In 2021, DOE conducted a series of controlled burns of grassland areas on the ORR as part of an overall effort to reduce the risk of wildland fires. These controlled burns were conducted in collaboration with the Tennessee Division of Forestry, Tennessee Wildlife Resource Agency, and the City of Oak Ridge Fire Department.
Photograph by Carlos Jones.

6

Oak Ridge Reservation Environmental Monitoring Program

ORR environmental surveillance is conducted to comply with DOE requirements to protect the public and the environment against undue risks associated with activities carried out by DOE. These requirements are established in DOE Order 458.1, *Radiation Protection of the Public and the Environment* (DOE 2020), and related guidance is provided in *Environmental Radiological Effluent Monitoring and Environmental Surveillance* (DOE 2015). The objective of the ORR environmental surveillance program is to characterize environmental conditions in areas outside the ORR facility boundaries, both on and off ORR.

In 2021, sampling and monitoring activities associated with some ORR environmental surveillance programs were cancelled because of social-distancing precautions taken in response to the COVID-19 pandemic. Deer and turkey hunts, typically conducted on ORR each year, were cancelled in both 2020 and 2021 but are expected to resume in 2022. ORR surveillance programs are not required by federal or state regulations, and there are no compliance issues related to the COVID-19 precautions taken in 2021.

6.1. Meteorological Monitoring

Eight meteorological towers provide data on meteorological conditions and on the transport and diffusion qualities of the atmosphere on ORR. Data collected at the towers are used in routine dispersion modeling to predict impacts from facility operations and as input to emergency response atmospheric models, which are used for simulated and actual accidental releases from a facility. Data from the towers are also used to support various research and engineering projects. Additionally, ORNL and Y-12 operate three wind profilers on ORR to better characterize upper-level winds (winds above 60 m above ground level).

6.1.1. Data Collection and Analysis

The eight meteorological towers on ORR are described in Table 6.1 and are depicted in Figure 6.1. In this document, the individual ORR-managed towers are designated by "MT" followed by a numeral. Other commonly used names for these sites are also provided in Table 6.1. Meteorological data are collected at different levels above the ground (2, 10, 15, 30, 33, 35, and 60 m) to assess the vertical structure of the atmosphere, particularly with respect to wind shear and stability. Stable boundary layers and significant wind shear zones (associated with the local ridge-and-valley terrain and the Great Valley of eastern Tennessee; see Appendix B) can significantly affect the movement of a plume after a facility release (Bowen et al. 2000). Data are collected at the 10 or 15 m level at most towers, but the wind measurement height is 25 m for MT11 and 20 m for MT13. Data are collected at some towers at 30, 33, 35, and 60 m levels. Temperature, relative humidity, and precipitation are measured at most sites at 2 m, but wind speed and wind direction typically are not. Atmospheric stability (a measure of the vertical mixing properties of the atmosphere) is measured at most towers; however, measurements involving vertical temperature profiles (i.e., measurements made by the solar radiation delta-T method) limit accurate determination of nighttime stability to the 60 m towers. Stability is also calculated for most sites using the sigma phi method, which relies heavily on the measurement of the standard deviation of vertical wind speed using three-dimensional sonic wind monitors. Barometric pressure is measured at one or more of the towers at each ORR plant (MT2, MT4, MT6, MT9, MT12, and MT13). Precipitation is measured at MT6 and MT9 at the Y-12 Complex; at MT13 at ETTP; and at MT2, MT3, MT4, and MT12 at ORNL. Solar radiation is measured at MT6 and MT9 at the Y-12 Complex and at MT2 and MT12 at ORNL. Instrument calibrations are managed by UT-Battelle and are performed every 6 months by an independent auditor (Holian Environmental). Additionally, Holian Environmental audits the Y-12–owned sites every 3 months (MT6, MT9, MT11).

Sonic detection and ranging (SODAR) devices have been installed at the east end of the Y-12 Complex (Pine Ridge) and adjacent to MT2 at ORNL. The SODAR devices use acoustic waves to estimate wind direction, wind speed, and turbulence at altitudes higher than the reach of meteorological towers (40 m up to 800 m above ground level). Although SODAR measurements are somewhat less accurate than measurements made on the meteorological towers, the SODAR devices provide useful information regarding stability, upper air winds, and mixing depth. Mixing depth represents the thickness of the air layer adjacent to the ground over which an emitted or entrained inert nonbuoyant tracer could potentially be mixed by turbulence within 1 h or less.

A light detection and ranging (LIDAR) device, which provides information similar to data provided by the SODAR devices, was installed near the ETTP at ORR Air Monitoring Station 35 by ORNL to provide wind data for the western part of ORR (August 2021). This device replaces wind measurements previously made at the now-defunct MT7 and MT10 meteorological towers.

Meteorological data are collected in real time from the meteorological towers for 1 min, 15 min, and hourly average intervals for emergency response purposes and for dispersion modeling at the ORNL and Y-12 Complex Emergency Operations Centers.

Annual dose estimates are calculated from the archived hourly data. Data quality is checked continuously against predetermined data constraints, and out-of-range parameters are marked as invalid and are excluded from compliance modeling. Appropriate substitution data are identified when possible. Quality assurance records of missing and erroneous data are routinely kept for the eight ORR towers.

Table 6.1. ORR meteorological towers

Tower	Alternate tower names	Location (latitude, longitude)	Altitude above MSL (m)	Measurement heights (m)
		ETTP		
MT13	J, YEOC	35.93043N, -84.39346W	237	20
		ORNL		
MT2	D,[a] 1047	35.92559N, -84.32379W	261	2, 15, 35, 60
MT3	B, 6555	35.93273N, -84.30254W	256	15, 30
MT4	A, 7571	35.92185N, -84.30470W	266	15, 30
MT12	F	35.95285N, -84.30314W	354	10
		Y-12 Complex		
MT6	W, West	35.98058N, -84.27358W	326	2, 10, 30, 60
MT9	Y, PSS Tower	35.98745N, -84.25363W	290	2, 15, 33
MT11	S, South Tower	35.98190N, -84.25504W	352	25

[a] *Tower "C" before May 2014.*

Acronyms:

ETTP = East Tennessee Technology Park
MSL = mean sea level
ORNL = Oak Ridge National Laboratory
PSS = plant shift superintendent
Y-12 Complex = Y-12 National Security Complex
YEOC = Y-12 Complex Emergency Operations Center

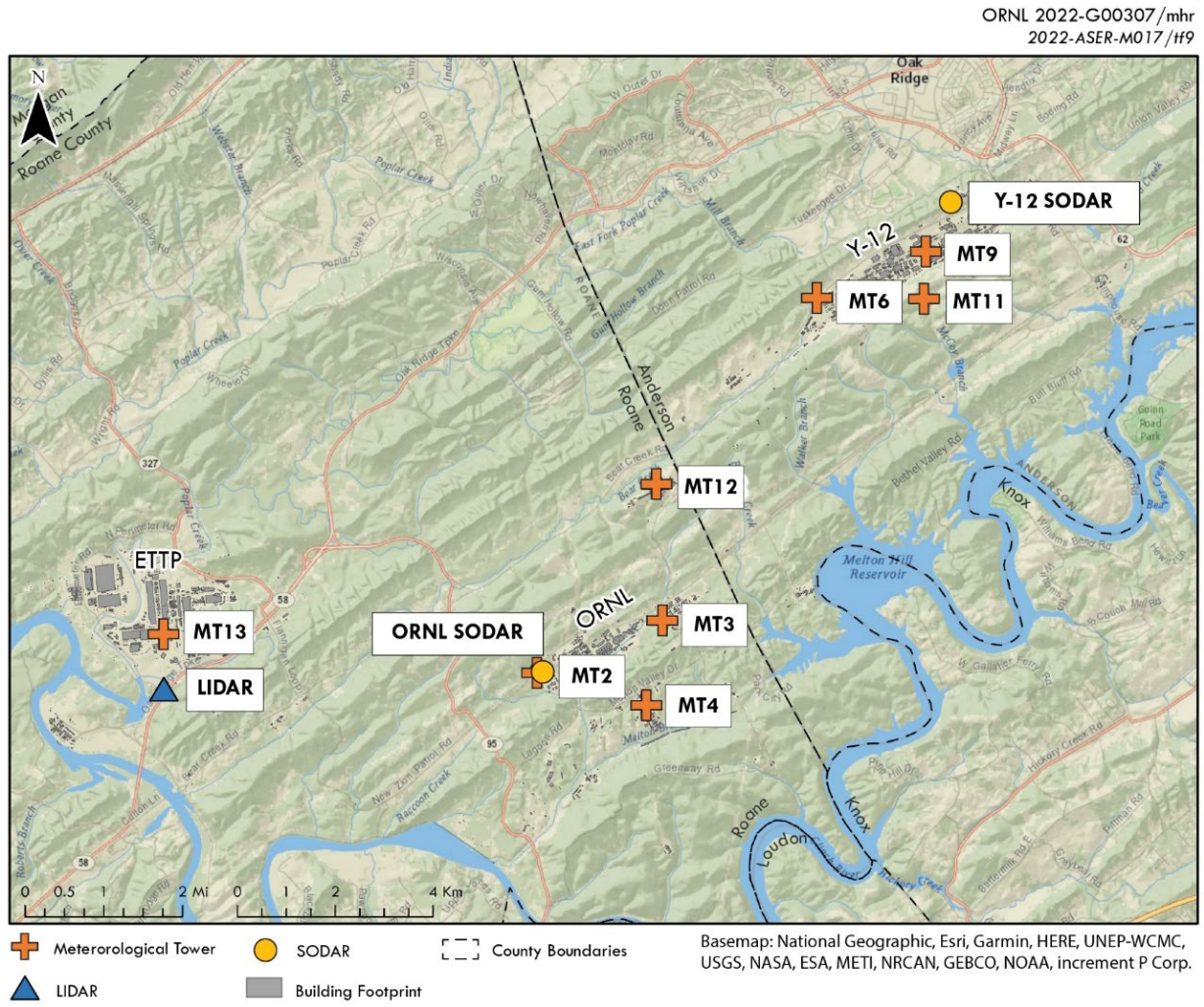


Figure 6.1. The ORR meteorological monitoring network, including light and sonic detection and ranging (LIDAR and SODAR) devices

6.1.2. Results

Prevailing winds are generally up-valley from the southwest and west-southwest or down-valley from the northeast and east-northeast, a pattern that typically results from channeling effects produced by the parallel ridges flanking the ORR sites. Winds in the valleys tend to follow the ridge axes, limiting crossridge flow within local valley bottoms. These conditions dominate over most of ORR, but flow variation is greater at ETTP, which is located within a less constrained open valley bottom.

