6. Oak Ridge Reservation Environmental Monitoring Program

In addition to environmental monitoring conducted at the three major Oak Ridge DOE installations, reservationwide environmental monitoring is performed to measure radiological and nonradiological parameters directly in environmental media adjacent to the facilities. Data from the ORR-wide environmental monitoring program are analyzed to assess the environmental impact of DOE operations on the entire reservation and the surrounding area. Dose assessment information based on data from this program is presented in Chapter 7.

Because of differing permit reporting requirements and instrument capabilities, various units of measurement are used in this report. The list of units of measure and conversion factors provided on pages xxvii and xxviii is intended to help readers convert numeric values presented herein as needed for specific calculations and comparisons.

6.1 Meteorological Monitoring

Nine meteorological towers provide data on meteorological conditions and on the transport and diffusion qualities of the atmosphere on the 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 potential accidental releases from a facility. Data from the towers are also used to support various research and engineering projects.

6.1.1 Description

The nine meteorological towers on ORR are described in Table 6.1 and depicted in Fig. 6.1. In this document, the individual ORR-managed towers are designated by "MT" followed by a numeral; however, other commonly used names for the sites are provided in Table 6.1. Meteorological data are collected at different levels above the ground (2, 10, 15, 30, 33, 35, 60, and 100 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 as well as 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 m level at most towers, but the lowest wind measurement height is 15 m for MT2, MT3, and MT9, and 25 m for MT11. Additionally, data are collected at selected towers at the 30, 33, 35, and 60 m levels. At each measurement level except 2 m, temperature, wind speed, and wind direction are measured. Atmospheric stability (a measure of vertical mixing properties of the atmosphere) is measured at most towers; however, measurements involving vertical temperature profiles (SRDT method) limit accurate determination of nighttime stability to those towers that are 60 m in height. Since May 2014, measurement of stability using the sigma phi method is now being conducted at Tower MT2 ("D"), which does not require dependence on vertical temperature profile measurements. Barometric pressure is measured at one or more of the towers at each ORR plant (MT1, MT2, MT4, MT6, MT7, and MT9). Precipitation is measured at MT6 and MT9 at Y-12, at MT1 and MT7 at ETTP, and at MT2 and MT4 at ORNL. Solar radiation is measured at MT6 and MT9 at Y-12, at MT1 and MT7 at ETTP, and at MT2 at ORNL. Data are collected at 1 second intervals and averaged for 1, 15, and 60 min intervals. Calibrations of the instruments are managed by UT-Battelle and

B&W Y-12 and were performed every 6 months by an independent auditor (Holian Environmental for ORNL and ETTP and CB&I for Y-12).

In addition to the meteorological towers, SOnic Detection And Ranging (SODAR) devices have been installed at the east end of Y-12 and adjacent to Tower MT2 at ORNL. These devices use acoustic waves to estimate wind direction, wind speed, and turbulence at altitudes higher than the reach of meteorological towers (60–500 m above ground level). Although SODAR measurements are somewhat less accurate than measurements made on the meteorological towers, 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 would be mixed by turbulence within 1 h or less.

Table 6.1. Oak Ridge Reservation meteorological towers

Tower	Alternate tower names	Location (latitude, longitude)	Altitude (m MSL)	Measurement heights (m)
		ETTP		
MT1	"K," 1208	35.93317N, -84.38833W	263	10, 60
MT7	"L," 1209	35.92522N, -84.39414W	233	10, 30
		ORNL		
MT2	"D"*, 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	10, 30
MT10	"M," 208A	35.90947N, -84.38796W	244	10
		Y-12		
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	35.98190 N,-84.25504W	352	25

Acronyms
ETTP = East Tennessee Technology Park
MSL = mean sea level
ORNL = Oak Ridge National Laboratory
PSS = Plant Shift Superintendent
Y-12 = Y-12 National Security Complex
*Tower "C" before May 2014 with measurement heights of 10, 30, and 100 m.

Data are collected in real time for 1 min, 15 min, and hourly average intervals for emergency-response purposes, including dispersion modeling at the ORNL and Y-12 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 invalid and are excluded from compliance modeling. Appropriate substitution data is identified when possible. Quality assurance records of missing and erroneous data are routinely kept for the nine DOE-managed towers.

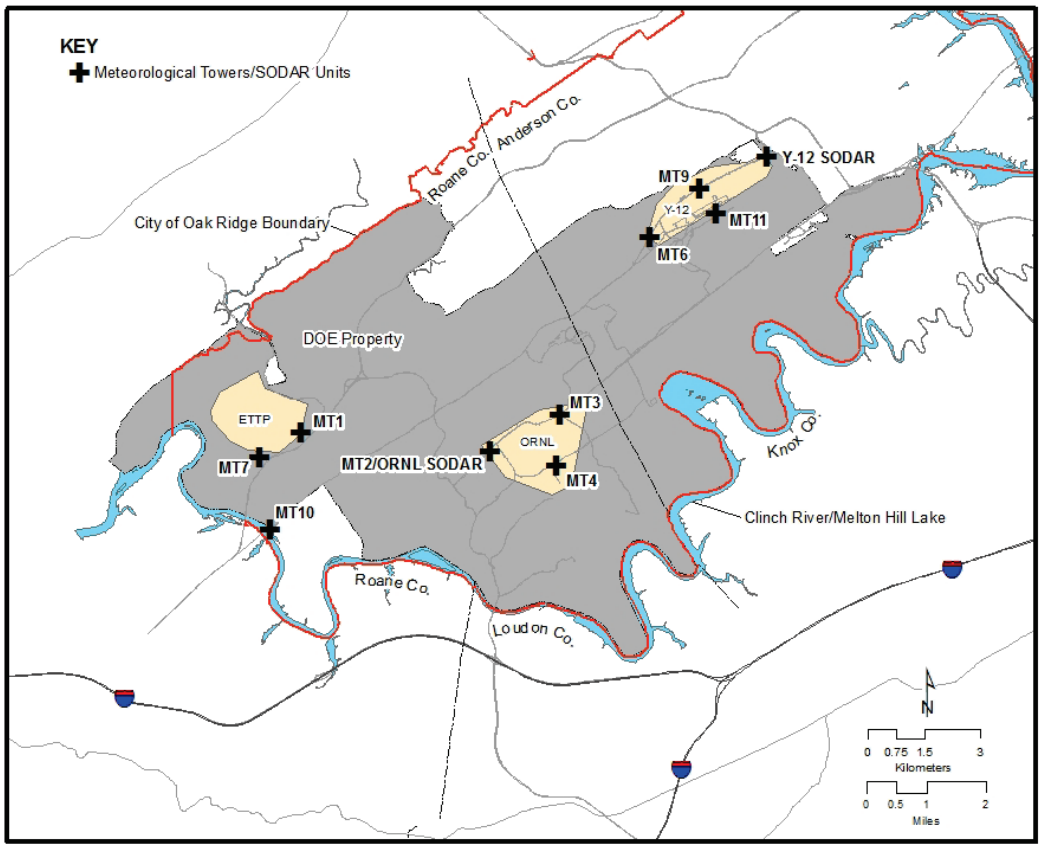

Fig. 6.1. The Oak Ridge Reservation meteorological monitoring network, including SODAR (sonic detection and ranging) devices.

