4. Effluent Monitoring

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Abstract

Effluent monitoring is a major activity on the ORR. Effluent monitoring is the collection and analysis of samples or measurements of liquid and gaseous effluents to determine and quantify contaminants and process-stream characteristics, assess any chemical or radiological exposures to members of the public, and demonstrate compliance with applicable standards.

4.1 AIRBORNE DISCHARGES

Airborne discharges from DOE Oak Ridge facilities, both radioactive and nonradioactive, are subject to regulations issued by EPA, the TDEC Air Pollution Control Board, and DOE orders. Radioactive emissions are regulated by EPA Region 4 under the CAA, NESHAP, 40 CFR 61, Subpart H. (See Appendix A for a list of radionuclides and their radioactive half-lives.) Nonradioactive emissions are regulated under the rules of the TDEC Division of Air Pollution Control.

The NESHAP regulations limit the amount of annual radioactive exposure or dose to the nearest or most exposed member of the public. In December 1989, the EPA NESHAP regulations were reissued. Negotiations between EPA and DOE were initiated to bring the ORR into full compliance with the new regulations. As a result of those negotiations, an FFCA was signed in May 1992 by the DOE-ORO manager and was implemented at the ORR facilities. The ORR fulfilled all of its FFCA commitments and came into compliance with the regulations by December 1992. On March 26, 1993, EPA Region 4 certified that DOE-ORO had completed all actions required by the FFCA and was considered to be in compliance with the radionuclide NESHAP regulations. An updated Rad-NESHAP Compliance Plan was sent to EPA Region 4 in May 1994.

In addition to federal regulations, DOE requirements for airborne emissions are established in DOE Order 5400.1, DOE Order 5400.5, and the *Environmental Regulatory Guide for Radiological Effluent Monitoring and Environmental Surveillance* (DOE 1991). The criteria in NESHAP regulations and DOE orders define major radionuclide effluent sources as emission points that have the potential to discharge radionuclides in quantities that could cause an EDE of 0.1 mrem/year or greater to the nearest member of the public. Calculations of potential emissions from a source do not take into account efficiencies of pollution control equipment if the source is otherwise operating normally.

Each ORR facility has a comprehensive air pollution control and monitoring program to ensure that airborne discharges meet regulatory requirements and do not adversely affect ambient air quality. Air pollution controls at the three Oak Ridge facilities include exhaust gas scrubbers, baghouses, and exhaust filtration systems designed to remove airborne pollution from exhaust gases before their release to the atmosphere. Process modifications and material substitutions are also made to minimize air emissions. In addition, administrative control plays a role in regulating emissions.

4.1.1 Y-12 Plant Radiological Airborne Effluent Monitoring

The release of radiological contaminants, primarily uranium, into the atmosphere at the Y-12 Plant 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 >0.1 mrem/year EDE to an off-site individual). During 1996, 55 of the Y-12 Plant's 68 stacks were judged to be major sources. Eight of these sources were not operational in 1996 because of work in progress on process and stack modifications. Twenty-one of the stacks having 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, 1996, the Y-12 Plant had a total of 68 stacks, 60 that were active and 8 that were temporarily shut down. During 1996, four additional stacks were placed into temporary shutdown. Thus, during the course of the year, 60 stacks were monitored, and there were 56 stacks being monitored at the end of 1996.

Radionuclides other than uranium are handled in millicurie quantities as part of ORNL and Y-12 Plant laboratory activities at facilities within the boundary of the Y-12 Plant. The releases from these activities are minimal, however, and have negligible impact on the total Y-12 Plant dose. Emissions from unmonitored process and laboratory exhausts, categorized as minor emission sources, are estimated according to EPA-approved calculation methods.

Emissions from room ventilation systems are estimated from health physics data collected on airborne radioactivity concentrations in the work areas. Areas where the monthly average concentration exceeded 10% of the DOE derived air concentration (DAC) worker protection guidelines were included in the annual emission estimate.

4.1.1.1 Sample Collection and Analytical Procedure

Uranium stack losses were measured continuously on 60 process exhaust stacks in 1996. Particulate matter (including uranium) was filtered from the stack sample; filters at each location were changed routinely, from one to five times per week, and analyzed for total uranium. In addition, the sampling probes and tubing were removed quarterly and 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.

In 1996, 81 emission points were identified from unmonitored radiological processes and laboratories. In addition, one ventilation area from a building that houses depleted uranium operations and one ventilation area from a building that houses enriched uranium operations were identified from health physics data, where one or more average monthly concentrations exceeded 10% of the DAC. For the area, the annual average concentration is used, with design ventilation rates, to arrive at the annual emission estimate. No areas from buildings that house enriched uranium operations met these criteria.

4.1.1.2 Results

An estimated 0.02 Ci (9.7 kg) of uranium was released into the atmosphere in 1996 as a result of Y-12 Plant activities (Table 4.1). The specific activity of enriched uranium is much greater than that of depleted uranium, and about 73% of the curie release was composed of emissions of enriched uranium particulate, even though less than 3% of the total mass of uranium released was enriched material (Figs. 4.1 and 4.2).

Table 4.1. Y-12 Plant airborne uranium emission estimates, 1996

Source of emissions	Quantity emitted	
	Ci[a]	kg
Enriched uranium		
Process exhaust (monitored)	0.014	0.21
Process and laboratory exhaust (unmonitored)	0.0003	0.0034
Room exhaust (from health physics data)	0.0024	0.016
Depleted uranium		
Process exhaust (monitored)	0.0016	3.0
Process and laboratory exhaust (unmonitored)	0.0022	4.0
Room exhaust (from health physics data)	0.0024	2.5
Total	0.023	9.7

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

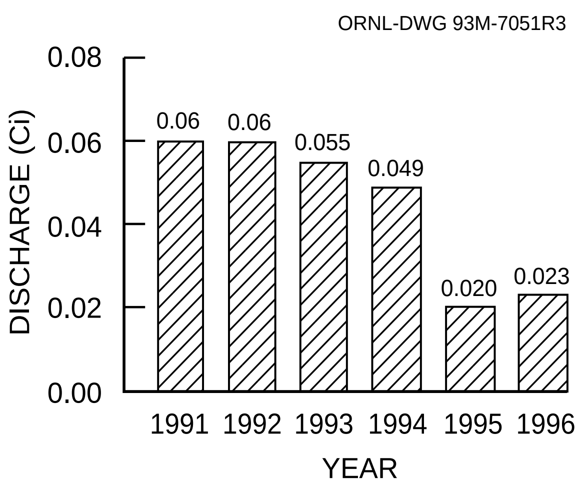

Fig. 4.1. Total curies of uranium discharged from the Y-12 Plant to the atmosphere, 1991–96.

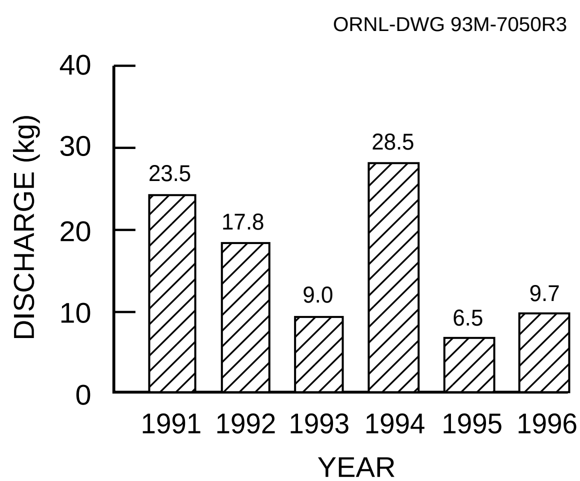

Fig. 4.2. Total kilograms of uranium discharged from the Y-12 Plant to the atmosphere, 1991–96.

4.1.2 ORNL Radiological Airborne Effluent Monitoring

Airborne discharges at ORNL consist primarily of ventilation air from radioactively contaminated or potentially contaminated areas, vents from tanks and processes, and ventilation for reactor facilities. These airborne emissions are treated, then filtered with high-efficiency particulate air (HEPA) and/or charcoal filters before discharge to ensure that any radioactivity released is as low as possible. Radiological gaseous emissions from ORNL consist of solid particulates, adsorbable gases (e.g., iodine), tritium, and nonadsorbable gases. The major radiological emission point sources for ORNL consist of the following four stacks located in Bethel and Melton valleys (Fig. 4.3):

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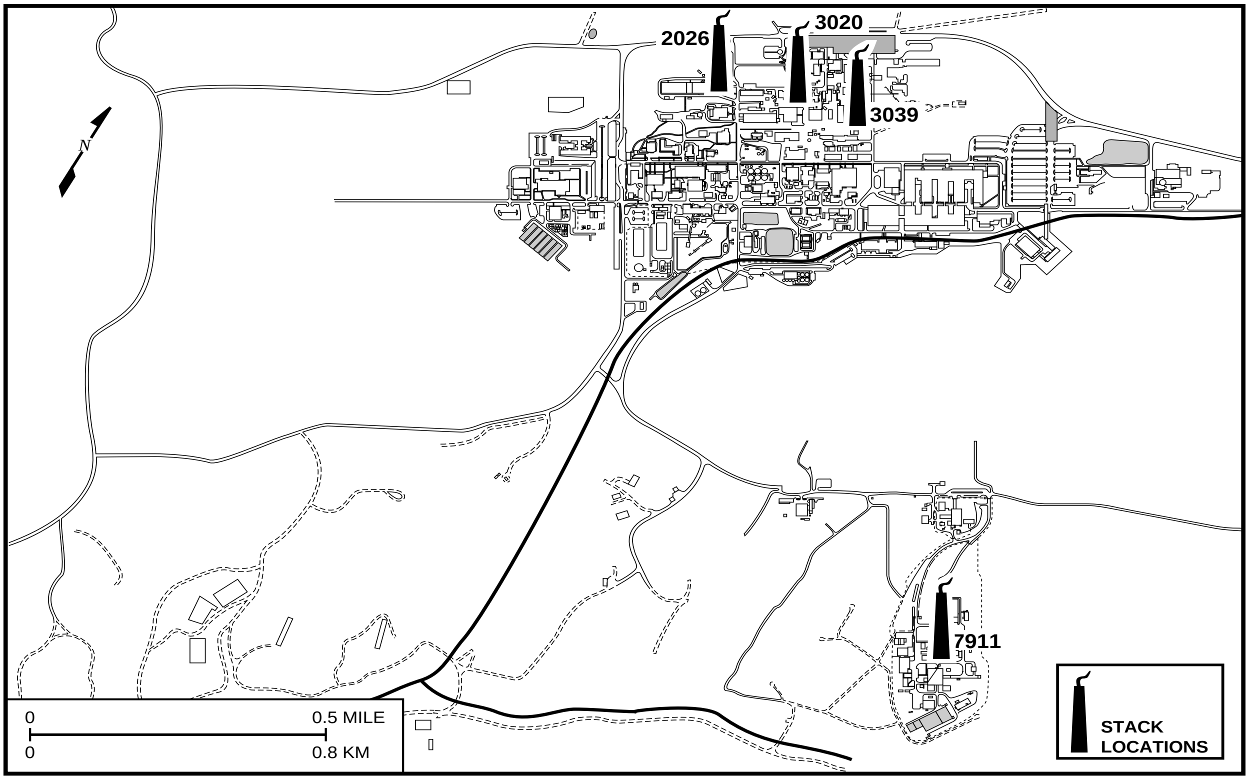

Fig. 4.3. Locations of major stacks (rad emission points) at ORNL.

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

In 1996, there were 23 minor point/group sources, and emission calculations/estimates were made for each of these sources. Three of these sources are continuously sampled.

4.1.2.1 Sample Collection and Analytical Procedure

Each of the four major point sources is equipped with a variety of surveillance instrumentation, including radiation alarms, near-real-time monitors, and continuous sample collectors. Only data resulting from analysis of the continuous samples are used in this report because the other equipment does not provide data of sufficient accuracy and precision to support the quantitation of emission source terms.

All ORNL in-stack source sampling systems comply with American National Standards Institute N 13.1 (ANSI 1969) criteria. The sampling systems generally consist of a multipoint in-stack sampling probe, sample transport line, a particulate filter, activated charcoal cartridges, a silica gel cartridge (if required), flow measurement and totalizing instruments, a sampling pump, and a return line to the stack. In addition to that instrumentation, the system at Stack 7911 includes a high-purity germanium detector with a NOMAD analyzer, which allows continuous isotopic identification and quantification of radioactive noble gases (i.e., ^{41}Ar) present in the effluent stream. To ensure that all radioactive particulates are accounted for, end-of-the-year samples are collected and analyzed by cleaning the in-stack sampling probes. This program requires annual removal, inspection, and cleaning of sample probes.

Velocity profiles are performed quarterly following the criteria in EPA Method 2 at all major and at some minor sources. The profiles provide accurate stack flow data for subsequent emission-rate calculations. An annual leak-check program is carried out to verify the integrity of the sample transport system.

In addition to the major sources, ORNL has a number of minor sources that have the potential to emit radionuclides to the atmosphere. Minor sources are composed of any ventilation systems or components such as vents, lab hoods, room exhausts, and stacks that do not meet the criteria for a major source but are located in or vent from a radiological control area. A variety of methods are used to determine the emissions from the various minor sources. All methods used for minor source emission calculations comply with criteria agreed upon by EPA and/or included in the NESHAP Compliance Plan for the ORR. These minor sources are evaluated on a one- to three-year basis, depending on the source type. All emissions, both major and minor, are compiled annually to determine the overall ORNL source term and associated dose.

4.1.2.2 Results

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

Annual radioactive airborne emissions for major sources are presented in Table 4.2. All data presented were determined to be significantly different from zero at the 95% confidence level. Any number not statistically different from zero was not included in the emission calculation. Historical trends for ^{3}H and ^{131}I are presented in Figs. 4.4 and 4.5, respectively.

The tritium emissions for 1996 totaled approximately 603 Ci (Fig. 4.4). The primary contributor was off-gas from Stack 7025 that vents the old Tritium Facility, even though it has been inoperative since 1989. The ^{131}I emission for 1996 is 0.28 Ci, which is higher than that of the past years (Fig. 4.5). The ^{3}H emissions are attributable to cleanup activities in April 1996 that exposed a small amount of tritium, which had adhered to the concrete walls and other solid surfaces as tritiated moisture. As the weather warmed up, this moisture was driven off slowly through the off-gas system.

4.1.3 ETTP Radiological Airborne Effluent Monitoring

Locations of airborne radionuclide point sources at the ETTP are shown in Fig. 4.6. These locations include both individual point sources and grouped point sources, such as laboratory hoods. Radioactive emissions data were determined from either EPA-approved sampling results or EPA-approved calculation methods.

Table 4.2. Major sources of radiological airborne emissions at ORNL, 1996 (in curies)[a]

Isotope	Stack			
	2026	3020	3039	7911
^{3}H	7.9E–01		8.1E+01	1.1E+02
^{7}Be	7.4E–07		2.2E–05	1.3E–06
^{40}K	4.2E–07			
^{41}Ar				2.0E+03
^{60}Co			2.1E–04	
^{85}Kr			1.0E+02	1.8E+02
^{85m}Kr				8.6E+00
^{87}Kr				2.0E+01
^{88}Kr				1.9E+01
^{89}Kr				9.9E+00
Total Sr	1.7E–06	3.4E–07	4.0E–05	3.1E–05
^{131}I	4.8E–06		4.3E–05	2.8E–01
^{132}I				1.5E–01
^{133}I	2.8E–07		8.3E–04	1.4E+00
^{135}I			2.2E–04	2.8E+00
^{131m}Xe				5.3E+00
^{133}Xe				1.1E+00
^{133m}Xe				7.4E–01
^{135}Xe	4.5E–06	9.1E–07	2.2E–04	1.6E+02
^{135m}Xe				1.2E+02
^{137}Xe				2.0E+02
^{138}Xe				8.0E+02
^{134}Cs				8.8E–06
^{137}Cs	1.4E–05	6.0E–07	1.2E–04	9.0E–06
^{138}Cs				2.9E+03
^{139}Ba				1.5E–01
^{140}Ba				7.9E–04
^{191}Os			1.2E–01	
^{212}Pb	1.3E–01	3.6E–01	9.6E–01	2.5E–01
^{228}Th	3.9E–08	1.5E–08	2.0E–08	3.0E–08
^{230}Th	4.4E–08	8.6E–08	2.0E–07	1.8E–07
^{232}Th	4.2E–09	1.3E–08	1.5E–08	3.5E–06
^{234}U	4.6E–07	2.7E–08	3.4E–07	1.6E–08
^{235}U	6.7E–09		3.6E–09	9.3E–09
^{238}U	1.2E–08	1.6E–08	6.0E–08	2.2E–08
^{238}Pu	1.5E–07	2.9E–09	4.8E–08	2.9E–09
^{239}Pu	4.7E–07	4.4E–08	8.2E–07	3.5E–08
^{241}Am	3.6E–07	5.9E–08	3.6E–07	8.1E–09
^{244}Cm	4.9E–06	6.1E–09	1.7E–07	1.7E–07
^{152}Eu			2.1E–06	
^{154}Eu			8.5E–07	
^{140}La				5.3E–06

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

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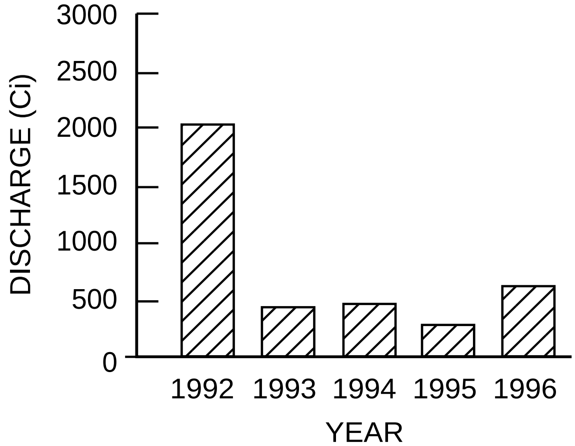

Fig. 4.4. Total discharges of ^{3}H from ORNL to the atmosphere, 1992–96.

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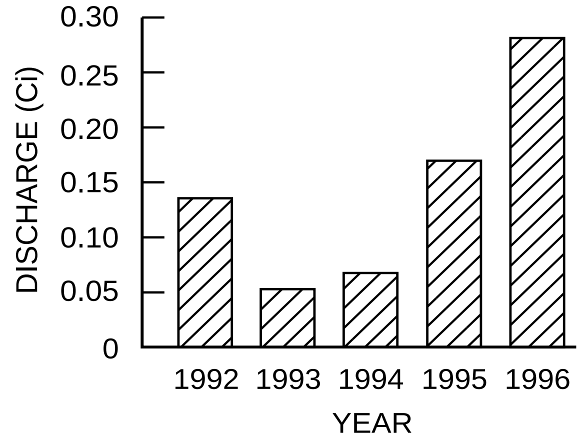

Fig. 4.5. Total discharges of ^{131}I from ORNL to the atmosphere, 1992–96.

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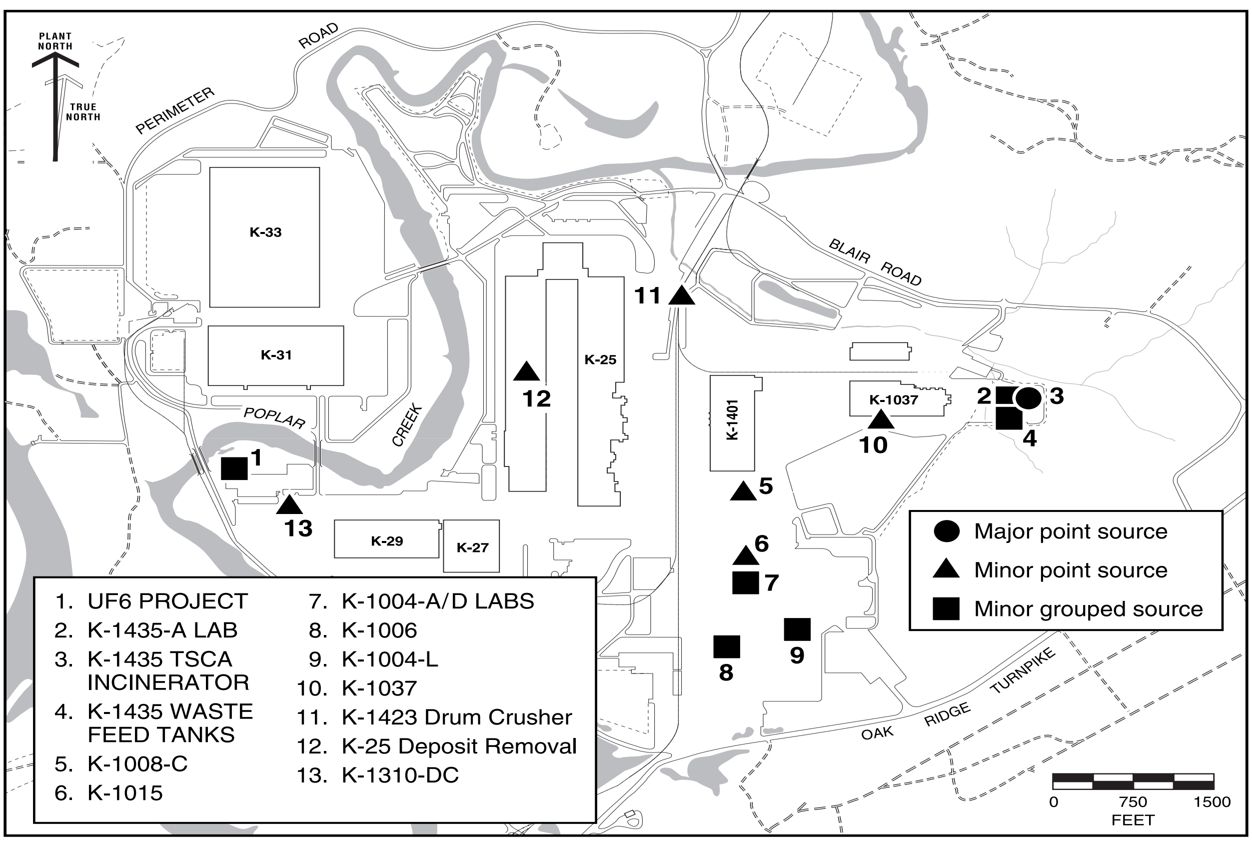

Fig. 4.6. ETTP active point sources of airborne radioactivity.