On ORR, low wind speeds dominate near the valley surfaces, largely because of the decelerating influence of nearby ridges and mountains. Wind acceleration is sometimes observed at ridgetop level, particularly when flow is not parallel to the ridges (see Appendix B).

The atmosphere over ORR is often dominated by stable conditions at night and for a few hours after sunrise. These conditions, when coupled with low wind speeds and channeling effects in the valleys, result in poor dilution of emissions from the facilities. However, high roughness values (caused by terrain and obstructions such as trees and buildings) may significantly mitigate these factors through an increase in turbulence (atmospheric mixing). These features are captured in dispersion model data input and are reflected in modeling studies conducted for each facility.

Precipitation data from MT2 are used in stream-flow modeling and in certain research efforts. The data indicate the variability of regional precipitation: the high winter rainfall resulting from frontal systems and the uneven, but occasionally intense, summer rainfall associated with frequent air mass thunderstorms. The total precipitation at ORNL during 2021 (1,499.3 mm or 59.01 in.) was about 10 percent above the long-term 1991–2020 average of 1,417.8 mm (55.80 in.). The average annual wind data recovery rates (a measure of acceptable data) across locations used for modeling during 2021 were greater than 98.3 percent for wind sensors at ORNL sites MT2, MT3, MT4, and MT12. Annual wind data recovery from Y-12 meteorological towers during 2021 exceeded 99 percent for MT9 and MT11 and exceeded 69 percent for MT6 (which is being rebuilt in 2021–2022).

6.2. Ambient Air Monitoring

In addition to exhaust stack monitoring conducted at ORR installations (see Chapters 3, 4, and 5), ambient air monitoring is performed to measure radiological parameters directly in the ambient air adjacent to the facilities (Figure 6.2). Ambient air monitoring provides a means to verify that contributions of fugitive and diffuse sources are insignificant, serves as a check on dose-modeling calculations, and would allow determination of contaminant levels at monitoring locations in the event of an emergency.

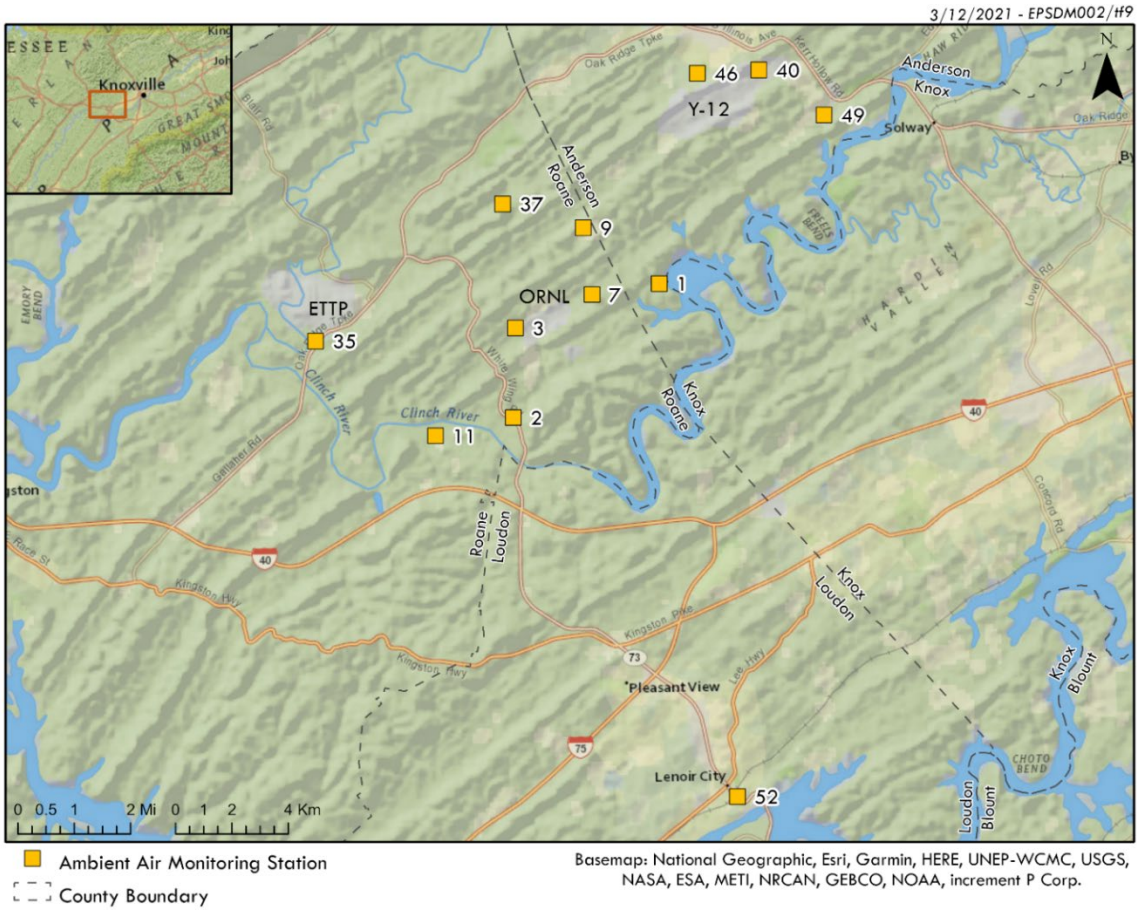
Figure 6.2. ORR ambient air station

6.2.1. Data Collection and Analysis

Ambient air monitoring conducted by individual site programs is discussed in Chapters 3, 4, and 5. The ORR ambient air monitoring program complements the individual site programs and permits the impacts of ORR operations to be assessed on an integrated basis.

The objectives of the ORR ambient air monitoring program are to perform surveillance of airborne radionuclides at the reservation perimeter and to collect reference data from a location not affected by activities on ORR. The perimeter air monitoring network was established in the early 1990s and was modified in 2016 in response to changes in DOE activities and operations that had occurred since the 1990s. The stations monitored in 2021

are shown in Figure 6.3. Reference samples are collected at Station 52 (Fort Loudoun Dam). Sampling was conducted at each ORR station during 2021 to quantify levels of alpha-, beta-, and gamma-emitting radionuclides. Once every 5 years, additional radiological analyses are performed to confirm dose calculations (see Chapter 7). In 2021, additional radionuclides analyzed included neptunium, plutonium, strontium, and thorium.



Notes:

1. *Reference samples are collected at Station 52 (Fort Loudoun Dam).*
2. *Station 7 is an ORNL site-specific monitoring location and is not part of the ORR perimeter network.*

Figure 6.3. Locations of ORR perimeter air monitoring stations

Atmospheric dispersion modeling was used to select appropriate sampling locations. The locations selected are those likely to be affected most by releases from the Oak Ridge facilities. Therefore, in the event of a release, no residence or business near ORR should receive a radiation dose greater than doses calculated at the sampled locations.

The sampling system consists of two separate instruments. Particulates are captured by high-volume air samplers equipped with glass-fiber filters. The filters are collected weekly, composited quarterly, and then submitted to an analytical laboratory to quantify gross alpha and gross beta activity and to determine the concentrations of specific isotopes of interest on ORR. The second system is designed to collect tritiated water vapor. The sampler consists of a prefilter followed by an adsorbent trap that contains indicating silica gel. The samples are collected weekly or biweekly, composited quarterly, and then submitted to an analytical laboratory for tritium analysis.

6.2.2. Results

Data from the ORR ambient air network are analyzed to assess the impact of DOE operations on the local air quality. Each measured radionuclide concentration (Table 6.2 and Table 6.3) is compared with derived concentration standards (DCSs) for air established by DOE as guidelines for controlling exposure to members of the public (DOE 2021a). All radionuclide concentrations measured at the ORR ambient air stations during 2021 were less than 1 percent of applicable DCSs.

Table 6.2. Radionuclide concentrations at ORR perimeter air monitoring stations sampled annually, 2021

Station	Average concentration (pCi/mL)[a,b] (Number detects/n)						
	^{7}Be	^{40}K	^{3}H	^{234}U	^{235}U	^{238}U	^{99}Tc
01	4.4E-08 (4/4)	9.1E-11 (0/4)	3.1E-06 (0/4)	2.5E-12 (4/4)	2.1E-13 (1/4)	2.2E-12 (4/4)	
02	4.2E-08 (4/4)	1.1E-10 (1/4)	6.3E-06 (0/4)	2.5E-12 (4/4)	8.6E-14 (1/4)	1.6E-12 (4/4)	
03	3.9E-08 (4/4)	9.6E-12 (0/4)	4.8E-06 (0/4)	3.8E-12 (4/4)	4.1E-13 (2/4)	2.3E-12 (4/4)	
09	3.9E-08 (4/4)	-6.4E-11 (0/4)	3.7E-05 (4/4)	4.7E-12 (4/4)	4.8E-13 (3/4)	2.6E-12 (4/4)	
11	3.8E-08 (4/4)	-2.2E-10 (0/4)	4.6E-06 (1/4)	2.0E-12 (4/4)	8.4E-14 (0/4)	1.9E-12 (4/4)	
35	3.6E-08 (4/4)	-3.2E-10 (0/4)	5.3E-06 (0/4)	2.7E-12 (4/4)	1.5E-13 (1/4)	2.2E-12 (4/4)	7.0E-10 (1/4)
37	3.3E-08 (4/4)	2.5E-10 (0/4)	2.0E-06 (0/4)	2.5E-12 (4/4)	1.7E-13 (1/4)	1.7E-12 (4/4)	
40	4.2E-08 (4/4)	7.3E-11 (0/4)	2.2E-08 (0/4)	1.4E-11 (4/4)	9.1E-13 (2/4)	4.0E-12 (4/4)	
46	4.2E-08 (4/4)	-7.4E-11 (0/4)	5.5E-06 (0/4)	4.8E-12 (4/4)	3.2E-13 (2/4)	3.0E-12 (4/4)	
49	4.0E-08 (4/4)	-1.3E-10 (0/4)	2.7E-06 (0/4)	3.5E-12 (4/4)	4.4E-13 (2/4)	2.2E-12 (4/4)	
52[c]	4.1E-08 (4/4)	-1.4E-10 (0/4)	8.5E-07 (0/4)	2.2E-12 (4/4)	2.0E-13 (2/4)	1.6E-12 (4/4)	-5.0E-11 (0/4)

[a] *1 pCi = 3.7 × 10^{-2} Bq.*

[b] *A negative concentration of radioactivity is reported by the laboratory when the sample count rate minus the background count rate is negative (i.e., the background count rate was greater than the sample count rate). When the background activity is subtracted from the sample activity to obtain a net value, a negative value results.*

[c] *Station 52 is the reference location.*

Table 6.3. Additional radionuclide concentrations at ORR perimeter air monitoring stations, requested every 5 years, 2021

