6. ORR Environmental Monitoring Program

In addition to environmental monitoring conducted at the three major Oak Ridge DOE installations, reservation-wide 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

Eight 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 would be used in the event of accidental releases from a facility. Data from the towers are also used to support various research and engineering projects.

6.1.1 Description

The eight meteorological towers on the ORR are described in Table 6.1 and depicted in Fig. 6.1. The "MT" name format for the meteorological towers is used in this document; however, other commonly used names for the sites are provided in Table 6.1. Meteorological data are collected at different levels (2, 10, 15, 30, 33, 60, and 100 m above the ground) 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; see Appendix C) 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 all towers except Towers MT3 and MT9, where lower-level data are collected at 15 m. Additionally, at selected towers, data are collected at the 30-, 33-, 60-, and 100-m levels. At each measurement level, temperature, wind speed, and wind direction are measured. Data needed to determine atmospheric stability (a measure of vertical mixing properties of the atmosphere) are measured at most towers. Barometric pressure is measured at one or more of the towers at each facility (MT1, MT2, MT7, and MT9). Precipitation is measured at MT6 and MT9 at the Y-12 Complex, at MT1 and MT7 at the East Tennessee Technology Park (ETTP), and at MT2 and MT4 at Oak Ridge National Laboratory (ORNL). Solar radiation is measured at MT6 and MT9 at the Y-12 Complex, at MT1 and MT7 at the ETTP, and at MT2 at ORNL. Data are collected at 1-, 15-, and 60- min intervals. Quarterly calibrations of the instruments are managed by UT-Battelle and B&W Y-12.

In addition to the meteorological towers, sonic detection and ranging (SODAR) devices have been located at the east end of Y-12 and at Tower MT2 at ORNL. These devices use acoustic waves to estimate wind direction, wind speed, and turbulence at altitudes higher than the meteorological towers can measure (generally 100 to 400 m above ground level). Although the SODAR measurements are less accurate than meteorological tower measurements, the SODAR devices provide useful information regarding stability, upper air wind conditions, and mixing height. Mixing height is the depth of the air layer adjacent to the ground over which an emitted or entrained inert nonbuoyant tracer will be mixed (by turbulence) within a time scale of about 1 h or less.

Data are collected in real time at 15-min and hourly intervals for emergency-response purposes, such as for input to dispersion models. Data from the eight ORR meteorological towers are distributed to dispersion models at the ORNL and Y-12 Emergency Operations Centers.

Table 6.1. Oak Ridge Reservation meteorological towers

Tower	Alternate tower names	Location lat., long.	Altitude (m MSL[a])	Measurement heights (m)
		ETTP		
MT1	"K," 1208	35.93317N, 84.38833W	253	10, 60
MT7	"L," 1209	35.92522N, 84.39414W	233	10, 30
		ORNL		
MT2	"C," 1057	35.92559N, 84.32379W	261	10, 30, 100
MT3	"B," 6555	35.93273N, 84.30254W	256	15, 30
MT4	"A," 7571	35.92185N, 84.30470W	263	10, 30
MT10	"M," 208A	35.90947N, 84.38796W	237	10
		Y-12 Complex		
MT6	"W," West	35.98467N, 84.26550W	326	2, 10, 30, 60
MT9	"Y," PSS Tower	35.98745N, 84.25363W	290	15, 33

[a]Mean sea level.

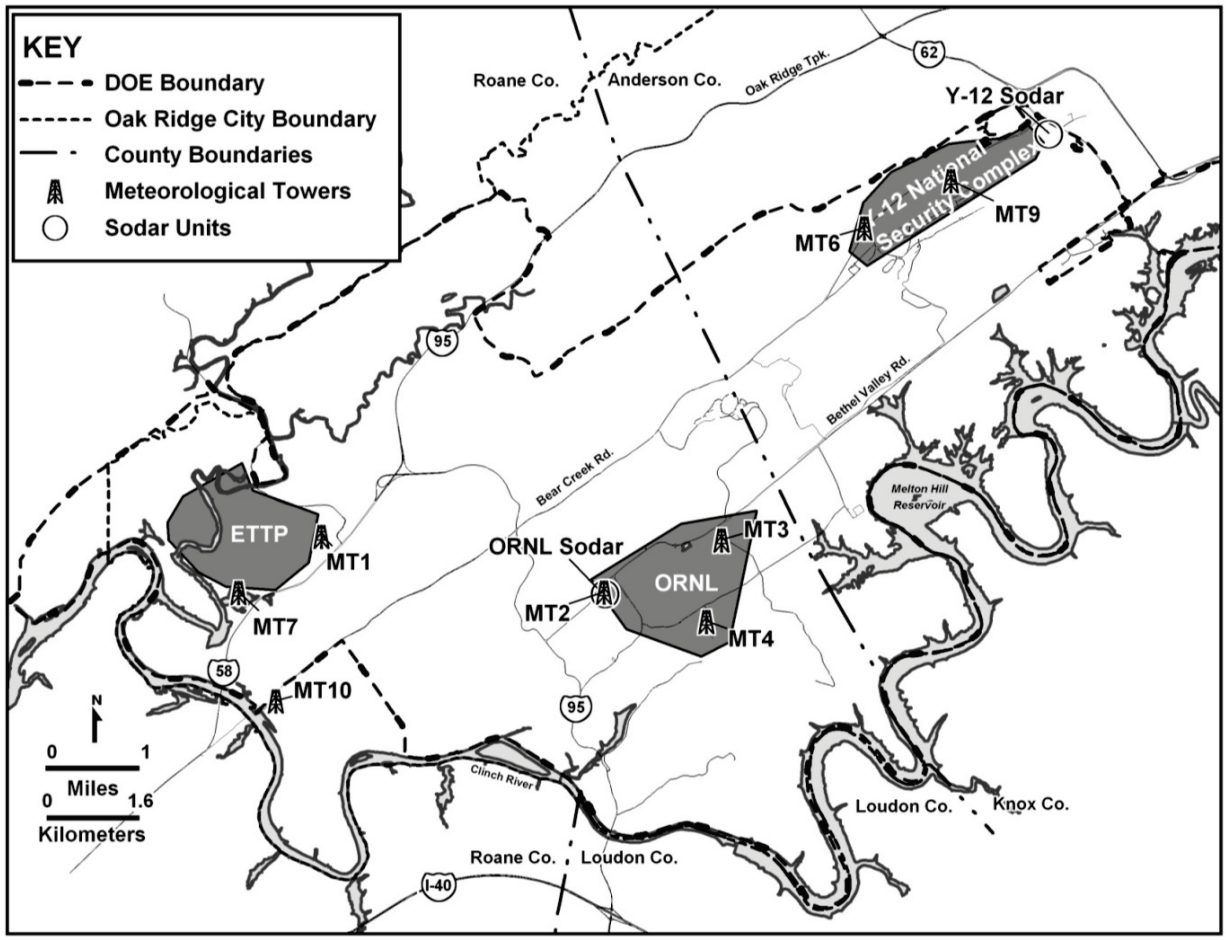

Fig. 6.1. The ORR meteorological monitoring network (SODAR: sonic detection and ranging wind profiler).

