5. ORNL Environmental Programs

Compliance and environmental monitoring programs required by federal and state regulation and by DOE orders are conducted for air, water, and groundwater environmental media. These programs include regulatory and monitoring activities for ORNL site facilities and other locations in Bethel Valley, Melton Valley, and the ORR.

5.1 ORNL RADIOLOGICAL AIRBORNE EFFLUENT MONITORING

Airborne discharges from DOE Oak Ridge facilities, both radioactive and nonradioactive, are subject to regulation by EPA and the TDEC Division of Air Pollution Control. Radioactive emissions are regulated by EPA under National Emission Standards for Hazardous Air Pollutants (NESHAP) regulations in 40 CFR 61, Subpart H, and the rules of the TDEC Division of Air Pollution Control, 1200-3-11.08. (See Appendix G, Table G.1 for a list of radionuclides and their radioactive half-lives.) Nonradioactive emissions are regulated under the rules of the TDEC Division of Air Pollution Control, 1200-3.

Radioactive airborne discharges at ORNL consist primarily of ventilation air from radioactively contaminated or potentially contaminated areas, vents from tanks and processes, and ventilation for reactor facilities. These airborne emissions are treated and then filtered with high-efficiency particulate air (HEPA) and/or charcoal filters before discharge. Radiological airborne emissions from ORNL consist of solid particulates; adsorbable gases (e.g., iodine); ^{3}H; and nonadsorbable gases (i.e., noble gases). The major radiological emission point sources for ORNL consist of the following five stacks located in Bethel and Melton Valleys (Fig. 5.1):

- 2026 High Radiation Level Analytical Laboratory;
- 3020 Radiochemical Processing Plant;
- 3039 central off-gas and scrubber system, which includes 3500 and 4500 areas' cell ventilation system, isotope solid state ventilation system, 3025 and 3026 areas' cell ventilation system, 3042 ventilation system, and 3092 central off-gas system;
- 7503 (formerly 7512) Molten Salt Reactor Experiment (MSRE) remediation; and
- 7911 Melton Valley complex, which includes the High Flux Isotope Reactor (HFIR) and the Radionuclide Engineering Development Center (REDC).

In 2000, there were 39 minor point/group sources, and emission calculations/estimates were made for each of these sources.

5.1.1 Sample Collection and Analytical Procedure

Each of the five major point sources is equipped with a variety of surveillance instrumentation. Only data resulting from analysis of the continuous samples are used in this report. ORNL in-stack source sampling systems comply with ANSI N 13.1 (ANSI 1969) criteria. The sampling systems generally consist of a multipoint in-stack sampling probe, a sample transport line, a particulate filter, activated charcoal cartridges, a silica-gel cartridge (if required), flow measurement and totalizing instruments, a sampling pump, and a return line to the stack. In addition to that instrumentation, the system at Stack 7911 includes a high-purity germanium detector with a NOMAD analyzer, which allows continuous isotopic identification and quantification of radioactive noble gases (e.g., ^{41}Ar) in the effluent stream. The sample probes are annually removed, inspected, and cleaned.

Velocity profiles are performed quarterly following the criteria in EPA Method 2 at major and some minor sources. The profiles provide accurate stack flow data for subsequent emission-rate calculations. An annual leak-check program

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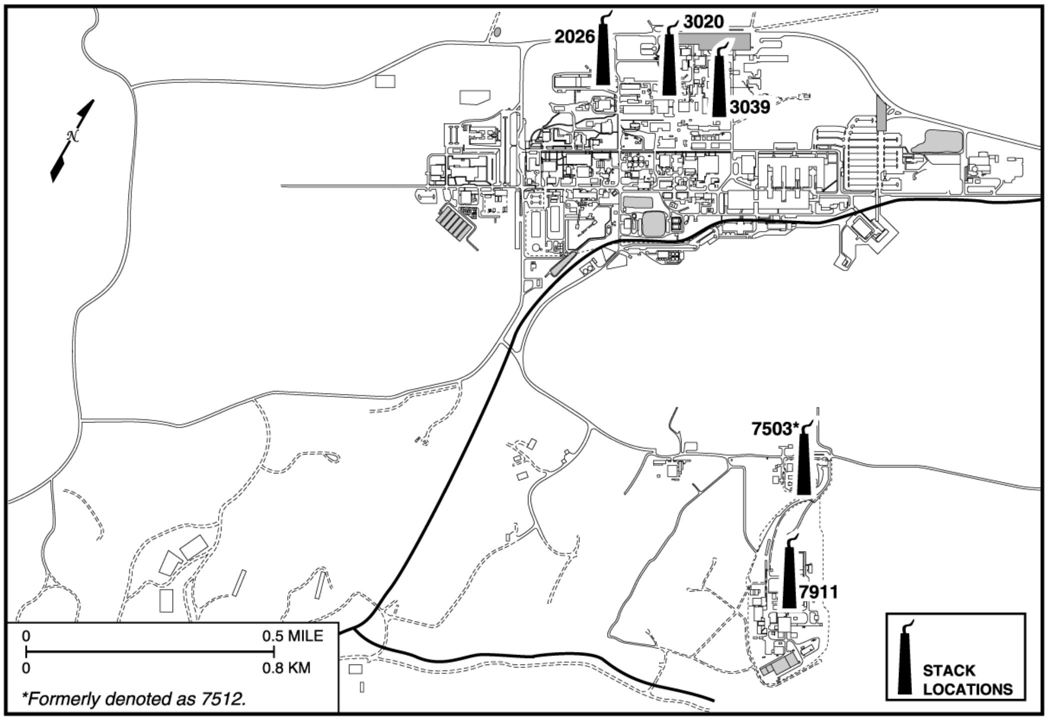

Fig. 5.1. Locations of major stacks (rad emission points) at ORNL.

is carried out to verify the integrity of the sample transport system.

In addition to the major sources, ORNL has a number of minor sources that have the potential to emit radionuclides to the atmosphere. Minor sources are composed of any ventilation systems or components such as vents, laboratory hoods, room exhausts, and stacks that do not meet the approved regulatory criteria for a major source but are located in or vent from a radiological control area as defined by Radiological Protection. A variety of methods are used to determine the emissions from the various minor sources. Methods used for minor source emission calculations comply with criteria agreed upon by EPA. These minor sources are evaluated on a 1- to 5-year basis. Emissions, both major and minor, are compiled annually to determine the overall ORNL source term and associated dose.

The charcoal cartridges, particulate filters, and silica-gel traps are collected weekly to biweekly. The use of charcoal cartridges is a standard method for capturing and quantifying radioactive iodines in airborne emissions. Gamma spectrometric analysis of the charcoal samples quantifies the adsorbable gases. Analysis is performed weekly to biweekly. Particulate filters are held for 8 days prior to a weekly gross alpha and gross beta analysis to minimize the contribution from short-lived isotopes such as ^{220}Rn and its daughter products. At Stack 7911, a weekly gamma scan is conducted to better detect short-lived gamma isotopes. The weekly to biweekly filters are then composited quarterly and analyzed for alpha-, beta-, and gamma-emitting isotopes. Compositing provides a better opportunity for quantification of these low-concentration isotopes. At the end of the year, each sample probe is rinsed, and the rinsate is collected and submitted to the laboratory for isotopic analysis identical to that of the particulate filter. The data from the charcoal cartridges, silica gel, probe wash, and the quarterly filter composites are compiled to give the annual emissions for each major source and some minor sources.

5.1.2 Results

Annual radioactive airborne emissions for ORNL major sources in 2000 are presented in Table 5.1. All data presented were determined to be statistically different from zero at the 95%

Table 5.1. Major sources of radiological airborne emissions at ORNL, 2000 (in curies)[a]

Isotope	Stack				
	2026	3020	3039	7503[b]	7911
^{241}Am	1.14E–07	1.74E–07	3.80E–07	3.60E–09	2.01E–08
^{41}Ar					3.62E+03
^{139}Ba					1.15E+00
^{140}Ba					2.00E–04
^{7}Be	5.55E–07	7.56E–07	2.41E–05	4.99E–07	1.93E–06
^{252}Cf					8.18E–09
^{244}Cm	1.26E–06	5.61E–09	3.45E–07	2.50E–10	1.06E–07
^{60}Co			7.47E–04		
^{137}Cs	4.27E–06	1.29E–06	1.89E–04	3.55E–06	6.31E–06
^{138}Cs	3.97E–01				2.35E+03
^{152}Eu			6.92E–06		
^{3}H	1.53E–01		1.17E+01	8.54E+00	8.48E+01
^{130}I					1.15E–05
^{131}I			2.17E–04		7.47E–02
^{132}I					6.19E–01
^{133}I					4.57E–01
^{134}I					5.68E–02
^{135}I					1.25E+00
^{85}Kr					2.83E+02
^{85m}Kr					6.72E+00
^{87}Kr					1.05E+01
^{88}Kr					3.96E+01
^{89}Kr					1.50E+01
^{140}La					7.49E–04
^{191}Os	8.70E–06		3.59E+00		
^{212}Pb	1.58E–01		1.56E+00	2.14E–01	1.65E–01
^{238}Pu	4.15E–08	1.34E–08	5.75E–08	4.24E–11	2.06E–09
^{239}Pu	1.44E–07	1.74E–07	1.04E–06	8.84E–10	4.39E–09
^{75}Se			5.99E–03		4.69E–06
^{228}Th	1.75E–08	1.19E–09	9.91E–09	2.86E–09	3.24E–09
^{230}Th	2.74E–09	3.09E–09	8.11E–09	9.95E–10	5.82E–09
^{232}Th	1.42E–09	2.57E–09	6.76E–09	8.03E–10	5.72E–09
Total Sr	5.73E–07	9.20E–07	5.75E–05	3.87E–08	2.10E–05
^{234}U	1.51E–07	7.13E–08	5.28E–07	4.06E–09	2.95E–08
^{235}U	2.35E–09	1.01E–09	2.29E–08	3.47E–10	1.45E–09
^{238}U	4.16E–09	1.05E–08	3.98E–08	1.80E–09	2.15E–08
^{131}Xe					1.73E+01
^{133}Xe					9.80E+01
^{133m}Xe					2.21E+00
^{135}Xe			1.29E–05		1.07E+02
^{135m}Xe					3.96E+01
^{137}Xe					1.32E+02
^{138}Xe					3.41E+02

[a]1 Ci = 3.7E+10 Bq.
[b]Formerly 7512.

confidence level. Any number not statistically different from zero was not included in the emission calculation. Because measuring a radionuclide requires a process of counting random radioactive emissions from a sample, the same result may not be obtained if the sample were analyzed repeatedly. This deviation is referred to as the "counting uncertainty." Statistical significance at the 95% confidence level means that there is a 5% chance that the results could be in error. Historical trends for ^{3}H and ^{131}I are presented in Figs. 5.2 and 5.3, respectively.

The ^{3}H emissions for 2000 totaled approximately 107 Ci (Fig. 5.2), which is consistent with findings in 1999. The ^{131}I emission for 2000 is essentially unchanged from that of the past years (Fig. 5.3). The major contributor to off-site doses at ORNL is ^{41}Ar, which totaled 3620 Ci in 2000 (Fig. 5.4). This discharge has decreased by 71% from the previous year.

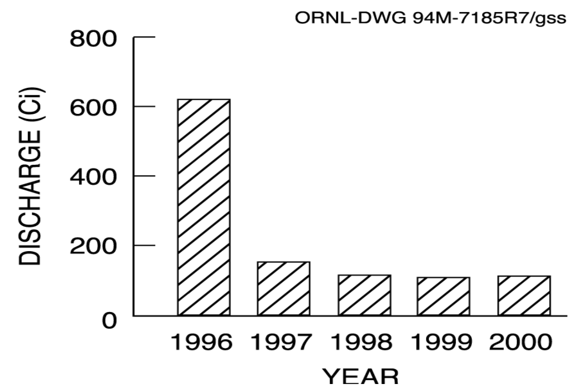

Fig. 5.2. Total discharges of ^{3}H from ORNL to the atmosphere, 1996–2000.

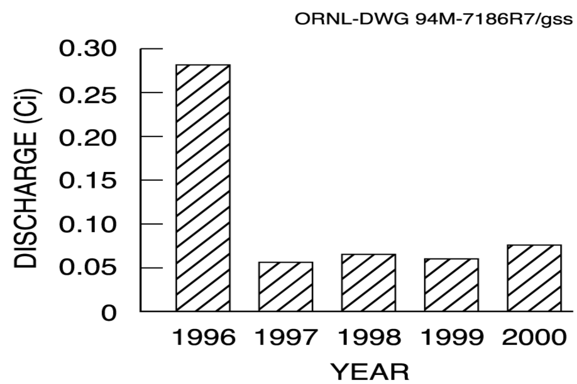

Fig. 5.3. Total discharges of ^{131}I from ORNL to the atmosphere, 1996–2000.

5.2 ORNL NONRADIOLOGICAL AIRBORNE EMISSIONS MONITORING

ORNL operates 23 permitted air emission sources. (See Appendix F, Table F.2.) Most of these sources are small-scale activities and result in very low emission rates. The steam plant and two small oil-fired boilers are the largest emission sources at ORNL and account for 98% of allowable emissions. The steam plant consists of six boilers. Four of these boilers are fired by coal, natural gas and fuel oil; two are fired by natural gas and fuel oil. As part of a 10-year plan to provide long-term reliability for the steam plant, the installation of a new 125-MBtu/h natural-gas-fired boiler was completed in December 1999. Also, as funding is made available, the four coal-fired boilers will be converted to natural gas and fuel oil firing, eliminating the use of coal at the steam plant.