Station	Average concentration (pCi/mL)[a,b] (Number detects/n)									
	^{241}Am	$^{243/244}$Cm	^{237}Np	^{238}Pu	$^{239/240}$Pu	^{89}Sr	^{90}Sr	^{228}Th	^{230}Th	^{232}Th
01	-9.0E-14 (0/4)	6.1E-14 (1/4)	2.9E-13 (1/4)	2.6E-13 (2/4)	1.4E-13 (0/4)	5.4E-11 (3/4)	-6.7E-12 (0/4)	3.4E-12 (4/4)	1.9E-12 (3/4)	1.7E-12 (4/4)
02	-1.7E-13 (0/4)	6.7E-14 (1/4)	6.7E-14 (0/4)	6.1E-14 (1/4)	1.3E-13 (1/4)	6.9E-11 (4/4)	-8.6E-12 (0/4)	2.9E-12 (4/4)	2.0E-12 (2/4)	1.5E-12 (4/4)
03	-1.9E-14 (0/4)	7.9E-14 (1/4)	3.5E-13 (0/4)	4.1E-14 (0/4)	3.4E-13 (2/4)	4.6E-11 (3/4)	-4.3E-12 (0/4)	3.9E-12 (3/4)	1.8E-12 (2/4)	1.8E-12 (3/4)
09	-3.6E-14 (0/4)	7.8E-14 (1/4)	5.9E-13 (2/4)	2.7E-13 (2/4)	1.9E-13 (2/4)	3.8E-11 (3/4)	-4.2E-12 (0/4)	4.8E-12 (4/4)	2.1E-12 (2/4)	2.0E-12 (4/4)
11	-8.7E-14 (0/4)	4.4E-14 (1/4)	2.6E-13 (0/4)	4.3E-14 (1/4)	1.8E-13 (1/4)	5.4E-11 (3/4)	-6.2E-12 (0/4)	3.8E-12 (3/4)	1.2E-12 (2/4)	1.6E-12 (4/4)
35	1.1E-13 (1/4)	8.6E-14 (1/4)	4.4E-13 (1/4)	4.2E-14 (0/4)	1.3E-13 (0/4)	4.9E-11 (3/4)	-6.0E-12 (0/4)	4.1E-12 (3/4)	2.2E-12 (3/4)	2.0E-12 (4/4)
37	-5.5E-14 (0/4)	7.5E-14 (1/4)	1.1E-13 (2/4)	1.9E-13 (1/4)	6.4E-14 (0/4)	4.1E-11 (3/4)	-5.6E-12 (0/4)	3.7E-12 (4/4)	2.3E-12 (4/4)	1.5E-12 (4/4)
40	-2.9E-14 (0/4)	-6.9E-15 (0/4)	1.6E-13 (0/4)	1.8E-13 (1/4)	2.2E-13 (1/4)	4.9E-11 (4/4)	-5.8E-12 (0/4)	4.3E-12 (4/4)	2.7E-12 (4/4)	2.2E-12 (4/4)
46	-1.8E-13 (0/4)	7.6E-14 (1/4)	5.3E-13 (1/4)	-2.4E-14 (0/4)	1.0E-13 (0/4)	5.0E-11 (3/4)	-6.2E-12 (0/4)	3.7E-12 (4/4)	2.4E-12 (3/4)	1.8E-12 (4/4)
49	7.7E-15 (0/4)	1.4E-14 (1/4)	4.7E-13 (1/4)	1.1E-13 (0/4)	1.1E-13 (1/4)	4.2E-11 (3/4)	-4.5E-12 (0/4)	4.5E-12 (4/4)	2.3E-12 (4/4)	2.1E-12 (4/4)
52[c,d]	3.0E-14 (0/4)	3.3E-14 (0/4)	4.3E-13 (2/4)	2.7E-13 (1/4)	1.3E-13 (0/4)	3.7E-11 (4/4)	-2.9E-12 (0/4)	4.9E-12 (4/4)	2.0E-12 (3/4)	2.2E-12 (4/4)

[a] *1 pCi = 3.7 × 10^{-2} Bq.*

[b] *A negative concentration of radioactivity is reported by the laboratory when the sample count rate minus the background count rate is negative (i.e., the background count rate was greater than the sample count rate). When the background activity is subtracted from the sample activity to obtain a net value, a negative value results.*

[c] *Station 52 is the reference location.*

[d] *Two additional radionuclides, ^{214}Bi and ^{214}Pb, were detected at Station 52 in the fourth quarter of 2021 with a concentration of 3.12E-10 and 2.20E-10 pCi/mL, respectively. These radionuclides were not detected and not reported in the other quarters.*

6.3. External Gamma Radiation Monitoring

Members of the public could hypothetically be exposed directly to gamma radiation from radionuclides released into the environment, from previously released radionuclides deposited on soil and vegetation or in sediments, from radiation-generating facilities—especially high-energy accelerators—and from the storage of radioactive materials (DOE 2021b). Continuous direct radiation levels are monitored at locations around ORR to complement the sample data collected as part of the ORR ambient air monitoring program. (See Section 6.2).

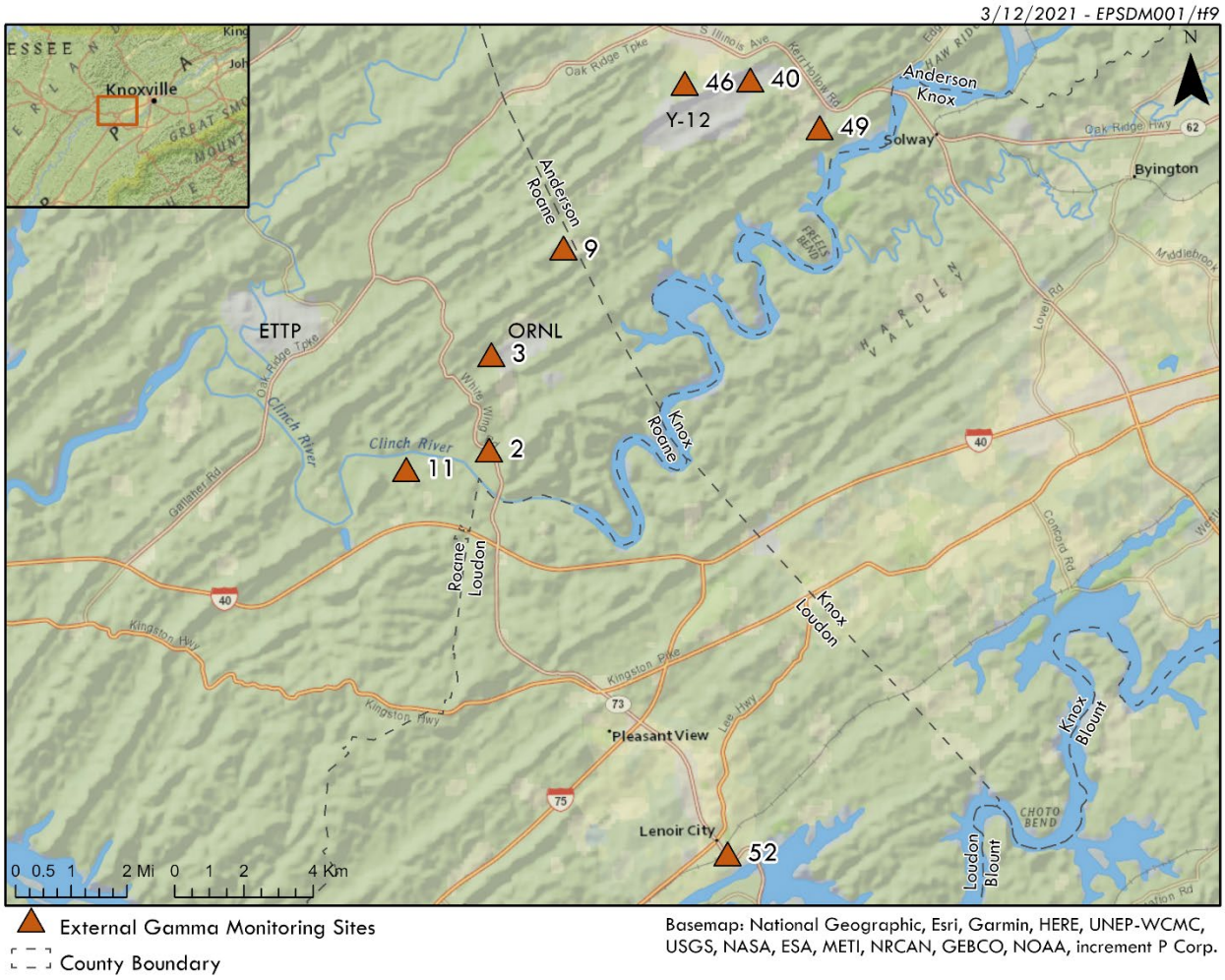
6.3.1. Data Collection and Analysis

External gamma exposure rates are continuously recorded by dual-range Geiger-Müller tube detectors colocated with ORR ambient air stations (see Section 6.2). Dose rates are recorded by the instruments every minute. The data are

downloaded weekly and are averaged for the entire year. Figure 6.4 shows locations that were monitored during 2021; Table 6.4 summarizes the data for each station.

6.3.2. Results

The mean exposure rate for the reservation network in 2021 was 9.5 µR/h, and the mean rate at the reference location (Fort Loudoun Dam) was 8.5 µR/h. Background direct radiation exposure rates have been collected at the Fort Loudoun Dam (Station 52) reference location for many years. From 2011 through 2020 (the preceding 10 years), the exposure rates at the reference location ranged from 6.5 to 11.4 µR/h and averaged 8.6 µR/h.



Note:
Reference samples are collected at Station 52 (Fort Loudoun Dam).

Figure 6.4. External gamma radiation monitoring locations on ORR

Table 6.4. External gamma exposure rate averages for ORR, 2021

Air station number	Number of data points (daily)	Measurement (μR/h)[a]		
		Min	Max	Mean
02	365	8.2	9.9	8.8
03	365	8.6	10.3	9.2
09	365	8.5	14.9	9.5
11	361	9.3	12.6	9.9
40	365	8.8	10.6	9.4
46	359	9.8	11.4	10.3
49	365	8.8	10.2	9.3
52	363	8.1	9.4	8.5

[a] *To convert microroentgens per hour (μR/h) to milliroentgens per year, multiply by 8.760.*

6.4. Surface Water Monitoring

The ORR surface water monitoring program consists of sample collection and analysis from four locations on the Clinch River, including public water intakes (Figure 6.5). The program is conducted in conjunction with site-specific surface water monitoring activities to enable an assessment of the impacts of past and current DOE operations on the quality of local surface water.

6.4.1. Data Collection and Analysis

Grab samples are collected quarterly at all four locations and are analyzed for general water quality parameters, screened for radioactivity, and analyzed for mercury and specific radionuclides when appropriate. Table 6.5 lists the specific locations and associated sampling frequencies and parameters.