Annual dose estimates are calculated using 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. Quality assurance records of data problems and errors are routinely kept for all eight tower sites.

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. This pattern is often the result of the channeling effect of the ridges flanking the ORR sites. Winds in the valleys tend to follow the ridge axes, with limited cross-ridge flow within local valley bottoms. These conditions are dominant over most of the ORR, with the exception of the ETTP, which is located in a relatively open valley bottom (resulting in slightly more varied flow).

On the ORR, low-speed winds dominate near the surface. This characteristic is typical of most near-surface measurements (as influenced by nearby ridges and mountains). Winds sometimes accelerate at ridgetop level, particularly when winds are not exactly parallel to the ridges (see Appendix C).

The atmosphere over the ORR is dominated by stable conditions on most nights and for a few hours after sunrise. These conditions, when coupled with the low wind speeds and channeling effects of the valleys, result in poor dilution of material emitted from the facilities. However, high roughness values (caused by terrain and obstructions such as trees and buildings) may partially mitigate these factors through increased turbulence (atmospheric mixing). These features are captured in the data input to the dispersion models and are reflected in the 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 at Oak Ridge (town site) during 2010 (1,306 mm or 51.38 in.) was near the long-term average of 1,343 mm (52.85 in.), yielding only a 3% deficit compared with the 30-year means.

The average data recovery rates (a measure of acceptable data) across locations used for modeling during 2010 were greater than 98.7% for ORNL sites (Towers MT2, MT3, MT4, and MT10); greater than 97.9% for ETTP sites (Towers MT1 and MT7); and 99.2% for Y-12 sites (Towers MT6 and MT9). Nearly all data recovery locations exceeded the required 90% per quarter recovery rate. Those locations that did not exceed the requirement were (1) Tower MT4 10-m temperatures for 2010 Quarters 1 and 2 and (2) Tower MT7 for three weeks of data in the December 2010 4th Quarter. In the former case, temperature data were successfully substituted from Towers MT3/MT4. In the latter case, data recovery was only slightly below the 90% threshold (89.4 to 89.6%). Data loss for Tower MT7 during the 2010 4th Quarter was related to the transfer of electrical power service to the jurisdiction of the City of Oak Ridge.

6.2 External Gamma Radiation Monitoring

6.2.1 Data Collection and Analysis

External gamma measurements (exposure rates) are recorded weekly at six ambient air stations from resident external gross gamma monitors (Fig. 6.2). Each consists of a dual-range, high-pressure ion chamber sensor and digital electronic count-rate meter and a totalizer. Totalizing consists of multiplying the count rate by the time of exposure to obtain total exposure.

6.2.2 Results

Table 6.2 summarizes the data collected at each station during the year. Values in this table have previously been presented as dose rates but this year are reported as exposure rates, in μR/h, to more accurately present actual measured values. The mean observed exposure rate for the reservation network for 2010 was 7.9 μR/h, and the average at the reference location was 7.1 μR/h. Exposure rates from background sources in Tennessee range from 2.9 to 11 μR/h. The average ORR exposure rate was within the range of normal background levels in Tennessee, indicating that activities on the ORR do not increase external gamma levels in the area above normal background levels.

