6. Y-12 Environmental Monitoring Programs

Compliance and environmental monitoring programs required by federal and state regulation and by DOE orders are conducted at the Y-12 National Security Complex for air, water, and groundwater environmental media.

6.1 Y-12 COMPLEX RADIOLOGICAL AIRBORNE EFFLUENT MONITORING

The release of radiological contaminants, primarily uranium, into the atmosphere at the Y-12 National Security Complex (Y-12 Complex) occurs almost exclusively as a result of plant production, maintenance, and waste management activities. NESHAP regulations for radionuclides require continuous emission sampling of major sources (a "major source" is considered to be any emission point that potentially can contribute more than 0.1 mrem/year EDE equivalent to an off-site individual). During 2003, 42 of the 55 stacks suitable for continuous monitoring were judged to be major sources. Eighteen of the stacks with the greatest potential to emit significant amounts of uranium are equipped with alarmed breakthrough detectors, which alert operations personnel to process-upset conditions or to a decline in filtration-system efficiencies, allowing them to investigate and correct the problem before a significant release occurs. As of January 1, 2003, the Y-12 Complex had continuous monitoring capability on a total of 55 stacks, 43 of which were active and 12 of which were temporarily shut down.

Emissions from unmonitored process and laboratory exhausts, categorized as minor emission sources, are estimated according to calculation methods approved by the EPA. In 2003, there were 43 unmonitored processes operated by Y-12. These are included as minor sources in the Y-12 Complex source term.

Uranium and other radionuclides are handled in millicurie quantities at facilities within the boundary of the Y-12 Complex as part of BJC, UT-Battelle, and BWXT Y-12 laboratory activities. Twenty-seven minor emission points were identified from laboratory activities at facilities within the boundary of the Y-12 Complex as being operated by BWXT Y-12. In addition, the BWXT Y-12 Analytical Chemistry Organization laboratory is operated in a leased facility that is not within the ORR boundary and is located approximately ⅓ mile east of the Y-12 Complex on Union Valley Road. The emissions from the Analytical Chemistry Organization Union Valley laboratory are included in the Y-12 Complex source term. Eight minor emission points were identified at the laboratory. The releases from these emission points are minimal, however, and have a negligible impact on the total Y-12 Complex dose.

Emissions from Y-12 Complex room ventilation systems are estimated from radiation control data collected on airborne radioactivity concentrations in the work areas. Areas where the monthly average concentration exceeded 10% of the DOE derived air concentration worker-protection guidelines are included in the annual emission estimate. One emission point in Building 9204-4 was identified in 2003 where room ventilation emissions exceeded 10% of the guidelines. However, because this enclosure exhausted to stack UB-088, its contribution was not specifically identified and was included in the stack emissions.

6.1.1 Sample Collection and Analytical Procedure

Uranium stack losses were measured continuously on monitored operating process exhaust stacks in 2003. Particulate matter (including uranium) was filtered from the stack emissions. Filters at each location were changed routinely, from one to three times per week, and were analyzed for total uranium. In addition, the sampling probes and tubing were removed quarterly and were washed with nitric acid; the washing was analyzed for total uranium. At the end of the year, the probe-wash data were included in the final calculations in determining total emissions from each stack.

6.1.2 Results

An estimated 0.012 Ci (2.0 kg) of uranium was released into the atmosphere in 2003 as a result of Y-12 activities (Figs. 6.1 and 6.2). The specific activity of enriched uranium is much greater than that of depleted uranium, and about 85% of the curie release was composed of emissions of enriched uranium particulate, even though approximately 8% of the total mass of uranium released was enriched material.

6.2 Y-12 COMPLEX NONRADIOLOGICAL AIRBORNE EMISSIONS MONITORING

The release of nonradiological contaminants into the atmosphere at the Y-12 Complex occurs as a result of plant production, maintenance, waste management operations, and steam generation. Most process operations are served by ventilation systems.

In CY 2003, the Y-12 Complex had 33 individual air permits. Approximately three-fifths of the permitted air sources release primarily nonradiological contaminants. The remaining two-fifths of the permitted sources process primarily radiological materials. TDEC air permits for the nonradiological sources do not require stack sampling or monitoring except for the opacity monitors used at the steam plant to ensure compliance with visible emission standards. For nonradiological sources where direct monitoring of airborne emissions is not required, monitoring of key process parameters is done to ensure compliance with all permitted emission limits. In the future, when the Y-12 Complex is issued its first-ever major-source (Clean Air Act Title V) operating permit, reporting of key process parameters is expected to increase. Also, a new requirement for the steam plant requires continuous emission monitoring for nitrogen oxides in which the compliance period begins in 2004.

The 2003 Y-12 Complex annual emission fee was calculated based on 10,033 tons per year of allowable emission of regulated pollutants, with an annual emission fee of $175,577.50. In accordance with TDEC regulations, Rule 1200-3-26-.02(9)(i), when there is no applicable standard or permit condition for a pollutant, the allowable emissions are based on the maximum actual emissions calculations (maximum design capacity for 8760 h/year). More than 90% of the Y-12 Complex pollutant emissions to the atmosphere are attributed to the operation of the steam plant. The emission fee rate was based on $17.50 per ton of regulated-pollutant allowable emissions. The actual emissions are much lower than the allowable amount; however, major sources are required to pay their annual emission fees based on allowable emissions until the issuance of the major source operating permit.

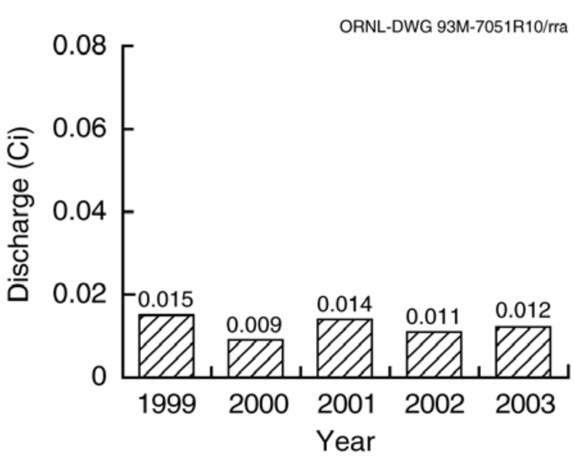

Fig. 6.1. Total curies of uranium discharged from the Y-12 Complex to the atmosphere, 1999–2003.

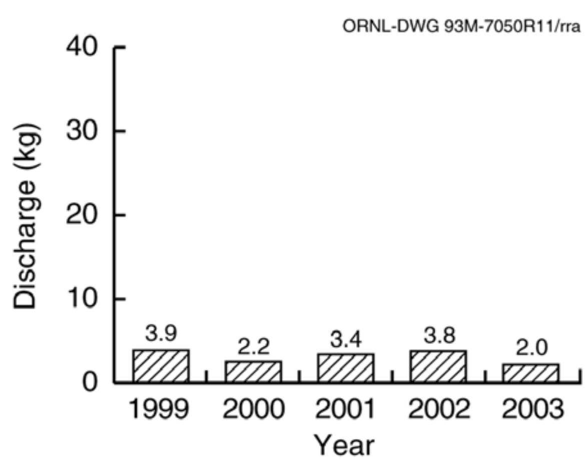

Fig. 6.2. Total kilograms of uranium discharged from the Y-12 Complex to the atmosphere, 1999–2003.

6.2.1 Results

The primary source of criteria pollutants at the Y-12 Complex is the steam plant, where coal and natural gas are burned. Information regarding actual vs allowable emissions from the steam plant is provided in Table 6.1. In addition, the annual toxic release inventory report (required by EPCRA Sect. 313) provides information on other nonradiological Y-12 Complex air emissions (Sect. 2.2.16.3).

The opacity monitoring systems for both the east and west at the Y-12 Steam Plant were taken out of service on March 5, 2003, for replacement with new opacity monitors. The new opacity monitors have been installed and certified. The certification reports were submitted to the Technical Secretary in June 2003 for his review and approval. Condition 8 of the current Y-12 Steam Plant air permit requires the opacity monitoring systems to be fully operational 95% of the operational time of the monitored units during each month of the calendar quarter. Due to the installation of the new opacity monitors, the east and west stack monitors did not meet the 95% operational availability level for the second quarter of 2003. TDEC personnel were informed of the new opacity monitors and approved their installation.

Condition 9 of the current Y-12 Steam Plant air permit requires that calibration error tests of the opacity monitoring systems be performed on a biennial basis. The calibration error tests for the opacity monitoring systems were part of the new opacity monitor certification reports submitted to TDEC personnel in June 2003. The next tests will be performed on a semiannual basis in accordance with Title V requirements. There were no periods of excess emissions due to the control device malfunction during 2003. The opacity monitors were inoperative during 2003. Quarterly reports of the status of the Y-12 Steam Plant opacity monitors are submitted to personnel at TDEC within 30 days after the end of each calendar quarter. Table E.4 in Appendix E is a record of excess emissions and out-of-service conditions for the east and west stack opacity monitors for 2003.

6.3 Y-12 COMPLEX AMBIENT AIR MONITORING

In 1994, Y-12 Complex personnel issued *Evaluation of the Ambient Air Monitoring*

Table 6.1. Actual vs allowable air emissions from the Oak Ridge Y-12 Steam Plant, 2003

Pollutant	Emissions (tons/year)		Percentage of allowable
	Actual	Allowable	
Particulate	32	945	3.4
Sulfur dioxide	2,606	20,803	12.5
Nitrogen oxides[a]	718	5,905	12.2
Volatile organic compounds[a]	3	41	7.3
Carbon monoxide[a]	27	543	5.0

[a]When there is no applicable standard or enforceable permit condition for some pollutants, the allowable emissions are based on the maximum actual emissions calculation as defined in Tennessee Department of Environment and Conservation Rule 1200-3-26-.02(2)(d)3 (maximum design capacity for 8760 h/year). The emissions for both the actual and allowable emissions were calculated based on the latest EPA compilation of air pollutant emission factors. (EPA 1995 and 1998. *Compilation of Air Pollutant Emission Factors AP-42, Fifth Edition, Volume 1: Stationary Point and Area Sources.* U.S. Environmental Protection Agency, Research Triangle Park, N.C. January 1995 and September 1998.)

Program at the Oak Ridge Y-12 Plant (MMES 1994b) and worked with DOE and TDEC in reviewing the ambient air program for applicability and usefulness of the data. There are no federal regulations, state regulations, or DOE orders that require this monitoring. All ambient air monitoring systems at the Y-12 Complex are operated as a best management practice. With the reduction of plant operations and improved emission and administrative controls, levels of measured pollutants have decreased significantly during the past several years. In addition, major processes that result in emission of enriched and depleted uranium are equipped with stack samplers that have been reviewed and approved by EPA to meet requirements of the NESHAP regulations. ORR air sampling stations, operated by ORNL in accordance with DOE orders, are located around the reservation. Their locations were selected so that areas of potentially high exposure to the public are monitored continuously for parameters of concern.

With agreement from TDEC personnel, the ambient air sampling program at the Y-12 Complex was significantly reduced, effective at the end of 1994. All sampling for fluoride, total suspended particulates, and particulate matter less than 10 microns in diameter (PM10) was discontinued, and all but 3 of the 12 uranium samplers were shut down. Effective April 1, 1999, an agreement was reached according to which TDEC personnel took over responsibility for sampling and analysis of the three remaining uranium samplers at the Y-12 Complex. The uranium samplers were operated by TDEC during 2003. On December 6, 1999, DOE submitted to TDEC a letter providing justification for reducing the number of on-site mercury-monitoring stations from four to two. Effective January 1, 2000, operation of the two monitors located in the interior of the Y-12 Complex (near Buildings 9805-1 and 9422-13) was discontinued. The two boundary mercury-monitoring stations (stations 2 and 8) remain in operation. The locations of these monitoring stations are shown in Fig. 6.3. During 2003, the project to restart the hydrogen fluoride system at Building 9212 was placed on hold. It is scheduled for restart in the summer of 2004.

6.3.1 Mercury

The Oak Ridge Y-12 Complex ambient air monitoring program for mercury was established in 1986 as a best management practice. The objectives of the program have been to maintain a database of mercury concentration in ambient air, to identify long-term spatial and temporal trends in ambient mercury vapor, and to demonstrate protection of the environment and human health from releases of mercury at the Y-12 Complex to the atmosphere. The two atmospheric mercury monitoring stations currently operating at the Y-12 Complex , Ambient Air Station No. 2 (AAS2) and Ambient Air Station No. 8 (AAS8), are located near the east and west boundaries of the Complex, respectively (see Fig. 6.4). Since

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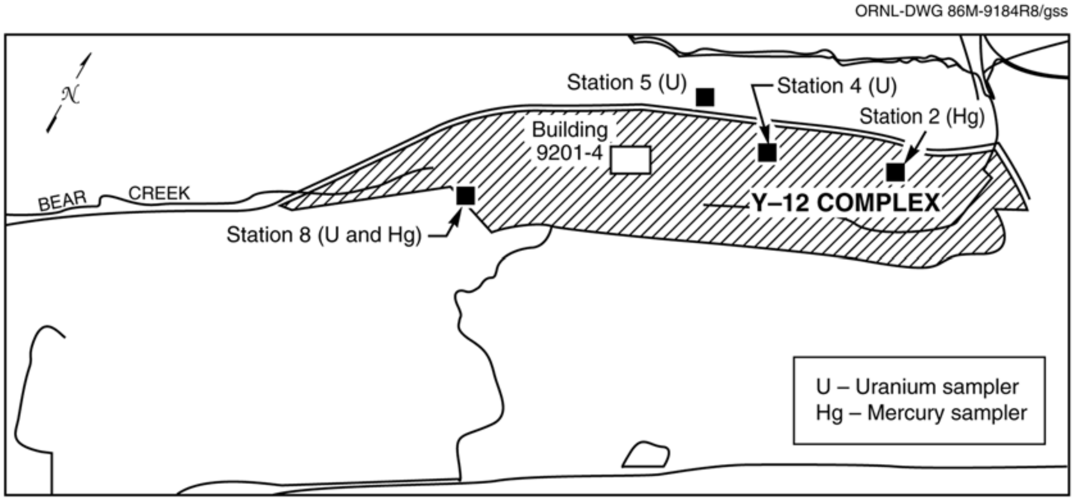

Fig. 6.3. Locations of ambient air monitoring stations at the Y-12 Complex.

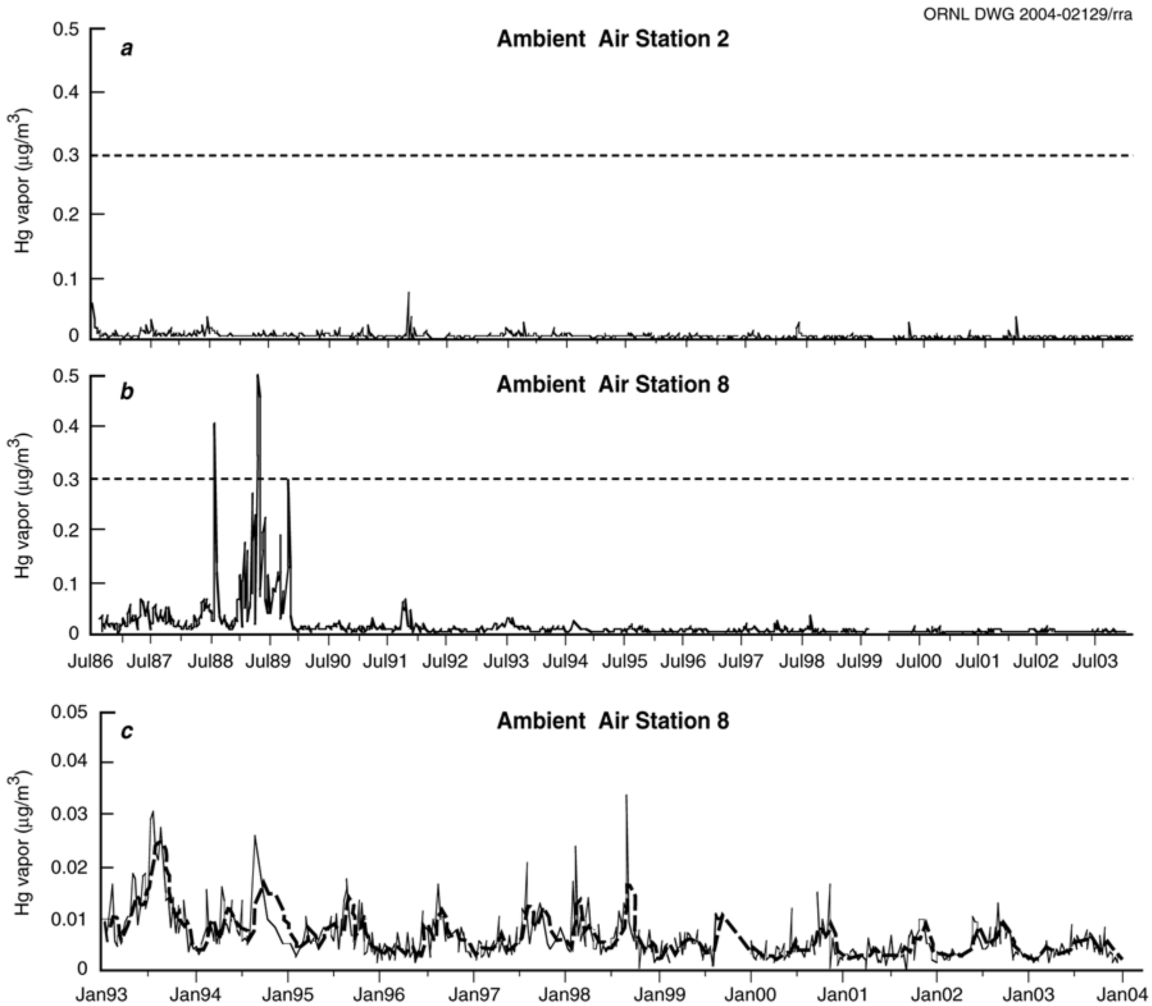

Fig. 6.4. Temporal trends in mercury vapor concentration for the four active airborne mercury monitoring sites at the Oak Ridge Y-12 Complex, July 1986 through July 2003. The dashed line represents the EPA reference concentration of 0.3 μg/m^3.

their establishment in 1986, AAS2 and AAS8 have monitored mercury in ambient air continuously with the exception of short periods of downtime because of electrical or equipment outages. In addition to the plant monitoring stations, a control or reference site (Rain Gauge No. 2) was operated on Chestnut Ridge in the Walker Branch Watershed for a 20-month period in 1988 and 1989 to establish local background concentrations at that time.

At each of the monitoring sites, airborne mercury vapor is collected by pulling ambient air through a sampling train consisting of a Teflon filter, a flow-limiting orifice, and an iodated charcoal-filled sampling tube or trap. The flow-limiting orifice restricts airflow through the sampling train to ~1 L/min, although actual flow rates are measured weekly with a calibrated Gilmont flowmeter. The sampling traps are changed out weekly. The charcoal in each trap is analyzed for total mercury absorbed using cold vapor atomic fluorescence after acid digestion. Average concentration of mercury vapor in the ambient air for each 7-day sampling period is calculated by dividing the total quantity of mercury collected on the charcoal by the total volume of air pulled through the charcoal trap. During the early years of the mercury air-monitoring program, Teflon filters in the sampling train were analyzed for particulate mercury. This practice was discontinued in 1989 after results revealed very low to nondetectable levels of particulate mercury. The filters are still present in the sampling train but solely to prevent particulates from clogging the flow-limiting orifice.

As reported in previous annual environmental reports, average mercury vapor concentrations at the Y-12 Complex mercury monitoring sites have declined significantly, especially after the initial three years of the monitoring program, with average mercury vapor concentrations at AAS8 declining almost tenfold and AAS2 threefold since the late 1980s. Recent average annual concentrations at the two boundary stations located at the east and west ends of the Y-12 Complex are comparable to those measured in 1988 and 1989 at the Chestnut Ridge reference site (see Table 6.2) and only slightly elevated above concentrations reported for continental background (i.e., ~0.002 μg/m^3). For 2003, the average mercury concentration was 0.0036 μg/m^3 for AAS2 (N = 52; S.E. = ±0.0002) and 0.0043 μg/m^3 for AAS8 (N = 52; S.E. = ±0.0002). These concentrations are comparable to average concentrations measured in 2001 (AAS2 = 0.0034μg/m^3, AAS8 = 0.0042 μg/m^3) and slightly lower, though not significantly different (Student's t-test), to those reported for 2002 (AAS2 = 0.0040 μg/m^3; AAS8 = 0.0050 μg/m^3). Table 6.2 summarizes the 2003 mercury results and the results from the 1986 through 1988 period for comparison. Graphs A, B, and C (Fig. 6.4) illustrate temporal trends in mercury concentration for the two active mercury monitoring sites since the inception of the program in 1986 through December 2003 and seasonal trends at AAS8 from 1993 to 2004.

In conclusion, annual average mercury concentrations during 2003 at the Y-12 east and west boundary monitoring stations are comparable to reference levels measured on Chestnut Ridge in 1988 and 1989 and approach values reported for continental background. These concentrations are well below current environmental and occupational health standards for inhalation exposure to mercury vapor. For example, they were less than the National Institute for Occupational Safety and Health recommended exposure limit of 50 μg/m^3 (time-weighted average for an 8-h workday), the American Conference of Governmental Industrial Hygienists workplace threshold limit value of 25 μg/m^3 (time-weighted average for an 8-h workday and 40-h workweek), the Agency for Toxic Substances and Disease Registry minimal risk level of 0.2 μg/m^3 for inhalation exposure, and the current EPA reference concentration of 0.3 μg/m^3) for elemental mercury for daily inhalation exposure without appreciable risk of harmful effects during a lifetime.

Table 6.2. 2003 summary results for the Oak Ridge Y-12 Plant mercury in ambient air monitoring program

Results of the 1986 through 1988 monitoring period are shown for reference

Ambient air monitoring stations	Mercury vapor concentration (μg/m^3)			
	2003 Average	2003 Maximum	2003 Minimum	1986–1988 Average
AAS2 (east end of the Y-12 Plant)	0.0036	0.0071	0.0018	0.010
AAS8 (west end of the Y-12 Plant)	0.0043	0.0091	0.0018	0.033
Reference site, Rain Gauge No.2 (1988[a])	N/A	N/A	N/A	0.006
Reference site, Rain Gauge No.2 (1989[b])	N/A	N/A	N/A	0.005

[a]Data for period from February 9 through December 31, 1988.
[b]Data for period from January 1 through October 31, 1989.

6.4 LIQUID DISCHARGES—Y-12 COMPLEX RADIOLOGICAL MONITORING SUMMARY

A radiological monitoring plan is in place at the Y-12 Complex to address compliance with DOE orders and NPDES Permit TN002968. The permit, issued in 1995, required Y-12 to reevaluate its radiological monitoring plan and to submit results from the monitoring program quarterly as an addendum to the NPDES Discharge Monitoring Report. There were no discharge limits set by the NPDES permit for radionuclides; the requirement is to monitor and report. A revised plan (LMES and H&R 1995) was fully implemented in 1995. The radiological monitoring plan was expanded at that time to allow sufficient collection of data such that an assessment of alpha, beta, and gamma emitters could be made. The intent was to more appropriately identify parameters to be monitored and to establish analytical detection limits necessary for dose evaluations.

Based on an analysis of operational history, expected chemical and physical relationships, and historical monitoring results, the plan was updated again in October 1997 (LMES 1997b). Under the existing plan, effluent monitoring is conducted at three types of locations: (1) treatment facilities, (2) other point-source and area-source discharges, and (3) instream locations. Operational history and past monitoring results provide a basis for parameters routinely monitored under the plan (Table 6.3).

The radiological monitoring plan also addresses monitoring of the sanitary sewer. The Y-12 Complex is permitted to discharge domestic wastewater to the city of Oak Ridge publicly owned treatment works under Industrial and Commercial User Wastewater Discharge Permit No. 1-91. As required by the discharge permit, radiological monitoring of this discharge is conducted and reported to the city of Oak Ridge, although there are no city-established limits. Potential sources of radionuclides discharging to the sanitary sewer have been identified in previous studies at the Y-12 Complex as part of an initiative to meet the "as low as reasonably achievable" goals. The radiological monitoring needs for the sanitary sewer were reviewed and were summarized in the 1997 update to the plan (LMES 1997b).