6.1.2 Meteorological Impacts on Modeling 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 ridges flanking the ORR sites. Winds in the valleys tend to follow the ridge axes, limiting cross-ridge flow within local valley bottoms. These conditions dominate over most of ORR, but less so at ETTP, which is located in a less constrained open valley bottom, resulting in greater flow variation.

On the ORR, low-speed winds dominate near the valley surfaces, largely because of the decelerating influence of nearby ridges and mountains. Wind acceleration sometimes is observed at ridge-top 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 pollutants emitted from the facilities. However, high roughness values (caused by terrain and obstructions such as trees and buildings) partially mitigate these factors through increased turbulence processes (atmospheric mixing). These features are captured in data input to dispersion models and are reflected in modeling studies conducted for each facility.

Precipitation data from tower 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 thunderstorms. The total precipitation in Oak Ridge (townsite) during 2014 (1,338 mm or 52.64 in.) was within 5% of the long-term average of 1,294 mm (50.91 in.).

The average data recovery rates (a measure of acceptable data) across locations used for modeling during 2014 were greater than 97% for wind sensors at the ORNL sites (towers MT2, MT3, MT4, and MT10); however, there were problems with a few sensors at towers MT2 and MT4. Because of structural problems, tower MT2 was replaced in May 2014 because it had been deemed unsafe for climbing. Therefore, some sensors at the 30 and 100 m levels could not be reached for repair during January to April 2014, and the recovery rate for 100 m temperature data was between 75% and 80% for the year 2014 as a whole (acceptable substitution values were available from tower MT1 and other ambient meteorological data). Similarly, the temperature sensors at tower MT4 were affected by electrical problems during the January–April 2014 period, and thus the data recovery rates for temperature at tower MT4 were between 75% and 80%. All other tower MT2 and MT4 instrument recoveries were well above 90% for both quarterly and annual values.

Annual data recovery from ETTP meteorological towers during 2014 ranged from 99% to 100% (towers MT1 and MT7). Y-12 sites (towers MT6, MT9, and MT11) also had recovery rates ranging from 99% to 100% during 2014.

6.2 External Gamma Radiation Monitoring

6.2.1 Data Collection and Analysis

External gamma exposure rates are continuously recorded at six ORR AASs (Fig. 6.2). During 2014, the high-pressure ion chamber (HPIC) detectors, which have been used since the early 1990s, were replaced with dual range Geiger–Müller (GM) tube detectors. HPIC and GM detectors are based on different principles of operation and therefore vary in terms of sensitivity, accuracy, reliability, cost, and portability. In general, HPIC instruments are more accurate, whereas GM-type detectors have greater sensitivity and are more rugged and less expensive. Instrument replacement began at Station 39 in June 2014, and the remaining instruments were installed between July and November 2014. Table 6.2 summarizes the data for each station.

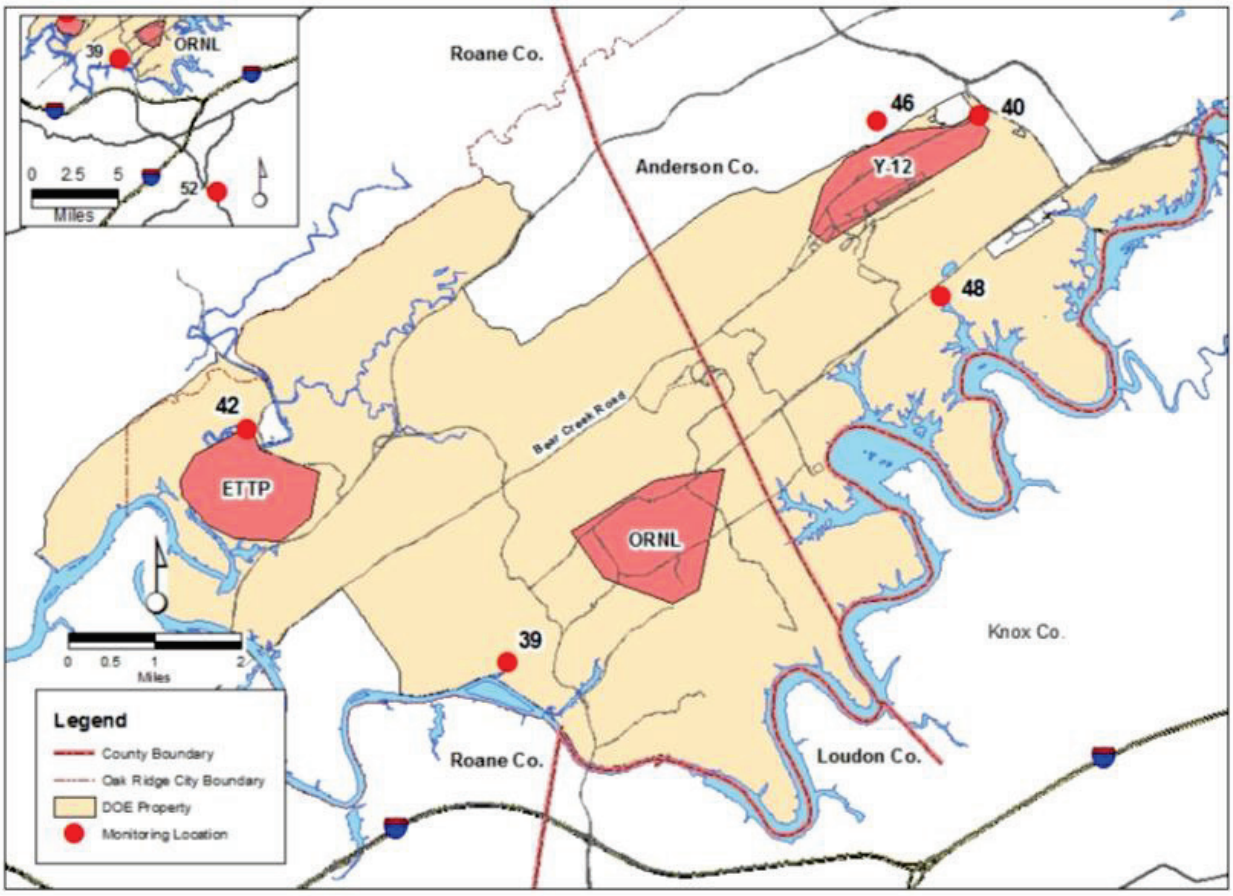

Fig. 6.2. External gamma radiation monitoring locations on the Oak Ridge Reservation.