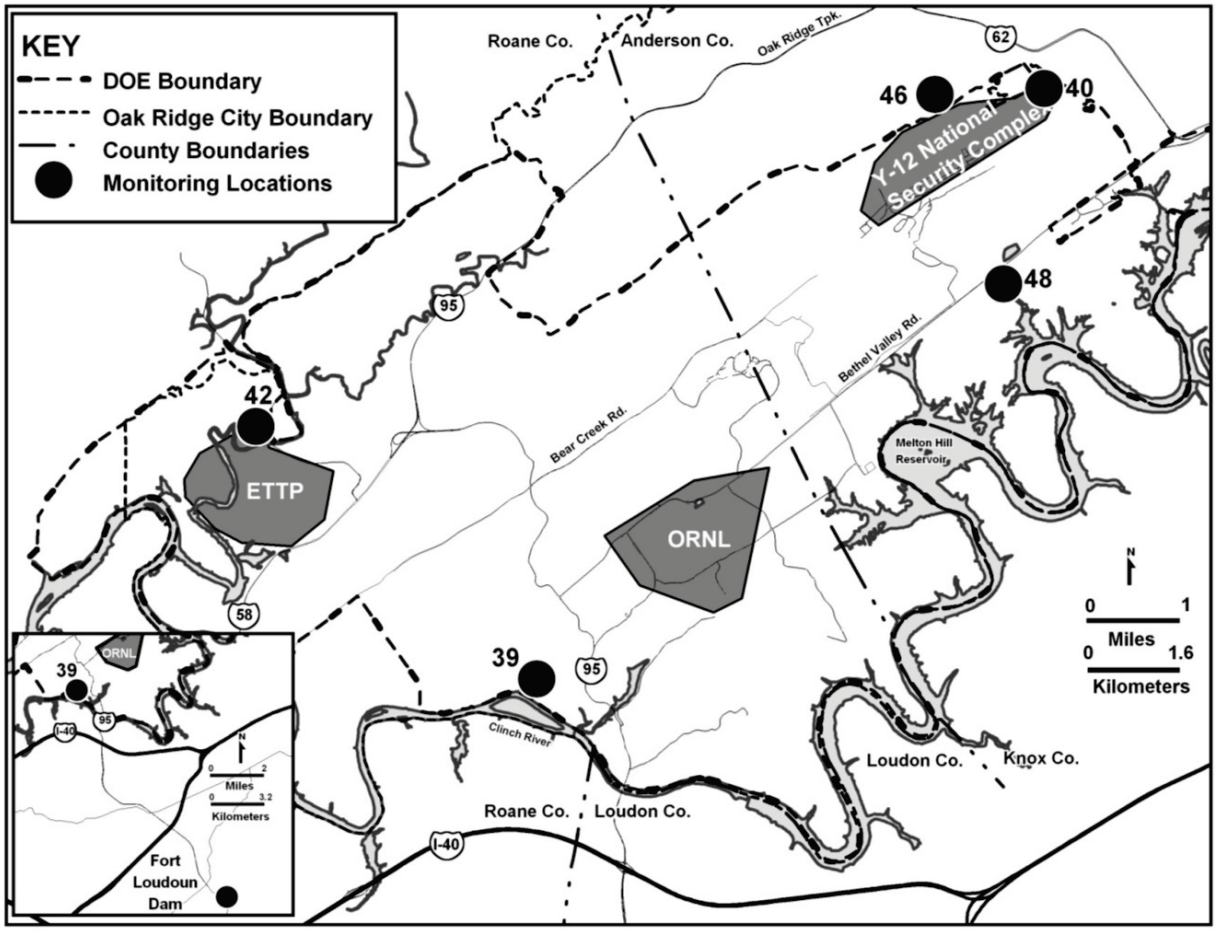

Fig. 6.2. External gamma radiation monitoring locations on the ORR.

Table 6.2. External gamma (exposure rates) averages for the ORR, 2010

Monitoring location	Number of data values collected	Measurement (μR/h)[a]		
		Min	Max	Mean
39	52	8.3	9.7	9.0
40	52	3.5	8.6	8.0
42	52	6.4	8.2	7.2
46	52	7.8	9.5	8.8
48	52	5.5	7.8	6.5
52	47	6.3	7.8.	7.1

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

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.

ORNL 2011-G00537/chj

Fig. 6.3. ORR Ambient Air Station.

Ambient air monitoring conducted by individual site programs is discussed in Chapters 3, 4, and 5. An ORR ambient air monitoring program complements these individual site programs and permits the assessment of the impacts of ORR operations on an integrated basis. This program is discussed in detail in the following sections.

6.3.1 ORR 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 the 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 2010 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 the 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 on glass-fiber filters using high-volume air samplers. The filters are collected weekly, composited quarterly, and then submitted to an analytical laboratory to quantify gross alpha and beta activity and to determine concentrations of specific isotopes of interest on the ORR. The second system is designed to collect tritiated water vapor. The sampler consists of a prefilter followed by an adsorbent trap consisting of indicating silica gel. The samples are collected weekly or biweekly, composited quarterly, and then submitted to an analytical laboratory for ^{3}H analysis.

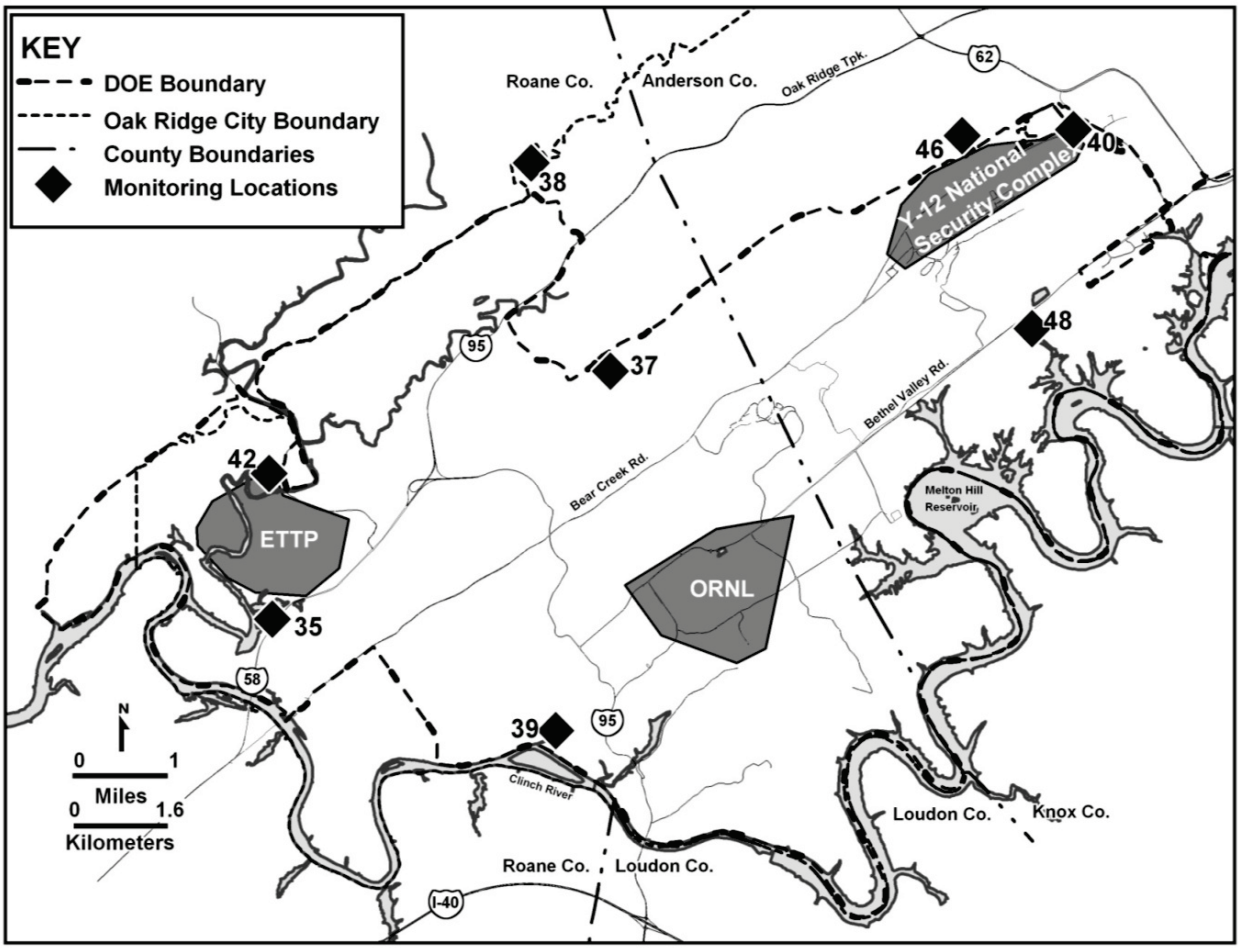

Fig. 6.4. Locations of ORR perimeter air monitoring stations.