Radiological monitoring of storm water is also required by the NPDES permit. A comprehensive monitoring plan has been designed to fully characterize pollutants in storm water runoff. The most recent revision of this plan, *Storm Water Pollution Prevention Plan for the Oak Ridge Y-12 Plant* (BWXT 2002), was issued in November 2002, and incorporates radiological-monitoring

Table 6.3. Radiological parameters monitored at the Y-12 Complex in 2003

Parameters	Specific isotopes	Rationale for monitoring
Uranium isotopes	^{238}U, ^{235}U, ^{234}U, total U, weight % ^{235}U	These parameters reflect the major activity, uranium processing, throughout the history of Y-12 and are the dominant detectable radiological parameters in surface water
Fission and activation products	^{90}Sr, ^{3}H, ^{99}Tc, ^{137}Cs	These parameters reflect a minor activity at Y-12, processing recycled uranium from reactor fuel elements, from the early 1960s to the late 1980s, and will continue to be monitored as tracers for beta and gamma radionuclides, although their concentrations in surface water are low
Transuranium isotopes	^{241}Am, ^{237}Np, ^{238}Pu,$^{239/240}Pu$	These parameters are related to recycle uranium processing. Monitoring has continued because of their half-lives and presence in groundwater
Other isotopes of interest	^{232}Th, ^{230}Th, ^{228}Th, ^{226}Ra, ^{228}Ra	These parameters reflect historical thorium processing and natural radionuclides necessary to characterize background radioisotopes

requirements. There are 75 storm water outfalls and monitoring points located at the Y-12 Complex, and the NPDES permit requires characterization of a minimum of 25 storm water outfalls per year.

6.4.1 Results

Radiological monitoring plan locations sampled in 2003 are noted in Fig. 6.5. Table 6.4 identifies the monitored locations, the frequency of monitoring, and the sum of the percentages of the DOE derived concentration guides (DCGs) for radionuclides measured in 2003. Radiological data were well below the allowable DCGs.

In 2003, the total mass of uranium and associated curies released from the Y-12 Complex at the easternmost monitoring station, Station 17 on Upper East Fork Poplar Creek, and the westernmost monitoring station, at Bear Creek kilometer (BCK) 4.55 (the former NPDES Outfall 304), was 346 kg, or 0.151 Ci (Table 6.5). Figure 6.6 illustrates a 5-year trend of these releases. The total release is calculated by multiplying the average concentration (grams per liter) by the average flow (million gallons per day). Converting units and multiplying by 365 days per year yields the calculated discharge.

The City of Oak Ridge Industrial and Commercial User Wastewater Discharge Permit allows the Y-12 Complex to discharge wastewater to be treated at the Oak Ridge publicly owned treatment works through the East End Sanitary Sewer Monitoring Station, also identified as SS-6 (Fig. 6.5). Compliance samples are collected at this location. No single radionuclide in the Y-12 contribution to the sanitary sewer exceeded 4% of the DCGs. Summed percentages of DCGs calculated from the Y-12 contribution to the sewer is about one. Results of radiological monitoring were reported to the city of Oak Ridge in quarterly monitoring reports.

Table 6.6 presents a summary of 2003 storm water data that exceeded screening levels. More detailed results are given in *Environmental Monitoring on the Oak Ridge Reservation: 2003 Results* (DOE 2004c). (See http://www.ornl.gov/aser.) Uranium remains the dominant radiological constituent and increases during storm flow. This increase is likely due to increased groundwater flow and storm water runoff from historically contaminated areas.

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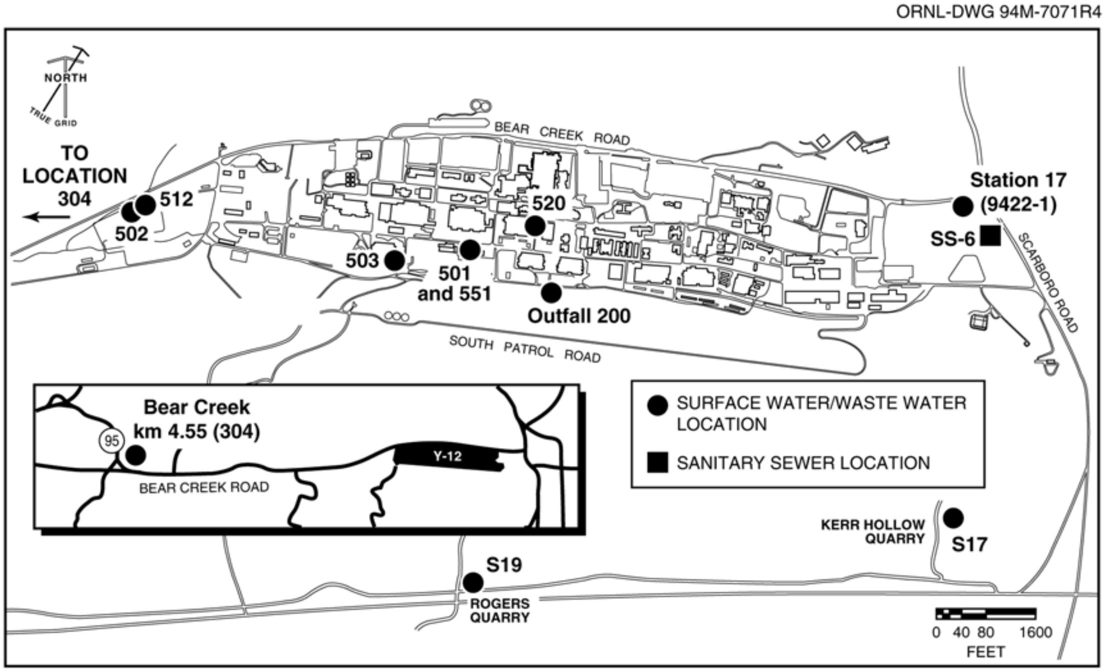

Fig. 6.5. Surface water and sanitary sewer radiological sampling locations at the Y-12 Complex.

Table 6.4. Summary of Y-12 Complex radiological monitoring plan sample requirements

Outfall No.	Location	Sample frequency	Sample type	Sum of DCG[a] percentage
	Y-12 Complex wastewater treatment facilities			
501	Central Pollution Control Facility	1/week	Composite during batch operation	1.7
502	West End Treatment Facility	1/week	24-hour composite	No flow
503	Steam Plant Wastewater Treatment Facility	1/week	24-hour composite	No flow
512	Groundwater Treatment Facility	1/week	24-hour composite	2.1
520 (402)[b]	Steam condensate	1/week	Grab	1.5
551	Central Mercury Treatment Facility	1/month	24-hour composite	2.3
	Other Y-12 Complex point and area source discharges			
S17 (301)[b]	Kerr Hollow Quarry	1/month	24-hour composite	0.83
S19 (302)[b]	Rogers Quarry	1/month	24-hour composite	1.1
	Y-12 Complex instream locations			
BCK 4.55 (304)[b]	Bear Creek, plant exit (west)	1/week	7-day composite	2.0
Station 17	East Fork Poplar Creek, plant exit (east)	1/week	7-day composite	2.1
200	North/south pipes	1/week	24-hour composite	4.2
	Y-12 Complex Sanitary Sewer			
SS-6	East End Sanitary Sewer Monitoring Station	1/week[c]	7-day composite	1

[a]DCG = the derived concentration guide found in DOE Order 5400.5.
[b]Outfall identifications were changed by the National Pollutant Discharge Elimination System permit effective July 1, 1995. Former outfall identifications are shown here in parentheses.
[c]Gamma emitters are analyzed once per year.

Table 6.5. Release of uranium from the Y-12 Complex to the off-site environment as a liquid effluent, 1999–2003

Year	Quantity released Ci[a]	Quantity released kg
	Station 17	
1999	0.07	123
2000	0.063	126
2001	0.043	82
2002	0.062	140
2003	0.073	167
	BCK 4.55[b]	
1999	0.096	183
2000	0.093	168
2001	0.065	136
2002	0.07	141
2003	0.078	179

[a]1 Ci = 3.7E+10 Bq.
[b]Formerly, NPDES outfall 304.

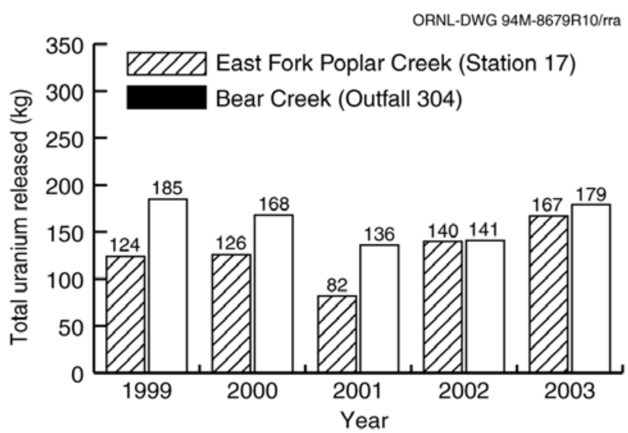

Fig. 6.6. Five-year trend of Y-12 Complex release of uranium to surface water.

Table 6.6. Summary of storm water data above screening levels at the Y-12 Complex

Parameter	Outfalls										
	48	54	57	135	200	S02	S03	S05	S12	S17	S20
Alpha activity						X		X			
Cadmium								X			
Copper	X	X	X	X							
Fecal coliform			X				X		X	X	X
Manganese								X	X		
Mercury	X				X						
Neptunium-237								X			
Nitrate as nitrogen								X			
Pesticides (Dieldrin)	X										
Phosphorus			X	X	X		X		X		
Total suspended solids				X					X	X	X
Uranium-234						X					
Uranium-238						X					
Zinc	X		X	X							

6.5 NONRADIOLOGICAL LIQUID DISCHARGES—Y-12 COMPLEX SURFACE WATER AND LIQUID EFFLUENTS

The current Y-12 NPDES permit, issued on April 28, 1995, and effective on July 1, 1995, requires sampling, analysis, and reporting for approximately 90 outfalls. Major outfalls are noted in Fig. 6.7. The number is subject to change as outfalls are eliminated or consolidated or if permitted discharges are added. Currently, Y-12 has outfalls and monitoring points in the following water drainage areas: East Fork Poplar Creek, Bear Creek, and several unnamed tributaries on the south side of Chestnut Ridge. These creeks and tributaries eventually drain to the Clinch River.

Discharges to surface water allowed under the permit include storm drainage, cooling water, cooling tower blowdown, steam condensate, and treated process wastewaters, including effluents from wastewater treatment facilities. Groundwater inflow into sumps in building basements and infiltration to the storm drain system are also permitted for discharge to the creek. The monitoring data collected by the sampling and analysis of permitted discharges are compared to NPDES limits if a limit exists for each parameter. Some parameters, defined as “monitor only,” have no specified limits.

The water quality of surface streams in the vicinity of the Y-12 Complex is affected by current and historical legacy operations. Discharges from the Y-12 Complex processes flow into East Fork Poplar Creek before the water exits the Y-12 Complex. East Fork Poplar Creek eventually flows through the city of Oak Ridge to Poplar Creek and into the Clinch River. Bear Creek water quality is affected by area source runoff and groundwater discharges. The NPDES permit requires regular monitoring and storm water characterization in Bear Creek and several of its tributaries.

The effluent limitations contained in the permit are based on the protection of water quality in the receiving streams. The permit emphasizes storm water runoff and biological, toxicological, and radiological monitoring. Some of the requirements in the permit and the status of compliance are as follows:

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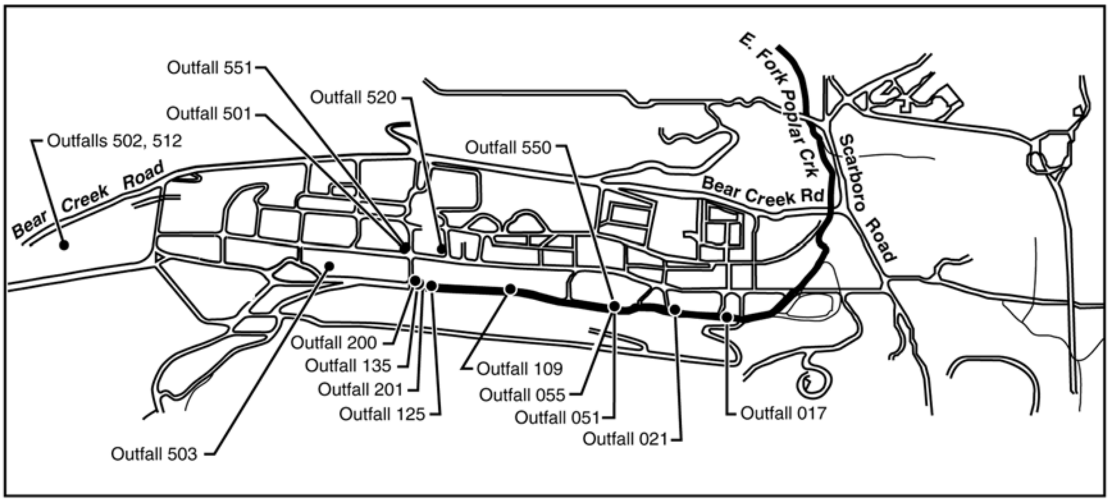

Fig. 6.7. Major Y-12 Complex NPDES outfalls.

- chlorine limitations based on water quality criteria at the headwaters of East Fork Poplar Creek (monitoring ongoing);
- instream pH limitations on tributaries to Bear Creek and various other tributaries on the south side of Chestnut Ridge (monitoring ongoing);
- a radiological monitoring plan requiring monitoring and reporting of uranium and other isotopes at pertinent locations (see Sect. 6.4);
- implementation of a storm water pollution prevention plan and sampling and characterization of storm water at a minimum of 25 locations per year (see Sect. 6.5.2);
- a requirement to manage the flow of East Fork Poplar Creek such that a minimum flow of 7 million gal/day is guaranteed by adding raw water from the Clinch River to the headwaters of East Fork Poplar Creek (see Sect. 6.5.4);
- toxicity limitation for the headwaters of East Fork Poplar Creek (see Sect. 6.6); and
- quarterly toxicity testing at the wastewater treatment facilities and storm drain locations (see Sect. 6.6).

An agreed-to consent order, dated September 27, 1999, resolved outstanding appeals to the NPDES permit by deleting mercury monitoring requirements and instream limits from the permit and deferring them to the CERCLA program. The CERCLA record of decision will define any mercury remediation requirements for East Fork Poplar Creek. As required, an NPDES permit application was submitted in October 1999, six months prior to the expiration date of the current permit (April 28, 2000). Since April 28, 2000, the Y-12 Complex has continued operation under the current permit.

6.5.1 Sanitary Wastewater

Sanitary wastewater from the Y-12 Complex is discharged to the city of Oak Ridge publicly owned treatment works under Industrial and Commercial Users Wastewater Permit Number 191. Monitoring is conducted under the terms of the permit for a variety of organic and inorganic pollutants. During 2003, the wastewater flow in this system averaged about 642,000 gal/day (2,430,000 L/day).

Compliance sampling is conducted at the East End Sanitary Sewer Monitoring Station (SS-6, Fig. 6.5) weekly. This monitoring station is also used for 24-h flow monitoring. As part of the city of Oak Ridge pretreatment program, city personnel use this monitoring station to perform compliance monitoring as required by pretreatment regulations.

6.5.2 Storm Water

The development and implementation of a storm water pollution prevention plan at the Y-12 Complex is designed to minimize the discharge of pollutants in storm water runoff. This plan requires (1) characterization of storm water by sampling during storm events, (2) implementation of measures to reduce storm water pollution, (3) facility inspections, and (4) employee training.

Storm water outfalls at the Y-12 Complex are located in subbasins (drainage areas) and are routinely sampled as required by the NPDES permit. The outfalls are categorized into four categories based on characteristics of the discharged water and are grouped within each category based on similarity as to land use of area drained and possible pollutants. A full chemical and radiological characterization of the discharge during a rain event is not required of all storm water outfalls each year. Representative sampling is permitted due to similarity within the same outfall groupings. A minimum of 25 storm water outfalls is required to be sampled and characterized each year during storm events, including both grab and composite sampling.

During 2003 approximately 5,000 data points were generated from storm water samples at the Y-12 Complex. By assessing the quality of storm water discharges from the site and by determining potential sources of pollutants affecting storm water, effective controls can be identified and put into place to reduce or eliminate these pollutant sources.

The storm water pollution prevention plan is reviewed at least annually and is updated as necessary to reflect changes in operations and to incorporate revised monitoring strategies based on data from past years. The most recent revision of this plan was issued in November 2002.

6.5.3 Results and Progress in Implementing Corrective Actions

In 2003, the Y-12 Complex experienced six NPDES excursions. There were four excursions in 2002, nine excursions in 2001, and six in 2000. Additional details on all Y-12 NPDES permit excursions recorded in 2003 and the associated corrective actions are summarized in Appendix D, Table D.1. Table 6.7 lists the NPDES compliance monitoring requirements and the 2003 compliance record.

During 2003, the Y-12 Complex experienced three exceedances of the Industrial and Commercial Users Wastewater Permit for discharge of sanitary wastewater to the city of Oak Ridge publicly owned treatment works. Table 6.8 lists the Industrial and Commercial Users Wastewater Permit compliance monitoring requirements and the 2003 compliance record. Two of the exceedances, iron (19.1 mg/L compared to the permit limit of 15.0 mg/L) and arsenic (0.0262 mg/L compared to the permit limit of 0.015 mg/L) occurred on July 29. A sample taken on December 22 indicated arsenic (0.0175 mg/L) to be slightly above the permit limit. These exceedances are believed to be related to upsets at the Steam Plant Wastewater Treatment Facility. Follow-up sampling conducted of the effluent from the treatment facility and at SS6 has indicated that both parameters are being maintained within permit limits. Upgrades in conduct of operations and the physical condition of the facility are under way. A project to remove sludge from the treatment facility equalization basin is being planned for 2004.

Review of storm water data from past years indicates that pollutant loads increase during storm events and that water quality may be affected by uncovered scrap metal storage sites. For example, some outfalls are showing levels above screening limits of total suspended solids, fecal coliform, PCBs, and metals during storm events (see Table 6.6). However, some monitored pollutants are not present at specific outfalls. Detailed storm water data summary tables are given in *Environmental Monitoring on the Oak Ridge Reservation: 2003 Results* (DOE 2004c). (See http://www.ornl.gov/ aser/.)

6.5.4 Flow Management (or Raw Water)

Because of concern about maintaining water quality and stable flow in the upper reaches of East Fork Poplar Creek, the NPDES permit requires addition of Clinch River water to the headwaters of East Fork Poplar Creek (North/ South Pipe-Outfall 200 area) so that a minimum

Table 6.7. NPDES compliance monitoring requirements and record for the Y-12 Complex
January through December 2003

Discharge point	Effluent parameter	Effluent limits				Percentage of compliance	No. of samples
		Daily avg (lb/d)	Daily max (lb/d)	Daily avg (mg/L)	Daily max (mg/L)		
Outfall 066	pH, standard units			*a*	9	*b*	0
Outfall 068	pH, standard units			*a*	9	*b*	0
Outfall 117	pH, standard units			*a*	9	*b*	0
Outfall 073	pH, standard units			*a*	9.0	*b*	0
	Total residual chlorine				0.5	*b*	
Outfall 077	pH, standard units			*a*	9.0	100	12
	Total residual chlorine				0.5	100	12
Outfall 122	pH, standard units			*a*	9.0	*b*	0
	Total residual chlorine				0.5	*b*	
Outfall 133	pH, standard units			*a*	9.0	*b*	0
	Total residual chlorine				0.5	*b*	
Outfall 125	pH, standard units			*a*	9.0	100	12
	Total residual chlorine				0.5	92	12
Category I outfalls (storm water, steam condensate, cooling tower blowdown, and groundwater)	pH, standard units			*a*	9	100	70
Category I outfalls (Outfalls S15 and S16)	pH, standard units			*a*	10	100	4
Category II outfalls (cooling water, steam condensate, storm water, and groundwater)	pH, standard units			*a*	9.0	100	137
	Total residual chlorine				0.5	100	73
Category II outfalls (S21, S22, S25, S26, S27, S28, and S29)	pH, standard units			*a*	10	100	25
Outfall S19 (Rogers Quarry)	pH, standard units			*a*	9	100	14
Category III outfalls (storm water, cooling water, cooling tower blowdown, steam condensate, and groundwater)	pH, standard units			*a*	9.0	100	161
	Total residual chlorine				0.5	100	144
Outfall 201 (below the North/South pipes)	Total residual chlorine			0.011	0.019	99	156
	Temperature, °C			*a*	30.5	100	157
	pH, standard units		8.5	*a*		100	157
Outfall 200 (North/South pipes)	Oil and grease			10	15	99	77
	Hexane extractable material			10	15	100	82

Table 6.7 (continued)

Discharge point	Effluent parameter	Effluent limits				Percentage of compliance	No. of samples
		Daily avg (lb/d)	Daily max (lb/d)	Daily avg (mg/L)	Daily max (mg/L)		
Outfall 021	Total residual chlorine			0.080	0.188	100	157
	Temperature, °C			*a*	30.5	100	158
	pH, standard units				9.0	100	158
Outfall 017	pH, standard units			*a*	9.0	100	55
	Ammonia as N			32.4	64.8	100	52
Outfall 055	pH, standard units			*a*	9.0	100	105
	Mercury				0.004	98	105
	Total residual chlorine				0.5	99	118
Outfall 55A	pH, standard units			*a*	9.0	*b*	0
	Mercury				0.004	*b*	0
Outfall 550	pH, standard units			*a*	9.0	100	52
	Mercury			0.002	0.004	100	52
Outfall 551	pH, standard units			0.002	9.0	100	52
	Mercury				0.004	100	52
Outfall 051	pH, standard units			*a*	9	100	106
Outfall 501	pH, standard units			*a*	9.0	100	2
(Central	Total suspended solids			31.0	40.0	100	2
Pollution Control	Total toxic organics				2.13	100	1
Facility)	Oil and grease			10	15	100	2
	Cadmium	0.16	0.4	0.075	0.15	100	2
	Chromium	1.0	1.7	0.5	1.0	100	2
	Copper	1.2	2.0	0.5	1.0	100	2
	Lead	0.26	0.4	0.1	0.2	100	2
	Nickel	1.4	2.4	2.38	3.98	100	2
	Nitrate/nitrite				100	100	2
	Silver	0.14	0.26	0.05	0.05	100	2
	Zinc	0.9	1.6	1.48	2.0	100	2
	Cyanide	0.4	0.72	0.65	1.20	100	2
	Polychlorinated biphenyls				0.001	100	1
Outfall 502	pH, standard units			*a*	9.0	*b*	0
(West End	Total suspended solids	18.6	36.0	31.0	40.0	*b*	0
Treatment	Total toxic organics				2.13	*b*	0
Facility)	Nitrate/nitrite			100	150	*b*	0
	Oil and grease			10	15	*b*	0
	Cadmium	0.16	0.4	0.075	0.15	*b*	0
	Chromium	1.0	1.7	0.5	1.0	*b*	0
	Copper	1.2	2.0	0.5	1.0	*b*	0
	Lead	0.26	0.4	0.10	0.20	*b*	0
	Nickel	1.4	2.4	2.38	3.98	*b*	0
	Silver	0.14	0.26	0.05	0.05	*b*	0
	Zinc	0.9	1.6	1.48	2.0	*b*	0
	Cyanide	0.4	0.72	0.65	1.20	*b*	0
	Polychlorinated biphenyls				0.001	*b*	0

Table 6.7 (continued)

Discharge point	Effluent parameter	Effluent limits: Daily avg (lb/d)	Daily max (lb/d)	Daily avg (mg/L)	Daily max (mg/L)	Percentage of compliance	No. of samples
Outfall 503 (Steam Plant Wastewater Treatment Facility)	pH, standard units			*a*	9.0	*b*	0
	Total suspended solids	125	417	30.0	40.0	*b*	0
	Oil and grease	62.6	83.4	10	15	*b*	0
	Iron	4.17	4.17	1.0	1.0	*b*	0
	Cadmium			0.075	0.15	*b*	0
	Chromium	0.83	0.83	0.20	0.20	*b*	0
	Copper	4.17	4.17	0.20	0.40	*b*	0
	Lead			0.10	0.20	*b*	0
	Zinc	4.17	4.17	1.0	1.0	*b*	0
Outfall 512 (Groundwater Treatment Facility)	pH			*a*	9.0	100	143
	Iron				1.0	100	142
	Polychlorinated biphenyls				0.001	100	12
Outfall 520	pH, standard units				9	100	25
Outfall 05A	pH				9	*b*	0

[a]Not applicable.
[b]No discharge.

Table 6.8. Y-12 Complex Discharge Point SS6, Sanitary Sewer Station 6
January through December 2003

Effluent parameter	Number of samples	Daily average value (effluent limit)[a]	Daily maximum value (effluent limit)[b]	Percentage of compliance
pH, standard units	55	*c*	9/6[d]	100
Silver	53	0.05	0.1	100
Arsenic	53	0.01	0.015	96
Benzene	11	0.01	0.015	100
Biochemical oxygen demand	53	200	300	100
Cadmium	53	0.0033	0.005	100
Chromium	53	0.05	0.075	100
Copper	53	0.14	0.21	100
Cyanide	13	0.041	0.062	100
Iron	53	10	15	98
Mercury	53	0.023	0.035	100
Kjeldahl nitrogen	53	45	90	100
Methylene chloride	11	0.027	0.041	100
Nickel	53	0.021	0.032	98
Oil and grease	53	25	50	100
Lead	53	0.049	0.074	100
Phenols—total recoverable	53	0.3	0.5	100
Suspended solids	53	200	300	100
Toluene	11	0.01	0.02	100
Trichloroethene	11	0.018	0.027	100
Zinc	53	0.35	0.75	100

[a]Units in milligrams per liter unless otherwise indicated.
[b]Industrial and Commercial Users Wastewater Permit limits.
[c]Not applicable.
[d]Maximum value/minimum value.

flow of 7 million gal/day (26.5 million L/day) is maintained at the point where East Fork Poplar Creek leaves the reservation (Station 17). The permit required that this project be implemented by March 1997, but the work was completed ahead of schedule (August 1996). With the completion of this project, instream water temperatures decreased approximately 5°C (from approximately 26°C at the headwaters).