At the sampling locations, the Clinch River is classified by the state of Tennessee for multiple uses, including recreation and domestic supply. These two designated uses have numeric Tennessee Water Quality Criteria (WQCs) related to protection of human health. The WQCs are used as references where applicable (TDEC 2014). The Tennessee WQCs do not include criteria for radionuclides. Four percent of the DOE DCS is used as the criterion for radionuclide comparison (DOE 2021a).

6.4.2. Results

In 2021, as has been the case since 2009, there were no statistical differences in radionuclide concentrations in surface water samples collected from the Clinch River upstream and downstream of DOE inputs. No radionuclides were detected above 4 percent of the respective DCSs. In 2021, ^{241}Am was detected by gamma spectroscopy analysis in the second-quarter grab sample from CRK 58 upstream of DOE inputs. It was not detected in samples from other surface water sampling locations, and it had not previously been detected at CRK 58. There were no further ^{241}Am detections in samples collected in the third or fourth quarters of 2021. The 13.6 pCi/L $\pm$ 8.51 pCi/L detected by gamma spectroscopy is below 4 percent of the applicable DCS for ^{241}Am, and other data collected at the same time and location point to laboratory contamination as a likely source of the detected ^{241}Am. In 2022, as part of a regular 5-year rotation to confirm the dose modeling (see Chapter 7), additional analyses, including a more sensitive method for quantifying ^{241}Am, will be performed at all ORR surface water monitoring locations on the Clinch River.

Mercury was not detected in 2021 in samples from any of the three sampling locations where mercury samples are collected, Clinch River kilometer (CRK) 66, CRK 32, and CRK 16.

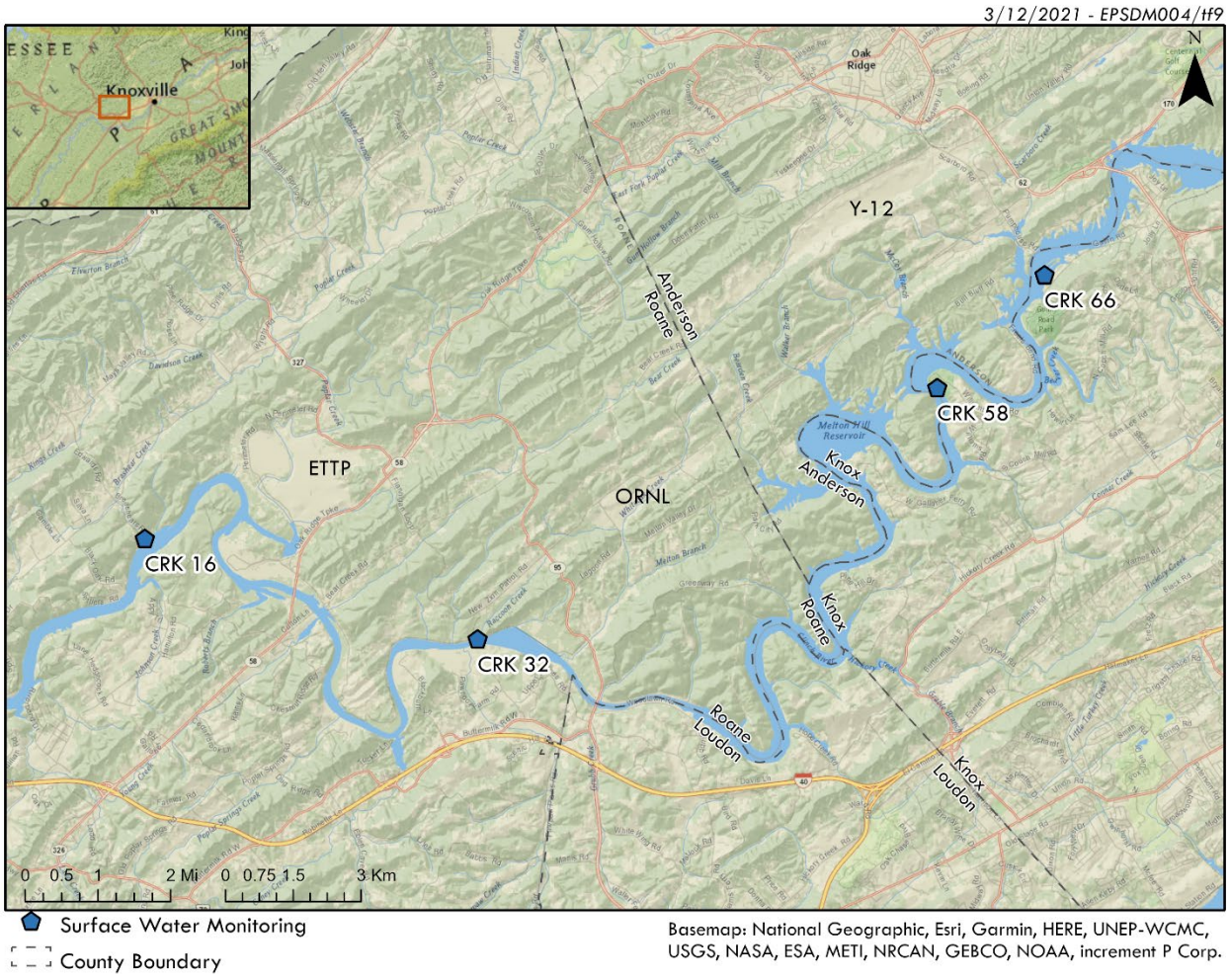


Figure 6.5. ORR surface water surveillance sampling locations

Table 6.5. ORR surface water sampling locations, frequencies, and parameters, 2021

Location[a]	Description	Frequency	Parameters
CRK 16	Clinch River downstream from all DOE ORR inputs	Quarterly	Mercury, gross alpha, gross beta, gamma scan, ^{3}H, field measurements[b]
CRK 32	Clinch River downstream from ORNL	Quarterly	Mercury, gross alpha, gross beta, gamma scan, total radioactive strontium, ^{3}H, field measurements[b]
CRK 58	Water supply intake for Knox County	Quarterly	Gross alpha, gross beta, gamma scan, ^{3}H, field measurements[b]
CRK 66	Melton Hill Reservoir above City of Oak Ridge water intake	Quarterly	Mercury, gross alpha, gross beta, gamma scan, total radioactive strontium, ^{3}H, field measurements[b]

[a] *Locations indicate the water body and distances upstream of the confluence of the Clinch and Tennessee Rivers (e.g., CRK 16 is 16 km upstream from the confluence of the Clinch River with the Tennessee River in the Watts Bar Reservoir).*

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

Acronyms:

CRK = Clinch River kilometer
DOE = US Department of Energy
ORNL = Oak Ridge National Laboratory
ORR = Oak Ridge Reservation

6.5. Groundwater Monitoring

Work continued in 2021 to implement key recommendations from the *Groundwater Strategy for the U.S. Department of Energy Oak Ridge Reservation* (DOE 2013), which was agreed to in 2014 by DOE, EPA, and the Tennessee Department of Environment and Conservation (TDEC). Work carried out during 2021 under the ORR Groundwater Program involved the complete installation of three multizone exit pathway groundwater monitoring wells in west Bethel Valley adjacent to the Clinch River. Work continued on site-scale groundwater flow models for the ORNL and ETTP sites.

6.5.1. Off-Site Groundwater Assessment

During FY 2021 the Oak Ridge Office of Environmental Management (OREM) continued to collect and analyze samples from the off-site groundwater monitoring well array west of the Clinch River adjacent to Melton Valley. In addition, exit pathway groundwater monitoring in Melton Valley is conducted as part of the OREM program, including sampling at six multiport monitoring wells in western Melton Valley (wells 4537, 4538, 4539, 4540, 4541, and 4542). Results of this monitoring are summarized in the 2022 *Remediation Effectiveness Report* (DOE 2022).

DOE completed an off-site groundwater assessment project and issued a final report on the off-site groundwater study in October 2017 (DOE 2017). The project was a cooperative effort among the parties to the ORR Federal Facility Agreement to investigate off-site groundwater quality and potential movement. To follow up on work from the off-site groundwater assessment, DOE conducts annual sampling and analysis of groundwater from several off-site residential wells and springs.

6.5.2. Regional and Site-Scale Flow Model

During FY 2017 DOE completed a project to construct and calibrate a regional-scale groundwater flow model that encompasses ORR and adjacent areas. The regional model provides an underlying framework to support creation of smaller, site-scale groundwater flow models for use in planning and monitoring effectiveness of future cleanup decisions and actions. During FY 2021, DOE further refined groundwater flow models for the Molten Salt Reactor Experiment

site to support the development of an updated feasibility study of remedial alternatives for that reactor facility.

6.6. Food

Food sources are analyzed to evaluate potential radiation doses to consumers of local food crops, fish, and harvested game and to monitor trends in environmental contamination and possible long-term accumulation of radionuclides. Samples of hay, vegetables, milk, fish, deer, Canada geese, and turkeys are usually collected every year from areas that could be affected by activities on the reservation and from off-site reference locations. Milk was not collected in 2021 because no dairies were found in potential ORR deposition areas. Surveys are conducted annually to determine whether any dairies are operating in areas of interest.

The wildlife administrative release limits associated with deer, turkey, and geese harvested on ORR are conservative and were established based on the "as low as reasonably achievable" principle to ensure that doses to consumers are managed at levels well below regulatory dose thresholds. This concept is not a dose limit but rather a philosophy that has the objective of maintaining exposures to workers, members of the public, and the environment below regulatory limits and as low as can be reasonably achieved. The administrative release limit of 5 pCi/g ^{137}Cs is based on the assumption that one person consumes all of the meat from a maximum-weight deer, goose, or turkey. This limit ensures that members of the public who harvest wildlife on the reservation will not receive significant radionuclide doses from that consumption pathway. In addition, a conservative administrative limit of 1.5 times background for gross beta activity has been established, a threshold that is near the detection limit for field measurements of $^{89/90}$Sr in deer leg bone.

6.6.1. Hay

Hay from an area on the eastern edge of ORR is made available to an off-site farming operation and is sampled annually. Eating beef and drinking milk obtained from cattle that eat hay is a potential radiation exposure pathway to humans, and hay is sampled to characterize any possible doses from this pathway. In 2021, hay was not cut by the farming operation and therefore was not available to be sampled. The field will be surveyed in 2022 for the availability of hay for analysis.

6.6.2. Vegetables

Contaminants may reach vegetation by deposition of airborne materials, uptake from soil, and deposition of materials contained in irrigation water. As available, food crops are sampled annually from garden locations that have the potential to be affected by airborne releases from ORR to evaluate possible radiation doses received by consumers. Vegetables are also sampled from a reference location for comparison. If available, crops that represent broad-leaf systems (e.g., lettuce, turnip greens), root-plant-vegetable systems (e.g., tomatoes), and root-system vegetables (e.g., turnips, potatoes) are obtained from each location and analyzed for radionuclides. Vegetable availability varies greatly from year to year.