Table 6.2. External gamma (exposure rate) averages for the Oak Ridge Reservation, 2014

Monitoring location	HPIC detector (µR/h)				GM detector (µR/h)			
	Number of data points (weekly)	Min	Max	Mean	Number of data points (daily)	Min	Max	Mean
39	23	*8.9*	9.3	9.1	197	11.1	13.2	11.9
40	28	*7.4*	8.2	7.9	162	9.7	11.6	10.4
42	37	*6.5*	8.2	7.4	89	8.9	10.7	9.6
46	27	*8.6*	8.9	8.7	133	9.5	12.2	11.0
48	26	*6.9*	8.1	7.2	147	9.4	11.3	9.9
52	43	*6.4*	7.3	6.9	50	9.0	10.7	9.6

Acronyms

GM = Geiger-Muller (tube for detection of ionizing radiation)
HPIC = high-pressure ion chamber

6.2.2 Results

The mean exposure rate for the reservation network calculated from measurements taken with the HPIC instrumentation in 2014 was 8.1 μR/h, and the average at the reference location was 6.9 μR/h. The mean exposure rate from measurements taken with the newly installed GM instrumentation was 10.6 μR/h, and the average at the reference location was 9.6 μR/h. Exposure rates from background sources in Tennessee range from 2.9 to 11 μR/h. Since the new instruments were not operational for the entire year and were installed at different times at each location, data analysis to determine the effects of variation in instrument sensitivity and accuracy, and efforts to resolve some questions and issues regarding operating status, are ongoing.

6.3 Ambient Air Monitoring

In addition to exhaust stack monitoring conducted at the DOE Oak Ridge installations, ambient air monitoring is performed to measure radiological parameters directly in the ambient air adjacent to the facilities (Fig. 6.3). 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.

Fig. 6.3. Oak Ridge Reservation ambient air station.

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

6.3.1 Oak Ridge Reservation Ambient Air Monitoring

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 ORR perimeter air monitoring network includes stations 35, 37, 38, 39, 40, 42, 46,

and 48 (Fig. 6.4). Reference samples are collected from Station 52 (Fort Loudoun Dam). Sampling was conducted at each ORR station during 2014 to quantify levels of alpha-, beta-, and gamma-emitting radionuclides.

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 in the vicinity of ORR should receive a radiation dose greater than doses calculated at the sampled locations.

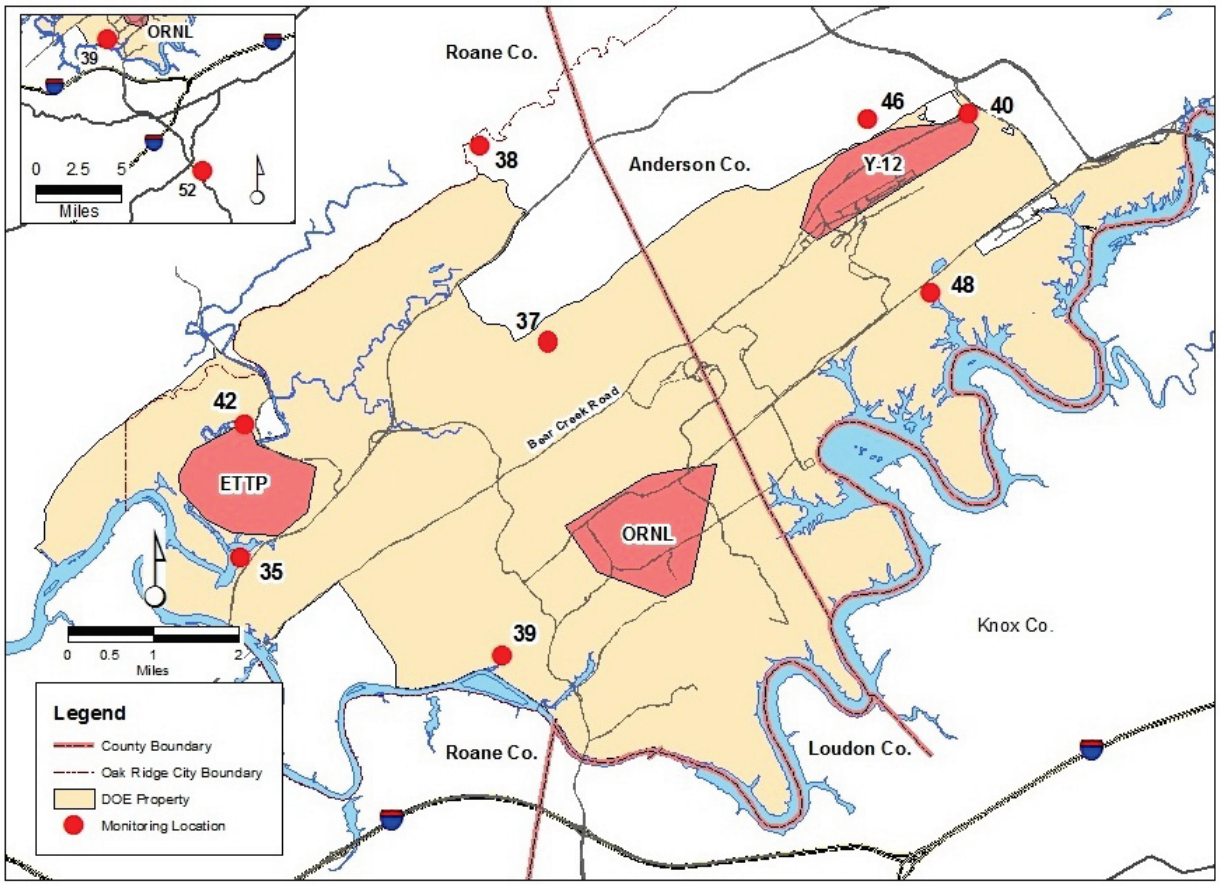

Fig. 6.4. Locations of Oak Ridge Reservation perimeter air monitoring stations.

The sampling system consists of two separate instruments. Particulates are captured by high-volume air samples equipped with glass-fiber filters. The filters are collected weekly, composited quarterly, and then submitted to an analytical laboratory to quantify gross alpha and 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.

6.3.2 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 6.3) is compared with DCSs for air established by DOE as guidelines for controlling exposure to members of the public. All radionuclide

concentrations measured at the ORR AASs during 2014 were less than 1% of applicable DCSs, indicating that activities on the reservation are not adversely affecting local air quality.