6.3.2 Results

Data from the ORR ambient air stations are analyzed to assess the impact of DOE operations on the local air quality. Each measured radionuclide concentration is compared with the appropriate derived concentration guide (DCG). DCGs serve as standard reference values for conducting environmental protection programs at DOE sites. All radionuclide concentrations measured at the ORR ambient air stations during 2010 were less than 1% of applicable DCGs, indicating that activities on the reservation are not adversely affecting local air quality. Statistical significance testing is also performed to compare average radionuclide concentrations measured at ORR ambient air stations with concentrations measured at the reference location. This test reflects the mathematical probability of certain outcomes but is not an indication of environmental significance. There were no calculated statistical differences in average concentrations of ^{7}Be or ^{40}K. The concentrations of ^{3}H, ^{234}U, ^{235}U, and ^{238}U at the ORR ambient air stations were slightly higher than those observed at the background location at the 95% confidence level. A summary of radionuclide concentrations measured at the ambient air stations is presented in Table 6.3.

Table 6.3. Average radionuclide concentrations at ORR perimeter air monitoring stations, 2010

Parameter	No. detected/ no. total	Concentration (pCi/mL)[a,b]		
		Average	Minimum	Maximum
		Station 35		
^{7}Be	4/4	3.31E-08	2.87E-08	3.69E-08
^{40}K	0/4	1.54E-10	−1.48E-10	4.29E-10
^{3}H	2/4	2.01E-05	5.34E-06	4.24E-05
^{234}U	4/4	6.68E-12	4.63E-12	1.19E-11
^{235}U	1/4	1.94E-13	8.95E-14	3.39E-13
^{238}U	4/4	2.96E-12	2.09E-12	4.06E-12
		Station 37		
^{7}Be	4/4	3.36E-08	2.96E-08	3.87E-08
^{40}K	0/4	-1.08E-10	−1.01E-09	6.12E-10
^{3}H	0/4	4.03E-06	9.99E-08	9.67E-06
^{234}U	4/4	4.69E-12	3.15E-12	7.02E-12
^{235}U	0/4	1.90E-13	6.87E-14	2.97E-13
^{238}U	4/4	2.04E-12	1.68E-12	2.69E-12
		Station 38		
^{7}Be	4/4	3.53E-08	2.87E-08	4.55E-08
^{40}K	0/4	8.65E-11	−3.15E-10	4.46E-10
^{3}H	1/4	4.04E-06	−6.01E-07	1.50E-05
^{234}U	4/4	6.83E-12	3.24E-12	1.67E-11
^{235}U	1/4	5.85E-13	1.43E-13	1.18E-12
^{238}U	4/4	3.16E-12	2.32E-12	3.88E-12
		Station 39		
^{7}Be	4/4	3.40E-08	2.79E-08	4.13E-08
^{40}K	0/4	-1.60E-10	−7.23E-10	2.30E-10
^{3}H	0/4	5.11E-06	2.92E-06	7.17E-06
^{234}U	4/4	4.91E-12	3.61E-12	8.02E-12
^{235}U	1/4	2.49E-13	4.39E-14	6.42E-13
^{238}U	4/4	2.20E-12	1.71E-12	2.57E-12
		Station 40		
^{7}Be	4/4	3.31E-08	2.84E-08	3.68E-08
^{40}K	0/4	-3.06E-10	−6.33E-10	2.13E-10
^{3}H	0/4	4.43E-06	7.62E-08	1.01E-05
^{234}U	4/4	2.12E-11	1.61E-11	2.50E-11
^{235}U	3/4	7.87E-13	5.00E-13	1.05E-12
^{238}U	4/4	4.16E-12	3.89E-12	4.77E-12
		Station 42		
^{7}Be	4/4	3.61E-08	3.12E-08	4.40E-08
^{214}Bi	1/4	1.68E-10	1.68E-10	1.68E-10
^{40}K	0/4	-1.40E-10	−3.59E-10	8.88E-11
^{3}H	1/4	8.36E-06	4.78E-06	1.80E-05
^{234}U	4/4	1.80E-11	4.22E-12	4.46E-11
^{235}U	1/4	1.08E-12	2.32E-13	3.01E-12
^{238}U	4/4	3.49E-12	1.52E-12	5.03E-12
		Station 46		
^{7}Be	4/4	3.85E-08	3.33E-08	4.37E-08
^{40}K	0/4	-6.70E-11	−3.73E-10	4.26E-10
^{3}H	0/4	2.14E-06	−4.36E-07	4.23E-06
^{234}U	4/4	1.61E-11	8.51E-12	2.28E-11
^{235}U	2/4	4.96E-13	−4.08E-14	8.79E-13
^{238}U	4/4	4.60E-12	3.95E-12	5.00E-12

Table 6.3 (continued)

Parameter	No. detected/ no. total	Concentration (pCi/mL)[a,b]		
		Average	Minimum	Maximum
		Station 48		
^{7}Be	4/4	3.78E-08	3.32E-08	4.22E-08
^{40}K	0/4	-6.99E-11	−4.10E-10	1.31E-10
^{3}H	0/4	3.42E-06	5.53E-07	5.03E-06
^{234}U	4/4	7.09E-12	4.93E-12	9.84E-12
^{235}U	0/4	3.58E-13	8.46E-14	6.79E-13
^{238}U	4/4	3.65E-12	3.21E-12	4.50E-12
		Station 52		
^{7}Be	4/4	4.22E-08	3.55E-08	5.09E-08
^{40}K	0/4	3.32E-10	−2.73E-10	7.80E-10
^{3}H	0/4	6.24E-07	−2.51E-06	4.31E-06
^{234}U	4/4	4.48E-12	3.28E-12	5.36E-12
^{235}U	0/4	3.01E-13	2.41E-13	3.92E-13
^{238}U	4/4	2.81E-12	2.08E-12	3.93E-12

[a]Units are picocuries per milliliter.
[b]Radiological results are reported after background activity has been subtracted. In cases where background activity exceeds the sample activity, this will result in negative values.

6.4 Surface Water Monitoring

6.4.1 ORR 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 water quality criteria associated with these classifications are used as references where applicable (TDEC 2008). The Tennessee water quality criteria do not include criteria for radionuclides. Four percent of the DOE DCG 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 U.S. Environmental Protection Agency radionuclide drinking water standards are based.

6.4.2 Results

Comparison of 2010 surface water sample results from locations upstream of DOE inputs with results from surface water samples obtained downstream of DOE inputs shows no statistically significant difference for any of the radionuclides; none of the radionuclides at any location was detected above 4% of the respective DCG or the 4-mrem dose limit, which is the maximum contaminant limit (MCL) for beta and photon emitters in community drinking water systems (CFR 2005). There were no mercury detections above MCLs at the three designated sampling locations for this parameter.