6.6.2.1. Data Collection and Analysis

Tomatoes, turnip greens, and turnips were purchased in 2021 from farms near ORR and from reference locations. The locations were chosen based on availability and on the likelihood of effects from routine releases from the Oak Ridge facilities. All vegetable samples were analyzed for gross alpha, gross beta, gamma emitters, and uranium isotopes.

6.6.2.2. Results

Analytical results for vegetable samples are provided in Table 6.6. No gamma-emitting radionuclides were detected above the minimum detectable activity except for the naturally occurring radionuclides ^{7}Be, ^{40}K, and ^{208}Tl. Uranium isotopes were not detected above minimum detectable activities in any of the samples.

6.6.3. Milk

Milk is a potentially significant exposure pathway to humans for some radionuclides deposited from airborne emissions because of the relatively large surface area on which a cow can graze daily, the rapid transfer of milk from producer to consumer, and the importance of milk in the diet. Since 2016, no dairies in potential ORR deposition areas have been located, and no milk samples have been collected. Surveys to identify dairies in potential deposition areas are conducted each year, and milk sampling will resume when dairy operations in appropriate areas are located.

6.6.4. Fish

Members of the public could be exposed to contaminants originating from DOE ORR activities through consumption of fish caught in area waters. This potential exposure pathway is monitored annually by collecting fish from three locations on the Clinch River and by analyzing edible flesh for specific contaminants. The locations are as follows (Figure 6.6):

- Clinch River upstream from all DOE ORR inputs (CRK 70)
- Clinch River downstream from ORNL (CRK 32)
- Clinch River downstream from all DOE ORR inputs (CRK 16)

6.6.4.1. Data Collection and Analysis

Sunfish (*Lepomis macrochirus*, *L. auritus*, and *Ambloplites rupestris*) and catfish (*Ictalurus punctatus*) are collected from each of the three locations to represent both top-feeding and bottom-feeding-predator species. In 2021, a composite sample of each of those species at each location was analyzed for selected metals, polychlorinated biphenyls (PCBs), tritium, gross alpha, gross beta, gamma-emitting radionuclides, and total radioactive strontium. To accurately estimate exposure levels to consumers, only edible portions of the fish were submitted for analysis. Once every 5 years, additional radiological analyses are performed to confirm the dose calculations (see Chapter 7). In 2019, additional analyses were performed on fish samples and radionuclides detected included neptunium, plutonium, thorium, and uranium isotopes. Based on the 2019 results, additional radionuclide analyses were again performed in 2020 and 2021, including americium, neptunium, plutonium, and thorium. Results are presented in Table 6.7.

TDEC issues advisories on consumption of certain fish species caught in specified Tennessee waters. The advisories apply to fish that could contain potentially hazardous contaminants. TDEC has issued a "do not consume" advisory for catfish in the Melton Hill Reservoir in its entirety, not just in areas that could be affected by ORR activities, because of PCB contamination. Similarly, a precautionary advisory for catfish in the Clinch River arm of Watts Bar Reservoir has been issued because of PCB contamination (TDEC 2020). TDEC also issues advisories for consumption of fish when mercury levels exceed 0.3 ppm; the three locations on the Clinch River where ORR fish are collected do not have mercury "do not consume" advisories (Denton 2007).

Table 6.6. Concentrations of radionuclides detected in turnips, turnip greens, and tomatoes, 2021 (pCi/kg)[a]

Location	Gross alpha	Gross beta	^{7}Be	^{40}K	^{234}U	^{235}U	^{238}U
			Turnips				
North of Y-12	*b*	2,910	*b*	*3,420*	*b*	*b*	*b*
Reference location	*b*	3,000	*b*	*3,290*	*b*	*b*	*b*
			Turnip Greens				
North of Y-12	118	6,410	*b*	*6,580*	*b*	*b*	*b*
Reference location	*b*	5,320	349	*5,770*	*b*	*b*	*b*
			Tomatoes				
North of Y-12	*b*	2,060	*b*	*2,260*	*b*	*b*	*b*
North of Y-12[c]	*b*	1,790	*b*	2,310	*b*	*b*	*b*
South of ORNL[d]	*b*	2,350	*b*	3,080	*b*	*b*	*b*
East of ORNL	*b*	1,950	*b*	*2,330*	*b*	*b*	*b*
West of ETTP	60.9	1,250	*b*	1,630	*b*	*b*	*b*
Reference location	*b*	1,930	*b*	*2,070*	*b*	*b*	*b*

[a] *Detected radionuclides are those at or above minimum detectable activity. 1 pCi = 3.7 × 10^{-2} Bq.*

[b] *Value was less than or equal to minimum detectable activity.*

[c] *Two separate sources for tomatoes were identified in the area north of Y-12 in 2021.*

[d] *An additional radionuclide, ^{208}Tl, was detected in the tomato sample from the area south of ORNL with a concentration of 5.6 pCi/kg, just above the minimum detectable activity of 5.2 pCi/kg. The ^{208}Tl radionuclide is a naturally occurring gamma-emitting radionuclide.*

Acronyms:

ETTP = East Tennessee Technology Park
ORNL = Oak Ridge National Laboratory
Y-12 = Y-12 National Security Complex

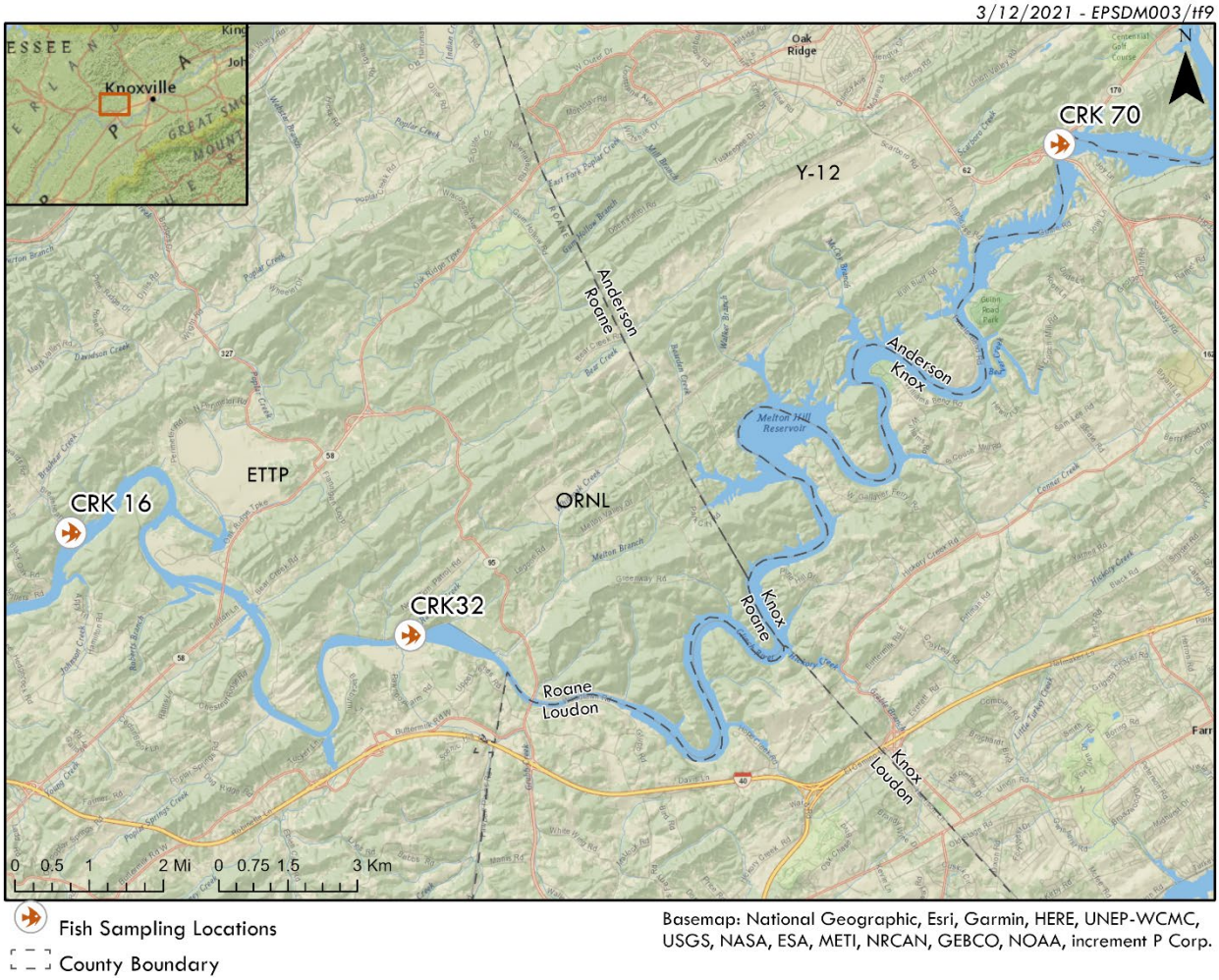


Figure 6.6. Fish-sampling locations for the ORR Surveillance Program

Table 6.7. Tissue concentrations in catfish and sunfish for detected PCBs and radionuclides, 2021[a]

	CRK 16 Downstream		CRK 32		CRK 70 Upstream	
	Catfish	**Sunfish**	**Catfish**	**Sunfish**	**Catfish**	**Sunfish**
Pesticides and PCBs (µg/kg)						
PCB-1260	J15.7[b]	c	20.3	c	c	c
Radionuclides (pCi/g)						
Beta activity	3.6	3.0	2.6	2.8	2.5	2.4
^{40}K	3.2	3.7	2.9	3.8	2.6	3.1

[a] *Only parameters that were detected for at least one species are listed in the table.*
[b] *"J" indicates that the result is an estimated value.*
[c] *Value was less than or equal to minimum detectable activity.*
Acronyms:
CRK = Clinch River kilometer
PCB = polychlorinated biphenyl

6.6.4.2. Results

PCBs, specifically Aroclor-1260, were detected in catfish at CRK 16 (estimated value) and CRK 32 in 2021. Mercury was not detected above minimum detectable activity in either species at any location in 2021. These results are consistent with the TDEC advisories. Detected PCBs, mercury, and radionuclide concentrations are shown in Table 6.7.

6.6.5. White-Tailed Deer

Three quota hunts were scheduled for 2021: November 7–8, November 14–15, and December 12–13. However, the hunts were cancelled because of the COVID-19 pandemic.