4.1.3.1 Sample Collection and Analytical Procedure

Routine emission estimates from the TSCA Incinerator were generated from the continuous stack sampling system. The TSCA Incinerator is the only operating major radionuclide emission source at the ETTP and is therefore the only stack that is continuously monitored. Estimates of TSCA Incinerator emissions were based on monthly composites of weekly stack samples.

Various techniques were used to determine all other radiological point source emissions. Representative grab sample techniques were used to generate emission estimates for the K-1015 Laundry. Material balance calculations were used to generate emission estimates for the UF_6 Cylinder Program, Deposit Removal Project, and K-1004-A through D laboratories. The remaining active sources were calculated using surrogate sample techniques as described in the EPA-approved NESHAP compliance plan, or from emission factors specified in 40 CFR 61, Appendix D. Both techniques are conservative methods of estimating emissions based on the physical form of the radionuclides and the maximum operating temperature of the process.

One new minor point source was approved for operation in 1996. A project for the UF_6 Cylinder Refurbishment Program was evaluated and approved for operation. The project includes controlled venting of cylinders containing depleted uranium hexafluoride. The controlled venting is performed to minimize the potential of uncontrolled releases caused by over-pressurization of breached cylinders during repairs.

The following minor sources were reactivated during 1996: the K-304-5 Deposit Removal Project activities to mechanically remove solidified deposits of radiological material from the interior of cascade components, K-1423 drum crushing of radiologically contaminated empty drums, and a HEPA vacuum cleaning facility located in K-1310-DC for servicing vacuums containing potentially contaminated debris.

4.1.3.2 Results

The ETTP 1996 radionuclide emissions from the TSCA Incinerator and minor emission sources are shown in Table 4.3. Additionally, Figs. 4.7 and 4.8 show a comparison of the total 1996 discharges of uranium with those of previous years. The total curies and mass of uranium discharged have decreased from the previous year. Variations are typically caused by changing levels of activities, waste burning, and uranium assay from year to year.

Table 4.3. ETTP radionuclide air emission totals, 1996 (in curies)[a]

Radionuclide	TSCA Incinerator	Minor sources
^{3}H	1.86E–07	5.41E–05
^{14}C	4.14E–09	7.00E–06
^{40}K	7.31E–05	
^{57}Co	7.14E–07	4.61E–08
^{60}Co	7.98E–04	3.15E–06
^{90}Sc		3.10E–06
^{99}Tc	6.57E–03	3.76E–04
^{131}I	2.49E–09	4.79E–07
^{137}Cs	8.54E–04	2.37E–05
^{203}Hg		9.00E–09
^{237}Np	7.55E–07	1.40E–05
^{238}Pu	2.94E–06	1.76E–05
^{239}Pu	4.70E–07	1.19E–05
^{228}Th	3.61E–06	1.24E–05
^{230}Th	7.40E–06	1.57E–05
^{232}Th	1.75E–06	1.04E–05
^{234}Th	4.66E–02	2.77E–04
^{234m}Pa	2.30E–01	5.69E–04
^{233}U		9.48E–07
^{234}U	6.59E–04	4.96E–04
^{235}U	1.18E–06	3.62E–05
^{236}U		9.86E–06
^{238}U	3.46E–03	9.07E–04
^{241}Am		5.83E–06
Totals	2.89E–01	2.85E–03

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

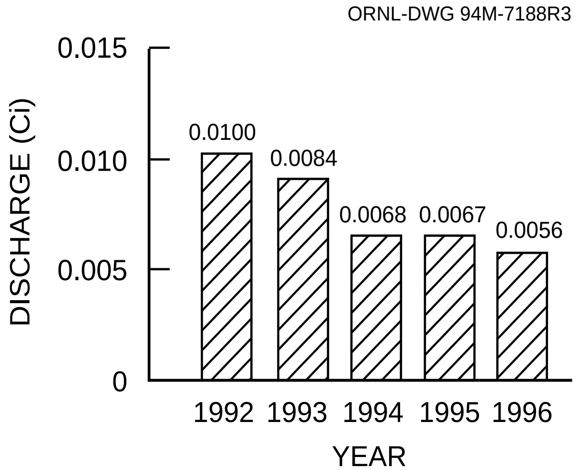

Fig. 4.7. Total curies of uranium discharged from the ETTP to the atmosphere, 1992–96.

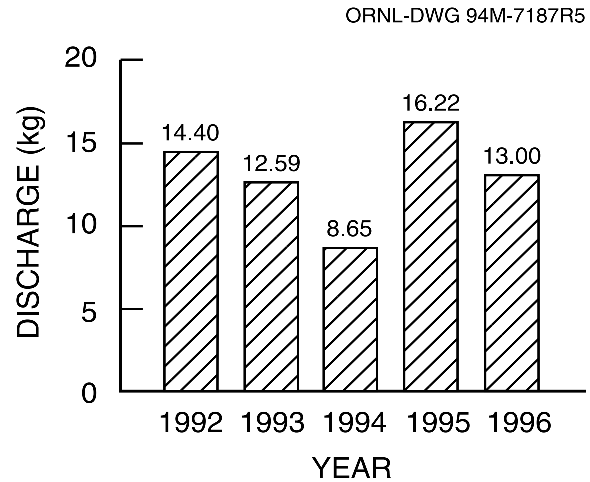

Fig. 4.8. Total kilograms of uranium discharged from the ETTP to the atmosphere, 1992–96.

4.1.4 Y-12 Plant Nonradiological Airborne Emissions Monitoring

The release of nonradiological contaminants into the atmosphere at the Y-12 Plant occurs as a result of plant production, maintenance, and waste management operations and of steam generation. Most process operations are served by ventilation systems that remove air contaminants from the workplace. TDEC has issued 52 air permits that cover 262 of these emission sources. The allowable level of air pollutant emissions from permitted emission sources in 1996 was approximately 10,345 tons per year of regulated pollutants. The actual emissions are much lower than the allowable amount; however, major sources are required to pay their annual emission fee based on allowable emissions until the issuance of the major source operating permit. Therefore, the annual emission fee is based on the sum of allowable air emissions of all regulated pollutants at the Y-12 Plant as defined in Chapter 1200-3-26 of the TDEC regulations.

The Y-12 Plant annual emission fee was calculated by TDEC personnel based on 10,199 tons per year of allowable emission of regulated pollutants, with an annual emission fee of $148,243.35, as defined in TDEC regulations, Chapter 1200-3-26-.02(9)(i). In calculating the annual emission fee, Schedule III of Chapter 26 was used, in which the adjusted emissions equal the total emissions minus carbon monoxide and exempt emissions and a 4,000-ton cap is imposed for SO_2 and NO_x. The emission fee rate is based on $14.65 per ton of regulated pollutant allowable emissions.

The level of pollutant emissions is expected to decline in the future because of the changing mission of the Y-12 Plant and downsizing of production areas. More than 90% of the pollutants are attributed to the operation of the Y-12 Steam Plant.

Nonradiological airborne emissions of materials have been estimated and are provided in Table 4.4. The past practice of monitoring beryllium process air emissions, as a BMP, was discontinued in 1996 (see Chap. 2, Clean Air Act, other NESHAPs for details).

In anticipation of permitting requirements and implementation of maximum achievable control technology (MACT) standards under Title V of the CAA amendments, an effort is under way to improve the stack and vent survey, criteria pollutant emission inventory, and hazardous air pollutant emission inventory. The Oak Ridge Y-12 Plant Title V permit application is expected to be prepared in 1997.

Planning for continued compliance with anticipated and newly issued requirements under Title VI of the CAA amendments is a major

Table 4.4. Y-12 Plant nonradiological airborne emissions, 1996

Chemical	Quantity released		Major release source	Basis of estimate
	lb	kg		
SARA 313 chemicals[a]				
Hydrochloric acid	870	395	Chemical processing aid	Engineering calculation
Lead	1	0.5	Ancillary	Engineering calculations
Methanol	27,630	12,560	Cleaning/cooling	Engineering calculation
Nitric acid	145	66	Chemical processing aid	Engineering calculation
Tetrachloroethene	1	0.5	Storage	Engineering calculation
Other large-inventory chemicals[b]				
Freon 11	550	250	Refrigerant	Quarterly report
Freon 12	224	102	Refrigerant	Quarterly report
Freon 22	1235	561	Refrigerant	Quarterly report
Freon 13	6	3	Refrigerant	Quarterly report
Freon 114	1800	818	Refrigerant	Quarterly report
Freon 502	10	4	Refrigerant	Quarterly report
Steam plant emissions (all calculated emissions)[c]				
Particulates	29,783	13,538	Stack emission	Engineering calculations based on emission facts
SO_x	6,090,853	2,768,570	Stack emission	Engineering calculations based on emission facts
Carbon monoxide	46,933	21,333	Stack emission	Engineering calculations based on emission facts
Volatile organic compounds	3,655	1,661	Stack emission	Engineering calculations based on emission facts
NO_x	3,047,371	1,385,169	Stack emission	Engineering calculations based on emission facts

[a]Superfund Amendments and Reauthorization Act, Title III, Section 313.
[b]Fugitive emissions.
[c]Point-source emissions.

effort. In accordance with the Y-12 Plant CAA implementation plan, a stratospheric ozone protection plan annual update has been issued outlining current and historical actions necessary to comply with the new limitations on the release of ozone-depleting chemicals and with the 1995 production ban on these chemicals.

The Y-12 Plant Environmental Compliance Organization personnel and refrigeration maintenance personnel successfully implemented work practices required to minimize releases of ozone-depleting refrigerants to the atmosphere. Requirements for refrigeration-system and motor-vehicle air-conditioner maintenance compliance are being met. To accommodate the production ban on ozone-depleting chemicals, studies are proceeding to find suitable replacements, and plant refrigeration equipment is being modified as needed. Funding was received and design work implemented on a line item project, Retrofit Heating, Ventilating, and Air-Conditioning (HVAC) Systems and Chillers for Ozone Protection. This project will eliminate the use of chlorofluorocarbon (CFC) refrigerants in chillers, direct expansion air conditioners, and process coolers, either by direct replacement of new equipment that operates with “ozone-friendly” refrigerants or by retrofit of existing equipment with new components to operate on "ozone-friendly" refrigerants. In addition, two general plant projects were completed to retrofit low-pressure chillers with high-efficiency purge units and pressurization/leak detection units to reduce CFC emissions to the atmosphere. Figure 4.9 illustrates the five-year trend of fugitive CFC emissions as reported by the Y-12 Plant. Table 4.4 includes the 1996 estimated emissions of these ozone-depleting substances as a result of Y-12 Plant activities.

4.1.4.1 Sample Collection and Analytical Procedure

The two Y-12 Steam Plant exhaust stacks are each equipped with Lear Siegler RM41 opacity-monitoring systems. Under the current operating permit, the opacity-monitoring systems are required to be fully operational for at least 95% of the operational time of the monitored units during each month of a calendar quarter.

4.1.4.2 Results

The east and west Y-12 Steam Plant stack opacity monitors were each operational more than 99% of the time in 1996. Both systems were taken out of service for annual calibration/recertification by Spectrum Systems Engineering, Inc., on April 19, 1996. The annual opacity calibration error test reports were submitted to TDEC in July 1996.

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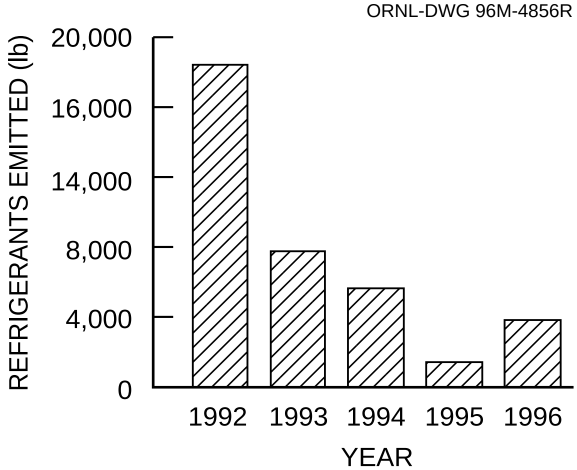

Fig. 4.9. Y-12 Plant CFC emissions, 1992–1996.

During 1996 there were a total of 14 six-minute periods of excess emissions and six occasions where the monitors were out of service. Quarterly opacity reports of the operational status of the Y-12 Steam Plant are submitted to personnel at TDEC within 30 days after the end of each calendar quarter to comply with the current air permit.

Table C.4 in Appendix C is a record of excess emissions and out-of-service conditions for the east and west stack opacity monitors for 1996.

4.1.5 ORNL Nonradiological Airborne Emissions Monitoring

ORNL operates 26 permitted air emission sources. Most of these sources are small-scale activities and result in very low emission rates. TDEC air permits for ORNL sources do not require stack sampling or monitoring; however, an opacity monitor is used at the steam plant to ensure compliance with visible emissions. The steam plant and two small oil-fired boilers are the largest emission sources at ORNL and account for 98% of all allowable emissions.

For the period from July 1, 1995 through June 30, 1996, ORNL paid $75,925 in annual emission fees to TDEC. These fees are based on allowable emissions (actual emissions are lower than allowable emissions). In early 1996, TDEC inspected all permitted emission sources to ensure compliance; no noncompliances were noted.

The ORNL Title V permit application was finalized during 1996 and early 1997. To facilitate the preparation of this application, an existing survey of all emission points at ORNL was updated. This survey located all emission points and evaluated their compliance status. Survey results provided information regarding small sources that are currently exempt from air permit requirements. The survey will also assist with compliance efforts that may be required under CAA Title III, Hazardous Air Pollutants.

Actions have been implemented to comply with the prohibition against releasing ozone-depleting substances under Title VI. Also, service requirements for refrigeration systems (including motor vehicle air conditioners), technician certification requirements, and labeling requirements, have been implemented. ORNL has taken actions to phase out the use of Class I ozone-depleting substances. The most significant challenge is the replacement or retrofit of large chiller systems that require Class I refrigerants.

4.1.6 ETTP Nonradiological Airborne Emissions Monitoring

The TDEC Division of Air Pollution Control has been delegated the authority by EPA to implement and enforce the sections of the CAA related to nonradiological air emissions in the state of Tennessee. As a result of TDEC rules promulgated pursuant to the CAA amendments of 1990, ETTP submitted a new operating air permit application package to TDEC for all major air emission sources in operation. The ETTP was one of many sources in the state that submitted applications early in the Title V Program as a participant in TDEC's early volunteer program. Development of the new permit application included an air emissions inventory of allowable and actual emissions from the ETTP.

To verify the annual air emission fee assessment, which is based on the ETTP's allowable limits for air pollutants, an inventory of potential emissions from the permitted sources at the ETTP is updated annually. Table 4.5 shows the allowable emissions of criteria pollutants from ETTP operations for the past five years. The ETTP paid annual emission fees based on allowable emissions in 1996 amounting to $14,635. An inventory of actual emissions from all permitted sources in operation at the ETTP was completed for 1996. Table 4.6 shows actual emissions from the ETTP during 1996.

Title VI of the CAA amendments addresses stratospheric ozone protection. This section authorizes a number of regulations to phase out the production and to eliminate the intentional release of regulated ozone- depleting substances to the atmosphere. Ozone- depleting substances are used at the ETTP primarily for office comfort cooling. All Class I CFC-11 comfort cooling units at the site were replaced during the year with Class II HCFC-22 units. In addition to these, a large CFC-12 unit containing 2,700 lbs. of refrigerant was replaced with a HCFC-22 unit. Recovered CFC-12 from this project was sent to ORNL for reuse in lieu of disposal.

4.1.6.1 Results

The major sources of criteria air pollutants at the ETTP are the three remaining steam-generating units in operation at the K-1501 Steam Plant. Boiler 4, a natural gas-fired unit, was abandoned in place and will no longer be used. The remain-

Table 4.5. Allowable emissions of criteria pollutants from ETTP, 1992–96

Pollutant	Allowable emissions (tons/year)				
	1992	1993	1994	1995	1996
Particulate matter	172	180	141	296	247
Volatile organic compounds	262	166	153	167	150
Sulfur dioxide	429	429	429	428	428
Nitrogen oxides	226	226	226	224	224
Carbon monoxide	157	157	157	157	157
Miscellaneous	291	291	145	149	0
Total	1537	1449	1251	1421	1206

ing units use natural gas as their primary fuel source, with No. 2 fuel oil used as backup during curtailment of natural gas supplies. Table 4.7 presents the actual and allowable emissions from the steam plant for 1996.

The TSCA Incinerator is also a major source of air emissions from the ETTP. Emissions from the incinerator are controlled by extensive exhaust-gas treatment. Actual emissions from the incinerator are significantly less than the permitted allowable emissions (Table 4.8).

Table 4.6. Actual emissions of criteria pollutants from ETTP, 1996

Pollutant	Actual emissions (tons/year)
Particulate matter	3.91
Volatile organic compounds	3.76
Sulfur dioxide	5.85
Nitrogen oxides	24.71
Carbon monoxide	30.08

4.2 LIQUID DISCHARGES

4.2.1 Radiological Liquid Discharges

DOE Order 5400.1 requires that effluent monitoring be conducted at all DOE sites. DOE Order 5400.5 sets annual dose standards to members of the public, as a consequence of routine DOE operations, of 100 mrem through all exposure pathways and 4 mrem from the drinking water pathway. Effluent monitoring results are a major component in the determination of compliance with these dose standards.

DOE Order 5400.5 also established DCGs for radionuclides in water. (See Appendix A for a list of radionuclides and their half-lives.) The DCG is the concentration of a given radionuclide for one exposure pathway (e.g., drinking water) that would result in an EDE of 100 mrem (1 mSv) per year to reference man, as defined by the International Commission on Radiological Protection (ICRP) publication 23 (ICRP 1975). The consumption of water is assumed to be 730 L/year at the DCG level. DCGs were calculated using methodologies consistent with recommendations found in ICRP publications 26 (ICRP 1977) and 30 (ICRP 1978). DCGs are used as reference concentrations for conducting environmental protection programs at DOE sites,

Table 4.7. Actual vs allowable air emissions from the K-1501 Steam Plant at ETTP, 1996

Pollutant	Emissions (tons/year)		Percentage of allowable
	Actual	Allowable	
Particulate matter	1.99	143	1.4
Sulfur dioxide	5.43	389	1.4
Nitrogen oxides	17.48	191	9.2
Volatile organic compounds	1.16	9	12.9
Carbon monoxide	28.07	135	20.8

Table 4.8. Actual vs allowable air emissions from the TSCA Incinerator at ETTP, 1996

Pollutant	Emissions (tons/year)		Percentage of allowable
	Actual	Allowable	
Lead	0.00058	0.575	0.1
Beryllium	0.0000056	0.00037	1.5
Mercury	0.0030	0.088	3.4
Fluorine	0.0030	2.82	0.1
Chlorine	0.080	15.68	0.5
Sulfur dioxide	0.24	38.54	0.6
Particulate	0.044	13.14	0.3

as screening values for considering best available technology for treatment of liquid effluents, and for making dose comparisons. Radiological data are determined as percentages of the DCG for a given isotope. In the event that a sum of the percentages of the DCGs for each location ever exceeds 100%, an analysis of the best available technology to reduce the sum of the percentages of the DCGs to less than 100% would be required as specified in DOE Order 5400.5.

4.2.1.1 Y-12 Plant Radiological Summary

Regulatory Requirements

At the Y-12 Plant, radiological monitoring of effluents and surface waters is also a component of the NPDES permit (TN002968). The permit, issued in 1995, required that the Y-12 Plant reevaluate the radiological monitoring plan and that it submit results from the monitoring program quarterly, as an addendum to the NPDES Discharge Monitoring Report. There were no discharge limits set by the new NPDES permit for radionuclides; the requirement is only to monitor and report. The *Radiological Monitoring Plan for the Y-12 Plant: Surface Water* (LMES 1995a) was revised and fully implemented in 1995 to better characterize the radiological components of plant effluents and to reflect changes in plant operations. The monitoring program was designed to monitor effluent at three types of locations: (1) treatment facilities, (2) other point and area source discharges, and (3) in-stream locations.

The following parameters are monitored routinely under the plan:

- alpha and beta activity,
- americium (^{241}Am),
- neptunium (^{237}Np),
- plutonium (^{238}Pu and $^{239/240}$Pu),
- radium (^{226}Ra and ^{228}Ra),
- strontium (^{90}Sr),
- technetium (^{99}Tc),
- thorium (^{228}Th, ^{230}Th, ^{232}Th, ^{234}Th, and total thorium),
- tritium (^{3}H), and
- uranium (^{234}U, ^{235}U, ^{236}U, ^{238}U, total uranium, and percentage of ^{235}U).

The 1995 revision to the radiological monitoring plan called for a routine gamma scan to be performed for a year and for an evaluation of the data at the end of the year. Review of that data supports eliminating gamma scans from routine sampling. However, gamma scans will continue as a BMP until such time that additional reviews would preclude continued monitoring.

In addition, the Y-12 Plant is permitted to discharge domestic wastewater to the city of Oak Ridge POTW under Industrial and Commercial User Wastewater Discharge Permit No. 1-91. Radiological monitoring of this discharge is also conducted and is reported to the city of Oak Ridge. The following parameters are monitored routinely:

- alpha, beta, and gamma activity;
- plutonium (^{238}Pu and $^{239/240}$Pu); and
- uranium (^{234}U, ^{235}U, ^{236}U, ^{238}U, total uranium, and percentage of ^{235}U).