Table 6.3. Average radionuclide concentrations at Oak Ridge Reservation perimeter air monitoring stations, 2014

Parameter	N detected/N total	Concentration (pCi/mL)		
		Average	Minimum	Maximum
		Station 35		
^{7}Be	4/4	2.27E-08	1.41E-08	2.82E-08
^{40}K	0/4	-2.80E-11	-8.81E-10	2.95E-10
^{99}Tc	1/2	3.20E-10	1.29E-10	5.11E-10
^{3}H	0/4	2.04E-06	1.35E-07	5.57E-06
^{234}U	4/4	2.04E-12	1.05E-12	4.31E-12
^{235}U	1/4	1.69E-13	3.99E-14	3.20E-13
^{238}U	4/4	1.51E-12	1.00E-12	2.10E-12
		Station 37		
^{7}Be	4/4	2.39E-08	2.04E-08	2.88E-08
^{40}K	0/4	3.96E-10	-2.53E-10	1.93E-09
^{99}Tc	2/2	1.70E-10	1.35E-10	2.06E-10
^{3}H	0/4	3.75E-07	-4.09E-07	1.91E-06
^{234}U	4/4	2.06E-12	1.38E-12	3.17E-12
^{235}U	1/4	9.59E-14	-6.94E-14	2.87E-13
^{238}U	4/4	1.25E-12	7.07E-13	1.95E-12
		Station 38		
^{7}Be	4/4	3.39E-08	2.33E-08	5.06E-08
^{40}K	0/4	-1.62E-10	-6.67E-10	2.07E-10
^{99}Tc	2/2	2.03E-10	1.93E-10	2.13E-10
^{3}H	2/4	4.79E-06	4.30E-07	1.19E-05
^{234}U	4/4	1.92E-12	1.44E-12	2.30E-12
^{235}U	1/4	1.96E-13	0	4.04E-13
^{238}U	4/4	1.81E-12	1.53E-12	2.18E-12
		Station 39		
^{7}Be	4/4	3.07E-08	2.26E-08	4.03E-08
^{40}K	0/4	9.22E-10	-4.15E-10	4.60E-09
^{99}Tc	0/2	1.43E-10	1.04E-10	1.81E-10
^{3}H	0/4	2.61E-06	1.84E-06	3.55E-06
^{234}U	4/4	1.67E-12	1.34E-12	2.07E-12
^{235}U	1/4	1.10E-13	3.93E-14	2.71E-13
^{238}U	4/4	1.29E-12	1.03E-12	1.53E-12
		Station 40		
^{7}Be	4/4	3.10E-08	2.09E-08	4.13E-08
^{40}K	0/4	1.55E-10	-2.95E-10	5.43E-10
^{99}Tc	1/2	1.14E-10	2.22E-11	2.06E-10
^{3}H	0/4	4.15E-06	-7.20E-08	1.12E-05
^{234}U	4/4	1.58E-11	6.42E-12	3.59E-11
^{235}U	3/4	8.73E-13	3.27E-13	1.67E-12
^{238}U	4/4	2.18E-12	1.22E-12	2.87E-12

Table 6.3 (continued)

Parameter	N detected/N total	Concentration (pCi/mL)		
		Average	Minimum	Maximum
		Station 42		
^{7}Be	4/4	2.80E-08	2.36E-08	3.71E-08
^{40}K	0/4	9.39E-10	-1.95E-10	3.43E-09
^{99}Tc	1/2	1.52E-10	8.24E-11	2.21E-10
^{3}H	0/4	2.92E-06	-6.72E-07	8.79E-06
^{234}U	4/4	2.34E-12	1.56E-12	4.12E-12
^{235}U	1/4	1.36E-13	6.11E-14	1.80E-13
^{238}U	4/4	1.45E-12	1.14E-12	1.61E-12
		Station 46		
^{7}Be	4/4	2.68E-08	2.08E-08	2.91E-08
^{40}K	0/4	7.37E-11	-2.38E-10	7.54E-10
^{99}Tc	0/2	7.06E-11	1.49E-11	1.26E-10
^{3}H	1/4	5.28E-06	2.10E-06	8.64E-06
^{234}U	4/4	4.40E-12	2.32E-12	7.25E-12
^{235}U	1/4	1.66E-13	1.18E-13	2.09E-13
^{238}U	4/4	1.68E-12	1.20E-12	2.61E-12
		Station 48		
^{7}Be	4/4	3.70E-08	3.08E-08	4.13E-08
^{214}Bi	1/4	5.30E-11	0[a]	2.12E-10
^{40}K	0/4	-1.26E-10	-4.99E-10	2.04E-10
^{99}Tc	1/2	1.44E-10	4.81E-11	2.39E-10
^{3}H	1/4	5.24E-06	3.78E-06	6.74E-06
^{234}U	4/4	2.83E-12	2.45E-12	3.18E-12
^{235}U	1/4	1.50E-13	6.98E-14	2.23E-13
^{238}U	4/4	2.39E-12	1.56E-12	3.68E-12
		Station 52		
^{7}Be	4/4	2.87E-08	2.40E-08	3.79E-08
^{40}K	0/4	2.60E-11	-1.87E-10	3.03E-10
^{99}Tc	1/2	1.44E-10	-2.57E-11	3.14E-10
^{3}H	0/4	2.95E-06	1.61E-07	8.76E-06
^{234}U	4/4	2.98E-12	2.26E-12	4.10E-12
^{235}U	2/4	3.50E-13	1.90E-13	6.27E-13
^{238}U	4/4	2.16E-12	1.75E-12	2.87E-12

[a]Bismuth-214 detected and reported in the fourth quarter of 2014. Bismuth-214 was not detected or reported for other 2015 sampling events.

6.4 Surface Water Monitoring

6.4.1 Oak Ridge Reservation Surface Water Monitoring

The ORR surface water monitoring program consists of sample collection and analysis from five locations on the Clinch River, including public water intakes (Fig. 6.5). This 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.

Grab samples are collected quarterly at all five locations and are analyzed for general water quality parameters, screened for radioactivity, and analyzed for mercury and specific radionuclides when appropriate. Table 6.4 lists the specific locations and associated sampling frequencies and parameters.

The sampling locations are classified by the State of Tennessee for recreation and domestic use. Tennessee WQCs associated with these classifications are used as references where applicable (TDEC 2008). The Tennessee WQCs do not include criteria for radionuclides. Four percent of the DOE DCS is used for radionuclide comparison because this value is roughly equivalent to the 4 mrem dose limit from ingestion of drinking water on which the EPA radionuclide drinking water standards are based.