Since 1985, 13,334 deer have been harvested from the Oak Ridge Wildlife Management Area, of which 218 (approximately 1.67 percent) have been retained because of potential radiological contamination. The heaviest buck ever harvested weighed 218 lb (1998), and the heaviest doe ever harvested weighed 139 lb (1985). The average weight of all harvested deer is approximately 86 lb (all weights are field-dressed weights). The oldest deer harvested was a doe estimated to be 12 years old (1989); the average age of all harvested deer is approximately 2 years. See the ORR hunt information website **here** for more information.

6.6.6. Waterfowl

Canada goose hunting was allowed on the Three Bends Area of ORR (excluding the shoreline of Gallaher Bend) during the statewide season in 2021, one half hour before sunrise until noon on September 5–7, 12–13, and 19–20 and on October 10–11 and 17–18. Hunting was allowed for wood duck and teal on September 12–13. The consumption of waterfowl is a potential pathway for exposing members of the public to radionuclides released from ORR operations.

6.6.6.1. Data Collection and Analysis

Canada geese are rounded up each summer for noninvasive gross radiological surveys to characterize concentrations of gamma-emitting radionuclides accumulated by waterfowl that feed and live on ORR.

6.6.6.2. Results

Thirty-four geese (20 adults and 14 juveniles) were captured during the June 24, 2021, roundup on ORR. All 34 captured geese were subjected to live whole-body gamma scans. Gamma scan results showed that all were all well below the administrative release limit of 5 pCi/g ^{137}Cs.

6.6.7. Wild Turkey

Two wild turkey quota hunts were scheduled to occur on April 17–18 and April 24–25. However, the turkey hunts were cancelled because of the COVID-19 pandemic.

Since 1997, 924 turkeys have been harvested on spring turkey hunts. Eleven additional turkeys have been harvested since 2012 by archery hunters during fall deer hunts. The largest turkey ever harvested on ORR weighed 25.7 lb (harvested in 2009). Of all turkeys harvested, only three (less than 0.34 percent) have been retained because of potential radiological contamination: one in 1997, one in 2001, and one in 2005. Additional information is available on the ORR hunt website **here**.

6.7. Invasive Plant Management

Invasive non-native plant species are among the greatest ecological threats across the country and around the world. Maintaining ecosystems, protecting natural areas, and ensuring functioning of facilities and their support infrastructures, power and communications rights-of-way, roadways, and waterways through actively managing invasive plant incursions is crucial, not only in natural areas, but in developed areas as well. Invasive plants can threaten forests, wetlands, cultural assets, and other resources through increased risk of fire; storm damage; and encroachment onto roads, railroads, power structures, waterways, and agricultural sites. Invasive plants disrupt vital habitats of threatened

and endangered species as well as other native wildlife and plant life by decreasing native plant diversity, crowding out native plants, and disrupting natural plant-animal interactions.

The Federal Noxious Weed Act (1974) was amended and incorporated into the Federal Plant Protection Act (2000), which mandates federal agencies to develop and coordinate a management program for control of invasive plants on lands under each agency's respective jurisdiction. Each agency must adequately fund the publication of an integrated pest management plan that will meet the regulatory requirements of federal laws, executive orders, presidential memorandums, contracts, and agreements. Other federal directives regarding control of invasive plants and subsequent restoration practices include the following:

- Presidential Memorandum, "Environmentally and Economically Beneficial Practices on Federal Landscaped Ground" (1994), which was replaced in 2000 by Executive Order 13148, "Greening the Government through Leadership in Environmental Management" (2000)
- "Federal Memorandum of Understanding to Establish a Federal Inter-agency Committee for the Management of Noxious and Exotic Weeds" (1994)
- Executive Order 13112, "Invasive Species" (1999)
- Presidential Memorandum, "Creating a Federal Strategy to Promote the Health of Honey Bees and Other Pollinators," (2014) includes control and removal of invasive plants and restoration and establishment of natural habitats
- Executive Order 13751, "Safeguarding the Nation from the Impacts of Invasive Species" (2016)

The DOE has maintained an invasive plant management plan for ORR since 2004. For details of federal and state laws and regulations driving the DOE plan, see *Invasive Plant Management Plan for the Oak Ridge Reservation* (Parr et al. 2004, Quarles et al. 2011, McCracken and Giffen 2017).

A technical report, *Assessment of Nonnative Invasive Plants in the DOE Oak Ridge National Environmental Research Park* (Drake et al. 2002) details the results of extensive survey efforts. These and subsequent surveys have been performed to identify invasive plant problems on ORR. The data are used to develop control plans identifying which invasive species to target and in which locations.

More than 1,100 species of plants are found on ORR, and of these approximately 170 plant species are non-native plants. Fifty-seven aggressive non-native (invasive) plant species have been identified on ORR, but control efforts have been primarily focused on a subset of 10 species. Two tree species were added as primary invasive plant targets in 2021: mimosa (*Albisia julibrissin*) and Bradford/Callery pear (*Pyrus calleryana*) (see Table 6.8). The selected invasive species have been found across ORR in disturbed areas; on powerline and gas line rights-of-way; throughout riparian buffer zones; and along state highways, railroad lines, and remote-access fire roads. They have invaded natural areas to varying degrees, causing vast ecological harm in both plant and animal communities. Other invasive plant species are also targets for control, using US Department of the Interior Early Detection and Rapid Response guidance (DOI 2020) and in concert with control efforts on the 12 highly invasive species listed in Table 6.8.

Table 6.8. Twelve most problematic invasive plants on the ORR

Common name	Scientific name
Japanese grass, Nepal grass	*Microstegium vimineum*
Japanese honeysuckle	*Lonicera japonica*
Chinese privet	*Ligustrum sinense*
Kudzu	*Pueraria montana*
Multiflora rose	*Rosa multiflora*
Tree-of-heaven	*Ailanthus altissima*
Autumn olive	*Elaeagnus umbellate*
Oriental bittersweet	*Celastrus orbiculatus*
Princess tree	*Paulownia tomentosa*
Winter creeper	*Euonymus hederaceus*
Bradford/Callery pear	*Pyrus calleryana*
Mimosa	*Albizia julibrissin*

The 32,258.54-acre ORR consists mostly of undeveloped land, such as forested land, extensive areas of undisturbed wetlands, open waterways and riparian vegetation, and several hundred acres of grassland communities and fallow fields. Three major developed facilities lie within ORR boundaries: ORNL, the Y-12 Complex, and ETTP. Surrounding these developed facilities and woven throughout ORR are safety and security areas, utility corridors, access roads, research and education areas, cultural and historic preservation sites, contamination areas that are undergoing cleanup and remediation, regulatory and monitoring sites, emergency corridors, new facility construction and laydown areas, and public use areas. This multiplicity of land uses presents challenges for effectively preventing and managing invasive species.

Numerous DOE contractors have responsibilities for land management of portions of ORR, as do other federal and state agencies, such as the Tennessee Valley Authority and the Tennessee Wildlife Resources Agency. The Natural Resources Management Team for ORR receives site-wide funding annually, a portion of which is designated for creation and implementation of an invasive plant management plan, mainly directed toward control efforts in natural areas and reference areas; however, efforts have included specific invasive plant incursions into locations within and surrounding campuses of developed facilities on ORR. The *Invasive Plant Management Plan for the Oak Ridge Reservation* (Parr et al. 2004) and two subsequent revisions (Quarles et al. 2011, McCracken and Giffen 2017) explain options for addressing the problem of invasive plants on ORR and discuss selection of appropriate control measures. Areas selected for invasive plant control tend to cover several acres or are spread out across portions of ORR. Use of select herbicides is the most cost-effective treatment method in most cases, and the invasive plants that are present inform which herbicides will be most effective without causing harm to surrounding native plant and animal habitats.

Invasive plant control on ORR has been conducted annually from 2003, when the invasive plant management program began, through 2021. Table 6.9 indicates the extent of annual invasive plant treatments; Figure 6.7 shows the major treatment areas.

Table 6.9. Invasive plant control on ORR, 2003–2021

Year	Treated area	
	Acres	Road miles
2003	98	
2004	136	
2005	125	
2006	254	
2007	236	
2008	427	
2009	526	
2010	884	
2011	806	
2012	615	
2013	329	
2014	950	
2015	629	
2016	952	
2017	542	47
2018	507	53
2019	450	57
2020	400	65
2021	400	51

Restoration of selected natural areas is done in addition to herbicide treatment of invasive plants. *The Native Grass Community Management Plan for the Oak Ridge Reservation* (Ryon et al. 2007) and the *Grassland Ecosystem Management Plan for the Oak Ridge Reservation* (Herold and McCracken 2018) discuss demonstration projects and larger grassland restoration projects across ORR. Demonstration projects have been done at ETTP, the Y-12 Complex, and ORNL. Native plant restoration projects totaling several hundred acres across ORR are located within the Oak Ridge National Environmental Research Park's natural areas.