Results

Radiological monitoring plan sampling locations are noted in Fig. 4.10. Table 4.9 identifies the monitored locations, the frequency of monitoring, and the sum of DCG percentages for radionuclides measured in 1996. Radiological data for all locations were well below the allowable DCGs. The highest summed percentage of DCGs was from the in-stream location at Bear Creek kilometer (BCK) 11.97. Uranium (^{234}U and ^{238}U) and ^{237}Np were the major contributors of radioactivity there, contributing 4.0, 6.5, and 2.9%, respectively, to the total 14.3% of the sum of the percentages of the DCGs.

With the concurrence of TDEC personnel, the frequency of monitoring at BCK 11.97 was reduced from weekly to semiannually in August 1996 after evaluation of monitoring sites located on Bear Creek and to address ongoing budget reductions. Sampling in the upper Bear Creek area was initiated in 1983 as part of a memorandum of understanding between DOE, EPA, and the state

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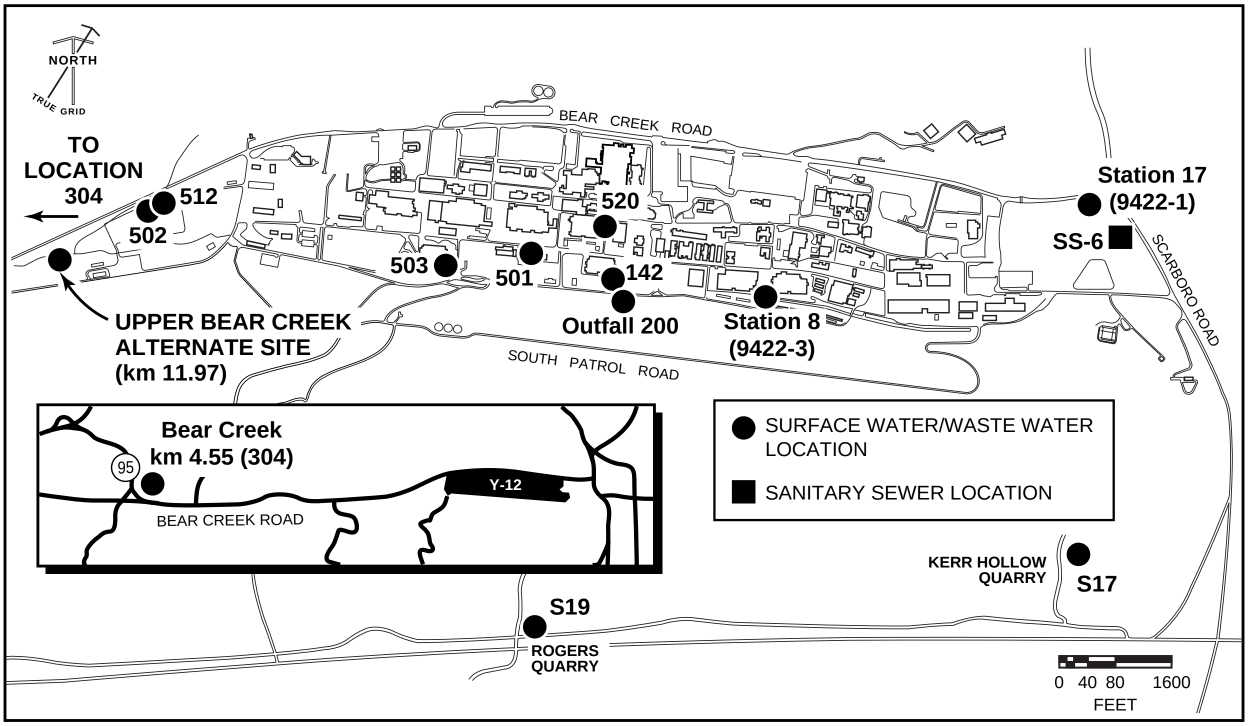

Fig. 4.10. Surface water and sanitary sewer radiological sampling locations at the Y-12 Plant.

of Tennessee to characterize effects of S-3 Pond discharges. This commitment has been satisfied; sampling of surface waters in the Bear Creek drainage area is now conducted at other locations to satisfy NPDES permit requirements and as part of remedial actions being conducted under CERCLA. This change in the monitoring program will be incorporated into the next update of the Radiological Monitoring Plan during 1997.

The Central Pollution Control Facility (Outfall 501) is the only treatment facility that has exceeded maximum allowable DCGs in the past; however, improvements in the treatment process since 1989 have resulted in effluent data consistently well below DCGs. This improvement can be seen in Fig. 4.11, which shows ^{238}U concentrations since 1989.

In 1996, the total mass of uranium and associated curies released from the Y-12 Plant at the easternmost monitoring station, Station 17 on UEFPC, and the westernmost monitoring station, at BCK 4.55 (former NPDES Outfall 304), was 474 kg, or 0.284 Ci (1.05E+10 Bq) (Table 4.10). Figure 4.12 illustrates a 5-year trend of these releases.

The total release is calculated by multiplying the average concentration (grams/liter) times the average flow (million gallons/day). Converting units and multiplying by 365 days/year yields the calculated discharge. Heavy rainfall during 1996 contributed to increased creek flows and also contributed to increased calculated discharges in both EFPC and Bear Creek.

The City of Oak Ridge Industrial and Commercial User Wastewater Discharge Permit allows the Y-12 Plant to discharge wastewater to be treated at the Oak Ridge POTW through the East End Sanitary Sewer Monitoring Station (EESSMS), also identified as SS-6 (Fig. 4.10). Radionuclide discharge levels are established by DOE via DOE Order 5400.5.

No single radionuclide in the Y-12 Plant contribution to the sanitary sewer exceeded 1% of the DCG listed in DOE Order 5400.5. Summed percentages of DCGs calculated from the Y-12 Plant contribution to the sewer are essentially

Table 4.9. Summary of Y-12 Plant radiological monitoring plan sample requirements

Outfall No.	Location	Sample frequency	Sample type	Sum of DCG percentage
		Y-12 Plant wastewater treatment facilities		
501	Central Pollution Control Facility	1/week	Composite during batch operation	–0.037
502	West End Treatment Facility	1/week	24-hour composite	–0.25
503	Steam Plant Wastewater Treatment Facility	1/week	24-hour composite	No flow
512	Groundwater Treatment Facility	1/week	24-hour composite	2.87
520 (402)[a]	Steam Condensate	1/week	Grab	No flow
		Other Y-12 Plant point and area source discharges		
142	Isotope Separation Process	1/month	24-hour composite	No flow
S17 (301)[a]	Kerr Hollow Quarry	1/month	24-hour composite	–0.70
S19 (302)[a]	Rogers Quarry	1/month	24-hour composite	–2.4
		Y-12 Plant in-stream locations		
BCK 4.55 (304)[a]	Bear Creek, Plant Exit (west)	1/week	7-day composite	2.4
Station 17	East Fork Poplar Creek, Plant Exit (east)	1/week	7-day composite	2.0
Station 8	East Fork Poplar Creek, Plant Site	1/week	7-day composite	3.3
200	North/South Pipes	1/week	24-hour composite	4.3
km 11.97	Bear Creek	1/week[b]	Grab	14.3

[a]Outfall identifications were changed by the new NPDES permit effective July 1, 1995. Former outfall identifications are shown here in parentheses.

[b]Reduced to semiannually effective August 1996.

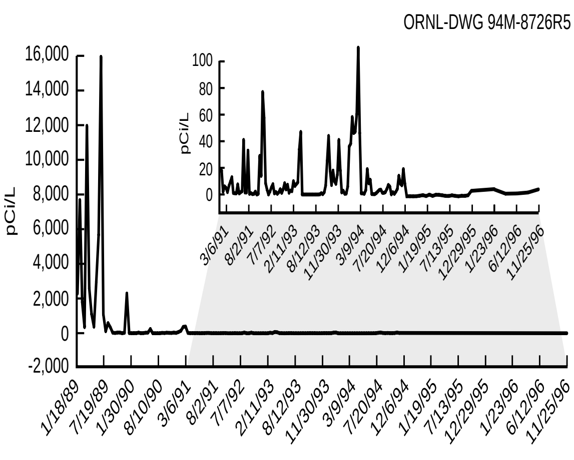

Fig. 4.11. Concentrations of ^{238}U at the Y-12 Plant Outfall 501, January 1989 through December 1996. The allowable DCG for ^{238}U is 600 pCi/L.

zero. Results of radiological monitoring were reported to the city of Oak Ridge with the quarterly monitoring report (Table 4.11).

Potential sources of radionuclides discharging to the sanitary sewer had been identified in previous studies at the Y-12 Plant as part of a BMP initiative to meet the ALARA goals of the Y-12 Plant. These data show that levels of radioactivity are orders of magnitude below regulatory levels established in DOE orders and are not thought to pose a safety or health risk. The radiological monitoring needs for the sanitary sewer will be reviewed and summarized in the 1997 update to the Radiological Monitoring Plan (RMP). Any recommendations or revisions to the radiological monitoring associated with the sanitary sewer will be documented in the RMP and implemented in 1997. Figure 4.13 illustrates the 5-year trend of

Table 4.10. Release of uranium from the Y-12 Plant to the off-site environment as a liquid effluent, 1991–96

Year	Quantity released	
	Ci[a]	kg
	Station 17	
1991	0.162	235
1992	0.087	130
1993	0.081	134
1994	0.11	185
1995	0.069	143
1996	0.135	215
	Outfall 304	
1991	0.082	159
1992	0.060	110
1993	0.094	167
1994	0.13	236
1995	0.066	105
1996	0.149	259

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

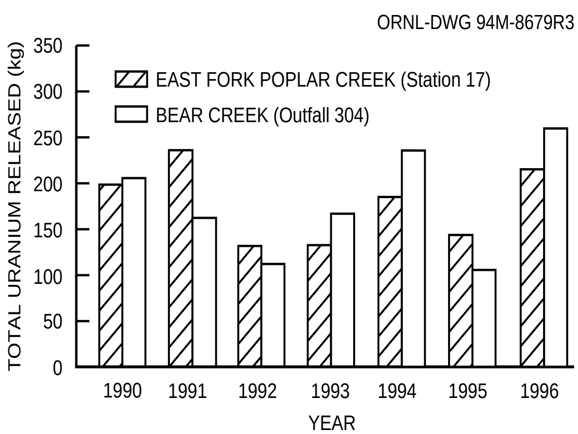

Fig. 4.12. Five-year trend of Y-12 Plant release of uranium to surface water.

total uranium discharges from the Y-12 Plant Sanitary Sewer.

4.2.1.2 ORNL Radiological Summary

ORNL Surface Waters Receiving Effluents

Under the RMP for the ORNL NPDES permit issued in 1986, sampling for radiological analyses was conducted at five NPDES stations and at six ambient stream locations around ORNL. The five NPDES stations were STP (X01), Nonradiological Wastewater Treatment Facility (NRWTF) (X12), Melton Branch 1 (X13), WOC (X14), and White Oak Dam (WOD) (X15). The six ambient stations were 7500 Road Bridge, First Creek, Fifth Creek, Melton Branch 2, Northwest Tributary, and Raccoon Creek (Fig. 4.14). In addition, water samples were collected for radiological analyses from the Clinch River at Melton Hill Dam and from WOC headwaters, two locations above ORNL discharge points that serve as references for other water sampling locations at the ORNL site.

DOE DCGs are used in this document as a means of standardized comparison for effluent points with different isotope signatures. The average concentration is expressed as a percentage of the DCG when a DCG exists and when the average concentration is significantly greater than zero. The calculation of percentage of the DCG for ingestion of water does not imply that effluent points or ambient water sampling stations at ORNL are sources of drinking water. For 1996, only three radionuclides had an average concentration greater than 5% of the relevant DCG; they were ^{3}H, total radioactive strontium (^{89}Sr + ^{90}Sr), and ^{137}Cs. The largest percentage was the total radioactive strontium concentration at NRWTF (X12), at 43% of the DCG (Fig. 4.15). Following guidelines given in DOE Order 5400.5, fractional DCG values for the radionuclides detected at each monitoring point are summed to determine whether radioactivity is within acceptable levels. In 1996, the sum of DCG percentages at each effluent point and ambient water station was less than 100% and therefore within acceptable levels.

Table 4.11. Y-12 Plant Discharge Point SS6, Sanitary Sewer Station 6, Radiological Summary (1/1/96–12/31/96)

Parameter	Number of samples	Concentration (pCi/L)						Standard error	Percentage of DCG	Total curies
		Max	+/–	Min	+/–	Median	+/–			
Alpha activity	53	22.0[a]	29	–10.0[a]	43	3.1[a]	3	0.7151	*b*	5.35E–03
Beta activity	53	20.0	8	–130.0[a]	99	5.2[a]	10	3.1536	*b*	1.91E–03
Gross gamma	53	460.0	57	–15.0[a]	31	23.0[a]	31	9.6637	*b*	4.52E–02
^{238}Plutonium	39	0.23[a]	20	–0.26[a]	19	0.017[a]	14	0.0171	0.0425	9.26E–06
$^{239/240}$Plutonium	39	0.2	23	–0.13[a]	15	0.0[a]	0	0.0093	0.0	–3.24E–06
^{234}Uranium	53	9.0	1	0.043	0.021	3.0	93	0.2397	0.6	4.02E–03
^{235}Uranium	53	0.44	40	–0.049[a]	0.098	0.13[a]	18	0.0163	0.0217	1.72E–04
^{236}Uranium	53	0.43	36	–0.14[a]	41	0.048[a]	0.097	0.0127	0.0096	7.00E–05
^{238}Uranium	53	18.0	3	0.014[a]	0.013	2.4	90	0.3611	0.4	3.40E–03

[a]Provisional data, result was below the minimum detectable activity.
[b]Not applicable.

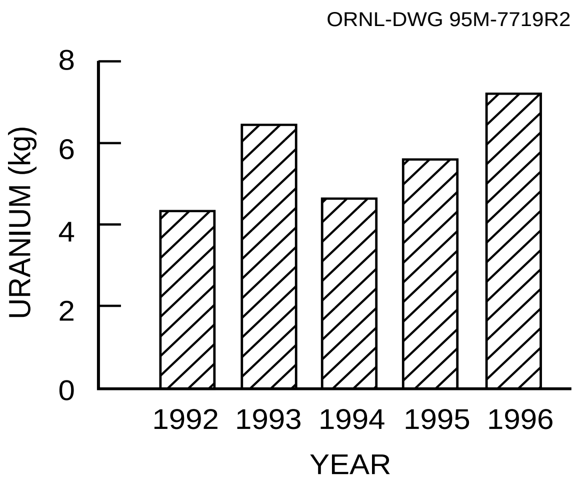

Fig. 4.13. Five-year trend of total uranium discharges from the Y-12 Plant Sanitary Sewer.

The discharge from ORNL of radioactive contaminants to the Clinch River is affected by stream flows. Clinch River flows are regulated by a series of TVA dams, one of which is Melton Hill Dam. In 1996, the monthly ratio of flow in WOC (measured at WOD) to flow in the Clinch River (measured at Melton Hill Dam) ranged from 0.00074 to 0.012, thus providing significant dilution of any radioactive contaminants released into the Clinch River from WOC.

Amounts of radioactivity released at WOD are calculated from concentration and flow. As shown in Figs. 4.16, 4.17, 4.18, 4.19, 4.20, and 4.21, the total discharges (or amounts) of radioactivity released at WOD during the past four years have remained in the same range of values.

Categories of Effluents

Under the RMP for the NPDES permit issued in 1986, monitoring was conducted quarterly at NPDES Category I and Category II outfalls. The permit defined Category I outfalls as storm drains and Category II outfalls as roof drains, parking lot drains, storage area drains, spill area drains, once-through cooling water, cooling-tower blowdown, condensate, and drains in the disposal demonstration area. Gross beta was measured at Category I and Category II outfalls in storm flow conditions. If a gross beta result exceeded a trigger level (810 pCi/L), then a total radioactive strontium analysis was conducted.

In 1996, none of the Category I or Category II gross beta results triggered a total radioactive strontium analysis. The maximum Category I

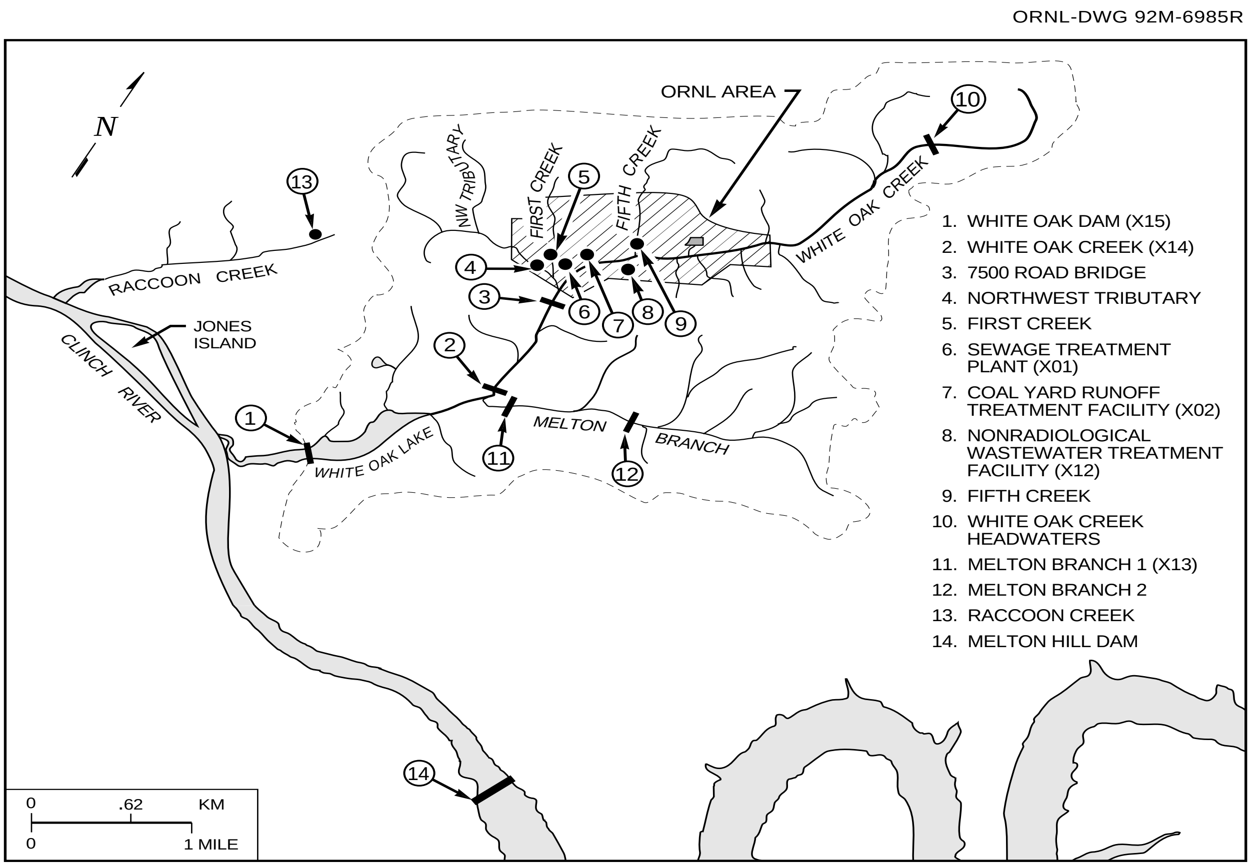

Fig. 4.14. ORNL surface water, NPDES, and reference sampling locations. Bars (**I**) indicate sampling locations that have weirs.

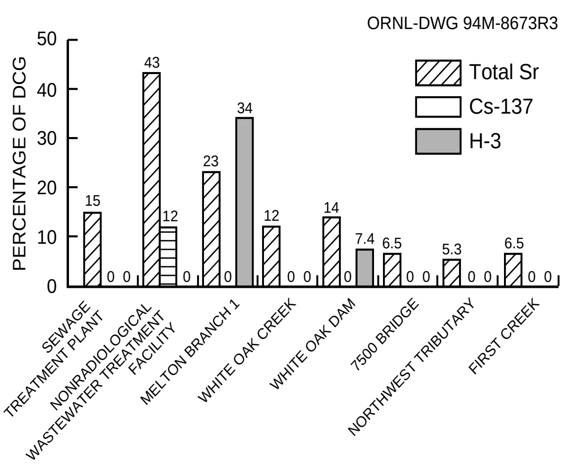

Fig. 4.15. Radionuclides at ORNL sampling sites having average concentrations greater than 5% of the relevant derived concentration guides in 1996.

gross beta value of 100 pCi/L occurred at Outfall 165, which discharges into Fifth Creek east of Building 3033. The maximum Category II gross beta value of 320 pCi/L occurred at Outfall 282, which discharges into WOC west of Building 7516.

4.2.1.3 ETTP Radiological Summary

The ETTP conducts radiological monitoring of liquid effluent to determine compliance with applicable dose standards. It also applies the ALARA process to maintain potential exposures to members of the public as low as is reasonably achievable.

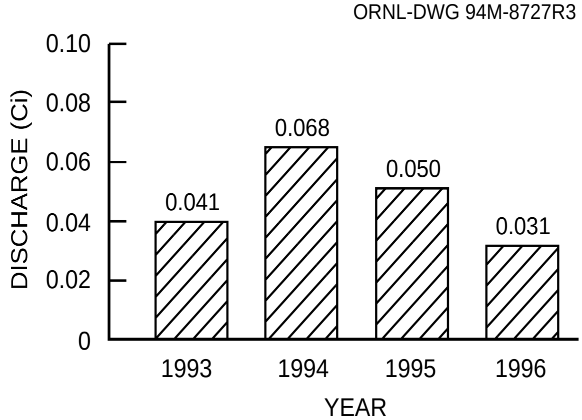

Fig. 4.16. Cobalt-60 discharges at White Oak Dam, 1993–96.