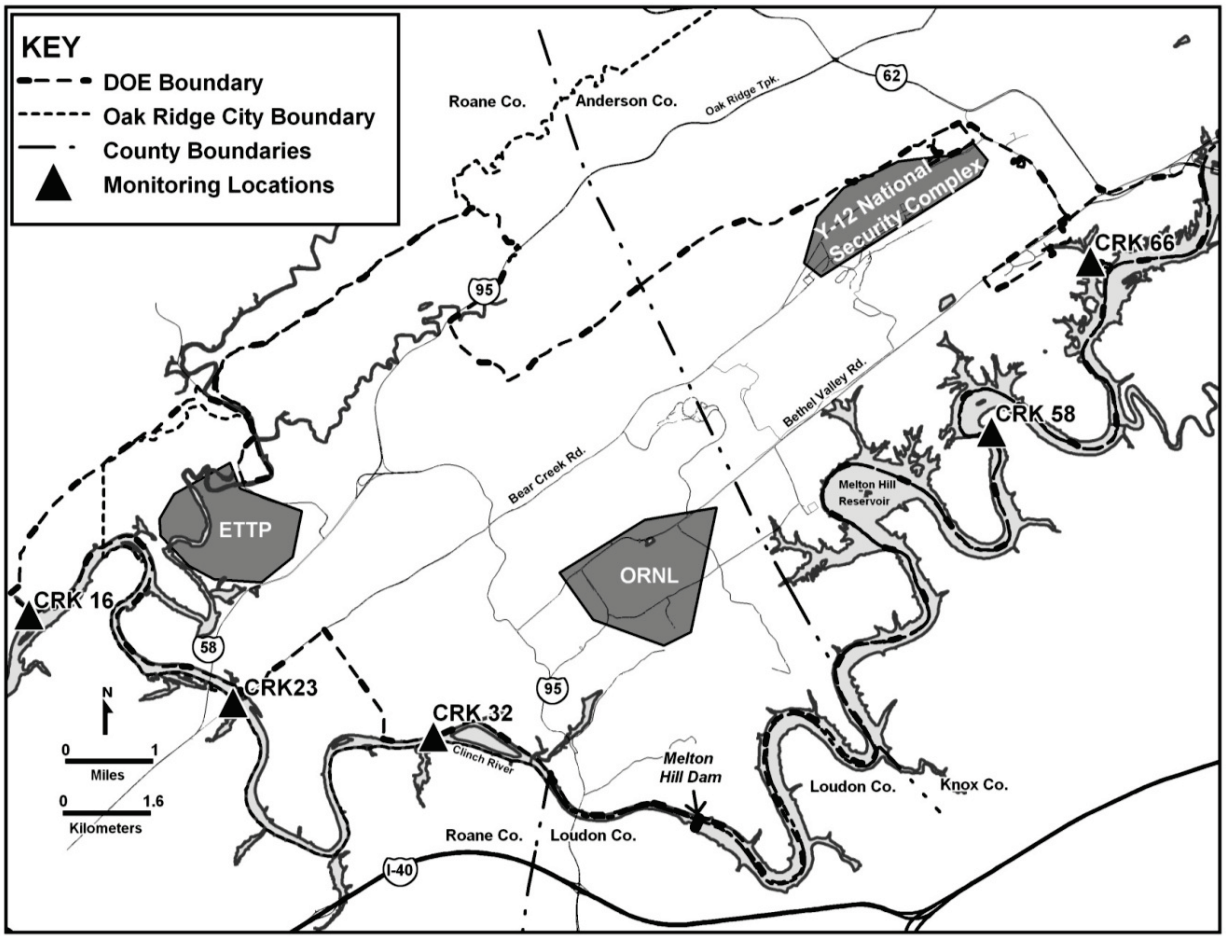

Fig. 6.5. ORR surface water surveillance sampling locations.

Table 6.4. ORR surface water sampling locations, frequencies, and parameters, 2010

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 the 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 bodies of water and distances (e.g., Clinch River kilometer 16 = 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.

6.5 Food

Vegetation samples are collected from areas that could be affected by activities on the reservation. Analysis of the samples enables the evaluation of potential radiation doses received by 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.

6.5.1 Vegetables

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

6.5.1.1 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.

6.5.2 Milk

Ingestion is one of the pathways of exposure to radioactivity for humans. Radionuclides can be transferred from the environment to people via food chains such 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 that a cow can graze daily, the rapid transfer of milk from producer to consumer, and the importance of milk in the diet.

The 2010 milk-sampling program consisted of grab samples collected every other month from a commercial dairy in Claxton and two reference locations, one in Maryville and one in Louisville (Fig. 6.6). Sampling at the Louisville reference location was discontinued after June 2010. 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 ^{3}H.

6.5.2.1 Results

Concentrations of radionuclides detected above MDA in milk are presented in Table 6.6. Total radioactive strontium (^{89}Sr + ^{90}Sr) was detected twice at the Claxton location. Total radioactive strontium (^{89}Sr + ^{90}Sr) was also detected three times at the reference locations. The total radioactive strontium measurement for the December sampling event at the Claxton location was 6.96 pCi/L, which is the highest level that has been detected at this site since sampling began in 2000. Total radioactive strontium was also detected at the reference location (unaffected by DOE activities) at 3.15 pCi/L, indicating a potential analytical laboratory interference. Investigations, including laboratory inquiries, identification of feed and water sources, and benchmarking with other DOE facilities, were conducted to determine potential causes for these atypical results. No identifiable cause has been identified. Two subsequent rounds of sampling were conducted in February and April of 2011, and results indicate that there are no ongoing issues or developing trends.