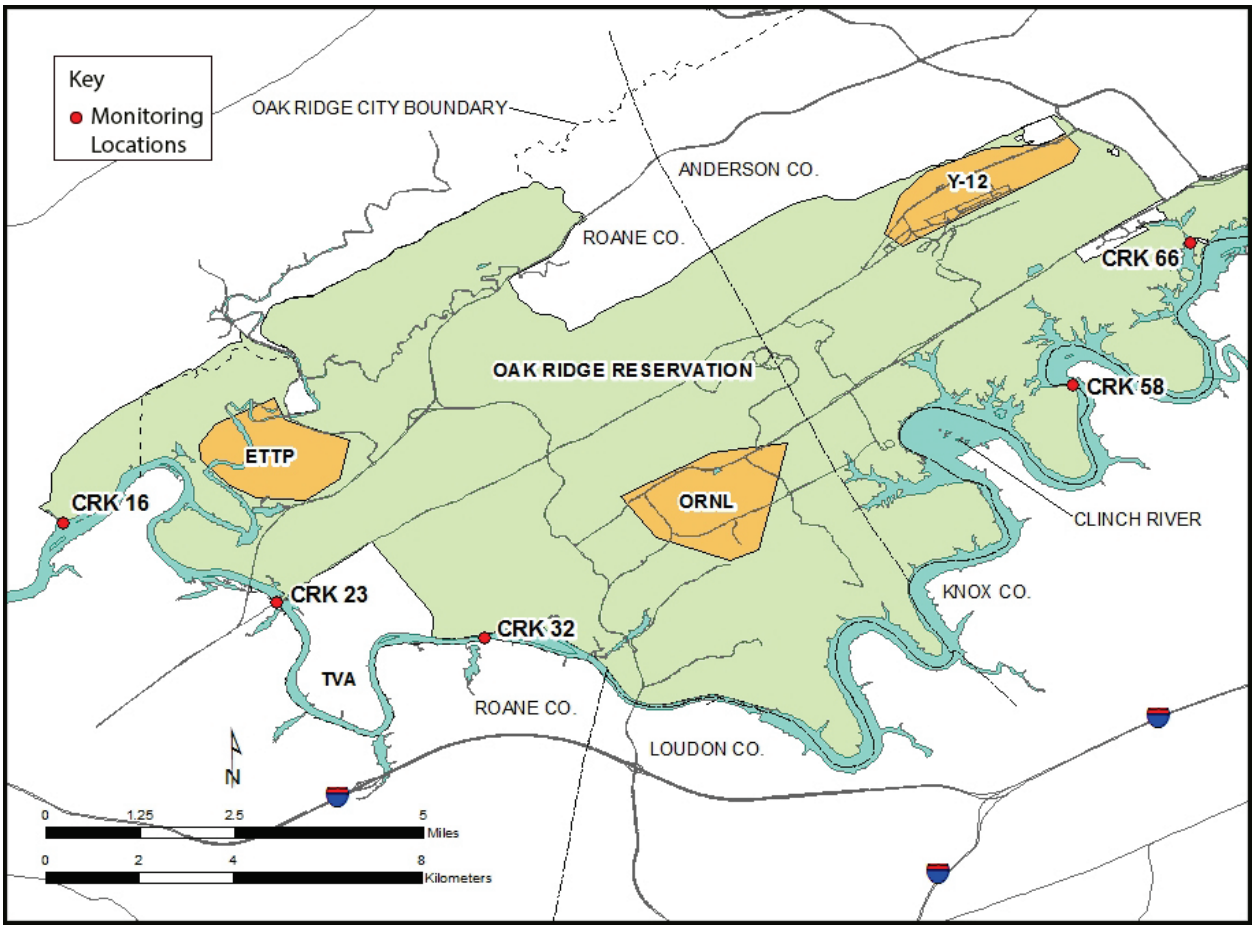

Fig. 6.5. Oak Ridge Reservation surface water surveillance sampling locations.

Table 6.4. Oak Ridge Reservation surface water sampling locations, frequencies, and parameters, 2014

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 23	Water supply intake for ETTP	Quarterly	Mercury, gross alpha, gross beta, gamma scan, ^{3}H, field measurements[b]
CRK 32	Clinch River downstream from ORNL	Quarterly	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, Watts Bar Reservoir).
[b]Field measurements consist of dissolved oxygen, pH, and temperature.

Acronyms
CRK = Clinch River kilometer
DOE = US Department of Energy
ETTP = East Tennessee Technology Park
ORNL = Oak Ridge National Laboratory
ORR = Oak Ridge Reservation

6.4.2 Results

A comparison of 2014 sampling results for surface water collected upstream of DOE inputs with surface water collected downstream of DOE inputs shows no statistically significant difference for any of the radionuclides. None of the radionuclides at any location were detected above 4% of the respective DCS or the 4 mrem dose limit, which is the MCL for beta and photon emitters in community drinking water systems (40 CFR 141.66, *Maximum Contaminant Levels for Radionuclides*). There were no mercury detections above MCLs at any of the three designated sampling locations.

6.5 Groundwater Monitoring

In 2014, a team of representatives from DOE EM, EPA, TDEC, and US Geological Survey developed strategy recommendations for future ORR groundwater characterization and monitoring that included the following.

- Establishment of a DOE ORR Groundwater Program to systematically prioritize and investigate groundwater plumes and data gaps.
- Data Quality Objectives workshops to define the type, quality, and quantity of data needed to evaluate off-site groundwater quality and movement. DOE is not aware of any adverse health effects from off-site groundwater. Sampling will be performed in 2015 in accordance with an approved work plan. After sampling and laboratory analysis are complete, results will be evaluated to determine if any follow-on actions are necessary.
- Initiation of efforts to develop an ORR-wide regional flow model. The model will serve as an underlying framework to support future cleanup decisions and actions.

6.6 Food

Vegetation samples are collected from areas that could be affected by activities on the reservation. The samples are analyzed to evaluate the potential radiation doses to people who consume local food crops. Food crop monitoring data are also used to monitor trends in environmental contamination and possible long-term accumulation of radionuclides.

6.6.1 Vegetables

Tomatoes, lettuce, and turnips were purchased from farms near ORR. The locations were chosen based on availability and on the likelihood of their being affected by routine releases from the Oak Ridge facilities.

6.6.1.1 Results

Samples were analyzed for gross alpha, gross beta, gamma emitters, and uranium isotopes. No gamma-emitting radionuclides were detected above the minimum detectable activity (MDA), with the exception of the naturally occurring radionuclides ^{7}Be and ^{40}K. Concentrations of radionuclides detected above MDA are shown in Table 6.5.