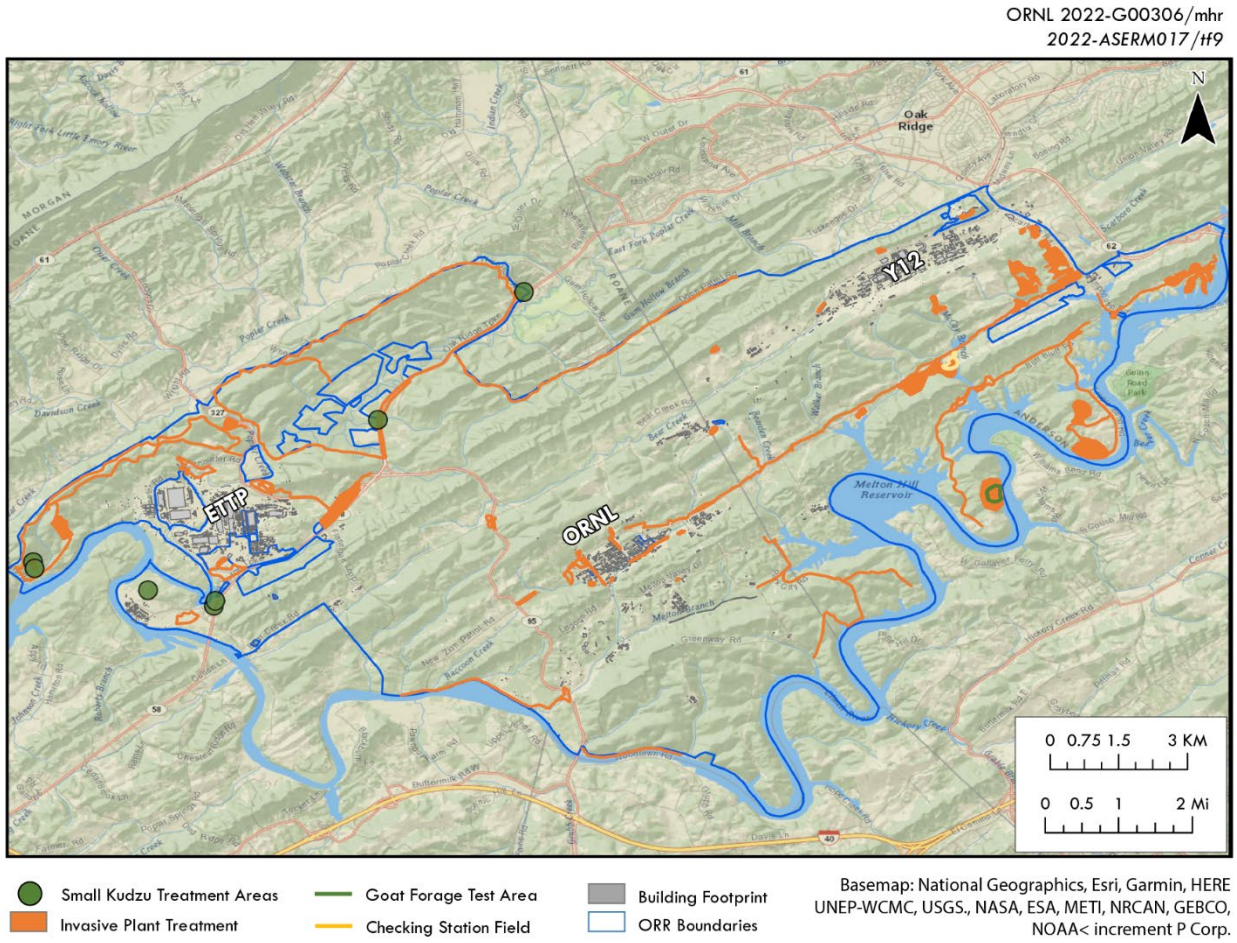


Figure 6.7. Map of invasive plant treatment areas on ORR for 2021

Invasive Plant management and grassland restoration completed in 2021 at each of the three facilities on ORR include the following:

- ORNL
  - First Creek grassland area management
  - First Creek riparian buffer zone
  - Fifth Creek riparian buffer zone
  - White Oak Creek riparian buffer zone
  - 1000 area invasive plant control
  - Demonstration plot at Spallation Drive and Bethel Valley Road management
  - Bethel Valley Road and Old Bethel Valley Road invasive plant control
  - East Bethel Valley Road native grasslands
  - Check Station native grasslands
  - Park City Road/Price Road invasive plant treatment
  - Three Bends Area invasive plant control
  - Gallaher Bend kudzu control using goats
- Y-12
  - Y-12 Native Grassland Area invasive plant treatment
  - Kudzu control on Pine Ridge and Chestnut Ridge overlooking the Y-12 campus
  - Midway Turnpike invasive plant control
  - Coal ash ponded area kudzu control

  - Walnut Orchard four corners kudzu control
  - Fire road invasive plant control
  - Mt. Vernon Road pine removal area
- ETTP
  - McKinney Ridge kudzu control
  - Black Oak Ridge Conservation Easement kudzu and invasive plant control
  - Black Oak Ridge Conservation Easement greenway and trail invasive plant control
  - Powerhouse Trail invasive plant control
  - Wheat Church Vista invasive plant control

6.7.1. Special Projects

Riparian buffer zone vegetation is important for maintaining water quality that meets standards set by TDEC. Native plants play a large role in bank stabilization and water filtration. A project was undertaken during the summers of 2020 and 2021 to kill and remove, where possible, invasive plants within the riparian buffer zones of select sections of First Creek, Fifth Creek, and White Oak Creek on the ORNL campus. Invasive plant control will be conducted in the riparian buffer zones of additional sections of these streams as funding is available.

Invasive plant treatment methods generally have involved a combination of herbicide use, mechanical removal, and prescribed burning. Biological control methods can be used in the control of invasive plants as well. In the summers of 2020 and 2021 a project using goats for kudzu control was carried out on Gallaher Bend (Figure 6.8). This project investigated the costs and level of successful kudzu control. Goats were rotated through fenced sections of a 46-acre plot during the summer of 2020. A prescribed burn of the area was conducted after grazing season in the spring of 2020. The following year, goats were rotated through the same fenced sections twice during grazing season. Results from this 2-year study indicate that stand-alone use of goats to control large patches of mature kudzu is not economically feasible, nor is it particularly successful. Indications are that multiple years of continual grazing would be needed to control mature kudzu plots. Additionally, goat grazing can leave areas barren of most plants and subject to erosion.

Figure 6.8. Experimental kudzu control using goats Photo by Kitty McCracken

6.8. Fire Protection Management and Planning

Wildland fire management plays a major part in DOE's overall management of ORR. A comprehensive wildfire management program has been established and implemented for the entire ORR. The *Oak Ridge Reservation Wildland Fire Management Plan (WFMP)* (DOE 2021d) assigns responsibilities for wildland fire management, and is reviewed every 3 years and revised as needed. The *Oak Ridge Reservation Wildland Fire Implementation Plan (WFIP)* (DOE 2021e) provides specific details on program implementation. The WFMP was prepared to satisfy the requirements of DOE Order 420.1C,

Facility Safety, Change 1 (DOE 2019), and relevant portions of National Fire Protection Association (NFPA) 1143 (NFPA 2018) (subsequently revised in 2022 as 1140). This plan outlines the overall goals and strategies necessary to manage, plan, and respond to fire in the wildland areas of ORR and to reduce the risk of wildland fire to personnel and facilities on the ORR and to the public. This plan is reviewed at least annually.

The WFMP applies to all DOE employees, contractors, and subcontractors working on the ORR and to all DOE ORR tenant activities. The DOE ORR federal manager is responsible for ORR wildland fire management activities.

The primary goal of the WFMP is to lower the overall risk of wildland fire to ORR by conducting prevention activities designed to prevent fires from starting and to reduce the spread of a fire should one start. Another goal of the WFMP is to contain wildfires that do start to the ORR unit of origin by conducting suppression activities.

Implementation of the WFMP relies on multiple organizations, including non-DOE entities, such as the City of Oak Ridge and the State of Tennessee Division of Forestry. Memorandums of understanding that ensure collaboration between organizations are maintained for each organization that provides firefighting support on ORR.

DOE actions associated with wildland fire management include the following:

- Controlling ignition sources in the wildland areas, particularly with respect to forecasted fire danger days
- Managing wildfire fuels in and near developed areas
- Developing and implementing controlled burning plans authorized by the DOE ORR federal manager
- Preparing and updating wildland fire pre-plans including maps of fuel types, topographic features, roads, cultural resources, sensitive natural resources, contamination areas and potential hazards
- Developing stakeholder involvement plans in support of the wildland fire program
- Reviewing current wildland fire-potential data, including indications of wildland fire risk
- Preparing a wildland fire risk report, including a wildland fire hazard severity analysis based on the National Fire Protection Association Standard for Wildland Fire Management (NFPA 2018)
- Maintaining a wildland fire road grid to support fire detection, containment, and suppression
- Conducting tabletop wildland fire exercises at least once every 3 years, and full-scale exercises at least every 5 years
- Incorporating wildland fire mitigation and response activities and procedures into the ORR land use planning process

The DOE roads and grounds contractor is responsible for establishing and maintaining the wildland fire roads, many of which delineate wildland management units (Figure 6.9), and for maintaining barricades that control access to ORR secondary roads. The management contractors at each of the three major ORR sites are responsible for providing personnel and equipment for initial response to wildland fire events and for establishing incident command. The City of Oak Ridge has entered into a mutual aid agreement with DOE to provide assistance for wildland fire activities. The State of Tennessee Department of Agriculture Division of Forestry has entered into a memorandum of understanding to provide trained personnel and heavy equipment, including fire plows, when requested to assist with wildland fires on ORR.

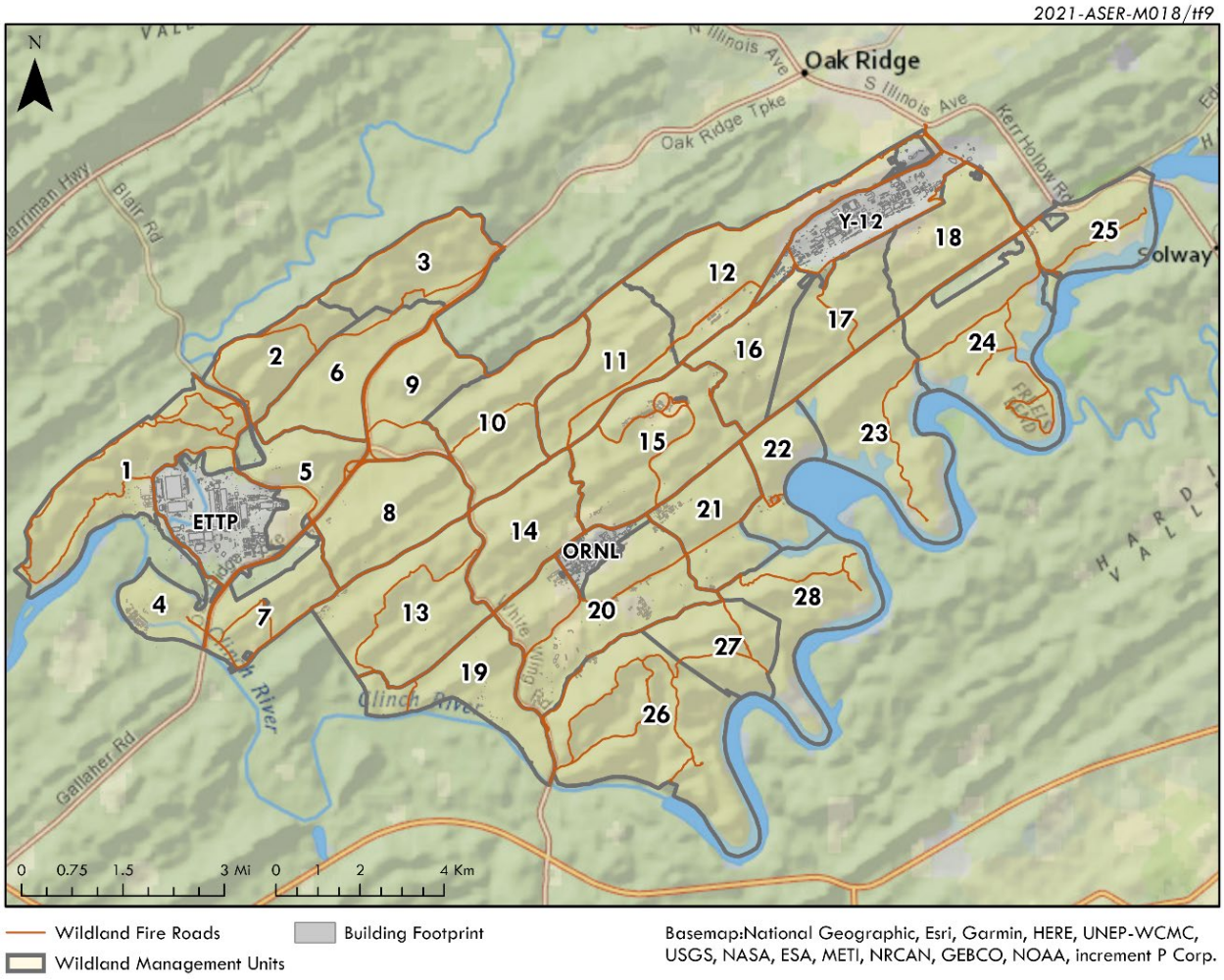


Figure 6.9. Wildland management units on ORR

Because ORR is a large (32,258.54 acres), mainly forested property with access restrictions, it is a challenge for site emergency personnel to maintain familiarity with all remote areas and back roads and to quickly recognize and access concerns associated with those areas. Wildland management unit pre-fire plans are designed to aid responders who may or may not be familiar with an area.