Table 6.5. Concentrations of radionuclides detected in vegetables, 2010 (pCi/kg)[a]

Location	Gross alpha	Gross beta	^{7}Be	^{40}K	^{234}U	^{235}U	^{238}U
Lettuce							
East of ORR (Claxton vicinity)	0.000041	0.0026	*b*	0.0030	*b*	*b*	*b*
North of ETTP	0.000034	0.0040	*b*	0.0046	0.0000087	*b*	0.0000056
Northeast of Y-12, Scarboro #2	*b*	0.0026	*b*	0.0048	0.000022	*b*	0.000028
Southwest of ORNL, Lenoir City #1	0.000046[c]	0.0045	*b*	0.0053	*b*	*b*	*b*
Southwest of ORNL, Lenoir City #2	0.000022	0.0020	*b*	0.0058	*b*	*b*	*b*
Reference location, Maryville	0.000027	0.0022	*b*	0.0064	*b*	*b*	*b*
Tomato							
East of ORR (Claxton vicinity)	*b*	0.00080	*b*	*B*	0.000027	*b*	*b*
North of ETTP	*b*	0.00082	*b*	0.0025	*b*	*b*	*b*
Northeast of Y-12, Scarboro #2	*b*	0.00095	*b*	0.0012	*b*	*b*	*b*
Southwest of ORNL, Lenoir City #1	*b*	0.00064	*b*	0.0020	*b*	*b*	*b*
Southwest of ORNL, Lenoir City #2	*b*[d]	0.0011	*b*	0.0013	0.0000041	*b*	*b*
Reference location, Maryville	0.000026	0.00045	*b*	0.0017	*b*	*b*	*b*
Turnips							
East of ORR (Claxton vicinity)	0.00028	0.0011	*b*	0.0022	*b*	*b*	*b*
North of ETTP	0.000032	0.0016	*b*	0.0026	*b*	*b*	*b*
Northeast of Y-12, Scarboro #2	0.00019	0.0018	*b*	0.0032	*b*	*b*	*b*
Southwest of ORNL, Lenoir City #1	*b*	0.0011	*b*	0.0033	*b*	*b*	*b*
Southwest of ORNL, Lenoir City #2	*b*	0.0014	*b*	0.0026	*b*	*b*	*b*
Reference location, Maryville	0.000031	0.00099	*b*	*b*	*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.

[c]Additional analyses were conducted to identify alpha activity: ^{241}Am was detected at 0.0000034 pCi/kg and ^{232}Th was detected at 0.000016 pCi/kg; none of the following were above minimum detectable activity: ^{242}Cm, ^{244}Cm, ^{237}Np, ^{238}Pu, $^{239/240}$Pu , ^{228}Th, and ^{230}Th.

[d]Additional analyses were conducted to identify alpha activity: ^{232}Th was detected at 0.000017 pCi/kg; none of the following were above minimum detectable activity: ^{241}Am, ^{242}Cm, ^{244}Cm, ^{237}Np, ^{238}Pu, $^{239/240}$Pu , ^{228}Th, and ^{230}Th.

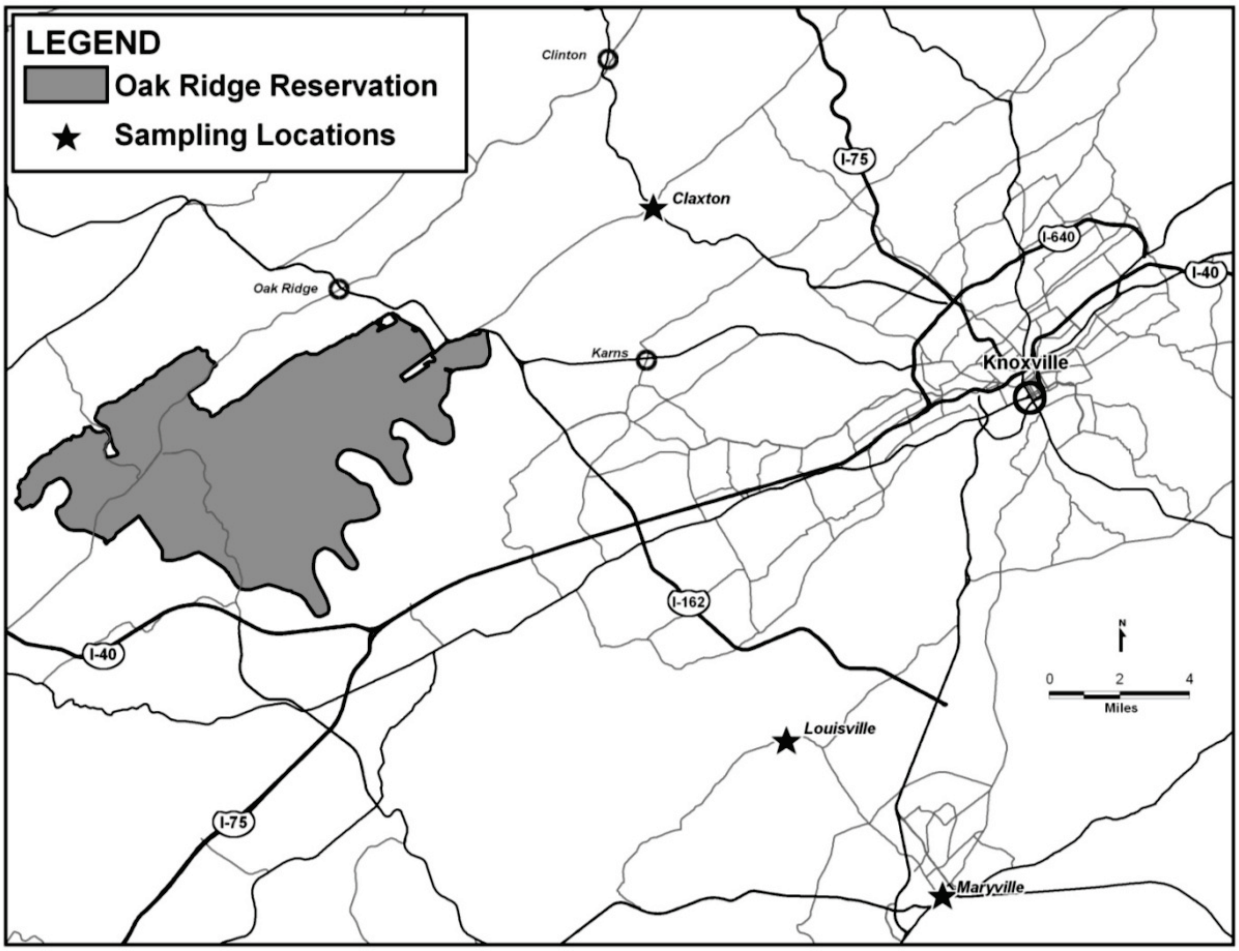

Fig. 6.6. Milk sampling locations in the vicinity of the ORR.