Table 6.5. Concentrations of radionuclides detected in vegetables, 2014 (pCi/kg)[a]

Location	Gross alpha	Gross beta	^{7}Be	^{40}K	^{234}U	^{235}U	^{238}U
			Lettuce				
East of Y-12, Claxton vicinity	*b*	0.00353	*b*	0.00402	0.00000754	*b*	0.00000651
West of ETTP	*b*	0.0047	*b*	0.00541	0.00000562	*b*	0.0000101
North of Y-12	*b*	0.00312	*b*	0.00413	0.00000344	*b*	0.00000376
South of ORNL	*b*	0.0035	*b*	0.00576	0.00000274	*b*	0.000000856
Southwest of ORNL, Lenoir City	*b*	0.00213	*b*	0.00384	*b*	0.000000879	0.00000149
Reference location, Maryville	*b*	0.00328	*b*	0.00455	*b*	*b*	*b*
			Tomato				
East of Y-12, Claxton vicinity	*b*	0.00419	*b*	0.00109	0.00000302	*b*	*b*
West of ETTP	*b*	0.000812	*b*	0.00187	0.00000234	*b*	*b*
North of Y-12	*b*	0.000483	*b*	*b*	0.00000158	*b*	*b*
South of ORNL	*b*	0.00109	*b*	0.00153	0.00000215	0.00000126	*b*
Southwest of ORNL, Lenoir City	*b*	0.00117	*b*	0.00151	*b*	*b*	*b*
Reference location, Maryville	*b*	0.000727	*b*	0.00188	*b*	*b*	0.00000139

Table 6.5 (continued)

Location	Gross alpha	Gross beta	^{7}Be	^{40}K	^{234}U	^{235}U	^{238}U
			Turnips				
East of Y-12, Claxton vicinity	*b*	0.00252	*b*	0.00292	*b*	*b*	*b*
West of ETTP	*b*	0.00313	*b*	0.00228	*b*	*b*	*b*
North of Y-12	*b*	0.00344	*b*	0.00297	*b*	*b*	*b*
South of ORNL	*b*	0.00215	*b*	0.00315	*b*	*b*	*b*
Southwest of ORNL, Lenoir City	*b*	0.00203	*b*	0.00232	*b*	*b*	*b*
Reference location, Maryville	*b*	0.00261	*b*	0.00428	*b*	*b*	*b*

[a]Detected radionuclides are those at or above minimum detectable activity. 1 pCi = 3.7×10^{-2} Bq.
[b]Value was not above minimum detectable activity.

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

6.6.2 Milk

Radionuclides can be transferred from the environment to people via such food chains as the grass–cow–milk pathway. Milk is a potentially significant source to humans of 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.

Information from county extension offices in counties where milk production could be impacted by activities on ORR is reviewed periodically to identify local dairy operations that could provide milk samples for this program.

The 2014 milk sampling program consisted of grab samples collected every other month from a dairy in Claxton and one reference location in Maryville (Fig. 6.6). Milk samples are analyzed for gamma emitters and for total radioactive strontium (^{89}Sr + ^{90}Sr) by chemical separation and low-background beta counting. Liquid scintillation is used to analyze for tritium.

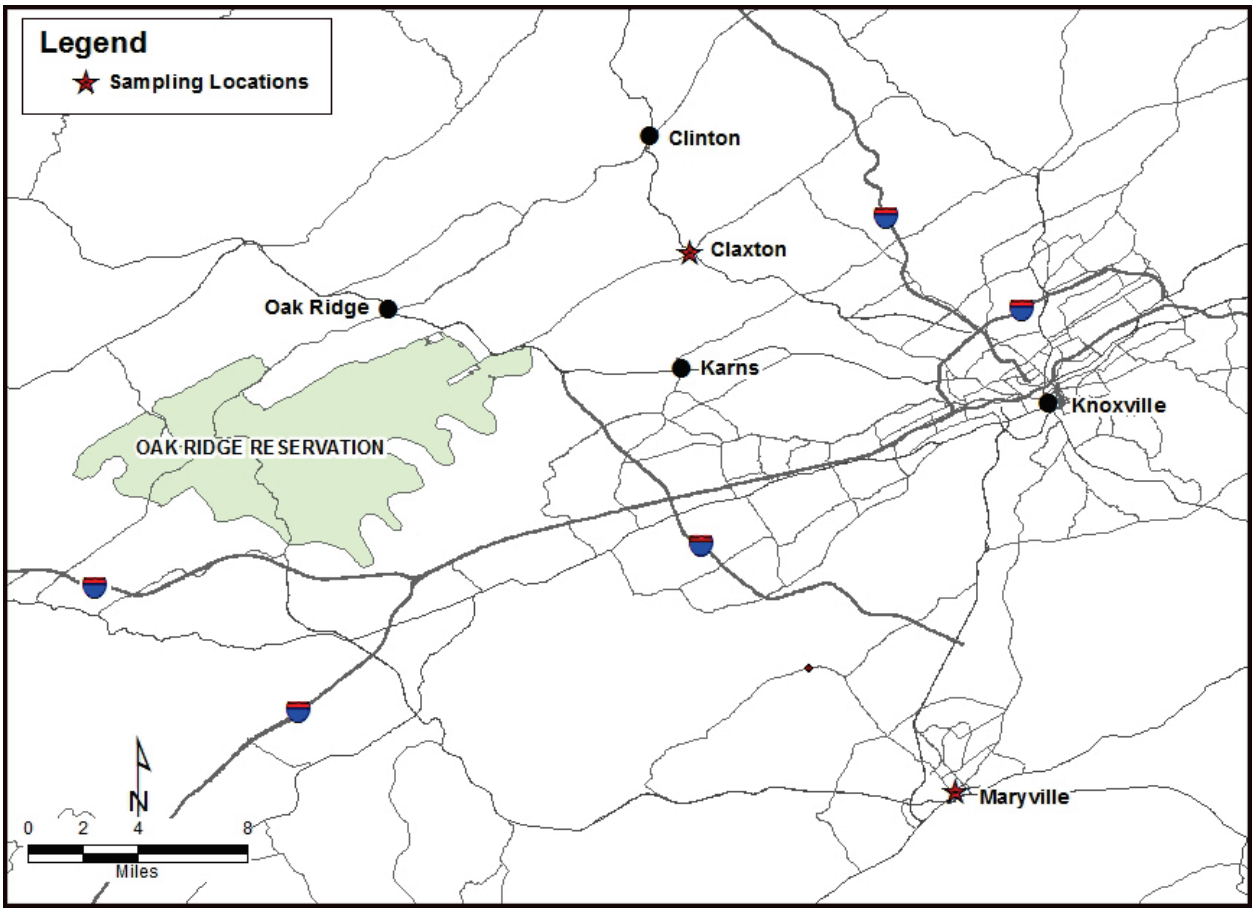

Fig. 6.6. Milk sampling locations in the vicinity of the Oak Ridge Reservation.

