. Radiological parameters detected in 2020 exit pathway groundwater monitoring

Monitoring location	Parameter	Concentration (pCi/L)		
		Wet season[a]	Dry season[a]	Reference value[b]
		7000 Bearden Creek Discharge Area		
Spring BC-01	^{214}Bi	14.2	NF	10,400
Spring BC-01	^{214}Pb	15.8	NF	8,000
		East End Discharge Area		
Well 923	Beta activity	U0.966	2.71	50
Well 923	^{214}Bi	8.4	ND	10,400
Well 923	^{212}Pb	11.1	ND	152
Stream EE-01	^{214}Bi	20.7	ND	10,400
Stream EE-01	^{40}K	U3.41	28.6	192
Stream EE-01	^{214}Pb	12.8	ND	8,000
Stream EE-02	Beta activity	4.09	NF	50
Stream EE-02	^{214}Bi	200	NF	10,400
Stream EE-02	^{214}Pb	232	NF	8,000
		Northwestern Discharge Area		
Well 531	Beta activity	2.29	3.97	50
Well 535	Alpha activity	3.15	U0.231	15
Well 535	Beta activity	2.25	U0.782	50
Well 535	^{212}Bi	ND	38.3	4,400
Well 535	^{214}Bi	65.8	39.1	10,400
Well 535	^{212}Pb	ND	5.03	152
Well 535	^{214}Pb	68.6	55.2	8,000
Well 807	Alpha activity	2.3	U0.329	15
Well 807	Beta activity	7.64	5.77	50
Well 807	^{214}Bi	18.1	47.7	10,400
Well 807	^{214}Pb	23	57	8,000
Well 807	$^{89/90}Sr$	2.34	U0.599	44
Well 808	Beta activity	3.7	6.71	50
		Southern Discharge Area		
Stream S-01	Beta activity	3.4	NF	50
Stream S-01	^{214}Bi	74.4	NF	10,400
Stream S-01	^{214}Pb	77.2	NF	8,000
Stream S-02	^{214}Bi	11.1	34.5	10,400
Stream S-02	^{214}Pb	14.4	40.6	8,000
		White Oak Creek Discharge Area		
Well 857	Beta activity	U1.67	3.12	50
Well 857	^{214}Bi	125	73.6	10,400
Well 857	^{214}Pb	134	78.5	8,000
Well 858	^{214}Bi	ND	5.47	10,400

Table 5.16. Radiological concentrations detected in 2020 exit pathway groundwater monitoring (continued)

Monitoring location	Parameter	Concentration (pCi/L)		
		Wet season[a]	Dry season[a]	Reference value[b]
Well 858	^{214}Pb	ND	9.93	8,000
Well 1190	Beta activity	2.07	5.01	50
Well 1190	^{214}Bi	70.1	42.5	10,400
Well 1190	^{212}Pb	5.09	ND	152
Well 1190	^{214}Pb	67.6	50	8,000
Well 1190	^{208}Tl	ND	4.25	NA
Well 1190	Tritium	13,000	20,500	20,000
Well 1191	Alpha activity	4.6	U1.33	15
Well 1191	Beta activity	220	198	50
Well 1191	^{214}Bi	44.4	28	10,400
Well 1191	^{212}Pb	4.66	ND	152
Well 1191	^{214}Pb	44	ND	8,000
Well 1191	$^{89/90}Sr$	123	120	44
Well 1191	Tritium	7,670	6,140	20,000
Well 1239	Alpha activity	2.96	U0.463	15
Well 1239	Beta activity	1.73	1.78	50

[a] *NF = there was no flow at the spring or stream sampling location during sampling attempts*
ND = the analyte was not detected in the gamma scan that was performed
U = the analyte was measured but not detected above the practical quantitation limit/contractor-required detection limit

[b] *NA = no applicable reference criteria for this parameter. Current federal and state standards were 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.*

Ten radiological contaminants were detected in exit pathway groundwater samples collected in 2020. Gross beta, $^{89/90}Sr$, and tritium were the only radiological parameters exceeding 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.