The new 125-MBtu/h boiler is subject to 40 CFR 60, Subpart Db requirements, and therefore monitoring for NO_x and opacity with quarterly reporting is required. During 2000, no exceedences of NO_x or opacity limits occurred. Other TDEC air permits for ORNL's sources do not require stack sampling or monitoring; how-

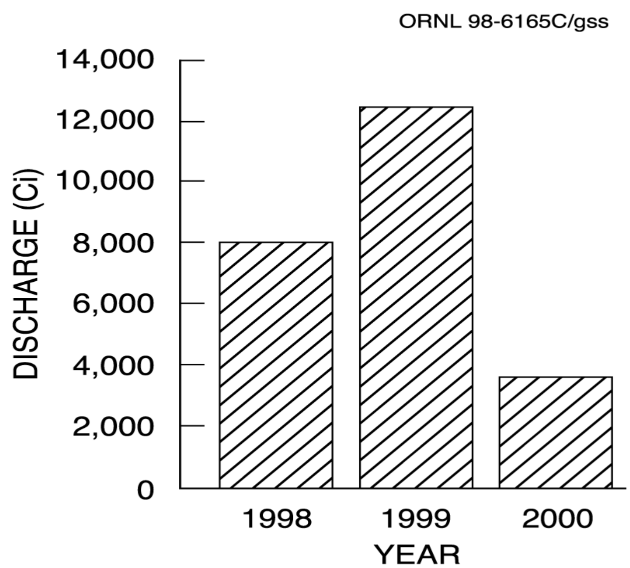

Fig. 5.4. Total discharges of ^{41}Ar from ORNL to the atmosphere, 1998–2000.

ever, an opacity monitor is used at the steam plant to ensure compliance with visible emissions.

For the period from July 1, 1999, through June 30, 2000, ORNL paid $67,743 in annual emission fees to TDEC. These fees are based on allowable emissions (actual emissions are lower than allowable emissions). During 2000, TDEC inspected all permitted emission sources; all were found to be in compliance.

ORNL's Title V permit application was submitted to TDEC on May 5, 1997. In a letter dated June 5, 1997, TDEC indicated that the application was complete and that ORNL met the requirement to submit an application. ORNL will continue to operate with existing permits until the Title V permit is issued. TDEC anticipates that ORNL's Title V permit will be issued in 2001.

As required by Title VI of the Clean Air Act (CAA) Amendments of 1990, actions have been implemented to comply with the prohibition against releasing ozone-depleting substances (ODSs) during maintenance activities performed on refrigeration equipment. In addition, service requirements for refrigeration systems (including motor vehicle air conditioners), technician certification requirements, and labeling requirements have been implemented. ORNL has implemented a plan to phase out the use of all Class I ozone-depleting substances. All critical applications of Class I ODSs have been eliminated, replaced, or retrofitted with other materials. Work is progressing as funding is available for small, noncritical applications with no disruption of service.

5.2.1 Results

The primary sources of nonradioactive emissions at ORNL include the steam plant on the main ORNL site and two small boilers located in the 7600-area complex. These units use fossil fuels; therefore, criteria pollutants are emitted. Actual and allowable emissions from these sources are compared in Table 5.2. Actual emissions were calculated from fuel usage and EPA emission factors. The steam plant and the 7600-area boilers operated in compliance with visible emission standards during 2000.

5.3 ORNL AMBIENT AIR MONITORING

The objectives of the ORNL ambient air monitoring program are to collect samples at perimeter air monitoring (PAM) stations most likely to show impacts of airborne emissions from the operation of ORNL and to provide for emergency response capability. Four stations, identified as Stations 1, 2, 3, and 7 (Fig. 5.5) make up the ORNL PAM network. Sampling is conducted at each ORNL station to quantify levels of ^{3}H, adsorbable gases (e.g., iodine), and gross alpha-, beta-, and gamma-emitting radionuclides (Table 5.3).

The sampling system consists of a low-volume air sampler for particulate collection in a 47-mm glass-fiber filter. The filters are collected biweekly, composited annually, then submitted to the laboratory for analysis. Following the filter is a charcoal cartridge used to collect adsorbable gases (e.g., iodine). The charcoal cartridges are analyzed biweekly by gamma spectroscopy for adsorbable gas quantification. A silica-gel column is used for collection of ^{3}H as tritiated water. These samples are collected biweekly or weekly. The silica gel from each station is composited each quarter and then submitted to the laboratory for ^{3}H analysis.

Table 5.2. Actual vs allowable air emissions from ORNL steam production, 2000

Pollutant	Emissions (tons/year)		Percentage of allowable
	Actual	Allowable	
Particulates	3	696	0.4
Sulfur dioxide	863	9102	9.5
Nitrogen oxides	102	600	17.0
Volatile organic compounds	1	18	5.6
Carbon monoxide	72	381	19.0

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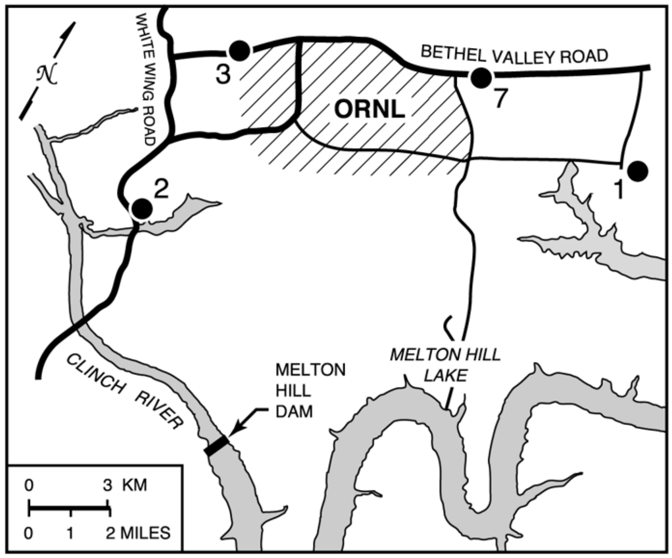

Fig. 5.5. Locations of ambient air monitoring stations at ORNL.

Table 5.3. Radionuclide concentrations measured at ORNL perimeter air monitoring stations, 2000 (pCi/mL)[a]

Parameter	Station				
	1	2	3	7	52[b]
^{7}Be	5.96E–09[c]	4.56E–09[c]	6.15E–09[c]	5.87E–09[c]	3.08E–08[c]
^{137}Cs	1.54E–12	5.96E–12	2.63E–12	–7.25E–13	1.74E–11[c]
^{60}Co	1.44E–11	8.41E–12	1.43E–11	1.83E–11	1.73E–11[c]
^{3}H	1.48E–06	2.13E–04	2.99E–06	1.15E–05	8.05E–08
^{131}I	1.04E–10	3.10E–10	–1.14E–12	7.28E–11	*d*
^{133}I	–5.21E–10	5.11E–10	1.89E–10	–1.70E–10	*d*
^{135}I	2.46E–08	6.44E–09	–3.30E–08	–2.46E–09	*d*
^{40}K	3.12E–10[c]	5.26E–10[c]	4.78E–10[c]	1.90E–10	3.41E–10[c]
^{191}Os	1.93E–08[c]	*e*	4.85E–08[c]	6.73E–08	*d*
^{234}U	2.84E–11[c]	2.52E–11[c]	2.29E–11[c]	2.83E–11[c]	6.15E–12[c]
^{235}U	0	1.65E–12	–1.13E–12	0	7.78E–13[c]
^{238}U	3.51E–11[c]	1.51E–11[c]	1.61E–11[c]	2.63E–11[c]	9.18E–12[c]

[a]1 pCi = 3.7E–02 Bq.
[b]Reference location off site.
[c]Statistically significant average at 95% confidence level.
[d]Not applicable.
[e]Not reported.

5.3.1 Results

The ORNL PAM stations are designed to provide data for collectively assessing the specific impact of ORNL operations on local air quality. Sampling data from the ORNL PAM stations (Table 5.3) are compared with air-sampling data from the reference station (station 52) at Fort Loudoun. Average radionuclide concentrations observed for the ORNL network were not significantly different from those observed at the reference location, with the exception of ^{3}H. Tritium concentrations are significantly greater at the ORNL stations but remain consistent with those observed at ORNL for the past several years.

5.4 LIQUID DISCHARGES—ORNL RADIOLOGICAL MONITORING SUMMARY

ORNL samples for radioactivity in NPDES discharges that have a potential to discharge radioactivity, and at three instream monitoring stations under a Radiological Monitoring Plan (RMP) that is required by Part III, Section J, of the ORNL NPDES permit. The current version of the plan was implemented on November 1, 1999. Table 5.4 contains the details of the locations sampled, frequency, and target analyses. Monitoring of radioactivity occurred at the three ORNL treatment facilities: the Sewage Treatment Plant (STP), the Coal Yard Runoff Treatment Facility (CYRTF), and the Process Waste Treatment Complex (PWTC); the three instream locations monitored were: X13 on Melton Branch, X14 on White Oak Creek, and X15 at White Oak Dam (Fig. 5.6). Data were also collected during dry-weather conditions at 27 category outfall locations and at 18 stormwater outfalls.

DOE derived concentration guide (DCG) values are used as a means of standardized comparison for effluent points with different isotope signatures. The average concentration is expressed as a percentage of the DCG when a DCG exists and when the average concentration is significantly greater than zero at the 95% confidence level. DCGs are not intended for comparison to instream values. However, they are useful as a frame of reference, so instream values are compared to DCGs in this section. The calculation of the percentage of the DCG for ingestion of water does not imply that effluent points or ambient-water-sampling stations at ORNL are sources of drinking water.

For 2000, three radionuclides had an average concentration greater than 4% of the relevant DCG; they were total radioactive strontium (^{89}Sr + ^{90}Sr), ^{3}H, and ^{137}Cs . Of the locations sampled, the highest total radioactive strontium was at the Outfall 381 (73% of the DCG); the highest ^{3}H was at Melton Branch (X13) monitoring station (17% of the DCG); and the highest ^{137}Cs was at the PWTC (43% of the DCG). Following guidelines given in DOE Order 5400.5, fractional DCG values for the radionuclides detected at each monitoring point are summed to determine whether radioactivity is within acceptable levels. In 2000, the sum of DCG percentages at each effluent point and ambient water station was less than 100% (Fig. 5.7).

Amounts of radioactivity released at White Oak Dam (WOD) are calculated from concentration and flow. As shown in Figs. 5.8–5.13, the total discharges (or amounts) of radioactivity released at WOD during the past 5 years have generally remained in the same range of values. Tritium has decreased since 1996. The 1999 ^{137}Cs value was higher than in the previously 4 years; however, in 2000, ^{137}Cs discharge decreased.

The RMP also includes requirements for monitoring radioactivity at category outfalls during storm conditions. There are 102 outfalls targeted for storm water sampling in the RMP. These 102 outfalls were grouped into 8 different categories with the knowledge that outfalls may move from one category to another as storm water data are collected. The storm water categories are defined by the availability of historic data and the levels of radioactivity detected in past monitoring. The goal is to perform monitoring at the rate of 20 outfalls per NPDES permit year (February 3 to February 2). The RMP sets frequency goals for storm water monitoring rather than hard requirements because opportunities for storm water sampling are weather dependent.

Eighteen outfalls were sampled under the storm water portion of the RMP during the permit year February 3, 2000, to February 2, 2001; of those, twelve outfalls were monitored during calendar year 2000. The outfalls chosen for the

Table 5.4. ORNL Radiological Monitoring Plan, effective November 1, 1999

Location	Frequency	Gross alpha[a]	Gross beta[a]	Gamma scan	Tritium	Total rad Sr	Isotopic uranium
Outfall 001	Annually	X					
Outfall 080	Monthly	X	X	X	X	X	
Outfall 081	Annually		X				
Outfall 085	Quarterly	X	X				
Outfall 086	When discharges		X		X		
Outfall 087	Annually		X	X			
Outfall 203	Annually		X				
Outfall 204	Quarterly	X	X			X	
Outfall 205	Annually		X				
Outfall 207	Quarterly	X	X	X		X	
Outfall 211	Quarterly		X			X	
Outfall 217	Annually		X				
Outfall 219	Annually		X				
Outfall 234	Annually	X					
Outfall 241	Annually		X				
Outfall 265	Annually		X	X			
Outfall 281	Quarterly	X	X	X	X		
Outfall 282	Quarterly	X	X				
Outfall 284	Annually		X				
Outfall 290	Annually			X			
Outfall 302	Monthly	X	X	X	X	X	
Outfall 304	Monthly	X	X	X	X	X	
Outfall 365	Quarterly	X	X				
Outfall 368	Quarterly	X	X	X			
Outfall 381	Quarterly		X	X	X		
Outfall 382	Annually		X	X			
Outfall 383	Annually		X		X		
Sewage Treatment Plant (X01)	Monthly	X	X			X	
Coal Yard Runoff Treatment Facility (X02)	Monthly	X	X				
Process Waste Treatment Complex (X12)	Monthly	X	X	X	X	X	X
Melton Branch 1 (X13)	Monthly	X	X	X	X	X	
White Oak Creek (X14)	Monthly	X	X	X	X	X	
White Oak Dam (X15)	Monthly	X	X	X	X	X	

[a]Isotopic analyses will be performed to identify contributors to gross activities when results exceed screening criteria described in the Radiological Monitoring Plan, June 1999.