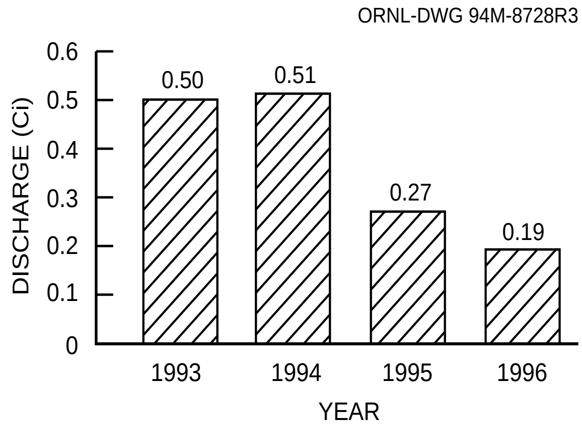

Fig. 4.17. Cesium-137 discharges at White Oak Dam, 1993–96.

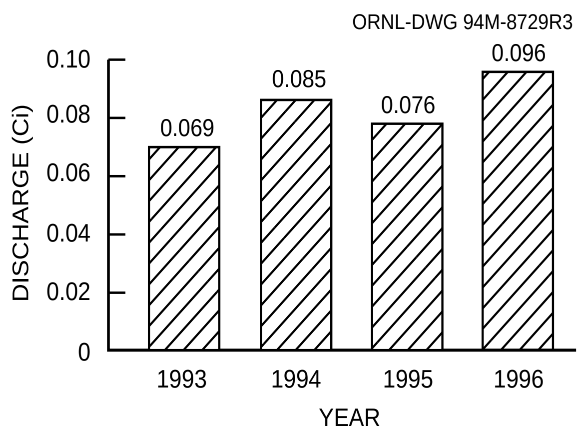

Fig. 4.18. Gross alpha discharges at White Oak Dam, 1993–96.

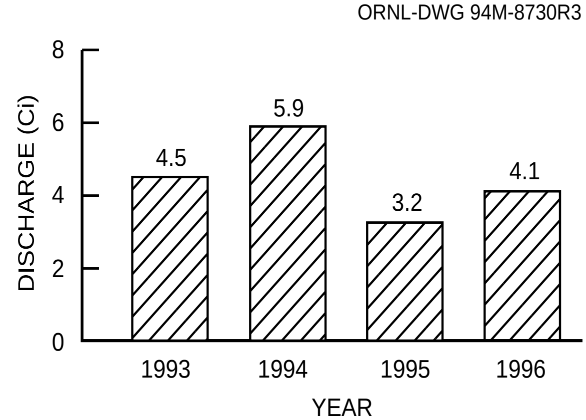

Fig. 4.19. Gross beta discharges at White Oak Dam, 1993–96.

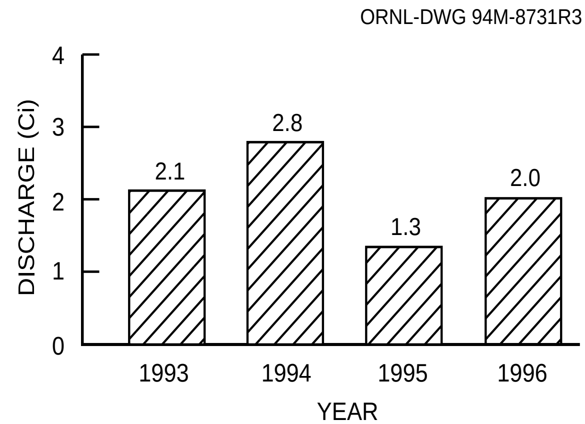

Fig. 4.20. Total radioactive strontium discharges at White Oak Dam, 1993–96.

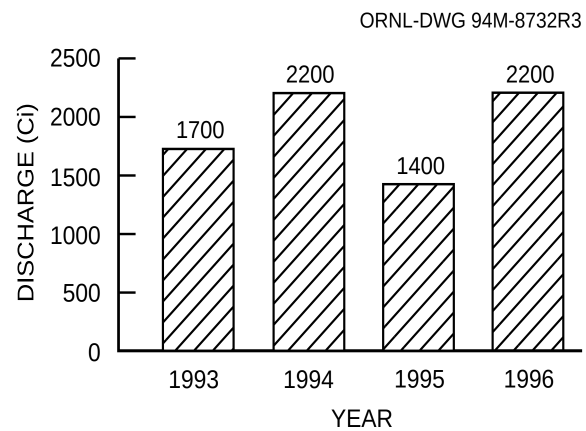

Fig. 4.21. Tritium discharges at White Oak Dam, 1993–96.

Sample Collection and Analytical Procedure

The ETTP monitored three major effluent discharge points for radiological parameters: the K-1203 STP discharge (Outfall 005), the treated effluent from the K-1407-J CNF (Outfall 014), and the K-1515-C filter backwash from the Sanitary Water Treatment Facility (Outfall 009) (Fig. 4.22). Weekly samples were collected from each of these locations. The weekly samples were composited into monthly samples and analyzed for radionuclides. Results of these sampling efforts were compared with the DCGs.

Results

The sum of the fractions of the DCGs at K-1407-J was calculated at 18% for CY 1996. The decrease in 1996 was determined to be caused by changes in TSCA Incinerator feed material. The sum of the fractions of the DCGs for effluent locations K-1203 and K-1515-C declined to less than 1%. Table 4.12 lists radionuclides discharged from the ETTP to off-site surface waters in 1996.

Uranium discharges to surface waters during a five-year period were investigated to observe their trend (Fig. 4.23). The effluent point having the greatest DCG percentage was the K-1407-J Outfall. Uranium isotopes contributed to this percentage (Fig. 4.24). The fluctuation in uranium discharges is attributed to TSCA Incinerator wastewater, which is sent to the Central Neutralization Facility (CNF) for treatment before discharging at K-1407-J (Outfall 014).

4.2.2 Nonradiological Liquid Discharges

The Federal Water Pollution Control Act and its amendments, more commonly known as the CWA, were the culmination of almost a century of

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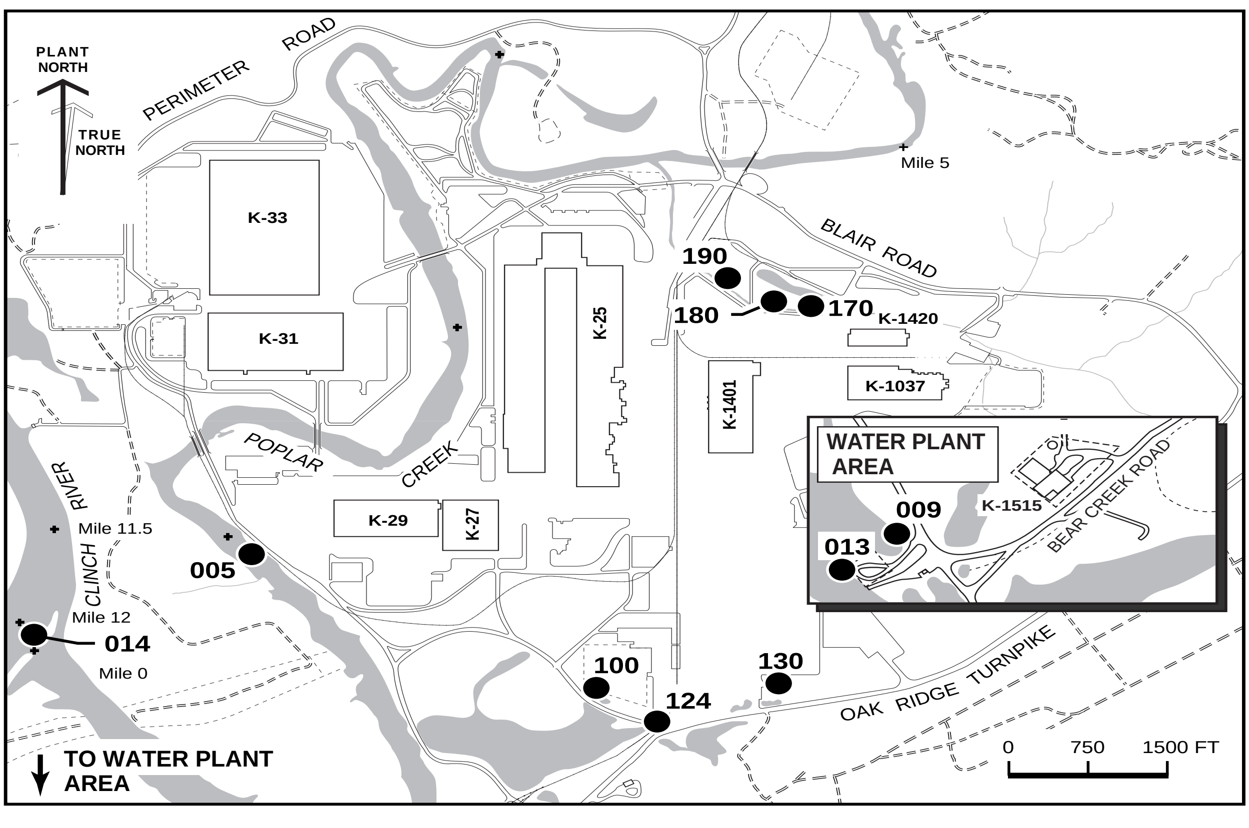

Fig. 4.22. ETTP NPDES major outfalls and Category I storm drain outfalls.

Table 4.12. Radionuclides released to off-site surface waters from the ETTP, 1996

Effluent discharge locations are K-1203, K-1407-J, and K-1515-C[a]

Isotope	Amount (Ci)[b]	Isotope	Amount (Ci)[b]
^{137}Cs	1.1E–04	^{234}Th	1.4E–03
^{237}Np	1.4E–05	^{234}U	4.6E–03
^{238}Pu	1.7E–04	^{235}U	3.7E–04
^{239}Pu	2.9E–05	^{236}U	5.2E–05
^{99}Tc	5.7E–02	^{238}U	6.1E–03

[a]Data collection for radionuclides at K-1515-C was discontinued in November.

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

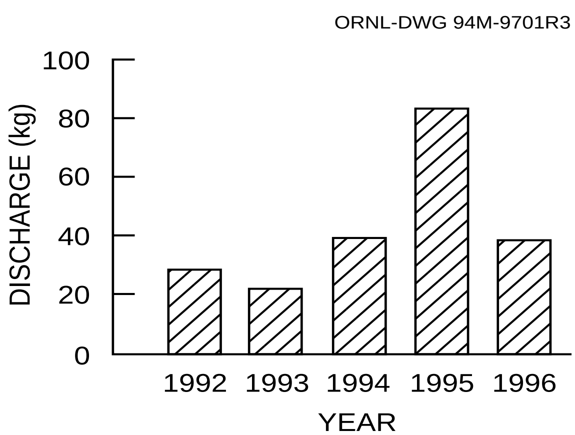

Fig. 4.23. Five-year trend of uranium releases to surface waters from the ETTP. Analysis includes discharge locations K-1203 and K-1407-J.

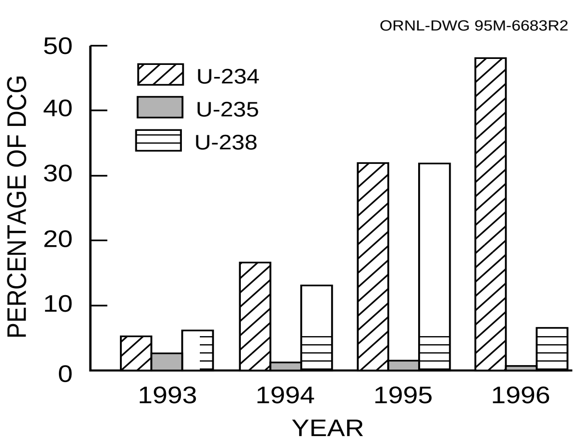

Fig. 4.24. Percentage of DCG for uranium isotopes from K-1407-J.

litigation and political debates about water pollution. The two main goals of the CWA are (1) to attain a level of water quality that provides for the protection and propagation of fish, shellfish, and wildlife and provides for recreation in and on the water and (2) to elimiate the discharge of pollutants into waters of the United States.

The CWA requires that EPA establish limits on the amounts of specific pollutants that may be discharged to surface waters. The standards, called effluent limitations, are written into NPDES permits issued to all municipal and industrial dischargers. The Y-12 Plant, ORNL, and the ETTP are each required to monitor discharges at frequencies specified in their permits to ensure compliance with the NPDES effluent limitations. The TDEC Division of Water Pollution Control has the authority to issue NPDES permits and to monitor compliance with the permits in the state of Tennessee under the Tennessee Water Control Act and according to the rules and regulations of the Tennessee Water Quality Control (QC) Board. DOE waste treatment facilities have formal wastewater acceptability control and surveillance programs that ensure the protection of the facilities and the proper treatment of wastes. Among other things, these programs define pretreatment requirements and waste acceptance criteria. Discharges are regulated under NPDES permits.

The CWA also created the Federal Pretreatment Program to regulate industrial discharges to sanitary sewer systems, which are also referred to as POTWs. Under the Federal Pretreatment Program, industries are required to monitor and regulate their discharges to a POTW. The state of Tennessee has created the Tennessee Pretreatment Program, which requires municipalities to develop their own municipal POTWs for their local industries. Municipal POTWs issue permits to industries, spelling out the responsibilities of the industries for pretreatment and compliance with the sewer-use ordinance. These responsibilities include monitoring their waste streams to determine pollutant concentration limits.

Sanitary wastewater from the Y-12 Plant is discharged to the city of Oak Ridge POTW. Both ORNL and the ETTP have on-site sewage treatment plants.

4.2.2.1 Y-12 Plant Surface Water and Liquid Effluents

The current Y-12 Plant NPDES permit, issued on April 28, 1995, and effective on July 1, 1995, requires sampling, analysis, and reporting at approximately 100 outfalls. The number is subject to change as outfalls are eliminated or consolidated or if permitted discharges are added. In 1996, two outfalls (outfall S21 and 55A) were physically eliminated; two outfalls (outfall 550 and 551) were activated; and outfall 05A was added. During the previous three years, 49 outfalls were eliminated as part of a program to remove or consolidate outfall pipes on EFPC. Since the mid-1980s more than 250 untreated wastewater point sources that had previously discharged to surface waters have been either eliminated from direct discharge or routed to a wastewater treatment facility. Currently, the Y-12 Plant has outfalls and monitoring points in the following water drainage areas: EFPC, Bear Creek, an unnamed tributary to McCoy Branch, and two unnamed tributaries to the Clinch River. At the end of 1996, there were 61 outfalls discharging various types of wastewater (condensate, cooling water, groundwater, water from building sumps, treated process wastewaters, and other wastewaters) to EFPC. Of the 61 outfalls, nine discharge storm water only; three discharge steam condensate only; two discharge groundwater only; and two are potable water blowdowns. Twenty-seven storm water outfalls are actually in-stream monitoring locations throughout the Y-12 Plant area. Seven internal monitoring points monitor the effluent from wastewater treatment facilities.

Discharges to surface water allowed under the permit include storm drainage, cooling water, cooling tower blowdown, and treated process wastewaters, including effluents from wastewater treatment facilities. Sumps that collect groundwater inflow in building basements are also permitted for discharge to the creek. The monitoring data collected by the sampling and analysis of permitted discharges are compared with the appropriate NPDES limits when a limit exists for each parameter. Some parameters are "monitor only," with no limits specified.

The water quality of surface streams in the vicinity of the Y-12 Plant is affected by current and past operations. Discharges from Y-12 Plant processes affect water quality and flow in EFPC before the water enters the Clinch River. In past years, discharge of coal bottom ash slurry to the McCoy Branch Watershed from the Y-12 Steam Plant occurred. This practice has been stopped, and coal ash is currently collected dry and is being used for recycle or for filler to support landfill operations. Bear Creek water quality is affected by area source runoff and groundwater discharges, and only storm water runoff is monitored under the NPDES permit (see Chap. 7 for details on groundwater).

1996 was the first full calendar year the Y-12 Plant operated under the permit that had been issued in 1995. The effluent limitations contained in the permit are based on the protection of water quality in the receiving streams. The permit places emphasis on storm water runoff and biological, toxicological, and radiological monitoring. Some of the more significant requirements in the permit are as follows:

- toxicity limitation for the headwaters of EFPC,
- quarterly toxicity testing at the wastewater treatment facilities,
- a compliance schedule to reduce mercury in EFPC,
- a compliance schedule for chlorine limitations at outfalls containing cooling water,
- chlorine limitations based on water quality criteria at the headwaters of EFPC,
- a compliance schedule for correction of elevated ammonia concentrations discharged to EFPC from a groundwater spring,
- a requirement to manage the flow of EFPC such that a minimum flow of 7 million gal/day is guaranteed by adding raw water from

the Clinch River to the headwaters of the creek,

- sampling of storm water at a minimum of 25 locations per year,
- a storm water pollution plan, and
- in-stream pH limitations on tributaries to Bear Creek and various other tributaries on the south side of Chestnut Ridge.

4.2.2.2 Sanitary Wastewater

Sanitary wastewater from the Y-12 Plant is discharged to the city of Oak Ridge POTW under Industrial and Commercial Users Wastewater Permit Number 1-91. Monitoring is conducted under the terms of the permit for a variety of organic and inorganic pollutants. During 1996, the wastewater flow in this system averaged about 854,000 gal/day (3,885,000 L/day).

Compliance sampling is conducted at the EESSMS (SS-6, Fig. 4.10) on a weekly basis. In addition, throughout 1996 mercury composite samples were obtained daily, Monday through Thursday, and a three-day composite was obtained for the weekend (Friday through Sunday). This monitoring station is also used for 24-hour flow monitoring. As part of the city of Oak Ridge pretreatment program, city personnel also use this monitoring station to perform compliance monitoring as required by pretreatment regulations.

Results

In 1996, the Y-12 Plant experienced an increase in NPDES excursions from six in 1995 to ten in 1996. Only four of the excursions were caused by exceedences of wastewater discharge limits. In 1996, none of the Y-12 Plant NPDES excursions were attributable to administrative errors such as missing analytical sample holding times, loss of a sample, or improper sample preservation. All Y-12 Plant NPDES permit excursions recorded in 1996 are summarized in Appendix F, Table F.1. Table 4.13 records the NPDES compliance monitoring requirements and the 1996 compliance record.

Monitoring of nonradiological parameters on Bear Creek at km 11.97 was reduced from weekly to semiannually in August 1996. Sampling in the upper Bear Creek area was initiated in 1983 as part of a memorandum of understanding between DOE, EPA, and the state of Tennessee to characterize effects of S-3 Pond discharges. This commitment has been satisfied; sampling of surface waters in the Bear Creek drainage area is now conducted at other locations to satisfy NPDES permit requirements and as part of remedial actions being conducted under CERCLA. Analytical data are reported to TDEC in an attachment to the discharge monitoring report required by NPDES. Surface water in the upper reaches of Bear Creek contains elevated trace metals and nitrate concentrations.

Table 4.14 summarizes Y-12 Plant contributions to the sanitary sewer system for 1996. During 1996, the Y-12 Plant experienced two exceedences of the discharge permit issued by the City of Oak Ridge. Both exceedences were for mercury and occurred as a result of rehabilitation activities on the sanitary sewer.

Progress in Implementing Corrective Actions and Significant Improvements

East Fork Poplar Creek Dechlorination

Two dechlorination systems that began operating in December 1992 continued to provide dechlorination for 75% of EFPC flow (20% of EFPC flow is estimated to be groundwater and 5% represents flows that do not require dechlorination). In-stream levels of total residual chlorine were typically about 0.01 mg/L during 1996 (outfall discharge levels before 1993 were about 0.3 to 1.0 mg/L). Fish populations and density have increased significantly. Additional dechlorination has been achieved by installation of tablet dechlorinators during 1993 through 1995 (which now total 42) at chlorine-discharge sources. Outfall 125, the next largest non-dechlorinated outfall, began treatment in 1995, following installation of a dechlorination system in late 1994.