6.6.2.1 Results

Concentrations of radionuclides detected above MDA in milk are presented in Table 6.6. Potassium-40 was detected at both locations for each sampling event and total radioactive strontium was detected twice at each location. In the last sampling event of the year, ^{214}Bi was detected in the milk from the Claxton location; it is thought that this sample was exposed to a dusty area at some point. While an animal would consume bismuth (from the grass), it is not thought that it would pass on to the milk production.

Comparing results for milk collected from the Claxton dairy with those for milk collected from the reference location dairy shows no statistical difference for any radionuclide except ^{214}Bi.

Table 6.6. Concentrations of radionuclides detected in raw milk, 2014

Analysis	Number detected/ total number	Detected concentration (pCi/L)[a]			Standard error of mean
		Maximum	Minimum	Average	
		Claxton			
^{214}Bi	1/6	J22[b]	*nd*[c]	3.6	3.6
^{40}K	6/6	1,400[b]	1,100[b]	1,300[b]	40
		Reference location			
^{40}K	6/6	1,400[b]	1,300[b]	1,300[b]	22

[a]Detected radionuclides are those above minimum detectable activity. 1 pCi = 3.7×10^{12} Bq.
[b]Individual and average concentrations significantly greater than zero at the 95% confidence level.
[c]Not detected and not reported by the gamma scan in the first five sampling events of the year.

6.7 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 analyzing edible flesh for specific contaminants. The locations are as follows (Fig. 6.7):

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

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 2014, a composite sample of each of these species at each location was analyzed for selected metals, 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.

It should be noted that TDEC issues advisories on consumption of certain fish species caught in specified Tennessee waters. These advisories apply to fish that could contain potentially hazardous contaminants. A "do not consume" advisory has been issued by TDEC for catfish in the Melton Hill Reservoir in its entirety, not just in those areas that could be impacted 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 2008).

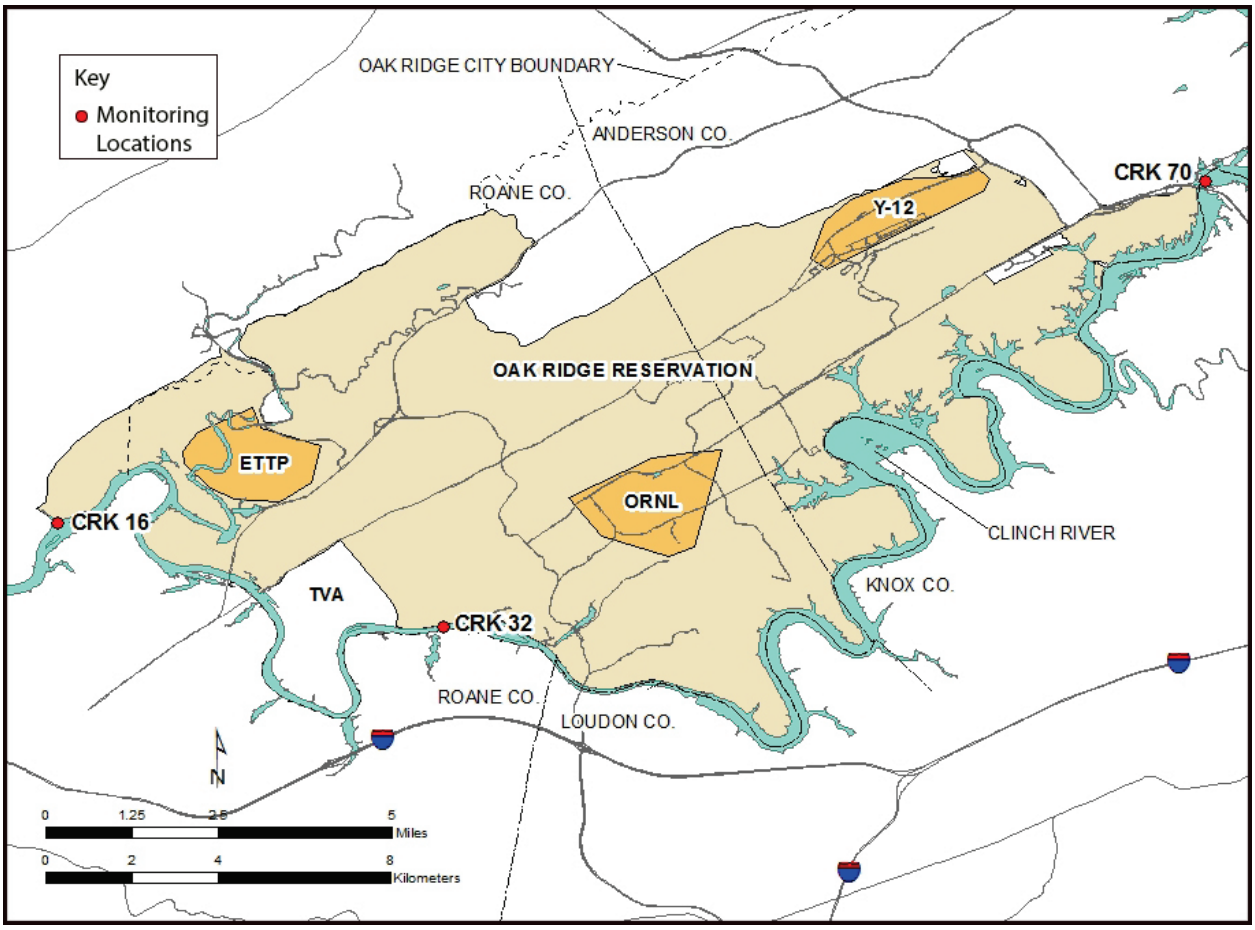

Fig. 6.7. Fish sampling locations for the Oak Ridge Reservation Surveillance Program.

6.7.1 Results

PCBs, specifically Aroclor-1260, and mercury were detected in both sunfish and catfish at all three locations in 2014. These results are consistent with the TDEC advisories discussed above. Detected PCBs, mercury, and radionuclides are shown in Table 6.7.

Radiological analyses for fish tissues sampled in 2014 showed few statistical differences (at the 95% confidence level) between the upstream and downstream locations, indicating that DOE activities on the ORR are not significant contributors to the public radiological dose from fish consumption.