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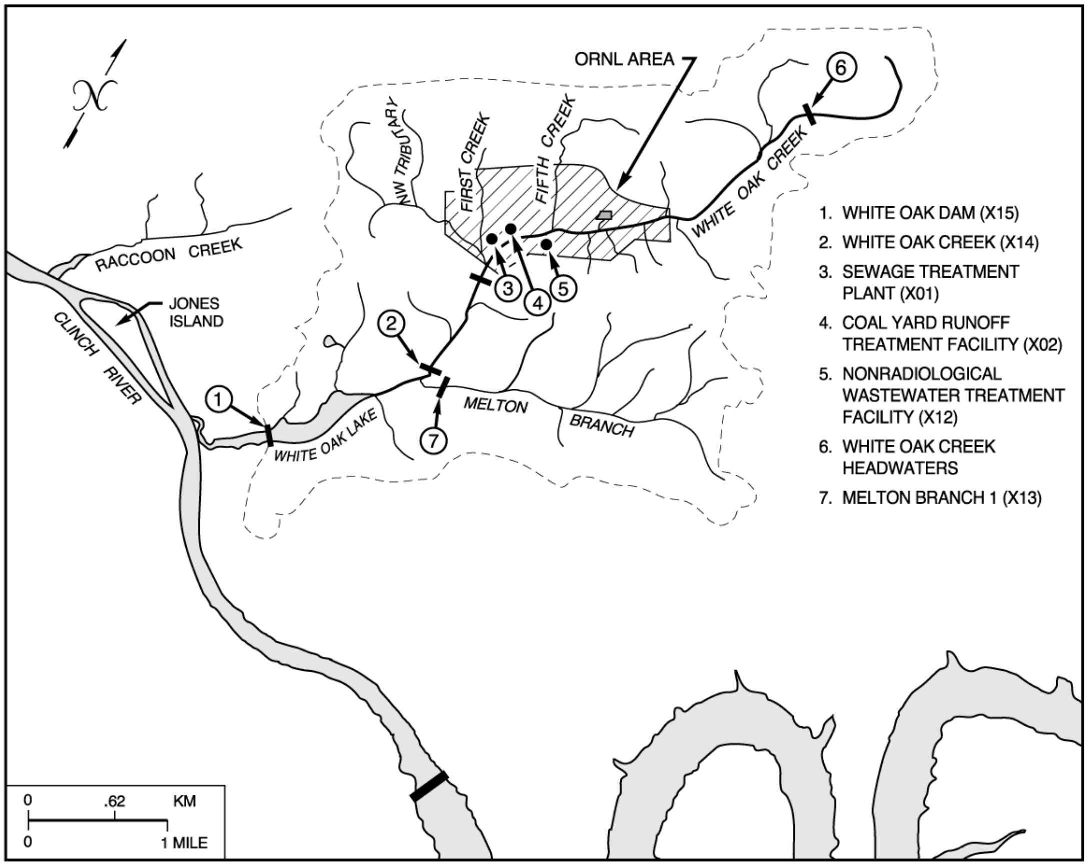

Fig. 5.6. ORNL surface water, NPDES, and reference sampling locations. Bars (**I**) indicate sampling locations that have weirs.

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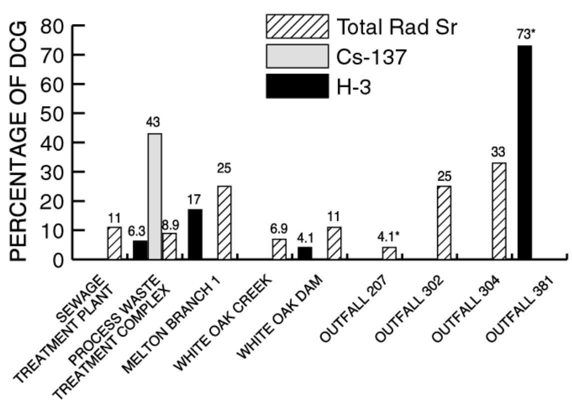

Fig. 5.7. Radionuclides at ORNL sampling sites having average concentrations greater than 4% of the relevant derived concentration guides in 2000.

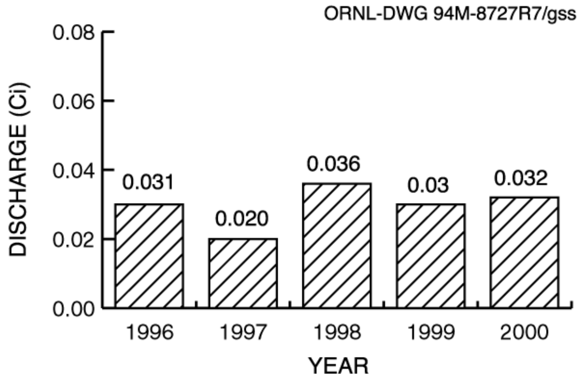

Fig. 5.8. Cobalt-60 discharges at White Oak Dam, 1996–2000.

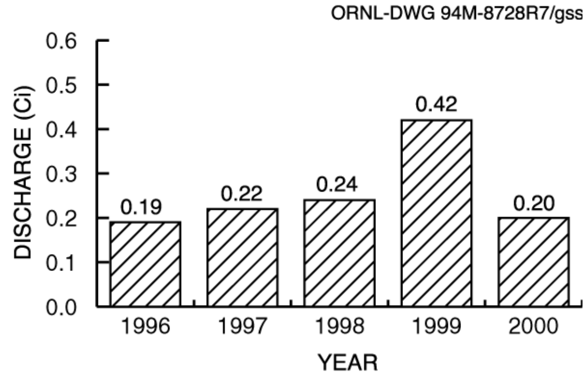

Fig. 5.9. Cesium-137 discharges at White Oak Dam, 1996–2000.

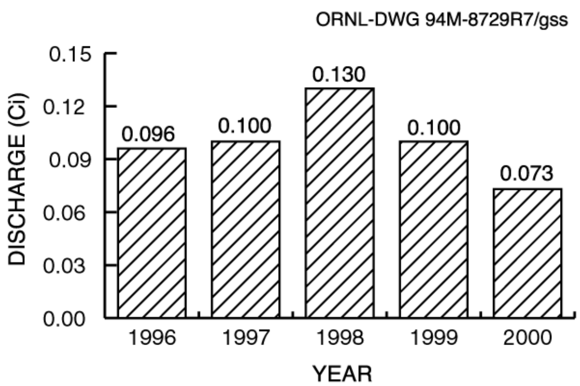

Fig. 5.10. Gross alpha discharges at White Oak Dam, 1996–2000.

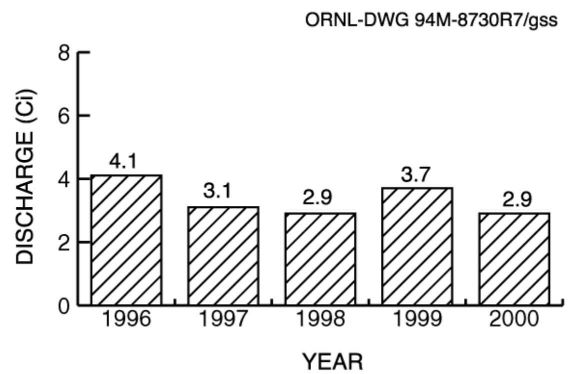

Fig. 5.11. Gross beta discharges at White Oak Dam, 1996–2000.

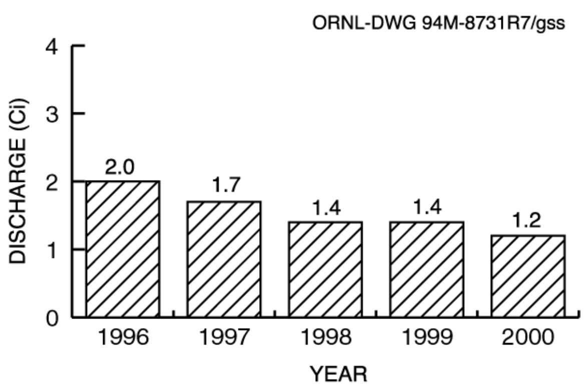

Fig. 5.12. Total radioactive strontium discharges at White Oak Dam, 1996–2000.

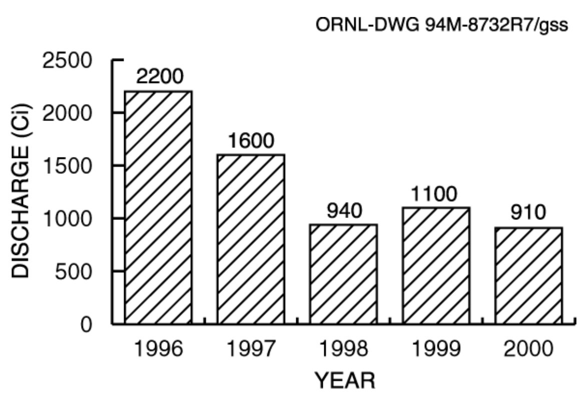

Fig. 5.13. Tritium discharges at White Oak Dam, 1996–2000.

first round of storm water sampling under the RMP were selected so that different parts of the ORNL facility would be represented. Storm water samples are analyzed for gross alpha, gross beta, and ^{3}H activities. A gamma scan is also performed. Under the RMP, additional analyses are added when there is enough gross alpha and/or gross beta activity at an outfall to indicate that DOE DCG levels may be exceeded. No additional tests were necessary for the samples collected in December 1999 and 2000. Because of a laboratory error associated with a gross alpha analysis, tests for uranium activity were performed at outfall 041, and these results are also presented.

Of the 85 individual stormwater sample results, 71 (83.5%) were less than the minimum detectable activities (MDAs). All of the isotope-specific measurements made in stormwater in 1999 and 2000 (^{3}H, ^{60}Co, ^{137}Cs, ^{234}U, ^{235}U, ^{236}U, and ^{238}U) were less than 1 percent of their DCGs. The maximum gross alpha and gross beta activities were measured at outfall 341; they were 13 ± 4 pCi/L and 340 ± 17 pCi/L, respectively. Discharges from this outfall are known to be affected by the Corehole 8 groundwater contamination plume. The primary contributors to the gross alpha and gross beta activities in that plume are ^{233}U and ^{90}Sr, respectively.

5.5 ORNL NPDES SUMMARY

5.5.1 NPDES Permit Monitoring

ORNL NPDES Permit TN0002941 was renewed on December 6, 1996, and became effective on February 3, 1997. Data collected for the NPDES permit are submitted to the state of Tennessee in the monthly Discharge Monitoring Report. The renewed permit includes 164 separate outfalls and monitoring points.

ORNL's NPDES permit requires that point-source outfalls be sampled before they are discharged into receiving waters or before they mix with any other wastewater stream (see Fig. 5.6). Under the renewed permit, numeric and aesthetic effluent limits have been placed on the following locations:

- X01—STP;
- X02—CYRTF;
- X12—PWTC;
- X13—Melton Branch (MB1);
- X14—White Oak Creek (WOC);
- X15—WOD;
- In-stream chlorine monitoring points (X16-X26);
- Steam condensate outfalls;
- Groundwater from building foundation drains;
- Category I outfalls [storm drains, water discharged under best management practices (BMPs), groundwater, steam, and water condensate];
- Category II outfalls (storm drains, water discharged under BMPs, groundwater, steam, and water condensate);
- Category III outfalls (storm drains, water discharged under BMPs, groundwater, steam, water condensate, cooling water, and cooling tower blowdown);
- Category IV outfalls (storm drains, water discharged under BMPs, groundwater, steam, water condensate, cooling water, and cooling tower blowdown); and
- Cooling systems (cooling water and cooling tower blowdown).

Permit limits and compliance statistics are shown in Table 5.5. Instream data collection points X-13, X-14, and X-15 are not included in the table because only flow measurements and aesthetics are required under the NPDES permit. Permit nonconformances in 2000 are shown in Fig. 5.14.

ORNL was in full compliance with numeric limits established in its NPDES Permit in 2000. However, measurements for the Biological Monitoring and Abatement Program (BMAP) Temperature Profile indicated exceedence of narrative conditions for temperature at two outfalls, 058 and 281, in August 2000. Outfall 058 caused the receiving-stream temperature to be slightly lower than allowed, and Outfall 281 caused the receiving-stream temperature to be slightly higher than allowed. The Outfall 281 exceedence is being addressed by a new cooling tower that will be completed in 2001. The Outfall 058 exceedence corrective action plan is still in progress.

Table 5.5. NPDES compliance at ORNL, 2000 (NPDES permit effective Feb. 3, 1997)

Discharge point	Effluent parameters	Permit limits					Permit compliance		
		Monthly avg (kg/d)	Daily max (kg/d)	Monthly avg (mg/L)	Daily max (mg/L)	Daily min (mg/L)	Number of noncompliances	Number of samples	Percentage of compliance[a]
X01 (Sewage Treatment Plant)	96-h LC_{50} for *Ceriodaphnia* (%)					41.1	0	4	100
	96-h LC_{50} for fathead minnows (%)					41.1	0	4	100
	Ammonia, as N (summer)	2.84	4.26	2.5	3.75		0	79	100
	Ammonia, as N (winter)	5.96	8.97	5.25	7.9		0	77	100
	Carbonaceous biochemical oxygen demand	8.7	13.1	10	15		0	156	100
	Dissolved oxygen					6	0	156	100
	Fecal coliform (col/100 mL)			1000	5000		0	156	100
	No-observed-effect conc. for *Ceriodaphnia* (%)					12.3	0	4	100
	No-observed-effect conc. for fathead minnows (%)					12.3	0	4	100
	Oil and grease	8.7	13.1	10	15		0	156	100
	pH (std. units)				9	6	0	156	100
	Total residual chlorine			0.038	0.066		0	156	100
	Total suspended solids	26.2	39.2	30	45		0	156	100
X02 (Coal Yard Runoff Treatment Facility)	96-h LC_{50} for *Ceriodaphnia* (%)					4.2	0	4	100
	96-h LC_{50} for fathead minnows (%)					4.2	0	4	100
	Copper, total			0.07	0.11		0	25	100
	Iron, total			1.0	1.0		0	25	100
	No-observed-effect conc. for *Ceriodaphnia* (%)					1.3	0	0[b]	100
	No-observed-effect conc. for fathead minnows (%)					1.3	0	0[b]	100
	Oil and grease			10	15		0	52	100
	pH (std. units)				9.0	6.0	0	52	100
	Selenium, total			0.22	0.95		0	25	100
	Silver, total				0.008		0	25	100
	Total suspended solids				50		0	52	100
	Zinc, total			0.87	0.95		0	25	100

Table 5.5 (continued)