A new maximum concentration was measured for one parameter at one monitoring location in the east end discharge area—surface water location EE-02—in the wet-season sampling event. The concentration of ^{214}Pb activity was measured at 232 pCi/L (compared to a previous maximum of 231 pCi/L). Lead-214 is short-lived radioisotope in the decay chain of ^{226}Ra (NIST 2020). Radium is a naturally occurring radioactive metal and the ^{226}Ra isotope is part of the uranium decay series (EPA 2019). Although this newest concentration is the highest measured to date at the EE-02 location, the concentration is similar to the previous maximum for the location when taking the analytical counting uncertainty into account. ^{214}Pb is often detected at this location, and sometimes detected at higher concentrations at other locations in the southern discharge area (locations S-01 and S-02).

First detections of ^{212}Bi and ^{212}Pb occurred at well number 535 in 2020. Both are short-lived radioisotopes in the decay chain of naturally occurring ^{232}Th (EPA 2021). Both isotopes are occasionally encountered at similar concentrations in groundwater from the ORNL area.

Twenty-four metallic parameters were detected in exit pathway groundwater samples collected in 2020. Only two metals, iron and manganese, were detected at concentrations exceeding reference values. Iron and manganese are commonly found in groundwater at ORNL.

One organic compound was detected at a concentration at or above the analytical report level in exit pathway groundwater monitoring in 2020. Acetone was detected in the wet-season sample from well 1191 at a concentration of 6.81 μg/L (the associated report level was 5 μg/L). Acetone is a common laboratory contaminant.

5.6.2.2. Active Sites Monitoring—High Flux Isotope Reactor

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

5.6.2.3. Active Sites Monitoring—Spallation Neutron Source

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

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

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

A total of seven springs, seeps, and surface water sampling points were routinely monitored as analogues to, and in lieu of, groundwater monitoring wells. Locations were chosen based on hydrogeological factors and proximity to the beam line. Figure 5.42 shows the locations of the specific monitoring points sampled during 2019.

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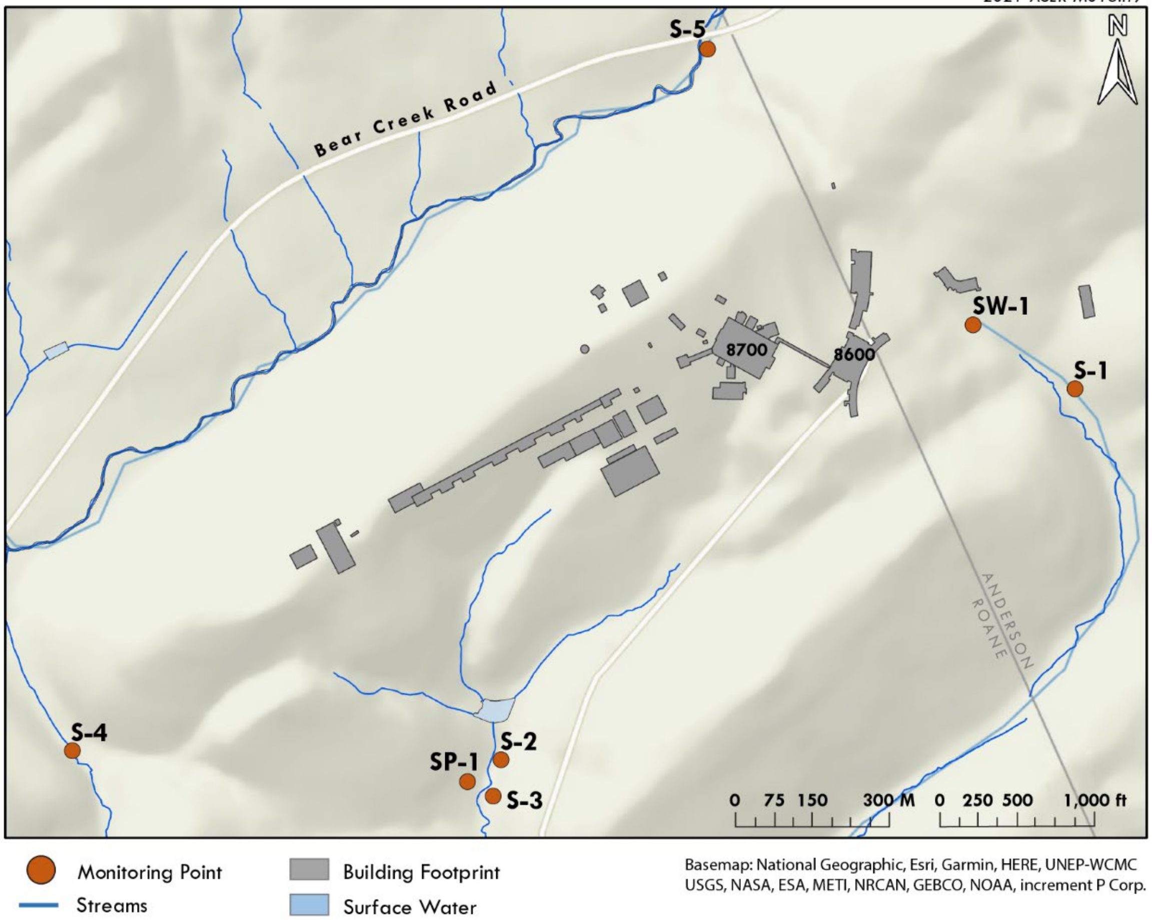