During CY 2003 the flow of Upper East Fork Poplar Creek was maintained in accordance with the permit conditions. The average daily flow during CY 2003 was 9.7 million gal/day.

6.5.5. Y-12 Fecal Coliform Study

Studies conducted by Y-12 personnel in the mid 1990s of fecal coliform concentrations in East Fork Poplar Creek and at NPDES outfalls recorded elevated levels during or immediately following rain events. Although the storm water monitoring program analyzes for fecal coliform at various outfalls each year, monitoring for bacteria in East Fork Poplar Creek where it exits from Y-12 property is not routinely performed. A major project to upgrade the sanitary sewer system within the Y-12 Complex and the sewer line along Scarboro Road, which connects into the city of Oak Ridge collection system, was completed by the end of 2000. In 2002, a new bacteria-sampling project for the upper reach of East Fork Poplar Creek inside the Y-12 Complex was initiated to determine whether a reduction of bacteria levels in the stream followed completion of the sewer improvement project.

Two sampling events one in the spring and another in the fall of 2002 were performed at two instream monitoring locations. Samples for *E. coli* and fecal coliform were taken at Station 17 (also known as 9422-1) located near to the point where East Fork Poplar Creek flows off the Y-12 Complex, and outfall 20, located near to the point where a major portion of the Y-12 storm drain system surfaces to form East Fork Poplar Creek. All results from samples taken at outfall 201 were very low and well within water quality criteria. Measurements of fecal coliform from samples taken at Station 17 were also below water criteria values. However, some individual values for *E. coli* and the geometric mean (132 colonies per 100 mL) for one group of results obtained during the fall event were above the recreational criteria of 126 colonies per 100 mL.

Comparison of 2002 data at Station 17 with earlier studies showed that increases in levels during rain events still occur. The 2002 data appear to show some improvement or a reduction of bacteria levels obtained in the earlier studies. A review of fecal coliform data taken at locations throughout the Y-12 area as part of the ongoing Stormwater Pollution Prevention Program has also been conducted. The data demonstrate that elevated levels of fecal coliform often occur in areas remote from the central part of the complex that are not served by the sanitary sewer system. Several of the higher readings in Y-12 also occur at outfalls that drain areas known to be frequented by wildlife. In 2004, additional monitoring in East Fork Poplar Creek and at designated outfalls is planned during a rain event to ascertain the location of bacteria sources to the stream.

6.5.6. Mercury Removal from Storm Drain Catch Basins

In May 2003, metallic mercury was observed in two storm drain catch basins located along G Road and southeast of Building 9201-4. The storm drain line on which the catch basins are located flows into East Fork Poplar Creek at outfall 200. Mercury tends to collect at these low spots in the drain system following heavy rains. During 2003, Y-12 spill response and waste services personnel conducted ten removals and recovered an estimated 28 lb of mercury. Recovery of mercury is expected to continue in 2004.

6.6 BIOMONITORING PROGRAM

In accordance with the 1995 NPDES permit (Part III-C, p. 39), a biomonitoring program is required that evaluates an East Fork Poplar Creek instream monitoring location (Outfall 201), wastewater treatment system discharges, and locations in the storm drain system. Table 6.9 summarizes the results of biomonitoring tests conducted during 2003 on effluent samples from wastewater treatment systems and storm drainage

Table 6.9. Y-12 Complex Biomonitoring Program summary information for wastewater treatment systems and storm sewer (cooling tower) effluents for 2003[a]

Site/building	Test date	Species	48-h LC_{50}[b] (%)	IWC[c] (%)
Groundwater Treatment Facility (512)	1/8/03	*Ceriodaphnia*	88.0	0.10
Cooling tower 9409-15	1/9/03	*Ceriodaphnia*	<6	*d*
Cooling tower 9409-15 (dechlorinated)	1/9/03	*Ceriodaphnia*	>100	*d*
Cooling tower 9409-26	1/9/03	*Ceriodaphnia*	>100	*d*
Cooling tower 9409-26 (dechlorinated)	1/9/03	*Ceriodaphnia*	>100	*d*
Central Mercury Treatment System (551)	1/10/03	*Ceriodaphnia*	>100	0.09
Cooling tower 9409-20	1/14/03	*Ceriodaphnia*	8.3	*d*
Cooling tower 9409-20 (dechlorinated)	1/14/03	*Ceriodaphnia*	>100	*d*
Cooling tower 9409-23	1/14/03	*Ceriodaphnia*	9.6	*d*
Cooling tower 9409-23 (dechlorinated)	1/14/03	*Ceriodaphnia*	>100	*d*
Cooling tower 9409-15	4/3/03	*Ceriodaphnia*	8.7	*d*
Cooling tower 9409-15 (dechlorinated)	4/3/03	*Ceriodaphnia*	>100	*d*
Cooling tower 9409-32	4/3/03	*Ceriodaphnia*	<6	*d*
Cooling tower 9409-32 (dechlorinated)	4/3/03	*Ceriodaphnia*	>100	*d*
Central Mercury Treatment System (551)	4/4/03	*Ceriodaphnia*	>100	0.07
Groundwater Treatment Facility (512)	4/8/03	*Ceriodaphnia*	44.1	0.09
Cooling tower 9409-10	4/8/03	*Ceriodaphnia*	>100	*d*
Cooling tower 9409-10 (dechlorinated)	4/8/03	*Ceriodaphnia*	>100	*d*
Cooling tower 9409-26	4/8/03	*Ceriodaphnia*	>100	*d*
Cooling tower 9409-26 (dechlorinated)	4/8/03	*Ceriodaphnia*	>100	*d*
Outfall 520	5/2/03	*Ceriodaphnia*	11.8	*d*
Central Pollution Control Facility (501)	5/21/03	*Ceriodaphnia*	>100	0.08
Groundwater Treatment Facility (512)	7/9/03	*Ceriodaphnia*	47.0	0.13
Central Mercury Treatment System (551)	7/9/03	*Ceriodaphnia*	>100	0.10
Outfall 520	7/9/03	*Ceriodaphnia*	28.2	*d*
Storm sewer 9422-10	7/10/03	*Ceriodaphnia*	75.8	*d*
Storm sewer 9422-10 (dechlorinated)	7/10/03	*Ceriodaphnia*	>100	*d*
Storm sewer 9422-15	7/10/03	*Ceriodaphnia*	>100	*d*
Storm sewer 9422-11	7/15/03	*Ceriodaphnia*	>100	*d*
Storm sewer 9422-12	7/15/03	*Ceriodaphnia*	17.3	*d*
Storm sewer 9422-12 (dechlorinated)	7/15/03	*Ceriodaphnia*	>100	*d*
Outfall 520	10/8/03	*Ceriodaphnia*	30.4	*d*
Storm sewer 9422-10	10/9/03	*Ceriodaphnia*	34.3	*d*
Storm sewer 9422-10 (dechlorinated)	10/9/03	*Ceriodaphnia*	>100	*d*
Storm sewer 9422-11	10/9/03	*Ceriodaphnia*	>100	*d*
Storm sewer 9422-12	10/14/03	*Ceriodaphnia*	70.7	*d*
Storm sewer 9422-12 (dechlorinated)	10/14/03	*Ceriodaphnia*	73.0	*d*
Storm sewer 9422-15	10/14/03	*Ceriodaphnia*	>100	*d*
Groundwater Treatment Facility (512)	10/16/03	*Ceriodaphnia*	>100	0.18
Central Mercury Treatment System (551)	10/17/03	*Ceriodaphnia*	>100	0.12

[a]Summarized are the effluents and their corresponding 48-h LC_{50}s and instream waste concentrations. Note: Discharges from treatment facilities are intermittent because of batch operations.

[b]The concentration of effluent (as a percentage of full-strength effluent diluted with laboratory control water) that is lethal to 50% of the test organisms in 48 h.

[c]IWC = instream waste concentration based on actual flows at Outfall 201 in East Fork Poplar Creek.

[d]This point is in the storm sewer system; therefore, an IWC is not applicable.

systems. The results of the biomonitoring tests are expressed as the concentration of effluent that is lethal to 50% of the test organisms (LC_{50}) during a 48-hour period. Thus, the lower the value, the more toxic an effluent. The LC_{50} is compared with the effluent's calculated instream waste concentration to determine the likelihood that the discharged effluent would be harmful to aquatic life in the receiving stream. If the LC_{50} is much greater than the instream waste concentration, it is less likely that there is an instream impact.

Effluent samples from three of the four wastewater treatment system discharges were tested on *Ceriodaphnia dubia* at least once during 2003. The West End Treatment Facility did not discharge in 2003. With LC_{50}s greater than 100% in each of four tests, effluents from the Central Mercury Treatment System were consistently nontoxic throughout the year. Effluent from the Central Pollution Control Facility was also nontoxic, with an LC_{50} greater than 100% in the one test conducted in 2003. In four tests during 2003, the LC_{50}s for effluent from the Groundwater Treatment Facility ranged from 44.1% to greater than 100%. In all cases, the calculated instream waste concentrations of the effluent were less than the LC_{50}s, suggesting that effluents from the individual treatment facilities would not be acutely toxic to the aquatic life of East Fork Poplar Creek.

Various locations in the storm drainage system upstream of outfalls 200 and 201 were also monitored during the year. When chlorine or similar chemicals (i.e., bromine) were detected in a sample, side-by-side tests were conducted with a sample that was treated (dechlorinated) to remove the chlorine or chlorine-like chemical. In all cases where toxicity was detected in the nontreated sample (LC_{50} less than 100%), survival was higher in the dechlorinated sample than in the nontreated sample. In most cases, the full-strength dechlorinated sample did not continue to reduce *Ceriodaphnia* survival, indicating that toxicity was due solely to chlorine or similar chemicals. In the few cases where *Ceriodaphnia* survival continued to be reduced after dechlorination, additional sources of toxicity are implicated. Because flow is not measured at these storm-drain points, it is not possible to know the contribution of each to the total flow at Outfall 201 (i.e., the instream waste concentration). It is notable, however, that the results of the biomonitoring tests at Outfall 201 (Table 6.10) demonstrated that when all discharges were combined (treated

Table 6.10. Y-12 Complex Biomonitoring Program summary information for Outfall 201 for 2003[a]

Site	Test date	Species	NOEC[b] (%)	96-h LC_{50}[c] (%)
Outfall 201	1/8	*Ceriodaphnia*	100	>100
		Fathead minnow	100	>100
Outfall 201	4/2	*Ceriodaphnia*	100	>100
		Fathead minnow	100	>100
Outfall 201	7/9	*Ceriodaphnia*	100	>100
		Fathead minnow	100	>100
Outfall 201	10/8	*Ceriodaphnia*	100	>100
		Fathead minnow	100	>100

[a]Summarized are the no-observed effect concentrations (NOECs) and the 96-h LC_{50}s for the instream monitoring location, Outfall 201.

[b]NOEC as a percentage of full-strength effluent from Outfall 201 diluted with laboratory control water. The NOEC must equal one of the test concentrations and is the concentration that does not reduce *Ceriodaphnia* survival or reproduction or fathead minnow survival or growth.

[c]The concentration of effluent (as a percentage of full-strength effluent diluted with laboratory control water) that is lethal to 50% of the test organisms in 96 h.

effluent, storm sewer contribution, plus flow management water) the result was a consistent absence of toxicity at Outfall 201

Table 6.10 summarizes the "no-observed-effect concentrations" (NOECs) and 96-hour LC_{50}s for the instream monitoring location Outfall 201. The NOEC is the concentration of effluent that does not reduce survival, growth, or reproduction of the biomonitoring test organisms during a 6- or 7-day test. Thus, like the LC_{50}, the lower the value, the more toxic the effluent. Water from the instream monitoring point, Outfall 201, was tested four times in 2003 using fathead minnow larvae (*Pimephales promelas*) and *Ceriodaphnia dubia*. The NOECs were 100% for all *Ceriodaphnia* and fathead minnow tests; the 96-h LC_{50}s were consistently greater than 100% for both *Ceriodaphnia* and fathead minnows.

6.7 BIOLOGICAL MONITORING AND ABATEMENT PROGRAMS

The NPDES permit issued to the Y-12 National Security Complex in 1995 mandates a Biological Monitoring and Abatement Program (BMAP) with the objective of demonstrating that the effluent limitations established for the facility protect the classified uses of the receiving stream, East Fork Poplar Creek. The BMAP consists of four major tasks that reflect complementary approaches to evaluating the effects of Y-12 Complex discharges on the aquatic integrity of East Fork Poplar Creek. These tasks are (1) toxicity monitoring; (2) biological indicator studies; (3) bioaccumulation studies; and (4) ecological surveys of the periphyton, benthic macroinvertebrate, and fish communities.

Monitoring is currently being conducted at five primary East Fork Poplar Creek sites, although sites may be excluded or added, depending upon the specific objectives of the various tasks. The primary sampling sites include upper East Fork Poplar Creek at East Fork Poplar Creek kilometer (EFK) 24.4 and 23.4 (upstream and downstream of Lake Reality, respectively); EFK 18.7 (also EFK 18 and 19), located off the ORR and below an area of intensive commercial and light industrial development; EFK 13.8 (also EFK 14), located upstream from the Oak Ridge Wastewater Treatment Facility; and EFK 6.3, located approximately 1.4 km below the ORR boundary (Fig. 6.8). Brushy Fork at Brushy Fork kilometer (BFK) 7.6 is used as a reference stream in most tasks of the BMAP. Additional sites off the ORR are also occasionally used for reference, including Beaver Creek, Bull Run, Cox Creek, Hinds Creek, Paint Rock Creek, and the Emory River in Watts Bar Reservoir (Fig. 6.9).

Trends of increases in species richness and diversity at upstream locations over the last decade, along with similar but more subtle trends in a number of other BMAP indicators, demonstrate that the overall ecological health of

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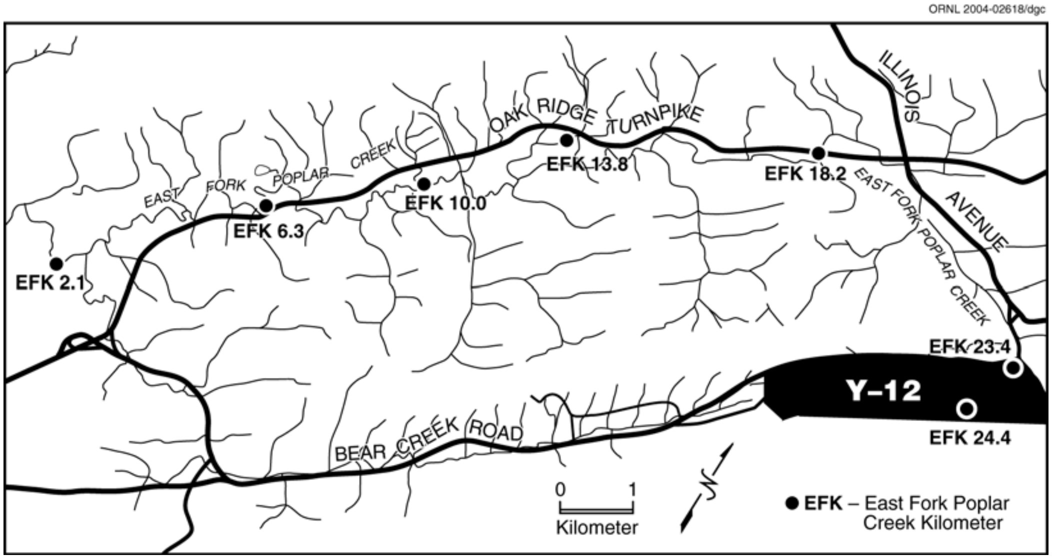

Fig. 6.8. Location of biological monitoring sites on East Fork Poplar Creek in relation to the Oak Ridge Y-12 National Security Complex.

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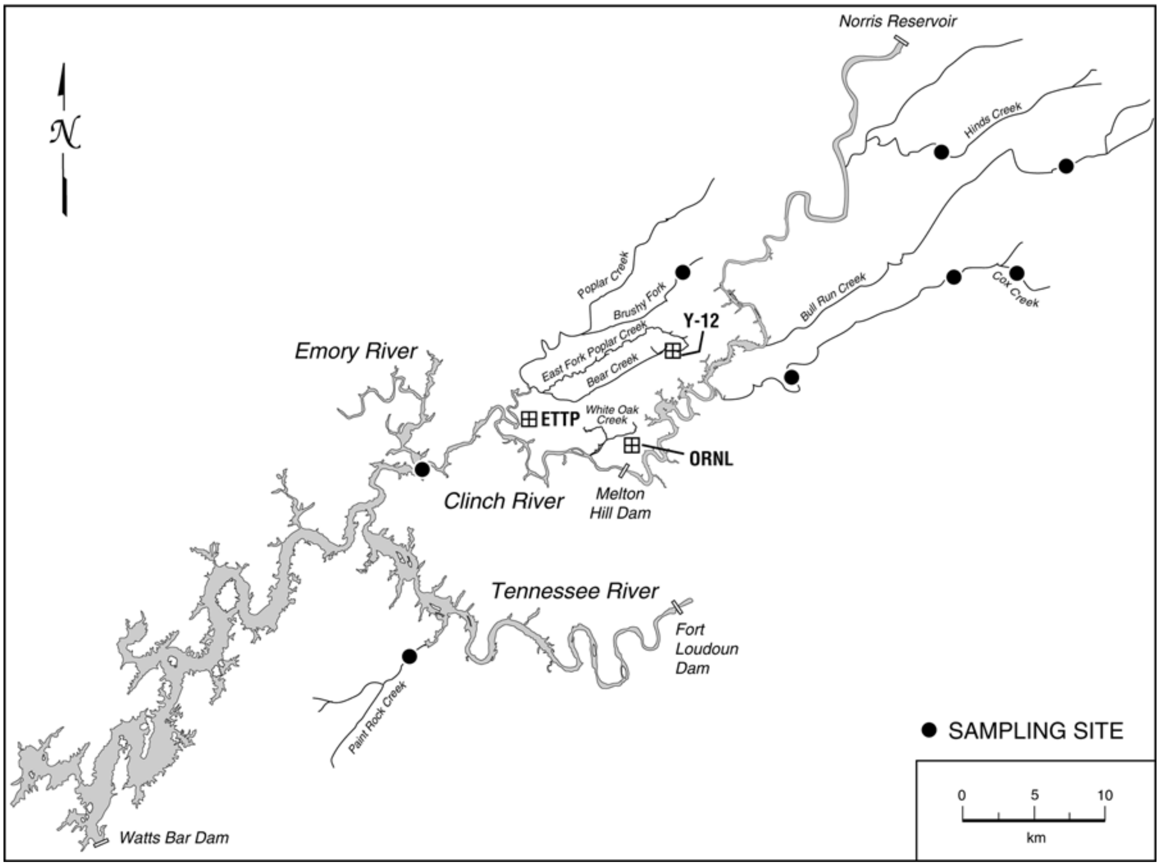

Fig. 6.9. Location of biological monitoring reference sites in relation to the Oak Ridge Y-12 National Security Complex.

East Fork Poplar Creek continues to improve. However, the pace of improvement in the health of East Fork Poplar Creek has slowed in recent years, and fish and invertebrate communities continue to be degraded in comparison with similar communities in reference streams.

6.7.1 Toxicity Monitoring

Toxicity monitoring employs EPA-approved methods with *Ceriodaphnia dubia* and fathead minnows to provide systematic information that is used to verify the biological water quality of East Fork Poplar Creek at intervals throughout the year. *Ceriodaphnia* tests were conducted quarterly in 2003 for one site upstream of Bear Creek Road (EFK 24.1). In addition, quarterly toxicity tests with both fathead minnows and *Ceriodaphnia* were conducted at Outfall 201 as required by the Y-12 Complex's NPDES permit. Because of the close proximity of Outfall 201 (an instream NPDES location in Upper East Fork Poplar Creek) to EFK 25.1, the tests of water from Outfall 201 also met the intent of the Y-12 BMAP Plan (Adams et al. 2000) to conduct quarterly toxicity tests at the latter location.

No evidence for toxicity was observed in any of the 2003 *Ceriodaphnia* tests (both East Fork Poplar Creek sites) or fathead minnow tests (Outfall 201). These results are consistent with the findings of previous *Ceriodaphnia* and fathead minnow tests conducted since flow management began in the latter half of 1996. Similarly, toxicity of East Fork Poplar Creek water in other chronic tests involving fish embryos and clams, which appear more sensitive to water quality conditions in the stream, continues to decrease. Fish embryo-larval test results are discussed in Sect. 6.7.3; clam tests are discussed in Sect. 6.7.4.

6.7.2 Bioaccumulation Studies

Mercury and PCBs have been historically elevated in East Fork Poplar Creek fish relative to fish in uncontaminated reference streams. Fish are monitored regularly in East Fork Poplar Creek for mercury and PCBs to assess spatial and temporal trends in bioaccumulation associated with ongoing remedial activities and plant operations.

As part of this monitoring effort, redbreast sunfish (*Lepomis auritus*) were sampled twice during 2003 from the mid to upper reaches of East Fork Poplar Creek and were analyzed for tissue concentrations of these two environmental contaminants. Largemouth bass (*Micropterus salmoides*) were collected once in 2003 from a site in Upper East Fork Poplar Creek (EFK 23.4) to monitor maximum bioaccumulation in larger piscivorous fish of the system. Stoneroller minnows (*Campostoma anomalum*) were collected from EFK 24.5 to evaluate potential ecological concerns associated with the accumulation of other metals by these prey fish. Mercury concentrations remained much higher during 2003 in fish from East Fork Poplar Creek than in fish from reference streams. Elevated mercury concentrations in fish from the upper reaches of East Fork Poplar Creek indicate that the Y-12 Complex remains a continuing source of mercury to fish in the stream. Although concentrations have leveled off in recent years, mercury concentrations in water in Upper East Fork Poplar Creek have decreased significantly over much of the last decade. In contrast, mercury concentrations in fish have remained relatively constant since the late 1980s (Fig. 6.10).

PCB concentrations measured in East Fork Poplar Creek sunfish during 2003 were within ranges typical of past monitoring efforts at these sites (Fig. 6.11). Mean PCB concentrations were again highest at sampling locations upstream of Bear Creek Road, indicating a continuing PCB source or sources within the Y-12 Complex.

6.7.3 Biological Indicator Studies

The biological indicator task is designed to evaluate the effects of water quality and other environmental variables on the health and reproductive condition of individual fish and fish populations in East Fork Poplar Creek. Redbreast sunfish were sampled from three sites in East Fork Poplar Creek and from two reference streams in the spring of 2003 prior to the onset of the breeding season. A fish embryo-larval test using the medaka (*Oryzias latipes*), a small model fish, was conducted on water from several sites in East

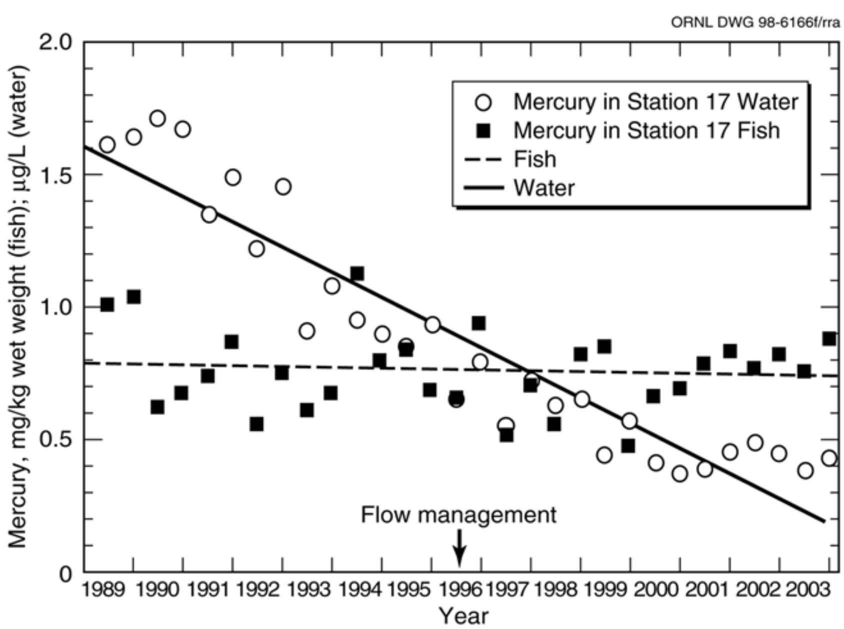

Fig. 6.10. Semiannual average mercury concentration in muscle fillets of redbreast sunfish and water in East Fork poplar Creek at Station 17 through spring 2003.