Discharge point	Effluent parameters	Permit limits: Monthly avg (kg/d)	Permit limits: Daily max (kg/d)	Permit limits: Monthly avg (mg/L)	Permit limits: Daily max (mg/L)	Permit limits: Daily min (mg/L)	Permit compliance: Number of noncompliances	Permit compliance: Number of samples	Permit compliance: Percentage of compliance[a]
X12 (Process Waste Treatment Complex)	96-h LC_{50} for *Ceriodaphnia* (%)					100	0	4	100
	96-h LC_{50} for fathead minnows (%)					100	0	4	100
	Cadmium, total	0.79	2.09	0.008	0.034		0	53	100
	Chromium, total	5.18	8.39	0.22	0.44		0	53	100
	Copper, total	6.27	10.24	0.07	0.11		0	53	100
	Cyanide, total	1.97	3.64	0.008	0.046		0	4	100
	Lead, total	1.3	2.09	0.028	0.69		0	53	100
	Nickel, total	7.21	12.06	0.87	3.98		0	53	100
	No-observed-effect conc. for *Ceriodaphnia* (%)					30.9	0	4	100
	No-observed-effect conc. for fathead minnows (%)					30.9	0	4	100
	Oil and grease	30.3	45.4	10	15		0	52	100
	pH (std. units)				9.0	6.0	0	156	100
	Silver, total	0.73	1.3		0.008		0	53	100
	Temperature (°C)				30.5		0	156	100
	Total toxic organics		6.45		2.13		0	12	100
	Zinc, total	4.48	7.91	0.87	0.95		0	53	100
Instream chlorine monitoring points	Total residual oxidant			0.011	0.019		0	264	100
Steam condensate outfalls	pH (std. units)				9.0/8.5	6.0/6.5	0	12	100
Groundwater/ pumpwater outfalls	pH (std. units)				9.0/8.5	6.0/6.5	0	4	100

Table 5.5 (continued)

Discharge point	Effluent parameters	Permit limits: Monthly avg (kg/d)	Permit limits: Daily max (kg/d)	Permit limits: Monthly avg (mg/L)	Permit limits: Daily max (mg/L)	Permit limits: Daily min (mg/L)	Permit compliance: Number of noncompliances	Permit compliance: Number of samples	Permit compliance: Percentage of compliance[a]
Cooling tower blowdown outfalls	pH (std. units)				9.0	6.0	0	4	100
Category I outfalls	pH (std. units)				9.0	6.0	0	21	100
Category II outfalls	pH (std. units)				9.0	6.0	0	19	100
Category III outfalls	pH (std. units)				9.0	6.0	0	55	100
Category IV outfalls	pH (std. units)				9.0	6.0	0	312	100
Cooling tower blowdown/ cooling water outfalls	pH (std. units)				9.0	6.0	0	48	100
	Total residual oxidant			0.011	0.019		0	48	100

[a]Percentage compliance = 100 – [(number of noncompliances/number of samples) * 100].
[b]Insufficient discharge for chronic test and determination of no-observed-effect concentration (NOEC) for each of the quarterly tests.

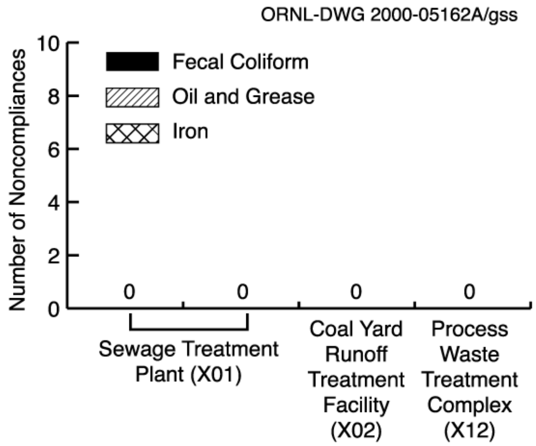

Fig. 5.14. ORNL NPDES permit limit exceedences in 2000.

Under the NPDES permit, ORNL conducts several monitoring plans and programs. These include the RMP, the chlorine control strategy (CCS), and the Storm Water Pollution Prevention Plan (SWP3). These are discussed in the following sections.

5.5.1.1 Radiological Monitoring Plan

In 2000, ORNL continued to sample under the revised RMP implemented on November 1, 1999. Results for the 2000 monitoring are presented in the ORNL Radiological Monitoring Summary section, Sect. 5.4.

5.5.1.2 Chlorine Control Strategy

The NPDES permit regulates the discharge of chlorinated water at ORNL by setting either total residual chlorine concentration limits or total residual oxidant (TRO) mass-loading action levels on outfalls, depending on the outfall's location and the volume of its discharge. At ORNL, TRO measurements may include both chlorine and bromine residuals. Most outfalls with TRO mass-loading action levels are monitored semiannually with the balance of them being monitored either weekly, semimonthly, or quarterly. A number of outfalls were dropped from the CCS in July 2000 because they do not have dry weather TRO discharges. Outfalls included in the CCS have a mass-loading action level for TRO that requires ORNL to reduce or eliminate TRO in the discharge if it exceeds the action level. The action level is 1.2 g/d and is calculated by multiplying the instantaneously measured concentration by the instantaneous flow rate of the outfall. ORNL monitored 234 measurable dry weather discharges during 2000. Two outfalls exceeded the action level one or more times. Actions to reduce or eliminate chlorine in these effluents are being investigated for these outfalls. A report detailing monitoring results, corrective actions, and proposed modifications is submitted to TDEC annually.

5.5.1.3 Storm Water Pollution Prevention Plan

The SWP3 is a requirement of the ORNL NPDES Permit to document existing material management practices and evaluate the vulnerability of those practices in contributing pollutants to area streams via storm water runoff. The plan consists of four major components:

1. assessment and mapping of outdoor material storage/handling at ORNL,
2. characterization of storm water runoff by monitoring,
3. training of employees, and
4. implementation of measures to minimize storm water pollution in areas of ORNL that may be vulnerable.

These four components of the plan were initiated in 1997 and are reviewed and updated by the facility at least annually. The ORNL SWP3 was last updated on August 1, 2000, to incorporate additional information and observations from the preceding year. The ORNL Storm Water Pollution Prevention (SWPP) Program, including the SWP3, SWPP training, and SWPP inspection program, is available to employees on the internal ORNL Web.

ORNL grouped its NPDES outfalls into ten groups based on the permit category and land uses within the outfall drainage area. Representative outfalls from each grouping were chosen for effluent sampling. The permit requires that Category I and II outfalls be characterized over a 5-year period and Category III and IV over a 3-year period. Storm water sampling of outfall effluent continued in 2000.

The U.S. EPA Nationwide Urban Runoff Program (NURP) was developed to expand the understanding of urban runoff pollution by instituting data collection and applied research projects in the urban areas of the United States. The 1983 NURP final report developed urban storm water runoff pollutant loading factors, called “event mean concentrations” (EMCs), for ten standard water quality constituents. The NURP findings were again updated in 1999 by using results of storm water data collected by the U.S. Geological Survey (USGS) and the NPDES Storm Water Program to refine the EMCs.

In a comparison with ORNL data and NURP data, most values for the ten water quality constituents are well below the NURP EMCs. Table 5.6 indicates (with an “X”) those outfalls that exceeded one of the ten NURP constituents. Patterns of values exceeding the EMCs can be generalized by occurring either at Outfall 235 and Outfall 113, or with the copper values. Outfall 235 drains an area (not including the coal pile) around the Building 2519 Steam Plant. Although runoff from the coal pile is not directly routed through this outfall, coal fines are present within the drainage area due to the normal coal yard operations. Outfall 113 drains a high-vehicle-traffic area. ORNL has continued efforts such as street sweeping and preventive maintenance of fleet vehicles to reduce the potential effect of vehicular traffic on storm water runoff.

5.5.2 ORNL Results and Progress in Implementing Programs and Corrective Actions

5.5.2.1 ORNL Sink and Drain Survey Program

In 1997, ORNL completed a comprehensive verification of the routing of all wastewater discharges from points of entry such as sinks and floor drains. As a result, more than 9000 sink and drain records were produced and are stored in a central database. ORNL continued its efforts in 2000 to ensure that sinks and drains discharge to the proper wastewater collection systems by implementing an annual division-by-division recertification of ORNL sinks and drains. An intranet web interface is available for facility personnel to record corrections and updates to sink and drain data. Program management is adapting to the new contracting approach by communicating sink and drain responsibilities to new companies and organizations at ORNL. Also, a new set of drain labels were developed, printed, and distributed.

Table 5.6. ORNL storm water outfalls exceeding published event mean concentrations (EMCs)

Constituent	EMC (mg/L)	Outfall								
		113	165	191	209	217	219	235	086	161
BOD	14.1									
COD	52.8									
Copper	0.0135		X			X	X	X		
Kjeldahl nitrogen	1.73				X					
Lead	0.0675									
Nitrate/ nitrite	0.0658	X								X
Phosphorus, total	0.315							X		
Suspended solids	78.4	X						X		
Zinc	0.162	X						X		

5.6 ORNL WASTEWATER BIOMONITORING

Under the NPDES permit, wastewaters from the STP, the CYRTF, and the PWTC were evaluated for toxicity. The results of the toxicity tests of wastewaters from the three treatment facilities are given in Table 5.7. This table provides, for each wastewater, the month the test was conducted, the wastewater's no-observed-effect concentration (NOEC), and the concentration that kills 50% of the test organisms (LC_{50}) for fathead minnows and *Ceriodaphnia*. The NOEC is the highest concentration tested that does not significantly reduce survival or growth of fathead minnows or survival or reproduction of *Ceriodaphnia*. The 96-h LC_{50} is the concentration of wastewater that kills 50% of the test organisms in 96 h. The NPDES permit defines the limits for the biomonitoring tests. For the X01 (STP) discharge, toxicity is demonstrated if more than 50% lethality of the test organisms occurs in 96 h in 41.1% effluent, or if the NOEC is <12.3%. For the X02 discharge (CYRTF), toxicity is demonstrated if more than 50% lethality of the test organisms occurs in 96 h in 4.2% effluent or the NOEC is <1.3%. Because of the batch mode of discharge at CYRTF, the limit for the NOEC only applies if the facility discharges for a sufficient length of time. For the X12 discharge (PWTC), toxicity is demonstrated if more than 50% lethality of the test organisms occurs in 96 h in 100% effluent (LC_{50}) or the NOEC is <30.9%.

During 2000, the STP, CYRTF, and PWTC were tested four times each. The biomonitoring limits for STP, CYRTF, and PWTC were not exceeded during 2000.

Table 5.7. Toxicity test results of ORNL wastewaters, 2000

Outfall	Test date	Test species	NOEC[a]	LC_{50}[b]
Sewage Treatment Plant (X01)	February	*Ceriodaphnia*	41.1	>41.1
		Fathead minnow	41.1	>41.1
	June	*Ceriodaphnia*	41.1	>41.1
		Fathead minnow	41.1	>41.1
	August	*Ceriodaphnia*	41.1	>41.1
		Fathead minnow	41.1	>41.1
	November	*Ceriodaphnia*	12.3	>41.1
		Fathead minnow	41.1	>41.1
Coal Yard Runoff Treatment Facility (X02)	February	*Ceriodaphnia*	NA	>4.2[c]
		Fathead minnow	*d*	>4.2[c]
	June	*Ceriodaphnia*	*d*	>4.2[c]
		Fathead minnow	*d*	>4.2[c]
	August	*Ceriodaphnia*	*d*	>4.2
		Fathead minnow	*d*	>4.2
	November	*Ceriodaphnia*	*d*	>4.2[c]
		Fathead minnow	*d*	>4.2[c]
Process Waste Treatment Complex (X12)	February	*Ceriodaphnia*	100	>100
		Fathead minnow	100	>100
	June	*Ceriodaphnia*	100	>100
		Fathead minnow	100	>100
	August	*Ceriodaphnia*	80	>100
		Fathead minnow	100	>100
	November	*Ceriodaphnia*	100	>100
		Fathead minnow	100	>100

[a]NOEC = no-observed-effect concentration [the concentration (as percentage of full-strength wastewater) that caused no reduction in *Ceriodaphnia* survival or reproduction or fathead minnow survival or growth].

[b]LC_{50} = the concentration (as percentage of full-strength wastewater) that kills 50% of the test species in 96 h.

[c]48-h LC_{50}.

[d]Insufficient duration of discharge for chronic test and determination of NOEC.

5.7 ORNL BIOLOGICAL MONITORING AND ABATEMENT PROGRAM

5.7.1 Bioaccumulation Studies

The bioaccumulation task addresses two NPDES permit requirements at ORNL: (1) evaluate whether mercury at the site is contributing to a stream such that it will impact fish and aquatic life or violate the recreational criteria (instream water analyses for mercury should be part of this activity); and (2) monitor the status of PCB contamination in fish tissue in the WOC watershed.

Water samples were collected for mercury analysis from four WOC sites on six occasions in 2000. The mean mercury concentration in WOC at the weir upstream from ORNL (WCK 6.8) was below the analytical detection limit (<10 ng/L) on all sampling dates. Downstream from ORNL, average mercury concentrations in WOC surface water exceeded the Tennessee water quality criterion (51 ng/L) at only one site, MS 3619 (the flume upstream from the nonradiological wastewater treatment facility), where mercury concentrations averaged [± the standard deviation (SD)] 162 ± 116 ng/L, and ranged from 26 ng/L to 319 ng/L. The mean mercury concentration was 49 ± 12 ng/L at the weir below Melton Valley Road, with a range of 37 ng/L to 70 ng/L. Mean concentrations were even lower downstream of White Oak Lake (WOL), averaging 36 ± 15 ng/L total mercury, with a range of 20 ng/L to 58 ng/L.