Table 4.13. NPDES compliance monitoring requirements and record for the Y-12 Plant, January through December 1996

Discharge point	Effluent parameter	Effluent limits				Percentage of compliance	No. of samples
		Daily av (kg/d)	Daily max (kg/d)	Daily av (mg/L)	Daily max (mg/L)		
Outfall 066	pH, standard units			*a*	9.0	100	5
Outfall 068	pH, standard units			*a*	9.0	100	12
Outfall 117	pH, standard units			*a*	9.0	100	7
Outfall 073	pH, standard units			*a*	9.0	100	12
	Total residual chlorine				0.5	100	12
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*	0
Outfall 133	pH, standard units			*a*	9.0	*b*	0
	Total residual chlorine				0.5	*b*	0
Outfall 125	pH, standard units			*a*	9.0	100	12
	Total residual chlorine				0.5	100	12
Category I outfalls (Storm water, steam condensate, cooling tower blowdown, and groundwater)	pH, standard units			*a*	9.0	100	60
Category I outfalls (Outfalls S15 and S16)	pH, standard units			*a*	10.0	100	6
Category II outfalls (cooling water, steam condensate, storm water, and groundwater)	pH, standard units			*a*	9.0	100	110
	Total residual chlorine				0.5	98	68
Category II outfalls (S21, S22, S25, S26, S27, S28, and S29)	pH, standard units			*a*	10.0	100	26
Outfall S19 (Rogers Quarry)	pH, standard units			*a*	9.0	100	14

Table 4.13 (continued)

Discharge point	Effluent parameter	Effluent limits: Daily av (kg/d)	Daily max (kg/d)	Daily av (mg/L)	Daily max (mg/L)	Percentage of compliance	No. of samples
Category III outfalls (storm water, cooling water, cooling tower blowdown, steam condensate, and groundwater)	pH, standard units			*a*	9.0	100	171
	Total residual chlorine				0.5	100	120
Outfall 201 (below the North/South pipes)	Total residual chlorine			0.011	0.019	100	160
	Temperature, °C			*a*	30.5	100	160
Outfall 200 (North/South pipes)	pH, standard units			10	8.5	99	160
	Oil and grease				15	100	160
Outfall 021	Total residual chlorine			0.080	0.188	100	158
	Temperature, °C			*a*	30.5	100	157
	pH, standard units				9.0	100	161
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	110
	Mercury				0.004	100	106
	Total residual chlorine				0.5	100	110
Outfall 55A	pH, standard units			*a*	9.0	100	26
	Mercury				0.004	100	26
Outfall 550	pH, standard units			*a*	9.0	*b*	35
	Mercury			0.002	0.004	*b*	35
Outfall 551	pH, standard units				9.0	*b*	76
	Mercury				0.004	*b*	7
Outfall 051	pH, standard units			*a*	9.0	100	110
Outfall 501 (Central Pollution Control Facility)	pH, standard units			*a*	9.0	100	8
	Total suspended solids	0.16	0.4	31.0	40.0	100	8
	Total toxic organics	1.0	1.7	10	2.13	100	0[c]
	Oil and grease	1.2	2.0	0.075	15	100	8
	Cadmium	0.26	0.4	0.5	0.15	100	8
	Chromium	1.4	2.4	0.5	1.0	100	8
	Copper	0.14	0.26	0.10	1.0	100	8
	Lead	0.9	1.6	2.38	0.20	100	8
	Nickel	0.4	0.72	0.05	3.98	100	8

Table 4.13 (continued)

Discharge point	Effluent parameter	Effluent limits				Percentage of compliance	No. of samples
		Daily av (kg/d)	Daily max (kg/d)	Daily av (mg/L)	Daily max (mg/L)		
	Silver			148	0.05	100	8
	Zinc			0.65	2.0	100	8
	Cyanide				1.20	100	8
	PCB				0.001	100	0[c]
Outfall 502 (West End Treatment Facility)	pH, standard units			*a*	9.0	100	39
	Total suspended solids	18.6	36.0	31.0	40.0	100	39
	Total toxic organics	0.16	0.4	100	2.13	100	5
	Nitrate/nitrite	1.0	1.7	10	150	100	39
	Oil and grease	1.2	2.0	0.075	15	100	39
	Cadmium	0.26	0.4	0.5	0.15	100	39
	Chromium	1.4	2.4	0.5	1.0	100	39
	Copper	0.14	0.26	0.10	1.0	100	39
	Lead	0.9	1.6	2.38	0.20	100	39
	Nickel	0.4	0.72	0.05	3.98	100	39
	Silver			1.48	0.05	100	39
	Zinc			0.65	2.0	100	39
	Cyanide				1.2	100	39
	PCB				0.001	100	5
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	0.83	0.83	0.075	0.15	*b*	0
	Chromium	4.17	4.17	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			1.0	1.0	*b*	0
Outfall 512 (Groundwater Treatment Facility)	pH			*a*	9.0	100	155
	Iron				1.0	99	157
	PCB				0.001	100	12
Outfall 520	pH, standard units				9.0	*b*	0

[a]Not applicable.

[b]No discharge.

[c]Last sample was July 1995 before a carbon column change. The next sample is due before the next carbon column change or before the end of the permit year, which is July 1997.

Table 4.14. Y-12 Plant Discharge Point SS6, Sanitary Sewer Station 6, Nonradiological Summary
(1/1/96–12/31/96)

Parameter	Number of samples	Concentration[a]			Reference value[b]	Number of values exceeding reference
		Max	Min	Av		
Flow, gpd[c]	366	2,601,718	227,610	852,312	*d*	*d*
pH, standard units	53	8.4	7.0	*d*	9/6[e]	0
Silver	53	0.027	<0.006	<0.007	0.1	0
Boron	53	0.05	<0.02	<0.03	*d*	*d*
Cadmium	53	<0.004	<0.004	<0.004	0.00024	0[f]
Cyanide	42	<0.01	<0.01	<0.01	0.007	0[f]
Chemical oxygen demand	42	170.0	25.0	56.6	*d*	*d*
Chromium	53	0.009	<0.006	<0.006	0.44	0
Ion chromium (Cr+6)	42	<0.01	<0.01	<0.01	0.002	0[f]
Copper	53	0.024	0.01	0.016	0.04	0
Iron	53	1.02	0.26	0.48	1.5	0
Mercury	249	0.066	0.0004	0.0056	0.1/0.035[g]	2
Manganese	53	0.141	0.028	0.057	1	0
Nitrogen as ammonia	39	9.1	1.7	6.0	*d*	*d*
Nickel	53	<0.008	<0.008	<0.008	0.1	0
Oil and grease	53	28.0	<2.0	<4.6321	50	0
Lead	53	<0.02	<0.02	<0.02	0.0016	0[f]
Phenols	42	0.26	<0.005	<0.0269	5	0
Selenium	53	<0.1	<0.1	<0.1	*d*	*d*
Total Kjeldahl nitrogen	53	28.0	5.2	11.9	90	0
Total suspended solids	53	100.0	<5.0	<45.6698	300	0
Zinc	53	0.23	0.09	0.13	2	0

[a]Units in mg/L unless otherwise indicated.
[b]Sanitary Sewer Industrial Users permit limits.
[c]Flow during operations and/or discharging.
[d]Not applicable.
[e]Maximum value/minimum value.
[f]The detection limit for this parameter is above the reference value.
[g]Reference value prior to April 14, 1996; reference value after April 14, 1996.

Ecological recovery of EFPC is continuing, and some significant recent trends have been observed. Pollution-intolerant fish species are being found below Lake Reality, and there has been substantial reduction in toxicity above Lake Reality. However, both fish and benthic macroinvertebrate communities in UEFPC are dominated by pollution-tolerant species, especially above Lake Reality. Additional recovery may occur in response to reductions in mercury levels in EFPC. Complete recovery may not occur because water temperatures remain elevated, inadvertent discharges/spills may occur, and availability of habitat is limited above Lake Reality.

Flow Management (or Raw Water) Project

Discharges to EFPC have decreased in volume from about 10 million gal/day (38 million L/day) in the early 1980s to about 3.5 million gal/day (13.2 million L/day) currently, primarily because of reductions in plant operations. These reductions have increased concern about maintaining water quality and stable flow in the upper reaches of EFPC. Accordingly, the current NPDES permit requires addition of Clinch River water to the headwaters of EFPC (North/South Pipe-Outfall 200 area) by March 1997 so that a minimum flow of 7 million gal/day (26.5 million L/day) is maintained at the point where EFPC leaves the reservation. This project was completed in August 1996, when raw water began flowing at 3.5 million gal/day (13.2 million L/day), thus increasing flow in EFPC to the required minimum. In-stream water temperatures decreased approximately 5°C (from approximately 26°C at the headwaters).

Non-Point-Source Studies

Storm water runoff is required to be sampled periodically and analyzed for many contaminants according to the *Stormwater Pollution Prevention Plan for the Oak Ridge Y-12 Plant* (LMES 1995b). The plan was issued in September 1995 in accordance with provisions of the NPDES permit. The plan presents (1) programmatic and physical BMP controls implemented at the Y-12 Plant, (2) surveillance programs, and (3) a monitoring plan for characterizing storm water discharges. Storm water runoff data from previous years were analyzed and the *Feasibility Study of Best Management Practices for Non-Point Source Pollution Control at the Oak Ridge Y-12 Plant* (CDM 1993) was issued in 1993. Additional studies were initiated on the basis of this report. Sampling of parking lots, the metal scrap yard, and selected building roofs was completed in 1994. The data will help determine whether the areas are specific sources of contaminants observed in storm water flow in EFPC. These types of investigations will continue as necessary to ensure compliance with the NPDES permit and other regulatory requirements.

Drain Modifications and Reroutes

Extensive drain surveys conducted in years previous to 1993 identified incorrectly connected building drains to either the sanitary or storm sewers. Most of these drains were administratively closed at that time. Permanent and physical changes to provide correct drain routings were designed and initiated in 1993 for 32 “major” buildings. Since that time, work has been completed in 29 buildings. Several changes were made to the initial plans because of the ongoing downsizing of the plant. The remaining buildings will be completed as funding appropriations permit.

In addition, a project to survey all the remaining and previously unsurveyed building drains at the Y-12 Plant was completed in early 1995. Incorrectly routed drains were identified for closure or correction, and many drains were corrected or eliminated. A validation project was initiated in 1996 to confirm the status of building floor drains. Any drains found to be open are required to be plugged or “permitted” open by an internal process. New building drain maps and drain status records are being generated. This work is planned for completion by 1998. Further corrective actions will be taken as funding appropriations permit and as needs dictate.

Reduction of Mercury in Plant Effluent (RMPE): Phase II

The legacy of contamination resulting from use and storage of mercury at the Y-12 Plant has prompted a series of remedial measures. The RMPE II program is structured to serve as a bridge between downstream remediation of EFPC and upstream remedial actions at the Y-12 Plant. These efforts are directed toward meeting the NPDES permit requirements of 5 g/day from the Y-12 Plant by December 31, 1998. Six projects (four building source elimination efforts and two treatment units) have been identified under the RMPE II program to reduce mercury contamination to UEFPC.

Significant progress toward reduction of mercury in discharges to EFPC has been achieved during the past three years. Construction and start-up of the Interim Mercury Treatment Unit (IHgTU) for Building 9201-2 was completed in September 1994. A study was initiated in 1995 to evaluate upgrading the IHgTU to a permanent system. The upgrade called the East End Mercury Treatment Facility (EEMTF) was completed in early 1996. The EEMTF, which continues to operate, treated more than 4.9 million gal (18.8 million L) of water in 1996. Some elimination work, consisting of rerouting pipes for buildings 9201-2, 9201-5, 9201-4, and 9204-4, was completed in early 1996, several months ahead of the required schedule.

To provide permanent mercury treatment capability, the Central Mercury Treatment System (CMTS) began operation on November 26, 1996. The facility is located in the existing Central Pollution Control Facility in Building 9623. Mercury-contaminated groundwater originating from sumps in buildings 9201-4, 9201-5, and 9204-4 is collected and piped or transported to CMTS for treatment. The discharge of the CMTS is through NPDES outfall 551.

Fish Kill Summary

During 1996, the Y-12 Plant reported no incidents to TDEC involving fish kills attributable to activities at the Y-12 Plant.

4.2.2.3 ORNL Nonradiological Summary

Effluents

ORNL NPDES permit TN0002941 was renewed on December 6, 1996, to become effective on February 3, 1997. Data collected for the NPDES permit are submitted to the state of Tennessee in the monthly *Discharge Monitoring Report*.

ORNL's NPDES permit requires that point-source outfalls be sampled before they are discharged into receiving waters or before they mix with any other wastewater stream (see Fig. 4.14). ORNL operated during all of CY 1996 under the permit that expired on December 6, 1996. Under that permit, numeric and aesthetic effluent limits have been placed on the following locations:

- X01-STP;
- X02-Coal Yard Runoff Treatment Facility (CYRTF);
- X12-NRWTF;
- X13-Melton Branch;
- X14-WOC;
- X15-WOD;
- CAT1-Category I outfalls (storm drains);
- CAT2-Category II outfalls (roof drains, parking lot drains, storage area drains, spill area drains, once-through cooling water, cooling-tower blowdown, condensate, and disposal demonstration area);
- CAT3-Category III outfalls (drains that at one time included process and/or lab constituents); and
- COOLS-Cooling Systems (cooling water, cooling tower blowdown, and cleaning wastes originating at space-cooling facilities).

Permit limits and compliance are shown by location in Table 4.15. Compliance with the NPDES permit for the last three years is summarized by major effluent locations in Fig. 4.25. The figure provides a list of the effluent locations and the number of noncompliances at each location. Most permit limit excursions in 1996 occurred at

Table 4.15. 1996 NPDES compliance at ORNL

Discharge point	Effluent parameters	Permit limits: Monthly av (kg/d)	Permit limits: Daily max (kg/d)	Permit limits: Monthly av (mg/L)	Permit limits: Daily max (mg/L)	Permit limits: Daily min (mg/L)	Permit compliance: Number of noncompliances	Permit compliance: Number of samples	Permit compliance: Percentage of compliance[a]
X01	Ammonia, as N (summer)	3.5	5.2	4.0	6.0		0	92	100
(Sewage	Ammonia, as N (winter)	7.8	11.8	9.0	13.5		0	66	100
Treatment	Biochemical oxygen demand	8.7	13.1	10	15		0	92	100
Plant)	(summer)								
	Biochemical oxygen demand (winter)	17.4	26.2	20	30		0	66	100
	Chlorine, total residual				0.5		0	157	100
	Dissolved oxygen					6.0	0	250	100
	Downstream pH (SU)				9.0	6.0	0	53	100
	Fecal coliform (col/100 mL)[b]			1000	5000		1	157	99
	Oil and grease	8.7	13.1	10	15		0	157	100
	pH (SU)				9.0	6.0	0	53	100
	Total suspended solids	26.2	39.2	30	45		0	158	100
X02	Chromium, total			0.2	0.2		0	52	100
(Coal Yard	Copper, total			1.0	1.0		0	52	100
Runoff	Downstream pH (SU)				9.0	6.0	0	52	100
Treatment	Iron, total			1.0	1.0		2	52	96
Facility)	Oil and grease			15	20		0	52	100
	pH (SU)				9.0	6.0	0	52	100
	Selenium, total			0.22	0.95		0	52	100
	Temperature (°C)				30.5		0	52	100
	Total suspended solids				50		0	52	100
	Zinc			1.0	1.0		0	52	100
X12	Cadmium, total	0.79	2.09	0.26	0.69		0	53	100
	Chromium, total	5.18	8.39	1.71	2.77		0	53	100
(Nonradiological	Copper, total	6.27	10.24	2.07	3.38		0	53	100
Wastewater	Cyanide, total	1.97	3.64	0.65	1.20		0	53	100
Treatment	Downstream pH (SU)				9.0	6.0	0	250	100
Facility)	Lead, total	1.30	2.09	0.43	0.69		0	53	100
	Nickel, total	7.21	12.06	2.38	3.98		0	53	100
	Oil and grease	30.3	45.4	10	15		0	53	100

Table 4.15 (continued)

Discharge point	Effluent parameters	Permit limits: Monthly av (kg/d)	Daily max (kg/d)	Monthly av (mg/L)	Daily max (mg/L)	Daily min (mg/L)	Permit compliance: Number of noncompliances	Number of samples	Percentage of compliance[a]
X12	pH (SU)				9.0	6.0	0	*c*	100
(Nonradiological	Silver, total	0.73	1.30	0.24	0.43		0	53	100
Wastewater	Temperature (°C)				30.5		0	250	100
Treatment	Total suspended solids	93.9	182	31	60		0	53	100
Facility)	Total toxic organics		6.45		2.13		0	53	100
	Zinc, total	4.48	7.91	1.48	2.61		0	53	100
Category I	Downstream pH (SU)				9.0	6.0	0	22	100
outfalls[d]	Oil and grease			10	15		0	22	100
	pH (SU)				9.0	6.0	0	22	100
	Temperature (°C)				30.5		0	22	100
	Total suspended solids			30	50		4	22	82
Category II	Downstream pH (SU)				9.0	6.0	0	148	100
outfalls	Downstream temperature (°C)[e]				30.5		0	39	100
	Oil and grease								
	pH (SU)			10	15		0	148	100
	Total suspended solids				9.0	6.0	0	148	100
				30	50		9	148	94
Cooling Systems	Chlorine, total residual				0.2		0	12	100
	Chromium, total				1.0		0	12	100
	Copper, total			0.5	1.0		0	12	100
	Downstream pH (SU)				9.0	6.0	0	12	100
	pH (SU)				9.0	6.0	0	12	100
	Temperature (°C)			35	38		0	12	100
	Zinc, total			0.5	1.0		0	12	100

[a]Percent compliance = 100 – [(number of noncompliances/number of samples) * 100].
[b]Colonies per 100 mL.
[c]pH monitoring is continuous.
[d]Category I outfalls are monitored annually by the NPDES permit year of April 1–March 31.
[e]Downstream temperature is monitored to check that the stream temperature standards stated in the General Water Quality Criteria for the Definition and Control of Pollution in the Waters of Tennessee are not violated as a result of this discharge.

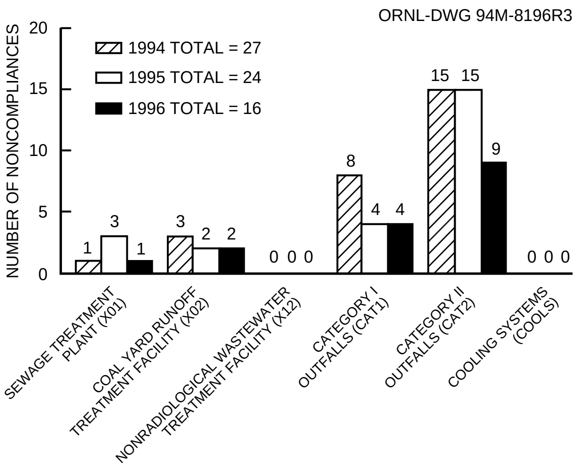

Fig. 4.25. ORNL NPDES limit compliance status comparison and locations of noncompliances, 1994–96.

the Category II outfalls. All Category II limit excursions in 1996 were associated with total suspended solids (TSS), typically residual dust or dirt particles, conveyed in storm water runoff.

ORNL Outfall X01, the STP, experienced one exceedence of the NPDES fecal coliform bacteria limit in July 1996. ORNL had received approximately 2.7 inches of rainfall on the day of the exceedence; however, other pertinent parameters that are monitored at STP, including chlorine, were within normal ranges. Therefore, no certain cause for the exceedence could be established. ORNL is currently in the process of installing an ozonation disinfection system for the STP, which should further enhance compliance with NPDES fecal coliform discharge limits in the future.

ORNL Outfall X02, the CYRTF, experienced two exceedences of the NPDES iron limit, one in May 1996 and one in August 1996. At the time of the May exceedence, ORNL personnel were in the process of removing accumulated sediment from the upper CYRTF settling basin. The sediment removal activity, which consisted of stabilizing the sediment with cement dust and removing the sediment with a mechanical loader, may have contributed to the concentration of effluent iron that was measured. No certain cause was established for the August iron exceedence. Previous ORNL investigations have shown that surface algae, which are abundant on the CYRTF discharge basin in late summer and early fall, tend to accumulate iron from the basin water. As no unusual circumstances were identified on the date of the iron exceedence, it is believed that algal accumulation of iron may have been a contributing factor. At X12, all parameters were 100% in compliance. All required NPDES monitoring and reporting were conducted on schedule. ORNL had no fish kills in 1996.

At the Category I and II outfalls, exceedences of limits on TSS were attributed to flushing of parking lots or streets by storm water runoff. Category I and II outfalls are not contaminated by any known activity, nor do they discharge through any oil-water separator, other treatment facility, or equipment. During rain events, waters from the parking lots and surrounding areas drain into these outfalls, carrying suspended solids and other residue. This situation may result in TSS exceedences. BMPs (including frequent street sweeping) are in place to help avoid these exceedences. In addition, a plan is currently being carried out to improve sampling points at selected outfalls. At the cooling systems, all parameters were 100% in compliance.

Mercury in the Aquatic Environment

The mercury-monitoring program at ORNL was conducted to comply with the CWA and Part III of the ORNL NPDES permit issued in 1986. Samples of surface water and stream sediment in Bethel and Melton valleys were collected semiannually and analyzed for mercury content.

Prior to the stringent regulations now in effect, some contaminants reached various streams primarily as the result of accidental spills or leakages. Most mercury spills occurred from 1954 through 1963, during a period when ORNL was involved with OREX and METALLEX separations processes. Most of this activity occurred in or around buildings 4501, 4505, and 3592 in the main plant area. These processes are no longer in operation at ORNL. During the time of operation, an unknown number of mercury spills occurred. The spills were cleaned up; however, some quantities of mercury escaped and reached the surrounding environment. Sampling locations were selected in areas surrounding known mercury spills. Additional sampling locations were selected downstream from the outfalls and drains to determine mercury transport in surface water and sediment.

Locations for surface water samples are shown in Fig. 4.26. In 1996, a total of 78 samples were taken from 13 locations. Mercury was detected at 6 of the 13 sampling locations. The highest value reported was 0.55 μg/L near Outfall 207 in WOC, slightly higher than the 1995 high value of 0.44 μg/L at the same location. Average concentrations ranged from 0.13 to 0.36 μg/L. The Tennessee Water Quality Criteria for the protection of fish and aquatic life sets a maximum concentration of 2.4 μg/L for mercury in water. The highest concentration, near Outfall 207, was 23% of the reference value.

Locations for sediment sampling are shown in Fig. 4.27. In 1996, a total of 54 sediment samples were taken from nine stream locations. The highest value reported was 120 μg/g near Outfall 261 on Fifth Creek, considerably lower than the 1995 high value of 880 μg/L at the same site. Average values at the other sites ranged from 0.056 to 17 μg/g.

PCBs in the Aquatic Environment

The PCB monitoring program at ORNL was conducted to comply with the CWA and Part III of the ORNL NPDES permit issued in 1986. Samples of stream sediment were collected semiannually and analyzed for PCB Aroclor content. The program to collect water samples for PCB analysis was dropped in 1992, because PCB levels in the water samples had been below analytical detection limits for several years.