Acronyms: *S = springs SP = seeps SW = surface water sampling areas*

Figure 5.42. Groundwater monitoring locations at the Spallation Neutron Source, 2020

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

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

Quarterly sampling at each monitoring point continued in 2020, allowing the opportunity for monitoring in wet and dry seasons. All sampling performed in 2020 was performed in conjunction with rainfall events, with samples being collected during rising or falling (recession) limb flow conditions. In Figure 5.43, the curves represent spring or seep flow (base flow, through flow, overland flow, peak flow); the bars represent rainfall amounts. Table 5.17 shows the sampling and parameter analysis schedule followed in 2020.

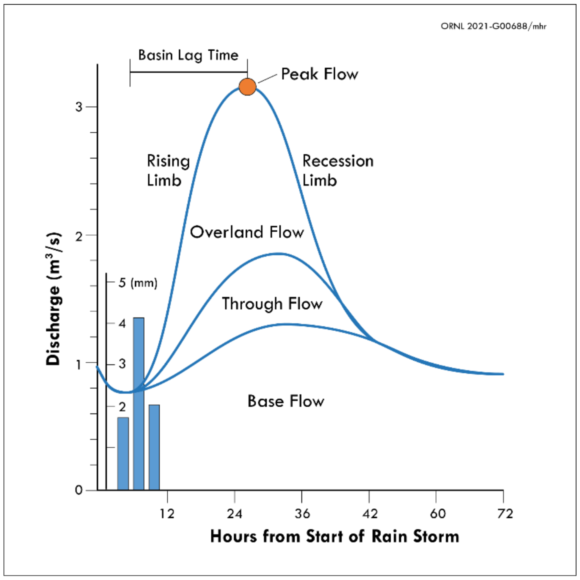

Figure 5.43. Simple hydrograph of spring discharge vs. time after initiation of rainfall

Spallation Neutron Source site results. Sampling at the SNS site occurred during each quarter in 2020. Low concentrations of several radionuclides were detected numerous times during 2020. The ^{214}Bi and ^{214}Pb are daughter radionuclides in the uranium decay series and are considered to be of natural origin in the SNS water samples because no man-made uranium sources are present at the site. The low values of alpha and beta activity detected at the S-5 monitoring location are attributed to CERCLA contaminants in Bear Creek Valley associated with legacy waste management practices at the Y-12 facility. Table 5.18 provides a summary of the locations for radionuclide detections observed during 2020.

Sampling results were compared with reference values. Reference values used for comparison are current federal or state standards or 4 percent of the DCS. No detected radionuclide exceeded its reference value at SNS monitoring locations in 2020.