The spatial pattern of mercury in WOC fish collected in the spring of 2000 was consistent with the pattern observed in the water. The highest concentrations in fish appeared to be localized within WOC-proper, where the mean mercury concentration [0.44 ± 0.06, µg/g ± the standard error (SE)] in redbreast sunfish was five times higher than the mean concentration in bluegill collected ~1.4 kilometers downstream in WOL (average 0.08 µg/g ± 0.01). Although aqueous mercury exceeded the state water quality standard adjacent to the main ORNL facility during this period, the mean mercury concentration in fish muscle from WCK 2.9 remained below 0.5 mg/kg (the level typically used by the state of Tennessee in issuing fish consumption advisories). However, the 0.44 µg/g average mercury concentration for this site was the highest reported since 1991, and four of the six fish collected exceeded the 0.5 µg/g level. Largemouth bass collected from WOL in 2000 exhibited a similar increase in mercury concentrations relative to the low concentrations in bass in recent years.

The mean PCB concentrations in sunfish from WCK 2.9 and WCK 1.5 were 0.44 ± 0.07 (µg/g ± SE) and 0.85 ± 0.21 (µg/g ± SE), respectively. Such PCB levels are high for relatively short-lived, lipid-poor fish such as sunfish. Reference-site sunfish analyzed at the same time averaged <0.01 µg/g PCBs. The mean PCB concentration in WCK 1.5 bass in the spring of 2000 was 2.58 ± 1.21 (µg/g ± SE). The state of Tennessee typically issues fish consumption advisories when average PCB levels in fish exceed approximately 0.8–1.0 µg/g, and the FDA threshold limit is 2 µg/g. Although the average PCB concentration in bass in 2000 was higher than in 1999 (average 0.85 µg/g), the 2000 average was within the range typically observed at this site in the recent past.

5.7.2 Ecological Surveys

The benthic macroinvertebrate communities of several streams of the WOC watershed have been monitored since 1986. The objectives of this effort are to help assess the condition of these streams, and evaluate the effectiveness of new pollution abatement facilities.

Results for April sampling periods through 1999 show that the benthic macroinvertebrate communities in First Creek, Fifth Creek, and WOC continue to be impacted by ORNL operations (Figs. 5.15, 5.16, and 5.17). Specifically, the total number of taxa (i.e., total taxonomic richness) and the number of pollution-intolerant taxa (i.e., Ephemeroptera, Plecoptera, and Trichoptera, or EPT richness) continue to remain markedly lower downstream of ORNL effluent discharges in all three streams. However, changes have occurred in the macroinvertebrate communities at all study sites that are indicative of improvements in environmental conditions. The benthic macroinvertebrate community in First Creek (FCK 0.1) has experienced two periods of change suggestive of improvements, particularly in the number of pollution-intolerant taxa (Fig. 5.15). These changes occurred after 1991 and 1994 when the pollution-intolerant taxa almost doubled.

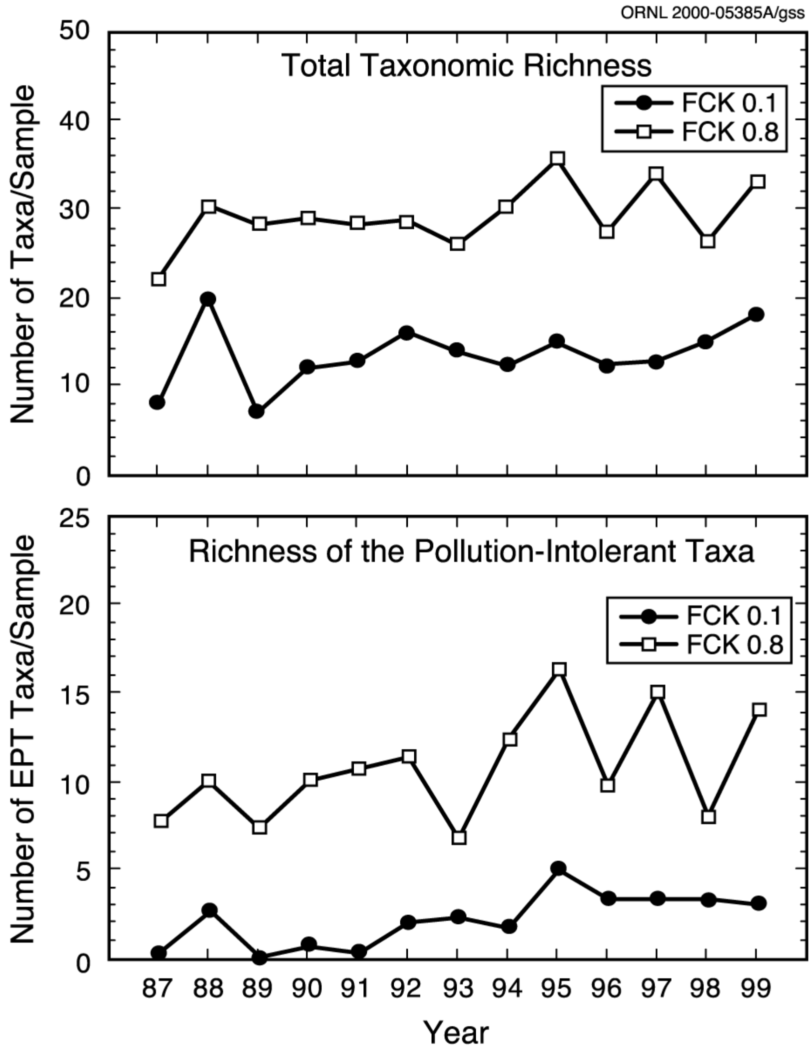

Fig. 5.15. Taxonomic richness and richness of the pollution intolerant taxa of the benthic macroinvertebrate communities in First Creek during April sampling periods, 1987–1999. FCK = First Creek kilometer. EPT = Ephemeroptaera, Plecoptera, and Trichoptera.

Major improvements appeared to occur in the macroinvertebrate community in lower Fifth Creek (FFK 0.2) from 1990 to 1993, when both total and EPT richness increased several fold. Since 1993, no further major changes have occurred at FFK 0.2, suggesting that conditions have stabilized. The macroinvertebrate community in WOC also appears to have experienced at least two major periods of improvement, particularly at site WCK 3.9. The first period was after 1989, when a persistent increase in the number of pollution intolerant taxa occurred at sites WCK 2.3 and WCK 3.9. The second period of change was after 1995 when both total and EPT richness increased, and they have since remained persistently higher than in previous years.

Monitoring of the fish communities in WOC and its major tributaries continued in 2000. Samples were taken at 11 and 9 sites in the spring and fall, respectively; sites closest to ORNL facilities were emphasized. In the main stem of WOC, the fish community continued to display characteristics of degraded conditions, with sites closest to the outfalls having lower species richness (number of species), fewer sensitive species, and more pollution-tolerant species, but higher density (number of fish/m^2). The sites adjacent to Bldg. 4515 (WCK 4.3 and 4.4) had very high densities

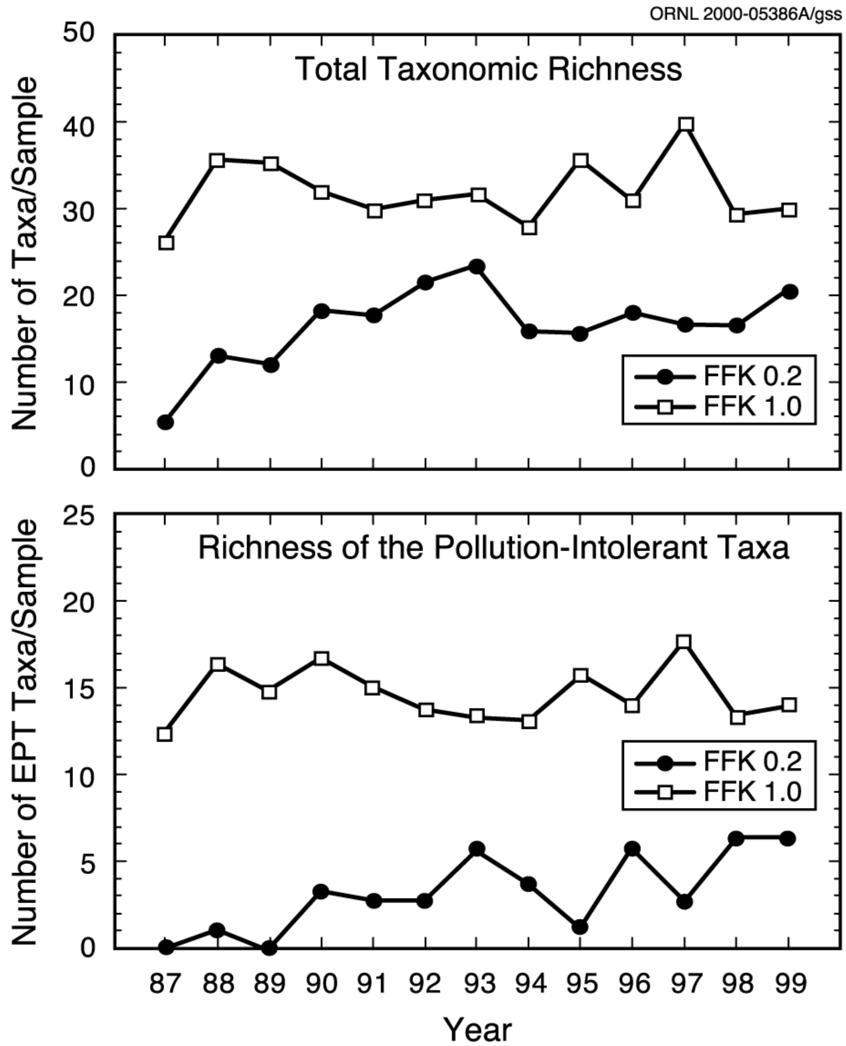

Fig. 5.16. Taxonomic richness and richness of the pollution intolerant taxa of the benthic macroinvertebrate communities in Fifth Creek during April sampling periods, 1987–1999. FFK = Fifth Creek kilometer. EPT = Ephemeroptaera, Plecoptera, and Trichoptera.

(8–16 fish/m^2) that were 7 to 50 times higher than the density at WCK 3.9, a site near the PWTC treatment discharge. These densities were also much higher than those at area reference streams, suggesting some stimulation of production, perhaps from nutrient enrichment. However, the high densities were countered by very low species richness, with these sites having only half as many species as similar-sized, nearby reference streams.

The data from 2000 continued to show a long-term positive trend, indicating that the fish communities at sites closest to the plant have improved since 1985. However, one trend in WOC was a continued decline in the fish density at WCK 3.9, which is one of the sites within the main ORNL complex. This decline almost totally reflected the reduced density of only one species, the central stoneroller (*Campostoma anomalum*). Densities also have been declining at the next main-stem site downstream of all ORNL outfalls (i.e., WCK 3.4). At WCK 2.3, which is below the confluence of Melton Branch with WOC, the fish community has shown some improvement, with several sucker species and a darter found in spring and fall 2000 samples. These species are more pollution sensitive, and were not found in early sampling at the site.

Upstream of ORNL, sampling at WCK 6.8 near the Spallation Neutron Source (SNS) con-

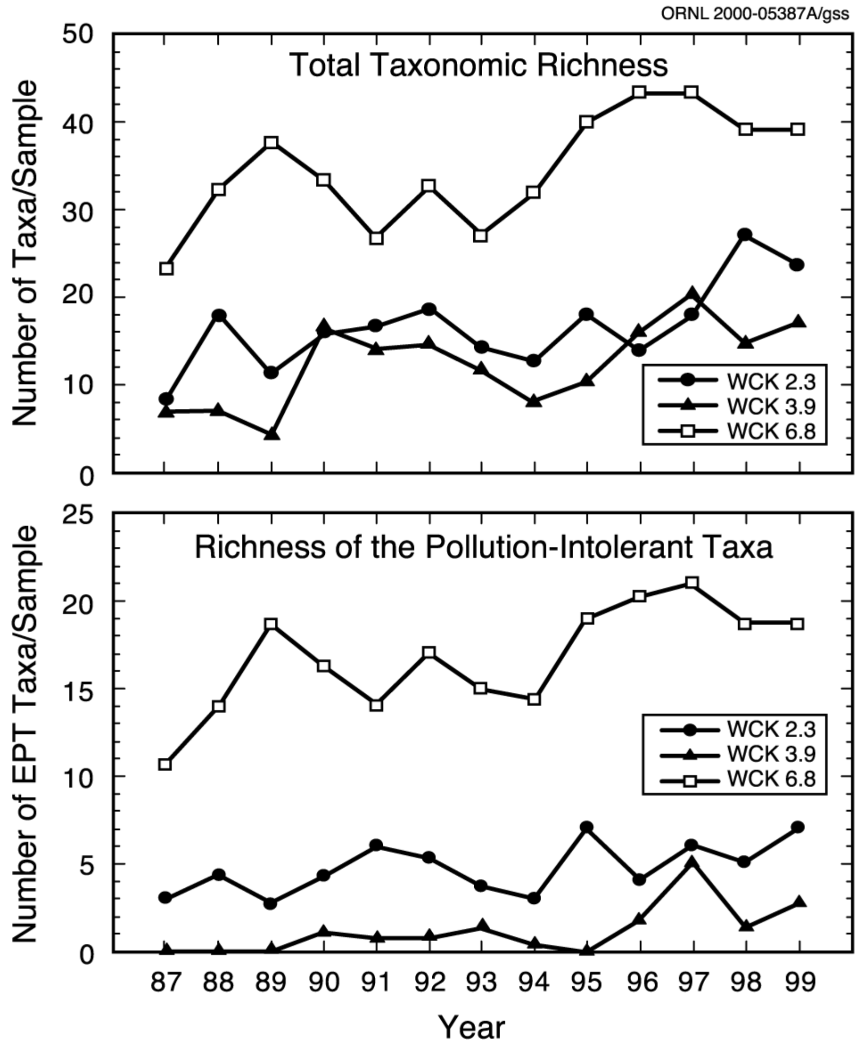

Fig. 5.17. Taxonomic richness and richness of the pollution-intolerant taxa of the benthic macroinvertebrate communities in White Oak Creek during April sampling periods, 1987–1999. WCK = White Oak Creek kilometer. EPT = Ephemeroptaera, Plecoptera, and Trichoptera.

struction site showed limited evidence of impacts on fish density and richness in fall 2000. Based on a visual examination of the stream habitat at this site, there appears to be a potential for some future changes in the fish community because stream-side vegetation was reduced and sedimentation increased.