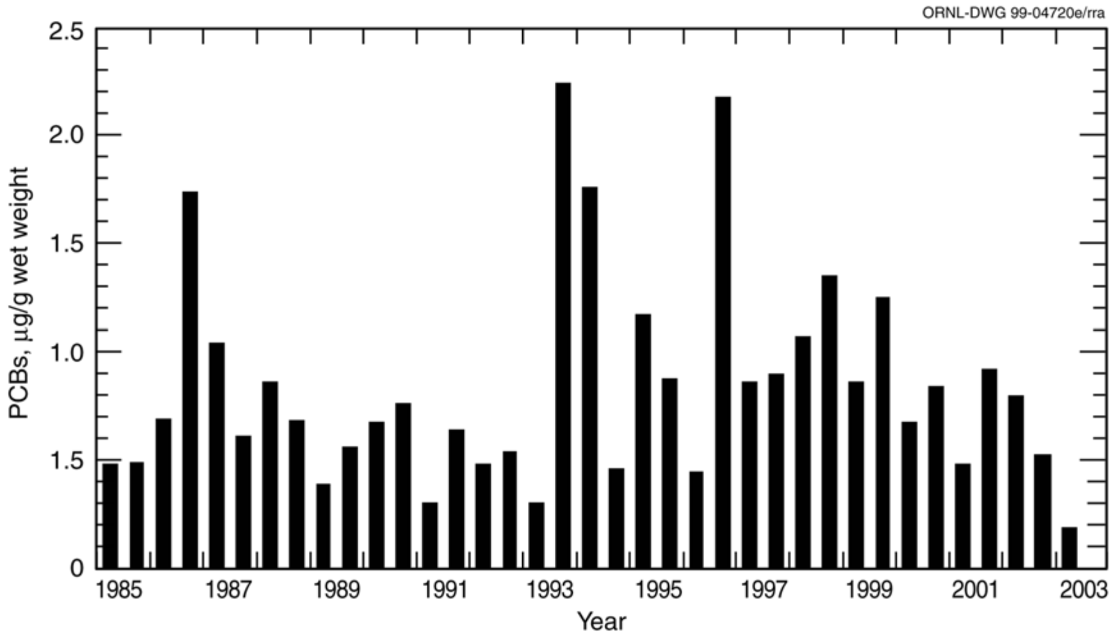

Fig. 6.11. Mean concentrations of PCBs in redbreast sunfish muscle fillets in East Fork Poplar Creek at Station 17 through spring 2003.

Fork Poplar Creek in order to test the ability of young fish to successfully develop in the stream.

Overall trends in many contamination-related bioindicators suggest that there has been measurable improvement in overall fish health in Upper East Fork Poplar Creek in recent years (Fig. 6.12). However, the health and reproductive condition of sunfish from East Fork Poplar Creek sites upstream of Bear Creek remain lower in several respects than in fish from reference sites or downstream East Fork Poplar Creek sites. Furthermore, the abundance of redbreast sunfish, which is not native to the region, continues to decline in both East Fork Poplar Creek and reference streams.

Water from East Fork Poplar Creek upstream of the Oak Ridge Wastewater Treatment Facility adversely affected fish embryos in only one of four medaka embryo-larval toxicity tests conducted during 2003 (Table 6.11). This continues a recent trend of significant improvement in the results of these tests.

6.7.4 Ecological Surveys

Periphyton was monitored quarterly during 2003 from three sites along East Fork Poplar Creek. Algal biomass (Table 6.12) and photosynthetic rates remained higher than in reference streams. Concentrations of various metals (Cu, Zn, Ag, and Cd in particular) continued to be elevated in East Fork Poplar Creek periphyton.

Fish communities were monitored in the spring and fall of 2003 at five sites along East Fork Poplar Creek and at two reference streams. Over the past decade, overall species richness and the number of pollution-sensitive fish species have increased at all sampling locations below Lake Reality (Fig. 6.13). However, improvement in the fish community of East Fork Poplar Creek has slowed in recent years, and the community continues to lag behind reference stream communities in these and other important metrics of community health.

Benthic macroinvertebrate communities were monitored at three sites in East Fork Poplar Creek and at two reference streams in the spring and fall of 2003. The macroinvertebrate communities at EFK 23.4 and EFK 24.4 remained significantly degraded as compared with reference communities (Fig. 6.14). Increases in total richness and the richness of pollution-tolerant taxa continue at the Upper East Fork Poplar Creek sites, although the pace of improvement in benthic macroinvertebrate communities has slowed in recent years.

The effects of in situ exposure on clam growth and survival were tested during 2003 at three sites in East Fork Poplar Creek and at three

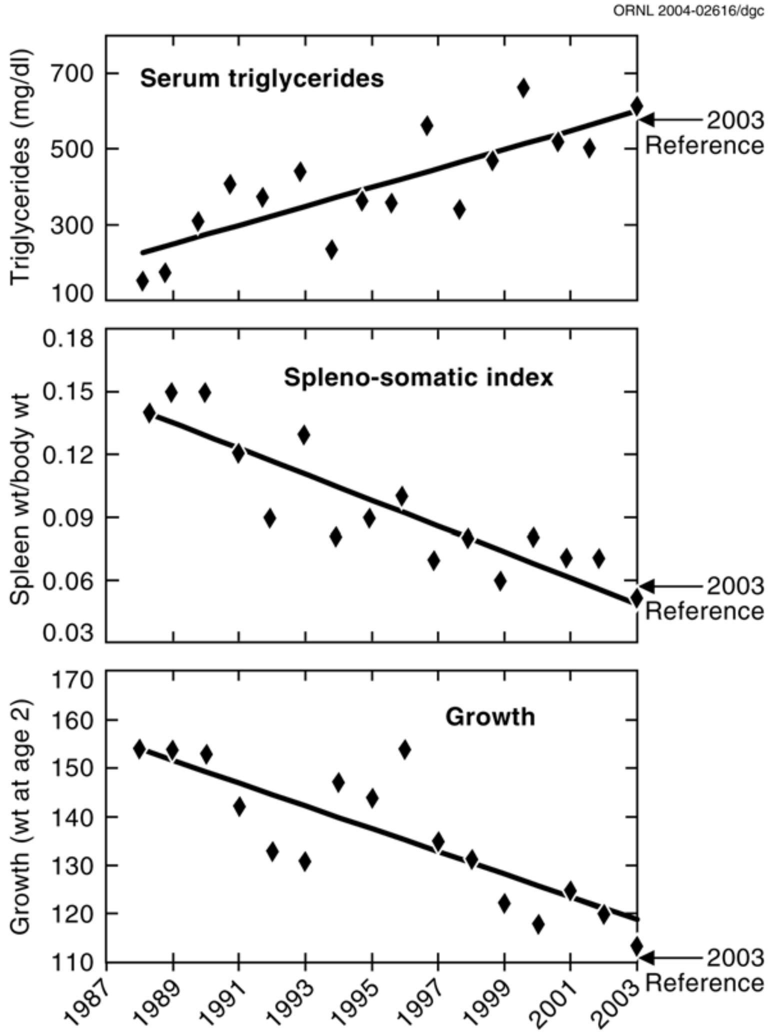

Fig. 6.12. Trends in three indicators of fish health measured over the last fifteen years in redbreast sunfish from EFK 23. Latest values for samples from the reference stream (Hinds Creek) are shown to the right (see arrows) for comparison purposes.

Table 6.11. Results of medaka development toxicity tests conducted on water from ambient sites in East Fork Poplar Creek, 2003
Embryo larval survival (%)

Sample[a]	Quarter			
	First	Second	Third	Fourth
Control	100	100	96	92
EFK 25.1	80	85	100	92
EFK 24.6	90	90	75[b]	92
EFK 23.4	90	95	62[b]	96
EFK 18.2	85	95	75[b]	100
EFK 13.8	100	90	75[b]	96
EFK 10.0	25[b]	75[b]	29[b]	33[b]
EFK 6.3	40[b]	85	33[b]	33[b]

[a]EFK = East Fork Poplar Creek kilometer
[b]Significant difference from control at $p = 0.05$

Table 6.12. Biomass of periphyton sampled from sites on East Fork Poplar Creek and Brushy Fork, 2003
Algal biomass (µg /Chla/cm)[a]

Sample[b]	Quarter			
	First	Second	Third	Fourth
EFK 24.4	56.1 ± 5.5	41.0 ± 14.2	28.7 ± 7.0	50.9 ± 17.4
EFK 23.4	50.2 ± 12.0	52.6± 24.2	25.7 ± 8.2	42.1 ± 6.5
EFK 6.3	31.8 ± 5.7	33.9 ± 25.9	20.9 ± 5.5	59.8 ± 5.5
BFK 7.6	16.3 ± 10.6	13.9 ± 4.1	13.7 ± 9.2	39.2 ± 12.9

[a]Chla= chlorophyll *a*
[b]EFK = East Fork Poplar Creek kilometer
BFK = Brushy Fork kilometer

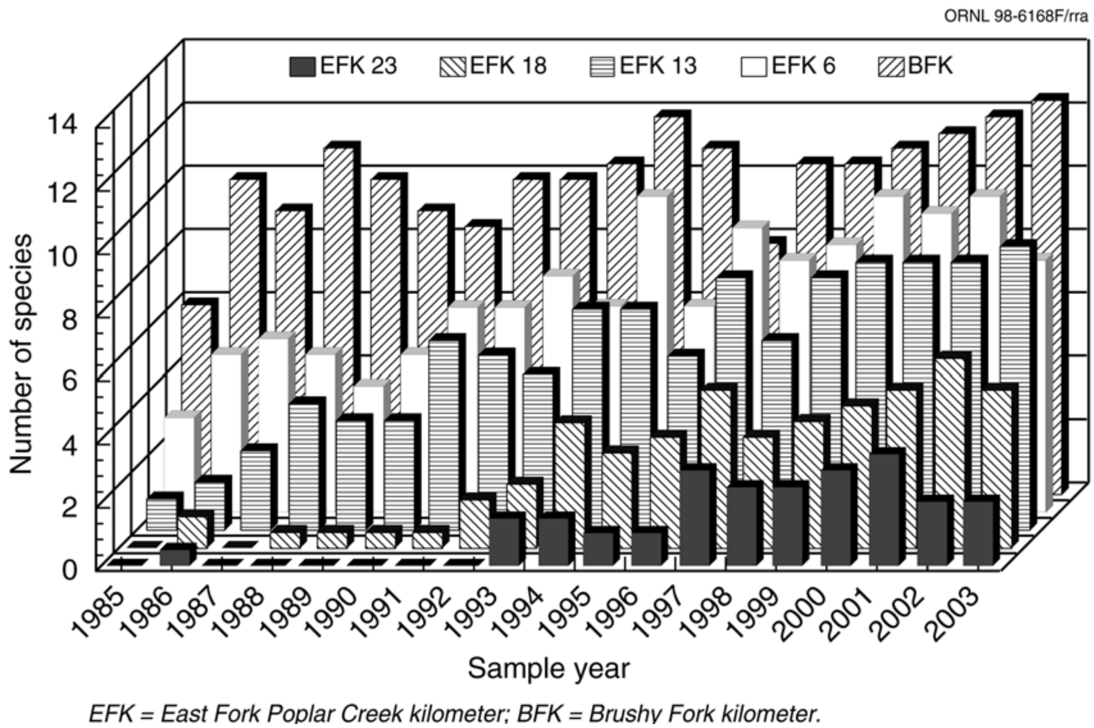

Fig. 6.13. Comparison of mean abundance of sensitive fish species collected during each year from 1985 through 2003 from four sites in East Fork Poplar Creek and a reference site (Brushy Fork). Results for an additional site in Upper East Fork Poplar Creek (EFK 24.4) and a second reference cite (Hinds Creek) are not shown.

reference streams. As in similar tests conducted in previous years, clam survival was significantly reduced at EFK 23.4 and EFK 24.4, while growth was reduced at each of the tested East Fork Poplar Creek sites. However, clam survival at the two Upper East Fork Poplar Creek locations has markedly improved over the last few years, continuing a recent trend of significant improvement in the results of these sensitive toxicity tests (Fig. 6.15).

6.8 Y-12 COMPLEX AMBIENT SURFACE WATER MONITORING

Routine surface water surveillance monitoring, above and beyond that required by the NPDES permit, is performed as a best management practice. The Y-12 Environmental Compliance Department staff monitor the surface water as it exits from each of the three hydrogeologic regimes that serve as an exit pathway for surface water (Fig. 6.16).

Monitoring is conducted in East Fork Poplar Creek at Station 17 (9422-1), near the junction of Scarboro and Bear Creek roads. The current sampling program consists of two 48-h composites plus a 3-day weekend composite. These samples are analyzed for mercury, ammonia-N, inductively coupled plasma (ICP) metals, and total suspended solids.

Monitoring is conducted in Bear Creek at BCK 4.55 (former NPDES Station 304), which is at the western boundary of the Y-12 Complex area of responsibility. A surveillance sample (a 7-day composite sample) is collected monthly for analysis for mercury; anions (sulfate, chloride, nitrate, nitrite); ICP metals; total phenols; and total suspended solids.

The exit pathway from the Chestnut Ridge Hydrogeologic Regime is monitored via NPDES location S19 (former NPDES Station 302) at Rogers Quarry. S19 is an instream location of McCoy Branch and is sampled monthly (a 24-h composite) for ICP metals. The NPDES requirement for this location other than a pH limit is to monitor and report metals data only.

In addition to these exit pathway locations, a network of real-time monitors is located at instream locations along Upper East Fork Poplar Creek and at key points on the storm drain system

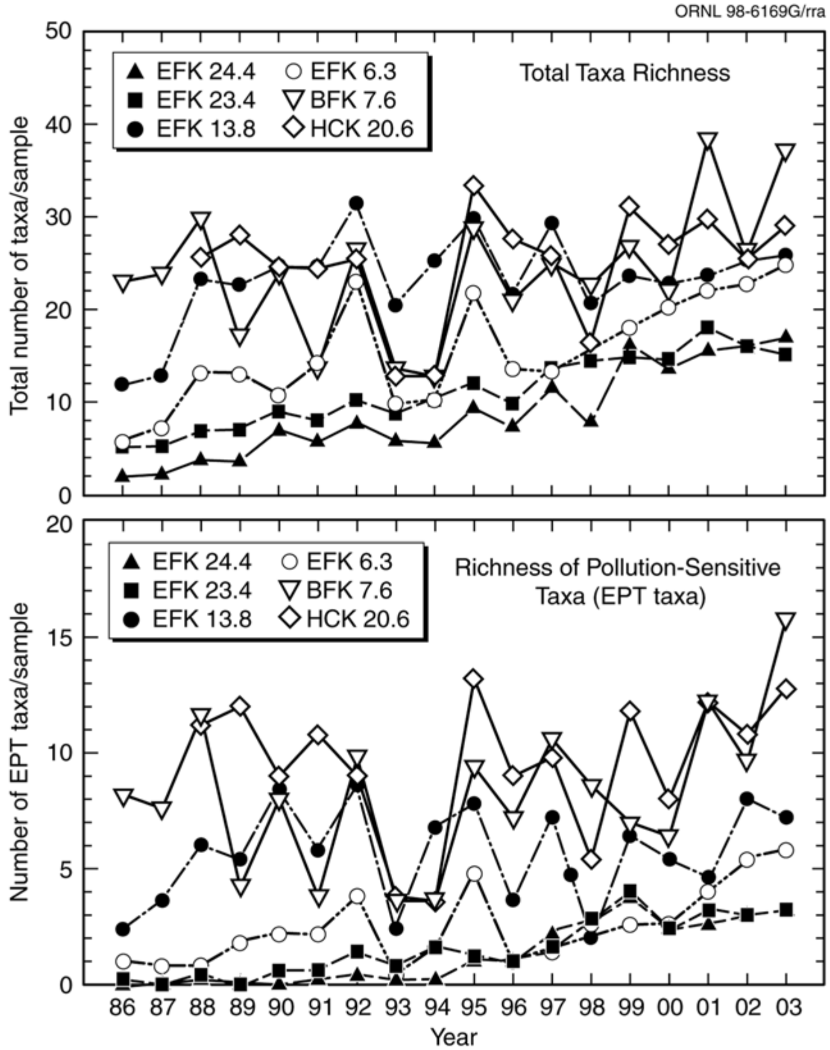

Fig. 6.14. Total taxonomic richness (mean number of taxa/sample) and total taxonomic richness of the Ephemeroptera, Plecoptera, and Trichoptera (EPT) (mean number of EPT taxa/sample) of the benthic macroinvertebrate communities in East Fork Poplar Creek and two reference sites, one on Brushy Fork and one on Hinds Creek (BFK 7.6 and HCK 20.6), spring data only. (EPT taxa include relatively pollution-sensitive species.)

that flows to the creek. The Surface Water Hydrological Information Support System is available for real-time water quality measurements, such as pH, temperature, dissolved oxygen, conductivity, and chlorine. The locations are noted in Fig. 6.17. Not all locations or parameters are operated on a routine basis.

For nonradiological parameters that are sampled and detected above the analytical method reporting detection limit, the data are compared with Tennessee water quality criteria. The most restrictive of either the "freshwater fish and aquatic life criterion maximum concentration" or the "recreation concentration for organisms only" standard is used. This comparison serves as a record of water quality, and the comparison to state water quality criteria limits is for informational purposes only; as such, no attempt is made to achieve the lowest possible detection limit for all parameters.

More than 5000 surface water surveillance samples were collected in 2003. Comparisons with Tennessee water quality criteria indicate that only mercury, zinc, and copper from samples collected at Station 17 were detected at values exceeding a criteria maximum. Results are shown in Table 6.13. Of all the parameters measured in the surface water as a best management practice,

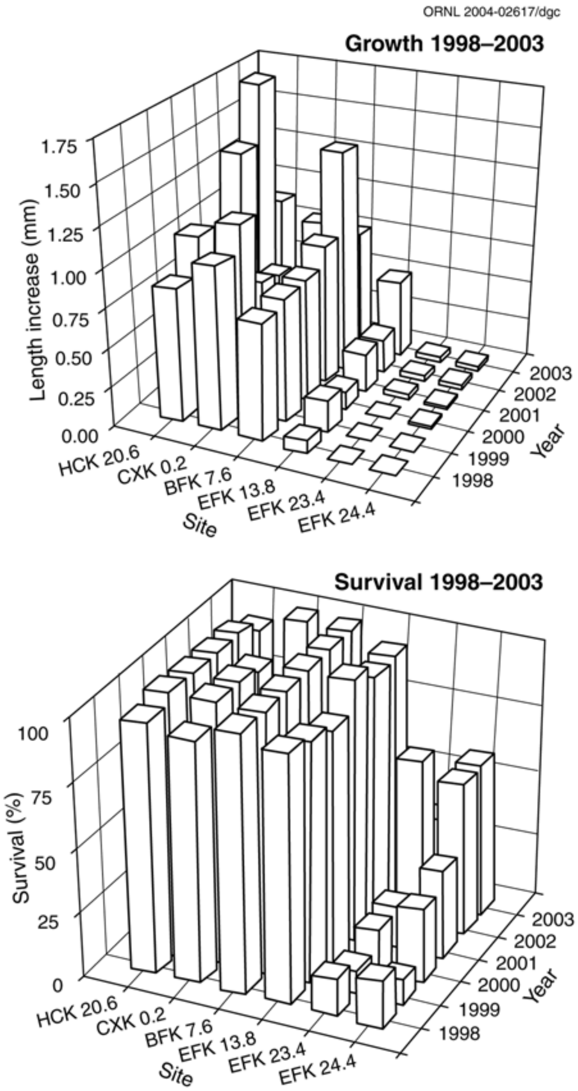

Fig. 6.15. Growth and survival of fingernail clams in situ bioassays in East Fork Poplar Creek, 1998–2003. Length of study is 80 to 86 days per test. No 2002 data are presented for Cox Creek because the bioassay units were lost to vandalism.

mercury is the only demonstrated contaminant of concern.

Additional surface-water sampling is conducted on Bear Creek in accordance with the Y-12 Groundwater Protection Program to monitor trends throughout the Bear Creek Hydrogeologic Regime (see Sect. 6.10.4.3).

6.9 Y-12 SEDIMENT SAMPLING

Historical data have shown that mercury, PCBs, and isotopes of uranium are present at detectable levels in sediment. Therefore, as a best management practice, the Y-12 Complex maintains an annual sampling program to determine whether these constituents are accumulating in the sediments of East Fork Poplar Creek and Bear Creek as a result of Y-12 Complex discharges. Results of the most recent monitoring activity are given in Table 6.14. The monitoring results indicate that the radiological levels including isotopes of uranium and thorium have not significantly changed. The mercury level increased this year at the Station 17 site, but this finding is based on only one result.

This activity is also used to comply with DOE Order 5400.5, which states in Chapter II.3.a.2 that measures be taken to prevent the buildup of radionuclides in sediments caused by releases of waste streams to natural waterways. The order limits the amount of activity that may be present in released settleable solids. Because waste streams from the Y-12 Complex have very low settleable-solid contents, this sampling program to measure activity in the sediments of East Fork Poplar Creek and Bear Creek is used to determine whether a buildup of radionuclide concentrations is occurring.

6.10 GROUNDWATER MONITORING AT THE Y-12 COMPLEX

More than 200 sites have been identified at the Y-12 Complex that represent known or potential sources of contamination to the environment as a result of past waste management practices. Figure 6.18 depicts the major facilities considered as known and/or potential contaminant source areas for which groundwater monitoring was performed during CY 2003. Because of this

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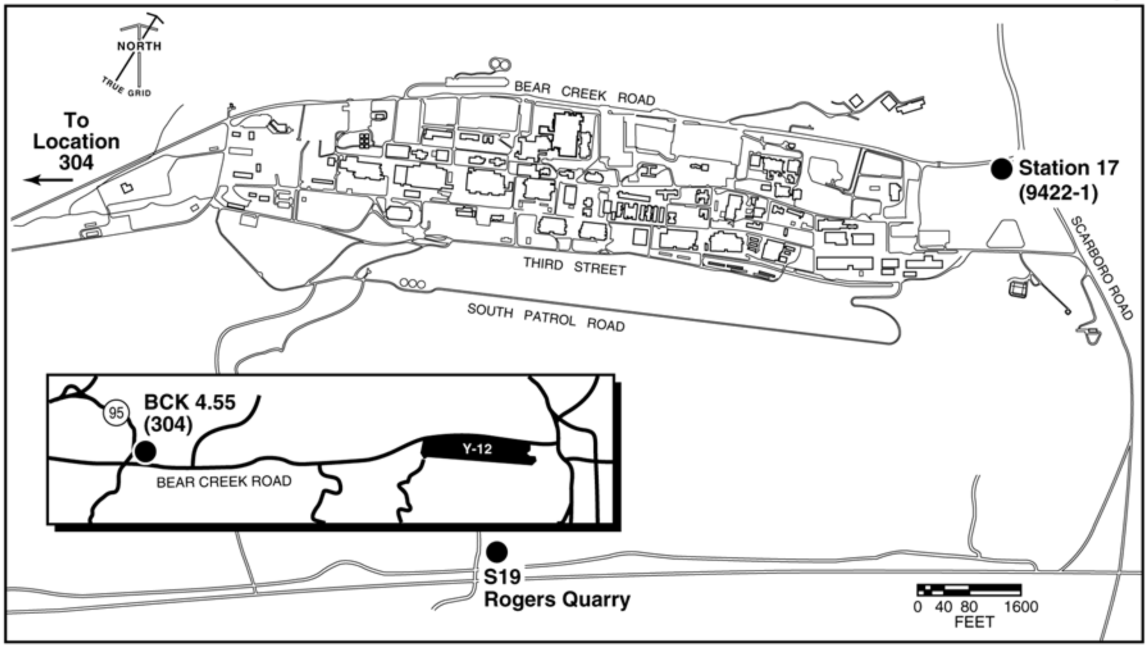

Fig. 6.16. Locations of Y-12 Complex surface water surveillance sampling stations.

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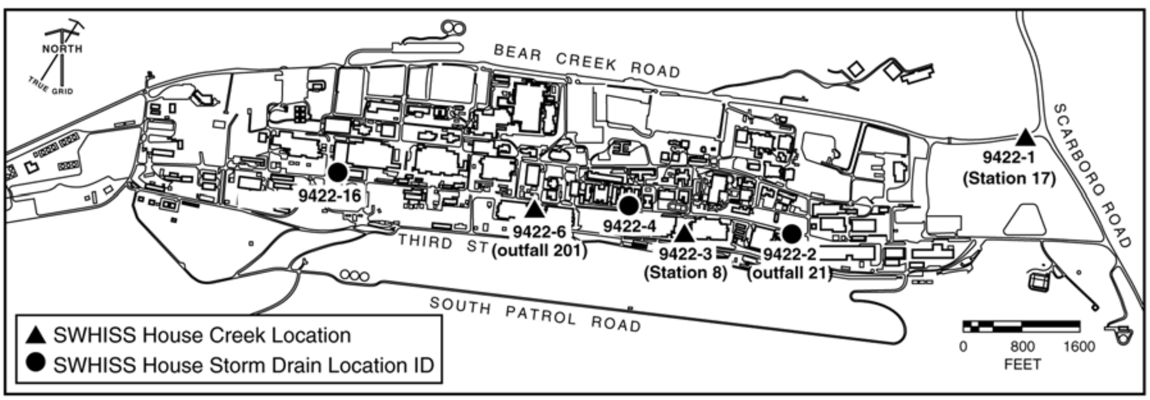

Fig. 6.17. Surface Water Hydrological Information Support System monitoring locations.