In 1996, duplicate samples of sediment were collected at ten locations in streams at and around ORNL (Figs. 4.28 and 4.29). Samples from each location were analyzed by the analytical laboratory for Aroclors 1016, 1221, 1232, 1242, 1248, 1254, and 1260. Only three locations had results above detection limits. Six additional locations had laboratory-estimated values below the detection limit. The maximum concentration, 1900 μg/kg for Aroclor-1260, was reported at a

ORNL-DWG 92M-13528R2

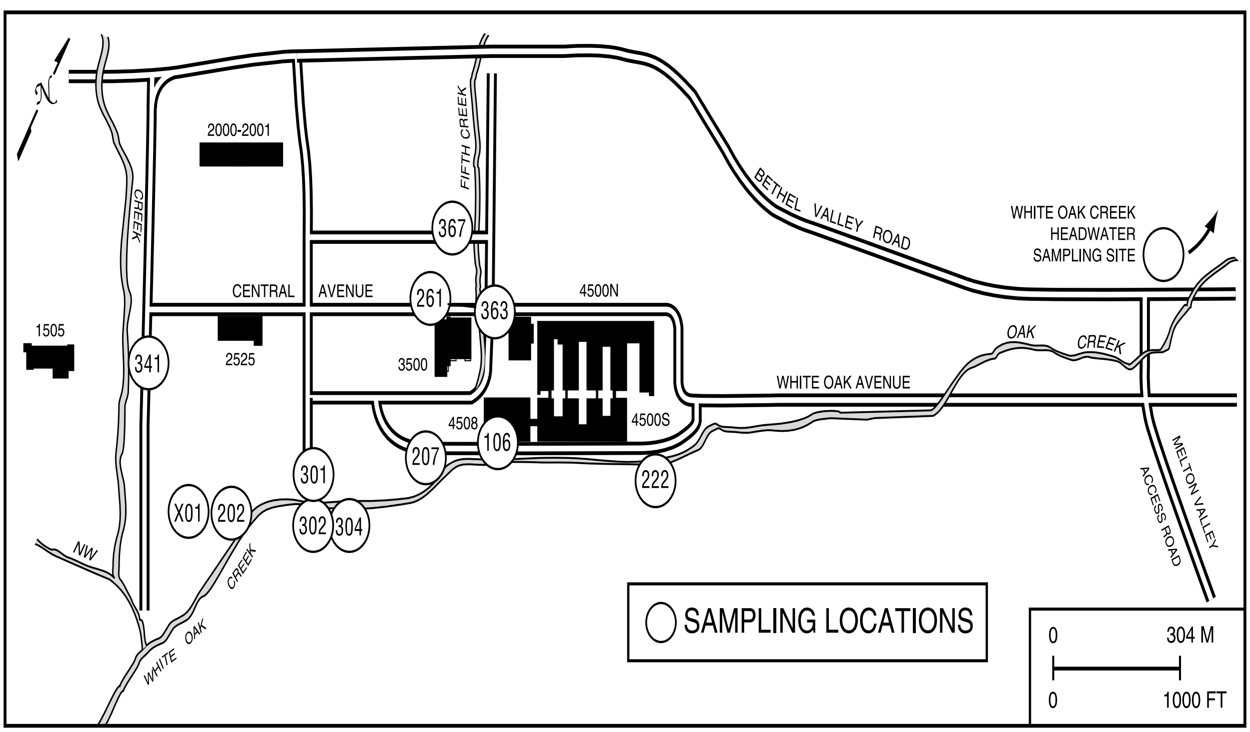

Fig. 4.26. ORNL sampling locations for mercury in water.

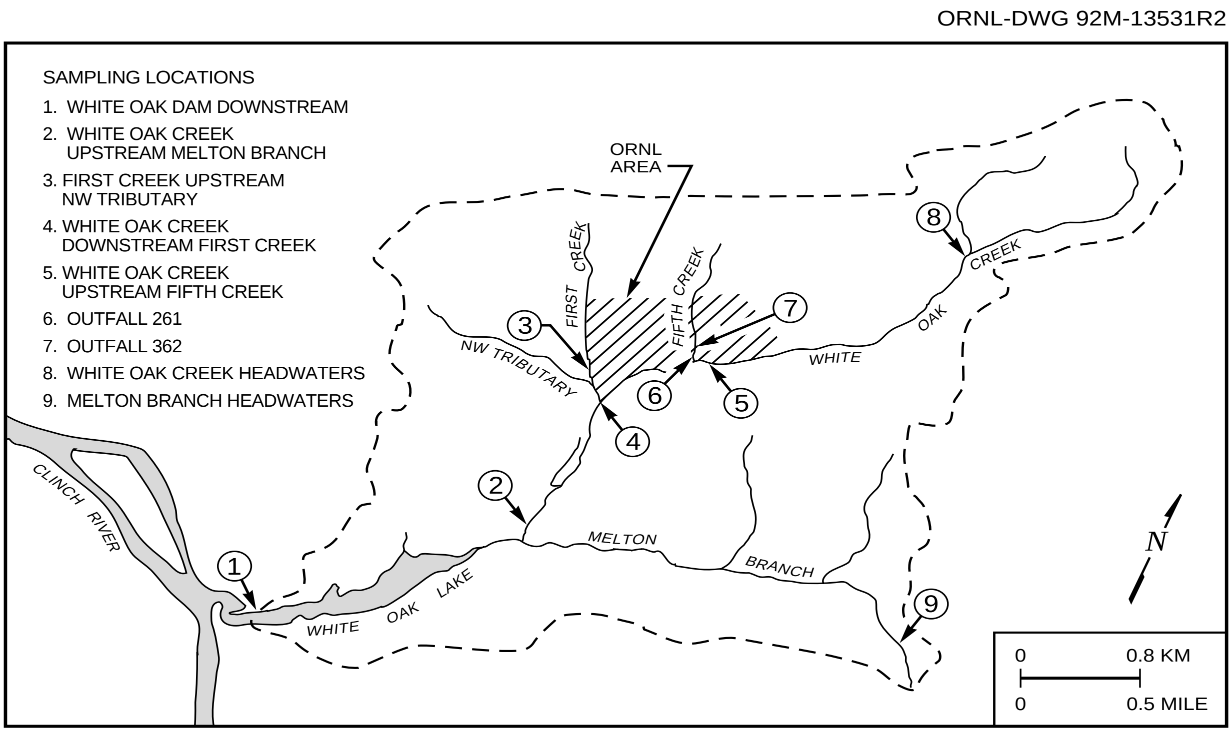

Fig. 4.27. ORNL sampling locations for mercury in sediment.

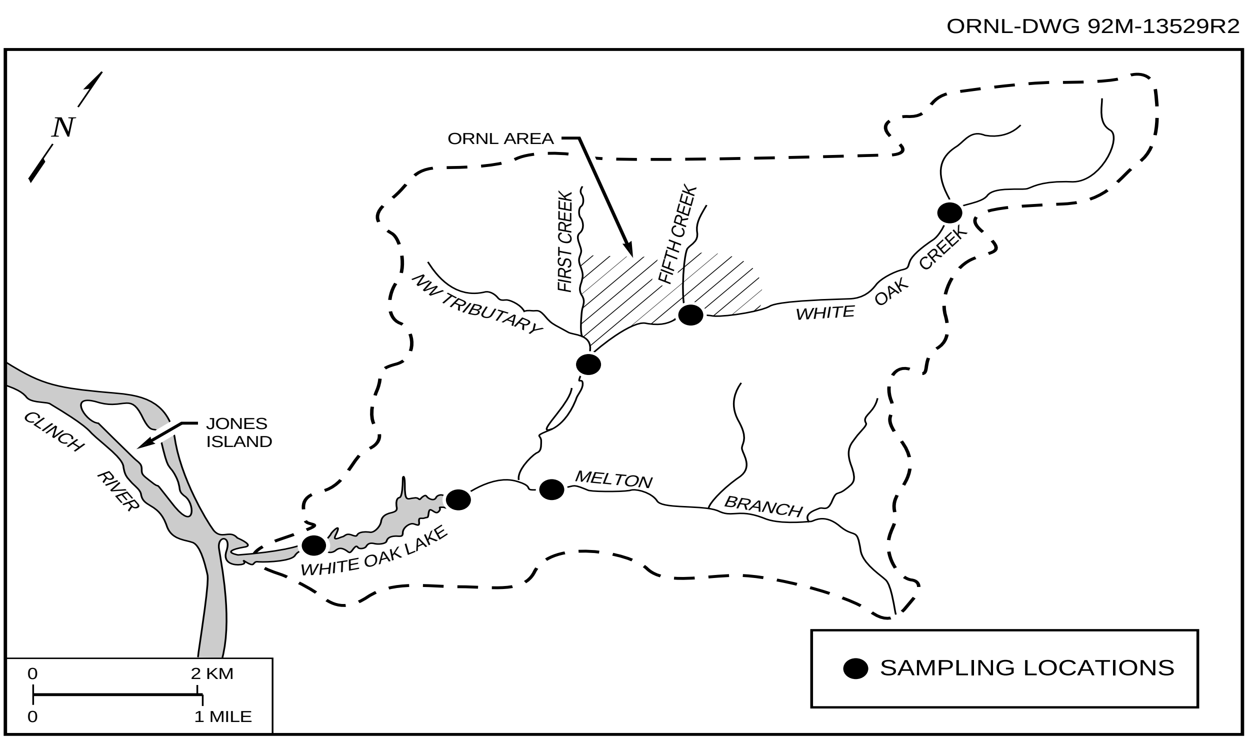

Fig. 4.28. ORNL sampling locations for polychlorinated biphenyls.

ORNL-DWG 92M-13530R

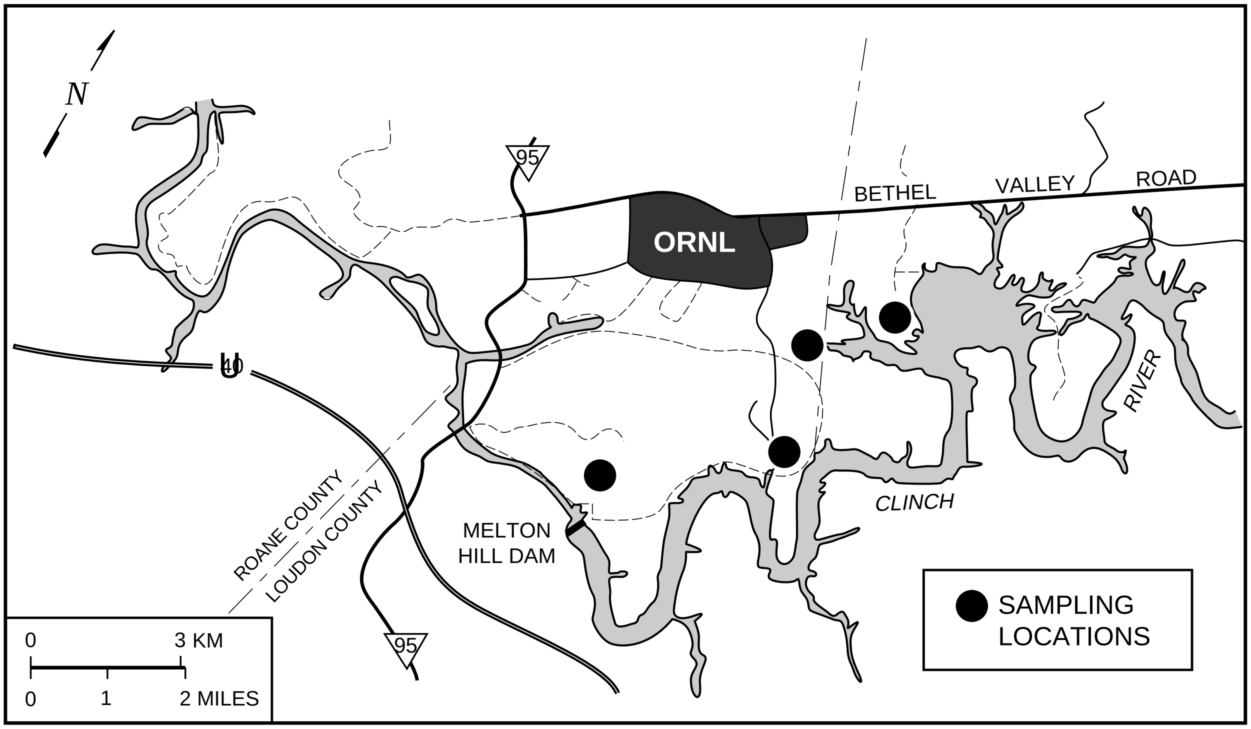

Fig. 4.29. Sampling locations for polychlorinated biphenyls in the greater ORNL area.

site on WOC, upstream of the weir at the 7500 Road Bridge. Results for most samples collected in 1996 were below analytical detection levels or were estimated by the laboratory at or below the detection level.

4.2.2.4 ETTP Surface Water Effluents

The current ETTP NPDES permit went into effect on October 1, 1992, and a major revision was issued effective June 1, 1995. The revision included the removal of inactive outfalls, the addition of effluent limits for new treatment technologies at CNF, the addition of new storm drains, and clarification of various requirements. In accordance with the NPDES permit, the ETTP is authorized to discharge process wastewater, cooling water, storm water, steam condensate, and groundwater to the Clinch River, Poplar Creek, and Mitchell Branch. The permit currently includes four facility outfalls and 136 storm water outfalls. Compliance with the permit for the last five years is summarized by the major effluent locations in Fig. 4.30. Table 4.16 details the permit requirements and compliance records for all of the outfalls that discharged during 1996. The table provides a list of the discharge points, effluent analytes, permit limits, number of noncompliances, and the percentage of com-

ORNL-DWG 94M-8675R3

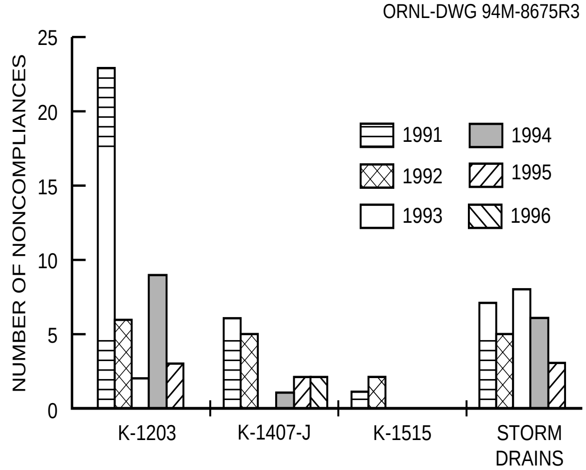

Fig. 4.30. ETTP NPDES compliance history by source of noncompliance.

Table 4.16. NPDES compliance at the ETTP, 1996

Discharge point	Effluent parameter	Effluent limits				No. of noncompliances	Percentage of compliance
		Monthly av[a]	Daily max[a]	Monthly av (lb/day)	Daily max (lb/day)		
005 (K-1203 Sewage Treatment Facility)	Ammonia nitrogen	5	7	12	17		100
	Biochemical oxygen demand	15	20	37	49		100
	Chlorine, total residual	0.14	0.24				100
	Dissolved oxygen		5[b]				100
	Fecal coliform, col/100 ml	200[c]	1,000				100
	Flow, Mgd	*d*	*d*				100
	LC_{50}, *Ceriodaphnia*, %		14.6[b]				100
	LC_{50}, *Pimephales*, %		14.6[b]				100
	NOEL,[e] *Ceriodaphnia*, %		4.2[b]				100
	NOEL,[e] *Pimephales*, %		4.2[b]				100
	pH, standard units		6.0–9.0				100
	Settleable solids, mL/L		0.5				100
	Suspended solids	30	45	74	111		100
	Unpermitted discharge	*f*	*f*	*f*	*f*		*f*
009 (K-1515-C Sanitary Water Plant)	Aluminum	1.0	2.0				100
	Chlorine, total residual		1.0				100
	Flow, Mgd	*d*	*d*				100
	pH, standard units		6.0–9.0				100
	Settleable solids, mL/L		0.5				100
	Suspended solids	30	40				100
	Unpermitted discharge	*f*	*f*	*f*	*f*		*f*
013 (K-1513 Sanitary Water Intake and Backwash filter	Visual inspection of receiving stream						
014 (K-1407-J Central Neutralization Facility to Clinch River)	1,1,1-Trichloroethane	*d*	*d*				100
	Acetone	*d*	*d*				100
	Acetonitrile	*d*	*d*				100
	Benzene	*d*	0.005				100
	Bromoform	*d*	*d*				100
	Cadmium	0.18	0.69				100
	Carbon tetrachloride	0.5	0.5				100
	Chemical oxygen demand	*d*	*d*				100
	Chloride, total	35,000	70,0000				100
	Chlorine, total residual		1.0				100
	Chlorodibromomethane	*d*	*d*				100
	Chloroform	0.5	0.5				100
	Chromium	1.71	2.77				100
	Copper	1.34	2.15				100
	Dichlorobromemethane	*d*	*d*				100
	Flow, Mgd	*d*	*d*				100
	Ethylbenzene	*d*	0.01				100
	Gross alpha, pCi/L	*d*	*d*				100
	Gross beta, Pci/L	*d*	*d*				100
	Lead	0.38	0.69				100
	Methyl ethyl ketone	*d*	*d*				100
	Methylene chloride	*d*	*d*				100
	Naphthalene	*d*	*d*				100
	Nickel	2.38	3.98				100
	Oil and grease		30				100
	PCB	0.00022	0.00045				100
	Petroleum hydrocarbons	*d*	0.1			1	91.7
	pH, standard units		6.0–9.0				100

Table 4.16 (continued)

Discharge point	Effluent parameter	Effluent limits: Monthly av[a]	Daily max[a]	Monthly av (lb/day)	Daily max (lb/day)	No. of noncompliances	Percentage of compliance
014 (continued)	Silver	0.24	0.43				100
	Suspended solids		40				100
	Tetrachloroethylene		0.7				100
	Toluene	*d*	0.01				100
	Total toxic organics		2.13				100
	Trichloroethylene	0.5	0.5				100
	Unpermitted discharge	*f*	*f*	*f*	*f*	1	*f*
	Uranium, total	*d*	*d*				100
	Vinyl chloride	0.2	0.2				100
	Zinc	1.48	2.61				100
Category I storm drains	Flow, Mgd	*d*	*d*				100
	pH, standard units		4.0–9.0				100
	Unpermitted discharge	*f*	*f*	*f*	*f*		*f*
Category II storm drains	Flow, Mgd	*d*	*d*				100
	pH, standard units		4.0–9.0				100
	Suspended solids	*d*	*d*				100
	Unpermitted discharge	*f*	*f*	*f*	*f*		*f*
Category III storm drains	Flow, Mgd	*d*	*d*				100
	Oil and grease	*d*	*d*				100
	pH, standard units		4.0–9.0				100
	Suspended solids	*d*	*d*				100
	Unpermitted discharge	*f*	*f*	*f*	*f*	1	*f*
Category IV storm drains (to Poplar Creek)	Chlorine, total residual		0.14				100
	Flow, Mgd	*d*	*d*				100
	Oil and grease	*d*	*d*				100
	pH, standard units		6.0–9.0				100
	Suspended solids	*d*	*d*				100
	Unpermitted discharge	*f*	*f*	*f*		1	*f*
Category IV storm drains (to Mitchell Branch)	Chlorine, total residual		0.019				100
	Flow, Mgd	*d*	*d*				100
	Oil and grease	*d*	*d*				100
	pH, standard units		6.0–9.0				100
	Suspended solids	*d*	*d*				100
	Unpermitted discharge	*f*	*f*	*f*	*f*		*f*

[a]Units are mg/L unless otherwise stated.
[b]Daily minimum.
[c]Geometric mean.
[d]Nonlimited parameter.
[e]No-observed-effect limit.
[f]Not applicable.

pliance for 1996. Samples from these outfalls are collected and analyzed as specified in the NPDES permit.

The following are the four permitted major outfalls at the ETTP (Fig. 4.22):

- 005 (K-1203 Sewage Treatment Plant),
- 009 (K-1515 Sanitary Water Treatment Facility),
- 013 (K-1513 Sanitary Water Intake Backwash Filter), and
- 014 (K-1407-J CNF discharge to the Clinch River).

Although no monitoring is required at Outfall 013, routine inspections are conducted to ensure that no unsightly debris or scum is discharged through this point as the result of backwash operations at the K-1513 sanitary intake filter. Outfall 014 is a permitted outfall for the discharge of effluent from the CNF to the Clinch River. Part I, Section E, of the permit required that CNF discharges through Outfall 011 cease and that CNF discharges through Outfall 014 be fully operational no later than April 30, 1996. This compliance schedule was completed in January 1996.

Results

Outfall 005 is the discharge point for the ETTP STP, which is an extended aeration treatment plant having a rated capacity of 2.3 million L/d [0.6 million gallons per day (Mgd)] and a current use of about 1.4 million L/d (0.36 Mgd). Treated effluent from the main plant is discharged into Poplar Creek through this outfall. This facility had no NPDES permit non-compliances during 1996.

Outfall 009 is the discharge point for the K-1515 sanitary water plant, which provides sanitary water to the ETTP to be used for drinking, fire protection, and other purposes. It also provides water to two industries in the Bear Creek Road Industrial Park through an arrangement with the city of Oak Ridge. Raw water is taken from the Clinch River and treated at K-1515. The K-1515 sanitary water plant exhibited 100% compliance with the ETTP NPDES permit during 1996.

The ETTP CNF, Outfall 014, has provisions for the treatment of nonhazardous and hazardous wastes. Nonhazardous flow entering the CNF consists of steam plant effluents and various small-quantity or infrequent streams from waste disposal requests. Hazardous streams include effluents from the TSCA Incinerator, the steam plant hydrogen softener waste stream, and various small-quantity or infrequent streams from waste disposal requests.

In order to begin treatment of waste streams contaminated with various organics, the CNF was upgraded in 1996 to include pressure filters, carbon adsorption, and air stripping. These upgrades were approved by TDEC, and construction was completed in April 1996. Operational testing was completed in June 1996, and the new organics treatment system went on line in July 1996. CNF had two NPDES noncompliances in 1996.

CNF experienced an exceedence of the NPDES permit limit for total petroleum hydrocarbons (TPH) in January 1996. The Outfall 014 permit limit for TPH was established as a technology-based limit contingent upon the upgrade of CNF to include organics waste treatment capabilities. This noncompliance occurred prior to the organic treatment system being brought on line. Since completion of the organics treatment upgrade, all TPH measurements have been below the NPDES permit limit.