In the major tributaries, the fish communities also showed some recovery, but they remain impacted relative to reference streams. Fifth Creek at site FFK 0.2 has shown the most improvement. This site has changed from one that was incapable of supporting a fish community before 1992 to one having a fairly stable, three-species community in 2000. The density has increased rapidly since 1992, and by fall 2000, density exceeded 5 fish/m^2. High densities also have been measured at the upstream reference site (FFK 1.0) since 1986. In Melton Branch, two species of fish first found at MEK 1.4 in 1999, the central stoneroller and redbreast sunfish, remained a part of the fish community. Densities in Melton Branch have remained relatively stable since 1988. In First Creek, the downstream site (FCK 0.1) had high species richness (seven species) but density that is low and that has been declining since 1985. This site has experienced a noticeable increase in sedimentation, especially near the stream's confluence with Northwest Tributary.

5.8 ORNL SURFACE WATER MONITORING AT REFERENCE LOCATION

WOC headwaters are monitored as a background or reference location. In 2000, data were collected from WOC headwaters until a storm event deposited excessive sediment at the monitoring site. The WOC headwaters site is being restored for use in 2001.

Analyses were performed to detect radioactive, conventional, and inorganic pollutants in the water. Conventional pollutants are indicated by measurements of conductivity, temperature, turbidity, pH, total suspended solids (TSS), and oil and grease. Inorganic parameters are indicated by analyses for metals and anions (Table 5.8).

In an effort to provide a basis for evaluation of analytical results and for assessment of nonradiological surface water quality, Tennessee General Water Quality Criteria (TWQC) have

Table 5.8. Analyses for ORNL reference surface waters, 2000

Parameter	N det/ N total	Concentration			Standard error[c]	Ref. value[d]	Percent of ref. value[e]
		Max[a]	Min[a]	Avg[b]			
White Oak Creek Headwaters							
Anions (mg/L)							
Sulfate, as SO_4	7/7	4.9	2.3	3.7	0.37	*f*	*f*
Field Measurements							
Conductivity (mS/cm)	33/33	0.22	0.098	0.16	0.0066	*f*	*f*
Dissolved oxygen (mg/L)	33/33	11	8.3	9.3	0.11	*f*	*f*
pH (SU)	33/33	8.1	7.0	7.7	0.048	*f*	*f*
Temperature (°C)	33/33	18	5.3	13	0.64	*f*	*f*
Turbidity (NTU)	33/33	1,000	4.0	65	30	*f*	*f*
Metals (mg/L)							
Antimony, total	1/7	0.00056	<0.00050	~0.00051	0.0000086	*f*	*f*
Arsenic, total	3/7	0.0079	<0.0010	~0.0023	0.00096	*f*	*f*
Cadmium, total	0/7	<0.00050	<0.00050	~0.00050	0	0.0039	*f*
Chromium, total	1/7	0.0086	<0.0020	~0.0029	0.00094	*f*	*f*
Copper, total	2/7	0.0051	<0.0010	~0.0016	0.00059	0.0177	9.1
Iron, total	5/7	7.7	<0.25	~1.7	1.0	*f*	*f*
Lead, total	7/7	0.0089	0.00012	0.0020	0.0012	0.0817	2.5
Nickel, total	3/7	0.0035	<0.0010	~0.0015	0.00035	1.418	0.10
Selenium, total	0/7	<0.0020	<0.0020	~0.0020	0	0.02	*f*
Silver, total	0/7	<0.00020	<0.00010	~0.00014	0.000020	0.0041	*f*
Zinc, total	7/7	0.023	0.0059	0.012	0.0022	0.117	10
Others (mg/L)							
Oil and grease	0/7	<5.9	<5.7	~5.7	0.030	*f*	*f*
Physical (mg/L)							
Total suspended solids	7/7	350	3.6	92	48	*f*	*f*

[a]Prefix "<" indicates the value of a parameter (excluding organics) was not quantifiable at the analytical detection limit.

[b]A tilde (~) indicates that estimated values and/or detection limits were used in the calculation.

[c]Standard error of the mean.

[d]Tennessee General Water Quality Criteria for Fish and Aquatic Life is used as a reference value for White Oak Creek headwaters.

[e]Average concentration as a percentage of the reference value, calculated when a reference exists, the parameter is a contaminant, and the parameter is detected.

[f]Not applicable.

been used as reference values. The TWQC for fish and aquatic life have been used at WOC headwaters (see Appendix D, Table D.2, for TWQC for all parameters in water and Table D.3 for surface water analyses).

A summary of the analyses at WOC headwaters is presented in Table 5.8. The average concentration is expressed as a percentage of the reference value when the parameter is a contaminant, the parameter is detected, and a reference value exists. The highest percentages of reference values were for copper and zinc at WOC headwaters. However, these values were only 13% of the reference values, indicating that these waters easily meet their respective TDEC WQC.

Radiological data are compared with DOE DCGs and EPA drinking water standards (DWSs) in Table 5.9. The average concentration for a radionuclide is expressed as a percentage of its DCG or DWS when either exists and when the average concentration is significantly greater than zero. At WOC headwaters in 2000, gross alpha and ^{137}Cs had a DCG/DWS percentage significantly greater than zero, at 10.0% and 0.033% of its DCG/DWS, respectively.

5.9 GROUNDWATER MONITORING AT ORNL

5.9.1 Background

The groundwater monitoring program at ORNL consists of a network of wells of two basic types and functions: (1) water quality monitoring wells built to RCRA specifications and used for site characterization and compliance purposes and (2) piezometer wells used to characterize groundwater flow conditions. The Environmental Management and Enrichment Facilities (EMEF) Program, formerly the Environmental Restoration (ER) Program, provides comprehensive cleanup of sites where past and current research, development, and waste management activities may have resulted in residual contamination of the environment. Individual monitoring and assessment are assumed impractical for each of these sites because their boundaries are indistinct and because there are hydrologic interconnections among many of them. Consequently, the concept of waste area groupings (WAGs) was developed to facilitate evaluation of potential sources of releases to

Table 5.9. Radionuclide concentrations for ORNL Reference surface waters, 2000

Radionuclide	N det/ N total	Concentration (pCi/L)			Standard error[c]	DCG[d]	Percent of DCG[e]
		Max[a]	Min[a]	Avg[b]			
			White Oak Creek Headwaters				
^{60}Co	0/7	3.2	–0.30	0.39	0.48	5,000	*f*
^{137}Cs	1/7	2.3*	0.16	0.99*	0.29	3,000	0.033
Gross alpha	3/7	3.2*	–0.055	1.5*	0.55	15[g]	10.0[h]
Gross beta	3/7	8.4*	–0.16	3.0*	1.1	*f*	*f*

[a]Individual radionuclide concentrations significantly greater than zero at the 95% confidence level are identified by an *.

[b]Average radionuclide concentrations significantly greater than zero at the 95% confidence level are identified by an *.

[c]Standard error of the mean.

[d]Derived concentration guide (DCG) for ingestion of water. From DOE Order 5400.5.

[e]Average concentration as a percentage of the DCG, calculated only when a DCG exists and the average concentration is significantly greater than zero at the 95% confidence level.

[f]Not applicable.

[g]EPA Drinking Water Standards (DWS)(40 CFR 141.15).

[h]Percent of EPA DWS.

the environment. A WAG is a grouping of multiple sites that are geographically contiguous and/or that occur within hydrologically (geohydrologically) defined areas. WAGs allow establishment of suitably comprehensive groundwater and surface water monitoring and remediation programs in a far shorter time than that required to deal with every facility, site, or Solid Waste Management Unit (SWMU) individually. Some WAGs share boundaries, but each WAG represents a collection of distinct small drainage areas, within which similar contaminants may have been introduced. Monitoring data from each WAG are used to direct further groundwater studies aimed at addressing individual sites or units within a WAG as well as contaminant plumes that extend beyond the perimeter of a WAG.

At ORNL, 20 WAGs were identified by the RCRA Facility Assessment (RFA) conducted in 1987. Thirteen of them have been identified as potential sources of groundwater contamination. Additionally, there are a few areas where potential remedial action sites are located outside the major WAGs. These individual sites have been considered separately (instead of expanding the area of the WAG). Water quality monitoring wells have been established around the perimeters of the WAGs determined to have a potential for release of contaminants. Figure 5.18 shows the location of each of the 20 WAGs.

Groundwater quality monitoring wells for the WAGs are designated as hydraulically upgradient or downgradient (perimeter), depending on their location relative to the general direction of groundwater flow. Upgradient wells are located to provide groundwater samples that are not expected to be affected by possible leakage from the site. Downgradient wells are positioned along the perimeter of the site to detect possible groundwater contaminant migration from the site. There are no groundwater quality monitoring wells installed for the WAG 10 grout sheets.

In 1996, DOE established the Integrated Water Quality Program (IWQP) (Sect. 3.10) to conduct long-term environmental monitoring throughout the ORR. The IWQP is the vehicle for the DOE to carry out the regulatory requirement from the Federal Facility Agreement (FFA) to conduct postremedial action monitoring. Under the IWQP Plan (DOE 1998e), there was a shift away from the use of the WAG concept to more of a watershed approach to remediation, which resulted in the assignment of two watersheds to ORNL, Bethel Valley, and Melton Valley. The Water Resources Restoration Program (WRRP) succeeded the IWQP in fall 1999.

The ORNL groundwater program was reviewed in 1996, and modifications included transfer of monitoring responsibility for some of the WAGs to IWQP (now WRRP). ORNL retained monitoring responsibility for WAGs that have the potential for groundwater contamination because of ongoing ORNL activities. A summary of the ORNL groundwater surveillance program is presented in Table 5.10, which indicates whether WAGs are within Bethel Valley or Melton Valley. To provide continuity with previous Annual Site Environmental Reports (ASERs) and to allow comparison of activities and sampling results, the WAG concept is used in the following discussions. In the current ORNL program, groundwater quality wells are sampled on a rotational basis (Table 5.10).

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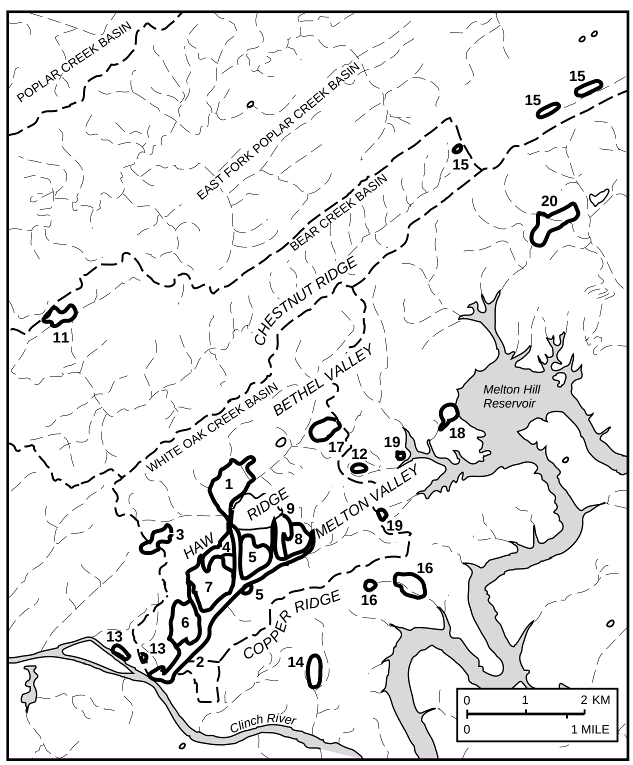

Fig. 5.18. Locations of ORNL waste area groupings (WAGs). (WAG 10 sites are underground, beneath WAG 5.)

Table 5.10. Summary of the groundwater surveillance program at ORNL, 2000

WAG	Regulatory status	Wells		Frequency and last date sampled in 2000	Locations	Parameters
		Upgradient	Downgradient			
			Bethel Valley			
1	CERCLA and DOE Orders 5400.1 and 5400.5	3	24	June–July 2000	4 wells	Radionuclides[a] and field measurements[b]
3	DOE Orders 5400.1 and 5400.5	3	12	*c*	*c*	*c*
17	DOE Orders 5400.1 and 5400.5	4	4	Rotation June 2000	All wells	Volatile organics, radionuclides,[a] and field measurements[b]
			Melton Valley			
2	CERCLA and DOE Orders 5400.1 and 5400.5	12	8	Rotation May–June 2000	4 wells 16 wells	Full set[d] and field measurements[b] radionuclides[a] and field measurements[b]
4	CERCLA and DOE Orders 5400.1 and 5400.5	4	11	*c*	*c*	*c*
5	CERCLA and DOE Orders 5400.1 and 5400.5	2	20	*c*	*c*	*c*
6	RCRA/CERCLA and DOE Orders 5400.1 and 5400.5	7	17	*e*	*e*	*e*

Table 5.10 (continued)

WAG	Regulatory status	Wells		Frequency and last date sampled in 2000	Locations	Parameters
		Upgradient	Downgradient			
7	CERCLA and DOE Orders 5400.1 and 5400.5	2	14	*c*	*c*	*c*
8 and 9	DOE Orders 5400.1 and 5400.5	2	9	April-May 2000	All wells	Radionuclides[a] and field measurements[b]
			White Wing Scrap Yard			
11	DOE Orders 5400.1 and 5400.5	6	5	*c*	*c*	*c*

[a]Gross alpha and beta, ^{3}H, ^{137}Cs, ^{60}Co, and total radioactive strontium.
[b]Standard field measurements: pH, conductivity, turbidity, oxidation/reduction potential, temperature, and dissolved oxygen.
[c]WRRP (formerly IWQP) samples selected wells for various purposes; other wells are inactive.
[d]Volatile organics, metals, gross alpha and beta, ^{3}H, ^{137}Cs, ^{60}Co, and total radioactive strontium.
[e]Sampled by EMEF and data reported in the *Groundwater Quality Assessment Report for Solid Waste Storage Area 6 at Oak Ridge National Laboratory, Oak Ridge, Tennessee CY 1999* (BJC 2001b).