Table 6.13. Surface water surveillance measurements exceeding Tennessee water quality criteria at the Y-12 Complex, 2003

Parameter detected	Location	Number of samples	Concentration (mg/L)			Water quality criteria (mg/L)	Number of measurements exceeding criteria
			Detection limit	Max	Avg		
Copper	Station 17	148	0.02	0.0307	<0.02	0.0177	1
Mercury	Station 17	398	0.00021	0.0086	<0.0005	0.000051	393
Zinc	Station 17	148	0.05	0.138	<0.05	0.177	1

Table 6.14. Results of Y-12 Complex sediment monitoring

Parameter	2000	+/–	MDA[a]	2001	+/–	MDA	2002	+/–	MDA	2003	+/–	MDA
Station 17												
^{226}Ra (pCi/g)	–0.67	0.48	0.30	–0.020	0.91	0.065	0.053	0.056	0.56	0.42	0.32	1.3
^{228}Th (pCi/g)	0.072	0.15	0.27	0.039	0.056	0.098	0.00063	0.0035	0.0058	0.46	0.24	0.19
^{230}Th (pCi/g)	0.79	0.3	0.16	0.11	0.064	0.062	–0.015	0.006	0.0057	0.77	0.4	0.15
^{232}Th (pCi/g)	0.10	0.099	0.13	0.042	0.043	0.062	0.0020	0.0029	0.0044	0.36	0.2	0.15
^{234}U (pCi/g)	1.4	0.19	0.017	1.5	0.26	0.063	0.25	0.039	0.0054	0.81	0.21	0.060
^{235}U (pCi/g)	0.078	0.03	0.007	0.050	0.041	0.023	0.012	0.0078	0.0072	0.047	0.057	0.062
^{238}U (pCi/g)	3	0.37	0.014	1.2	0.22	0.044	0.31	0.044	0.0054	1.2	0.26	0.050
Mercury (µg/g)	18.5			6.67			8.14			37.1		
Total polychlorinated biphenyls (µg/kg)	180			270			1400			310		
BCK 9.4												
^{226}Ra (pCi/g)	0.92	0.5	0.41	1.0	0.77	0.075	0.26	0.096	0.31	-0.16	0.1	1.2
^{228}Th (pCi/g)	0.54	0.19	0.16	0.51	0.13	0.038	0.51	0.07	0.0075	0.52	0.17	0.10
^{230}Th (pCi/g)	0.38	0.15	0.11	0.21	0.075	0.016	0.21	0.038	0.0074	0.39	0.2	0.088
^{232}Th (pCi/g)	0.28	0.13	0.078	0.41	0.11	0.016	0.37	0.055	0.0043	0.25	0.11	0.069
^{234}U (pCi/g)	3.5	0.42	0.016	1.1	0.21	0.083	2.1	0.21	0.0043	3.9	0.53	0.056
^{235}U (pCi/g)	0.16	0.047	0.0079	0.11	0.061	0.022	0.10	0.022	0.0051	0.25	0.96	0.047
^{238}U (pCi/g)	6.7	0.77	0.0064	2.5	0.37	0.042	4.1	0.4	0.0045	8.2		0.050
Mercury (µg/g)	0.262			0.187			0.277			0.167		
Total polychlorinated biphenyls (µg/kg)	340			550			590			490		

[a]Minimum detectable activity.

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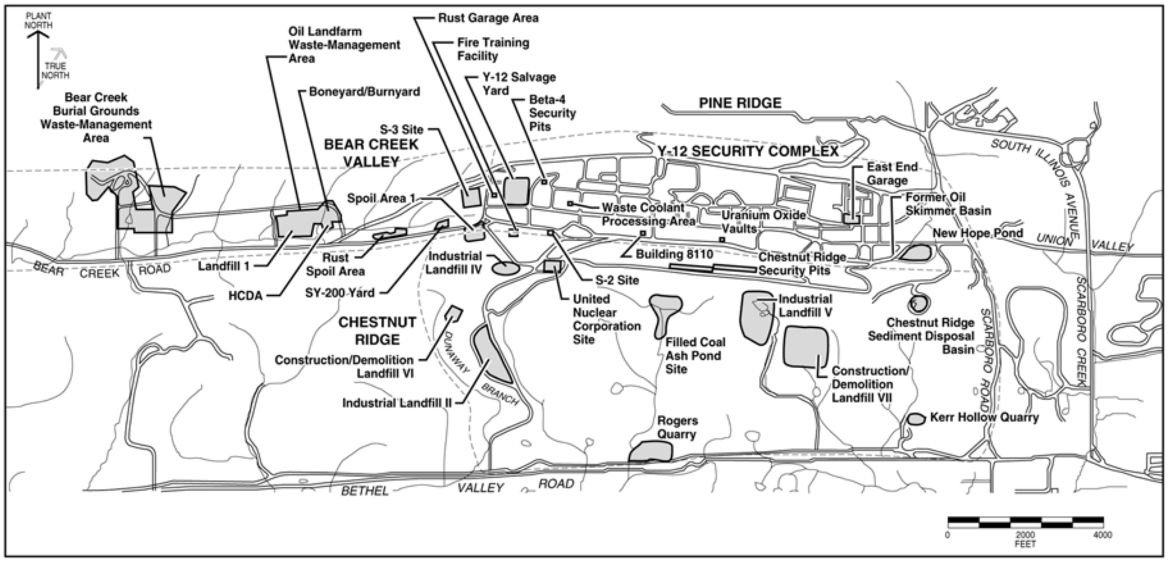

Fig. 6.18. Known or potential contaminant sources for which groundwater monitoring was performed during CY 2003.

contamination, extensive groundwater monitoring is required to comply with regulations and DOE orders.

During CY 2003, routine groundwater monitoring at Y-12 was conducted primarily by two programs, the Y-12 Groundwater Protection Program, managed by BWXT Y-12 LLC, and the Water Resources Restoration Program, managed by Bechtel Jacobs Company, LLC (BJC). Each program is responsible for monitoring groundwater to meet specific compliance requirements. In CY 2003, the Groundwater Protection Program performed monitoring to comply with DOE orders, while the Water Resources Restoration Program performed groundwater monitoring in compliance with CERCLA and RCRA. In addition to the monitoring performed by the Water Resources Restoration Program, BJC monitors groundwater at the solid waste disposal landfills on Chestnut Ridge and the Environmental Management Waste Management Facility (EMWMF) in Bear Creek Valley.

Although the Groundwater Protection Program, the Water Resources Restoration Program, and other projects have differing technical objectives and responsibilities, considerable efforts are made to maintain consistency in groundwater monitoring activities at the Y-12 Complex. Communication among the programs has been crucial in eliminating any redundancies in monitoring activities. In addition, communication and mutual cooperation provided for more consistent and efficient data collection, evaluation, and overall quality. All groundwater monitoring data obtained by all programs are evaluated to provide a comprehensive view of groundwater quality at the Y-12 Complex.

6.10.1 Hydrogeologic Setting

The Y-12 Complex is divided into three hydrogeologic regimes, which are delineated by surface water drainage patterns, topography, and groundwater flow characteristics. The regimes are further defined by the waste sites they contain. These regimes include the Bear Creek Hydrogeologic Regime, the Upper East Fork Poplar Creek Hydrogeologic Regime, and the Chestnut Ridge Hydrogeologic Regime (Fig. 6.19). Most of the Bear Creek and Upper East Fork Poplar Creek regimes are underlain by the ORR Aquitards. The extreme southern portion of these two regimes is underlain by the Maynardville Limestone, which is part of the Knox Aquifer. The entire Chestnut Ridge regime is underlain by the Knox Aquifer (Fig. 1.6). In general, groundwater flow in the water table interval follows topography. Shallow groundwater flow in the Bear Creek regime and the Upper East Fork regime is divergent from a topographic and groundwater divide located near the western end of the Y-12 Complex that defines the boundary between the two regimes. In addition, flow

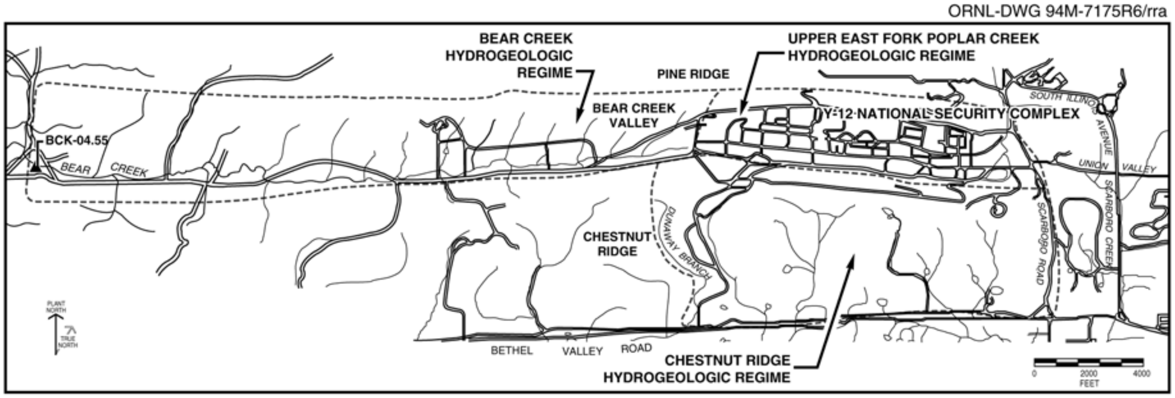

Fig. 6.19. Hydrogeologic regimes at the Y-12 Complex.

converges on the primary surface streams from Pine Ridge and Chestnut Ridge. In the Chestnut Ridge regime, a groundwater divide exists that approximately coincides with the crest of the ridge. Shallow groundwater flow tends to be toward either flank of the ridge, with discharge primarily to surface streams and springs located in Bethel Valley to the south and Bear Creek Valley to the north.

In Bear Creek Valley, groundwater in the intermediate and deep intervals moves predominantly through fractures in the ORR Aquitards, converging on and then moving through fractures and solution conduits in the Maynardville Limestone. Karst development in the Maynardville Limestone has a significant impact on groundwater flow paths in the water table and intermediate intervals. In general, groundwater flow parallels the valley and geologic strike. Groundwater flow rates in Bear Creek Valley vary widely; they are very slow within the deep interval of the ORR aquitards but can be quite rapid within solution conduits in the Maynardville Limestone.

The rate of groundwater flow perpendicular to geologic strike from the ORR aquitards to the Maynardville Limestone has been estimated to be very slow below the water table interval. Most contaminant migration appears to be via surface tributaries to Bear Creek or along utility traces and buried tributaries in the Upper East Fork regime. In the Bear Creek regime, strike-parallel transport of some contaminants can occur within the ORR aquitards for significant distances. Continuous elevated levels of nitrate within the ORR Aquitards are known to extend east and west from the S-3 Site for thousands of feet. Volatile organic compounds at source units in the ORR Aquitards, however, tend to remain close to source areas because they tend to adsorb to the bedrock matrix, diffuse into pore spaces within the matrix, and degrade prior to migrating to exit pathways, where rapid transport occurs for long distances. Regardless, extensive volatile organic compound contamination occurs throughout groundwater in both the Bear Creek and Upper East Fork regimes.

Groundwater flow in the Chestnut Ridge regime is almost exclusively through fractures and solution conduits in the Knox Group. Discharge points for intermediate and deep flow are not well known. Groundwater is currently presumed to flow primarily toward Bear Creek Valley to the north and Bethel Valley to the south. Groundwater from intermediate and deep zones may discharge at certain spring locations along the flanks of Chestnut Ridge. Following the crest of the ridge, water table elevations decrease from west to east, demonstrating an overall easterly trend in groundwater flow.

6.10.2 Well Installation and Plugging and Abandonment Activities

A number of monitoring devices are routinely used for groundwater data collection at Y-12. Monitoring wells are permanent devices used for the collection of groundwater samples; they are installed according to established regulatory and industry specifications. Piezometers are primarily temporary devices used to measure groundwater table levels and are often constructed of polyvinyl chloride or other low-cost materials. Other devices or techniques are sometimes employed to gather data, including well points and push probes. No compliance monitoring wells were installed in CY 2003. However, 15 piezometers were installed at the EMWMF site in Bear Creek Valley to evaluate groundwater elevations for design of a second waste cell.

Well plugging and abandonment activities are conducted to protect human health and the environment, maintain the Y-12 monitoring well network, and meet operational needs. Wells that are damaged beyond rehabilitation, that interfere with planned construction activities, or from which no useful data can be obtained, are selected for plugging and abandonment. In 2003, seven wells were plugged and abandoned. Three wells are located in the Y-12 Coal Pile and were plugged due to damage or risk of damage caused by heavy equipment operations in the area. Four other wells were plugged to make way for construction of building 9720-82.

6.10.3 CY 2003 Monitoring Program

Groundwater monitoring in CY 2003 was performed to comply with DOE orders and regulations by the Groundwater Protection Program, Water Resources Restoration Program, and other BJC projects. Compliance requirements were met by the monitoring of 168 wells, 14 springs, and 37 surface water locations (Table 6.15). Figure 6.20 shows the locations of ORR perimeter/exit pathway groundwater monitoring stations as specified in the *ORR Environmental Monitoring Plan (*DOE 2003c).

Comprehensive water quality results of monitoring activities at Y-12 in CY 2003 are presented in the annual *Groundwater Monitoring Report* (BWXT 2004a).

Details of monitoring efforts performed specifically for CERCLA baseline and remediation evaluation are published in the FY 2003 and *FY 2004 Water Resources Restoration Program Sampling and Analysis Plans* (BJC 2002 and BJC 2003b), and the 2004 *Remediation Effectiveness Reports* (DOE 2004a).

Groundwater monitoring compliance reporting to meet RCRA postclosure permit requirements can be found in the RCRA annual reports (BJC 2004a, BJC 2004b, BJC 2004c).

6.10.4 Y-12 Groundwater Quality

Historical monitoring efforts have shown that four types of contaminants have affected groundwater quality at Y-12: nitrate, volatile organic compounds, metals, and radionuclides. Of those, nitrate and volatile organic compounds are the most widespread. Some radionuclides, particularly uranium and ^{99}Tc, are significant, principally in the Bear Creek regime and the western and central portions of the Upper East Fork regime. Trace metals, the least extensive groundwater contaminants, generally occur in a small area of low-pH groundwater at the western end of Y-12, near the S-2 and S-3 sites. Historical data have shown that plumes from multiple-source units have mixed with one another and that contaminants (other than nitrate and ^{99}Tc) are no longer easily associated with a single source.

6.10.4.1 Upper East Fork Poplar Creek Hydrogeologic Regime

The Upper East Fork regime contains contaminant source areas and surface water and groundwater components of the hydrogeologic system within the Y-12 production complex and Union Valley to the east and off the ORR. Among the three hydrogeologic regimes at Y-12, the Upper East Fork regime encompasses most of the known and potential sources of surface water and groundwater contamination. A brief description of waste management sites is given in Table 6.16. Chemical constituents from the S-3 Site (primarily nitrate and ^{99}Tc) dominate groundwater contamination in the western portion of the Upper East Fork regime, while groundwater in the eastern portion, including Union Valley, is predominantly contaminated with volatile organic compounds.

Plume Delineation

The primary groundwater contaminants in the Upper East Fork regime are nitrates, volatile organic compounds, trace metals, and radionuclides. Sources of these contaminants

Table 6.15. Types and numbers of groundwater monitoring stations sampled at the Y-12 Complex during CY 2003

	Bear Creek	Chestnut Ridge	Upper East Fork Poplar Creek	Total
Conventional wells	51	39	77	167
Multiport wells	0	0	1	1
Surface water	23	5	9	37
Springs	7	5	2	14
Total number of monitoring stations	81	49	89	219

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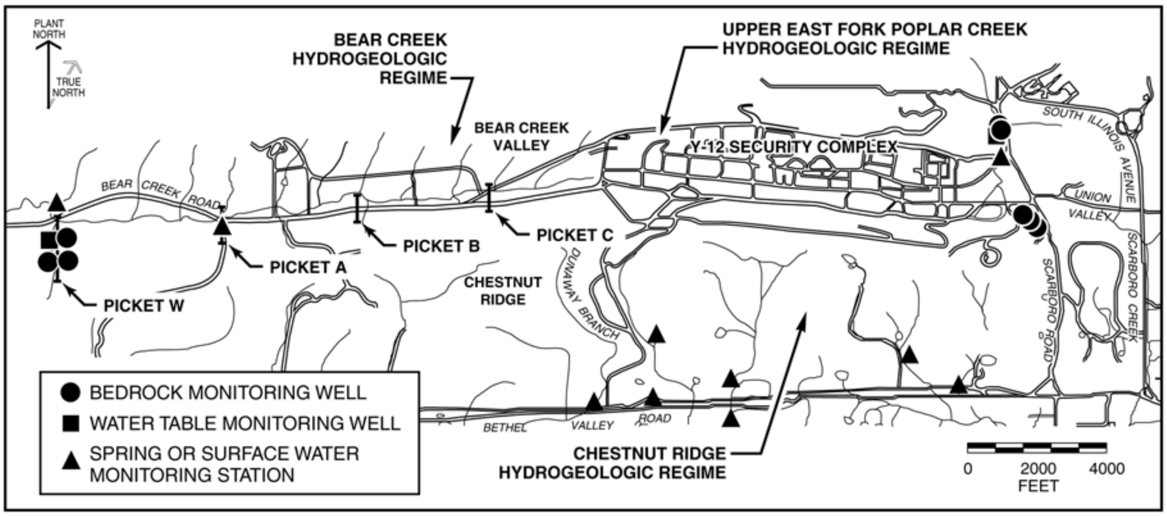

Fig. 6.20. Locations of ORR perimeter/exit pathway well, spring, and surface water monitoring stations in the *Environmental Monitoring Plan for the Oak Ridge Reservation*.

monitored during CY 2003 are the S-2 Site, the Fire Training Facility, the S-3 Site, the Waste Coolant Processing Facility, the 9418-3 Uranium Oxide Vault, petroleum underground storage tanks (USTs), New Hope Pond, Beta-4 Security Pits, Salvage Yard, and process/production buildings throughout the Y-12 Complex. Although it is located west of the current hydrologic divide that separates the Upper East Fork regime from the Bear Creek regime, the S-3 Site, now closed under RCRA, has contributed to groundwater contamination in the western part of this regime.

Nitrate

Nitrate concentrations in groundwater at Y-12 exceed the 10-mg/L maximum drinking water contamination level (a complete list of national drinking water standards is presented in Appendix C) in a large part of the western portion of the Upper East Fork regime (Fig. 6.21). The two primary sources of nitrate contamination are the S-3 and S-2 sites. In CY 2003, Groundwater containing nitrate concentrations as high as 10,400 mg/L (Wells GW-108 and GW-109) occurred in the unconsolidated zone and at shallow bedrock depths just east of the S-3 Site. These results are consistent with results in previous years. The extent of the nitrate plume is essentially defined in the unconsolidated zone and the shallow bedrock zone. An increasing trend in nitrate concentrations at GW-606 has been observed (Fig. 6.22). This increase possibly indicates that the nitrate plume in the Maynardville Limestone has migrated into the eastern area of the Y-12 Complex from the S-2 and/or the S-3 sites. Historical results from Well GW-108 indicates a generally decreasing trend in near-source areas.

Table 6.16. History of waste management units and underground storage tanks included in CY 2003 groundwater monitoring activities, Upper East Fork Poplar Creek Hydrogeologic Regime[a]

Site	Historical data
New Hope Pond	Built in 1963. Regulated flow of water in Upper East Fork Poplar Creek before exiting the Y-12 Complex grounds. Sediments include PCBs, mercury, and uranium but not hazardous according to toxicity characteristic leaching procedure. Closed under RCRA in 1990
Salvage Yard Scrap Metal Storage Area	Used from 1950 to present for scrap metal storage. Some metals contaminated with low levels of depleted or enriched uranium. Runoff and infiltration are the principal release mechanisms to groundwater
Salvage Yard Oil/ Solvent Drum Storage Area	Primary wastes included waste oils, solvents, uranium, and beryllium. Both closed under RCRA. Leaks and spills represent the primary contamination mechanisms for groundwater
Salvage Yard Oil Storage Tanks	Used from 1978 to 1986. Two tanks used to store PCB-contaminated oils, both within a diked area
Salvage Yard Drum Deheader	Used from 1959 to 1989. Sump tanks 2063-U, 2328-U, and 2329-U received residual drum contents. Sump leakage is a likely release mechanism to groundwater
Building 81-10 Area	Mercury recovery facility operated from 1957 to 1962. Potential historical releases to groundwater from leaks and spills of liquid wastes or mercury. The building structure was demolished in 1995
Rust Garage Area	Former vehicle and equipment maintenance area, including four former petroleum USTs. Petroleum product releases to groundwater are documented
9418-3 Uranium Oxide Vault	Originally contained an oil storage tank. Used from 1960 to 1964 to dispose of nonenriched uranium oxide. Leakage from the vault to groundwater is the likely release mechanism
Fire Training Facility	Used for hands-on fire-fighting training. Sources of contamination to soil include flammable liquids and chlorinated solvents. Infiltration is the primary release mechanism to groundwater
Beta-4 Security Pits	Used from 1968 to 1972 for disposal of classified materials, scrap metals, and liquid wastes. Site is closed and capped. Primary release mechanism to groundwater is infiltration
S-2 Site	Used from 1945 to 1951. An unlined reservoir received liquid wastes. Infiltration is the primary release mechanism to groundwater
Waste Coolant Processing Area	Used from 1977 to 1985. Former biodegradation facility used to treat waste coolants from various machining processes. Closed under RCRA in 1988
East End Garage	Used from 1945 to 1989 as a vehicle fueling station. Five USTs used for petroleum fuel storage were excavated, 1989 to 1993. Petroleum releases to the groundwater are documented
Coal Pile Trench	Located beneath the current steam plant coal pile. Disposals included solid materials (primarily alloys). Trench leachate is a potential release mechanism to groundwater

[a]Abbreviations

PCB = polychlorinated biphenyl

RCRA= Resource Conservation and Recovery Act

UST = underground storage tank

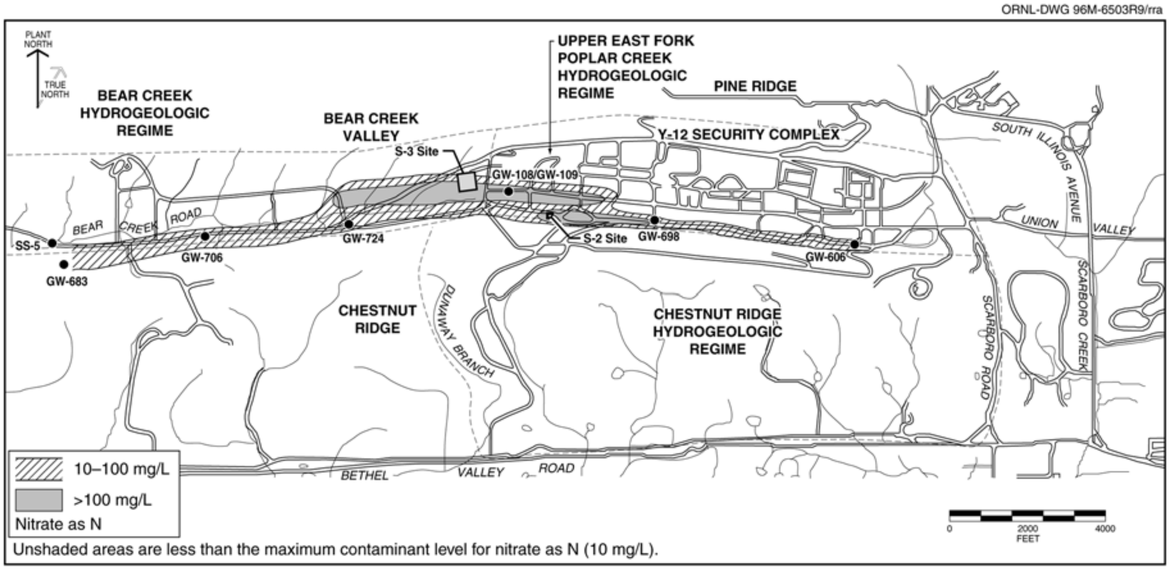

Fig. 6.21. Nitrate (as N) observed in groundwater at the Y-12 Complex.