In August 1996, CNF had an unpermitted discharge to the Clinch River. An improper alignment of the CNF valving configuration resulted in a bypass of the organics treatment system. Upon discovering the inappropriate valving configuration, the discharge was immediately halted. Organics samples taken of the wastewater treatment batch that was being discharged at that time revealed that all organic contaminants were below the NPDES permit limits. However, because the wastewater did not properly pass through the treatment system, the event was categorized as an unpermitted discharge. No adverse impacts to the receiving stream were observed as a result of this noncompliance. Automatic valving interlocks have been installed to prevent recurrence.

The ETTP NPDES permit includes 136 storm water outfalls that are grouped into four categories based on their potential for pollutants to be present in their discharge. Category I storm water outfalls have intermittent flow and drain storm water runoff from areas remotely associated with plant activities and subsurface runoff; Category II storm water outfalls have intermittent flow and drain storm water runoff from building roof drains and paved areas associated with plant activities; Category III storm water outfalls have intermittent flow and drain storm water runoff from areas associated with concentrated storage areas, roof drains, coolant systems, and parking lots; and Category IV storm water outfalls have continuous flow and drain cooling water discharges and runoff from industrial areas. Monitoring at storm water outfalls is conducted semiannually, quarterly, monthly, or weekly for Categories I through IV, respectively, with those outfalls that have the highest potential for pollution being sampled most frequently.

The remaining two ETTP NPDES noncompliances for 1996 occurred at storm water outfalls. These noncompliances occurred at Outfall 120 and Outfall 170.

In February 1996, a sewage bypass pump failed during a relining operation as part of the sanitary sewer upgrade project at the low point of the system, causing sewage to back up and overflow from a manhole. As a result, a small amount of raw sewage spilled onto a parking area and flowed into a nearby storm drain catch basin leading to Outfall 120. The bypass pump was immediately brought back on-line, and the sewage remaining in the parking area was cleaned up. A receiving stream inspection revealed no impacts.

In February 1996, there were discharges of sanitary sewage to Outfall 170 caused by damage to the sewage system that resulted from a freeze/thaw cycle related to extremely cold temperatures followed by warmer temperatures. Corrective actions were taken to protect storm drain catch basins, cease discharge of the sewage, and clean up residual wastes. Inspections of the receiving stream for outfall 170 revealed no impacts to the environment. Cold weather inspection checklists have been revised to include additional sanitary sewer checks.

The Storm Water Pollution Prevention (SWPP) Program is another requirement of the NPDES permit. The purpose of the ETTP SWPP Program is to assess the quality of storm water discharges from ETTP, determine potential sources of pollutants affecting storm water, and provide effective controls to reduce or eliminate these pollutant sources. The SWPP Program provides a means whereby sources of pollutants that are likely to affect the quality of storm water discharges are identified, BMPs that can be used to control the entry of pollutants into storm water discharges are developed, and methods for implementing pollution prevention practices are devised.

As part of the 1995–1996 SWPP sampling effort, storm water outfalls at ETTP were grouped (as permitted under Part IV.C.4 of the ETTP NPDES permit), and storm water samples were collected from a representative outfall from each group. Storm water outfalls were placed in a group based on several criteria: (1) knowledge of drainage areas obtained from block plans and maps of ETTP, (2) knowledge of various processes and functions conducted at ETTP, and (3) information in the ETTP NPDES permit application. The individual outfall chosen to represent the group was selected based on the location of the outfalls storm drain network in relation to the other storm drain networks in the group, the representativeness of previously collected analytical data in relation to other outfalls in the group, the likelihood of the outfall having sufficient flow for sample collection to take place during a storm event, ease of access to the outfall during storm events, and categorization of the outfall in the ETTP NPDES permit.

Several of the storm water outfalls did not fit into groups and were therefore sampled individually. Screening criteria used to determine the outfalls that should be sampled individually were developed from the TDEC general water quality criteria for various uses, Part III.A.a. (Toxic Pollutants) criteria of the ETTP NPDES permit, discussions in NPDES permit rationale and addendums, and SDWA maximum contaminant levels. These criteria were applied to data collected under previous SWPP monitoring efforts. In general, the most stringent criterion was selected to be included in the overall screening criteria.

Several outfalls were to be sampled at their discharge points and in critical points in their storm drainage piping networks. Network sampling locations were determined by using the sitewide storm drain camera survey that was conducted in FY 1994 and FY 1995. The storm drain network sampling was to be conducted during both wet and dry weather conditions in order to determine if groundwater infiltration contributed to the presence of pollutants in the storm water effluent from these locations.

Analytical parameters that were monitored under this sampling and analysis (S&A) plan were selected based on the review of previous SWPP analytical data, historical knowledge of ETTP, information obtained from the site-wide storm drain camera survey, data from sump discharge sampling efforts, and groundwater data from plant areas near drains where significant groundwater and surface water interactions are suspected. The previously mentioned screening levels were used to indicate the outfalls that may discharge pollutants at potentially significant levels.

In addition, dry weather samples were taken from the outfalls that flow during the absence of rainfall. Dry weather samples were collected from outfalls that continued to flow at least 72 hours after the last qualifying rainfall event. Analysis of data collected during dry weather sampling of continuous flow storm water outfalls may (1) indicate contamination found in these drains, which can be attributed to groundwater infiltration into the storm drain system, (2) distinguish contaminants in storm water runoff from those found in groundwater that may be discharging through these storm drains, and (3) indicate the presence of sources of illicit or previously undetermined flows through the storm drain, such as chlorinated water from sanitary water line leaks and sanitary sewage from sewer line breaks.

As part of the FY 1996 SWPP sampling effort, semipermeable membrane devices (SPMDs) were utilized in locations upstream of the discharge point of selected storm drains associated with switchyards at ETTP. This was done in an effort to pinpoint specific sources of PCBs that might be entering the storm drain system. It is known from past sampling efforts and by process knowledge that the ETTP switchyards are possible sources of PCB-contaminated storm water discharges. The extent of the contamination of these discharges, the exact location of any significantly contaminated discharges, and the effectiveness of oil skimmers in the prevention of the discharge of PCBs to receiving waters were observed as part of this SPMD study.

4.3 TOXICITY CONTROL AND MONITORING PROGRAM

4.3.1 Y-12 Plant Biomonitoring Program

In accordance with the 1995 NPDES permit (Part III-C, page 39), a Biomonitoring Program that evaluates an EFPC in-stream monitoring location (Outfall 201), wastewater treatment system discharges, and four locations in the storm sewer system, are required. Table 4.17 is a summary of the results of biomonitoring tests conducted on effluent samples from wastewater treatment systems and storm sewer effluents. The results of the biomonitoring tests are expressed as the concentration of effluent that is lethal to 50% of the test organisms (LC_{50}s) during a 48-h period. Thus, the lower the value, the more toxic an effluent. The LC_{50} is compared to the effluent's calculated instream-waste-concentration (IWC) to determine the likelihood that the discharged effluent would be harmful to aquatic biota in the receiving stream. If the LC_{50} is much greater than the IWC, it is less likely that there is an instream impact. Table 4.18 is a summary of the no-observed-effect concentrations (NOECs) and 96-h LC_{50}s for the in-stream monitoring location, Outfall 201. The NOEC is an NPDES-compliance limit and is the concentration of effluent which does not reduce survival, growth or reproduction of the biomonitoring test organisms. Thus, unlike the LC_{50}, the higher the value the less toxic an effluent.

Effluent from the Groundwater Treatment Facility was tested in January, April, July, and October, using *Ceriodaphnia dubia*. The effluent's 48-hour LC_{50}s were 64.0%, 48.2%, 42.4%, and 60.6%, respectively. The calculated IWCs (1.02%, 0.45%, 0.95%, and 0.15%, respectively) were below the LC_{50}s; therefore, it is unlikely that treated effluent from the Groundwater Treatment Facility adversely affected the aquatic biota in EFPC.

Table 4.17. Y-12 Plant Biomonitoring Program summary information for wastewater treatment systems and storm sewer effluents for 1996[a]

Site/building	Test date	Species	48-h LC_{50}[b] (%)	IWC[c] (%)
Groundwater Treatment Facility (Outfall 512)	1/11	*Ceriodaphnia*	64.0	1.02
9422-11 Storm Sewer	1/11	*Ceriodaphnia*	70.7	*d*
9422-12 Storm Sewer	1/11	*Ceriodaphnia*	70.7	*d*
9422-12 Storm Sewer (dechlorinated)	1/11	*Ceriodaphnia*	>100	*d*
9422-15 Storm Sewer	1/12	*Ceriodaphnia*	>100	*d*
9422-16 Storm Sewer	1/16	*Ceriodaphnia*	>100	*d*
Central Pollution Control Facility (Outfall 501)	1/24	*Ceriodaphnia*	>100	0.10
9422-10 Storm Sewer	4/13	*Ceriodaphnia*	8.0	*d*
9422-10 Storm Sewer (dechlorinated)	4/13	*Ceriodaphnia*	66.9	*d*
9422-11 Storm Sewer	4/13	*Ceriodaphnia*	72.6	*d*
9422-12 Storm Sewer	4/16	*Ceriodaphnia*	70.7	*d*
9422-12 Storm Sewer (dechlorinated)	4/16	*Ceriodaphnia*	>100	*d*
Storm Sewer Drain E3305	4/16	*Ceriodaphnia*	>100	*d*
Groundwater Treatment Facility (Outfall 512)	4/17	*Ceriodaphnia*	48.2	0.45
Central Pollution Control Facility (Outfall 501)	6/7	*Ceriodaphnia*	>100	0.62
Storm Sewer Drain E3305	7/17	*Ceriodaphnia*	>100	*d*
9422-12 Storm Sewer	7/17	*Ceriodaphnia*	24.0	*d*
9422-12 Storm Sewer (dechlorinated)	7/17	*Ceriodaphnia*	>100	*d*
Groundwater Treatment Facility (Outfall 512)	7/18	*Ceriodaphnia*	42.4	0.95
9422-10 Storm Sewer	7/23	*Ceriodaphnia*	29.6	*d*
9422-10 Storm Sewer (dechlorinated)	7/23	*Ceriodaphnia*	40.9	*d*
9422-11 Storm Sewer	7/23	*Ceriodaphnia*	Invalid[e]	Invalid[e]
9422-11 Storm Sewer	7/30	*Ceriodaphnia*	66.6	*d*
West End Treatment Facility (Outfall 502)	8/15	*Ceriodaphnia*	11.2	0.23
West End Treatment Facility (Outfall 502)	10/2	*Ceriodaphnia*	39.4	0.16
Groundwater Treatment Facility (Outfall 512)	10/2	*Ceriodaphnia*	60.6	0.15
9422-12 Storm Sewer	10/2	*Ceriodaphnia*	64.8	*d*
9422-12 Storm Sewer (dechlorinated)	10/2	*Ceriodaphnia*	>100	*d*
9422-10 Storm Sewer	10/8	*Ceriodaphnia*	14.5	*d*
9422-10 Storm Sewer (dechlorinated)	10/8	*Ceriodaphnia*	51.4	*d*
9422-11 Storm Sewer	10/8	*Ceriodaphnia*	40.6	*d*
Storm Sewer Drain E3305	10/8	*Ceriodaphnia*	>100	*d*
Central Pollution Control Facility (Outfall 501)	11/26	*Ceriodaphnia*	67.7	0.08
Central Mercury Treatment System (Outfall 551)	12/17	*Ceriodaphnia*	>100	0.14

[a]Summarized are the effluents and their corresponding 48-h LC_{50}s, and in-stream waste concentrations (IWCs). NOTE: Discharges from treatment facilities are intermittent because of batch operations.

[b]The concentration of effluent (as a percent 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. The calculated percentage of wastewater present when mixed with East Fork Poplar Creek. The IWC is based on actual flows at East Fork Poplar Creek, Station 8.

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

[e]This test was invalid because of unacceptable survival of control organisms. This location was retested on July 30, 1996.

Table 4.18. Y-12 Plant Biomonitoring Program summary information for Outfall 201 for 1996[a]

Site	Test date	Species	NOEC[b] (%)	96-h LC_{50}[c] (%)
Outfall 201	1/10	*Ceriodaphnia* Fathead minnow	80 100	>100 >100
Outfall 201	1/31	*Ceriodaphnia*	Terminated[d]	Terminated[d]
Outfall 201	2/14	*Ceriodaphnia*	80	>100
Outfall 201	4/12 4/13	*Ceriodaphnia* Fathead minnow	100 100	>100 >100
Outfall 201	7/17	*Ceriodaphnia* Fathead minnow	100 100	>100 >100
Outfall 201	10/2	*Ceriodaphnia* Fathead minnow	100 100	>100 >100

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

[b]No-observed-effect concentration as a percent 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 percent of full-strength effluent diluted with laboratory control water) that is lethal to 50% of the test organisms in 96 h.

[d]This test was terminated on February 2, 1996, because of inclement weather. More than 12 inches of ice and snow prevented sampling and toxicology laboratory personnel from continuing the test.

Effluent from the Central Pollution Control Facility was tested in January, June, and November, using *Ceriodaphnia*. In January and June, treated effluent from the Central Pollution Control Facility had 48-hour LC_{50}s of >100%. In November, the Central Pollution Control Facility effluent had a 48-hour LC_{50} of 67.7%. The calculated IWCs of Central Pollution Control Facility effluent were 0.10% in January, 0.62% in June, and 0.08% in November. Because the IWCs were less than the LC_{50}s, it is unlikely that treated effluent from that facility adversely affected the aquatic biota in EFPC.

Effluent from the West End Treatment Facility was tested in August and October using *Ceriodaphnia*. The August 48-hour LC_{50} was 11.2% and the October 48-hour LC_{50} was 39.4%. The calculated IWCs (0.23% and 0.16%) were below the LC_{50}s; therefore, it is unlikely that treated effluent from the facility adversely affected the aquatic biota in EFPC.

Central Mercury Treatment System effluent was tested in December using *Ceriodaphnia*. The calculated IWC (0.14%) was less than the 48-hour LC_{50} (>100%); therefore, it is unlikely that treated effluent from the Central Mercury Treatment System adversely affected the aquatic biota in EFPC.

Toxicity testing of storm sewers was conducted at Buildings 9422-10, 9422-11, 9422-12, 9422-15, and 9422-16, which are monitoring locations in the storm system as part of the Surface Water Hydrologic Information Support System (SWHISS). Water from the storm sewer at Building 9422-10 was tested in April, July, and October using *Ceriodaphnia*. In April, water from the storm sewer at Building 9422-10 had a 48-hour LC_{50} of 8.0%. A portion of this water was treated by dechlorination before testing. The

48-hour LC_{50} of the dechlorinated water was 66.9%. In July, the 48-hour LC_{50} was 29.6%, and the 48-hour LC_{50} of dechlorinated water was 40.9%. In October, the 48-hour LC_{50} was 14.5%, and the 48-hour LC_{50} of dechlorinated water was 51.4%.

Storm sewer water from Building 9422-11 was tested in January, April, July, and October using *Ceriodaphnia*. The 48-hour LC_{50}s were 70.7%, 72.6%, 66.6%, and 40.6%, respectively. (A test of water at Building 9422-11, started on July 23, 1996, was invalid because of the unacceptable survival of control organisms. This location was retested on July 30, 1996.)

Storm sewer water at Building 9422-12 was tested in January, April, July, and October, using *Ceriodaphnia*. The 48-hour LC_{50} s were 70.7%, 70.7%, 24.0%, and 64.8%, respectively. The 48-hour LC_{50} s of dechlorinated storm sewer water were all >100%.

The storm sewer at Building 9422-16 was tested in January using *Ceriodaphnia*. The 48-hour LC_{50} was >100%. The storm sewer at Building 9422-15 was tested in January using *Ceriodaphnia*. The 48-hour LC_{50} was >100%.

The storm sewer at Drain E3305 (also known as 192N and 192S) was tested in April, July, and October. The 48-hour LC_{50} s were all >100% for *Ceriodaphnia*.

Water from the in-stream monitoring point, Outfall 201, was tested six times during 1996 using fathead minnow larvae and/or *Ceriodaphnia dubia*. On January 10, 1996, the NOEC was 80% for *Ceriodaphnia* and 100% for fathead minnows. The 96-hour LC_{50} was >100% for both *Ceriodaphnia* and fathead minnows. A confirmatory test started on January 31, 1996, was terminated on February 2, 1996, because of inclement weather. (More than 12 inches of ice and snow prevented sampling and toxicology laboratory personnel from continuing the test.) In February, the NOEC was 80% for *Ceriodaphnia*, and the 96-hour LC_{50} was >100%. For tests in April, July, and October, the NOECs were all 100% for both *Ceriodaphnia* and fathead minnows; the 96-hour LC_{50} s were all >100% for both *Ceriodaphnia* and fathead minnows.

4.3.2 ORNL Toxicity Control and Monitoring Program

Under the TCMP, wastewaters from the STP, the CYRTF, and the NRWTF were evaluated for toxicity. In addition, two ambient in-stream sites were evaluated; one site is located on Melton Branch (NPDES permit point X13) and the other on White Oak Creek (permit point X14). The results of the toxicity tests of wastewaters from the three treatment facilities and the two ambient stream sites are given in Table 4.19. This table provides, for each wastewater and ambient water, the month the test was conducted, sample treatment (if any), the wastewater's NOEC for fathead minnows and *Ceriodaphnia*, and the IWC, if appropriate. The NOEC is the concentration that did not significantly reduce survival or growth of fathead minnows or survival or reproduction of *Ceriodaphnia*. Average water quality measurements obtained during each toxicity test are shown in Table 4.20.

During 1996, the CYRTF and the NRWTF were tested three times each, and the STP was tested nine times. The CYRTF wastewater's NOECs were 100% for fathead minnows and 25% and 12% for *Ceriodaphnia*. The corresponding wastewater's IWCs were 2.4% and 2.7%. Because the IWC was consistently lower than the NOEC, it is unlikely that wastewater from the CYRTF adversely affected the aquatic biota of WOC during 1996. Full-strength wastewater from the NRWTF was not toxic to *Ceriodaphnia* during April and October. A toxicity test conducted in October on samples split with TDEC resulted in no toxicity to fathead minnows. The NRWTF wastewater's NOECs were all 100%; therefore, no IWCs were calculated during 1996.

The STP wastewater's NOECs for *Ceriodaphnia* ranged from < 6% to 100% during 1996. The NOEC for the STP was <6% in July, September, and October; 25% in January and July; 50% in November; and 100% in March and May. Per guidelines in the NPDES permit, no fathead minnow tests were conducted for the STP.

Table 4.19. 1996 toxicity test results of ORNL wastewaters and ambient waters

Outfall	Test date	Treatment[a]	Fathead minnow NOEC[b] (%)	*Ceriodaphnia* NOEC[b] (%)	IWC[c] (%)
Coal Yard Runoff Treatment Facility (X02)	May	N	*d*	25	2.4
	Jun[e]	N	100	*f*	*g*
	Nov	N	100	12	2.7
Sewage Treatment Plant (X01)	Jan	N	*f*	25	21.5
	Mar	N	*f*	100	*g*
	May	N	*f*	100	*g*
	July	N	*f*	25	19.5
	Aug	N	*f*	<6	*g*
	Sep[e]	N	*f*	*e*	16.4
	Sep[d]	N	*f*	<6	*g*
	Oct[d]	N	*f*	<6	17.6
	Nov[d]	N	*f*	50	17.8
Nonradiological Wastewater Treatment Facility (X12)	Apr	N	*f*	100	*g*
	Oct	N	*f*	100	*g*
	Oct[h]	N	100	*f*	*g*
Melton Branch (X13)	Jan[d]	N	<80	*f*	
		UV	100	*f*	
	Feb	N	100	100	
		UV	100	*f*	
	Apr	N	100	100	
		UV	100	*f*	
	Jun	N	80	100	
		UV	100	*f*	
	Jun[d]	N	100	*f*	
		UV	100	*f*	
	Aug	N	100	100	
		UV	100	*f*	
	Oct	N	100	100	
		UV	100	*f*	
	Dec	N	100	<80	
		UV	100	*f*	
	Dec[d]	N	*f*	80	
		UV	*f*	*f*	

Table 4.19 (continued)

Outfall	Test date	Treatment[a]	Fathead minnow NOEC[b] (%)	*Ceriodaphnia* NOEC[b] (%)	IWC[c] (%)
White Oak Creek (X14)	Jan[e]	N	<80	*f*	
		UV	100	*f*	
	Feb	N	100	100	
		UV	100	*f*	
	Apr	N	100	100	
		UV	100	*f*	
	Jun	N	80	100	
		UV	100	*f*	
	Jun[e]	N	100	*f*	
		UV	100	*f*	
	Aug	N	100	100	
		UV	100	*f*	
	Oct	N	100	100	
		UV	100	*f*	
	Dec	N	100	100	
		UV	100	*f*	

[a]N = no sample pretreatment; UV = ultraviolet light pretreatment.
[b]No-observed-effect concentration.
[c]Mean in-stream waste concentration (based on critical low flow of White Oak Creek).
[d]Invalid test.
[e]Confirmatory test.
[f]Not tested.
[g]Not calculated.
[h]Split-sample test; tested concurrently with TDEC.

A Toxicity Control Plan developed and implemented for the STP in 1995 was continued through 1996, with toxicity testing for this facility conducted every other month.

During 1996, the Melton Branch (X13) site was tested nine times, and the WOC (X14) site was tested eight times. Water from X13 and X14 reduced fathead minnow survival on two occasions (January and June). Follow-up confirmatory tests conducted in June showed the water from X13 and X14 to be nontoxic to fathead minnows; thus the toxicity appeared to be transient. To determine whether fathead minnow mortality in the ambient water samples might be caused by a fungal or bacterial pathogen, water from X13 and X14 was exposed to ultraviolet (UV) light for a 20-minute period. Tests of water from sites X13 and X14 showed improved fathead minnow survival in water treated with UV light (NOECs were 100%). Water from X13 reduced *Ceriodaphnia* reproduction in December. A confirmatory test conducted in December again reduced *Ceriodaphnia* reproduction. Water from X14 was not toxic to *Ceriodaphnia*.