Monitoring results for remedial actions (i.e., under WRRP purview) that are in progress or that have been completed within specific WAGs are reported annually in the Remediation Effectiveness Report (RER) (DOE 2001). Additionally, in the case of WAG 6, which is regulated under both RCRA and CERCLA, specific monitoring results and interpretations required by RCRA are reported in the annual Groundwater Quality Assessment Report for WAG 6, which is issued in February of each year (BJC 2000b).

The ORNL exit pathway program is designated to monitor groundwater at locations that are thought to be likely exit pathways for groundwater affected by activities at ORNL. The program was initiated in 1993 and was reviewed in 1996, which resulted in WOC/Melton Valley being the focus of the program (Fig. 5.19). A summary of the current program is presented in Table 5.11.

Groundwater monitoring for the ORNL WAG perimeter monitoring network and the ORNL plant perimeter surveillance during 2000 involved approximately 49 wells.

Four of the ten wells identified by the *ORR Environmental Monitoring Plan* (EMP) (DOE 1998b) as ORNL's exit pathway monitoring program are also part of the WAG perimeter monitoring program. These four wells are located on WAG 2, and 2000 data from sampling conducted under the WAG perimeter program were used for the exit pathway monitoring program. The surface water location (WOC at WOD) was sampled in October 2000. The results of the plant perimeter monitoring program are discussed in part in the following sections.

Groundwater quality is regulated under RCRA by referring to the Safe Drinking Water Act (SDWA) standards. The standards are applied when a site undergoes RCRA permitting. None of the ORNL WAGs are under RCRA permits at this time; therefore, no permit standards exist with which to compare sampling results. In an effort to provide a basis for evaluation of analytical results and for assessment of groundwater quality at ORNL WAGs, federal drinking water standards, and Tennessee WQC for domestic water supplies are used as reference values in the following discussions. When no federal or state standard has been established for a radionuclide, then 4% of the DOE DCG is used. Although DWSs are used, it is unrealistic to assume that members of the public are going to drink groundwater from ORNL WAGs. There are no groundwater wells furnishing drinking water to personnel at ORNL or the public.

ORNL-DWG 93M-10468

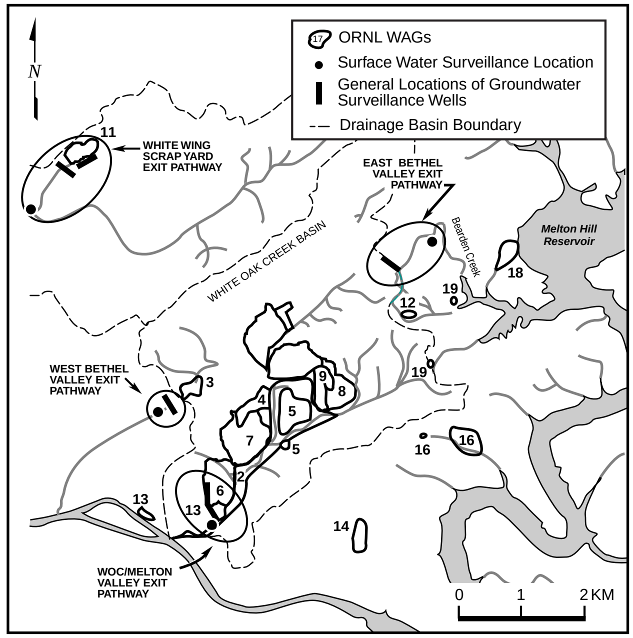

Fig. 5.19. Groundwater exit pathways on the Oak Ridge Reservation that are likely to be affected by Oak Ridge operations.

Table 5.11. Summary of the plant perimeter surveillance program at ORNL, 2000

Exit pathway	WAG	Number of wells	Surface water locations	Parameters
White Oak Creek/ Melton Valley	6 and 2[a]	10	White Oak Creek at White Oak Dam	Volatile organics, ICP metals, ^{3}H, total radioactive strontium, gross alpha and beta, ^{60}Co and ^{137}Cs

[a]Four wells are part of the ORNL WAG 2 perimeter network.

5.9.2 Bethel Valley

Bethel Valley, located in the southeastern portion of the ORR, lies between two prominent, parallel, northeast-southwest trending ridges, Chestnut Ridge to the north and Haw Ridge to the south. Research and development facilities have been located within it for 50 years, and it contains the main ORNL facilities complex, including buildings, reactors, surface impoundments, and buried waste tank farms with transfer pipelines. In most instances, groundwater in the valley flows northeast-southwest (i.e., parallel to the strike direction), and contaminant plumes generally enter the surface water system where contaminants can be readily monitored.

5.9.2.1 WAG 1 Area

WAG 1, the ORNL main plant area, contains about one-half of the remedial action (RA) sites identified to date by the EMEF Program. WAG 1 lies within the Bethel Valley portion of the WOC drainage basin. The boundaries of the basin extend to the southeast and northeast along Chestnut Ridge and Haw Ridge. The WAG boundary extends to the water gap in Haw Ridge. The total area of the basin in Bethel Valley is about 2040 acres. Bedrock beneath the main plant area is limestone, siltstone, and calcareous shale facies of the Ordovician Chickamauga Group.

Many of the WAG 1 sites were used to collect and store low-level waste (LLW) in tanks, ponds, and waste treatment facilities, but some sites also include landfills and contaminated sites resulting from spills and leaks that have occurred over the last 50 years. Because of the nature of cleanup and repair, it is not possible to determine which spill or leak sites still represent potential sources of release. Most of the SWMUs are related to ORNL's past waste management operations. Recent EMEF activities within WAG 1 include several CERCLA actions associated with sources of contamination [e.g., removal of liquids and sludge from the Gunite and Associated Tanks (GAAT) and the removal of liquids and sludge from the 190 ponds and subsequent backfilling with rocks and grout].

WAG 1 Results

In 2000, four WAG 1 wells potentially affected by current ORNL activities were sampled for radionuclides only. These four wells (807, 808, 809, and 830) are in the southwest area of WAG 1. Tritium ranged from below detection to 3400 pCi/L, and total radioactive strontium ranged from below detection to 8.7 pCi/L at well 830, which is above the DWS of 8 pCi/L. All four wells' results were consistent with historical data with respect to all radionuclides except gross beta. Gross beta activity at wells 807 and 808 were higher during 2000, as compared to historical values.

5.9.2.2 WAG 3 Area

WAG 3 is located in Bethel Valley about 0.6 mile (1 km) west of the main plant area. WAG 3 is composed of three SWMUs: Solid Waste Storage Area (SWSA) 3, the Closed Scrap Metal Area (1562), and the Contractors' Landfill (1554).

SWSA 3 and the Closed Scrap Metal Area are inactive landfills known to contain radioactive solid wastes and surplus materials generated at ORNL from 1946 to 1979. Burial of solid waste ceased at this site in 1951; however, the site continued to be used as an aboveground scrap metal storage area until 1979. Sometime during the period from 1946 to 1949, radioactive solid wastes removed from SWSA 2 were buried at this site. In 1979, most of the scrap metal stored aboveground at SWSA 3 was either transferred to other storage areas or buried on site in a triangular-shaped disposal area immediately south of SWSA 3.

Records of the composition of radioactive solid waste buried in SWSA 3 were destroyed in a fire in 1961. Sketches and drawings of the site indicate that alpha and beta-gamma wastes were segregated and buried in separate areas or trenches. Chemical wastes were probably also buried in SWSA 3 because there are no records of disposal elsewhere. Although the information is sketchy, the larger scrap metal equipment (such as tanks and drums) stored on the surface at this site was also probably contaminated. Because only a portion of this material is now buried in the Closed Scrap Metal Area, it is not possible to estimate the amount of contamination that exists in this SWMU.

The Contractors' Landfill was opened in 1975 and is now closed. It was used to dispose of various uncontaminated construction materials. No contaminated waste or asbestos was allowed to be buried at the site. ORNL disposal procedures required that only non-RCRA, nonradioactive solid wastes were to be buried in the Contractors' Landfill.

WAG 3 Results

Groundwater monitoring in WAG 3 was transferred to the IWQP (now the WRRP) in 1996. Any activities to be reported are published in the WRRP Annual RER (DOE 2001).

5.9.2.3 WAG 17 Area

WAG 17 is located about 1 mile (1.6 km) directly east of the ORNL main plant area. This area has served as the major craft and machine shop area for ORNL since the late 1940s. The area includes the receiving and shipping departments, machine shops, carpenter shops, paint shops, lead-melting facilities, garage facilities, welding facilities, and material storage areas needed to support ORNL's routine and experimental operations. WAG 17 is composed of 18 SWMUs. A former septic tank is now used as a sewage collection/pumping station for the area. Photographic waste tanks have been removed. Four old petroleum underground storage tanks (USTs) were removed during the period from 1987 to 1990, and closure approval for these four USTs was received from TDEC in 1997. Two relatively new USTs are currently registered to store diesel fuel and gasoline.

WAG 17 Results

WAG 17 is located on a northwest-facing slope, with its upgradient wells on the eastern border and downgradient wells on the western border. Although none of the wells had radiological levels above a DWS, the data for wells along the eastern and western boundaries show evidence of radioactivity, including gross alpha activity and ^{3}H. In the past, gross alpha activity has exceeded the DWS at two wells; however, this has not occurred in the past six sampling events. The highest gross alpha activity was 5.3 pCi/L, the highest gross beta activity was 14 pCi/L, and ^{3}H was 3700 pCi/L. Total radioactive strontium was not detected.

The data for the wells along the southeastern and southwestern boundaries show evidence of volatile organic compounds (VOCs). The contamination has consistently been located primarily in one well. The contaminants include trichloroethene, 1,2-dichloroethene, vinyl chloride, which is a degradation product of trichloroethene, 1,1-dichloroethane, tetrachloroethene, and benzene.

5.9.3 Melton Valley

Melton Valley is the second of the two valleys that comprise ORNL. Melton Valley is of primary importance on the ORR because it is one of the major waste storage areas on the reservation. In addition to containing surface structures, it is the location of shallow waste burial trenches and auger holes, landfills, tanks, impoundments, seepage pits, hydrofracture wells and grout sheets, and waste transfer pipelines and associated leak sites. As with Bethel Valley, groundwater plumes within Melton Valley generally enter the surface water system, where contaminants are frequently encountered.

5.9.3.1 WAG 2 Area

WAG 2 is composed of WOC discharge points and includes the associated floodplain and subsurface environment. It represents the major drainage system for ORNL and the surrounding facilities.

In addition to natural drainage, WOC has received treated and untreated effluents and reactor cooling water from ORNL activities since 1943. Controlled releases include those from the PWTC, the STP, and a variety of process waste holdup ponds throughout the ORNL main plant area (WAG 1). It also receives groundwater discharge and surface drainage from WAGs 1, 4, 5, 6, 7, 8, and 9.

There is little doubt that WAG 2 represents a source of continuing contaminant release (radionuclides and/or chemical contaminants) to the

Clinch River. Although it is known that WAG 2 receives groundwater contamination from other WAGs, the extent to which it may be contributing to groundwater contamination has yet to be determined. Recent EMEF activities to determine the extent of WAG 2 groundwater contamination include continued monitoring and support of the WAG 5 seeps removal action, as well as performing a remedial investigation (RI) of the WOC Watershed.

WAG 2 Results

At WAG 2, most of the downgradient wells are to the west and downstream. The upgradient wells are to the east and upstream. As a major drainage system, WAG 2 is influenced by other WAGs, and this seems to be reflected in the analytical results. Major contributors of ^{3}H and total radioactive strontium to WAG 2 (in order of contribution) are WAGs 5, 8, 9, 4, 1, 6, and 7 (see Fig. 5.18).

For example, four of the WAG 2 wells that exhibited high levels of ^{3}H are located south of and downgradient of WAGs 5, 6, and 8. All of the WAG 2 wells show evidence of radioactivity, including gross alpha and gross beta activity and ^{3}H.

Gross beta activity above the screening level was detected at one well at WOD and at one well along the eastern border of WAG 6. Per the discussion in 40 CFR 141.26(b), compliance with the 4 mrem/year standard can be assumed if the average annual gross beta particle activity is less than 50 pCi/L and if the average annual concentrations of ^{3}H and ^{90}Sr are less than 20,000 pCi/L and 8 pCi/L, respectively, provided that, if both radionuclides are present, the sum of their annual dose equivalents to bone marrow is less than 4 mrem/year.

The elevated levels of ^{3}H and total radioactive strontium in the perimeter wells at WOD are believed to be the result of surface water underflow at the dam, not groundwater contamination. Gross alpha activity at WAG 2 ranged from not detected to 17 pCi/L (the DWS is 15 pCi/L), beta activity ranged from not detected to 500 pCi/L, and total radioactive strontium ranged from not detected to 240 pCi/L (the DWS is 8 pCi/L). Tritium ranged from not detected to 460,000 pCi/L (the DWS is 20,000 pCi/L).

Chromium was detected above the DWS at one well south of WAG 6. Chromium has been found to be above the DWS in the past seven sampling events at this well.

5.9.3.2 WAG 4 Area

WAG 4 is located in Melton Valley about 0.5 mile (0.8 km) southwest of the main ORNL plant site. It comprises the SWSA 4 waste disposal area, liquid low-level waste (LLLW) transfer lines, and the experimental Pilot Pit Area (Area 7811).