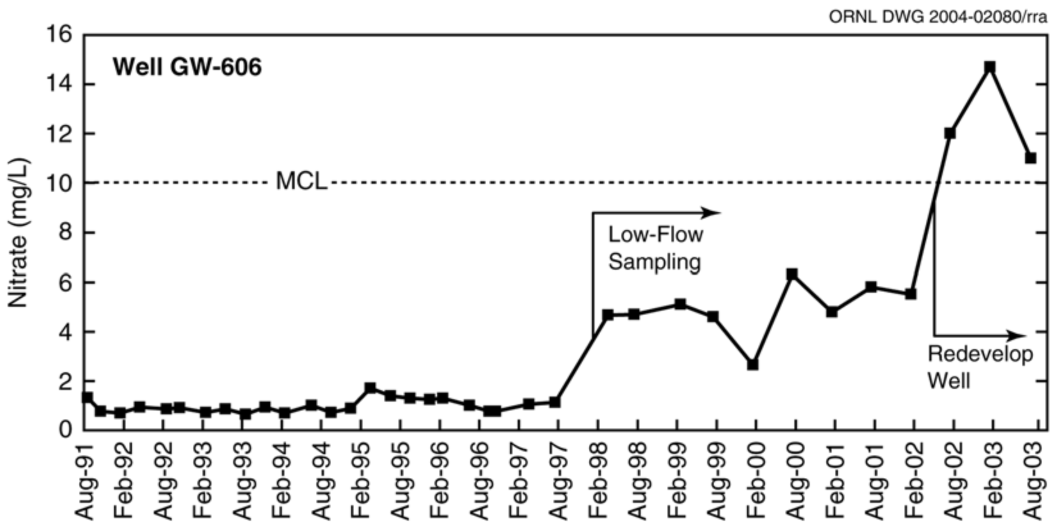

Fig. 6.22. Nitrate concentrations in well GW-606, at the eastern end of the Y-12 Complex.

Trace Metals

Concentrations of antimony, barium, beryllium, cadmium, chromium, copper, lead, mercury, nickel, thallium, and uranium exceeded drinking water standards during CY 2003 in samples collected from various monitoring wells and surface water locations downgradient of the S-2 Site, the S-3 Site, the Salvage Yard, and throughout the complex. Elevated concentrations of these metals in groundwater were most commonly observed from monitoring wells in the unconsolidated zone. Trace metals above standards tend to occur only adjacent to the source areas due to their low solubility in natural water systems on the ORR. However, some metals, such as uranium and mercury, are being transported through the surface water system and have been observed in concentrations above the drinking water standards. In December 2000, the EPA promulgated a drinking water standard of 0.03 mg/L for uranium that went into effect in 2003. This standard was used to evaluate uranium concentrations in groundwater and surface water at the Y-12 Complex. Concentrations of uranium exceed this standard in a number of source areas (e.g., production areas and the Uranium Oxide Vault) and contribute this trace metal to Upper East Fork Poplar Creek.

Volatile Organic Compounds

Because of the many source areas, volatile organic compounds are the most widespread groundwater contaminants in the East Fork regime. Dissolved volatile organic compounds in the regime primarily consist of chlorinated solvents and petroleum hydrocarbons. In CY 2003, the highest concentration of dissolved chlorinated solvents (9688 μg/L) was found in groundwater at Well GW-820 in the eastern portion of the Y-12 Complex (Fig. 6.23). The highest dissolved concentration of petroleum hydrocarbons obtained in CY 2003 (21,391 μg/L at Well GW-658) occurred at the closed East End Garage.

The CY 2003 monitoring results generally confirm findings from the previous years of monitoring. A continuous dissolved plume of volatile organic compounds in groundwater in the bedrock zone extends eastward from the S-3 Site over the entire length of the regime (Fig. 6.23). The primary sources are the Waste Coolant Processing Facility and other waste-disposal and production areas throughout the Y-12 Complex.

Chloroethene compounds (tetrachloroethene, trichloroethene, dichloroethene, and vinyl chloride) tend to dominate the volatile organic plume composition in the western and central portions of Y-12. However, tetrachloroethene and isomers of dichloroethene are almost ubiquitous throughout the extent of the plume, indicating many source areas. Chloromethane compounds (carbon tetrachloride, chloroform, and methylene chloride) are the predominant volatile organic compounds in the eastern portion of Y-12.

Variability in concentration trends of chlorinated volatile organic compounds near source areas are seen within the East Fork regime. As seen in previous years, data from most of the monitoring wells have remained relatively constant (i.e., stable) or have decreased since 1988. Other locations reveal an increasing trend, indicating that some plumes are still mobile (Fig. 6.24). Within the exit pathway, with the exception of wells GW-151 and GW-220, the general trends are also stable or decreasing (Fig. 6.25). These decreasing and stable trends west of New Hope Pond are indicators that the contaminants from source areas are attenuating due to factors such as dilution, dispersion, degradation, or adsorption. Wells within the vicinity of New Hope Pond and to the southeast are displaying the effects of the pumping well (GW-845) operated to capture the volatile organic compound plume prior to migration off of the ORR into Union Valley. Wells GW-151 and GW-220 exhibit an increasing trend in volatile organic compound concentrations, indicating that little impact or attenuation from the plume capture system is apparent across lithologic units (perpendicular to strike). Preferential transport of groundwater contaminants is parallel to strike in the Knox Aquifer.

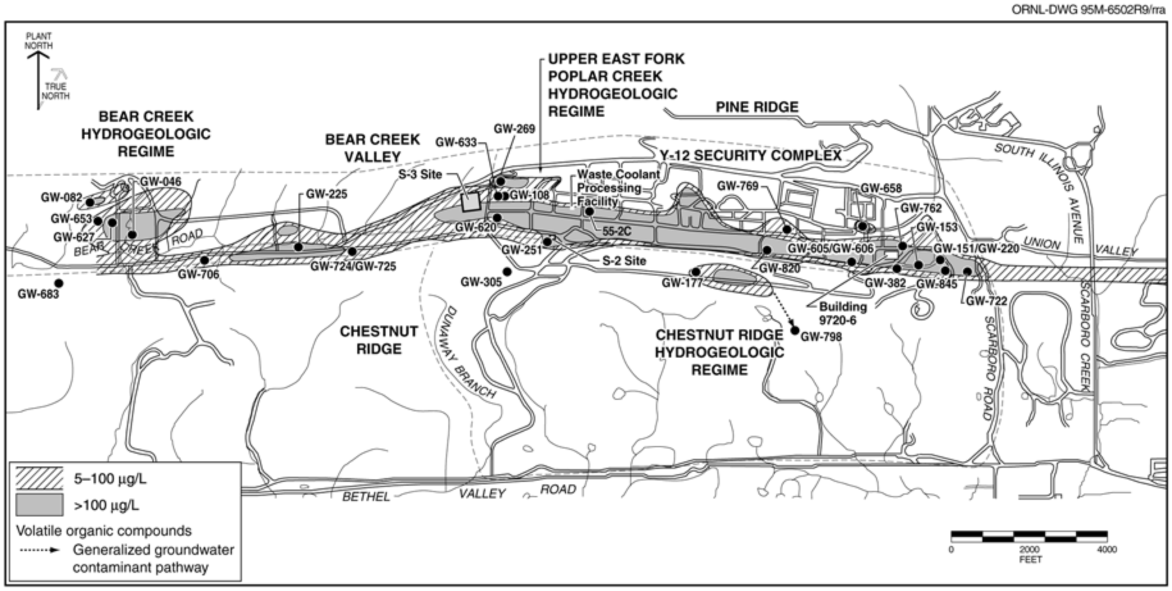

Fig. 6.23. Summed volatile organic compounds in groundwater at the Y-12 Complex.

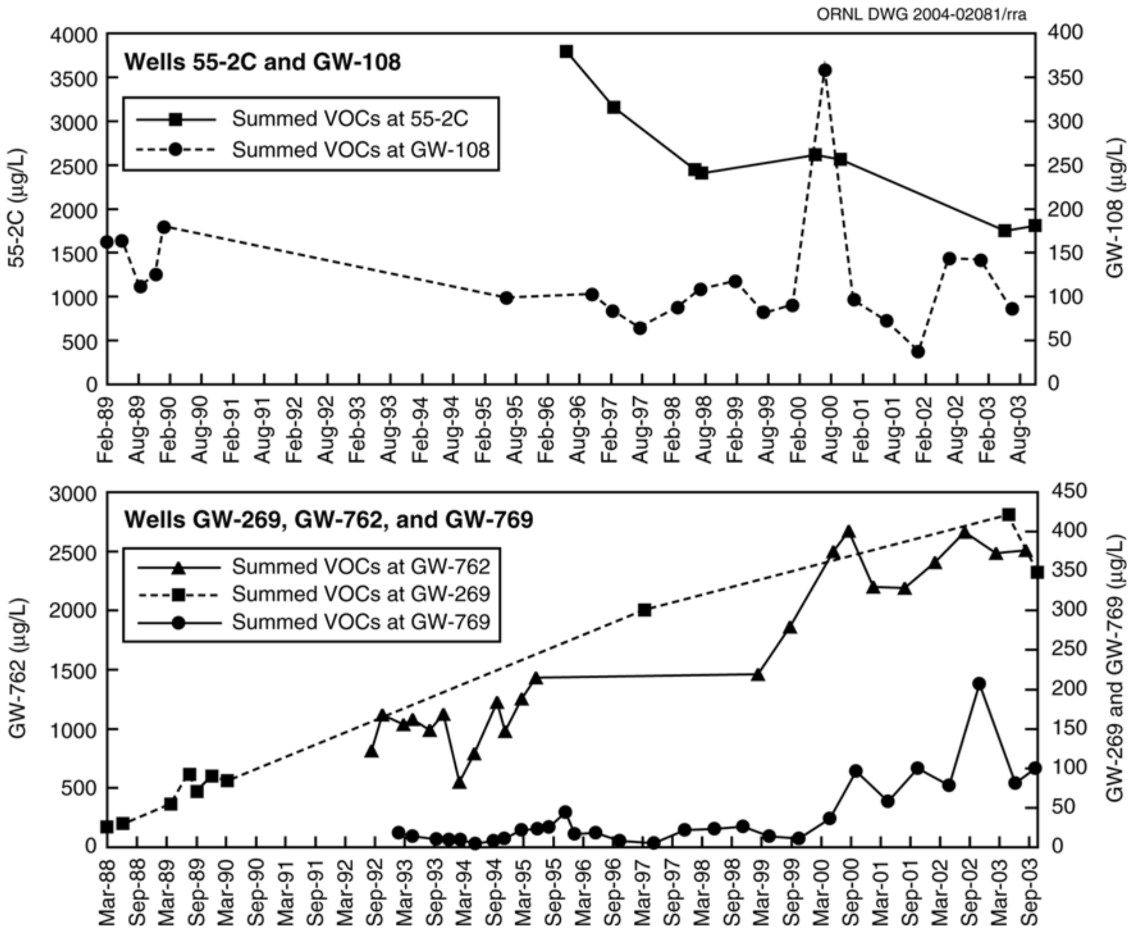

Fig. 6.24. Summed volatile organic compound concentrations in selected wells near source areas in the Upper East Fork Poplar Creek Hydrogeologic Regime.

Monitoring wells at two former petroleum hydrocarbon contaminant sources (Rust Garage Area and East End Garage) were sampled to evaluate the present condition of groundwater. Wells GW-633 and GW-658 are located at the west and east ends of the East Fork Regime, respectively. Well GW-633 has shown a significant increase in concentration since the early 1990s. Well GW-658 shows petroleum hydrocarbon concentrations consistent with those observed during the early 1990s. These observations indicate that there is still an accumulation of contaminants within and surrounding each well.

Radionuclides

The primary alpha-emitting radionuclides found in the East Fork regime during CY 2003 are isotopes of uranium. Groundwater with gross alpha activity greater than 15 pCi/L (the drinking water standard) occurs in scattered areas throughout the East Fork regime (Fig. 6.26). Historical data show that gross alpha activity consistently exceeds the drinking water standard and is most extensive in groundwater in the unconsolidated zone in the western portion of Y-12 near source areas such as the S-3 Site, the S-2 Site, and the Y-12 Salvage Yard. The highest gross alpha activity (1335 pCi/L) was observed during CY 2003 in groundwater from Well GW-108, east of the S-3 site. Other areas of elevated gross alpha activity are present within the production areas in the western portion of Y-12, near the Former Oil Skimmer Basin, and east of the 9418-3 Uranium Oxide Vault.

The primary beta-emitting radionuclides observed in the East Fork regime during CY 2003 are uranium and ^{99}Tc. Elevated gross beta activity in groundwater in the East Fork regime shows a pattern similar to that observed for gross alpha activity (Fig. 6.27), where uranium is the primary

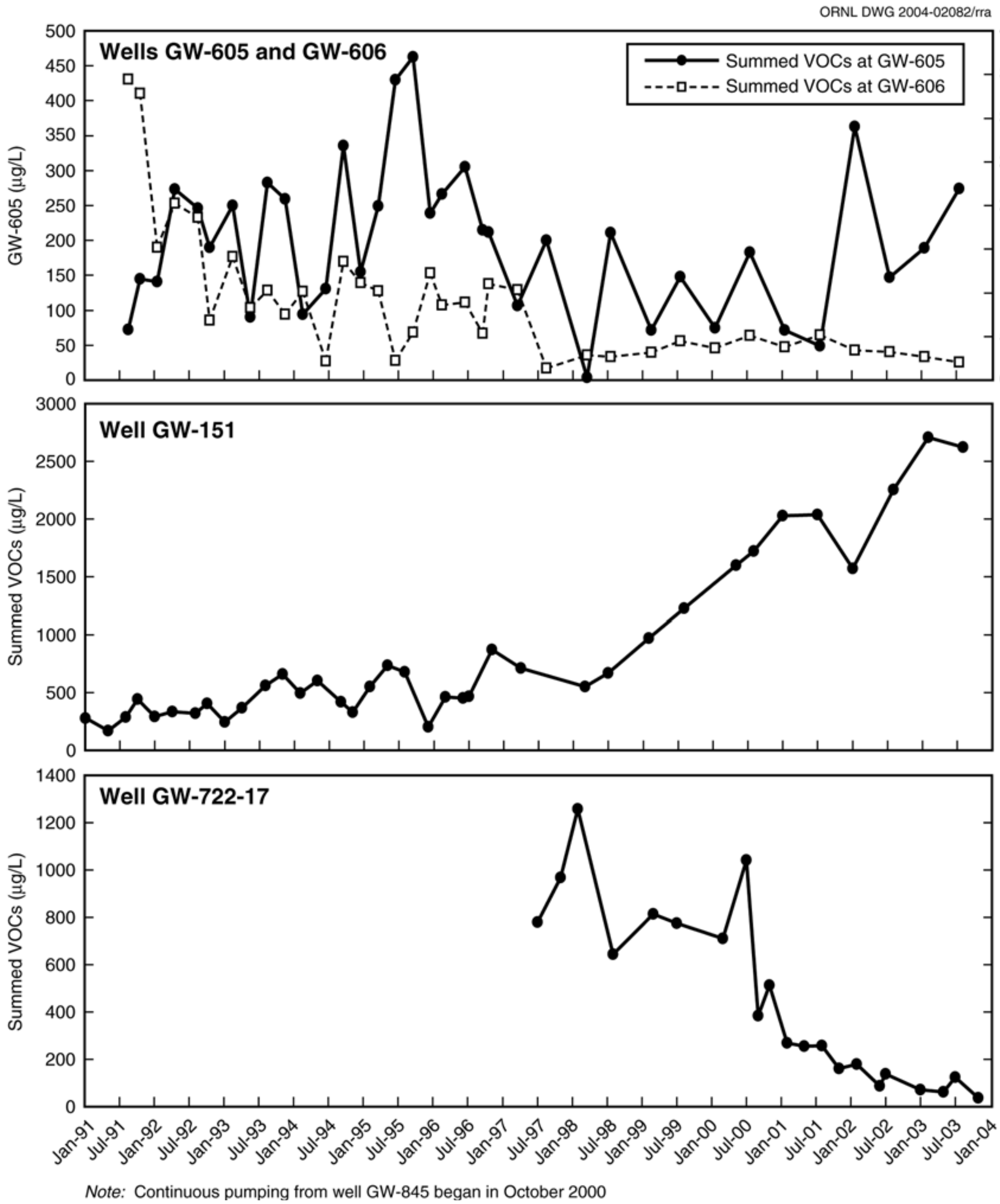

Fig. 6.25. Summed volatile organic compound concentrations in selected wells near New Hope Pond and exit pathway.

screening level of 50 pCi/L in groundwater in the western portion of the regime, with the primary source being the S-3 Site. The highest gross beta activity was observed during CY 2003 in groundwater from Well GW-109 (19,000 pCi/L), east of the S-3 site.

Exit Pathway and Perimeter Monitoring

Exit pathway groundwater monitoring activities in the East Fork regime in CY 2003 involved continued collection and trending of data from exit pathway monitoring stations. Data collected to date indicate that volatile organic compounds are the primary class of contaminants that are migrating through the exit pathways in the East Fork regime (Fig. 6.23). These compounds are migrating at depths of almost 500 ft in the

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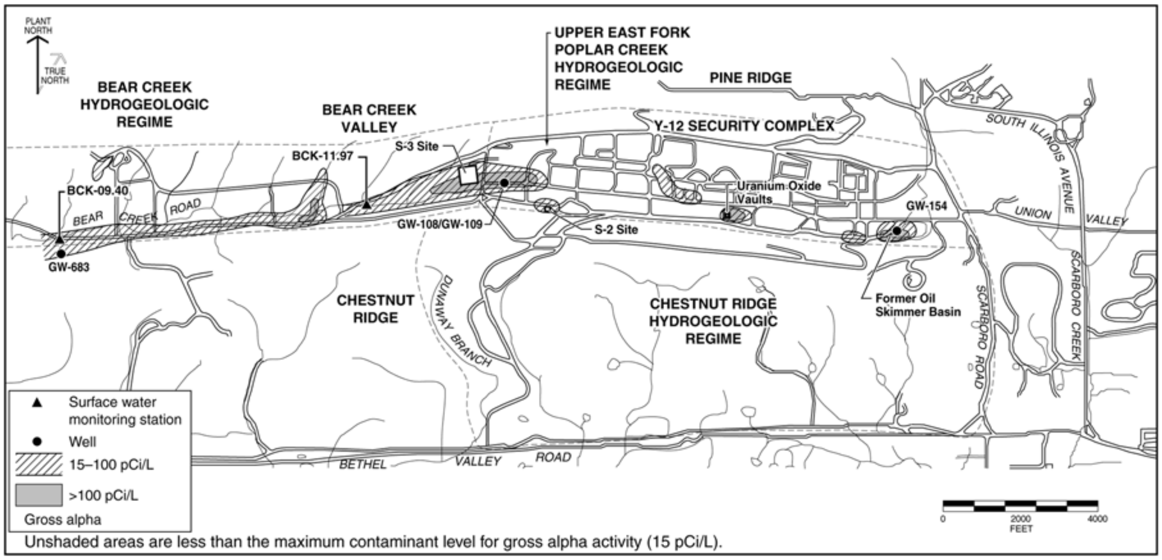

Fig. 6.26. Gross alpha activity in groundwater at the Y-12 Complex.

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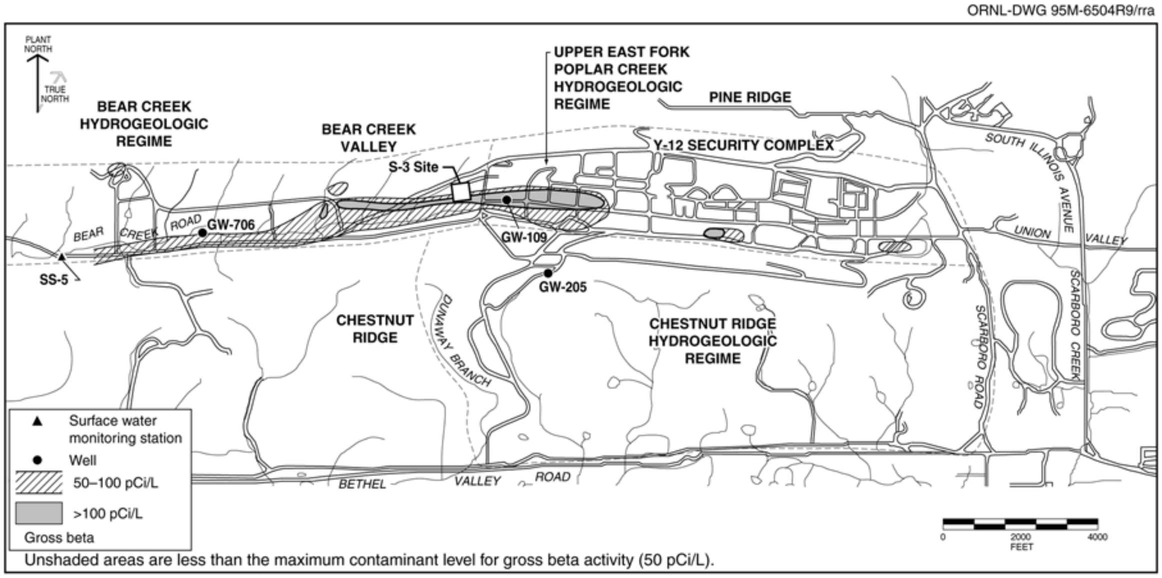

Fig. 6.27. Gross beta activity in groundwater at the Y-12 Complex.

Maynardville Limestone, the primary intermediate to the deep groundwater exit pathway on the east end of Y-12 (Fig. 6.28). Concentrations are typically higher at depth because most dilution and mixing with rainfall in Upper East Fork Poplar Creek occur in the shallow portions of the Maynardville limestone. In addition, most of the volatile organic contaminants at Y-12 are denser than water; therefore, they tend to migrate downward within the subsurface. The deep fractures and solution channels that constitute flow paths within the Maynardville Limestone appear to be well connected, resulting in the migration of these contaminants for substantial distances off the ORR into Union Valley to the east of Y-12.

In addition to the intermediate to deep pathways within the Maynardville Limestone, shallow groundwater within the water table interval near New Hope Pond, Lake Reality, and Upper East Fork Poplar Creek is also monitored. Historically, volatile organic compounds have been observed near Lake Reality from wells, a dewatering sump, and the New Hope Pond distribution channel underdrain. In this area, shallow groundwater flows north-northeast through the water table interval east of New Hope

Pond and Lake Reality, following the path of the distribution channel for Upper East Fork Poplar Creek.

During CY 2003, the observed concentrations of volatile organic compounds at the New Hope Pond distribution channel underdrain continue to remain low. This may be because the continued operation of a groundwater plume-capture system in Well GW-845 (Fig. 6.28) south of the spillway may be reducing the levels of volatile organic compounds in the area. BJC completed the installation of this system in June 2000. This system pumps groundwater from the intermediate bedrock depth to mitigate off-site migration of volatile organic compounds. Groundwater is continuously pumped from the Maynardville Limestone at about 25 gpm, passes through a treatment system to remove the volatile organic compounds, and then discharges to Upper East Fork Poplar Creek.

As previously mentioned, monitoring wells near Well GW-845 have shown some encouraging response to pumping activities. The multi-port system installed in Well GW-722 permits sampling of ten discrete zones within the Maynardville Limestone between 87 and 560 ft below ground surface. This well has been instrumental in characterizing the vertical extent of the east-end plume of volatile organic compounds and is critical in the evaluation of the effectiveness of the plume capture system. Monitoring results from some sampled zones in Well GW-722 indicate reductions in volatile organic compounds due to groundwater pumping upgradient at Well GW-845 (Fig. 6.25). Other wells, such as GW-153 and GW-382, also show

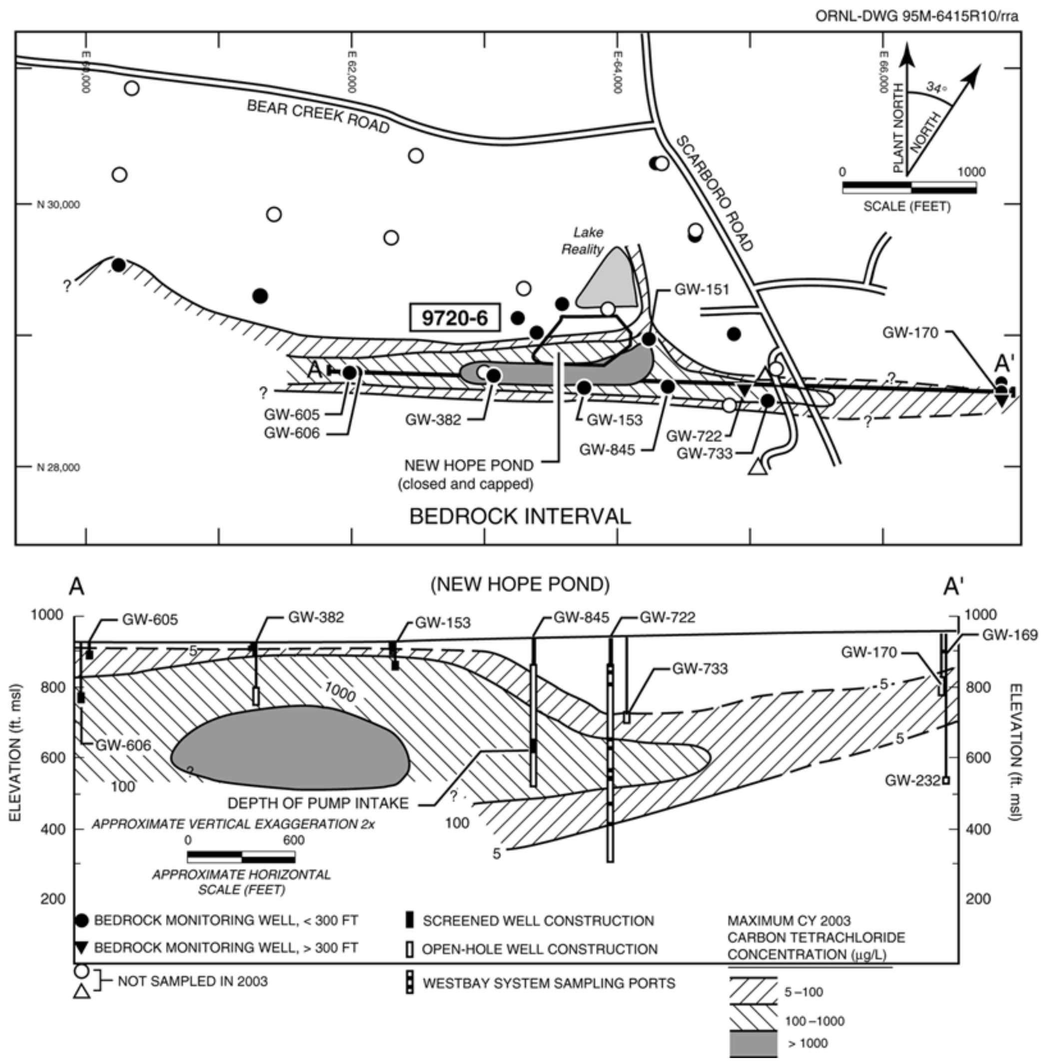

Fig. 6.28. Maximum carbon tetrachloride concentrations in Maynardville Limestone at depths between 200 and 500 ft.

decreases that may be attributable to the plume capture system operation. These indicators show that operation of the plume capture system is decreasing volatile organic compounds upgradient and downgradient of Well GW-845.