The pre-fire plans are brief, concise documents for each of the 28 ORR wildlife management units (Figure 6.9) that summarize access issues, assets, and hazard concerns. These plans include the wildlife management unit's name and identification number, its general location within ORR, and its boundaries and size. Important information and hazard descriptions s are listed near the top of the form, followed by guidance on tactics, access, vegetation and fuels, water sources, topographic considerations, and hazards. Plan maps depict access, utilities, hazards, research areas, fuel types, water sources, urban interface areas, and sensitive resources. Pre-fire plans are reviewed on a 3-year cycle and are updated as significant changes occur.

Copies of the plans kept in responder vehicles for immediate reference during remote events and are available to site fire departments and emergency operations centers, shift superintendent offices, and appropriate management staff. The plans are easily updated, stored, and shared electronically. They are meant

to enable quick decisions but not to dictate tactics. The ORR forester is the point of contact for plan distribution.

The 2016 Great Smoky Mountains wildfires, also known as the Gatlinburg wildfires, demonstrated that large fires, while more frequent in western states, can occur on or near ORR. Issues related to wildland/urban interface areas are a growing concern. These areas may feature relatively high housing density and increasing recreational use by the public. DOE has prioritized interface areas and has conducted controlled wildfire fuel reduction burns (Figure 6.10) to limit the spread of fire to and from the community. The presence of dense pine forests increase community vulnerability to potential high-intensity wildfires. Actions to protect these areas include thinning or replacing dense pine growth, mechanical treatments to proactively thin younger pine, and mulching heavy logging slash and insect-damaged timber to interrupt fuel beds.

Figure 6.10. Controlled burn on Oak Ridge Reservation, March 2021. Photograph by Carlos Jones.

6.9. Quality Assurance

UT-Battelle performs the activities associated with administration, sampling, data management, and reporting for ORR environmental surveillance programs. Project scope is established by a task team whose members represent DOE; UT-Battelle; Consolidated Nuclear Security, LLC; and UCOR. UT-Battelle integrates quality assurance, environmental, and safety considerations into every aspect of ORR environmental monitoring. (See Chapter 5, Section. 5.7, for a detailed discussion of UT-Battelle quality assurance program elements for environmental monitoring and surveillance activities.).

6.10. References

Bowen et al. 2000. Bowen, B. M., J. A. Baars, and G. L. Stone. "Nocturnal Wind Shear and Its Potential Impact on Pollutant Transport." *Journal of Applied Meteorology* 39(3), 437–45.

Denton 2007. Denton, G. M. *Mercury Levels in Tennessee Fish.* Tennessee Department of Environment and Conservation, Nashville Tennessee. https://www.tn.gov/content/dam/tn/environment/water/documents/fishmercurylevels.pdf

DOE 2019. *Facility Safety*. DOE Order 420.1C. US Department of Energy, Washington, DC (https://www.directives.doe.gov/directives-documents/400-series/0420.1-B Order-C-chg3-ltdchg, accessed June 15, 2021).

DOE 2013. *Groundwater Strategy for the U.S. Department of Energy Oak Ridge Reservation, Oak Ridge, Tennessee*. Volume 1. Main Text. DOE/OR/01-2628/V1&D1. US Department of Energy Office of Environmental Management, Washington, DC. (PDF version available through online catalog at http://doeic.science.energy.gov/)

DOE 2015. *Environmental Radiological Effluent Monitoring and Environmental Surveillance*. DOE-HDBK-1216-2015. US Department of Energy, Washington, DC. https://www.standards.doe.gov/standards-documents/1200/1216-bhdbk-2015 (accessed May 18, 2021).

DOE 2017. *Offsite Groundwater Assessment Remedial Site Evaluation, Oak Ridge, Tennessee*. DOE/OR/01-2715&D2_R. US Department of Energy Office of Environmental Management, Washington, DC.

DOE 2020. DOE Order 458.1, *Radiation Protection of the Public and the Environment*. US Department of Energy, Washington, DC.

DOE 2021a. *Derived Concentration Technical Standard*. DOE-STD-1196-2021. US Department of Energy, Washington, DC (https://www.standards.doe.gov/ standards-documents/1100/1196-astd-2021/@@images/file, accessed March 28, 2022).

DOE 2021b. *Environmental Monitoring Plan for the Oak Ridge Reservation, Calendar Year 2021*. DOE/ORO-228/R12. US Department of Energy Office of Science, Washington, DC. (https://doeic.science.energy.gov/ASER/ORR_EMP_CY2021_Final.pdf, accessed April 11, 2021)

DOE 2021c. *Phased Groundwater Remedial Investigation Work Plan for the Bethel Valley Final Groundwater Record of Decision.* Oak Ridge, Tennessee. DOE/OR/01-2824&d2. US Department of Energy Office of Science, Washington, DC.

DOE 2021d. *Oak Ridge Reservation Wildland Fire Management Plan.* US Department of Energy Office of Science. Washington, DC.

DOE 2021e. *Oak Ridge Reservation Wildland Fire Implementation Plan.* US Department of Energy Office of Science. Washington, DC.

DOE 2022. *2022 Remediation Effectiveness Report for the U.S. Department of Energy Oak Ridge Site, Oak Ridge, Tennessee: Data and Evaluations.* DOE/OR/01-2916&D1. Prepared by the Water Resources Restoration Program, UCOR for the US Department of Energy Office of Environmental Management, Oak Ridge, Tennessee.

DOI 2020. *Early Detection and Rapid Response.* National Invasive Species Council, US Department of the Interior, Washington, DC. https://www.doi.gov/invasivespecies/early-detection-and-rapid-response (no date, accessed April 20, 2021)

Drake et al. 2002. Drake, S. J., J. F. Weltzin, and P. D. Parr, *Assessment of Nonnative Invasive Plants in the DOE Oak Ridge National Environmental Research Park.* ORNL/TM-2001/113. Oak Ridge National Laboratory, Oak Ridge, Tennessee (2002).

Executive Order 13112, "Invasive Species" (1999). https://www.invasivespeciesinfo.gov/executive-order-13112

Executive Order 13148, "Greening the Government Through Leadership in Environmental Management." (2000). https://www.govinfo.gov/content/pkg/WCPD-2000-05-01/pdf/WCPD-2000-05-01-Pg891.pdf

Executive Order 13751, "Safeguarding the Nation from the Impacts of Invasive Species." (2016). (https://www.invasivespeciesinfo.gov/executive-order-13751

Federal Memorandum of Understanding to Establish a Federal Inter-agency Committee for the Management of Noxious and Exotic Weeds (1994). https://my.usgs.gov/confluence/download/attachments/535986746/1994_FICMNEW-MOU-508.pdf?version=1&modificationDate=1530204027466&api=v2

Federal Noxious Weed Act 1974. Public Law 93-629 (7 U.S.C. 2801 et seq.; 88 Stat. 2148).

Federal Plant Protection Act 2000. (part of Pub.L. 106–224) https://www.govinfo.gov/content/pkg/STATUTE-114/pdf/STATUTE-114-Pg358.pdf#page=1

Herold and McCracken 2018. Herold, J. and K. McCracken. *Grassland Ecosystem Management Plan for the Oak Ridge Reservation*. ORNL/TM-2007/38/R1. Oak Ridge National Laboratory, Oak Ridge, Tennessee (2018).

McCracken and Giffen 2017. McCracken, M. K., and N. R. Giffen, *Invasive Plant Management Plan for the Oak Ridge Reservation*. ORNL/TM-2004/98/R2. Oak Ridge National Laboratory, Oak Ridge, Tennessee (2017).

NFPA 2018. *Standard for Wildland Fire Management*. NFPA 1143. National Fire Protection Association, Quincy, Massachusetts. https://www.nfpa.org/codes-and-standards/all-codes-and-standards/list-of-codes-and-standards/detail?code=1143

Parr et al. 2004. Parr, P. D., M. G. Ryon, H. D. Quarles, N. R. Giffen, M. S. Salk, and J. W. Webb. *Invasive Plant Management Plan for the Oak Ridge Reservation*. ORNL/TM-2004/98. Oak Ridge National Laboratory, Oak Ridge, Tennessee (2004).

Presidential Memorandum, "Creating a Federal Strategy to Promote the Health of Honey Bees and Other Pollinators," (2014). https://obamawhitehouse.archives.gov/the-press-office/2014/06/20/presidential-memorandum-creating-federal-strategy-promote-health-honey-b

Presidential Memorandum, "Environmentally and Economically Beneficial Practices on Federal Landscaped Ground" (1994). https://www.govinfo.gov/content/pkg/WCPD-1994-05-02/pdf/WCPD-1994-05-02-Pg916.pdf

Quarles et al. 2011. Quarles, H. D., M. S. Salk, P. D. Parr, M. G. Ryon, and N. R. Giffen. *Invasive Plant Management Plan for the Oak Ridge Reservation.* ORNL/TM-2004/98/R1. Oak Ridge National Laboratory, Oak Ridge, Tennessee (2011).

Ryon et al. 2007. Ryon, M. J., P. D. Parr, and K. Cohen. *The Native Grass Community Management Plan for the Oak Ridge Reservation*. ORNL/TM-2007/38. Oak Ridge National Laboratory, Oak Ridge, Tennessee (2007).

TDEC 2014. *The Status of Water Quality in Tennessee*. 305b Report. Tennessee Department of Environment and Conservation, Division of Water Resources, Nashville, Tennessee. (https://www.tn.gov/content/dam/tn/environment/water/documents/wr_wq_report-305b-2014.pdf)

TDEC 2020. *Posted Streams, Rivers, and Reservoirs in Tennessee*. Tennessee Department of Environment and Conservation, Division of Water Resources, Nashville, Tennessee. (https://www.tn.gov/content/dam/tn/environment/water/planning-and-standards/wr_wq_fish-advisories.pdf)