Table 6.7. Tissue concentrations in catfish and sunfish for mercury, detected PCBs, and detected radionuclides, 2014[a]

Parameter	Catfish[b]	Sunfish[b]
Clinch River downstream from all DOE ORR inputs (CRK 16)		
Metals (mg/kg)		
Hg	0.18	0.11
Pesticides and PCBs (µg/kg)		
PCB-1260	99	36
Radionuclides (pCi/g)[b]		
Beta activity	3.2[c]	1.6[c]
^{40}K	3.4[c]	3.3[c]
^{90}Sr	0.38[c]	0.011[c]
Clinch River downstream from ORNL (CRK 32)		
Metals (mg/kg)		
Hg	0.39	0.047
Pesticides and PCBs (µg/kg)		
PCB-1260	80	39
Radionuclides (pCi/g)[b]		
Beta activity	3.0[c]	3.7[c]
^{0}K	2.9[c]	2.0[c]
^{90}Sr	0.13[c]	0.13[c]
Tritium	-0.064	2.3[c]
Clinch River (Solway Bridge) upstream from all DOE ORR inputs (CRK 70)		
Metals (mg/kg)		
Hg	0.091	0.04
Pesticides and PCBs (µg/kg)		
PCB-1260	110	20
Radionuclides (pCi/g)[b]		
Alpha activity	-0.0058	0.092[c]
Beta activity	3.2[c]	3.1[c]
^{40}K	3.3[c]	4.2[c]
^{90}Sr	0.14[c]	0.23[c]

[a]Only parameters that were detected for at least one species are listed in the table. The sampling and analysis plan contains a complete list of analyses performed.
[b]Radiological results are reported after background activity has been subtracted. Negative values are reported when background activity exceeds sample activity.
[c]Radionuclide concentrations were significantly greater than zero. Detected radionuclides are at or above the minimum detectable activity.

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

6.8 White-Tailed Deer

Three deer hunts took place on ORR during the final quarter of 2014. ORNL staff, Tennessee Wildlife Resources Agency (TWRA) personnel, and student members of the Wildlife Society (University of Tennessee chapter) performed most of the necessary operations at the checking station.

Shotgun/muzzleloader and archery hunts took place November 1–2, November 15–16, and December 13–14. About 450 shotgun/muzzleloader-permitted hunters and 600 archery-permitted hunters participated per weekend. Areas adjacent to the Tower Shielding facility, Park City Road and Chestnut Ridge, and Poplar Creek Road were opened for an archery-only hunt on the three weekends. The year's total harvest was 416 deer. From the total deer harvest, 252 (60.6%) were bucks, and 164 (39.4%) were does. The heaviest buck had eight antler points and weighed 156 lb. The greatest number of antler points found on one buck was 14. The heaviest doe weighed 115 lb.

Since 1985, 12,237 deer have been harvested. Of these, only 208 (1.7%) have been retained because of potential radiological contamination. The heaviest buck was 218 lb (harvested in 1998); the average weight is 82.0 lb. The oldest deer harvested was estimated to be 12 years old (harvested in 1989); the average age is 2.0 years. For more information, see the ORR hunt information website (http://web.ornl.gov/sci/rmal/hunts/).

6.8.1 Results

The wildlife administrative release limits associated with deer, turkey, and geese harvested on ORR are conservative and were established based on ALARA principles to ensure that doses to consumers of wildlife harvested on the reservation are managed and controlled to levels well below regulatory dose thresholds. The ALARA 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. The administrative release limit of 5 pCi/g for ^{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 this consumption pathway. Similarly, the gross beta count administrative limit of 2.5 times background is near the detection limit for field measurements.

Of the 416 deer harvested on ORR during the 2014 hunts, three (0.7%) were retained for exceeding the administrative release limits [1.5 times the background for beta activity in bone (~20 pCi/g) or 5 pCi/g of ^{137}Cs in edible tissue]. The retained deer exceeded the limit for beta-particle activity in bone.

6.9 Fowl

6.9.1 Waterfowl Surveys—Canada Geese

The consumption of Canada geese is a potential pathway for exposure of members of the public to radionuclides released from ORR operations because open hunts for Canada geese take place each year on ORR and in counties adjacent to the reservation. To determine concentrations of gamma-emitting radionuclides accumulated by waterfowl that feed and live on ORR, Canada geese are rounded up each summer for noninvasive gross radiological surveys.

6.9.1.1 Results

During the 2014 roundup, 17 geese were subjected to live whole-body gamma scans. The geese were collected from ORNL (*n*=14) and ETTP (*n*=3). Gamma scan results showed all 17 geese to be at least an order of magnitude (0.16–0.43 pCi/g) below the administrative release limit of 5 pCi/g.

The 5 pCi/g administrative release limit for ^{137}Cs discussed for deer is also applied to geese. This limit assumes that one person consumes all of the meat from a maximum-weight goose. The administrative limits were established to keep doses ALARA and to provide consistent standards for releasing harvested wildlife

6.9.2 Turkey Monitoring

Two wild turkey hunts managed by DOE and TWRA were held on the reservation (April 5–6 and April 12–13, 2014). Hunting was open for both shotguns and archery. Twenty-three turkeys were harvested, of which 3 (13.0%) were juveniles and 20 (87.0%) were adults. The average turkey weight was about 18.9 lb, with the largest weighing 23.6 lb. The longest beard was 11.5 in., and the average was 9.1 in. The longest spur was 1.3 in., and the average was 0.8 in.

6.9.2.1 Results

None of the 23 turkeys harvested in 2014 exceeded the administrative release limits established for radiological contamination. Since 1997, 767 turkeys have been harvested on spring turkey hunts. Five additional turkeys have been harvested (since 2012) by archery hunters during fall deer hunts. Of all turkeys harvested, only three (0.4%) have been retained because of potential radiological contamination. For additional information, see http://web.ornl.gov/sci/rmal/hunts/.

The 5 pCi/g administrative release limit for ^{137}Cs that is applied to deer and geese is also applied to turkey. This limit assumes that one person consumes all of the meat from a maximum-weight turkey. The administrative limits were established to keep doses ALARA and to provide consistent standards for releasing harvested wildlife.

6.10 Quality Assurance

The activities associated with administration, sampling, data management, and reporting for the ORR environmental surveillance programs are performed by the UT-Battelle EPSD. Project scope is established by a task team whose members represent DOE, UT-Battelle, CNS, and UCOR. UT-Battelle integrates quality assurance, environmental, and safety considerations into every aspect of ORR environmental monitoring. (See Section 5.7 for a discussion of UT-Battelle quality assurance program elements for environmental monitoring and surveillance activities.)

6.11 References

Bowen, B. M., J. A. Baars, and G. L. Stone. 2000. "Nocturnal wind shear and its potential impact on pollutant transport." *Journal of Applied Meteorology* **39**(3), 437–45.

TDEC. 2008. *The Status of Water Quality in Tennessee*. 305b Report. Tennessee Department of Environment and Conservation, Division of Water Pollution Control, Nashville, Tennessee.