Three wells, located in the large gap in Pine Ridge through which Upper East Fork Poplar Creek exits Y-12, are used to monitor shallow, intermediate, and deep groundwater intervals. Shallow groundwater moves through this exit pathway, and very strong upward vertical flow gradients exist; two of the three wells located in this area are artesian (water flows from the well casing due to unusually high naturally occurring water pressure). Continued monitoring of these wells since about 1990 has not shown that any contaminants are moving via this exit pathway.

Five sampling locations continue to be monitored north and northwest of Y-12 to evaluate possible contaminant transport from the ORR (Fig. 6.29). These locations are considered unlikely groundwater or surface water contaminant exit pathways; however, monitoring was performed due to recent public concerns regarding potential health impacts from Y-12 operations to nearby residences. Two of the stations monitored tributaries that drain the north slope of Pine Ridge on the ORR and discharge into the adjacent Scarboro Community. One location monitors an upper reach of Mill Branch, which discharges into the residential areas along Wiltshire Drive. The remaining two locations monitor Gum Hollow Branch as it discharges from the ORR and flows adjacent to the Country Club Estates community. Samples were obtained and analyzed for metals, inorganic parameters, volatile organic compounds, and gross alpha and gross beta activities. No results exceeded a drinking water standard, nor were there any indications that contaminants were being discharged from the ORR into these communities.

6.10.4.2 Union Valley Monitoring

Groundwater monitoring data obtained in 1993 provided the first strong indication that volatile organic compounds were being transported off the ORR through the deep Maynardville Limestone exit pathway. The Upper East Fork Poplar Creek remedial investigation (DOE 1998) provided a discussion of the nature and extent of the volatile organic compounds.

In CY 2003, monitoring of locations in Union Valley continued, showing an overall decreasing trend in the concentrations of contaminants forming the groundwater contaminant plume in Union Valley.

Under the terms of an interim record of decision, administrative controls, such as restriction on potential future groundwater use, have been established. Additionally, the previously discussed plume capture system (Well GW-845) was installed and initiated to reduce volatile organic compounds in Union Valley (DOE 2004a).

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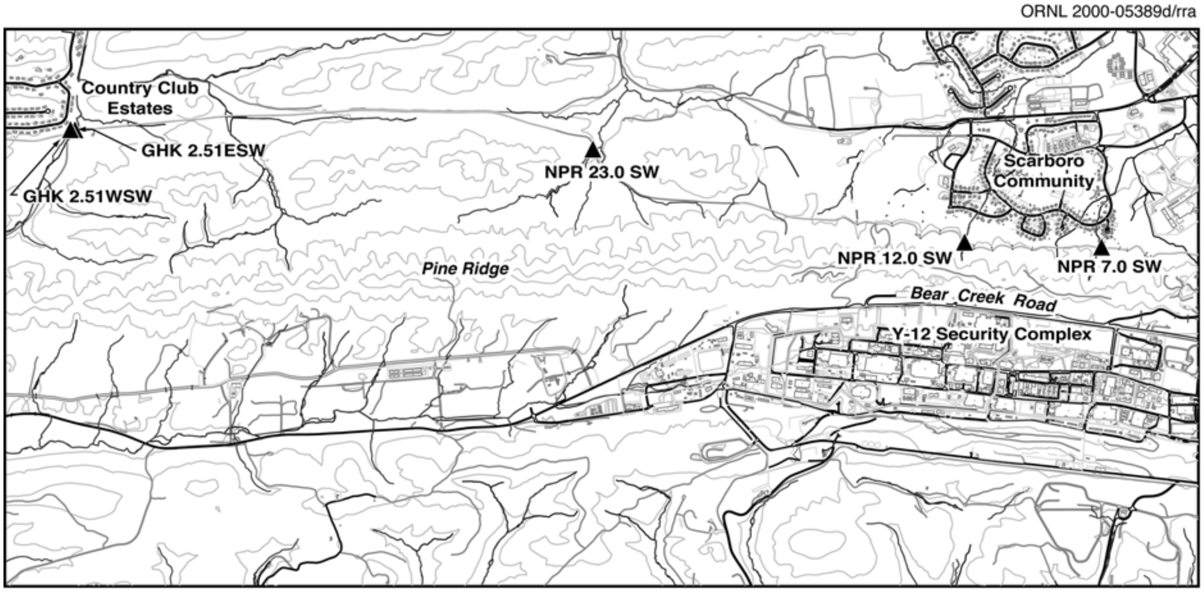

Fig. 6.29. Surface water sampling locations north of Pine Ridge, 2003.

6.10.4.3 Bear Creek Hydrogeologic Regime

Located west of Y-12 in Bear Creek Valley, the Bear Creek regime is bounded to the north by Pine Ridge and to the south by Chestnut Ridge. The regime encompasses the portion of Bear Creek Valley extending from the west end of the Y-12 Complex to Highway 95. Table 6.17 describes each of the waste management sites within the Bear Creek regime.

Plume Delineation

The primary groundwater contaminants in the Bear Creek regime are nitrate, trace metals, volatile organic compounds, and radionuclides. The S-3 Site is a source of all four of these contaminants. The Oil Landfarm waste management area, consisting of the Oil Landfarm, the Boneyard/Burnyard, the Hazardous Chemical Disposal Area, and Landfill I, is a significant source of uranium, other trace metals, and volatile organic compounds. Other sources of volatile organic compounds include the Rust Spoil Area, and the Bear Creek Burial Grounds waste management area. Dense nonaqueous phase liquids (DNAPLs), heavier-than-water solvents that have a low water solubility, exist at depths as great as or greater than 270 ft below the Bear Creek Burial Grounds. The DNAPLs consist primarily of volatile organic compounds such as tetrachloroethene, trichloroethene, 1,1-dichloroethene, 1,2-dichloroethene, and high concentrations of PCBs.

Contaminant plume boundaries are essentially defined in the bedrock formations that directly underlie many waste disposal areas in the Bear Creek regime, particularly the Nolichucky Shale. The elongated shape of the contaminant plumes in the Bear Creek regime is the result of preferential transport of the contaminants parallel to strike in both the Knox Aquifer and the ORR Aquitards.

Nitrate

Unlike many groundwater contaminants, nitrate is highly soluble and moves easily with groundwater. The limits of the nitrate plume probably define the maximum extent of subsurface contamination in the Bear Creek regime. The horizontal extent of the nitrate plume is essentially defined in groundwater in the upper to intermediate part of the aquitard and aquifer [less than 300 ft (91 m) below the ground surface].

Data obtained during CY 2003 indicate that nitrate concentrations in groundwater exceed the drinking water standard in an area that extends west from the S-3 Site for approximately 11,000 ft (3,352 m) down Bear Creek Valley (Fig. 6.21). Nitrate concentrations greater than 100 mg/L persist out to about 3000 ft (915 m) west of the S-3 Site, indicating no significant change from previous years. Historically, the highest nitrate concentrations are observed adjacent to the S-3 Site in groundwater in the unconsolidated zone and at shallow depths [less than 100 ft (30.5 m) below ground surface] in the Nolichucky Shale. Elevated concentrations of nitrate have been observed as deep as 740 ft (226 m) below ground surface. Surface water nitrate results exceeding the drinking water standard during CY 2003 were observed as far as 8,000 to 11,000 ft (2,438 to 3,352 m) west of the S-3 Site. The extent of nitrate contamination in the surface waters of the Bear Creek regime appears to be shrinking when compared with the extents observed in CY 2002. This is possibly due to attenuation by dilution from rainfall, which was heavier than usual in CY 2003.

Trace Metals

During CY 2003, uranium, barium, cadmium, chromium, lead, beryllium, nickel, thallium, arsenic, and selenium were identified from groundwater monitoring as the trace metal contaminants in the Bear Creek regime that exceeded drinking water standards. Historically, elevated concentrations of many of these metals were observed at shallow depths near the S-3 Site. Disposal of acidic liquid wastes at the S-3 Site reduced the pH of the groundwater, which allows the metals to remain in solution. Elsewhere in the Bear Creek regime, where natural geochemical conditions prevail, these trace metals may occur sporadically and in close association with source areas because conditions are typically not

Table 6.17. History of waste management units included in CY 2003 groundwater monitoring activities, Bear Creek Hydrogeologic Regime[a]

Site	Historical data
S-3 Site	Four unlined surface impoundments constructed in 1951. Received liquid nitric acid/uranium-bearing wastes via the Nitric Acid Pipeline until 1983. Closed and capped under RCRA in 1988. Infiltration was the primary release mechanism to groundwater
Oil Landfarm	Operated from 1973 to 1982. Received waste oils and coolants tainted with metals and PCBs. Closed and capped under RCRA in 1989. Infiltration was the primary release mechanism to groundwater
Boneyard	Used from 1943 to 1970. Unlined shallow trenches used to dispose of construction debris and to burn magnesium chips and wood. Excavated and restored in 2002
Burnyard	Used from 1943 to 1968. Wastes, metal shavings, solvents, oils, and laboratory chemicals were burned in two unlined trenches. Excavated and restored in 2002
Hazardous Chemical Disposal Area	Used from 1975 to 1981. Built over the burnyard. Handled compressed gas cylinders and reactive chemicals. Residues placed in a small, unlined pit. The northwest portion was excavated and restored in 2002 as part of Boneyard/Burnyard remedial activities
Sanitary Landfill I	Used from 1968 to 1982. TDEC-permitted, nonhazardous industrial landfill. May be a source of certain contaminants to groundwater. Closed and capped under TDEC requirements in 1985
Bear Creek Burial Grounds: A, C, and Walk-in Pits	A and C received waste oils, coolants, beryllium and uranium, various metallic wastes, and asbestos into unlined trenches and standpipes. Walk-in Pits received chemical wastes, shock-sensitive reagents, and uranium saw fines. Activities ceased in 1981. Final closure certified for A (1989), C (1993), and the Walk-in Pits (1995). Infiltration is the primary release mechanism to groundwater
Bear Creek Burial Grounds: B, D, E, J, and Oil Retention Ponds 1 and 2	Burial Grounds B, D, E, and J, unlined trenches, received depleted uranium metal and oxides and minor a mounts of debris and inorganic salts. Ponds 1 and 2, built in 1971 and 1972, respectively, captured waste oils seeping into two Bear Creek tributaries. The ponds were closed and capped under RCRA in 1989. Certification of closure and capping of Burial Grounds B and part of C was granted February 1995
Rust Spoil Area	Used from 1975 to 1983 for disposal of construction debris, but may have included materials bearing solvents, asbestos, mercury, and uranium. Closed under RCRA in 1984. Site is a source of volatile organic compounds to shallow groundwater according to CERCLA remedial investigation
Spoil Area I	Used from 1980 to 1988 for disposal of construction debris and other stable, nonrad wastes. Permitted under TDEC solid waste management regulations in 1986; closure began shortly thereafter. Soil contamination is of primary concern. CERCLA record of decision issued in 1996
SY-200 Yard	Used from 1950 to 1986 for equipment and materials storage. No documented waste disposal at the site occurred. Leaks, spills, and soil contamination are concerns. CERCLA record of decision issued in 1996
Above-Grade LLW Storage Facility	Constructed in 1993. Consists of six above-grade storage pads used to store inert, low-level radioactive debris and solid wastes packaged in steel containers

[a]Abbreviations

CERCLA = Comprehensive Environmental Response, Compensation, and Liability Act

LLW = low-level radioactive waste

PCB = polychlorinated biphenyl

RCRA = Resource Conservation and Recovery Act

TDEC = Tennessee Department of Environment and Conservation favorable for dissolution and migration. In CY 2003, these trace metals were evident at elevated concentrations within the surface water and groundwater downgradient of the S-3 Site, the Bear Creek Burial Ground, and the Oil Landfarm waste management areas.

The most prevalent trace metal contaminant observed within the Bear Creek regime is uranium, indicating that geochemical conditions are favorable for its migration. The Boneyard/Burnyard site has been identified as the primary source of uranium contamination of surface water and groundwater. Historically, uranium is observed at concentrations exceeding the drinking water standard of 0.03 mg/L in shallow monitoring wells, springs, and surface water locations downgradient from all of the waste areas. In 2002, BJC performed the final remedial actions at the Boneyard/Burnyard with the objective of removing materials contributing to surface water and groundwater contamination to meet existing record-of-decision goals. Approximately 86,000 yd^3 of waste materials were excavated and placed in the EMWMF (DOE 2004a). Some evidence of improved water quality is indicated in Bear Creek. Uranium concentrations above the drinking water standard were still observed in surface water monitoring stations over 2.6 miles (4.2 km) from Bear Creek Burial Ground, the westernmost waste area. However, the slight drop in concentrations in CY 2003 in surface water and spring locations downgradient of the Boneyard/Burnyard may be attributable to the remedial action performed in 2002.

Other trace metal contaminants that have been observed in the Bear Creek regime are boron, cobalt, and strontium. Concentrations of these metals have commonly exceeded background values in groundwater near contaminant source areas.

Volatile Organic Compounds

Volatile organic compounds are widespread in groundwater in the Bear Creek regime (Fig. 6.23). The primary compounds are tetrachloroethene, trichloroethene, 1,2-dichloroethene, 1,1-dichloroethane, and vinyl chloride. In most areas, they are dissolved in the groundwater, and DNAPL accumulations occur in bedrock more than 250 ft (76 m) below the Bear Creek Burial Ground waste management area. Groundwater in the aquitards that contains detectable levels of volatile organic compounds occurs primarily within about 1000 ft (305 m) of the source areas. The highest concentrations observed in CY 2003 in the Bear Creek regime occurred in the unconsolidated zone at the Bear Creek Burial Ground waste management area in monitoring Well GW-046, with a maximum summed volatile organic compound concentration of 18,602 µg/L. The extent of the dissolved plumes of volatile organic compounds is greater in the underlying bedrock. The highest levels in bedrock, in the Bear Creek regime, occur just south of the Bear Creek Burial Ground waste management area. Historical levels have been as high as 7,000,000 µg/L in groundwater near the source area. The maximum summed volatile organic compound concentration observed in the Bear Creek regime from the bedrock interval was 4,786 µg/L (well GW-082). Well GW-082 monitors the shallow (21 to 30 ft below ground surface) bedrock interval downgradient of the Bear Creek Burial Ground waste management area. This well and Wells GW-627 and GW-653 continue to exhibit an increase in volatile organic compound concentration (Fig. 6.30). The increasing trends observed in wells GW-082, GW-627, and GW-653 indicate that some migration of volatile organic compounds is occurring. This migration through the aquitards parallel to the valley axis and toward the exit pathway (Maynardville Limestone) is occurring in both the unconsolidated and bedrock intervals.

Significant transport of volatile organic compounds has occurred in the Maynardville Limestone. Data obtained from exit pathway monitoring locations show that in the vicinity of the water table, an apparently continuous dissolved plume extends 10,000 to 12,000 ft (3,048 to 3,660 m) westward from the S-3 Site to just southwest of the Bear Creek Burial Ground waste management area. Typical summed concentrations observed in CY 2003 in the Maynardville Limestone range from 297 µg/L in the central part of the regime (Well GW-225) to less than detectable levels approximately 12,000 ft (3,660 m) to the west of the S-3 site.

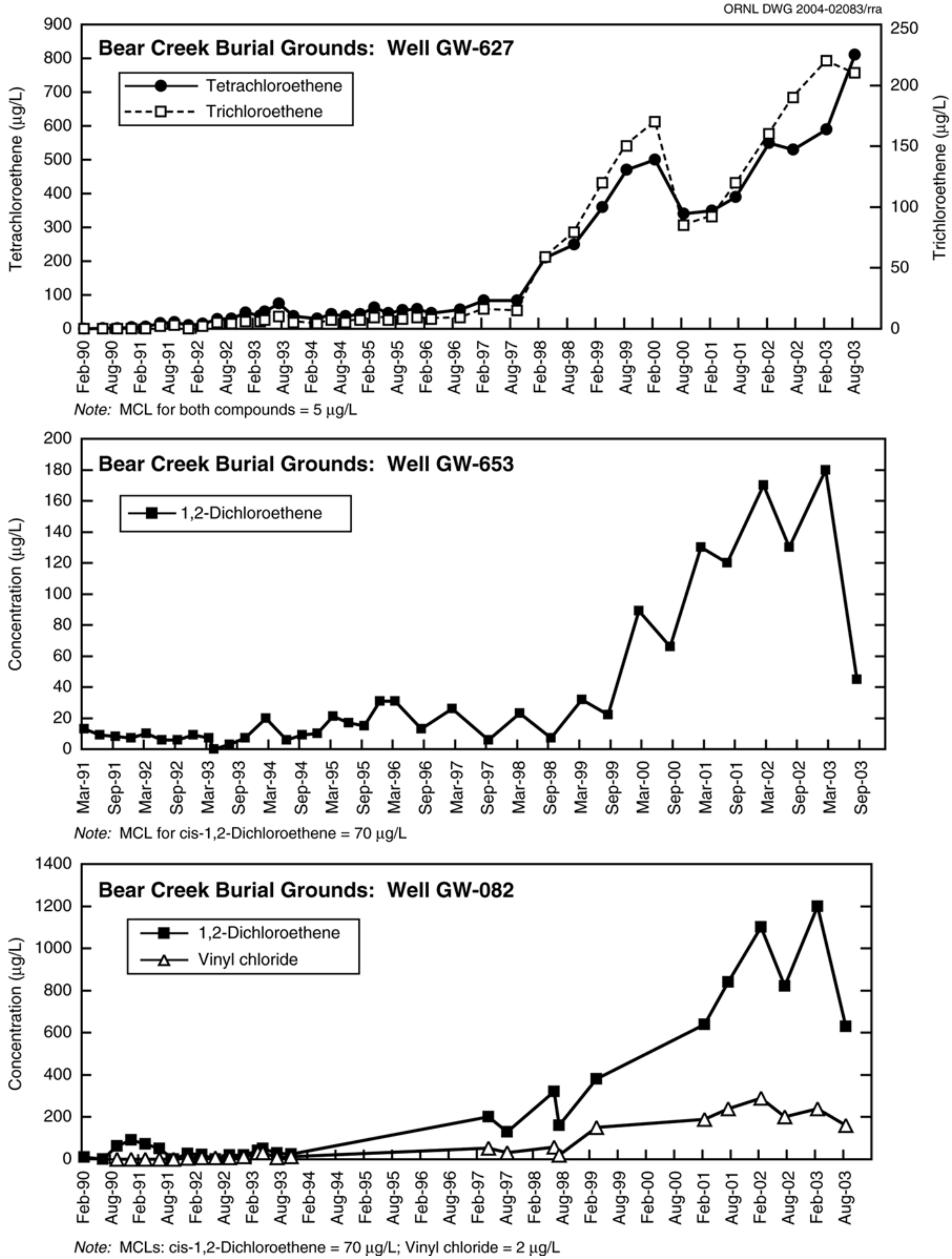

Fig. 6.30. Volatile organic compound concentrations in Bear Creek Burial Grounds wells GW-082, GW-653, and GW-627.

Radionuclides

The primary radionuclides identified in the Bear Creek regime are isotopes of uranium and ^{99}Tc. Neptunium-237, ^{241}Am, radium, strontium, thorium, plutonium, and tritium are secondary and less widespread radionuclides, primarily present in groundwater near the S-3 Site.

Evaluations of the extent of these radionuclides in groundwater in the Bear Creek regime during CY 2003 were based primarily on measurements of gross alpha activity and gross beta activity. If the annual average gross alpha activity in groundwater samples from a well exceeded 15 pCi/L (the drinking water standard for gross alpha activity), then one (or more) of the alpha-emitting radionuclides (e.g., uranium) was assumed to be present in the groundwater monitored by the well. A similar rationale was used for annual average gross beta activity that exceeded 50 pCi/L. Technetium-99, a more volatile radionuclide, is qualitatively screened by gross beta activity analysis and, at certain monitoring locations, is evaluated isotopically.

Groundwater with elevated levels of gross alpha activity occurs near the S-3 Site and the Oil Landfarm waste management areas (Fig. 6.26). In the bedrock interval, gross alpha activity exceeds 15 pCi/L in groundwater in the Nolichucky Shale only near source areas. Data obtained from exit pathway monitoring stations show that gross alpha activity in groundwater in the Maynardville Limestone exceeds the drinking water standard for almost 12,000 ft (3,660 m) west of the S-3 Site. Gross alpha activities above the drinking water standard in surface water samples were observed about 4.7 miles (7.6 km) west of the S-3 Site (e.g., BCK 4.55; see Fig. 6.19). This is further reaching in the surface water than in previous years and is attributed to heavier rainfall following the remediation efforts at the Boneyard/Burnyard Area, which may have mobilized more uranium in Bear Creek.

The distribution of gross beta radioactivity in groundwater in the unconsolidated zone is similar to that of gross alpha radioactivity (Fig. 6.27). During CY 2003, gross beta activities exceeded 50 pCi/L within the Maynardville Limestone exit pathway for 8,000 to 10,000 ft (2,438 to 3,048 m) from the S-3 Site (i.e., Well GW-706). It appears that the lateral extent of gross beta activity within the exit pathway groundwater interval has receded slightly from previous years. Surface water gross beta activities above the drinking water standard also exhibit this apparent receding characteristic. In 2002, gross beta activities in surface water exceeding the drinking water standard were observed about 3 miles (4.8 km) west of the S-3 Site, while in 2003, this distance from the S-3 Site shrank to 2.3 miles (3.7 km). The withdrawal of gross beta activity seems to contradict the observed character of gross alpha and uranium in the exit pathway. The primary source of uranium is the Oil Landfarm Area (i.e., Boneyard/Burnyard). Differences should be expected because gross beta activity is used to qualitatively determine the extent to which ^{99}Tc has migrated from the S-3 Site. Heavy rainfall during CY 2003 may have caused a dilution effect, thus decreasing gross beta activities across Bear Creek Valley.

Exit Pathway and Perimeter Monitoring

Exit pathway monitoring began in 1990 to provide data on the quality of groundwater and surface water exiting the Bear Creek regime. The Maynardville Limestone is the primary exit pathway for groundwater. Bear Creek, which flows across the Maynardville Limestone in much of the Bear Creek regime, is the principal exit pathway for surface water. Various studies have shown that surface water in Bear Creek, springs along the valley floor, and groundwater in the Maynardville Limestone are hydraulically connected. The western exit pathway well transect (Picket W) serves as the ORR perimeter well location for the Bear Creek regime (Fig. 6.20).