Table 5.17. 2020 Spallation Neutron Source monitoring program schedule

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

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

Table 5.18. Radiological concentrations detected in samples collected at the Spallation Neutron Source during 2020[a]

Parameter	Concentrations (pCi/L)				Reference value[b]
	January	April	August	October	
			SW-1 [c]		
^{214}Bi		38.3			10,400
^{214}Pb		46.6			8,000
Tritium	627	3,240	1,870	381	20,000
			S-1 [c]		
^{214}Bi		21.4			10,400
Tritium	512	2,380	1,120	300	20,000
			S-2 [d]		
^{214}Bi			36.6		10,400
^{214}Pb			61.3		8,000
Tritium	515	399	1,340	795	20,000
			S-3 [d]		
^{214}Bi			52.1		10,400
^{214}Pb			71.1		8,000
Tritium	378	644	350	253	20,000
			S-4 [e]		
Beta				6.45	50
Tritium	290	596	477	180	20,000
			S-5 [e]		
Alpha				12.3	15
Beta				16.3	50
^{214}Bi				24.4	10,400
^{40}K				74.9	195
^{214}Pb				25.7	8,000
Tritium	274	535	478	255	20,000
			SP-1 [e]		
Alpha				6.02	15
Tritium	323	303	344	364	20,000

[a] *In addition to tritium analyses, analysis of an extended suite of parameters was completed at each location during one 2020 sampling event. The extended suite includes gross alpha, gross beta, gamma scan, and ^{14}C. Only 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 April.*

[d] *Analysis of extended suite completed in August.*

[e] *Analysis of extended suite completed in October.*

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

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

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

Historically, training of firefighters at ORNL included training in the use of AFFFs, and it is believed that the foams that were used in past training activities contained PFAS compounds. It is suspected that discharges of these foams to the environment during the training activities are the most significant potential source of PFAS releases to the environment at ORNL. Most of the training was conducted at four locations: adjacent to the ORNL Fire Station (Building 2500), at the Fire Training and Test Facility (Building 2648), on the southeast corner of First Street and Bethel Valley Road (near where Building 2040 was later constructed), and at a location on the north side of Old Bethel Valley Road in the Bearden Creek watershed. In 2019, a sampling and analysis plan (SAP) was developed to assess these areas for the presence of PFAS compounds in groundwater and in surface water bodies draining these areas. The plan also includes monitoring of surface water locations draining other parts of the ORNL campus, including former waste storage areas, to determine if PFAS compounds from sources other than the use of AFFFs are present and are reaching surface water bodies. Surface water monitoring will include the use of passive sampling devices, which are deployed in stream environments for long periods of time (typically 4-week deployment periods) and which can accumulate PFAS compounds and allow the detection of trace concentrations that might not be detectable with traditional water sampling techniques. The sampling and analysis plan will be implemented in 2021.

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

5.7. Quality Assurance Program

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

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

5.7.1. Work/Project Planning and Control

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

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

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

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. The UT-Battelle Office of Technical Training is responsible for managing and integrating training activities, and it provides infrastructure of supporting systems and processes, including site-level procedures and guidance for training program implementation.

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

5.7.3. Equipment and Instrumentation

The UT-Battelle QMS includes subject area directives that require all UT-Battelle staff to use equipment of known accuracy based on appropriate calibration requirements and traceable standards to ensure measurement quality and traceability. The UT-Battelle Facilities and Operations Instrumentation and Control Services team tracks all equipment used in EPSD environmental monitoring programs through a maintenance recall program to ensure that equipment is functioning properly and within defined tolerance ranges.

5.7.3.1. Calibration

The determination of calibration schedules and frequencies is based on a graded approach at the activity planning level. EPSD environmental monitoring programs follow rigorous calibration schedules to eliminate gross drift and the need for data adjustments. Instrument tolerances, functions, ranges, and calibration frequencies are established based on manufacturer specifications, program requirements, actual operating environment and conditions, and budget considerations.