4.3.3 ETTP Toxicity Control and Monitoring Program

The NPDES permit requires that toxicity testing be performed at Outfall 005. Accordingly, toxicity testing was conducted at Outfall 005 bimonthly until 1995, when the outfall was placed on a biannual sampling schedule.

The results of the toxicity tests of wastewaters conducted during 1996 are given in Table 4.21. This table provides the wastewater's no-observed-effect level (NOEL) and 96-hour LC_{50} for fathead minnows and *Ceriodaphnia* for

Table 4.20. 1996 average water quality parameters measured during toxicity tests of ORNL wastewaters and ambient waters.
Values are for full-strength wastewater for each test (N = 1 or 7) or averages of full-strength ambient water for each test (N = 7)

Outfall	Test date	pH[a]	Conductivity[b]	Alkalinity[c]	Hardness[c]
Coal Yard Runnoff Treatment Facility (X02)	May	7.55	4080	20	1760
	June	7.38	3340	19	1980
	Nov	7.39	3690	28	722
Sewage Treatment Plant (X01)	Jan	7.67	494	92	164
	Mar	7.84	438	88	152
	May	8.05	416	93	145
	Jul	7.92	392	78	141
	Aug	7.88	384	89	140
	Sep	7.97	402	95	145
	Sep	7.96	406	94	152
	Oct	7.95	417	100	152
	Nov	7.98	421	100	159
Nonradiological Wastewater Treatment Facility (X12)	Apr	8.05	435	85	91
	Oct	7.96	511	91	82
	Oct	8.03	431	94	100
Melton Branch (X13)	Jan	7.67	281	72	124
	Feb	8.02	361	91	161
	Apr	8.02	366	101	171
	Jun	8.16	371	149	180
	Jun	8.18	459	157	223
	Aug	7.91	745	100	351
	Oct	8.07	479	183	229
	Dec	8.01	299	126	145
	Dec	7.77	256	83	123
White Oak Creek (X14)	Jan	7.89	284	98	121
	Feb	8.16	332	105	140
	Apr	8.11	320	109	136
	Jun	8.14	278	114	129
	Jun	8.15	339	127	141
	Aug	8.04	394	119	159
	Oct	8.04	379	127	145
	Dec	8.04	320	122	138

[a]Standard units.
[b]µS/cm; corrected to 25°C.
[c]mg/L as $CaCO_3$.

Table 4.21. 1996 ETTP NPDES Permit Number TN 0002950 toxicity tests results

ETTP Outfall	Test date	Species	NOEL[a] (%)	LC_{50}[b] (%)	IWC[c] (%)
K-1203 (Outfall 005)	January	Fathead minnow	100	>100	2.91
		Ceriodaphnia	100	>100	2.91
	July	Fathead minnow	100	>100	1.99
		Ceriodaphnia	100	>100	1.99

[a]No-observable-effect level.
[b]96-hour lethal concentration for 50% of the test organisms.
[c]In-stream waste concentration (based on critical low flow of Poplar Creek).

each test. Average water quality measures obtained during each toxicity test are shown in Table 4.22.

Effluent from K-1203 was tested twice with fathead minnows and *Ceriodaphnia*. In both tests, full-strength samples did not reduce survival, growth, or reproduction. Thus the NOELs were 100% and the LC_{50}s were >100%.

4.4 BIOLOGICAL MONITORING AND ABATEMENT PROGRAMS

The NPDES permits issued to the Y-12 Plant in 1995, the ETTP in 1992, and ORNL in 1986 mandate BMAPs with the objective of demonstrating that the effluent limitations established for each facility protect the classified uses of the receiving streams. The Y-12 Plant effluents discharge to EFPC; ETTP effluents discharge to Mitchell Branch, Poplar Creek, and the Clinch River; and ORNL effluents discharge to WOC and its tributaries. Each of the BMAPs is unique and consists of three or four major tasks that reflect different but complementary approaches to evaluating the effects of the effluent discharges on the aquatic integrity of the receiving streams. Tasks present in one or more of the BMAPs include (1) toxicity monitoring; (2) bioaccumulation studies; (3) biological indicator studies; (4) waterfowl surveys; and (5) ecological surveys of the periphyton, benthic macroinvertebrate, and fish communities.

4.4.1 Y-12 Plant BMAP

Two major changes in the UEFPC watershed— flow management and a partial bypass of Lake Reality—were initiated during 1996. Flow management, which began in the summer of 1996 and reached full implementation in the fall, could have influenced some BMAP results in 1996 but is expected to exert its full influence during 1997. Testing for the bypass of Lake Reality did not begin until mid-December 1996, so this change almost certainly did not affect any of the BMAP tasks during the year.

4.4.1.1 Toxicity monitoring

Toxicity monitoring uses EPA-approved methods with *Ceriodaphnia dubia* (an invertebrate “water flea”) and fathead minnow (fish) larvae to assess the toxicity of stream water to aquatic life. Toxicity monitoring is conducted monthly at several sites upstream of Bear Creek Road, including Lake Reality outlet or LR-o (EFK 23.8), LR inlet or LR-i (EFK 24.1) and Area Source Study Site 8 or AS-8 (EFK 24.6)]. Water samples from sites downstream of Bear Creek Road (EFKs 22.8, 21.9, 20.5, 18.2, 13.8, and 10.9) are tested quarterly. No evidence for toxicity was found during tests conducted in 1996.

4.4.1.2 Bioaccumulation studies

Elevated concentrations (relative to local reference sites) of mercury and PCBs in biota are

Table 4.22. 1996 ETTP average water quality parameters measured during toxicity tests of ETTP wastewaters

Values are averages of full-strength wastewater for each test (N = 7)

ETTP Outfall	Test date	pH (standard units)	Conductivity (µS/cm)	Alkalinity (mg/L $CaCO_3$)	Hardness (mg/L $CaCO_3$)
K-1203 (005)	January	7.97	465	102	162
	July	8.00	374	69	148

associated with discharges from the Y-12 Plant. Redbreast sunfish (*Lepomis auritus*) are collected twice annually from seven sites along the length of EFPC to evaluate spatial and temporal trends in mercury and PCB contamination. The forage fish species (stoneroller, *Campostoma anomalum*) is collected once annually to evaluate PCB contamination in the food of fish-eating wildlife.

In spring 1996, the mean mercury concentrations in fish sampled from EFPC ranged from five to fifteen times higher than the average concentration in fish from the reference stream. Highest levels of contamination continued to occur upstream of Lake Reality, suggesting that Y-12 Plant discharges continue to be an important source of mercury in fish in the upper reaches of EFPC. There was some indication that mercury concentrations may be decreasing in fish from sites downstream of Lake Reality compared with those of previous years.

PCB concentrations in sunfish sampled from EFPC during 1996 fell within ranges typical of past monitoring efforts at these sites. Mean PCB concentrations were highest in Lake Reality and the reaches of EFPC above Lake Reality, and decreased downstream of Lake Reality. Stonerollers contained much higher concentrations of PCBs than sunfish, with the greatest average concentration (12 mg/kg) at EFK 23.4, immediately downstream from the Lake Reality discharge. A sharp decrease occurred between that site and EFK 18.2. These data suggest that the use of PCB concentrations in sunfish fillets to directly estimate ecological risk to fish-eating wildlife in the EFPC floodplain could result in underestimating actual risk by several fold.

Kingfishers are highly piscivorus birds that consume up to half their body weight each day in fish or crayfish. For two years, the ORR ecological risk assessment (Sample et al. 1995, 1996) has identified kingfishers as being highly at risk on all ORR streams. In 1996, BMAP researchers began to study kingfishers in the EFPC floodplain. No nest sites were identified during 1996, but preparations are under way for further investigations during the 1997 nesting season.

Another special study under the bioaccumulation task of the Y-12 Plant BMAP involves the deployment in EFPC of a number of SPMDs. SPMDs are passive sampling devices that provide a time-integrated measurement of dissolved (bioavailable) PCB concentrations. The goal of this work is to determine the significance of releases from the Y-12 Plant to the overall flux of PCBs in local surface waters and to the total budget of PCB releases from DOE facilities in Oak Ridge. Highest concentrations of PCBs were observed in the reaches of EFPC within the Y-12 Plant, ranging from approximately 26–32 ng/L. Concentrations decreased to 5 ng/L PCBs at Turtle Park (near EFK 13.8), but then increased to almost 9 ng/L farther downstream, possibly reflecting additional downstream sources of contamination.

4.4.1.4 Biological indicator studies

The bioindicator 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 EFPC. The health of individual sunfish in EFPC upstream of Bear Creek continues to differ significantly from fish at reference sites. Female sunfish collected during 1996 from these upper reaches were more emaciated than fish from downstream sites in EFPC or from reference sites, and continued to exhibit characteristically high incidences of oocyte atresia (death of immature eggs). Water sampled throughout the length of EFPC during 1996 remained toxic to developing fish embryos in the medaka test. Preliminary tests suggest that medaka embryos are very sensitive to mercury contamination, offering one potential explanation for the observed toxicity.

4.4.1.5 Ecological surveys and fish kill results

Periphyton monitoring in EFPC occurs four times a year. Algal biomass and photosynthetic rates were generally within the range of measurements made over the past eight years, but areal-specific photosynthetic rates and chlorophyll-specific photosynthetic rates were somewhat lower than previous years. Nutrient concentrations in EFPC were found to be 1 to 2 orders of magnitude higher during 1996 than in reference streams (such as BFK 7.6), and both nitrogen and phosphorus were likely to be growth-saturating for periphyton in EFPC. Ammonia levels were elevated at EFK 24.4 (0.3 mg/L), suggesting continuing influence from the legacy area source near Outfall 017.

Overall, periphyton biomass and photosynthesis in 1996 were roughly similar to that measured previously. However, photosynthesis and chlorophyll-specific photosynthesis at EFK 24.4 were lower in fall than in spring, suggesting that photosynthesis in the upper reaches of EFPC may have been diminished by flow management activities. If this trend continues, then growth and reproduction of the current major fish species in upper EFPC could eventually be adversely affected by flow management activities.

The fish community task is responsible for conducting biannual estimates of the fish community at six EFPC sites and two reference stream sites and for investigating fish kills near the Y-12 Plant. Improvements in fish communities in EFPC continued during 1996. Two sensitive species, the northern hog sucker and the snubnose darter, were observed at EFK 23.4, and the redline darter persisted at EFK 13.8. Further improvement in species diversity at sites downstream of Lake Reality is expected in association with decreases in stream temperatures accompanying the flow management activities in upper EFPC. The new temperature regime in upper EFPC now approximates other area streams and is no longer elevated to potentially stressful levels for sensitive fish species. However, whether many additional species will ever occur upstream of Lake Reality is questionable because of the difficulty of fish migration through the current siphon bypass arrangement used to shunt water around the lake.

Fish kill investigations are conducted in response to chemical spills, unplanned water releases, or when dead fish are observed in EFPC. The basic procedure for fish kill investigations is a survey of upper EFPC (above Bear Creek Road to the N/S Pipes), during which numbers and locations of dead, dying, and stressed fish are recorded. In previous years, fish kills were often associated with the spawning period of stonerollers in EFPC. No fish kills were observed in EFPC during the period of January to March, 1996. From March through May, a total of 299 dead fish were recorded, of which 275 were stonerollers and 64% were in spawning condition. Thereafter, the average dead per survey decreased to less than 1 fish, a value similar to background mortality levels.

Benthic macroinvertebrate communities are sampled from four sites in EFPC and from two reference streams in the fall and spring of each year. The macroinvertebrate communities at EFK 23.4 and EFK 24.4 remained significantly degraded through 1996. However, subtle but persistent increases in total richness and the richness of pollution tolerant taxa at these sites indicate some improvement in water quality. The benthic macroinvertebrate community at sites further downstream (i.e., EFK 13.8) appear only minimally impacted relative to reference conditions.

4.4.2 Oak Ridge National Laboratory BMAP

4.4.2.1 Toxicity monitoring

Toxicity monitoring involves the use of EPA-approved methods with *Ceriodaphnia dubia* and fathead minnow larvae to assess the toxicity of stream water to aquatic life. Toxicity monitoring was conducted three times in 1996 at three sites in the WOC watershed [Fifth Creek, First Creek and WOC (WCK 3.4)]. No evidence for toxicity was found during tests conducted in 1996.

4.4.2.2 Bioaccumulation studies

Monitoring of mercury contamination in sunfish and largemouth bass continued in 1996. Redbreast sunfish were collected in the spring of 1996 from WOC (WCK 2.9), and bluegill sunfish (*Lepomis macrochirus*) and largemouth bass *(Micropterus salmoides)* were collected from White Oak Lake (WOL). Mercury concentrations (relative to local reference sites) in sunfish were highest in WOC proper and decreased with distance downstream. The present level of mercury contamination in WOC sunfish is approximately three times higher than concentrations observed in fish from reference streams or reservoirs in east Tennessee. Mercury concentrations in largemouth bass appear to have stabilized since much higher concentrations were observed during the 1991–93 time period; mercury concentrations in bass from the 1994–96 period are about half the levels observed from the 1991–93 period.

In 1996, monitoring of PCB contamination in sunfish was conducted at two WOC sites: WCK 2.9 and WOL. Monitoring of PCB contamination in largemouth bass was conducted at WOL. Since 1994, PCB concentrations in WOC sunfish and largemouth bass have remained approximately 2 to 3 times higher than concentrations reported in the early 1990s.

Forage fish collected from WCK 3.9 and WCK 2.9 in 1996 were also analyzed for a suite of metals and PCBs. Cadmium, copper, mercury, selenium, zinc, and PCBs in forage fish from WOC proper were clearly elevated in comparison with fish from the reference site. Differences between WOC sites and the reference stream ranged from approximately a factor of two to three (for cadmium, copper, selenium, and zinc) to greater than two orders of magnitude for PCBs. High concentrations of PCBs in forage fish at WCK 3.9 near the main ORNL complex, with lower levels in fish collected 1 km downstream, are consistent with the presence of continuing PCB inputs upstream of WCK 3.9.

4.4.2.3 Ecological surveys

Periphyton monitoring in WOC was conducted three times in 1996 at two sites located upstream of ORNL discharges to WOC (WCK 6.8 and WCK 5.1) and three sites located downstream of ORNL discharges (WCK 3.9, WCK 3.4, and WCK 2.3). Algal biomass and photosynthetic rates were generally within the range of measurements made since 1992, indicating little change in conditions. Algal biomass and chlorophyll-specific photosynthetic rates tend to be higher downstream of ORNL discharges than upstream. Samples for nutrient analyses were taken in April 1996. Nitrate and soluble reactive phosphorus increased steadily with distance downstream in WOC. High nutrient concentrations contribute to high photosynthetic rates in WOC and are at least partly responsible for the herbivore- (stoneroller-) dominated fish assemblages in unshaded portions of the stream.

Quantitative samples at established biomonitoring sites in the WOC watershed in the spring and fall of 1996 were collected under the fish community task. Total density and biomass values for the fall were similar to those for previous years with the exception of the site located downstream on First Creek. Total density and biomass values at this site were at the lowest levels in fall 1996 since sampling began in 1985. Total density and biomass at WCK 3.9 continues to decline from the peak values in fall 1992 following the start-up of the NRWTF in March 1990. This decline may be part of the normal fluctuations that will occur in fish populations when new habitat is opened for occupation. In the fall sampling, two fish species were collected at two separate sites for the first time. The redbreast sunfish was collected for the first time in lower First Creek (FCK 0.1), and the spotted bass (*Micropterus punctulatus*) was collected for the first time at WCK 3.9.

The benthic macroinvertebrate communities were sampled at nine sites in the WOC watershed during the spring and fall of 1996. Results of the April sampling periods through 1995 continued to show that ORNL operations are having adverse ecological effects on First Creek, Fifth Creek, Melton Branch, and WOC. The most severely affected site continued to be WCK 3.9, where pollution-intolerant species are rare. Total richness (i.e., the mean number of different kinds of taxa per sample) increased substantially at WCK 3.9 after 1989 and then stabilized. Conditions further downstream at WCK 2.3 appear unchanged since 1986. The macroinvertebrate community of lower Fifth Creek (FFK 0.2) exhibited strong evidence of gradual improvement through 1993 and then appears to have stabilized through 1995. A reduction in total richness may indicate that FFK 0.2 experienced an additional perturbation after the 1993 sampling; results of the spring 1996 samples will be used to determine whether a persistent decline has occurred in ecological conditions or if the decline is a result of natural temporal variability.

4.4.3 East Tennessee Technology Park BMAP

4.4.3.1 Toxicity monitoring

The toxicity monitoring task for the ETTP BMAP includes tests of effluent from treatment facilities (see ETTP Toxicity Control and Monitoring Program, Sect. 4.3.3); effluent from storm drains SD170, SD180, and SD190; and surface water from six sites within Mitchell Branch. Effluent from SD170 and SD190 was evaluated for toxicity six times using *Ceriodaphnia dubia*. Full-strength effluent from SD170 reduced *Ceriodaphnia* survival or reproduction in one of six tests. Full-strength effluent from SD190 reduced *Ceriodaphnia* survival or reproduction in five of six tests. Effluent from SD180 was evaluated for toxicity three times in 1996; the effluent did not reduce *Ceriodaphnia* survival or reproduction in any test. Toxicity tests were conducted using ambient water from Mitchell Branch downstream of each storm drain. For each test period, the toxicity of the storm drain effluents was not reflected in reduced survival or reproduction of *Ceriodaphnia* in the corresponding Mitchell Branch samples.

4.4.3.2 Bioaccumulation studies

In July 1996, caged clams were used to evaluate potential PCB sources to ETTP waters, and in November, resident fish were collected from Mitchell Branch, the K-1007-P1 pond, and the K901-A pond to evaluate the potential human-health risks associated with fish ingestion. In Mitchell Branch, caged clam studies showed that SD190 and a site near the Mitchell Branch weir provide the highest influx of PCBs to downstream waters and that at the K-1007-P1 pond the highest PCB concentration was at the SD100 outfall (11.16 µg/g). The average PCB concentration in clams placed for four weeks at the K901-A outlet (0.30 µg/g) was approximately two times higher than reference clams, but was relatively low compared with that at lower Mitchell Branch and the K-1007-P1 pond outlets to Poplar Creek (1.3 and 1.4 µg/g, respectively). The mean PCB concentrations (µg/g wet wt., mean ± S.E.) in resident sport fish were as follows: 1.63 ± 0.48 in redbreast sunfish from Mitchell Branch, 26.19 ± 5.59 in largemouth bass from the K-1007-P1 pond, and 0.64 ± 0.12 in largemouth bass from the K-901-A pond (n = 4 fish/site). Considered together, the clam and fish studies in 1996 indicate that Mitchell Branch and the K-1007-P1 pond are the major ETTP sources of PCBs to downstream waters and would provide the greatest potential risk (if these sites were accessible to the public) to human consumers.

4.4.4 Waterfowl Surveys

In conjunction with TWRA personnel, ORR personnel monitor waterfowl populations on the

ORR, and geese are measured occasionally for gross radiological activity. In 1996, Canada geese were "whole-body counted" for gamma radiation and averaged 0.08 pCi/g, a level comparable with that of geese collected at other sites in the area. Since 1993, more than 300 geese captured on or near the ORR have undergone such "whole body counts." Only five of these geese (< 2%) had gross gamma activity ≥ 0.5pCi/g. Three of these, however, occurred in 1996, and all five were captured at ORNL. ORR Canada goose observations continued to decline in 1996 (down 27% from 1995), while non-goose waterfowl observations increased 46% during the same period.

4.4.5 Ecological Surveys

The benthic macroinvertebrate communities downstream of the main storm drains in Mitchell Branch continue to show impacts compared with the upstream reference site. The most affected site is MIK 0.45 (downstream of SD 190), where very few pollution-intolerant Ephemeroptera, Plecoptera, and Trichoptera (i.e., mayflies, stoneflies, and caddisflies) taxa exist, and the least affected site is MIK 0.78 (immediately upstream of SD 170). Since showing some recovery at MIK 0.45 and MIK 0.71 after the 1989 or 1990 sampling periods, "steady state" conditions appear to have been reached, indicating that no further detectable improvements have occurred.

In April 1996, the fish communities were quantitatively sampled at sites MIK 0.71, MIK 0.45, and the reference site, Scarboro Creek. In general, fish community studies have shown that stream conditions have improved since the early 1990s, when fish populations first became established in Mitchell Branch. The estimated fish density has generally increased at MIK 0.71 as represented in both spring and fall samples from 1991 through spring 1996. A total of ten fish species has been collected at MIK 0.71. In contrast, total estimated fish density has shown an overall decline at MIK 0.45 from fall 1991 through spring 1996. A total of seven fish species has been collected at MIK 0.45; however, the fish population at MIK 0.45 consists of relatively stable populations of only two species, blacknose dace and creek chub. Compared with the reference stream, Mitchell Branch is lacking stable populations of several fish species.

4.4.6 BMAP Trends on the ORR

Several tasks were common to each of the three ORR BMAPs during 1996, and these provide some basis for examining trends in environmental quality for the ORR. The receiving streams for discharges from each facility were consistently nontoxic in standardized fish- and invertebrate-based laboratory tests conducted during 1996, although water from EFPC (the only receiving stream tested by this procedure) continued to be toxic to fish embryos in the medaka embryo test. Mercury and PCBs remained elevated in fish downstream of each facility, but there was some indication of mercury decreases in fish downstream of Lake Reality on EFPC. Canada geese, which cross facility boundaries, averaged levels of gamma radiation comparable with those of geese collected at other sites in the area, although a few geese—all at ORNL—continued to show individual levels of elevated gamma radiation. Fish communities continued to improve to varying degrees during 1996 in streams draining all three facilities, although the fish communities remained largely degraded relative to reference streams. Invertebrate communities showed similar trends. Improvements were observed at some sites on the reservation; continuing significant degradation was observed elsewhere relative to reference sites.