SWSA 4 was opened for routine burial of solid radioactive wastes in 1951. From 1955 to 1963, Oak Ridge was designated by the Atomic Energy Commission as the Southern Regional Burial Ground; as such, SWSA 4 received a wide variety of poorly characterized solid wastes (including radioactive waste) from about 50 sources. These wastes consisted of paper, clothing, equipment, filters, animal carcasses, and related laboratory wastes. About 50% of the waste was received from sources outside of Oak Ridge facilities. Wastes were placed in trenches, shallow auger holes, and in piles on the ground for covering at a later date.

From 1954 to 1975, LLLW was transported from storage tanks at the main ORNL complex to waste pits and trenches in Melton Valley (WAG 7), and later to the hydrofracture disposal sites through underground transfer lines. The Pilot Pit Area (Area 7811) was constructed for use in pilot-scale radioactive waste disposal studies from 1955 to 1959; three large concrete cylinders containing experimental equipment remain embedded in the ground. A removal action was conducted at WAG 4 during 1996 to grout in place sources of ^{90}Sr contamination emanating from selected trenches located within the WAG. A control building and asphalt pad have been used for storage through the years.

WAG 4 Results

Groundwater monitoring in WAG 4 was transferred to the IWQP (now the WRRP) in 1996. Any activities to be reported are published in the WRRP RER (DOE 2001).

5.9.3.3 WAG 5 Area

WAG 5 contains 33 SWMUs, 13 of which are tanks that were used to store LLLW prior to disposal by the hydrofracture process. WAG 5 also includes the surface facilities constructed in support of both the old and new hydrofracture facilities. The largest land areas in WAG 5 are devoted to transuranic (TRU) waste in SWSA 5 South and SWSA 5 North. The remaining sites are support facilities for ORNL's hydrofracture operations, two LLW pipeline leak/spill sites, and an impoundment in SWSA 5 used to dewater sludge from the original PWTF. Currently, LLW tanks at the new hydrofracture facility are being used to store evaporator concentrates pending a decision regarding ultimate disposal of these wastes.

SWSA 5 South was used to dispose of solid LLW generated at ORNL from 1959 to 1973. During this time, the burial ground served as the Southern Regional Burial Ground for the Atomic Energy Commission. At the time SWSA 5 burial operations were initiated, about 10 acres of the site were set aside for the retrievable storage of TRU wastes.

The WAG 5 boundary includes the old hydrofracture facilities (OHF) and new hydrofracture facilities (NHF). Because Melton Branch flows between these facilities, the NHF has a separate boundary. The OHF Tanks were emptied in a non-time-critical removal action conducted in the summer of 1998. A CERCLA removal action was initiated in 1994 to remove ^{90}Sr from Seeps C and D, located along the southern boundary of WAG 5, and continues through the present.

WAG 5 Results

Groundwater monitoring in WAG 5 was transferred to the WRRP in 1996. Any activities to be reported are published in the WRRP Annual RER (DOE 2001).

5.9.3.4 WAG 6 Area

WAG 6 consists of four SWMUs: (1) SWSA 6, (2) Building 7878, (3) the explosives detonation trench, and (4) Building 7842. SWSA 6 is located in Melton Valley, northwest of WOL and southeast of Lagoon Road and Haw Ridge. The site is about 1.2 miles (2 km) south of the main ORNL complex. Waste burials at the 68-acre site were initiated in 1973, when SWSA 5 was closed. Various radioactive and chemical wastes were buried in trenches and auger holes. SWSA 6 is the only currently operating disposal area for LLW at ORNL. The emergency waste basin was constructed in 1961 to provide storage of liquid wastes that could not be released from ORNL to WOC. The basin is located northwest of SWSA 6 and has a capacity of 15 million gal, but has never been used. Radiological sampling of the small drainage from the basin has shown the presence of some radioactivity. The source of this contamination is not known.

WAG 6 was among the first WAGs to be investigated at ORNL by the EMEF Program. WAG 6 is an interim-status RCRA unit because of past disposal of RCRA-regulated hazardous waste. Environmental monitoring is carried out under CERCLA and RCRA. A proposed CERCLA remedial action, which involved capping WAG 6, was abandoned after a public meeting in which members of the community objected to the high cost of capping. Groundwater monitoring continues to be carried out under the auspices of the EMP for WAG 6 at ORNL, which was implemented after abandonment of the RA chosen at WAG 6.

WAG 6 Results

Information about WAG 6 monitoring results in 2000 is available in the 2000 Groundwater Quality Assessment Report for ORNL's SWSA 6 (BJC 2000).

5.9.3.5 WAG 7 Area

WAG 7 is located in Melton Valley about 1 mile (1.6 km) south of the ORNL main plant area. The major sites in WAG 7 are the seven pits and trenches used from 1951 to 1966 for disposal of LLLW. WAG 7 also includes a decontamination facility, three leak sites, a storage area containing shielded transfer tanks and other equipment, and seven fuel wells used to dispose of acid solutions primarily containing enriched uranium from Homogeneous Reactor Experiment fuel. WAG 7 has been used to demonstrate the efficacy of in situ vitrification technology to immobilize radioactive waste streams buried in the WAG. However, because of a release of fission products (^{137}Cs) during testing of the in situ vitrification technology, the project was placed in shutdown mode.

WAG 7 Results

Groundwater monitoring in WAG 7 was transferred to the IWQP (now the WRRP) in 1996. Any activities to be reported are published in the WRRP Annual RER (DOE 2001).

5.9.3.6 WAGs 8 and 9 Area

Because of the small number of groundwater monitoring wells in WAG 8 and WAG 9, they are sampled together. The analytical results for the two WAGs are also reported together.

WAG 8, located in Melton Valley, south of the main plant area, is composed of 36 SWMUs associated with the reactor facilities in Melton Valley. The SWMUs consist of active LLLW collection and storage tanks, leak/spill sites, a contractors' soils area, radioactive waste ponds and impoundments, and chemical and sewage waste treatment facilities. WAG 8 includes the MSRE facility, the HFIR, and the REDC. A removal action was initiated at the MSRE during 1995 to remove filtration devices contaminated with uranium.

Radioactive wastes from WAG 8 facilities are collected in on-site LLLW tanks and are periodically pumped to the main plant area (WAG 1) for storage and treatment. The waste includes demineralizer backwash, regeneration effluents, decontamination fluids, experimental coolant, and drainage from the compartmental areas of filter pits.

An abnormally high ^{3}H concentration was reported for a routine monthly sample collected in October 2000 to monitor the french drain system, which is used to drain groundwater away from the HFIR building foundation. An investigation revealed a leak in the process waste drain system leaving the HFIR facility. Water levels in the process waste drain were lowered to minimize leakage, and follow-up sampling showed that these efforts were effective. Concentrations of ^{3}H in weekly samples taken to monitor the effectiveness of efforts to reduce the leak declined throughout November and December 2000. An operational monitoring plan for the HFIR area will be developed and implemented in 2001 to provide for early detection of groundwater contamination due to operational activities or system failures and to monitor significant changes in groundwater contamination due to the ^{3}H leak.

WAG 9 is located in Melton Valley about 0.6 mile (1 km) southeast of the ORNL main plant area and adjacent to WAG 8. WAG 9 is composed of eight SWMUs, including the Homogeneous Reactor Experiment pond, which was used from 1958 to 1961 to hold contaminated condensate and shield water from the reactor, and LLLW collection and storage tanks, which were used from 1957 to 1986.

WAGs 8 and 9 Results

The two upgradient wells are located north of the WAGs, two of the downgradient wells are located northwest of the WAGs, two are located south of WAG 8, and the remaining five are in WAG 8 west of WAG 9 and in WAG 9. The analytical results for 2000 are comparable to results from the previous years.

The two wells on the northwestern perimeter exceeded standards, one well with respect to the DWS for ^{3}H contamination and the other with respect to the screening level for gross beta activity and the DWS for total radioactive strontium contamination. The two wells in WAG 9 both exceeded the assumed compliance level for gross beta activity and total radioactive strontium. Gross alpha activity ranged from not detected to 4.4 pCi/L (the DWS is 15 pCi/L), beta activity ranged from not detected to 4000 pCi/L (the screening level for gross beta activity is 50 pCi/L), and total radioactive strontium ranged from not detected to 1900 pCi/L (the DWS is 8 pCi/L). Tritium ranged from not detected to 49,000 pCi/L (the DWS is 20,000 pCi/L).

5.9.3.7 WAG 10 Area

WAG 10 consists of the OHF grout sheets, the NHF, and NHF grout sheets. The surface facilities are associated with WAGs 5, 7, and 8.

Hydrofracture Experiment Site 1 is located within the boundary of WAG 7 (south of Lagoon Road) and was the site of the first experimental injection of grout (October 1959) as a testing program for observing the fracture pattern created in the shale and for identifying potential operating problems. Injected waste was water tagged with ^{137}Cs and ^{141}Ce. Grout consisted of diatomaceous earth and cement.

Hydrofracture Experiment Site 2 is located about 0.8 km (0.5 mile) south of the 7500 (experimental reactor) area (WAG 8). The second hydrofracture experiment was designed to duplicate, in scale, an actual disposal operation; however, radioactive tracers were used instead of actual waste. Cement, bentonite, and water tagged with ^{137}Cs were used in formulating the grout.

The OHF is located about 1.6 km (1.0 mile) southwest of the main ORNL complex near the southwest corner of WAG 5. The facility, commissioned in 1963, was used to dispose of liquid radioactive waste in impermeable shale formations at depths of 800 to 1000 ft by hydrofracture methods. Wastes used in the disposal operations included concentrated LLLW from the gunite tanks in WAG 2, ^{90}Sr, ^{137}Cs, ^{244}Cm, TRU, and other, unidentified radionuclides.

The NHF is located 900 ft southwest of the OHF on the south side of Melton Branch. The facility was constructed to replace the OHF. Wastes used in the injections were concentrated LLLW and sludge removed from the gunite tanks, ^{90}Sr, ^{137}Cs, ^{244}Cm, TRU, and other nuclides. Plans to plug and abandon several deep injection wells at WAG 10 were made in 1995.

WAG 10 Results

No groundwater monitoring wells were installed in WAG 10.

5.9.3.8 Exit Pathway Results

In the Melton Valley exit pathway, WOC at WOD had gross beta activity (230 pCi/L) and total radioactive strontium (84 pCi/L). One of the wells also had gross beta activity detected above the screening level and total radioactive strontium concentrations detected above DWS. This is consistent with historical data. No VOCs (other than a common laboratory contaminant at estimated levels) were detected above DWSs in either the wells or the surface water location.

5.9.4 White Wing Scrap Yard

5.9.4.1 White Wing Scrap Yard (WAG 11) Area

The White Wing Scrap Yard (WAG 11), a largely wooded area of about 30 acres, is located in the McNew Hollow area on the western edge of East Fork Ridge. It is 1.4 km (0.9 mile) east of the junction of White Wing Road and the Oak Ridge Turnpike. Geologically, the White Oak thrust fault bisects WAG 11. Lower-Cambrian-age strata of the Rome Formation occur southwest of the fault and overlie the younger Ordovician-age Chickamauga Limestone northeast of the fault. There is only one SWMU in WAG 11.

The White Wing Scrap Yard was used for aboveground storage of contaminated material from ORNL, the ETTP, and the Y-12 Complex. The material stored at the site by ORNL consisted largely of contaminated steel tanks; trucks; earth-moving equipment; assorted large pieces of steel, stainless steel, and aluminum; and reactor cell vessels removed during cleanup of Bldg. 3019. An interim record of decision (ROD) was agreed to by TDEC, EPA, and DOE, requiring surface debris to be removed from the site. This work was completed in 1994.

The area began receiving material (primarily metal, glass, concrete, and trash with alpha, beta, and gamma contamination) in the early 1950s. Information regarding possible hazardous waste contamination has not been found. The precise dates of material storage are uncertain, as is the time when the area was closed to further storage. In 1966, efforts were begun to clean up the area by disposing of contaminated materials in ORNL's SWSA 5 and by the sale of uncontaminated material to an outside contractor for scrap. Cleanup continued at least into 1970, and removal of contaminated soil began in the same year. Some scrap metal, concrete, and other trash are still located in the area. Numerous radioactive areas, steel drums, and PCB-contaminated soil were identified during surface radiological investigations conducted during 1989 and 1990 at WAG 11. The amount of material or contaminated soil remaining in the area is not known.

White Wing Scrap Yard (WAG 11) Results

Groundwater monitoring in WAG 11 was transferred to the IWQP (now the WRRP) in 1996. Any activities to be reported are published in the WRRP Annual RER (DOE 2001).

5.10 WELL PLUGGING AND ABANDONMENT AT ORNL

The purpose of the ORNL well plugging and abandonment program is to remove unneeded wells and boreholes as possible sources of cross-contamination of groundwater from the surface or between geological formations. Because of the complex geology and groundwater pathways at ORNL, it has been necessary to drill many wells and boreholes to establish the information base needed to predict groundwater properties and behavior. However, many of the wells established before the 1980s were not constructed satisfactorily to serve current long-term monitoring requirements. Where existing wells do not meet monitoring requirements, they become candidates for plugging and abandonment.

5.10.1 Wells Plugged During 2000

No wells were plugged and abandoned during calendar year 2000 at ORNL.

5.10.2 Methods Used

Plugging and abandonment of wells are accomplished by splitting the existing well casing and filling the casing and annular voids with grout or bentonite to create a seal between the ground surface and water-bearing formations, and between naturally isolated water-bearing formations.

Splitting and abandoning the well casing in place minimizes the generation of waste that would be created if other methods were used. Specialized tools have been developed to split well casings of different sizes and compositions and are used when wells are plugged and abandoned at ORNL.

Detailed procedures have been developed and documented regarding the use of specific grout materials in different well environments. These procedures were tested and evaluated during the 1993 plugging and abandonment activities.