In addition, a continuous monitor used for CAA compliance monitoring at ORNL Boiler 6 is subject to rigorous QA protocols as specified by EPA methods. A relative accuracy test audit is performed annually to certify the Predictive Emissions Monitoring System for nitroxen oxides and oxygen. The purpose of a relative accuracy test audit is to provide a rigorous QA assessment in accordance with *Performance Specification 16* (40 CFR Parts 60 and 63.). The accuracy of Predictive Emissions Monitoring System is also evaluated by performing relative accuracy audits in accordance with *Performance Specification 16*. The results of the QA tests are provided to TDEC quarterly, semiannually, or annually as applicable.

5.7.3.2. Standardization

EPSD sampling procedures are maintained in Integrated Document 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 follow when standardization steps do not produce required values. Standard operating procedures for sampling also include instructions for designating nonconforming instruments as “out-of-service” and initiating requests for maintenance.

5.7.3.3. Visual Inspection, Housekeeping, and Grounds Maintenance

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

5.7.4. Assessment

Independent audits, surveillance, and internal management assessments are performed to verify that requirements have been accurately specified and that activities that have been performed conform to expectations and requirements. External assessments are scheduled based on requests from auditing agencies. Table 5.1 presents a list of environmental audits and assessments performed at ORNL in 2020 and information on 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.

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

5.7.5. Analytical Quality Assurance

Laboratories that perform analyses of 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. As applicable, 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). Any issues identified through accreditation/ certification programs or 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.

Analysis of environmental samples collected in support of EPSD environmental monitoring programs in 2020 were performed by either one of the three contracted commercial laboratories discussed below 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. The laboratories are required to participate in third-party accreditation, certification, and approval programs, which evaluate laboratories according to stringent and widely accepted criteria for quality, accuracy, reliability, and efficiency.

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 ISO 17025 (general requirements for the competence of testing and calibration laboratories), Department of Defense Environmental Laboratory Accreditation Program (DOD-ELAP), DOECAP, and NELAP. No external audits were performed at GEL in 2020 due to social-distancing precautions implemented in response to COVID-19 concerns. Ten internal audits focusing on analytical and support service activities were conducted to verify compliance with the requirements of the GEL QA/QC program and with client-specified terms. No issues were identified that would negatively impact analytical data reported to clients. In 2020, GEL reported results from 5,476 performance test analyses (including DMRQA, MAPEP, DOECAP, and NELAP). Of these, 5,372 (98.1 percent) fell within acceptance ranges. Those that did not meet acceptance criteria were found to have no impact on data reported to clients.

ALS, a radiochemistry and environmental laboratory in Fort Collins, Colorado, is accredited, certified, or approved by 18 third-party programs including ISO 17025 (ISO 2017), NELAP. DOD-ELAP, DOECAP, and several state accrediting and licensing programs. In 2020, ALS was audited by the states of Arizona and California, and by a third party for DOECAP and DOD-ELAP certification. Several internal audits on adherence to methods and recordkeeping were also performed. There were no audit findings related to analyses or recordkeeping in support of EPSD environmental monitoring programs. ALS participated in 12 performance studies during 2020, and all applicable test results were in acceptable ranges.

Eurofins, a contracted environmental laboratory in Redmond, Washington, is accredited, licensed, or approved by 20 third-party programs, including ISO 17025, DOD-ELAP, DOECAP, NELAP, and several state licensing or accrediting programs. In November 2020, Eurofins was audited by the American National Standards Institute's National Accreditation Auditing Board and was recertified by DOECAP and DOD-ELAP. In addition, multiple internal system and method audits were conducted during the year. No audit findings required data corrections or repeated analyses of samples. In 2020, Eurofins participated in MAPEP and DMRQA, and all applicable test results were within acceptable ranges.

RMAL does not hold any outside accreditations. However, the laboratory operates in compliance with ISO-17025 (ISO 2017), *DOD/DOE Consolidated Quality Systems Manual* (DOD/DOE 2018), and requirements from DOE 414.1D (DOE 2011d) and 10 CFR 830 Subpart A, *Quality Assurance Requirements*. The UT-Battelle Chemical Sciences Division's quality assurance plan also meets applicable requirements of the American Society of Mechanical Engineers' Nuclear Quality Assurance Program. No external audits of RMAL activities were conducted in 2020, but 12 internal assessments that were focused on adherence to approved analytical methods, waste management, and recordkeeping were performed. No issues that would require reanalysis or data corrections related to environmental sampling results were identified. In 2020, RMAL participated in MAPEP and DMRQA, and all test results for analyses that RMAL performs in support in EPSD environmental monitoring programs were within acceptable ranges. Several analytes that were analyzed by RMAL for MAPEP testing were inadvertently not reported. Based on MAPEP acceptable ranges for that study, the unreported results were all within limits.