Exit pathway monitoring consists of continued monitoring at four well transects (pickets) and selected springs and surface water stations. Groundwater quality data obtained during CY 2003 from the exit pathway monitoring wells indicate that contaminated groundwater does not consistently occur above drinking water standards beyond the western side of the Bear Creek Burial Ground waste management area (Fig. 6.31). However, nitrate and uranium concentrations and gross alpha and gross beta activities exceeding their respective drinking

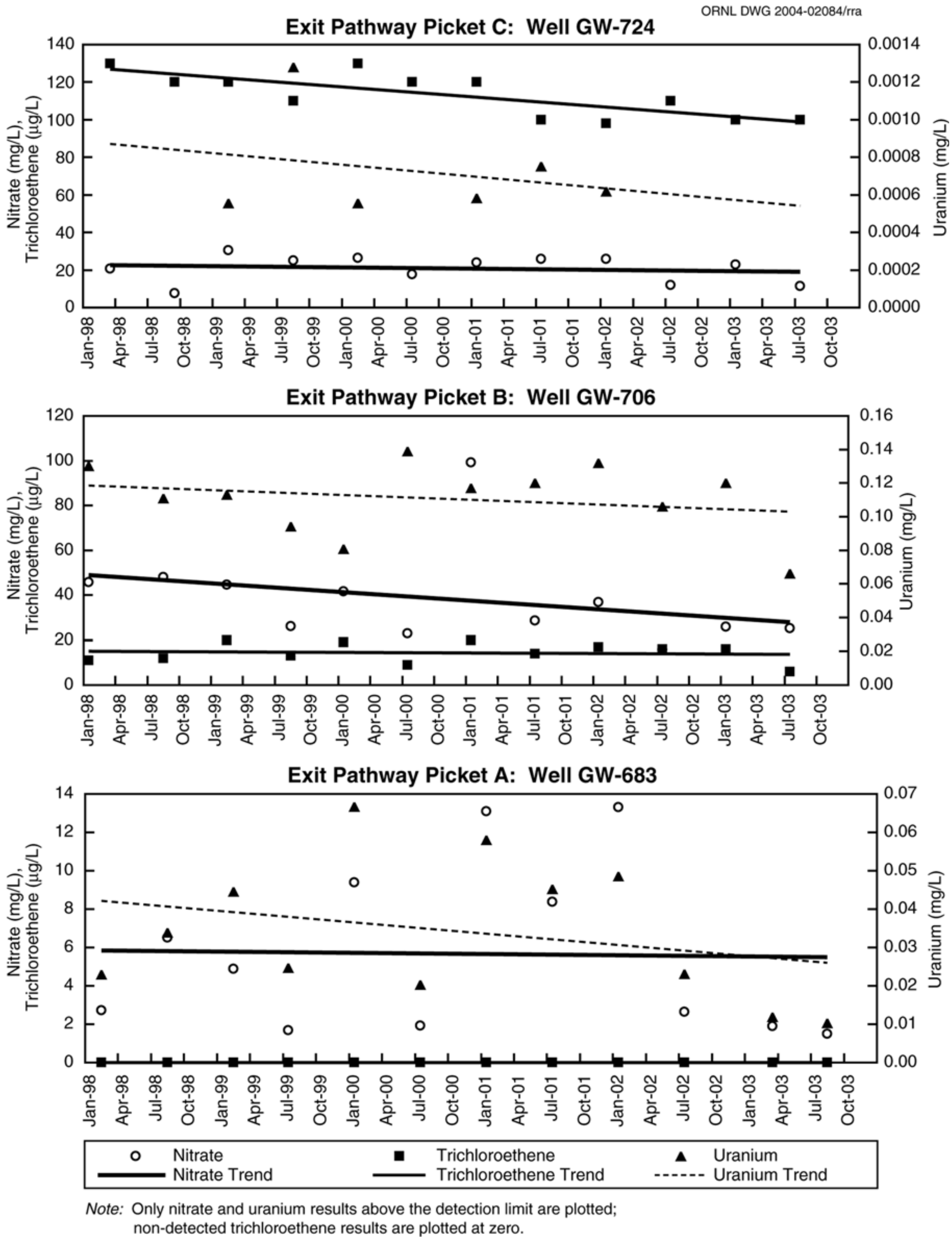

Fig. 6.31. Concentrations of selected contaminants in exit pathway monitoring wells GW-683, GW-706, and GW-724, in the Bear Creek Hydrogeologic Regime.

water standards have been observed in surface water west of the burial grounds (BWXT 2004).

Surface water and spring samples collected during CY 2003 indicate that spring discharges and water in upper reaches of Bear Creek contain many of the compounds found in the groundwater. The concentrations in the creek and spring discharge decrease with distance downstream of the waste disposal sites (Fig. 6.32). A long-term trend of slightly increasing gross alpha activity continues to be observed in middle and lower Bear Creek (BCK 9.40 and BCK 4.55). Remediation efforts at the Oil Landfarm Waste Management Area in CY 2002 are intended to reverse these trends.

6.10.4.4 Chestnut Ridge Hydrogeologic Regime

The Chestnut Ridge Hydrogeologic Regime is south of Y-12 and is flanked to the north by Bear Creek Valley and to the south by Bethel Valley Road (Fig. 6.19). The regime encompasses the portion of Chestnut Ridge extending from

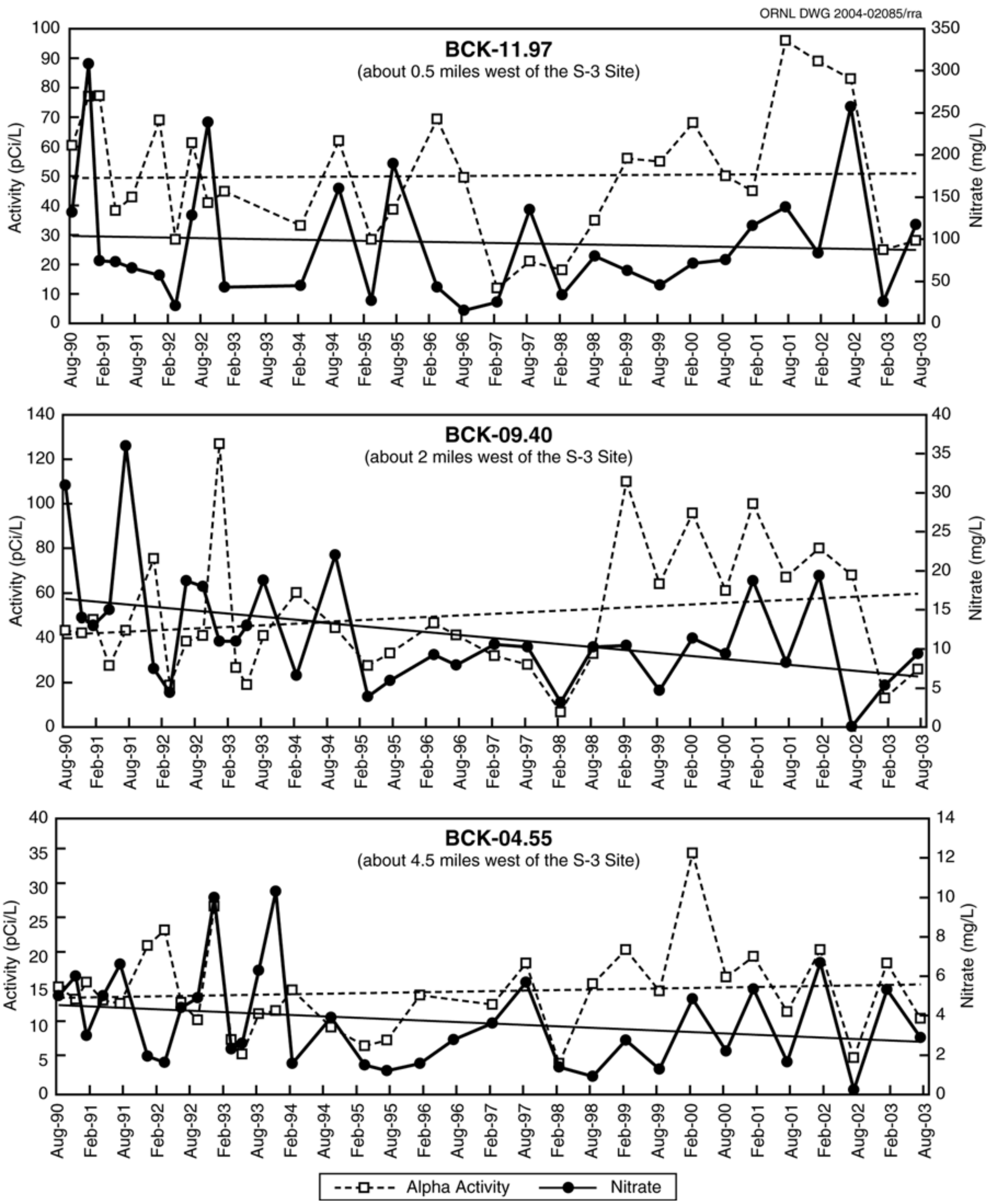

Fig. 6.32. Concentrations of selected groundwater contaminants in Bear Creek.

Scarboro Road, east of Y-12, to Dunaway Branch, located just west of Industrial Landfill II.

The Chestnut Ridge Security Pits area is the only documented source of groundwater contamination in the regime. Contamination from the Security Pits is distinct and does not mingle with plumes from other sources. Table 6.18 summarizes the operational history of waste management units in the regime.

Plume Delineation

The horizontal extent of the volatile organic compound plume at the Chestnut Ridge Security Pits is reasonably well defined in the water table and shallow bedrock zones (Fig. 6.23). Groundwater quality data obtained during CY 2003 indicates that the western lateral extent of the plume of volatile organic compounds at the site has not changed significantly from previous years (GW-177, Fig. 6.33). However, an increase in volatile organic compound contaminants over the past several years at well GW-798 shows that some migration of the eastern plume is occurring (Fig. 6.32).

Nitrate

Nitrate concentrations were below the drinking water standard of 10 mg/L at all monitoring stations.

Trace Metals

Groundwater concentrations of trace metals exceeded regulatory standards during CY 2003 at five locations. Concentrations above the drinking water standard for nickel were observed in samples from four monitoring wells. Two surface water monitoring stations showed elevated concentrations of arsenic.

Nickel concentrations above the drinking water standard (0.1 mg/L) were observed from two well at the Industrial Landfill IV and from two wells at the United Nuclear Corporation site (Fig. 6.18). The presence of nickel in groundwater samples from monitoring wells at both the Landfill IV and the United Nuclear site is probably due to corrosion of well casings. This also accounts for the elevated concentrations of chromium seen in one of the wells at the United Nuclear Corporation Site. Nickel and chromium are both primary components of stainless steel, and the presence of both potentially indicates the occurrence of corrosion and subsequent dissolution of stainless steel well casing and screen materials (LMES 1999).

Elevated concentrations of arsenic above the drinking water standard (0.01 mg/L) were observed in two surface water monitoring location downstream from the Filled Coal Ash Pond, which is monitored under a CERCLA record of decision (DOE 2004a). A constructed wetland area is being utilized to prevent surface water contamination by effluent from the Filled Coal Ash Pond. During CY 2003, the locations where elevated arsenic levels were detected are both upgradient and downgradient of this wetland area. Downgradient of the wetlands, concentrations are noticeably lower and surface water samples obtained approximately 2000 ft (610 m) downstream (Rogers Quarry) exhibit no detectable arsenic.

Volatile Organic Compounds

Efforts to delineate the extent of volatile organic compounds in groundwater attributable to the Chestnut Ridge Security Pits have been in progress since 1987. A review of historical data indicates that concentrations of volatile organic compounds in groundwater at the site have generally decreased since 1988. However, the CY 2003 monitoring in and around the Chestnut Ridge Security Pits presents a changing picture. Well GW-177 (western side of the Security Pits) was monitored, and stable levels of volatile organic compounds continued to be observed, indicating that interior portions of the plumes are not decreasing substantially. A general increasing trend in volatile organic compounds in groundwater samples from monitoring well GW-798 to the southeast and downgradient of the Chestnut Ridge Security Pits has been developing since CY 2000 (Fig. 6.33). The volatile organic compounds detected in CY 2003 are characteristic of the Chestnut Ridge Security Pits plume; and the constituent tetrachloroethene continued to

Table 6.18. History of waste management units included in CY 2003 groundwater monitoring activities, Chestnut Ridge Hydrogeologic Regime[a]

Site	Historical data
Chestnut Ridge Sediment Disposal Basin	Operated from 1973 to 1989. Received soil and sediment from New Hope Pond and mercury-contaminated soils from the Y-12 Complex. Site was closed under RCRA in 1989. Not a documented source of groundwater contamination
Kerr Hollow Quarry	Operated from 1940s to 1988. Used for the disposal of reactive materials, compressed gas cylinders, and various debris. RCRA closure (waste removal) was conducted between 1990 and 1993. Certification of closure with some wastes remaining in place was approved by TDEC February 1995
Chestnut Ridge Security Pits	Operated from 1973 to 1988. Series of trenches for disposal of classified materials, liquid wastes, thorium, uranium, heavy metals, and various debris. Closed under RCRA in 1989. Infiltration is the primary release mechanism to groundwater
United Nuclear Corporation Site	Received about 29,000 drums of cement-fixed sludges and soils demolition materials, and low-level radioactive contaminated soils. Closed in 1992; CERCLA record of decision has been issued
Industrial Landfill II	Central sanitary landfill for the Oak Ridge Reservation. Detection monitoring under postclosure plan has been ongoing since 1996
Industrial Landfill IV	Permitted to receive only nonhazardous industrial solid wastes. Detection monitoring under TDEC solid-waste-management regulations has been ongoing since 1988
Industrial Landfill V	Facility completed and initiated operations April 1994. Baseline groundwater monitoring began May 1993 and was completed January 1995. Currently under TDEC solid-waste-management detection monitoring
Construction/Demolition Landfill VI	Facility completed and initiated operations December 1993. Baseline groundwater quality monitoring began May 1993 and was completed December 1993. Currently under permit-required detection monitoring per TDEC
Construction/Demolition Landfill VII	Facility construction completed in December 1994. TDEC granted approval to operate January 1995. Baseline groundwater quality monitoring began in May 1993 and was completed in January 1995. Permit-required detection monitoring per TDEC was temporarily suspended October 1997 pending closure of construction/demolition Landfill VI. Reopened and began waste disposal operations in April 2001
Filled Coal Ash Pond	Site received Y-12 Steam Plant coal ash slurries. A CERCLA record of decision has been issued. Remedial action complete

[a]Abbreviations

CERCLA = Comprehensive Environmental Response, Compensation, and Liability Act.

RCRA = Resource Conservation and Recovery Act.

TDEC = Tennessee Department of Environment and Conservation.

consistently exceed the drinking water standard (5 μg/L). These results indicate that there is some migration occurring through the developed fracture and conduit system of the karst dolostone to the southeast.

The volatile organic compound concentrations observed in Well GW-305, located immediately to the southeast of Landfill IV, are increasing (Fig. 6.34). Concentrations of the volatile organic compounds in Well GW-305 have remained below applicable drinking water standards. The drinking water standard for the volatile organic compound 1,1-dichloroethene is 7 μg/L. During CY 2003, this compound was detected just below this standard (4.3, 4.6, 6.4, and 6.0 μg/L).

Radionuclides

In CY 2003, Gross alpha activities were below the drinking water standard of 15 pCi/L at all monitoring stations but two. Monitoring wells GW-145, at the Kerr Hollow Quarry, and GW-

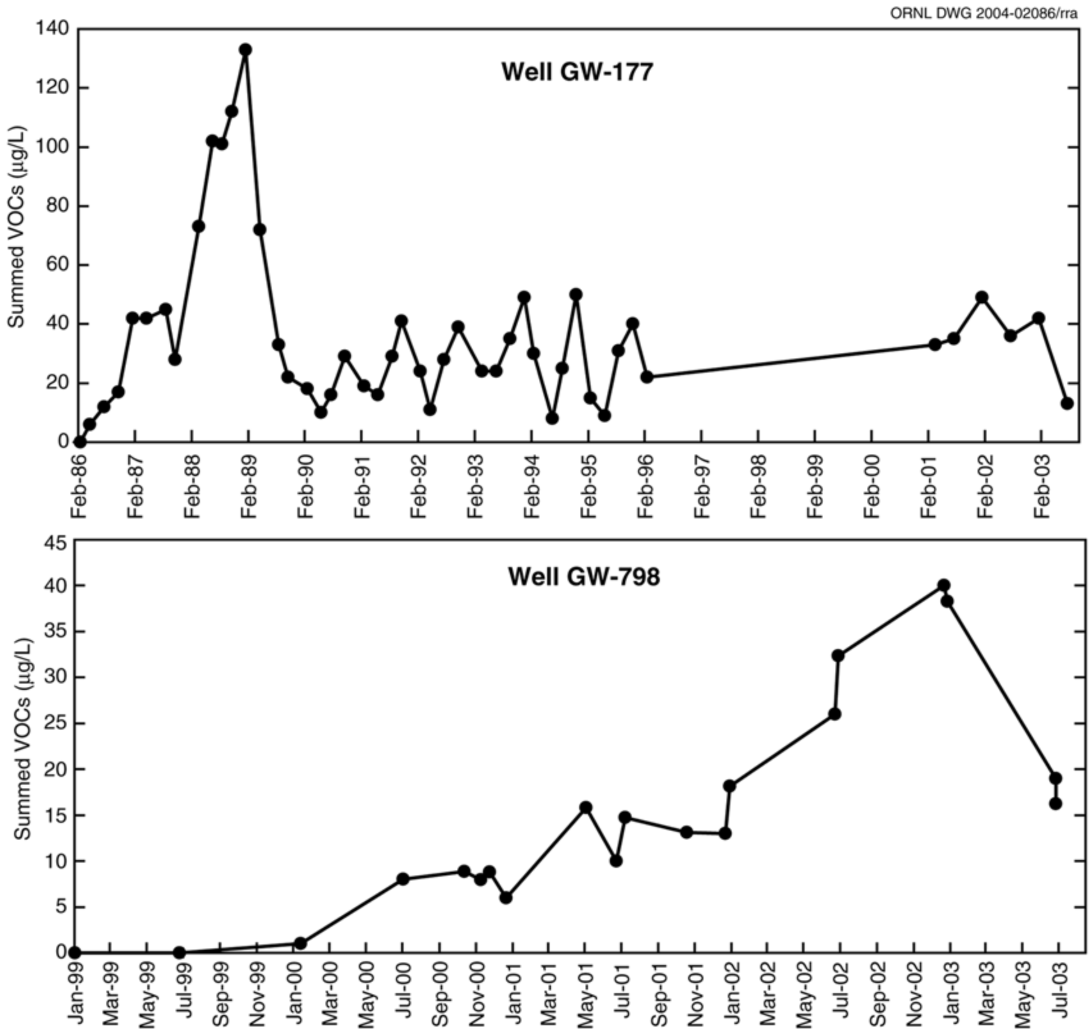

Fig. 6.33. Summed volatile organic compound concentrations in wells GW-177 and GW-798.

203, at the United Nuclear Corporation site, were sampled twice during the year. One of the samples from each well exceeded the standard. Gross beta activities were below the screening level of 50 pCi/L at all monitoring stations except at monitoring well GW-205, at the United Nuclear Corporation site. This location has consistently exceeded 50 pCi/L gross beta activity since August 1999 with the exception of the sample from January 30, 2002 (47.23 pCi/L). Isotopic analyses show a correlative increase in the beta-emitting radionuclide ^{40}K, which is not a known contaminant of concern at the United Nuclear site. The source of the radioisotope is not known.

Exit Pathway and Perimeter Monitoring

Contaminant and groundwater flow paths in the karst bedrock underlying the Chestnut Ridge regime have not been well characterized by conventional monitoring techniques. Tracer studies have been used in the past to attempt to identify exit pathways. Based on the results of tracer studies to date, no springs or surface streams that represent discharge points for groundwater have been conclusively correlated to a waste management unit that is a known or potential groundwater contaminant source.

Monitoring of natural groundwater exit pathways is a basic monitoring strategy in a karst regime such as that of Chestnut Ridge. Perimeter springs and surface water tributaries were monitored to determine whether contaminants are exiting the downgradient southern side of the

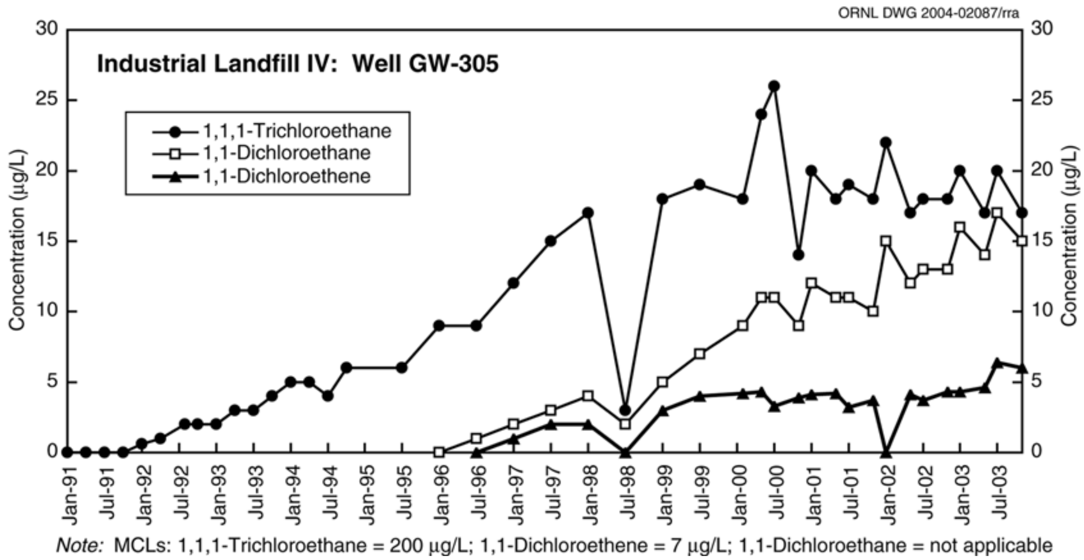

Fig. 6.34. Volatile organic compound concentrations in Industrial Landfill IV Well GW-305.

regime. Five springs and five surface water monitoring locations were sampled during CY 2003. No contaminants were detected at these natural discharge points.

6.11 MODERNIZATION ACTIVITIES AT THE Y-12 NATIONAL SECURITY COMPLEX

The National Nuclear Security Administration (NNSA) is embarking on a significant facility and infrastructure modernization program at the Y-12 Complex. BWXT Y-12, LLC, pursuant to NNSA direction, will manage numerous construction projects as a part of this modernization program. The objectives of the program are to

- consolidate operations to reduce footprint and maintenance cost,
- reuse and upgrade facilities and site infrastructure systems to be used in the future,
- replace facilities when it is the most effective alternative (new construction), and
- disposition surplus facilities and materials (infrastructure reduction).

Overall implementation of the modernization program is consistent with the site-wide environmental impact statement for the Y-12 National Security Complex and its associated record of decision. Key considerations of the modernization strategy include maintaining compliance with regulatory requirements and coordinating NNSA's modernization activities with CERCLA requirements. The construction of new NNSA facilities is scheduled to begin prior to completion of remediation of the soils and groundwater of the Upper East Fork Poplar Creek characterization areas (see Sect. 3.4.3).

6.11.1 New Construction

New construction projects and initiatives in the design/planning stages include the following.

- **Special Materials Capability Program projects.**
  - **Purification Facility.** The project is for the design and construction of a facility for the purification of a special material to provide historical production capacity. The original purification process was last operated about 1990. The evolution of health and safety requirements and considerations makes reuse of the original facility not viable. Construction started in August 2003 and is scheduled for completion in 2004.
  - **Beryllium Operational Efficiency.** The project is in the planning/design stage to retrofit and upgrade to conform to the safety standards of an existing facility.

- — **Other Special Materials Facilities.** Additional projects related to special materials are in the early conceptual stage.
- **Highly Enriched Uranium Material Facility.** The project will design and construct a facility for the storage of highly enriched uranium, including highly enriched uranium under International Atomic Energy Agency control. Design of the facility is complete; excavation and grading are anticipated to start in May 2004.
- **Support Facilities.** Support Facilities projects will be designed and constructed to include office space, record storage, a fire station, change houses, and other support facilities. Construction of a 7000-ft^2 change house was completed October 2003.
- **Utilities Upgrade Projects.** Several utility projects are being planned. An existing facility is being proposed for reuse under the Compressed Air Project, and construction is anticipated to begin in November 2004. Other utility system projects will include a steam plant life extension, potable water system upgrades, electrical distribution system upgrades and improvements, and upgrades to other utility distribution systems.
- **Alternate Financed Development**. NNSA intends to transfer two parcels of land at Y-12, one near the current Administration Building and the other on the east end of Scarboro Road, to a private developer who will finance, design, and build modern office and laboratory facilities for long-term lease by NNSA to support Y-12 missions. This is an innovative approach to facility modernization and should enhance productivity, employee health and safety, and the ability to attract and retain new employees. The transfer will require an environmental assessment resulting in a "finding of no significant impact" and approval from the state of Tennessee and EPA Region 4 for a CERCLA covenant deferral request.

6.11.2 Infrastructure Reduction

The Facility and Infrastructure Recapitalization Program is an NNSA initiative to revitalize the physical infrastructure, including demolishing deteriorated structures across the nuclear weapons complex. By removing excess buildings and equipment, the Y-12 Infrastructure Reduction campaign is helping clear the way for more modern and efficient structures. Infrastructure reduction contributes to the long-term viability of the Y-12 National Security Complex through more effective use of new and existing facilities and the elimination of excess facilities and their attendant costs. The initial goal of the infrastructure reduction program of reducing the Y-12 footprint by 500,000 ft^2 was achieved at the end of FY 2002. An additional 140,000 ft^2 was demolished in FY 2003, and 108,000 ft^2 is scheduled for demolition in FY 2004.