Table 6.6. Concentration of radionuclides detected in raw milk, 2010

Analysis	No. detected/ no. total	Detected concentration (pCi/L)[a]			Standard error of mean
		Max	Min	Avg	
Claxton					
Potassium-40	6/6	1400[b]	1100[b]	1200[b]	52
Total rad Sr	2/6	7.0[b]	−0.29	2.4[b]	1.0
Combined reference locations					
Potassium-40	9/9	1500[b]	1100[b]	1300[b]	47
Total rad Sr	3/9	3.2[b]	−0.053	1.5[b]	0.39

[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.

6.6 Fish

Members of the public could be exposed to contaminants originating from DOE-ORO activities through consumption of fish caught in area waters. This potential exposure pathway is monitored by collecting fish from three locations on the Clinch River annually and analyzing edible fish flesh for specific contaminants. The locations are as follows (Fig. 6.7):

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

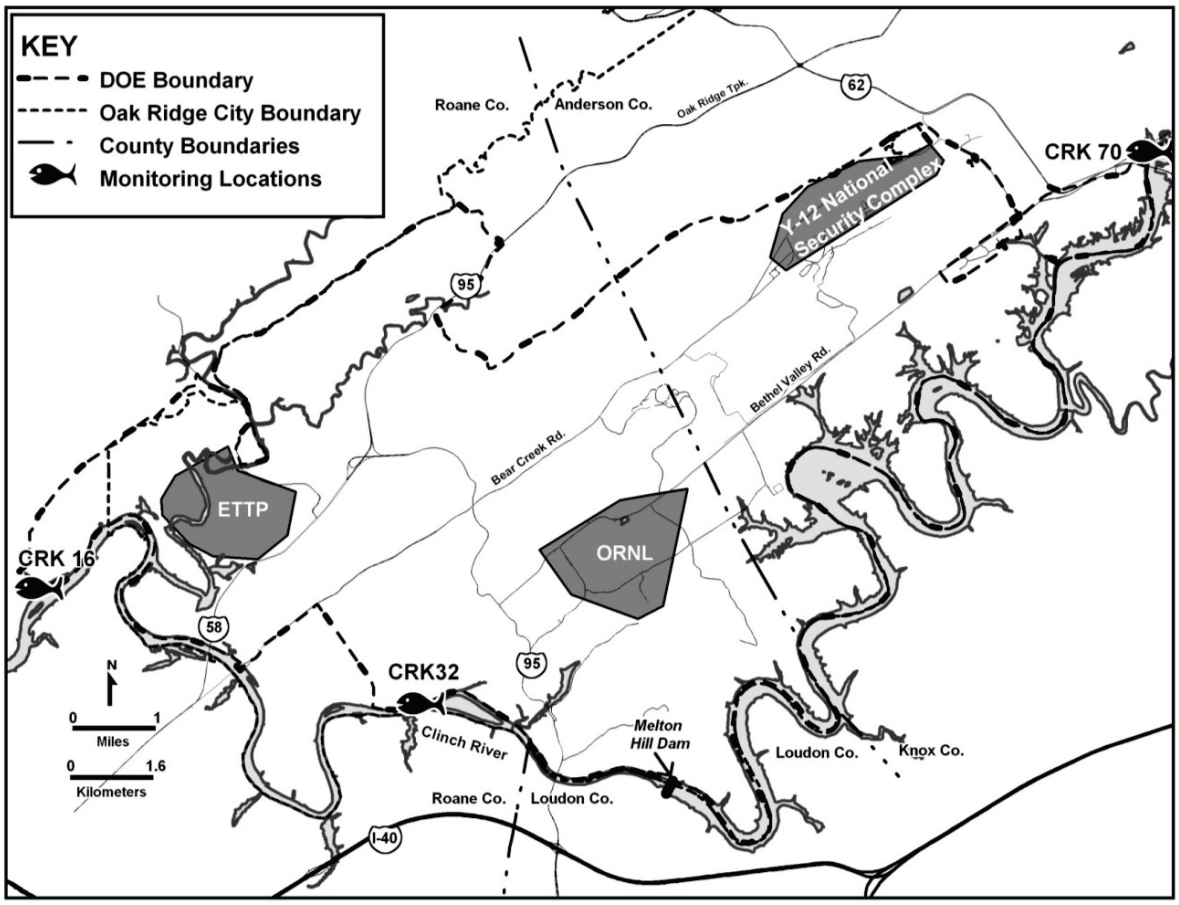

Fig. 6.7. Fish sampling locations for the ORR.

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 2010, a composite sample for each of these species at each location was analyzed for selected metals, polychlorinated biphenyls (PCBs), ^{3}H, gross alpha, gross beta, gamma-emitting radionuclides, and total radioactive strontium. In order to accurately estimate exposure levels to consumers, only edible portions of the fish were submitted for analyses.

It should be noted that TDEC issues advisories for consumption of certain species of fish 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, and 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).

6.6.1 Results

Detected PCBs, mercury, and radionuclides are shown in Table 6.7. PCBs and mercury were detected in both sunfish and catfish at all three locations in 2010. Aroclor-1260 was detected in both species at all locations; Aroclor-1254 was observed in the both species of fish at CRK 32 (Aroclor-1260 and -1254 are PCBs). These results are consistent with the TDEC advisories discussed above.

Table 6.7. Tissue concentrations in catfish and sunfish for mercury, detected PCBs, and detected radionuclides[a], 2010

Parameter	Catfish[b]	Sunfish[b]
Clinch River downstream from all DOE ORR inputs (CRK 16)		
Metals (mg/kg)		
Mercury	0.33	0.39
Pesticides and PCBs (µg/kg)		
PCB-1260	300	31
Radionuclides (pCi/g)[c]		
Beta activity	2.9*	1.8*
Potassium-40	3.7*	3.2*
Strontium-90	.079*	0.0057
Clinch River downstream from ORNL (CRK 32)		
Metals (mg/kg)		
Mercury	0.31	0.11
Pesticides and PCBs (µg/kg)		
PCB-1254	39	U20
PCB-1260	120	J17
Radionuclides (pCi/g)[c]		
Beta activity	2.6*	1.9*
Potassium-40	3.0*	2.1*
Strontium-90	0.0031	0.042*
Clinch River (Solway Bridge) upstream from all DOE ORR inputs (CRK 70)		
Metals (mg/kg)		
Mercury	0.16	0.16
Pesticides and PCBs (µg/kg)		
PCB-1260	140	34
Radionuclides (pCi/g)[c]		
Beta activity	2.6*	0.92*
Potassium-40	4.8*	2.3*

[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]Prefix "U" indicates that the value was undetected at the analytical detection limit and prefix "J" indicates that the result is estimated.