The Environmental Toxicology Laboratory does not hold any outside accreditations, but it operates in compliance with all EPA, TDEC, and NPDES required methods and the UT-Battelle Environmental Sciences Division's Quality Assurance Management Program. No external audits of the Environmental Toxicology Laboratory were conducted in 2020, but six internal assessments focused on adherence to approved analytical methods and data analysis were performed. No issues that would require reanalysis or data corrections related to standard toxicity testing results were identified. In addition, updates of all of the standard operating procedures, reference toxicity control charts, and training requirements in were completed in 2020. All standard operating procedures and lab methods comply with EPA's acute and chronic testing requirements for freshwater species (EPA 2002a and EPA 2002b, respectively). In 2020, the Environmental Toxicology Laboratory participated in the DRMQA program for whole effluent toxicity testing of *Pimephales promelas* (fathead minnow, a freshwater fish) and *Ceriodaphnia dubia* (water flea, a freshwater invertebrate). All results were in acceptable ranges for fathead minnows but a second test was required for *Ceriodaphnia dubia*. The results of the second test, conducted in December 2020, were acceptable.

5.7.6. Data Management and Reporting

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

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

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

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

5.7.7. Records Management

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

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

5.8. Environmental Management and Waste Management Activities at 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 remaining from 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 the EPA and TDEC. The *2020 Cleanup Progress Annual Report to the Oak Ridge Regional Community* (UCOR 2020) provides detailed information on DOE OREM's 2020 cleanup activities.

5.8.1. Wastewater Treatment

At ORNL, DOE OREM operates PWTC and the Liquid Low-Level Waste Treatment Facility. In 2020, 347.5 million L of wastewater were treated and released at PWTC. In addition, the liquid LLW system at ORNL received 141,676 L of waste. The waste treatment activities of these facilities support both DOE OREM and DOE SC mission activities, ensuring that wastewaters from activities associated with projects of both offices are managed in a safe and compliant manner.

5.8.2. Newly Generated Waste Management

ORNL is the largest, most diverse DOE SC laboratory in the DOE complex. Although much effort is expended to prevent pollution and to eliminate waste generation, some waste streams are generated as a by-product of performing research and operational activities and must be managed to ensure that the environment is protected from associated hazards. As the prime contractor for the management of ORNL, UT-Battelle is responsible for management of most of the wastes generated from R&D activities and wastes generated from operation of the R&D facilities. Waste streams that can be treated by on-site liquid and/or gaseous waste treatment facilities operated by OREM are treated via these systems. Other R&D waste streams are generally packaged by UT-Battelle in appropriate shipping containers for off-site transport to commercial waste-processing facilities. In 2020, ORNL performed 91 waste and recycle shipments to off-site hazardous/radiological/mixed waste treatment and/or disposal vendors with no shipment rejections.

5.8.3. Transuranic Waste Processing Center

TRU waste-processing activities carried out for DOE in 2020 by NWSol addressed contact-handled solids/debris and remotely handled solids/debris, which involved processing, treating, and repackaging of waste. In 2020, LLW/mixed LLW was transported to the Nevada National Security Site or to another approved offsite facility for disposal. TRU waste disposal at the Waste Isolation Pilot Plant resumed in 2017. In 2020, NWSol shipped 7.4 m^3 of contact-handled TRU waste from TWPC in 1 shipment (35 containers).

During 2020, 6.5 m^3 of contact-handled waste and 0.2 m^3 of remotely handled waste were processed, and 35.7 m^3 of mixed LLW (TRU waste that was recharacterized as LLW) was shipped off the site.

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