[c]Radionuclide concentrations significantly greater than zero are identified by an asterisk (*). Detected radionuclides are those at or above MDA.

[d] Radiological results are reported after background activity has been subtracted. Where background activity exceeds sample activity, this will result in negative values.

Abbreviations

CRK = Clinch River kilometer

MDA = minimum detectable activity

PCB = polychlorinated biphenyl

Radiological analyses for fish tissues sampled in 2010 showed statistical differences (at the 95% confidence level) in gross beta results from sunfish collected upstream from ORNL relative to results from sunfish collected downstream of ORNL. Similarly, results for ^{90}Sr in both catfish and sunfish indicated statistical differences between ^{90}Sr levels observed in upstream and downstream samples. There were no other statistical differences in radionuclide concentrations in upstream and downstream locations, indicating that DOE activities on the ORR are not significant contributors to public radiological dose from fish consumption.

6.7 White-Tailed Deer

Three deer hunts were held on the ORR during the final quarter of 2010. 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.

The 2010 hunts were held on three weekends. Shotgun/muzzleloader and archery hunts were held October 23–24, November 13–14, and December 11–12. In 2010, there were about 450 shotgun/ muzzleloader–permitted hunters and 675 archery-permitted hunters. The Tower Shielding area, Park City Road/Chestnut Ridge area, and Poplar Creek Road area were opened for an archery-only hunt on all three weekends. There was a two-deer limit for the November and December hunts; one could be an antlered buck.

The year's total harvest was 357 deer. From the total deer harvest, 216 (60.5%) were bucks and 141 (39.5%) were does. The heaviest buck had ten antler points and weighed 181 lb. The greatest number of antler points found on one buck was 13. The heaviest doe weighed 112 lb.

Since 1985 11,056 deer have been harvested. Of these only 200 (1.8%) have been retained as a result of potential radiological contamination. The heaviest buck was 218 lb (harvested in 1998); the average weight is 85.9 lb. The oldest deer harvested was 12 years old; the average age is 2.0 years. For more information, see the ORNL wildlife webpage: http://www.ornl.gov/sci/rmal/huntinfo.htm.

6.7.1 Results

The wildlife administrative release limits associated with deer, turkey, and geese harvested on the ORR are conservative and were established based on as-low-as-reasonably-achievable (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.

During the 2010 hunts, 357 deer were harvested on the ORR, and 3 (0.84%) 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 three retained deer exceeded the limit for beta-particle activity in bone. The average weight of the released deer was 87.3 lb; the maximum weight was 181 lb. The average ^{137}Cs concentration in the released deer was 0.5 pCi/g, and the maximum ^{137}Cs concentration in the released deer was 1 pCi/g.

Total field-dressed weight of the released deer was 30,893 lb. It is assumed that 55% of the field weight is edible meat; therefore, the total harvest of edible meat (357 released deer) is estimated to be 16,991 lb.

6.8 Fowl

6.8.1 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 are held on the ORR and in counties adjacent to the reservation each year. To determine concentrations of gamma-emitting radionuclides accumulated by waterfowl that feed and live on the ORR, Canada geese are rounded up each summer for noninvasive gross radiological surveys.

From the roundup, 46 geese were subjected to live whole-body gamma scans. The geese were collected from ORNL (17), Y-12 (10), and Clark Center Park (19). None exceeded the administrative release limits.

The same ^{137}Cs release administrative limit as is applied to deer is also applied to geese. For ^{137}Cs, the administrative release limit of 5 pCi/g assumes one person consumes all of the meat from a maximum-weight goose. The administrative limits were established to keep doses ALARA and to be consistent among harvested wildlife.

6.8.1.1 Results

The average ^{137}Cs concentration in the released geese was about 0.16 pCi/g. However, most of the ^{137}Cs concentrations were less than the minimum detection level. The maximum ^{137}Cs concentration in the released geese was about 0.41 pCi/g. The average weight of the geese screened during the roundup was 10.4 lb, and the maximum goose weight was 14.8 lb. No geese were sacrificed for radiological analyses in 2010.

6.8.2 Turkey Monitoring

Three wild turkey hunts managed by DOE and TWRA were held on the reservation (April 10 and 11, April 17 and 18, and November 13 and 14, 2010). Hunting was open for both shotguns and archery. Fifty-six turkeys were harvested, of which 5 (9%) were juveniles and 51 (91.1%) were adults. The average turkey weight was about 19.4 lb. The largest tom weighed 23.9 lb. The longest beard was 12 inches, and the average was 9.4 inches. The longest spur was 1.5 in. and the average was 0.9 in.

Since 1997, 602 turkeys have been harvested. Of these, only three (0.5%) have been retained because of potential radiological contamination. The heaviest turkey was 25.7 lb; the average weight is 18.8 lb. The longest spur on a turkey harvested on the ORR was 1.5 in. (average 0.8 in.) and the longest beard was 13.5 in. (average 9.2 in.). For additional information, see the ORNL wildlife webpage: http://www.ornl.gov/rmal/huntinfo.htm.

The same ^{137}Cs release administrative limits as are applied to deer and geese are also applied to turkey. For ^{137}Cs, the administrative release limit of 5 pCi/g assumes one person consumes all of the meat from a maximum-weight turkey. The administrative limits were established to keep doses ALARA and to be consistent between harvested wildlife.

6.8.2.1 Results

In 2010, none of the 56 turkeys harvested exceeded the administrative release limits established for radiological contamination. The average ^{137}Cs concentration in the released turkeys was 0.1pCi/g, and the maximum ^{137}Cs concentration in the released turkeys was 0.2 pCi/g. Most of the ^{137}Cs concentrations were less than the minimum detection level. It is assumed that about 50% of the field weight is edible meat; therefore, the average turkey would yield about 9.7 lb of meat. Based on the individual weights, the total harvest of edible meat (56 released turkeys) is estimated to be about 542 lb. No turkeys were sacrificed for radiological analyses in 2010.

6.9 Quality Assurance

The activities associated with administration, sampling, data management, and reporting for the ORR environmental surveillance programs are performed by the UT-Battelle Environmental Protection and Waste Services Division. Project scope is established by a task team whose members represent DOE, UT-Battelle, B&W Y-12, and BJC. UT-Battelle integrates quality assurance, environmental, and safety considerations into every aspect of ORR environmental monitoring. See Sect. 5.8 for a discussion of UT-Battelle quality assurance program elements for environmental monitoring and surveillance activities.

6.10 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.

CFR. 2005. *Title 40: Protection of the Environment*. 40 CFR 141.66, December.

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